Information Technology —
Portable Operating System Interface (POSIX®)

Shell and Utilities

Sponsor

Portable Applications Standards Committee
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IEEE Computer Society

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Abstract


This standard defines a standard operating system interface and environment, including a command interpreter (or “shell”), and common utility programs to support applications portability at the source code level. This standard is intended to be used by both applications developers and system implementors and comprises four major components (each in an associated volume):

- General terms, concepts, and interfaces common to all volumes of this standard, including utility conventions and C-language header definitions, are included in the Base Definitions volume.
- Definitions for system service functions and subroutines, language-specific system services for the C programming language, function issues, including portability, error handling, and error recovery, are included in the System Interfaces volume.
- Definitions for a standard source code-level interface to command interpretation services (a “shell”) and common utility programs for application programs are included in the Shell and Utilities volume.
- Extended rationale that did not fit well into the rest of the document structure, which contains historical information concerning the contents of this standard and why features were included or discarded by the standard developers, is included in the Rationale (Informative) volume.

The following areas are outside the scope of this standard:

- Graphics interfaces
- Database management system interfaces
- Record I/O considerations
- Object or binary code portability
- System configuration and resource availability

This standard describes the external characteristics and facilities that are of importance to applications developers, rather than the internal construction techniques employed to achieve these capabilities. Special emphasis is placed on those functions and facilities that are needed in a wide variety of commercial applications.

Keywords

application program interface (API), argument, asynchronous, basic regular expression (BRE), batch job, batch system, built-in utility, byte, child, command language interpreter, CPU, extended regular expression (ERE), FIFO, file access control mechanism, input/output (I/O), job control, network, portable operating system interface (POSIX®), parent, shell, stream, string, synchronous, system, thread, X/Open System Interface (XSI)
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Foreword

Structure of the Standard

This standard was originally developed by the Austin Group, a joint working group of members of the IEEE, members of The Open Group, and members of ISO/IEC Joint Technical Committee 1, as one of the four volumes of IEEE Std 1003.1-2001. The standard was approved by ISO and IEC and published in four parts, correlating to the original volumes.

A mapping of the parts to the volumes is shown below:

<table>
<thead>
<tr>
<th>ISO/IEC 9945 Part</th>
<th>IEEE Std 1003.1</th>
<th>Description</th>
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<tr>
<td>9945-1</td>
<td>Base Definitions</td>
<td>Includes general terms, concepts, and interfaces common to all parts of ISO/IEC 9945, including utility conventions and C-language header definitions.</td>
</tr>
<tr>
<td>9945-2</td>
<td>System Interfaces</td>
<td>Includes definitions for system service functions and subroutines, language-specific system services for the C programming language, function issues, including portability, error handling, and error recovery.</td>
</tr>
<tr>
<td>9945-3</td>
<td>Shell and Utilities</td>
<td>Includes definitions for a standard source code-level interface to command interpretation services (a “shell”) and common utility programs for application programs.</td>
</tr>
<tr>
<td>9945-4</td>
<td>Rationale</td>
<td>Includes extended rationale that did not fit well into the rest of the document structure, containing historical information concerning the contents of ISO/IEC 9945 and why features were included or discarded by the standard developers.</td>
</tr>
</tbody>
</table>

All four parts comprise the entire standard, and are intended to be used together to accommodate significant internal referencing among them. POSIX-conforming systems are required to support all four parts.
Introduction

Note: This introduction is not part of IEEE Std 1003.1-2001, Standard for Information Technology — Portable Operating System Interface (POSIX).

This standard has been jointly developed by the IEEE and The Open Group. It is simultaneously an IEEE Standard, an ISO/IEC Standard, and an Open Group Technical Standard.

The Austin Group

This standard was developed, and is maintained, by a joint working group of members of the IEEE Portable Applications Standards Committee, members of The Open Group, and members of ISO/IEC Joint Technical Committee 1. This joint working group is known as the Austin Group.³ The Austin Group arose out of discussions amongst the parties which started in early 1998, leading to an initial meeting and formation of the group in September 1998. The purpose of the Austin Group has been to revise, combine, and update the following standards: ISO/IEC 9945-1, ISO/IEC 9945-2, IEEE Std 1003.1, IEEE Std 1003.2, and the Base Specifications of The Open Group Single UNIX Specification.

After two initial meetings, an agreement was signed in July 1999 between The Open Group and the Institute of Electrical and Electronics Engineers (IEEE), Inc., to formalize the project with the first draft of the revised specifications being made available at the same time. Under this agreement, The Open Group and IEEE agreed to share joint copyright of the resulting work. The Open Group has provided the chair and secretariat for the Austin Group.

The base document for the revision was The Open Group’s Base volumes of its Single UNIX Specification, Version 2. These were selected since they were a superset of the existing POSIX.1 and POSIX.2 specifications and had some organizational aspects that would benefit the audience for the new revision.

The approach to specification development has been one of “write once, adopt everywhere”, with the deliverables being a set of specifications that carry the IEEE POSIX designation, The Open Group’s Technical Standard designation, and an ISO/IEC designation. This set of specifications forms the core of the Single UNIX Specification, Version 3.

This unique development has combined both the industry-led efforts and the formal standardization activities into a single initiative, and included a wide spectrum of participants. The Austin Group continues as the maintenance body for this document.

Anyone wishing to participate in the Austin Group should contact the chair with their request. There are no fees for participation or membership. You may participate as an observer or as a contributor. You do not have to attend face-to-face meetings to participate; electronic participation is most welcome. For more information on the Austin Group and how to participate, see http://www.opengroup.org/austin.

³. The Austin Group is named after the location of the inaugural meeting held at the IBM facility in Austin, Texas in September 1998.
Background

The developers of this standard represent a cross section of hardware manufacturers, vendors of operating systems and other software development tools, software designers, consultants, academics, authors, applications programmers, and others.

Conceptually, this standard describes a set of fundamental services needed for the efficient construction of application programs. Access to these services has been provided by defining an interface, using the C programming language, a command interpreter, and common utility programs that establish standard semantics and syntax. Since this interface enables application writers to write portable applications—it was developed with that goal in mind—it has been designated POSIX, an acronym for Portable Operating System Interface.

Although originated to refer to the original IEEE Std 1003.1-1988, the name POSIX more correctly refers to a family of related standards: IEEE Std 1003.n and the parts of ISO/IEC 9945. In earlier editions of the IEEE standard, the term POSIX was used as a synonym for IEEE Std 1003.1-1988. A preferred term, POSIX.1, emerged. This maintained the advantages of readability of the symbol “POSIX” without being ambiguous with the POSIX family of standards.

Audience

The intended audience for this standard is all persons concerned with an industry-wide standard operating system based on the UNIX system. This includes at least four groups of people:

1. Persons buying hardware and software systems
2. Persons managing companies that are deciding on future corporate computing directions
3. Persons implementing operating systems, and especially
4. Persons developing applications where portability is an objective

Purpose

Several principles guided the development of this standard:

• Application-Oriented

The basic goal was to promote portability of application programs across UNIX system environments by developing a clear, consistent, and unambiguous standard for the interface specification of a portable operating system based on the UNIX system documentation. This standard codifies the common, existing definition of the UNIX system.

• Interface, Not Implementation

This standard defines an interface, not an implementation. No distinction is made between library functions and system calls; both are referred to as functions. No details of the implementation of any function are given (although historical practice is sometimes indicated in the RATIONALE section). Symbolic names are given for constants (such as signals and error numbers) rather than numbers.

4. The name POSIX was suggested by Richard Stallman. It is expected to be pronounced pahz-icks, as in positive, not poh-six, or other variations. The pronunciation has been published in an attempt to promulgate a standardized way of referring to a standard operating system interface.
• Source, Not Object, Portability

This standard has been written so that a program written and translated for execution on one conforming implementation may also be translated for execution on another conforming implementation. This standard does not guarantee that executable (object or binary) code will execute under a different conforming implementation than that for which it was translated, even if the underlying hardware is identical.

• The C Language

The system interfaces and header definitions are written in terms of the standard C language as specified in the ISO C standard.

• No Superuser, No System Administration

There was no intention to specify all aspects of an operating system. System administration facilities and functions are excluded from this standard, and functions usable only by the superuser have not been included. Still, an implementation of the standard interface may also implement features not in this standard. This standard is also not concerned with hardware constraints or system maintenance.

• Minimal Interface, Minimally Defined

In keeping with the historical design principles of the UNIX system, the mandatory core facilities of this standard have been kept as minimal as possible. Additional capabilities have been added as optional extensions.

• Broadly Implementable

The developers of this standard endeavored to make all specified functions implementable across a wide range of existing and potential systems, including:

1. All of the current major systems that are ultimately derived from the original UNIX system code (Version 7 or later)
2. Compatible systems that are not derived from the original UNIX system code
3. Emulations hosted on entirely different operating systems
4. Networked systems
5. Distributed systems
6. Systems running on a broad range of hardware

No direct references to this goal appear in this standard, but some results of it are mentioned in the Rationale (Informative) volume.

• Minimal Changes to Historical Implementations

When the original version of IEEE Std 1003.1 was published, there were no known historical implementations that did not have to change. However, there was a broad consensus on a set of functions, types, definitions, and concepts that formed an interface that was common to most historical implementations.

The adoption of the 1988 and 1990 IEEE system interface standards, the 1992 IEEE shell and utilities standard, the various Open Group (formerly X/Open) specifications, and the subsequent revisions and addenda to all of them have consolidated this consensus, and this revision reflects the significantly increased level of consensus arrived at since the original versions. The earlier standards and their modifications specified a number of areas where consensus had not been reached before, and these are now reflected in this revision. The authors of the original versions tried, as much as possible, to follow the principles below
when creating new specifications:

1. By standardizing an interface like one in an historical implementation; for example, directories

2. By specifying an interface that is readily implementable in terms of, and backwards-compatible with, historical implementations, such as the extended tar format defined in the pax utility

3. By specifying an interface that, when added to an historical implementation, will not conflict with it; for example, the sigaction() function

This revision tries to minimize the number of changes required to implementations which conform to the earlier versions of the approved standards to bring them into conformance with the current standard. Specifically, the scope of this work excluded doing any “new” work, but rather collecting into a single document what had been spread across a number of documents, and presenting it in what had been proven in practice to be a more effective way. Some changes to prior conforming implementations were unavoidable, primarily as a consequence of resolving conflicts found in prior revisions, or which became apparent when bringing the various pieces together.

However, since it references the 1999 version of the ISO C standard, and no longer supports “Common Usage C”, there are a number of unavoidable changes. Applications portability is similarly affected.

This standard is specifically not a codification of a particular vendor’s product.

It should be noted that implementations will have different kinds of extensions. Some will reflect “historical usage” and will be preserved for execution of pre-existing applications. These functions should be considered “obsolete” and the standard functions used for new applications. Some extensions will represent functions beyond the scope of this standard. These need to be used with careful management to be able to adapt to future extensions of this standard and/or port to implementations that provide these services in a different manner.

- Minimal Changes to Existing Application Code

A goal of this standard was to minimize additional work for the developers of applications. However, because every known historical implementation will have to change at least slightly to conform, some applications will have to change.

This Standard

This standard defines the Portable Operating System Interface (POSIX) requirements and consists of the following volumes:

- Base Definitions
- Shell and Utilities (this volume)
- System Interfaces
- Rationale (Informative)
Introduction

This Volume

The Shell and Utilities volume describes the commands and utilities offered to application programs on POSIX-conformant systems. Readers are expected to be familiar with the Base Definitions volume.

This volume is structured as follows:

- Chapter 1 explains the status of this volume and its relationship to other formal standards. It also describes the defaults used by the utility descriptions in Chapter 4.
- Chapter 2 describes the command language used in POSIX-conformant systems.
- Chapter 3 describes a set of services and utilities that are implemented on systems supporting the Batch Environment Services and Utilities option.
- Chapter 4 consists of reference pages for all utilities available on POSIX-conformant systems.

Comprehensive references are available in the index.

Typographical Conventions

The following typographical conventions are used throughout this standard. In the text, this standard is referred to as IEEE Std 1003.1-2001, which is technically identical to The Open Group Base Specifications, Issue 6.

The typographical conventions listed here are for ease of reading only. Editorial inconsistencies in the use of typography are unintentional and have no normative meaning in this standard.

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<th>Example</th>
<th>Notes</th>
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Notes:

1. Conversion specifications, specifier characters, and modifier characters are used primarily in date-related functions and utilities and the fprintf and fscanf formatting functions.

2. Unless otherwise noted, the quotes shall not be used as input or output. When used in a list item, the quotes are omitted. For literal characters, ‘’ (or any of the other sequences such as ‘’’’) is the same as the C constant ‘’’’ (or ‘’’’).

3. The style selected for some of the special characters, such as <newline>, matches the form of the input given to the localedef utility. Generally, the characters selected for this special treatment are those that are not visually distinct, such as the control characters <tab> or <newline>.

4. Names surrounded by braces represent symbolic limits or configuration values which may be declared in appropriate headers by means of the C #define construct.

5. Brackets shown in this font, "[ ]", are part of the syntax and do not indicate optional items. In syntax the ' | ' symbol is used to separate alternatives, and ellipses (" . . ") are used to show that additional arguments are optional.

Shading is used to identify extensions and options; see Section 1.8.1 (on page 9).

Footnotes and notes within the body of the normative text are for information only (informative).

Informative sections (such as Rationale, Change History, Application Usage, and so on) are denoted by continuous shading bars in the margins.

Ranges of values are indicated with parentheses or brackets as follows:

- $(a,b)$ means the range of all values from $a$ to $b$, including neither $a$ nor $b$.
- $[a,b]$ means the range of all values from $a$ to $b$, including $a$ and $b$.
- $(a,b)$ means the range of all values from $a$ to $b$, including $a$, but not $b$.
- $(a,b]$ means the range of all values from $a$ to $b$, including $b$, but not $a$. 
IEEE Std 1003.1-2001 was prepared by the Austin Group, sponsored by the Portable Applications Standards Committee of the IEEE Computer Society, The Open Group, and ISO/SC22 WG15.

The Austin Group

At the time of approval, the membership of the Austin Group was as follows:

Andrew Josey, Chair
Donald W. Cragun, Organizational Representative, IEEE PASC
Nicholas Stoughton, Organizational Representative, ISO/SC22 WG15
Mark Brown, Organizational Representative, The Open Group
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Walter Briscoe   Yvette Ho Sang        Glen Seeds
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Dave Butenhof    Lowell G. Johnson     Raja Srinivasan
Geoff Clare      Andrew Josey          Nicholas Stoughton
Donald W. Cragun Michael Kavanaugh    Donn S. Terry
Lee Damico       David Korn            Fred Tydeman
Ulrich Drepper   Marc Aurele La France  Peter Van Der Veen
Paul Eggert      Jim Meyering          James Youngman
Joanna Farley    Gary Miller           Jim Zepeda
Clive D.W. Feather Finnbarr P. Murphy Joseph S. Myers
Andrew Gollan
Participants

Austin Group Working Group Members

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<td>Andrew Gollan</td>
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Participants

The Open Group

When The Open Group approved the Base Specifications, Issue 6 on 12 September 2001, the membership of The Open Group Base Working Group was as follows:

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Mark Brown, Austin Group Liaison
Cathy Hughes, Technical Editor

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Mark Brown       Andrew Gollan  Andrew K. Roach
Donald W. Cragun Gary Miller  Nicholas Stoughton
Larry Dwyer      Finnbarr P. Murphy  Kenjiro Tsuji
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*Andrew Josey*, Functional Chair  
*Curtis Royster Jr.*, Functional Chair  
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The following organizational representative voted on this standard:

*Andrew Josey*, X/Open Company Ltd.
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IEEE Std 1003.1-2001/Cor 1-2002 was prepared by the Austin Group, sponsored by the Portable Applications Standards Committee of the IEEE Computer Society, The Open Group, and ISO/IEC JTC 1/SC22/WG15.

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Alexander Terekhov
Donn S. Terry
Mike Wilson
Garrett A. Wollman
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- Michael Gonzalez  
- Charles Ngethe  
- Jay Ashford  
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- Donn S. Terry  
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- Roger J. Martin  
- Oren Yuen  
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- AT&T for permission to reproduce portions of its copyrighted System V Interface Definition (SVID) and material from the UNIX System V Release 2.0 documentation.
- The SC22 WG14 Committees.

This standard was prepared by the Austin Group, a joint working group of the IEEE, The Open Group, and ISO SC22 WG15.
Referenced Documents

Normative References
Normative references for this standard are defined in the Base Definitions volume.

Informative References
The following documents are referenced in this standard:

1984 /usr/group Standard

Almasi and Gottlieb

ANSI C

ANSI X3.226-1994

Brawer

DeRemer and Pennello Article

Draft ANSI X3J11.1
IEEE Floating Point draft report of ANSI X3J11.1 (NCEG).

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Federal Information Procurement Standard (FIPS) 151-1. Portable Operating System Interface (POSIX)—Part 1: System Application Program Interface (API) [C Language].

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Federal Information Procurement Standards (FIPS) 151-2, Portable Operating System Interface (POSIX)—Part 1: System Application Program Interface (API) [C Language].

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IETF RFC 822

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Broadcasting Internet Datagrams, J. Mogul, October 1984.

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Domain Name System Implementation Schedule, J. Postel, October 1984.

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IETF RFC 1034

IETF RFC 1035

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Requirements for Internet Hosts — Application and Support, R. Braden, October 1989.

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Multipurpose Internet Mail Extensions (MIME), Part 1: Format of Internet Message Bodies, N. Freed, N. Borenstein, November 1996.

IETF RFC 2181

IETF RFC 2373

IETF RFC 2460

Internationalisation Guide

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ISO/IEC 9899:1990, Programming Languages — C, including Amendment 1:1995 (E), C Integrity (Multibyte Support Extensions (MSE) for ISO C).
ISO 2375: 1985

ISO 8652: 1987

ISO/IEC 1539: 1990
ISO/IEC 1539: 1990, Information Technology — Programming Languages — Fortran (technically identical to the ANSI X3.9-1978 standard [FORTRAN 77]).

ISO/IEC 4873: 1991

ISO/IEC 6429: 1992

ISO/IEC 6937: 1994

ISO/IEC 8802-3: 1996

ISO/IEC 8859
ISO/IEC 8859, Information Technology — 8-Bit Single-Byte Coded Graphic Character Sets:

- Part 1: Latin Alphabet No. 1
- Part 2: Latin Alphabet No. 2
- Part 3: Latin Alphabet No. 3
- Part 4: Latin Alphabet No. 4
- Part 5: Latin/Cyrillic Alphabet
- Part 6: Latin/Arabic Alphabet
- Part 7: Latin/Greek Alphabet
- Part 8: Latin/Hebrew Alphabet
- Part 9: Latin Alphabet No. 5
- Part 10: Latin Alphabet No. 6
- Part 13: Latin Alphabet No. 7
- Part 14: Latin Alphabet No. 8
- Part 15: Latin Alphabet No. 9

ISO POSIX-1: 1996

ISO POSIX-2: 1993
Issue 1

Issue 2
X/Open Portability Guide, January 1987:

Issue 3

Issue 4
CAE Specification, July 1992, published by The Open Group:

Issue 4, Version 2
CAE Specification, August 1994, published by The Open Group:

Issue 5
Technical Standard, February 1997, published by The Open Group:

Knuth Article
Knuth, Donald E., On the Translation of Languages from Left to Right, Information and Control, Volume 8, No. 6, October 1965.
KornShell

MSE Working Draft

POSIX.0: 1995

POSIX.1: 1988

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POSIX.2b
P1003.2b, Standard for Information Technology — Portable Operating System Interface (POSIX) — Part 2: Shell and Utilities — Amendment.

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Sarwate, Dilip V., Computation of Cyclic Redundancy Checks via Table Lookup, Communications of the ACM, Volume 30, No. 8, August 1988.

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SVID, Issue 1

SVID, Issue 2

SVID, Issue 3

The AWK Programming Language

UNIX Programmer’s Manual

XNS, Issue 4

XNS, Issue 5

XNS, Issue 5.2

X/Open Curses, Issue 4, Version 2

Yacc
Source Documents

Parts of the following documents were used to create the base documents for this standard:

AIX 3.2 Manual

OSF/1

OSF AES

System V Release 2.0

System V Release 4.2
Chapter 1
Introduction

1.1 Scope

1.2 Conformance

1.3 Normative References

1.4 Change History
Change history is described in the Rationale (Informative) volume of IEEE Std 1003.1-2001, and in the CHANGE HISTORY section of reference pages.

1.5 Terminology
This section appears in the Base Definitions volume of IEEE Std 1003.1-2001, but is repeated here for convenience:

For the purposes of IEEE Std 1003.1-2001, the following terminology definitions apply:

- **can**
  Describes a permissible optional feature or behavior available to the user or application. The feature or behavior is mandatory for an implementation that conforms to IEEE Std 1003.1-2001. An application can rely on the existence of the feature or behavior.

- **implementation-defined**
  Describes a value or behavior that is not defined by IEEE Std 1003.1-2001 but is selected by an implementor. The value or behavior may vary among implementations that conform to IEEE Std 1003.1-2001. An application should not rely on the existence of the value or behavior. An application that relies on such a value or behavior cannot be assured to be portable across conforming implementations.

  The implementor shall document such a value or behavior so that it can be used correctly by an application.

- **legacy**
  Describes a feature or behavior that is being retained for compatibility with older applications, but which has limitations which make it inappropriate for developing portable
Terminology

Introduction

33 applications. New applications should use alternative means of obtaining equivalent
functionality.

**may**

Describes a feature or behavior that is optional for an implementation that conforms to
IEEE Std 1003.1-2001. An application should not rely on the existence of the feature or
behavior. An application that relies on such a feature or behavior cannot be assured to be
portable across conforming implementations.

To avoid ambiguity, the opposite of **may** is expressed as **need not**, instead of **may not**.

**shall**

For an implementation that conforms to IEEE Std 1003.1-2001, describes a feature or
behavior that is mandatory. An application can rely on the existence of the feature or
behavior.

For an application or user, describes a behavior that is mandatory.

**should**

For an implementation that conforms to IEEE Std 1003.1-2001, describes a feature or
behavior that is recommended but not mandatory. An application should not rely on the
existence of the feature or behavior. An application that relies on such a feature or behavior
cannot be assured to be portable across conforming implementations.

For an application, describes a feature or behavior that is recommended programming
practice for optimum portability.

**undefined**

Describes the nature of a value or behavior not defined by IEEE Std 1003.1-2001 which
results from use of an invalid program construct or invalid data input.

The value or behavior may vary among implementations that conform to
IEEE Std 1003.1-2001. An application should not rely on the existence or validity of the
value or behavior. An application that relies on any particular value or behavior cannot be
assured to be portable across conforming implementations.

**unspecified**

Describes the nature of a value or behavior not specified by IEEE Std 1003.1-2001 which
results from use of a valid program construct or valid data input.

The value or behavior may vary among implementations that conform to
IEEE Std 1003.1-2001. An application should not rely on the existence or validity of the
value or behavior. An application that relies on any particular value or behavior cannot be
assured to be portable across conforming implementations.
1.6 Definitions


1.7 Relationship to Other Documents

1.7.1 System Interfaces

This subsection describes some of the features provided by the System Interfaces volume of IEEE Std 1003.1-2001 that are assumed to be globally available on all systems conforming to this volume of IEEE Std 1003.1-2001. This subsection does not attempt to detail all of the features defined in the System Interfaces volume of IEEE Std 1003.1-2001 that are required by all of the utilities defined in this volume of IEEE Std 1003.1-2001; the utility and function descriptions point out additional functionality required to provide the corresponding specific features needed by each.

The following subsections describe frequently used concepts. Many of these concepts are described in the Base Definitions volume of IEEE Std 1003.1-2001. Utility and function description statements override these defaults when appropriate.

1.7.1.1 Process Attributes

The following process attributes, as described in the System Interfaces volume of IEEE Std 1003.1-2001, are assumed to be supported for all processes in this volume of IEEE Std 1003.1-2001:

- Controlling Terminal
- Real Group ID
- Current Working Directory
- Real User ID
- Effective Group ID
- Root Directory
- Effective User ID
- Saved Set-Group-ID
- File Descriptors
- Saved Set-User-ID
- File Mode Creation Mask
- Session Membership
- Process Group ID
- Supplementary Group IDs
- Process ID

A conforming implementation may include additional process attributes.

1.7.1.2 Concurrent Execution of Processes

The following functionality of the `fork()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001 shall be available on all systems conforming to this volume of IEEE Std 1003.1-2001:

1. Independent processes shall be capable of executing independently without either process terminating.
2. A process shall be able to create a new process with all of the attributes referenced in Section 1.7.1.1, determined according to the semantics of a call to the `fork()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001 followed by a call in the child process to one of the `exec` functions defined in the System Interfaces volume of IEEE Std 1003.1-2001.
1.7.1.3  File Access Permissions

The file access control mechanism described by the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.4, File Access Permissions shall apply to all files on an implementation conforming to this volume of IEEE Std 1003.1-2001.

1.7.1.4  File Read, Write, and Creation

If a file that does not exist is to be written, it shall be created as described below, unless the utility description states otherwise.

When a file that does not exist is created, the following features defined in the System Interfaces volume of IEEE Std 1003.1-2001 shall apply unless the utility or function description states otherwise:

1. The user ID of the file shall be set to the effective user ID of the calling process.
2. The group ID of the file shall be set to the effective group ID of the calling process or the group ID of the directory in which the file is being created.
3. If the file is a regular file, the permission bits of the file shall be set to:
   
   S_IROTH | S_IWOTH | S_IRGRP | S_IWGRP | S_IRUSR | S_IWUSR

   (see the description of File Modes in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 13, Headers, <sys/stat.h>) except that the bits specified by the file mode creation mask of the process shall be cleared. If the file is a directory, the permission bits shall be set to:

   S_IRWXU | S_IRWXG | S_IRWXO

   except that the bits specified by the file mode creation mask of the process shall be cleared.
5. If the file is a directory, it shall be an empty directory; otherwise, the file shall have length zero.
6. If the file is a symbolic link, the effect shall be undefined unless the [POSIX2_SYMLINKS] variable is in effect for the directory in which the symbolic link would be created.
7. Unless otherwise specified, the file created shall be a regular file.

When an attempt is made to create a file that already exists, the utility shall take the action indicated in Table 1-1 (on page 5) corresponding to the type of the file the utility is trying to create and the type of the existing file, unless the utility description states otherwise.
### Table 1-1 Actions when Creating a File that Already Exists

<table>
<thead>
<tr>
<th>Existing Type</th>
<th>New Type</th>
<th>Function Creating New</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> <code>fattach()</code>-ed STREAM</td>
<td>F F F F — — — — OF — —</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>B</strong> Block Special</td>
<td>F F F F — — — — OF — —</td>
<td><code>mknod()</code>**</td>
</tr>
<tr>
<td><strong>C</strong> Character Special</td>
<td>F F F F — — — — OF — —</td>
<td><code>mknod()</code>**</td>
</tr>
<tr>
<td><strong>D</strong> Directory</td>
<td>F F F F — — — — F — —</td>
<td><code>mkdir()</code></td>
</tr>
<tr>
<td><strong>E</strong> FIFO Special File</td>
<td>F F F F — — — — O — —</td>
<td><code>mkfifo()</code></td>
</tr>
<tr>
<td><strong>L</strong> Symbolic Link</td>
<td>F F F F — — FL — —</td>
<td><code>symlink()</code></td>
</tr>
<tr>
<td><strong>M</strong> Shared Memory</td>
<td>F F F F — — — — — —</td>
<td><code>shm_open()</code></td>
</tr>
<tr>
<td><strong>P</strong> Semaphore</td>
<td>F F F F — — — — — —</td>
<td><code>sem_open()</code></td>
</tr>
<tr>
<td><strong>Q</strong> Message Queue</td>
<td>F F F F — — — — — —</td>
<td><code>mq_open()</code></td>
</tr>
<tr>
<td><strong>R</strong> Regular File</td>
<td>F F F F — — RF — —</td>
<td><code>open()</code></td>
</tr>
<tr>
<td><strong>S</strong> Socket</td>
<td>F F F F — — — — — —</td>
<td><code>bind()</code></td>
</tr>
<tr>
<td><strong>T</strong> Typed Memory</td>
<td>F F F F — — — — — —</td>
<td>*</td>
</tr>
</tbody>
</table>

The following codes are used in Table 1-1:

- **F** Fail. The attempt to create the new file shall fail and the utility shall either continue with its operation or exit immediately with a non-zero exit status, depending on the description of the utility.

- **FL** Follow link. Unless otherwise specified, the symbolic link shall be followed as specified for pathname resolution, and the operation performed shall be as if the target of the symbolic link (after all resolution) had been named. If the target of the symbolic link does not exist, it shall be as if that nonexistent target had been named directly.

- **O** Open FIFO. When attempting to create a regular file, and the existing file is a FIFO special file:
  1. If the FIFO is not already open for reading, the attempt shall block until the FIFO is opened for reading.
  2. Once the FIFO is open for reading, the utility shall open the FIFO for writing and continue with its operation.

- **OF** The named file shall be opened with the consequences defined for that file type.

- **RF** Regular file. When attempting to create a regular file, and the existing file is a regular file:
  1. The user ID, group ID, and permission bits of the file shall not be changed.
  2. The file shall be truncated to zero length.
  3. The `st_ctime` and `st_mtime` fields shall be marked for update.

- **O_APPEND** The effect is implementation-defined unless specified by the utility description.

- **O_TRUNC** There is no portable way to create a file of this type.

- **Not portable.**

When a file is to be appended, the file shall be opened in a manner equivalent to using the O_APPEND flag, without the O_TRUNC flag, in the `open()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001.

When a file is to be read or written, the file shall be opened with an access mode corresponding to the operation to be performed. If file access permissions deny access, the requested operation shall fail.
1.7.1.5 File Removal

When a directory that is the root directory or current working directory of any process is removed, the effect is implementation-defined. If file access permissions deny access, the requested operation shall fail. Otherwise, when a file is removed:

1. Its directory entry shall be removed from the file system.

2. The link count of the file shall be decremented.

3. If the file is an empty directory (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.143, Empty Directory):
   a. If no process has the directory open, the space occupied by the directory shall be freed and the directory shall no longer be accessible.
   b. If one or more processes have the directory open, the directory contents shall be preserved until all references to the file have been closed.

4. If the file is a directory that is not empty, the st_ctime field shall be marked for update.

5. If the file is not a directory:
   a. If the link count becomes zero:
      i. If no process has the file open, the space occupied by the file shall be freed and the file shall no longer be accessible.
      ii. If one or more processes have the file open, the file contents shall be preserved until all references to the file have been closed.
   b. If the link count is not reduced to zero, the st_ctime field shall be marked for update.

6. The st_ctime and st_mtime fields of the containing directory shall be marked for update.

1.7.1.6 File Time Values

All files shall have the three time values described by the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.7, File Times Update.

1.7.1.7 File Contents

When a reference is made to the contents of a file, pathname, this means the equivalent of all of the data placed in the space pointed to by buf when performing the read() function calls in the following operations defined in the System Interfaces volume of IEEE Std 1003.1-2001:

\[
\text{while (read (fildes, buf, nbytes) > 0) }
\]

If the file is indicated by a pathname pathname, the file descriptor shall be determined by the equivalent of the following operation defined in the System Interfaces volume of IEEE Std 1003.1-2001:

\[
\text{fildes = open (pathname, O_RDONLY);}
\]

The value of nbytes in the above sequence is unspecified; if the file is of a type where the data returned by read() would vary with different values, the value shall be one that results in the most data being returned.

If the read() function calls would return an error, it is unspecified whether the contents of the file are considered to include any data from offsets in the file beyond where the error would be returned.
1.7.1.8 Pathname Resolution

The pathname resolution algorithm, described by the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.11, Pathname Resolution, shall be used by implementations conforming to this volume of IEEE Std 1003.1-2001; see also the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.5, File Hierarchy.

1.7.1.9 Changing the Current Working Directory

When the current working directory (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.436, Working Directory) is to be changed, unless the utility or function description states otherwise, the operation shall succeed unless a call to the `chdir()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001 would fail when invoked with the new working directory pathname as its argument.

1.7.1.10 Establish the Locale

The functionality of the `setlocale()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001 shall be available on all systems conforming to this volume of IEEE Std 1003.1-2001; that is, utilities that require the capability of establishing an international operating environment shall be permitted to set the specified category of the international environment.

1.7.1.11 Actions Equivalent to Functions

Some utility descriptions specify that a utility performs actions equivalent to a function defined in the System Interfaces volume of IEEE Std 1003.1-2001. Such specifications require only that the external effects be equivalent, not that any effect within the utility and visible only to the utility be equivalent.

1.7.2 Concepts Derived from the ISO C Standard

Some of the standard utilities perform complex data manipulation using their own procedure and arithmetic languages, as defined in their EXTENDED DESCRIPTION or OPERANDS sections. Unless otherwise noted, the arithmetic and semantic concepts (precision, type conversion, control flow, and so on) shall be equivalent to those defined in the ISO C standard, as described in the following sections. Note that there is no requirement that the standard utilities be implemented in any particular programming language.

1.7.2.1 Arithmetic Precision and Operations

Integer variables and constants, including the values of operands and option-arguments, used by the standard utilities listed in this volume of IEEE Std 1003.1-2001 shall be implemented as equivalent to the ISO C standard `signed long` data type; floating point shall be implemented as equivalent to the ISO C standard `double` type. Conversions between types shall be as described in the ISO C standard. All variables shall be initialized to zero if they are not otherwise assigned by the input to the application.

Arithmetic operators and control flow keywords shall be implemented as equivalent to those in the cited ISO C standard section, as listed in Table 1-2 (on page 8).
The evaluation of arithmetic expressions shall be equivalent to that described in Section 6.5, Expressions, of the ISO C standard.

Table 1-2  Selected ISO C Standard Operators and Control Flow Keywords

<table>
<thead>
<tr>
<th>Operation</th>
<th>ISO C Standard Equivalent Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>()</td>
<td>Section 6.5.1, Primary Expressions</td>
</tr>
<tr>
<td>postfix ++</td>
<td>Section 6.5.2, Postfix Operators</td>
</tr>
<tr>
<td>postfix --</td>
<td></td>
</tr>
<tr>
<td>unary +</td>
<td>Section 6.5.3, Unary Operators</td>
</tr>
<tr>
<td>unary -</td>
<td></td>
</tr>
<tr>
<td>prefix ++</td>
<td></td>
</tr>
<tr>
<td>prefix --</td>
<td></td>
</tr>
<tr>
<td>~</td>
<td></td>
</tr>
<tr>
<td>!</td>
<td></td>
</tr>
<tr>
<td>sizeof()</td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>Section 6.5.5, Multiplicative Operators</td>
</tr>
<tr>
<td>/</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>Section 6.5.6, Additive Operators</td>
</tr>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>&lt;&lt;=, &gt;&gt;=, &amp;=,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>=</td>
</tr>
<tr>
<td>^</td>
<td>Section 6.5.11, Bitwise Exclusive OR Operator</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>&amp;&amp;</td>
<td>Section 6.5.13, Logical AND Operator</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>expr?expr:expr</td>
<td>Section 6.5.15, Conditional Operator</td>
</tr>
<tr>
<td>=, *=, /=, %=, +=, -=</td>
<td>Section 6.5.16, Assignment Operators</td>
</tr>
<tr>
<td>&lt;&lt;=, &gt;&gt;=, &amp;=, ^=,</td>
<td>=</td>
</tr>
<tr>
<td>if ()</td>
<td>Section 6.8.4, Selection Statements</td>
</tr>
<tr>
<td>if () . . else</td>
<td></td>
</tr>
<tr>
<td>switch ()</td>
<td></td>
</tr>
<tr>
<td>while ()</td>
<td>Section 6.8.5, Iteration Statements</td>
</tr>
<tr>
<td>do . . while ()</td>
<td></td>
</tr>
<tr>
<td>for ()</td>
<td></td>
</tr>
<tr>
<td>goto</td>
<td>Section 6.8.6, Jump Statements</td>
</tr>
<tr>
<td>continue</td>
<td></td>
</tr>
<tr>
<td>break</td>
<td></td>
</tr>
<tr>
<td>return</td>
<td></td>
</tr>
</tbody>
</table>
1.7.2.2 Mathematical Functions

Any mathematical functions with the same names as those in the following sections of the ISO C standard:

- Section 7.12, Mathematics, `<math.h>
- Section 7.20.2, Pseudo-Random Sequence Generation Functions

shall be implemented to return the results equivalent to those returned from a call to the corresponding function described in the ISO C standard.

1.8 Portability

Some of the utilities in the Shell and Utilities volume of IEEE Std 1003.1-2001 and functions in the System Interfaces volume of IEEE Std 1003.1-2001 describe functionality that might not be fully portable to systems meeting the requirements for POSIX conformance (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 2, Conformance).

Where optional, enhanced, or reduced functionality is specified, the text is shaded and a code in the margin identifies the nature of the option, extension, or warning (see Section 1.8.1). For maximum portability, an application should avoid such functionality.

Unless the primary task of a utility is to produce textual material on its standard output, application developers should not rely on the format or content of any such material that may be produced. Where the primary task is to provide such material, but the output format is incompletely specified, the description is marked with the OF margin code and shading. Application developers are warned not to expect that the output of such an interface on one system is any guide to its behavior on another system.

1.8.1 Codes

Codes and their meanings are listed in the Base Definitions volume of IEEE Std 1003.1-2001, but are repeated here for convenience:

**ADV** Advisory Information

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the ADV margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the ADV margin legend.

**AIO** Asynchronous Input and Output

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the AIO margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the AIO margin legend.

**BAR** Barriers

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the BAR margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the BAR margin legend.
Batch Environment Services and Utilities
The functionality described is optional.
Where applicable, utilities are marked with the BE margin legend in the SYNOPSIS section.
Where additional semantics apply to a utility, the material is identified by use of the BE margin legend.

C-Language Development Utilities
The functionality described is optional.
Where applicable, utilities are marked with the CD margin legend in the SYNOPSIS section.
Where additional semantics apply to a utility, the material is identified by use of the CD margin legend.

Process CPU-Time Clocks
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the CPT margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the CPT margin legend.

Clock Selection
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the CS margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the CS margin legend.

Extension to the ISO C standard
The functionality described is an extension to the ISO C standard. Application writers may make use of an extension as it is supported on all IEEE Std 1003.1-2001-conforming systems.
With each function or header from the ISO C standard, a statement to the effect that “any conflict is unintentional” is included. That is intended to refer to a direct conflict. IEEE Std 1003.1-2001 acts in part as a profile of the ISO C standard, and it may choose to further constrain behaviors allowed to vary by the ISO C standard. Such limitations are not considered conflicts.
Where additional semantics apply to a function or header, the material is identified by use of the CX margin legend.

FORTRAN Development Utilities
The functionality described is optional.
Where applicable, utilities are marked with the FD margin legend in the SYNOPSIS section.
Where additional semantics apply to a utility, the material is identified by use of the FD margin legend.

FORTRAN Runtime Utilities
The functionality described is optional.
Where applicable, utilities are marked with the FR margin legend in the SYNOPSIS section.
Where additional semantics apply to a utility, the material is identified by use of the FR margin legend.

File Synchronization
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the FSC margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the FSC margin legend.

**IP6**

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the IP6 margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the IP6 margin legend.

**MC1**

Advisory Information and either Memory Mapped Files or Shared Memory Objects

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

This is a shorthand notation for combinations of multiple option codes.

Where applicable, functions are marked with the MC1 margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MC1 margin legend.

Refer to the Base Definitions volume of IEEE Std 1003.1-2001, Section 1.5.2, Margin Code Notation.

**MC2**

Memory Mapped Files, Shared Memory Objects, or Memory Protection

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

This is a shorthand notation for combinations of multiple option codes.

Where applicable, functions are marked with the MC2 margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MC2 margin legend.

Refer to the Base Definitions volume of IEEE Std 1003.1-2001, Section 1.5.2, Margin Code Notation.

**MC3**

Memory Mapped Files, Shared Memory Objects, or Typed Memory Objects

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

This is a shorthand notation for combinations of multiple option codes.

Where applicable, functions are marked with the MC3 margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MC3 margin legend.

Refer to the Base Definitions volume of IEEE Std 1003.1-2001, Section 1.5.2, Margin Code Notation.

**MF**

Memory Mapped Files

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the MF margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MF margin legend.

**ML**

Process Memory Locking

The functionality described is optional. The functionality described is also an extension to the
ISO C standard.

Where applicable, functions are marked with the ML margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the ML margin legend.

**MLR**

Range Memory Locking

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the MLR margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MLR margin legend.

**MON**

Monotonic Clock

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the MON margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MON margin legend.

**MPR**

Memory Protection

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the MPR margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MPR margin legend.

**MSG**

Message Passing

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the MSG margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MSG margin legend.

**MX**

IEC 60559 Floating-Point Option

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the MX margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the MX margin legend.

**OB**

Obsolescent

The functionality described may be withdrawn in a future version of this volume of IEEE Std 1003.1-2001. Strictly Conforming POSIX Applications and Strictly Conforming XSI Applications shall not use obsolescent features.

Where applicable, the material is identified by use of the OB margin legend.

**OF**

Output Format Incompletely Specified

The functionality described is an XSI extension. The format of the output produced by the utility is not fully specified. It is therefore not possible to post-process this output in a consistent fashion. Typical problems include unknown length of strings and unspecified field delimiters.

Where applicable, the material is identified by use of the OF margin legend.
Optional Header

In the SYNOPSIS section of some interfaces in the System Interfaces volume of IEEE Std 1003.1-2001 an included header is marked as in the following example:

```
#include <sys/types.h>
#include <grp.h>
struct group *getgrnam(const char *name);
```

The OH margin legend indicates that the marked header is not required on XSI-conformant systems.

Prioritized Input and Output

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the PIO margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the PIO margin legend.

Process Scheduling

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the PS margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the PS margin legend.

Raw Sockets

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the RS margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the RS margin legend.

Realtime Signals Extension

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the RTS margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the RTS margin legend.

Software Development Utilities

The functionality described is optional.

Where applicable, utilities are marked with the SD margin legend in the SYNOPSIS section. Where additional semantics apply to a utility, the material is identified by use of the SD margin legend.

Semaphores

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the SEM margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the SEM margin legend.

Shared Memory Objects

The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the SHM margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the SHM margin legend.

SIO
Synchronized Input and Output
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the SIO margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the SIO margin legend.

SPI
Spin Locks
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the SPI margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the SPI margin legend.

SPN
Spawn
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the SPN margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the SPN margin legend.

SS
Process Sporadic Server
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the SS margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the SS margin legend.

TCT
Thread CPU-Time Clocks
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the TCT margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TCT margin legend.

TEF
Trace Event Filter
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the TEF margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TEF margin legend.

THR
Threads
The functionality described is optional. The functionality described is also an extension to the ISO C standard.
Where applicable, functions are marked with the THR margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the THR
margin legend.

TMO  Timeouts
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TMO margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TMO
margin legend.

TMR  Timers
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TMR margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TMR
margin legend.

TPI  Thread Priority Inheritance
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TPI margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TPI
margin legend.

TPP  Thread Priority Protection
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TPP margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TPP
margin legend.

TPS  Thread Execution Scheduling
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TPS margin legend for the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TPS
margin legend.

TRC  Trace
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TRC margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TRC
margin legend.

TRI  Trace Inherit
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.
Where applicable, functions are marked with the TRI margin legend in the SYNOPSIS section.
Where additional semantics apply to a function, the material is identified by use of the TRI
margin legend.

TRL  Trace Log
The functionality described is optional. The functionality described is also an extension to the
ISO C standard.

Where applicable, functions are marked with the TRL margin legend in the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TRL margin legend.

Thread Stack Address Attribute

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the TSA margin legend for the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TSA margin legend.

Thread-Safe Functions

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the TSF margin legend in the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TSF margin legend.

Thread Process-Shared Synchronization

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the TSH margin legend in the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TSH margin legend.

Thread Sporadic Server

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the TSP margin legend in the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TSP margin legend.

Thread Stack Size Attribute

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the TSS margin legend in the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TSS margin legend.

Typed Memory Objects

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the TYM margin legend in the SYNOPSIS section.

Where additional semantics apply to a function, the material is identified by use of the TYM margin legend.

User Portability Utilities

The functionality described is optional.

Where applicable, utilities are marked with the UP margin legend in the SYNOPSIS section.

Where additional semantics apply to a utility, the material is identified by use of the UP margin legend.
The functionality described is an XSI extension. Functionality marked XSI is also an extension to the ISO C standard. Application writers may confidently make use of an extension on all systems supporting the X/Open System Interfaces Extension.

If an entire SYNOPSIS section is shaded and marked XSI, all the functionality described in that reference page is an extension. See the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.439, XSI.

The functionality described is optional. The functionality described is also an extension to the ISO C standard.

Where applicable, functions are marked with the XSR margin legend in the SYNOPSIS section. Where additional semantics apply to a function, the material is identified by use of the XSR margin legend.

1.9 Utility Limits

This section lists magnitude limitations imposed by a specific implementation. The braces notation, [LIMIT], is used in this volume of IEEE Std 1003.1-2001 to indicate these values, but the braces are not part of the name.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[POSIX2_BC_BASE_MAX]</td>
<td>The maximum obase value allowed by the bc utility.</td>
<td>99</td>
</tr>
<tr>
<td>[POSIX2_BC_DIM_MAX]</td>
<td>The maximum number of elements permitted in an array by the bc utility.</td>
<td>2048</td>
</tr>
<tr>
<td>[POSIX2_BC_SCALE_MAX]</td>
<td>The maximum scale value allowed by the bc utility.</td>
<td>99</td>
</tr>
<tr>
<td>[POSIX2_BC_STRING_MAX]</td>
<td>The maximum length of a string constant accepted by the bc utility.</td>
<td>1000</td>
</tr>
<tr>
<td>[POSIX2_COLL_WEIGHTS_MAX]</td>
<td>The maximum number of weights that can be assigned to an entry of the LC_COLLATE order keyword in the locale definition file; see the border_start keyword in the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3.2, LC_COLLATE.</td>
<td>2</td>
</tr>
<tr>
<td>[POSIX2_EXPR_NEST_MAX]</td>
<td>The maximum number of expressions that can be nested within parentheses by the expr utility.</td>
<td>32</td>
</tr>
<tr>
<td>[POSIX2_LINE_MAX]</td>
<td>Unless otherwise noted, the maximum length, in bytes, of the input line of a utility (either standard input or another file), when the utility is described as processing text files. The length includes room for the trailing &lt;newline&gt;.</td>
<td>2048</td>
</tr>
</tbody>
</table>
The maximum number of repeated occurrences of a BRE permitted when using the interval notation \( \{m,n\} \); see the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3.6, BREs Matching Multiple Characters.

Implementations may provide more liberal, or less restrictive, values than shown in Table 1-3 (on page 17). These possibly more liberal values are accessible using the symbols in Table 1-4.

The `sysconf()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001 or the `getconf` utility return the value of each symbol on each specific implementation. The value so retrieved is the largest, or most liberal, value that is available throughout the session lifetime, as determined at session creation. The literal names shown in the table apply only to the `getconf` utility; the high-level language binding describes the exact form of each name to be used by the interfaces in that binding.

All numeric limits defined by the System Interfaces volume of IEEE Std 1003.1-2001, such as `{PATH_MAX}`, shall also apply to this volume of IEEE Std 1003.1-2001. All the utilities defined by this volume of IEEE Std 1003.1-2001 are implicitly limited by these values, unless otherwise noted in the utility descriptions.

It is not guaranteed that the application can actually reach the specified limit of an implementation in any given case, or at all, as a lack of virtual memory or other resources may prevent this. The limit value indicates only that the implementation does not specifically impose any arbitrary, more restrictive limit.

---

**Table 1-4 Symbolic Utility Limits**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Minimum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>{BC_BASE_MAX}</code></td>
<td>The maximum <code>obase</code> value allowed by the <code>bc</code> utility.</td>
<td><code>{POSIX2_BC_BASE_MAX}</code></td>
</tr>
<tr>
<td><code>{BC_DIM_MAX}</code></td>
<td>The maximum number of elements permitted in an array by the <code>bc</code> utility.</td>
<td><code>{POSIX2_BC_DIM_MAX}</code></td>
</tr>
<tr>
<td><code>{BC_SCALE_MAX}</code></td>
<td>The maximum <code>scale</code> value allowed by the <code>bc</code> utility.</td>
<td><code>{POSIX2_BC_SCALE_MAX}</code></td>
</tr>
<tr>
<td><code>{BC_STRING_MAX}</code></td>
<td>The maximum length of a string constant accepted by the <code>bc</code> utility.</td>
<td><code>{POSIX2_BC_STRING_MAX}</code></td>
</tr>
<tr>
<td><code>{COLL_WEIGHTS_MAX}</code></td>
<td>The maximum number of weights that can be assigned to an entry of the <code>LC_COLLATE order</code> keyword in the locale definition file; see the</td>
<td><code>{POSIX2_COLL_WEIGHTS_MAX}</code></td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
<td>Minimum Value</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>{EXPR_NEST_MAX}</td>
<td>The maximum number of expressions that can be nested within parentheses by the <code>expr</code> utility.</td>
<td>{POSIX2_EXPR_NEST_MAX}</td>
</tr>
<tr>
<td>{LINE_MAX}</td>
<td>Unless otherwise noted, the maximum length, in bytes, of the input line of a utility (either standard input or another file), when the utility is described as processing text files. The length includes room for the trailing <code>&lt;newline&gt;</code>.</td>
<td>{POSIX2_LINE_MAX}</td>
</tr>
<tr>
<td>{RE_DUP_MAX}</td>
<td>The maximum number of repeated occurrences of a BRE permitted when using the interval notation <code>{m;n}</code>; see the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3.6, BREs Matching Multiple Characters.</td>
<td>{POSIX2_RE_DUP_MAX}</td>
</tr>
</tbody>
</table>

The following value may be a constant within an implementation or may vary from one pathname to another.

{POSIX2_SYMLINKS}

When referring to a directory, the system supports the creation of symbolic links within that directory; for non-directory files, the meaning of {POSIX2_SYMLINKS} is undefined.

### 1.10 Grammar Conventions

Portions of this volume of IEEE Std 1003.1-2001 are expressed in terms of a special grammar notation. It is used to portray the complex syntax of certain program input. The grammar is based on the syntax used by the `yacc` utility. However, it does not represent fully functional `yacc` input, suitable for program use; the lexical processing and all semantic requirements are described only in textual form. The grammar is not based on source used in any traditional implementation and has not been tested with the semantic code that would normally be required to accompany it. Furthermore, there is no implication that the partial `yacc` code presented represents the most efficient, or only, means of supporting the complex syntax within the utility. Implementations may use other programming languages or algorithms, as long as the syntax supported is the same as that represented by the grammar.

The following typographical conventions are used in the grammar; they have no significance except to aid in reading.
• The identifiers for the reserved words of the language are shown with a leading capital letter. (These are terminals in the grammar; for example, **While, Case.**)

• The identifiers for terminals in the grammar are all named with uppercase letters and underscores; for example, **NEWLINE, ASSIGN_OP, NAME.**

• The identifiers for non-terminals are all lowercase.

### 1.11 Utility Description Defaults

This section describes all of the subsections used within the utility descriptions, including:

- Intended usage of the section
- Global defaults that affect all the standard utilities
- The meanings of notations used in this volume of IEEE Std 1003.1-2001 that are specific to individual utility sections

**NAME**

This section gives the name or names of the utility and briefly states its purpose.

**SYNOPSIS**


**DESCRIPTION**

The DESCRIPTION section describes the actions of the utility. If the utility has a very complex set of subcommands or its own procedural language, an EXTENDED DESCRIPTION section is also provided. Most explanations of optional functionality are omitted here, as they are usually explained in the OPTIONS section.

As stated in Section 1.7.1.11 (on page 7), some functions are described in terms of equivalent functionality. When specific functions are cited, the implementation shall provide equivalent functionality including side effects associated with successful execution of the function. The treatment of errors and intermediate results from the individual functions cited is generally not specified by this volume of IEEE Std 1003.1-2001. See the utility’s EXIT STATUS and CONSEQUENCES OF ERRORS sections for all actions associated with errors encountered by the utility.

**OPTIONS**

The OPTIONS section describes the utility options and option-arguments, and how they modify the actions of the utility. Standard utilities that have options either fully comply with the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines or describe all deviations. Apparent disagreements between functionality descriptions in the OPTIONS and DESCRIPTION (or EXTENDED DESCRIPTION) sections are always resolved in favor of the OPTIONS section.

Each OPTIONS section that uses the phrase “The … utility shall conform to the Utility Syntax Guidelines …” refers only to the use of the utility as specified by this volume of IEEE Std 1003.1-2001; implementation extensions should also conform to the guidelines, but may allow exceptions for historical practice.
Unless otherwise stated in the utility description, when given an option unrecognized
by the implementation, or when a required option-argument is not provided, standard
utilities shall issue a diagnostic message to standard error and exit with a non-zero exit
status.

All utilities in this volume of IEEE Std 1003.1-2001 shall be capable of processing
arguments using eight-bit transparency.

**Default Behavior:** When this section is listed as "None.", it means that the
implementation need not support any options. Standard utilities that do not accept
options, but that do accept operands, shall recognize "--" as a first argument to be
discarded.

The requirement for recognizing "--" is because conforming applications need a way
to shield their operands from any arbitrary options that the implementation may
provide as an extension. For example, if the standard utility *foo* is listed as taking no
options, and the application needed to give it a pathname with a leading hyphen, it
could safely do it as:

```bash
foo -- --myfile
```
and avoid any problems with --m used as an extension.

**OPERANDS**
The OPERANDS section describes the utility operands, and how they affect the actions
of the utility. Apparent disagreements between functionality descriptions in the
OPERANDS and DESCRIPTION (or EXTENDED DESCRIPTION) sections shall be
resolved in favor of the OPERANDS section.

If an operand naming a file can be specified as ‘--’, which means to use the standard
input instead of a named file, this is explicitly stated in this section. Unless otherwise
stated, the use of multiple instances of ‘--’ to mean standard input in a single
command produces unspecified results.

Unless otherwise stated, the standard utilities that accept operands shall process those
operands in the order specified in the command line.

**Default Behavior:** When this section is listed as "None.", it means that the
implementation need not support any operands.

**STDIN**
The STDIN section describes the standard input of the utility. This section is frequently
merely a reference to the following section, as many utilities treat standard input and
input files in the same manner. Unless otherwise stated, all restrictions described in the
INPUT FILES section shall apply to this section as well.

Use of a terminal for standard input can cause any of the standard utilities that read
standard input to stop when used in the background. For this reason, applications
should not use interactive features in scripts to be placed in the background.

The specified standard input format of the standard utilities shall not depend on the
existence or value of the environment variables defined in this volume of

**Default Behavior:** When this section is listed as "Not used.", it means that the
standard input shall not be read when the utility is used as described by this volume of
INPUT FILES

The INPUT FILES section describes the files, other than the standard input, used as input by the utility. It includes files named as operands and option-arguments as well as other files that are referred to, such as start-up and initialization files, databases, and so on. Commonly-used files are generally described in one place and cross-referenced by other utilities.

All utilities in this volume of IEEE Std 1003.1-2001 shall be capable of processing input files using eight-bit transparency.

When a standard utility reads a seekable input file and terminates without an error before it reaches end-of-file, the utility shall ensure that the file offset in the open file description is properly positioned just past the last byte processed by the utility. For files that are not seekable, the state of the file offset in the open file description for that file is unspecified. A conforming application shall not assume that the following three commands are equivalent:

```
tail -n +2 file
(sed -n 1q; cat) < file
cat file | (sed -n 1q; cat)
```

The second command is equivalent to the first only when the file is seekable. The third command leaves the file offset in the open file description in an unspecified state. Other utilities, such as `head`, `read`, and `sh`, have similar properties.

Some of the standard utilities, such as filters, process input files a line or a block at a time and have no restrictions on the maximum input file size. Some utilities may have size limitations that are not as obvious as file space or memory limitations. Such limitations should reflect resource limitations of some sort, not arbitrary limits set by implementors. Implementations shall document those utilities that are limited by constraints other than file system space, available memory, and other limits specifically cited by this volume of IEEE Std 1003.1-2001, and identify what the constraint is and indicate a way of estimating when the constraint would be reached. Similarly, some utilities descend the directory tree (recursively). Implementations shall also document any limits that they may have in descending the directory tree that are beyond limits cited by this volume of IEEE Std 1003.1-2001.

When an input file is described as a "text file", the utility produces undefined results if given input that is not from a text file, unless otherwise stated. Some utilities (for example, `make`, `read`, `sh`) allow for continued input lines using an escaped <newline> convention; unless otherwise stated, the utility need not be able to accumulate more than `{LINE_MAX}` bytes from a set of multiple, continued input lines. Thus, for a conforming application the total of all the continued lines in a set cannot exceed `{LINE_MAX}`. If a utility using the escaped <newline> convention detects an end-of-file condition immediately after an escaped <newline>, the results are unspecified.

Record formats are described in a notation similar to that used by the C-language function, `printf()`. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation for a description of this notation. The format description is intended to be sufficiently rigorous to allow other applications to generate these input files. However, since <blank>s can legitimately be included in some of the fields described by the standard utilities, particularly in locales other than the POSIX locale, this intent is not always realized.

Default Behavior: When this section is listed as "None.", it means that no input files are required to be supplied when the utility is used as described by this volume of
ENVIRONMENT VARIABLES

The ENVIRONMENT VARIABLES section lists what variables affect the utility's execution.

The entire manner in which environment variables described in this volume of IEEE Std 1003.1-2001 affect the behavior of each utility is described in the ENVIRONMENT VARIABLES section for that utility, in conjunction with the global effects of the LANG, LC_ALL, and NLSPATH environment variables described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

The existence or value of environment variables described in this volume of IEEE Std 1003.1-2001 shall not otherwise affect the specified behavior of the standard utilities. Any effects of the existence or value of environment variables not described by this volume of IEEE Std 1003.1-2001 upon the standard utilities are unspecified.

For those standard utilities that use environment variables as a means for selecting a utility to execute (such as CC in make), the string provided to the utility is subjected to the path search described for PATH in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

All utilities in this volume of IEEE Std 1003.1-2001 shall be capable of processing environment variable names and values using eight-bit transparency.

Default Behavior: When this section is listed as "None.", it means that the behavior of the utility is not directly affected by environment variables described by this volume of IEEE Std 1003.1-2001 when the utility is used as described by this volume of IEEE Std 1003.1-2001.

ASYNCHRONOUS EVENTS

The ASYNCHRONOUS EVENTS section lists how the utility reacts to such events as signals and what signals are caught.

Default Behavior: When this section is listed as "Default.", or it refers to "the standard action for all other signals; see Section 1.11 (on page 20)" it means that the action taken as a result of the signal shall be one of the following:

1. The action shall be that inherited from the parent according to the rules of inheritance of signal actions defined in the System Interfaces volume of IEEE Std 1003.1-2001.

2. When no action has been taken to change the default, the default action shall be that specified by the System Interfaces volume of IEEE Std 1003.1-2001.

3. The result of the utility's execution is as if default actions had been taken.

A utility is permitted to catch a signal, perform some additional processing (such as deleting temporary files), restore the default signal action (or action inherited from the parent process), and resignal itself.

STDOUT

The STDOUT section completely describes the standard output of the utility. This section is frequently merely a reference to the following section, OUTPUT FILES, because many utilities treat standard output and output files in the same manner.

Use of a terminal for standard output may cause any of the standard utilities that write standard output to stop when used in the background. For this reason, applications should not use interactive features in scripts to be placed in the background.
Record formats are described in a notation similar to that used by the C-language function, `printf()`. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation for a description of this notation.

The specified standard output of the standard utilities shall not depend on the existence or value of the environment variables defined in this volume of IEEE Std 1003.1-2001, except as provided by this volume of IEEE Std 1003.1-2001.

Some of the standard utilities describe their output using the verb `display`, defined in the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.132, Display. Output described in the STDOUT sections of such utilities may be produced using means other than standard output. When standard output is directed to a terminal, the output described shall be written directly to the terminal. Otherwise, the results are undefined.

**Default Behavior:** When this section is listed as "Not used.", it means that the standard output shall not be written when the utility is used as described by this volume of IEEE Std 1003.1-2001.

**STDERR**

The STDERR section describes the standard error output of the utility. Only those messages that are purposely sent by the utility are described.

Use of a terminal for standard error may cause any of the standard utilities that write standard error output to stop when used in the background. For this reason, applications should not use interactive features in scripts to be placed in the background.

The format of diagnostic messages for most utilities is unspecified, but the language and cultural conventions of diagnostic and informative messages whose format is unspecified by this volume of IEEE Std 1003.1-2001 should be affected by the setting of `LC_MESSAGES` and `NLSPATH`.

The specified standard error output of standard utilities shall not depend on the existence or value of the environment variables defined in this volume of IEEE Std 1003.1-2001, except as provided by this volume of IEEE Std 1003.1-2001.

**Default Behavior:** When this section is listed as "The standard error shall be used only for diagnostic messages.", it means that, unless otherwise stated, the diagnostic messages shall be sent to the standard error only when the exit status is non-zero and the utility is used as described by this volume of IEEE Std 1003.1-2001.

When this section is listed as "Not used.", it means that the standard error shall not be used when the utility is used as described in this volume of IEEE Std 1003.1-2001.

**OUTPUT FILES**

The OUTPUT FILES section completely describes the files created or modified by the utility. Temporary or system files that are created for internal usage by this utility or other parts of the implementation (for example, spool, log, and audit files) are not described in this, or any, section. The utilities creating such files and the names of such files are unspecified. If applications are written to use temporary or intermediate files, they should use the `TMPDIR` environment variable, if it is set and represents an accessible directory, to select the location of temporary files.

Implementations shall ensure that temporary files, when used by the standard utilities, are named so that different utilities or multiple instances of the same utility can operate simultaneously without regard to their working directories, or any other process characteristic other than process ID. There are two exceptions to this rule:
1. Resources for temporary files other than the name space (for example, disk space, available directory entries, or number of processes allowed) are not guaranteed.

2. Certain standard utilities generate output files that are intended as input for other utilities (for example, \texttt{lex} generates \texttt{lex.yy.c}), and these cannot have unique names. These cases are explicitly identified in the descriptions of the respective utilities.

Any temporary file created by the implementation shall be removed by the implementation upon a utility’s successful exit, exit because of errors, or before termination by any of the SIGHUP, SIGINT, or SIGTERM signals, unless specified otherwise by the utility description.

Receipt of the SIGQUIT signal should generally cause termination (unless in some debugging mode) that would bypass any attempted recovery actions.

Record formats are described in a notation similar to that used by the C-language function, \texttt{printf()}; see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation for a description of this notation.

\textbf{Default Behavior:} When this section is listed as “None.”, it means that no files are created or modified as a consequence of direct action on the part of the utility when the utility is used as described by this volume of IEEE Std 1003.1-2001. However, the utility may create or modify system files, such as log files, that are outside the utility’s normal execution environment.

\textbf{EXTENDED DESCRIPTION}

The EXTENDED DESCRIPTION section provides a place for describing the actions of very complicated utilities, such as text editors or language processors, which typically have elaborate command languages.

\textbf{Default Behavior:} When this section is listed as “None.”, no further description is necessary.

\textbf{EXIT STATUS}

The EXIT STATUS section describes the values the utility shall return to the calling program, or shell, and the conditions that cause these values to be returned. Usually, utilities return zero for successful completion and values greater than zero for various error conditions. If specific numeric values are listed in this section, the system shall use those values for the errors described. In some cases, status values are listed more loosely, such as >0. A strictly conforming application shall not rely on any specific value in the range shown and shall be prepared to receive any value in the range.

For example, a utility may list zero as a successful return, 1 as a failure for a specific reason, and >1 as “an error occurred”. In this case, unspecified conditions may cause a 2 or 3, or other value, to be returned. A conforming application should be written so that it tests for successful exit status values (zero in this case), rather than relying upon the single specific error value listed in this volume of IEEE Std 1003.1-2001. In that way, it has maximum portability, even on implementations with extensions.

Unspecified error conditions may be represented by specific values not listed in this volume of IEEE Std 1003.1-2001.

\textbf{CONSEQUENCES OF ERRORS}

The CONSEQUENCES OF ERRORS section describes the effects on the environment, file systems, process state, and so on, when error conditions occur. It does not describe error messages produced or exit status values used.
The many reasons for failure of a utility are generally not specified by the utility descriptions. Utilities may terminate prematurely if they encounter: invalid usage of options, arguments, or environment variables; invalid usage of the complex syntaxes expressed in EXTENDED DESCRIPTION sections; difficulties accessing, creating, reading, or writing files; or difficulties associated with the privileges of the process.

The following shall apply to each utility, unless otherwise stated:

- If the requested action cannot be performed on an operand representing a file, directory, user, process, and so on, the utility shall issue a diagnostic message to standard error and continue processing the next operand in sequence, but the final exit status shall be returned as non-zero.

For a utility that recursively traverses a file hierarchy (such as `find` or `chown` -R), if the requested action cannot be performed on a file or directory encountered in the hierarchy, the utility shall issue a diagnostic message to standard error and continue processing the remaining files in the hierarchy, but the final exit status shall be returned as non-zero.

- If the requested action characterized by an option or option-argument cannot be performed, the utility shall issue a diagnostic message to standard error and the exit status returned shall be non-zero.

- When an unrecoverable error condition is encountered, the utility shall exit with a non-zero exit status.

- A diagnostic message shall be written to standard error whenever an error condition occurs.

When a utility encounters an error condition several actions are possible, depending on the severity of the error and the state of the utility. Included in the possible actions of various utilities are: deletion of temporary or intermediate work files; deletion of incomplete files; validity checking of the file system or directory.

**Default Behavior:** When this section is listed as "Default.", it means that any changes to the environment are unspecified.

**APPLICATION USAGE**

This section is informative.

The APPLICATION USAGE section gives advice to the application programmer or user about the way the utility should be used.

**EXAMPLES**

This section is informative.

The EXAMPLES section gives one or more examples of usage, where appropriate. In the event of conflict between an example and a normative part of the specification, the normative material is to be taken as correct.

In all examples, quoting has been used, showing how sample commands (utility names combined with arguments) could be passed correctly to a shell (see `sh`) or as a string to the `system()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001. Such quoting would not be used if the utility is invoked using one of the `exec` functions defined in the System Interfaces volume of IEEE Std 1003.1-2001.

**RATIONALE**

This section is informative.
This section contains historical information concerning the contents of this volume of IEEE Std 1003.1-2001 and why features were included or discarded by the standard developers.

**FUTURE DIRECTIONS**
This section is informative.

The FUTURE DIRECTIONS section should be used as a guide to current thinking; there is not necessarily a commitment to implement all of these future directions in their entirety.

**SEE ALSO**
This section is informative.

The SEE ALSO section lists related entries.

**CHANGE HISTORY**
This section is informative.

This section shows the derivation of the entry and any significant changes that have been made to it.

Certain of the standard utilities describe how they can invoke other utilities or applications, such as by passing a command string to the command interpreter. The external influences (STDIN, ENVIRONMENT VARIABLES, and so on) and external effects (STDOUT, CONSEQUENCES OF ERRORS, and so on) of such invoked utilities are not described in the section concerning the standard utility that invokes them.

### 1.12 Considerations for Utilities in Support of Files of Arbitrary Size

The following utilities support files of any size up to the maximum that can be created by the implementation. This support includes correct writing of file size-related values (such as file sizes and offsets, line numbers, and block counts) and correct interpretation of command line arguments that contain such values.

- **basename** Return non-directory portion of pathname.
- **cat** Concatenate and print files.
- **cd** Change working directory.
- **chgrp** Change file group ownership.
- **chmod** Change file modes.
- **chown** Change file ownership.
- **cksum** Write file checksums and sizes.
- **cmp** Compare two files.
- **cp** Copy files.
- **dd** Convert and copy a file.
- **df** Report free disk space.
- **dirname** Return directory portion of pathname.
- **du** Estimate file space usage.
Considerations for Utilities in Support of Files of Arbitrary Size

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find  Find files.
ln    Link files.
ls    List directory contents.
mkdir Make directories.
mv    Move files.
pathchk Check pathnames.
pwd   Return working directory name.
rm    Remove directory entries.
rmdir Remove directories.
sh    Shell, the standard command language interpreter.
sum   Print checksum and block or byte count of a file.
test  Evaluate expression.
touch Change file access and modification times.
ulimit Set or report file size limit.

Exceptions to the requirement that utilities support files of any size up to the maximum are as follows:

1. Uses of files as command scripts, or for configuration or control, are exempt. For example, it is not required that `sh` be able to read an arbitrarily large `.profile`.

2. Shell input and output redirection are exempt. For example, it is not required that the redirections `sum < file` or `echo foo > file` succeed for an arbitrarily large existing file.

1.13 Built-In Utilities

Any of the standard utilities may be implemented as regular built-in utilities within the command language interpreter. This is usually done to increase the performance of frequently used utilities or to achieve functionality that would be more difficult in a separate environment. The utilities named in Table 1-5 are frequently provided in built-in form. All of the utilities named in the table have special properties in terms of command search order within the shell, as described in Section 2.9.1.1 (on page 48).

<table>
<thead>
<tr>
<th>Table 1-5 Regular Built-In Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>alias</td>
</tr>
<tr>
<td>bg</td>
</tr>
<tr>
<td>cd</td>
</tr>
<tr>
<td>command</td>
</tr>
</tbody>
</table>

However, all of the standard utilities, including the regular built-ins in the table, but not the special built-ins described in Section 2.14 (on page 64), shall be implemented in a manner so that they can be accessed via the `exec` family of functions as defined in the System Interfaces volume of IEEE Std 1003.1-2001 and can be invoked directly by those standard utilities that require it (`env, find, nice, nohup, time, xargs`).

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This chapter contains the definition of the Shell Command Language.

2.1 Shell Introduction

The shell is a command language interpreter. This chapter describes the syntax of that command language as it is used by the sh utility and the system() and popen() functions defined in the System Interfaces volume of IEEE Std 1003.1-2001.

The shell operates according to the following general overview of operations. The specific details are included in the cited sections of this chapter.

1. The shell reads its input from a file (see sh), from the –c option or from the system() and popen() functions defined in the System Interfaces volume of IEEE Std 1003.1-2001. If the first line of a file of shell commands starts with the characters "#!", the results are unspecified.

2. The shell breaks the input into tokens: words and operators; see Section 2.3 (on page 31).

3. The shell parses the input into simple commands (see Section 2.9.1 (on page 47)) and compound commands (see Section 2.9.4 (on page 52)).

4. The shell performs various expansions (separately) on different parts of each command, resulting in a list of pathnames and fields to be treated as a command and arguments; see Section 2.6 (on page 36).

5. The shell performs redirection (see Section 2.7 (on page 43)) and removes redirection operators and their operands from the parameter list.

6. The shell executes a function (see Section 2.9.5 (on page 54)), built-in (see Section 2.14 (on page 64)), executable file, or script, giving the names of the arguments as positional parameters numbered 1 to n, and the name of the command (or in the case of a function within a script, the name of the script) as the positional parameter numbered 0 (see Section 2.9.1.1 (on page 48)).

7. The shell optionally waits for the command to complete and collects the exit status (see Section 2.8.2 (on page 46)).
2.2 Quoting

Quoting is used to remove the special meaning of certain characters or words to the shell. Quoting can be used to preserve the literal meaning of the special characters in the next paragraph, prevent reserved words from being recognized as such, and prevent parameter expansion and command substitution within here-document processing (see Section 2.7.4 (on page 44)).

The application shall quote the following characters if they are to represent themselves:

| & ; < > ( ) $ ' \ " ' <space> <tab> <newline>

and the following may need to be quoted under certain circumstances. That is, these characters may be special depending on conditions described elsewhere in this volume of IEEE Std 1003.1-2001:

* ? [ # ~ = %

The various quoting mechanisms are the escape character, single-quotes, and double-quotes. The here-document represents another form of quoting; see Section 2.7.4 (on page 44).

2.2.1 Escape Character (Backslash)

A backslash that is not quoted shall preserve the literal value of the following character, with the exception of a <newline>. If a <newline> follows the backslash, the shell shall interpret this as line continuation. The backslash and <newline>s shall be removed before splitting the input into tokens. Since the escaped <newline> is removed entirely from the input and is not replaced by any white space, it cannot serve as a token separator.

2.2.2 Single-Quotes

Enclosing characters in single-quotes (' ') shall preserve the literal value of each character within the single-quotes. A single-quote cannot occur within single-quotes.

2.2.3 Double-Quotes

Enclosing characters in double-quotes (" ") shall preserve the literal value of all characters within the double-quotes, with the exception of the characters dollar sign, backquote, and backslash, as follows:

$ The dollar sign shall retain its special meaning introducing parameter expansion (see Section 2.6.2 (on page 37)), a form of command substitution (see Section 2.6.3 (on page 40)), and arithmetic expansion (see Section 2.6.4 (on page 41)).

The input characters within the quoted string that are also enclosed between "$ (" and the matching ")" shall not be affected by the double-quotes, but rather shall define that command whose output replaces the "$ (...)" when the word is expanded. The tokenizing rules in Section 2.3 (on page 31), not including the alias substitutions in Section 2.3.1 (on page 32), shall be applied recursively to find the matching ")".

Within the string of characters from an enclosed "$ { " to the matching ")", an even number of unescaped double-quotes or single-quotes, if any, shall occur. A preceding backslash character shall be used to escape a literal '{ or '}. The rule in Section 2.6.2 (on page 37) shall be used to determine the matching '{ or '.

' The backquote shall retain its special meaning introducing the other form of command substitution (see Section 2.6.3 (on page 40)). The portion of the quoted string from the initial backquote and the characters up to the next backquote that is not preceded by a backslash,
having escape characters removed, defines that command whose output replaces "..." when the word is expanded. Either of the following cases produces undefined results:

- A single-quoted or double-quoted string that begins, but does not end, within the "..." sequence
- A "..." sequence that begins, but does not end, within the same double-quoted string

\ The backslash shall retain its special meaning as an escape character (see Section 2.2.1 (on page 30)) only when followed by one of the following characters when considered special:

\ $ ' " \ <newline>

The application shall ensure that a double-quote is preceded by a backslash to be included within double-quotes. The parameter '@' has special meaning inside double-quotes and is described in Section 2.5.2 (on page 34).

### 2.3 Token Recognition

The shell shall read its input in terms of lines from a file, from a terminal in the case of an interactive shell, or from a string in the case of `sh` or `system()`. The input lines can be of unlimited length. These lines shall be parsed using two major modes: ordinary token recognition and processing of here-documents.

When an `io_here` token has been recognized by the grammar (see Section 2.10 (on page 55)), one or more of the subsequent lines immediately following the next `NEWLINE` token form the body of one or more here-documents and shall be parsed according to the rules of Section 2.7.4 (on page 44).

When it is not processing an `io_here`, the shell shall break its input into tokens by applying the first applicable rule below to the next character in its input. The token shall be from the current position in the input until a token is delimited according to one of the rules below; the characters forming the token are exactly those in the input, including any quoting characters. If it is indicated that a token is delimited, and no characters have been included in a token, processing shall continue until an actual token is delimited.

1. If the end of input is recognized, the current token shall be delimited. If there is no current token, the end-of-input indicator shall be returned as the token.

2. If the previous character was used as part of an operator and the current character is not quoted and can be used with the current characters to form an operator, it shall be used as part of that (operator) token.

3. If the previous character was used as part of an operator and the current character cannot be used with the current characters to form an operator, the operator containing the previous character shall be delimited.

4. If the current character is backslash, single-quote, or double-quote (" ", ",", or ") and it is not quoted, it shall affect quoting for subsequent characters up to the end of the quoted text. The rules for quoting are as described in Section 2.2 (on page 30). During token recognition no substitutions shall be actually performed, and the result token shall contain exactly the characters that appear in the input (except for <newline> joining), unmodified, including any embedded or enclosing quotes or substitution operators, between the quote mark and the end of the quoted text. The token shall not be delimited by the end of the quoted field.
5. If the current character is an unquoted ‘$’ or ‘”’, the shell shall identify the start of any candidates for parameter expansion (Section 2.6.2 (on page 37)), command substitution (Section 2.6.3 (on page 40)), or arithmetic expansion (Section 2.6.4 (on page 41)) from their introductory unquoted character sequences: ‘$’, “${”, “$” or ‘”’, and “$(“, respectively. The shell shall read sufficient input to determine the end of the unit to be expanded (as explained in the cited sections). While processing the characters, if instances of expansions or quoting are found nested within the substitution, the shell shall recursively process them in the manner specified for the construct that is found. The characters found from the beginning of the substitution to its end, allowing for any recursion necessary to recognize embedded constructs, shall be included unmodified in the result token, including any embedded or enclosing substitution operators or quotes. The token shall not be delimited by the end of the substitution.

6. If the current character is not quoted and can be used as the first character of a new operator, the current token (if any) shall be delimited. The current character shall be used as the beginning of the next (operator) token.

7. If the current character is an unquoted <newline>, the current token shall be delimited.

8. If the current character is an unquoted <blank>, any token containing the previous character is delimited and the current character shall be discarded.

9. If the previous character was part of a word, the current character shall be appended to that word.

10. If the current character is a ‘#’, it and all subsequent characters up to, but excluding, the next <newline> shall be discarded as a comment. The <newline> that ends the line is not considered part of the comment.

11. The current character is used as the start of a new word.

Once a token is delimited, it is categorized as required by the grammar in Section 2.10 (on page 55).

### 2.3.1 Alias Substitution

The processing of aliases shall be supported on all XSI-conformant systems or if the system supports the User Portability Utilities option (and the rest of this section is not further shaded for these options).

After a token has been delimited, but before applying the grammatical rules in Section 2.10 (on page 55), a resulting word that is identified to be the command name word of a simple command shall be examined to determine whether it is an unquoted, valid alias name. However, reserved words in correct grammatical context shall not be candidates for alias substitution. A valid alias name (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.10, Alias Name) shall be one that has been defined by the alias utility and not subsequently undefined using unalias. Implementations also may provide predefined valid aliases that are in effect when the shell is invoked. To prevent infinite loops in recursive aliasing, if the shell is not currently processing an alias of the same name, the word shall be replaced by the value of the alias; otherwise, it shall not be replaced.

If the value of the alias replacing the word ends in a <blank>, the shell shall check the next command word for alias substitution; this process shall continue until a word is found that is not a valid alias or an alias value does not end in a <blank>.

When used as specified by this volume of IEEE Std 1003.1-2001, alias definitions shall not be inherited by separate invocations of the shell or by the utility execution environments invoked by the shell; see Section 2.12 (on page 61).
2.4 Reserved Words

Reserved words are words that have special meaning to the shell; see Section 2.9 (on page 47).

The following words shall be recognized as reserved words:

```
!  do  esac  in
{  done  fi  then
}  elif  for  until
  case  else  if  while
```

This recognition shall only occur when none of the characters is quoted and when the word is used as:

- The first word of a command
- The first word following one of the reserved words other than `case`, `for`, or `in`
- The third word in a `case` command (only `in` is valid in this case)
- The third word in a `for` command (only `in` and `do` are valid in this case)

See the grammar in Section 2.10 (on page 55).

The following words may be recognized as reserved words on some implementations (when none of the characters are quoted), causing unspecified results:

```
[ [ ] ]  function  select
```

Words that are the concatenation of a name and a colon (`:`) are reserved; their use produces unspecified results.

2.5 Parameters and Variables

A parameter can be denoted by a name, a number, or one of the special characters listed in Section 2.5.2 (on page 34). A variable is a parameter denoted by a name.

A parameter is set if it has an assigned value (null is a valid value). Once a variable is set, it can only be unset by using the `unset` special built-in command.

2.5.1 Positional Parameters

A positional parameter is a parameter denoted by the decimal value represented by one or more digits, other than the single digit 0. The digits denoting the positional parameters shall always be interpreted as a decimal value, even if there is a leading zero. When a positional parameter with more than one digit is specified, the application shall enclose the digits in braces (see Section 2.6.2 (on page 37)). Positional parameters are initially assigned when the shell is invoked (see `sh`), temporarily replaced when a shell function is invoked (see Section 2.9.5 (on page 54)), and can be reassigned with the `set` special built-in command.
2.5.2 Special Parameters

Listed below are the special parameters and the values to which they shall expand. Only the values of the special parameters are listed; see Section 2.6 (on page 36) for a detailed summary of all the stages involved in expanding words.

@ Expands to the positional parameters, starting from one. When the expansion occurs within double-quotes, and where field splitting (see Section 2.6.5 (on page 42)) is performed, each positional parameter shall expand as a separate field, with the provision that the expansion of the first parameter shall still be joined with the beginning part of the original word (assuming that the expanded parameter was embedded within a word), and the expansion of the last parameter shall still be joined with the last part of the original word. If there are no positional parameters, the expansion of '@' shall generate zero fields, even when '@' is double-quoted.

* Expands to the positional parameters, starting from one. When the expansion occurs within a double-quoted string (see Section 2.2.3 (on page 30)), it shall expand to a single field with the value of each parameter separated by the first character of the $IFS variable, or by a <space> if $IFS is unset. If $IFS is set to a null string, this is not equivalent to unsetting it; its first character does not exist, so the parameter values are concatenated.

# Expands to the decimal number of positional parameters. The command name (parameter 0) shall not be counted in the number given by '#' because it is a special parameter, not a positional parameter.

? Expands to the decimal exit status of the most recent pipeline (see Section 2.9.2 (on page 49)).

- (Hyphen.) Expands to the current option flags (the single-letter option names concatenated into a string) as specified on invocation, by the set special built-in command, or implicitly by the shell.

$ Expands to the decimal process ID of the invoked shell. In a subshell (see Section 2.12 (on page 61)), '$' shall expand to the same value as that of the current shell.

! Expands to the decimal process ID of the most recent background command (see Section 2.9.3 (on page 50)) executed from the current shell. (For example, background commands executed from subshells do not affect the value of "$!" in the current shell environment.) For a pipeline, the process ID is that of the last command in the pipeline.

0 (Zero.) Expands to the name of the shell or shell script. See sh (on page 850) for a detailed description of how this name is derived.

See the description of the $IFS variable in Section 2.5.3.

2.5.3 Shell Variables

Variables shall be initialized from the environment (as defined by the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables and the exec function in the System Interfaces volume of IEEE Std 1003.1-2001) and can be given new values with variable assignment commands. If a variable is initialized from the environment, it shall be marked for export immediately; see the export special built-in. New variables can be defined and initialized with variable assignments, with the read or getopts utilities, with the name parameter in a for loop, with the $[name=word] expansion, or with other mechanisms provided as implementation extensions.

The following variables shall affect the execution of the shell:
The processing of the ENV shell variable shall be supported on all XSI-conformant systems or if the system supports the User Portability Utilities option.

This variable, when and only when an interactive shell is invoked, shall be subjected to parameter expansion (see Section 2.6.2) by the shell and the resulting value shall be used as a pathname of a file containing shell commands to execute in the current environment. The file need not be executable. If the expanded value of ENV is not an absolute pathname, the results are unspecified. ENV shall be ignored if the user’s real and effective user IDs or real and effective group IDs are different.

HOME The pathname of the user’s home directory. The contents of HOME are used in tilde expansion (see Section 2.6.1).

IFS (Input Field Separators.) A string treated as a list of characters that is used for field splitting and to split lines into fields with the read command. If IFS is not set, the shell shall behave as if the value of IFS is <space>, <tab>, and <newline>; see Section 2.6.5. Implementations may ignore the value of IFS in the environment at the time the shell is invoked, treating IFS as if it were not set.

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL The value of this variable overrides the LC_* variables and LANG, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

LC_COLLATE Determine the behavior of range expressions, equivalence classes, and multi-character collating elements within pattern matching.

LC_CTYPE Determine the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters), which characters are defined as letters (character class alpha) and <blank>s (character class blank), and the behavior of character classes within pattern matching. Changing the value of LC_CTYPE after the shell has started shall not affect the lexical processing of shell commands in the current shell execution environment or its subshells. Invoking a shell script or performing exec sh subjects the new shell to the changes in LC_CTYPE.

LC_MESSAGES Determine the language in which messages should be written.

LINENO Set by the shell to a decimal number representing the current sequential line number (numbered starting with 1) within a script or function before it executes each command. If the user unsets or resets LINENO, the variable may lose its special meaning for the life of the shell. If the shell is not currently executing a script or function, the value of LINENO is unspecified. This volume of IEEE Std 1003.1-2001 specifies the effects of the variable only for systems supporting the User Portability Utilities option.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

PATH A string formatted as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables, used to effect
command interpretation; see Section 2.9.1.1 (on page 48).

**PPID**
Set by the shell to the decimal process ID of the process that invoked this shell. In a subshell (see Section 2.12 (on page 61)), PPID shall be set to the same value as that of the parent of the current shell. For example, echo $PPID and (echo $PPID) would produce the same value. This volume of IEEE Std 1003.1-2001 specifies the effects of the variable only for systems supporting the User Portability Utilities option.

**PS1**
Each time an interactive shell is ready to read a command, the value of this variable shall be subjected to parameter expansion and written to standard error. The default value shall be "$ ". For users who have specific additional implementation-defined privileges, the default may be another, implementation-defined value. The shell shall replace each instance of the character ‘! ‘ in PS1 with the history file number of the next command to be typed. Escaping the ‘! ‘ with another ‘! ‘ (that is, "!!") shall place the literal character ‘! ‘ in the prompt. This volume of IEEE Std 1003.1-2001 specifies the effects of the variable only for systems supporting the User Portability Utilities option.

**PS2**
Each time the user enters a <newline> prior to completing a command line in an interactive shell, the value of this variable shall be subjected to parameter expansion and written to standard error. The default value is " > ". This volume of IEEE Std 1003.1-2001 specifies the effects of the variable only for systems supporting the User Portability Utilities option.

**PS4**
When an execution trace (set −x) is being performed in an interactive shell, before each line in the execution trace, the value of this variable shall be subjected to parameter expansion and written to standard error. The default value is " + ". This volume of IEEE Std 1003.1-2001 specifies the effects of the variable only for systems supporting the User Portability Utilities option.

**PWD**
Set by the shell to be an absolute pathname of the current working directory, containing no components of type symbolic link, no components that are dot, and no components that are dot-dot when the shell is initialized. If an application sets or unsets the value of PWD, the behaviors of the cd and pwd utilities are unspecified.

### 2.6 Word Expansions

This section describes the various expansions that are performed on words. Not all expansions are performed on every word, as explained in the following sections.

Tilde expansions, parameter expansions, command substitutions, arithmetic expansions, and quote removals that occur within a single word expand to a single field. It is only field splitting or pathname expansion that can create multiple fields from a single word. The single exception to this rule is the expansion of the special parameter ‘@’ within double-quotes, as described in Section 2.5.2 (on page 34).

The order of word expansion shall be as follows:

1. Tilde expansion (see Section 2.6.1 (on page 37)), parameter expansion (see Section 2.6.2 (on page 37)), command substitution (see Section 2.6.3 (on page 40)), and arithmetic expansion (see Section 2.6.4 (on page 41)) shall be performed, beginning to end. See item 5 in Section 2.3 (on page 31).
2. Field splitting (see Section 2.6.5 (on page 42)) shall be performed on the portions of the
fields generated by step 1, unless \texttt{IFS} is null.

3. Pathname expansion (see Section 2.6.6 (on page 42)) shall be performed, unless \texttt{set -f} is in
effect.

4. Quote removal (see Section 2.6.7 (on page 42)) shall always be performed last.

The expansions described in this section shall occur in the same shell environment as that in
which the command is executed.

If the complete expansion appropriate for a word results in an empty field, that empty field shall
be deleted from the list of fields that form the completely expanded command, unless the
original word contained single-quote or double-quote characters.

The `$` character is used to introduce parameter expansion, command substitution, or
arithmetic evaluation. If an unquoted `$` is followed by a character that is either not numeric,
the name of one of the special parameters (see Section 2.5.2 (on page 34)), a valid first character
of a variable name, a left curly brace (`{`) or a left parenthesis, the result is unspecified.

### 2.6.1 Tilde Expansion

A “tilde-prefix” consists of an unquoted tilde character at the beginning of a word, followed by
all of the characters preceding the first unquoted slash in the word, or all the characters in the
word if there is no slash. In an assignment (see the Base Definitions volume of
\texttt{IEEE Std 1003.1-2001}, Section 4.21, Variable Assignment), multiple tilde-prefixes can be used: at
the beginning of the word (that is, following the equal sign of the assignment), following any
unquoted colon, or both. A tilde-prefix in an assignment is terminated by the first unquoted
colon or slash. If none of the characters in the tilde-prefix are quoted, the characters in the tilde-
prefix following the tilde are treated as a possible login name from the user database. A portable
login name cannot contain characters outside the set given in the description of the \texttt{LOGNAME}
environment variable in the Base Definitions volume of \texttt{IEEE Std 1003.1-2001}, Section 8.3, Other
Environment Variables. If the login name is null (that is, the tilde-prefix contains only the tilde),
the tilde-prefix is replaced by the value of the variable \texttt{HOME}. If \texttt{HOME} is unset, the results are
specified. Otherwise, the tilde-prefix shall be replaced by a pathname of the initial working
directory associated with the login name obtained using the \texttt{getpwnam()} function as defined in
the System Interfaces volume of \texttt{IEEE Std 1003.1-2001}. If the system does not recognize the login
name, the results are undefined.

### 2.6.2 Parameter Expansion

The format for parameter expansion is as follows:

\[
\${\text{\textit{expression}}}
\]

where \textit{expression} consists of all characters until the matching `}`. Any `} ` escaped by a
backslash or within a quoted string, and characters in embedded arithmetic expansions,
command substitutions, and variable expansions, shall not be examined in determining the
matching `}`.

The simplest form for parameter expansion is:

\[
\${\text{\textit{parameter}}}
\]

The value, if any, of \textit{parameter} shall be substituted.

The parameter name or symbol can be enclosed in braces, which are optional except for
positional parameters with more than one digit or when \textit{parameter} is followed by a character that
could be interpreted as part of the name. The matching closing brace shall be determined by
counting brace levels, skipping over enclosed quoted strings, and command substitutions.

If the parameter name or symbol is not enclosed in braces, the expansion shall use the longest valid name (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.230, Name), whether or not the symbol represented by that name exists.

If a parameter expansion occurs inside double-quotes:

- Pathname expansion shall not be performed on the results of the expansion.
- Field splitting shall not be performed on the results of the expansion, with the exception of `@`; see Section 2.5.2 (on page 34).

In addition, a parameter expansion can be modified by using one of the following formats. In each case that a value of word is needed (based on the state of parameter, as described below), word shall be subjected to tilde expansion, parameter expansion, command substitution, and arithmetic expansion. If word is not needed, it shall not be expanded. The `'` character that delimits the following parameter expansion modifications shall be determined as described previously in this section and in Section 2.2.3 (on page 30). (For example, `/{$foo-bar|xyz}` would result in the expansion of `foo` followed by the string `xyz` if `foo` is set, else the string `"barxyz"`).

`$[parameter := word]` **Use Default Values.** If parameter is unset or null, the expansion of word shall be substituted; otherwise, the value of parameter shall be substituted.

`$[parameter := word]` **Assign Default Values.** If parameter is unset or null, the expansion of word shall be assigned to parameter. In all cases, the final value of parameter shall be substituted. Only variables, not positional parameters or special parameters, can be assigned in this way.

`$[parameter ?:word]` **Indicate Error if Null or Unset.** If parameter is unset or null, the expansion of word (or a message indicating it is unset if word is omitted) shall be written to standard error and the shell exits with a non-zero exit status. Otherwise, the value of parameter shall be substituted. An interactive shell need not exit.

`$[parameter :+word]` **Use Alternative Value.** If parameter is unset or null, null shall be substituted; otherwise, the expansion of word shall be substituted.

In the parameter expansions shown previously, use of the colon in the format shall result in a test for a parameter that is unset or null; omission of the colon shall result in a test for a parameter that is only unset. The following table summarizes the effect of the colon:

<table>
<thead>
<tr>
<th>parameter</th>
<th>parameter</th>
<th>parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Set and Not Null</code></td>
<td><code>Set But Null</code></td>
<td><code>Unset</code></td>
</tr>
<tr>
<td><code>$[parameter := word]</code></td>
<td>substitute parameter</td>
<td>substitute word</td>
</tr>
<tr>
<td><code>$[parameter =word]</code></td>
<td>substitute parameter</td>
<td>substitute null</td>
</tr>
<tr>
<td><code>$[parameter =word]</code></td>
<td>substitute parameter</td>
<td>assign word</td>
</tr>
<tr>
<td><code>$[parameter ?:word]</code></td>
<td>substitute parameter</td>
<td>substitute null</td>
</tr>
<tr>
<td><code>$[parameter :?word]</code></td>
<td>substitute parameter</td>
<td>substitute null</td>
</tr>
<tr>
<td><code>$[parameter :+word]</code></td>
<td>substitute word</td>
<td>substitute null</td>
</tr>
<tr>
<td><code>$[parameter +word]</code></td>
<td>substitute word</td>
<td>substitute word</td>
</tr>
</tbody>
</table>

In all cases shown with “substitute”, the expression is replaced with the value shown. In all cases shown with “assign”, parameter is assigned that value, which also replaces the expression.
String Length. The length in characters of the value of parameter shall be substituted. If parameter is ‘*’ or ‘@’, the result of the expansion is unspecified.

The following four varieties of parameter expansion provide for substring processing. In each case, pattern matching notation (see Section 2.13 (on page 62)), rather than regular expression notation, shall be used to evaluate the patterns. If parameter is ‘*’ or ‘@’, the result of the expansion is unspecified. Enclosing the full parameter expansion string in double-quotes shall not cause the following four varieties of pattern characters to be quoted, whereas quoting characters within the braces shall have this effect.

Remove Smallest Suffix Pattern. The word shall be expanded to produce a pattern. The parameter expansion shall then result in parameter, with the smallest portion of the suffix matched by the pattern deleted.

Remove Largest Suffix Pattern. The word shall be expanded to produce a pattern. The parameter expansion shall then result in parameter, with the largest portion of the suffix matched by the pattern deleted.

Remove Smallest Prefix Pattern. The word shall be expanded to produce a pattern. The parameter expansion shall then result in parameter, with the smallest portion of the prefix matched by the pattern deleted.

Remove Largest Prefix Pattern. The word shall be expanded to produce a pattern. The parameter expansion shall then result in parameter, with the largest portion of the prefix matched by the pattern deleted.

Examples

In this example, ls is executed only if x is null or unset. (The $(ls) command substitution notation is explained in Section 2.6.3 (on page 40).)

```bash
${x:-$(ls)}
```

```bash
unset X
echo ${X:=abc}
abc
```

```bash
unset posix
echo ${posix:?}
sh: posix: parameter null or not set
```

```bash
set a b c
echo ${3:+posix}
posix
```

```bash
HOME=/usr/posix
echo ${#HOME}
10
```

```bash
x=file.c
echo ${x%.c}.o
```
file.o

$[parameter%%word]
x=posix/src/std
echo ${x%/*}

posix

$[parameter#word]
x=${HOME}/src/cmd
echo ${x#$HOME}

/src/cmd

$[parameter##word]
x=/one/two/three
echo ${x##/*/}

three

The double-quoting of patterns is different depending on where the double-quotes are placed:

"${x#*}"  The asterisk is a pattern character.

${x#"*"}   The literal asterisk is quoted and not special.

2.6.3 Command Substitution

Command substitution allows the output of a command to be substituted in place of the command name itself. Command substitution shall occur when the command is enclosed as follows:

$(command)

or (backquoted version):

'command'

The shell shall expand the command substitution by executing command in a subshell environment (see Section 2.12 (on page 61)) and replacing the command substitution (the text of command plus the enclosing "$()" or backquotes) with the standard output of the command, removing sequences of one or more <newline>s at the end of the substitution. Embedded <newline>s before the end of the output shall not be removed; however, they may be treated as field delimiters and eliminated during field splitting, depending on the value of IFS and quoting that is in effect.

Within the backquoted style of command substitution, backslash shall retain its literal meaning, except when followed by: ’$’, ’\’’, or ’\’ (dollar sign, backquote, backslash). The search for the matching backquote shall be satisfied by the first backquote found without a preceding backslash; during this search, if a non-escaped backquote is encountered within a shell comment, a here-document, an embedded command substitution of the $(command) form, or a quoted string, undefined results occur. A single-quoted or double-quoted string that begins, but does not end, within the "..." sequence produces undefined results.

With the $(command) form, all characters following the open parenthesis to the matching closing parenthesis constitute the command. Any valid shell script can be used for command, except a script consisting solely of redirections which produces unspecified results.

The results of command substitution shall not be processed for further tilde expansion, parameter expansion, command substitution, or arithmetic expansion. If a command substitution occurs inside double-quotes, field splitting and pathname expansion shall not be performed on the results of the substitution.
Command substitution can be nested. To specify nesting within the backquoted version, the application shall precede the inner backquotes with backslashes, for example:

```
\ 'command'
```

If the command substitution consists of a single subshell, such as:

```
$ ( (command) )
```

a conforming application shall separate the "$" and '(' into two tokens (that is, separate them with white space). This is required to avoid any ambiguities with arithmetic expansion.

### 2.6.4 Arithmetic Expansion

Arithmetic expansion provides a mechanism for evaluating an arithmetic expression and substituting its value. The format for arithmetic expansion shall be as follows:

```
$( (expression) )
```

The expression shall be treated as if it were in double-quotes, except that a double-quote inside the expression is not treated specially. The shell shall expand all tokens in the expression for parameter expansion, command substitution, and quote removal.

Next, the shell shall treat this as an arithmetic expression and substitute the value of the expression. The arithmetic expression shall be processed according to the rules given in Section 1.7.2.1 (on page 7), with the following exceptions:

- Only signed long integer arithmetic is required.
- Only the decimal-constant, octal-constant, and hexadecimal-constant constants specified in the ISO C standard, Section 6.4.4.1 are required to be recognized as constants.
- The `sizeof()` operator and the prefix and postfix "++" and "--" operators are not required.
- Selection, iteration, and jump statements are not supported.

As an extension, the shell may recognize arithmetic expressions beyond those listed. The shell may use a signed integer type with a rank larger than the rank of `signed long`. The shell may use a real-floating type instead of `signed long` as long as it does not affect the results in cases where there is no overflow. If the expression is invalid, the expansion fails and the shell shall write a message to standard error indicating the failure.

#### Examples

A simple example using arithmetic expansion:

```
# repeat a command 100 times
x=100
while [ $x -gt 0 ]
do
    command
    x=$((x-1))
done
```
2.6.5 Field Splitting

After parameter expansion (Section 2.6.2 (on page 37)), command substitution (Section 2.6.3 (on page 40)), and arithmetic expansion (Section 2.6.4 (on page 41)), the shell shall scan the results of expansions and substitutions that did not occur in double-quotes for field splitting and multiple fields can result.

The shell shall treat each character of the $IFS$ as a delimiter and use the delimiters to split the results of parameter expansion and command substitution into fields.

1. If the value of $IFS$ is a <space>, <tab>, and <newline>, or if it is unset, any sequence of <space>s, <tab>s, or <newline>s at the beginning or end of the input shall be ignored and any sequence of those characters within the input shall delimit a field. For example, the input:

   <newline><space><tab>foo<tab><tab>bar<space>

   yields two fields, foo and bar.

2. If the value of $IFS$ is null, no field splitting shall be performed.

3. Otherwise, the following rules shall be applied in sequence. The term “$IFS$ white space” is used to mean any sequence (zero or more instances) of white space characters that are in the $IFS$ value (for example, if $IFS$ contains <space>/<comma>/<tab>, any sequence of <space>s and <tab>s is considered $IFS$ white space).

   a. $IFS$ white space shall be ignored at the beginning and end of the input.

   b. Each occurrence in the input of an $IFS$ character that is not $IFS$ white space, along with any adjacent $IFS$ white space, shall delimit a field, as described previously.

   c. Non-zero-length $IFS$ white space shall delimit a field.

2.6.6 Pathname Expansion

After field splitting, if set −f is not in effect, each field in the resulting command line shall be expanded using the algorithm described in Section 2.13 (on page 62), qualified by the rules in Section 2.13.3 (on page 63).

2.6.7 Quote Removal

The quote characters: ‘ \ ’, ‘ ’, and ‘ ’ (backslash, single-quote, double-quote) that were present in the original word shall be removed unless they have themselves been quoted.
2.7 Redirection

Redirection is used to open and close files for the current shell execution environment (see Section 2.12 (on page 61)) or for any command. Redirection operators can be used with numbers representing file descriptors (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.165, File Descriptor) as described below.

The overall format used for redirection is:

\[ [n]\ redir-op\ word \]

The number \( n \) is an optional decimal number designating the file descriptor number; the application shall ensure it is delimited from any preceding text and immediately precede the redirection operator \( \text{redir-op} \). If \( n \) is quoted, the number shall not be recognized as part of the redirection expression. For example:

\[
\text{echo} \ 2> \text{a}
\]

writes the character 2 into file \( \text{a} \). If any part of \( \text{redir-op} \) is quoted, no redirection expression is recognized. For example:

\[
\text{echo}\ 2>\text{a}
\]

writes the characters \( 2>\text{a} \) to standard output. The optional number, redirection operator, and word shall not appear in the arguments provided to the command to be executed (if any).

Open files are represented by decimal numbers starting with zero. The largest possible value is implementation-defined; however, all implementations shall support at least 0 to 9, inclusive, for use by the application. These numbers are called “file descriptors”. The values 0, 1, and 2 have special meaning and conventional uses and are implied by certain redirection operations; they are referred to as standard input, standard output, and standard error, respectively. Programs usually take their input from standard input, and write output on standard output. Error messages are usually written on standard error. The redirection operators can be preceded by one or more digits (with no intervening <blank>s allowed) to designate the file descriptor number.

If the redirection operator is "<<" or "<<−", the word that follows the redirection operator shall be subjected to quote removal; it is unspecified whether any of the other expansions occur. For the other redirection operators, the word that follows the redirection operator shall be subjected to tilde expansion, parameter expansion, command substitution, arithmetic expansion, and quote removal. Pathname expansion shall not be performed on the word by a non-interactive shell; an interactive shell may perform it, but shall do so only when the expansion would result in one word.

If more than one redirection operator is specified with a command, the order of evaluation is from beginning to end.

A failure to open or create a file shall cause a redirection to fail.
2.7.1 Redirecting Input

Input redirection shall cause the file whose name results from the expansion of word to be opened for reading on the designated file descriptor, or standard input if the file descriptor is not specified.

The general format for redirecting input is:

```
[n] <word
```

where the optional n represents the file descriptor number. If the number is omitted, the redirection shall refer to standard input (file descriptor 0).

2.7.2 Redirecting Output

The two general formats for redirecting output are:

```
[n] >word
[n] >| word
```

where the optional n represents the file descriptor number. If the number is omitted, the redirection shall refer to standard output (file descriptor 1).

Output redirection using the ‘>’ format shall fail if the noclobber option is set (see the description of set −C) and the file named by the expansion of word exists and is a regular file. Otherwise, redirection using the ‘>’ or “>|” formats shall cause the file whose name results from the expansion of word to be created and opened for output on the designated file descriptor, or standard output if none is specified. If the file does not exist, it shall be created; otherwise, it shall be truncated to be an empty file after being opened.

2.7.3 Appending Redirected Output

Appended output redirection shall cause the file whose name results from the expansion of word to be opened for output on the designated file descriptor. The file is opened as if the open() function as defined in the System Interfaces volume of IEEE Std 1003.1-2001 was called with the O_APPEND flag. If the file does not exist, it shall be created.

The general format for appending redirected output is as follows:

```
[n] >>word
```

where the optional n represents the file descriptor number. If the number is omitted, the redirection refers to standard output (file descriptor 1).

2.7.4 Here-Document

The redirection operators "<<" and "<<−" both allow redirection of lines contained in a shell input file, known as a “here-document”, to the input of a command.

The here-document shall be treated as a single word that begins after the next <newline> and continues until there is a line containing only the delimiter and a <newline>, with no <blank>s in between. Then the next here-document starts, if there is one. The format is as follows:

```
[n] <<word
    here-document
    delimiter
```

where the optional n represents the file descriptor number. If the number is omitted, the here-document refers to standard input (file descriptor 0).
If any character in `word` is quoted, the delimiter shall be formed by performing quote removal on `word`, and the here-document lines shall not be expanded. Otherwise, the delimiter shall be the `word` itself.

If no characters in `word` are quoted, all lines of the here-document shall be expanded for parameter expansion, command substitution, and arithmetic expansion. In this case, the backslash in the input behaves as the backslash inside double-quotes (see Section 2.2.3 (on page 30)). However, the double-quote character (`"`) shall not be treated specially within a here-document, except when the double-quote appears within `${}`, `""`, or `" caregiver`. If the redirection symbol is `<<<`, all leading `<tab>`s shall be stripped from input lines and the line containing the trailing delimiter. If more than one `<<<` or `<<−` operator is specified on a line, the here-document associated with the first operator shall be supplied first by the application and shall be read first by the shell.

**Examples**

An example of a here-document follows:

```
cat <<eof1; cat <<eof2
Hi,
eof1
Helene.
eof2
eof2
```
2.7.7 Open File Descriptors for Reading and Writing

The redirection operator:

\[(n) <> word\]

shall cause the file whose name is the expansion of word to be opened for both reading and writing on the file descriptor denoted by n, or standard input if n is not specified. If the file does not exist, it shall be created.

2.8 Exit Status and Errors

2.8.1 Consequences of Shell Errors

For a non-interactive shell, an error condition encountered by a special built-in (see Section 2.14 (on page 64)) or other type of utility shall cause the shell to write a diagnostic message to standard error and exit as shown in the following table:

<table>
<thead>
<tr>
<th>Error</th>
<th>Special Built-In</th>
<th>Other Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell language syntax error</td>
<td>Shall exit</td>
<td>Shall exit</td>
</tr>
<tr>
<td>Utility syntax error (option or operand error)</td>
<td>Shall exit</td>
<td>Shall not exit</td>
</tr>
<tr>
<td>Redirection error</td>
<td>Shall exit</td>
<td>Shall not exit</td>
</tr>
<tr>
<td>Variable assignment error</td>
<td>Shall exit</td>
<td>Shall not exit</td>
</tr>
<tr>
<td>Expansion error</td>
<td>Shall exit</td>
<td>Shall exit</td>
</tr>
<tr>
<td>Command not found</td>
<td>N/A</td>
<td>May exit</td>
</tr>
<tr>
<td>Dot script not found</td>
<td>Shall exit</td>
<td>N/A</td>
</tr>
</tbody>
</table>

An expansion error is one that occurs when the shell expansions defined in Section 2.6 (on page 36) are carried out (for example, "${x!y}"), because ‘!’ is not a valid operator; an implementation may treat these as syntax errors if it is able to detect them during tokenization, rather than during expansion.

If any of the errors shown as ‘’ shall exit ‘’ or ‘’(may) exit’’ occur in a subshell, the subshell shall (respectively may) exit with a non-zero status, but the script containing the subshell shall not exit because of the error.

In all of the cases shown in the table, an interactive shell shall write a diagnostic message to standard error without exiting.

2.8.2 Exit Status for Commands

Each command has an exit status that can influence the behavior of other shell commands. The exit status of commands that are not utilities is documented in this section. The exit status of the standard utilities is documented in their respective sections.

If a command is not found, the exit status shall be 127. If the command name is found, but it is not an executable utility, the exit status shall be 126. Applications that invoke utilities without using the shell should use these exit status values to report similar errors.

If a command fails during word expansion or redirection, its exit status shall be greater than zero.

Internally, for purposes of deciding whether a command exits with a non-zero exit status, the shell shall recognize the entire status value retrieved for the command by the equivalent of the $WEXITSTATUS macro (as defined in the System Interfaces volume of IEEE Std 1003.1-2001). When reporting the exit status with the special parameter ‘ ’, the shell
shall report the full eight bits of exit status available. The exit status of a command that terminated because it received a signal shall be reported as greater than 128.

2.9 Shell Commands

This section describes the basic structure of shell commands. The following command descriptions each describe a format of the command that is only used to aid the reader in recognizing the command type, and does not formally represent the syntax. Each description discusses the semantics of the command; for a formal definition of the command language, consult Section 2.10 (on page 55).

A command is one of the following:

- Simple command (see Section 2.9.1)
- Pipeline (see Section 2.9.2 (on page 49))
- List compound-list (see Section 2.9.3 (on page 50))
- Compound command (see Section 2.9.4 (on page 52))
- Function definition (see Section 2.9.5 (on page 54))

Unless otherwise stated, the exit status of a command shall be that of the last simple command executed by the command. There shall be no limit on the size of any shell command other than that imposed by the underlying system (memory constraints, \{ARG_MAX\}, and so on).

2.9.1 Simple Commands

A “simple command” is a sequence of optional variable assignments and redirections, in any sequence, optionally followed by words and redirections, terminated by a control operator.

When a given simple command is required to be executed (that is, when any conditional construct such as an AND-OR list or a case statement has not bypassed the simple command), the following expansions, assignments, and redirections shall all be performed from the beginning of the command text to the end:

1. The words that are recognized as variable assignments or redirections according to Section 2.10.2 (on page 56) are saved for processing in steps 3 and 4.
2. The words that are not variable assignments or redirections shall be expanded. If any fields remain following their expansion, the first field shall be considered the command name and remaining fields are the arguments for the command.
3. Redirections shall be performed as described in Section 2.7 (on page 43).
4. Each variable assignment shall be expanded for tilde expansion, parameter expansion, command substitution, arithmetic expansion, and quote removal prior to assigning the value.

In the preceding list, the order of steps 3 and 4 may be reversed for the processing of special built-in utilities; see Section 2.14 (on page 64).

If no command name results, variable assignments shall affect the current execution environment. Otherwise, the variable assignments shall be exported for the execution environment of the command and shall not affect the current execution environment (except for special built-ins). If any of the variable assignments attempt to assign a value to a read-only variable, a variable assignment error shall occur. See Section 2.8.1 (on page 46) for the consequences of these errors.
If there is no command name, any redirections shall be performed in a subshell environment; it is unspecified whether this subshell environment is the same one as that used for a command substitution within the command. (To affect the current execution environment, see the exec special built-in.) If any of the redirections performed in the current shell execution environment fail, the command shall immediately fail with an exit status greater than zero, and the shell shall write an error message indicating the failure. See Section 2.8.1 (on page 46) for the consequences of these failures on interactive and non-interactive shells.

If there is a command name, execution shall continue as described in Section 2.9.1.1. If there is no command name, but the command contained a command substitution, the command shall complete with the exit status of the last command substitution performed. Otherwise, the command shall complete with a zero exit status.

2.9.1.1 Command Search and Execution

If a simple command results in a command name and an optional list of arguments, the following actions shall be performed:

1. If the command name does not contain any slashes, the first successful step in the following sequence shall occur:

   a. If the command name matches the name of a special built-in utility, that special built-in utility shall be invoked.

   b. If the command name matches the name of a function known to this shell, the function shall be invoked as described in Section 2.9.5 (on page 54). If the implementation has provided a standard utility in the form of a function, it shall not be recognized at this point. It shall be invoked in conjunction with the path search in step 1d.

   c. If the command name matches the name of a utility listed in the following table, that utility shall be invoked.

   

<table>
<thead>
<tr>
<th>alias</th>
<th>false</th>
<th>jobs</th>
<th>read</th>
<th>wait</th>
</tr>
</thead>
<tbody>
<tr>
<td>bg</td>
<td>fc</td>
<td>kill</td>
<td>true</td>
<td></td>
</tr>
<tr>
<td>cd</td>
<td>fg</td>
<td>newgrp</td>
<td>umask</td>
<td></td>
</tr>
<tr>
<td>command</td>
<td>getopts</td>
<td>pwd</td>
<td>unalias</td>
<td></td>
</tr>
</tbody>
</table>

   d. Otherwise, the command shall be searched for using the PATH environment variable as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables:

      i. If the search is successful:

         a. If the system has implemented the utility as a regular built-in or as a shell function, it shall be invoked at this point in the path search.

         b. Otherwise, the shell executes the utility in a separate utility environment (see Section 2.12 (on page 61)) with actions equivalent to calling the execve() function as defined in the System Interfaces volume of IEEE Std 1003.1-2001 with the path argument set to the pathname resulting from the search, arg0 set to the command name, and the remaining arguments set to the operands, if any.

            If the execve() function fails due to an error equivalent to the [ENOEXEC] error defined in the System Interfaces volume of IEEE Std 1003.1-2001, the shell shall execute a command equivalent to having a shell invoked with the command name as its first operand, with any remaining arguments
passed to the new shell. If the executable file is not a text file, the shell may bypass this command execution. In this case, it shall write an error message, and shall return an exit status of 126.

Once a utility has been searched for and found (either as a result of this specific search or as part of an unspecified shell start-up activity), an implementation may remember its location and need not search for the utility again unless the PATH variable has been the subject of an assignment. If the remembered location fails for a subsequent invocation, the shell shall repeat the search to find the new location for the utility, if any.

If the search is unsuccessful, the command shall fail with an exit status of 127 and the shell shall write an error message.

2. If the command name contains at least one slash, the shell shall execute the utility in a separate utility environment with actions equivalent to calling the execve() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 with the path and arg0 arguments set to the command name, and the remaining arguments set to the operands, if any.

If the execve() function fails due to an error equivalent to the [ENOEXEC] error, the shell shall execute a command equivalent to having a shell invoked with the command name as its first operand, with any remaining arguments passed to the new shell. If the executable file is not a text file, the shell may bypass this command execution. In this case, it shall write an error message and shall return an exit status of 126.

2.9.2 Pipelines

A pipeline is a sequence of one or more commands separated by the control operator ' | '. The standard output of all but the last command shall be connected to the standard input of the next command.

The format for a pipeline is:

```
[!] command1 [ | command2 ...]
```

The standard output of command1 shall be connected to the standard input of command2. The standard input, standard output, or both of a command shall be considered to be assigned by the pipeline before any redirection specified by redirection operators that are part of the command (see Section 2.7 (on page 43)).

If the pipeline is not in the background (see Section 2.9.3.1 (on page 50)), the shell shall wait for the last command specified in the pipeline to complete, and may also wait for all commands to complete.

Exit Status

If the reserved word ! does not precede the pipeline, the exit status shall be the exit status of the last command specified in the pipeline. Otherwise, the exit status shall be the logical NOT of the exit status of the last command. That is, if the last command returns zero, the exit status shall be 1; if the last command returns greater than zero, the exit status shall be zero.
2.9.3 Lists

An AND-OR list is a sequence of one or more pipelines separated by the operators "&&" and "||".

A list is a sequence of one or more AND-OR lists separated by the operators ‘;’ and ‘&’ and optionally terminated by ‘;’, ‘&’, or <newline>.

The operators "&&" and "||" shall have equal precedence and shall be evaluated with left associativity. For example, both of the following commands write solely bar to standard output:

```
false && echo foo || echo bar
true || echo foo & echo bar
```

A ‘;’ or <newline> terminator shall cause the preceding AND-OR list to be executed sequentially; an ‘&’ shall cause asynchronous execution of the preceding AND-OR list.

The term “compound-list” is derived from the grammar in Section 2.10 (on page 55); it is equivalent to a sequence of lists, separated by <newline>s, that can be preceded or followed by an arbitrary number of <newline>s.

Examples

The following is an example that illustrates <newline>s in compound-lists:

```
while
  # a couple of <newline>s
  # a list
  date && who || ls; cat file
  # a couple of <newline>s

  # another list
  wc file > output & true

do
  # 2 lists
  ls
  cat file
done
```

2.9.3.1 Asynchronous Lists

If a command is terminated by the control operator ampersand (‘&’), the shell shall execute the command asynchronously in a subshell. This means that the shell shall not wait for the command to finish before executing the next command.

The format for running a command in the background is:

```
command1 & [command2 & ... ]
```

The standard input for an asynchronous list, before any explicit redirections are performed, shall be considered to be assigned to a file that has the same properties as /dev/null. If it is an interactive shell, this need not happen. In all cases, explicit redirection of standard input shall override this activity.

When an element of an asynchronous list (the portion of the list ended by an ampersand, such as command1, above) is started by the shell, the process ID of the last command in the asynchronous list element shall become known in the current shell execution environment; see Section 2.12 (on page 61). This process ID shall remain known until:
1. The command terminates and the application waits for the process ID.

2. Another asynchronous list invoked before "$!" (corresponding to the previous asynchronous list) is expanded in the current execution environment.

The implementation need not retain more than the \{CHILD_MAX\} most recent entries in its list of known process IDs in the current shell execution environment.

**Exit Status**

The exit status of an asynchronous list shall be zero.

### 2.9.3.2 Sequential Lists

Commands that are separated by a semicolon (‘;’) shall be executed sequentially.

The format for executing commands sequentially shall be:

```
command1 [ ; command2 ] ...
```

Each command shall be expanded and executed in the order specified.

**Exit Status**

The exit status of a sequential list shall be the exit status of the last command in the list.

### 2.9.3.3 AND Lists

The control operator "&&" denotes an AND list. The format shall be:

```
command1 [ && command2 ] ...
```

First \textit{command1} shall be executed. If its exit status is zero, \textit{command2} shall be executed, and so on, until a command has a non-zero exit status or there are no more commands left to execute. The commands are expanded only if they are executed.

**Exit Status**

The exit status of an AND list shall be the exit status of the last command that is executed in the list.

### 2.9.3.4 OR Lists

The control operator "||" denotes an OR List. The format shall be:

```
command1 [ || command2 ] ...
```

First, \textit{command1} shall be executed. If its exit status is non-zero, \textit{command2} shall be executed, and so on, until a command has a zero exit status or there are no more commands left to execute.

**Exit Status**

The exit status of an OR list shall be the exit status of the last command that is executed in the list.
2.9.4 Compound Commands

The shell has several programming constructs that are "compound commands", which provide control flow for commands. Each of these compound commands has a reserved word or control operator at the beginning, and a corresponding terminator reserved word or operator at the end.

In addition, each can be followed by redirections on the same line as the terminator. Each redirection shall apply to all the commands within the compound command that do not explicitly override that redirection.

2.9.4.1 Grouping Commands

The format for grouping commands is as follows:

```
(compound-list)  Execute compound-list in a subshell environment; see Section 2.12 (on page 61). Variable assignments and built-in commands that affect the environment shall not remain in effect after the list finishes.
{ compound-list;}  Execute compound-list in the current process environment. The semicolon shown here is an example of a control operator delimiting the } reserved word. Other delimiters are possible, as shown in Section 2.10 (on page 55); a <newline> is frequently used.
```

Exit Status

The exit status of a grouping command shall be the exit status of compound-list.

2.9.4.2 The for Loop

The for loop shall execute a sequence of commands for each member in a list of items. The for loop requires that the reserved words do and done be used to delimit the sequence of commands.

The format for the for loop is as follows:

```
for name [ in [word ... ]]
do
  compound-list
done
```

First, the list of words following in shall be expanded to generate a list of items. Then, the variable name shall be set to each item, in turn, and the compound-list executed each time. If no items result from the expansion, the compound-list shall not be executed. Omitting:

```
in word...
```

shall be equivalent to:

```
in "$@"
```

Exit Status

The exit status of a for command shall be the exit status of the last command that executes. If there are no items, the exit status shall be zero.
2.9.4.3 Case Conditional Construct

The conditional construct `case` shall execute the `compound-list` corresponding to the first one of several `patterns` (see Section 2.13 (on page 62)) that is matched by the string resulting from the tilde expansion, parameter expansion, command substitution, arithmetic expansion, and quote removal of the given word. The reserved word `in` shall denote the beginning of the patterns to be matched. Multiple patterns with the same `compound-list` shall be delimited by the `|` symbol. The control operator `)` terminates a list of patterns corresponding to a given action. The `compound-list` for each list of patterns, with the possible exception of the last, shall be terminated with `;;;`. The `case` construct terminates with the reserved word `esac` (`case` reversed).

The format for the `case` construct is as follows:

```
case word in
    [[{pattern}] compound-list;;]
    [[{pattern} | pattern] ...] compound-list;;] ...
    [[{pattern} | pattern] ...] compound-list]
esac
```

The ";;;" is optional for the last `compound-list`.

In order from the beginning to the end of the `case` statement, each `pattern` that labels a `compound-list` shall be subjected to tilde expansion, parameter expansion, command substitution, and arithmetic expansion, and the result of these expansions shall be compared against the expansion of `word`, according to the rules described in Section 2.13 (on page 62) (which also describes the effect of quoting parts of the pattern). After the first match, no more patterns shall be expanded, and the `compound-list` shall be executed. The order of expansion and comparison of multiple `patterns` that label a `compound-list` statement is unspecified.

Exit Status

The exit status of `case` shall be zero if no patterns are matched. Otherwise, the exit status shall be the exit status of the last command executed in the `compound-list`.

2.9.4.4 The if Conditional Construct

The `if` command shall execute a `compound-list` and use its exit status to determine whether to execute another `compound-list`.

The format for the `if` construct is as follows:

```
if compound-list
    then
        compound-list
    [elif compound-list
        then
            compound-list] ...
    [else
        compound-list]
fi
```

The `if compound-list` shall be executed; if its exit status is zero, the `then compound-list` shall be executed and the command shall complete. Otherwise, each `elif compound-list` shall be executed, in turn, and if its exit status is zero, the `then compound-list` shall be executed and the command shall complete. Otherwise, the `else compound-list` shall be executed.
The exit status of the if command shall be the exit status of the then or else compound-list that was executed, or zero, if none was executed.

The while loop shall continuously execute one compound-list as long as another compound-list has a zero exit status. The format of the while loop is as follows:

```
while compound-list-1
do
  compound-list-2
done
```

The compound-list-1 shall be executed, and if it has a non-zero exit status, the while command shall complete. Otherwise, the compound-list-2 shall be executed, and the process shall repeat.

The exit status of the while loop shall be the exit status of the last compound-list-2 executed, or zero if none was executed.

The until loop shall continuously execute one compound-list as long as another compound-list has a non-zero exit status. The format of the until loop is as follows:

```
until compound-list-1
do
  compound-list-2
done
```

The compound-list-1 shall be executed, and if it has a zero exit status, the until command completes. Otherwise, the compound-list-2 shall be executed, and the process repeats.

The exit status of the until loop shall be the exit status of the last compound-list-2 executed, or zero if none was executed.

A function is a user-defined name that is used as a simple command to call a compound command with new positional parameters. A function is defined with a “function definition command”.

The format of a function definition command is as follows:

```
fname() compound-command [io-redirect ...]
```

The function is named fname; the application shall ensure that it is a name (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.230, Name). An implementation may allow other characters in a function name as an extension. The implementation shall maintain separate name spaces for functions and variables.
The argument *compound-command* represents a compound command, as described in Section 2.9.4 (on page 52).

When the function is declared, none of the expansions in Section 2.6 (on page 36) shall be performed on the text in *compound-command* or *io-redirect*; all expansions shall be performed as normal each time the function is called. Similarly, the optional *io-redirect* redirections and any variable assignments within *compound-command* shall be performed during the execution of the function itself, not the function definition. See Section 2.8.1 (on page 46) for the consequences of failures of these operations on interactive and non-interactive shells.

When a function is executed, it shall have the syntax-error and variable-assignment properties described for special built-in utilities in the enumerated list at the beginning of Section 2.14 (on page 64).

The *compound-command* shall be executed whenever the function name is specified as the name of a simple command (see Section 2.9.1.1 (on page 48)). The operands to the command temporarily shall become the positional parameters during the execution of the *compound-command*; the special parameter ‘#’ also shall be changed to reflect the number of operands. The special parameter 0 shall be unchanged. When the function completes, the values of the positional parameters and the special parameter ‘#’ shall be restored to the values they had before the function was executed. If the special built-in *return* is executed in the *compound-command*, the function completes and execution shall resume with the next command after the function call.

**Exit Status**

The exit status of a function definition shall be zero if the function was declared successfully; otherwise, it shall be greater than zero. The exit status of a function invocation shall be the exit status of the last command executed by the function.

### 2.10 Shell Grammar

The following grammar defines the Shell Command Language. This formal syntax shall take precedence over the preceding text syntax description.

#### 2.10.1 Shell Grammar Lexical Conventions

The input language to the shell must be first recognized at the character level. The resulting tokens shall be classified by their immediate context according to the following rules (applied in order). These rules shall be used to determine what a “token” is that is subject to parsing at the token level. The rules for token recognition in Section 2.3 (on page 31) shall apply.

1. A `<newline>` shall be returned as the token identifier `NEWLINE`.
2. If the token is an operator, the token identifier for that operator shall result.
3. If the string consists solely of digits and the delimiter character is one of `<` or `>`, the token identifier `IO_NUMBER` shall be returned.
4. Otherwise, the token identifier `TOKEN` results.

Further distinction on `TOKEN` is context-dependent. It may be that the same `TOKEN` yields `WORD`, a `NAME`, an `ASSIGNMENT`, or one of the reserved words below, dependent upon the context. Some of the productions in the grammar below are annotated with a rule number from the following list. When a `TOKEN` is seen where one of those annotated productions could be used to reduce the symbol, the applicable rule shall be applied to convert the token identifier.
type of the `TOKEN` to a token identifier acceptable at that point in the grammar. The reduction shall then proceed based upon the token identifier type yielded by the rule applied. When more than one rule applies, the highest numbered rule shall apply (which in turn may refer to another rule). (Note that except in rule 7, the presence of an `=` in the token has no effect.)

The `WORD` tokens shall have the word expansion rules applied to them immediately before the associated command is executed, not at the time the command is parsed.

### 2.10.2 Shell Grammar Rules

1. **[Command Name]**

   When the `TOKEN` is exactly a reserved word, the token identifier for that reserved word shall result. Otherwise, the token `WORD` shall be returned. Also, if the parser is in any state where only a reserved word could be the next correct token, proceed as above.

   **Note:** Because at this point quote marks are retained in the token, quoted strings cannot be recognized as reserved words. This rule also implies that reserved words are not recognized except in certain positions in the input, such as after a `<newline>` or semicolon; the grammar presumes that if the reserved word is intended, it is properly delimited by the user, and does not attempt to reflect that requirement directly. Also note that line joining is done before tokenization, as described in Section 2.2.1 (on page 30), so escaped `<newline>`s are already removed at this point.

   Rule 1 is not directly referenced in the grammar, but is referred to by other rules, or applies globally.

2. **[Redirection to or from filename]**

   The expansions specified in Section 2.7 (on page 43) shall occur. As specified there, exactly one field can result (or the result is unspecified), and there are additional requirements on pathname expansion.

3. **[Redirection from here-document]**

   Quote removal shall be applied to the word to determine the delimiter that is used to find the end of the here-document that begins after the next `<newline>`.

4. **[Case statement termination]**

   When the `TOKEN` is exactly the reserved word `esac`, the token identifier for `esac` shall result. Otherwise, the token `WORD` shall be returned.

5. **[NAME in for]**

   When the `TOKEN` meets the requirements for a name (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.230, Name), the token identifier `NAME` shall result. Otherwise, the token `WORD` shall be returned.

6. **[Third word of for and case]**

   a. **[case only]**

      When the `TOKEN` is exactly the reserved word `in`, the token identifier for `in` shall result. Otherwise, the token `WORD` shall be returned.

   b. **[for only]**

      When the `TOKEN` is exactly the reserved word `in` or `do`, the token identifier for `in` or `do` shall result, respectively. Otherwise, the token `WORD` shall be returned.
(For a. and b.: As indicated in the grammar, a linebreak precedes the tokens in and do. If
<newline>s are present at the indicated location, it is the token after them that is treated in
this fashion.)

7. [Assignment preceding command name]
   
a. [When the first word]
   
   If the TOKEN does not contain the character ‘=', rule 1 is applied. Otherwise, 7b
   shall be applied.
   
b. [Not the first word]
   
   If the TOKEN contains the equal sign character:
   
   — If it begins with ‘=', the token WORD shall be returned.
   
   — If all the characters preceding ‘=' form a valid name (see the Base Definitions
     volume of IEEE Std 1003.1-2001, Section 3.230, Name), the token
     ASSIGNMENT_WORD shall be returned. (Quoted characters cannot participate
     in forming a valid name.)
   
   — Otherwise, it is unspecified whether it is ASSIGNMENT_WORD or WORD that
     is returned.
   
   Assignment to the NAME shall occur as specified in Section 2.9.1 (on page 47).

8. [NAME in function]
   
   When the TOKEN is exactly a reserved word, the token identifier for that reserved word
   shall result. Otherwise, when the TOKEN meets the requirements for a name, the token
   identifier NAME shall result. Otherwise, rule 7 applies.

9. [Body of function]
   
   Word expansion and assignment shall never occur, even when required by the rules above,
   when this rule is being parsed. Each TOKEN that might either be expanded or have
   assignment applied to it shall instead be returned as a single WORD consisting only of
   characters that are exactly the token described in Section 2.3 (on page 31).

/* -------------------------------------------------------
   The grammar symbols
   ------------------------------------------------------- */

%token WORD
%token ASSIGNMENT_WORD
%token NAME
%token NEWLINE
%token IO_NUMBER

/* The following are the operators mentioned above. */

%token AND_IF OR_IF DSEMI
/*  '&&' '||' ';' */

%token DLESS DGREAT LESSAND GREATAND LESSGREAT GREATAND DLESSDASH
/*  '<<' '>' '&>' '&' '<>' '&>' '<-' */

%token CLOBBER
/*  '>' '|' */
/* The following are the reserved words. */
%token If Then Else Elif Fi Do Done
/* 'if' 'then' 'else' 'elif' 'fi' 'do' 'done' */
%token Case Esac While Until For
/* 'case' 'esac' 'while' 'until' 'for' */
/* These are reserved words, not operator tokens, and are
recognized when reserved words are recognized. */
%token Lbrace Rbrace Bang
/* '{' '}' '!' */
%token In
/* 'in' */
/* -------------------------------------------------------
The Grammar
------------------------------------------------------- */
%start complete_command
%
complete_command : list separator
| list
|
list : list separator_op and_or
| and_or
|
and_or : pipeline
| and_or AND_IF linebreak pipeline
| and_or OR_IF linebreak pipeline
|
pipeline : pipe_sequence
| Bang pipe_sequence
|
pipe_sequence : command
| pipe_sequence '|' linebreak command
|
command : simple_command
| compound_command
| compound_command redirect_list
| function_definition
|
compound_command : brace_group
| subshell
| for_clause
| case_clause
| if_clause
| while_clause
| until_clause
|
subshell : '(' compound_list ')'
|
compound_list : term
| newline_list term
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| term separator |
| newline_list term separator |
| term : term separator and_or |
| and_or |
| for_clause : For name linebreak do_group |
| For name linebreak in sequential_sep do_group |
| For name linebreak in wordlist sequential_sep do_group |
| name : NAME /* Apply rule 5 */ |
| in : In /* Apply rule 6 */ |
| wordlist : wordlist WORD |
| case_clause : Case WORD linebreak in linebreak case_list Esac |
| Case WORD linebreak in linebreak case_list_ns Esac |
| Case WORD linebreak in linebreak |
| case_list_ns : case_list case_item_ns |
| case_item : pattern ')'| linebreak |
| '{' pattern ')'| compound_list linebreak |
| '{' '{' pattern ')'| compound_list linebreak |
| pattern : WORD /* Apply rule 4 */ |
| if_clause : If compound_list Then compound_list else_part Fi |
| If compound_list Then compound_list Fi |
| else_part : Elif compound_list Then else_part |
| Else compound_list |
| while_clause : While compound_list do_group |
| until_clause : Until compound_list do_group |
| function_definition : fname '(' ')' linebreak function_body |

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```plaintext
function_body : compound_command /* Apply rule 9 */
| compound_command redirect_list /* Apply rule 9 */
| ;
fname : NAME /* Apply rule 8 */
| ;
brace_group : Lbrace compound_list Rbrace
| ;
do_group : Do compound_list Done /* Apply rule 6 */
| ;
simple_command : cmd_prefix cmd_word cmd_suffix
| cmd_prefix cmd_word
| cmd_prefix
| cmd_name cmd_suffix
| cmd_name
| ;
cmd_name : WORD /* Apply rule 7a */
| ;
cmd_word : WORD /* Apply rule 7b */
| ;
cmd_prefix : io_redirect
| cmd_prefix io_redirect
| ASSIGNMENT_WORD
| cmd_prefix ASSIGNMENT_WORD
| ;
cmd_suffix : io_redirect
| cmd_suffix io_redirect
| WORD
| cmd_suffix WORD
| ;
redirect_list : io_redirect
| redirect_list io_redirect
| ;
io_redirect : io_file
| IO_NUMBER io_file
| io_here
| IO_NUMBER io_here
| ;
io_file : '<' filename
| LESSAND filename
| '>' filename
| GREATAND filename
| DGREAT filename
| LESSGREAT filename
| CLOBBER filename
| ;
filename : WORD /* Apply rule 2 */
| ;
io_here : DLESS here_end
| DLESSDASH here_end
| ;
here_end : WORD /* Apply rule 3 */
| ;
```
2.11 Signals and Error Handling

When a command is in an asynchronous list, the shell shall prevent SIGQUIT and SIGINT signals from the keyboard from interrupting the command. Otherwise, signals shall have the values inherited by the shell from its parent (see also the `trap` special built-in).

When a signal for which a trap has been set is received while the shell is waiting for the completion of a utility executing a foreground command, the trap associated with that signal shall not be executed until after the foreground command has completed. When the shell is waiting, by means of the `wait` utility, for asynchronous commands to complete, the reception of a signal for which a trap has been set shall cause the `wait` utility to return immediately with an exit status >128, immediately after which the trap associated with that signal shall be taken.

If multiple signals are pending for the shell for which there are associated trap actions, the order of execution of trap actions is unspecified.

2.12 Shell Execution Environment

A shell execution environment consists of the following:

- Open files inherited upon invocation of the shell, plus open files controlled by `exec`
- Working directory as set by `cd`
- File creation mask set by `umask`
- Current traps set by `trap`
- Shell parameters that are set by variable assignment (see the `set` special built-in) or from the System Interfaces volume of IEEE Std 1003.1-2001 environment inherited by the shell when it begins (see the `export` special built-in)
- Shell functions; see Section 2.9.5 (on page 54)
- Options turned on at invocation or by `set`
- Process IDs of the last commands in asynchronous lists known to this shell environment; see Section 2.9.3.1 (on page 50)
Utilities other than the special built-ins (see Section 2.14 (on page 64)) shall be invoked in a separate environment that consists of the following. The initial value of these objects shall be the same as that for the parent shell, except as noted below.

- Open files inherited on invocation of the shell, open files controlled by the exec special built-in plus any modifications, and additions specified by any redirections to the utility
- Current working directory
- File creation mask

- If the utility is a shell script, traps caught by the shell shall be set to the default values and traps ignored by the shell shall be set to be ignored by the utility; if the utility is not a shell script, the trap actions (default or ignore) shall be mapped into the appropriate signal handling actions for the utility
- Variables with the export attribute, along with those explicitly exported for the duration of the command, shall be passed to the utility environment variables

The environment of the shell process shall not be changed by the utility unless explicitly specified by the utility description (for example, cd and umask).

A subshell environment shall be created as a duplicate of the shell environment, except that signal traps set by that shell environment shall be set to the default values. Changes made to the subshell environment shall not affect the shell environment. Command substitution, commands that are grouped with parentheses, and asynchronous lists shall be executed in a subshell environment. Additionally, each command of a multi-command pipeline is in a subshell environment; as an extension, however, any or all commands in a pipeline may be executed in the current environment. All other commands shall be executed in the current shell environment.

### 2.13 Pattern Matching Notation

The pattern matching notation described in this section is used to specify patterns for matching strings in the shell. Historically, pattern matching notation is related to, but slightly different from, the regular expression notation described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 9, Regular Expressions. For this reason, the description of the rules for this pattern matching notation are based on the description of regular expression notation, modified to include backslash escape processing.

#### 2.13.1 Patterns Matching a Single Character

The following patterns matching a single character shall match a single character: ordinary characters, special pattern characters, and pattern bracket expressions. The pattern bracket expression also shall match a single collating element. A backslash character shall escape the following character. The escaping backslash shall be discarded.

An ordinary character is a pattern that shall match itself. It can be any character in the supported character set except for NUL, those special shell characters in Section 2.2 (on page 30) that require quoting, and the following three special pattern characters. Matching shall be based on the bit pattern used for encoding the character, not on the graphic representation of the character. If any character (ordinary, shell special, or pattern special) is quoted, that pattern shall match the character itself. The shell special characters always require quoting.
When unquoted and outside a bracket expression, the following three characters shall have special meaning in the specification of patterns:

?  A question-mark is a pattern that shall match any character.

*  An asterisk is a pattern that shall match multiple characters, as described in Section 2.13.2.

[  The open bracket shall introduce a pattern bracket expression.

The description of basic regular expression bracket expressions in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3.5, RE Bracket Expression shall also apply to the pattern bracket expression, except that the exclamation mark character (‘!’) shall replace the circumflex character (‘ˆ’) in its role in a “non-matching list” in the regular expression notation.

A bracket expression starting with an unquoted circumflex character produces unspecified results.

When pattern matching is used where shell quote removal is not performed (such as in the argument to the find -name primary when find is being called using one of the exec functions as defined in the System Interfaces volume of IEEE Std 1003.1-2001, or in the pattern argument to the fnmatch() function), special characters can be escaped to remove their special meaning by preceding them with a backslash character. This escaping backslash is discarded. The sequence "\" represents one literal backslash. All of the requirements and effects of quoting on ordinary, shell special, and special pattern characters shall apply to escaping in this context.

2.13.2 Patterns Matching Multiple Characters

The following rules are used to construct patterns matching multiple characters from patterns matching a single character:

1. The asterisk (‘*’) is a pattern that shall match any string, including the null string.

2. The concatenation of patterns matching a single character is a valid pattern that shall match the concatenation of the single characters or collating elements matched by each of the concatenated patterns.

3. The concatenation of one or more patterns matching a single character with one or more asterisks is a valid pattern. In such patterns, each asterisk shall match a string of zero or more characters, matching the greatest possible number of characters that still allows the remainder of the pattern to match the string.

2.13.3 Patterns Used for Filename Expansion

The rules described so far in Section 2.13.1 (on page 62) and Section 2.13.2 are qualified by the following rules that apply when pattern matching notation is used for filename expansion:

1. The slash character in a pathname shall be explicitly matched by using one or more slashes in the pattern; it shall neither be matched by the asterisk or question-mark special characters nor by a bracket expression. Slashes in the pattern shall be identified before bracket expressions; thus, a slash cannot be included in a pattern bracket expression used for filename expansion. If a slash character is found following an unescaped open square bracket character before a corresponding closing square bracket is found, the open bracket shall be treated as an ordinary character. For example, the pattern "a[b/c]d" does not match such pathnames as abd or a/d. It only matches a pathname of literally a[b/c]d.

2. If a filename begins with a period (‘.’), the period shall be explicitly matched by using a period as the first character of the pattern or immediately following a slash character. The leading period shall not be matched by:
• The asterisk or question-mark special characters

• A bracket expression containing a non-matching list, such as "[!a]", a range expression, such as "[%0]", or a character class expression, such as "[:punct:]

It is unspecified whether an explicit period in a bracket expression matching list, such as "[.abc]", can match a leading period in a filename.

3. Specified patterns shall be matched against existing filenames and pathnames, as appropriate. Each component that contains a pattern character shall require read permission in the directory containing that component. Any component, except the last, that does not contain a pattern character shall require search permission. For example, given the pattern:

```
/foo/bar/x*/bam
```

search permission is needed for directories / and foo, search and read permissions are needed for directory bar, and search permission is needed for each x* directory. If the pattern matches any existing filenames or pathnames, the pattern shall be replaced with those filenames and pathnames, sorted according to the collating sequence in effect in the current locale. If the pattern contains an invalid bracket expression or does not match any existing filenames or pathnames, the pattern string shall be left unchanged.

### 2.14 Special Built-In Utilities

The following “special built-in” utilities shall be supported in the shell command language. The output of each command, if any, shall be written to standard output, subject to the normal redirection and piping possible with all commands.

The term “built-in” implies that the shell can execute the utility directly and does not need to search for it. An implementation may choose to make any utility a built-in; however, the special built-in utilities described here differ from regular built-in utilities in two respects:

1. A syntax error in a special built-in utility may cause a shell executing that utility to abort, while a syntax error in a regular built-in utility shall not cause a shell executing that utility to abort. (See Section 2.8.1 (on page 46) for the consequences of errors on interactive and non-interactive shells.) If a special built-in utility encountering a syntax error does not abort the shell, its exit value shall be non-zero.

2. Variable assignments specified with special built-in utilities remain in effect after the built-in completes; this shall not be the case with a regular built-in or other utility.

The special built-in utilities in this section need not be provided in a manner accessible via the exec family of functions defined in the System Interfaces volume of IEEE Std 1003.1-2001.

Some of the special built-ins are described as conforming to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines. For those that are not, the requirement in Section 1.11 (on page 20) that "---" be recognized as a first argument to be discarded does not apply and a conforming application shall not use that argument.
NAME
break — exit from for, while, or until loop

SYNOPSIS
break [n]

DESCRIPTION
The `break` utility shall exit from the smallest enclosing `for`, `while`, or `until` loop, if any; or from the `n`th enclosing loop if `n` is specified. The value of `n` is an unsigned decimal integer greater than or equal to 1. The default shall be equivalent to `n=1`. If `n` is greater than the number of enclosing loops, the outermost enclosing loop shall be exited. Execution shall continue with the command immediately following the loop.

OPTIONS
None.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
0 Successful completion.
>0 The `n` value was not an unsigned decimal integer greater than or equal to 1.

CONSEQUENCES OF ERRORS
Default.
APPLICATION USAGE
None.

EXAMPLES
for i in * do
  if test -d "$i" then break fi done

RATIONALE
In early proposals, consideration was given to expanding the syntax of break and continue to refer to a label associated with the appropriate loop as a preferable alternative to the n method. However, this volume of IEEE Std 1003.1-2001 does reserve the name space of command names ending with a colon. It is anticipated that a future implementation could take advantage of this and provide something like:

outofloop: for i in abcde
do
  for j in 0 1 2 3 4 5 6 7 8 9
do
    if test -r "${i}${j}"
      then break outofloop
    fi
  done
done

and that this might be standardized after implementation experience is achieved.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.14 (on page 64)

CHANGE HISTORY
Issue 6
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME

colon — null utility

SYNOPSIS

: [argument ...]

DESCRIPTION

This utility shall only expand command arguments. It is used when a command is needed, as in the then condition of an if command, but nothing is to be done by the command.

OPTIONS

None.

OPERANDS

See the DESCRIPTION.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

None.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Not used.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

Zero.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

None.

EXAMPLES

: ${X=abc}
if false
then :
else echo $X
fi
abc

As with any of the special built-ins, the null utility can also have variable assignments and redirections associated with it, such as:
2766 \texttt{x=y : > z}
2767 which sets variable \textit{x} to the value \textit{y} (so that it persists after the null utility completes) and creates
2768 or truncates file \textit{z}.
2769 \textbf{RATIONALE}
2770 None.
2771 \textbf{FUTURE DIRECTIONS}
2772 None.
2773 \textbf{SEE ALSO}
2774 Section 2.14 (on page 64)
2775 \textbf{CHANGE HISTORY}
2776 \textbf{Issue 6}
2777 IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page
2778 sections use terms as described in the Utility Description Defaults (Section 1.11). No change in
2779 behavior is intended.
NAME
continue — continue for, while, or until loop

SYNOPSIS
continue [n]

DESCRIPTION
The continue utility shall return to the top of the smallest enclosing for, while, or until loop, or to the top of the nth enclosing loop, if n is specified. This involves repeating the condition list of a while or until loop or performing the next assignment of a for loop, and re-executing the loop if appropriate.

The value of n is a decimal integer greater than or equal to 1. The default shall be equivalent to n=1. If n is greater than the number of enclosing loops, the outermost enclosing loop shall be used.

OPTIONS
None.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
0 Successful completion.

>0 The n value was not an unsigned decimal integer greater than or equal to 1.

CONSEQUENCES OF ERRORS
Default.
APPLICATION USAGE
None.

EXAMPLES
for i in *
do
    if test -d "$i"
    then continue
    fi
    echo """"$i" is not a directory."
done

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.14 (on page 64)

CHANGE HISTORY

Issue 6
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME

dot — execute commands in the current environment

SYNOPSIS

.. file

DESCRIPTION

The shell shall execute commands from the file in the current environment.

If file does not contain a slash, the shell shall use the search path specified by PATH to find the
directory containing file. Unlike normal command search, however, the file searched for by the
dot utility need not be executable. If no readable file is found, a non-interactive shell shall abort;
an interactive shell shall write a diagnostic message to standard error, but this condition shall
not be considered a syntax error.

OPTIONS

None.

OPERANDS

See the DESCRIPTION.

STDIN

Not used.

INPUT FILES

See the DESCRIPTION.

ENVIRONMENT VARIABLES

See the DESCRIPTION.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Not used.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

Returns the value of the last command executed, or a zero exit status if no command is executed.

CONSEQUENCES OF ERRORS

Default.
APPLICATION USAGE

None.

EXAMPLES

cat foobar
foo=hello bar=world
.
.

echo $foo $bar

hello world

RATIONALE

Some older implementations searched the current directory for the file, even if the value of PATH disallowed it. This behavior was omitted from this volume of IEEE Std 1003.1-2001 due to concerns about introducing the susceptibility to trojan horses that the user might be trying to avoid by leaving dot out of PATH.

The KornShell version of dot takes optional arguments that are set to the positional parameters.

This is a valid extension that allows a dot script to behave identically to a function.

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.14 (on page 64)

CHANGE HISTORY

Issue 6

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME
  eval — construct command by concatenating arguments

SYNOPSIS
  eval [argument ...]

DESCRIPTION
  The eval utility shall construct a command by concatenating arguments together, separating each
  with a <space>. The constructed command shall be read and executed by the shell.

OPTIONS
  None.

OPERANDS
  See the DESCRIPTION.

STDIN
  Not used.

INPUT FILES
  None.

ENVIRONMENT VARIABLES
  None.

ASYNCHRONOUS EVENTS
  Default.

STDOUT
  Not used.

STDERR
  The standard error shall be used only for diagnostic messages.

OUTPUT FILES
  None.

EXTENDED DESCRIPTION
  None.

EXIT STATUS
  If there are no arguments, or only null arguments, eval shall return a zero exit status; otherwise, it
  shall return the exit status of the command defined by the string of concatenated arguments
  separated by <space>s.

CONSEQUENCES OF ERRORS
  Default.

APPLICATION USAGE
  None.

EXAMPLES
  foo=10 x=foo
  y='$'$x
  echo $y
  $foo
  eval y='$'$x
  echo $y
  10
eval

\textbf{RATIONALE}
None.

\textbf{FUTURE DIRECTIONS}
None.

\textbf{SEE ALSO}
Section 2.14 (on page 64)

\textbf{CHANGE HISTORY}

\textbf{Issue 6}
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME
exec — execute commands and open, close, or copy file descriptors

SYNOPSIS
exec [command [argument ...]]

DESCRIPTION
The exec utility shall open, close, and/or copy file descriptors as specified by any redirections as part of the command.

If exec is specified without command or arguments, and any file descriptors with numbers greater than 2 are opened with associated redirection statements, it is unspecified whether those file descriptors remain open when the shell invokes another utility. Scripts concerned that child shells could misuse open file descriptors can always close them explicitly, as shown in one of the following examples.

If exec is specified with command, it shall replace the shell with command without creating a new process. If arguments are specified, they shall be arguments to command. Redirection affects the current shell execution environment.

OPTIONS
None.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
If command is specified, exec shall not return to the shell; rather, the exit status of the process shall be the exit status of the program implementing command, which overlaid the shell. If command is not found, the exit status shall be 127. If command is found, but it is not an executable utility, the exit status shall be 126. If a redirection error occurs (see Section 2.8.1 (on page 46)), the shell shall exit with a value in the range 1–125. Otherwise, exec shall return a zero exit status.
CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

None.

EXAMPLES

Open *readfile* as file descriptor 3 for reading:
```
exec 3< readfile
```
Open *writefile* as file descriptor 4 for writing:
```
exec 4> writefile
```
Make file descriptor 5 a copy of file descriptor 0:
```
exec 5<&0
```
Close file descriptor 3:
```
exec 3<&-
```
Cat the file *maggie* by replacing the current shell with the *cat* utility:
```
exec cat maggie
```

RATIONALE

Most historical implementations were not conformant in that:
```
foo=bar exec cmd
did not pass *foo* to *cmd*.
```

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.14 (on page 64)

CHANGE HISTORY

**Issue 6**

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME
exit — cause the shell to exit

SYNOPSIS
exit [n]

DESCRIPTION
The exit utility shall cause the shell to exit with the exit status specified by the unsigned decimal
integer n. If n is specified, but its value is not between 0 and 255 inclusively, the exit status is
undefined.

A trap on EXIT shall be executed before the shell terminates, except when the exit utility is
invoked in that trap itself, in which case the shell shall exit immediately.

OPTIONS
None.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The exit status shall be n, if specified. Otherwise, the value shall be the exit value of the last
command executed, or zero if no command was executed. When exit is executed in a trap action,
the last command is considered to be the command that executed immediately preceding the
trap action.

CONSEQUENCES OF ERRORS
Default.
APPLICATION USAGE
None.

EXAMPLES
Exit with a true value:
exit 0

Exit with a false value:
exit 1

RATIONALE
As explained in other sections, certain exit status values have been reserved for special uses and should be used by applications only for those purposes:

126 A file to be executed was found, but it was not an executable utility.
127 A utility to be executed was not found.
>128 A command was interrupted by a signal.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.14 (on page 64)

CHANGE HISTORY
Issue 6
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME
export — set the export attribute for variables

SYNOPSIS
export name [=word] ...
export -p

DESCRIPTION
The shell shall give the export attribute to the variables corresponding to the specified names, which shall cause them to be in the environment of subsequently executed commands. If the name of a variable is followed by =word, then the value of that variable shall be set to word.

When -p is specified, export shall write to the standard output the names and values of all exported variables, in the following format:
*export %s=%s\n", <name>, <value>
if name is set, and:
*export %s\n", <name>
if name is unset.
The shell shall format the output, including the proper use of quoting, so that it is suitable for reinput to the shell as commands that achieve the same exporting results, except:
1. Read-only variables with values cannot be reset.
2. Variables that were unset at the time they were output need not be reset to the unset state if a value is assigned to the variable between the time the state was saved and the time at which the saved output is reinput to the shell.

When no arguments are given, the results are unspecified.

OPTIONS
See the DESCRIPTION.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
See the DESCRIPTION.
export

3117  STDERR
3118      The standard error shall be used only for diagnostic messages.
3119  OUTPUT FILES
3120       None.
3121  EXTENDED DESCRIPTION
3122       None.
3123  EXIT STATUS
3124       Zero.
3125  CONSEQUENCES OF ERRORS
3126       Default.
3127  APPLICATION USAGE
3128       None.
3129  EXAMPLES
3130       Export PWD and HOME variables:
3131          export PWD HOME
3132       Set and export the PATH variable:
3133          export PATH=/local/bin:$PATH
3134       Save and restore all exported variables:
3135          export -p > temp-file
3136          unset a lot of variables
3137          ... processing
3138          . temp-file
3139  RATIONALE
3140      Some historical shells use the no-argument case as the functional equivalent of what is required
3141      here with -p. This feature was left unspecified because it is not historical practice in all shells,
3142      and some scripts may rely on the now-unspecified results on their implementations. Attempts to
3143      specify the -p output as the default case were unsuccessful in achieving consensus. The -p
3144      option was added to allow portable access to the values that can be saved and then later restored
3145      using; for example, a dot script.
3146  FUTURE DIRECTIONS
3147       None.
3148  SEE ALSO
3149       Section 2.14 (on page 64)
3150  CHANGE HISTORY
3151  Issue 6
3152      IEEE PASC Interpretation 1003.2 #203 is applied, clarifying the format when a variable is unset.
3153      IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page
3154      sections use terms as described in the Utility Description Defaults (Section 1.11). No change in
3155      behavior is intended.
3156      IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/6 is applied, adding the following text to
3157      the end of the first paragraph of the DESCRIPTION: “If the name of a variable is followed by
3158      =word, then the value of that variable shall be set to word.”. The reason for this change is that the
3159      SYNOPSIS for export includes:
export name[=word]...

but the meaning of the optional "=word" is never explained in the text.
NAME
readonly — set the readonly attribute for variables

SYNOPSIS
readonly name [=word] ...
readonly -p

DESCRIPTION
The variables whose names are specified shall be given the readonly attribute. The values of variables with the readonly attribute cannot be changed by subsequent assignment, nor can those variables be unset by the unset utility. If the name of a variable is followed by =word, then the value of that variable shall be set to word.


When -p is specified, readonly writes to the standard output the names and values of all read-only variables, in the following format:
"readonly %s=%s\n", <name>, <value>
if name is set, and
"readonly %s\n", <name>
if name is unset.

The shell shall format the output, including the proper use of quoting, so that it is suitable for reinput to the shell as commands that achieve the same value and readonly attribute-setting results in a shell execution environment in which:
1. Variables with values at the time they were output do not have the readonly attribute set.
2. Variables that were unset at the time they were output do not have a value at the time at which the saved output is reinput to the shell.

When no arguments are given, the results are unspecified.

OPTIONS
See the DESCRIPTION.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
See the DESCRIPTION.
readonly

### STDERR
The standard error shall be used only for diagnostic messages.

### OUTPUT FILES
None.

### EXTENDED DESCRIPTION
None.

### EXIT STATUS
Zero.

### CONSEQUENCES OF ERRORS
Default.

### APPLICATION USAGE
None.

### EXAMPLES
readonly HOME PWD

### RATIONALE
Some historical shells preserve the `readonly` attribute across separate invocations. This volume of IEEE Std 1003.1-2001 allows this behavior, but does not require it.

The `−p` option allows portable access to the values that can be saved and then later restored using, for example, a dot script. Also see the RATIONALE for `export` (on page 79) for a description of the no-argument and `−p` output cases and a related example.

Read-only functions were considered, but they were omitted as not being historical practice or particularly useful. Furthermore, functions must not be read-only across invocations to preclude "spoofing" (spoofing is the term for the practice of creating a program that acts like a well-known utility with the intent of subverting the real intent of the user) of administrative or security-relevant (or security-conscious) shell scripts.

### FUTURE DIRECTIONS
None.

### SEE ALSO
Section 2.14 (on page 64)

### CHANGE HISTORY

**Issue 6**
IEEE PASC Interpretation 1003.2 #203 is applied, clarifying the format when a variable is unset.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/7 is applied, adding the following text to the end of the first paragraph of the DESCRIPTION: "If the name of a variable is followed by `=word`, then the value of that variable shall be set to `word`.". The reason for this change is that the SYNOPSIS for `readonly` includes:

```sh
readonly name[=word]...
```

but the meaning of the optional "`=word`" is never explained in the text.
NAME
return — return from a function

SYNOPSIS
return [n]

DESCRIPTION
The return utility shall cause the shell to stop executing the current function or dot script. If the
shell is not currently executing a function or dot script, the results are unspecified.

OPTIONS
None.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The value of the special parameter ‘?’ shall be set to n, an unsigned decimal integer, or to the
exit status of the last command executed if n is not specified. If the value of n is greater than 255,
the results are undefined. When return is executed in a trap action, the last command is
considered to be the command that executed immediately preceding the trap action.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The behavior of return when not in a function or dot script differs between the System V shell
and the KornShell. In the System V shell this is an error, whereas in the KornShell, the effect is
the same as exit.
The results of returning a number greater than 255 are undefined because of differing practices in the various historical implementations. Some shells AND out all but the low-order 8 bits; others allow larger values, but not of unlimited size.

See the discussion of appropriate exit status values under `exit` (on page 77).

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Section 2.14 (on page 64)

**CHANGE HISTORY**

**Issue 6**

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME  
set — set or unset options and positional parameters

SYNOPSIS  
XSI  
set [-abCefmnuvx] [-h] [-o option] [argument...]

XSI  
set [+abCefmnuvx] [+h] [+o option] [argument...]

set -- [argument...]

set -o

set +o

DESCRIPTION  
If no options or arguments are specified, set shall write the names and values of all shell variables in the collation sequence of the current locale. Each name shall start on a separate line, using the format:

"%s=%s\n", <name>, <value>

The value string shall be written with appropriate quoting; see the description of shell quoting in Section 2.2 (on page 30). The output shall be suitable for reinput to the shell, setting or resetting, as far as possible, the variables that are currently set; read-only variables cannot be reset.

When options are specified, they shall set or unset attributes of the shell, as described below. When arguments are specified, they cause positional parameters to be set or unset, as described below. Setting or unsetting attributes and positional parameters are not necessarily related actions, but they can be combined in a single invocation of set.

The set special built-in shall support the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines except that options can be specified with either a leading hyphen (meaning enable the option) or plus sign (meaning disable it) unless otherwise specified.

Implementations shall support the options in the following list in both their hyphen and plus-sign forms. These options can also be specified as options to sh.

-a  When this option is on, the export attribute shall be set for each variable to which an assignment is performed; see the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.21, Variable Assignment. If the assignment precedes a utility name in a command, the export attribute shall not persist in the current execution environment after the utility completes, with the exception that preceding one of the special built-in utilities causes the export attribute to persist after the built-in has completed. If the assignment does not precede a utility name in the command, or if the assignment is a result of the operation of the getopts or read utilities, the export attribute shall persist until the variable is unset.

-b  This option shall be supported if the implementation supports the User Portability Utilities option. It shall cause the shell to notify the user asynchronously of background job completions. The following message is written to standard error:

"[%d]%c %s%s\n", <job-number>, <current>, <status>, <job-name>

where the fields shall be as follows:

<current>  The character ‘+’ identifies the job that would be used as a default for the fg or bg utilities; this job can also be specified using the job_id "%+%" or "%-%". The character ‘−’ identifies the job that would become the default if the current default job were to exit; this job can also be specified using the job_id "%-%". For other jobs, this field is a <space>. At most one job can be identified with ‘+’ and at most one job can be identified with ‘−’.
If there is any suspended job, then the current job shall be a suspended
job. If there are at least two suspended jobs, then the previous job also
shall be a suspended job.

A number that can be used to identify the process group to the wait, fg, bg,
and kill utilities. Using these utilities, the job can be identified by
prefixing the job number with ' % '.

Unspecified.

Unspecified.

When the shell notifies the user a job has been completed, it may remove the job’s process
ID from the list of those known in the current shell execution environment; see Section
2.9.3.1 (on page 50). Asynchronous notification shall not be enabled by default.

(Uppercase C.) Prevent existing files from being overwritten by the shell’s ‘ > ’ redirection
operator (see Section 2.7.2 (on page 44)); the " > | " redirection operator shall override this
noclobber option for an individual file.

When this option is on, if a simple command fails for any of the reasons listed in Section
2.8.1 (on page 46) or returns an exit status value >0, and is not part of the compound list
following a while, until, or if keyword, and is not a part of an AND or OR list, and is not a
pipeline preceded by the ! reserved word, then the shell shall immediately exit.

The shell shall disable pathname expansion.

Locate and remember utilities invoked by functions as those functions are defined (the
utilities are normally located when the function is executed).

This option shall be supported if the implementation supports the User Portability Utilities
option. All jobs shall be run in their own process groups. Immediately before the shell issues
a prompt after completion of the background job, a message reporting the exit status of the
background job shall be written to standard error. If a foreground job stops, the shell shall
write a message to standard error to that effect, formatted as described by the jobs utility. In
addition, if a job changes status other than exiting (for example, if it stops for input or
output or is stopped by a SIGSTOP signal), the shell shall write a similar message
immediately prior to writing the next prompt. This option is enabled by default for
interactive shells.

The shell shall read commands but does not execute them; this can be used to check for
shell script syntax errors. An interactive shell may ignore this option.

Write the current settings of the options to standard output in an unspecified format.

Write the current option settings to standard output in a format that is suitable for reinput
to the shell as commands that achieve the same options settings.

This option is supported if the system supports the User Portability Utilities option. It shall
set various options, many of which shall be equivalent to the single option letters. The
following values of option shall be supported:

Equivalent to --a.

Equivalent to --e.

Prevent an interactive shell from exiting on end-of-file. This setting prevents
accidental logouts when < control > - D is entered. A user shall explicitly exit to
leave the interactive shell.
set

3385  **monitor**  Equivalent to `−m`. This option is supported if the system supports the User Portability Utilities option.

3387  **noclobber**  Equivalent to `−C` (uppercase C).

3388  **noglob**  Equivalent to `−f`.

3389  **noexec**  Equivalent to `−n`.

3390  **nolog**  Prevent the entry of function definitions into the command history; see `Command History List` (on page 854).

3392  **notify**  Equivalent to `−b`.

3393  **nounset**  Equivalent to `−u`.

3394  **verbose**  Equivalent to `−v`.

3395  **vi**  Allow shell command line editing using the built-in vi editor. Enabling vi mode shall disable any other command line editing mode provided as an implementation extension.

3398  It need not be possible to set vi mode on for certain block-mode terminals.

3399  **xtrace**  Equivalent to `−x`.

```
−u  The shell shall write a message to standard error when it tries to expand a variable that is not set and immediately exit. An interactive shell shall not exit.

−v  The shell shall write its input to standard error as it is read.

−x  The shell shall write to standard error a trace for each command after it expands the command and before it executes it. It is unspecified whether the command that turns tracing off is traced.
```

The default for all these options shall be off (unset) unless stated otherwise in the description of the option or unless the shell was invoked with them on; see `sh`.

The remaining arguments shall be assigned in order to the positional parameters. The special parameter `’#’` shall be set to reflect the number of positional parameters. All positional parameters shall be unset before any new values are assigned.

The special argument "−−" immediately following the `set` command name can be used to delimit the arguments if the first argument begins with `’+’` or `’−’`, or to prevent inadvertent listing of all shell variables when there are no arguments. The command `set −−` without argument shall unset all positional parameters and set the special parameter `’#’` to zero.

**OPTIONS**

See the DESCRIPTION.

**OPERANDS**

See the DESCRIPTION.

**STDIN**

Not used.

**INPUT FILES**

None.
ENIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
See the DESCRIPTION.

STDOUT
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
Zero.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
Write out all variables and their values:

```bash
set
set $1, $2, and $3 and set "$#" to 3:
set c a b
Turn on the −x and −v options:
set −xv
Unset all positional parameters:
set --
Set $1 to the value of x, even if it begins with ’−’ or ’+’:
set -- "$x"
Set the positional parameters to the expansion of x, even if x expands with a leading ’−’ or ’+’:
set -- $x
```

RATIONALE
The set -- form is listed specifically in the SYNOPSIS even though this usage is implied by the Utility Syntax Guidelines. The explanation of this feature removes any ambiguity about whether the set -- form might be misinterpreted as being equivalent to set without any options or arguments. The functionality of this form has been adopted from the KornShell. In System V, set -- only unsets parameters if there is at least one argument; the only way to unset all parameters is to use shift. Using the KornShell version should not affect System V scripts because there should be no reason to issue it without arguments deliberately; if it were issued as, for example:

```bash
set -- "$@"
```
and there were in fact no arguments resulting from "@", unsetting the parameters would have no result.

The set + form in early proposals was omitted as being an unnecessary duplication of set alone and not widespread historical practice.

The noclobber option was changed to allow set -C as well as the set -o noclobber option. The single-letter version was added so that the historical "-" paradigm would not be broken; see Section 2.5.2 (on page 34).

The -h flag is related to command name hashing and is only required on XSI-conformant systems.

The following set flags were omitted intentionally with the following rationale:

- The -k flag was originally added by the author of the Bourne shell to make it easier for users of pre-release versions of the shell. In early versions of the Bourne shell the construct
  set name=value had to be used to assign values to shell variables. The problem with -k is that the behavior affects parsing, virtually precluding writing any compilers. To explain the behavior of -k, it is necessary to describe the parsing algorithm, which is implementation-defined. For example:

  set -k; echo name=value

  and:

  set -k
  echo name=value

  behave differently. The interaction with functions is even more complex. What is more, the -k flag is never needed, since the command line could have been reordered.

- The -t flag is hard to specify and almost never used. The only known use could be done with here-documents. Moreover, the behavior with ksh and sh differs. The reference page says that it exits after reading and executing one command. What is one command? If the input is date;date, sh executes both date commands while ksh does only the first.

Consideration was given to rewriting set to simplify its confusing syntax. A specific suggestion was that the unset utility should be used to unset options instead of using the non-getopt-able +option syntax. However, the conclusion was reached that the historical practice of using +option was satisfactory and that there was no compelling reason to modify such widespread historical practice.

The -o option was adopted from the KornShell to address user needs. In addition to its generally friendly interface, -o is needed to provide the vi command line editing mode, for which historical practice yields no single-letter option name. (Although it might have been possible to invent such a letter, it was recognized that other editing modes would be developed and -o provides ample name space for describing such extensions.)

Historical implementations are inconsistent in the format used for -o option status reporting. The +o format without an option-argument was added to allow portable access to the options that can be saved and then later restored using, for instance, a dot script.

Historically, sh did trace the command set +x, but ksh did not.

The ignoreeof setting prevents accidental logouts when the end-of-file character (typically <control>-D) is entered. A user shall explicitly exit to leave the interactive shell.

The set -m option was added to apply only to the UPE because it applies primarily to interactive use, not shell script applications.
The ability to do asynchronous notification became available in the 1988 version of the KornShell. To have it occur, the user had to issue the command:

```bash
trap "jobs -n" CLD
```

The C shell provides two different levels of an asynchronous notification capability. The environment variable `notify` is analogous to what is done in `set -b` or `set -o notify`. When set, it notifies the user immediately of background job completions. When unset, this capability is turned off.

The other notification ability comes through the built-in utility `notify`. The syntax is:

```bash
notify [%job ... ]
```

By issuing `notify` with no operands, it causes the C shell to notify the user asynchronously when the state of the current job changes. If given operands, `notify` asynchronously informs the user of changes in the states of the specified jobs.

To add asynchronous notification to the POSIX shell, neither the KornShell extensions to `trap`, nor the C shell `notify` environment variable seemed appropriate (`notify` is not a proper POSIX environment variable name).

The `set -b` option was selected as a compromise.

The `notify` built-in was considered to have more functionality than was required for simple asynchronous notification.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Section 2.14 (on page 64)

**CHANGE HISTORY**

**Issue 6**

The obsolescent `set` command name followed by `'-t'` has been removed.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The `nolog` option is added to `set -o`.

IEEE PASC Interpretation 1003.2 #167 is applied, clarifying that the options default also takes into account the description of the option.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/8 is applied, changing the square brackets in the example in RATIONALE to be in bold, which is the typeface used for optional items.
NAME
shift — shift positional parameters

SYNOPSIS
shift [n]

DESCRIPTION
The positional parameters shall be shifted. Positional parameter 1 shall be assigned the value of parameter (1+n), parameter 2 shall be assigned the value of parameter (2+n), and so on. The parameters represented by the numbers "$#" down to "$#−n+1" shall be unset, and the parameter '"#' is updated to reflect the new number of positional parameters.

The value n shall be an unsigned decimal integer less than or equal to the value of the special parameter '"#' . If n is not given, it shall be assumed to be 1. If n is 0, the positional and special parameters are not changed.

OPTIONS
None.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The exit status is >0 if n>#$; otherwise, it is zero.

CONSEQUENCES OF ERRORS
Default.
APPLICATION USAGE

None.

EXAMPLES

$ set a b c d e
$ shift 2
$ echo $*
  c  d  e

RATIONALE

None.

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.14 (on page 64)

CHANGE HISTORY

Issue 6

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
NAME

times — write process times

SYNOPSIS

times

DESCRIPTION

The *times* utility shall write the accumulated user and system times for the shell and for all of its child processes, in the following POSIX locale format:

"%dm%fs %dm%fs %dm%fs %dm%fs
%dm%fs %dm%fs %dm%fs %dm%fs
%dm%fs %dm%fs %dm%fs %dm%fs\n", <shell user minutes>,
<shell user seconds>, <shell system minutes>,
<shell system seconds>, <children user minutes>,
<children user seconds>, <children system minutes>,
<children system seconds>

The four pairs of times shall correspond to the members of the `<sys/times.h>` *tms* structure (defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 13, Headers) as returned by *times()*: *tms_utime*, *tms_stime*, *tms_cutime*, and *tms_cstime*, respectively.

OPTIONS

None.

OPERANDS

None.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

None.

ASYNCHRONOUS EVENTS

Default.

STDOUT

See the DESCRIPTION.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

Zero.

CONSEQUENCES OF ERRORS

Default.
APPLICATION USAGE

None.

EXAMPLES

$ times
0m0.43s 0m1.11s
8m44.18s 1m43.23s

RATIONALE

The `times` special built-in from the Single UNIX Specification is now required for all conforming shells.

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.14 (on page 64)

CHANGE HISTORY

Issue 6

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/9 is applied, changing text in the DESCRIPTION from: “Write the accumulated user and system times for the shell and for all of its child processes ...” to: “The `times` utility shall write the accumulated user and system times for the shell and for all of its child processes ...”.
NAME

trap — trap signals

SYNOPSIS

trap [action condition ...]

DESCRIPTION

If action is ‘−’, the shell shall reset each condition to the default value. If action is null (""), the
shell shall ignore each specified condition if it arises. Otherwise, the argument action shall be read
and executed by the shell when one of the corresponding conditions arises. The action of trap
shall override a previous action (either default action or one explicitly set). The value of "$?"
after the trap action completes shall be the value it had before trap was invoked.

The condition can be EXIT, 0 (equivalent to EXIT), or a signal specified using a symbolic name,
without the SIG prefix, as listed in the tables of signal names in the <signal.h> header defined in
the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 13, Headers; for example, HUP,
INT, QUIT, TERM. Implementations may permit names with the SIG prefix or ignore case in
signal names as an extension. Setting a trap for SIGKILL or SIGSTOP produces undefined
results.

The environment in which the shell executes a trap on EXIT shall be identical to the environment
immediately after the last command executed before the trap on EXIT was taken.

Each time trap is invoked, the action argument shall be processed in a manner equivalent to:

eval action

Signals that were ignored on entry to a non-interactive shell cannot be trapped or reset, although
no error need be reported when attempting to do so. An interactive shell may reset or catch
signals ignored on entry. Traps shall remain in place for a given shell until explicitly changed
with another trap command.

When a subshell is entered, traps that are not being ignored are set to the default actions. This
does not imply that the trap command cannot be used within the subshell to set new traps.

The trap command with no arguments shall write to standard output a list of commands
associated with each condition. The format shall be:

"trap -- %s $s ...\n", <action>, <condition> ...

The shell shall format the output, including the proper use of quoting, so that it is suitable for
reinput to the shell as commands that achieve the same trapping results. For example:

save_traps=$(trap)
...
eval "$save_traps"

XSI-conformant systems also allow numeric signal numbers for the conditions corresponding to
the following signal names:

| 1  | SIGHUP     |
| 2  | SIGINT     |
| 3  | SIGQUIT    |
| 6  | SIGABRT    |
| 9  | SIGKILL    |
| 14 | SIGALRM    |

OPTIONS

None.

OPERANDS

See the DESCRIPTION.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

None.

ASYNCHRONOUS EVENTS

Default.

STDOUT

See the DESCRIPTION.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

XSI If the trap name or number is invalid, a non-zero exit status shall be returned; otherwise, zero shall be returned. For both interactive and non-interactive shells, invalid signal names or numbers shall not be considered a syntax error and do not cause the shell to abort.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

None.

EXAMPLES

Write out a list of all traps and actions:

```
trap
```

Set a trap so the `logout` utility in the directory referred to by the `HOME` environment variable executes when the shell terminates:

```
trap ‘$HOME/logout’ EXIT
```

or:

```
trap ‘$HOME/logout’ 0
```

Unset traps on INT, QUIT, TERM, and EXIT:
trap

- INT QUIT TERM EXIT

RATIONALE
Implementations may permit lowercase signal names as an extension. Implementations may
also accept the names with the SIG prefix; no known historical shell does so. The trap and kill
utilities in this volume of IEEE Std 1003.1-2001 are now consistent in their omission of the SIG
prefix for signal names. Some kill implementations do not allow the prefix, and kill –l lists the
signals without prefixes.

Trapping SICKILL or SIGSTOP is syntactically accepted by some historical implementations, but
it has no effect. Portable POSIX applications cannot attempt to trap these signals.

The output format is not historical practice. Since the output of historical trap commands is not
portable (because numeric signal values are not portable) and had to change to become so, an
opportunity was taken to format the output in a way that a shell script could use to save and
then later reuse a trap if it wanted.

The KornShell uses an ERR trap that is triggered whenever set –e would cause an exit. This is
allowable as an extension, but was not mandated, as other shells have not used it.

The text about the environment for the EXIT trap invalidates the behavior of some historical
versions of interactive shells which, for example, close the standard input before executing a
trap on 0. For example, in some historical interactive shell sessions the following trap on 0 would
always print "--":

```
trap 'read foo; echo "--\$foo--"' 0
```

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.14 (on page 64)

CHANGE HISTORY

Issue 6
XSI-conforming implementations provide the mapping of signal names to numbers given above
(previously this had been marked obsolescent). Other implementations need not provide this
optional mapping.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page
sections use terms as described in the Utility Description Defaults (Section 1.11). No change in
behavior is intended.
NAME
unset — unset values and attributes of variables and functions

SYNOPSIS
unset [−fv] name ...

DESCRIPTION
Each variable or function specified by name shall be unset.
If −v is specified, name refers to a variable name and the shell shall unset it and remove it from
the environment. Read-only variables cannot be unset.
If −f is specified, name refers to a function and the shell shall unset the function definition.
If neither −f nor −v is specified, name refers to a variable; if a variable by that name does not
exist, it is unspecified whether a function by that name, if any, shall be unset.
Unsetting a variable or function that was not previously set shall not be considered an error and
does not cause the shell to abort.
The unset special built-in shall support the Base Definitions volume of IEEE Std 1003.1-2001,
Section 12.2, Utility Syntax Guidelines.
Note that:
VARIABLE=
is not equivalent to an unset of VARIABLE; in the example, VARIABLE is set to " ". Also, the
variables that can be unset should not be misinterpreted to include the special parameters (see
Section 2.5.2 (on page 34)).

OPTIONS
See the DESCRIPTION.

OPERANDS
See the DESCRIPTION.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.
EXIT STATUS
0  All name operands were successfully unset.
>0  At least one name could not be unset.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
Unset VISUAL variable:
unset -v VISUAL
Unset the functions foo and bar:
unset -f foo bar

RATIONALE
Consideration was given to omitting the -f option in favor of an unfunction utility, but the standard developers decided to retain historical practice.
The -v option was introduced because System V historically used one name space for both variables and functions. When unset is used without options, System V historically unset either a function or a variable, and there was no confusion about which one was intended. A portable POSIX application can use unset without an option to unset a variable, but not a function; the -f option must be used.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.14 (on page 64)

CHANGE HISTORY
Issue 6
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/5 is applied so that the reference page sections use terms as described in the Utility Description Defaults (Section 1.11). No change in behavior is intended.
This chapter describes the services and utilities that shall be implemented on all systems that claim conformance to the Batch Environment Services and Utilities option. This functionality is dependent on support of this option (and the rest of this section is not further shaded for this option).

3.1 General Concepts

3.1.1 Batch Client-Server Interaction

Batch jobs are created and managed by batch servers. A batch client interacts with a batch server to access batch services on behalf of the user. In order to use batch services, a user must have access to a batch client.

A batch server is a computational entity, such as a daemon process, that provides batch services. Batch servers route, queue, modify, and execute batch jobs on behalf of batch clients.

The batch utilities described in this volume of IEEE Std 1003.1-2001 (and listed in Table 3-1) are clients of batch services; they allow users to perform actions on the job such as creating, modifying, and deleting batch jobs from a shell command line. Although these batch utilities may be said to accomplish certain services, they actually obtain services on behalf of a user by means of requests to batch servers.

Table 3-1 Batch Utilities

| qalter | qmove | qrls | qstat |
| qdel   | qmsg  | qselect | qsub |
| qhold  | qrerun | qsig   |

Client-server interaction takes place by means of the batch requests defined in this chapter. Because direct access to batch jobs and queues is limited to batch servers, clients and servers of different implementations can interoperate, since dependencies on private structures for batch jobs and queues are limited to batch servers. Also, batch servers may be clients of other batch servers.

3.1.2 Batch Queues

Two types of batch queue are described: routing queues and execution queues. When a batch job is placed in a routing queue, it is a candidate for routing. A batch job is removed from routing queues under the following conditions:

- The batch job has been routed to another queue.
- The batch job has been deleted from the batch queue.
- The batch job has been aborted.

When a batch job is placed in an execution queue, it is a candidate for execution.

A batch job is removed from an execution queue under the following conditions:
• The batch job has been executed and exited.
• The batch job has been aborted.
• The batch job has been deleted from the batch queue.
• The batch job has been moved to another queue.

Access to a batch queue is limited to the batch server that manages the batch queue. Clients never access a batch queue or a batch job directly, either to read or write information; all client access to batch queues or jobs takes place through batch servers.

### 3.1.3 Batch Job Creation

When a batch server creates a batch job on behalf of a client, it shall assign a batch job identifier to the job. A batch job identifier consists of both a sequence number that is unique among the sequence numbers issued by that server and the name of the server. Since the batch server name is unique within a name space, the job identifier is likewise unique within the name space.

The batch server that creates a batch job shall return the batch server-assigned job identifier to the client that requested the job creation. If the batch server routes or moves the job to another server, it sends the job identifier with the job. Once assigned, the job identifier of a batch job shall never change.

### 3.1.4 Batch Job Tracking

Since a batch job may be moved after creation, the batch server name component of the job identifier need not indicate the location of the job. An implementation may provide a batch job tracking mechanism, in which case the user generally does not need to know the location of the job. However, an implementation need not provide a batch job tracking mechanism, in which case the user must find routed jobs by probing the possible destinations.

### 3.1.5 Batch Job Routing

To route a batch job, a batch server either moves the job to some other queue that is managed by the batch server, or requests that some other batch server accept the job.

Each routing queue has one or more queues to which it can route batch jobs. The batch server administrator creates routing queues.

A batch server may route a batch job from a routing queue to another routing queue. Batch servers shall prevent or otherwise handle cases of circular routing paths. As a deferred service, a batch server routes jobs from the routing queues that it manages. The algorithm by which a batch server selects a batch queue to which to route a batch job is implementation-defined.

A batch job need not be eligible for routing to all the batch queues fed by the routing queue from which it is routed. A batch server that has been asked to accept the job may reject the request if the job requires resources that are unavailable to that batch server, or if the client is not authorized to access the batch server.

Batch servers may route high-priority jobs before low-priority jobs, but, on other than overloaded systems, the effect may be imperceptible to the user. If all the batch servers fed by a routing queue reject requests to accept the job for reasons that are permanent, the batch server that manages the job shall abort the job. If all or some rejections are temporary, the batch server should try to route the job again at some later point.

The reasons for rejecting a batch job are implementation-defined.
The reasons for which the routing should be retried later and the reasons for which the job should be aborted are also implementation-defined.

3.1.6 Batch Job Execution

To execute a batch job is to create a session leader (a process) that runs the shell program indicated by the Shell_Path attribute of the job. The script shall be passed to the program as its standard input. An implementation may pass the script to the program by other implementation-defined means. At the time a batch job begins execution, it is defined to enter the RUNNING state. The primary program that is executed by a batch job is typically, though not necessarily, a shell program.

A batch server shall execute eligible jobs as a deferred service—no client request is necessary once the batch job is created and eligible. However, the attributes of a batch job, such as the job hold type, may render the job ineligible. A batch server shall scan the execution queues that it manages for jobs that are eligible for execution. The algorithm by which the batch server selects eligible jobs for execution is implementation-defined.

As part of creating the process for the batch job, the batch server shall open the standard output and standard error streams of the session.

The attributes of a batch job may indicate that the batch server executing the job shall send mail to a list of users at the time it begins execution of the job.

3.1.7 Batch Job Exit

When the session leader of an executing job terminates, the job exits. As part of exiting a batch job, the batch server that manages the job shall remove the job from the batch queue in which it resides. The server shall transfer output files of the job to a location described by the attributes of the job.

The attributes of a batch job may indicate that the batch server managing the job shall send mail to a list of users at the time the job exits.

3.1.8 Batch Job Abort

A batch server shall abort jobs for which a required deferred service cannot be performed. The attributes of a batch job may indicate that the batch server that aborts the job shall send mail to a list of users at the time it aborts the job.

3.1.9 Batch Authorization

Clients, such as the batch environment utilities (marked BE), access batch services by means of requests to one or more batch servers. To acquire the services of any given batch server, the user identifier under which the client runs must be authorized to use that batch server.

The user with an associated user name that creates a batch job shall own the job and can perform actions such as read, modify, delete, and move.

A user identifier of the same value at a different host need not be the same user. For example, user name smith at host alpha may or may not represent the same person as user name smith at host beta. Likewise, the same person may have access to different user names on different hosts.

An implementation may optionally provide an authorization mechanism that permits one user name to access jobs under another user name.

A process on a client host may be authorized to run processes under multiple user names at a batch server host. Where appropriate, the utilities defined in this volume of IEEE Std 1003.1-2001
provide a means for a user to choose from among such user names when creating or modifying a batch job.

3.1.10 **Batch Administration**

The processing of a batch job by a batch server is affected by the attributes of the job. The processing of a batch job may also be affected by the attributes of the batch queue in which the job resides and by the status of the batch server that manages the job. See also the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 3, Definitions for batch definitions.

3.1.11 **Batch Notification**

Whereas batch servers are persistent entities, clients are often transient. For example, the `qsub` utility creates a batch job and exits. For this reason, batch servers notify users of batch job events by sending mail to the user that owns the job, or to other designated users.

3.2 **Batch Services**

The presence of Batch Environment Services and Utilities option services is indicated by the configuration variable POSIX2_PBS. A conforming batch server provides services as defined in this section.

A batch server shall provide batch services in two ways:

1. The batch server provides a service at the request of a client.
2. The batch server provides a deferred service as a result of a change in conditions monitored by the batch server.

If a batch server cannot complete a request, it shall reject the request. If a batch server cannot complete a deferred service for a batch job, the batch server shall abort the batch job. Table 3-2 (on page 105) is a summary of environment variables that shall be supported by an implementation of the batch server and utilities.
### Table 3-2 Environment Variable Summary

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBS_DPREFIX</td>
<td>Defines the directive prefix (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_ENVIRONMENT</td>
<td>Batch Job is batch or interactive (see Section 3.2.2.1)</td>
</tr>
<tr>
<td>PBS_JOBNAMES</td>
<td>The <code>job_identifier</code> attribute of job (see Section 3.2.3.8)</td>
</tr>
<tr>
<td>PBS_JOBNAME</td>
<td>The <code>job_name</code> attribute of job (see Section 3.2.3.8)</td>
</tr>
<tr>
<td>PBS_O_HOME</td>
<td>Defines the <code>HOME</code> of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_HOST</td>
<td>Defines the host name of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_LOGNAME</td>
<td>Defines the <code>LOGNAME</code> of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_MAIL</td>
<td>Defines the <code>MAIL</code> of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_PATH</td>
<td>Defines the <code>PATH</code> of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_QUEUE</td>
<td>Defines the submit queue of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_SHELL</td>
<td>Defines the <code>SHELL</code> of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_TZ</td>
<td>Defines the <code>TZ</code> of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_O_WORKDIR</td>
<td>Defines the working directory of the batch client (see <code>qsub</code>)</td>
</tr>
<tr>
<td>PBS_QUEUE</td>
<td>Defines the initial execution queue (see Section 3.2.2.1)</td>
</tr>
</tbody>
</table>

### 3.2.1 Batch Job States

A batch job shall always be in one of the following states: QUEUED, RUNNING, HELD, WAITING, EXITING, or TRANSITING. The state of a batch job determines the types of requests that the batch server that manages the batch job can accept for the batch job. A batch server shall change the state of a batch job either in response to service requests from clients or as a result of deferred services, such as job execution or job routing.

A batch job that is in the QUEUED state resides in a queue but is still pending either execution or routing, depending on the queue type.

A batch server that queues a batch job in a routing queue shall put the batch job in the QUEUED state. A batch server that puts a batch job in an execution queue, but has not yet executed the batch job, shall put the batch job in the QUEUED state. A batch job that resides in an execution queue and is executing is defined to be in the RUNNING state. While a batch job is in the RUNNING state, a session leader is associated with the batch job.

A batch job that resides in an execution queue, but is ineligible to run because of a hold attribute, is defined to be in the HELD state.

A batch job that is not held, but must wait until a future date and time before executing, is defined to be in the WAITING state.

When the session leader associated with a running job exits, the batch job shall be placed in the EXITING state.

A batch job for which the session leader has terminated is defined to be in the EXITING state, and the batch server that manages such a batch job cannot accept job modification requests that affect the batch job. While a batch job is in the EXITING state, the batch server that manages the batch job is staging output files and notifying clients of job completion. Once a batch job has exited, it no longer exists as an object managed by a batch server.

A batch job that is being moved from a routing queue to another queue is defined to be in the TRANSITING state.
When a batch job in a routing queue has been selected to be moved to a new destination, then the batch job shall be in either the QUEUED state or the TRANSITING state, depending on the batch server implementation.

Batch jobs with either an Execution_Time attribute value set in the future or a Hold_Types attribute of value not equal to NO_HOLD, or both, may be routed or held in the routing queue. The treatment of jobs with the Execution_Time or Hold_Types attributes in a routing queue is implementation-defined.

When a batch job in a routing queue has not been selected to be moved to a new destination and the batch job has a Hold_Types attribute value of other than NO_HOLD, then the job should be in the HELD state.

Note: The effect of a hold upon a batch job in a routing queue is implementation-defined. The implementation should use the state that matches whether the batch job can route with a hold or not.

When a batch job in a routing queue has not been selected to be moved to a new destination and the batch job has:

- A Hold_Types attribute value of NO_HOLD
- An Execution_Time attribute in the past

then the batch job shall be in the QUEUED state.

When a batch job in a routing queue has not been selected to be moved to a new destination and the batch job has:

- A Hold_Types attribute value of NO_HOLD
- An Execution_Time attribute in the future

then the batch job may be in the WAITING state.

Note: The effect of a future execution time upon a batch job in a routing queue is implementation-defined. The implementation should use the state that matches whether the batch job can route with a hold or not.

Table 3-3 (on page 107) describes the next state of a batch job, given the current state of the batch job and the type of request. Table 3-4 (on page 108) describes the response of a batch server to a request, given the current state of the batch job and the type of request.

### 3.2.2 Deferred Batch Services

This section describes the deferred services performed by batch servers: job execution, job routing, job exit, job abort, and the rerunning of jobs after a restart.

#### 3.2.2.1 Batch Job Execution

To execute a batch job is to create a session leader (a process) that runs the shell program indicated by the Shell_Path_List attribute of the batch job. The script is passed to the program as its standard input. An implementation may pass the script to the program by other implementation-defined means. At the time a batch job begins execution, it is defined to enter the RUNNING state.
A batch server that executes a batch job shall create, in the environment of the session leader of the batch job, an environment variable named `PBS_ENVIRONMENT`, the value of which is the string `PBS_BATCH` encoded in the portable character set.

A batch server that executes a batch job shall create, in the environment of the session leader of the batch job, an environment variable named `PBS_QUEUE`, the value of which is the name of the execution queue of the batch job encoded in the portable character set.

To rerun a batch job is to requeue a batch job that is currently executing and then kill the session leader of the executing job by sending a SIGKILL prior to completion; see Section 3.2.3.11 (on page 120). A batch server that reruns a batch job shall append the standard output and standard error files of the batch job to the corresponding files of the previous execution, if they exist, with appropriate annotation. If either file does not exist, that file shall be created as in normal execution.

---

**Table 3-3  Next State Table**

<table>
<thead>
<tr>
<th>Request Type</th>
<th>Current State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queue Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Modify Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Delete Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Batch Job Message Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Rerun Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Signal Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Job Status Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Batch Queue Status Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Server Status Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Select Batch Jobs Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Move Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Hold Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Release Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Server Shutdown Request</td>
<td>X Q R H W E T</td>
</tr>
<tr>
<td>Locate Batch Job Request</td>
<td>X Q R H W E T</td>
</tr>
</tbody>
</table>

**Legend**

- **X**: Nonexistent
- **Q**: QUEUED
- **R**: RUNNING
- **H**: HELD
- **W**: WAITING
- **E**: EXITING
- **T**: TRANSITING
- **e**: Error
Batch checkpointing is an optional feature of batch servers. If a batch server implements checkpointing, the statements in this section apply and the configuration variable POSIX2_PBS_CHECKPOINT shall be set to 1.

A batch server that executes a batch job shall charge the account named in the Account_Name attribute of the batch job for resources consumed by the batch job.

If the Account_Name attribute of the batch job is absent from the batch job attribute list or is altered while the batch job is in execution, the batch server action is implementation-defined.

Checkpoint Attribute

Batch checkpointing is an optional feature of batch servers. If a batch server implements checkpointing, the statements in this section apply and the configuration variable POSIX2_PBS_CHECKPOINT shall be set to 1.

There are two attributes associated with the checkpointing feature: Checkpoint and Minimum_Cpu_Interval. Checkpoint is a batch job attribute, while Minimum_Cpu_Interval is a queue attribute. An implementation that does not support checkpointing shall support the Checkpoint job attribute to the extent that the batch server shall maintain and pass this attribute to other servers.

The behavior of a batch server that executes a batch job for which the value of the Checkpoint attribute is CHECKPOINT_UNSPECIFIED is implementation-defined. A batch server that executes a batch job for which the value of the Checkpoint attribute is NO_CHECKPOINT shall
not checkpoint the batch job.

A batch server that executes a batch job for which the value of the `Checkpoint` attribute is `CHECKPOINT_AT_SHUTDOWN` shall checkpoint the batch job only when the batch server accepts a request to shut down during the time when the batch job is in the RUNNING state.

A batch server that executes a batch job for which the value of the `Checkpoint` attribute is `CHECKPOINT_AT_MIN_CPU_INTERVAL` shall checkpoint the batch job at the interval specified by the `Minimum_Cpu_Interval` attribute of the queue for which the batch job has been selected. The `Minimum_Cpu_Interval` attribute shall be specified in units of CPU minutes.

A batch server that executes a batch job for which the value of the `Checkpoint` attribute is an unsigned integer shall checkpoint the batch job at an interval that is the value of either the `Checkpoint` attribute, or the `Minimum_Cpu_Interval` attribute of the queue for which the batch job has been selected, whichever is greater. Both intervals shall be in units of CPU minutes. When the `Minimum_Cpu_Interval` attribute is greater than the `Checkpoint` attribute, the batch job shall write a warning message to the standard error stream of the batch job.

**Error_Path Attribute**

The `Error_Path` attribute of a running job cannot be changed by a `Modify Batch Job Request`. When the `Join_Path` attribute of the batch job is set to the value FALSE and the `Keep_Files` attribute of the batch job does not contain the value `KEEP_STD_ERROR`, a batch server that executes a batch job shall perform one of the following actions:

- Set the standard error stream of the session leader of the batch job to the path described by the value of the `Error_Path` attribute of the batch job.
- Buffer the standard error of the session leader of the batch job until completion of the batch job, and when the batch job exits return the contents to the destination described by the value of the `Error_Path` attribute of the batch job.

Applications shall not rely on having access to the standard error of a batch job prior to the completion of the batch job.

When the `Error_Path` attribute does not specify a host name, then the batch server shall retain the standard error of the batch job on the host of execution.

When the `Error_Path` attribute does specify a host name and the `Keep_Files` attribute does not contain the value `KEEP_STD_ERROR`, then the final destination of the standard error of the batch job shall be on the host whose host name is specified.

If the path indicated by the value of the `Error_Path` attribute of the batch job is a relative path, the batch server shall expand the path relative to the home directory of the user on the host to which the file is being returned.

When the batch server buffers the standard error of the batch job and the file cannot be opened for write upon completion of the batch job, then the server shall place the standard error in an implementation-defined location and notify the user of the location via mail. It shall be possible for the user to process this mail using the `mailx` utility.

If a batch server that does not buffer the standard error cannot open the standard error path of the batch job for write access, then the batch server shall abort the batch job.
**Execution_Time Attribute**

A batch server shall not execute a batch job before the time represented by the value of the `Execution_Time` attribute of the batch job. The `Execution_Time` attribute is defined in seconds since the Epoch.

**Hold_Types Attribute**

A batch server shall support the following hold types:

- `s` Can be set or released by a user with at least a privilege level of batch administrator (SYSTEM).
- `o` Can be set or released by a user with at least a privilege level of batch operator (OPERATOR).
- `u` Can be set or released by the user with at least a privilege level of user, where the user is defined in the `Job_Owner` attribute (USER).
- `n` Indicates that none of the `Hold_Types` attributes are set (NO_HOLD).

An implementation may define other hold types. Any additional hold types, how they are specified, their internal representation, their behavior, and how they affect the behavior of other utilities are implementation-defined.

The value of the `Hold_Types` attribute shall be the union of the valid hold types (`'s'`, `'o'`, `'u'`, and any implementation-defined hold types), or `'n'`.

A batch server shall not execute a batch job if the `Hold_Types` attribute of the batch job has a value other than NO_HOLD. If the `Hold_Types` attribute of the batch job has a value other than NO_HOLD, the batch job shall be in the HELD state.

**Job_Owner Attribute**

The `Job_Owner` attribute consists of a pair of user name and host name values of the form:

```
username@hostname
```

A batch server that accepts a `Queue Batch Job Request` shall set the `Job_Owner` attribute to a string that is the `username@hostname` of the user who submitted the job.

**Join_Path Attribute**

A batch server that executes a batch job for which the value of the `Join_Path` attribute is TRUE shall ignore the value of the `Error_Path` attribute and merge the standard error of the batch job with the standard output of the batch job.

**Keep_Files Attribute**

A batch server that executes a batch job for which the value of the `Keep_Files` attribute includes the value `KEEP_STD_OUTPUT` shall retain the standard output of the batch job on the host where execution occurs. The standard output shall be retained in the home directory of the user under whose user ID the batch job is executed and the filename shall be the default filename for the standard output as defined under the `−o` option of the `qsub` utility. The `Output_Path` attribute is not modified.

A batch server that executes a batch job for which the value of the `Keep_Files` attribute includes the value `KEEP_STD_ERROR` shall retain the standard error of the batch job on the host where execution occurs. The standard error shall be retained in the home directory of the user under whose user ID the batch job is executed and the filename shall be the default filename for
standard error as defined under the \(-e\) option of the \texttt{qsub} utility. The \textit{Error\_Path} attribute is not modified.

A batch server that executes a batch job for which the value of the \textit{Keep\_Files} attribute includes values other than \texttt{KEEP\_STD\_OUTPUT} and \texttt{KEEP\_STD\_ERROR} shall retain these other files on the host where execution occurs. These files (with implementation-defined names) shall be retained in the home directory of the user under whose user identifier the batch job is executed.

\textbf{Mail\_Points and Mail\_Users Attributes}

A batch server that executes a batch job for which one of the values of the \textit{Mail\_Points} attribute is the value \texttt{MAIL\_AT\_BEGINNING} shall send a mail message to each user account listed in the \textit{Mail\_Users} attribute of the batch job.

The mail message shall contain at least the batch job identifier, queue, and server at which the batch job currently resides, and the \textit{Job\_Owner} attribute.

\textbf{Output\_Path Attribute}

The \textit{Output\_Path} attribute of a running job cannot be changed by a \textit{Modify Batch Job Request}. When the \textit{Keep\_Files} attribute of the batch job does not contain the value \texttt{KEEP\_STD\_OUTPUT}, a batch server that executes a batch job shall either:

- Set the standard output stream of the session leader of the batch job to the destination described by the value of the \textit{Output\_Path} attribute of the batch job.

  or:

- Buffer the standard output of the session leader of the batch job until completion of the batch job, and when the batch job exits return the contents to the destination described by the value of the \textit{Output\_Path} attribute of the batch job.

When the \textit{Output\_Path} attribute does not specify a host name, then the batch server shall retain the standard output of the batch job on the host of execution.

When the \textit{Keep\_Files} attribute does not contain the value \texttt{KEEP\_STD\_OUTPUT} and the \textit{Output\_Path} attribute does specify a host name, then the final destination of the standard output of the batch job shall be on the host specified.

If the path specified in the \textit{Output\_Path} attribute of the batch job is a relative path, the batch server shall expand the path relative to the home directory of the user on the host to which the file is being returned.

Whether or not the batch server buffers the standard output of the batch job until completion of the batch job is implementation-defined. Applications shall not rely on having access to the standard output of a batch job prior to the completion of the batch job.

When the batch server does buffer the standard output of the batch job and the file cannot be opened for write upon completion of the batch job, then the batch server shall place the standard output in an implementation-defined location and notify the user of the location via mail. It shall be possible for the user to process this mail using the \texttt{mailx} utility.

If a batch server that does not buffer the standard output cannot open the standard output path of the batch job for write access, then the batch server shall abort the batch job.
Priority Attribute

A batch server implementation may choose to preferentially execute a batch job based on the Priority attribute. The interpretation of the batch job Priority attribute by a batch server is implementation-defined. If an implementation uses the Priority attribute, it shall interpret larger values of the Priority attribute to mean the batch job shall be preferentially selected for execution.

Rerunable Attribute

A batch job that began execution but did not complete, because the batch server either shut down or terminated abnormally, shall be requeued if the Rerunable attribute of the batch job has the value TRUE.

If a batch job, which was requeued after beginning execution but prior to completion, has a valid checkpoint file and the batch server supports checkpointing, then the batch job shall be restarted from the last valid checkpoint.

If the batch job cannot be restarted from a checkpoint, then when a batch job has a Rerunable attribute value of TRUE and was requeued after beginning execution but prior to completion, the batch server shall place the batch job into execution at the beginning of the job.

When a batch job has a Rerunable attribute value other than TRUE and was requeued after beginning execution but prior to completion, and the batch job cannot be restarted from a checkpoint, then the batch server shall abort the batch job.

Resource_List Attribute

A batch server that executes a batch job shall establish the resource limits of the session leader of the batch job according to the values of the Resource_List attribute of the batch job. Resource limits shall be enforced by an implementation-defined method.

Shell_Path_List Attribute

The Shell_Path_List job attribute consists of a list of pairs of pathname and host name values. The host name component can be omitted, in which case the pathname serves as the default pathname when a batch server cannot find the name of the host on which it is running in the list.

A batch server that executes a batch job shall select, from the value of the Shell_Path_List attribute of the batch job, a pathname where the shell to execute the batch job shall be found. The batch server shall select the pathname, in order of preference, according to the following methods:

- Select the pathname that contains the name of the host on which the batch server is running.
- Select the pathname for which the host name has been omitted.
- Select the pathname for the login shell of the user under which the batch job is to execute.

If the shell path value selected is an invalid pathname, the batch server shall abort the batch job.

If the value of the selected pathname from the Shell_Path_List attribute of the batch job represents a partial path, the batch server shall expand the path relative to a path that is implementation-defined.

The batch server that executes the batch job shall execute the program that was selected from the Shell_Path_List attribute of the batch job. The batch server shall pass the path to the script of the batch job as the first argument to the shell program.
**User_List Attribute**

The *User_List* job attribute consists of a list of pairs of user name and host name values. The host name component can be omitted, in which case the user name serves as a default when a batch server cannot find the name of the host on which it is running in the list.

A batch server that executes a batch job shall select, from the value of the *User_List* attribute of the batch job, a user name under which to create the session leader. The server shall select the user name, in order of preference, according to the following methods:

- Select the user name of a value that contains the name of the host on which the batch server executes.
- Select the user name of a value for which the host name has been omitted.
- Select the user name from the *Job_Owner* attribute of the batch job.

**Variable_List Attribute**

A batch server that executes a batch job shall create, in the environment of the session leader of the batch job, each environment variable listed in the *Variable_List* attribute of the batch job, and set the value of each such environment variable to that of the corresponding variable in the variable list.

### 3.2.2.2 Batch Job Routing

To route a batch job is to select a queue from a list and move the batch job to that queue.

A batch server that has routing queues, which have been started, shall route the jobs in the routing queues owned by the batch server. A batch server may delay the routing of a batch job. The algorithm for selecting a batch job and the queue to which it will be routed is implementation-defined.

When a routing queue has multiple possible destinations specified, then the precedence of the destinations is implementation-defined.

A batch server that routes a batch job to a queue at another server shall move the batch job into the target queue with a *Queue Batch Job Request*.

If the target server rejects the *Queue Batch Job Request*, the routing server shall retry routing the batch job or abort the batch job. A batch server that retries failed routings shall provide a means for the batch administrator to specify the number of retries and the minimum period of time between retries. The means by which an administrator specifies the number of retries and the delay between retries is implementation-defined. When the number of retries specified by the batch administrator has been exhausted, the batch server shall abort the batch job and perform the functions of *Batch Job Exit*; see Section 3.2.2.3.

### 3.2.2.3 Batch Job Exit

For each job in the EXITING state, the batch server that exited the batch job shall perform the following deferred services in the order specified:

1. If buffering standard error, move that file into the location specified by the *Error(Path* attribute of the batch job.
2. If buffering standard output, move that file into the location specified by the *Output(Path* attribute of the batch job.
3. If the *Mail_Points* attribute of the batch job includes MAIL_AT_EXIT, send mail to the users listed in the *Mail_Users* attribute of the batch job. The mail message shall contain at least
the batch job identifier, queue, and server at which the batch job currently resides, and the 
Job_Owner attribute.

4. Remove the batch job from the queue.

If a batch server that buffers the standard error output cannot return the standard error file to 
the standard error path at the time the batch job exits, the batch server shall do one of the 
following:

- Mail the standard error file to the batch job owner.
- Save the standard error file and mail the location and name of the file where the standard 
  error is stored to the batch job owner.
- Save the standard error file and notify the user by other implementation-defined means.

If a batch server that buffers the standard output cannot return the standard output file to the 
standard output path at the time the batch job exits, the batch server shall do one of the 
following:

- Mail the standard output file to the batch job owner.
- Save the standard output file and mail the location and name of the file where the standard 
  output is stored to the batch job owner.
- Save the standard output file and notify the user by other implementation-defined means.

At the conclusion of job exit processing, the batch job is no longer managed by a batch server.

3.2.2.4 Batch Server Restart

A batch server that has been either shutdown or terminated abnormally, and has returned to 
operation, is said to have “restarted”.

Upon restarting, a batch server shall requeue those jobs managed by the batch server that were 
in the RUNNING state at the time the batch server shut down and for which the Rerunable 
attribute of the batch job has the value TRUE.

Queues are defined to be non-volatile. A batch server shall store the content of queues that it 
controls in such a way that server and system shutdowns do not erase the content of the queues.

3.2.2.5 Batch Job Abort

A batch server that cannot perform a deferred service for a batch job shall abort the batch job.

A batch server that aborts a batch job shall perform the following services:

- Delete the batch job from the queue in which it resides.

- If the Mail_Points attribute of the batch job includes the value MAIL_AT_ABORT, send mail 
to the users listed in the value of the Mail_Users attribute of the job. The mail message shall 
contain at least the batch job identifier, queue, and server at which the batch job currently 
resides, the Job_Owner attribute, and the reason for the abort.

- If the batch job was in the RUNNING state, terminate the session leader of the executing job 
by sending the session leader a SIGKILL, place the batch job in the EXITING state, and 
perform the actions of Batch Job Exit.
3.2.3 Requested Batch Services

This section describes the services provided by batch servers in response to requests from clients. Table 3-5 summarizes the current set of batch service requests and for each gives its type (deferred or not) and whether it is an optional function.

<table>
<thead>
<tr>
<th>Batch Service</th>
<th>Deferred</th>
<th>Optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch Job Execution</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Batch Job Routing</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Batch Job Exit</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Batch Server Restart</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Batch Job Abort</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Delete Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hold Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Batch Job Message Request</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Batch Job Status Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Locate Batch Job Request</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Modify Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Move Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Queue Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Batch Queue Status Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Release Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Rerun Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Select Batch Jobs Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Server Shutdown Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Server Status Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Signal Batch Job Request</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Track Batch Job Request</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

If a request is rejected because the batch client is not authorized to perform the action, the batch server shall return the same status as when the batch job does not exist.

3.2.3.1 Delete Batch Job Request

A batch job is defined to have been deleted when it has been removed from the queue in which it resides and not instantiated in another queue. A client requests that the server that manages a batch job delete the batch job. Such a request is called a Delete Batch Job Request.

A batch server shall reject a Delete Batch Job Request if any of the following statements are true:

- The user of the batch client is not authorized to delete the designated job.
- The designated job is not managed by the batch server.
- The designated job is in a state inconsistent with the delete request.

A batch server may reject a Delete Batch Job Request for other implementation-defined reasons.

A batch server requested to delete a batch job shall delete the batch job if the batch job exists and is not in the EXITING state.

A batch server that deletes a batch job in the RUNNING state shall send a SIGKILL signal to the session leader of the batch job. It is implementation-defined whether additional signals are sent...
A batch server that deletes a batch job in the RUNNING state shall place the batch job in the EXITING state after it has killed the session leader of the batch job and shall perform the actions of Batch Job Exit.

### 3.2.3.2 Hold Batch Job Request

A batch client can request that the batch server add one or more holds to a batch job. Such a request is called a Hold Batch Job Request.

A batch server shall reject a Hold Batch Job Request if any of the following statements are true:

- The batch server does not support one or more of the requested holds to be added to the batch job.
- The user of the batch client is not authorized to add one or more of the requested holds to the batch job.
- The batch server does not manage the specified job.
- The designated job is in the EXITING state.

A batch server may reject a Hold Batch Job Request for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a Hold Batch Job Request for a batch job in the RUNNING state shall place a hold on the batch job. The effects, if any, the hold will have on a batch job in the RUNNING state are implementation-defined.

A batch server that accepts a Hold Batch Job Request shall add each type of hold listed in the Hold Batch Job Request, that is not already present, to the value of the Hold_Types attribute of the batch job.

### 3.2.3.3 Batch Job Message Request

Batch Job Message Request is an optional feature of batch servers. If an implementation supports Batch Job Message Request, the statements in this section apply and the configuration variable POSIX2_PBS_MESSAGE shall be set to 1.

A batch client can request that a batch server write a message into certain output files of a batch job. Such a request is called a Batch Job Message Request.

A batch server shall reject a Batch Job Message Request if any of the following statements are true:

- The batch server does not support sending messages to jobs.
- The user of the batch client is not authorized to post a message to the designated job.
- The designated job does not exist on the batch server.
- The designated job is not in the RUNNING state.

A batch server may reject a Batch Job Message Request for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a Batch Job Message Request shall write the message sent by the batch client into the files indicated by the batch client.
3.2.3.4 **Batch Job Status Request**

A batch client can request that a batch server respond with the status and attributes of a batch job. Such a request is called a *Batch Job Status Request*.

A batch server shall reject a *Batch Job Status Request* if any of the following statements are true:

- The user of the batch client is not authorized to query the status of the designated job.
- The designated job is not managed by the batch server.

A batch server may reject a *Batch Job Status Request* for other implementation-defined reasons.

The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a *Batch Job Status Request* shall return a *Batch Job Status Message* to the batch client.

A batch server may return other information in response to a *Batch Job Status Request*.

3.2.3.5 **Locate Batch Job Request**

*Locate Batch Job Request* is an optional feature of batch servers. If an implementation supports *Locate Batch Job Request*, the statements in this section apply and the configuration variable POSIX2_PBS_LOCATE shall be set to 1.

A batch client can ask a batch server to respond with the location of a batch job that was created by the batch server. Such a request is called a *Locate Batch Job Request*.

A batch server that accepts a *Locate Batch Job Request* shall return a *Batch Job Location Message* to the batch client.

A batch server may reject a *Locate Batch Job Request* for a batch job that was not created by that server.

A batch server may reject a *Locate Batch Job Request* for a batch job that is no longer managed by that server; that is, for a batch job that is not in a queue owned by that server.

A batch server may reject a *Locate Batch Job Request* for other implementation-defined reasons.

3.2.3.6 **Modify Batch Job Request**

Batch clients modify (alter) the attributes of a batch job by making a request to the server that manages the batch job. Such a request is called a *Modify Batch Job Request*.

A batch server shall reject a *Modify Batch Job Request* if any of the following statements are true:

- The user of the batch client is not authorized to make the requested modification to the batch job.
- The designated job is not managed by the batch server.
- The requested modification is inconsistent with the state of the batch job.
- An unrecognized resource is requested for a batch job in an execution queue.

A batch server may reject a *Modify Batch Job Request* for other implementation-defined reasons.

The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a *Modify Batch Job Request* shall modify all the specified attributes of the batch job. A batch server that rejects a *Modify Batch Job Request* shall modify none of the attributes of the batch job.
If the servicing by a batch server of an otherwise valid request would result in no change, then
the batch server shall indicate successful completion of the request.

3.2.3.7 Move Batch Job Request

A batch client can request that a batch server move a batch job to another destination. Such a
request is called a Move Batch Job Request.

A batch server shall reject a Move Batch Job Request if any of the following statements are true:

- The user of the batch client is not authorized to remove the designated job from the queue in
  which the batch job resides.
- The user of the batch client is not authorized to move the designated job to the destination.
- The designated job is not managed by the batch server.
- The designated job is in the EXITING state.
- The destination is inaccessible.

A batch server can reject a Move Batch Job Request for other implementation-defined reasons. The
method used to determine whether the user of a client is authorized to perform the requested
action is implementation-defined.

A batch server that accepts a Move Batch Job Request shall perform the following services:

- Queue the designated job at the destination.
- Remove the designated job from the queue in which the batch job resides.

If the destination resides on another batch server, the batch server shall queue the batch job at
the destination by sending a Queue Batch Job Request to the other server. If the Queue Batch Job
Request fails, the batch server shall reject the Move Batch Job Request. If the Queue Batch Job Request
succeeds, the batch server shall remove the batch job from its queue.

The batch server shall not modify any attributes of the batch job.

3.2.3.8 Queue Batch Job Request

A batch queue is controlled by one and only one batch server. A batch server is said to own the
queues that it controls. Batch clients make requests of batch servers to have jobs queued. Such a
request is called a Queue Batch Job Request.

A batch server requested to queue a batch job for which the queue is not specified shall select an
implementation-defined queue for the batch job. Such a queue is called the “default queue” of
the batch server. The implementation shall provide the means for a batch administrator to
specify the default queue. The queue, whether specified or defaulted, is called the “target
queue”.

A batch server shall reject a Queue Batch Job Request if any of the following statements are true:

- The client is not authorized to create a batch job in the target queue.
- The request specifies a queue that does not exist on the batch server.
- The target queue is an execution queue and the batch server cannot satisfy a resource
  requirement of the batch job.
- The target queue is an execution queue and an unrecognized resource is requested.
- The target queue is an execution queue, the batch server does not support checkpointing, and
  the value of the Checkpoint attribute of the batch job is not NO_CHECKPOINT.
• The job requires access to a user identifier that the batch client is not authorized to access.

A batch server may reject a Queue Batch Job Request for other implementation-defined reasons.

A batch server that accepts a Queue Batch Job Request for a batch job for which the PBS_O_QUEUE value is missing from the value of the Variable_List attribute of the batch job shall add that variable to the list and set the value to the name of the target queue. Once set, no server shall change the value of PBS_O_QUEUE, even if the batch job is moved to another queue.

A batch server that accepts a Queue Batch Job Request for a batch job for which the PBS_JOBID value is missing from the value of the Variable_List attribute shall add that variable to the list and set the value to the batch job identifier assigned by the server in the format:

sequence_number.server

A batch server that accepts a Queue Batch Job Request for a batch job for which the PBS_JOBNAME value is missing from the value of the Variable_List attribute of the batch job shall add that variable to the list and set the value to the Job_Name attribute of the batch job.

3.2.3.9 Batch Queue Status Request

A batch client can request that a batch server respond with the status and attributes of a queue. Such a request is called a Batch Queue Status Request.

A batch server shall reject a Batch Queue Status Request if any of the following statements are true:

• The user of the batch client is not authorized to query the status of the designated queue.
• The designated queue does not exist on the batch server.

A batch server may reject a Batch Queue Status Request for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a Batch Queue Status Request shall return a Batch Queue Status Reply to the batch client.

3.2.3.10 Release Batch Job Request

A batch client can request that the server remove one or more holds from a batch job. Such a request is called a Release Batch Job Request.

A batch server shall reject a Release Batch Job Request if any of the following statements are true:

• The user of the batch client is not authorized to remove one or more of the requested holds from the batch job.
• The batch server does not manage the specified job.

A batch server may reject a Release Batch Job Request for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a Release Batch Job Request shall remove each type of hold listed in the Release Batch Job Request, that is present, from the value of the Hold_Types attribute of the batch job.
3.2.3.11 Rerun Batch Job Request

To rerun a batch job is to kill the session leader of the batch job and leave the batch job eligible for re-execution. A batch client can request that a batch server rerun a batch job. Such a request is called Rerun Batch Job Request.

A batch server shall reject a Rerun Batch Job Request if any of the following statements are true:

- The user of the batch client is not authorized to rerun the designated job.
- The Rerunable attribute of the designated job has the value FALSE.
- The designated job is not in the RUNNING state.
- The batch server does not manage the designated job.

A batch server may reject a Rerun Batch Job Request for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that rejects a Rerun Batch Job Request shall in no way modify the execution of the batch job.

A batch server that accepts a request to rerun a batch job shall perform the following services:

- Requeue the batch job in the execution queue in which it was executing.
- Send a SIGKILL signal to the process group of the session leader of the batch job.

An implementation may indicate to the batch job owner that the batch job has been rerun. Whether and how the batch job owner is notified that a batch job is rerun is implementation-defined.

A batch server that reruns a batch job may send other implementation-defined signals to the session leader of the batch job prior to sending the SIGKILL signal.

A batch server may preferentially select a rerun job for execution. Whether rerun jobs shall be selected for execution before other jobs is implementation-defined.

3.2.3.12 Select Batch Jobs Request

A batch client can request from a batch server a list of jobs managed by that server that match a list of selection criteria. Such a request is called a Select Batch Jobs Request. All the batch jobs managed by the batch server that receives the request are candidates for selection.

A batch server that accepts a Select Batch Jobs Request shall return a list of zero or more job identifiers that correspond to jobs that meet the selection criteria.

If the batch client is not authorized to query the status of a batch job, the batch server shall not select the batch job.

3.2.3.13 Server Shutdown Request

A batch server is defined to have shut down when it does not respond to requests from clients and does not perform deferred services for jobs. A batch client can request that a batch server shut down. Such a request is called a Server Shutdown Request.

A batch server shall reject a Server Shutdown Request from a client that is not authorized to shut down the batch server. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.
A batch server may reject a *Server Shutdown Request* for other implementation-defined reasons. The reasons for which a *Server Shutdown Request* may be rejected are implementation-defined.

At server shutdown, a batch server shall do, in order of preference, one of the following:

- If checkpointing is implemented and the batch job is checkpointable, then checkpoint the batch job and requeue it.
- If the batch job is rerunnable, then requeue the batch job to be rerun (restarted from the beginning).
- Abort the batch job.

3.2.3.14 *Server Status Request*

A batch client can request that a batch server respond with the status and attributes of the batch server. Such a request is called a *Server Status Request*.

A batch server shall reject a *Server Status Request* if the following statement is true:

- The user of the batch client is not authorized to query the status of the designated server.

A batch server may reject a *Server Status Request* for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a *Server Status Request* shall return a *Server Status Reply* to the batch client.

3.2.3.15 *Signal Batch Job Request*

A batch client can request that a batch server signal the session leader of a batch job. Such a request is called a *Signal Batch Job Request*.

A batch server shall reject a *Signal Batch Job Request* if any of the following statements are true:

- The user of the batch client is not authorized to signal the batch job.
- The job is not in the RUNNING state.
- The batch server does not manage the designated job.
- The requested signal is not supported by the implementation.

A batch server may reject a *Signal Batch Job Request* for other implementation-defined reasons. The method used to determine whether the user of a client is authorized to perform the requested action is implementation-defined.

A batch server that accepts a request to signal a batch job shall send the signal requested by the batch client to the process group of the session leader of the batch job.

3.2.3.16 *Track Batch Job Request*

*Track Batch Job Request* is an optional feature of batch servers. If an implementation supports *Track Batch Job Request*, the statements in this section apply and the configuration variable POSIX2_PBS_TRACK shall be set to 1.

*Track Batch Job Request* provides a method for tracking the current location of a batch job. Clients may use the tracking information to determine the batch server that should receive a batch server request.
If Track Batch Job Request is supported by a batch server, then when the batch server queues a batch job as a result of a Queue Batch Job Request, and the batch server is not the batch server that created the batch job, the batch server shall send a Track Batch Job Request to the batch server that created the job.

If Track Batch Job Request is supported by a batch server, then the Track Batch Job Request may also be sent to other servers as a backup to the primary server. The method by which backup servers are specified is implementation-defined.

If Track Batch Job Request is supported by a batch server that receives a Track Batch Job Request, then the batch server shall record the current location of the batch job as contained in the request.

### 3.3 Common Behavior for Batch Environment Utilities

#### 3.3.1 Batch Job Identifier

A utility shall recognize job identifiers of the format:

```
[sequence_number] [.server_name] [@server]
```

where:

- **sequence_number** An integer that, when combined with server_name, provides a batch job identifier that is unique within the batch system.
- **server_name** The name of the batch server to which the batch job was originally submitted.
- **server** The name of the batch server that is currently managing the batch job.

If the application omits the batch server_name portion of a batch job identifier, a utility shall use the name of a default batch server.

If the application omits the batch server portion of a batch job identifier, a utility shall use:

- The batch server indicated by server_name, if present
- The name of the default batch server
- The name of the batch server that is currently managing the batch job

If only @server is specified, then the status of all jobs owned by the user on the requested server is listed.

The means by which a utility determines the default batch server is implementation-defined.

If the application presents the batch server portion of a batch job identifier to a utility, the utility shall send the request to the specified server.

A strictly conforming application shall use the syntax described for the job identifier. Whenever a batch job identifier is specified whose syntax is not recognized by an implementation, then a message for each error that occurs shall be written to standard error and the utility shall exit with an exit status greater than zero.

When a batch job identifier is supplied as an argument to a batch utility and the server_name portion of the batch job identifier is omitted, then the utility shall use the name of the default batch server.

When a batch job identifier is supplied as an argument to a batch utility and the batch server portion of the batch job identifier is omitted, then the utility shall use either:
• The name of the default batch server

or:

• The name of the batch server that is currently managing the batch job

When a batch job identifier is supplied as an argument to a batch utility and the batch server portion of the batch job identifier is specified, then the utility shall send the required Batch Server Request to the specified server.

### 3.3.2 Destination

The utility shall recognize a destination of the format:

```
[queue] [@server]
```

where:

- **queue**
  The name of a valid execution or routing queue at the batch server denoted by
  @server, defined as a string of up to 15 alphanumeric characters in the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set) where the first character is alphabetic.

- **server**
  The name of a batch server, defined as a string of alphanumeric characters in the portable character set.

If the application omits the batch server portion of a destination, then the utility shall use either:

• The name of the default batch server

  or:

• The name of the batch server that is currently managing the batch job

The means by which a utility determines the default batch server is implementation-defined.

If the application omits the queue portion of a destination, then the utility shall use the name of the default queue at the batch server chosen. The means by which a batch server determines its default queue is implementation-defined. If a destination is specified in the queue@server form, then the utility shall use the specified queue at the specified server.

A strictly conforming application shall use the syntax described for a destination. Whenever a destination is specified whose syntax is not recognized by an implementation, then a message shall be written to standard error and the utility shall exit with an exit status greater than zero.

### 3.3.3 Multiple Keyword-Value Pairs

For each option that can have multiple keyword-value pair arguments, the following rules shall apply. Examples of options that can have list-oriented option-arguments are `-u value@keyword` and `-l keyword=value`.

1. If a batch utility is presented with a list-oriented option-argument for which a keyword has a corresponding value that begins with a single or double quote, then the utility shall stop interpreting the input stream for delimiters until a second single or double quote, respectively, is encountered. This feature allows some flexibility for a comma (`,`) or equals sign (`=`) to be part of the value string for a particular keyword; for example:

   ```
   keywd1="val1,val2", keywd2="val3,val4"
   ```

   **Note:** This may require the user to escape the quotes as in the following command:
2. If a batch server is presented with a list-oriented attribute that has a keyword that was encountered earlier in the list, then the later entry for that keyword shall replace the earlier entry.

3. If a batch server is presented with a list-oriented attribute that has a keyword without any corresponding value of the form keyword= or @keyword and the same keyword was encountered earlier in the list, then the prior entry for that keyword shall be ignored by the batch server.

4. If a batch utility is expecting a list-oriented option-argument entry of the form keyword=value, but is presented with an entry of the form keyword without any corresponding value, then the entry shall be treated as though a default value of NULL was assigned (that is, keyword=NULL) for entry parsing purposes. The utility shall include only the keyword, not the NULL value, in the associated job attribute.

5. If a batch utility is expecting a list-oriented option-argument entry of the form value@keyword, but is presented with an entry of the form value without any corresponding keyword, then the entry shall be treated as though a keyword of NULL was assigned (that is, value@NULL) for entry parsing purposes. The utility shall include only the value, not the NULL keyword, in the associated job attribute.

6. A batch server shall accept a list-oriented attribute that has multiple occurrences of the same keyword, interpreting the keywords, in order, with the last value encountered taking precedence over prior instances of the same keyword. This rule allows, but does not require, a batch utility to preprocess the attribute to remove duplicate keywords.

7. If a batch utility is presented with multiple list-oriented option-arguments on the command line or in script directives, or both, for a single option, then the utility shall concatenate, in order, any command line keyword and value pairs to the end of any directive keyword and value pairs separated by a single comma to produce a single string that is an equivalent, valid option-argument. The resulting string shall be assigned to the associated attribute of the batch job (after optionally removing duplicate entries as described in item 6).
This chapter contains the definitions of the utilities, as follows:

- Mandatory utilities that are present on every conformant system
- Optional utilities that are present only on systems supporting the associated option; see Section 1.8.1 (on page 9) for information on the options in this volume of IEEE Std 1003.1-2001
NAME
admin — create and administer SCCS files (DEVELOPMENT)

SYNOPSIS
admin -i [name] [-n] [-a login] [-d flag] [-e login] [-f flag] [-m mrlist] [-r rel] [-t [name]] [-y [comment]] newfile
exec
admin -n [-i [name] [-a login] [-d flag] [-e login] [-f flag] [-m mrlist] [-r rel] [-t [name]] [-y [comment]] newfile ...
exec
admin [-a login] [-d flag] [-f flag] [-m mrlist] [-r rel] [-t [name]] [-y [comment]] newfile ...
exec
admin -h file ...
exec
admin -z file ...
exec

DESCRIPTION
The admin utility shall create new SCCS files or change parameters of existing ones. If a named file does not exist, it shall be created, and its parameters shall be initialized according to the specified options. Parameters not initialized by an option shall be assigned a default value. If a named file does exist, parameters corresponding to specified options shall be changed, and other parameters shall be left as is.

All SCCS filenames supplied by the application shall be of the form s.filename. New SCCS files shall be given read-only permission mode. Write permission in the parent directory is required to create a file. All writing done by admin shall be to a temporary x-file, named x.filename (see get), created with read-only mode if admin is creating a new SCCS file, or created with the same mode as that of the SCCS file if the file already exists. After successful execution of admin, the SCCS file shall be removed (if it exists), and the x-file shall be renamed with the name of the SCCS file. This ensures that changes are made to the SCCS file only if no errors occur.

The admin utility shall also use a transient lock file (named z.filename), which is used to prevent simultaneous updates to the SCCS file; see get.

OPTIONS
The admin utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the -i, -t, and -y options have optional option-arguments. These optional option-arguments shall not be presented as separate arguments. The following options are supported:

- n
  Create a new SCCS file. When -n is used without -i, the SCCS file shall be created with control information but without any file data.

- i [name]
  Specify the name of a file from which the text for a new SCCS file shall be taken. The text constitutes the first delta of the file (see the -r option for the delta numbering scheme). If the -i option is used, but the name option-argument is omitted, the text shall be obtained by reading the standard input. If this option is omitted, the SCCS file shall be created with control information but without any file data. The -i option implies the -n option.

- r SID
  Specify the SID of the initial delta to be inserted. This SID shall be a trunk SID; that is, the branch and sequence numbers shall be zero or missing. The level number is optional, and defaults to 1.

- t [name]
  Specify the name of a file from which descriptive text for the SCCS file shall be taken. In the case of existing SCCS files (neither -i nor -n is specified):
• A −t option without a name option-argument shall cause the removal of descriptive text (if any) currently in the SCCS file.

• A −t option with a name option-argument shall cause the text (if any) in the named file to replace the descriptive text (if any) currently in the SCCS file.

−f flag Specify a flag, and, possibly, a value for the flag, to be placed in the SCCS file.

Several −f options may be supplied on a single admin command line. Implementations shall recognize the following flags and associated values:

b Allow use of the −b option on a get command to create branch deltas.

c ceil Specify the highest release (that is, ceiling), a number less than or equal to 9999, which may be retrieved by a get command for editing. The default value for an unspecified c flag shall be 9999.

ffloor Specify the lowest release (that is, floor), a number greater than 0 but less than 9999, which may be retrieved by a get command for editing. The default value for an unspecified f flag shall be 1.

dSID Specify the default delta number (SID) to be used by a get command.

istr Treat the “No ID keywords” message issued by get or delta as a fatal error. In the absence of this flag, the message is only a warning. The message is issued if no SCCS identification keywords (see get) are found in the text retrieved or stored in the SCCS file. If a value is supplied, the application shall ensure that the keywords exactly match the given string; however, the string shall contain a keyword, and no embedded <newline>s.

j Allow concurrent get commands for editing on the same SID of an SCCS file. This allows multiple concurrent updates to the same version of the SCCS file.

list Specify a list of releases to which deltas can no longer be made (that is, get −e against one of these locked releases fails). Conforming applications shall use the following syntax to specify a list. Implementations may accept additional forms as an extension:

\[
\text{<list>} ::= \text{a} | \text{<range-list>}
\]

\[
\text{<range-list>} ::= \text{<range>} | \text{<range-list>}, \text{<range>}
\]

\[
\text{<range>} ::= \text{<SID>}
\]

The character a in the list shall be equivalent to specifying all releases for the named SCCS file. The non-terminal <SID> in range shall be the delta number of an existing delta associated with the SCCS file.

n Cause delta to create a null delta in each of those releases (if any) being skipped when a delta is made in a new release (for example, in making delta 5.1 after delta 2.7, releases 3 and 4 are skipped). These null deltas shall serve as anchor points so that branch deltas may later be created from them. The absence of this flag shall cause skipped releases to be nonexistent in the SCCS file, preventing branch deltas from being created from them in the future. During the initial creation of an SCCS file, the n flag may be ignored; that is, if the −r option is used to set the release number of the initial SID to a value greater than 1, null deltas need not be created for the “skipped” releases.
qtex

Substitute user-definable text for all occurrences of the %Q% keyword in the SCCS file text retrieved by get.

mmod

Specify the module name of the SCCS file substituted for all occurrences of the %M% keyword in the SCCS file text retrieved by get. If the m flag is not specified, the value assigned shall be the name of the SCCS file with the leading ‘.’ removed.

typ

Specify the type of module in the SCCS file substituted for all occurrences of the %Y% keyword in the SCCS file text retrieved by get.

vpnm

Cause delta to prompt for modification request (MR) numbers as the reason for creating a delta. The optional value specifies the name of an MR number validation program. (If this flag is set when creating an SCCS file, the application shall ensure that the m option is also used even if its value is null.)

-d flag

Remove (delete) the specified flag from an SCCS file. Several -d options may be supplied on a single admin command. See the -f option for allowable flag names. (The llist flag gives a list of releases to be unlocked. See the -f option for further description of the l flag and the syntax of a list.)

-a login

Specify a login name, or numerical group ID, to be added to the list of users who may make deltas (changes) to the SCCS file. A group ID shall be equivalent to specifying all login names common to that group ID. Several -a options may be used on a single admin command line. As many logins, or numerical group IDs, as desired may be on the list simultaneously. If the list of users is empty, then anyone may add deltas. If login or group ID is preceded by a ‘!’ , the users so specified shall be denied permission to make deltas.

-e login

Specify a login name, or numerical group ID, to be erased from the list of users allowed to make deltas (changes) to the SCCS file. Specifying a group ID is equivalent to specifying all login names common to that group ID. Several -e options may be used on a single admin command line.

-y[comment]

Insert the comment text into the SCCS file as a comment for the initial delta in a manner identical to that of delta. In the POSIX locale, omission of the -y option shall result in a default comment line being inserted in the form:

"date and time created %s %s by %s", <date>, <time>, <login>

where <date> is expressed in the format of the date utility’s %y/%m/%d conversion specification, <time> in the format of the date utility’s %T conversion specification format, and <login> is the login name of the user creating the file.

-m mrlist

Insert the list of modification request (MR) numbers into the SCCS file as the reason for creating the initial delta in a manner identical to delta. The application shall ensure that the v flag is set and the MR numbers are validated if the v flag has a value (the name of an MR number validation program). A diagnostic message shall be written if the v flag is not set or MR validation fails.

-h

Check the structure of the SCCS file and compare the newly computed checksum with the checksum that is stored in the SCCS file. If the newly computed checksum does not match the checksum in the SCCS file, a diagnostic message shall be written.

-z

Recompute the SCCS file checksum and store it in the first line of the SCCS file (see the -h option above). Note that use of this option on a truly corrupted file may
prevent future detection of the corruption.

OPERANDS

The following operands shall be supported:

file A pathname of an existing SCCS file or a directory. If file is a directory, the admin utility shall behave as though each file in the directory were specified as a named file, except that non-SCCS files (last component of the pathname does not begin with s.) and unreadable files shall be silently ignored.

newfile A pathname of an SCCS file to be created.

If exactly one file or newfile operand appears, and it is ‘−’, the standard input shall be read; each line of the standard input shall be taken to be the name of an SCCS file to be processed. Non-SCCS files and unreadable files shall be silently ignored.

STDIN

The standard input shall be a text file used only if ‘−i’ is specified without an option-argument or if a file or newfile operand is specified as ‘−’. If the first character of any standard input line is <SOH> in the POSIX locale, the results are unspecified.

INPUT FILES

The existing SCCS files shall be text files of an unspecified format.

The application shall ensure that the file named by the ‘−i’ option’s name option-argument shall be a text file; if the first character of any line in this file is <SOH> in the POSIX locale, the results are unspecified. If this file contains more than 99,999 lines, the number of lines recorded in the header for this file shall be 99,999 for this delta.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of admin:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and the contents of the default −y comment.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Not used.
STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
Any SCCS files created shall be text files of an unspecified format. During processing of a file, a locking z-file, as described in get (on page 476), may be created and deleted.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
It is recommended that directories containing SCCS files be writable by the owner only, and that SCCS files themselves be read-only. The mode of the directories should allow only the owner to modify SCCS files contained in the directories. The mode of the SCCS files prevents any modification at all except by SCCS commands.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
delta, get, prs, what

CHANGE HISTORY
First released in Issue 2.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.
The normative text is reworded to emphasize the term “shall” for implementation requirements.
The grammar is updated.
The Open Group Base Resolution bwg2001-007 is applied, adding new text to the INPUT FILES section warning that the maximum lines recorded in the file is 99,999.
The Open Group Base Resolution bwg2001-009 is applied, amending the description of the −h option.
NAME
alias — define or display aliases

SYNOPSIS
UP  alias [alias-name[=string] ...]

DESCRIPTION
The alias utility shall create or redefine alias definitions or write the values of existing alias
definitions to standard output. An alias definition provides a string value that shall replace a
command name when it is encountered; see Section 2.3.1 (on page 32).

An alias definition shall affect the current shell execution environment and the execution
environments of the subshells of the current shell. When used as specified by this volume of
IEEE Std 1003.1-2001, the alias definition shall not affect the parent process of the current shell
nor any utility environment invoked by the shell; see Section 2.12 (on page 61).

OPTIONS
None.

OPERANDS
The following operands shall be supported:

alias-name  Write the alias definition to standard output.

alias-name=string
Assign the value of string to the alias alias-name.

If no operands are given, all alias definitions shall be written to standard output.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of alias:

LANG  Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

xsi  NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.
ASYNCHRONOUS EVENTS
Default.

STDOUT
The format for displaying aliases (when no operands or only name operands are specified) shall be:

"%s=%s\n", name, value

The value string shall be written with appropriate quoting so that it is suitable for reinput to the shell. See the description of shell quoting in Section 2.2 (on page 30).

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.
>0 One of the name operands specified did not have an alias definition, or an error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
1. Change ls to give a columnated, more annotated output:
   alias ls="ls -CF"
2. Create a simple ‘redo’ command to repeat previous entries in the command history file:
   alias r='fc -s'
3. Use 1K units for du:
   alias du=du\  -k
4. Set up nohup so that it can deal with an argument that is itself an alias name:
   alias nohup="nohup 

RATIONALE
The alias description is based on historical KornShell implementations. Known differences exist between that and the C shell. The KornShell version was adopted to be consistent with all the other KornShell features in this volume of IEEE Std 1003.1-2001, such as command line editing.

Since alias affects the current shell execution environment, it is generally provided as a shell regular built-in.

Historical versions of the KornShell have allowed aliases to be exported to scripts that are invoked by the same shell. This is triggered by the alias −x flag; it is allowed by this volume of IEEE Std 1003.1-2001 only when an explicit extension such as −x is used. The standard developers considered that aliases were of use primarily to interactive users and that they
Utilities

5070 should normally not affect shell scripts called by those users; functions are available to such scripts.

5072 Historical versions of the KornShell had not written aliases in a quoted manner suitable for reentry to the shell, but this volume of IEEE Std 1003.1-2001 has made this a requirement for all similar output. Therefore, consistency with this volume of IEEE Std 1003.1-2001 was chosen over this detail of historical practice.

5076 FUTURE DIRECTIONS
5077 None.

5078 SEE ALSO
5079 Section 2.9.5 (on page 54)

5080 CHANGE HISTORY
5081 First released in Issue 4.

5082 Issue 6
5083 This utility is marked as part of the User Portability Utilities option.

5084 The APPLICATION USAGE section is added.
NAME
ar — create and maintain library archives

SYNOPSIS
SD  ar -d[-v] archive file ...

XSI ar -m [-v] archive file ...
  ar -m -a[-v] posname archive file ...
  ar -m -b[-v] posname archive file ...
  ar -m -i[-v] posname archive file ...

XSI ar -p[-v] [-s] archive [file ...]
  ar -q[-cv] archive file ...

ar -r[-cuv] archive file ...
  ar -r -a[-cuv] posname archive file ...
  ar -r -b[-cuv] posname archive file ...
  ar -r -i[-cuv] posname archive file ...

XSI ar -t[-v] [-s] archive [file ...]
  ar -x[-v] [-sCT] archive [file ...]

DESCRIPTION

The ar utility is part of the Software Development Utilities option.

The ar utility can be used to create and maintain groups of files combined into an archive. Once
an archive has been created, new files can be added, and existing files in an archive can be
extracted, deleted, or replaced. When an archive consists entirely of valid object files, the
implementation shall format the archive so that it is usable as a library for link editing (see c99
and fort77). When some of the archived files are not valid object files, the suitability of the
archive for library use is undefined. If an archive consists entirely of printable files, the entire
archive shall be printable.

When ar creates an archive, it creates administrative information indicating whether a symbol
table is present in the archive. When there is at least one object file that ar recognizes as such in
the archive, an archive symbol table shall be created in the archive and maintained by ar; it is
used by the link editor to search the archive. Whenever the ar utility is used to create or update
the contents of such an archive, the symbol table shall be rebuilt. The -s option shall force the
symbol table to be rebuilt.

All file operands can be pathnames. However, files within archives shall be named by a filename,
which is the last component of the pathname used when the file was entered into the archive.
The comparison of file operands to the names of files in archives shall be performed by
comparing the last component of the operand to the name of the file in the archive.

It is unspecified whether multiple files in the archive may be identically named. In the case of
such files, however, each file and posname operand shall match only the first file in the archive
having a name that is the same as the last component of the operand.

The following options shall be supported:

- **a** Position new files in the archive after the file named by the `posname` operand.
- **b** Position new files in the archive before the file named by the `posname` operand.
- **c** Suppress the diagnostic message that is written to standard error by default when the archive `archive` is created.
- **C** Prevent extracted files from replacing like-named files in the file system. This option is useful when `-T` is also used, to prevent truncated filenames from replacing files with the same prefix.
- **d** Delete one or more files from `archive`.
- **i** Position new files in the archive before the file in the archive named by the `posname` operand (equivalent to `-b`).
- **m** Move the named files in the archive. The `-a`, `-b`, or `-i` options with the `posname` operand indicate the position; otherwise, move the names files in the archive to the end of the archive.
- **p** Write the contents of the files in the archive named by file operands from `archive` to the standard output. If no file operands are specified, the contents of all files in the archive shall be written in the order of the archive.
- **q** Append the named files to the end of the archive. In this case `ar` does not check whether the added files are already in the archive. This is useful to bypass the searching otherwise done when creating a large archive piece by piece.
- **r** Replace or add files to `archive`. If the archive named by `archive` does not exist, a new archive shall be created and a diagnostic message shall be written to standard error (unless the `-c` option is specified). If no files are specified and the `archive` exists, the results are undefined. Files that replace existing files in the archive shall not change the order of the archive. Files that do not replace existing files in the archive shall be appended to the archive unless a `-a`, `-b`, or `-i` option specifies another position.
- **s** Force the regeneration of the archive symbol table even if `ar` is not invoked with an option that modifies the archive contents. This option is useful to restore the archive symbol table after it has been stripped; see `strip`.
- **t** Write a table of contents of `archive` to the standard output. The files specified by the file operands shall be included in the written list. If no file operands are specified, all files in `archive` shall be included in the order of the archive.
- **T** Allow filename truncation of extracted files whose archive names are longer than the file system can support. By default, extracting a file with a name that is too long shall be an error; a diagnostic message shall be written and the file shall not be extracted.
- **u** Update older files in the archive. When used with the `-r` option, files in the archive shall be replaced only if the corresponding file has a modification time that is at least as new as the modification time of the file in the archive.
−v Give verbose output. When used with the option characters −d, −r, or −x, write a
detailed file-by-file description of the archive creation and maintenance activity, as
described in the STDOUT section.

When used with −p, write the name of the file in the archive to the standard output
before writing the file in the archive itself to the standard output, as described in
the STDOUT section.

When used with −t, include a long listing of information about the files in the
archive, as described in the STDOUT section.

−x Extract the files in the archive named by the file operands from archive. The
contents of the archive shall not be changed. If no file operands are given, all files
in the archive shall be extracted. The modification time of each file extracted shall
be set to the time the file is extracted from the archive.

OPERANDS

The following operands shall be supported:

archive A pathname of the archive.

file A pathname. Only the last component shall be used when comparing against the
names of files in the archive. If two or more file operands have the same last
pathname component (basename), the results are unspecified. The
implementation's archive format shall not truncate valid filenames of files added
to or replaced in the archive.

posname The name of a file in the archive, used for relative positioning; see options −m and
−r.

STDIN

Not used.

INPUT FILES

The archive named by archive shall be a file in the format created by ar −r.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of ar:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

LC_TIME Determine the format and content for date and time strings written by ar −tv.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

TMPDIR Determine the pathname that overrides the default directory for temporary files, if
any.
Determine the timezone used to calculate date and time strings written by `ar -tv`. If `TZ` is unset or null, an unspecified default timezone shall be used.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

If the `-d` option is used with the `-v` option, the standard output format shall be:

```
"d - %s\n", <file>
```

where `file` is the operand specified on the command line.

If the `-p` option is used with the `-v` option, `ar` shall precede the contents of each file with:

```
"\n<%s>\n\n", <file>
```

where `file` is the operand specified on the command line, if `file` operands were specified, and the name of the file in the archive if they were not.

If the `-r` option is used with the `-v` option:

- If `file` is already in the archive, the standard output format shall be:

```
"r - %s\n", <file>
```

where `<file>` is the operand specified on the command line.

- If `file` is not already in the archive, the standard output format shall be:

```
"a - %s\n", <file>
```

where `<file>` is the operand specified on the command line.

If the `-t` option is used, `ar` shall write the names of the files in the archive to the standard output in the format:

```
"%s\n", <file>
```

where `file` is the operand specified on the command line, if `file` operands were specified, or the name of the file in the archive if they were not.

If the `-t` option is used with the `-v` option, the standard output format shall be:

```
"%s %u/%u %u %s %d %d:%d %d %s\n", <member mode>, <user ID>,
<group ID>, <number of bytes in member>,
<abbreviated month>, <day-of-month>, <hour>,
<minute>, <year>, <file>
```

where:

- `<file>` shall be the operand specified on the command line, if `file` operands were specified, or the name of the file in the archive if they were not.

- `<member mode>` shall be formatted the same as the `<file mode>` string defined in the STDOUT section of `ls`, except that the first character, the `<entry type>`, is not used; the string represents the file mode of the file in the archive at the time it was added to or replaced in the archive.

The following represent the last-modification time of a file when it was most recently added to or replaced in the archive:
<abbreviated month>
Equivalent to the format of the %b conversion specification format in date.
<day-of-month>
Equivalent to the format of the %e conversion specification format in date.
<hour>
Equivalent to the format of the %H conversion specification format in date.
<minute>
Equivalent to the format of the %M conversion specification format in date.
<year>
Equivalent to the format of the %Y conversion specification format in date.

When LC_TIME does not specify the POSIX locale, a different format and order of presentation of these fields relative to each other may be used in a format appropriate in the specified locale. If the −x option is used with the −v option, the standard output format shall be:
"x − %s\n", <file>
where file is the operand specified on the command line, if file operands were specified, or the name of the file in the archive if they were not.

STDERR
The standard error shall be used only for diagnostic messages. The diagnostic message about creating a new archive when −c is not specified shall not modify the exit status.

OUTPUT FILES
Archives are files with unspecified formats.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The archive format is not described. It is recognized that there are several known ar formats, which are not compatible. The ar utility is included, however, to allow creation of archives that are intended for use only on one machine. The archive is specified as a file, and it can be moved as a file. This does allow an archive to be moved from one machine to another machine that uses the same implementation of ar.
Utilities such as pax (and its forebears tar and cpio) also provide portable “archives”. This is a not a duplication; the ar utility is included to provide an interface primarily for make and the compilers, based on a historical model.
In historical implementations, the −q option (available on XSI-conforming systems) is known to execute quickly because ar does not check on whether the added members are already in the archive. This is useful to bypass the searching otherwise done when creating a large archive.
piece-by-piece. These remarks may but need not remain true for a brand new implementation of this utility; hence, these remarks have been moved into the RATIONALE.

BSD implementations historically required applications to provide the `−s` option whenever the archive was supposed to contain a symbol table. As in this volume of IEEE Std 1003.1-2001, System V historically creates or updates an archive symbol table whenever an object file is removed from, added to, or updated in the archive.

The OPERANDS section requires what might seem to be true without specifying it: the archive cannot truncate the filenames below `|NAME_MAX|`. Some historical implementations do so, however, causing unexpected results for the application. Therefore, this volume of IEEE Std 1003.1-2001 makes the requirement explicit to avoid misunderstandings.

According to the System V documentation, the options `−dmpqrtx` are not required to begin with a hyphen (`'−'`). This volume of IEEE Std 1003.1-2001 requires that a conforming application use the leading hyphen.

The archive format used by the 4.4 BSD implementation is documented in this RATIONALE as an example:

A file created by `ar` begins with the "′magic′" string "′!<arch>\n′". The rest of the archive is made up of objects, each of which is composed of a header for a file, a possible filename, and the file contents. The header is portable between machine architectures, and, if the file contents are printable, the archive is itself printable.

The header is made up of six ASCII fields, followed by a two-character trailer. The fields are the object name (16 characters), the file last modification time (12 characters), the user and group IDs (each 6 characters), the file mode (8 characters), and the file size (10 characters). All numeric fields are in decimal, except for the file mode, which is in octal.

The modification time is the file `st_mtime` field. The user and group IDs are the file `st_uid` and `st_gid` fields. The file mode is the file `st_mode` field. The file size is the file `st_size` field. The two-byte trailer is the string "′<newline>′".

Only the name field has any provision for overflow. If any filename is more than 16 characters in length or contains an embedded space, the string "′#1/′" followed by the ASCII length of the name is written in the name field. The file size (stored in the archive header) is incremented by the length of the name. The name is then written immediately following the archive header.

Any unused characters in any of these fields are written as <space>s. If any fields are their particular maximum number of characters in length, there is no separation between the fields.

Objects in the archive are always an even number of bytes long; files that are an odd number of bytes long are padded with a <newline>, although the size in the header does not reflect this.

The `ar` utility description requires that (when all its members are valid object files) `ar` produce an object code library, which the linkage editor can use to extract object modules. If the linkage editor needs a symbol table to permit random access to the archive, `ar` must provide it; however, `ar` does not require a symbol table.

The BSD `−o` option was omitted. It is a rare conforming application that uses `ar` to extract object code from a library with concern for its modification time, since this can only be of importance to make. Hence, since this functionality is not deemed important for applications portability, the modification time of the extracted files is set to the current time.
There is at least one known implementation (for a small computer) that can accommodate only object files for that system, disallowing mixed object and other files. The ability to handle any type of file is not only historical practice for most implementations, but is also a reasonable expectation.

Consideration was given to changing the output format of \texttt{ar -tv} to the same format as the output of \texttt{ls -I}. This would have made parsing the output of \texttt{ar} the same as that of \texttt{ls}. This was rejected in part because the current \texttt{ar} format is commonly used and changes would break historical usage. Second, \texttt{ar} gives the user ID and group ID in numeric format separated by a slash. Changing this to be the user name and group name would not be correct if the archive were moved to a machine that contained a different user database. Since \texttt{ar} cannot know whether the archive was generated on the same machine, it cannot tell what to report.

The text on the \texttt{-ur} option combination is historical practice—since one filename can easily represent two different files (for example, /a/foo and /b/foo), it is reasonable to replace the file in the archive even when the modification time in the archive is identical to that in the file system.

\textbf{FUTURE DIRECTIONS}

None.

\textbf{SEE ALSO}

c99, date, for77, pax, strip the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 13, Headers, <unistd.h> description of [POSIX_NO_TRUNC]

\textbf{CHANGE HISTORY}

First released in Issue 2.

Issue 5

The FUTURE DIRECTIONS section is added.

Issue 6

This utility is marked as part of the Software Development Utilities option.

The STDOUT description is changed for the \texttt{-v} option to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term "must" for application requirements.

The TZ entry is added to the ENVIRONMENT VARIABLES section.

IEEE PASC Interpretation 1003.2 #198 is applied, changing the description to consistently use "file" to refer to a file in the file system hierarchy, "archive" to refer to the archive being operated upon by the \texttt{ar} utility, and "file in the archive" to refer to a copy of a file that is contained in the archive.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/10 is applied, making corrections to the SYNOPSIS. The change was needed since the \texttt{-a}, \texttt{-b}, and \texttt{-i} options are mutually-exclusive, and \texttt{posname} is required if any of these options is specified.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/11 is applied, correcting the description of the two-byte trailer in RATIONALE which had missed out a backquote. The correct trailer is a backquote followed by a <newline>.
NAME
asa — interpret carriage-control characters

SYNOPSIS
asa [ file ... ]

DESCRIPTION
The asa utility shall write its input files to standard output, mapping carriage-control characters from the text files to line-printer control sequences in an implementation-defined manner.

The first character of every line shall be removed from the input, and the following actions are performed.

If the character removed is:

- `<space>` The rest of the line is output without change.

- `0` A `<newline>` is output, then the rest of the input line.

- `1` One or more implementation-defined characters that causes an advance to the next page shall be output, followed by the rest of the input line.

- `+` The `<newline>` of the previous line shall be replaced with one or more implementation-defined characters that causes printing to return to column position 1, followed by the rest of the input line. If the `'+'` is the first character in the input, it shall be equivalent to `<space>`.

The action of the asa utility is unspecified upon encountering any character other than those listed above as the first character in a line.

OPTIONS
None.

OPERANDS

file A pathname of a text file used for input. If no file operands are specified, the standard input shall be used.

STDIN
The standard input shall be used only if no file operands are specified; see the INPUT FILES section.

INPUT FILES
The input files shall be text files.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of asa:

- LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

- LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).
Utilities

ASA

5421

LC_MESSAGES
5422 Determine the locale that should be used to affect the format and contents of
5423 diagnostic messages written to standard error.

5424 XSI

NLSPATH

5425 Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

5426 Default.

STDOUT

5427 The standard output shall be the text from the input file modified as described in the
5428 DESCRIPTION section.

STDERR

5429 None.

OUTPUT FILES

5430 None.

EXTENDED DESCRIPTION

5431 None.

EXIT STATUS

5432 The following exit values shall be returned:

5433 0 All input files were output successfully.

5434 >0 An error occurred.

CONSEQUENCES OF ERRORS

5435 Default.

APPLICATION USAGE

5436 None.

EXAMPLES

5437 1. The following command:

5438 asa file

5439 permits the viewing of file (created by a program using FORTRAN-style carriage-control
5440 characters) on a terminal.

5441 2. The following command:

5442 a.out | asa | lp

5443 formats the FORTRAN output of a.out and directs it to the printer.

RATIONALE

5444 The asa utility is needed to map “standard” FORTRAN 77 output into a form acceptable to
5445 contemporary printers. Usually, asa is used to pipe data to the lp utility; see lp.

5446 This utility is generally used only by FORTRAN programs. The standard developers decided to
5447 retain asa to avoid breaking the historical large base of FORTRAN applications that put
5448 carriage-control characters in their output files. There is no requirement that a system have a
5449 FORTRAN compiler in order to run applications that need asa.

5450 Historical implementations have used an ASCII <form-feed> in response to a 1 and an ASCII
5451 <carriage-return> in response to a ‘+’. It is suggested that implementations treat characters
5452 other than 0, 1, and ‘+’ as <space> in the absence of any compelling reason to do otherwise.

5453 However, the action is listed here as “unspecified”, permitting an implementation to provide
extensions to access fast multiple-line slewing and channel seeking in a non-portable manner.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`fort77`, `lp`

**CHANGE HISTORY**

First released in Issue 4.

**Issue 6**

This utility is marked as part of the FORTRAN Runtime Utilities option.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME

at — execute commands at a later time

SYNOPSIS

UP

at [-m] [-f file] [-q queuename] -t time_arg

at [-m] [-f file] [-q queuename] timespec ...

at -r at_job_id ...

at -l -q queuename

at -l [at_job_id ...]

DESCRIPTION

The at utility shall read commands from standard input and group them together as an at-job, to be executed at a later time.

The at-job shall be executed in a separate invocation of the shell, running in a separate process group with no controlling terminal, except that the environment variables, current working directory, file creation mask, and other implementation-defined execution-time attributes in effect when the at utility is executed shall be retained and used when the at-job is executed.

When the at-job is submitted, the at_job_id and scheduled time shall be written to standard error. The at_job_id is an identifier that shall be a string consisting solely of alphanumeric characters and the period character. The at_job_id shall be assigned by the system when the job is scheduled such that it uniquely identifies a particular job.

User notification and the processing of the job’s standard output and standard error are described under the -m option.

XSI

Users shall be permitted to use at if their name appears in the file /usr/lib/cron/at.allow. If that file does not exist, the file /usr/lib/cron/at.deny shall be checked to determine whether the user shall be denied access to at. If neither file exists, only a process with the appropriate privileges shall be allowed to submit a job. If only at.deny exists and is empty, global usage shall be permitted. The at.allow and at.deny files shall consist of one user name per line.

OPTIONS


The following options shall be supported:

-f file

Specify the pathname of a file to be used as the source of the at-job, instead of standard input.

-l

(The letter ell.) Report all jobs scheduled for the invoking user if no at_job_id operands are specified. If at_job_ids are specified, report only information for these jobs. The output shall be written to standard output.

-m

Send mail to the invoking user after the at-job has run, announcing its completion. Standard output and standard error produced by the at-job shall be mailed to the user as well, unless redirected elsewhere. Mail shall be sent even if the job produces no output.

If -m is not used, the job’s standard output and standard error shall be provided to the user by means of mail, unless they are redirected elsewhere; if there is no such output to provide, the implementation need not notify the user of the job’s completion.
Specify in which queue to schedule a job for submission. When used with the −l option, limit the search to that particular queue. By default, at-jobs shall be scheduled in queue a. In contrast, queue b shall be reserved for batch jobs; see batch. The meanings of all other queuenames are implementation-defined. If −q is specified along with either of the −t time_arg or timespec arguments, the results are unspecified.

Remove the jobs with the specified at_job_id operands that were previously scheduled by the at utility.

Submit the job to be run at the time specified by the time option-argument, which the application shall ensure has the format as specified by the touch −t time utility.

The following operands shall be supported:

at_job_id The name reported by a previous invocation of the at utility at the time the job was scheduled.

timespec Submit the job to be run at the date and time specified. All of the timespec operands are interpreted as if they were separated by <space>s and concatenated, and shall be parsed as described in the grammar at the end of this section. The date and time shall be interpreted as being in the timezone of the user (as determined by the TZ variable), unless a timezone name appears as part of time, below.

In the POSIX locale, the following describes the three parts of the time specification string. All of the values from the LC_TIME categories in the POSIX locale shall be recognized in a case-insensitive manner.

The time can be specified as one, two, or four digits. One-digit and two-digit numbers shall be taken to be hours; four-digit numbers to be hours and minutes. The time can alternatively be specified as two numbers separated by a colon, meaning hour:minute. An AM/PM indication (one of the values from the am_pm keywords in the LC_TIME locale category) can follow the time; otherwise, a 24-hour clock time shall be understood. A timezone name can also follow to further qualify the time. The acceptable timezone names are implementation-defined, except that they shall be case-insensitive and the string utc is supported to indicate the time is in Coordinated Universal Time. In the POSIX locale, the time field can also be one of the following tokens:

midnight Indicates the time 12:00 am (00:00).

noon Indicates the time 12:00 pm.

now Indicates the current day and time. Invoking at <now> shall submit an at-job for potentially immediate execution (that is, subject only to unspecified scheduling delays).

date An optional date can be specified as either a month name (one of the values from the mon or abmon keywords in the LC_TIME locale category) followed by a day number (and possibly year number preceded by a comma), or a day of the week (one of the values from the day or abday keywords in the LC_TIME locale category). In the POSIX locale, two special days shall be recognized:
today Indicates the current day.

tomorrow Indicates the day following the current day.

If no date is given, today shall be assumed if the given time is greater than the current time, and tomorrow shall be assumed if it is less. If the given month is less than the current month (and no year is given), next year shall be assumed.

increment The optional increment shall be a number preceded by a plus sign ('+') and suffixed by one of the following: minutes, hours, days, weeks, months, or years. (The singular forms shall also be accepted.) The keyword next shall be equivalent to an increment number of +1. For example, the following are equivalent commands:

at 2pm + 1 week
at 2pm next week

The following grammar describes the precise format of timespec in the POSIX locale. The general conventions for this style of grammar are described in Section 1.10 (on page 19). This formal syntax shall take precedence over the preceding text syntax description. The longest possible token or delimiter shall be recognized at a given point. When used in a timespec, white space shall also delimit tokens.

%token hr24clock_hr_min
%token hr24clock_hour
/*
An hr24clock_hr_min is a one, two, or four-digit number. A one-digit or two-digit number constitutes an hr24clock_hour. An hr24clock_hour may be any of the single digits [0,9], or may be double digits, ranging from [00,23]. If an hr24clock_hr_min is a four-digit number, the first two digits shall be a valid hr24clock_hour, while the last two represent the number of minutes, from [00,59].
*/

%token wallclock_hr_min
%token wallclock_hour
/*
A wallclock_hr_min is a one, two-digit, or four-digit number. A one-digit or two-digit number constitutes a wallclock_hour. A wallclock_hour may be any of the single digits [1,9], or may be double digits, ranging from [01,12]. If a wallclock_hr_min is a four-digit number, the first two digits shall be a valid wallclock_hour, while the last two represent the number of minutes, from [00,59].
*/

%token minute
/*
A minute is a one or two-digit number whose value can be [0,9] or [00,59].
*/

%token day_number
/*
A day_number is a number in the range appropriate for the particular month and year specified by month_name and year_number, respectively.
If no year_number is given, the current year is assumed if the given
date and time are later this year. If no year_number is given and
the date and time have already occurred this year and the month is
not the current month, next year is the assumed year.

*/

%token year_number

/*
A year_number is a four-digit number representing the year A.D., in
which the at_job is to be run.
*/

%token inc_number

/*
The inc_number is the number of times the succeeding increment
period is to be added to the specified date and time.
*/

%token timezone_name

/*
The name of an optional timezone suffix to the time field, in an
implementation-defined format.
*/

%token month_name

/*
One of the values from the mon or abmon keywords in the LC_TIME
locale category.
*/

%token day_of_week

/*
One of the values from the day or abday keywords in the LC_TIME
locale category.
*/

%token am_pm

/*
One of the values from the am_pm keyword in the LC_TIME locale
category.
*/

%start timespec

%%
timespec : time
    | time date
    | time increment
    | time date increment
    | nowspec
    |

nowspec : "now"
    | "now" increment
    |

time : hr24clock_hr_min
    | hr24clock_hr_min timezone_name
Utilities

| hr24clock_hour ":" minute |
| hr24clock_hour ":" minute timezone_name |
| wallclock_hr_min am_pm |
| wallclock_hr_min am_pm timezone_name |
| wallclock_hour ":" minute am_pm |
| wallclock_hour ":" minute am_pm timezone_name |
| "noon" |
| "midnight" |
| date : month_name day_number |
| month_name day_number "," year_number |
| day_of_week |
| "today" |
| "tomorrow" |
| increment : "+" inc_number inc_period |
| "next" inc_period |
| inc_period : "minute" | "minutes" |
| "hour" | "hours" |
| "day" | "days" |
| "week" | "weeks" |
| "month" | "months" |
| "year" | "years" |

STDIN

The standard input shall be a text file consisting of commands acceptable to the shell command language described in Chapter 2 (on page 29). The standard input shall only be used if no \-f file option is specified.

INPUT FILES

See the STDIN section.

XSI

The text files /usr/lib/cron/at.allow and /usr/lib/cron/at.deny shall contain zero or more user names, one per line, of users who are, respectively, authorized or denied access to the at and batch utilities.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of at:

LANG

Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL

If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES

Determine the locale that should be used to affect the format and contents of
Utilities

5707 diagnostic messages written to standard error and informative messages written to
standard output.

5709 XSI NLS_PATH

5710 LC_TIME Determine the location of message catalogs for the processing of LC_MESSAGES.

5711 LC_TIME Determine the format and contents for date and time strings written and accepted
by at.

5712 SHELL Determine a name of a command interpreter to be used to invoke the at-job. If the
variable is unset or null, sh shall be used. If it is set to a value other than a name for
sh, the implementation shall do one of the following: use that shell; use sh; use the
login shell from the user database; or any of the preceding accompanied by a
warning diagnostic about which was chosen.

5717 TZ Determine the timezone. The job shall be submitted for execution at the time
specified by timespec or −t time relative to the timezone specified by the TZ
variable. If timespec specifies a timezone, it shall override TZ. If timespec does not
specify a timezone and TZ is unset or null, an unspecified default timezone shall
be used.

5722 ASYNCHRONOUS EVENTS

5723 Default.

5724 STDOUT

5725 When standard input is a terminal, prompts of unspecified format for each line of the user input
described in the STDIN section may be written to standard output.

5727 In the POSIX locale, the following shall be written to the standard output for each job when jobs
are listed in response to the −I option:

5729 "%s\t%s\n", at_job_id, <date>

5730 where date shall be equivalent in format to the output of:

5731 date +"%a %b %e %T %Y"

5732 The date and time written shall be adjusted so that they appear in the timezone of the user (as
determined by the TZ variable).

5734 STDERR

5735 In the POSIX locale, the following shall be written to standard error when a job has been
successfully submitted:

5737 "job %s at %s\n", at_job_id, <date>

5738 where date has the same format as that described in the STDOUT section. Neither this, nor
warning messages concerning the selection of the command interpreter, shall be considered a
diagnostic that changes the exit status.

5741 Diagnostic messages, if any, shall be written to standard error.

5742 OUTPUT FILES

5743 None.

5744 EXTENDED DESCRIPTION

5745 None.

5746 EXIT STATUS

5747 The following exit values shall be returned:

5748 0 The at utility successfully submitted, removed, or listed a job or jobs.
An error occurred.

CONSEQUENCES OF ERRORS
The job shall not be scheduled, removed, or listed.

APPLICATION USAGE
The format of the `at` command line shown here is guaranteed only for the POSIX locale. Other cultures may be supported with substantially different interfaces, although implementations are encouraged to provide comparable levels of functionality.

Since the commands run in a separate shell invocation, running in a separate process group with no controlling terminal, open file descriptors, traps, and priority inherited from the invoking environment are lost.

Some implementations do not allow substitution of different shells using `SHELL`. System V systems, for example, have used the login shell value for the user in `/etc/passwd`. To select reliably another command interpreter, the user must include it as part of the script, such as:

```
$ at 1800
myshell myscript
EOT
job ... at ...
$
```

EXAMPLES

1. This sequence can be used at a terminal:

```
  at -m 0730 tomorrow
  sort < file >outfile
  EOT
```

2. This sequence, which demonstrates redirecting standard error to a pipe, is useful in a command procedure (the sequence of output redirection specifications is significant):

```
  at now + 1 hour <<!
  diff file1 file2 2>&1 >outfile | mailx mygroup
  !
```

3. To have a job reschedule itself, `at` can be invoked from within the at-job. For example, this daily processing script named `my.daily` runs every day (although `crontab` is a more appropriate vehicle for such work):

```
  # my.daily runs every day
daily processing
  at now tomorrow < my.daily
```

4. The spacing of the three portions of the POSIX locale `timespec` is quite flexible as long as there are no ambiguities. Examples of various times and operand presentation include:

```
  at 0815am Jan 24
  at 8 :15amjan24
  at now "+ 1day"
  at 5 pm FRIday
  at ‘17
    utc+
  30minutes’
```
The *at* utility reads from standard input the commands to be executed at a later time. It may be useful to redirect standard output and standard error within the specified commands.

The *−t time* option was added as a new capability to support an internationalized way of specifying a time for execution of the submitted job.

Early proposals added a "jobname" concept as a way of giving submitted jobs names that are meaningful to the user submitting them. The historical, system-specified *at_job_id* gives no indication of what the job is. Upon further reflection, it was decided that the benefit of this was not worth the change in historical interface. The *at* functionality is useful in simple environments, but in large or complex situations, the functionality provided by the Batch Services option is more suitable.

The *−q* option historically has been an undocumented option, used mainly by the *batch* utility.

The System V *−m* option was added to provide a method for informing users that an at-job had completed. Otherwise, users are only informed when output to standard error or standard output are not redirected.

The behavior of *at <now>* was changed in an early proposal from being unspecified to submitting a job for potentially immediate execution. Historical BSD *at* implementations support this. Historical System V implementations give an error in that case, but a change to the System V versions should have no backwards-compatibility ramifications.

On BSD-based systems, a *−u user* option has allowed those with appropriate privileges to access the work of other users. Since this is primarily a system administration feature and is not universally implemented, it has been omitted. Similarly, a specification for the output format for a user with appropriate privileges viewing the queues of other users has been omitted.

The *−f file* option from System V is used instead of the BSD method of using the last operand as the pathname. The BSD method is ambiguous—does:

```
at 1200 friday
```

mean the same thing if there is a file named *friday* in the current directory?

The *at_job_id* is composed of a limited character set in historical practice, and it is mandated here to invalidate systems that might try using characters that require shell quoting or that could not be easily parsed by shell scripts.

The *at* utility varies between System V and BSD systems in the way timezones are used. On System V systems, the *TZ* variable affects the at-job submission times and the times displayed for the user. On BSD systems, *TZ* is not taken into account. The BSD behavior is easily achieved with the current specification. If the user wishes to have the timezone default to that of the system, they merely need to issue the *at* command immediately following an unsetting or null assignment to *TZ*. For example:

```
TZ= at noon ...
```

gives the desired BSD result.

While the *yacc*-like grammar specified in the OPERANDS section is lexically unambiguous with respect to the digit strings, a lexical analyzer would probably be written to look for and return digit strings in those cases. The parser could then check whether the digit string returned is a valid *day_number, year_number*, and so on, based on the context.
FUTURE DIRECTIONS

None.

SEE ALSO

batch, crontab

CHANGE HISTORY

First released in Issue 2.

Issue 6

This utility is marked as part of the User Portability Utilities option.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

• If -m is not used, the job’s standard output and standard error are provided to the user by mail.

The effects of using the -q and -t options as defined in the IEEE P1003.2b draft standard are specified.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
awk — pattern scanning and processing language

SYNOPSIS
awk [-F ERE] [−v assignment] ... program [argument ...]
awk [-F ERE] −f progfile ... [−v assignment] ...[argument ...]

DESCRIPTION
The awk utility shall execute programs written in the awk programming language, which is
specialized for textual data manipulation. An awk program is a sequence of patterns and
corresponding actions. When input is read that matches a pattern, the action associated with
that pattern is carried out.

Input shall be interpreted as a sequence of records. By default, a record is a line, less its
terminating <newline>, but this can be changed by using the RS built-in variable. Each record of
input shall be matched in turn against each pattern in the program. For each pattern matched,
the associated action shall be executed.

The awk utility shall interpret each input record as a sequence of fields where, by default, a field
is a string of non-<blank>s. This default white-space field delimiter can be changed by using the
FS built-in variable or −F ERE. The awk utility shall denote the first field in a record $1, the
second $2, and so on. The symbol $0 shall refer to the entire record; setting any other field causes
the re-evaluation of $0. Assigning to $0 shall reset the values of all other fields and the NF built-
in variable.

OPTIONS
The awk utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

−F ERE Define the input field separator to be the extended regular expression ERE, before
any input is read; see Regular Expressions (on page 161).

−f progfile Specify the pathname of the file progfile containing an awk program. If multiple
instances of this option are specified, the concatenation of the files specified as
progfile in the order specified shall be the awk program. The awk program can
alternatively be specified in the command line as a single argument.

−v assignment
The application shall ensure that the assignment argument is in the same form as an
assignment operand. The specified variable assignment shall occur prior to
executing the awk program, including the actions associated with BEGIN patterns
(if any). Multiple occurrences of this option can be specified.

OPERANDS
The following operands shall be supported:

program If no −f option is specified, the first operand to awk shall be the text of the awk
program. The application shall supply the program operand as a single argument to
awk. If the text does not end in a <newline>, awk shall interpret the text as if it did.

argument Either of the following two types of argument can be intermixed:

file A pathname of a file that contains the input to be read, which is
matched against the set of patterns in the program. If no file operands
are specified, or if a file operand is ‘−’, the standard input shall be
used.
An operand that begins with an underscore or alphabetic character from the portable character set (see the table in the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set), followed by a sequence of underscores, digits, and alphabetics from the portable character set, followed by the '=' character, shall specify a variable assignment rather than a pathname. The characters before the '=' represent the name of an awk variable; if that name is an awk reserved word (see Grammar (on page 170)) the behavior is undefined. The characters following the equal sign shall be interpreted as if they appeared in the awk program preceded and followed by a double-quote ('"') character, as a STRING token (see Grammar (on page 170)), except that if the last character is an unescaped backslash, it shall be interpreted as a literal backslash rather than as the first character of the sequence "\"". The variable shall be assigned the value of that STRING token and, if appropriate, shall be considered a numeric string (see Expressions in awk (on page 156)), the variable shall also be assigned its numeric value. Each such variable assignment shall occur just prior to the processing of the following file, if any. Thus, an assignment before the first file argument shall be executed after the BEGIN actions (if any), while an assignment after the last file argument shall occur before the END actions (if any). If there are no file arguments, assignments shall be executed before processing the standard input.

STDIN
The standard input shall be used only if no file operands are specified, or if a file operand is '-'; see the INPUT FILES section. If the awk program contains no actions and no patterns, but is otherwise a valid awk program, standard input and any file operands shall not be read and awk shall exit with a return status of zero.

INPUT FILES
Input files to the awk program from any of the following sources shall be text files:
- Any file operands or their equivalents, achieved by modifying the awk variables ARGV and argc
- Standard input in the absence of any file operands
- Arguments to the getline function

Whether the variable RS is set to a value other than a <newline> or not, for these files, implementations shall support records terminated with the specified separator up to {LINE_MAX} bytes and may support longer records.

If -f progfile is specified, the application shall ensure that the files named by each of the progfile option-arguments are text files and their concatenation, in the same order as they appear in the arguments, is an awk program.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of awk:

LANG
Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
**Utilities**

**awk**

5940  **LC_ALL**  If set to a non-empty string value, override the values of all the other internationalization variables.

5942  **LC_COLLATE**  Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions and in comparisons of string values.

5946  **LC_CTYPE**  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), the behavior of character classes within regular expressions, the identification of characters as letters, and the mapping of uppercase and lowercase characters for the `toupper` and `tolower` functions.

5951  **LC_MESSAGES**  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

5954  **LC_NUMERIC**  Determine the radix character used when interpreting numeric input, performing conversions between numeric and string values, and formatting numeric output. Regardless of locale, the period character (the decimal-point character of the POSIX locale) is the decimal-point character recognized in processing `awk` programs (including assignments in command line arguments).

5960  **NLSPATH**  Determine the location of message catalogs for the processing of `LC_MESSAGES`.

5961  **PATH**  Determine the search path when looking for commands executed by `system(expr)`, or input and output pipes; see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

5964  In addition, all environment variables shall be visible via the `awk` variable `ENVIRON`.

5965  **ASYNCHRONOUS EVENTS**
5966  Default.

5967  **STDOUT**  The nature of the output files depends on the `awk` program.

5969  **STDERR**  The standard error shall be used only for diagnostic messages.

5972  **OUTPUT FILES**  The nature of the output files depends on the `awk` program.

5973  **EXTENDED DESCRIPTION**

5974  **Overall Program Structure**

5975  An `awk` program is composed of pairs of the form:

5976  ```
5977     pattern { action }
5978  ```

5977  Either the pattern or the action (including the enclosing brace characters) can be omitted.

5978  A missing pattern shall match any record of input, and a missing action shall be equivalent to:

5979  ```
5980     { print }
5981  ```

5980  Execution of the `awk` program shall start by first executing the actions associated with all `BEGIN` patterns in the order they occur in the program. Then each `file` operand (or standard input if no

5981  ```
files were specified) shall be processed in turn by reading data from the file until a record
separator is seen (<newline> by default). Before the first reference to a field in the record is
evaluated, the record shall be split into fields, according to the rules in Regular Expressions (on
page 161), using the value of FS that was current at the time the record was read. Each pattern in
the program then shall be evaluated in the order of occurrence, and the action associated with
each pattern that matches the current record executed. The action for a matching pattern shall be
executed before evaluating subsequent patterns. Finally, the actions associated with all END
patterns shall be executed in the order they occur in the program.

Expressions in awk

Expressions describe computations used in patterns and actions. In the following table, valid
expression operations are given in groups from highest precedence first to lowest precedence
last, with equal-precedence operators grouped between horizontal lines. In expression
evaluation, where the grammar is formally ambiguous, higher precedence operators shall be
evaluated before lower precedence operators. In this table expr, expr1, expr2, and expr3 represent
any expression, while lvalue represents any entity that can be assigned to (that is, on the left side
of an assignment operator). The precise syntax of expressions is given in Grammar (on page
170).

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Name</th>
<th>Type of Result</th>
<th>Associativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>( expr )</td>
<td>Grouping</td>
<td>Type of expr</td>
<td>N/A</td>
</tr>
<tr>
<td>$expr</td>
<td>Field reference</td>
<td>String</td>
<td>N/A</td>
</tr>
<tr>
<td>++ lvalue</td>
<td>Pre-increment</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>-- lvalue</td>
<td>Pre-decrement</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>lvalue ++</td>
<td>Post-increment</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>lvalue --</td>
<td>Post-decrement</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>expr ^ expr</td>
<td>Exponentiation</td>
<td>Numeric</td>
<td>Right</td>
</tr>
<tr>
<td>! expr</td>
<td>Logical not</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>+ expr</td>
<td>Unary plus</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>- expr</td>
<td>Unary minus</td>
<td>Numeric</td>
<td>N/A</td>
</tr>
<tr>
<td>expr * expr</td>
<td>Multiplication</td>
<td>Numeric</td>
<td>Left</td>
</tr>
<tr>
<td>expr / expr</td>
<td>Division</td>
<td>Numeric</td>
<td>Left</td>
</tr>
<tr>
<td>expr % expr</td>
<td>Modulus</td>
<td>Numeric</td>
<td>Left</td>
</tr>
<tr>
<td>expr + expr</td>
<td>Addition</td>
<td>Numeric</td>
<td>Left</td>
</tr>
<tr>
<td>expr - expr</td>
<td>Subtraction</td>
<td>Numeric</td>
<td>Left</td>
</tr>
<tr>
<td>expr expr</td>
<td>String concatenation</td>
<td>String</td>
<td>Left</td>
</tr>
<tr>
<td>expr &lt; expr</td>
<td>Less than</td>
<td>Numeric</td>
<td>None</td>
</tr>
<tr>
<td>expr &lt;= expr</td>
<td>Less than or equal to</td>
<td>Numeric</td>
<td>None</td>
</tr>
<tr>
<td>expr != expr</td>
<td>Not equal to</td>
<td>Numeric</td>
<td>None</td>
</tr>
<tr>
<td>expr == expr</td>
<td>Equal to</td>
<td>Numeric</td>
<td>None</td>
</tr>
<tr>
<td>expr &gt; expr</td>
<td>Greater than</td>
<td>Numeric</td>
<td>None</td>
</tr>
<tr>
<td>expr &gt;= expr</td>
<td>Greater than or equal to</td>
<td>Numeric</td>
<td>None</td>
</tr>
</tbody>
</table>
Each expression shall have either a string value, a numeric value, or both. Except as stated for specific contexts, the value of an expression shall be implicitly converted to the type needed for the context in which it is used. A string value shall be converted to a numeric value by the equivalent of the following calls to functions defined by the ISO C standard:

```
setlocale(LC_NUMERIC, "");
numeric_value = atof(string_value);
```

A numeric value that is exactly equal to the value of an integer (see Section 1.7.2 (on page 7)) shall be converted to a string by the equivalent of a call to the `sprintf` function (see String Functions (on page 167)) with the string "%d" as the `fmt` argument and the numeric value being converted as the first and only `expr` argument. Any other numeric value shall be converted to a string by the equivalent of a call to the `sprintf` function with the value of the variable `CONVFMT` as the `fmt` argument and the numeric value being converted as the first and only `expr` argument. The result of the conversion is unspecified if the value of `CONVFMT` is not a floating-point format specification. This volume of IEEE Std 1003.1-2001 specifies no explicit conversions between numbers and strings. An application can force an expression to be treated as a number by adding zero to it, or can force it to be treated as a string by concatenating the null string ("") to it.

A string value shall be considered a numeric string if it comes from one of the following:

1. Field variables
2. Input from the `getline()` function
3. `FILENAME`
4. `ARGV` array elements
5. `ENVIRON` array elements
6. Array elements created by the `split()` function
7. A command line variable assignment
8. Variable assignment from another numeric string variable

and after all the following conversions have been applied, the resulting string would lexically be
recognized as a NUMBER token as described by the lexical conventions in Grammar (on page
170):

- All leading and trailing <blank>s are discarded.
- If the first non-<blank> is ‘+’ or ‘-’, it is discarded.
- Changing each occurrence of the decimal point character from the current locale to a period.

If a ‘−’ character is ignored in the preceding description, the numeric value of the numeric string
shall be the negation of the numeric value of the recognized NUMBER token. Otherwise, the
numeric value of the numeric string shall be the numeric value of the recognized NUMBER
token. Whether or not a string is a numeric string shall be relevant only in contexts where that
term is used in this section.

When an expression is used in a Boolean context, if it has a numeric value, a value of zero shall
be treated as false and any other value shall be treated as true. Otherwise, a string value of the
null string shall be treated as false and any other value shall be treated as true. A Boolean
context shall be one of the following:

- The first subexpression of a conditional expression
- An expression operated on by logical NOT, logical AND, or logical OR
- The second expression of a for statement
- The expression of an if statement
- The expression of the while clause in either a while or do...while statement
- An expression used as a pattern (as in Overall Program Structure)

All arithmetic shall follow the semantics of floating-point arithmetic as specified by the ISO C
standard (see Section 1.7.2 (on page 7)).

The value of the expression:

```
expr1 ^ expr2
```

shall be equivalent to the value returned by the ISO C standard function call:

```
pow(expr1, expr2)
```

The expression:

```
lvalue ^= expr
```

shall be equivalent to the ISO C standard expression:

```
lvalue = pow(lvalue, expr)
```

except that lvalue shall be evaluated only once. The value of the expression:

```
expr1 % expr2
```

shall be equivalent to the value returned by the ISO C standard function call:

```
fmod(expr1, expr2)
```

The expression:

```
lvalue %= expr
```
shall be equivalent to the ISO C standard expression:
\[
\text{lvalue} = \text{fmod(lvalue, expr)}
\]
except that lvalue shall be evaluated only once.

Variables and fields shall be set by the assignment statement:
\[
\text{lvalue} = \text{expression}
\]

and the type of expression shall determine the resulting variable type. The assignment includes
the arithmetic assignments ("+=", "-=", "+=", "/=", "%=", "+", "-"), all of which
shall produce a numeric result. The left-hand side of an assignment and the target of increment
and decrement operators can be one of a variable, an array with index, or a field selector.

The awk language supplies arrays that are used for storing numbers or strings. Arrays need not
be declared. They shall initially be empty, and their sizes shall change dynamically. The
subscripts, or element identifiers, are strings, providing a type of associative array capability. An
array name followed by a subscript within square brackets can be used as an lvalue and thus as
an expression, as described in the grammar; see Grammar (on page 170). Unsubscripted array
names can be used in only the following contexts:

- A parameter in a function definition or function call
- The NAME token following any use of the keyword in as specified in the grammar (see
  Grammar (on page 170)); if the name used in this context is not an array name, the behavior
  is undefined

A valid array index shall consist of one or more comma-separated expressions, similar to the way
in which multi-dimensional arrays are indexed in some programming languages. Because awk
arrays are really one-dimensional, such a comma-separated list shall be converted to a single
string by concatenating the string values of the separate expressions, each separated from the
other by the value of the SUBSEP variable. Thus, the following two index operations shall be
equivalent:

\[
\text{var[expr1, expr2, ... exprn]}
\]
\[
\text{var[expr1 SUBSEP expr2 SUBSEP ... SUBSEP exprn]}
\]
The application shall ensure that a multi-dimensioned index used with the in operator is
parenthesized. The in operator, which tests for the existence of a particular array element, shall
not cause that element to exist. Any other reference to a nonexistent array element shall
automatically create it.

Comparisons (with the '<', '<=', '!=', '==', '>', and '>= operators) shall be made
numerically if both operands are numeric, if one is numeric and the other has a string value that
is a numeric string, or if one is numeric and the other has the uninitialized value. Otherwise,
operands shall be converted to strings as required and a string comparison shall be made using
the locale-specific collation sequence. The value of the comparison expression shall be 1 if the
relation is true, or 0 if the relation is false.
Variables and Special Variables

Variables can be used in an awk program by referencing them. With the exception of function parameters (see User-Defined Functions (on page 169)), they are not explicitly declared. Function parameter names shall be local to the function; all other variable names shall be global. The same name shall not be used both as a function parameter name and as the name of a function or a special awk variable. The same name shall not be used both as a variable name with global scope and as the name of a function. The same name shall not be used within the same scope both as a scalar variable and as an array. Uninitialized variables, including scalar variables, array elements, and field variables, shall have an uninitialized value. An uninitialized value shall have both a numeric value of zero and a string value of the empty string. Evaluation of variables with an uninitialized value, to either string or numeric, shall be determined by the context in which they are used.

Field variables shall be designated by a ‘$’ followed by a number or numerical expression. The effect of the field number expression evaluating to anything other than a non-negative integer is unspecified; uninitialized variables or string values need not be converted to numeric values in this context. New field variables can be created by assigning a value to them. References to nonexistent fields (that is, fields after $NF), shall evaluate to the uninitialized value. Such references shall not create new fields. However, assigning to a nonexistent field (for example, $NF=2) shall increase the value of NF; create any intervening fields with the uninitialized value; and cause the value of $0 to be recomputed, with the fields being separated by the value of OFS. Each field variable shall have a string value or an uninitialized value when created. Field variables shall have the uninitialized value when created from $0 using FS and the variable does not contain any characters. If appropriate, the field variable shall be considered a numeric string (see Expressions in awk (on page 156)).

Implementations shall support the following other special variables that are set by awk:

ARGC The number of elements in the ARGV array.

ARGV An array of command line arguments, excluding options and the program argument, numbered from zero to ARGC-1.

The arguments in ARGV can be modified or added to; ARGC can be altered. As each input file ends, awk shall treat the next non-null element of ARGV, up to the current value of ARGC-1, inclusive, as the name of the next input file. Thus, setting an element of ARGV to null means that it shall not be treated as an input file. The name ‘−’ indicates the standard input. If an argument matches the format of an assignment operand, this argument shall be treated as an assignment rather than a file argument.

CONVFMT The printf format for converting numbers to strings (except for output statements, where OFMT is used); "% .6g" by default.

ENVIRON An array representing the value of the environment, as described in the exec functions defined in the System Interfaces volume of IEEE Std 1003.1-2001. The indices of the array shall be strings consisting of the names of the environment variables, and the value of each array element shall be a string consisting of the value of that variable. If appropriate, the environment variable shall be considered a numeric string (see Expressions in awk (on page 156)); the array element shall also have its numeric value.

In all cases where the behavior of awk is affected by environment variables (including the environment of any commands that awk executes via the system function or via pipeline redirections with the print statement, the printf statement, or the getline function), the environment used shall be the environment at the time
awk began executing; it is implementation-defined whether any modification of
ENVIRON affects this environment.

FILENAME A pathname of the current input file. Inside a BEGIN action the value is
undefined. Inside an END action the value shall be the name of the last input file
processed.

FNR The ordinal number of the current record in the current file. Inside a BEGIN action
the value shall be zero. Inside an END action the value shall be the number of the
last record processed in the last file processed.

FS Input field separator regular expression; a <space> by default.

NF The number of fields in the current record. Inside a BEGIN action, the use of NF is
undefined unless a getline function without a var argument is executed
previously. Inside an END action, NF shall retain the value it had for the last
record read, unless a subsequent, redirected, getline function without a var
argument is performed prior to entering the END action.

NR The ordinal number of the current record from the start of input. Inside a BEGIN
action the value shall be zero. Inside an END action the value shall be the number
of the last record processed.

OFMT The printf format for converting numbers to strings in output statements (see
Output Statements (on page 165)); "%.6g" by default. The result of the
conversion is unspecified if the value of OFMT is not a floating-point format
specification.

OFS The print statement output field separation; <space> by default.

ORS The print statement output record separator; a <newline> by default.

RLENGTH The length of the string matched by the match function.

RS The first character of the string value of RS shall be the input record separator; a
<newline> by default. If RS contains more than one character, the results are
unspecified. If RS is null, then records are separated by sequences consisting of a
<newline> plus one or more blank lines, leading or trailing blank lines shall not
result in empty records at the beginning or end of the input, and a <newline> shall
always be a field separator, no matter what the value of FS is.

RSTART The starting position of the string matched by the match function, numbering from
1. This shall always be equivalent to the return value of the match function.

SUBSEP The subscript separator string for multi-dimensional arrays; the default value is
implementation-defined.

Regular Expressions

The awk utility shall make use of the extended regular expression notation (see the Base
Definitions volume of IEEE Std 1003.1-2001, Section 9.4, Extended Regular Expressions) except
that it shall allow the use of C-language conventions for escaping special characters within the
EREs, as specified in the table in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5,
File Format Notation (‘\\’, ‘\a’, ‘\b’, ‘\f’, ‘\n’, ‘\v’, ‘\r’, ‘\t’, ‘\ ’) and the following
table; these escape sequences shall be recognized both inside and outside bracket expressions.
Note that records need not be separated by <newline>s and string constants can contain
<newline>s, so even the "\n" sequence is valid in awk EREs. Using a slash character within an
ERE requires the escaping shown in the following table.
A regular expression can be matched against a specific field or string by using one of the two regular expression matching operators, ‘˜’ and "!". These operators shall interpret their right-hand operand as a regular expression and their left-hand operand as a string. If the regular expression matches the string, the ‘˜’ expression shall evaluate to a value of 1, and the "!" expression shall evaluate to a value of 0. (The regular expression matching operation is as defined by the term matched in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.1, Regular Expression Definitions, where a match occurs on any part of the string unless the regular expression is limited with the circumflex or dollar sign special characters.) If the regular expression does not match the string, the ‘˜’ expression shall evaluate to a value of 0, and the "!" expression shall evaluate to a value of 1. If the right-hand operand is any expression other than the lexical token ERE, the string value of the expression shall be interpreted as an extended regular expression, including the escape conventions described above. Note that these same escape conventions shall also be applied in determining the value of a string literal (the lexical token STRING), and thus shall be applied a second time when a string literal is used in this context.

When an ERE token appears as an expression in any context other than as the right-hand of the ‘˜’ or "!" operator or as one of the built-in function arguments described below, the value of the resulting expression shall be the equivalent of:

\$0 ˜ /ere/

The ere argument to the gsub, match, sub functions, and the fs argument to the split function (see String Functions (on page 167)) shall be interpreted as extended regular expressions. These can be either ERE tokens or arbitrary expressions, and shall be interpreted in the same manner as the right-hand side of the ‘˜’ or "!" operator.

An extended regular expression can be used to separate fields by using the –F ERE option or by assigning a string containing the expression to the built-in variable FS. The default value of the FS variable shall be a single <space>. The following describes FS behavior:

1. If FS is a null string, the behavior is unspecified.

### Table 4-2  Escape Sequences in awk

<table>
<thead>
<tr>
<th>Escape Sequence</th>
<th>Description</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;</td>
<td>Backslash quotation-mark</td>
<td>Quotation-mark character</td>
</tr>
<tr>
<td>/</td>
<td>Backslash slash</td>
<td>Slash character</td>
</tr>
<tr>
<td>\ddd</td>
<td>A backslash character followed by the longest sequence of one, two, or three octal-digit characters (01234567). If all of the digits are 0 (that is, representation of the NUL character), the behavior is undefined.</td>
<td>The character whose encoding is represented by the one, two, or three-digit octal integer. Multi-byte characters require multiple, concatenated escape sequences of this type, including the leading ‘\’ for each byte.</td>
</tr>
<tr>
<td>\c</td>
<td>A backslash character followed by any character not described in this table or in the table in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation (‘\‘, ‘\a’, ‘\b’, ‘\f’, ‘\n’, ‘\r’, ‘\t’, ‘\v’).</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

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2. If FS is a single character:
   a. If FS is <space>, skip leading and trailing <blank>s; fields shall be delimited by sets
      of one or more <blank>s.
   b. Otherwise, if FS is any other character c, fields shall be delimited by each single
      occurrence of c.
3. Otherwise, the string value of FS shall be considered to be an extended regular expression.
   Each occurrence of a sequence matching the extended regular expression shall delimit
   fields.

Except for the ‘˜’ and "!˜" operators, and in the gsub, match, split, and sub built-in functions,
ERE matching shall be based on input records; that is, record separator characters (the first
character of the value of the variable RS, <newline> by default) cannot be embedded in the
expression, and no expression shall match the record separator character. If the record separator
is not <newline>, <newline>s embedded in the expression can be matched. For the ‘˜’ and
"!˜" operators, and in those four built-in functions, ERE matching shall be based on text strings;
that is, any character (including <newline> and the record separator) can be embedded in the
pattern, and an appropriate pattern shall match any character. However, in all awk ERE
matching, the use of one or more NUL characters in the pattern, input record, or text string
produces undefined results.

Patterns

A pattern is any valid expression, a range specified by two expressions separated by a comma, or
one of the two special patterns BEGIN or END.

Special Patterns

The awk utility shall recognize two special patterns, BEGIN and END. Each BEGIN pattern
shall be matched once and its associated action executed before the first record of input is read
(except possibly by use of the getline function—see Input/Output and General Functions (on
page 168)—in a prior BEGIN action) and before command line assignment is done. Each END
pattern shall be matched once and its associated action executed after the last record of input has
been read. These two patterns shall have associated actions.

BEGIN and END shall not combine with other patterns. Multiple BEGIN and END patterns
shall be allowed. The actions associated with the BEGIN patterns shall be executed in the order
specified in the program, as are the END actions. An END pattern can precede a BEGIN pattern
in a program.

If an awk program consists of only actions with the pattern BEGIN, and the BEGIN action
contains no getline function, awk shall exit without reading its input when the last statement in
the last BEGIN action is executed. If an awk program consists of only actions with the pattern
END or only actions with the patterns BEGIN and END, the input shall be read before the
statements in the END actions are executed.
Expression Patterns

An expression pattern shall be evaluated as if it were an expression in a Boolean context. If the result is true, the pattern shall be considered to match, and the associated action (if any) shall be executed. If the result is false, the action shall not be executed.

Pattern Ranges

A pattern range consists of two expressions separated by a comma; in this case, the action shall be performed for all records between a match of the first expression and the following match of the second expression, inclusive. At this point, the pattern range can be repeated starting at input records subsequent to the end of the matched range.

Actions

An action is a sequence of statements as shown in the grammar in Grammar (on page 170). Any single statement can be replaced by a statement list enclosed in braces. The application shall ensure that statements in a statement list are separated by <newline>s or semicolons. Statements in a statement list shall be executed sequentially in the order that they appear.

The expression acting as the conditional in an if statement shall be evaluated and if it is non-zero or non-null, the following statement shall be executed; otherwise, if else is present, the statement following the else shall be executed.

The if, while, do...while, for, break, and continue statements are based on the ISO C standard (see Section 1.7.2 (on page 7)), except that the Boolean expressions shall be treated as described in Expressions in awk (on page 156), and except in the case of:

```
for (variable in array)
```

which shall iterate, assigning each index of array to variable in an unspecified order. The results of adding new elements to array within such a for loop are undefined. If a break or continue statement occurs outside of a loop, the behavior is undefined.

The delete statement shall remove an individual array element. Thus, the following code deletes an entire array:

```
for (index in array)
    delete array[index]
```

The next statement shall cause all further processing of the current input record to be abandoned. The behavior is undefined if a next statement appears or is invoked in a BEGIN or END action.

The exit statement shall invoke all END actions in the order in which they occur in the program source and then terminate the program without reading further input. An exit statement inside an END action shall terminate the program without further execution of END actions. If an expression is specified in an exit statement, its numeric value shall be the exit status of awk, unless subsequent errors are encountered or a subsequent exit statement with an expression is executed.
Output Statements

Both print and printf statements shall write to standard output by default. The output shall be written to the location specified by output redirection if one is supplied, as follows:

> expression
>> expression
| expression

In all cases, the expression shall be evaluated to produce a string that is used as a pathname into which to write (for ‘>’ or ‘>>’) or as a command to be executed (for ‘|’). Using the first two forms, if the file of that name is not currently open, it shall be opened, creating it if necessary and using the first form, truncating the file. The output then shall be appended to the file. As long as the file remains open, subsequent calls in which expression evaluates to the same string value shall simply append output to the file. The file remains open until the close function (see Input/Output and General Functions (on page 168)) is called with an expression that evaluates to the same string value.

The third form shall write output onto a stream piped to the input of a command. The stream shall be created if no stream is currently open with the value of expression as its command name. The stream created shall be equivalent to one created by a call to the popen() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 with the value of expression as the command argument and a value of w as the mode argument. As long as the stream remains open, subsequent calls in which expression evaluates to the same string value shall write output to the existing stream. The stream shall remain open until the close function (see Input/Output and General Functions (on page 168)) is called with an expression that evaluates to the same string value. At that time, the stream shall be closed as if by a call to the pclose() function defined in the System Interfaces volume of IEEE Std 1003.1-2001.

As described in detail by the grammar in Grammar (on page 170), these output statements shall take a comma-separated list of expressions referred to in the grammar by the non-terminal symbols expr_list, print_expr_list, or print_expr_list_opt. This list is referred to here as the expression list, and each member is referred to as an expression argument.

The print statement shall write the value of each expression argument onto the indicated output stream separated by the current output field separator (see variable OFS above), and terminated by the output record separator (see variable ORS above). All expression arguments shall be taken as strings, being converted if necessary; this conversion shall be as described in Expressions in awk (on page 156), with the exception that the printf format in OFMT shall be used instead of the value in CONVFMT. An empty expression list shall stand for the whole input record ($0).

The printf statement shall produce output based on a notation similar to the File Format Notation used to describe file formats in this volume of IEEE Std 1003.1-2001 (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation). Output shall be produced as specified with the first expression argument as the string format and subsequent expression arguments as the strings arg1 to argn, inclusive, with the following exceptions:

1. The format shall be an actual character string rather than a graphical representation. Therefore, it cannot contain empty character positions. The <space> in the format string, in any context other than a flag of a conversion specification, shall be treated as an ordinary character that is copied to the output.

2. If the character set contains a ‘Δ’ character and that character appears in the format string, it shall be treated as an ordinary character that is copied to the output.
3. The escape sequences beginning with a backslash character shall be treated as sequences of ordinary characters that are copied to the output. Note that these same sequences shall be interpreted lexically by awk when they appear in literal strings, but they shall not be treated specially by the printf statement.

4. A field width or precision can be specified as the ‘*’ character instead of a digit string. In this case the next argument from the expression list shall be fetched and its numeric value taken as the field width or precision.

5. The implementation shall not precede or follow output from the d or u conversion specifier characters with <blank>s not specified by the format string.

6. The implementation shall not precede output from the o conversion specifier character with leading zeros not specified by the format string.

7. For the c conversion specifier character: if the argument has a numeric value, the character whose encoding is that value shall be output. If the value is zero or is not the encoding of any character in the character set, the behavior is undefined. If the argument does not have a numeric value, the first character of the string value shall be output; if the string does not contain any characters, the behavior is undefined.

8. For each conversion specification that consumes an argument, the next expression argument shall be evaluated. With the exception of the c conversion specifier character, the value shall be converted (according to the rules specified in Expressions in awk (on page 156)) to the appropriate type for the conversion specification.

9. If there are insufficient expression arguments to satisfy all the conversion specifications in the format string, the behavior is undefined.

10. If any character sequence in the format string begins with a ‘%’ character, but does not form a valid conversion specification, the behavior is unspecified.

Both print and printf can output at least {LINE_MAX} bytes.

Functions

The awk language has a variety of built-in functions: arithmetic, string, input/output, and general.

Arithmetic Functions

The arithmetic functions, except for int, shall be based on the ISO C standard (see Section 1.7.2 (on page 7)). The behavior is undefined in cases where the ISO C standard specifies that an error be returned or that the behavior is undefined. Although the grammar (see Grammar (on page 170)) permits built-in functions to appear with no arguments or parentheses, unless the argument or parentheses are indicated as optional in the following list (by displaying them within the " [] " brackets), such use is undefined.

atan2(y,x) Return arctangent of y/x in radians in the range [−π,π].
cos(x) Return cosine of x, where x is in radians.
sin(x) Return sine of x, where x is in radians.
exp(x) Return the exponential function of x.
log(x) Return the natural logarithm of x.
sqrt(x) Return the square root of x.
int(x) Return the argument truncated to an integer. Truncation shall be toward 0 when $x > 0$.

rand() Return a random number $n$, such that $0 \leq n < 1$.

srand([expr]) Set the seed value for rand to expr or use the time of day if expr is omitted. The previous seed value shall be returned.

String Functions

The string functions in the following list shall be supported. Although the grammar (see Grammar (on page 170)) permits built-in functions to appear with no arguments or parentheses, unless the argument or parentheses are indicated as optional in the following list (by displaying them within the " [ ] " brackets), such use is undefined.

gsub(ere, repl[ , in])
Behave like sub (see below), except that it shall replace all occurrences of the regular expression (like the ed utility global substitute) in $0$ or in the in argument, when specified.

index(s, t) Return the position, in characters, numbering from 1, in string s where string t first occurs, or zero if it does not occur at all.

length([s]) Return the length, in characters, of its argument taken as a string, or of the whole record, $0$, if there is no argument.

match(s, ere) Return the position, in characters, numbering from 1, in string s where the extended regular expression ere occurs, or zero if it does not occur at all. RSTART shall be set to the starting position (which is the same as the returned value), zero if no match is found; RLENGTH shall be set to the length of the matched string, $-1$ if no match is found.

split(s, a[ , fs ]) Split the string s into array elements $a[1]$, $a[2]$, ..., $a[n]$, and return $n$. All elements of the array shall be deleted before the split is performed. The separation shall be done with the ERE fs or with the field separator FS if fs is not given. Each array element shall have a string value when created and, if appropriate, the array element shall be considered a numeric string (see Expressions in awk (on page 156)). The effect of a null string as the value of fs is unspecified.

sprintf(fmt, expr, expr, ...) Format the expressions according to the printf format given by fmt and return the resulting string.

sub(ere, repl[ , in ]) Substitute the string repl in place of the first instance of the extended regular expression ERE in string in and return the number of substitutions. An ampersand (‘&’) appearing in the string repl shall be replaced by the string from in that matches the ERE. An ampersand preceded with a backslash (‘\’) shall be interpreted as the literal ampersand character. An occurrence of two consecutive backslashes shall be interpreted as just a single literal backslash character. Any other occurrence of a backslash (for example, preceding any other character) shall be treated as a literal backslash character. Note that if repl is a string literal (the lexical token STRING; see Grammar (on page 170)), the handling of the ampersand character occurs after any lexical processing, including any lexical backslash escape sequence processing. If in is specified and it is not an lvalue (see Expressions in awk (on page 156)), the behavior is undefined. If in is omitted, awk
shall use the current record ($0) in its place.

\[ \text{substr}(s, m[, n]) \]
Return the at most \( n \)-character substring of \( s \) that begins at position \( m \), numbering from 1. If \( n \) is omitted, or if \( n \) specifies more characters than are left in the string, the length of the substring shall be limited by the length of the string \( s \).

\[ \text{tolower}(s) \]
Return a string based on the string \( s \). Each character in \( s \) that is an uppercase letter specified to have a tolower mapping by the LC_CTYPE category of the current locale shall be replaced in the returned string by the lowercase letter specified by the mapping. Other characters in \( s \) shall be unchanged in the returned string.

\[ \text{toupper}(s) \]
Return a string based on the string \( s \). Each character in \( s \) that is a lowercase letter specified to have a toupper mapping by the LC_CTYPE category of the current locale is replaced in the returned string by the uppercase letter specified by the mapping. Other characters in \( s \) are unchanged in the returned string.

All of the preceding functions that take ERE as a parameter expect a pattern or a string valued expression that is a regular expression as defined in Regular Expressions (on page 161).

Input/Output and General Functions

The input/output and general functions are:

\[ \text{close}(\text{expression}) \]
Close the file or pipe opened by a print or printf statement or a call to getline with the same string-valued expression. The limit on the number of open expression arguments is implementation-defined. If the close was successful, the function shall return zero; otherwise, it shall return non-zero.

\[ \text{getline } [\text{var}] \]
Read a record of input from a stream piped from the output of a command. The stream shall be created if no stream is currently open with the value of expression as its command name. The stream created shall be equivalent to one created by a call to the popen() function with the value of expression as the command argument and a value of \( r \) as the mode argument. As long as the stream remains open, subsequent calls in which expression evaluates to the same string value shall read subsequent records from the stream. The stream shall remain open until the close function is called with an expression that evaluates to the same string value. At that time, the stream shall be closed as if by a call to the pclose() function. If \( \text{var} \) is omitted, \$0 and NF shall be set; otherwise, \( \text{var} \) shall be set and, if appropriate, it shall be considered a numeric string (see Expressions in awk (on page 156)).

The getline operator can form ambiguous constructs when there are unparenthesized operators (including concatenate) to the left of the ‘|’ (to the beginning of the expression containing getline). In the context of the ‘$’ operator, ‘|’ shall behave as if it had a lower precedence than ‘$’. The result of evaluating other operators is unspecified, and conforming applications shall parenthesize properly all such usages.

\[ \text{getline} \]
Set \$0 to the next input record from the current input file. This form of getline shall set the NF, NR, and FNR variables.

\[ \text{getline } \text{var} \]
Set variable \( \text{var} \) to the next input record from the current input file and, if appropriate, \( \text{var} \) shall be considered a numeric string (see Expressions in awk (on page 156)). This form of getline shall set the FNR and NR variables.
Utilities

awk

ggetline [var] < expression

Read the next record of input from a named file. The expression shall be evaluated
to produce a string that is used as a pathname. If the file of that name is not
currently open, it shall be opened. As long as the stream remains open, subsequent
calls in which expression evaluates to the same string value shall read subsequent
records from the file. The file shall remain open until the close function is called
with an expression that evaluates to the same string value. If var is omitted, $0 and
NF shall be set; otherwise, var shall be set and, if appropriate, it shall be considered
a numeric string (see Expressions in awk (on page 156)).

The getline operator can form ambiguous constructs when there are
unparenthesized binary operators (including concatenate) to the right of the ' <'
(up to the end of the expression containing the getline). The result of evaluating
such a construct is unspecified, and conforming applications shall parenthesize
properly all such usages.

system(expression)

Execute the command given by expression in a manner equivalent to the system()
function defined in the System Interfaces volume of IEEE Std 1003.1-2001 and
return the exit status of the command.

All forms of getline shall return 1 for successful input, zero for end-of-file, and −1 for an error.

Where strings are used as the name of a file or pipeline, the application shall ensure that the
strings are textually identical. The terminology "same string value" implies that "equivalent
strings", even those that differ only by <space>s, represent different files.

User-Defined Functions

The awk language also provides user-defined functions. Such functions can be defined as:

function name([parameter, ...]) { statements }

A function can be referred to anywhere in an awk program; in particular, its use can precede its
definition. The scope of a function is global.

Function parameters, if present, can be either scalars or arrays; the behavior is undefined if an
array name is passed as a parameter that the function uses as a scalar, or if a scalar expression is
passed as a parameter that the function uses as an array. Function parameters shall be passed by
value if scalar and by reference if array name.

The number of parameters in the function definition need not match the number of parameters
in the function call. Excess formal parameters can be used as local variables. If fewer arguments
are supplied in a function call than are in the function definition, the extra parameters that are
used in the function body as scalars shall evaluate to the uninitialized value until they are
otherwise initialized, and the extra parameters that are used in the function body as arrays shall
be treated as uninitialized arrays where each element evaluates to the uninitialized value until
otherwise initialized.

When invoking a function, no white space can be placed between the function name and the
opening parenthesis. Function calls can be nested and recursive calls can be made upon
functions. Upon return from any nested or recursive function call, the values of all of the calling
function's parameters shall be unchanged, except for array parameters passed by reference. The
return statement can be used to return a value. If a return statement appears outside of a
function definition, the behavior is undefined.

In the function definition, <newline>s shall be optional before the opening brace and after the
closing brace. Function definitions can appear anywhere in the program where a pattern-action
pair is allowed.

**Grammar**

The grammar in this section and the lexical conventions in the following section shall together
describe the syntax for awk programs. The general conventions for this style of grammar are
described in Section 1.10 (on page 19). A valid program can be represented as the non-terminal
symbol `program` in the grammar. This formal syntax shall take precedence over the preceding
text syntax description.

```awk
%token NAME NUMBER STRING ERE
%token FUNC_NAME /* Name followed by '(', without white space. */
/* Keywords */
%token BEGIN END /* 'BEGIN' 'END' */
%token Break Continue Delete Do Else /* 'break' 'continue' 'delete' 'do' 'else' */
%token Exit For Function If In /* 'exit' 'for' 'function' 'if' 'in' */
%token Next Print Printf Return While /* 'next' 'print' 'printf' 'return' 'while' */
/* Reserved function names */
%token BUILTIN_FUNC_NAME /* One token for the following: */
* atan2 cos sin log sqrt int rand srand
* gsub index length match split sprintf sub
* substr tolower toupper close system
/* Two-character tokens. */
%token ADD_ASSIGN SUB_ASSIGN MUL_ASSIGN DIV_ASSIGN MOD_ASSIGN POW_ASSIGN
/* '+=' '−=' '*=' '/=' '%' '^=' */
%token OR AND NO_MATCH EQ LE GE NE INCR DECR APPEND
/* '||' '&amp;' '!' '=' '<=' '>=' '!=' '<' '>' '+' '-' '++' '--' '>>' */
/* One-character tokens. */
%token '{' '}' '(' ')' '[' ']' ',' ';' NEWLINE
%token '+' '−' '!' '??' '!' '!' '>' '<' '|' '??' '??' ':=' '~' '$' '='
%start program
%
program : item_list
  | actionless_item_list
  ;
item_list : newline_opt
  | actionless_item_list item terminator
  | item_list item terminator
  | item_list action terminator
  ;
```

---

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actionless_item_list : item_list pattern terminator
    | actionless_item_list pattern terminator
    
    item : pattern action
    | Function NAME '(' param_list_opt ')' newline_opt action
    | Function FUNC_NAME '(' param_list_opt ')' newline_opt action
    
    param_list_opt : /* empty */
    | param_list
    
    param_list : NAME
    | param_list ',' NAME
    
    pattern : Begin
    | End
    | expr
    | expr ',' newline_opt expr
    
    action : '{ newline_opt },'
    | '{ newline_opt terminated_statement_list '}
    | '{ newline_opt unterminated_statement_list '}
    
    terminator : terminator ';
    | terminator NEWLINE
    | ';
    | NEWLINE
    
    terminated_statement_list : terminated_statement
    | terminated_statement_list terminated_statement
    
    unterminated_statement_list : unterminated_statement
    | terminated_statement_list unterminated_statement
    
    terminated_statement : action newline_opt
    | If '(' expr ')' newline_opt terminated_statement
    | If '(' expr ')' newline_opt terminated_statement
    | Else newline_opt terminated_statement
    | While '(' expr ')' newline_opt terminated_statement
    | For '(' simple_statement_opt ';
    | expr_opt ';' simple_statement_opt ')' newline_opt
    | terminated_statement
    | For '(' NAME In NAME ')' newline_opt
    | ';' newline_opt
    | terminatable_statement NEWLINE newline_opt
    | terminatable_statement ';' newline_opt
awk

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unterminated_statement : terminatable_statement
  | If '(' expr ')' newline_opt unterminated_statement
  | If '(' expr ')' newline_opt terminated_statement
  | Else newline_opt unterminated_statement
  | While '(' expr ')' newline_opt unterminated_statement
  | For '(' simple_statement_opt ';' expr_opt ';' simple_statement_opt ')' newline_opt unterminated_statement
  | For '(' NAME In NAME ')' newline_opt unterminated_statement
  | newline_opt unterminated_statement

terminatable_statement : simple_statement
  | Break
  | Continue
  | Next
  | Exit expr_opt
  | Return expr_opt
  | Do newline_opt terminated_statement While '(' expr ')' newline_opt

simple_statement_opt : /* empty */
  | simple_statement

simple_statement : Delete NAME '[' expr_list ']'
  | expr
  | print_statement

print_statement : simple_print_statement
  | simple_print_statement output_redirection

simple_print_statement : Print print_expr_list_opt
  | Print '(' multiple_expr_list ')' printf print_expr_list
  | Printf '(' multiple_expr_list ')

output_redirection : '>' expr
  | APPEND expr
  | '!' expr

expr_list_opt : /* empty */
  | expr_list

expr_list : expr
  | multiple_expr_list

multiple_expr_list : expr ',' newline_opt expr
  | multiple_expr_list ',' newline_opt expr
awk

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| non_unary_expr OR newline_opt expr |
| non_unary_expr '? expr ':' expr |
| NUMBER |
| STRING |
| lvalue |
| ERE |
| lvalue INCR |
| lvalue DECR |
| INCR lvalue |
| DECR lvalue |
| lvalue POW_ASSIGN expr |
| lvalue MOD_ASSIGN expr |
| lvalue MUL_ASSIGN expr |
| lvalue DIV_ASSIGN expr |
| lvalue ADD_ASSIGN expr |
| lvalue SUB_ASSIGN expr |
| lvalue '=' expr |
| FUNC_NAME '(' expr_list_opt ')' |
| /* no white space allowed before '(' */ |
| BUILTIN_FUNC_NAME '(' expr_list_opt ')' |
| BUILTIN_FUNC_NAME |
| non_unary_input_function |

print_expr_list_opt : /* empty */ |
| print_expr_list |
| ; |

print_expr_list : print_expr |
| print_expr_list ',', newline_opt print_expr |
| ; |

print_expr : unary_print_expr |
| non_unary_print_expr |
| ; |

unary_print_expr : '+' print_expr |
| '-' print_expr |
| unary_print_expr '^', print_expr |
| unary_print_expr '*', print_expr |
| unary_print_expr '/', print_expr |
| unary_print_expr '%', print_expr |
| unary_print_expr '+', print_expr |
| unary_print_expr '-', print_expr |
| unary_print_expr '-', print_expr |
| unary_print_expr NO_MATCH print_expr |
| unary_print_expr In NAME |
| unary_print_expr AND newline_opt print_expr |
| unary_print_expr OR newline_opt print_expr |
| unary_print_expr '?', print_expr ':' print_expr |
| ; |

non_unary_print_expr : '(' expr ')' |
| ')' print_expr |
Utilities

awk

| non_unary_print_expr '^'      | print_expr   |
| non_unary_print_expr '*'      | print_expr   |
| non_unary_print_expr '/'      | print_expr   |
| non_unary_print_expr '%'      | print_expr   |
| non_unary_print_expr '+'      | print_expr   |
| non_unary_print_expr '-'      | print_expr   |
| non_unary_print_expr '~'      | print_expr   |
| non_unary_print_expr NO_MATCH | print_expr   |
| non_unary_print_expr In NAME  |             |
| '{' 'multiple_expr_list '}'   | In NAME     |
| non_unary_print_expr AND newline_opt print_expr |
| non_unary_print_expr OR newline_opt print_expr |
| non_unary_print_expr '?' print_expr ':' print_expr |
| NUMBER                        |
| STRING                        |
| lvalue                        |
| ERE                           |
| lvalue INCR                   |
| lvalue DECR                   |
| INCR lvalue                   |
| DECR lvalue                   |
| lvalue POW_ASSIGN print_expr   |
| lvalue MOD_ASSIGN print_expr   |
| lvalue MUL_ASSIGN print_expr   |
| lvalue DIV_ASSIGN print_expr   |
| lvalue ADD_ASSIGN print_expr   |
| lvalue SUB_ASSIGN print_expr   |
| lvalue '=' print_expr         |
| FUNC_NAME '{' expr_list_opt '}' |
| /* no white space allowed before '{' */ |
| BUILTIN_FUNC_NAME '{' expr_list_opt '}' |
| BUILTIN_FUNC_NAME             |
| ;                             |
| lvalue                         : NAME |
| NAME '{' expr_list '}'        |
| '$' expr                      |
| ;                             |
| non_unary_input_function : simple_get |
| simple_get '<' expr           |
| non_unary_expr '|' simple_get |
| ;                             |
| unary_input_function : unary_expr '|' simple_get |
| ;                             |
| simple_get : GETLINE          |
| GETLINE lvalue                |
| ;                             |
| newline_opt : /* empty */     |
| newline_opt NEWLINE           |
| ;                             |
This grammar has several ambiguities that shall be resolved as follows:

- Operator precedence and associativity shall be as described in Table 4-1 (on page 156).
- In case of ambiguity, an else shall be associated with the most immediately preceding if that would satisfy the grammar.
- In some contexts, a slash ('/') that is used to surround an ERE could also be the division operator. This shall be resolved in such a way that wherever the division operator could appear, a slash is assumed to be the division operator. (There is no unary division operator.)

One convention that might not be obvious from the formal grammar is where <newline>s are acceptable. There are several obvious placements such as terminating a statement, and a backslash can be used to escape <newline>s between any lexical tokens. In addition, <newline>s without backslashes can follow a comma, an open brace, logical AND operator ('&&'), logical OR operator ('||'), the do keyword, the else keyword, and the closing parenthesis of an if, for, or while statement. For example:

```awk
{ print $1,
  $2 }
```

**Lexical Conventions**

The lexical conventions for awk programs, with respect to the preceding grammar, shall be as follows:

1. Except as noted, awk shall recognize the longest possible token or delimiter beginning at a given point.
2. A comment shall consist of any characters beginning with the number sign character and terminated by, but excluding the next occurrence of, a <newline>. Comments shall have no effect, except to delimit lexical tokens.
3. The <newline> shall be recognized as the token NEWLINE.
4. A backslash character immediately followed by a <newline> shall have no effect.
5. The token STRING shall represent a string constant. A string constant shall begin with the character '"'. Within a string constant, a backslash character shall be considered to begin an escape sequence as specified in the table in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation (" \", ", \a", ", \b", ", \f", ", \n", ", \r", ", \t", ", \v"). In addition, the escape sequences in Table 4-2 (on page 162) shall be recognized. A <newline> shall not occur within a string constant. A string constant shall be terminated by the first unescaped occurrence of the character '"' after the one that begins the string constant. The value of the string shall be the sequence of all unescaped characters and values of escape sequences between, but not including, the two delimiting '"' characters.
6. The token ERE represents an extended regular expression constant. An ERE constant shall begin with the slash character '/'. Within an ERE constant, a backslash character shall be considered to begin an escape sequence as specified in the table in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation. In addition, the escape sequences in Table 4-2 (on page 162) shall be recognized. The application shall ensure that a <newline> does not occur within an ERE constant. An ERE constant shall be terminated by the first unescaped occurrence of the slash character after the one that begins the ERE constant. The extended regular expression represented by the ERE constant shall be the sequence of all unescaped characters and values of escape sequences between, but not including, the two delimiting slash characters.
7. A <blank> shall have no effect, except to delimit lexical tokens or within STRING or ERE
tokens.

8. The token NUMBER shall represent a numeric constant. Its form and numeric value shall
be equivalent to either of the tokens floating-constant or integer-constant as specified by
the ISO C standard, with the following exceptions:

a. An integer constant cannot begin with 0x or include the hexadecimal digits ‘a’, ‘b’,

b. The value of an integer constant beginning with 0 shall be taken in decimal rather
than octal.

c. An integer constant cannot include a suffix (‘u’, ‘U’, ‘l’, or ‘L’).

d. A floating constant cannot include a suffix (‘f’, ‘F’, ‘L’, or ‘L’).

If the value is too large or too small to be representable (see Section 1.7.2 (on page 7)), the
behavior is undefined.

9. A sequence of underscores, digits, and alphabets from the portable character set (see the
Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set),
beginning with an underscore or alphabetic, shall be considered a word.

10. The following words are keywords that shall be recognized as individual tokens; the name
of the token is the same as the keyword:

```
BEGIN delete END function in printf
break do exit getline next return
continue else for if print while
```

11. The following words are names of built-in functions and shall be recognized as the token
BUILTIN_FUNC_NAME:

```
atan2 gsub log split sub toupper
close index match sprintf substr
cos int rand sqrt system
exp length sin srand tolower
```

The above-listed keywords and names of built-in functions are considered reserved words.

12. The token NAME shall consist of a word that is not a keyword or a name of a built-in
function and is not followed immediately (without any delimiters) by the ‘(‘ character.

13. The token FUNC_NAME shall consist of a word that is not a keyword or a name of a
built-in function, followed immediately (without any delimiters) by the ‘(‘ character. The
‘(‘ character shall not be included as part of the token.

14. The following two-character sequences shall be recognized as the named tokens:

```
<table>
<thead>
<tr>
<th>Token Name</th>
<th>Sequence</th>
<th>Token Name</th>
<th>Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD_ASSIGN</td>
<td>+=</td>
<td>NO_MATCH</td>
<td>! ~</td>
</tr>
<tr>
<td>SUB_ASSIGN</td>
<td>-=</td>
<td>EQ</td>
<td>==</td>
</tr>
<tr>
<td>MUL_ASSIGN</td>
<td>*=</td>
<td>LE</td>
<td>&lt;=</td>
</tr>
<tr>
<td>DIV_ASSIGN</td>
<td>/=</td>
<td>GE</td>
<td>&gt;=</td>
</tr>
<tr>
<td>MOD_ASSIGN</td>
<td>%=</td>
<td>NE</td>
<td>!=</td>
</tr>
<tr>
<td>POW_ASSIGN</td>
<td>^=</td>
<td>INCR</td>
<td>++</td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AND</td>
<td>&amp; &amp;</td>
<td>APPEND</td>
<td>&gt;&gt;</td>
</tr>
</tbody>
</table>
```
15. The following single characters shall be recognized as tokens whose names are the character:

\(<\text{newline}>\{\}\) () [] , ; + - * % ^ ! > < | ? : ~ $ =

There is a lexical ambiguity between the token \texttt{ERE} and the tokens '//' and \texttt{DIV_ASSIGN}. When an input sequence begins with a slash character in any syntactic context where the token '//' or \texttt{DIV_ASSIGN} could appear as the next token in a valid program, the longer of those two tokens that can be recognized shall be recognized. In any other syntactic context where the token \texttt{ERE} could appear as the next token in a valid program, the token \texttt{ERE} shall be recognized.

\textbf{EXIT STATUS}

The following exit values shall be returned:

- 0 All input files were processed successfully.
- >0 An error occurred.

The exit status can be altered within the program by using an \texttt{exit} expression.

\textbf{CONSEQUENCES OF ERRORS}

If any file operand is specified and the named file cannot be accessed, \texttt{awk} shall write a diagnostic message to standard error and terminate without any further action.

If the program specified by either the program operand or a profile operand is not a valid \texttt{awk} program (as specified in the EXTENDED DESCRIPTION section), the behavior is undefined.

\textbf{APPLICATION USAGE}

The \texttt{index}, \texttt{length}, \texttt{match}, and \texttt{substr} functions should not be confused with similar functions in the ISO C standard; the \texttt{awk} versions deal with characters, while the ISO C standard deals with bytes.

Because the concatenation operation is represented by adjacent expressions rather than an explicit operator, it is often necessary to use parentheses to enforce the proper evaluation precedence.

\textbf{EXAMPLES}

The \texttt{awk} program specified in the command line is most easily specified within single-quotes (for example, \texttt{"program"}) for applications using \texttt{sh}, because \texttt{awk} programs commonly contain characters that are special to the shell, including double-quotes. In the cases where an \texttt{awk} program contains single-quote characters, it is usually easiest to specify most of the program as strings within single-quotes concatenated by the shell with quoted single-quote characters. For example:

```
awk '\"\'/ \{ print "quote:\", $0 \}'
```

prints all lines from the standard input containing a single-quote character, prefixed with \texttt{quote:}.

The following are examples of simple \texttt{awk} programs:

1. Write to the standard output all input lines for which field 3 is greater than 5:

```
$3 > 5
```

2. Write every tenth line:

```
(NR % 10) == 0
```

3. Write any line with a substring matching the regular expression:

```
//(G|D)(2[0-9][[:alpha:]]*)/
```
4. Print any line with a substring containing a ‘G’ or ‘D’, followed by a sequence of digits and characters. This example uses character classes \texttt{digit} and \texttt{alpha} to match language-independent digit and alphabetic characters respectively:
\begin{verbatim}
\(G|D)((?:digit:)|(?:alpha:))*(\)
\end{verbatim}

5. Write any line in which the second field matches the regular expression and the fourth field does not:
\begin{verbatim}
\$2 ~ /xyz/ && $4 !~ /xyz/
\end{verbatim}

6. Write any line in which the second field contains a backslash:
\begin{verbatim}
\$2 ~ /\\/
\end{verbatim}

7. Write any line in which the second field contains a backslash. Note that backslash escapes are interpreted twice; once in lexical processing of the string and once in processing the regular expression:
\begin{verbatim}
\$2 ~ "\\\\"
\end{verbatim}

8. Write the second to the last and the last field in each line. Separate the fields by a colon:
\begin{verbatim}
{OFS=":";print $(NF-1), $NF}
\end{verbatim}

9. Write the line number and number of fields in each line. The three strings representing the line number, the colon, and the number of fields are concatenated and that string is written to standard output:
\begin{verbatim}
{print NR "":" NF}
\end{verbatim}

10. Write lines longer than 72 characters:
\begin{verbatim}
length($0) > 72
\end{verbatim}

11. Write the first two fields in opposite order separated by \texttt{OFS}:
\begin{verbatim}
{ print $2, $1 }
\end{verbatim}

12. Same, with input fields separated by a comma or <space>s and <tab>s, or both:
\begin{verbatim}
BEGIN { FS = "",[ \t]*|[ \t]+ " }
\end{verbatim}

13. Add up the first column, print sum, and average:
\begin{verbatim}
{s += $1 }
END {print "sum is ", s, " average is ", s/NR}
\end{verbatim}

14. Write fields in reverse order, one per line (many lines out for each line in):
\begin{verbatim}
{ for (i = NF; i > 0; --i) print $i }
\end{verbatim}

15. Write all lines between occurrences of the strings \texttt{start} and \texttt{stop}:
\begin{verbatim}
/start/, /stop/
\end{verbatim}

16. Write all lines whose first field is different from the previous one:
\begin{verbatim}
$1 != prev { print; prev = $1 }
\end{verbatim}

17. Simulate \texttt{echo}:
\begin{verbatim}
BEGIN {
   for (i = 1; i < ARGC; ++i)
      printf("%s%s", ARGV[i], i==ARGC-1?"\n": "
\end{verbatim}
18. Write the path prefixes contained in the \textit{PATH} environment variable, one per line:

\begin{verbatim}
BEGIN {
    n = split (ENVIRON["PATH"], path, ":")
    for (i = 1; i <= n; ++i)
        print path[i]
}
\end{verbatim}

19. If there is a file named \texttt{input} containing page headers of the form:

\begin{verbatim}
Page #
\end{verbatim}

and a file named \texttt{program} that contains:

\begin{verbatim}
/Page/ { $2 = n++; }
{ print }
\end{verbatim}

then the command line:

\begin{verbatim}
awk −f program n=5 input
\end{verbatim}

prints the file \texttt{input}, filling in page numbers starting at 5.

\textbf{RATIONALE}

This description is based on the new \textit{awk}, "nawk", (see the referenced \textit{The AWK Programming Language}), which introduced a number of new features to the historical \textit{awk}:

1. New keywords: \texttt{delete, do, function, return}
2. New built-in functions: \texttt{atan2, close, cos, gsub, match, rand, sin, srand, sub, system}
3. New predefined variables: \texttt{FNR, ARGC, ARGV, RSTART, RLENGTH, SUBSEP}
4. New expression operators: ?, :, ^
5. The \texttt{FS} variable and the third argument to \texttt{split}, now treated as extended regular expressions.
6. The operator precedence, changed to more closely match the C language. Two examples of code that operate differently are:

\begin{verbatim}
while ( n /= 10 > 1) ...  
if (!"wk" ~ /bwk/) ...  
\end{verbatim}

Several features have been added based on newer implementations of \textit{awk}:

- Multiple instances of \texttt{−f proglfile} are permitted.
- The new option \texttt{−v assignment}.
- The new predefined variable \texttt{ENVIRON}.
- New built-in functions \texttt{toupper} and \texttt{tolower}.
- More formatting capabilities are added to \texttt{printf} to match the ISO C standard.

The overall \textit{awk} syntax has always been based on the C language, with a few features from the shell command language and other sources. Because of this, it is not completely compatible with any other language, which has caused confusion for some users. It is not the intent of the standard developers to address such issues. A few relatively minor changes toward making the language more compatible with the ISO C standard were made; most of these changes are based on similar changes in recent implementations, as described above. There remain several C-
language conventions that are not in *awk*. One of the notable ones is the comma operator, which is commonly used to specify multiple expressions in the C language for statement. Also, there are various places where *awk* is more restrictive than the C language regarding the type of expression that can be used in a given context. These limitations are due to the different features that the *awk* language does provide.

Regular expressions in *awk* have been extended somewhat from historical implementations to make them a pure superset of extended regular expressions, as defined by IEEE Std 1003.1-2001 (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.4, Extended Regular Expressions). The main extensions are internationalization features and interval expressions. Historical implementations of *awk* have long supported backslash escape sequences as an extension to extended regular expressions, and this extension has been retained despite inconsistency with other utilities. The number of escape sequences recognized in both extended regular expressions and strings has varied (generally increasing with time) among implementations. The set specified by IEEE Std 1003.1-2001 includes most sequences known to be supported by popular implementations and by the ISO C standard. One sequence that is not supported is hexadecimal value escapes beginning with ‘\x’. This would allow values expressed in more than 9 bits to be used within *awk* as in the ISO C standard. However, because this syntax has a non-deterministic length, it does not permit the subsequent character to be a hexadecimal digit. This limitation can be dealt with in the C language by the use of lexical string concatenation. In the *awk* language, concatenation could also be a solution for strings, but not for extended regular expressions (either lexical ERE tokens or strings used dynamically as regular expressions). Because of this limitation, the feature has not been added to IEEE Std 1003.1-2001.

When a string variable is used in a context where an extended regular expression normally appears (where the lexical token ERE is used in the grammar) the string does not contain the literal slashes.

Some versions of *awk* allow the form:

```
func name(args, ...) { statements }
```

This has been deprecated by the authors of the language, who asked that it not be specified.

Historical implementations of *awk* produce an error if a `next` statement is executed in a `BEGIN` action, and cause *awk* to terminate if a `next` statement is executed in an `END` action. This behavior has not been documented, and it was not believed that it was necessary to standardize it.

The specification of conversions between string and numeric values is much more detailed than in the documentation of historical implementations or in the referenced *The AWK Programming Language*. Although most of the behavior is designed to be intuitive, the details are necessary to ensure compatible behavior from different implementations. This is especially important in relational expressions since the types of the operands determine whether a string or numeric comparison is performed. From the perspective of an application writer, it is usually sufficient to expect intuitive behavior and to force conversions (by adding zero or concatenating a null string) when the type of an expression does not obviously match what is needed. The intent has been to specify historical practice in almost all cases. The one exception is that, in historical implementations, variables and constants maintain both string and numeric values after their original value is converted by any use. This means that referencing a variable or constant can have unexpected side effects. For example, with historical implementations the following program:

```bash
{   a = "+2" 
    b = 2
```
if (NR % 2)
    c = a + b
if (a == b)
    print "numeric comparison"
else
    print "string comparison"
}

would perform a numeric comparison (and output numeric comparison) for each odd-numbered line, but perform a string comparison (and output string comparison) for each even-numbered line. IEEE Std 1003.1-2001 ensures that comparisons will be numeric if necessary.

With historical implementations, the following program:

BEGIN {
    OFMT = "%e"
    print 3.14
    OFMT = "%f"
    print 3.14
}

would output "3.140000e+00" twice, because in the second print statement the constant "3.14" would have a string value from the previous conversion. IEEE Std 1003.1-2001 requires that the output of the second print statement be "3.140000". The behavior of historical implementations was seen as too unintuitive and unpredictable.

It was pointed out that with the rules contained in early drafts, the following script would print nothing:

BEGIN {
    y[1.5] = 1
    OFMT = "%e"
    print y[1.5]
}

Therefore, a new variable, CONVFMT, was introduced. The OFMT variable is now restricted to affecting output conversions of numbers to strings and CONVFMT is used for internal conversions, such as comparisons or array indexing. The default value is the same as that for OFMT, so unless a program changes CONVFMT (which no historical program would do), it will receive the historical behavior associated with internal string conversions.

The POSIX awk lexical and syntactic conventions are specified more formally than in other sources. Again the intent has been to specify historical practice. One convention that may not be obvious from the formal grammar as in other verbal descriptions is where <newline>s are acceptable. There are several obvious placements such as terminating a statement, and a backslash can be used to escape <newline>s between any lexical tokens. In addition, <newline>s without backslashes can follow a comma, an open brace, a logical AND operator ("&&"), a logical OR operator ("||"), the do keyword, the else keyword, and the closing parenthesis of an if, for, or while statement. For example:

{ print $1, 
  $2 } 

The requirement that awk add a trailing <newline> to the program argument text is to simplify the grammar, making it match a text file in form. There is no way for an application or test suite to determine whether a literal <newline> is added or whether awk simply acts as if it did.
IEEE Std 1003.1-2001 requires several changes from historical implementations in order to support internationalization. Probably the most subtle of these is the use of the decimal-point character, defined by the LC_NUMERIC category of the locale, in representations of floating-point numbers. This locale-specific character is used in recognizing numeric input, in converting between strings and numeric values, and in formatting output. However, regardless of locale, the period character (the decimal-point character of the POSIX locale) is the decimal-point character recognized in processing awk programs (including assignments in command line arguments). This is essentially the same convention as the one used in the ISO C standard. The difference is that the C language includes the setlocale() function, which permits an application to modify its locale. Because of this capability, a C application begins executing with its locale set to the C locale, and only executes in the environment-specified locale after an explicit call to setlocale(). However, adding such an elaborate new feature to the awk language was seen as inappropriate for IEEE Std 1003.1-2001. It is possible to execute an awk program explicitly in any desired locale by setting the environment in the shell.

The undefined behavior resulting from NULs in extended regular expressions allows future extensions for the GNU gawk program to process binary data.

The behavior in the case of invalid awk programs (including lexical, syntactic, and semantic errors) is undefined because it was considered overly limiting on implementations to specify. In most cases such errors can be expected to produce a diagnostic and a non-zero exit status. However, some implementations may choose to extend the language in ways that make use of certain invalid constructs. Other invalid constructs might be deemed worthy of a warning, but otherwise cause some reasonable behavior. Still other constructs may be very difficult to detect in some implementations. Also, different implementations might detect a given error during an initial parsing of the program (before reading any input files) while others might detect it when executing the program after reading some input. Implementors should be aware that diagnosing errors as early as possible and producing useful diagnostics can ease debugging of applications, and thus make an implementation more usable.

The unspecified behavior from using multi-character RS values is to allow possible future extensions based on extended regular expressions used for record separators. Historical implementations take the first character of the string and ignore the others.

Unspecified behavior when split(string_array,<null>) is used is to allow a proposed future extension that would split up a string into an array of individual characters.

In the context of the getline function, equally good arguments for different precedences of the | and < operators can be made. Historical practice has been that:

```
getline < "a" "b"
```

is parsed as:

```
( getline < "a" ) "b"
```

although many would argue that the intent was that the file ab should be read. However:

```
getline < "x" + 1
```

parses as:

```
getline < ( "x" + 1 )
```

Similar problems occur with the | version of getline, particularly in combination with $. For example:

```
$"echo hi" | getline
```
(This situation is particularly problematic when used in a print statement, where the | getline part might be a redirection of the print.)

Since in most cases such constructs are not (or at least should not) be used (because they have a natural ambiguity for which there is no conventional parsing), the meaning of these constructs has been made explicitly unspecified. (The effect is that a conforming application that runs into the problem must parenthesize to resolve the ambiguity.) There appeared to be few if any actual uses of such constructs.

Grammars can be written that would cause an error under these circumstances. Where backwards-compatibility is not a large consideration, implementors may wish to use such grammars.

Some historical implementations have allowed some built-in functions to be called without an argument list, the result being a default argument list chosen in some “reasonable” way. Use of length as a synonym for length($0) is the only one of these forms that is thought to be widely known or widely used; this particular form is documented in various places (for example, most historical awk reference pages, although not in the referenced The AWK Programming Language) as legitimate practice. With this exception, default argument lists have always been undocumented and vaguely defined, and it is not at all clear how (or if) they should be generalized to user-defined functions. They add no useful functionality and preclude possible future extensions that might need to name functions without calling them. Not standardizing them seems the simplest course. The standard developers considered that length merited special treatment, however, since it has been documented in the past and sees possibly substantial use in historical programs. Accordingly, this usage has been made legitimate, but Issue 5 removed the obsolescent marking for XSI-conforming implementations and many otherwise conforming applications depend on this feature.

In sub and gsub, if repl is a string literal (the lexical token STRING), then two consecutive backslash characters should be used in the string to ensure a single backslash will precede the ampersand when the resultant string is passed to the function. (For example, to specify one literal ampersand in the replacement string, use gsub(ERE, "\&").) Historically the only special character in the repl argument of sub and gsub string functions was the ampersand (‘&’) character and preceding it with the backslash character was used to turn off its special meaning.

The description in the ISO POSIX-2: 1993 standard introduced behavior such that the backslash character was another special character and it was unspecified whether there were any other special characters. This description introduced several portability problems, some of which are described below, and so it has been replaced with the more historical description. Some of the problems include:

- Historically, to create the replacement string, a script could use gsub(ERE, "\&"), but with the ISO POSIX-2: 1993 standard wording, it was necessary to use gsub(ERE, "\\\&"). Backslash characters are doubled here because all string literals are subject to lexical analysis, which would reduce each pair of backslash characters to a single backslash before being passed to gsub.

- Since it was unspecified what the special characters were, for portable scripts to guarantee that characters are printed literally, each character had to be preceded with a backslash. (For example, a portable script had to use gsub(ERE, "\\h\\i") to produce a replacement string of "hi ".)

The description for comparisons in the ISO POSIX-2: 1993 standard did not properly describe historical practice because of the way numeric strings are compared as numbers. The current rules cause the following code:
if (0 == "000")
    print "strange, but true"
else
    print "not true"

to do a numeric comparison, causing the if to succeed. It should be intuitively obvious that this is incorrect behavior, and indeed, no historical implementation of awk actually behaves this way.

To fix this problem, the definition of numeric string was enhanced to include only those values obtained from specific circumstances (mostly external sources) where it is not possible to determine unambiguously whether the value is intended to be a string or a numeric.

Variables that are assigned to a numeric string shall also be treated as a numeric string. (For example, the notion of a numeric string can be propagated across assignments.) In comparisons, all variables having the uninitialized value are to be treated as a numeric operand evaluating to the numeric value zero.

Uninitialized variables include all types of variables including scalars, array elements, and fields. The definition of an uninitialized value in Variables and Special Variables (on page 160) is necessary to describe the value placed on uninitialized variables and on fields that are valid (for example, < $NF) but have no characters in them and to describe how these variables are to be used in comparisons. A valid field, such as $1, that has no characters in it can be obtained from an input line of "\t\t" when FS='\t'. Historically, the comparison ($1<10) was done numerically after evaluating $1 to the value zero.

The phrase ‘… also shall have the numeric value of the numeric string’ was removed from several sections of the ISO POSIX-2:1993 standard because it specifies an unnecessary implementation detail. It is not necessary for IEEE Std 1003.1-2001 to specify that these objects be assigned two different values. It is only necessary to specify that these objects may evaluate to two different values depending on context.

The description of numeric string processing is based on the behavior of the atof() function in the ISO C standard. While it is not a requirement for an implementation to use this function, many historical implementations of awk do. In the ISO C standard, floating-point constants use a period as a decimal point character for the language itself, independent of the current locale, but the atof() function and the associated strtod() function use the decimal point character of the current locale when converting strings to numeric values. Similarly in awk, floating-point constants in an awk script use a period independent of the locale, but input strings use the decimal point character of the locale.

FUTURE DIRECTIONS

None.

SEE ALSO
Section 1.10 (on page 19), grep, lex, sed, the System Interfaces volume of IEEE Std 1003.1-2001, atof(), exec, popen(), setlocale(), strtod()
IEEE PASC Interpretation 1003.2 #211 is applied, adding the sentence “An occurrence of two consecutive backslashes shall be interpreted as just a single literal backslash character.” into the description of the `sub` string function.
NAME
basename — return non-directory portion of a pathname

SYNOPSIS
basename string [suffix]

DESCRIPTION
The *string* operand shall be treated as a pathname, as defined in the Base Definitions volume of
IEEE Std 1003.1-2001, Section 3.266, Pathname. The string *string* shall be converted to the
filename corresponding to the last pathname component in *string* and then the suffix string
*suffix*, if present, shall be removed. This shall be done by performing actions equivalent to the
following steps in order:

1. If *string* is a null string, it is unspecified whether the resulting string is ‘. ’ or a null string.
In either case, skip steps 2 through 6.
2. If *string* is "//", it is implementation-defined whether steps 3 to 6 are skipped or
processed.
3. If *string* consists entirely of slash characters, *string* shall be set to a single slash character. In
this case, skip steps 4 to 6.
4. If there are any trailing slash characters in *string*, they shall be removed.
5. If there are any slash characters remaining in *string*, the prefix of *string* up to and including
the last slash character in *string* shall be removed.
6. If the *suffix* operand is present, is not identical to the characters remaining in *string*, and is
identical to a suffix of the characters remaining in *string*, the suffix *suffix* shall be removed
from *string*. Otherwise, *string* is not modified by this step. It shall not be considered an
error if *suffix* is not found in *string*.

The resulting string shall be written to standard output.

OPTIONS
None.

OPERANDS
The following operands shall be supported:

string A string.
suffix A string.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of basename:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.
Utilities

**LC_CTYPE**
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**basename**

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
The *basename* utility shall write a line to the standard output in the following format:

```
"%s\n", <resulting string>
```

**STDERR**
The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

**CONSEQUENCES OF ERRORS**
Default.

**APPLICATION USAGE**
The definition of *pathname* specifies implementation-defined behavior for pathnames starting with two slash characters. Therefore, applications shall not arbitrarily add slashes to the beginning of a pathname unless they can ensure that there are more or less than two or are prepared to deal with the implementation-defined consequences.

**EXAMPLES**
If the string *string* is a valid pathname:

```bash
$(basename "string")
```

produces a filename that could be used to open the file named by *string* in the directory returned by:

```bash
$(dirname "string")
```

If the string *string* is not a valid pathname, the same algorithm is used, but the result need not be a valid filename. The *basename* utility is not expected to make any judgements about the validity of *string* as a pathname; it just follows the specified algorithm to produce a result string.

The following shell script compiles `/usr/src/cmd/cat.c` and moves the output to a file named *cat* in the current directory when invoked with the argument `/usr/src/cmd/cat` or with the argument `/usr/src/cmd/cat.c`:
Utilities

basename

c99 $(dirname "$1")/$(basename "$1" .c).c
mv a.out $(basename "$1" .c)

RATIONALE
The behaviors of basename and dirname have been coordinated so that when string is a valid pathname:

$(basename "string")

would be a valid filename for the file in the directory:

$(dirname "string")

This would not work for the early proposal versions of these utilities due to the way it specified handling of trailing slashes.

Since the definition of pathname specifies implementation-defined behavior for pathnames starting with two slash characters, this volume of IEEE Std 1003.1-2001 specifies similar implementation-defined behavior for the basename and dirname utilities.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.5 (on page 33), dirname

CHANGE HISTORY
First released in Issue 2.

Issue 6
IEEE PASC Interpretation 1003.2 #164 is applied.
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
batch — schedule commands to be executed in a batch queue

SYNOPSIS
batch

DESCRIPTION
The batch utility shall read commands from standard input and schedule them for execution in a batch queue. It shall be the equivalent of the command:

```
at -q b -m now
```

where queue b is a special at queue, specifically for batch jobs. Batch jobs shall be submitted to the batch queue with no time constraints and shall be run by the system using algorithms, based on unspecified factors, that may vary with each invocation of batch.

XSI Users shall be permitted to use batch if their name appears in the file /usr/lib/cron/at.allow. If that file does not exist, the file /usr/lib/cron/at.deny shall be checked to determine whether the user shall be denied access to batch. If neither file exists, only a process with the appropriate privileges shall be allowed to submit a job. If only at.deny exists and is empty, global usage shall be permitted. The at.allow and at.deny files shall consist of one user name per line.

OPTIONS
None.

OPERANDS
None.

STDIN
The standard input shall be a text file consisting of commands acceptable to the shell command language described in Chapter 2 (on page 29).

INPUT FILES
The text files /usr/lib/cron/at.allow and /usr/lib/cron/at.deny shall contain zero or more user names, one per line, of users who are, respectively, authorized or denied access to the at and batch utilities.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of batch:

```
LANG
```

Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

```
LC_ALL
```

If set to a non-empty string value, override the values of all the other internationalization variables.

```
LC_CTYPE
```

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

```
LC_MESSAGES
```

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

```
LC_TIME
```

Determine the format and contents for date and time strings written by batch.
Utilities

Determine the location of message catalogs for the processing of LC_MESSAGES.

Determine the name of a command interpreter to be used to invoke the at-job. If
the variable is unset or null, sh shall be used. If it is set to a value other than a name
for sh, the implementation shall do one of the following: use that shell; use sh; use
the login shell from the user database; any of the preceding accompanied by a
warning diagnostic about which was chosen.

Determine the timezone. The job shall be submitted for execution at the time
specified by timespec or −t time relative to the timezone specified by the TZ
variable. If timespec specifies a timezone, it overrides TZ. If timespec does not
specify a timezone and TZ is unset or null, an unspecified default timezone shall
be used.

ASYNCHRONOUS EVENTS

Default.

STDOUT

When standard input is a terminal, prompts of unspecified format for each line of the user input
described in the STDIN section may be written to standard output.

STDERR

The following shall be written to standard error when a job has been successfully submitted:

"job %s at %s\n", at_job_id, <date>

where date shall be equivalent in format to the output of:

date +"%a %b %e %T %Y"

The date and time written shall be adjusted so that they appear in the timezone of the user (as
determined by the TZ variable).

Neither this, nor warning messages concerning the selection of the command interpreter, are
considered a diagnostic that changes the exit status.

Diagnostic messages, if any, shall be written to standard error.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0   Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS

The job shall not be scheduled.
APPLICATION USAGE

It may be useful to redirect standard output within the specified commands.

EXAMPLES

1. This sequence can be used at a terminal:
   
   batch
   sort < file > outfile
   EOT

2. This sequence, which demonstrates redirecting standard error to a pipe, is useful in a command procedure (the sequence of output redirection specifications is significant):
   
   batch <<
   ! diff file1 file2 2>&1 > outfile | mailx mygroup
   !

RATIONALE

Early proposals described batch in a manner totally separated from at, even though the historical model treated it almost as a synonym for at −qb. A number of features were added to list and control batch work separately from those in at. Upon further reflection, it was decided that the benefit of this did not merit the change to the historical interface.

The −m option was included on the equivalent at command because it is historical practice to mail results to the submitter, even if all job-produced output is redirected. As explained in the RATIONALE for at, the now keyword submits the job for immediate execution (after scheduling delays), despite some historical systems where at now would have been considered an error.

FUTURE DIRECTIONS

None.

SEE ALSO

at

CHANGE HISTORY

First released in Issue 2.

Issue 6

This utility is marked as part of the User Portability Utilities option.

The NAME is changed to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME

`bc` — arbitrary-precision arithmetic language

SYNOPSIS

```
bc [-l] [file ...]
```

DESCRIPTION

The `bc` utility shall implement an arbitrary precision calculator. It shall take input from any files given, then read from the standard input. If the standard input and standard output to `bc` are attached to a terminal, the invocation of `bc` shall be considered to be interactive, causing behavioral constraints described in the following sections.

OPTIONS


The following option shall be supported:

```
-l
```

(The letter ell.) Define the math functions and initialize `scale` to 20, instead of the default zero; see the EXTENDED DESCRIPTION section.

OPERANDS

The following operand shall be supported:

```
file
```

A pathname of a text file containing `bc` program statements. After all `files` have been read, `bc` shall read the standard input.

STDIN

See the INPUT FILES section.

INPUT FILES

Input files shall be text files containing a sequence of comments, statements, and function definitions that shall be executed as they are read.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `bc`:

```
LANG
```

Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

```
LC_ALL
```

If set to a non-empty string value, override the values of all the other internationalization variables.

```
LC_CTYPE
```

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

```
LC_MESSAGES
```

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

```
NLSPATH
```

Determine the location of message catalogs for the processing of `LC_MESSAGES`.

ASYNCHRONOUS EVENTS

Default.
The output of the bc utility shall be controlled by the program read, and consist of zero or more lines containing the value of all executed expressions without assignments. The radix and precision of the output shall be controlled by the values of the obase and scale variables; see the EXTENDED DESCRIPTION section.

The standard error shall be used only for diagnostic messages.

None.

Grammer
The grammar in this section and the lexical conventions in the following section shall together describe the syntax for bc programs. The general conventions for this style of grammar are described in Section 1.10 (on page 19). A valid program can be represented as the non-terminal symbol program in the grammar. This formal syntax shall take precedence over the text syntax description.

%token EOF NEWLINE STRING LETTER NUMBER
%token MUL_OP /* '*', '/', '%' */
%token ASSIGN_OP /* '=', '+=', '-=', '*=', '/=', '%=', '^=' */
%token REL_OP /* '==', '<=', '>=', '!=', '<', '>' */
%token INCR_DECR /* '++', '−−' */
%token Define Break Quit Length /* 'define', 'break', 'quit', 'length' */
%token Return For If While Sqrt /* 'return', 'for', 'if', 'while', 'sqrt' */
%token Scale Ibase Obase Auto /* 'scale', 'ibase', 'obase', 'auto' */
%start program

program : EOF
    | input_item program
    |
input_item : semicolon_list NEWLINE
    | function
    |
semicolon_list : /* empty */
    | statement
    | semicolon_list ';' statement
    | semicolon_list ';'
Utilities

bc

statement_list : /* empty */
| statement
| statement_list NEWLINE
| statement_list NEWLINE statement
| statement_list ';'
| statement_list ';' statement

statement : expression
| STRING
| Break
| Quit
| Return
| Return '(' return_expression ')' | For '(' expression ';' relational_expression ';' expression ')' statement
| If '(' relational_expression ')' statement
| While '(' relational_expression ')' statement
| '{' statement_list '}'

function : Define LETTER '{' opt_parameter_list '}'
| '{' NEWLINE opt_auto_define_list statement_list '}'

opt_parameter_list : /* empty */
| parameter_list

parameter_list : LETTER
| define_list ',' LETTER

opt_auto_define_list : /* empty */
| Auto define_list NEWLINE
| Auto define_list ';'

define_list : LETTER
| LETTER '[' ']'
| define_list ',' LETTER
| define_list ',' LETTER '[' ']'

opt_argument_list : /* empty */
| argument_list

argument_list : expression
| LETTER '[' ']',' argument_list
Lexical Conventions in bc

The lexical conventions for bc programs, with respect to the preceding grammar, shall be as follows:

1. Except as noted, bc shall recognize the longest possible token or delimiter beginning at a given point.

2. A comment shall consist of any characters beginning with the two adjacent characters "/:*" and terminated by the next occurrence of the two adjacent characters "*/". Comments shall have no effect except to delimit lexical tokens.

3. The <newline> shall be recognized as the token NEWLINE.

4. The token STRING shall represent a string constant; it shall consist of any characters beginning with the double-quote character (""") and terminated by another occurrence of the double-quote character. The value of the string is the sequence of all characters between, but not including, the two double-quote characters. All characters shall be taken literally from the input, and there is no way to specify a string containing a double-quote character. The length of the value of each string shall be limited to \{BC_STRING_MAX\} bytes.

5. A <blank> shall have no effect except as an ordinary character if it appears within a STRING token, or to delimit a lexical token other than STRING.
6. The combination of a backslash character immediately followed by a `\<newline>` shall have no effect other than to delimit lexical tokens with the following exceptions:
   • It shall be interpreted as the character sequence `"\<newline>"` in STRING tokens.
   • It shall be ignored as part of a multi-line NUMBER token.

7. The token NUMBER shall represent a numeric constant. It shall be recognized by the following grammar:

   ```
   NUMBER : integer
           | '.' integer
           | integer '.'
           | integer integer
   integer : digit
           | integer digit
   digit : 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7
           | 8 | 9 | A | B | C | D | E | F
   ```

8. The value of a NUMBER token shall be interpreted as a numeral in the base specified by the value of the internal register ibase (described below). Each of the digit characters shall have the value from 0 to 15 in the order listed here, and the period character shall represent the radix point. The behavior is undefined if digits greater than or equal to the value of ibase appear in the token. However, note the exception for single-digit values being assigned to ibase and obase themselves, in Operations in bc (on page 198).

9. The following keywords shall be recognized as tokens:

   ```
   auto    ibase    length    return    while
   break   if       obase    scale
   define  for      quit     sqrt
   ```

10. Any of the following characters occurring anywhere except within a keyword shall be recognized as the token LETTER:

    ```
    a b c d e f g h i j k l m n o p q r s t u v w x y z
    ```

11. The following single-character and two-character sequences shall be recognized as the token ASSIGN_OP:

    ```
    =  +=  -=  *=  /=  %=  ^=  
    ```

12. If an `=` character, as the beginning of a token, is followed by a `=-` character with no intervening delimiter, the behavior is undefined.

13. The following single-characters shall be recognized as the token MUL_OP:

    ```
    *  /  %
    ```

14. The following single-character and two-character sequences shall be recognized as the token REL_OP:

    ```
    ==  <=  =>  !=  <  >
    ```

15. The following two-character sequences shall be recognized as the token INCR_DECR:
16. The following single characters shall be recognized as tokens whose names are the character:

\[
<\text{newline}>\ (\ )\ ,\ +\ -\ ;\ [\ ]\ ^{\{\}\}\}
\]

17. The token EOF is returned when the end of input is reached.

Operations in bc

There are three kinds of identifiers: ordinary identifiers, array identifiers, and function identifiers. All three types consist of single lowercase letters. Array identifiers shall be followed by square brackets ("[ ]"). An array subscript is required except in an argument or auto list. Arrays are singly dimensioned and can contain up to \{BC_DIM_MAX\} elements. Indexing shall begin at zero so an array is indexed from 0 to \{BC_DIM_MAX\}−1. Subscripts shall be truncated to integers. The application shall ensure that function identifiers are followed by parentheses, possibly enclosing arguments. The three types of identifiers do not conflict.

The following table summarizes the rules for precedence and associativity of all operators. Operators on the same line shall have the same precedence; rows are in order of decreasing precedence.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Associativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>++, −−</td>
<td>N/A</td>
</tr>
<tr>
<td>unary −</td>
<td>N/A</td>
</tr>
<tr>
<td>^</td>
<td>Right to left</td>
</tr>
<tr>
<td>*, /, %</td>
<td>Left to right</td>
</tr>
<tr>
<td>+, binary −</td>
<td>Left to right</td>
</tr>
<tr>
<td>=, +=, −=, *=, /=, %=, ^=</td>
<td>Right to left</td>
</tr>
<tr>
<td>==, &lt;=, &gt;=, !=, &lt;, &gt;</td>
<td>None</td>
</tr>
</tbody>
</table>

Each expression or named expression has a \textit{scale}, which is the number of decimal digits that shall be maintained as the fractional portion of the expression.

\textit{Named expressions} are places where values are stored. Named expressions shall be valid on the left side of an assignment. The value of a named expression shall be the value stored in the place named. Simple identifiers and array elements are named expressions; they have an initial value of zero and an initial scale of zero.

The internal registers \textit{scale}, \textit{ibase}, and \textit{obase} are all named expressions. The scale of an expression consisting of the name of one of these registers shall be zero; values assigned to any of these registers are truncated to integers. The \textit{scale} register shall contain a global value used in computing the scale of expressions (as described below). The value of the register \textit{scale} is limited to \[2 \leq \text{scale} \leq \{\text{BC_SCALE_MAX}\}\] and shall have a default value of zero. The \textit{ibase} and \textit{obase} registers are the input and output number radix, respectively. The value of \textit{ibase} shall be limited to:

\[2 \leq \text{ibase} \leq 16\]

The value of \textit{obase} shall be limited to:

\[2 \leq \text{obase} \leq \{\text{BC_BASE_MAX}\}\]

When either \textit{ibase} or \textit{obase} is assigned a single \textit{digit} value from the list in \textbf{Lexical Conventions in bc} (on page 196), the value shall be assumed in hexadecimal. (For example, \texttt{ibase=A} sets to
Utilities

base ten, regardless of the current \texttt{ibase} value.) Otherwise, the behavior is undefined when digits greater than or equal to the value of \texttt{ibase} appear in the input. Both \texttt{ibase} and \texttt{obase} shall have initial values of 10.

Internal computations shall be conducted as if in decimal, regardless of the input and output bases, to the specified number of decimal digits. When an exact result is not achieved (for example, \texttt{scale}=0; 3.2/1), the result shall be truncated.

For all values of \texttt{obase} specified by this volume of IEEE Std 1003.1-2001, \texttt{bc} shall output numeric values by performing each of the following steps in order:

1. If the value is less than zero, a hyphen ('\textquotesingle-\textquotesingle') character shall be output.
2. One of the following is output, depending on the numerical value:
   - If the absolute value of the numerical value is greater than or equal to one, the integer portion of the value shall be output as a series of digits appropriate to \texttt{obase} (as described below), most significant digit first. The most significant non-zero digit shall be output next, followed by each successively less significant digit.
   - If the absolute value of the numerical value is less than one but greater than zero and the scale of the numerical value is greater than zero, it is unspecified whether the character 0 is output.
   - If the numerical value is zero, the character 0 shall be output.
3. If the scale of the value is greater than zero and the numeric value is not zero, a period character shall be output, followed by a series of digits appropriate to \texttt{obase} (as described below) representing the most significant portion of the fractional part of the value. If \texttt{s} represents the scale of the value being output, the number of digits output shall be \texttt{s} if \texttt{obase} is 10, less than or equal to \texttt{s} if \texttt{obase} is greater than 10, or greater than or equal to \texttt{s} if \texttt{obase} is less than 10. For \texttt{obase} values other than 10, this should be the number of digits needed to represent a precision of \texttt{10}^{s}.

For \texttt{obase} values from 2 to 16, valid digits are the first \texttt{obase} of the single characters:

\begin{verbatim}
  0 1 2 3 4 5 6 7 8 9 A B C D E F
\end{verbatim}

which represent the values zero to 15, inclusive, respectively.

For bases greater than 16, each digit shall be written as a separate multi-digit decimal number.

Each digit except the most significant fractional digit shall be preceded by a single \textless space\textgreater{}. For bases from 17 to 100, \texttt{bc} shall write two-digit decimal numbers; for bases from 101 to 1 000, three-digit decimal strings, and so on. For example, the decimal number 1 024 in base 25 would be written as:

\begin{verbatim}
\textbackslash D01\textbackslash D15\textbackslash DA24
\end{verbatim}

and in base 125, as:

\begin{verbatim}
\textbackslash D008\textbackslash DA24
\end{verbatim}

Very large numbers shall be split across lines with 70 characters per line in the POSIX locale; other locales may split at different character boundaries. Lines that are continued shall end with a backslash ('\textquotesingle \textquotesingle').

A function call shall consist of a function name followed by parentheses containing a comma-separated list of expressions, which are the function arguments. A whole array passed as an argument shall be specified by the array name followed by empty square brackets. All function arguments shall be passed by value. As a result, changes made to the formal parameters shall have no effect on the actual arguments. If the function terminates by executing a \texttt{return}
The result of `sqrt(expression)` shall be the square root of the expression. The result shall be truncated in the least significant decimal place. The scale of the result shall be the scale of the expression or the value of `scale`, whichever is larger.

The result of `length(expression)` shall be the total number of significant decimal digits in the expression. The scale of the result shall be zero.

The result of `scale(expression)` shall be the scale of the expression. The scale of the result shall be zero.

A numeric constant shall be an expression. The scale shall be the number of digits that follow the radix point in the input representing the constant, or zero if no radix point appears.

The sequence `(expression)` shall be an expression with the same value and scale as `expression`. The parentheses can be used to alter the normal precedence.

The semantics of the unary and binary operators are as follows:

```
−expression
  The result shall be the negative of the `expression`. The scale of the result shall be the scale of `expression`.
```

The unary increment and decrement operators shall not modify the scale of the named expression upon which they operate. The scale of the result shall be the scale of that named expression.

```
++named-expression
  The named expression shall be incremented by one. The result shall be the value of the named expression after incrementing.
```

```
−−named-expression
  The named expression shall be decremented by one. The result shall be the value of the named expression after decrementing.
```

```
named-expression++
  The named expression shall be incremented by one. The result shall be the value of the named expression before incrementing.
```

```
named-expression−−
  The named expression shall be decremented by one. The result shall be the value of the named expression before decrementing.
```

The exponentiation operator, circumflex (`^`), shall bind right to left.

```
expression^expression
  The result shall be the first `expression` raised to the power of the second `expression`. If the second expression is not an integer, the behavior is undefined. If `a` is the scale of the left expression and `b` is the absolute value of the right expression, the scale of the result shall be:

  if b >= 0 min(a * b, max(scale, a)) if b < 0 scale
```

The multiplicative operators (`∗`, `/`, `%`) shall bind left to right.

```
expression*expression
  The result shall be the product of the two expressions. If `a` and `b` are the scales of the two expressions, then the scale of the result shall be:
```
\[ \min(a+b, \max(scale, a, b)) \]

**expression / expression**

The result shall be the quotient of the two expressions. The scale of the result shall be the value of `scale`.

**expression % expression**

For expressions \( a \) and \( b \), \( a \% b \) shall be evaluated equivalent to the steps:

1. Compute \( a / b \) to current scale.
2. Use the result to compute:
   \[
   a - (a / b) \times b
   \]
   to scale:
   \[
   \max(scale + scale(b), scale(a))
   \]

The scale of the result shall be:

\[
\max(scale + scale(b), scale(a))
\]

When `scale` is zero, the `\%' operator is the mathematical remainder operator.

The additive operators (`\+'`, `\-'`) shall bind left to right.

**expression + expression**

The result shall be the sum of the two expressions. The scale of the result shall be the maximum of the scales of the expressions.

**expression − expression**

The result shall be the difference of the two expressions. The scale of the result shall be the maximum of the scales of the expressions.

The assignment operators (`\='`, `\+=`, `\-=`, `\*=`, `\/=`, `\%=`, `\^=`) shall bind right to left.

**named-expression = expression**

This expression shall result in assigning the value of the expression on the right to the named expression on the left. The scale of both the named expression and the result shall be the scale of `expression`.

The compound assignment forms:

**named-expression <operator>= expression**

shall be equivalent to:

**named-expression=named-expression <operator> expression**

except that the `named-expression` shall be evaluated only once.

Unlike all other operators, the relational operators (`\<'`, `\>'`, `\<='`, `\>='`, `\==`, `\!=`) shall be only valid as the object of an `if`, `while`, or inside a `for` statement.

**expression1<expression2**

The relation shall be true if the value of `expression1` is strictly less than the value of `expression2`.

**expression1>expression2**

The relation shall be true if the value of `expression1` is strictly greater than the value of `expression2`.
expression1<=expression2

The relation shall be true if the value of expression1 is less than or equal to the value of expression2.

expression1>=expression2

The relation shall be true if the value of expression1 is greater than or equal to the value of expression2.

expression1==expression2

The relation shall be true if the values of expression1 and expression2 are equal.

expression1!=expression2

The relation shall be true if the values of expression1 and expression2 are unequal.

There are only two storage classes in bc: global and automatic (local). Only identifiers that are local to a function need be declared with the auto command. The arguments to a function shall be local to the function. All other identifiers are assumed to be global and available to all functions. All identifiers, global and local, have initial values of zero. Identifiers declared as auto shall be allocated on entry to the function and released on returning from the function. They therefore do not retain values between function calls. Auto arrays shall be specified by the array name followed by empty square brackets. On entry to a function, the old values of the names that appear as parameters and as automatic variables shall be pushed onto a stack. Until the function returns, reference to these names shall refer only to the new values.

References to any of these names from other functions that are called from this function also refer to the new value until one of those functions uses the same name for a local variable.

When a statement is an expression, unless the main operator is an assignment, execution of the statement shall write the value of the expression followed by a <newline>.

When a statement is a string, execution of the statement shall write the value of the string.

Statements separated by semicolons or <newline>s shall be executed sequentially. In an interactive invocation of bc, each time a <newline> is read that satisfies the grammatical production:

```
input_item : semicolon_list NEWLINE
```

the sequential list of statements making up the semicolon_list shall be executed immediately and any output produced by that execution shall be written without any delay due to buffering.

In an if statement (if(relation) statement), the statement shall be executed if the relation is true.

The while statement (while(relation) statement) implements a loop in which the relation is tested; each time the relation is true, the statement shall be executed and the relation retested. When the relation is false, execution shall resume after statement.

A for statement(for(expression; relation; expression) statement) shall be the same as:

```
first-expression
while (relation) {
    statement
    last-expression
}
```

The application shall ensure that all three expressions are present.

The break statement shall cause termination of a for or while statement.

The auto statement (auto identifier [identifier] ...) shall cause the values of the identifiers to be pushed down. The identifiers can be ordinary identifiers or array identifiers. Array identifiers
shall be specified by following the array name by empty square brackets. The application shall ensure that the \texttt{auto} statement is the first statement in a function definition.

A \texttt{define} statement:

\begin{verbatim}
define LETTER ( opt_parameter_list ) {
    opt_auto_define_list
    statement_list
}
\end{verbatim}

defines a function named \texttt{LETTER}. If a function named \texttt{LETTER} was previously defined, the \texttt{define} statement shall replace the previous definition. The expression:

\begin{verbatim}
LETTER ( opt_argument_list )
\end{verbatim}

shall invoke the function named \texttt{LETTER}. The behavior is undefined if the number of arguments in the invocation does not match the number of parameters in the definition. Functions shall be defined before they are invoked. A function shall be considered to be defined within its own body, so recursive calls are valid. The values of numeric constants within a function shall be interpreted in the base specified by the value of the \texttt{ibase} register when the function is invoked.

The \texttt{return} statements (\texttt{return} and \texttt{return(expression)}) shall cause termination of a function, popping of its auto variables, and specification of the result of the function. The first form shall be equivalent to \texttt{return(0)}. The value and scale of the result returned by the function shall be the value and scale of the expression returned.

The \texttt{quit} statement (\texttt{quit}) shall stop execution of a \texttt{bc} program at the point where the statement occurs in the input, even if it occurs in a function definition, or in an \texttt{if}, \texttt{for}, or \texttt{while} statement.

The following functions shall be defined when the \texttt{−l} option is specified:

\texttt{s( expression )} \hspace{1cm} \text{Sine of argument in radians.}
\texttt{c( expression )} \hspace{1cm} \text{Cosine of argument in radians.}
\texttt{a( expression )} \hspace{1cm} \text{Arctangent of argument.}
\texttt{l( expression )} \hspace{1cm} \text{Natural logarithm of argument.}
\texttt{e( expression )} \hspace{1cm} \text{Exponential function of argument.}
\texttt{j( expression, expression )} \hspace{1cm} \text{Bessel function of integer order.}

The scale of the result returned by these functions shall be the value of the \texttt{scale} register at the time the function is invoked. The value of the \texttt{scale} register after these functions have completed their execution shall be the same value it had upon invocation. The behavior is undefined if any of these functions is invoked with an argument outside the domain of the mathematical function.

\textbf{EXIT STATUS}

The following exit values shall be returned:

\begin{verbatim}
0 \hspace{1cm} \text{All input files were processed successfully.}
\end{verbatim}
CONSEQUENCES OF ERRORS

If any file operand is specified and the named file cannot be accessed, bc shall write a diagnostic message to standard error and terminate without any further action.

In an interactive invocation of bc, the utility should print an error message and recover following any error in the input. In a non-interactive invocation of bc, invalid input causes undefined behavior.

APPLICATION USAGE

Automatic variables in bc do not work in exactly the same way as in either C or PL/1.

For historical reasons, the exit status from bc cannot be relied upon to indicate that an error has occurred. Returning zero after an error is possible. Therefore, bc should be used primarily by interactive users (who can react to error messages) or by application programs that can somehow validate the answers returned as not including error messages.

The bc utility always uses the period (\'.\') character to represent a radix point, regardless of any decimal-point character specified as part of the current locale. In languages like C or awk, the period character is used in program source, so it can be portable and unambiguous, while the locale-specific character is used in input and output. Because there is no distinction between source and input in bc, this arrangement would not be possible. Using the locale-specific character in bc's input would introduce ambiguities into the language; consider the following example in a locale with a comma as the decimal-point character:

```
define f(a,b) {
    ...
    ...
    f(1,2,3)
}
```

Because of such ambiguities, the period character is used in input. Having input follow different conventions from output would be confusing in either pipeline usage or interactive usage, so the period is also used in output.

EXAMPLES

In the shell, the following assigns an approximation of the first ten digits of \(\pi\) to the variable x:

```
x=$(printf "%.10f
" scale = 10; 104348/33215 | bc)
```

The following bc program prints the same approximation of \(\pi\), with a label, to standard output:

```
scale = 10
"pi equals"
104348 / 33215
```

The following defines a function to compute an approximate value of the exponential function (note that such a function is predefined if the –l option is specified):

```
scale = 20
define e(x) {
    auto a, b, c, i, s
    a = 1
    b = 1
    s = 1
    ...
for (i = 1; 1 == 1; i++) {
    a = a*x
    b = b*i
    c = a/b
    if (c == 0) {
        return(s)
    }
    s = s+c
}

The following prints approximate values of the exponential function of the first ten integers:
for (i = 1; i <= 10; ++i) {
    e(i)
}

RATIONALE

The bc utility is implemented historically as a front-end processor for dc; dc was not selected to be part of this volume of IEEE Std 1003.1-2001 because bc was thought to have a more intuitive programmatic interface. Current implementations that implement bc using dc are expected to be compliant.

The exit status for error conditions has been left unspecified for several reasons:

- The bc utility is used in both interactive and non-interactive situations. Different exit codes may be appropriate for the two uses.
- It is unclear when a non-zero exit should be given; divide-by-zero, undefined functions, and syntax errors are all possibilities.
- It is not clear what utility the exit status has.
- In the 4.3 BSD, System V, and Ninth Edition implementations, bc works in conjunction with dc. The dc utility is the parent, bc is the child. This was done to cleanly terminate bc if dc aborted.

The decision to have bc exit upon encountering an inaccessible input file is based on the belief that bc file1 file2 is used most often when at least file1 contains data/function declarations-initializations. Having bc continue with prerequisite files missing is probably not useful. There is no implication in the CONSEQUENCES OF ERRORS section that bc must check all its files for accessibility before opening any of them.

There was considerable debate on the appropriateness of the language accepted by bc. Several reviewers preferred to see either a pure subset of the C language or some changes to make the language more compatible with C. While the bc language has some obvious similarities to C, it has never claimed to be compatible with any version of C. An interpreter for a subset of C might be a very worthwhile utility, and it could potentially make bc obsolete. However, no such utility is known in historical practice, and it was not within the scope of this volume of IEEE Std 1003.1-2001 to define such a language and utility. If and when they are defined, it may be appropriate to include them in a future version of IEEE Std 1003.1. This left the following alternatives:


The consensus of the standard developers was that a simple programmatic calculator language is very useful for both applications and interactive users. The only arguments for excluding any calculator were that it would become obsolete if and when a C-compatible
one emerged, or that the absence would encourage the development of such a C-compatible one. These arguments did not sufficiently address the needs of current application writers.

2. Standardize the historical dc, possibly with minor modifications.

The consensus of the standard developers was that dc is a fundamentally less usable language and that that would be far too severe a penalty for avoiding the issue of being similar to but incompatible with C.

3. Standardize the historical bc, possibly with minor modifications.

This was the approach taken. Most of the proponents of changing the language would not have been satisfied until most or all of the incompatibilities with C were resolved. Since most of the changes considered most desirable would break historical applications and require significant modification to historical implementations, almost no modifications were made. The one significant modification that was made was the replacement of the historical bc assignment operators "+=" and so on, with the more modern "+=" and so on. The older versions are considered to be fundamentally flawed because of the lexical ambiguity in uses like \texttt{a = −1}.

In order to permit implementations to deal with backwards-compatibility as they see fit, the behavior of this one ambiguous construct was made undefined. (At least three implementations have been known to support this change already, so the degree of change involved should not be great.)

The \texttt{'}\%\texttt{'} operator is the mathematical remainder operator when \texttt{scale} is zero. The behavior of this operator for other values of \texttt{scale} is from historical implementations of \texttt{bc}, and has been maintained for the sake of historical applications despite its non-intuitive nature.

Historical implementations permit setting \texttt{ibase} and \texttt{obase} to a broader range of values. This includes values less than 2, which were not seen as sufficiently useful to standardize. These implementations do not interpret input properly for values of \texttt{ibase} that are greater than 16. This is because numeric constants are recognized syntactically, rather than lexically, as described in this volume of IEEE Std 1003.1-2001. They are built from lexical tokens of single hexadecimal digits and periods. Since <blank>s between tokens are not visible at the syntactic level, it is not possible to recognize the multi-digit “digits” used in the higher bases properly. The ability to recognize input in these bases was not considered useful enough to require modifying these implementations. Note that the recognition of numeric constants at the syntactic level is not a problem with conformance to this volume of IEEE Std 1003.1-2001, as it does not impact the behavior of conforming applications (and correct \texttt{bc} programs). Historical implementations also accept input with all of the digits \texttt{‘0’−‘9’} and \texttt{‘A’−‘F’} regardless of the value of \texttt{ibase}; since digits with value greater than or equal to \texttt{ibase} are not really appropriate, the behavior when they appear is undefined, except for the common case of:

\begin{verbatim}
ibase=8;
   /* Process in octal base. */
...
ibase=A
   /* Restore decimal base. */
\end{verbatim}

In some historical implementations, if the expression to be written is an uninitialized array element, a leading \texttt{<space>} and/or up to four leading \texttt{0} characters may be output before the character \texttt{0}. This behavior is considered a bug; it is unlikely that any currently conforming application relies on:
Utilities

bc

8135   echo 'b[3]' | bc

8136   returning 00000 rather than 0.

8137   Exact calculation of the number of fractional digits to output for a given value in a base other
8138   than 10 can be computationally expensive. Historical implementations use a faster
8139   approximation, and this is permitted. Note that the requirements apply only to values of obase
8140   that this volume of IEEE Std 1003.1-2001 requires implementations to support (in particular, not
8141   to 1, 0, or negative bases, if an implementation supports them as an extension).

8142   Historical implementations of bc did not allow array parameters to be passed as the last
8143   parameter to a function. New implementations are encouraged to remove this restriction even
8144   though it is not required by the grammar.

8145   FUTURE DIRECTIONS

8146   None.

8147   SEE ALSO

8148   Section 1.10 (on page 19), awk

8149   CHANGE HISTORY

8150   First released in Issue 4.

8151   Issue 5

8152   The FUTURE DIRECTIONS section is added.

8153   Issue 6

8154   Updated to align with the IEEE P1003.2b draft standard, which included resolution of several

8156   The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
bg — run jobs in the background

SYNOPSIS
bg [job_id ...]

DESCRIPTION
If job control is enabled (see the description of set --m), the bg utility shall resume suspended jobs
from the current environment (see Section 2.12 (on page 61)) by running them as background
jobs. If the job specified by job_id is already a running background job, the bg utility shall have no
effect and shall exit successfully.
Using bg to place a job into the background shall cause its process ID to become “known in the
current shell execution environment”, as if it had been started as an asynchronous list; see
Section 2.9.3.1 (on page 50).

OPTIONS
None.

OPERANDS
The following operand shall be supported:

job_id Specify the job to be resumed as a background job. If no job_id operand is given,
the most recently suspended job shall be used. The format of job_id is described in
the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.203, Job Control Job
ID.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of bg:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.
The output of `bg` shall consist of a line in the format:

```
"[%d] %s\n", <job-number>, <command>
```

where the fields are as follows:

- `<job-number>`: A number that can be used to identify the job to the `wait`, `fg`, and `kill` utilities. Using these utilities, the job can be identified by prefixing the job number with `';'`.

- `<command>`: The associated command that was given to the shell.

The standard error shall be used only for diagnostic messages.

### APPLICATION USAGE

A job is generally suspended by typing the SUSP character (`<control>-Z` on most systems); see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface. At that point, `bg` can put the job into the background. This is most effective when the job is expecting no terminal input and its output has been redirected to non-terminal files. A background job can be forced to stop when it has terminal output by issuing the command:

```
stty tostop
```

A background job can be stopped with the command:

```
k exit-s stop job ID
```

The `bg` utility does not work as expected when it is operating in its own utility execution environment because that environment has no suspended jobs. In the following examples:

```
... | xargs bg
```

each `bg` operates in a different environment and does not share its parent shell’s understanding of jobs. For this reason, `bg` is generally implemented as a shell regular built-in.

### RATIONALE

The extensions to the shell specified in this volume of IEEE Std 1003.1-2001 have mostly been based on features provided by the KornShell. The job control features provided by `bg`, `fg`, and `jobs` are also based on the KornShell. The standard developers examined the characteristics of the C shell versions of these utilities and found that differences exist. Despite widespread use of the C
shell, the KornShell versions were selected for this volume of IEEE Std 1003.1-2001 to maintain a degree of uniformity with the rest of the KornShell features selected (such as the very popular command line editing features).

The `bg` utility is expected to wrap its output if the output exceeds the number of display columns.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Section 2.9.3.1 (on page 50), `fg`, `kill`, `jobs`, `wait`

**CHANGE HISTORY**

First released in Issue 4.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The JC margin marker on the SYNOPSIS is removed since support for Job Control is mandatory in this issue. This is a FIPS requirement.
NAME

c99 — compile standard C programs

SYNOPSIS

c99 [-c] [-D name=[value]] ... [-E] [-g] [-I directory] ... [-L directory]

... [-o outfile] [-O optlevel] [-s] [-U name] ... operand ...

DESCRIPTION

The c99 utility is an interface to the standard C compilation system; it shall accept source code
conforming to the ISO C standard. The system conceptually consists of a compiler and link
editor. The files referenced by operands shall be compiled and linked to produce an executable
file. (It is unspecified whether the linking occurs entirely within the operation of c99; some
implementations may produce objects that are not fully resolved until the file is executed.)

If the -c option is specified, for all pathname operands of the form file.c, the files:

$(basename pathname .c).o

shall be created as the result of successful compilation. If the -c option is not specified, it is
unspecified whether such .o files are created or deleted for the file.c operands.

If there are no options that prevent link editing (such as -c or -E), and all operands compile and
link without error, the resulting executable file shall be written according to the -o outfile option
(if present) or to the file a.out.

The executable file shall be created as specified in Section 1.7.1.4 (on page 4), except that the file
permission bits shall be set to:

S_IRWXO | S_IRWXG | S_IRWXU

and the bits specified by the umask of the process shall be cleared.

OPTIONS

The c99 utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
12.2, Utility Syntax Guidelines, except that:

• The -I library operands have the format of options, but their position within a list of
operands affects the order in which libraries are searched.

• The order of specifying the -I and -L options is significant.

• Conforming applications shall specify each option separately; that is, grouping option letters
(for example, -cO) need not be recognized by all implementations.

The following options shall be supported:

-c Suppress the link-edit phase of the compilation, and do not remove any object files
that are produced.

-g Produce symbolic information in the object or executable files; the nature of this
information is unspecified, and may be modified by implementation-defined
interactions with other options.

-s Produce object or executable files, or both, from which symbolic and other
information not required for proper execution using the exec family defined in the
System Interfaces volume of IEEE Std 1003.1-2001 has been removed (stripped). If
both -g and -s options are present, the action taken is unspecified.

-o outfile Use the pathname outfile, instead of the default a.out, for the executable file
produced. If the -o option is present with -c or -E, the result is unspecified.
−D name[=value]

Define name as if by a C-language \#define directive. If no =value is given, a value of 1 shall be used. The −D option has lower precedence than the −U option. That is, if name is used in both a −U and a −D option, name shall be undefined regardless of the order of the options. Additional implementation-defined names may be provided by the compiler. Implementations shall support at least 2 048 bytes of −D definitions and 256 names.

−E

Copy C-language source files to standard output, expanding all preprocessor directives; no compilation shall be performed. If any operand is not a text file, the effects are unspecified.

−I directory

Change the algorithm for searching for headers whose names are not absolute pathnames to look in the directory named by the directory pathname before looking in the usual places. Thus, headers whose names are enclosed in double-quotes (" ") shall be searched for first in the directory of the file with the \#include line, then in directories named in −I options, and last in the usual places. For headers whose names are enclosed in angle brackets ("<>"), the header shall be searched for only in directories named in −I options and then in the usual places. Directories named in −I options shall be searched in the order specified. Implementations shall support at least ten instances of this option in a single c99 command invocation.

−L directory

Change the algorithm of searching for the libraries named in the −I objects to look in the directory named by the directory pathname before looking in the usual places. Directories named in −L options shall be searched in the order specified. Implementations shall support at least ten instances of this option in a single c99 command invocation. If a directory specified by a −L option contains files named libc.a, libm.a, libl.a, or liby.a, the results are unspecified.

−O optlevel

Specify the level of code optimization. If the optlevel option-argument is the digit '0', all special code optimizations shall be disabled. If it is the digit '1', the nature of the optimization is unspecified. If the −O option is omitted, the nature of the system's default optimization is unspecified. It is unspecified whether code generated in the presence of the −O 0 option is the same as that generated when −O is omitted. Other optlevel values may be supported.

−U name

Remove any initial definition of name.

Multiple instances of the −D, −I, −U, and −L options can be specified.

OPERANDS

An operand is either in the form of a pathname or the form −l library. The application shall ensure that at least one operand of the pathname form is specified. The following operands shall be supported:

file.c

A C-language source file to be compiled and optionally linked. The application shall ensure that the operand is of this form if the −c option is used.

file.a

A library of object files typically produced by the ar utility, and passed directly to the link editor. Implementations may recognize implementation-defined suffixes other than .a as denoting object file libraries.

file.o

An object file produced by c99 −c and passed directly to the link editor. Implementations may recognize implementation-defined suffixes other than .o as denoting object files.
The processing of other files is implementation-defined.

(The letter ell.) Search the library named:

liblibrary.a

A library shall be searched when its name is encountered, so the placement of a –I operand is significant. Several standard libraries can be specified in this manner, as described in the EXTENDED DESCRIPTION section. Implementations may recognize implementation-defined suffixes other than .a as denoting libraries.

STDIN
Not used.

INPUT FILES
The input file shall be one of the following: a text file containing a C-language source program, an object file in the format produced by c99 −c, or a library of object files, in the format produced by archiving zero or more object files, using ar. Implementations may supply additional utilities that produce files in these formats. Additional input file formats are implementation-defined.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of c99:

LANG
Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

TMPDIR
Provide a pathname that should override the default directory for temporary files, if any. On XSI-conforming systems, provide a pathname that shall override the default directory for temporary files, if any.

ASYNCHRONOUS EVENTS
Default.

STDOUT
If more than one file operand ending in .c (or possibly other unspecified suffixes) is given, for each such file:

"%s:
", <file>

may be written. These messages, if written, shall precede the processing of each input file; they shall not be written to the standard output if they are written to the standard error, as described in the STDERR section.

If the −E option is specified, the standard output shall be a text file that represents the results of the preprocessing stage of the language; it may contain extra information appropriate for subsequent compilation passes.
The standard error shall be used only for diagnostic messages. If more than one file operand ending in .c (or possibly other unspecified suffixes) is given, for each such file:

"%s:\n", <file>

may be written to allow identification of the diagnostic and warning messages with the appropriate input file. These messages, if written, shall precede the processing of each input file; they shall not be written to the standard error if they are written to the standard output, as described in the STDOUT section.

This utility may produce warning messages about certain conditions that do not warrant returning an error (non-zero) exit value.

OUTPUT FILES

Object files or executable files or both are produced in unspecified formats.

EXTENDED DESCRIPTION

Standard Libraries

The c99 utility shall recognize the following −l operands for standard libraries:

−l c This operand shall make visible all functions referenced in the System Interfaces volume of IEEE Std 1003.1-2001, with the possible exception of those functions listed as residing in <aio.h>, <arpa/inet.h>, <complex.h>, <fenv.h>, <math.h>, <mqueue.h>, <netdb.h>, <netinet/in.h>, <pthread.h>, <semaphore.h>, <spawn.h>, <sys/socket.h>, <sys/mman.h>, <fcntl.h>, <semaphore.h>, <spawn.h>, <sys/socket.h>, pthread_kill(), and pthread_sigmask() in <signal.h>, <trace.h>, functions marked as extensions other than as part of the MF or MPR extensions in <sys/mman.h>, functions marked as ADV in <fcntl.h>, and functions marked as CS, CPT, and TMR in <time.h>. This operand shall not be required to be present to cause a search of this library.

−l l This operand shall make visible all functions required by the C-language output of lex that are not made available through the −l c operand.

−l pthread This operand shall make visible all functions referenced in <pthread.h> and pthread_kill() and pthread_sigmask() referenced in <signal.h>. An implementation may search this library in the absence of this operand.

−l m This operand shall make visible all functions referenced in <math.h>, <complex.h>, and <fenv.h>. An implementation may search this library in the absence of this operand.

−l rt This operand shall make visible all functions referenced in <aio.h>, <mqueue.h>, <sched.h>, <semaphore.h>, and <spawn.h>, functions marked as extensions other than as part of the MF or MPR extensions in <sys/mman.h>, functions marked as ADV in <fcntl.h>, and functions marked as CS, CPT, and TMR in <time.h>. An implementation may search this library in the absence of this operand.

−l trace This operand shall make visible all functions referenced in <trace.h>. An implementation may search this library in the absence of this operand.

−l xnet This operand makes visible all functions referenced in <arpa/inet.h>, <netdb.h>, <netinet/in.h>, and <sys/socket.h>. An implementation may search this library in the absence of this operand.

−l y This operand shall make visible all functions required by the C-language output of yacc that are not made available through the −l c operand.
In the absence of options that inhibit invocation of the link editor, such as `-c` or `-E`, the `c99` utility shall cause the equivalent of a `-l c` operand to be passed to the link editor as the last `-l` operand, causing it to be searched after all other object files and libraries are loaded.

It is unspecified whether the libraries `libc.a`, `libm.a`, `librt.a`, `libpthread.a`, `libl.a`, `liby.a`, or `libxnet.a` exist as regular files. The implementation may accept as `-l` operands names of objects that do not exist as regular files.

**External Symbols**

The C compiler and link editor shall support the significance of external symbols up to a length of at least 31 bytes; the action taken upon encountering symbols exceeding the implementation-defined maximum symbol length is unspecified.

The compiler and link editor shall support a minimum of 511 external symbols per source or object file, and a minimum of 4 095 external symbols in total. A diagnostic message shall be written to the standard output if the implementation-defined limit is exceeded; other actions are unspecified.

**Programming Environments**

All implementations shall support one of the following programming environments as a default. Implementations may support more than one of the following programming environments. Applications can use `sysconf()` or `getconf` to determine which programming environments are supported.

<table>
<thead>
<tr>
<th>Programming Environment</th>
<th>Bits in int</th>
<th>Bits in long</th>
<th>Bits in pointer</th>
<th>Bits in off_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>_POSIX_V6_ILP32_OFF32</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>_POSIX_V6_ILP32_OFFBIG</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>64 &gt;=</td>
</tr>
<tr>
<td>_POSIX_V6_LP64_OFF64</td>
<td>32</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>_POSIX_V6_LPBIG_OFFBIG</td>
<td>64 &gt;=</td>
<td>64</td>
<td>64</td>
<td>64 &gt;=</td>
</tr>
</tbody>
</table>

All implementations shall support one or more environments where the widths of the following types are no greater than the width of type `long`:

- `blksize_t`, `cc_t`, `mode_t`, `nfds_t`, `pid_t`, `ptrdiff_t`, `size_t`, `speed_t`, `ssize_t`, `suseconds_t`, `tcflag_t`, `useconds_t`, `wchar_t`, `wint_t`

The executable files created when these environments are selected shall be in a proper format for execution by the `exec` family of functions. Each environment may be one of the ones in Table 4-4, or it may be another environment. The names for the environments that meet this requirement shall be output by a `getconf` command using the `_POSIX_V6_WIDTH_RESTRICTED_ENVS` argument. If more than one environment meets the requirement, the names of all such environments shall be output on separate lines. Any of these names can then be used in a subsequent `getconf` command to obtain the flags specific to that environment with the following suffixes added as appropriate:

- `_CFLAGS` To get the C compiler flags.
- `_LDFLAGS` To get the linker/loader flags.
- `_LIBS` To get the libraries.

This requirement may be removed in a future version of IEEE Std 1003.1.
When this utility processes a file containing a function called `main()`, it shall be defined with a return type equivalent to `int`. Using return from the initial call to `main()` shall be equivalent (other than with respect to language scope issues) to calling `exit()` with the returned value. Reaching the end of the initial call to `main()` shall be equivalent to calling `exit(0)`. The implementation shall not declare a prototype for this function.

Implementations provide configuration strings for C compiler flags, linker/loader flags, and libraries for each supported environment. When an application needs to use a specific programming environment rather than the implementation default programming environment while compiling, the application shall first verify that the implementation supports the desired environment. If the desired programming environment is supported, the application shall then invoke `c99` with the appropriate C compiler flags as the first options for the compile, the appropriate linker/loader flags after any other options but before any operands, and the appropriate libraries at the end of the operands.

Conforming applications shall not attempt to link together object files compiled for different programming models. Applications shall also be aware that binary data placed in shared memory or in files might not be recognized by applications built for other programming models.

### Table 4-5 Programming Environments: c99 and cc Arguments

<table>
<thead>
<tr>
<th>Programming Environment</th>
<th>Use</th>
<th>c99 and cc Arguments getconf Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>_POSIX_V6_ILP32_OFF32</code></td>
<td>C Compiler Flags</td>
<td>POSIX_V6_ILP32_OFF32_CFLAGS</td>
</tr>
<tr>
<td></td>
<td>Linker/Loader Flags</td>
<td>POSIX_V6_ILP32_OFF32_LDFLAGS</td>
</tr>
<tr>
<td></td>
<td>Libraries</td>
<td>POSIX_V6_ILP32_OFF32_LIBS</td>
</tr>
<tr>
<td><code>_POSIX_V6_ILP32_OFFBIG</code></td>
<td>C Compiler Flags</td>
<td>POSIX_V6_ILP32_OFFBIG_CFLAGS</td>
</tr>
<tr>
<td></td>
<td>Linker/Loader Flags</td>
<td>POSIX_V6_ILP32_OFFBIG_LDFLAGS</td>
</tr>
<tr>
<td></td>
<td>Libraries</td>
<td>POSIX_V6_ILP32_OFFBIG_LIBS</td>
</tr>
<tr>
<td><code>_POSIX_V6_LP64_OFF64</code></td>
<td>C Compiler Flags</td>
<td>POSIX_V6_LP64_OFF64_CFLAGS</td>
</tr>
<tr>
<td></td>
<td>Linker/Loader Flags</td>
<td>POSIX_V6_LP64_OFF64_LDFLAGS</td>
</tr>
<tr>
<td></td>
<td>Libraries</td>
<td>POSIX_V6_LP64_OFF64_LIBS</td>
</tr>
<tr>
<td><code>_POSIX_V6_LPBIG_OFFBIG</code></td>
<td>C Compiler Flags</td>
<td>POSIX_V6_LPBIG_OFFBIG_CFLAGS</td>
</tr>
<tr>
<td></td>
<td>Linker/Loader Flags</td>
<td>POSIX_V6_LPBIG_OFFBIG_LDFLAGS</td>
</tr>
<tr>
<td></td>
<td>Libraries</td>
<td>POSIX_V6_LPBIG_OFFBIG_LIBS</td>
</tr>
</tbody>
</table>

**EXIT STATUS**

The following exit values shall be returned:

- 0    Successful compilation or link edit.
- >0   An error occurred.

**CONSEQUENCES OF ERRORS**

When `c99` encounters a compilation error that causes an object file not to be created, it shall write a diagnostic to standard error and continue to compile other source code operands, but it shall not perform the link phase and return a non-zero exit status. If the link edit is unsuccessful, a diagnostic message shall be written to standard error and `c99` exits with a non-zero status. A conforming application shall rely on the exit status of `c99`, rather than on the existence or mode of the executable file.
Since the c99 utility usually creates files in the current directory during the compilation process, it is typically necessary to run the c99 utility in a directory in which a file can be created.

On systems providing POSIX Conformance (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 2, Conformance), c99 is required only with the C-Language Development option; XSI-conformant systems always provide c99.

Some historical implementations have created .o files when −c is not specified and more than one source file is given. Since this area is left unspecified, the application cannot rely on .o files being created, but it also must be prepared for any related .o files that already exist being deleted at the completion of the link edit.

Some historical implementations have permitted −L options to be interspersed with −l operands on the command line. For an application to compile consistently on systems that do not behave like this, it is necessary for a conforming application to supply all −L options before any of the −l options.

There is the possible implication that if a user supplies versions of the standard functions (before they would be encountered by an implicit −I c or explicit −I m), that those versions would be used in place of the standard versions. There are various reasons this might not be true (functions defined as macros, manipulations for clean name space, and so on), so the existence of files named in the same manner as the standard libraries within the −L directories is explicitly stated to produce unspecified behavior.

All of the functions specified in the System Interfaces volume of IEEE Std 1003.1-2001 may be made visible by implementations when the Standard C Library is searched. Conforming applications must explicitly request searching the other standard libraries when functions made visible by those libraries are used.

**EXAMPLES**

1. The following usage example compiles foo.c and creates the executable file foo:

   c99 −o foo foo.c

2. The following usage example compiles foo.c and creates the object file foo.o:

   c99 −c foo.c

3. The following usage example compiles foo.c and creates the executable file a.out:

   c99 foo.c

4. The following usage example compiles foo.c, links it with bar.o, and creates the executable file a.out. It may also create and leave foo.o:

   c99 foo.c bar.o

5. The following example shows how an application using threads interfaces can test for support of and use a programming environment supporting 32-bit int, long, and pointer types and an off_t type using at least 64 bits:

   if [ $(getconf _POSIX_V6_ILP32_OFFBIG) != "−1" ]
   then
   c99 $(getconf POSIX_V6_ILP32_OFFBIG_CFLAGS) −D_XOPEN_SOURCE=600
   $(getconf POSIX_V6_ILP32_OFFBIG_LDFLAGS) foo.c −o foo
   $(getconf POSIX_V6_ILP32_OFFBIG_LIBS) −l pthread
   else
   echo ILP32_OFFBIG programming environment not supported
exit 1
fi

3. The following examples clarify the use and interactions of \texttt{\-L} options and \texttt{\-l} operands.

Consider the case in which module \texttt{a.c} calls function \texttt{f()} in library \texttt{libQ.a}, and module \texttt{b.c} calls function \texttt{g()} in library \texttt{libp.a}. Assume that both libraries reside in \texttt{/a/b/c}. The command line to compile and link in the desired way is:

\begin{verbatim}
c99 \-L /a/b/c main.o a.c \-l Q b.c \-l p
\end{verbatim}

In this case the \texttt{\-l Q} operand need only precede the first \texttt{\-l p} operand, since both \texttt{libQ.a} and \texttt{libp.a} reside in the same directory.

Multiple \texttt{\-L} operands can be used when library name collisions occur. Building on the previous example, suppose that the user wants to use a new \texttt{libp.a}, in \texttt{/a/a/a}, but still wants \texttt{f()} from \texttt{/a/b/c/libQ.a}:

\begin{verbatim}
c99 \-L /a/a/a \-L /a/b/c main.o a.c \-l Q b.c \-l p
\end{verbatim}

In this example, the linker searches the \texttt{\-L} options in the order specified, and finds \texttt{/a/a/a/libp.a} before \texttt{/a/b/c/libp.a} when resolving references for \texttt{b.c}. The order of the \texttt{\-l} operands is still important, however.

4. The following example shows how an application can use a programming environment where the widths of the following types:

\begin{verbatim}
blksize_t, cc_t, mode_t, nfds_t, pid_t, ptdiff_t, size_t, speed_t, ssize_t, suseconds_t, tcflag_t, useconds_t, wchar_t, wint_t
\end{verbatim}

are no greater than the width of type \texttt{long}:

# First choose one of the listed environments ...

# ... if there are no additional constraints, the first one will do:
CENV=$(getconf \_POSIX\_V6\_WIDTH\_RESTRICTED\_ENVS | head -n 1)

# ... or, if an environment that supports large files is preferred,
# look for names that contain "OFF64" or "OFFBIG". (This chooses
# the last one in the list if none match.)
for CENV in $(getconf \_POSIX\_V6\_WIDTH\_RESTRICTED\_ENVS)
do
case $CENV in
  *OFF64*|*OFFBIG*) break ;;
esacctdone

# The chosen environment name can now be used like this:
c99 $(getconf $(\{CENV\}\_CFLAGS) -D \_POSIX\_C\_SOURCE=200112L \ $(getconf $(\{CENV\}\_LDFLAGS) foo.c -o foo \ $(getconf $(\{CENV\}\_LIBS)

\textbf{RATIONALE}

The \texttt{c99} utility is based on the \texttt{c89} utility originally introduced in the ISO POSIX-2: 1993 standard. Some of the changes from \texttt{c89} include the modification to the contents of the Standard Libraries section to account for new headers and options; for example, \texttt{<spawn.h>} added to the \texttt{\-l rt} operand, and the \texttt{\-l trace} operand added for the Tracing functions.
Utilities

FUTURE DIRECTIONS
None.

SEE ALSO
Section 1.7.1.4 (on page 4), ar, getconf, make, nm, strip, umask, the System Interfaces volume of
IEEE Std 1003.1-2001, exec, sysconf(), the Base Definitions volume of IEEE Std 1003.1-2001,
Chapter 13, Headers

CHANGE HISTORY
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/12 is applied, correcting the EXTENDED
DESCRIPTION of −lc and −lm. Previously, the text did not take into account the presence of
the c99 math headers.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/13 is applied, changing the reference to
the libxnet library to libxnet.a.
NAME
cal — print a calendar

SYNOPSIS
XSI

cal [[month] year ]

DESCRIPTION
The cal utility shall write a calendar to standard output using the Julian calendar for dates from
January 1, 1 through September 2, 1752 and the Gregorian calendar for dates from September 14,
1752 through December 31, 9999 as though the Gregorian calendar had been adopted on
September 14, 1752.

OPTIONS
None.

OPERANDS
The following operands shall be supported:

month Specify the month to be displayed, represented as a decimal integer from 1
(January) to 12 (December). The default shall be the current month.

year Specify the year for which the calendar is displayed, represented as a decimal
integer from 1 to 9999. The default shall be the current year.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of cal:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error, and informative messages written
to standard output.

LC_TIME Determine the format and contents of the calendar.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

TZ Determine the timezone used to calculate the value of the current month.
ASYNCHRONOUS EVENTS
Default.

STDOUT
The standard output shall be used to display the calendar, in an unspecified format.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Note that:
cal 83
refers to A.D. 83, not 1983.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
A future version of IEEE Std 1003.1-2001 may support locale-specific recognition of the date of adoption of the Gregorian calendar.

SEE ALSO
None.

CHANGE HISTORY
First released in Issue 2.

Issue 6
The DESCRIPTION is updated to allow for traditional behavior for years before the adoption of the Gregorian calendar.
NAME
   cat — concatenate and print files

SYNOPSIS
   cat [-u] [file ...]

DESCRIPTION
   The cat utility shall read files in sequence and shall write their contents to the standard output in
   the same sequence.

OPTIONS
   The cat utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
   Utility Syntax Guidelines.
   The following option shall be supported:
   -u       Write bytes from the input file to the standard output without delay as each is
            read.

OPERANDS
   The following operand shall be supported:
   file     A pathname of an input file. If no file operands are specified, the standard input
            shall be used. If a file is ‘−’, the cat utility shall read from the standard input at
            that point in the sequence. The cat utility shall not close and reopen standard input
            when it is referenced in this way, but shall accept multiple occurrences of ‘−’ as a
            file operand.

STDIN
   The standard input shall be used only if no file operands are specified, or if a file operand is ‘−’.
   See the INPUT FILES section.

INPUT FILES
   The input files can be any file type.

ENVIRONMENT VARIABLES
   The following environment variables shall affect the execution of cat:
   LANG     Provide a default value for the internationalization variables that are unset or null.
            (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
            Internationalization Variables for the precedence of internationalization variables
            used to determine the values of locale categories.)
   LC_ALL    If set to a non-empty string value, override the values of all the other
            internationalization variables.
   LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
            characters (for example, single-byte as opposed to multi-byte characters in
            arguments).
   LC_MESSAGES
            Determine the locale that should be used to affect the format and contents of
            diagnostic messages written to standard error.
   NLSPATH   Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCRONOUS EVENTS
   Default.
STDOUT

The standard output shall contain the sequence of bytes read from the input files. Nothing else shall be written to the standard output.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

- 0 All input files were output successfully.
- >0 An error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

The −u option has value in prototyping non-blocking reads from FIFOs. The intent is to support the following sequence:

mkfifo foo
cat −u foo > /dev/tty13 &
cat −u > foo

It is unspecified whether standard output is or is not buffered in the default case. This is sometimes of interest when standard output is associated with a terminal, since buffering may delay the output. The presence of the −u option guarantees that unbuffered I/O is available. It is implementation-defined whether the cat utility buffers output if the −u option is not specified. Traditionally, the −u option is implemented using the equivalent of the setvbuf() function defined in the System Interfaces volume of IEEE Std 1003.1-2001.

EXAMPLES

The following command:

cat myfile

writes the contents of the file myfile to standard output.

The following command:

cat doc1 doc2 > doc.all

concatenates the files doc1 and doc2 and writes the result to doc.all.

Because of the shell language mechanism used to perform output redirection, a command such as this:

cat doc doc.end > doc

causes the original data in doc to be lost.

The command:

cat start − middle − end > file
when standard input is a terminal, gets two arbitrary pieces of input from the terminal with a
single invocation of cat. Note, however, that if standard input is a regular file, this would be
equivalent to the command:

```
cat start - middle /dev/null end > file
```

because the entire contents of the file would be consumed by cat the first time ‘−’ was used as a
file operand and an end-of-file condition would be detected immediately when ‘−’ was
referenced the second time.

**RATIONALE**

Historical versions of the cat utility include the options −e, −t, and −v, which permit the ends of
lines, <tab>s, and invisible characters, respectively, to be rendered visible in the output. The
standard developers omitted these options because they provide too fine a degree of control
over what is made visible, and similar output can be obtained using a command such as:

```
  sed −n −e 's/$/$/ −e l pathname
```

The −s option was omitted because it corresponds to different functions in BSD and System V-
based systems. The BSD −s option to squeeze blank lines can be accomplished by the shell script
shown in the following example:

```
  sed −n '
  # Write non-empty lines.
  /*.*/ { 
    p
    d
  }
  # Write a single empty line, then look for more empty lines.
  /^$/ p
  # Get next line, discard the held <newline> (empty line),
  # and look for more empty lines.
  :Empty
  /^$/ { 
    N
    s/.//
    b Empty
  }
  # Write the non-empty line before going back to search
  # for the first in a set of empty lines.
  p
  ,
  ...

  The System V −s option to silence error messages can be accomplished by redirecting the
  standard error. Note that the BSD documentation for cat uses the term “blank line” to mean the
  same as the POSIX “empty line”: a line consisting only of a <newline>.
  The BSD −n option was omitted because similar functionality can be obtained from the −n
  option of the pr utility.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

more, the System Interfaces volume of IEEE Std 1003.1-2001, setvbuf()
Utilities

8817 CHANGE HISTORY
8818 First released in Issue 2.
NAME
   cd — change the working directory

SYNOPSIS
   cd [-L | -P] [directory]
   cd -

DESCRIPTION
   The cd utility shall change the working directory of the current shell execution environment (see Section 2.12 (on page 61)) by executing the following steps in sequence. (In the following steps, the symbol curpath represents an intermediate value used to simplify the description of the algorithm used by cd. There is no requirement that curpath be made visible to the application.)

1. If no directory operand is given and the HOME environment variable is empty or undefined, the default behavior is implementation-defined and no further steps shall be taken.

2. If no directory operand is given and the HOME environment variable is set to a non-empty value, the cd utility shall behave as if the directory named in the HOME environment variable was specified as the directory operand.

3. If the directory operand begins with a slash character, set curpath to the operand and proceed to step 7.

4. If the first component of the directory operand is dot or dot-dot, proceed to step 6.

5. Starting with the first pathname in the colon-separated pathnames of CDPATH (see the ENVIRONMENT VARIABLES section) if the pathname is non-null, test if the concatenation of that pathname, a slash character, and the directory operand names a directory. If the pathname is null, test if the concatenation of dot, a slash character, and the operand names a directory. In either case, if the resulting string names an existing directory, set curpath to that string and proceed to step 7. Otherwise, repeat this step with the next pathname in CDPATH until all pathnames have been tested.

6. Set curpath to the string formed by the concatenation of the value of PWD, a slash character, and the operand.

7. If the -P option is in effect, the cd utility shall perform actions equivalent to the chdir() function, called with curpath as the path argument. If these actions succeed, the PWD environment variable shall be set to an absolute pathname for the current working directory and shall not contain filename components that, in the context of pathname resolution, refer to a file of type symbolic link. If there is insufficient permission on the new directory, or on any parent of that directory, to determine the current working directory, the value of the PWD environment variable is unspecified. If the actions equivalent to chdir() fail for any reason, the cd utility shall display an appropriate error message and not alter the PWD environment variable. Whether the actions equivalent to chdir() succeed or fail, no further steps shall be taken.

8. The curpath value shall then be converted to canonical form as follows, considering each component from beginning to end, in sequence:
   a. Dot components and any slashes that separate them from the next component shall be deleted.
   b. For each dot-dot component, if there is a preceding component and it is neither root nor dot-dot, the preceding component, all slashes separating the preceding component from dot-dot, dot-dot and all slashes separating dot-dot from the following component shall be deleted.
c. An implementation may further simplify curpath by removing any trailing slash characters that are not also leading slashes, replacing multiple non-leading consecutive slashes with a single slash, and replacing three or more leading slashes with a single slash. If, as a result of this canonicalization, the curpath variable is null, no further steps shall be taken.

9. The cd utility shall then perform actions equivalent to the chdir() function called with curpath as the path argument. If these actions failed for any reason, the cd utility shall display an appropriate error message and no further steps shall be taken. The PWD environment variable shall be set to curpath.

If, during the execution of the above steps, the PWD environment variable is changed, the OLDPWD environment variable shall also be changed to the value of the old working directory (that is the current working directory immediately prior to the call to cd).

OPTIONS


The following options shall be supported by the implementation:

-\(L\) Handle the operand dot-dot logically; symbolic link components shall not be resolved before dot-dot components are processed (see steps 8. and 9. in the DESCRIPTION).

-\(P\) Handle the operand dot-dot physically; symbolic link components shall be resolved before dot-dot components are processed (see step 7. in the DESCRIPTION).

If both -\(L\) and -\(P\) options are specified, the last of these options shall be used and all others ignored. If neither -\(L\) nor -\(P\) is specified, the operand shall be handled dot-dot logically; see the DESCRIPTION.

OPERANDS

The following operands shall be supported:

directory

An absolute or relative pathname of the directory that shall become the new working directory. The interpretation of a relative pathname by cd depends on the -\(L\) option and the CDPATH and PWD environment variables. If directory is an empty string, the results are unspecified.

- When a hyphen is used as the operand, this shall be equivalent to the command:

\[
\text{cd "\$OLDPWD" \\ & pwd}
\]

which changes to the previous working directory and then writes its name.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of cd:

CDPATH A colon-separated list of pathnames that refer to directories. The cd utility shall use this list in its attempt to change the directory, as described in the DESCRIPTION.

An empty string in place of a directory pathname represents the current directory.

If CDPATH is not set, it shall be treated as if it were an empty string.
HOME  The name of the directory, used when no directory operand is specified.

LANG  Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_TYPE  Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

OLDPWD  A pathname of the previous working directory, used by cd –.

PWD  This variable shall be set as specified in the DESCRIPTION. If an application sets
or unsets the value of PWD, the behavior of cd is unspecified.

ASYNCHRONOUS EVENTS
Default.

STDOUT  If a non-empty directory name from CDPATH is used, or if cd – is used, an absolute pathname of
the new working directory shall be written to the standard output as follows:
"%s\n", <new directory>
Otherwise, there shall be no output.

STDERR  The standard error shall be used only for diagnostic messages.

OUTPUT FILES  None.

EXTENDED DESCRIPTION  None.

EXIT STATUS  The following exit values shall be returned:
0  The directory was successfully changed.
>0  An error occurred.

CONSEQUENCES OF ERRORS  The working directory shall remain unchanged.
APPLICATION USAGE
Since cd affects the current shell execution environment, it is always provided as a shell regular built-in. If it is called in a subshell or separate utility execution environment, such as one of the following:

(cd /tmp)
nohup cd
find . -exec cd {} \;

it does not affect the working directory of the caller’s environment.

The user must have execute (search) permission in directory in order to change to it.

EXAMPLES
None.

RATIONALE
The use of the CDPATH was introduced in the System V shell. Its use is analogous to the use of the PATH variable in the shell. The BSD C shell used a shell parameter cdpath for this purpose.

A common extension when HOME is undefined is to get the login directory from the user database for the invoking user. This does not occur on System V implementations.

Some historical shells, such as the KornShell, took special actions when the directory name contained a dot-dot component, selecting the logical parent of the directory, rather than the actual parent directory; that is, it moved up one level toward the '/' in the pathname, remembering what the user typed, rather than performing the equivalent of:

chdir("..");

In such a shell, the following commands would not necessarily produce equivalent output for all directories:

cd .. && ls ls ..

This behavior is now the default. It is not consistent with the definition of dot-dot in most historical practice; that is, while this behavior has been optionally available in the KornShell, other shells have historically not supported this functionality. The logical pathname is stored in the PWD environment variable when the cd utility completes and this value is used to construct the next directory name if cd is invoked with the -L option.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.12 (on page 61), pwd, the System Interfaces volume of IEEE Std 1003.1-2001, chdir()

CHANGE HISTORY
First released in Issue 2.

Issue 6
The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

• The cd - operand, PWD, and OLDPWD are added.

The -L and -P options are added to align with the IEEE P1003.2b draft standard. This also includes the introduction of a new description to include the effect of these options.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/14 is applied, changing the SYNOPSIS to make it clear that the –L and –P options are mutually-exclusive.
NAME

cflow — generate a C-language flowgraph (DEVELOPMENT)

SYNOPSIS

XSI


cflow [−r] [−d num] [−D name [=def]] ... [−i incl] [−I dir] ... [−U dir] ... file ...

DESCRIPTION

The cflow utility shall analyze a collection of object files or assembler, C-language, lex, or yacc source files, and attempt to build a graph, written to standard output, charting the external references.

OPTIONS

The cflow utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the order of the −D, −I, and −U options (which are identical to their interpretation by c99) is significant.

The following options shall be supported:

−d num  Indicate the depth at which the flowgraph is cut off. The application shall ensure that the argument num is a decimal integer. By default this is a very large number (typically greater than 32,000). Attempts to set the cut-off depth to a non-positive integer shall be ignored.

−i incl  Increase the number of included symbols. The incl option-argument is one of the following characters:

x  Include external and static data symbols. The default shall be to include only functions in the flowgraph.

_ (Underscore) Include names that begin with an underscore. The default shall be to exclude these functions (and data if −i x is used).

−r  Reverse the caller: callee relationship, producing an inverted listing showing the callers of each function. The listing shall also be sorted in lexicographical order by callee.

OPERANDS

The following operand is supported:

file  The pathname of a file for which a graph is to be generated. Filenames suffixed by .l shall be taken to be lex input, .y as yacc input, .c as c99 input, and .i as the output of c99 −E. Such files shall be processed as appropriate, determined by their suffix.

Files suffixed by .s (conventionally assembler source) may have more limited information extracted from them.

STDIN

Not used.

INPUT FILES

The input files shall be object files or assembler, C-language, lex, or yacc source files.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of cflow:

LANG  Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Utilities

9032 Internationalization Variables for the precedence of internationalization variables
9033 used to determine the values of locale categories.

9034 **LC_ALL** If set to a non-empty string value, override the values of all the other
9035 internationalization variables.

9036 **LC_COLLATE** Determine the locale for the ordering of the output when the \(-r\) option is used.

9037 **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as
9038 characters (for example, single-byte as opposed to multi-byte characters in
9039 arguments and input files).

9040 **LC_MESSAGES** Determine the locale that should be used to affect the format and contents of
9041 diagnostic messages written to standard error.

9042 **NLSPATH** Determine the location of message catalogs for the processing of **LC_MESSAGES**.

9043

**ASYNCHRONOUS EVENTS**
9044 Default.

9045 **STDOUT** The flowgraph written to standard output shall be formatted as follows:
9046 "%d %s:%s\n", <reference number>, <global>, <definition>
9047 Each line of output begins with a reference (that is, line) number, followed by indentation of at
9048 least one column position per level. This is followed by the name of the global, a colon, and its
9049 definition. Normally globals are only functions not defined as an external or beginning with an
9050 underscore; see the OPTIONS section for the \(-i\) inclusion option. For information extracted from
9051 C-language source, the definition consists of an abstract type declaration (for example, **char \*\**) and,
9052 delimited by angle brackets, the name of the source file and the line number where the
9053 definition was found. Definitions extracted from object files indicate the filename and location
9054 counter under which the symbol appeared (for example, **text**).

9055 Once a definition of a name has been written, subsequent references to that name contain only
9056 the reference number of the line where the definition can be found. For undefined references,
9057 only "< >" shall be written.

9058 **STDERR** The standard error shall be used only for diagnostic messages.

9059 **OUTPUT FILES** None.

9060 **EXTENDED DESCRIPTION** None.

9061 **EXIT STATUS** The following exit values shall be returned:
9062 0 Successful completion.
9063 >0 An error occurred.

9064

**CONSEQUENCES OF ERRORS** Default.
APPLICATION USAGE

Files produced by lex and yacc cause the reordering of line number declarations, and this can confuse cflow. To obtain proper results, the input of yacc or lex must be directed to cflow.

EXAMPLES

Given the following in file.c:

```c
int i;
int f();
int g();
int h();

main()
{
    f();
    g();
    f();
}

int f()
{
    i = h();
}
```

The command:

```
cflow -i x file.c
```

produces the output:

```
1 main: int(), <file.c 6>
2    f: int(), <file.c 13>
3       h: <>
4       i: int, <file.c 1>
5       g: <>
```

RATIONALE

None.

FUTURE DIRECTIONS

None.

SEE ALSO

c99, lex, yacc

CHANGE HISTORY

First released in Issue 2.

Issue 6

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
chgrp — change the file group ownership

SYNOPSIS
chgrp [−hR] group file ...
chgrp −R [−H | −L | −P ] group file ...

DESCRIPTION
The chgrp utility shall set the group ID of the file named by each file operand to the group ID
specified by the group operand.
For each file operand, or, if the −R option is used, each file encountered while walking the
directory trees specified by the file operands, the chgrp utility shall perform actions equivalent to
the chown() function defined in the System Interfaces volume of IEEE Std 1003.1-2001, called
with the following arguments:
• The file operand shall be used as the path argument.
• The user ID of the file shall be used as the owner argument.
• The specified group ID shall be used as the group argument.
Unless chgrp is invoked by a process with appropriate privileges, the set-user-ID and set-group-
ID bits of a regular file shall be cleared upon successful completion; the set-user-ID and set-
group-ID bits of other file types may be cleared.

OPTIONS
The chgrp utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
The following options shall be supported by the implementation:

−h If the system supports group IDs for symbolic links, for each file operand that
names a file of type symbolic link, chgrp shall attempt to set the group ID of the
symbolic link instead of the file referenced by the symbolic link. If the system does
not support group IDs for symbolic links, for each file operand that names a file of
type symbolic link, chgrp shall do nothing more with the current file and shall go
on to any remaining files.

−H If the −R option is specified and a symbolic link referencing a file of type directory
is specified on the command line, chgrp shall change the group of the directory
referenced by the symbolic link and all files in the file hierarchy below it.

−L If the −R option is specified and a symbolic link referencing a file of type directory
is specified on the command line or encountered during the traversal of a file
hierarchy, chgrp shall change the group of the directory referenced by the symbolic
link and all files in the file hierarchy below it.

−P If the −R option is specified and a symbolic link is specified on the command line
or encountered during the traversal of a file hierarchy, chgrp shall change the
group ID of the symbolic link if the system supports this operation. The chgrp
utility shall not follow the symbolic link to any other part of the file hierarchy.

−R Recursively change file group IDs. For each file operand that names a directory,
chgrp shall change the group of the directory and all files in the file hierarchy below
it. Unless a −H, −L, or −P option is specified, it is unspecified which of these
options will be used as the default.
Specifying more than one of the mutually-exclusive options `-H`, `-L`, and `-P` shall not be considered an error. The last option specified shall determine the behavior of the utility.

**OPERANDS**

The following operands shall be supported:

- **group**
  A group name from the group database or a numeric group ID. Either specifies a group ID to be given to each file named by one of the `file` operands. If a numeric `group` operand exists in the group database as a group name, the group ID number associated with that group name is used as the group ID.

- **file**
  A pathname of a file whose group ID is to be modified.

**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of `chgrp`:

- **LANG**
  Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**
  Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

Not used.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- **0**
  The utility executed successfully and all requested changes were made.

- **>0**
  An error occurred.
CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Only the owner of a file or the user with appropriate privileges may change the owner or group of a file.

Some implementations restrict the use of chgrp to a user with appropriate privileges when the group specified is not the effective group ID or one of the supplementary group IDs of the calling process.

EXAMPLES
None.

RATIONALE
The System V and BSD versions use different exit status codes. Some implementations used the exit status as a count of the number of errors that occurred; this practice is unworkable since it can overflow the range of valid exit status values. The standard developers chose to mask these by specifying only 0 and >0 as exit values.

The functionality of chgrp is described substantially through references to chown(). In this way, there is no duplication of effort required for describing the interactions of permissions, multiple groups, and so on.

FUTURE DIRECTIONS
None.

SEE ALSO
chmod, chown, the System Interfaces volume of IEEE Std 1003.1-2001, chown()

CHANGE HISTORY
First released in Issue 2.

Issue 6
New options −H, −L, and −P are added to align with the IEEE P1003.2b draft standard. These options affect the processing of symbolic links.

IEEE PASC Interpretation 1003.2 #172 is applied, changing the CONSEQUENCES OF ERRORS section to “Default.”.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/15 is applied, changing the SYNOPSIS to make it clear that −h and −R are optional.
NAME
chmod — change the file modes

SYNOPSIS
chmod [-R] mode file ...

DESCRIPTION
The chmod utility shall change any or all of the file mode bits of the file named by each file operand in the way specified by the mode operand.

It is implementation-defined whether and how the chmod utility affects any alternate or additional file access control mechanism (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.4, File Access Permissions) being used for the specified file.

Only a process whose effective user ID matches the user ID of the file, or a process with the appropriate privileges, shall be permitted to change the file mode bits of a file.

OPTIONS

The following option shall be supported:

-R    Recursively change file mode bits. For each file operand that names a directory, chmod shall change the file mode bits of the directory and all files in the file hierarchy below it.

OPERANDS
The following operands shall be supported:

mode  Represents the change to be made to the file mode bits of each file named by one of the file operands; see the EXTENDED DESCRIPTION section.

file   A pathname of a file whose file mode bits shall be modified.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of chmod:

LANG    Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
Determine the location of message catalogs for the processing of **LC_MESSAGES**.

### ASYNCHRONOUS EVENTS

- **Default.**

### STDOUT

- **Not used.**

### STDERR

The standard error shall be used only for diagnostic messages.

### OUTPUT FILES

- **None.**

### EXTENDED DESCRIPTION

The **mode** operand shall be either a **symbolic_mode** expression or a non-negative octal integer. The **symbolic_mode** form is described by the grammar later in this section.

Each **clause** shall specify an operation to be performed on the current file mode bits of each **file**. The operations shall be performed on each **file** in the order in which the **clauses** are specified.

The **who** symbols **u**, **g**, and **o** shall specify the **user**, **group**, and **other** parts of the file mode bits, respectively. A **who** consisting of the symbol **a** shall be equivalent to **ugo**.

The **perm** symbols **r**, **w**, and **x** represent the **read**, **write**, and **execute/search** portions of file mode bits, respectively. The **perm** symbol **s** shall represent the **set-user-ID-on-execution** (when **who** contains or implies **u**) and **set-group-ID-on-execution** (when **who** contains or implies **g**) bits.

The **perm** symbol **X** shall represent the execute/search portion of the file mode bits if the file is a directory or if the current (unmodified) file mode bits have at least one of the execute bits (S_IXUSR, S_IXGRP, or S_IXOTH) set. It shall be ignored if the file is not a directory and none of the execute bits are set in the current file mode bits.

The **permcopy** symbols **u**, **g**, and **o** shall represent the current permissions associated with the user, group, and other parts of the file mode bits, respectively. For the remainder of this section, **perm** refers to the non-terminals **perm** and **permcopy** in the grammar.

If multiple **actionlists** are grouped with a single **wholist** in the grammar, each **actionlist** shall be applied in the order specified with that **wholist**. The **op** symbols shall represent the operation performed, as follows:

- **+** If **perm** is not specified, the `' + '` operation shall not change the file mode bits.
  - If **who** is not specified, the file mode bits represented by **perm** for the owner, group, and other permissions, except for those with corresponding bits in the file mode creation mask of the invoking process, shall be set.
  - Otherwise, the file mode bits represented by the specified **who** and **perm** values shall be set.
- **−** If **perm** is not specified, the `' − '` operation shall not change the file mode bits.
  - If **who** is not specified, the file mode bits represented by **perm** for the owner, group, and other permissions, except for those with corresponding bits in the file mode creation mask of the invoking process, shall be cleared.
  - Otherwise, the file mode bits represented by the specified **who** and **perm** values shall be cleared.
- **=** Clear the file mode bits specified by the **who** value, or, if no **who** value is specified, all of the file mode bits specified in this volume of IEEE Std 1003.1-2001.
If `perm` is not specified, the `=` operation shall make no further modifications to the file mode bits.

If `who` is not specified, the file mode bits represented by `perm` for the owner, group, and other permissions, except for those with corresponding bits in the file mode creation mask of the invoking process, shall be set.

Otherwise, the file mode bits represented by the specified `who` and `perm` values shall be set.

When using the symbolic mode form on a regular file, it is implementation-defined whether or not:

- Requests to set the set-user-ID-on-execution or set-group-ID-on-execution bit when all execute bits are currently clear and none are being set are ignored.
- Requests to clear all execute bits also clear the set-user-ID-on-execution and set-group-ID-on-execution bits.
- Requests to clear the set-user-ID-on-execution or set-group-ID-on-execution bits when all execute bits are currently clear are ignored. However, if the command `ls -l file` writes an `s` in the position indicating that the set-user-ID-on-execution or set-group-ID-on-execution is set, the commands `chmod u-s file` or `chmod g-s file`, respectively, shall not be ignored.

When using the symbolic mode form on other file types, it is implementation-defined whether or not requests to set or clear the set-user-ID-on-execution or set-group-ID-on-execution bits are honored.

If the `who` symbol `o` is used in conjunction with the `perm` symbol `s` with no other `who` symbols being specified, the set-user-ID-on-execution and set-group-ID-on-execution bits shall not be modified. It shall not be an error to specify the `who` symbol `o` in conjunction with the `perm` symbol `s`.

The `perm` symbol `t` shall specify the S_ISVTX bit. When used with a file of type directory, it can be used with the `who` symbol `a`, or with no `who` symbol. It shall not be an error to specify a `who` symbol of `u`, `g`, or `o` in conjunction with the `perm` symbol `t`, but the meaning of these combinations is unspecified. The effect when using the `perm` symbol `t` with any file type other than directory is unspecified.

For an octal integer `mode` operand, the file mode bits shall be set absolutely.

For each bit set in the octal number, the corresponding file permission bit shown in the following table shall be set; all other file permission bits shall be cleared. For regular files, for each bit set in the octal number corresponding to the set-user-ID-on-execution or the set-group-ID-on-execution, bits shown in the following table shall be set; if these bits are not set in the octal number, they are cleared. For other file types, it is implementation-defined whether or not requests to set or clear the set-user-ID-on-execution or set-group-ID-on-execution bits are honored.

<table>
<thead>
<tr>
<th>Octal</th>
<th>Mode Bit</th>
<th>Octal</th>
<th>Mode Bit</th>
<th>Octal</th>
<th>Mode Bit</th>
<th>Octal</th>
<th>Mode Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000</td>
<td>S_ISUID</td>
<td>0040</td>
<td>S_IRUSR</td>
<td>0020</td>
<td>S_IWGRP</td>
<td>0020</td>
<td>S_IWOTH</td>
</tr>
<tr>
<td>2000</td>
<td>S_ISGID</td>
<td>0040</td>
<td>S_IWUSR</td>
<td>0040</td>
<td>S_IRGRP</td>
<td>0040</td>
<td>S_IXOTH</td>
</tr>
<tr>
<td>1000</td>
<td>S_ISVTX</td>
<td>1010</td>
<td>S_IXUSR</td>
<td>1010</td>
<td>S_IXGRP</td>
<td>1010</td>
<td>S_IXOTH</td>
</tr>
</tbody>
</table>

When bits are set in the octal number other than those listed in the table above, the behavior is unspecified.
Grammar for chmod

The grammar and lexical conventions in this section describe the syntax for the symbolic_mode operand. The general conventions for this style of grammar are described in Section 1.10 (on page 19). A valid symbolic_mode can be represented as the non-terminal symbol symbolic_mode in the grammar. This formal syntax shall take precedence over the preceding text syntax description.

The lexical processing is based entirely on single characters. Implementations need not allow <blank>s within the single argument being processed.

```plaintext
%start symbolic_mode

symbolic_mode : clause
  | symbolic_mode ',' clause
;
clause : actionlist
  | wholist actionlist
;
wholist : who
  | wholist who
;
who : 'u' | 'g' | 'o' | 'a'
;
actionlist : action
  | actionlist action
;
action : op
  | op permperm
  | op permpermcopy
;
permpermcopy : 'u' | 'g' | 'o'
;
op : '+' | '-' | '='
;
permperm : perm
  | perm permperm
;
permpermperm : 'r' | 'w' | 'x' | 'X' | 's' | 'T'
;
EXIT STATUS
The following exit values shall be returned:

  0  The utility executed successfully and all requested changes were made.
  >0  An error occurred.
```
CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Some implementations of the `chmod` utility change the mode of a directory before the files in the directory when performing a recursive (`-R` option) change; others change the directory mode after the files in the directory. If an application tries to remove read or search permission for a file hierarchy, the removal attempt fails if the directory is changed first; on the other hand, trying to re-enable permissions to a restricted hierarchy fails if directories are changed last. Users should not try to make a hierarchy inaccessible to themselves.

Some implementations of `chmod` never used the process' `umask` when changing modes; systems conformant with this volume of IEEE Std 1003.1-2001 do so when `who` is not specified. Note the difference between:

`chmod a-w file`

which removes all write permissions, and:

`chmod -- -w file`

which removes write permissions that would be allowed if `file` was created with the same `umask`.

Conforming applications should never assume that they know how the set-user-ID and set-group-ID bits on directories are interpreted.

EXAMPLES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>a+=</code></td>
<td>Equivalent to <code>a+,a=</code>; clears all file mode bits.</td>
</tr>
<tr>
<td><code>go+-w</code></td>
<td>Equivalent to <code>go+go-w</code>; clears group and other write bits.</td>
</tr>
<tr>
<td><code>g=a-w</code></td>
<td>Equivalent to <code>g=a,g-w</code>; sets group bit to match other bits and then clears group write bit.</td>
</tr>
<tr>
<td><code>g-r+w</code></td>
<td>Equivalent to <code>g-r,g+w</code>; clears group read bit and sets group write bit.</td>
</tr>
<tr>
<td><code>uo=g</code></td>
<td>Sets owner bits to match group bits and sets other bits to match group bits.</td>
</tr>
</tbody>
</table>

RATIONALE

The functionality of `chmod` is described substantially through references to concepts defined in the System Interfaces volume of IEEE Std 1003.1-2001. In this way, there is less duplication of effort required for describing the interactions of permissions. However, the behavior of this utility is not described in terms of the `chmod()` function from the System Interfaces volume of IEEE Std 1003.1-2001 because that specification requires certain side effects upon alternate file access control mechanisms that might not be appropriate, depending on the implementation.

Implementations that support mandatory file and record locking as specified by the 1984 `/usr/group` standard historically used the combination of set-group-ID bit set and group execute bit clear to indicate mandatory locking. This condition is usually set or cleared with the symbolic mode `perm` symbol `l` instead of the `perm` symbols `s` and `x` so that the mandatory locking mode is not changed without explicit indication that that was what the user intended. Therefore, the details on how the implementation treats these conditions must be defined in the documentation. This volume of IEEE Std 1003.1-2001 does not require mandatory locking (nor does the System Interfaces volume of IEEE Std 1003.1-2001), but does allow it as an extension. However, this volume of IEEE Std 1003.1-2001 does require that the `ls` and `chmod` utilities work
consistently in this area. If `ls -l file` indicates that the set-group-ID bit is set, `chmod g-s file` must
clear it (assuming appropriate privileges exist to change modes).

The System V and BSD versions use different exit status codes. Some implementations used the
exit status as a count of the number of errors that occurred; this practice is unworkable since it
can overflow the range of valid exit status values. This problem is avoided here by specifying
only 0 and >0 as exit values.

The System Interfaces volume of IEEE Std 1003.1-2001 indicates that implementation-defined
restrictions may cause the S_ISUID and S_ISGID bits to be ignored. This volume of
IEEE Std 1003.1-2001 allows the `chmod` utility to choose to modify these bits before calling
`chmod()` (or some function providing equivalent capabilities) for non-regular files. Among other
things, this allows implementations that use the set-user-ID and set-group-ID bits on directories
to enable extended features to handle these extensions in an intelligent manner.

The `X perm` symbol was adopted from BSD-based systems because it provides commonly
desired functionality when doing recursive (−R option) modifications. Similar functionality is
not provided by the `find` utility. Historical BSD versions of `chmod`, however, only supported `X
with op+`; it has been extended in this volume of IEEE Std 1003.1-2001 because it is also useful
with `op=`. (It has also been added for `op−` even though it duplicates `x`, in this case, because it is
intuitive and easier to explain.)

The grammar was extended with the `permcopy` non-terminal to allow historical-practice forms of
symbolic modes like `o=u−g` (that is, set the ‘other’ permissions to the permissions of ‘owner’
minus the permissions of ‘group’).

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`ls`, `umask`, the System Interfaces volume of IEEE Std 1003.1-2001, `chmod()`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

The following new requirements on POSIX implementations derive from alignment with the
Single UNIX Specification:

- Octal modes have been kept and made mandatory despite being marked obsolescent in the

IEEE PASC Interpretation 1003.2 #172 is applied, changing the CONSEQUENCES OF ERRORS
section to “Default.”.

The Open Group Base Resolution bwg2001-010 is applied, adding the description of the
S_ISVTX bit and the `t perm` symbol as an XSI extension.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/16 is applied, changing the XSI shaded
text in the EXTENDED DESCRIPTION from:

```
"The perm symbol t shall specify the S_ISVTX bit and shall apply to directories only. The
effect when using it with any other file type is unspecified. It can be used with the who
symbols o, a, or with no who symbol. It shall not be an error to specify a who symbol of u or
g in conjunction with the perm symbol t; it shall be ignored for u and g."
```

to:

```
"The perm symbol t shall specify the S_ISVTX bit and shall apply to directories only. The
```
“The perm symbol t shall specify the S_ISVTX bit. When used with a file of type directory, it can be used with the who symbol a, or with no who symbol. It shall not be an error to specify a who symbol of u, g, or o in conjunction with the perm symbol t, but the meaning of these combinations is unspecified. The effect when using the perm symbol t with any file type other than directory is unspecified.”

This change is to permit historical behavior.
NAME
chown — change the file ownership

SYNOPSIS
chown [-hR] owner[:group] file ...
chown -R [-H | -L | -P ] owner[:group] file ...

DESCRIPTION
The chown utility shall set the user ID of the file named by each file operand to the user ID specified by the owner operand.

For each file operand, or, if the -R option is used, each file encountered while walking the directory trees specified by the file operands, the chown utility shall perform actions equivalent to the chown() function defined in the System Interfaces volume of IEEE Std 1003.1-2001, called with the following arguments:

1. The file operand shall be used as the path argument.
2. The user ID indicated by the owner portion of the first operand shall be used as the owner argument.
3. If the group portion of the first operand is given, the group ID indicated by it shall be used as the group argument; otherwise, the group ownership shall not be changed.

Unless chown is invoked by a process with appropriate privileges, the set-user-ID and set-group-ID bits of a regular file shall be cleared upon successful completion; the set-user-ID and set-group-ID bits of other file types may be cleared.

OPTIONS

The following options shall be supported by the implementation:

-h If the system supports user IDs for symbolic links, for each file operand that names a file of type symbolic link, chown shall attempt to set the user ID of the symbolic link. If the system supports group IDs for symbolic links, and a group ID was specified, for each file operand that names a file of type symbolic link, chown shall attempt to set the group ID of the symbolic link. If the system does not support user or group IDs for symbolic links, for each file operand that names a file of type symbolic link, chown shall do nothing more with the current file and shall go on to any remaining files.

-H If the -R option is specified and a symbolic link referencing a file of type directory is specified on the command line, chown shall change the user ID (and group ID, if specified) of the directory referenced by the symbolic link and all files in the file hierarchy below it.

-L If the -R option is specified and a symbolic link referencing a file of type directory is specified on the command line or encountered during the traversal of a file hierarchy, chown shall change the user ID (and group ID, if specified) of the directory referenced by the symbolic link and all files in the file hierarchy below it.

-P If the -R option is specified and a symbolic link is specified on the command line or encountered during the traversal of a file hierarchy, chown shall change the owner ID (and group ID, if specified) of the symbolic link if the system supports this operation. The chown utility shall not follow the symbolic link to any other part of the file hierarchy.
Recursively change file user and group IDs. For each file operand that names a directory, chown shall change the user ID (and group ID, if specified) of the directory and all files in the file hierarchy below it. Unless a \(-H\), \(-L\), or \(-P\) option is specified, it is unspecified which of these options will be used as the default.

Specifying more than one of the mutually-exclusive options \(-H\), \(-L\), and \(-P\) shall not be considered an error. The last option specified shall determine the behavior of the utility.

### OPERANDS

The following operands shall be supported:

- **owner[\(\)group]** A user ID and optional group ID to be assigned to file. The **owner** portion of this operand shall be a user name from the user database or a numeric user ID. Either specifies a user ID which shall be given to each file named by one of the file operands. If a numeric **owner** operand exists in the user database as a user name, the user ID number associated with that user name shall be used as the user ID. Similarly, if the **group** portion of this operand is present, it shall be a group name from the group database or a numeric group ID. Either specifies a group ID which shall be given to each file. If a numeric group operand exists in the group database as a group name, the group ID number associated with that group name shall be used as the group ID.

- **file** A pathname of a file whose user ID is to be modified.

### STDIN

Not used.

### INPUT FILES

None.

### ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of chown:

- **LANG** Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH** Determine the location of message catalogs for the processing of **LC_MESSAGES**.

### ASYNCHRONOUS EVENTS

Default.

### STDOUT

Not used.
**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- 0  The utility executed successfully and all requested changes were made.
- >0  An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

Only the owner of a file or the user with appropriate privileges may change the owner or group of a file.

Some implementations restrict the use of *chown* to a user with appropriate privileges.

**EXAMPLES**

None.

**RATIONALE**

The System V and BSD versions use different exit status codes. Some implementations used the exit status as a count of the number of errors that occurred; this practice is unworkable since it can overflow the range of valid exit status values. These are masked by specifying only 0 and >0 as exit values.

The functionality of *chown* is described substantially through references to functions in the System Interfaces volume of IEEE Std 1003.1-2001. In this way, there is no duplication of effort required for describing the interactions of permissions, multiple groups, and so on.

The 4.3 BSD method of specifying both owner and group was included in this volume of IEEE Std 1003.1-2001 because:

- There are cases where the desired end condition could not be achieved using the *chgrp* and *chown* (that only changed the user ID) utilities. (If the current owner is not a member of the desired group and the desired owner is not a member of the current group, the *chown()* function could fail unless both owner and group are changed at the same time.)

- Even if they could be changed independently, in cases where both are being changed, there is a 100% performance penalty caused by being forced to invoke both utilities.

The BSD syntax `user[.group]` was changed to `user[:group]` in this volume of IEEE Std 1003.1-2001 because the period is a valid character in login names (as specified by the Base Definitions volume of IEEE Std 1003.1-2001, login names consist of characters in the portable filename character set). The colon character was chosen as the replacement for the period character because it would never be allowed as a character in a user name or group name on historical implementations.

The --R option is considered by some observers as an undesirable departure from the historical UNIX system tools approach; since a tool, *find*, already exists to recurse over directories, there seemed to be no good reason to require other tools to have to duplicate that functionality. However, the --R option was deemed an important user convenience, is far more efficient than
Utilities

chown

forking a separate process for each element of the directory hierarchy, and is in widespread historical use.

FUTURE DIRECTIONS
None.

SEE ALSO
chmod, chgrp, the System Interfaces volume of IEEE Std 1003.1-2001, chown()

CHANGE HISTORY
First released in Issue 2.

Issue 6
New options –h, –H, –L, and –P are added to align with the IEEE P1003.2b draft standard. These options affect the processing of symbolic links.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE PASC Interpretation 1003.2 #172 is applied, changing the CONSEQUENCES OF ERRORS section to “Default.”.

The “otherwise, …” text in item 3. of the DESCRIPTION is changed to “otherwise, the group ownership shall not be changed”.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/17 is applied, changing the SYNOPSIS to make it clear that –h and –R are optional.
NAME
cksum — write file checksums and sizes

SYNOPSIS
cksum [file ...]

DESCRIPTION
The cksum utility shall calculate and write to standard output a cyclic redundancy check (CRC) for each input file, and also write to standard output the number of octets in each file. The CRC used is based on the polynomial used for CRC error checking in the ISO/IEC 8802-3:1996 standard (Ethernet).

The encoding for the CRC checksum is defined by the generating polynomial:

\[ G(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1 \]

Mathematically, the CRC value corresponding to a given file shall be defined by the following procedure:

1. The \( n \) bits to be evaluated are considered to be the coefficients of a mod 2 polynomial \( M(x) \) of degree \( n-1 \). These \( n \) bits are the bits from the file, with the most significant bit being the most significant bit of the first octet of the file and the last bit being the least significant bit of the last octet, padded with zero bits (if necessary) to achieve an integral number of octets, followed by one or more octets representing the length of the file as a binary value, least significant octet first. The smallest number of octets capable of representing this integer shall be used.

2. \( M(x) \) is multiplied by \( x^{32} \) (that is, shifted left 32 bits) and divided by \( G(x) \) using mod 2 division, producing a remainder \( R(x) \) of degree \( \leq 31 \).

3. The coefficients of \( R(x) \) are considered to be a 32-bit sequence.

4. The bit sequence is complemented and the result is the CRC.

OPTIONS
None.

OPERANDS
The following operand shall be supported:

file
A pathname of a file to be checked. If no file operands are specified, the standard input shall be used.

STDIN
The standard input shall be used only if no file operands are specified. See the INPUT FILES section.

INPUT FILES
The input files can be any file type.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of cksum:

LANG
Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other internationalization variables.
Utilities

**cksum**

| **LC_CTYPE** | Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments). |
| **LC_MESSAGES** | Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error. |

**xsi**  
**NLSPATH** Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

For each file processed successfully, the `cksum` utility shall write in the following format:

```
%u %d %s
```

If no file operand was specified, the pathname and its leading space shall be omitted.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>All files were processed successfully.</td>
</tr>
<tr>
<td>&gt;0</td>
<td>An error occurred.</td>
</tr>
</tbody>
</table>

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

The `cksum` utility is typically used to quickly compare a suspect file against a trusted version of the same, such as to ensure that files transmitted over noisy media arrive intact. However, this comparison cannot be considered cryptographically secure. The chances of a damaged file producing the same CRC as the original are small; deliberate deception is difficult, but probably not impossible.

Although input files to `cksum` can be any type, the results need not be what would be expected on character special device files or on file types not described by the System Interfaces volume of IEEE Std 1003.1-2001. Since this volume of IEEE Std 1003.1-2001 does not specify the block size used when doing input, checksums of character special files need not process all of the data in those files.

The algorithm is expressed in terms of a bitstream divided into octets. If a file is transmitted between two systems and undergoes any data transformation (such as changing little-endian byte ordering to big-endian), identical CRC values cannot be expected. Implementations performing such transformations may extend `cksum` to handle such situations.
EXAMPLES
None.

RATIONALE
The following C-language program can be used as a model to describe the algorithm. It assumes that a char is one octet. It also assumes that the entire file is available for one pass through the function. This was done for simplicity in demonstrating the algorithm, rather than as an implementation model.

static unsigned long crctab[] = {
    0x00000000,
    0x04c11db7, 0x09823b6e, 0x0d4326d9, 0x130476dc, 0x17c56b6b,
    0x1a864db2, 0x1e475005, 0x2608edb8, 0x22c9f00f, 0x2f8ad6d6,
    0x2b4bcb61, 0x350c9b64, 0x31cd86d3, 0x3c8ea00a, 0x384fbdbd,
    0x4c11db70, 0x48d0c6c7, 0x4593e01e, 0x4152fda9, 0x5f15adac,
    0x5bd4b01b, 0x569796c2, 0x52a58075, 0x6a1936c8, 0x6ed82b7f,
    0x639b0da6, 0x675a1011, 0x791d4014, 0x7ddc5da3, 0x709f7b7a,
    0x745e66c4, 0x7923b6e0, 0x7ce2ab57, 0x71a18db7, 0x85609039,
    0x8b27c03c, 0x8fe6dd8b, 0x82a5fb52, 0x8664e6e5, 0x9e2b5058,
    0x9bb8bb46, 0x97f9a6d8, 0x9356b6b0, 0x9075b05f, 0xa13ef6f4,
    0xbfa1b04b, 0xb760adfc, 0xb527904e, 0xaeb5a610, 0xaafbe615,
    0x0315d626, 0x07d4cb91, 0x0a97ed48, 0xe6f37072, 0x0571d7d1,
    0x053dc066, 0x049b3063, 0x04952ad4, 0x044190b0, 0x040d16ba,
    0x0a5c697, 0x0864d2b0, 0x0a527f93, 0x0a1e6e04, 0x0b51a0b4,
    0x0b60a92b, 0x0b6238b2, 0x0b2e9b92, 0x08a2e2bf, 0x086e3698,
    0x0832f1041, 0x087ee0df6, 0x099a95df3, 0x09684044, 0x0902b66d9,
    0x094ea7b2a, 0x0e0b41de7, 0x0e475050, 0xe9362689, 0xe0f37b3e,
    0x0f3b06b3b, 0xf771768c, 0xfa325055, 0xfef34de2, 0xc6b70505f,
    0xc27d6ede8, 0xcf3e3bc31, 0xcbb7f68, 0xd5b88683, 0xda799b34,
    0xdc3adbfd, 0xdf86ba05a, 0x690ce0ee, 0x6dcd5f59, 0x608eb80,
    0x644fc637, 0x67a09632, 0x67ec98b5, 0x6738aad5c, 0x6774bb0eb,
    0x65f40d56, 0x64bc510e1, 0x64863638, 0x64272bf8, 0x65007b8a,
    0x6581663d, 0x6558240e4, 0x651435d3, 0x251d3be9, 0xe21de262,
    0x62c9f00f0, 0x285ed1d7, 0x36194d42, 0x32d805f5, 0x3f9b762c,
    0x3b5a69b9, 0x0315d626, 0x07d4cb91, 0x0a97ed48, 0xe6f37072,
    0x10110ba, 0x140db4d4, 0x19939b94, 0xd1528623, 0xf12f560e,
    0xf5ee4bb9, 0xf86ad6d0, 0xfcc67072, 0xe22b202d, 0xe6e6a36d5,
    0xe6eb91bc, 0xef68060b, 0xd727bb6, 0xd3e6a601, 0xdae580d8,
    0xda649d6f, 0xc423cd6a, 0xc0e2d0dd, 0xcda1f604, 0x9c96e0bb3,
    0xb3e8d7e, 0xb9ff90c9, 0xb4bcb610, 0xb07daba7, 0xae3afba2,
    0xaafbe615, 0xa78b0cc, 0xa379d7db, 0xc9b3660c6, 0x9ff77d71,
    0x92b45ba8, 0x96754d1f, 0x8832161a, 0x8cf3b05d, 0x81b02d74,
    0x857130c3, 0x5d8a9099, 0x594b8d2e, 0x5408af7, 0x50cb640,
    0x4e88ed45, 0x4a4ffbf2, 0x470cd2db, 0x43cdd0c9, 0x7bb827d21,
    0x7f436096, 0x720464f, 0x76c156bf, 0x686b0fbd, 0x6ca4716a,
    0x61043093, 0x65c52d24, 0x119b4be9, 0x155a565e, 0x18197087,
Utilities

Utilities

cksum

unsigned long memcrc(const unsigned char *b, size_t n)
{
    /* Input arguments:
    * const char* b == byte sequence to checksum
    * size_t n == length of sequence
    */
    register unsigned i, c, s = 0;
    for (i = n; i > 0; --i) {
        c = (unsigned)(*b++);
        s = (s << 8) ^ crctab[(s >> 24) ^ c];
    }
    /* Extend with the length of the string. */
    while (n != 0) {
        c = n & 0377;
        n >>= 8;
        s = (s << 8) ^ crctab[(s >> 24) ^ c];
    }
    return ~s;
}

The historical practice of writing the number of "blocks" has been changed to writing the number of octets, since the latter is not only more useful, but also since historical implementations have not been consistent in defining what a "block" meant. Octets are used instead of bytes because bytes can differ in size between systems.

The algorithm used was selected to increase the operational robustness of cksum. Neither the System V nor BSD sum algorithm was selected. Since each of these was different and each was the default behavior on those systems, no realistic compromise was available if either were selected—some set of historical applications would break. Therefore, the name was changed to cksum. Although the historical sum commands will probably continue to be provided for many years, programs designed for portability across systems should use the new name.

The algorithm selected is based on that used by the ISO/IEC 8802-3:1996 standard (Ethernet) for the frame check sequence field. The algorithm used does not match the technical definition of a checksum; the term is used for historical reasons. The length of the file is included in the CRC calculation because this parallels inclusion of a length field by Ethernet in its CRC, but also because it guards against inadvertent collisions between files that begin with different series of zero octets. The chance that two different files produce identical CRCs is much greater when their lengths are not considered. Keeping the length and the checksum of the file itself separate would yield a slightly more robust algorithm, but historical usage has always been that a single number (the checksum as printed) represents the signature of the file. It was decided that...
historical usage was the more important consideration.

Early proposals contained modifications to the Ethernet algorithm that involved extracting table values whenever an intermediate result became zero. This was demonstrated to be less robust than the current method and mathematically difficult to describe or justify.

The calculation used is identical to that given in pseudo-code in the referenced Sarwate article. The pseudo-code rendition is:

\[
\begin{align*}
X &\leftarrow 0; Y \leftarrow 0; \\
\text{for } i \leftarrow m - 1 \text{ step } -1 \text{ until } 0 &\text{ do} \\
&\begin{aligned}
T &\leftarrow X(1)^\wedge A[i]; \\
X(1) &\leftarrow X(0); X(0) \leftarrow Y(1); Y(1) \leftarrow Y(0); Y(0) \leftarrow 0; \\
\text{comment: } f[T] \text{ and } f'[T] &\text{ denote the } T\text{-th words in the } \\
&\begin{aligned}
&\text{table } f \text{ and } f' \text{;} \\
&X \leftarrow X \wedge f[T]; Y \leftarrow Y \wedge f'[T]; \\
&\end{aligned}
\end{aligned}
\end{align*}
\]

The pseudo-code is reproduced exactly as given; however, note that in the case of \textit{cksum}, \(A[i]\) represents a byte of the file, the words \(X\) and \(Y\) are treated as a single 32-bit value, and the tables \(f\) and \(f'\) are a single table containing 32-bit values.

The referenced Sarwate article also discusses generating the table.

\section*{FUTURE DIRECTIONS}
None.

\section*{SEE ALSO}
None.

\section*{CHANGE HISTORY}
First released in Issue 4.
NAME
cmp — compare two files

SYNOPSIS
cmp [ −l | −s ] file1 file2

DESCRIPTION
The cmp utility shall compare two files. The cmp utility shall write no output if the files are the same. Under default options, if they differ, it shall write to standard output the byte and line number at which the first difference occurred. Bytes and lines shall be numbered beginning with 1.

OPTIONS

The following options shall be supported:
−l (Lowercase ell.) Write the byte number (decimal) and the differing bytes (octal) for each difference.
−s Write nothing for differing files; return exit status only.

OPERANDS
The following operands shall be supported:
file1 A pathname of the first file to be compared. If file1 is ‘−’, the standard input shall be used.
file2 A pathname of the second file to be compared. If file2 is ‘−’, the standard input shall be used.

If both file1 and file2 refer to standard input or refer to the same FIFO special, block special, or character special file, the results are undefined.

STDIN
The standard input shall be used only if the file1 or file2 operand refers to standard input. See the INPUT FILES section.

INPUT FILES
The input files can be any file type.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of cmp:
LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.
Determine the location of message catalogs for the processing of LC_MESSAGES.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

In the POSIX locale, results of the comparison shall be written to standard output. When no options are used, the format shall be:

```
%s %s differ: char %d, line %d
```

When the –I option is used, the format shall be:

```
%d %o %o
```

for each byte that differs. The first <differing byte> number is from file1 while the second is from file2. In both cases, <byte number> shall be relative to the beginning of the file, beginning with 1.

No output shall be written to standard output when the –s option is used.

**STDERR**

The standard error shall be used only for diagnostic messages. If file1 and file2 are identical for the entire length of the shorter file, in the POSIX locale the following diagnostic message shall be written, unless the –s option is specified:

```
"cmp: EOF on %s
```

The <additional info> field shall either be null or a string that starts with a <blank> and contains no <newline>s. Some implementations report on the number of lines in this case.

**OUTPUT FILES**

None.

**EXTERNAL DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

<table>
<thead>
<tr>
<th>Exit Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The files are identical.</td>
</tr>
<tr>
<td>1</td>
<td>The files are different; this includes the case where one file is identical to the first part of the other.</td>
</tr>
<tr>
<td>&gt;1</td>
<td>An error occurred.</td>
</tr>
</tbody>
</table>

**APPLICATION USAGE**

Although input files to cmp can be any type, the results might not be what would be expected on character special device files or on file types not described by the System Interfaces volume of IEEE Std 1003.1-2001. Since this volume of IEEE Std 1003.1-2001 does not specify the block size used when doing input, comparisons of character special files need not compare all of the data in those files.

For files which are not text files, line numbers simply reflect the presence of a <newline>, without any implication that the file is organized into lines.
EXAMPLES
None.

RATIONALE
The global language in Section 1.11 (on page 20) indicates that using two mutually-exclusive options together produces unspecified results. Some System V implementations consider the option usage:

```
cmp -l -s ...
```
to be an error. They also treat:

```
cmp -s -l ...
```
as if no options were specified. Both of these behaviors are considered bugs, but are allowed.

The word `char` in the standard output format comes from historical usage, even though it is actually a byte number. When `cmp` is supported in other locales, implementations are encouraged to use the word `byte` or its equivalent in another language. Users should not interpret this difference to indicate that the functionality of the utility changed between locales.

Some implementations report on the number of lines in the identical-but-shorter file case. This is allowed by the inclusion of the `<additional info>` fields in the output format. The restriction on having a leading `<blank>` and no `<newline>`s is to make parsing for the filename easier. It is recognized that some filenames containing white-space characters make parsing difficult anyway, but the restriction does aid programs used on systems where the names are predominantly well behaved.

FUTURE DIRECTIONS
None.

SEE ALSO
`comm`, `diff`

CHANGE HISTORY
First released in Issue 2.
comm

NAME
comm — select or reject lines common to two files

SYNOPSIS
comm [-123] file1 file2

DESCRIPTION
The comm utility shall read file1 and file2, which should be ordered in the current collating sequence, and produce three text columns as output: lines only in file1, lines only in file2, and lines in both files.

If the lines in both files are not ordered according to the collating sequence of the current locale, the results are unspecified.

OPTIONS

The following options shall be supported:
-1 Suppress the output column of lines unique to file1.
-2 Suppress the output column of lines unique to file2.
-3 Suppress the output column of lines duplicated in file1 and file2.

OPERANDS
The following operands shall be supported:

file1 A pathname of the first file to be compared. If file1 is ‘−’, the standard input shall be used.
file2 A pathname of the second file to be compared. If file2 is ‘−’, the standard input shall be used.

If both file1 and file2 refer to standard input or to the same FIFO special, block special, or character special file, the results are undefined.

STDIN
The standard input shall be used only if one of the file1 or file2 operands refers to standard input. See the INPUT FILES section.

INPUT FILES
The input files shall be text files.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of comm:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_COLLATE
Determine the locale for the collating sequence comm expects to have been used when the input files were sorted.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**XSI NLSPATH**
Determine the location of message catalogs for the processing of LC_MESSAGES.

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
The `comm` utility shall produce output depending on the options selected. If the −1, −2, and −3 options are all selected, `comm` shall write nothing to standard output.

If the −1 option is not selected, lines contained only in `file1` shall be written using the format:

```
"%s \n", <line in file1>
```

If the −2 option is not selected, lines contained only in `file2` are written using the format:

```
"%s%s\n", <lead>, <line in file2>
```

where the string `<lead>` is as follows:

- `<tab>` The −1 option is not selected.
- null string The −1 option is selected.

If the −3 option is not selected, lines contained in both files shall be written using the format:

```
"%s%s\n", <lead>, <line in both>
```

where the string `<lead>` is as follows:

- `<tab>` Neither the −1 nor the −2 option is selected.
- `<tab>` Exactly one of the −1 and −2 options is selected.
- null string Both the −1 and −2 options are selected.

If the input files were ordered according to the collating sequence of the current locale, the lines written shall be in the collating sequence of the original lines.

**STDERR**
The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
The following exit values shall be returned:

- 0 All input files were successfully output as specified.
- >0 An error occurred.

**CONSEQUENCES OF ERRORS**
Default.
APPLICATION USAGE

If the input files are not properly presorted, the output of com might not be useful.

EXAMPLES

If a file named xcu contains a sorted list of the utilities in this volume of IEEE Std 1003.1-2001, a
file named xpg3 contains a sorted list of the utilities specified in the X/Open Portability Guide,
Issue 3, and a file named svid89 contains a sorted list of the utilities in the System V Interface
Definition Third Edition:

```
comm -23 xcu xpg3 | comm -23 - svid89
```

would print a list of utilities in this volume of IEEE Std 1003.1-2001 not specified by either of the
other documents:

```
comm -12 xcu xpg3 | comm -12 - svid89
```

would print a list of utilities specified by all three documents, and:

```
comm -12 xpg3 svid89 | comm -23 - xcu
```

would print a list of utilities specified by both XPG3 and the SVID, but not specified in this

RATIONALE

None.

FUTURE DIRECTIONS

None.

SEE ALSO

cmp, diff, sort, uniq

CHANGE HISTORY

First released in Issue 2.

Issue 6

The normative text is reworded to avoid use of the term “must” for application requirements.
Utilities

command

NAME
command — execute a simple command

SYNOPSIS
command [−p] command_name [argument ...]
command [−v | −V ] command_name

DESCRIPTION
The command utility shall cause the shell to treat the arguments as a simple command, suppressing the shell function lookup that is described in Section 2.9.1.1 (on page 48), item 1b.

If the command_name is the same as the name of one of the special built-in utilities, the special properties in the enumerated list at the beginning of Section 2.14 (on page 64) shall not occur. In every other respect, if command_name is not the name of a function, the effect of command (with no options) shall be the same as omitting command.

On systems supporting the User Portability Utilities option, the command utility also shall provide information concerning how a command name is interpreted by the shell; see −v and −V.

OPTIONS

The following options shall be supported:

−p Perform the command search using a default value for PATH that is guaranteed to find all of the standard utilities.

−v (On systems supporting the User Portability Utilities option.) Write a string to standard output that indicates the pathname or command that will be used by the shell, in the current shell execution environment (see Section 2.12 (on page 61)), to invoke command_name, but do not invoke command_name.

−V (On systems supporting the User Portability Utilities option.) Write a string to standard output that indicates how the name given in the command_name operand will be interpreted by the shell, in the current shell execution environment (see Section 2.12 (on page 61)), but do not invoke command_name. Although the format of this string is unspecified, it shall indicate in which of the following categories command_name falls and shall include the information stated:

• Utilities, regular built-in utilities, and any implementation-defined functions that are found using the PATH variable (as described in Section 2.9.1.1 (on page 48)), shall be identified as such and include the absolute pathname in the string.
• Other shell functions shall be identified as functions.

• Aliases shall be identified as aliases and their definitions included in the string.

• Special built-in utilities shall be identified as special built-in utilities.

• Regular built-in utilities not associated with a PATH search shall be identified as regular built-in utilities. (The term “regular” need not be used.)

• Shell reserved words shall be identified as reserved words.

OPERANDS

The following operands shall be supported:

```
argument
```
One of the strings treated as an argument to command_name.

```
command_name
```
The name of a utility or a special built-in utility.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of command:

```
LANG
```
Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

```
LC_ALL
```
If set to a non-empty string value, override the values of all the other
internationalization variables.

```
LC_CTYPE
```
Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

```
LC_MESSAGES
```
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error and informative messages written to
standard output.

```
NLSPATH
```
Determine the location of message catalogs for the processing of LC_MESSAGES.

```
PATH
```
Determine the search path used during the command search described in Section
2.9.1.1 (on page 48), except as described under the −p option.

ASYNCHRONOUS EVENTS

Default.

STDOUT

When the −v option is specified, standard output shall be formatted as:

```
"%s\n", <pathname or command>
```

When the −V option is specified, standard output shall be formatted as:

```
"%s\n", <unspecified>
```
Utilities

command

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

When the −v or −V options are specified, the following exit values shall be returned:

0 Successful completion.

>0 The command_name could not be found or an error occurred.

Otherwise, the following exit values shall be returned:

126 The utility specified by command_name was found but could not be invoked.

127 An error occurred in the command utility or the utility specified by command_name could not be found.

Otherwise, the exit status of command shall be that of the simple command specified by the arguments to command.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

The order for command search allows functions to override regular built-ins and path searches.

This utility is necessary to allow functions that have the same name as a utility to call the utility (instead of a recursive call to the function).

The system default path is available using getconf; however, since getconf may need to have the PATH set up before it can be called itself, the following can be used:

command −p getconf _CS_PATH

There are some advantages to suppressing the special characteristics of special built-ins on occasion. For example:

command exec > unwritable-file

does not cause a non-interactive script to abort, so that the output status can be checked by the script.

The command, env, nohup, time, and xargs utilities have been specified to use exit code 127 if an error occurs so that applications can distinguish “failure to find a utility” from “invoked utility exited with an error indication”. The value 127 was chosen because it is not commonly used for other meanings; most utilities use small values for “normal error conditions” and the values above 128 can be confused with termination due to receipt of a signal. The value 126 was chosen in a similar manner to indicate that the utility could be found, but not invoked. Some scripts produce meaningful error messages differentiating the 126 and 127 cases. The distinction between exit codes 126 and 127 is based on KornShell practice that uses 127 when all attempts to exec the utility fail with [ENOENT], and uses 126 when any attempt to exec the utility fails for any other reason.

Since the −v and −V options of command produce output in relation to the current shell execution environment, command is generally provided as a shell regular built-in. If it is called in a subshell or separate utility execution environment, such as one of the following:
it does not necessarily produce correct results. For example, when called with `nohup` or an `exec` function, in a separate utility execution environment, most implementations are not able to identify aliases, functions, or special built-ins.

Two types of regular built-ins could be encountered on a system and these are described separately by `command`. The description of command search in Section 2.9.1.1 (on page 48) allows for a standard utility to be implemented as a regular built-in as long as it is found in the appropriate place in a `PATH` search. So, for example, `command -v true` might yield `/bin/true` or some similar pathname. Other implementation-defined utilities that are not defined by this volume of IEEE Std 1003.1-2001 might exist only as built-ins and have no pathname associated with them. These produce output identified as (regular) built-ins. Applications encountering these are not able to count on `exec`ing them, using them with `nohup`, overriding them with a different `PATH`, and so on.

**EXAMPLES**

1. Make a version of `cd` that always prints out the new working directory exactly once:

   ```bash
   cd() {
       command cd "$@" >/dev/null
       pwd
   }
   ```

2. Start off a "secure shell script" in which the script avoids being spoofed by its parent:

   ```bash
   IFS=’
   # The preceding value should be <space><tab><newline>.
   # Set IFS to its default value.
   \unalias -a
   # Unset all possible aliases.
   # Note that unalias is escaped to prevent an alias
   # being used for unalias.
   unset -f command
   # Ensure command is not a user function.
   PATH="$(command -p getconf _CS_PATH):$PATH"
   # Put on a reliable PATH prefix.
   # ...
   ```

   At this point, given correct permissions on the directories called by `PATH`, the script has the ability to ensure that any utility it calls is the intended one. It is being very cautious because it assumes that implementation extensions may be present that would allow user functions to exist when it is invoked; this capability is not specified by this volume of IEEE Std 1003.1-2001, but it is not prohibited as an extension. For example, the `ENV` variable precedes the invocation of the script with a user start-up script. Such a script could define functions to spoof the application.

**RATIONALE**

Since `command` is a regular built-in utility it is always found prior to the `PATH` search.

There is nothing in the description of `command` that implies the command line is parsed any differently from that of any other simple command. For example:
command a | b ; c

is not parsed in any special way that causes '|' or ';' to be treated other than a pipe operator
or semicolon or that prevents function lookup on b or c.

The command utility is somewhat similar to the Eighth Edition shell builtin command, but since
command also goes to the file system to search for utilities, the name builtin would not be
intuitive.

The command utility is most likely to be provided as a regular built-in. It is not listed as a special
built-in for the following reasons:

- The removal of exportable functions made the special precedence of a special built-in
  unnecessary.
- A special built-in has special properties (see Section 2.14 (on page 64)) that were
  inappropriate for invoking other utilities. For example, two commands such as:

  date > unwritable-file
  command date > unwritable-file

  would have entirely different results; in a non-interactive script, the former would continue
to execute the next command, the latter would abort. Introducing this semantic difference
along with suppressing functions was seen to be non-intuitive.

The -p option is present because it is useful to be able to ensure a safe path search that finds all
the standard utilities. This search might not be identical to the one that occurs through one of the
exec functions (as defined in the System Interfaces volume of IEEE Std 1003.1-2001) when PATH
is unset. At the very least, this feature is required to allow the script to access the correct version
of getconf so that the value of the default path can be accurately retrieved.

The command -v and -V options were added to satisfy requirements from users that are
currently accomplished by three different historical utilities: type in the System V shell, whence in
the KornShell, and which in the C shell. Since there is no historical agreement on how and what
to accomplish here, the POSIX command utility was enhanced and the historical utilities were left
unmodified. The C shell which merely conducts a path search. The KornShell whence is more
elaborate—in addition to the categories required by POSIX, it also reports on tracked aliases,
exported aliases, and undefined functions.

The output format of -V was left mostly unspecified because human users are its only audience.
Applications should not be written to care about this information; they can use the output of -v
to differentiate between various types of commands, but the additional information that may be
emitted by the more verbose -V is not needed and should not be arbitrarily constrained in its
verbosity or localization for application parsing reasons.

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.9.1.1 (on page 48), Section 2.12 (on page 61), Section 2.14 (on page 64), sh, type, the
System Interfaces volume of IEEE Std 1003.1-2001, exec

CHANGE HISTORY

First released in Issue 4.
NAME
compress — compress data

SYNOPSIS
compress [-fv] [-b bits] [file ...]
compress [-cfv] [-b bits] [file]

DESCRIPTION
The compress utility shall attempt to reduce the size of the named files by using adaptive
Lempel-Ziv coding algorithm.

Note: Lempel-Ziv is US Patent 4464650, issued to William Eastman, Abraham Lempel, Jacob Ziv,
Martin Cohn on August 7th, 1984, and assigned to Sperry Corporation.
Lempel-Ziv-Welch compression is covered by US Patent 4558302, issued to Terry A. Welch on
December 10th, 1985, and assigned to Sperry Corporation.

On systems not supporting adaptive Lempel-Ziv coding algorithm, the input files shall not be
changed and an error value greater than two shall be returned. Except when the output is to the
standard output, each file shall be replaced by one with the extension .Z. If the invoking process
has appropriate privileges, the ownership, modes, access time, and modification time of the
original file are preserved. If appending the .Z to the filename would make the name exceed
(NAME_MAX) bytes, the command shall fail. If no files are specified, the standard input shall be
compressed to the standard output.

OPTIONS
The compress utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001,
Section 12.2, Utility Syntax Guidelines.
The following options shall be supported:

-b bits Specify the maximum number of bits to use in a code. For a conforming
application, the bits argument shall be:
9 <= bits <= 14
The implementation may allow bits values of greater than 14. The default is 14, 15,
or 16.
-c Cause compress to write to the standard output; the input file is not changed, and
no .Z files are created.
-f Force compression of file, even if it does not actually reduce the size of the file, or if
the corresponding file.Z file already exists. If the -f option is not given, and the
process is not running in the background, the user is prompted as to whether an
existing file.Z file should be overwritten.
-v Write the percentage reduction of each file to standard error.

OPERANDS
The following operand shall be supported:

file A pathname of a file to be compressed.

STDIN
The standard input shall be used only if no file operands are specified, or if a file operand is ‘-’.
INPUT FILES
If file operands are specified, the input files contain the data to be compressed.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of compress:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT If no file operands are specified, or if a file operand is ‘−’, or if the −c option is specified, the
standard output contains the compressed output.

STDERR The standard error shall be used only for diagnostic and prompt messages and the output from
−v.

OUTPUT FILES The output files shall contain the compressed output. The format of compressed files is
unspecified and interchange of such files between implementations (including access via
unspecified file sharing mechanisms) is not required by IEEE Std 1003.1-2001.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

1 An error occurred.

2 One or more files were not compressed because they would have increased in size (and the
−f option was not specified).

>2 An error occurred.

CONSEQUENCES OF ERRORS
The input file shall remain unmodified.
APPLICATION USAGE

The amount of compression obtained depends on the size of the input, the number of bits per code, and the distribution of common substrings. Typically, text such as source code or English is reduced by 50-60%. Compression is generally much better than that achieved by Huffman coding or adaptive Huffman coding (compact), and takes less time to compute.

Although `compress` strictly follows the default actions upon receipt of a signal or when an error occurs, some unexpected results may occur. In some implementations it is likely that a partially compressed file is left in place, alongside its uncompressed input file. Since the general operation of `compress` is to delete the uncompressed file only after the `.Z` file has been successfully filled, an application should always carefully check the exit status of `compress` before arbitrarily deleting files that have like-named neighbors with `.Z` suffixes.

The limit of 14 on the `bits` option-argument is to achieve portability to all systems (within the restrictions imposed by the lack of an explicit published file format). Some implementations based on 16-bit architectures cannot support 15 or 16-bit uncompression.

EXAMPLES

None.

RATIONALE

None.

FUTURE DIRECTIONS

None.

SEE ALSO

`uncompress`, `zcat`

CHANGE HISTORY

First released in Issue 4.

Issue 6

The normative text is reworded to avoid use of the term “must” for application requirements.

An error case is added for systems not supporting adaptive Lempel-Ziv coding.
NAME
    cp — copy files

SYNOPSIS
    cp [-fip] source_file target_file
    cp [-fip] source_file ... target
    cp -R [-H | -L | -P] [-fip] source_file ... target
    cp -r [-H | -L | -P] [-fip] source_file ... target

DESCRIPTION
The first synopsis form is denoted by two operands, neither of which are existing files of type directory. The cp utility shall copy the contents of source_file (or, if source_file is a file of type symbolic link, the contents of the file referenced by source_file) to the destination path named by target_file.

The second synopsis form is denoted by two or more operands where the -R or -r options are not specified and the first synopsis form is not applicable. It shall be an error if any source_file is a file of type directory, if target does not exist, or if target is a file of a type defined by the System Interfaces volume of IEEE Std 1003.1-2001, but is not a file of type directory. The cp utility shall copy the contents of each source_file (or, if source_file is a file of type symbolic link, the contents of the file referenced by source_file) to the destination path named by the concatenation of target, a slash character, and the last component of source_file.

The third and fourth synopsis forms are denoted by two or more operands where the -R or -r options are specified. The cp utility shall copy each file in the file hierarchy rooted in each source_file to a destination path named as follows:

- If target exists and is a file of type directory, the name of the corresponding destination path for each file in the file hierarchy shall be the concatenation of target, a slash character, and the pathname of the file relative to the directory containing source_file.
- If target does not exist and two operands are specified, the name of the corresponding destination path for source_file shall be target; the name of the corresponding destination path for all other files in the file hierarchy shall be the concatenation of target, a slash character, and the pathname of the file relative to source_file.

It shall be an error if target does not exist and more than two operands are specified, or if target exists and is a file of a type defined by the System Interfaces volume of IEEE Std 1003.1-2001, but is not a file of type directory.

In the following description, the term dest_file refers to the file named by the destination path. The term source_file refers to the file that is being copied, whether specified as an operand or a file in a file hierarchy rooted in a source_file operand. If source_file is a file of type symbolic link:

- If neither the -R nor -r options were specified, cp shall take actions based on the type and contents of the file referenced by the symbolic link, and not by the symbolic link itself.
- If the -R option was specified:
  - If none of the options -H, -L, nor -P were specified, it is unspecified which of -H, -L, or -P will be used as a default.
  - If the -H option was specified, cp shall take actions based on the type and contents of the file referenced by any symbolic link specified as a source_file operand.
  - If the -L option was specified, cp shall take actions based on the type and contents of the file referenced by any symbolic link specified as a source_file operand or any symbolic
10428 links encountered during traversal of a file hierarchy.

10429 — If the −P option was specified, cp shall copy any symbolic link specified as a source_file operand and any symbolic links encountered during traversal of a file hierarchy, and shall not follow any symbolic links.

10430 • If the −r option was specified, the behavior is implementation-defined.

For each source_file, the following steps shall be taken:

10434 1. If source_file references the same file as dest_file, cp may write a diagnostic message to standard error; it shall do nothing more with source_file and shall go on to any remaining files.

10437 2. If source_file is of type directory, the following steps shall be taken:

10438 a. If neither the −R or −r options were specified, cp shall write a diagnostic message to standard error, do nothing more with source_file, and go on to any remaining files.

10440 b. If source_file was not specified as an operand and source_file is dot or dot-dot, cp shall do nothing more with source_file and go on to any remaining files.

10442 c. If dest_file exists and it is a file type not specified by the System Interfaces volume of IEEE Std 1003.1-2001, the behavior is implementation-defined.

10444 d. If dest_file exists and it is not of type directory, cp shall write a diagnostic message to standard error, do nothing more with source_file or any files below source_file in the file hierarchy, and go on to any remaining files.

10447 e. If the directory dest_file does not exist, it shall be created with file permission bits set to the same value as those of source_file, modified by the file creation mask of the user if the −p option was not specified, and then bitwise-inclusively OR’ed with S_IRWXU. If dest_file cannot be created, cp shall write a diagnostic message to standard error, do nothing more with source_file, and go on to any remaining files. It is unspecified if cp attempts to copy files in the file hierarchy rooted in source_file.

10453 f. The files in the directory source_file shall be copied to the directory dest_file, taking the four steps (1 to 4) listed here with the files as source_files.

10455 g. If dest_file was created, its file permission bits shall be changed (if necessary) to be the same as those of source_file, modified by the file creation mask of the user if the −p option was not specified.

10458 h. The cp utility shall do nothing more with source_file and go on to any remaining files.

3. If source_file is of type regular file, the following steps shall be taken:

10460 a. If dest_file exists, the following steps shall be taken:

10461 i. If the −i option is in effect, the cp utility shall write a prompt to the standard error and read a line from the standard input. If the response is not affirmative, cp shall do nothing more with source_file and go on to any remaining files.

10464 ii. A file descriptor for dest_file shall be obtained by performing actions equivalent to the open() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 called using dest_file as the path argument, and the bitwise-inclusive OR of O_WRONLY and O_TRUNC as the oflag argument.

10468 iii. If the attempt to obtain a file descriptor fails and the −f option is in effect, cp shall attempt to remove the file by performing actions equivalent to the unlink() function defined in the System Interfaces volume of
IEEE Std 1003.1-2001 called using dest_file as the path argument. If this attempt
succeeds, cp shall continue with step 3b.

b. If dest_file does not exist, a file descriptor shall be obtained by performing actions
equivalent to the open() function defined in the System Interfaces volume of
IEEE Std 1003.1-2001 called using dest_file as the path argument, and the bitwise-
inclusive OR of O_WRONLY and O_CREAT as the oflag argument. The file
permission bits of source_file shall be the mode argument.

c. If the attempt to obtain a file descriptor fails, cp shall write a diagnostic message to
standard error, do nothing more with source_file, and go on to any remaining files.

d. The contents of source_file shall be written to the file descriptor. Any write errors
shall cause cp to write a diagnostic message to standard error and continue to step 3e.

e. The file descriptor shall be closed.

f. The cp utility shall do nothing more with source_file. If a write error occurred in step
3d, it is unspecified if cp continues with any remaining files. If no write error
occurred in step 3d, cp shall go on to any remaining files.

4. Otherwise, the following steps shall be taken:

a. If the −r option was specified, the behavior is implementation-defined.

b. If the −R option was specified, the following steps shall be taken:

i. The dest_file shall be created with the same file type as source_file.

ii. If source_file is a file of type FIFO, the file permission bits shall be the same as
those of source_file, modified by the file creation mask of the user if the −p
option was not specified. Otherwise, the permissions, owner ID, and group ID
of dest_file are implementation-defined.

If this creation fails for any reason, cp shall write a diagnostic message to
standard error, do nothing more with source_file, and go on to any remaining files.

iii. If source_file is a file of type symbolic link, the pathname contained in dest_file
shall be the same as the pathname contained in source_file.

If this fails for any reason, cp shall write a diagnostic message to standard error,
do nothing more with source_file, and go on to any remaining files.

If the implementation provides additional or alternate access control mechanisms (see the Base
Definitions volume of IEEE Std 1003.1-2001, Section 4.4, File Access Permissions), their effect on
copies of files is implementation-defined.

OPTIONS

The cp utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.

The following options shall be supported:

−f If a file descriptor for a destination file cannot be obtained, as described in step
3.a.ii., attempt to unlink the destination file and proceed.

−H Take actions based on the type and contents of the file referenced by any symbolic
link specified as a source_file operand.

−i Write a prompt to standard error before copying to any existing destination file. If
the response from the standard input is affirmative, the copy shall be attempted;
otherwise, it shall not.

−L

Take actions based on the type and contents of the file referenced by any symbolic
link specified as a source_file operand or any symbolic links encountered during
traversal of a file hierarchy.

−P

Take actions on any symbolic link specified as a source_file operand or any
symbolic link encountered during traversal of a file hierarchy.

−p

Duplicate the following characteristics of each source file in the corresponding
destination file:

1. The time of last data modification and time of last access. If this duplication
fails for any reason, cp shall write a diagnostic message to standard error.

2. The user ID and group ID. If this duplication fails for any reason, it is
unspecified whether cp writes a diagnostic message to standard error.

3. The file permission bits and the S_ISUID and S_ISGID bits. Other,
implementation-defined, bits may be duplicated as well. If this duplication
fails for any reason, cp shall write a diagnostic message to standard error.

If the user ID or the group ID cannot be duplicated, the file permission bits
S_ISUID and S_ISGID shall be cleared. If these bits are present in the source file but
are not duplicated in the destination file, it is unspecified whether cp writes a
diagnostic message to standard error.

The order in which the preceding characteristics are duplicated is unspecified. The
dest_file shall not be deleted if these characteristics cannot be preserved.

−R

Copy file hierarchies.

−r

Copy file hierarchies. The treatment of special files is implementation-defined.

Specifying more than one of the mutually-exclusive options –H, –L, and –P shall not be
considered an error. The last option specified shall determine the behavior of the utility.

OPERANDS

The following operands shall be supported:

source_file
A pathname of a file to be copied.

target_file
A pathname of an existing or nonexistent file, used for the output when a single
file is copied.

target
A pathname of a directory to contain the copied files.

The standard input shall be used to read an input line in response to each prompt specified in
the STDERR section. Otherwise, the standard input shall not be used.

The input files specified as operands may be of any file type.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of cp:

LANG
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)
Utilities

If set to a non-empty string value, override the values of all the other
internationalization variables.

Determine the locale for the behavior of ranges, equivalence classes, and multi-
character collating elements used in the extended regular expression defined for
the `yesexpr` locale keyword in the `LC_MESSAGES` category.

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files) and the behavior of character classes used in the
extended regular expression defined for the `yesexpr` locale keyword in the
`LC_MESSAGES` category.

Determine the locale for the processing of affirmative responses that should be
used to affect the format and contents of diagnostic messages written to standard
error.

Determine the location of message catalogs for the processing of `LC_MESSAGES`.

Default.

Not used.

A prompt shall be written to standard error under the conditions specified in the DESCRIPTION
section. The prompt shall contain the destination pathname, but its format is otherwise
unspecified. Otherwise, the standard error shall be used only for diagnostic messages.

The output files may be of any type.

None.

The following exit values shall be returned:

- 0 All files were copied successfully.
- >0 An error occurred.

If `cp` is prematurely terminated by a signal or error, files or file hierarchies may be only partially
copied and files and directories may have incorrect permissions or access and modification
times.
APPLICATION USAGE

The difference between −R and −r is in the treatment by \( cp \) of file types other than regular and directory. The original −r flag, for historic reasons, does not handle special files any differently from regular files, but always reads the file and copies its contents. This has obvious problems in the presence of special file types; for example, character devices, FIFOs, and sockets. The −R option is intended to recreate the file hierarchy and the −r option supports historical practice. It was anticipated that a future version of this volume of IEEE Std 1003.1-2001 would deprecate the −r option, and for that reason, there has been no attempt to fix its behavior with respect to FIFOs or other file types where copying the file is clearly wrong. However, some implementations support −r with the same abilities as the −R defined in this volume of IEEE Std 1003.1-2001. To accommodate them as well as systems that do not, the differences between −r and −R are implementation-defined. Implementations may make them identical. The −r option is marked obsolescent.

The set-user-ID and set-group-ID bits are explicitly cleared when files are created. This is to prevent users from creating programs that are set-user-ID or set-group-ID to them when copying files or to make set-user-ID or set-group-ID files accessible to new groups of users. For example, if a file is set-user-ID and the copy has a different group ID than the source, a new group of users has execute permission to a set-user-ID program than did previously. In particular, this is a problem for superusers copying users' trees.

EXAMPLES

None.

RATIONALE

The −i option exists on BSD systems, giving applications and users a way to avoid accidentally removing files when copying. Although the 4.3 BSD version does not prompt if the standard input is not a terminal, the standard developers decided that use of −i is a request for interaction, so when the destination path exists, the utility takes instructions from whatever responds on standard input.

The exact format of the interactive prompts is unspecified. Only the general nature of the contents of prompts are specified because implementations may desire more descriptive prompts than those used on historical implementations. Therefore, an application using the −i option relies on the system to provide the most suitable dialog directly with the user, based on the behavior specified.

The −p option is historical practice on BSD systems, duplicating the time of last data modification and time of last access. This volume of IEEE Std 1003.1-2001 extends it to preserve the user and group IDs, as well as the file permissions. This requirement has obvious problems in that the directories are almost certainly modified after being copied. This volume of IEEE Std 1003.1-2001 requires that the modification times be preserved. The statement that the order in which the characteristics are duplicated is unspecified is to permit implementations to provide the maximum amount of security for the user. Implementations should take into account the obvious security issues involved in setting the owner, group, and mode in the wrong order or creating files with an owner, group, or mode different from the final value.

It is unspecified whether \( cp \) writes diagnostic messages when the user and group IDs cannot be set due to the widespread practice of users using −p to duplicate some portion of the file characteristics, indifferent to the duplication of others. Historic implementations only write diagnostic messages on errors other than [EPERM].

The −r option is historical practice on BSD and BSD-derived systems, copying file hierarchies as opposed to single files. This functionality is used heavily in historical applications, and its loss would significantly decrease consensus. The −R option was added as a close synonym to the −r option, selected for consistency with all other options in this volume of IEEE Std 1003.1-2001 that
do recursive directory descent.

When a failure occurs during the copying of a file hierarchy, *cp* is required to attempt to copy files that are on the same level in the hierarchy or above the file where the failure occurred. It is unspecified if *cp* shall attempt to copy files below the file where the failure occurred (which cannot succeed in any case).

Permissions, owners, and groups of created special file types have been deliberately left as implementation-defined. This is to allow systems to satisfy special requirements (for example, allowing users to create character special devices, but requiring them to be owned by a certain group). In general, it is strongly suggested that the permissions, owner, and group be the same as if the user had run the historical *mknod*, *ln*, or other utility to create the file. It is also probable that additional privileges are required to create block, character, or other implementation-defined special file types.

Additionally, the `-p` option explicitly requires that all set-user-ID and set-group-ID permissions be discarded if any of the owner or group IDs cannot be set. This is to keep users from unintentionally giving away special privilege when copying programs.

When creating regular files, historical versions of *cp* use the mode of the source file as modified by the file mode creation mask. Other choices would have been to use the mode of the source file unmodified by the creation mask or to use the same mode as would be given to a new file created by the user (plus the execution bits of the source file) and then modify it by the file mode creation mask. In the absence of any strong reason to change historic practice, it was in large part retained.

When creating directories, historical versions of *cp* use the mode of the source directory, plus read, write, and search bits for the owner, as modified by the file mode creation mask. This is done so that *cp* can copy trees where the user has read permission, but the owner does not. A side effect is that if the file creation mask denies the owner permissions, *cp* fails. Also, once the copy is done, historical versions of *cp* set the permissions on the created directory to be the same as the source directory, unmodified by the file creation mask.

This behavior has been modified so that *cp* is always able to create the contents of the directory, regardless of the file creation mask. After the copy is done, the permissions are set to be the same as the source directory, as modified by the file creation mask. This latter change from historical behavior is to prevent users from accidentally creating directories with permissions beyond those they would normally set and for consistency with the behavior of *cp* in creating files.

It is not a requirement that *cp* detect attempts to copy a file to itself; however, implementations are strongly encouraged to do so. Historical implementations have detected the attempt in most cases.

There are two methods of copying subtrees in this volume of IEEE Std 1003.1-2001. The other method is described as part of the *pax* utility (see *pax*). Both methods are historical practice. The *cp* utility provides a simpler, more intuitive interface, while *pax* offers a finer granularity of control. Each provides additional functionality to the other; in particular, *pax* maintains the hard-link structure of the hierarchy, while *cp* does not. It is the intention of the standard developers that the results be similar (using appropriate option combinations in both utilities). The results are not required to be identical; there seemed insufficient gain to applications to balance the difficulty of implementations having to guarantee that the results would be exactly identical.

The wording allowing *cp* to copy a directory to implementation-defined file types not specified by the System Interfaces volume of IEEE Std 1003.1-2001 is provided so that implementations supporting symbolic links are not required to prohibit copying directories to symbolic links. Other extensions to the System Interfaces volume of IEEE Std 1003.1-2001 file types may need to
use this loophole as well.

**FUTURE DIRECTIONS**

The −r option may be removed; use −R instead.

**SEE ALSO**

`mv`, `find`, `ln`, `pax`, the System Interfaces volume of IEEE Std 1003.1-2001, `open()`, `unlink()`.

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

The −r option is marked obsolescent.

The new options −H, −L, and −P are added to align with the IEEE P1003.2b draft standard. These options affect the processing of symbolic links.

IEEE PASC Interpretation 1003.2 #194 is applied, adding a description of the −P option.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/18 is applied, correcting an error in the SEE ALSO section.
NAME

crontab — schedule periodic background work

SYNOPSIS

UP

crontab [ file ]
crontab [ -e | -l | -r ]

DESCRIPTION

The crontab utility shall create, replace, or edit a user’s crontab entry; a crontab entry is a list of
commands and the times at which they shall be executed. The new crontab entry can be input by
specifying file or input from standard input if no file operand is specified, or by using an editor, if
-e is specified.

Upon execution of a command from a crontab entry, the implementation shall supply a default
environment, defining at least the following environment variables:

HOME A pathname of the user’s home directory.
LOGNAME The user’s login name.
PATH A string representing a search path guaranteed to find all of the standard utilities.
SHELL A pathname of the command interpreter. When crontab is invoked as specified by
this volume of IEEE Std 1003.1-2001, the value shall be a pathname for sh.

The values of these variables when crontab is invoked as specified by this volume of
IEEE Std 1003.1-2001 shall not affect the default values provided when the scheduled command
is run.

If standard output and standard error are not redirected by commands executed from the
crontab entry, any generated output or errors shall be mailed, via an implementation-defined
method, to the user.

Users shall be permitted to use crontab if their names appear in the file /usr/lib/cron/cron.allow.
If that file does not exist, the file /usr/lib/cron/cron.deny shall be checked to determine whether
the user shall be denied access to crontab. If neither file exists, only a process with appropriate
privileges shall be allowed to submit a job. If only cron.deny exists and is empty, global usage
shall be permitted. The cron.allow and cron.deny files shall consist of one user name per line.

OPTIONS

The crontab utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

-e Edit a copy of the invoking user’s crontab entry, or create an empty entry to edit if
the crontab entry does not exist. When editing is complete, the entry shall be
installed as the user’s crontab entry.

-l (The letter ell.) List the invoking user’s crontab entry.

-r Remove the invoking user’s crontab entry.

OPERANDS

The following operand shall be supported:

file The pathname of a file that contains specifications, in the format defined in the
INPUT FILES section, for crontab entries.
STDIN

See the INPUT FILES section.

INPUT FILES

In the POSIX locale, the user or application shall ensure that a crontab entry is a text file consisting of lines of six fields each. The fields shall be separated by <blank>s. The first five fields shall be integer patterns that specify the following:

1. Minute [0,59]
2. Hour [0,23]
3. Day of the month [1,31]
4. Month of the year [1,12]
5. Day of the week ([0,6] with 0=Sunday)

Each of these patterns can be either an asterisk (meaning all valid values), an element, or a list of elements separated by commas. An element shall be either a number or two numbers separated by a hyphen (meaning an inclusive range). The specification of days can be made by two fields (day of the month and day of the week). If month, day of month, and day of week are all asterisks, every day shall be matched. If either the month or day of month is specified as an element or list, but the day of week is an asterisk, the month and day of month fields shall specify the days that match. If both month and day of month are specified as an asterisk, but day of week is an element or list, then only the specified days of the week match. Finally, if either the month or day of month is specified as an element or list, and the day of week is also specified as an element or list, then any day matching either the month and day of month, or the day of week, shall be matched.

The sixth field of a line in a crontab entry is a string that shall be executed by sh at the specified times. A percent sign character in this field shall be translated to a <newline>. Any character preceded by a backslash (including the ‘%’) shall cause that character to be treated literally.

Blank lines and those whose first non-<blank> is ‘#’ shall be ignored.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of crontab:

EDITOR Determine the editor to be invoked when the −e option is specified. The default editor shall be vi.
LANG Provide a default value for the internationalization variables that are unset or null.
LC_ALL If set to a non-empty string value, override the values of all the other localization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).
Utilities

**crontab**

10789  \_LC\_MESSAGES
10790  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
10791
10792  \_XSI\_ NLSPATH
10793  Determine the location of message catalogs for the processing of \_LC\_MESSAGES.
10794
10795  **ASYNCHRONOUS EVENTS**
10796  Default.
10797
10798  **STDOUT**
10799  If the \_l option is specified, the crontab entry shall be written to the standard output.
10800
10801  **STDERR**
10802  The standard error shall be used only for diagnostic messages.
10803
10804  **OUTPUT FILES**
10805  None.
10806
10807  **EXTENDED DESCRIPTION**
10808  None.
10809
10810  **EXIT STATUS**
10811  The following exit values shall be returned:
10812
10813  0  Successful completion.
10814
10815  >0  An error occurred.
10816
10817  **CONSEQUENCES OF ERRORS**
10818  The user’s crontab entry is not submitted, removed, edited, or listed.
10819
10820  **APPLICATION USAGE**
10821  The format of the crontab entry shown here is guaranteed only for the POSIX locale. Other
cultures may be supported with substantially different interfaces, although implementations are
encouraged to provide comparable levels of functionality.
10822
10823  The default settings of the \_HOME, LOGNAME, PATH, and SHELL variables that are given to the
scheduled job are not affected by the settings of those variables when crontab is run; as stated,
they are defaults. The text about “invoked as specified by this volume of IEEE Std 1003.1-2001”
means that the implementation may provide extensions that allow these variables to be affected
at runtime, but that the user has to take explicit action in order to access the extension, such as
give a new option flag or modify the format of the crontab entry.
10824
10825  A typical user error is to type only crontab; this causes the system to wait for the new crontab
entry on standard input. If end-of-file is typed (generally \_control\_D), the crontab entry is
replaced by an empty file. In this case, the user should type the interrupt character, which
prevents the crontab entry from being replaced.
10826
10827  **EXAMPLES**
10828
10829  1.  Clean up core files every weekday morning at 3:15 am:
10830       \_15 3 \_* \_* \_− \_5 find \_$HOME \_− \_name \_core \_2>/dev/null \_| \_xargs \_rm \_−\_f
10831  2.  Mail a birthday greeting:
10832       \_0 \_12 \_14 \_2 \_* \_mailx \_john%Happy Birthday!%Time for lunch.
10833  3.  As an example of specifying the two types of days:
10834       \_0 \_0 \_1,15 \_* \_1
would run a command on the first and fifteenth of each month, as well as on every Monday. To specify days by only one field, the other field should be set to ‘*’; for example:

```
0 0 * * 1
```

would run a command only on Mondays.

**RATIONALE**

All references to a `cron` daemon and to `cron files` have been omitted. Although historical implementations have used this arrangement, there is no reason to limit future implementations. This description of `crontab` is designed to support only users with normal privileges. The format of the input is based on the System V `crontab`; however, there is no requirement here that the actual system database used by the `cron` daemon (or a similar mechanism) use this format internally. For example, systems derived from BSD are likely to have an additional field appended that indicates the user identity to be used when the job is submitted.

The `−e` option was adopted from the SVID as a user convenience, although it does not exist in all historical implementations.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`at`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
csplit — split files based on context

SYNOPSIS
up:    csplit [-ks] [-f prefix] [-n number] file arg1 ... argn

DESCRIPTION
The csplit utility shall read the file named by the file operand, write all or part of that file into other files as directed by the arg operands, and write the sizes of the files.

OPTIONS

The following options shall be supported:

- f prefix  Name the created files prefix00, prefix01, ..., prefixxn. The default is xx00 ... xnn. If the prefix argument would create a filename exceeding [NAME_MAX] bytes, an error shall result, csplit shall exit with a diagnostic message, and no files shall be created.

- k  Leave previously created files intact. By default, csplit shall remove created files if an error occurs.

- n number  Use number decimal digits to form filenames for the file pieces. The default shall be 2.

- s  Suppress the output of file size messages.

OPERANDS
The following operands shall be supported:

file  The pathname of a text file to be split. If file is '-', the standard input shall be used.

The operands arg1 ... argn can be a combination of the following:

/rexp[/offset]  A file shall be created using the content of the lines from the current line up to, but not including, the line that results from the evaluation of the regular expression with offset, if any, applied. The regular expression rexp shall follow the rules for basic regular expressions described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic Regular Expressions. The application shall use the sequence "\" to specify a slash character within the rexp. The optional offset shall be a positive or negative integer value representing a number of lines. A positive integer value can be preceded by '+' or '−'. If the selection of lines from an offset expression of this type would create a file with zero lines, or one with greater than the number of lines left in the input file, the results are unspecified. After the section is created, the current line shall be set to the line that results from the evaluation of the regular expression with any offset applied. If the current line is the first line in the file and a regular expression operation has not yet been performed, the pattern match of rexp shall be applied from the current line to the end of the file. Otherwise, the pattern match of rexp shall be applied from the line following the current line to the end of the file.

%rexp%[offset]  Equivalent to /rexp[/offset], except that no file shall be created for the selected section of the input file. The application shall use the sequence "\%" to specify a
percent-sign character within the `rexp`.

`line_no` Create a file from the current line up to (but not including) the line number `line_no`.

Lines in the file shall be numbered starting at one. The current line becomes `line_no`.

Repeat operand. This operand can follow any of the operands described previously. If it follows a `rexp` type operand, that operand shall be applied `num` more times. If it follows a `line_no` operand, the file shall be split every `line_no` lines, `num` times, from that point.

An error shall be reported if an operand does not reference a line between the current position and the end of the file.

STDIN

See the INPUT FILES section.

INPUT FILES

The input file shall be a text file.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `csplit`:

`LANG` Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

`LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.

`LC_COLLATE` Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.

`LC_CTYPE` Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and the behavior of character classes within regular expressions.

`LC_MESSAGES` Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

XSI `NLSPATH` Determine the location of message catalogs for the processing of `LC_MESSAGES`.

ASYNCHRONOUS EVENTS

If the `−k` option is specified, created files shall be retained. Otherwise, the default action occurs.

STDOUT

Unless the `−s` option is used, the standard output shall consist of one line per file created, with a format as follows:

"%d\n", <file size in bytes>

STDERR

The standard error shall be used only for diagnostic messages.
OUTPUT FILES

The output files shall contain portions of the original input file; otherwise, unchanged.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS

By default, created files shall be removed if an error occurs. When the −k option is specified, created files shall not be removed if an error occurs.

APPLICATION USAGE

None.

EXAMPLES

1. This example creates four files, cobol00 . . . cobol03:

   csplit −f cobol file ’/procedure division’ /par5./ /par16./

   After editing the split files, they can be recombined as follows:

   cat cobol0[0−3] > file

   Note that this example overwrites the original file.

2. This example would split the file after the first 99 lines, and every 100 lines thereafter, up to 9999 lines; this is because lines in the file are numbered from 1 rather than zero, for historical reasons:

   csplit −k file 100 {99}

3. Assuming that prog.c follows the C-language coding convention of ending routines with a ’}’ at the beginning of the line, this example creates a file containing each separate C routine (up to 21) in prog.c:

   csplit −k prog.c ’%main(% /” /}+1’ {20}

RATIONALE

The −n option was added to extend the range of filenames that could be handled.

Consideration was given to adding a −a flag to use the alphabetic filename generation used by the historical split utility, but the functionality added by the −n option was deemed to make alphabetic naming unnecessary.

FUTURE DIRECTIONS

None.

SEE ALSO

sed, split

CHANGE HISTORY

First released in Issue 2.
10979  Issue 5
10980   The FUTURE DIRECTIONS section is added.
10981  Issue 6
10982   This utility is marked as part of the User Portability Utilities option.
10983   The APPLICATION USAGE section is added.
10984   The description of regular expression operands is changed to align with the IEEE P1003.2b draft
10985   standard.
10986   The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
ctags — create a tags file (DEVELOPMENT, FORTRAN)

SYNOPSIS
ctags [-a] [-f tagsfile] pathname ...
ctags -x pathname ...

DESCRIPTION
The ctags utility shall be provided on systems that support the User Portability Utilities option, the Software Development Utilities option, and either or both of the C-Language Development Utilities option and FORTRAN Development Utilities option. On other systems, it is optional.

The ctags utility shall write a tagsfile or an index of objects from C-language or FORTRAN source files specified by the pathname operands. The tagsfile shall list the locators of language-specific objects within the source files. A locator consists of a name, pathname, and either a search pattern or a line number that can be used in searching for the object definition. The objects that shall be recognized are specified in the EXTENDED DESCRIPTION section.

OPTIONS

The following options shall be supported:

-a Append to tagsfile.
-f tagsfile Write the object locator lists into tagsfile instead of the default file named tags in the current directory.
-x Produce a list of object names, the line number, and filename in which each is defined, as well as the text of that line, and write this to the standard output. A tagsfile shall not be created when -x is specified.

OPERANDS
The following pathname operands are supported:

file.c Files with basenames ending with the .c suffix shall be treated as C-language source code. Such files that are not valid input to c99 produce unspecified results.
file.h Files with basenames ending with the .h suffix shall be treated as C-language source code. Such files that are not valid input to c99 produce unspecified results.
file.f Files with basenames ending with the .f suffix shall be treated as FORTRAN-language source code. Such files that are not valid input to for77 produce unspecified results.

The handling of other files is implementation-defined.

STDIN
See the INPUT FILES section.

INPUT FILES
The input files shall be text files containing source code in the language indicated by the operand filename suffixes.
ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of ctags:

- **LANG**
  
  Provide a default value for the internationalization variables that are unset or null.

  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_COLLATE**
  
  Determine the order in which output is sorted for the -x option. The POSIX locale determines the order in which the tagsfile is written.

- **LC_CTYPE**
  
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files). When processing C-language source code, if the locale is not compatible with the C locale described by the ISO C standard, the results are unspecified.

- **LC_MESSAGES**
  
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**
  
  Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

- **STDOUT**
  
  The list of object name information produced by the -x option shall be written to standard output in the following format:

  "%s %d %s %s", <object-name>, <line-number>, <filename>, <text>

  where <text> is the text of line <line-number> of file <filename>.

- **STDERR**
  
  The standard error shall be used only for diagnostic messages.

OUTPUT FILES

- **When the -x option is not specified, the format of the output file shall be:**

  "%s\t%t\s/t\s/%n", <identifier>, <filename>, <pattern>

  where <pattern> is a search pattern that could be used by an editor to find the defining instance of <identifier> in <filename> (where defining instance is indicated by the declarations listed in the EXTENDED DESCRIPTION).

  An optional circumflex (‘ˆ’) can be added as a prefix to <pattern>, and an optional dollar sign can be appended to <pattern> to indicate that the pattern is anchored to the beginning (end) of a line of text. Any slash or backslash characters in <pattern> shall be preceded by a backslash character. The anchoring circumflex, dollar sign, and escaping backslash characters shall not be considered part of the search pattern. All other characters in the search pattern shall be considered literal characters.
An alternative format is:

```
"%s\t%s\t%"n", <identifier>, <filename>, <pattern>
```

which is identical to the first format except that slashes in `<pattern>` shall not be preceded by escaping backslash characters, and question mark characters in `<pattern>` shall be preceded by backslash characters.

A second alternative format is:

```
"%s\t%s\t%d"n", <identifier>, <filename>, <lineno>
```

where `<lineno>` is a decimal line number that could be used by an editor to find `<identifier>` in `<filename>`.

Neither alternative format shall be produced by `ctags` when it is used as described by IEEE Std 1003.1-2001, but the standard utilities that process tags files shall be able to process those formats as well as the first format.

In any of these formats, the file shall be sorted by identifier, based on the collation sequence in the POSIX locale.

**EXTENDED DESCRIPTION**

If the operand identifies C-language source, the `ctags` utility shall attempt to produce an output line for each of the following objects:

- Function definitions
- Type definitions
- Macros with arguments

It may also produce output for any of the following objects:

- Function prototypes
- Structures
- Unions
- Global variable definitions
- Enumeration types
- Macros without arguments
- `#define` statements
- `#line` statements

Any `#if` and `#ifdef` statements shall produce no output. The tag `main` is treated specially in C programs. The tag formed shall be created by prefixing `M` to the name of the file, with the trailing `.c`, and leading pathname components (if any) removed.

On systems that do not support the C-Language Development Utilities option, `ctags` produces unspecified results for C-language source code files. It should write to standard error a message identifying this condition and cause a non-zero exit status to be produced.

If the operand identifies FORTRAN source, the `ctags` utility shall produce an output line for each function definition. It may also produce output for any of the following objects:

- Subroutine definitions
- COMMON statements
• PARAMETER statements
• DATA and BLOCK DATA statements
• Statement numbers

On systems that do not support the FORTRAN Development Utilities option, ctags produces unspecified results for FORTRAN source code files. It should write to standard error a message identifying this condition and cause a non-zero exit status to be produced.

It is implementation-defined what other objects (including duplicate identifiers) produce output.

EXIT STATUS
The following exit values shall be returned:
0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The output with –x is meant to be a simple index that can be written out as an off-line readable function index. If the input files to ctags (such as .c files) were not created using the same locale as that in effect when ctags –x is run, results might not be as expected.

The description of C-language processing says “attempts to” because the C language can be greatly confused, especially through the use of #defines, and this utility would be of no use if the real C preprocessor were run to identify them. The output from ctags may be fooled and incorrect for various constructs.

EXAMPLES
None.

RATIONALE
The option list was significantly reduced from that provided by historical implementations. The –F option was omitted as redundant, since it is the default. The –B option was omitted as being of very limited usefulness. The –t option was omitted since the recognition of typedefs is now required for C source files. The –u option was omitted because the update function was judged to be not only inefficient, but also rarely needed.

An early proposal included a –w option to suppress warning diagnostics. Since the types of such diagnostics could not be described, the option was omitted as being not useful.

The text for LC_CTYPE about compatibility with the C locale acknowledges that the ISO C standard imposes requirements on the locale used to process C source. This could easily be a superset of that known as “the C locale” by way of implementation extensions, or one of a few alternative locales for systems supporting different codesets. No statement is made for FORTRAN because the ANSI X3.9-1978 standard (FORTRAN 77) does not (yet) define a similar locale concept. However, a general rule in this volume of IEEE Std 1003.1-2001 is that any time that locales do not match (preparing a file for one locale and processing it in another), the results are suspect.

The collation sequence of the tags file is not affected by LC_COLLATE because it is typically not used by human readers, but only by programs such as vi to locate the tag within the source files. Using the POSIX locale eliminates some of the problems of coordinating locales between the ctags file creator and the vi file reader.
Historically, the tags file has been used only by *ex* and *vi*. However, the format of the tags file has been published to encourage other programs to use the tags in new ways. The format allows either patterns or line numbers to find the identifiers because the historical *vi* recognizes either. The *ctags* utility does not produce the format using line numbers because it is not useful following any source file changes that add or delete lines. The documented search patterns match historical practice. It should be noted that literal leading circumflex or trailing dollar-sign characters in the search pattern will only behave correctly if anchored to the beginning of the line or end of the line by an additional circumflex or dollar-sign character.

Historical implementations also understand the objects used by the languages Pascal and sometimes LISP, and they understand the C source output by *lex* and *yacc*. The *ctags* utility is not required to accommodate these languages, although implementors are encouraged to do so.

The following historical option was not specified, as *vgrind* is not included in this volume of IEEE Std 1003.1-2001:

```
−v
```

If the −v flag is given, an index of the form expected by *vgrind* is produced on the standard output. This listing contains the function name, filename, and page number (assuming 64-line pages). Since the output is sorted into lexicographic order, it may be desired to run the output through *sort* −f. Sample use:

```
ctags −v files | sort −f > index vgrind −x index
```

The special treatment of the tag main makes the use of *ctags* practical in directories with more than one program.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

c99, fort77, *vi*

**CHANGE HISTORY**

First released in Issue 4.

**Issue 5**

The FUTURE DIRECTIONS section is added.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The OUTPUT FILES section is changed to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE PASC Interpretation 1003.2 #168 is applied, changing “create” to “write” in the DESCRIPTION.
cut

NAME

          cut — cut out selected fields of each line of a file

SYNOPSIS

          cut -b list [-n] [file ...]
          cut -c list [file ...]
          cut -f list [-d delim] [-s] [file ...]

DESCRIPTION

          The cut utility shall cut out bytes (-b option), characters (-c option), or character-delimited fields
          (-f option) from each line in one or more files, concatenate them, and write them to standard
          output.

OPTIONS

          The cut utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

          The application shall ensure that the option-argument list (see options -b, -c, and -f below) is a
          comma-separated list or <blank>-separated list of positive numbers and ranges. Ranges can be
          in three forms. The first is two positive numbers separated by a hyphen (low–high), which
          represents all fields from the first number to the second number. The second is a positive
          number preceded by a hyphen (–high), which represents all fields from field number 1 to that
          number. The third is a positive number followed by a hyphen (low–), which represents that
          number to the last field, inclusive. The elements in list can be repeated, can overlap, and can be
          specified in any order, but the bytes, characters, or fields selected shall be written in the order of
          the input data. If an element appears in the selection list more than once, it shall be written
          exactly once.

          The following options shall be supported:

          -b list     Cut based on a list of bytes. Each selected byte shall be output unless the -n option
                      is also specified. It shall not be an error to select bytes not present in the input line.

          -c list     Cut based on a list of characters. Each selected character shall be output. It shall
                      not be an error to select characters not present in the input line.

          -d delim    Set the field delimiter to the character delim. The default is the <tab>.

          -f list     Cut based on a list of fields, assumed to be separated in the file by a delimiter
                      character (see -d). Each selected field shall be output. Output fields shall be
                      separated by a single occurrence of the field delimiter character. Lines with no field
                      delimiters shall be passed through intact, unless -s is specified. It shall not be an
                      error to select fields not present in the input line.

          -n          Do not split characters. When specified with the -b option, each element in list of
                      the form low–high (hyphen-separated numbers) shall be modified as follows:

                      • If the byte selected by low is not the first byte of a character, low shall be
                        decremented to select the first byte of the character originally selected by low.
                      • If the byte selected by high is not the last byte of a character, high shall be
                        decremented to select the last byte of the character prior to the character
                        originally selected by high, or zero if there is no prior character. If the resulting
                        range element has high equal to zero or low greater than high, the list element
                        shall be dropped from list for that input line without causing an error.

          Each element in list of the form low– shall be treated as above with high set to the
          number of bytes in the current line, not including the terminating <newline>. Each
element in list of the form –high shall be treated as above with low set to 1. Each
element in list of the form num (a single number) shall be treated as above with low
set to num and high set to num.

−s

Suppress lines with no delimiter characters, when used with the –f option. Unless
specified, lines with no delimiters shall be passed through untouched.

OPERANDS

The following operand shall be supported:

file A pathname of an input file. If no file operands are specified, or if a file operand is
‘−’, the standard input shall be used.

STDIN

The standard input shall be used only if no file operands are specified, or if a file operand is ‘−’.
See the INPUT FILES section.

INPUT FILES

The input files shall be text files, except that line lengths shall be unlimited.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of cut:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

The cut utility output shall be a concatenation of the selected bytes, characters, or fields (one of
the following):

"%s\n", <concatenation of bytes>
"%s\n", <concatenation of characters>
"%s\n", <concatenation of fields and field delimiters>

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.
EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  All input files were output successfully.
>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Earlier versions of the cut utility worked in an environment where bytes and characters were considered equivalent (modulo <backspace> and <tab> processing in some implementations). In the extended world of multi-byte characters, the new −b option has been added. The −n option (used with −b) allows it to be used to act on bytes rounded to character boundaries. The algorithm specified for −n guarantees that:

cut −b 1-500 −n file > file1
cut −b 501- −n file > file2

ends up with all the characters in file appearing exactly once in file1 or file2. (There is, however, a <newline> in both file1 and file2 for each <newline> in file.)

EXAMPLES
Examples of the option qualifier list:

1,4,7  Select the first, fourth, and seventh bytes, characters, or fields and field delimiters.

1-3,8  Equivalent to 1,2,3,8.

−5,10  Equivalent to 1,2,3,4,5,10.

3−    Equivalent to third to last, inclusive.

The low−high forms are not always equivalent when used with −b and −n and multi-byte characters; see the description of −n.

The following command:

cut −d : −f 1,6 /etc/passwd

reads the System V password file (user database) and produces lines of the form:

<user ID>:<home directory>

Most utilities in this volume of IEEE Std 1003.1-2001 work on text files. The cut utility can be used to turn files with arbitrary line lengths into a set of text files containing the same data. The paste utility can be used to create (or recreate) files with arbitrary line lengths. For example, if file contains long lines:

cut −b 1-500 −n file > file1
cut −b 501- −n file > file2

creates file1 (a text file) with lines no longer than 500 bytes (plus the <newline>) and file2 that contains the remainder of the data from file. (Note that file2 is not a text file if there are lines in file that are longer than 500 + [LINE_MAX] bytes.) The original file can be recreated from file1 and file2 using the command:

paste −d "\0" file1 file2 > file
Utilities

RATIONAL

Some historical implementations do not count <backspace>s in determining character counts with the \texttt{-c} option. This may be useful for using \texttt{cut} for processing \texttt{nroff} output. It was deliberately decided not to have the \texttt{-c} option treat either <backspace>s or <tab>s in any special fashion. The \texttt{fold} utility does treat these characters specially.

Unlike other utilities, some historical implementations of \texttt{cut} exit after not finding an input file, rather than continuing to process the remaining file operands. This behavior is prohibited by this volume of IEEE Std 1003.1-2001, where only the exit status is affected by this problem.

The behavior of \texttt{cut} when provided with either mutually-exclusive options or options that do not work logically together has been deliberately left unspecified in favor of global wording in Section 1.11 (on page 20).

The OPTIONS section was changed in response to IEEE PASC Interpretation 1003.2 #149. The change represents historical practice on all known systems. The original standard was ambiguous on the nature of the output.

The list option-arguments are historically used to select the portions of the line to be written, but do not affect the order of the data. For example:

\begin{verbatim}
  echo abcdefghi | cut -c6,2,4-7,1
\end{verbatim}

yields "abdefg".

A proposal to enhance \texttt{cut} with the following option:

\begin{verbatim}
  -o  Preserve the selected field order. When this option is specified, each byte, character, or field (or ranges of such) shall be written in the order specified by the list option-argument, even if this requires multiple outputs of the same bytes, characters, or fields.
\end{verbatim}

was rejected because this type of enhancement is outside the scope of the IEEE P1003.2b draft standard.

FUTURE DIRECTIONS

None.

SEE ALSO

\texttt{grep}, \texttt{paste}, Section 2.5 (on page 33)

CHANGE HISTORY

First released in Issue 2.

Issue 6

The OPTIONS section is changed to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term "must" for application requirements.
NAME
cxref — generate a C-language program cross-reference table (DEVELOPMENT)

SYNOPSIS
xsi  cxref [-cs] [-o file] [-w num] [-D name[=def]] ... [-I dir] ...
     [-U name] ... file ...

DESCRIPTION
The cxref utility shall analyze a collection of C-language files and attempt to build a cross-
reference table. Information from #define lines shall be included in the symbol table. A sorted
listing shall be written to standard output of all symbols (auto, static, and global) in each file
separately, or with the -c option, in combination. Each symbol shall contain an asterisk before
the declaring reference.

OPTIONS
The cxref utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
12.2, Utility Syntax Guidelines, except that the order of the -D, -I, and -U options (which are
identical to their interpretation by c99) is significant. The following options shall be supported:

- c  Write a combined cross-reference of all input files.
- s  Operate silently; do not print input filenames.
- o file  Direct output to named file.
- w num  Format output no wider than num (decimal) columns. This option defaults to 80 if
         num is not specified or is less than 51.
- D  Equivalent to c99.
- I  Equivalent to c99.
- U  Equivalent to c99.

OPERANDS
The following operand shall be supported:

file  A pathname of a C-language source file.

STDIN
Not used.

INPUT FILES
The input files are C-language source files.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of cxref:

LANG  Provide a default value for the internationalization variables that are unset or null.
       (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
       Internationalization Variables for the precedence of internationalization variables
       used to determine the values of locale categories.)
LC_ALL  If set to a non-empty string value, override the values of all the other
        internationalization variables.
LC_COLLATE  Determine the locale for the ordering of the output.
LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
         characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The standard output shall be used for the cross-reference listing, unless the --o option is used to select a different output file.

The format of standard output is unspecified, except that the following information shall be included:

• If the --c option is not specified, each portion of the listing shall start with the name of the input file on a separate line.

• The name line shall be followed by a sorted list of symbols, each with its associated location pathname, the name of the function in which it appears (if it is not a function name itself), and line number references.

• Each line number may be preceded by an asterisk (‘*’) flag, meaning that this is the declaring reference. Other single-character flags, with implementation-defined meanings, may be included.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
The output file named by the --o option shall be used instead of standard output.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  Successful completion.
>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.
SEE ALSO

c99

CHANGE HISTORY

First released in Issue 2.

Issue 5  In the SYNOPSIS, [-U dir] is changed to [-U name].

Issue 6  The APPLICATION USAGE section is added.
NAME
date — write the date and time

SYNOPSIS
date [-u] [+format]
dxsi
date [-u] mmdhmmm[[cc]yy]

DESCRIPTION
The date utility shall write the date and time to standard output or attempt to set the system date
and time. By default, the current date and time shall be written. If an operand beginning with
'+' is specified, the output format of date shall be controlled by the conversion specifications
and other text in the operand.

OPTIONS
The date utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following option shall be supported:
- u
Perform operations as if the TZ environment variable was set to the string "UTC0",
or its equivalent historical value of "GMT0". Otherwise, date shall use the
timezone indicated by the TZ environment variable or the system default if that
variable is unset or null.

OPERANDS
The following operands shall be supported:
+format
When the format is specified, each conversion specifier shall be replaced in the
standard output by its corresponding value. All other characters shall be copied to
the output without change. The output shall always be terminated with a
<newline>.

Conversion Specifications
%a Locale’s abbreviated weekday name.
%A Locale’s full weekday name.
%b Locale’s abbreviated month name.
%B Locale’s full month name.
%c Locale’s appropriate date and time representation.
%c Century (a year divided by 100 and truncated to an integer) as a decimal
number [00,99].
%d Day of the month as a decimal number [01,31].
%d Date in the format mm/dd/yy.
%e Day of the month as a decimal number [1,31] in a two-digit field with
leading space character fill.
%h A synonym for %b.
%H Hour (24-hour clock) as a decimal number [00,23].
%I Hour (12-hour clock) as a decimal number [01,12].
Day of the year as a decimal number [001,366].
Month as a decimal number [01,12].
Minute as a decimal number [00,59].
A <newline>.
Locale's equivalent of either AM or PM.
12-hour clock time [01,12] using the AM/PM notation; in the POSIX locale, this shall be equivalent to %T:%M:%S %p.
Seconds as a decimal number [00,60].
A <tab>.
24-hour clock time [00,23] in the format HH:MM:SS.
Weekday as a decimal number [1,7] (1=Monday).
Week of the year (Sunday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Sunday shall be considered to be in week 0.
Week of the year (Monday as the first day of the week) as a decimal number [01,53]. If the week containing January 1 has four or more days in the new year, then it shall be considered week 1; otherwise, it shall be the last week of the previous year, and the next week shall be week 1.
Weekday as a decimal number [0,6] (0=Sunday).
Week of the year (Monday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Monday shall be considered to be in week 0.
Locale's alternative appropriate date representation.
Locale's alternative appropriate time representation.
Year within century [00,99].
Year with century as a decimal number.
Timezone name, or no characters if no timezone is determinable.
A percent sign character.
See the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3.5, LC_TIME for the conversion specifier values in the POSIX locale.

**Modified Conversion Specifications**

Some conversion specifiers can be modified by the E and O modifier characters to indicate a different format or specification as specified in the LC_TIME locale description (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3.5, LC_TIME). If the corresponding keyword (see era, era_year, era_d_fmt, and alt_digits in the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3.5, LC_TIME) is not specified or not supported for the current locale, the unmodified conversion specifier value shall be used.

Locale's alternative appropriate date and time representation.
Utilities

The name of the base year (period) in the locale’s alternative representation.

Locale’s alternative date representation.

Locale’s alternative time representation.

Offset from %EC (year only) in the locale’s alternative representation.

Full alternative year representation.

Day of month using the locale’s alternative numeric symbols.

Day of month using the locale’s alternative numeric symbols.

Hour (24-hour clock) using the locale’s alternative numeric symbols.

Hour (12-hour clock) using the locale’s alternative numeric symbols.

Month using the locale’s alternative numeric symbols.

Minutes using the locale’s alternative numeric symbols.

Seconds using the locale’s alternative numeric symbols.

Weekday as a number in the locale’s alternative representation (Monday = 1).

Week number of the year (Sunday as the first day of the week) using the locale’s alternative numeric symbols.

Week number of the year (Monday as the first day of the week, rules corresponding to %V), using the locale’s alternative numeric symbols.

Weekday as a number in the locale’s alternative representation (Sunday = 0).

Week number of the year (Monday as the first day of the week) using the locale’s alternative numeric symbols.

Year (offset from %C) in alternative representation.

Attempt to set the system date and time from the value given in the operand. This is only possible if the user has appropriate privileges and the system permits the setting of the system date and time. The first mm is the month (number); dd is the day (number); hh is the hour (number, 24-hour system); the second mm is the minute (number); cc is the century and is the first two digits of the year (this is optional); yy is the last two digits of the year and is optional. If century is not specified, then values in the range [69,99] shall refer to years 1969 to 1999 inclusive, and values in the range [00,68] shall refer to years 2000 to 2068 inclusive. The current year is the default if yy is omitted.

Note: It is expected that in a future version of IEEE Std 1003.1-2001 the default century inferred from a 2-digit year will change. (This would apply to all commands accepting a 2-digit year as input.)

STDIN

Not used.
INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of date:

LANG
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE
Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

LC_TIME
Determine the format and contents of date and time strings written by date.

XSI NLS_PATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

TZ
Determine the timezone in which the time and date are written, unless the –u
option is specified. If the TZ variable is unset or null and –u is not specified, an
unspecified system default timezone is used.

ASYNCHRONOUS EVENTS
Default.

STDOUT
When no formatting operand is specified, the output in the POSIX locale shall be equivalent to
specifying:

date "+%a %b %e %H:%M:%S %z %Y"

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 The date was written successfully.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.
Conversion specifiers are of unspecified format when not in the POSIX locale. Some of them can contain <newline>s in some locales, so it may be difficult to use the format shown in standard output for parsing the output of date in those locales.

The range of values for %S extends from 0 to 60 seconds to accommodate the occasional leap second.

Although certain of the conversion specifiers in the POSIX locale (such as the name of the month) are shown with initial capital letters, this need not be the case in other locales. Programs using these fields may need to adjust the capitalization if the output is going to be used at the beginning of a sentence.

The date string formatting capabilities are intended for use in Gregorian-style calendars, possibly with a different starting year (or years). The %x and %c conversion specifications, however, are intended for local representation; these may be based on a different, non-Gregorian calendar.

The %C conversion specification was introduced to allow a fallback for the %EC (alternative year format base year); it can be viewed as the base of the current subdivision in the Gregorian calendar. The century number is calculated as the year divided by 100 and truncated to an integer; it should not be confused with the use of ordinal numbers for centuries (for example, “twenty-first century’’). Both the %Ey and %y can then be viewed as the offset from %EC and %C, respectively.

The $E and $O modifiers modify the traditional conversion specifiers, so that they can always be used, even if the implementation (or the current locale) does not support the modifier.

The $E modifier supports alternative date formats, such as the Japanese Emperor’s Era, as long as these are based on the Gregorian calendar system. Extending the $E modifiers to other date elements may provide an implementation-defined extension capable of supporting other calendar systems, especially in combination with the $O modifier.

The $O modifier supports time and date formats using the locale’s alternative numerical symbols, such as Kanji or Hindi digits or ordinal number representation.

Non-European locales, whether they use Latin digits in computational items or not, often have local forms of the digits for use in date formats. This is not totally unknown even in Europe; a variant of dates uses Roman numerals for the months: the third day of September 1991 would be written as 3.IX.1991. In Japan, Kanji digits are regularly used for dates; in Arabic-speaking countries, Hindi digits are used. The %d, %e, %H, %I, %m, %S, %U, %w, %W, and %y conversion specifications always return the date and time field in Latin digits (that is, 0 to 9). The $O modifier was introduced to support the use for display purposes of non-Latin digits. In the LC_TIME category in localedef, the optional alt_digits keyword is intended for this purpose. As an example, assume the following (partial) localedef source:

```bash
alt_digits "";"I";"II";"III";"IV";"V";"VI";"VII";"VIII" \
    "IX";"X";"XI";"XII"

d_fmt "%e.%0m.%Y"
```

With the above date, the command:

date "+%x"

would yield 3.IX.1991. With the same d_fmt, but without the alt_digits, the command would yield 3.9.1991.
EXAMPLES

1. The following are input/output examples of date used at arbitrary times in the POSIX locale:

   $ date
   Tue Jun 26 09:58:10 PDT 1990

   $ date "+%DATE: %m/%d/%y%nTIME: %H:%M:%S"
   DATE: 11/02/91
   TIME: 13:36:16

   $ date "+%TIME: %r"
   TIME: 01:36:32 PM

2. Examples for Denmark, where the default date and time format is %a%d%b%Y%T%Z:

   $ LANG=da_DK.iso_8859-1 date
   ons 02 okt 1991 15:03:32 CET

   $ LANG=da_DK.iso_8859-1 \(  
   date "+DATO: %A den %e. %B %Y%nKLOKKEN: %H:%M:%S"
   DATO: onsdag den 2. oktober 1991
   KLOKKEN: 15:03:56

3. Examples for Germany, where the default date and time format is %a%d%h%Y%Z%T%Z:

   $ LANG=De_DE.88591 date
   Mi 02.Okt.1991, 15:01:21 MEZ

   $ LANG=De_DE.88591 date "+DATUM: %A, %d. %B %Y%nZEIT: %H:%M:%S"
   DATUM: Mittwoch, 02. Oktober 1991
   ZEIT: 15:02:02

4. Examples for France, where the default date and time format is %a%d%h%Y%Z%T%:

   $ LANG=Fr_FR.88591 date
   Mer 02 oct 1991 MET 15:03:32

   $ LANG=Fr_FR.88591 date "+JOUR: %A %d %B %Y%nHEURE: %H:%M:%S"
   JOUR: Mercredi 02 octobre 1991
   HEURE: 15:03:56

RATIONALE

Some of the new options for formatting are from the ISO C standard. The –u option was introduced to allow portable access to Coordinated Universal Time (UTC). The string "GMT0" is allowed as an equivalent TZ value to be compatible with all of the systems using the BSD implementation, where this option originated.

The %e format conversion specification (adopted from System V) was added because the ISO C standard conversion specifications did not provide any way to produce the historical default date output during the first nine days of any month.

There are two varieties of day and week numbering supported (in addition to any others created with the locale-dependent %E and %O modifier characters):

- The historical variety in which Sunday is the first day of the week and the weekdays preceding the first Sunday of the year are considered week 0. These are represented by %w and %u. A variant of this is %W, using Monday as the first day of the week, but still referring to week 0. This view of the calendar was retained because so many historical applications depend on it and the ISO C standard strftime() function, on which many date
implementations are based, was defined in this way.

- The international standard, based on the ISO 8601:2000 standard where Monday is the first weekday and the algorithm for the first week number is more complex: If the week (Monday to Sunday) containing January 1 has four or more days in the new year, then it is week 1; otherwise, it is week 53 of the previous year, and the next week is week 1. These are represented by the new conversion specifications %u and %V, added as a result of international comments.

FUTURE DIRECTIONS
None.

SEE ALSO
The System Interfaces volume of IEEE Std 1003.1-2001, printf(), strftime() 

CHANGE HISTORY
First released in Issue 2.

Issue 5
Changes are made for Year 2000 alignment.

Issue 6
The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The %EX modified conversion specification is added.

The Open Group Corrigendum U048/2 is applied, correcting the examples.

The DESCRIPTION is updated to refer to conversion specifications, instead of field descriptors for consistency with the LC_TIME category.

A clarification is made such that the current year is the default if the yy argument is omitted when setting the system date and time.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/19 is applied, correcting the CHANGE HISTORY section.
NAME
dd — convert and copy a file

SYNOPSIS
dd [operand ...]

DESCRIPTION
The *dd* utility shall copy the specified input file to the specified output file with possible conversions using specific input and output block sizes. It shall read the input one block at a time, using the specified input block size; it shall then process the block of data actually returned, which could be smaller than the requested block size. It shall apply any conversions that have been specified and write the resulting data to the output in blocks of the specified output block size. If the **bs=expr** operand is specified and no conversions other than **sync**, **noerror**, or **notrunc** are requested, the data returned from each input block shall be written as a separate output block; if the read returns less than a full block and the **sync** conversion is not specified, the resulting output block shall be the same size as the input block. If the **bs=expr** operand is not specified, or a conversion other than **sync**, **noerror**, or **notrunc** is requested, the input shall be processed and collected into full-sized output blocks until the end of the input is reached.

The processing order shall be as follows:

1. An input block is read.
2. If the input block is shorter than the specified input block size and the **sync** conversion is specified, null bytes shall be appended to the input data up to the specified size. (If either **block** or **unblock** is also specified, <space>s shall be appended instead of null bytes.) The remaining conversions and output shall include the pad characters as if they had been read from the input.
3. If the **bs=expr** operand is specified and no conversion other than **sync** or **noerror** is requested, the resulting data shall be written to the output as a single block, and the remaining steps are omitted.
4. If the **swab** conversion is specified, each pair of input data bytes shall be swapped. If there is an odd number of bytes in the input block, the last byte in the input record shall not be swapped.
5. Any remaining conversions (**block**, **unblock**, **lcase**, and **ucase**) shall be performed. These conversions shall operate on the input data independently of the input blocking; an input or output fixed-length record may span block boundaries.
6. The data resulting from input or conversion or both shall be aggregated into output blocks of the specified size. After the end of input is reached, any remaining output shall be written as a block without padding if **conv=sync** is not specified; thus, the final output block may be shorter than the output block size.

OPTIONS
None.

OPERANDS
All of the operands shall be processed before any input is read. The following operands shall be supported:

- **if=file**  Specify the input pathname; the default is standard input.
- **of=file**  Specify the output pathname; the default is standard output. If the **seek=expr** conversion is not also specified, the output file shall be truncated before the copy begins if an explicit **of=file** operand is specified, unless **conv=notrunc** is specified.
If `seek=expr` is specified, but `conv=notrunc` is not, the effect of the copy shall be to preserve the blocks in the output file over which `dd` seeks, but no other portion of the output file shall be preserved. (If the size of the seek plus the size of the input file is less than the previous size of the output file, the output file shall be shortened by the copy.)

**ibs=expr** Specify the input block size, in bytes, by `expr` (default is 512).

**obs=expr** Specify the output block size, in bytes, by `expr` (default is 512).

**bs=expr** Set both input and output block sizes to `expr` bytes, superseding `ibs=` and `obs=`. If no conversion other than `sync`, `noerror`, and `notrunc` is specified, each input block shall be copied to the output as a single block without aggregating short blocks.

**cbs=expr** Specify the conversion block size for `block` and `unblock` in bytes by `expr` (default is zero). If `cbs=` is omitted or given a value of zero, using `block` or `unblock` produces unspecified results.

**skip=n** Skip `n` input blocks (using the specified input block size) before starting to copy. On seekable files, the implementation shall read the blocks or seek past them; on non-seeable files, the blocks shall be read and the data shall be discarded.

**seek=n** Skip `n` blocks (using the specified output block size) from the beginning of the output file before copying. On non-seeable files, existing blocks shall be read and space from the current end-of-file to the specified offset, if any, filled with null bytes; on seekable files, the implementation shall seek to the specified offset or read the blocks as described for non-seeable files.

**count=n** Copy only `n` input blocks.

**conv=value[value ...]**

Where `values` are comma-separated symbols from the following list:

- **ascii** Convert EBCDIC to ASCII; see Table 4-6 (on page 305).
- **ebcdic** Convert ASCII to EBCDIC; see Table 4-6 (on page 305).
- **ibm** Convert ASCII to a different EBCDIC set; see Table 4-7 (on page 306).

The `ascii`, `ebcdic`, and `ibm` values are mutually-exclusive.

**block** Treat the input as a sequence of `<newline>`-terminated or end-of-file-terminated variable-length records independent of the input block boundaries. Each record shall be converted to a record with a fixed length specified by the conversion block size. Any `<newline>` shall be removed from the input line; `<space>`s shall be appended to lines that are shorter than their conversion block size to fill the block. Lines that are longer than the conversion block size shall be truncated to the largest number of characters that fit into that size; the number of truncated lines shall be reported (see the STDERR section).
Utilities

The block and unblock values are mutually-exclusive.

**unblock**

Convert fixed-length records to variable length. Read a number of bytes equal to the conversion block size (or the number of bytes remaining in the input, if less than the conversion block size), delete all trailing <space>s, and append a <newline>.

**lcase**

Map uppercase characters specified by the LC_CTYPE keyword tolower to the corresponding lowercase character. Characters for which no mapping is specified shall not be modified by this conversion.

The lcase and ucase symbols are mutually-exclusive.

**ucase**

Map lowercase characters specified by the LC_CTYPE keyword toupper to the corresponding uppercase character. Characters for which no mapping is specified shall not be modified by this conversion.

**swab**

Swap every pair of input bytes.

**noerror**

Do not stop processing on an input error. When an input error occurs, a diagnostic message shall be written on standard error, followed by the current input and output block counts in the same format as used at completion (see the STDERR section). If the sync conversion is specified, the missing input shall be replaced with null bytes and processed normally; otherwise, the input block shall be omitted from the output.

**notrunc**

Do not truncate the output file. Preserve blocks in the output file not explicitly written by this invocation of the dd utility. (See also the preceding of=file operand.)

**sync**

Pad every input block to the size of the ibs= buffer, appending null bytes. (If either block or unblock is also specified, append <space>s, rather than null bytes.)

The behavior is unspecified if operands other than conv= are specified more than once.

For the bs=, cbs=, ibs=, and obs= operands, the application shall supply an expression specifying a size in bytes. The expression, expr, can be:

1. A positive decimal number
2. A positive decimal number followed by k, specifying multiplication by 1024
3. A positive decimal number followed by b, specifying multiplication by 512
4. Two or more positive decimal numbers (with or without k or b) separated by x, specifying the product of the indicated values

All of the operands are processed before any input is read.

The following two tables display the octal number character values used for the ascii and ebcdic conversions (first table) and for the ibm conversion (second table). In both tables, the ASCII values are the row and column headers and the EBCDIC values are found at their intersections. For example, ASCII 0012 (LF) is the second row, third column, yielding 0045 in EBCDIC. The inverted tables (for EBCDIC to ASCII conversion) are not shown, but are in one-to-one correspondence with these tables. The differences between the two tables are highlighted by small boxes drawn around five entries.
### Table 4-6: ASCII to EBCDIC Conversion

<table>
<thead>
<tr>
<th>Character</th>
<th>ASCII Code</th>
<th>EBCDIC Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0000</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>0001</td>
</tr>
<tr>
<td>2</td>
<td>0002</td>
<td>0002</td>
</tr>
<tr>
<td>3</td>
<td>0003</td>
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<td>4</td>
<td>0004</td>
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<td>8</td>
<td>0008</td>
<td>0008</td>
</tr>
<tr>
<td>9</td>
<td>0009</td>
<td>0009</td>
</tr>
<tr>
<td>A</td>
<td>0041</td>
<td>0041</td>
</tr>
<tr>
<td>B</td>
<td>0042</td>
<td>0042</td>
</tr>
<tr>
<td>C</td>
<td>0043</td>
<td>0043</td>
</tr>
<tr>
<td>D</td>
<td>0044</td>
<td>0044</td>
</tr>
<tr>
<td>E</td>
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<td>0054</td>
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<td>V</td>
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<td>Y</td>
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</tr>
<tr>
<td>Z</td>
<td>005A</td>
<td>005A</td>
</tr>
</tbody>
</table>

*Note: The table continues with additional characters and their corresponding ASCII and EBCDIC codes.*
Table 4-7  ASCII to IBM EBCDIC Conversion

<table>
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<tr>
<th>0</th>
<th>0000</th>
<th>0010</th>
<th>0020</th>
<th>0030</th>
<th>0040</th>
<th>0050</th>
<th>0060</th>
<th>0070</th>
<th>0080</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0090</td>
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<td>00B0</td>
<td>00C0</td>
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<td>01F0</td>
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If no `if=` operand is specified, the standard input shall be used. See the INPUT FILES section.

The input file can be any file type.

The following environment variables shall affect the execution of `dd`:

- **LANG**
  - Provide a default value for the internationalization variables that are unset or null.
  - (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  - If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**
  - Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), the classification of characters as uppercase or lowercase, and the mapping of characters from one case to the other.

- **LC_MESSAGES**
  - Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

- **XSI**
  - **NLSPATH**
    - Determine the location of message catalogs for the processing of **LC_MESSAGES**.

For SIGINT, the `dd` utility shall interrupt its current processing, write status information to standard error, and exit as though terminated by SIGINT. It shall take the standard action for all other signals; see the ASYNCHRONOUS EVENTS section in Section 1.11 (on page 20).

If no `of=` operand is specified, the standard output shall be used. The nature of the output depends on the operands selected.

On completion, `dd` shall write the number of input and output blocks to standard error. In the POSIX locale the following formats shall be used:

```
"%u+%u records in
", <number of whole input blocks>,
<number of partial input blocks>
"%u+%u records out
", <number of whole output blocks>,
<number of partial output blocks>
```

A partial input block is one for which `read()` returned less than the input block size. A partial output block is one that was written with fewer bytes than specified by the output block size.

In addition, when there is at least one truncated block, the number of truncated blocks shall be written to standard error. In the POSIX locale, the format shall be:

```
"%u truncated %s\n", <number of truncated blocks>, "record" (if
<number of truncated blocks> is one) "records" (otherwise)
```

Diagnostic messages may also be written to standard error.
OUTPUT FILES
If the of= operand is used, the output shall be the same as described in the STDOUT section.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 The input file was copied successfully.
>0 An error occurred.

CONSEQUENCES OF ERRORS
If an input error is detected and the noerror conversion has not been specified, any partial output block shall be written to the output file, a diagnostic message shall be written, and the copy operation shall be discontinued. If some other error is detected, a diagnostic message shall be written and the copy operation shall be discontinued.

APPLICATION USAGE
The input and output block size can be specified to take advantage of raw physical I/O.
There are many different versions of the EBCDIC codesets. The ASCII and EBCDIC conversions specified for the dd utility perform conversions for the version specified by the tables.

EXAMPLES
The following command:
```
dd if=/dev/rmt0h of=/dev/rmt1h
```
copies from tape drive 0 to tape drive 1, using a common historical device naming convention.
The following command:
```
dd ibs=10 skip=1
```
strips the first 10 bytes from standard input.
This example reads an EBCDIC tape blocked ten 80-byte EBCDIC card images per block into the ASCII file x:
```
dd if=/dev/tape of=x ibs=800 cbs=80 conv=ascii,lcase
```

RATIONALE
The OPTIONS section is listed as "None" because there are no options recognized by historical dd utilities. Certainly, many of the operands could have been designed to use the Utility Syntax Guidelines, which would have resulted in the classic hyphenated option letters. In this version of this volume of IEEE Std 1003.1-2001, dd retains its curious JCL-like syntax due to the large number of applications that depend on the historical implementation.
A suggested implementation technique for conv=noerror,sync is to zero (or <space>-fill, if blocking or unblocking) the input buffer before each read and to write the contents of the input buffer to the output even after an error. In this manner, any data transferred to the input buffer before the error was detected is preserved. Another point is that a failed read on a regular file or a disk generally does not increment the file offset, and dd must then seek past the block on which the error occurred; otherwise, the input error occurs repetitively. When the input is a magnetic tape, however, the tape normally has passed the block containing the error when the error is reported, and thus no seek is necessary.
The default ibs= and obs= sizes are specified as 512 bytes because there are historical (largely portable) scripts that assume these values. If they were left unspecified, unusual results could...
Historical implementations of `dd` used `creat()` when processing `of=file`. This makes the `seek=` operand unusable except on special files. The `conv=notrunc` feature was added because more recent BSD-based implementations use `open()` (without `O_TRUNC`) instead of `creat()`, but they fail to delete output file contents after the data copied.

The `w` multiplier (historically meaning `word`), is used in System V to mean 2 and in 4.2 BSD to mean 4. Since `word` is inherently non-portable, its use is not supported by this volume of IEEE Std 1003.1-2001.

Standard EBCDIC does not have the characters ‘[‘ and ‘]’ . The values used in the table are taken from a common print train that does contain them. Other than those characters, the print train values are not filled in, but appear to provide some of the motivation for the historical choice of translations reflected here.

The Standard EBCDIC table provides a 1:1 translation for all 256 bytes.

The IBM EBCDIC table does not provide such a translation. The marked cells in the tables differ in such a way that:

1. EBCDIC 0112 (‘¢’) and 0152 (broken pipe) do not appear in the table.
2. EBCDIC 0137 (‘¬’) translates to/from ASCII 0236 (‘ˆ’). In the standard table, EBCDIC 0232 (no graphic) is used.
3. EBCDIC 0241 (‘˜’) translates to/from ASCII 0176 (‘˜’). In the standard table, EBCDIC 0137 (‘¬’) is used.
4. 0255 (‘[’) and 0275 (‘]’) appear twice, once in the same place as for the standard table and once in place of 0112 (‘¢’) and 0241 (‘˜’).

In net result:

```
EBCDIC 0275 (‘]’) displaced EBCDIC 0241 (‘˜’) in cell 0345.
```

```
That displaced EBCDIC 0137 (‘¬’) in cell 0176.
```

```
That displaced EBCDIC 0232 (no graphic) in cell 0136.
```

```
That replaced EBCDIC 0152 (broken pipe) in cell 0313.
```

```
EBCDIC 0255 (‘[’) replaced EBCDIC 0112 (‘¢’).
```

This translation, however, reflects historical practice that (ASCII) ‘˜’ and ‘¬’ were often mapped to each other, as were ‘[’ and ‘¢’; and ‘]’ and (EBCDIC) ‘˜’.

The `cbs` operand is required if any of the `ascii`, `ebcdic`, or `ibm` operands are specified. For the `ascii` operand, the input is handled as described for the `unblock` operand except that characters are converted to ASCII before the trailing <space>s are deleted. For the `ebcdic` and `ibm` operands, the input is handled as described for the `block` operand except that the characters are converted to EBCDIC or IBM EBCDIC after the trailing <space>s are added.

The `block` and `unblock` keywords are from historical BSD practice.

The consistent use of the word `record` in standard error messages matches most historical practice. An earlier version of System V used `block`, but this has been updated in more recent releases.

Early proposals only allowed two numbers separated by x to be used in a product when specifying `bs=`, `cbs=`, `ibs=`, and `obs=` sizes. This was changed to reflect the historical practice of allowing multiple numbers in the product as provided by Version 7 and all releases of System V.
Utilities

A change to the **swab** conversion is required to match historical practice and is the result of IEEE PASC Interpretations 1003.2 #03 and #04, submitted for the ISO POSIX-2: 1993 standard.

A change to the handling of SIGINT is required to match historical practice and is the result of IEEE PASC Interpretation 1003.2 #06 submitted for the ISO POSIX-2: 1993 standard.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Section 1.11 (on page 20), `sed`, `tr`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

The second paragraph of the `cbs=` description is reworded and marked EX.

The FUTURE DIRECTIONS section is added.

**Issue 6**

Changes are made to **swab** conversion and SIGINT handling to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE PASC Interpretation 1003.2 #209 is applied, clarifying the interaction between `dd of=file` and `conv=notrunc`. 


NAME  

delta — make a delta (change) to an SCCS file (DEVELOPMENT)

SYNOPSIS


delta [−nps][−g list][−m mrlist][−r SID][−y[comment]] file...

DESCRIPTION

The delta utility shall be used to permanently introduce into the named SCCS files changes that
were made to the files retrieved by get (called the g-files, or generated files).

OPTIONS

The delta utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
12.2, Utility Syntax Guidelines, except that the −y option has an optional option-argument. This
optional option-argument shall not be presented as a separate argument.

The following options shall be supported:

−r SID  Uniquely identify which delta is to be made to the SCCS file. The use of this option
shall be necessary only if two or more outstanding get commands for editing (get −e) on the same SCCS file were done by the same person (login name). The SID value specified with the −r option can be either the SID specified on the get command line or the SID to be made as reported by the get utility; see get (on page 476).

−s  Suppress the report to standard output of the activity associated with each file. See the STDOUT section.

−n  Specify retention of the edited g-file (normally removed at completion of delta processing).

−g list  Specify a list (see get for the definition of list) of deltas that shall be ignored when
the file is accessed at the change level (SID) created by this delta.

−m mrlist  Specify a modification request (MR) number that the application shall supply as
the reason for creating the new delta. This shall be used if the SCCS file has the v flag set; see admin.

If −m is not used and '−' is not specified as a file argument, and the standard input is a terminal, the prompt described in the STDOUT section shall be written
to standard output before the standard input is read; if the standard input is not a
terminal, no prompt shall be issued.

MRs in a list shall be separated by <blank>s or escaped <newline>s. An
unescape <newline> shall terminate the MR list. The escape character is
<backslash>.

If the v flag has a value, it shall be taken to be the name of a program which
validates the correctness of the MR numbers. If a non-zero exit status is returned
from the MR number validation program, the delta utility shall terminate. (It is
assumed that the MR numbers were not all valid.)

−y[comment]  Describe the reason for making the delta. The comment shall be an arbitrary group
of lines that would meet the definition of a text file. Implementations shall support
comments from zero to 512 bytes and may support longer values. A null string
(specified as either −y, −y "", or in response to a prompt for a comment) shall be
considered a valid comment.
If \( \texttt{-y} \) is not specified and \( \texttt{\'--\'} \) is not specified as a file argument, and the standard input is a terminal, the prompt described in the STDOUT section shall be written to standard output before the standard input is read; if the standard input is not a terminal, no prompt shall be issued. An unescaped \texttt{<newline>} shall terminate the comment text. The escape character is \texttt{<backslash>}. The \texttt{-y} option shall be required if the \texttt{file} operand is specified as \texttt{\'--\'}.

\texttt{-p} Write (to standard output) the SCCS file differences before and after the delta is applied in \texttt{diff} format; see \texttt{diff}.

### OPERANDS

The following operand shall be supported:

- **\texttt{file}**: A pathname of an existing SCCS file or a directory. If \texttt{file} is a directory, the \texttt{delta} utility shall behave as though each file in the directory were specified as a named file, except that non-SCCS files (last component of the pathname does not begin with \texttt{s}) and unreadable files shall be silently ignored.

If exactly one \texttt{file} operand appears, and it is \texttt{\'--\'}, the standard input shall be read; each line of the standard input shall be taken to be the name of an SCCS file to be processed. Non-SCCS files and unreadable files shall be silently ignored.

### STDIN

The standard input shall be a text file used only in the following cases:

- To read an \texttt{mrlist} or a \texttt{comment} (see the \texttt{-m} and \texttt{-y} options).
- A \texttt{file} operand shall be specified as \texttt{\'--\'}. In this case, the \texttt{-y} option must be used to specify the comment, and if the SCCS file has the \texttt{v} flag set, the \texttt{-m} option must also be used to specify the MR list.

### INPUT FILES

Input files shall be text files whose data is to be included in the SCCS files. If the first character of any line of an input file is \texttt{<SOH>} in the POSIX locale, the results are unspecified. If this file contains more than 99 999 lines, the number of lines recorded in the header for this file shall be 99 999 for this delta.

### ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of \texttt{delta}:

- **\texttt{LANG}**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- **\texttt{LC_ALL}**: If set to a non-empty string value, override the values of all the other internationalization variables.
- **\texttt{LC_CTYPE}**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).
- **\texttt{LC_MESSAGES}**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error, and informative messages written to standard output.
- **\texttt{NLSPATH}**: Determine the location of message catalogs for the processing of \texttt{LC_MESSAGES}.
TZ Determine the timezone in which the time and date are written in the SCCS file. If
the TZ variable is unset or NULL, an unspecified system default timezone is used.

ASYNCHRONOUS EVENTS
If SIGINT is caught, temporary files shall be cleaned up and delta shall exit with a non-zero exit
code. The standard action shall be taken for all other signals; see Section 1.11 (on page 20).

STDOUT
The standard output shall be used only for the following messages in the POSIX locale:

• Prompts (see the −m and −y options) in the following formats:
  "MRs? "
  "comments? "
  The MR prompt, if written, shall always precede the comments prompt.

• A report of each file’s activities (unless the −s option is specified) in the following format:
  "%s
%d inserted
%d deleted
%d unchanged
", <New SID>,
  <number of lines inserted>, <number of lines deleted>,
  <number of lines unchanged>

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
Any SCCS files updated shall be files of an unspecified format.

EXTENDED DESCRIPTION

System Date and Time
When a delta is added to an SCCS file, the system date and time shall be recorded for the new
delta. If a get is performed using an SCCS file with a date recorded apparently in the future, the
behavior is unspecified.

EXIT STATUS
The following exit values shall be returned:
  0 Successful completion.
  >0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Problems can arise if the system date and time have been modified (for example, put forward
and then back again, or unsynchronized clocks across a network) and can also arise when
different values of the TZ environment variable are used.

Problems of a similar nature can also arise for the operation of the get utility, which records the
date and time in the file body.

EXAMPLES
None.
RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 1.11 (on page 20), admin, diff, get,prs, rmdel

CHANGE HISTORY
First released in Issue 2.

Issue 5
The output format description in the STDOUT section is corrected.

Issue 6
The APPLICATION USAGE section is added.
The normative text is reworded to avoid use of the term “must” for application requirements.
The Open Group Base Resolution bwg2001-007 is applied as follows:

- The use of ‘−’ as a file argument is clarified.
- The use of STDIN is added.
- The ASYNCHRONOUS EVENTS section is updated to remove the implicit requirement that implementations re-signal themselves when catching a normally fatal signal.
- New text is added to the INPUT FILES section warning that the maximum lines recorded in the file is 99 999.
New text is added to the EXTENDED DESCRIPTION and APPLICATION USAGE sections regarding how the system date and time may be taken into account, and the TZ environment variable is added to the ENVIRONMENT VARIABLES section as per The Open Group Base Resolution bwg2001-007.
NAME

df — report free disk space

SYNOPSIS

UP  XSI  df [-k] [-P|-t] [file...]

DESCRIPTION

The df utility shall write the amount of available space and file slots for file systems on which the invoking user has appropriate read access. File systems shall be specified by the file operands; when none are specified, information shall be written for all file systems. The format of the default output from df is unspecified, but all space figures are reported in 512-byte units, unless the –k option is specified. This output shall contain at least the file system names, amount of available space on each of these file systems, and the number of free file slots, or inodes, available; when –t is specified, the output shall contain the total allocated space as well.

OPTIONS


The following options shall be supported:

-k  Use 1024-byte units, instead of the default 512-byte units, when writing space figures.

-P  Produce output in the format described in the STDOUT section.

-t  XSI  Include total allocated-space figures in the output.

OPERANDS

The following operand shall be supported:

file  A pathname of a file within the hierarchy of the desired file system. If a file other than a FIFO, a regular file, a directory, or a special file representing the device containing the file system (for example, /dev/dsk/0s1) is specified, the results are unspecified. Otherwise, df shall write the amount of free space in the file system containing the specified file operand.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of df:

LANG  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

**XSI**  
Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**ASYNCHRONOUS EVENTS**

Default.

When both the –k and –P options are specified, the following header line shall be written (in the POSIX locale):

"Filesystem 1024-blocks Used Available Capacity Mounted on
"

When the –P option is specified without the –k option, the following header line shall be written (in the POSIX locale):

"Filesystem 512-blocks Used Available Capacity Mounted on
"

The implementation may adjust the spacing of the header line and the individual data lines so that the information is presented in orderly columns.

The remaining output with –P shall consist of one line of information for each specified file system. These lines shall be formatted as follows:

"%s %d %d %d %d%% %s
", <file system name>, <total space>,<space used>, <space free>, <percentage used>,<file system root>

In the following list, all quantities expressed in 512-byte units (1 024-byte when –k is specified) shall be rounded up to the next higher unit. The fields are:

- `<file system name>`
  - The name of the file system, in an implementation-defined format.

- `<total space>`
  - The total size of the file system in 512-byte units. The exact meaning of this figure is implementation-defined, but should include `<space used>`, `<space free>`, plus any space reserved by the system not normally available to a user.

- `<space used>`
  - The total amount of space allocated to existing files in the file system, in 512-byte units.

- `<space free>`
  - The total amount of space available within the file system for the creation of new files by unprivileged users, in 512-byte units. When this figure is less than or equal to zero, it shall not be possible to create any new files on the file system without first deleting others, unless the process has appropriate privileges. The figure written may be less than zero.

- `<percentage used>`
  - The percentage of the normally available space that is currently allocated to all files on the file system. This shall be calculated using the fraction:

    `<space used>/(<space used>+<space free>)`

  expressed as a percentage. This percentage may be greater than 100 if `<space free>` is less than zero. The percentage value shall be expressed as a positive integer, with any fractional result causing it to be rounded to the next highest integer.
Utilities

The directory below which the file system hierarchy appears.

The output format is unspecified when \( -t \) is used.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

Default.

On most systems, the “name of the file system, in an implementation-defined format” is the special file on which the file system is mounted.

On large file systems, the calculation specified for percentage used can create huge rounding errors.

1. The following example writes portable information about the /usr file system:

   \( \text{df \ -P \ /usr} \)

2. Assuming that /usr/src is part of the /usr file system, the following produces the same output as the previous example:

   \( \text{df \ -P \ /usr/src} \)

The behavior of \( \text{df} \) with the \( \text{-P} \) option is the default action of the 4.2 BSD \( \text{df} \) utility. The uppercase \( \text{-P} \) was selected to avoid collision with a known industry extension using \( \text{-p} \).

Historical \( \text{df} \) implementations vary considerably in their default output. It was therefore necessary to describe the default output in a loose manner to accommodate all known historical implementations and to add a portable option (\( \text{-P} \)) to provide information in a portable format.

The use of 512-byte units is historical practice and maintains compatibility with \( \text{ls} \) and other utilities in this volume of IEEE Std 1003.1-2001. This does not mandate that the file system itself be based on 512-byte blocks. The \( \text{-k} \) option was added as a compromise measure. It was agreed by the standard developers that 512 bytes was the best default unit because of its complete historical consistency on System V (versus the mixed 512/1024-byte usage on BSD systems), and that a \( \text{-k} \) option to switch to 1024-byte units was a good compromise. Users who prefer the more logical 1024-byte quantity can easily alias \( \text{df} \) to \( \text{df \ -k} \) without breaking many historical scripts relying on the 512-byte units.

It was suggested that \( \text{df} \) and the various related utilities be modified to access a BLOCKSIZE environment variable to achieve consistency and user acceptance. Since this is not historical practice on any system, it is left as a possible area for system extensions and will be re-evaluated.
in a future version if it is widely implemented.

FUTURE DIRECTIONS
None.

SEE ALSO
find

CHANGE HISTORY
First released in Issue 2.

Issue 6
This utility is marked as part of the User Portability Utilities option.
NAME
diff — compare two files

SYNOPSIS
diff [-c| -e| -f| -C n][-br] file1 file2

DESCRIPTION
The diff utility shall compare the contents of file1 and file2 and write to standard output a list of changes necessary to convert file1 into file2. This list should be minimal. No output shall be produced if the files are identical.

OPTIONS
The following options shall be supported:

- b  Cause any amount of white space at the end of a line to be treated as a single <newline> (that is, the white-space characters preceding the <newline> are ignored) and other strings of white-space characters, not including <newline>s, to compare equal.
- c  Produce output in a form that provides three lines of context.
- C n  Produce output in a form that provides n lines of context (where n shall be interpreted as a positive decimal integer).
- e  Produce output in a form suitable as input for the ed utility, which can then be used to convert file1 into file2.
- f  Produce output in an alternative form, similar in format to -e, but not intended to be suitable as input for the ed utility, and in the opposite order.
- r  Apply diff recursively to files and directories of the same name when file1 and file2 are both directories.

OPERANDS
The following operands shall be supported:

file1, file2  A pathname of a file to be compared. If either the file1 or file2 operand is ‘−’, the standard input shall be used in its place.

If both file1 and file2 are directories, diff shall not compare block special files, character special files, or FIFO special files to any files and shall not compare regular files to directories. Further details are as specified in Diff Directory Comparison Format (on page 320). The behavior of diff on other file types is implementation-defined when found in directories.

If only one of file1 and file2 is a directory, diff shall be applied to the non-directory file and the file contained in the directory file with a filename that is the same as the last component of the non-directory file.

STDIN
The standard input shall be used only if one of the file1 or file2 operands references standard input. See the INPUT FILES section.

INPUT FILES
The input files may be of any type.
ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `diff`:

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

- **LC_TIME**: Determine the locale for affecting the format of file timestamps written with the \(-C\) and \(-c\) options.

- **XSI_NLSPATH**: Determine the location of message catalogs for the processing of `LC_MESSAGES`.

- **TZ**: Determine the timezone used for calculating file timestamps written with the \(-C\) and \(-c\) options. If `TZ` is unset or null, an unspecified default timezone shall be used.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Diff Directory Comparison Format

If both `file1` and `file2` are directories, the following output formats shall be used.

In the POSIX locale, each file that is present in only one directory shall be reported using the following format:

"Only in %s: %s\n", <directory pathname>, <filename>

In the POSIX locale, subdirectories that are common to the two directories may be reported with the following format:

"Common subdirectories: %s and %s\n", <directory1 pathname>,
<directory2 pathname>

For each file common to the two directories if the two files are not to be compared, the following format shall be used in the POSIX locale:

"File %s is a %s while file %s is a %s\n", <directory1 pathname>,
<file type of directory1 pathname>, <directory2 pathname>,
<file type of directory2 pathname>

For each file common to the two directories, if the files are compared and are identical, no output shall be written. If the two files differ, the following format is written:

"diff %s %s %s\n", <diff_options>, <filename1>, <filename2>
where `<diff_options>` are the options as specified on the command line.

All directory pathnames listed in this section shall be relative to the original command line arguments. All other names of files listed in this section shall be filenames (pathname components).

### Diff Binary Output Format

In the POSIX locale, if one or both of the files being compared are not text files, an unspecified format shall be used that contains the pathnames of two files being compared and the string "differ".

If both files being compared are text files, depending on the options specified, one of the following formats shall be used to write the differences.

### Diff Default Output Format

The default (without `-e`, `-f`, `-c`, or `-C` options) `diff` utility output shall contain lines of these forms:

```
"%da%d\n", <num1>, <num2>
"%da%d,%d\n", <num1>, <num2>, <num3>
"%dd%d\n", <num1>, <num2>
"%d,%dd%d\n", <num1>, <num2>, <num3>
"%dc%d\n", <num1>, <num2>
"%d,%dc%d\n", <num1>, <num2>, <num3>
"%dc%d,%d\n", <num1>, <num2>, <num3>
"%d,%dc%d,%d\n", <num1>, <num2>, <num3>, <num4>
```

These lines resemble `ed` subcommands to convert `file1` into `file2`. The line numbers before the action letters shall pertain to `file1`; those after shall pertain to `file2`. Thus, by exchanging `a` for `d` and reading the line in reverse order, one can also determine how to convert `file2` into `file1`. As in `ed`, identical pairs (where `num1 = num2`) are abbreviated as a single number.

Following each of these lines, `diff` shall write to standard output all lines affected in the first file using the format:

```
"<Δ%s", <line>
```

and all lines affected in the second file using the format:

```
">Δ%s", <line>
```

If there are lines affected in both `file1` and `file2` (as with the `c` subcommand), the changes are separated with a line consisting of three hyphens:

```
"−−−\n"
```
Diff –e Output Format

With the –e option, a script shall be produced that shall, when provided as input to ed, along
with an appended w (write) command, convert file1 into file2. Only the a (append), c (change), d
(delete), i (insert), and s (substitute) commands of ed shall be used in this script. Text lines,
except those consisting of the single character period (‘.’), shall be output as they appear in the
file.

Diff –f Output Format

With the –f option, an alternative format of script shall be produced. It is similar to that
produced by –e, with the following differences:

1. It is expressed in reverse sequence; the output of –e orders changes from the end of the file
to the beginning; the –f from beginning to end.

2. The command form <lines> <command-letter> used by –e is reversed. For example,
10c with –e would be c10 with –f.

3. The form used for ranges of line numbers is <space>-separated, rather than comma-
separated.

Diff –c or –C Output Format

With the –c or –C option, the output format shall consist of affected lines along with
surrounding lines of context. The affected lines shall show which ones need to be deleted or
changed in file1, and those added from file2. With the –c option, three lines of context, if
available, shall be written before and after the affected lines. With the –C option, the user can
specify how many lines of context are written. The exact format follows.

The name and last modification time of each file shall be output in the following format:

"*** %s %s
", file1, <file1 timestamp>
"--- %s %s
", file2, <file2 timestamp>

Each <file> field shall be the pathname of the corresponding file being compared. The pathname
written for standard input is unspecified.

In the POSIX locale, each <timestamp> field shall be equivalent to the output from the following
command:

date "+%a %b %e %T %Y"

without the trailing <newline>, executed at the time of last modification of the corresponding
file (or the current time, if the file is standard input).

Then, the following output formats shall be applied for every set of changes.

First, a line shall be written in the following format:

"**************
"

Next, the range of lines in file1 shall be written in the following format if the range contains two
or more lines:

"*** %d,%d ****\n", <beginning line number>, <ending line number>

and the following format otherwise:

"*** %d ****\n", <ending line number>
The ending line number of an empty range shall be the number of the preceding line, or 0 if the range is at the start of the file. Next, the affected lines along with lines of context (unaffected lines) shall be written. Unaffected lines shall be written in the following format:

"\Delta\%s", <unaffected_line>

Deleted lines shall be written as:

"-\Delta\%s", <deleted_line>

Changed lines shall be written as:

"!\Delta\%s", <changed_line>

Next, the range of lines in file2 shall be written in the following format if the range contains two or more lines:

"--- %d,%d ----\n", <beginning line number>, <ending line number>

and the following format otherwise:

"--- %d ----\n", <ending line number>

Then, lines of context and changed lines shall be written as described in the previous formats. Lines added from file2 shall be written in the following format:

"+\Delta\%s", <added_line>

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  No differences were found.
1  Differences were found.
>1  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
If lines at the end of a file are changed and other lines are added, diff output may show this as a delete and add, as a change, or as a change and add; diff is not expected to know which happened and users should not care about the difference in output as long as it clearly shows the differences between the files.

EXAMPLES
If dir1 is a directory containing a directory named x, dir2 is a directory containing a directory named x, dir1/x and dir2/x both contain files named date.out, and dir2/x contains a file named y, the command:

diff -r dir1 dir2
Utilities could produce output similar to:

Common subdirectories: dir1/x and dir2/x

Only in dir2/x: y

diff −r dir1/x/date.out dir2/x/date.out

1c1
< Mon Jul 2 13:12:16 PDT 1990
---
> Tue Jun 19 21:41:39 PDT 1990

RATIONALE

The −h option was omitted because it was insufficiently specified and does not add to applications portability.

Historical implementations employ algorithms that do not always produce a minimum list of differences; the current language about making every effort is the best this volume of IEEE Std 1003.1-2001 can do, as there is no metric that could be employed to judge the quality of implementations against any and all file contents. The statement “This list should be minimal” clearly implies that implementations are not expected to provide the following output when comparing two 100-line files that differ in only one character on a single line:

```
1,100c1,100
all 100 lines from file1 preceded with "< "
---
all 100 lines from file2 preceded with "> "
```

The “Only in” messages required when the −r option is specified are not used by most historical implementations if the −e option is also specified. It is required here because it provides useful information that must be provided to update a target directory hierarchy to match a source hierarchy. The “Common subdirectories” messages are written by System V and 4.3 BSD when the −r option is specified. They are allowed here but are not required because they are reporting on something that is the same, not reporting a difference, and are not needed to update a target hierarchy.

The −c option, which writes output in a format using lines of context, has been included. The format is useful for a variety of reasons, among them being much improved readability and the ability to understand difference changes when the target file has line numbers that differ from another similar, but slightly different, copy. The patch utility is most valuable when working with difference listings using the context format. The BSD version of −c takes an optional argument specifying the amount of context. Rather than overloading −c and breaking the Utility Syntax Guidelines for diff, the standard developers decided to add a separate option for specifying a context diff with a specified amount of context (−C). Also, the format for context diffs was extended slightly in 4.3 BSD to allow multiple changes that are within context lines from each other to be merged together. The output format contains an additional four asterisks after the range of affected lines in the first filename. This was to provide a flag for old programs (like old versions of patch) that only understand the old context format. The version of context described here does not require that multiple changes within context lines be merged, but it does not prohibit it either. The extension is upwards-compatible, so any vendors that wish to retain the old version of diff can do so by adding the extra four asterisks (that is, utilities that currently use diff and understand the new merged format will also understand the old unmerged format, but not vice versa).

The substitute command was added as an additional format for the −e option. This was added to provide implementations with a way to fix the classic “dot alone on a line” bug present in many versions of diff. Since many implementations have fixed this bug, the standard developers decided not to standardize broken behavior, but rather to provide the necessary tool for fixing
the bug. One way to fix this bug is to output two periods whenever a lone period is needed, then
terminate the append command with a period, and then use the substitute command to convert
the two periods into one period.

The BSD-derived \texttt{−r} option was added to provide a mechanism for using \texttt{diff} to compare two file
system trees. This behavior is useful, is standard practice on all BSD-derived systems, and is not
easily reproducible with the \texttt{find} utility.

The requirement that \texttt{diff} not compare files in some circumstances, even though they have the
same name, is based on the actual output of historical implementations. The message specified
here is already in use when a directory is being compared to a non-directory. It is extended here
to preclude the problems arising from running into FIFOs and other files that would cause \texttt{diff} to
hang waiting for input with no indication to the user that \texttt{diff} was hung. In most common usage,
\texttt{diff −r} should indicate differences in the file hierarchies, not the difference of contents of devices
pointed to by the hierarchies.

Many early implementations of \texttt{diff} require seekable files. Since the System Interfaces volume of
IEEE Std 1003.1-2001 supports named pipes, the standard developers decided that such a
restriction was unreasonable. Note also that the allowed filename \texttt{−} almost always refers to a
pipe.

No directory search order is specified for \texttt{diff}. The historical ordering is, in fact, not optimal, in
that it prints out all of the differences at the current level, including the statements about all
common subdirectories before recursing into those subdirectories.

The message:

\begin{verbatim}
"diff %s %s %s
", <diff_options>, <filename1>, <filename2>
\end{verbatim}

does not vary by locale because it is the representation of a command, not an English sentence.

\textbf{FUTURE DIRECTIONS}

None.

\textbf{SEE ALSO}

\texttt{cmp, comm, ed, find}

\textbf{CHANGE HISTORY}

First released in Issue 2.

\textbf{Issue 5}

The FUTURE DIRECTIONS section is added.

\textbf{Issue 6}

The following new requirements on POSIX implementations derive from alignment with the
Single UNIX Specification:

- The \texttt{−f} option is added.

The output format for \texttt{−c} or \texttt{−C} format is changed to align with changes to the IEEE P1003.2b
draft standard resulting from IEEE PASC Interpretation 1003.2 \#71.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/20 is applied, changing the STDOUT
section. This changes the specification of \texttt{diff −c} so that it agrees with existing practice when
contexts contain zero lines or one line.
NAME
dirname — return the directory portion of a pathname

SYNOPSIS
dirname string

DESCRIPTION
The string operand shall be treated as a pathname, as defined in the Base Definitions volume of
IEEE Std 1003.1-2001, Section 3.266, Pathname. The string string shall be converted to the name
of the directory containing the filename corresponding to the last pathname component in
string, performing actions equivalent to the following steps in order:

1. If string is //, skip steps 2 to 5.
2. If string consists entirely of slash characters, string shall be set to a single slash character. In this case, skip steps 3 to 8.
3. If there are any trailing slash characters in string, they shall be removed.
4. If there are no slash characters remaining in string, string shall be set to a single period character. In this case, skip steps 5 to 8.
5. If there are any trailing non-slash characters in string, they shall be removed.
6. If the remaining string is //, it is implementation-defined whether steps 7 and 8 are skipped or processed.
7. If there are any trailing slash characters in string, they shall be removed.
8. If the remaining string is empty, string shall be set to a single slash character.

The resulting string shall be written to standard output.

OPTIONS
None.

OPERANDS
The following operand shall be supported:

string A string.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of dirname:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).
Utilities

dirname

Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

Default.

The dirname utility shall write a line to the standard output in the following format:

"%s\n", <resulting string>

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

Successful completion.

An error occurred.

Default.

The definition of pathname specifies implementation-defined behavior for pathnames starting
with two slash characters. Therefore, applications shall not arbitrarily add slashes to the
beginning of a pathname unless they can ensure that there are more or less than two or are
prepared to deal with the implementation-defined consequences.

<table>
<thead>
<tr>
<th>Command</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>dirname /</td>
<td>/</td>
</tr>
<tr>
<td>dirname //</td>
<td>/ or //</td>
</tr>
<tr>
<td>dirname /a/b/</td>
<td>/a</td>
</tr>
<tr>
<td>dirname /a//b///</td>
<td>//a</td>
</tr>
<tr>
<td>dirname</td>
<td>Unspecified</td>
</tr>
<tr>
<td>dirname a</td>
<td>. ($? = 0)</td>
</tr>
<tr>
<td>dirname &quot;&quot;</td>
<td>. ($? = 0)</td>
</tr>
<tr>
<td>dirname /a</td>
<td>/</td>
</tr>
<tr>
<td>dirname /a//b</td>
<td>/a</td>
</tr>
<tr>
<td>dirname a/b</td>
<td>a</td>
</tr>
</tbody>
</table>

The dirname utility originated in System III. It has evolved through the System V releases to a
version that matches the requirements specified in this description in System V Release 3. 4.3
BSD and earlier versions did not include dirname.

The behaviors of basename and dirname in this volume of IEEE Std 1003.1-2001 have been
coordinated so that when string is a valid pathname:
would be a valid filename for the file in the directory:

$(dirname "string")

This would not work for the versions of these utilities in early proposals due to the way processing of trailing slashes was specified. Consideration was given to leaving processing unspecified if there were trailing slashes, but this cannot be done; the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.266, Pathname allows trailing slashes. The basename and dirname utilities have to specify consistent handling for all valid pathnames.

FUTURE DIRECTIONS
None.

SEE ALSO
basename, Section 2.5 (on page 33)

CHANGE HISTORY
First released in Issue 2.
NAME
du — estimate file space usage

SYNOPSIS

```
  du [-a | -s] [-kx] [-H | -L] [file ...]
```

DESCRIPTION

By default, the du utility shall write to standard output the size of the file space allocated to, and
the size of the file space allocated to each subdirectory of, the file hierarchy rooted in each of the
specified files. By default, when a symbolic link is encountered on the command line or in the
file hierarchy, du shall count the size of the symbolic link (rather than the file referenced by the
link), and shall not follow the link to another portion of the file hierarchy. The size of the file
space allocated to a file of type directory shall be defined as the sum total of space allocated to
all files in the file hierarchy rooted in the directory plus the space allocated to the directory itself.

When du cannot stat() files or stat() or read directories, it shall report an error condition and the
final exit status is affected. Files with multiple links shall be counted and written for only one
entry. The directory entry that is selected in the report is unspecified. By default, file sizes shall
be written in 512-byte units, rounded up to the next 512-byte unit.

OPTIONS

The du utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.

The following options shall be supported:

- `−a`  In addition to the default output, report the size of each file not of type directory in
the file hierarchy rooted in the specified file. Regardless of the presence of the `−a`
option, non-directories given as file operands shall always be listed.

- `−H`  If a symbolic link is specified on the command line, du shall count the size of the
file or file hierarchy referenced by the link.

- `−k`  Write the files sizes in units of 1024 bytes, rather than the default 512-byte units.

- `−L`  If a symbolic link is specified on the command line or encountered during the
traversal of a file hierarchy, du shall count the size of the file or file hierarchy
referenced by the link.

- `−s`  Instead of the default output, report only the total sum for each of the specified
files.

- `−x`  When evaluating file sizes, evaluate only those files that have the same device as
the file specified by the file operand.

Specifying more than one of the mutually-exclusive options `−H` and `−L` shall not be considered
an error. The last option specified shall determine the behavior of the utility.

OPERANDS

The following operand shall be supported:

- `file`  The pathname of a file whose size is to be written. If no file is specified, the current
directory shall be used.

STDIN

Not used.
INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of du:

LANG    Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL   If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT The output from du shall consist of the amount of space allocated to a file and the name of the
file, in the following format:

"%d %s
", <size>, <pathname>

STDERR The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0   Successful completion.
>0   An error occurred.

CONSEQUENCES OF ERRORS
Default.
APPLICATION USAGE

None.

EXAMPLES

None.

RATIONALE

The use of 512-byte units is historical practice and maintains compatibility with ls and other utilities in this volume of IEEE Std 1003.1-2001. This does not mandate that the file system itself be based on 512-byte blocks. The −k option was added as a compromise measure. It was agreed by the standard developers that 512 bytes was the best default unit because of its complete historical consistency on System V (versus the mixed 512/1024-byte usage on BSD systems), and that a −k option to switch to 1024-byte units was a good compromise. Users who prefer the 1024-byte quantity can easily alias du to du −k without breaking the many historical scripts relying on the 512-byte units.

The −b option was added to an early proposal to provide a resolution to the situation where System V and BSD systems give figures for file sizes in blocks, which is an implementation-defined concept. (In common usage, the block size is 512 bytes for System V and 1024 bytes for BSD systems.) However, −b was later deleted, since the default was eventually decided as 512-byte units.

Historical file systems provided no way to obtain exact figures for the space allocation given to files. There are two known areas of inaccuracies in historical file systems: cases of indirect blocks being used by the file system or sparse files yielding incorrectly high values. An indirect block is space used by the file system in the storage of the file, but that need not be counted in the space allocated to the file. A sparse file is one in which an lseek() call has been made to a position beyond the end of the file and data has subsequently been written at that point. A file system need not allocate all the intervening zero-filled blocks to such a file. It is up to the implementation to define exactly how accurate its methods are.

The −a and −s options were mutually-exclusive in the original version of du. The POSIX Shell and Utilities description is implied by the language in the SVID where −s is described as causing “only the grand total” to be reported. Some systems may produce output for −sa, but a Strictly Conforming POSIX Shell and Utilities Application cannot use that combination.

The −a and −s options were adopted from the SVID except that the System V behavior of not listing non-directories explicitly given as operands, unless the −a option is specified, was considered a bug; the BSD-based behavior (report for all operands) is mandated. The default behavior of du in the SVID with regard to reporting the failure to read files (it produces no messages) was considered counter-intuitive, and thus it was specified that the POSIX Shell and Utilities default behavior shall be to produce such messages. These messages can be turned off with shell redirection to achieve the System V behavior.

The −x option is historical practice on recent BSD systems. It has been adopted by this volume of IEEE Std 1003.1-2001 because there was no other historical method of limiting the du search to a single file hierarchy. This limitation of the search is necessary to make it possible to obtain file space usage information about a file system on which other file systems are mounted, without having to resort to a lengthy find and awk script.

FUTURE DIRECTIONS

None.
SEE ALSO

ls, the System Interfaces volume of IEEE Std 1003.1-2001, stat()

CHANGE HISTORY

First released in Issue 2.

Issue 6

This utility is marked as part of the User Portability Utilities option.

The APPLICATION USAGE section is added.

The obsolescent −r option has been removed.

The Open Group Corrigendum U025/3 is applied. The du utility is reinstated, as it had incorrectly been marked LEGACY in Issue 5.

The −H and −L options for symbolic links are added as described in the IEEE P1003.2b draft standard.
Utilities

echo

NAME
echo — write arguments to standard output

SYNOPSIS
echo [string ...]

DESCRIPTION
The echo utility writes its arguments to standard output, followed by a <newline>. If there are
no arguments, only the <newline> is written.

OPTIONS
The echo utility shall not recognize the "−−" argument in the manner specified by Guideline 10
"−−" shall be recognized as a string operand.

Implementations shall not support any options.

OPERANDS
The following operands shall be supported:

string A string to be written to standard output. If the first operand is −n, or if any of the
operands contain a backslash (\) character, the results are implementation-defined.

XSI On XSI-conformant systems, if the first operand is −n, it shall be treated as a string,
ot an option. The following character sequences shall be recognized on XSI-conformant systems within any of the arguments:

\a Write an <alert>.
\b Write a <backspace>.
\c Suppress the <newline> that otherwise follows the final argument in the
output. All characters following the \c in the arguments shall be ignored.
\f Write a <form-feed>.
\n Write a <newline>.
\r Write a <carriage-return>.
\t Write a <tab>.
\v Write a <vertical-tab>.
\ Write a backslash character.
\0 num Write an 8-bit value that is the zero, one, two, or three-digit octal number
num.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of echo:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Echo

Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**: Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**Asynchronous Events**

Default.

**Stdout**

The `echo` utility arguments shall be separated by single <space>s and a <newline> shall follow the last argument. Output transformations shall occur based on the escape sequences in the input. See the OPERANDS section.

**Stderr**

The standard error shall be used only for diagnostic messages.

**Output Files**

None.

**Extended Description**

None.

**Exit Status**

The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

**Consequences of Errors**

Default.

**Application Usage**

It is not possible to use `echo` portably across all POSIX systems unless both `-n` (as the first argument) and escape sequences are omitted.

The `printf` utility can be used portably to emulate any of the traditional behaviors of the `echo` utility as follows (assuming that `IFS` has its standard value or is unset):

- The historic System V `echo` and the requirements on XSI implementations in this volume of IEEE Std 1003.1-2001 are equivalent to:

  ```
  printf "%b\n" "$*
  ```

- The BSD `echo` is equivalent to:

  ```
  if [ "X$1" = "X-n" ]
  then
    shift
  printf "%s" "$**
  else
  ```
Utilities

echo

```c
    printf "%s\n" "$*
    fi
```

New applications are encouraged to use `printf` instead of `echo`.

**EXAMPLES**

None.

**RATIONALE**

The `echo` utility has not been made obsolescent because of its extremely widespread use in historical applications. Conforming applications that wish to do prompting without `<newline>`s or that could possibly be expecting to echo a `-n`, should use the `printf` utility derived from the Ninth Edition system.

As specified, `echo` writes its arguments in the simplest of ways. The two different historical versions of `echo` vary in fatally incompatible ways.

The BSD `echo` checks the first argument for the string `-n` which causes it to suppress the `<newline>` that would otherwise follow the final argument in the output.

The System V `echo` does not support any options, but allows escape sequences within its operands, as described for XSI implementations in the OPERANDS section.

The `echo` utility does not support Utility Syntax Guideline 10 because historical applications depend on `echo` to echo *all* of its arguments, except for the `-n` option in the BSD version.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`printf`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

In the OPTIONS section, the last sentence is changed to indicate that implementations “do not” support any options; in the previous issue this said “need not”.

**Issue 6**

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- A set of character sequences is defined as *string* operands.
- `LC_CTYPE` is added to the list of environment variables affecting `echo`.
- In the OPTIONS section, implementations shall not support any options.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/21 is applied, so that the `echo` utility can accommodate historical BSD behavior.
NAME
ed — edit text

SYNOPSIS
ed [-p string] [-s] [file]

DESCRIPTION
The ed utility is a line-oriented text editor that uses two modes: command mode and input mode. In command mode the input characters shall be interpreted as commands, and in input mode they shall be interpreted as text. See the EXTENDED DESCRIPTION section.

OPTIONS

The following options shall be supported:

- **-p string**  Use string as the prompt string when in command mode. By default, there shall be no prompt string.

- **-s**  Suppress the writing of byte counts by e, E, r, and w commands and of the `'!'` prompt after a `!command`.

OPERANDS
The following operand shall be supported:

- **file**  If the file argument is given, ed shall simulate an e command on the file named by the pathname, file, before accepting commands from the standard input. If the file operand is `-' or `−', the results are unspecified.

STDIN
The standard input shall be a text file consisting of commands, as described in the EXTENDED DESCRIPTION section.

INPUT FILES
The input files shall be text files.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of ed:

- **HOME**  Determine the pathname of the user's home directory.

- **LANG**  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_COLLATE**  Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.

- **LC_CTYPE**  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and the behavior of character classes within regular expressions.

- **LC_MESSAGES**  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error and informative messages written to standard output.

**XSI NLSPATH**

Determine the location of message catalogs for the processing of LC_MESSAGES.

**ASYNCHRONOUS EVENTS**

The *ed* utility shall take the standard action for all signals (see the ASYNCHRONOUS EVENTS section in Section 1.11 (on page 20)) with the following exceptions:

- **SIGINT**  
The *ed* utility shall interrupt its current activity, write the string "?\n" to standard output, and return to command mode (see the EXTENDED DESCRIPTION section).

- **SIGHUP**  
If the buffer is not empty and has changed since the last write, the *ed* utility shall attempt to write a copy of the buffer in a file. First, the file named *ed.hup* in the current directory shall be used; if that fails, the file named *ed.hup* in the directory named by the HOME environment variable shall be used. In any case, the *ed* utility shall exit without returning to command mode.

- **SIGQUIT**  
The *ed* utility shall ignore this event.

**STDOUT**

Various editing commands and the prompting feature (see −p) write to standard output, as described in the EXTENDED DESCRIPTION section.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

The output files shall be text files whose formats are dependent on the editing commands given.

**EXTENDED DESCRIPTION**

The *ed* utility shall operate on a copy of the file it is editing; changes made to the copy shall have no effect on the file until a w (write) command is given. The copy of the text is called the buffer.

Commands to *ed* have a simple and regular structure: zero, one, or two addresses followed by a single-character command, possibly followed by parameters to that command. These addresses specify one or more lines in the buffer. Every command that requires addresses has default addresses, so that the addresses very often can be omitted. If the −p option is specified, the prompt string shall be written to standard output before each command is read.

In general, only one command can appear on a line. Certain commands allow text to be input. This text is placed in the appropriate place in the buffer. While *ed* is accepting text, it is said to be in input mode. In this mode, no commands shall be recognized; all input is merely collected. Input mode is terminated by entering a line consisting of two characters: a period (’. ’) followed by a <newline>. This line is not considered part of the input text.

**Regular Expressions in ed**

The *ed* utility shall support basic regular expressions, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic Regular Expressions. Since regular expressions in *ed* are always matched against single lines (excluding the terminating <newline>s), never against any larger section of text, there is no way for a regular expression to match a <newline>.

A null RE shall be equivalent to the last RE encountered.

Regular expressions are used in addresses to specify lines, and in some commands (for example, the s substitute command) to specify portions of a line to be substituted.
Addresses in ed

Addressing in ed relates to the current line. Generally, the current line is the last line affected by a command. The current line number is the address of the current line. If the edit buffer is not empty, the initial value for the current line shall be the last line in the edit buffer; otherwise, zero.

Addresses shall be constructed as follows:

1. The period character (‘.’) shall address the current line.
2. The dollar sign character (‘$’) shall address the last line of the edit buffer.
3. The positive decimal number \( n \) shall address the \( n \)th line of the edit buffer.
4. The apostrophe-x character pair ("'x") shall address the line marked with the mark name character \( x \), which shall be a lowercase letter from the portable character set. It shall be an error if the character has not been set to mark a line or if the line that was marked is not currently present in the edit buffer.
5. A BRE enclosed by slash characters (’/’) shall address the first line found by searching forwards from the line following the current line toward the end of the edit buffer and stopping at the first line for which the line excluding the terminating <newline> matches the BRE. The BRE consisting of a null BRE delimited by a pair of slash characters shall address the next line for which the line excluding the terminating <newline> matches the last BRE encountered. In addition, the second slash can be omitted at the end of a command line. Within the BRE, a backslash-slash pair ("\") shall represent a literal slash instead of the BRE delimiter. If necessary, the search shall wrap around to the beginning of the buffer and continue up to and including the current line, so that the entire buffer is searched.
6. A BRE enclosed by question-mark characters (’?’) shall address the first line found by searching backwards from the line preceding the current line toward the beginning of the edit buffer and stopping at the first line for which the line excluding the terminating <newline> matches the BRE. The BRE consisting of a null BRE delimited by a pair of question-mark characters ("???") shall address the previous line for which the line excluding the terminating <newline> matches the last BRE encountered. In addition, the second question-mark can be omitted at the end of a command line. Within the BRE, a backslash-question-mark pair ("\?") shall represent a literal question mark instead of the BRE delimiter. If necessary, the search shall wrap around to the end of the buffer and continue up to and including the current line, so that the entire buffer is searched.
7. A plus-sign (’+’) or hyphen character (’−’) followed by a decimal number shall address the current line plus or minus the number. A plus-sign or hyphen character not followed by a decimal number shall address the current line plus or minus 1.

Addresses can be followed by zero or more address offsets, optionally <blank>-separated. Address offsets are constructed as follows:

- A plus-sign or hyphen character followed by a decimal number shall add or subtract, respectively, the indicated number of lines to or from the address. A plus-sign or hyphen character not followed by a decimal number shall add or subtract 1 to or from the address.
- A decimal number shall add the indicated number of lines to the address.

It shall not be an error for an intermediate address value to be less than zero or greater than the last line in the edit buffer. It shall be an error for the final address value to be less than zero or greater than the last line in the edit buffer. It shall be an error if a search for a BRE fails to find a matching line.
Commands accept zero, one, or two addresses. If more than the required number of addresses are provided to a command that requires zero addresses, it shall be an error. Otherwise, if more than the required number of addresses are provided to a command, the addresses specified first shall be evaluated and then discarded until the maximum number of valid addresses remain, for the specified command.

Addresses shall be separated from each other by a comma (`,`) or semicolon character (`;`). In the case of a semicolon separator, the current line (`.`) shall be set to the first address, and only then will the second address be calculated. This feature can be used to determine the starting line for forwards and backwards searches; see rules 5. and 6.

Addresses can be omitted on either side of the comma or semicolon separator, in which case the resulting address pairs shall be as follows:

<table>
<thead>
<tr>
<th>Specified</th>
<th>Resulting</th>
</tr>
</thead>
<tbody>
<tr>
<td>,</td>
<td>1, $</td>
</tr>
<tr>
<td>, addr</td>
<td>1, addr</td>
</tr>
<tr>
<td>addr ,</td>
<td>addr , addr</td>
</tr>
<tr>
<td>;</td>
<td>.; $</td>
</tr>
<tr>
<td>; addr</td>
<td>.; addr</td>
</tr>
<tr>
<td>addr ;</td>
<td>addr ; addr</td>
</tr>
</tbody>
</table>

Any `<blank>`s included between addresses, address separators, or address offsets shall be ignored.

**Commands in ed**

In the following list of *ed* commands, the default addresses are shown in parentheses. The number of addresses shown in the default shall be the number expected by the command. The parentheses are not part of the address; they show that the given addresses are the default.

It is generally invalid for more than one command to appear on a line. However, any command (except *e*, *E*, *f*, *q*, *Q*, *r*, *w*, and !) can be suffixed by the letter *l*, *n*, or *p*; in which case, except for the *l*, *n*, and *p* commands, the command shall be executed and then the new current line shall be written as described below under the *l*, *n*, and *p* commands. When an *l*, *n*, or *p* suffix is used with an *l*, *n*, or *p* command, the command shall write to standard output as described below, but it is unspecified whether the suffix writes the current line again in the requested format or whether the suffix has no effect. For example, the *pl* command (base *p* command with an *l* suffix) shall either write just the current line or write it twice—once as specified for *p* and once as specified for *l*. Also, the *g*, *G*, *v*, and *V* commands shall take a command as a parameter.

Each address component can be preceded by zero or more `<blank>`s. The command letter can be preceded by zero or more `<blank>`s. If a suffix letter (*l*, *n*, or *p*) is given, the application shall ensure that it immediately follows the command.

The *e*, *E*, *f*, *r*, and *w* commands shall take an optional *file* parameter, separated from the command letter by one or more `<blank>`s.

If changes have been made in the buffer since the last *w* command that wrote the entire buffer, *ed* shall warn the user if an attempt is made to destroy the editor buffer via the *e* or *q* commands. The *ed* utility shall write the string:

```
"?\n"
```

(followed by an explanatory message if *help mode* has been enabled via the *H* command) to standard output and shall continue in command mode with the current line number unchanged. If the *e* or *q* command is repeated with no intervening command, it shall take effect.
If a terminal disconnect is detected:

- If the buffer is not empty and has changed since the last write, the ed utility shall attempt to write a copy of the buffer to a file named `ed.hup` in the current directory. If this write fails, ed shall attempt to write a copy of the buffer to a filename `ed.hup` in the directory named by the `HOME` environment variable. If both these attempts fail, ed shall exit without saving the buffer.

- The ed utility shall not write the file to the currently remembered pathname or return to command mode, and shall terminate with a non-zero exit status.

If an end-of-file is detected on standard input:

- If the ed utility is in input mode, ed shall terminate input mode and return to command mode.
  - It is unspecified if any partially entered lines (that is, input text without a terminating <newline>) are discarded from the input text.

- If the ed utility is in command mode, it shall act as if a q command had been entered.

If the closing delimiter of an RE or of a replacement string (for example, `'/') in a g, G, s, v, or V command would be the last character before a <newline>, that delimiter can be omitted, in which case the addressed line shall be written. For example, the following pairs of commands are equivalent:

`s/s1/s2` `s/s1/s2/p`
`g/s1` `g/s1/p`
`?s1` `?s1?`

If an invalid command is entered, ed shall write the string:

```
"?\n"
```

(followed by an explanatory message if help mode has been enabled via the H command) to standard output and shall continue in command mode with the current line number unchanged.

### Append Command

**Synopsis:**

```
(..)a
<text>
```

The a command shall read the given text and append it after the addressed line; the current line number shall become the address of the last inserted line or, if there were none, the addressed line. Address 0 shall be valid for this command; it shall cause the appended text to be placed at the beginning of the buffer.

### Change Command

**Synopsis:**

```
(.,.).c
<text>
```

The c command shall delete the addressed lines, then accept input text that replaces these lines; the current line shall be set to the address of the last line input; or, if there were none, at the line after the last line deleted; if the lines deleted were originally at the end of the buffer, the current line number shall be set to the address of the new last line; if no lines remain in the buffer, the current line number shall be set to zero. Address 0 shall be valid for this command; it shall be interpreted as if address 1 were specified.
Delete Command

Synopsis: 

The \texttt{d} command shall delete the addressed lines from the buffer. The address of the line after the last line deleted shall become the current line number; if the lines deleted were originally at the end of the buffer, the current line number shall be set to the address of the new last line; if no lines remain in the buffer, the current line number shall be set to zero.

Edit Command

Synopsis:

The \texttt{e} command shall delete the entire contents of the buffer and then read in the file named by the pathname \texttt{file}. The current line number shall be set to the address of the last line of the buffer. If no pathname is given, the currently remembered pathname, if any, shall be used (see the \texttt{f} command). The number of bytes read shall be written to standard output, unless the \texttt{−s} option was specified, in the following format:

"%d\n", <number of bytes read>

The name \texttt{file} shall be remembered for possible use as a default pathname in subsequent \texttt{e}, \texttt{E}, \texttt{r}, and \texttt{w} commands. If \texttt{file} is replaced by \texttt{!'}, the rest of the line shall be taken to be a shell command line whose output is to be read. Such a shell command line shall not be remembered as the current \texttt{file}. All marks shall be discarded upon the completion of a successful \texttt{e} command. If the buffer has changed since the last time the entire buffer was written, the user shall be warned, as described previously.

Edit Without Checking Command

Synopsis:

The \texttt{E} command shall possess all properties and restrictions of the \texttt{e} command except that the editor shall not check to see whether any changes have been made to the buffer since the last \texttt{w} command.

Filename Command

Synopsis:

If \texttt{file} is given, the \texttt{f} command shall change the currently remembered pathname to \texttt{file}; whether the name is changed or not, it shall then write the (possibly new) currently remembered pathname to the standard output in the following format:

"%s\n", <pathname>

The current line number shall be unchanged.

Global Command

Synopsis:

In the \texttt{g} command, the first step shall be to mark every line for which the line excluding the terminating <newline> matches the given RE. Then, going sequentially from the beginning of the file to the end of the file, the given \texttt{command list} shall be executed for each marked line, with the current line number set to the address of that line. Any line modified by the \texttt{command list} shall be unmarked. When the \texttt{g} command completes, the current line number shall have the value assigned by the last command in the \texttt{command list}. If there were no matching lines, the current line number shall not be changed. A single command or the first of a list of commands
shall appear on the same line as the global command. All lines of a multi-line list except the last
line shall be ended with a backslash preceding the terminating <newline>; the a, i, and c
commands and associated input are permitted. The ‘.’ terminating input mode can be omitted
if it would be the last line of the command list. An empty command list shall be equivalent to the p
command. The use of the g, G, v, V, and ! commands in the command list produces undefined
results. Any character other than <space> or <newline> can be used instead of a slash to delimit
the RE. Within the RE, the RE delimiter itself can be used as a literal character if it is preceded by
a backslash.

Interactive Global Command

Synopsis:   (1, $) G/RE/

In the G command, the first step shall be to mark every line for which the line excluding the
terminating <newline> matches the given RE. Then, for every such line, that line shall be
written, the current line number shall be set to the address of that line, and any one command
(other than one of the a, c, i, g, G, v, and V commands) shall be read and executed. A <newline>
shall act as a null command (causing no action to be taken on the current line); an ‘&’ shall
cause the re-execution of the most recent non-null command executed within the current
invocation of G. Note that the commands input as part of the execution of the G command can
address and affect any lines in the buffer. Any line modified by the command shall be
unmarked. The final value of the current line number shall be the value set by the last command
successfully executed. (Note that the last command successfully executed shall be the G
command itself if a command fails or the null command is specified.) If there were no matching
lines, the current line number shall not be changed. The G command can be terminated by a
SIGINT signal. Any character other than <space> or <newline> can be used instead of a slash to
delimit the RE and the replacement. Within the RE, the RE delimiter itself can be used as a literal
character if it is preceded by a backslash.

Help Command

Synopsis:   h

The h command shall write a short message to standard output that explains the reason for the
most recent ‘?’ notification. The current line number shall be unchanged.

Help-Mode Command

Synopsis:   H

The H command shall cause ed to enter a mode in which help messages (see the h command)
shall be written to standard output for all subsequent ‘?’ notifications. The H command
alternately shall turn this mode on and off; it is initially off. If the help-mode is being turned on,
the H command also explains the previous ‘?’ notification, if there was one. The current line
number shall be unchanged.

Insert Command

Synopsis:   (.) i
<text>

The i command shall insert the given text before the addressed line; the current line is set to the
last inserted line or, if there was none, to the addressed line. This command differs from the a
command only in the placement of the input text. Address 0 shall be valid for this command; it
shall be interpreted as if address 1 were specified.
Join Command

Synopsis: \((.,.+1)j\)

The `j` command shall join contiguous lines by removing the appropriate `<newline>`s. If exactly one address is given, this command shall do nothing. If lines are joined, the current line number shall be set to the address of the joined line; otherwise, the current line number shall be unchanged.

Mark Command

Synopsis: \((.)kx\)

The `k` command shall mark the addressed line with name `x`, which the application shall ensure is a lowercase letter from the portable character set. The address "'x" shall then refer to this line; the current line number shall be unchanged.

List Command

Synopsis: \((.,.)l\)

The `l` command shall write to standard output the addressed lines in a visually unambiguous form. The characters listed in the Base Definitions volume of IEEE Std 1003.1-2001, Table 5-1, Escape Sequences and Associated Actions ('\', 'a', 'b', 'f', 'r', 't', 'v') shall be written as the corresponding escape sequence; the '\n' in that table is not applicable. Non-printable characters not in the table shall be written as one three-digit octal number (with a preceding backslash character) for each byte in the character (most significant byte first). If the size of a byte on the system is greater than nine bits, the format used for non-printable characters is implementation-defined.

Long lines shall be folded, with the point of folding indicated by `<newline>` preceded by a backslash; the length at which folding occurs is unspecified, but should be appropriate for the output device. The end of each line shall be marked with a 'S', and 'S' characters within the text shall be written with a preceding backslash. An `l` command can be appended to any other command other than `e`, `E`, `f`, `q`, `Q`, `r`, `w`, or `!`. The current line number shall be set to the address of the last line written.

Move Command

Synopsis: \((.,.)maddress\)

The `m` command shall reposition the addressed lines after the line addressed by `address`. Address 0 shall be valid for `address` and cause the addressed lines to be moved to the beginning of the buffer. It shall be an error if address `address` falls within the range of moved lines. The current line number shall be set to the address of the last line moved.

Number Command

Synopsis: \((.,.)n\)

The `n` command shall write to standard output the addressed lines, preceding each line by its line number and a '<tab>'; the current line number shall be set to the address of the last line written. The `n` command can be appended to any command other than `e`, `E`, `f`, `q`, `Q`, `r`, `w`, or `!`. 
Print Command

Synopsis: \( (. . ) p \)

The \( p \) command shall write to standard output the addressed lines; the current line number shall
be set to the address of the last line written. The \( p \) command can be appended to any command
other than \( e, E, f, q, Q, r, w, \) or \( ! \).

Prompt Command

Synopsis: \( P \)

The \( P \) command shall cause \texttt{ed} to prompt with an asterisk (‘*’) (or \texttt{string}, if \( -p \) is specified) for
all subsequent commands. The \( P \) command alternatively shall turn this mode on and off; it shall
be initially on if the \( -p \) option is specified; otherwise, off. The current line number shall be
unchanged.

Quit Command

Synopsis: \( q \)

The \( q \) command shall cause \texttt{ed} to exit. If the buffer has changed since the last time the entire
buffer was written, the user shall be warned, as described previously.

Quit Without Checking Command

Synopsis: \( Q \)

The \( Q \) command shall cause \texttt{ed} to exit without checking whether changes have been made in the
buffer since the last \( w \) command.

Read Command

Synopsis: \( ($) r \ [\texttt{file}] \)

The \( r \) command shall read in the file named by the pathname \texttt{file} and append it after the
addressed line. If no \texttt{file} argument is given, the currently remembered pathname, if any, shall be
used (see the \( e \) and \( f \) commands). The currently remembered pathname shall not be changed
unless there is no remembered pathname. Address 0 shall be valid for \( r \) and shall cause the file to
be read at the beginning of the buffer. If the read is successful, and \( -s \) was not specified, the
number of bytes read shall be written to standard output in the following format:

\[
\text{"%d\n", <number of bytes read>}
\]

The current line number shall be set to the address of the last line read in. If \texttt{file} is replaced by
‘!’, the rest of the line shall be taken to be a shell command line whose output is to be read.
Such a shell command line shall not be remembered as the current pathname.

Substitute Command

Synopsis: \( (. . ) s/\texttt{RE}/\texttt{replacement}/\texttt{flags} \)

The \( s \) command shall search each addressed line for an occurrence of the specified \texttt{RE} and
replace either the first or all (non-overlapped) matched strings with the \texttt{replacement}; see the
following description of the \( g \) suffix. It is an error if the substitution fails on every addressed
line. Any character other than \(<\text{space}>\) or \(<\text{newline}>\) can be used instead of a slash to delimit the
\texttt{RE} and the replacement. Within the \texttt{RE}, the \texttt{RE} delimiter itself can be used as a literal character
if it is preceded by a backslash. The current line shall be set to the address of the last line on
which a substitution occurred.
An ampersand (‘&’) appearing in the replacement shall be replaced by the string matching the RE on the current line. The special meaning of ‘&’ in this context can be suppressed by preceding it by backslash. As a more general feature, the characters ‘\n’, where n is a digit, shall be replaced by the text matched by the corresponding back-reference expression. When the character ‘%’ is the only character in the replacement, the replacement used in the most recent substitute command shall be used as the replacement in the current substitute command; if there was no previous substitute command, the use of ‘%’ in this manner shall be an error. The ‘%’ shall lose its special meaning when it is in a replacement string of more than one character or is preceded by a backslash. As a more general feature, the characters ‘\n’, where n is a digit, shall be replaced by the text matched by the corresponding back-reference expression. When the character ‘%’ is the only character in the replacement, the replacement used in the most recent substitute command shall be used as the replacement in the current substitute command; if there was no previous substitute command, the use of ‘%’ in this manner shall be an error. The ‘%’ shall lose its special meaning when it is in a replacement string of more than one character or is preceded by a backslash. For each backslash (‘\’) encountered in scanning replacement from beginning to end, the following character shall lose its special meaning (if any). It is unspecified what special meaning is given to any character other than ‘&’, ‘\’, ‘%’, or digits.

A line can be split by substituting a <newline> into it. The application shall ensure it escapes the <newline> in the replacement by preceding it by backslash. Such substitution cannot be done as part of a g or v command list. The current line number shall be set to the address of the last line on which a substitution is performed. If no substitution is performed, the current line number shall be unchanged. If a line is split, a substitution shall be considered to have been performed on each of the new lines for the purpose of determining the new current line number. A substitution shall be considered to have been performed even if the replacement string is identical to the string that it replaces.

The application shall ensure that the value of flags is zero or more of:

- count: Substitute for the countth occurrence only of the RE found on each addressed line.
- g: Globally substitute for all non-overlapping instances of the RE rather than just the first one. If both g and count are specified, the results are unspecified.
- l: Write to standard output the final line in which a substitution was made. The line shall be written in the format specified for the l command.
- n: Write to standard output the final line in which a substitution was made. The line shall be written in the format specified for the n command.
- p: Write to standard output the final line in which a substitution was made. The line shall be written in the format specified for the p command.

Copy Command

Synopsis: (.,.)taddress

The t command shall be equivalent to the m command, except that a copy of the addressed lines shall be placed after address address (which can be 0); the current line number shall be set to the address of the last line added.

Undo Command

Synopsis: u

The u command shall nullify the effect of the most recent command that modified anything in the buffer, namely the most recent a, c, d, g, i, j, m, r, s, t, u, v, G, or V command. All changes made to the buffer by a g, G, v, or V global command shall be undone as a single change; if no changes were made by the global command (such as with g/RE/p), the u command shall have no effect. The current line number shall be set to the value it had immediately before the command being undone started.
Global Non-Matched Command

Synopsis: \((1,\$)v/RE/command \ list\)

This command shall be equivalent to the global command \texttt{g} except that the lines that are marked during the first step shall be those for which the line excluding the terminating \texttt{<newline>} does not match the RE.

Interactive Global Not-Matched Command

Synopsis: \((1,\$)V/RE/\)

This command shall be equivalent to the interactive global command \texttt{G} except that the lines that are marked during the first step shall be those for which the line excluding the terminating \texttt{<newline>} does not match the RE.

Write Command

Synopsis: \((1,\$)w \ [file]\)

The \texttt{w} command shall write the addressed lines into the file named by the pathname \texttt{file}. The command shall create the file, if it does not exist, or shall replace the contents of the existing file. The currently remembered pathname shall not be changed unless there is no remembered pathname. If no pathname is given, the currently remembered pathname, if any, shall be used (see the \texttt{e} and \texttt{f} commands); the current line number shall be unchanged. If the command is successful, the number of bytes written shall be written to standard output, unless the \texttt{−s} option was specified, in the following format:

\"%d\n", \textit{<number of bytes written>}\n
If \texttt{file} begins with ‘!’’, the rest of the line shall be taken to be a shell command line whose standard input shall be the addressed lines. Such a shell command line shall not be remembered as the current pathname. This usage of the write command with ‘!’’ shall not be considered as a “last \texttt{w} command that wrote the entire buffer”, as described previously; thus, this alone shall not prevent the warning to the user if an attempt is made to destroy the editor buffer via the \texttt{e} or \texttt{q} commands.

Line Number Command

Synopsis: \((\$)=\)

The line number of the addressed line shall be written to standard output in the following format:

\"%d\n", \textit{<line number>}\n
The current line number shall be unchanged by this command.

Shell Escape Command

Synopsis: \texttt{!command}\n
The remainder of the line after the ‘!’ shall be sent to the command interpreter to be interpreted as a shell command line. Within the text of that shell command line, the unescaped character ‘%’ shall be replaced with the remembered pathname; if a ‘!’’ appears as the first character of the command, it shall be replaced with the text of the previous shell command executed via ‘!’’. Thus, "!!" shall repeat the previous \texttt{!command}. If any replacements of ‘%’ or ‘!’’ are performed, the modified line shall be written to the standard output before \texttt{command} is executed. The \texttt{!} command shall write:
Null Command

Synopsis: (. +1)

An address alone on a line shall cause the addressed line to be written. A <newline> alone shall be equivalent to "+1p". The current line number shall be set to the address of the written line.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion without any file or command errors.

>0 An error occurred.

CONSEQUENCES OF ERRORS

When an error in the input script is encountered, or when an error is detected that is a consequence of the data (not) present in the file or due to an external condition such as a read or write error:

• If the standard input is a terminal device file, all input shall be flushed, and a new command shall be read.

• If the standard input is a regular file, ed shall terminate with a non-zero exit status.

APPLICATION USAGE

Because of the extremely terse nature of the default error messages, the prudent script writer begins the ed input commands with an H command, so that if any errors do occur at least some clue as to the cause is made available.

In previous versions, an obsolescent −s option was described. This is no longer specified. Applications should use the −s option. Using − as a file operand now produces unspecified results. This allows implementations to continue to support the former required behavior.

EXAMPLES

None.

RATIONALE

The initial description of this utility was adapted from the SVID. It contains some features not found in Version 7 or BSD-derived systems. Some of the differences between the POSIX and BSD ed utilities include, but need not be limited to:

• The BSD – option does not suppress the ‘!’ prompt after a ! command.

• BSD does not support the special meanings of the ‘%’ and ‘!’ characters within a ! command.

• BSD does not support the addresses ‘;’ and ‘,’.

• BSD allows the command/suffix pairs pp, ll, and so on, which are unspecified in this volume of IEEE Std 1003.1-2001.

• BSD does not support the ‘!’ character part of the e, r, or w commands.

• A failed g command in BSD sets the line number to the last line searched if there are no matches.
BSD does not default the command list to the p command.

- BSD does not support the G, h, H, n, or V commands.
- On BSD, if there is no inserted text, the insert command changes the current line to the referenced line –1; that is, the line before the specified line.
- On BSD, the join command with only a single address changes the current line to that address.
- BSD does not support the P command; moreover, in BSD it is synonymous with the p command.
- BSD does not support the undo of the commands j, m, r, s, or t.

The –s option was added to allow the functionality of the now withdrawn – option in a manner compatible with the Utility Syntax Guidelines.

In early proposals there was a limit, {ED_FILE_MAX}, that described the historical limitations of some ed utilities in their handling of large files; some of these have had problems with files larger than 100 000 bytes. It was this limitation that prompted much of the desire to include a split command in this volume of IEEE Std 1003.1-2001. Since this limit was removed, this volume of IEEE Std 1003.1-2001 requires that implementations document the file size limits imposed by ed in the conformance document. The limit {ED_LINE_MAX} was also removed; therefore, the global limit {LINE_MAX} is used for input and output lines.

The manner in which the I command writes non-printable characters was changed to avoid the historical backspace-overstrike method. On video display terminals, the overstrike is ambiguous because most terminals simply replace overstruck characters, making the I format not useful for its intended purpose of unambiguously understanding the content of the line. The historical backslash escapes were also ambiguous. (The string "a\0011" could represent a line containing those six characters or a line containing the three characters ‘a’, a byte with a binary value of 1, and a 1.) In the format required here, a backslash appearing in the line is written as "\\" so that the output is truly unambiguous. The method of marking the ends of lines was adopted from the ex editor and is required for any line ending in <space>s; the ‘\$’ is placed on all lines so that a real ‘\$’ at the end of a line cannot be misinterpreted.

Systems with bytes too large to fit into three octal digits must devise other means of displaying non-printable characters. Consideration was given to requiring that the number of octal digits be large enough to hold a byte, but this seemed to be too confusing for applications on the vast majority of systems where three digits are adequate. It would be theoretically possible for the application to use the getconf utility to find out the CHAR_BIT value and deal with such an algorithm; however, there is really no portable way that an application can use the octal values of the bytes across various coded character sets, so the additional specification was not worthwhile.

The description of how a NUL is written was removed. The NUL character cannot be in text files, and this volume of IEEE Std 1003.1-2001 should not dictate behavior in the case of undefined, erroneous input.

Unlike some of the other editing utilities, the filenames accepted by the E, e, R, and r commands are not patterns.

Early proposals stated that the –p option worked only when standard input was associated with a terminal device. This has been changed to conform to historical implementations, thereby allowing applications to interpose themselves between a user and the ed utility.
The form of the substitute command that uses the \text{n} suffix was limited in some historical documentation (where this was described incorrectly as “backreferencing”). This limit has been omitted because there is no reason why an editor processing lines of \{LINE\_MAX\} length should have this restriction. The command \text{s/x/X/2047} should be able to substitute the 2047th occurrence of ‘x’ on a line.

The use of printing commands with printing suffixes (such as \text{pn}, \text{lp}, and so on) was made unspecified because BSD-based systems allow this, whereas System V does not.

Some BSD-based systems exit immediately upon receipt of end-of-file if all of the lines in the file have been deleted. Since this volume of IEEE Std 1003.1-2001 refers to the \text{q} command in this instance, such behavior is not allowed.

Some historical implementations returned exit status zero even if command errors had occurred; this is not allowed by this volume of IEEE Std 1003.1-2001.

Some historical implementations contained a bug that allowed a single period to be entered in input mode as <backslash> <period> <newline>. This is not allowed by \text{ed} because there is no description of escaping any of the characters in input mode; backslashes are entered into the buffer exactly as typed. The typical method of entering a single period has been to precede it with another character and then use the substitute command to delete that character.

It is difficult under some modes of some versions of historical operating system terminal drivers to distinguish between an end-of-file condition and terminal disconnect. IEEE Std 1003.1-2001 does not require implementations to distinguish between the two situations, which permits historical implementations of the \text{ed} utility on historical platforms to conform. Implementations are encouraged to distinguish between the two, if possible, and take appropriate action on terminal disconnect.

Historically, \text{ed} accepted a zero address for the \text{a} and \text{r} commands in order to insert text at the start of the edit buffer. When the buffer was empty the command \text{.=} returned zero. IEEE Std 1003.1-2001 requires conformance to historical practice.

For consistency with the \text{a} and \text{r} commands and better user functionality, the \text{i} and \text{c} commands must also accept an address of 0, in which case 0\text{i} is treated as 1\text{i} and likewise for the \text{c} command.

All of the following are valid addresses:

- \text{+++} Three lines after the current line.
- \text{/pattern/-} One line before the next occurrence of pattern.
- \text{−2} Two lines before the current line.
- \text{3 −−−− 2} Line one (note the intermediate negative address).
- \text{1 2 3} Line six.

Any number of addresses can be provided to commands taking addresses; for example, "1, 2, 3, 4, 5p" prints lines 4 and 5, because two is the greatest valid number of addresses accepted by the \text{print} command. This, in combination with the semicolon delimiter, permits users to create commands based on ordered patterns in the file. For example, the command \text{"3;/foo/;+2p"} will display the first line after line 3 that contains the pattern \text{foo}, plus the next two lines. Note that the address "3;" must still be evaluated before being discarded, because the search origin for the "/foo/" command depends on this.

Historically, \text{ed} disallowed address chains, as discussed above, consisting solely of comma or semicolon separators; for example, ",,,," or ";;;" were considered an error. For consistency of address specification, this restriction is removed. The following table lists some of the address
forms now possible:

<table>
<thead>
<tr>
<th>Address</th>
<th>Addr1</th>
<th>Addr2</th>
<th>Status</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,</td>
<td>7</td>
<td>7</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7, 5,</td>
<td>5</td>
<td>5</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7, 5, 9</td>
<td>5</td>
<td>9</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7, 9</td>
<td>7</td>
<td>9</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7, +</td>
<td>7</td>
<td>8</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>,</td>
<td>1</td>
<td>$</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>,,</td>
<td>$</td>
<td>$</td>
<td>Extension</td>
<td></td>
</tr>
<tr>
<td>;</td>
<td>7</td>
<td>1</td>
<td>Extension</td>
<td></td>
</tr>
<tr>
<td>;,</td>
<td>$</td>
<td>$</td>
<td>Extension</td>
<td></td>
</tr>
<tr>
<td>7;</td>
<td>7</td>
<td>7</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7; 5;</td>
<td>5</td>
<td>5</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7; 5; 9</td>
<td>5</td>
<td>9</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7; 5; 9</td>
<td>5</td>
<td>9</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7; $; 4</td>
<td>$</td>
<td>4</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7; 9</td>
<td>7</td>
<td>9</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>7; +</td>
<td>7</td>
<td>8</td>
<td>Historical</td>
<td></td>
</tr>
<tr>
<td>;</td>
<td>.</td>
<td>$</td>
<td>Historical</td>
<td></td>
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<td>;,</td>
<td>$</td>
<td>$</td>
<td>Extension</td>
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<td>;;</td>
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<tr>
<td>;</td>
<td>$</td>
<td>$</td>
<td>Extension</td>
<td></td>
</tr>
</tbody>
</table>

Historically, values could be added to addresses by including them after one or more <blank>s; for example, "3 − 5p" wrote the seventh line of the file, and "/foo/ 5" was the same as "/5 /foo/". However, only absolute values could be added; for example, "5 /foo/" was an error. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, ed accepted the ‘^’ character as an address, in which case it was identical to the hyphen character. IEEE Std 1003.1-2001 does not require or prohibit this behavior.

FUTURE DIRECTIONS
None.

SEE ALSO
Section 1.11 (on page 20), ex, sed, sh, vi

CHANGE HISTORY
First released in Issue 2.

Issue 5
In the OPTIONS section, the meaning of –s and – is clarified.
A second FUTURE DIRECTION is added.

Issue 6
The obsolescent single-minus form is removed.
A second APPLICATION USAGE note is added.
The Open Group Corrigendum U025/2 is applied, correcting the description of the Edit section.
The ed utility is updated to align with the IEEE P1003.2b draft standard. This includes addition of the treatment of the SIGQUIT signal, changes to ed addressing, and changes to processing when end-of-file is detected and when terminal disconnect is detected.
The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/22 is applied, adding the text: “Any line modified by the command list shall be unmarked.” to the G command. This change corresponds to a similar change made to the g command in the first version of IEEE Std 1003.1-2001.
NAME
env — set the environment for command invocation

SYNOPSIS
env [-i][name=value]... [utility [argument...]]

DESCRIPTION
The env utility shall obtain the current environment, modify it according to its arguments, then
invoke the utility named by the utility operand with the modified environment.
Optional arguments shall be passed to utility.
If no utility operand is specified, the resulting environment shall be written to the standard
output, with one name=value pair per line.

OPTIONS
The env utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
The following options shall be supported:
-i Invoke utility with exactly the environment specified by the arguments; the
inherited environment shall be ignored completely.

OPERANDS
The following operands shall be supported:
name=value Arguments of the form name=value shall modify the execution environment, and
shall be placed into the inherited environment before the utility is invoked.
utility The name of the utility to be invoked. If the utility operand names any of the
special built-in utilities in Section 2.14 (on page 64), the results are undefined.
argument A string to pass as an argument for the invoked utility.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of env:
LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).
LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.
Determine the location of the utility, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables. If PATH is specified as a name=value operand to env, the value given shall be used in the search for utility.

ASYNCHRONOUS EVENTS
Default.

STDOUT
If no utility operand is specified, each name=value pair in the resulting environment shall be written in the form:

"%s=%s\n", <name>, <value>

If the utility operand is specified, the env utility shall not write to standard output.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
If utility is invoked, the exit status of env shall be the exit status of utility; otherwise, the env utility shall exit with one of the following values:

0 The env utility completed successfully.
1–125 An error occurred in the env utility.
126 The utility specified by utility was found but could not be invoked.
127 The utility specified by utility could not be found.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The command, env, nice, nohup, time, and xargs utilities have been specified to use exit code 127 if an error occurs so that applications can distinguish “failure to find a utility” from “invoked utility exited with an error indication”. The value 127 was chosen because it is not commonly used for other meanings; most utilities use small values for “normal error conditions” and the values above 128 can be confused with termination due to receipt of a signal. The value 126 was chosen in a similar manner to indicate that the utility could be found, but not invoked. Some scripts produce meaningful error messages differentiating the 126 and 127 cases. The distinction between exit codes 126 and 127 is based on KornShell practice that uses 127 when all attempts to exec the utility fail with [ENOENT], and uses 126 when any attempt to exec the utility fails for any other reason.

Historical implementations of the env utility use the execvp() or execlp() functions defined in the System Interfaces volume of IEEE Std 1003.1-2001 to invoke the specified utility; this provides better performance and keeps users from having to escape characters with special meaning to the shell. Therefore, shell functions, special built-ins, and built-ins that are only provided by the shell are not found.
EXAMPLES

The following command:

```
env -i PATH=/mybin mygrep xyz myfile
```

invokes the command `mygrep` with a new `PATH` value as the only entry in its environment. In this case, `PATH` is used to locate `mygrep`, which then must reside in `/mybin`.

RATIONALE

As with all other utilities that invoke other utilities, this volume of IEEE Std 1003.1-2001 only specifies what `env` does with standard input, standard output, standard error, input files, and output files. If a utility is executed, it is not constrained by the specification of input and output by `env`.

The `-i` option was added to allow the functionality of the withdrawn `−i` option in a manner compatible with the Utility Syntax Guidelines.

Some have suggested that `env` is redundant since the same effect is achieved by:

```
name=value ... utility [ argument ... ]
```

The example is equivalent to `env` when an environment variable is being added to the environment of the command, but not when the environment is being set to the given value. The `env` utility also writes out the current environment if invoked without arguments. There is sufficient functionality beyond what the example provides to justify inclusion of `env`.

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.5 (on page 33), Section 2.14 (on page 64)

CHANGE HISTORY

First released in Issue 2.
NAME
ex — text editor

SYNOPSIS
ex [-rR] [-s] [-v] [-c command] [-t tagstring] [-w size] [file ...]

DESCRIPTION
The ex utility is a line-oriented text editor. There are two other modes of the editor—open and
visual—in which screen-oriented editing is available. This is described more fully by the ex open
and visual commands and in vi.
This section uses the term edit buffer to describe the current working text. No specific
implementation is implied by this term. All editing changes are performed on the edit buffer,
and no changes to it shall affect any file until an editor command writes the file.
Certain terminals do not have all the capabilities necessary to support the complete ex definition,
such as the full-screen editing commands (visual mode or open mode). When these commands
cannot be supported on such terminals, this condition shall not produce an error message such
as “not an editor command” or report a syntax error. The implementation may either accept the
commands and produce results on the screen that are the result of an unsuccessful attempt to
meet the requirements of this volume of IEEE Std 1003.1-2001 or report an error describing the
terminal-related deficiency.

OPTIONS
The ex utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.
The following options shall be supported:

-c command Specify an initial command to be executed in the first edit buffer loaded from an
existing file (see the EXTENDED DESCRIPTION section). Implementations may
support more than a single -c option. In such implementations, the specified
commands shall be executed in the order specified on the command line.
-r Recover the named files (see the EXTENDED DESCRIPTION section). Recovery
information for a file shall be saved during an editor or system crash (for example,
when the editor is terminated by a signal which the editor can catch), or after the
use of an ex preserve command.
A crash in this context is an unexpected failure of the system or utility that requires
restarting the failed system or utility. A system crash implies that any utilities
running at the time also crash. In the case of an editor or system crash, the number
of changes to the edit buffer (since the most recent preserve command) that will be
recovered is unspecified.
If no file operands are given and the -t option is not specified, all other options, the
EXINIT variable, and any .exrc files shall be ignored; a list of all recoverable files
available to the invoking user shall be written, and the editor shall exit normally
without further action.
-R Set readonly edit option.
-s Prepare ex for batch use by taking the following actions:
  • Suppress writing prompts and informational (but not diagnostic) messages.
  • Ignore the value of TERM and any implementation default terminal type and
  assume the terminal is a type incapable of supporting open or visual modes;
see the visual command and the description of vi.

• Suppress the use of the EXINIT environment variable and the reading of any .exrc file; see the EXTENDED DESCRIPTION section.

• Suppress autoindentation, ignoring the value of the autoindent edit option.

−t tagstring Edit the file containing the specified tagstring; see ctags. The tags feature represented by −t tagstring and the tag command is optional. It shall be provided on any system that also provides a conforming implementation of ctags; otherwise, the use of −t produces undefined results. On any system, it shall be an error to specify more than a single −t option.

−v Begin in visual mode (see vi).

−w size Set the value of the window editor option to size.

OPERANDS

The following operand shall be supported:

file A pathname of a file to be edited.

STDIN

The standard input consists of a series of commands and input text, as described in the EXTENDED DESCRIPTION section. The implementation may limit each line of standard input to a length of {LINE_MAX}.

If the standard input is not a terminal device, it shall be as if the −s option had been specified.

If a read from the standard input returns an error, or if the editor detects an end-of-file condition from the standard input, it shall be equivalent to a SIGHUP asynchronous event.

INPUT FILES

Input files shall be text files or files that would be text files except for an incomplete last line that is not longer than {LINE_MAX}−1 bytes in length and contains no NUL characters. By default, any incomplete last line shall be treated as if it had a trailing <newline>. The editing of other forms of files may optionally be allowed by ex implementations.

The .exrc files and source files shall be text files consisting of ex commands; see the EXTENDED DESCRIPTION section.

By default, the editor shall read lines from the files to be edited without interpreting any of those lines as any form of editor command.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of ex:

COLUMNS Override the system-selected horizontal screen size. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables for valid values and results when it is unset or null.

EXINIT Determine a list of ex commands that are executed on editor start-up. See the EXTENDED DESCRIPTION section for more details of the initialization phase.

HOME Determine a pathname of a directory that shall be searched for an editor start-up file named .exrc; see the EXTENDED DESCRIPTION section.

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
If set to a non-empty string value, override the values of all the other
internationalization variables.

**LC_COLLATE**

Determine the locale for the behavior of ranges, equivalence classes, and multi-
character collating elements within regular expressions.

**LC_CTYPE**

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files), the behavior of character classes within regular
expressions, the classification of characters as uppercase or lowercase letters, the
case conversion of letters, and the detection of word boundaries.

**LC_MESSAGES**

Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

**LINES**

Override the system-selected vertical screen size, used as the number of lines in a
screenful and the vertical screen size in visual mode. See the Base Definitions
volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables for valid values
and results when it is unset or null.

**NLSPATH**

Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**PATH**

Determine the search path for the shell command specified in the `ex` editor
commands `!`, `shell`, `read`, and `write`, and the open and visual mode command `!`; see
the description of command search and execution in Section 2.9.1.1 (on page 48).

**SHELL**

Determine the preferred command line interpreter for use as the default value of
the `shell` edit option.

**TERM**

Determine the name of the terminal type. If this variable is unset or null, an
unspecified default terminal type shall be used.

**ASYNCHRONOUS EVENTS**

The following term is used in this and following sections to specify command and asynchronous
event actions:

**complete write**

A complete write is a write of the entire contents of the edit buffer to a file of a type
other than a terminal device, or the saving of the edit buffer caused by the user
executing the `ex preserve` command. Writing the contents of the edit buffer to a
temporary file that will be removed when the editor exits shall not be considered a
complete write.

The following actions shall be taken upon receipt of signals:

**SIGINT**

If the standard input is not a terminal device, `ex` shall not write the file or return to
command or text input mode, and shall exit with a non-zero exit status.

Otherwise, if executing an open or visual text input mode command, `ex` in receipt
of SIGINT shall behave identically to its receipt of the `<ESC>` character.

Otherwise:

1. If executing an `ex` text input mode command, all input lines that have been
   completely entered shall be resolved into the edit buffer, and any partially
   entered line shall be discarded.
2. If there is a currently executing command, it shall be aborted and a message displayed. Unless otherwise specified by the `ex` or `vi` command descriptions, it is unspecified whether any lines modified by the executing command appear modified, or as they were before being modified by the executing command, in the buffer.

   If the currently executing command was a motion command, its associated command shall be discarded.

3. If in open or visual command mode, the terminal shall be alerted.

4. The editor shall then return to command mode.

SIGCONT The screen shall be refreshed if in open or visual mode.

SIGHUP If the edit buffer has been modified since the last complete write, `ex` shall attempt to save the edit buffer so that it can be recovered later using the `−r` option or the `ex recover` command. The editor shall not write the file or return to command or text input mode, and shall terminate with a non-zero exit status.

SIGTERM Refer to SIGHUP.

The action taken for all other signals is unspecified.

STDOUT The standard output shall be used only for writing prompts to the user, for informational messages, and for writing lines from the file.

STDERR The standard error shall be used only for diagnostic messages.

OUTPUT FILES The output from `ex` shall be text files.

EXTENDED DESCRIPTION Only the `ex` mode of the editor is described in this section. See `vi` for additional editing capabilities available in `ex`.

When an error occurs, `ex` shall write a message. If the terminal supports a standout mode (such as inverse video), the message shall be written in standout mode. If the terminal does not support a standout mode, and the edit option `errorbells` is set, an alert action shall precede the error message.

By default, `ex` shall start in command mode, which shall be indicated by a `:` prompt; see the `prompt` command. Text input mode can be entered by the `append`, `insert`, or `change` commands; it can be exited (and command mode re-entered) by typing a period (`. . .`) alone at the beginning of a line.

Initialization in `ex` and `vi`

The following symbols are used in this and following sections to specify locations in the edit buffer:

alternate and current pathnames Two pathnames, named `current` and `alternate`, are maintained by the editor. Any `ex` commands that take filenames as arguments shall set them as follows:

1. If a `file` argument is specified to the `ex edit`, `ex`, or `recover` commands, or if an `ex tag` command replaces the contents of the edit buffer.
a. If the command replaces the contents of the edit buffer, the current pathname shall be set to the file argument or the file indicated by the tag, and the alternate pathname shall be set to the previous value of the current pathname.

b. Otherwise, the alternate pathname shall be set to the file argument.

2. If a file argument is specified to the ex next command:
   a. If the command replaces the contents of the edit buffer, the current pathname shall be set to the first file argument, and the alternate pathname shall be set to the previous value of the current pathname.
   
   3. If a file argument is specified to the ex file command, the current pathname shall be set to the file argument, and the alternate pathname shall be set to the previous value of the current pathname.

   4. If a file argument is specified to the ex read and write commands (that is, when reading or writing a file, and not to the program named by the shell edit option), or a file argument is specified to the ex xit command:
      a. If the current pathname has no value, the current pathname shall be set to the file argument.
      
      b. Otherwise, the alternate pathname shall be set to the file argument.

If the alternate pathname is set to the previous value of the current pathname when the current pathname had no previous value, then the alternate pathname shall have no value as a result.

current line
The line of the edit buffer referenced by the cursor. Each command description specifies the current line after the command has been executed, as the current line value. When the edit buffer contains no lines, the current line shall be zero; see Addressing in ex (on page 361).

current column
The current display line column occupied by the cursor. (The columns shall be numbered beginning at 1.) Each command description specifies the current column after the command has been executed, as the current column value. This column is an ideal column that is remembered over the lifetime of the editor. The actual display line column upon which the cursor rests may be different from the current column; see the cursor positioning discussion in Command Descriptions in vi (on page 988).

set to non-<blank>
A description for a current column value, meaning that the current column shall be set to the last display line column on which is displayed any part of the first non-<blank> of the line. If the line has no non-<blank> non-<newline>, the current column shall be set to the last display line column on which is displayed any part of the last non-<newline> in the line. If the line is empty, the current column shall be set to column position 1.

The length of lines in the edit buffer may be limited to (LINE_MAX) bytes. In open and visual mode, the length of lines in the edit buffer may be limited to the number of characters that will fit in the display. If either limit is exceeded during editing, an error message shall be written. If either limit is exceeded by a line read in from a file, an error message shall be written and the edit session may be terminated.

If the editor stops running due to any reason other than a user command, and the edit buffer has been modified since the last complete write, it shall be equivalent to a SIGHUP asynchronous event. If the system crashes, it shall be equivalent to a SIGHUP asynchronous event.
During initialization (before the first file is copied into the edit buffer or any user commands from the terminal are processed) the following shall occur:

1. If the environment variable EXINIT is set, the editor shall execute the ex commands contained in that variable.

2. If the EXINIT variable is not set, and all of the following are true:
   a. The HOME environment variable is not null and not empty.
   b. The file .exrc in the directory referred to by the HOME environment variable:
      1. Exists
      2. Is owned by the same user ID as the real user ID of the process or the process has appropriate privileges
      3. Is not writable by anyone other than the owner
   the editor shall execute the ex commands contained in that file.

3. If and only if all of the following are true:
   a. The current directory is not referred to by the HOME environment variable.
   b. A command in the EXINIT environment variable or a command in the .exrc file in the directory referred to by the HOME environment variable sets the editor option exrc.
   c. The .exrc file in the current directory:
      1. Exists
      2. Is owned by the same user ID as the real user ID of the process, or by one of a set of implementation-defined user IDs
      3. Is not writable by anyone other than the owner
   the editor shall attempt to execute the ex commands contained in that file.

Lines in any .exrc file that are blank lines shall be ignored. If any .exrc file exists, but is not read for ownership or permission reasons, it shall be an error.

After the EXINIT variable and any .exrc files are processed, the first file specified by the user shall be edited, as follows:

1. If the user specified the -t option, the effect shall be as if the ex tag command was entered with the specified argument, with the exception that if tag processing does not result in a file to edit, the effect shall be as described in step 3. below.

2. Otherwise, if the user specified any command line file arguments, the effect shall be as if the ex edit command was entered with the first of those arguments as its file argument.

3. Otherwise, the effect shall be as if the ex edit command was entered with a nonexistent filename as its file argument. It is unspecified whether this action shall set the current pathname. In an implementation where this action does not set the current pathname, any editor command using the current pathname shall fail until an editor command sets the current pathname.

If the -r option was specified, the first time a file in the initial argument list or a file specified by the -t option is edited, if recovery information has previously been saved about it, that information shall be recovered and the editor shall behave as if the contents of the edit buffer have already been modified. If there are multiple instances of the file to be recovered, the one most recently saved shall be recovered, and an informational message that there are previous
versions of the file that can be recovered shall be written. If no recovery information about a file is available, an informational message to this effect shall be written, and the edit shall proceed as usual.

If the \( -c \) option was specified, the first time a file that already exists (including a file that might not exist but for which recovery information is available, when the \( -r \) option is specified) replaces or initializes the contents of the edit buffer, the current line shall be set to the last line of the edit buffer, the current column shall be set to non-<blank>, and the \texttt{ex} commands specified with the \( -c \) option shall be executed. In this case, the current line and current column shall not be set as described for the command associated with the replacement or initialization of the edit buffer contents. However, if the \( -t \) option or a \texttt{tag} command is associated with this action, the \( -c \) option commands shall be executed and then the movement to the tag shall be performed.

The current argument list shall initially be set to the filenames specified by the user on the command line. If no filenames are specified by the user, the current argument list shall be empty. If the \( -t \) option was specified, it is unspecified whether any filename resulting from tag processing shall be prepended to the current argument list. In the case where the filename is added as a prefix to the current argument list, the current argument list reference shall be set to that filename. In the case where the filename is not added as a prefix to the current argument list, the current argument list reference shall logically be located before the first of the filenames specified on the command line (for example, a subsequent \texttt{ex next} command shall edit the first filename from the command line). If the \( -t \) option was not specified, the current argument list reference shall be to the first of the filenames on the command line.

### Addressing in \texttt{ex}

Addressing in \texttt{ex} relates to the current line and the current column; the address of a line is its 1-based line number, the address of a column is its 1-based count from the beginning of the line. Generally, the current line is the last line affected by a command. The current line number is the address of the current line. In each command description, the effect of the command on the current line number and the current column is described.

Addresses are constructed as follows:

1. The character ‘.’ (period) shall address the current line.
2. The character ‘$’ shall address the last line of the edit buffer.
3. The positive decimal number \( n \) shall address the \( n \)th line of the edit buffer.
4. The address ‘\( x \)’ refers to the line marked with the mark name character ‘\( x \)’, which shall be a lowercase letter from the portable character set or one of the characters ‘\’’ or ‘\’’’. It shall be an error if the line that was marked is not currently present in the edit buffer or the mark has not been set. Lines can be marked with the \texttt{ex mark} or \texttt{k} commands, or the \texttt{vi m} command.
5. A regular expression enclosed by slashes (‘/’) shall address the first line found by searching forwards from the line following the current line toward the end of the edit buffer and stopping at the first line for which the line excluding the terminating <newline> matches the regular expression. As stated in \textbf{Regular Expressions in \texttt{ex}} (on page 391), an address consisting of a null regular expression delimited by slashes ”//” shall address the next line for which the line excluding the terminating <newline> matches the last regular expression encountered. In addition, the second slash can be omitted at the end of a command line. If the \texttt{wrapscan} edit option is set, the search shall wrap around to the beginning of the edit buffer and continue up to and including the current line, so that the entire edit buffer is searched. Within the regular expression, the sequence ”\( \backslash / \)” shall represent a literal slash instead of the regular expression delimiter.
6. A regular expression enclosed in question marks (’?’) shall address the first line found by searching backwards from the line preceding the current line toward the beginning of the edit buffer and stopping at the first line for which the line excluding the terminating <newline> matches the regular expression. An address consisting of a null regular expression delimited by question marks "??" shall address the previous line for which the line excluding the terminating <newline> matches the last regular expression encountered. In addition, the second question mark can be omitted at the end of a command line. If the wrapscan edit option is set, the search shall wrap around from the beginning of the edit buffer to the end of the edit buffer and continue up to and including the current line, so that the entire edit buffer is searched. Within the regular expression, the sequence "\?" shall represent a literal question mark instead of the RE delimiter.

7. A plus sign (’+’) or a minus sign (’−’) followed by a decimal number shall address the current line plus or minus the number. A ’+’ or ’−’ not followed by a decimal number shall address the current line plus or minus 1. Addresses can be followed by zero or more address offsets, optionally <blank>-separated. Address offsets are constructed as follows:

1. A ’+’ or ’−’ immediately followed by a decimal number shall add (subtract) the indicated number of lines to (from) the address. A ’+’ or ’−’ not followed by a decimal number shall add (subtract) 1 to (from) the address.

2. A decimal number shall add the indicated number of lines to the address.

It shall not be an error for an intermediate address value to be less than zero or greater than the last line in the edit buffer. It shall be an error for the final address value to be less than zero or greater than the last line in the edit buffer.

Commands take zero, one, or two addresses; see the descriptions of 1addr and 2addr in Command Descriptions in ex (on page 368). If more than the required number of addresses are provided to a command that requires zero addresses, it shall be an error. Otherwise, if more than the required number of addresses are provided to a command, the addresses specified first shall be evaluated and then discarded until the maximum number of valid addresses remain.

Addresses shall be separated from each other by a comma (’,’) or a semicolon (’;’). If no address is specified before or after a comma or semicolon separator, it shall be as if the address of the current line was specified before or after the separator. In the case of a semicolon separator, the current line (’.;’) shall be set to the first address, and only then will the next address be calculated. This feature can be used to determine the starting line for forwards and backwards searches (see rules 5. and 6.).

A percent sign (’%’) shall be equivalent to entering the two addresses "1, $".

Any delimiting <blank>s between addresses, address separators, or address offsets shall be discarded.

Command Line Parsing in ex

The following symbol is used in this and following sections to describe parsing behavior:

escape If a character is referred to as “backslash-escaped” or “<control>-V-escaped,” it shall mean that the character acquired or lost a special meaning by virtue of being preceded, respectively, by a backslash or <control>-V character. Unless otherwise specified, the escaping character shall be discarded at that time and shall not be further considered for any purpose.
Utilities

Command-line parsing shall be done in the following steps. For each step, characters already evaluated shall be ignored; that is, the phrase “leading character” refers to the next character that has not yet been evaluated.

1. Leading colon characters shall be skipped.

2. Leading <blank>s shall be skipped.

3. If the leading character is a double-quote character, the characters up to and including the next non-backslash-escaped <newline> shall be discarded, and any subsequent characters shall be parsed as a separate command.

4. Leading characters that can be interpreted as addresses shall be evaluated; see Addressing in ex (on page 361).

5. Leading <blank>s shall be skipped.

6. If the next character is a vertical-line character or a <newline>:
   a. If the next character is a <newline>:
      1. If ex is in open or visual mode, the current line shall be set to the last address specified, if any.
      2. Otherwise, if the last command was terminated by a vertical-line character, no action shall be taken; for example, the command "||<newline>" shall execute two implied commands, not three.
   b. Otherwise, the implied command shall be the print command. The last #, p, and l flags specified to any ex command shall be remembered and shall apply to this implied command. Executing the ex number, print, or list command shall set the remembered flags to #, nothing, and l, respectively, plus any other flags specified for that execution of the number, print, or list command.
   c. The <newline> or vertical-line character shall be discarded and any subsequent characters shall be parsed as a separate command.

7. The command name shall be comprised of the next character (if the character is not alphabetic), or the next character and any subsequent alphabetic characters (if the character is alphabetic), with the following exceptions:
   a. Commands that consist of any prefix of the characters in the command name delete, followed immediately by any of the characters ‘l’, ‘p’, ‘+’, ‘−’, or ‘#’ shall be interpreted as a delete command, followed by a <blank>, followed by the characters that were not part of the prefix of the delete command. The maximum number of characters shall be matched to the command name delete; for example, "de1" shall not be treated as "de" followed by the flag l.
   b. Commands that consist of the character ‘k’, followed by a character that can be used as the name of a mark, shall be equivalent to the mark command followed by a <blank>, followed by the character that followed the ‘k’.
   c. Commands that consist of the character ‘s’, followed by characters that could be interpreted as valid options to the s command, shall be the equivalent of the s
command, without any pattern or replacement values, followed by a <blank>,
followed by the characters after the ‘s’.

8. The command name shall be matched against the possible command names, and a
command name that contains a prefix matching the characters specified by the user shall
be the executed command. In the case of commands where the characters specified by the
user could be ambiguous, the executed command shall be as follows:

| a | append |
| c | change |
| ch | change |
| e | edit |
| m | move |
| ma | mark |
| n | next |
| p | print |
| pr | print |
| r | read |
| re | read |
| t | t |
| u | undo |
| un | undo |
| v | v |
| w | write |

Implementation extensions with names causing similar ambiguities shall not be checked
for a match until all possible matches for commands specified by IEEE Std 1003.1-2001
have been checked.

9. If the command is a ! command, or if the command is a read command followed by zero
or more <blank>s and a !, or if the command is a write command followed by one or more
<blank>s and a !, the rest of the command shall include all characters up to a non-
backslash-escaped <newline>. The <newline> shall be discarded and any subsequent
characters shall be parsed as a separate ex command.

10. Otherwise, if the command is an edit, ex, or next command, or a visual command while in
open or visual mode, the next part of the command shall be parsed as follows:

a. Any ‘!’ character immediately following the command shall be skipped and be part
of the command.

b. Any leading <blank>s shall be skipped and be part of the command.

c. If the next character is a ‘+’, characters up to the first non-backslash-escaped
<newline> or non-backslash-escaped <blank> shall be skipped and be part of the
command.

d. The rest of the command shall be determined by the steps specified in paragraph 12.

11. Otherwise, if the command is a global, open, s, or v command, the next part of the
command shall be parsed as follows:

a. Any leading <blank>s shall be skipped and be part of the command.

b. If the next character is not an alphanumeric, double-quote, <newline>, backslash, or
vertical-line character:

1. The next character shall be used as a command delimiter.

2. If the command is a global, open, or v command, characters up to the first
non-backslash-escaped <newline>, or first non-backslash-escaped delimiter
character, shall be skipped and be part of the command.

3. If the command is an s command, characters up to the first non-backslash-
escaped <newline>, or second non-backslash-escaped delimiter character, shall
be skipped and be part of the command.

c. If the command is a global or v command, characters up to the first non-backslash-
escaped <newline> shall be skipped and be part of the command.
12. Otherwise:

a. If the command was a map, unmap, abbreviate, or unabbreviate command, characters up to the first non-<control>-V-escaped <newline>, vertical-line, or double-quote character shall be skipped and be part of the command.

b. Otherwise, characters up to the first non-backslash-escaped <newline>, vertical-line, or double-quote character shall be skipped and be part of the command.

c. If the command was an append, change, or insert command, and the step 12.b. ended at a vertical-line character, any subsequent characters, up to the next non-backslash-escaped <newline> shall be used as input text to the command.

d. If the command was ended by a double-quote character, all subsequent characters, up to the next non-backslash-escaped <newline>, shall be discarded.

e. The terminating <newline> or vertical-line character shall be discarded and any subsequent characters shall be parsed as a separate ex command.

Command arguments shall be parsed as described by the Synopsis and Description of each individual ex command. This parsing shall not be <blank>-sensitive, except for the ! argument, which must follow the command name without intervening <blank>s, and where it would otherwise be ambiguous. For example, count and flag arguments need not be <blank>-separated because "d22p" is not ambiguous, but file arguments to the ex next command must be separated by one or more <blank>s. Any <blank> in command arguments for the abbreviate, unabbreviate, map, and unmap commands can be <control>-V-escaped, in which case the <blank> shall not be used as an argument delimiter. Any <blank> in the command argument for any other command can be backslash-escaped, in which case that <blank> shall not be used as an argument delimiter.

Within command arguments for the abbreviate, unabbreviate, map, and unmap commands, any character can be <control>-V-escaped. All such escaped characters shall be treated literally and shall have no special meaning. Within command arguments for all other ex commands that are not regular expressions or replacement strings, any character that would otherwise have a special meaning can be backslash-escaped. Escaped characters shall be treated literally, without special meaning as shell expansion characters or '!', '%', and '#' expansion characters. See Regular Expressions in ex (on page 391) and Replacement Strings in ex (on page 391) for descriptions of command arguments that are regular expressions or replacement strings.

Non-backslash-escaped '!' characters appearing in file arguments to any ex command shall be replaced by the current pathname; unescaped '#' characters shall be replaced by the alternate pathname. It shall be an error if '!' or '#' characters appear unescaped in an argument and their corresponding values are not set.

Non-backslash-escaped '!' characters in the arguments to either the ex! command or the open and visual mode ! command, or in the arguments to the ex read command, where the first non-<blank> after the command name is a '!' character, or in the arguments to the ex write command where the command name is followed by one or more <blank>s and the first non-<blank> after the command name is a '!' character, shall be replaced with the arguments to the last of those three commands as they appeared after all unescaped '!', '%', and '#' characters were replaced. It shall be an error if '!' characters appear unescaped in one of these commands and there has been no previous execution of one of these commands.

If an error occurs during the parsing or execution of an ex command:
An informational message to this effect shall be written. Execution of the \texttt{ex} command shall stop, and the cursor (for example, the current line and column) shall not be further modified.

If the \texttt{ex} command resulted from a map expansion, all characters from that map expansion shall be discarded, except as otherwise specified by the \texttt{map} command.

Otherwise, if the \texttt{ex} command resulted from the processing of an \texttt{EXINIT} environment variable, a \texttt{.exrc} file, a \texttt{source} command, a \texttt{−c} option, or a \texttt{+command} specified to an \texttt{ex edit}, \texttt{ex}, \texttt{next}, or \texttt{visual} command, no further commands from the source of the commands shall be executed.

Otherwise, if the \texttt{ex} command resulted from the execution of a buffer or a \texttt{global} or \texttt{v} command, no further commands caused by the execution of the buffer or the \texttt{global} or \texttt{v} command shall be executed.

Otherwise, if the \texttt{ex} command was not terminated by a \texttt{<newline>}, all characters up to and including the next non-backslash-escaped \texttt{<newline>} shall be discarded.

\section*{Input Editing in \texttt{ex}}

The following symbol is used in this and the following sections to specify command actions:

\begin{itemize}
  \item \texttt{word} In the POSIX locale, a word consists of a maximal sequence of letters, digits, and underscores, delimited at both ends by characters other than letters, digits, or underscores, or by the beginning or end of a line or the edit buffer.
\end{itemize}

When accepting input characters from the user, in either \texttt{ex} command mode or \texttt{ex} text input mode, \texttt{ex} shall enable canonical mode input processing, as defined in the System Interfaces volume of IEEE Std 1003.1-2001.

If in \texttt{ex} text input mode:

1. If the \texttt{number} edit option is set, \texttt{ex} shall prompt for input using the line number that would be assigned to the line if it is entered, in the format specified for the \texttt{ex number} command.

2. If the \texttt{autoindent} edit option is set, \texttt{ex} shall prompt for input using \texttt{autoindent} characters, as described by the \texttt{autoindent} edit option. \texttt{autoindent} characters shall follow the line number, if any.

If in \texttt{ex} command mode:

1. If the \texttt{prompt} edit option is set, input shall be prompted for using a single \texttt{'} : \texttt{'} character; otherwise, there shall be no prompt.

The input characters in the following sections shall have the following effects on the input line.

\section*{Scroll}

\textbf{Synopsis:} \texttt{eof}

See the description of the \texttt{stty eof} character in \texttt{stty}.

If in \texttt{ex} command mode:

If the \texttt{eof} character is the first character entered on the line, the line shall be evaluated as if it contained two characters: a \texttt{<control>-D} and a \texttt{<newline>}.

Otherwise, the \texttt{eof} character shall have no special meaning.
If in ex text input mode:

If the cursor follows an autoindent character, the autoindent characters in the line shall be
modified so that a part of the next text input character will be displayed on the first column
in the line after the previous shiftwidth edit option column boundary, and the user shall be
prompted again for input for the same line.

Otherwise, if the cursor follows a ‘0’, which follows an autoindent character, and the ‘0’
was the previous text input character, the ‘0’ and all autoindent characters in the line shall
be discarded, and the user shall be prompted again for input for the same line.

Otherwise, if the cursor follows a ‘^’, which follows an autoindent character, and the ‘^’
was the previous text input character, the ‘^’ and all autoindent characters in the line shall
be discarded, and the user shall be prompted again for input for the same line. In addition,
the autoindent level for the next input line shall be derived from the same line from which
the autoindent level for the current input line was derived.

Otherwise, if there are no autoindent or text input characters in the line, the eof character
shall be discarded.

Otherwise, the eof character shall have no special meaning.

Synopsis:

<newline>

If in ex command mode:

Cause the command line to be parsed; <control>-J shall be mapped to the <newline> for this
purpose.

If in ex text input mode:

Terminate the current line. If there are no characters other than autoindent characters on the
line, all characters on the line shall be discarded.

Prompt for text input on a new line after the current line. If the autoindent edit option is set,
an appropriate number of autoindent characters shall be added as a prefix to the line as
described by the ex autoindent edit option.

Synopsis:

<backslash>

Allow the entry of a subsequent <newline> or <control>-J as a literal character, removing any
special meaning that it may have to the editor during text input mode. The backslash character
shall be retained and evaluated when the command line is parsed, or retained and included
when the input text becomes part of the edit buffer.
<control>-V

Synopsis:  <control>-V

Allow the entry of any subsequent character as a literal character, removing any special meaning
that it may have to the editor during text input mode. The <control>-V character shall be
discarded before the command line is parsed or the input text becomes part of the edit buffer.
If the “literal next” functionality is performed by the underlying system, it is implementation-
defined whether a character other than <control>-V performs this function.

<control>-W

Synopsis:  <control>-W

Discard the <control>-W, and the word previous to it in the input line, including any <blank>s
following the word and preceding the <control>-W. If the “word erase” functionality is
performed by the underlying system, it is implementation-defined whether a character other
than <control>-W performs this function.

Command Descriptions in ex

The following symbols are used in this section to represent command modifiers. Some of these
modifiers can be omitted, in which case the specified defaults shall be used.

1addr  A single line address, given in any of the forms described in Addressing in ex (on
        page 361); the default shall be the current line (‘.’), unless otherwise specified.
        If the line address is zero, it shall be an error, unless otherwise specified in the
        following command descriptions.
        If the edit buffer is empty, and the address is specified with a command other than
        =, append, insert, open, put, read, or visual, or the address is not zero, it shall be
        an error.

2addr  Two addresses specifying an inclusive range of lines. If no addresses are specified,
        the default for 2addr shall be the current line only (“..”), unless otherwise
        specified in the following command descriptions. If one address is specified, 2addr
        shall specify that line only, unless otherwise specified in the following command
descriptions.
        It shall be an error if the first address is greater than the second address.
        If the edit buffer is empty, and the two addresses are specified with a command
        other than the !, write, wq, or xit commands, or either address is not zero, it shall
        be an error.

count  A positive decimal number. If count is specified, it shall be equivalent to specifying
        an additional address to the command, unless otherwise specified by the following
        command descriptions. The additional address shall be equal to the last address
        specified to the command (either explicitly or by default) plus count−1.
        If this would result in an address greater than the last line of the edit buffer, it shall
        be corrected to equal the last line of the edit buffer.

flags  One or more of the characters ‘+’, ‘−’, ‘#’, ‘p’, or ‘1’ (ell). The flag characters
can be <blank>-separated, and in any order or combination. The characters ‘#’,
‘p’, and ‘1’ shall cause lines to be written in the format specified by the print
command with the specified flags.
The lines to be written are as follows:

1. All edit buffer lines written during the execution of the `ex &`, `~`, `list`, `number`, `open`, `print`, `s`, `visual`, and `z` commands shall be written as specified by `flags`.

2. After the completion of an `ex` command with a flag as an argument, the current line shall be written as specified by `flags`, unless the current line was the last line written by the command.

The characters `'+' and '−' cause the value of the current line after the execution of the `ex` command to be adjusted by the offset address as described in `Addressing in ex` (on page 361). This adjustment shall occur before the current line is written as described in 2. above.

The default for `flags` shall be none.

---

One of a number of named areas for holding text. The named buffers are specified by the alphanumeric characters of the POSIX locale. There shall also be one "unnamed" buffer. When no buffer is specified for editor commands that use a buffer, the unnamed buffer shall be used. Commands that store text into buffers shall store the text as it was before the command took effect, and shall store text occurring earlier in the file before text occurring later in the file, regardless of how the text region was specified. Commands that store text into buffers shall store the text into the unnamed buffer as well as any specified buffer.

In `ex` commands, buffer names are specified as the name by itself. In open or visual mode commands the name is preceded by a double quote ('"') character.

If the specified buffer name is an uppercase character, and the buffer contents are to be modified, the buffer shall be appended to rather than being overwritten. If the buffer is not being modified, specifying the buffer name in lowercase and uppercase shall have identical results.

There shall also be buffers named by the numbers 1 through 9. In open and visual mode, if a region of text including characters from more than a single line is being modified by the `vi c` or `d` commands, the motion character associated with the `c` or `d` commands specifies that the buffer text shall be in line mode, or the commands `%`, ``, `i`, `?`, `(, )`, `N`, `n`, `{, or }` are used to define a region of text for the `c` or `d` commands, the contents of buffers 1 through 8 shall be moved into the buffer named by the next numerically greater value, the contents of buffer 9 shall be discarded, and the region of text shall be copied into buffer 1. This shall be in addition to copying the text into a user-specified buffer or unnamed buffer, or both. Numeric buffers can be specified as a source buffer for open and visual mode commands; however, specifying a numeric buffer as the write target of an open or visual mode command shall have unspecified results.

The text of each buffer shall have the characteristic of being in either line or character mode. Appending text to a non-empty buffer shall set the mode to match the characteristic of the text being appended. Appending text to a buffer shall cause the creation of at least one additional line in the buffer. All text stored into buffers by `ex` commands shall be in line mode. The `ex` commands that use buffers as the source of text specify individually how buffers of different modes are handled. Each open or visual mode command that uses buffers for any purpose specifies individually the mode of the text stored into the buffer and how buffers of different modes are handled.
file Command text used to derive a pathname. The default shall be the current
pathname, as defined previously, in which case, if no current pathname has yet
been established it shall be an error, except where specifically noted in the
individual command descriptions that follow. If the command text contains any of
the characters ‘˜’, ‘{’, ‘[’, ‘*’, ‘?’, ‘$’, ‘\’, ‘’’, ‘’’, ‘”’, and ‘\’, it shall be
subjected to the process of “shell expansions”, as described below; if more than a
single pathname results and the command expects only one, it shall be an error.

The process of shell expansions in the editor shall be done as follows. The ex utility
shall pass two arguments to the program named by the shell edit option; the first
shall be –c, and the second shall be the string "echo" and the command text as a
single argument. The standard output and standard error of that command shall
replace the command text.

! A character that can be appended to the command name to modify its operation,
as detailed in the individual command descriptions. With the exception of the ex
read, write, and ! commands, the ‘!’ character shall only act as a modifier if there
are no <blank>s between it and the command name.

remembered search direction
The vi commands N and n begin searching in a forwards or backwards direction in
the edit buffer based on a remembered search direction, which is initially unset,
and is set by the ex global, v, s, and tag commands, and the vi / and ? commands.

Abbreviate

Synopsis: ab[breviate] [lhs rhs]

If lhs and rhs are not specified, write the current list of abbreviations and do nothing more.
Implementations may restrict the set of characters accepted in lhs or rh, except that printable
characters and <blank>s shall not be restricted. Additional restrictions shall be implementation-
defined.

In both lhs and rhs, any character may be escaped with a <control>-V, in which case the
character shall not be used to delimit lhs from rhs, and the escaping <control>-V shall be
discarded.

In open and visual text input mode, if a non-word or <ESC> character that is not escaped by a
<control>-V character is entered after a word character, a check shall be made for a set of
characters matching lhs, in the text input entered during this command. If it is found, the effect
shall be as if rhs was entered instead of lhs.

The set of characters that are checked is defined as follows:

1. If there are no characters inserted before the word and non-word or <ESC> characters that
   triggered the check, the set of characters shall consist of the word character.

2. If the character inserted before the word and non-word or <ESC> characters that triggered
   the check is a word character, the set of characters shall consist of the characters inserted
   immediately before the triggering characters that are word characters, plus the triggering
   word character.

3. If the character inserted before the word and non-word or <ESC> characters that triggered
   the check is not a word character, the set of characters shall consist of the characters that
   were inserted before the triggering characters that are neither <blank>s nor word
   characters, plus the triggering word character.
It is unspecified whether the *lhs* argument entered for the *ex abbreviate* and *unabbreviate* commands is replaced in this fashion. Regardless of whether or not the replacement occurs, the effect of the command shall be as if the replacement had not occurred.

**Current line:** Unchanged.

**Current column:** Unchanged.

### Append

**Synopsis:** 
\[1addr\] a[ppend] [!]

Enter *ex* text input mode; the input text shall be placed after the specified line. If line zero is specified, the text shall be placed at the beginning of the edit buffer.

This command shall be affected by the *number* and *autoindent* edit options; following the command name with ‘!’ shall cause the *autoindent* edit option setting to be toggled for the duration of this command only.

**Current line:** Set to the last input line; if no lines were input, set to the specified line, or to the first line of the edit buffer if a line of zero was specified, or zero if the edit buffer is empty.

**Current column:** Set to non-<blank>.

### Arguments

**Synopsis:** 
az [gs]

Write the current argument list, with the current argument-list entry, if any, between ‘[’ and ‘]’ characters.

**Current line:** Unchanged.

**Current column:** Unchanged.

### Change

**Synopsis:** 
\[2addr\] c[har]ge [!] [count]

Enter *ex* text input mode; the input text shall replace the specified lines. The specified lines shall be copied into the unnamed buffer, which shall become a line mode buffer.

This command shall be affected by the *number* and *autoindent* edit options; following the command name with ‘!’ shall cause the *autoindent* edit option setting to be toggled for the duration of this command only.

**Current line:** Set to the last input line; if no lines were input, set to the line before the first address, or to the first line of the edit buffer if there are no lines preceding the first address, or to zero if the edit buffer is empty.

**Current column:** Set to non-<blank>. 
Change Directory

Synopsis: chd[i]r![i][directory]
        cd![i][directory]

Change the current working directory to directory.

If no directory argument is specified, and the HOME environment variable is set to a non-null and non-empty value, directory shall default to the value named in the HOME environment variable. If the HOME environment variable is empty or is undefined, the default value of directory is implementation-defined.

If no '!' is appended to the command name, and the edit buffer has been modified since the last complete write, and the current pathname does not begin with a '/', it shall be an error.

Current line: Unchanged.
Current column: Unchanged.

Copy

Synopsis: [2addr] co[py] 1addr [flags]
        [2addr] t 1addr [flags]

Copy the specified lines after the specified destination line; line zero specifies that the lines shall be placed at the beginning of the edit buffer.

Current line: Set to the last line copied.
Current column: Set to non-<blank>.

Delete

Synopsis: [2addr] d[elete] [buffer] [count] [flags]

Delete the specified lines into a buffer (defaulting to the unnamed buffer), which shall become a line-mode buffer.

Flags can immediately follow the command name; see Command Line Parsing in ex (on page 362).

Current line: Set to the line following the deleted lines, or to the last line in the edit buffer if that line is past the end of the edit buffer, or to zero if the edit buffer is empty.

Current column: Set to non-<blank>.

Edit

Synopsis: e[dit][!] [+command] [file]
        ex![i][+]command] [file]

If no '!' is appended to the command name, and the edit buffer has been modified since the last complete write, it shall be an error.

If file is specified, replace the current contents of the edit buffer with the current contents of file, and set the current pathname to file. If file is not specified, replace the current contents of the edit buffer with the current contents of the file named by the current pathname. If for any reason the current contents of the file cannot be accessed, the edit buffer shall be empty.

The +command option shall be <blank>-delimited; <blank>s within +command can be escaped by preceding them with a backslash character. The +command shall be interpreted as an ex command immediately after the contents of the edit buffer have been replaced and the current
line and column have been set.

If the edit buffer is empty:

Current line: Set to 0.

Current column: Set to 1.

Otherwise, if executed while in ex command mode or if the +command argument is specified:

Current line: Set to the last line of the edit buffer.

Current column: Set to non-<blank>.

Otherwise, if file is omitted or results in the current pathname:

Current line: Set to the first line of the edit buffer.

Current column: Set to non-<blank>.

Otherwise, if file is the same as the last file edited, the line and column shall be set as follows; if
the file was previously edited, the line and column may be set as follows:

Current line: Set to the last value held when that file was last edited. If this value is not a valid
line in the new edit buffer, set to the first line of the edit buffer.

Current column: If the current line was set to the last value held when the file was last edited, set
to the last value held when the file was last edited. Otherwise, or if the last value is not a valid
column in the new edit buffer, set to non-<blank>.

Otherwise:

Current line: Set to the first line of the edit buffer.

Current column: Set to non-<blank>.

File

Synopsis: f[ile][file]

If a file argument is specified, the alternate pathname shall be set to the current pathname, and
the current pathname shall be set to file.

Write an informational message. If the file has a current pathname, it shall be included in this
message; otherwise, the message shall indicate that there is no current pathname. If the edit
buffer contains lines, the current line number and the number of lines in the edit buffer shall be
included in this message; otherwise, the message shall indicate that the edit buffer is empty. If
the edit buffer has been modified since the last complete write, this fact shall be included in this
message. If the readonly edit option is set, this fact shall be included in this message. The
message may contain other unspecified information.

Current line: Unchanged.

Current column: Unchanged.
Global

Synopsis:  
\[2addr\] g[lobal] /pattern/ [commands]
\[2addr\] v /pattern/ [commands]

The optional ‘!‘ character after the global command shall be the same as executing the v command.

If pattern is empty (for example, "///") or not specified, the last regular expression used in the editor command shall be used as the pattern. The pattern can be delimited by slashes (shown in the Synopsis), as well as any non-alphanumeric or non-<blank> other than backslash, vertical line, double quote, or <newline>.

If no lines are specified, the lines shall default to the entire file.

The global and v commands are logically two-pass operations. First, mark the lines within the specified lines for which the line excluding the terminating <newline> matches (global) or does not match (v or global!) the specified pattern. Second, execute the ex commands given by commands, with the current line (‘.’) set to each marked line. If an error occurs during this process, or the contents of the edit buffer are replaced (for example, by the ex:edit command) an error message shall be written and no more commands resulting from the execution of this command shall be processed.

Multiple ex commands can be specified by entering multiple commands on a single line using a vertical line to delimit them, or one per line, by escaping each <newline> with a backslash.

If no commands are specified:

1. If in ex command mode, it shall be as if the print command were specified.
2. Otherwise, no command shall be executed.

For the append, change, and insert commands, the input text shall be included as part of the command, and the terminating period can be omitted if the command ends the list of commands. The open and visual commands can be specified as one of the commands, in which case each marked line shall cause the editor to enter open or visual mode. If open or visual mode is exited using the vi Q command, the current line shall be set to the next marked line, and open or visual mode reentered, until the list of marked lines is exhausted.

The global, v, and undo commands cannot be used in commands. Marked lines may be deleted by commands executed for lines occurring earlier in the file than the marked lines. In this case, no commands shall be executed for the deleted lines.

If the remembered search direction is not set, the global and v commands shall set it to forward.

The autoprint and autoindent edit options shall be inhibited for the duration of the g or v command.

Current line: If no commands executed, set to the last marked line. Otherwise, as specified for the executed ex commands.

Current column: If no commands are executed, set to non-<blank>; otherwise, as specified for the individual ex commands.
Insert

Synopsis:  \([1addr]\ i[nsert][!]\)

Enter ex text input mode; the input text shall be placed before the specified line. If the line is zero or 1, the text shall be placed at the beginning of the edit buffer.

This command shall be affected by the number and autoindent edit options; following the command name with '!' shall cause the autoindent edit option setting to be toggled for the duration of this command only.

Current line: Set to the last input line; if no lines were input, set to the line before the specified line, or to the first line of the edit buffer if there are no lines preceding the specified line, or zero if the edit buffer is empty.

Current column: Set to non-<blank>.

Join

Synopsis:  \([2addr]\ j[oin][!] [count] [flags]\)

If count is specified:

If no address was specified, the join command shall behave as if \(2addr\) were the current line and the current line plus count (., . + count).

If one address was specified, the join command shall behave as if \(2addr\) were the specified address and the specified address plus count (addr,addr + count).

If two addresses were specified, the join command shall behave as if an additional address, equal to the last address plus count −1 (addr1,addr2,addr2 + count −1), was specified.

If this would result in a second address greater than the last line of the edit buffer, it shall be corrected to be equal to the last line of the edit buffer.

If no count is specified:

If no address was specified, the join command shall behave as if \(2addr\) were the current line and the next line (., +1).

If one address was specified, the join command shall behave as if \(2addr\) were the specified address and the next line (addr,addr +1).

Join the text from the specified lines together into a single line, which shall replace the specified lines.

If a '!' character is appended to the command name, the join shall be without modification of any line, independent of the current locale.

Otherwise, in the POSIX locale, set the current line to the first of the specified lines, and then, for each subsequent line, proceed as follows:

1. Discard leading <space>s from the line to be joined.

2. If the line to be joined is now empty, delete it, and skip steps 3 through 5.

3. If the current line ends in a <blank>, or the first character of the line to be joined is a ')', character, join the lines without further modification.

4. If the last character of the current line is a ' .', join the lines with two <space>s between them.
5. Otherwise, join the lines with a single <space> between them.

Current line: Set to the first line specified.

Current column: Set to non-<blank>.

List

Synopsis: [2addr] l[ist] [count] [flags]

This command shall be equivalent to the ex command:

[2addr] p[rint] [count] l[flags]

See Print (on page 380).

Map

Synopsis: map[!] [lhs rhs]

If lhs and rhs are not specified:

1. If ‘!’ is specified, write the current list of text input mode maps.

2. Otherwise, write the current list of command mode maps.

3. Do nothing more.

Implementations may restrict the set of characters accepted in lhs or rhs, except that printable characters and <blank>s shall not be restricted. Additional restrictions shall be implementation-defined. In both lhs and rhs, any character can be escaped with a <control>-V, in which case the character shall not be used to delimit lhs from rhs, and the escaping <control>-V shall be discarded.

If the character ‘!’ is appended to the map command name, the mapping shall be effective during open or visual text input mode rather than open or visual command mode. This allows lhs to have two different map definitions at the same time: one for command mode and one for text input mode.

For command mode mappings:

When the lhs is entered as any part of a vi command in open or visual mode (but not as part of the arguments to the command), the action shall be as if the corresponding rhs had been entered.

If any character in the command, other than the first, is escaped using a <control>-V character, that character shall not be part of a match to an lhs.

It is unspecified whether implementations shall support map commands where the lhs is more than a single character in length, where the first character of the lhs is printable.

If lhs contains more than one character and the first character is ‘#’, followed by a sequence of digits corresponding to a numbered function key, then when this function key is typed it shall be mapped to rhs. Characters other than digits following a ‘#’ character also represent the function key named by the characters in the lhs following the ‘#’ and may be mapped to rhs. It is unspecified how function keys are named or what function keys are supported.

For text input mode mappings:
When the lhs is entered as any part of text entered in open or visual text input modes, the action shall be as if the corresponding rhs had been entered.

If any character in the input text is escaped using a <control>-V character, that character shall not be part of a match to an lhs.

It is unspecified whether the lhs text entered for subsequent map or unmap commands is replaced with the rhs text for the purposes of the screen display; regardless of whether or not the display appears as if the corresponding rhs text was entered, the effect of the command shall be as if the lhs text was entered.

If only part of the lhs is entered, it is unspecified how long the editor will wait for additional, possibly matching characters before treating the already entered characters as not matching the lhs.

The rhs characters shall themselves be subject to remapping, unless otherwise specified by the remap edit option, except that if the characters in lhs occur as prefix characters in rhs, those characters shall not be remapped.

On block-mode terminals, the mapping need not occur immediately (for example, it may occur after the terminal transmits a group of characters to the system), but it shall achieve the same results as if it occurred immediately.

Current line: Unchanged.

Current column: Unchanged.

Mark

Synopsis:  [1addr] ma[rlk] character
           [1addr] k character

Implementations shall support character values of a single lowercase letter of the POSIX locale and the characters ‘ ’ and ’ ’; support of other characters is implementation-defined.

If executing the vi m command, set the specified mark to the current line and 1-based numbered character referenced by the current column, if any; otherwise, column position 1.

Otherwise, set the specified mark to the specified line and 1-based numbered first non-<blank> non-<newline> in the line, if any; otherwise, the last non-<newline> in the line, if any; otherwise, column position 1.

The mark shall remain associated with the line until the mark is reset or the line is deleted. If a deleted line is restored by a subsequent undo command, any marks previously associated with the line, which have not been reset, shall be restored as well. Any use of a mark not associated with a current line in the edit buffer shall be an error.

The marks ‘ and ’ shall be set as described previously, immediately before the following events occur in the editor:

1. The use of ‘ $’ as an ex address
2. The use of a positive decimal number as an ex address
3. The use of a search command as an ex address
4. The use of a mark reference as an ex address
5. The use of the following open and visual mode commands: <control>-], %, (, ), [ , ]
6. The use of the following open and visual mode commands: ’, G, H, L, M, z if the current line will change as a result of the command
7. The use of the open and visual mode commands: \texttt{L}, \texttt{?, N, ', n} if the current line or column will change as a result of the command.

8. The use of the \texttt{ex} mode commands: \texttt{z, undo, global, v}

For rules 1., 2., 3., and 4., the ‘ and ’ marks shall not be set if the \texttt{ex} command is parsed as specified by rule 6.a. in \textbf{Command Line Parsing in ex} (on page 362).

For rules 5., 6., and 7., the ‘ and ’ marks shall not be set if the commands are used as motion commands in open and visual mode.

For rules 1., 2., 3., 4., 5., 6., 7., and 8., the ‘ and ’ marks shall not be set if the command fails.

The ‘ and ’ marks shall be set as described previously, each time the contents of the edit buffer are replaced (including the editing of the initial buffer), if in open or visual mode, or if in \texttt{ex} mode and the edit buffer is not empty, before any commands or movements (including commands or movements specified by the \texttt{−c} or \texttt{−t} options or the \texttt{+command} argument) are executed on the edit buffer. If in open or visual mode, the marks shall be set as if executing the \texttt{vi m} command; otherwise, as if executing the \texttt{ex mark} command.

When changing from \texttt{ex} mode to open or visual mode, if the ‘ and ’ marks are not already set, the ‘ and ’ marks shall be set as described previously.

\textbf{Current line}: Unchanged.
\textbf{Current column}: Unchanged.

\textbf{Move}

\textit{Synopsis}: \texttt{[2addr] move 1addr [flags]}

Move the specified lines after the specified destination line. A destination of line zero specifies that the lines shall be placed at the beginning of the edit buffer. It shall be an error if the destination line is within the range of lines to be moved.

\textbf{Current line}: Set to the last of the moved lines.
\textbf{Current column}: Set to non-\texttt{<blank>}.

\textbf{Next}

\textit{Synopsis}: \texttt{n[ext][!] [+command] [file ...]}

If no ‘!’ is appended to the command name, and the edit buffer has been modified since the last complete write, it shall be an error, unless the file is successfully written as specified by the \texttt{autowrite} option.

If one or more files is specified:

1. Set the argument list to the specified filenames.
2. Set the current argument list reference to be the first entry in the argument list.
3. Set the current pathname to the first filename specified.

Otherwise:

1. It shall be an error if there are no more filenames in the argument list after the filename currently referenced.
2. Set the current pathname and the current argument list reference to the filename after the filename currently referenced in the argument list.
Replace the contents of the edit buffer with the contents of the file named by the current
pathname. If for any reason the contents of the file cannot be accessed, the edit buffer shall be
empty.

This command shall be affected by the **autowrite** and **writeany** edit options.

The +command option shall be <blank>-delimited; <blank>s can be escaped by preceding them
with a backslash character. The +command shall be interpreted as an ex command immediately
after the contents of the edit buffer have been replaced and the current line and column have
been set.

*Current line*: Set as described for the **edit** command.

*Current column*: Set as described for the **edit** command.

### Number

**Synopsis**: 

```
[2addr] nu[mber][count][flags]
[2addr] #[count][flags]
```

These commands shall be equivalent to the **ex** command:

```
```

See **Print** (on page 380).

### Open

**Synopsis**: 

```
[1addr] o[pen] /pattern/ [flags]
```

This command need not be supported on block-mode terminals or terminals with insufficient
capabilities. If standard input, standard output, or standard error are not terminal devices, the
results are unspecified.

Enter open mode.

The trailing delimiter can be omitted from *pattern* at the end of the command line. If *pattern* is
empty (for example, "//") or not specified, the last regular expression used in the editor shall be
used as the pattern. The pattern can be delimited by slashes (shown in the Synopsis), as well as
any alphanumeric, or non-<blank> other than backslash, vertical line, double quote, or
<newline>.

*Current line*: Set to the specified line.

*Current column*: Set to non-<blank>.

### Preserve

**Synopsis**: 

```
pre[serve]
```

Save the edit buffer in a form that can later be recovered by using the −r option or by using the **ex**
recover command. After the file has been preserved, a mail message shall be sent to the user.
This message shall be readable by invoking the mailx utility. The message shall contain the name
of the file, the time of preservation, and an **ex** command that could be used to recover the file.
Additional information may be included in the mail message.

*Current line*: Unchanged.

*Current column*: Unchanged.
Print

Synopsis:  \[2addr\] p[rint][count][flags]

Write the addressed lines. The behavior is unspecified if the number of columns on the display is less than the number of columns required to write any single character in the lines being written.

Non-printable characters, except for the <tab>, shall be written as implementation-defined multi-character sequences.

If the # flag is specified or the number edit option is set, each line shall be preceded by its line number in the following format:

"%6dΔΔ", <line number>

If the l flag is specified or the list edit option is set:

1. The characters listed in the Base Definitions volume of IEEE Std 1003.1-2001, Table 5-1, Escape Sequences and Associated Actions shall be written as the corresponding escape sequence.

2. Non-printable characters not in the Base Definitions volume of IEEE Std 1003.1-2001, Table 5-1, Escape Sequences and Associated Actions shall be written as one three-digit octal number (with a preceding backslash) for each byte in the character (most significant byte first). If the size of a byte on the system is greater than 9 bits, the format used for non-printable characters is implementation-defined.

3. The end of each line shall be marked with a '§', and literal ‘§’ characters within the line shall be written with a preceding backslash.

Long lines shall be folded; the length at which folding occurs is unspecified, but should be appropriate for the output terminal, considering the number of columns of the terminal.

If a line is folded, and the l flag is not specified and the list edit option is not set, it is unspecified whether a multi-column character at the folding position is separated; it shall not be discarded.

Current line: Set to the last written line.

Current column: Unchanged if the current line is unchanged; otherwise, set to non-<blank>.

Put

Synopsis:  \[laddr\] pu[t][buffer]

Append text from the specified buffer (by default, the unnamed buffer) to the specified line; line zero specifies that the text shall be placed at the beginning of the edit buffer. Each portion of a line in the buffer shall become a new line in the edit buffer, regardless of the mode of the buffer.

Current line: Set to the last line entered into the edit buffer.

Current column: Set to non-<blank>.

Quit

Synopsis:  q[uit][!]

If no '!' is appended to the command name:

1. If the edit buffer has been modified since the last complete write, it shall be an error.

2. If there are filenames in the argument list after the filename currently referenced, and the last command was not a quit, wq, xit, or ZZ (see Exit (on page 1022)) command, it shall be an error.
Utilities

Read

Synopsis: \texttt{\{laddr\} \texttt{r[ead]} \[!\] \{file\]}

If ‘! ’ is not the first non-<blank> to follow the command name, a copy of the specified file shall be appended into the edit buffer after the specified line; line zero specifies that the copy shall be placed at the beginning of the edit buffer. The number of lines and bytes read shall be written. If no file is named, the current pathname shall be the default. If there is no current pathname, then file shall become the current pathname. If there is no current pathname or file operand, it shall be an error. Specifying a file that is not of type regular shall have unspecified results.

Otherwise, if file is preceded by ‘! ’, the rest of the line after the ‘! ’ shall have ‘%’, ‘#’, and ‘! ’ characters expanded as described in Command Line Parsing in ex (on page 362).

The ex utility shall then pass two arguments to the program named by the shell edit option; the first shall be \texttt{-c} and the second shall be the expanded arguments to the read command as a single argument. The standard input of the program shall be set to the standard input of the ex program when it was invoked. The standard error and standard output of the program shall be appended into the edit buffer after the specified line.

Each line in the copied file or program output (as delimited by <newline>s or the end of the file or output if it is not immediately preceded by a <newline>), shall be a separate line in the edit buffer. Any occurrences of <carriage-return> and <newline> pairs in the output shall be treated as single <newline>s.

The special meaning of the ‘! ’ following the read command can be overridden by escaping it with a backslash character.

Current line: If no lines are added to the edit buffer, unchanged. Otherwise, if in open or visual mode, set to the first line entered into the edit buffer. Otherwise, set to the last line entered into the edit buffer.

Current column: Set to non-<blank>.

Recover

Synopsis: \texttt{\texttt{\{laddr\} \texttt{r[ead]} \[!\] \{file\]}

If no ‘! ’ is appended to the command name, and the edit buffer has been modified since the last complete write, it shall be an error.

If no file operand is specified, then the current pathname shall be used. If there is no current pathname or file operand, it shall be an error.

If no recovery information has previously been saved about file, the recover command shall behave identically to the edit command, and an informational message to this effect shall be written.

Otherwise, set the current pathname to file, and replace the current contents of the edit buffer with the recovered contents of file. If there are multiple instances of the file to be recovered, the one most recently saved shall be recovered, and an informational message that there are previous versions of the file that can be recovered shall be written. The editor shall behave as if the contents of the edit buffer have already been modified.

Current file: Set as described for the edit command.

Current column: Set as described for the edit command.
Rewind

**Synopsis:** `rew[ind][!]`

If no `!' is appended to the command name, and the edit buffer has been modified since the last complete write, it shall be an error, unless the file is successfully written as specified by the `autowrite` option.

If the argument list is empty, it shall be an error.

The current argument list reference and the current pathname shall be set to the first filename in the argument list.

Replace the contents of the edit buffer with the contents of the file named by the current pathname. If for any reason the contents of the file cannot be accessed, the edit buffer shall be empty.

This command shall be affected by the `autowrite` and `writeany` edit options.

**Current line:** Set as described for the `edit` command.

**Current column:** Set as described for the `edit` command.

Set

**Synopsis:** `set[option=[value]] ...[nooption ...][option? ...][all]`

When no arguments are specified, write the value of the `term` edit option and those options whose values have been changed from the default settings; when the argument `all` is specified, write all of the option values.

Giving an option name followed by the character `?' shall cause the current value of that option to be written. The `?' can be separated from the option name by zero or more `<blank>`s. The `?' shall be necessary only for Boolean valued options. Boolean options can be given values by the form `set option` to turn them on or `set nooption` to turn them off; string and numeric options can be assigned by the form `set option=value`. Any `<blank>`s in strings can be included as is by preceding each `<blank>` with an escaping backslash. More than one option can be set or listed by a single `set` command by specifying multiple arguments, each separated from the next by one or more `<blank>`s.

See `Edit Options in ex` (on page 392) for details about specific options.

**Current line:** Unchanged.

**Current column:** Unchanged.

Shell

**Synopsis:** `sh[ell]`

Invoke the program named in the `shell` edit option with the single argument `-i` (interactive mode). Editing shall be resumed when the program exits.

**Current line:** Unchanged.

**Current column:** Unchanged.
**Source**

*Synopsis:* `source` *file*

Read and execute *ex* commands from *file*. Lines in the file that are blank lines shall be ignored.

*Current line:* As specified for the individual *ex* commands.

*Current column:* As specified for the individual *ex* commands.

**Substitute**

*Synopsis:*
- `[2addr] s [substitute] [/pattern/repl/ [options] [count] [flags]]`
- `[2addr] & [options] [count] [flags]]`
- `[2addr] ~ [options] [count] [flags]]`

Replace the first instance of the pattern *pattern* by the string *repl* on each specified line. (See [Regular Expressions in *ex*](on page 391) and [Replacement Strings in *ex*](on page 391).) Any non-alphabetic, non-<blank> delimiter other than ‘\’, ‘|’, double quote, or <newline> can be used instead of ‘/’. Backslash characters can be used to escape delimiters, backslash characters, and other special characters.

The trailing delimiter can be omitted from *pattern* or from *repl* at the end of the command line. If both *pattern* and *repl* are not specified or are empty (for example, "//"), the last *s* command shall be repeated. If only *pattern* is not specified or is empty, the last regular expression used in the editor shall be used as the pattern. If only *repl* is not specified or is empty, the pattern shall be replaced by nothing. If the entire replacement pattern is ‘%’, the last replacement pattern to an *s* command shall be used.

Entering a <carriage-return> in *repl* (which requires an escaping backslash in *ex* mode and an escaping <control>-V in open or *vi* mode) shall split the line at that point, creating a new line in the edit buffer. The <carriage-return> shall be discarded.

If *options* includes the letter ‘g’ (*global*), all non-overlapping instances of the pattern in the line shall be replaced.

If *options* includes the letter ‘c’ (*confirm*), then before each substitution the line shall be written; the written line shall reflect all previous substitutions. On the following line, <space>s shall be written beneath the characters from the line that are before the *pattern* to be replaced, and ‘^’ characters written beneath the characters included in the *pattern* to be replaced. The *ex* utility shall then wait for a response from the user. An affirmative response shall cause the substitution to be done, while any other input shall not make the substitution. An affirmative response shall consist of a line with the affirmative response (as defined by the current locale) at the beginning of the line. This line shall be subject to editing in the same way as the *ex* command line.

If interrupted (see the [ASYNCHRONOUS EVENTS section](#)), any modifications confirmed by the user shall be preserved in the edit buffer after the interrupt.

If the remembered search direction is not set, the *s* command shall set it to forward.

In the second Synopsis, the & command shall repeat the previous substitution, as if the & command were replaced by:

`s/pattern/repl/`

where *pattern* and *repl* are as specified in the previous *s*, &, or ~ command.

In the third Synopsis, the ~ command shall repeat the previous substitution, as if the ‘~’ were replaced by:
Utilities

14852  \texttt{s/pattern/repl/}

where \texttt{pattern} shall be the last regular expression specified to the editor, and \texttt{repl} shall be from
the previous substitution (including \texttt{&} and \texttt{\}) command.

14855 These commands shall be affected by the \texttt{LC_MESSAGES} environment variable.

14856 \textit{Current line}: Set to the last line in which a substitution occurred, or, unchanged if no
substitution occurred.

14858 \textit{Current column}: Set to non-\texttt{<blank>}.

\subsection*{Suspend}

\textit{Synopsis}: \texttt{su[spend] [!]}

\begin{verbatim}
   st[op] [!]  
\end{verbatim}

Allow control to return to the invoking process; \texttt{ex} shall suspend itself as if it had received the
\texttt{SIGTSTP} signal. The suspension shall occur only if job control is enabled in the invoking shell
(see the description of \texttt{set -m}).

14865 These commands shall be affected by the \texttt{autowrite} and \texttt{writeany} edit options.

14866 The current \texttt{susp} character (see \texttt{stty}) shall be equivalent to the \texttt{suspend} command.

\subsection*{Tag}

\textit{Synopsis}: \texttt{ta[g] [!] tagstring}

The results are unspecified if the format of a tags file is not as specified by the \texttt{ctags} utility (see
\texttt{ctags}) description.

14871 The \texttt{tag} command shall search for \texttt{tagstring} in the tag files referred to by the \texttt{tag} edit option, in
the order they are specified, until a reference to \texttt{tagstring} is found. Files shall be searched from
beginning to end. If no reference is found, it shall be an error and an error message to this effect
shall be written. If the reference is not found, or if an error occurs while processing a file referred
to in the \texttt{tag} edit option, it shall be an error, and an error message shall be written at the first
occurrence of such an error.

14877 Otherwise, if the tags file contained a pattern, the pattern shall be treated as a regular expression
used in the editor; for example, for the purposes of the \texttt{s} command.

14879 If the \texttt{tagstring} is in a file with a different name than the current pathname, set the current
pathname to the name of that file, and replace the contents of the edit buffer with the contents of
that file. In this case, if no \texttt{\'} \texttt{!} \texttt{'} is appended to the command name, and the edit buffer has been
modified since the last complete write, it shall be an error, unless the file is successfully written
as specified by the \texttt{autowrite} option.

14884 This command shall be affected by the \texttt{autowrite}, \texttt{tag}, \texttt{taglength}, and \texttt{writeany} edit options.

14885 \textit{Current line}: If the tags file contained a line number, set to that line number. If the line number is
larger than the last line in the edit buffer, an error message shall be written and the current line
shall be set as specified for the \texttt{edit} command.

14888 If the tags file contained a pattern, set to the first occurrence of the pattern in the file. If no
matching pattern is found, an error message shall be written and the current line shall be set as
specified for the \texttt{edit} command.

14891 \textit{Current column}: If the tags file contained a line-number reference and that line-number was not
larger than the last line in the edit buffer, or if the tags file contained a pattern and that pattern
was found, set to non-\texttt{<blank>}. Otherwise, set as specified for the \texttt{edit} command.
Unabbreviate

Synopsis: unabbrev \ lhs

If \ lhs is not an entry in the current list of abbreviations (see Abbreviate (on page 370)), it shall be an error. Otherwise, delete \ lhs from the list of abbreviations.

Current line: Unchanged.

Current column: Unchanged.

Undo

Synopsis: undo

Reverse the changes made by the last command that modified the contents of the edit buffer, including undo. For this purpose, the global, v, open, and visual commands, and commands resulting from buffer executions and mapped character expansions, are considered single commands.

If no action that can be undone preceded the undo command, it shall be an error.

If the undo command restores lines that were marked, the mark shall also be restored unless it was reset subsequent to the deletion of the lines.

Current line:

1. If lines are added or changed in the file, set to the first line added or changed.
2. Set to the line before the first line deleted, if it exists.
3. Set to 1 if the edit buffer is not empty.
4. Set to zero.

Current column: Set to non-<blank>.

Unmap

Synopsis: unm[ap] ! \ lhs

If ‘!’ is appended to the command name, and if \ lhs is not an entry in the list of text input mode map definitions, it shall be an error. Otherwise, delete \ lhs from the list of text input mode map definitions.

If no ‘!’ is appended to the command name, and if \ lhs is not an entry in the list of command mode map definitions, it shall be an error. Otherwise, delete \ lhs from the list of command mode map definitions.

Current line: Unchanged.

Current column: Unchanged.

Version

Synopsis: version

Write a message containing version information for the editor. The format of the message is unspecified.

Current line: Unchanged.

Current column: Unchanged.
Visual

Synopsis: \[1addr\] vi[ual][type][count][flags]

If \texttt{ex} is currently in open or visual mode, the Synopsis and behavior of the visual command shall be the same as the \texttt{edit} command, as specified by \texttt{Edit} (on page 372).

Otherwise, this command need not be supported on block-mode terminals or terminals with insufficient capabilities. If standard input, standard output, or standard error are not terminal devices, the results are unspecified.

If \texttt{count} is specified, the value of the \texttt{window} edit option shall be set to \texttt{count} (as described in \texttt{window} (on page 398)). If the \texttt{'}\texttt{^}\texttt{'} type character was also specified, the \texttt{window} edit option shall be set before being used by the type character.

Enter visual mode. If \texttt{type} is not specified, it shall be as if a \texttt{type} of \texttt{'}\texttt{+}\texttt{'} was specified. The \texttt{type} shall cause the following effects:

\begin{itemize}
  \item[+] Place the beginning of the specified line at the top of the display.
  \item[-] Place the end of the specified line at the bottom of the display.
  \item[.] Place the beginning of the specified line in the middle of the display.
  \item[^] If the specified line is less than or equal to the value of the \texttt{window} edit option, set the line to 1; otherwise, decrement the line by the value of the \texttt{window} edit option minus 1. Place the beginning of this line as close to the bottom of the displayed lines as possible, while still displaying the value of the \texttt{window} edit option number of lines.
\end{itemize}

\textbf{Current line}: Set to the specified line.

\textbf{Current column}: Set to non-<blank>.

Write

Synopsis: \[2addr\] w[rite][!][>>][file]

\begin{verbatim}
[2addr] w[rite][!][>>][file]
[2addr] wq[!][>>][file]
\end{verbatim}

If no lines are specified, the lines shall default to the entire file.

The command \texttt{wq} shall be equivalent to a \texttt{write} command followed by a \texttt{quit} command; \texttt{wq!} shall be equivalent to \texttt{write!} followed by \texttt{quit}. In both cases, if the \texttt{write} command fails, the \texttt{quit} shall not be attempted.

If the command name is not followed by one or more <blank>s, or \texttt{file} is not preceded by a \texttt{'}\texttt{!}\texttt{'} character, the \texttt{write} shall be to a file.

1. If the \texttt{>>} argument is specified, and the file already exists, the lines shall be appended to the file instead of replacing its contents. If the \texttt{>>} argument is specified, and the file does not already exist, it is unspecified whether the write shall proceed as if the \texttt{>>} argument had not been specified or if the write shall fail.

2. If the \texttt{readonly} edit option is set (see \texttt{readonly} (on page 395)), the \texttt{write} shall fail.

3. If \texttt{file} is specified, and is not the current pathname, and the file exists, the \texttt{write} shall fail.

4. If \texttt{file} is not specified, the current pathname shall be used. If there is no current pathname, the \texttt{write} command shall fail.

5. If the current pathname is used, and the current pathname has been changed by the \texttt{file} or \texttt{read} commands, and the file exists, the \texttt{write} shall fail. If the \texttt{write} is successful,
subsequent writes shall not fail for this reason (unless the current pathname is changed again).

6. If the whole edit buffer is not being written, and the file to be written exists, the write shall fail.

For rules 1., 2., 4., and 5., the write can be forced by appending the character ‘! ’ to the command name.

For rules 2., 4., and 5., the write can be forced by setting the writeany edit option.

Additional, implementation-defined tests may cause the write to fail.

If the edit buffer is empty, a file without any contents shall be written.

An informational message shall be written noting the number of lines and bytes written.

Otherwise, if the command is followed by one or more <blank>s, and the file is preceded by ‘!’, the rest of the line after the ‘! ’ shall have ‘%’, ‘#’, and ‘!’ characters expanded as described in Command Line Parsing in ex (on page 362).

The ex utility shall then pass two arguments to the program named by the shell edit option; the first shall be –c and the second shall be the expanded arguments to the write command as a single argument. The specified lines shall be written to the standard input of the command. The standard error and standard output of the program, if any, shall be written as described for the print command. If the last character in that output is not a <newline>, a <newline> shall be written at the end of the output.

The special meaning of the ‘! ’ following the write command can be overridden by escaping it with a backslash character.

Current line: Unchanged.

Current column: Unchanged.

Write and Exit

Synopsis: [2addr] x[it][!] [file]

If the edit buffer has not been modified since the last complete write, xit shall be equivalent to the quit command, or if a ‘! ’ is appended to the command name, to quit!.

Otherwise, xit shall be equivalent to the wq command, or if a ‘! ’ is appended to the command name, to wq!.

Current line: Unchanged.

Current column: Unchanged.

Yank

Synopsis: [2addr] ya[nk] [buffer] [count]

Copy the specified lines to the specified buffer (by default, the unnamed buffer), which shall become a line-mode buffer.

Current line: Unchanged.

Current column: Unchanged.
Adjust Window

Synopsis:  \([\text{1addr}] \ z[!]\ [\text{type} \ldots] \ [\text{count}] \ [\text{flags}]\)

If no line is specified, the current line shall be the default; if \text{type} is omitted as well, the current line value shall first be incremented by 1. If incrementing the current line would cause it to be greater than the last line in the edit buffer, it shall be an error.

If there are <blank>s between the \text{type} argument and the preceding \text{z} command name or optional ‘!’ character, it shall be an error.

If \text{count} is specified, the value of the \text{window} edit option shall be set to \text{count} (as described in \text{window} on page 398). If \text{count} is omitted, it shall default to 2 times the value of the \text{scroll} edit option, or if ‘!’ was specified, the number of lines in the display minus 1.

If \text{type} is omitted, then \text{count} lines starting with the specified line shall be written. Otherwise, \text{count} lines starting with the line specified by the \text{type} argument shall be written.

The \text{type} argument shall change the lines to be written. The possible values of \text{type} are as follows:

- The specified line shall be decremented by the following value:
  
  \[
  (((\text{number of ‘-’ characters}) \times \text{count}) - 1)
  \]

  If the calculation would result in a number less than 1, it shall be an error. Write lines from the edit buffer, starting at the new value of line, until \text{count} lines or the last line in the edit buffer has been written.

- The specified line shall be incremented by the following value:
  
  \[
  (((\text{number of ‘+’ characters}) - 1) \times \text{count}) + 1
  \]

  If the calculation would result in a number greater than the last line in the edit buffer, it shall be an error. Write lines from the edit buffer, starting at the new value of line, until \text{count} lines or the last line in the edit buffer has been written.

- If more than a single ‘.’ or ‘=’ is specified, it shall be an error. The following steps shall be taken:

  1. If \text{count} is zero, nothing shall be written.

  2. Write as many of the \(N\) lines before the current line in the edit buffer as exist. If \text{count} or ‘!’ was specified, \(N\) shall be:

    \[
    (\text{count} - 1) / 2
    \]

    Otherwise, \(N\) shall be:

    \[
    (\text{count} - 3) / 2
    \]

    If \(N\) is a number less than 3, no lines shall be written.

  3. If ‘=’ was specified as the type character, write a line consisting of the smaller of the number of columns in the display divided by two, or 40 ‘−’ characters.

  4. Write the current line.

  5. Repeat step 3.

  6. Write as many of the \(N\) lines after the current line in the edit buffer as exist. \(N\) shall be defined as in step 2. If \(N\) is a number less than 3, no lines shall be written. If \text{count} is less than 3, no lines shall be written.
The specified line shall be decremented by the following value:

\[
((\text{number of `'` characters} +1) \times \text{count}) - 1
\]

If the calculation would result in a number less than 1, it shall be an error. Write lines from the edit buffer, starting at the new value of line, until \text{count} lines or the last line in the edit buffer has been written.

\textit{Current line}: Set to the last line written, unless the type is \texttt{=} in which case, set to the specified line.

\textit{Current column}: Set to non-<blank>.

\textbf{Escape}

\textbf{Synopsis:} \texttt{! command [addr] ! command}

The contents of the line after the \texttt{!} shall have \texttt{%}, \texttt{#}, and \texttt{!} characters expanded as described in \textit{Command Line Parsing in ex} (on page 362). If the expansion causes the text of the line to change, it shall be redisplayed, preceded by a single \texttt{!} character.

The ex utility shall execute the program named by the \texttt{shell} edit option. It shall pass two arguments to the program; the first shall be \texttt{--c}, and the second shall be the expanded arguments to the \texttt{!} command as a single argument.

If no lines are specified, the standard input, standard output, and standard error of the program shall be set to the standard input, standard output, and standard error of the ex program when it was invoked. In addition, a warning message shall be written if the edit buffer has been modified since the last complete write, and the \texttt{warn} edit option is set.

If lines are specified, they shall be passed to the program as standard input, and the standard output and standard error of the program shall replace those lines in the edit buffer. Each line in the program output (as delimited by <newline>s or the end of the output if it is not immediately preceded by a <newline>), shall be a separate line in the edit buffer. Any occurrences of <carriage-return> and <newline> pairs in the output shall be treated as single <newline>s. The specified lines shall be copied into the unnamed buffer before they are replaced, and the unnamed buffer shall become a line-mode buffer.

If in \texttt{ex} mode, a single \texttt{!'!} character shall be written when the program completes.

This command shall be affected by the \texttt{shell} and \texttt{warn} edit options. If no lines are specified, this command shall be affected by the \texttt{autowrite} and \texttt{writeany} edit options. If lines are specified, this command shall be affected by the \texttt{autoprint} edit option.

\textit{Current line}:

1. If no lines are specified, unchanged.
2. Otherwise, set to the last line read in, if any lines are read in.
3. Otherwise, set to the line before the first line of the lines specified, if that line exists.
4. Otherwise, set to the first line of the edit buffer if the edit buffer is not empty.
5. Otherwise, set to zero.

\textit{Current column}: If no lines are specified, unchanged. Otherwise, set to non-<blank>.
Shift Left

Synopsis: \[2addr\] < [< \ldots \text{] count} \text{] flags]\]

Shift the specified lines to the start of the line; the number of column positions to be shifted shall be the number of command characters times the value of the shiftwidth edit option. Only leading <blank>s shall be deleted or changed into other <blank>s in shifting; other characters shall not be affected.

Lines to be shifted shall be copied into the unnamed buffer, which shall become a line-mode buffer.

This command shall be affected by the \texttt{autoprint} edit option.

Current line: Set to the last line in the lines specified.

Current column: Set to non-<blank>.

Shift Right

Synopsis: \[2addr\] > [> \ldots \text{] count} \text{] flags]\]

Shift the specified lines away from the start of the line; the number of column positions to be shifted shall be the number of command characters times the value of the shiftwidth edit option. The shift shall be accomplished by adding <blank>s as a prefix to the line or changing leading <blank>s into other <blank>s. Empty lines shall not be changed.

Lines to be shifted shall be copied into the unnamed buffer, which shall become a line-mode buffer.

This command shall be affected by the \texttt{autoprint} edit option.

Current line: Set to the last line in the lines specified.

Current column: Set to non-<blank>.

<control>-D

Synopsis: <control>-D

Write the next \(n\) lines, where \(n\) is the minimum of the values of the scroll edit option and the number of lines after the current line in the edit buffer. If the current line is the last line of the edit buffer it shall be an error.

Current line: Set to the last line written.

Current column: Set to non-<blank>.

Write Line Number

Synopsis: \[1addr\] = [flags]

If line is not specified, it shall default to the last line in the edit buffer. Write the line number of the specified line.

Current line: Unchanged.

Current column: Unchanged.
Utilities

15122 Execute

15123 Synopsis:  [2addr] @ buffer
15124 [2addr] * buffer

15125 If no buffer is specified or is specified as ' @ ' or ' * ', the last buffer executed shall be used. If no
previous buffer has been executed, it shall be an error.

15126 For each line specified by the addresses, set the current line (('.')) to the specified line, and
execute the contents of the named buffer (as they were at the time the @ command was executed)
as ex commands. For each line of a line-mode buffer, and all but the last line of a character-mode
buffer, the ex command parser shall behave as if the line was terminated by a <newline>.

15127 If an error occurs during this process, or a line specified by the addresses does not exist when the
current line would be set to it, or more than a single line was specified by the addresses, and the
contents of the edit buffer are replaced (for example, by the ex:edit command) an error message
shall be written, and no more commands resulting from the execution of this command shall be
processed.

15128 Current line:  As specified for the individual ex commands.

15129 Current column:  As specified for the individual ex commands.

15130 Regular Expressions in ex

15131 The ex utility shall support regular expressions that are a superset of the basic regular
expressions described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic
Regular Expressions. A null regular expression ("//") shall be equivalent to the last regular
expression encountered.

15132 Regular expressions can be used in addresses to specify lines and, in some commands (for
example, the substitute command), to specify portions of a line to be substituted.

15133 The following constructs can be used to enhance the basic regular expressions:

15134 \<  Match the beginning of a word. (See the definition of word at the beginning of Command
15135 Descriptions in ex (on page 368).)

15136 \>  Match the end of a word.

15137 ~  Match the replacement part of the last substitute command. The tilde ('~') character can
be escaped in a regular expression to become a normal character with no special meaning.

15138 The backslash shall be discarded.

15139 When the editor option magic is not set, the only characters with special meanings shall be ' ^ ',
at the beginning of a pattern, ' $ ' at the end of a pattern, and ' \ '. The characters ' ', ' * ',
' [ ', and ' ] ' shall be treated as ordinary characters unless preceded by a ' \ '; when preceded
by a ' \ ' they shall regain their special meaning, or in the case of backslash, be handled as a
single backslash. Backslashes used to escape other characters shall be discarded.

15140 Replacement Strings in ex

15141 The character ' & ' ('\&' if the editor option magic is not set) in the replacement string shall
stand for the text matched by the pattern to be replaced. The character ' ~ ' ('\~' if magic is not
set) shall be replaced by the replacement part of the previous substitute command. The
sequence '\n', where n is an integer, shall be replaced by the text matched by the pattern
enclosed in the n-th set of parentheses '\ ( ' and ' \ ) '.

15142 The strings '\1', '\u', '\L', and '\U' can be used to modify the case of elements in the
replacement string (using the '\&' or '"digit' notation). The string '\1' ('\1') shall cause
the character that follows to be converted to lowercase (uppercase). The string '\L' ('\U')
shall cause all characters subsequent to it to be converted to lowercase (uppercase) as they are
inserted by the substitution until the string '\e' or '\E', or the end of the replacement string,
is encountered.

Otherwise, any character following a backslash shall be treated as that literal character, and the
escaping backslash shall be discarded.

An example of case conversion with the \s command is as follows:

```
:p
The cat sat on the mat.
:s/\.<.at\>/\u&/gp
The Cat Sat on the Mat.
:s/S\(.\*\)M/S\U\1\eM/p
The Cat SAT ON THE Mat.
```

**Edit Options in ex**

The \ex utility has a number of options that modify its behavior. These options have default
settings, which can be changed using the \set command.

Options are Boolean unless otherwise specified.

**autoindent, ai**

[Default unset]

If autoindent is set, each line in input mode shall be indented (using first as many <tab>s as
possible, as determined by the editor option \tabstop, and then using <space>s) to align with
another line, as follows:

1. If in open or visual mode and the text input is part of a line-oriented command (see the
   EXTENDED DESCRIPTION in \vi), align to the first column.

2. Otherwise, if in open or visual mode, indentation for each line shall be set as follows:

   a. If a line was previously inserted as part of this command, it shall be set to the
      indentation of the last inserted line by default, or as otherwise specified for the
      <control>-D character in **Input Mode Commands in vi** (on page 1022).

   b. Otherwise, it shall be set to the indentation of the previous current line, if any;
      otherwise, to the first column.

3. For the \ex a, i, and c commands, indentation for each line shall be set as follows:

   a. If a line was previously inserted as part of this command, it shall be set to the
      indentation of the last inserted line by default, or as otherwise specified for the \eof
      character in **Scroll** (on page 366).

   b. Otherwise, if the command is the \ex a command, it shall be set to the line appended
      after, if any; otherwise to the first column.

   c. Otherwise, if the command is the \ex i command, it shall be set to the line inserted
      before, if any; otherwise to the first column.

   d. Otherwise, if the command is the \ex c command, it shall be set to the indentation of
      the line replaced.
utilities

15205 autoprint, ap
15206 [Default set]
15207 If autoprint is set, the current line shall be written after each \texttt{ex} command that modifies the contents of the current edit buffer, and after each \texttt{tag} command for which the tag search pattern was found or tag line number was valid, unless:
15210 1. The command was executed while in open or visual mode.
15211 2. The command was executed as part of a \texttt{global} or \texttt{v} command or \@ buffer execution.
15212 3. The command was the form of the \texttt{read} command that reads a file into the edit buffer.
15213 4. The command was the \texttt{append}, \texttt{change}, or \texttt{insert} command.
15214 5. The command was not terminated by a \texttt{<newline>}.
15215 6. The current line shall be written by a flag specified to the command; for example, \texttt{delete \#} shall write the current line as specified for the flag modifier to the \texttt{delete} command, and not as specified by the \texttt{autoprint} edit option.

15218 autowrite, aw
15219 [Default unset]
15220 If autowrite is set, and the edit buffer has been modified since it was last completely written to any file, the contents of the edit buffer shall be written as if the \texttt{ex write} command had been specified without arguments, before each command affected by the autowrite edit option is executed. Appending the character \texttt{!} to the command name of any of the \texttt{ex} commands except \texttt{!} shall prevent the write. If the write fails, it shall be an error and the command shall not be executed.

15226 beautify, bf
15227 [Default unset]
15228 If beautify is set, all non-printable characters, other than \texttt{<tab>s, <newline>s, and <form-feed>s}, shall be discarded from text read in from files.

15230 directory, dir
15231 [Default implementation-defined]
15232 The value of this option specifies the directory in which the editor buffer is to be placed. If this directory is not writable by the user, the editor shall quit.

15234 edcompatible, ed
15235 [Default unset]
15236 Causes the presence of \texttt{g} and \texttt{c} suffixes on substitute commands to be remembered, and toggled by repeating the suffixes.
errorbells, eb

[Default unset]

If the editor is in ex mode, and the terminal does not support a standout mode (such as inverse video), and errorbells is set, error messages shall be preceded by alerting the terminal.

exrc

[Default unset]

If exrc is set, ex shall access any .exrc file in the current directory, as described in Initialization in ex and vi (on page 358). If exrc is not set, ex shall ignore any .exrc file in the current directory during initialization, unless the current directory is that named by the HOME environment variable.

ignorecase, ic

[Default unset]

If ignorecase is set, characters that have uppercase and lowercase representations shall have those representations considered as equivalent for purposes of regular expression comparison.

The ignorecase edit option shall affect all remembered regular expressions; for example, unsetting the ignorecase edit option shall cause a subsequent vi n command to search for the last basic regular expression in a case-sensitive fashion.

list

[Default unset]

If list is set, edit buffer lines written while in ex command mode shall be written as specified for the print command with the l flag specified. In open or visual mode, each edit buffer line shall be displayed as specified for the ex print command with the l flag specified. In open or visual text input mode, when the cursor does not rest on any character in the line, it shall rest on the ' $ ' marking the end of the line.

magic

[Default set]

If magic is set, modify the interpretation of characters in regular expressions and substitution replacement strings (see Regular Expressions in ex (on page 391) and Replacement Strings in ex (on page 391)).

mesg

[Default set]

If mesg is set, the permission for others to use the write or talk commands to write to the terminal shall be turned on while in open or visual mode. The shell-level command mesg n shall take precedence over any setting of the ex mesg option; that is, if mesg y was issued before the editor started (or in a shell escape), such as:

: !mesg y

the mesg option in ex shall suppress incoming messages, but the mesg option shall not enable incoming messages if mesg n was issued.
number, nu

[Default unset]

If number is set, edit buffer lines written while in ex command mode shall be written with line numbers, in the format specified by the print command with the # flag specified. In ex text input mode, each line shall be preceded by the line number it will have in the file.

In open or visual mode, each edit buffer line shall be displayed with a preceding line number, in the format specified by the ex print command with the # flag specified. This line number shall not be considered part of the line for the purposes of evaluating the current column; that is, column position 1 shall be the first column position after the format specified by the print command.

paragraphs, para

[Default in the POSIX locale \texttt{IPLPPPQPP LIpp1pipbp}]

The paragraphs edit option shall define additional paragraph boundaries for the open and visual mode commands. The paragraphs edit option can be set to a character string consisting of zero or more character pairs. It shall be an error to set it to an odd number of characters.

prompt

[Default set]

If prompt is set, ex command mode input shall be prompted for with a colon (‘:’); when unset, no prompt shall be written.

readonly

[Default see text]

If the readonly edit option is set, read-only mode shall be enabled (see Write (on page 386)). The readonly edit option shall be initialized to set if either of the following conditions are true:

- The command-line option –R was specified.
- Performing actions equivalent to the access( ) function called with the following arguments indicates that the file lacks write permission:
  1. The current pathname is used as the path argument.
  2. The constant W_OK is used as the amode argument.

The readonly edit option may be initialized to set for other, implementation-defined reasons. The readonly edit option shall not be initialized to unset based on any special privileges of the user or process. The readonly edit option shall be reinitialized each time that the contents of the edit buffer are replaced (for example, by an edit or next command) unless the user has explicitly set it, in which case it shall remain set until the user explicitly unsets it. Once unset, it shall again be reinitialized each time that the contents of the edit buffer are replaced.
redraw

[Default unset]

The editor simulates an intelligent terminal on a dumb terminal. (Since this is likely to require a large amount of output to the terminal, it is useful only at high transmission speeds.)

remap

[Default set]

If remap is set, map translation shall allow for maps defined in terms of other maps; translation shall continue until a final product is obtained. If unset, only a one-step translation shall be done.

report

[Default 5]

The value of this report edit option specifies what number of lines being added, copied, deleted, or modified in the edit buffer will cause an informational message to be written to the user. The following conditions shall cause an informational message. The message shall contain the number of lines added, copied, deleted, or modified, but is otherwise unspecified.

• An ex or vi editor command, other than open, undo, or visual, that modifies at least the value of the report edit option number of lines, and which is not part of an ex global or v command, or ex or vi buffer execution, shall cause an informational message to be written.

• An ex yank or vi y or Y command, that copies at least the value of the report edit option plus 1 number of lines, and which is not part of an ex global or v command, or ex or vi buffer execution, shall cause an informational message to be written.

• An ex global, v, open, undo, or visual command or ex or vi buffer execution, that adds or deletes a total of at least the value of the report edit option number of lines, and which is not part of an ex global or v command, or ex or vi buffer execution, shall cause an informational message to be written. (For example, if 3 lines were added and 8 lines deleted during an ex visual command, 5 would be the number compared against the report edit option after the command completed.)

scroll, scr

[Default (number of lines in the display −1)/2]

The value of the scroll edit option shall determine the number of lines scrolled by the ex <control>-D and z commands. For the vi <control>-D and <control>-U commands, it shall be the initial number of lines to scroll when no previous <control>-D or <control>-U command has been executed.

sections

[Default in the POSIX locale NHSHH \u0141\u0103\u0141\u0103\u0142\u0141]

The sections edit option shall define additional section boundaries for the open and visual mode commands. The sections edit option can be set to a character string consisting of zero or more character pairs; it shall be an error to set it to an odd number of characters.
shell, sh

[Default from the environment variable SHELL]

The value of this option shall be a string. The default shall be taken from the SHELL environment variable. If the SHELL environment variable is null or empty, the sh (see sh) utility shall be the default.

shiftwidth, sw

[Default 8]

The value of this option shall give the width in columns of an indentation level used during autoindentation and by the shift commands (< and >).

showmatch, sm

[Default unset]

The functionality described for the showmatch edit option need not be supported on block-mode terminals or terminals with insufficient capabilities.

If showmatch is set, in open or visual mode, when a ‘)’ or ‘}’ is typed, if the matching ‘(’ or ‘{’ is currently visible on the display, the matching ‘(’ or ‘{’ shall be flagged moving the cursor to its location for an unspecified amount of time.

showmode

[Default unset]

If showmode is set, in open or visual mode, the current mode that the editor is in shall be displayed on the last line of the display. Command mode and text input mode shall be differentiated; other unspecified modes and implementation-defined information may be displayed.

slowopen

[Default unset]

If slowopen is set during open and visual text input modes, the editor shall not update portions of the display other than those display line columns that display the characters entered by the user (see Input Mode Commands in vi (on page 1022)).

tabstop, ts

[Default 8]

The value of this edit option shall specify the column boundary used by a <tab> in the display (see autoprint, ap (on page 393) and Input Mode Commands in vi (on page 1022)).

taglength, tl

[Default zero]

The value of this edit option shall specify the maximum number of characters that are considered significant in the user-specified tag name and in the tag name from the tags file. If the value is zero, all characters in both tag names shall be significant.
tags

[Default see text]

The value of this edit option shall be a string of <blank>-delimited pathnames of files used by the tag command. The default value is unspecified.

term

[Default from the environment variable TERM]

The value of this edit option shall be a string. The default shall be taken from the TERM variable in the environment. If the TERM environment variable is empty or null, the default is unspecified. The editor shall use the value of this edit option to determine the type of the display device.

The results are unspecified if the user changes the value of the term edit option after editor initialization.

terse

[Default unset]

If terse is set, error messages may be less verbose. However, except for this caveat, error messages are unspecified. Furthermore, not all error messages need change for different settings of this option.

warn

[Default set]

If warn is set, and the contents of the edit buffer have been modified since they were last completely written, the editor shall write a warning message before certain commands (see Escape (on page 389)).

window

[Default see text]

A value used in open and visual mode, by the <control>-B and <control>-F commands, and, in visual mode, to specify the number of lines displayed when the screen is repainted.

If the −w command-line option is not specified, the default value shall be set to the value of the LINES environment variable. If the LINES environment variable is empty or null, the default shall be the number of lines in the display minus 1.

Setting the window edit option to zero or to a value greater than the number of lines in the display minus 1 (either explicitly or based on the −w option or the LINES environment variable) shall cause the window edit option to be set to the number of lines in the display minus 1.

The baud rate of the terminal line may change the default in an implementation-defined manner.
wrapmargin, wm

[Default 0]

If the value of this edit option is zero, it shall have no effect.

If not in the POSIX locale, the effect of this edit option is implementation-defined.

Otherwise, it shall specify a number of columns from the ending margin of the terminal.

During open and visual text input modes, for each character for which any part of the character is displayed in a column that is less than wrapmargin columns from the ending margin of the display line, the editor shall behave as follows:

1. If the character triggering this event is a <blank>, it, and all immediately preceding <blank>s on the current line entered during the execution of the current text input command, shall be discarded, and the editor shall behave as if the user had entered a single <newline> instead. In addition, if the next user-entered character is a <space>, it shall be discarded as well.

2. Otherwise, if there are one or more <blank>s on the current line immediately preceding the last group of inserted non-<blank>s which was entered during the execution of the current text input command, the <blank>s shall be replaced as if the user had entered a single <newline> instead.

If the autoindent edit option is set, and the events described in 1. or 2. are performed, any <blank>s at or after the cursor in the current line shall be discarded.

The ending margin shall be determined by the system or overridden by the user, as described for COLUMNS in the ENVIRONMENT VARIABLES section and the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

wrapscan, ws

[Default set]

If wrapscan is set, searches (the ex / or ? addresses, or open and visual mode /, ?, N, and n commands) shall wrap around the beginning or end of the edit buffer; when unset, searches shall stop at the beginning or end of the edit buffer.

writeany, wa

[Default unset]

If writeany is set, some of the checks performed when executing the ex write commands shall be inhibited, as described in editor option autowrite.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS

When any error is encountered and the standard input is not a terminal device file, ex shall not write the file or return to command or text input mode, and shall terminate with a non-zero exit status.

Otherwise, when an unrecoverable error is encountered, it shall be equivalent to a SIGHUP asynchronous event.
Otherwise, when an error is encountered, the editor shall behave as specified in Command Line Parsing in ex (on page 362).

APPLICATION USAGE

If a SIGSEGV signal is received while ex is saving a file, the file might not be successfully saved. The next command can accept more than one file, so usage such as:

```
next `ls [abc]*`
```

is valid; it would not be valid for the edit or read commands, for example, because they expect only one file and unspecified results occur.

EXAMPLES

None.

RATIONALE

The ex/vi specification is based on the historical practice found in the 4 BSD and System V implementations of ex and vi. A freely redistributable implementation of ex/vi, which is tracking IEEE Std 1003.1-2001 fairly closely, and demonstrates the intended changes between historical implementations and IEEE Std 1003.1-2001, may be obtained by anonymous FTP from:

```
```

A restricted editor (both the historical red utility and modifications to ex) were considered and rejected for inclusion. Neither option provided the level of security that users might expect.

It is recognized that ex visual mode and related features would be difficult, if not impossible, to implement satisfactorily on a block-mode terminal, or a terminal without any form of cursor addressing; thus, it is not a mandatory requirement that such features should work on all terminals. It is the intention, however, that an ex implementation should provide the full set of capabilities on all terminals capable of supporting them.

Options

The -c replacement for +command was inspired by the -e option of sed. Historically, all such commands (see edit and next as well) were executed from the last line of the edit buffer. This meant, for example, that "+/pattern" would fail unless the wrapscan option was set. IEEE Std 1003.1-2001 requires conformance to historical practice. Historically, some implementations restricted the ex commands that could be listed as part of the command line arguments. For consistency, IEEE Std 1003.1-2001 does not permit these restrictions.

In historical implementations of the editor, the -R option (and the readonly edit option) only prevented overwriting of files; appending to files was still permitted, mapping loosely into the csh noclobber variable. Some implementations, however, have not followed this semantic, and readonly does not permit appending either. IEEE Std 1003.1-2001 follows the latter practice, believing that it is a more obvious and intuitive meaning of readonly.

The -s option suppresses all interactive user feedback and is useful for editing scripts in batch jobs. The list of specific effects is historical practice. The terminal type “incapable of supporting open and visual modes” has historically been named “dumb”.

The -t option was required because the ctags utility appears in IEEE Std 1003.1-2001 and the option is available in all historical implementations of ex.

Historically, the ex and vi utilities accepted a -x option, which did encryption based on the algorithm found in the historical crypt utility. The -x option for encryption, and the associated crypt utility, were omitted because the algorithm used was not specifiable and the export control laws of some nations make it difficult to export cryptographic technology. In addition, it did not
Utilities

15501 historically provide the level of security that users might expect.

15502 **Standard Input**

15503 An end-of-file condition is not equivalent to an end-of-file character. A common end-of-file character, <control>-D, is historically an ex command.

15504 There was no maximum line length in historical implementations of ex. Specifically, as it was parsed in chunks, the addresses had a different maximum length than the filenames. Further, the maximum line buffer size was declared as BUFSIZ, which was different lengths on different systems. This version selected the value of {LINE_MAX} to impose a reasonable restriction on portable usage of ex and to aid test suite writers in their development of realistic tests that exercise this limit.

15505 **Input Files**

15506 It was an explicit decision by the standard developers that a <newline> be added to any file lacking one. It was believed that this feature of ex and vi was relied on by users in order to make text files lacking a trailing <newline> more portable. It is recognized that this will require a user-specified option or extension for implementations that permit ex and vi to edit files of type other than text if such files are not otherwise identified by the system. It was agreed that the ability to edit files of arbitrary type can be useful, but it was not considered necessary to mandate that an ex or vi implementation be required to handle files other than text files.

15507 The paragraph in the INPUT FILES section, "By default, . . .", is intended to close a long-standing security problem in ex and vi; that of the "modeline" or "modelines" edit option. This feature allows any line in the first or last five lines of the file containing the strings "ex:" or "vi:" (and, apparently, "ei:" or "vx:" ) to be a line containing editor commands, and ex interprets all the text up to the next ':' or <newline> as a command. Consider the consequences, for example, of an unsuspecting user using ex or vi as the editor when replying to a mail message in which a line such as:

```
ex:! rm -rf :
```

appeared in the signature lines. The standard developers believed strongly that an editor should not by default interpret any lines of a file. Vendors are strongly urged to delete this feature from their implementations of ex and vi.

15508 **Asynchronous Events**

15509 The intention of the phrase "complete write" is that the entire edit buffer be written to stable storage. The note regarding temporary files is intended for implementations that use temporary files to back edit buffers unnamed by the user.

15510 Historically, SIGQUIT was ignored by ex, but was the equivalent of the Q command in visual mode; that is, it exited visual mode and entered ex mode. IEEE Std 1003.1-2001 permits, but does not require, this behavior. Historically, SIGINT was often used by vi users to terminate text input mode (<control>-C is often easier to enter than <ESC>). Some implementations of vi alerted the terminal on this event, and some did not. IEEE Std 1003.1-2001 requires that SIGINT behave identically to <ESC>, and that the terminal not be alerted.

15511 Historically, suspending the ex editor during text input mode was similar to SIGINT, as completed lines were retained, but any partial line discarded, and the editor returned to command mode. IEEE Std 1003.1-2001 is silent on this issue; implementations are encouraged to follow historical practice, where possible.
Historically, the \texttt{vi} editor did not treat \texttt{SIGTSTP} as an asynchronous event, and it was therefore impossible to suspend the editor in visual text input mode. There are two major reasons for this. The first is that \texttt{SIGTSTP} is a broadcast signal on UNIX systems, and the chain of events where the shell \texttt{execs} an application that then \texttt{execs} \texttt{vi} usually caused confusion for the terminal state if \texttt{SIGTSTP} was delivered to the process group in the default manner. The second was that most implementations of the UNIX \texttt{curses} package are not reentrant, and the receipt of \texttt{SIGTSTP} at the wrong time will cause them to crash. IEEE Std 1003.1-2001 is silent on this issue; implementations are encouraged to treat suspension as an asynchronous event if possible.

Historically, modifications to the edit buffer made before \texttt{SIGINT} interrupted an operation were retained; that is, anywhere from zero to all of the lines to be modified might have been modified by the time the \texttt{SIGINT} arrived. These changes were not discarded by the arrival of \texttt{SIGINT}. IEEE Std 1003.1-2001 permits this behavior, noting that the \texttt{undo} command is required to be able to undo these partially completed commands.

The action taken for signals other than \texttt{SIGINT}, \texttt{SIGCONT}, \texttt{SIGHUP}, and \texttt{SIGTERM} is unspecified because some implementations attempt to save the edit buffer in a useful state when other signals are received.

\section*{Standard Error}

For \texttt{ex/vi}, diagnostic messages are those messages reported as a result of a failed attempt to invoke \texttt{ex} or \texttt{vi}, such as invalid options or insufficient resources, or an abnormal termination condition. Diagnostic messages should not be confused with the error messages generated by inappropriate or illegal user commands.

\section*{Initialization in ex and vi}

If an \texttt{ex} command (other than \texttt{cd}, \texttt{chdir}, or \texttt{source}) has a filename argument, one or both of the alternate and current pathnames will be set. Informally, they are set as follows:

1. If the \texttt{ex} command is one that replaces the contents of the edit buffer, and it succeeds, the current pathname will be set to the filename argument (the first filename argument in the case of the \texttt{next} command) and the alternate pathname will be set to the previous current pathname, if there was one.

2. In the case of the file read/write forms of the \texttt{read} and \texttt{write} commands, if there is no current pathname, the current pathname will be set to the filename argument.

3. Otherwise, the alternate pathname will be set to the filename argument.

For example, \texttt{edit foo} and \texttt{recover foo}, when successful, set the current pathname, and, if there was a previous current pathname, the alternate pathname. The commands \texttt{write}, \texttt{!command}, and \texttt{edit} set neither the current or alternate pathnames. If the \texttt{edit foo} command were to fail for some reason, the alternate pathname would be set. The \texttt{read} and \texttt{write} commands set the alternate pathname to their \texttt{file} argument, unless the current pathname is not set, in which case they set the current pathname to their \texttt{file} arguments. The alternate pathname was not historically set by the \texttt{source} command. IEEE Std 1003.1-2001 requires conformance to historical practice. Implementations adding commands that take filenames as arguments are encouraged to set the alternate pathname as described here.

Historically, \texttt{ex} and \texttt{vi} read the \texttt{.exrc} file in the \texttt{$HOME} directory twice, if the editor was executed in the \texttt{$HOME} directory. IEEE Std 1003.1-2001 prohibits this behavior.

Historically, the 4 BSD \texttt{ex} and \texttt{vi} read the \texttt{$HOME} and local \texttt{.exrc} files if they were owned by the real ID of the user, or the \texttt{sourceman} option was set, regardless of other considerations. This was a security problem because it is possible to put normal UNIX system commands inside a \texttt{.exrc}
file. IEEE Std 1003.1-2001 does not specify the `sourceany` option, and historical implementations are encouraged to delete it.

The `.exrc` files must be owned by the real ID of the user, and not writable by anyone other than the owner. The appropriate privileges exception is intended to permit users to acquire special privileges, but continue to use the `.exrc` files in their home directories.

System V Release 3.2 and later `vi` implementations added the option `[no]exrc`. The behavior is that local `.exrc` files are read-only if the `exrc` option is set. The default for the `exrc` option was off, so by default, local `.exrc` files were not read. The problem this was intended to solve was that System V permitted users to give away files, so there is no possible ownership or writeability test to ensure that the file is safe. This is still a security problem on systems where users can give away files, but there is nothing additional that IEEE Std 1003.1-2001 can do. The implementation-defined exception is intended to permit groups to have local `.exrc` files that are shared by users, by creating pseudo-users to own the shared files.

IEEE Std 1003.1-2001 does not mention system-wide `ex` and `vi` start-up files. While they exist in several implementations of `ex` and `vi`, they are not present in any implementations considered historical practice by IEEE Std 1003.1-2001. Implementations that have such files should use them only if they are owned by the real user ID or an appropriate user (for example, root on UNIX systems) and if they are not writable by any user other than their owner. System-wide start-up files should be read before the `EXINIT` variable, $HOME/.exrc, or local `.exrc` files are evaluated.

Historically, any `ex` command could be entered in the `EXINIT` variable or the `.exrc` file, although ones requiring that the edit buffer already contain lines of text generally caused historical implementations of the editor to drop `core`. IEEE Std 1003.1-2001 requires that any `ex` command be permitted in the `EXINIT` variable and `.exrc` files, for simplicity of specification and consistency, although many of them will obviously fail under many circumstances.

The initialization of the contents of the edit buffer uses the phrase “the effect shall be” with regard to various `ex` commands. The intent of this phrase is that edit buffer contents loaded during the initialization phase not be lost; that is, loading the edit buffer should fail if the `.exrc` file read in the contents of a file and did not subsequently write the edit buffer. An additional intent of this phrase is to specify that the initial current line and column is set as specified for the individual `ex` commands.

Historically, the –t option behaved as if the tag search were a `+command`; that is, it was executed from the last line of the file specified by the tag. This resulted in the search failing if the pattern was a forward search pattern and the `wrapscan` edit option was not set. IEEE Std 1003.1-2001 does not permit this behavior, requiring that the search for the tag pattern be performed on the entire file, and, if not found, that the current line be set to a more reasonable location in the file.

Historically, the empty edit buffer presented for editing when a file was not specified by the user was unnamed. This is permitted by IEEE Std 1003.1-2001; however, implementations are encouraged to provide users a temporary filename for this buffer because it permits them the use of `ex` commands that use the current pathname during temporary edit sessions.

Historically, the file specified using the –t option was not part of the current argument list. This practice is permitted by IEEE Std 1003.1-2001; however, implementations are encouraged to include its name in the current argument list for consistency.

Historically, the –c command was generally not executed until a file that already exists was edited. IEEE Std 1003.1-2001 requires conformance to this historical practice. Commands that could cause the –c command to be executed include the `ex` commands `edit`, `next`, `recover`, `rewind`, and `tag`, and the `vi` commands `<control>-` and `<control>-`. Historically, reading a file into an edit buffer did not cause the –c command to be executed (even though it might set the
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15637 current pathname) with the exception that it did cause the −c command to be executed if: the
15638 editor was in ex mode, the edit buffer had no current pathname, the edit buffer was empty, and
15639 no read commands had yet been attempted. For consistency and simplicity of specification,
15640 IEEE Std 1003.1-2001 does not permit this behavior.

15641 Historically, the −r option was the same as a normal edit session if there was no recovery
15642 information available for the file. This allowed users to enter:

```
vi −r *.c
```

15643 and recover whatever files were recoverable. In some implementations, recovery was attempted
15644 only on the first file named, and the file was not entered into the argument list; in others,
15645 recovery was attempted for each file named. In addition, some historical implementations
15646 ignored −r if −t was specified or did not support command line file arguments with the −t option.
15647 For consistency and simplicity of specification, IEEE Std 1003.1-2001 disallows these special
15648 cases, and requires that recovery be attempted the first time each file is edited.

15649 Historically, vi initialized the ‘ and ’ marks, but ex did not. This meant that if the first command
15650 in ex mode was visual or if an ex command was executed first (for example, vi +10 file), vi was
15651 entered without the marks being initialized. Because the standard developers believed the marks
15652 to be generally useful, and for consistency and simplicity of specification, IEEE Std 1003.1-2001
15653 requires that they always be initialized if in open or visual mode, or if in ex mode and the edit
15654 buffer is not empty. Not initializing it in ex mode if the edit buffer is empty is historical practice;
15655 however, it has always been possible to set (and use) marks in empty edit buffers in open and
15656 visual mode edit sessions.

15657 Addressing

15658 Historically, ex and vi accepted the additional addressing forms \ and ?. They were
15659 equivalent to // and ??, respectively. They are not required by IEEE Std 1003.1-2001,
15660 mostly because nobody can remember whether they ever did anything different historically.

15661 Historically, ex and vi permitted an address of zero for several commands, and permitted the %
15662 address in empty files for others. For consistency, IEEE Std 1003.1-2001 requires support for the
15663 former in the few commands where it makes sense, and disallows it otherwise. In addition,
15664 because IEEE Std 1003.1-2001 requires that % be logically equivalent to "1, $", it is also
15665 supported where it makes sense and disallowed otherwise.

15666 Historically, the % address could not be followed by further addresses. For consistency and
15667 simplicity of specification, IEEE Std 1003.1-2001 requires that additional addresses be supported.

15668 All of the following are valid addresses:

```
+++ Three lines after the current line.
/re/- One line before the next occurrence of re.
-2 Two lines before the current line.
3 ---- 2 Line one (note intermediate negative address).
1 2 3 Line six.
```

15670 Any number of addresses can be provided to commands taking addresses; for example,
15671 "1, 2, 3, 4, 5p" prints lines 4 and 5, because two is the greatest valid number of addresses
15672 accepted by the print command. This, in combination with the semicolon delimiter, permits
15673 users to create commands based on ordered patterns in the file. For example, the command
15674 3/foo/+/2print will display the first line after line 3 that contains the pattern foo, plus the next
15675 two lines. Note that the address 3; must be evaluated before being discarded because the search
origin for the /foo/ command depends on this.

Historically, values could be added to addresses by including them after one or more <blank>s; for example, 3 – 5p wrote the seventh line of the file, and /foo/ 5 was the same as /foo/+5. However, only absolute values could be added; for example, 5 /foo/ was an error.

IEEE Std 1003.1-2001 requires conformance to historical practice. Address offsets are separately specified from addresses because they could historically be provided to visual mode search commands.

Historically, any missing addresses defaulted to the current line. This was true for leading and trailing comma-delimited addresses, and for trailing semicolon-delimited addresses. For consistency, IEEE Std 1003.1-2001 requires it for leading semicolon addresses as well.

Historically, ex and vi accepted the ‘ˆ’ character as both an address and as a flag offset for commands. In both cases it was identical to the ‘−’ character. IEEE Std 1003.1-2001 does not require or prohibit this behavior.

Historically, the enhancements to basic regular expressions could be used in addressing; for example, ‘ˆ’, '\<', and '\>’. IEEE Std 1003.1-2001 requires conformance to historical practice; that is, that regular expression usage be consistent, and that regular expression enhancements be supported wherever regular expressions are used.

Command Line Parsing in ex

Historical ex command parsing was even more complex than that described here. IEEE Std 1003.1-2001 requires the subset of the command parsing that the standard developers believed was documented and that users could reasonably be expected to use in a portable fashion, and that was historically consistent between implementations. (The discarded functionality is obscure, at best.) Historical implementations will require changes in order to comply with IEEE Std 1003.1-2001; however, users are not expected to notice any of these changes. Most of the complexity in ex parsing is to handle three special termination cases:

1. The !, global, v, and the filter versions of the read and write commands are delimited by <newline>s (they can contain vertical-line characters that are usually shell pipes).

2. The ex, edit, next, and visual in open and visual mode commands all take ex commands, optionally containing vertical-line characters, as their first arguments.

3. The s command takes a regular expression as its first argument, and uses the delimiting characters to delimit the command.

Historically, vertical-line characters in the +command argument of the ex, edit, next, vi, and visual commands, and in the pattern and replacement parts of the s command, did not delimit the command, and in the filter cases for read and write, and the !, global, and v commands, they did not delimit the command at all. For example, the following commands are all valid:

```
:edit +25 | s/abc/ABC/ file.c
:s/ | /PIPE/
:read !spell % | columnate
:global/pattern/p | l
:s/a/b/ | s/c/d | set
```

Historically, empty or <blank> filled lines in .exrc files and sourced files (as well as EXINIT variables and ex command scripts) were treated as default commands; that is, print commands. IEEE Std 1003.1-2001 specifically requires that they be ignored when encountered in .exrc and sourced files to eliminate a common source of new user error.
Historically, *ex* commands with multiple adjacent (or <blank>-separated) vertical lines were handled oddly when executed from *ex* mode. For example, the command `||<carriage-return>`, when the cursor was on line 1, displayed lines 2, 3, and 5 of the file. In addition, the command `|` would only display the line after the next line, instead of the next two lines. The former worked more logically when executed from *vi* mode, and displayed lines 2, 3, and 4.

IEEE Std 1003.1-2001 requires the *vi* behavior; that is, a single default command and line number increment for each command separator, and trailing <newline>s after vertical-line separators are discarded.

Historically, *ex* permitted a single extra colon as a leading command character; for example, `:g/pattern:/p` was a valid command. IEEE Std 1003.1-2001 generalizes this to require that any number of leading colon characters be stripped.

Historically, any prefix of the delete command could be followed without intervening <blank>s by a flag character because in the command `d p`, `p` is interpreted as the buffer `p`. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the `k` command could be followed by the mark name without intervening <blank>s. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the `s` command could be immediately followed by flag and option characters; for example, `s/e/E/|s|sgc3p` was a valid command. However, flag characters could not stand alone; for example, the commands `sp` and `s 1` would fail, while the command `sgp` and `sg l` would succeed. (Obviously, the `'#'` flag character was used as a delimiter character if it followed the command.) Another issue was that option characters had to precede flag characters even when the command was fully specified; for example, the command `s/e/E/pg` would fail, while the command `s/e/E/gp` would succeed. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the first command name that had a prefix matching the input from the user was the executed command; for example, `ve`, `ver`, and `vers` all executed the version command. Commands were in a specific order, however, so that `a` matched append, not abbreviate. IEEE Std 1003.1-2001 requires conformance to historical practice. The restriction on command search order for implementations with extensions is to avoid the addition of commands such that the historical prefixes would fail to work portably.

Historical implementations of *ex* and *vi* did not correctly handle multiple *ex* commands, separated by vertical-line characters, that entered or exited visual mode or the editor. Because implementations of *vi* exist that do not exhibit this failure mode, IEEE Std 1003.1-2001 does not permit it.

The requirement that alphabetic command names consist of all following alphabetic characters up to the next non-alphabetic character means that alphabetic command names must be separated from their arguments by one or more non-alphabetic characters, normally a <blank> or `'#'` character, except as specified for the exceptions, the delete, k, and s commands.

Historically, the repeated execution of the *ex* default print commands (<control>-D,_eof,<newline>,<carriage-return>) erased any prompting character and displayed the next lines without scrolling the terminal; that is, immediately below any previously displayed lines. This provided a cleaner presentation of the lines in the file for the user. IEEE Std 1003.1-2001 does not require this behavior because it may be impossible in some situations; however, implementations are strongly encouraged to provide this semantic if possible.

Historically, it was possible to change files in the middle of a command, and have the rest of the command executed in the new file; for example:
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```bash
:edit +25 file.c | s/abc/ABC/ | 1
```

was a valid command, and the substitution was attempted in the newly edited file.
IEEE Std 1003.1-2001 requires conformance to historical practice. The following commands are
examples that exercise the `ex` parser:

```bash
echo 'foo | bar' > file1; echo 'foo/bar' > file2;
vi
:edit +1 | s/|/PIPE/ | w file1 | e file2 | 1 | s/\//SLASH/ | wq
```

Historically, there was no protection in editor implementations to avoid `ex` **global**, `v`, @, or `*`
commands changing edit buffers during execution of their associated commands. Because this
would almost invariably result in catastrophic failure of the editor, and implementations exist
that do exhibit these problems, IEEE Std 1003.1-2001 requires that changing the edit buffer
during a **global** or `v` command, or during a @ or `*` command for which there will be more than a
single execution, be an error. Implementations supporting multiple edit buffers simultaneously
are strongly encouraged to apply the same semantics to switching between buffers as well.

The `ex` command quoting required by IEEE Std 1003.1-2001 is a superset of the quoting in
historical implementations of the editor. For example, it was not historically possible to escape a
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during a **global** or `v` command, or during a @ or `*` command for which there will be more than a
single execution, be an error. Implementations supporting multiple edit buffers simultaneously
are strongly encouraged to apply the same semantics to switching between buffers as well.
map = foo<control-V><newline>bar

would succeed, although it was sometimes difficult to get the <control>-V and the inserted <newline> passed to the ex parser. For consistency and simplicity of specification, IEEE Std 1003.1-2001 requires that it be possible to escape <newline>s in ex commands at all times, using backslashes for most ex commands, and using <control>-V characters for the map and abbreviation commands. For example, the command print<newline>list is required to be parsed as the single command print<newline>list. While this differs from historical practice, IEEE Std 1003.1-2001 developers believed it unlikely that any script or user depended on the historical behavior.

Historically, an error in a command specified using the −c option did not cause the rest of the −c commands to be discarded. IEEE Std 1003.1-2001 disallows this for consistency with mapped keys, the @, global, source, and v commands, the EXINIT environment variable, and the .exrc files.

Input Editing in ex

One of the common uses of the historical ex editor is over slow network connections. Editors that run in canonical mode can require far less traffic to and from, and far less processing on, the host machine, as well as more easily supporting block-mode terminals. For these reasons, IEEE Std 1003.1-2001 requires that ex be implemented using canonical mode input processing, as was done historically.

IEEE Std 1003.1-2001 does not require the historical 4 BSD input editing characters “word erase” or “literal next”. For this reason, it is unspecified how they are handled by ex, although they must have the required effect. Implementations that resolve them after the line has been ended using a <newline> or <control>-M character, and implementations that rely on the underlying system terminal support for this processing, are both conforming. Implementations are strongly urged to use the underlying system functionality, if at all possible, for compatibility with other system text input interfaces.

Historically, when the eof character was used to decrement the autoindent level, the cursor moved to display the new end of the autoindent characters, but did not move the cursor to a new line, nor did it erase the <control>-D character from the line. IEEE Std 1003.1-2001 does not specify that the cursor remain on the same line or that the rest of the line is erased; however, implementations are strongly encouraged to provide the best possible user interface; that is, the cursor should remain on the same line, and any <control>-D character on the line should be erased.

IEEE Std 1003.1-2001 does not require the historical 4 BSD input editing character “reprint”, traditionally <control>-R, which redisplayed the current input from the user. For this reason, and because the functionality cannot be implemented after the line has been terminated by the user, IEEE Std 1003.1-2001 makes no requirements about this functionality. Implementations are strongly urged to make this historical functionality available, if possible.

Historically, <control>-Q did not perform a literal next function in ex, as it did in vi. IEEE Std 1003.1-2001 requires conformance to historical practice to avoid breaking historical ex scripts and .exrc files.
Whether the \textit{eof} character immediately modifies the \texttt{autoindent} characters in the prompt is left unspecified so that implementations can conform in the presence of systems that do not support this functionality. Implementations are encouraged to modify the line and redisplay it immediately, if possible.

The specification of the handling of the \textit{eof} character differs from historical practice only in that \textit{eof} characters are not discarded if they follow normal characters in the text input. Historically, they were always discarded.

\textbf{Command Descriptions in ex}

Historically, several commands (for example, \texttt{global}, \texttt{v}, \texttt{visual}, \texttt{s}, \texttt{write}, \texttt{wq}, \texttt{yank}, \texttt{!,}, \texttt{<}, \texttt{>}, \texttt{&}, and \texttt{~}) were executable in empty files (that is, the default address(es) were 0), or permitted explicit addresses of 0 (for example, 0 was a valid address, or 0,0 was a valid range). Addresses of 0, or command execution in an empty file, make sense only for commands that add new text to the edit buffer or write commands (because users may wish to write empty files). IEEE Std 1003.1-2001 requires this behavior for such commands and disallows it otherwise, for consistency and simplicity of specification.

A count to an \texttt{ex} command has been historically corrected to be no greater than the last line in a file; for example, in a five-line file, the command 1,6\texttt{print} would fail, but the command 1\texttt{print300} would succeed. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the use of flags in \texttt{ex} commands could be obscure. General historical practice was as described by IEEE Std 1003.1-2001, but there were some special cases. For instance, the \texttt{list}, \texttt{number}, and \texttt{print} commands ignored trailing address offsets; for example, \texttt{3p +++#} would display line 3, and 3 would be the current line after the execution of the command. The \texttt{open} and \texttt{visual} commands ignored both the trailing offsets and the trailing flags. Also, flags specified to the \texttt{open} and \texttt{visual} commands interacted badly with the \texttt{list} edit option, and setting and then unsetting it during the open/visual session would cause \texttt{vi} to stop displaying lines in the specified format. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit any of these exceptions to the general rule.

IEEE Std 1003.1-2001 uses the word \textit{copy} in several places when discussing buffers. This is not intended to imply implementation.

Historically, \texttt{ex} users could not specify numeric buffers because of the ambiguity this would cause; for example, in the command 3 delete 2, it is unclear whether 2 is a buffer name or a \texttt{count}. IEEE Std 1003.1-2001 requires conformance to historical practice by default, but does not preclude extensions.

Historically, the contents of the unnamed buffer were frequently discarded after commands that did not explicitly affect it; for example, when using the \texttt{edit} command to switch files. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

The \texttt{ex} utility did not historically have access to the numeric buffers, and, furthermore, deleting lines in \texttt{ex} did not modify their contents. For example, if, after doing a delete in \texttt{vi}, the user switched to \texttt{ex}, did another delete, and then switched back to \texttt{vi}, the contents of the numeric buffers would not have changed. IEEE Std 1003.1-2001 requires conformance to historical practice. Numeric buffers are described in the \texttt{ex} utility in order to confine the description of buffers to a single location in IEEE Std 1003.1-2001.

The metacharacters that trigger shell expansion in \texttt{file} arguments match historical practice, as does the method for doing shell expansion. Implementations wishing to provide users with the flexibility to alter the set of metacharacters are encouraged to provide a \texttt{shellmeta} string edit
option.

Historically, _ex_ commands executed from _vi_ refreshed the screen when it did not strictly need to do so; for example, `date > /dev/null` does not require a screen refresh because the output of the UNIX _date_ command requires only a single line of the screen. IEEE Std 1003.1-2001 requires that the screen be refreshed if it has been overwritten, but makes no requirements as to how an implementation should make that determination. Implementations may prompt and refresh the screen regardless.

**Abbreviate**

Historical practice was that characters that were entered as part of an abbreviation replacement were subject to _map_ expansions, the _showmatch_ edit option, further abbreviation expansions, and so on; that is, they were logically pushed onto the terminal input queue, and were not a simple replacement. IEEE Std 1003.1-2001 requires conformance to historical practice. Historical practice was that whenever a non-word character (that had not been escaped by a <control>-V) was entered after a word character, _vi_ would check for abbreviations. The check was based on the type of the character entered before the word character of the word/non-word pair that triggered the check. The word character of the word/non-word pair that triggered the check and all characters entered before the trigger pair that were of that type were included in the check, with the exception of <blank>s, which always delimited the abbreviation.

This means that, for the abbreviation to work, the _lhs_ must end with a word character, there can be no transitions from word to non-word characters (or _vice versa_) other than between the last and next-to-last characters in the _lhs_, and there can be no <blank>s in the _lhs_. In addition, because of the historical quoting rules, it was impossible to enter a literal <control>-V in the _lhs_. IEEE Std 1003.1-2001 requires conformance to historical practice. Historical implementations did not inform users when abbreviations that could never be used were entered; implementations are strongly encouraged to do so.

For example, the following abbreviations will work:

- `:ab (p REPLACE`
- `:ab p  REPLACE`
- `:ab ((p REPLACE`

The following abbreviations will not work:

- `:ab ( Replace`
- `:ab (pp REPLACE`

Historical practice is that words on the _vi_ colon command line were subject to abbreviation expansion, including the arguments to the _abbrev_ (and more interestingly) the _unabbrev_ command. Because there are implementations that do not do abbreviation expansion for the first argument to those commands, this is permitted, but not required, by IEEE Std 1003.1-2001. However, the following sequence:

- `:ab foo bar`
- `:ab foo baz`

resulted in the addition of an abbreviation of "baz" for the string "bar" in historical _ex/vi_, and the sequence:

- `:ab foo1 bar`
- `:ab foo2 bar`
- `:unabbreviate foo2`
deleted the abbreviation "foo1", not "foo2". These behaviors are not permitted by IEEE Std 1003.1-2001 because they clearly violate the expectations of the user.

It was historical practice that <control>-V, not backslash, characters be interpreted as escaping subsequent characters in the abbreviate command. IEEE Std 1003.1-2001 requires conformance to historical practice; however, it should be noted that an abbreviation containing a <blank> will never work.

Append

Historically, any text following a vertical-line command separator after an append, change, or insert command became part of the insert text. For example, in the command:

```
:g/pattern/append|stuff1
```

a line containing the text "stuff1" would be appended to each line matching pattern. It was also historically valid to enter:

```
:append|stuff1
stuff2
```

and the text on the ex command line would be appended along with the text inserted after it. There was an historical bug, however, that the user had to enter two terminating lines (the ‘.’ lines) to terminate text input mode in this case. IEEE Std 1003.1-2001 requires conformance to historical practice, but disallows the historical need for multiple terminating lines.

Change

See the RATIONALE for the append command. Historical practice for cursor positioning after the change command when no text is input, is as described in IEEE Std 1003.1-2001. However, one System V implementation is known to have been modified such that the cursor is positioned on the first address specified, and not on the line before the first address. IEEE Std 1003.1-2001 disallows this modification for consistency.

Historically, the change command did not support buffer arguments, although some implementations allow the specification of an optional buffer. This behavior is neither required nor disallowed by IEEE Std 1003.1-2001.

Change Directory

A common extension in ex implementations is to use the elements of a cdpath edit option as prefix directories for path arguments to chdir that are relative pathnames and that do not have ‘.’ or "." as their first component. Elements in the cdpath edit option are colon-separated. The initial value of the cdpath edit option is the value of the shell CDPATH environment variable. This feature was not included in IEEE Std 1003.1-2001 because it does not exist in any of the implementations considered historical practice.

Copy

Historical implementations of ex permitted copies to lines inside of the specified range; for example, 2,5copy3 was a valid command. IEEE Std 1003.1-2001 requires conformance to historical practice.
Delete

IEEE Std 1003.1-2001 requires support for the historical parsing of a delete command followed by flags, without any intervening <blank>s. For example:

1dp  Deletes the first line and prints the line that was second.
1delep  As for 1dp.
1d    Deletes the first line, saving it in buffer p.
1d p1l (Pee-one-ell.) Deletes the first line, saving it in buffer p, and listing the line that was second.

Edit

Historically, any ex command could be entered as a +command argument to the edit command, although some (for example, insert and append) were known to confuse historical implementations. For consistency and simplicity of specification, IEEE Std 1003.1-2001 requires that any command be supported as an argument to the edit command.

Historically, the command argument was executed with the current line set to the last line of the file, regardless of whether the edit command was executed from visual mode or not. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the +command specified to the edit and next commands was delimited by the first <blank>, and there was no way to quote them. For consistency, IEEE Std 1003.1-2001 requires that the usual ex backslash quoting be provided.

Historically, specifying the +command argument to the edit command required a filename to be specified as well; for example, \edit +100 would always fail. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this usage to fail for that reason.

Historically, only the cursor position of the last file edited was remembered by the editor. IEEE Std 1003.1-2001 requires that this be supported; however, implementations are permitted to remember and restore the cursor position for any file previously edited.

File

Historical versions of the ex editor file command displayed a current line and number of lines in the edit buffer of 0 when the file was empty, while the vi <control>-G command displayed a current line and number of lines in the edit buffer of 1 in the same situation. IEEE Std 1003.1-2001 does not permit this discrepancy, instead requiring that a message be displayed indicating that the file is empty.

Global

The two-pass operation of the global and v commands is not intended to imply implementation, only the required result of the operation.

The current line and column are set as specified for the individual ex commands. This requirement is cumulative; that is, the current line and column must track across all the commands executed by the global or v commands.
Insert

See the RATIONALE for the `append` command.

Historically, `insert` could not be used with an address of zero; that is, not when the edit buffer was empty. IEEE Std 1003.1-2001 requires that this command behave consistently with the `append` command.

Join

The action of the `join` command in relation to the special characters is only defined for the POSIX locale because the correct amount of white space after a period varies; in Japanese none is required, in French only a single space, and so on.

List

The historical output of the `list` command was potentially ambiguous. The standard developers believed correcting this to be more important than adhering to historical practice, and IEEE Std 1003.1-2001 requires unambiguous output.

Map

Historically, command mode maps only applied to command names; for example, if the character "x" was mapped to "y", the command `fx` searched for the "x" character, not the "y" character. IEEE Std 1003.1-2001 requires this behavior. Historically, entering `<control>-V` as the first character of a `vi` command was an error. Several implementations have extended the semantics of `vi` such that `<control>-V` means that the subsequent command character is not mapped. This is permitted, but not required, by IEEE Std 1003.1-2001. Regardless, using `<control>-V` to escape the second or later character in a sequence of characters that might match a `map` command, or any character in text input mode, is historical practice, and stops the entered keys from matching a map. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historical implementations permitted digits to be used as a `map` command `lhs`, but then ignored the map. IEEE Std 1003.1-2001 requires that the mapped digits not be ignored.

The historical implementation of the `map` command did not permit `map` commands that were more than a single character in length if the first character was printable. This behavior is permitted, but not required, by IEEE Std 1003.1-2001.

Historically, mapped characters were remapped unless the `remap` edit option was not set, or the prefix of the mapped characters matched the mapping characters; for example, in the `map`:

```
:map ab abcd
```

the characters "ab" were used as is and were not remapped, but the characters "cd" were mapped if appropriate. This can cause infinite loops in the `vi` mapping mechanisms. IEEE Std 1003.1-2001 requires conformance to historical practice, and that such loops be interruptible.

Text input maps had the same problems with expanding the `lhs` for the `ex map!` and `unmap!` command as did the `ex abbreviate` and `unabbreviate` commands. See the RATIONALE for the `ex abbreviate` command. IEEE Std 1003.1-2001 requires similar modification of some historical practice for the `map` and `unmap` commands, as described for the `abbreviate` and `unabbreviate` commands.

Historically, `maps` that were subsets of other `maps` behaved differently depending on the order in which they were defined. For example:
Utilities

would always translate the characters "ab" to "short", regardless of how fast the characters "abc" were entered. If the entry order was reversed:

the characters "ab" would cause the editor to pause, waiting for the completing 'c' character, and the characters might never be mapped to "short". For consistency and simplicity of specification, IEEE Std 1003.1-2001 requires that the shortest match be used at all times.

The length of time the editor spends waiting for the characters to complete the lhs is unspecified because the timing capabilities of systems are often inexact and variable, and it may depend on other factors such as the speed of the connection. The time should be long enough for the user to be able to complete the sequence, but not long enough for the user to have to wait. Some implementations of vi have added a keytime option, which permits users to set the number of 0,1 seconds the editor waits for the completing characters. Because mapped terminal function and cursor keys tend to start with an <ESC> character, and <ESC> is the key ending vi text input mode, maps starting with <ESC> characters are generally exempted from this timeout period, or, at least timed out differently.

Mark

Historically, users were able to set the "previous context" marks explicitly. In addition, the ex commands '' and '' and the vi commands '' , '' , and '' all referred to the same mark. In addition, the previous context marks were not set if the command, with which the address setting the mark was associated, failed. IEEE Std 1003.1-2001 requires conformance to historical practice. Historically, if marked lines were deleted, the mark was also deleted, but would reappear if the change was undone. IEEE Std 1003.1-2001 requires conformance to historical practice.

The description of the special events that set the ' ' and ' ' marks matches historical practice. For example, historically the command /a/,/b/ did not set the ' ' and ' ' marks, but the command /a/,/b/delete did.

Next

Historically, any ex command could be entered as a +command argument to the next command, although some (for example, insert and append) were known to confuse historical implementations. IEEE Std 1003.1-2001 requires that any command be permitted and that it behave as specified. The next command can accept more than one file, so usage such as:

next 'ls [abc] '

is valid; it need not be valid for the edit or read commands, for example, because they expect only one filename.

Historically, the next command behaved differently from the :rewind command in that it ignored the force flag if the autowrite flag was set. For consistency, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, the next command positioned the cursor as if the file had never been edited before, regardless. IEEE Std 1003.1-2001 does not permit this behavior, for consistency with the edit command.

Implementations wanting to provide a counterpart to the next command that edited the previous file have used the command previous, which takes no file argument.
IEEE Std 1003.1-2001 does not require this command.

Open
Historically, the open command would fail if the open edit option was not set. IEEE Std 1003.1-2001 does not mention the open edit option and does not require this behavior. Some historical implementations do not permit entering open mode from open or visual mode, only from ex mode. For consistency, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, entering open mode from the command line (that is, vi +open) resulted in anomalous behaviors; for example, the ex file and set commands, and the vi command <control>-G did not work. For consistency, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, the open command only permitted ' /' characters to be used as the search pattern delimiter. For consistency, IEEE Std 1003.1-2001 requires that the search delimiters used by the s, global, and v commands be accepted as well.

Preserve
The preserve command does not historically cause the file to be considered unmodified for the purposes of future commands that may exit the editor. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historical documentation stated that mail was not sent to the user when preserve was executed; however, historical implementations did send mail in this case. IEEE Std 1003.1-2001 requires conformance to the historical implementations.

Print
The writing of NUL by the print command is not specified as a special case because the standard developers did not want to require ex to support NUL characters. Historically, characters were displayed using the ARPA standard mappings, which are as follows:

1. Printable characters are left alone.
2. Control characters less than \177 are represented as ‘^’ followed by the character offset from the ‘@’ character in the ASCII map; for example, \007 is represented as ‘^G’.
3. \177 is represented as ‘^’ followed by ‘?’.

The display of characters having their eighth bit set was less standard. Existing implementations use hex (0x00), octal (\000), and a meta-bit display. (The latter displayed bytes that had their eighth bit set as the two characters "M-" followed by the seven-bit display as described above.) The latter probably has the best claim to historical practice because it was used for the -v option of 4 BSD and 4 BSD-derived versions of the cat utility since 1980.

No specific display format is required by IEEE Std 1003.1-2001.

Explicit dependence on the ASCII character set has been avoided where possible, hence the use of the phrase an “implementation-defined multi-character sequence” for the display of non-printable characters in preference to the historical usage of, for instance, "^I" for the <tab>. Implementations are encouraged to conform to historical practice in the absence of any strong reason to diverge.

Historically, all ex commands beginning with the letter ‘p’ could be entered using capitalized versions of the commands; for example, P[rint], Pr[eserve], and Pu[lt] were all valid command names. IEEE Std 1003.1-2001 permits, but does not require, this historical practice because capital forms of the commands are used by some implementations for other purposes.
Put

Historically, an `ex put` command, executed from open or visual mode, was the same as the open or visual mode `P` command, if the buffer was named and was cut in character mode, and the same as the `p` command if the buffer was named and cut in line mode. If the unnamed buffer was the source of the text, the entire line from which the text was taken was usually `put`, and the buffer was handled as if in line mode, but it was possible to get extremely anomalous behavior. In addition, using the `Q` command to switch into `ex` mode, and then doing a `put` often resulted in errors as well, such as appending text that was unrelated to the (supposed) contents of the buffer. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit these behaviors. All `ex put` commands are required to operate in line mode, and the contents of the buffers are not altered by changing the mode of the editor.

Read

Historically, an `ex read` command executed from open or visual mode, executed in an empty file, left an empty line as the first line of the file. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior. Historically, a `read` in open or visual mode from a program left the cursor at the last line read in, not the first. For consistency, IEEE Std 1003.1-2001 does not permit this behavior.

Historical implementations of `ex` were unable to undo `read` commands that read from the output of a program. For consistency, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, the `ex` and `vi` message after a successful `read` or `write` command specified “characters”, not “bytes”. IEEE Std 1003.1-2001 requires that the number of bytes be displayed, not the number of characters, because it may be difficult in multi-byte implementations to determine the number of characters read. Implementations are encouraged to clarify the message displayed to the user.

Historically, reads were not permitted on files other than type regular, except that FIFO files could be read (probably only because they did not exist when `ex` and `vi` were originally written). Because the historical `ex` evaluated `read!` and `read !` equivalently, there can be no optional way to force the read. IEEE Std 1003.1-2001 permits, but does not require, this behavior.

Recover

Some historical implementations of the editor permitted users to recover the edit buffer contents from a previous edit session, and then exit without saving those contents (or explicitly discarding them). The intent of IEEE Std 1003.1-2001 in requiring that the edit buffer be treated as already modified is to prevent this user error.

Rewind

Historical implementations supported the `rewind` command when the user was editing the first file in the list; that is, the file that the `rewind` command would edit. IEEE Std 1003.1-2001 requires conformance to historical practice.
Historically, `ex` accepted an `r` option to the `s` command. The effect of the `r` option was to use the last regular expression used in any command as the pattern, the same as the `˜` command. The `r` option is not required by IEEE Std 1003.1-2001. Historically, the `c` and `g` options were toggled; for example, the command `:s/abc/def/` was the same as `s/abc/def/cccggg`. For simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

The tilde command is often used to replace the last search RE. For example, in the sequence:

```
s/red/blue/
/green
~
```

the `˜` command is equivalent to:

```
s/green/blue/
```

Historically, `ex` accepted all of the following forms:

```
s/abc/def/
s/abc/def
s/abc/
s/abc
```

IEEE Std 1003.1-2001 requires conformance to this historical practice.

The `s` command presumes that the `ˆ` character only occupies a single column in the display. Much of the `ex` and `vi` specification presumes that the `<space>` only occupies a single column in the display. There are no known character sets for which this is not true.

Historically, the final column position for the substitute commands was based on previous column movements; a search for a pattern followed by a substitution would leave the column position unchanged, while a `0` command followed by a substitution would change the column position to the first non-<blank>. For consistency and simplicity of specification, IEEE Std 1003.1-2001 requires that the final column position always be set to the first non-<blank>.

Set

Historical implementations redisplayed all of the options for each occurrence of the `all` keyword. IEEE Std 1003.1-2001 permits, but does not require, this behavior.

Tag

No requirement is made as to where `ex` and `vi` shall look for the file referenced by the tag entry. Historical practice has been to look for the path found in the `tags` file, based on the current directory. A useful extension found in some implementations is to look based on the directory containing the tags file that held the entry, as well. No requirement is made as to which reference for the tag in the tags file is used. This is deliberate, in order to permit extensions such as multiple entries in a tags file for a tag.

Because users often specify many different tags files, some of which need not be relevant or exist at any particular time, IEEE Std 1003.1-2001 requires that error messages about problem tags files be displayed only if the requested tag is not found, and then, only once for each time that the `tag` edit option is changed.

The requirement that the current edit buffer be unmodified is only necessary if the file indicated by the tag entry is not the same as the current file (as defined by the current pathname).
Historically, the file would be reloaded if the filename had changed, as well as if the filename was different from the current pathname. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior, requiring that the name be the only factor in the decision.

Historically, vi only searched for tags in the current file from the current cursor to the end of the file, and therefore, if the wrapscan option was not set, tags occurring before the current cursor were not found. IEEE Std 1003.1-2001 considers this a bug, and implementations are required to search for the first occurrence in the file, regardless.

**Undo**

The undo description deliberately uses the word “modified”. The undo command is not intended to undo commands that replace the contents of the edit buffer, such as edit, next, tag, or recover.

Cursor positioning after the undo command was inconsistent in the historical vi, sometimes attempting to restore the original cursor position (global, undo, and v commands), and sometimes, in the presence of maps, placing the cursor on the last line added or changed instead of the first. IEEE Std 1003.1-2001 requires a simplified behavior for consistency and simplicity of specification.

**Version**

The version command cannot be exactly specified since there is no widely-accepted definition of what the version information should contain. Implementations are encouraged to do something reasonably intelligent.

**Write**

Historically, the ex and vi message after a successful read or write command specified “characters”, not “bytes”. IEEE Std 1003.1-2001 requires that the number of bytes be displayed, not the number of characters because it may be difficult in multi-byte implementations to determine the number of characters written. Implementations are encouraged to clarify the message displayed to the user.

Implementation-defined tests are permitted so that implementations can make additional checks; for example, for locks or file modification times.

Historically, attempting to append to a nonexistent file caused an error. It has been left unspecified in IEEE Std 1003.1-2001 to permit implementations to let the write succeed, so that the append semantics are similar to those of the historical csh.

Historical vi permitted empty edit buffers to be written. However, since the way vi got around dealing with “empty” files was to always have a line in the edit buffer, no matter what, it wrote them as files of a single, empty line. IEEE Std 1003.1-2001 does not permit this behavior.

Historically, ex restored standard output and standard error to their values as of when ex was invoked, before writes to programs were performed. This could disturb the terminal configuration as well as be a security issue for some terminals. IEEE Std 1003.1-2001 does not permit this, requiring that the program output be captured and displayed as if by the ex print command.
Utilities

Adjust Window

Historically, the line count was set to the value of the scroll option if the type character was end-of-file. This feature was broken on most historical implementations long ago, however, and is not documented anywhere. For this reason, IEEE Std 1003.1-2001 is resolutely silent.

Historically, the z command was <blank>-sensitive and z+ and z− did different things than z+. (The commands z . and z = were historically invalid.) IEEE Std 1003.1-2001 requires conformance to this historical practice.

Historically, the z command was further <blank>-sensitive in that the count could not be <blank>-delimited; for example, the commands z= 5 and z− 5 were also invalid. Because the count is not ambiguous with respect to either the type character or the flags, this is not permitted by IEEE Std 1003.1-2001.

Escape

Historically, ex filter commands only read the standard output of the commands, letting standard error appear on the terminal as usual. The vi utility, however, read both standard output and standard error. IEEE Std 1003.1-2001 requires the latter behavior for both ex and vi, for consistency.

Shift Left and Shift Right

Historically, it was possible to add shift characters to increase the effect of the command; for example, <<< outdented (or >>> indented) the lines 3 levels of indentation instead of the default 1. IEEE Std 1003.1-2001 requires conformance to historical practice.

<control>-D

Historically, the <control>-D command erased the prompt, providing the user with an unbroken presentation of lines from the edit buffer. This is not required by IEEE Std 1003.1-2001; implementations are encouraged to provide it if possible. Historically, the <control>-D command took, and then ignored, a count. IEEE Std 1003.1-2001 does not permit this behavior.

Write Line Number

Historically, the ex = command, when executed in ex mode in an empty edit buffer, reported 0, and from open or visual mode, reported 1. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Execute

Historically, ex did not correctly handle the inclusion of text input commands (that is, append, insert, and change) in executed buffers. IEEE Std 1003.1-2001 does not permit this exclusion for consistency.

Historically, the logical contents of the buffer being executed did not change if the buffer itself were modified by the commands being executed; that is, buffer execution did not support self-modifying code. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the @ command took a range of lines, and the @ buffer was executed once per line, with the current line (’ .’ ) set to each specified line. IEEE Std 1003.1-2001 requires conformance to historical practice.

Some historical implementations did not notice if errors occurred during buffer execution. This, coupled with the ability to specify a range of lines for the ex @ command, makes it trivial to cause them to drop core. IEEE Std 1003.1-2001 requires that implementations stop buffer
execution if any error occurs, if the specified line doesn’t exist, or if the contents of the edit buffer itself are replaced (for example, the buffer executes the `ex:edit` command).

**Regular Expressions in ex**

Historical practice is that the characters in the replacement part of the last `s` command—that is, those matched by entering a ‘˜’ in the regular expression—were not further expanded by the regular expression engine. So, if the characters contained the string "a . ," they would match ‘a’ followed by ". ," and not ‘a’ followed by any character. IEEE Std 1003.1-2001 requires conformance to historical practice.

**Edit Options in ex**

The following paragraphs describe the historical behavior of some edit options that were not, for whatever reason, included in IEEE Std 1003.1-2001. Implementations are strongly encouraged to only use these names if the functionality described here is fully supported.

- **extended** The *extended* edit option has been used in some implementations of *vi* to provide extended regular expressions instead of basic regular expressions. This option was omitted from IEEE Std 1003.1-2001 because it is not widespread historical practice.

- **flash** The *flash* edit option historically caused the screen to flash instead of beeping on error. This option was omitted from IEEE Std 1003.1-2001 because it is not found in some historical implementations.

- **hardtabs** The *hardtabs* edit option historically defined the number of columns between hardware tab settings. This option was omitted from IEEE Std 1003.1-2001 because it was believed to no longer be generally useful.

- **modeline** The *modeline* (sometimes named *modelines*) edit option historically caused *ex* or *vi* to read the five first and last lines of the file for editor commands. This option is a security problem, and vendors are strongly encouraged to delete it from historical implementations.

- **open** The *open* edit option historically disallowed the *ex open* and *visual* commands. This edit option was omitted because these commands are required by IEEE Std 1003.1-2001.

- **optimize** The *optimize* edit option historically expedited text throughput by setting the terminal to not do automatic `<carriage-return>`s when printing more than one logical line of output. This option was omitted from IEEE Std 1003.1-2001 because it was intended for terminals without addressable cursors, which are rarely, if ever, still used.

- **ruler** The *ruler* edit option has been used in some implementations of *vi* to present a current row/column ruler for the user. This option was omitted from IEEE Std 1003.1-2001 because it is not widespread historical practice.

- **sourceany** The *sourceany* edit option historically caused *ex* or *vi* to source start-up files that were owned by users other than the user running the editor. This option is a security problem, and vendors are strongly encouraged to remove it from their implementations.

- **timeout** The *timeout* edit option historically enabled the (now standard) feature of only waiting for a short period before returning keys that could be part of a macro. This feature was omitted from IEEE Std 1003.1-2001 because its behavior is now standard, it is not widely useful, and it was rarely documented.
The **verbose** edit option has been used in some implementations of *vi* to cause *vi* to output error messages for common errors; for example, attempting to move the cursor past the beginning or end of the line instead of only alerting the screen. (The historical *vi* only alerted the terminal and presented no message for such errors. The historical editor option **terse** did not select when to present error messages, it only made existing error messages more or less verbose.) This option was omitted from IEEE Std 1003.1-2001 because it is not widespread historical practice; however, implementors are encouraged to use it if they wish to provide error messages for naive users.

The **wraplen** edit option has been used in some implementations of *vi* to specify an automatic margin measured from the left margin instead of from the right margin. This is useful when multiple screen sizes are being used to edit a single file. This option was omitted from IEEE Std 1003.1-2001 because it is not widespread historical practice; however, implementors are encouraged to use it if they add this functionality.

**autoindent, ai**

Historically, the command `0a` did not do any autoindentation, regardless of the current indentation of line 1. IEEE Std 1003.1-2001 requires that any indentation present in line 1 be used.

**autoprint, ap**

Historically, the **autoprint** edit option was not completely consistent or based solely on modifications to the edit buffer. Exceptions were the **read** command (when reading from a file, but not from a filter), the **append**, **change**, **insert**, **global**, and **v** commands, all of which were not affected by **autoprint**, and the **tag** command, which was affected by **autoprint**. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the **autoprint** option only applied to the last of multiple commands entered using vertical-bar delimiters; for example, `delete <newline>` was affected by **autoprint**, but `delete | version <newline>` was not. IEEE Std 1003.1-2001 requires conformance to historical practice.

**autowrite, aw**

Appending the `!` character to the **ex** next command to avoid performing an automatic write was not supported in historical implementations. IEEE Std 1003.1-2001 requires that the behavior match the other **ex** commands for consistency.

**ignorecase, ic**

Historical implementations of case-insensitive matching (the **ignorecase** edit option) lead to counterintuitive situations when uppercase characters were used in range expressions. Historically, the process was as follows:

1. Take a line of text from the edit buffer.
2. Convert uppercase to lowercase in text line.
3. Convert uppercase to lowercase in regular expressions, except in character class specifications.
4. Match regular expressions against text.

This would mean that, with **ignorecase** in effect, the text:
The cat sat on the mat
would be matched by

/^the/

but not by:

/^ [A-Z]he/

For consistency with other commands implementing regular expressions, IEEE Std 1003.1-2001 does not permit this behavior.

paragraphs, para

The ISO POSIX-2:1993 standard made the default paragraphs and sections edit options implementation-defined, arguing they were historically oriented to the UNIX system troff text formatter, and a “portable user” could use the { }, [ ], ( ), and ) commands in open or visual mode and have the cursor stop in unexpected places. IEEE Std 1003.1-2001 specifies their values in the POSIX locale because the unusual grouping (they only work when grouped into two characters at a time) means that they cannot be used for general-purpose movement, regardless.

readonly

Implementations are encouraged to provide the best possible information to the user as to the read-only status of the file, with the exception that they should not consider the current special privileges of the process. This provides users with a safety net because they must force the overwrite of read-only files, even when running with additional privileges.

The readonly edit option specification largely conforms to historical practice. The only difference is that historical implementations did not notice that the user had set the readonly edit option in cases where the file was already marked read-only for some reason, and would therefore reinitialize the readonly edit option the next time the contents of the edit buffer were replaced. This behavior is disallowed by IEEE Std 1003.1-2001.

report

The requirement that lines copied to a buffer interact differently than deleted lines is historical practice. For example, if the report edit option is set to 3, deleting 3 lines will cause a report to be written, but 4 lines must be copied before a report is written.

The requirement that the ex global, v, open, undo, and visual commands present reports based on the total number of lines added or deleted during the command execution, and that commands executed by the global and v commands not present reports, is historical practice. IEEE Std 1003.1-2001 extends historical practice by requiring that buffer execution be treated similarly. The reasons for this are two-fold. Historically, only the report by the last command executed from the buffer would be seen by the user, as each new report would overwrite the last. In addition, the standard developers believed that buffer execution had more in common with global and v commands than it did with other ex commands, and should behave similarly, for consistency and simplicity of specification.
showmatch, sm

The length of time the cursor spends on the matching character is unspecified because the timing capabilities of systems are often inexact and variable. The time should be long enough for the user to notice, but not long enough for the user to become annoyed. Some implementations of vi have added a matchtime option that permits users to set the number of 0.1 second intervals the cursor pauses on the matching character.

showmode

The showmode option has been used in some historical implementations of ex and vi to display the current editing mode when in open or visual mode. The editing modes have generally included “command” and “input”, and sometimes other modes such as “replace” and “change”. The string was usually displayed on the bottom line of the screen at the far right-hand corner. In addition, a preceding ‘*’ character often denoted whether the contents of the edit buffer had been modified. The latter display has sometimes been part of the showmode option, and sometimes based on another option. This option was not available in the 4 BSD historical implementation of vi, but was viewed as generally useful, particularly to novice users, and is required by IEEE Std 1003.1-2001.

The smd shorthand for the showmode option was not present in all historical implementations of the editor. IEEE Std 1003.1-2001 requires it, for consistency.

Not all historical implementations of the editor displayed a mode string for command mode, differentiating command mode from text input mode by the absence of a mode string. IEEE Std 1003.1-2001 permits this behavior for consistency with historical practice, but implementations are encouraged to provide a display string for both modes.

slowopen

Historically the slowopen option was automatically set if the terminal baud rate was less than 1200 baud, or if the baud rate was 1200 baud and the redraw option was not set. The slowopen option had two effects. First, when inserting characters in the middle of a line, characters after the cursor would not be pushed ahead, but would appear to be overwritten. Second, when creating a new line of text, lines after the current line would not be scrolled down, but would appear to be overwritten. In both cases, ending text input mode would cause the screen to be refreshed to match the actual contents of the edit buffer. Finally, terminals that were sufficiently intelligent caused the editor to ignore the slowopen option. IEEE Std 1003.1-2001 permits most historical behavior, extending historical practice to require slowopen behaviors if the edit option is set by the user.

tags

The default path for tags files is left unspecified as implementations may have their own tags implementations that do not correspond to the historical ones. The default tags option value should probably at least include the file ./tags.
Historical implementations of *ex* and *vi* ignored changes to the *term* edit option after the initial terminal information was loaded. This is permitted by IEEE Std 1003.1-2001; however, implementations are encouraged to permit the user to modify their terminal type at any time.

**terse**

Historically, the *terse* edit option optionally provided a shorter, less descriptive error message, for some error messages. This is permitted, but not required, by IEEE Std 1003.1-2001. Historically, most common visual mode errors (for example, trying to move the cursor past the end of a line) did not result in an error message, but simply alerted the terminal. Implementations wishing to provide messages for novice users are urged to do so based on the *edit* option *verbose*, and not *terse*.

**window**

In historical implementations, the default for the *window* edit option was based on the baud rate as follows:

1. If the baud rate was less than 1200, the *edit* option *w300* set the window value; for example, the line:
   ```
   set w300=12
   ```
   would set the window option to 12 if the baud rate was less than 1 200.

2. If the baud rate was equal to 1 200, the *edit* option *w1200* set the window value.

3. If the baud rate was greater than 1 200, the *edit* option *w9600* set the window value.

The *w300*, *w1200*, and *w9600* options do not appear in IEEE Std 1003.1-2001 because of their dependence on specific baud rates.

In historical implementations, the size of the window displayed by various commands was related to, but not necessarily the same as, the *window* edit option. For example, the size of the window was set by the *ex* command *visual 10*, but it did not change the value of the *window* edit option. However, changing the value of the *window* edit option did change the number of lines that were displayed when the screen was repainted. IEEE Std 1003.1-2001 does not permit this behavior in the interests of consistency and simplicity of specification, and requires that all commands that change the number of lines that are displayed do it by setting the value of the *window* edit option.

**wrapmargin, wm**

Historically, the *wrapmargin* option did not affect maps inserting characters that also had associated *counts*; for example *map K 5aABC DEF*. Unfortunately, there are widely used maps that depend on this behavior. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, *wrapmargin* was calculated using the column display width of all characters on the screen. For example, an implementation using "\^\ I\" to represent <tab>s when the *list* edit option was set, where \'^\' and \'\ I\' each took up a single column on the screen, would calculate the *wrapmargin* based on a value of 2 for each <tab>. The *number* edit option similarly changed the effective length of the line as well. IEEE Std 1003.1-2001 requires conformance to historical practice.
FUTURE DIRECTIONS

None.

SEE ALSO
Section 2.9.1.1 (on page 48), ctags, ed, sed, sh, stty, vi, the System Interfaces volume of IEEE Std 1003.1-2001, access()

CHANGE HISTORY
First released in Issue 2.

Issue 5
The FUTURE DIRECTIONS section is added.

Issue 6
This utility is marked as part of the User Portability Utilities option.

The obsolescent SYNOPSIS is removed, removing the +command and – options.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

• In the map command description, the sequence #digit is added.

• The directory, edcompatible, redraw, and slowopen edit options are added.

The ex utility is extensively changed for alignment with the IEEE P1003.2b draft standard. This includes changes as a result of the IEEE PASC Interpretations 1003.2 #31, #38, #49, #50, #51, #52, #55, #56, #57, #61, #62, #63, #64, #65, and #78.

The –l option is removed.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/23 is applied, correcting a URL.
NAME
expand — convert tabs to spaces

SYNOPSIS
expand [-t tablist][file ...]

DESCRIPTION
The expand utility shall write files or the standard input to the standard output with <tab>s replaced with one or more <space>s needed to pad to the next tab stop. Any <backspace>s shall be copied to the output and cause the column position count for tab stop calculations to be decremented; the column position count shall not be decremented below zero.

OPTIONS

The following option shall be supported:

-t tablist Specify the tab stops. The application shall ensure that the argument tablist consists of either a single positive decimal integer or a list of tabstops. If a single number is given, tabs shall be set that number of column positions apart instead of the default 8.

If a list of tabstops is given, the application shall ensure that it consists of a list of two or more positive decimal integers, separated by <blank>s or commas, in ascending order. The tabs shall be set at those specific column positions. Each tab stop N shall be an integer value greater than zero, and the list is in strictly ascending order. This is taken to mean that, from the start of a line of output, tabbing to position N shall cause the next character output to be in the (N+1)th column position on that line.

In the event of expand having to process a <tab> at a position beyond the last of those specified in a multiple tab-stop list, the <tab> shall be replaced by a single <space> in the output.

OPERANDS
The following operand shall be supported:

file The pathname of a text file to be used as input.

STDIN
See the INPUT FILES section.

INPUT FILES
Input files shall be text files.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of expand:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in...
arguments and input files), the processing of <tab>s and <space>s, and for the
determination of the width in column positions each character would occupy on
an output device.

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

**XSI**

**NLSPATH** Determine the location of message catalogs for the processing of LC_MESSAGES.

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
The standard output shall be equivalent to the input files with <tab>s converted into the
appropriate number of <space>s.

**STDERR**
The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
The following exit values shall be returned:

- 0 Successful completion
- >0 An error occurred.

**CONSEQUENCES OF ERRORS**
The expand utility shall terminate with an error message and non-zero exit status upon
encountering difficulties accessing one of the file operands.

**APPLICATION USAGE**
None.

**EXAMPLES**
None.

**RATIONALE**
The expand utility is useful for preprocessing text files (before sorting, looking at specific
columns, and so on) that contain <tab>s.

See the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.103, Column Position.

The tablist option-argument consists of integers in ascending order. Utility Syntax Guideline 8
mandates that expand shall accept the integers (within the single argument) separated using
either commas or <blank>s.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
tabs, unexpand
CHANGE HISTORY

First released in Issue 4.

This utility is marked as part of the User Portability Utilities option.

The APPLICATION USAGE section is added.

The obsolescent SYNOPSIS is removed.

The $LC_CTYPE$ environment variable description is updated to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
expr — evaluate arguments as an expression

SYNOPSIS
expr operand

DESCRIPTION
The expr utility shall evaluate an expression and write the result to standard output.

OPTIONS
None.

OPERANDS
The single expression evaluated by expr shall be formed from the operands, as described in the
EXTENDED DESCRIPTION section. The application shall ensure that each of the expression
operator symbols:

and the symbols integer and string in the table are provided as separate arguments to expr.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of expr:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_COLLATE Determine the locale for the behavior of ranges, equivalence classes, and multi-
character collating elements within regular expressions and by the string
comparison operators.

LCCTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments) and the behavior of character classes within regular expressions.

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The expr utility shall evaluate the expression and write the result, followed by a <newline>, to
standard output.
STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
The formation of the expression to be evaluated is shown in the following table. The symbols `expr`, `expr1`, and `expr2` represent expressions formed from integer and string symbols and the expression operator symbols (all separate arguments) by recursive application of the constructs described in the table. The expressions are listed in order of increasing precedence, with equal-precedence operators grouped between horizontal lines. All of the operators shall be left-associative.

<table>
<thead>
<tr>
<th>Expression</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>`expr1</td>
<td>expr2`</td>
</tr>
<tr>
<td><code>expr1 &amp; expr2</code></td>
<td>Returns the evaluation of <code>expr1</code> if neither expression evaluates to null or zero; otherwise, returns zero.</td>
</tr>
<tr>
<td><code>expr1 = expr2</code></td>
<td>Equal.</td>
</tr>
<tr>
<td><code>expr1 &gt; expr2</code></td>
<td>Greater than.</td>
</tr>
<tr>
<td><code>expr1 &gt;= expr2</code></td>
<td>Greater than or equal.</td>
</tr>
<tr>
<td><code>expr1 &lt; expr2</code></td>
<td>Less than.</td>
</tr>
<tr>
<td><code>expr1 &lt;= expr2</code></td>
<td>Less than or equal.</td>
</tr>
<tr>
<td><code>expr1 != expr2</code></td>
<td>Not equal.</td>
</tr>
<tr>
<td><code>expr1 + expr2</code></td>
<td>Addition of decimal integer-valued arguments.</td>
</tr>
<tr>
<td><code>expr1 - expr2</code></td>
<td>Subtraction of decimal integer-valued arguments.</td>
</tr>
<tr>
<td><code>expr1 * expr2</code></td>
<td>Multiplication of decimal integer-valued arguments.</td>
</tr>
<tr>
<td><code>expr1 / expr2</code></td>
<td>Integer division of decimal integer-valued arguments, producing an integer result.</td>
</tr>
<tr>
<td><code>expr1 % expr2</code></td>
<td>Remainder of integer division of decimal integer-valued arguments.</td>
</tr>
<tr>
<td><code>expr1 : expr2</code></td>
<td>Matching expression; see below.</td>
</tr>
<tr>
<td><code>( expr )</code></td>
<td>Grouping symbols. Any expression can be placed within parentheses. Parentheses can be nested to a depth of <code>EXPR_NEST_MAX</code>.</td>
</tr>
<tr>
<td><code>integer</code></td>
<td>An argument consisting only of an (optional) unary minus followed by digits.</td>
</tr>
<tr>
<td><code>string</code></td>
<td>A string argument; see below.</td>
</tr>
</tbody>
</table>
Matching Expression

The `:` matching operator shall compare the string resulting from the evaluation of expr1 with
the regular expression pattern resulting from the evaluation of expr2. Regular expression syntax
shall be that defined in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic
Regular Expressions, except that all patterns are anchored to the beginning of the string (that is,
only sequences starting at the first character of a string are matched by the regular expression)
and, therefore, it is unspecified whether `^` is a special character in that context. Usually, the
matching operator shall return a string representing the number of characters matched (`0` on
failure). Alternatively, if the pattern contains at least one regular expression subexpression
" [ \ ( \ . \ ) ] ", the string corresponding to " \1 " shall be returned.

String Operand

A string argument is an argument that cannot be identified as an integer argument or as one of
the expression operator symbols shown in the OPERANDS section.

The use of string arguments length, substr, index, or match produces unspecified results.

EXIT STATUS

The following exit values shall be returned:

0  The expression evaluates to neither null nor zero.
1  The expression evaluates to null or zero.
2  Invalid expression.
>2  An error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

After argument processing by the shell, expr is not required to be able to tell the difference
between an operator and an operand except by the value. If "$a" is `=`, the command:

```
expr $a = `=`
```

looks like:

```
expr = = =
```

as the arguments are passed to expr (and they all may be taken as the `=` operator). The
following works reliably:

```
ex$expr = X=
```

Also note that this volume of IEEE Std 1003.1-2001 permits implementations to extend utilities.
The expr utility permits the integer arguments to be preceded with a unary minus. This means
that an integer argument could look like an option. Therefore, the conforming application must
employ the "---" construct of Guideline 10 of the Base Definitions volume of
IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines to protect its operands if there is
any chance the first operand might be a negative integer (or any string with a leading minus).

EXAMPLES

The expr utility has a rather difficult syntax:

- Many of the operators are also shell control operators or reserved words, so they have to be
  escaped on the command line.
• Each part of the expression is composed of separate arguments, so liberal usage of <blank>s is required. For example:

<table>
<thead>
<tr>
<th></th>
<th>Invalid</th>
<th>Valid</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr 1+2</td>
<td>expr 1 + 2</td>
<td></td>
</tr>
<tr>
<td>expr &quot;1 + 2&quot;</td>
<td>expr 1 + 2</td>
<td></td>
</tr>
<tr>
<td>expr 1 + (2 * 3)</td>
<td>expr 1 + ( 2 * 3 )</td>
<td></td>
</tr>
</tbody>
</table>

In many cases, the arithmetic and string features provided as part of the shell command language are easier to use than their equivalents in `expr`. Newly written scripts should avoid `expr` in favor of the new features within the shell; see Section 2.5 (on page 33) and Section 2.6.4 (on page 41).

The following command:

```
a=$(expr $a + 1)
```

adds 1 to the variable `a`.

The following command, for "$a" equal to either `/usr/abc/file` or just `file`:

```
expr $a : '.*/\(.*\)' \| $a
```

returns the last segment of a pathname (that is, `file`). Applications should avoid the character `'/` used alone as an argument; `expr` may interpret it as the division operator.

The following command:

```
expr "//$a" : '.*/\(.*\)'
```

is a better representation of the previous example. The addition of the "//$" characters eliminates any ambiguity about the division operator and simplifies the whole expression. Also note that pathnames may contain characters contained in the `IFS` variable and should be quoted to avoid having "$a" expand into multiple arguments.

The following command:

```
expr "$VAR" : '.*'
```

returns the number of characters in `VAR`.

**Rationale**

In an early proposal, EREs were used in the matching expression syntax. This was changed to BREs to avoid breaking historical applications.

The use of a leading circumflex in the BRE is unspecified because many historical implementations have treated it as a special character, despite their system documentation. For example:

```
expr foo : ^foo  expr ^foo : ^foo
```

return 3 and 0, respectively, on those systems; their documentation would imply the reverse. Thus, the anchoring condition is left unspecified to avoid breaking historical scripts relying on this undocumented feature.

**Future Directions**

None.
SEE ALSO
Section 2.5 (on page 33), Section 2.6.4 (on page 41)

CHANGE HISTORY
First released in Issue 2.

Issue 5
The FUTURE DIRECTIONS section is added.

Issue 6
The expr utility is aligned with the IEEE P1003.2b draft standard, to include resolution of IEEE PASC Interpretation 1003.2 #104.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
false — return false value

SYNOPSIS
false

DESCRIPTION
The false utility shall return with a non-zero exit code.

OPTIONS
None.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
Not used.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The false utility shall always exit with a value other than zero.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
true
<table>
<thead>
<tr>
<th>CHANGE HISTORY</th>
<th>16847</th>
<th>First released in Issue 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issue 6</strong></td>
<td>16848</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16849</td>
<td>IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/24 is applied, changing the STDERR section from “None.” to “Not used.” for alignment with Section 1.11 (on page 20).</td>
</tr>
</tbody>
</table>
NAME
fc — process the command history list

SYNOPSIS
UP
fc [-r] [-e editor] [first[last]]
fc -l [-nr] [first[last]]
fc -s [old=new] [first]

DESCRIPTION
The fc utility shall list, or shall edit and re-execute, commands previously entered to an interactive sh.

The command history list shall reference commands by number. The first number in the list is selected arbitrarily. The relationship of a number to its command shall not change except when the user logs in and no other process is accessing the list, at which time the system may reset the numbering to start the oldest retained command at another number (usually 1). When the number reaches an implementation-defined upper limit, which shall be no smaller than the value in HISTSIZE or 32 767 (whichever is greater), the shell may wrap the numbers, starting the next command with a lower number (usually 1). However, despite this optional wrapping of numbers, fc shall maintain the time-ordering sequence of the commands. For example, if four commands in sequence are given the numbers 32 766, 32 767, 1 (wrapped), and 2 as they are executed, command 32 767 is considered the command previous to 1, even though its number is higher.

When commands are edited (when the -l option is not specified), the resulting lines shall be entered at the end of the history list and then re-executed by sh. The fc command that caused the editing shall not be entered into the history list. If the editor returns a non-zero exit status, this shall suppress the entry into the history list and the command re-execution. Any command line variable assignments or redirection operators used with fc shall affect both the fc command itself as well as the command that results; for example:

fc -s -- -l 2>/dev/null

reinvokes the previous command, suppressing standard error for both fc and the previous command.

OPTIONS

The following options shall be supported:

-e editor Use the editor named by editor to edit the commands. The editor string is a utility name, subject to search via the PATH variable (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables). The value in the FCEDIT variable shall be used as a default when -e is not specified. If FCEDIT is null or unset, ed shall be used as the editor.

-l (The letter ell.) List the commands rather than invoking an editor on them. The commands shall be written in the sequence indicated by the first and last operands, as affected by -r, with each command preceded by the command number.

-n Suppress command numbers when listing with -l.

-r Reverse the order of the commands listed (with -l) or edited (with neither -l nor -s).
Utilities

−s  
Re-execute the command without invoking an editor.

OPERANDS

The following operands shall be supported:

first, last  
Select the commands to list or edit. The number of previous commands that can be accessed shall be determined by the value of the HISTSIZE variable. The value of first or last or both shall be one of the following:

[+]number  
A positive number representing a command number; command numbers can be displayed with the −l option.

−number  
A negative decimal number representing the command that was executed number of commands previously. For example, −1 is the immediately previous command.

string  
A string indicating the most recently entered command that begins with that string. If the old=new operand is not also specified with −s, the string form of the first operand cannot contain an embedded equal sign.

When the synopsis form with −s is used:

• If first is omitted, the previous command shall be used.

For the synopsis forms without −s:

• If last is omitted, last shall default to the previous command when −l is specified; otherwise, it shall default to first.

• If first and last are both omitted, the previous 16 commands shall be listed or the previous single command shall be edited (based on the −l option).

• If first and last are both present, all of the commands from first to last shall be edited (without −l) or listed (with −l). Editing multiple commands shall be accomplished by presenting to the editor all of the commands at one time, each command starting on a new line. If first represents a newer command than last, the commands shall be listed or edited in reverse sequence, equivalent to using −r. For example, the following commands on the first line are equivalent to the corresponding commands on the second:

  fc −r 10 20  fc 30 40
  fc 20 10  fc −r 40 30

• When a range of commands is used, it shall not be an error to specify first or last values that are not in the history list; fc shall substitute the value representing the oldest or newest command in the list, as appropriate. For example, if there are only ten commands in the history list, numbered 1 to 10:

  fc −l
  fc 1 99

shall list and edit, respectively, all ten commands.

old=new  
Replace the first occurrence of string old in the commands to be re-executed by the string new.
STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of fc:

FCEDIT
This variable, when expanded by the shell, shall determine the default value for
the −e editor option's editor option-argument. If FCEDIT is null or unset, ed shall be
used as the editor.

HISTFILE
Determine a pathname naming a command history file. If the HISTFILE variable is
not set, the shell may attempt to access or create a file .sh_history in the directory
referred to by the HOME environment variable. If the shell cannot obtain both read
and write access to, or create, the history file, it shall use an unspecified
mechanism that allows the history to operate properly. (References to history
“file” in this section shall be understood to mean this unspecified mechanism in
such cases.) An implementation may choose to access this variable only when
initializing the history file; this initialization shall occur when fc or sh first attempt
to retrieve entries from, or add entries to, the file, as the result of commands issued
by the user, the file named by the ENV variable, or implementation-defined system
start-up files. In some historical shells, the history file is initialized just after the
ENV file has been processed. Therefore, it is implementation-defined whether
changes made to HISTFILE after the history file has been initialized are effective.
Implementations may choose to disable the history list mechanism for users with
appropriate privileges who do not set HISTFILE; the specific circumstances under
which this occurs are implementation-defined. If more than one instance of the
shell is using the same history file, it is unspecified how updates to the history file
from those shells interact. As entries are deleted from the history file, they shall be
deleted oldest first. It is unspecified when history file entries are physically
removed from the history file.

HISTSIZE
Determine a decimal number representing the limit to the number of previous
commands that are accessible. If this variable is unset, an unspecified default
greater than or equal to 128 shall be used. The maximum number of commands in
the history list is unspecified, but shall be at least 128. An implementation may
choose to access this variable only when initializing the history file, as described
under HISTFILE. Therefore, it is unspecified whether changes made to HISTSIZE
after the history file has been initialized are effective.

LANG
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE
Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

When the `-l` option is used to list commands, the format of each command in the list shall be as follows:

```
"%d\t%s\n", <line number>, <command>
```

If both the `-l` and `-n` options are specified, the format of each command shall be:

```
"\t%s\n", <command>
```

If the `<command>` consists of more than one line, the lines after the first shall be displayed as:

```
"\t%s\n", <continued-command>
```

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- `0` Successful completion of the listing.
- `>0` An error occurred.

Otherwise, the exit status shall be that of the commands executed by `fc`.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

Since editors sometimes use file descriptors as integral parts of their editing, redirecting their file descriptors as part of the `fc` command can produce unexpected results. For example, if `vi` is the `FCEDIT` editor, the command:

```
fc −s | more
```

does not work correctly on many systems.

Users on windowing systems may want to have separate history files for each window by setting `HISTFILE` as follows:

```
HISTFILE=$HOME/.sh_hist$
```

**EXAMPLES**

None.

**RATIONALE**

This utility is based on the `fc` built-in of the KornShell.

An early proposal specified the `-e` option as `[-e editor [old = new ]]`, which is not historical practice. Historical practice in `fc` of either `[-e editor]` or `[-e − [ old = new ]]` is acceptable, but not both together. To clarify this, a new option `−s` was introduced replacing the `[-e −]`. This resolves the conflict and makes `fc` conform to the Utility Syntax Guidelines.
Some implementations of the KornShell check for the superuser and do not create a history file unless HISTFILE is set. This is done primarily to avoid creating unlinked files in the root file system when logging in during single-user mode. HISTFILE must be set for the superuser to have history.

HISTSIZE Needed to limit the size of history files. It is the intent of the standard developers that when two shells share the same history file, commands that are entered in one shell shall be accessible by the other shell. Because of the difficulties of synchronization over a network, the exact nature of the interaction is unspecified.

The initialization process for the history file can be dependent on the system start-up files, in that they may contain commands that effectively preempt the settings the user has for HISTFILE and HISTSIZE. For example, function definition commands are recorded in the history file. If the system administrator includes function definitions in some system start-up file called before the ENV file, the history file is initialized before the user can influence its characteristics. In some historical shells, the history file is initialized just after the ENV file has been processed. Because of these situations, the text requires the initialization process to be implementation-defined.

Consideration was given to omitting the fc utility in favor of the command line editing feature in sh. For example, in vi editing mode, typing "<ESC> v" is equivalent to:

EDITOR=vi fc

However, the fc utility allows the user the flexibility to edit multiple commands simultaneously (such as fc 10 20) and to use editors other than those supported by sh for command line editing.

In the KornShell, the alias r ("re-do") is preset to fc -e - (equivalent to the POSIX fc -s). This is probably an easier command name to remember than fc ("fix command"), but it does not meet the Utility Syntax Guidelines. Renaming fc to hist or redo was considered, but since this description closely matches historical KornShell practice already, such a renaming was seen as gratuitous. Users are free to create aliases whenever odd historical names such as fc, awk, cat, grep, or yacc are standardized by POSIX.

Command numbers have no ordering effects; they are like serial numbers. The -r option and -number operand address the sequence of command execution, regardless of serial numbers. So, for example, if the command number wrapped back to 1 at some arbitrary point, there would be no ambiguity associated with traversing the wrap point. For example, if the command history were:

32766: echo 1
32767: echo 2
1: echo 3

the number -2 refers to command 32 767 because it is the second previous command, regardless of serial number.

FUTURE DIRECTIONS
None.

SEE ALSO
sh

CHANGE HISTORY
First released in Issue 4.
**Issue 5**

The FUTURE DIRECTIONS section is added.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

In the ENVIRONMENT VARIABLES section, the text “user’s home directory” is updated to “directory referred to by the HOME environment variable”.
NAME
fg — run jobs in the foreground

SYNOPSIS
Up    fg [job_id]

DESCRIPTION
If job control is enabled (see the description of set -m), the fg utility shall move a background job from the current environment (see Section 2.12 (on page 61)) into the foreground.

Using fg to place a job into the foreground shall remove its process ID from the list of those “known in the current shell execution environment”; see Section 2.9.3.1 (on page 50).

OPTIONS
None.

OPERANDS
The following operand shall be supported:

job_id Specify the job to be run as a foreground job. If no job_id operand is given, the job_id for the job that was most recently suspended, placed in the background, or run as a background job shall be used. The format of job_id is described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.203, Job Control Job ID.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of fg:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The fg utility shall write the command line of the job to standard output in the following format:

"%s\n", <command>
The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

If job control is disabled, the fg utility shall exit with an error and no job shall be placed in the foreground.

The fg utility does not work as expected when it is operating in its own utility execution environment because that environment has no applicable jobs to manipulate. See the APPLICATION USAGE section for bg. For this reason, fg is generally implemented as a shell regular built-in.

The extensions to the shell specified in this volume of IEEE Std 1003.1-2001 have mostly been based on features provided by the KornShell. The job control features provided by bg, fg, and jobs are also based on the KornShell. The standard developers examined the characteristics of the C shell versions of these utilities and found that differences exist. Despite widespread use of the C shell, the KornShell versions were selected for this volume of IEEE Std 1003.1-2001 to maintain a degree of uniformity with the rest of the KornShell features selected (such as the very popular command line editing features).

None.

Section 2.9.3.1 (on page 50), Section 2.12 (on page 61), bg, kill, jobs, wait

First released in Issue 4.

This utility is marked as part of the User Portability Utilities option.

The APPLICATION USAGE section is added.

The JC marking is removed from the SYNOPSIS since job control is mandatory is this issue.
NAME
file — determine file type

SYNOPSIS
file [-dh] [-M file] [-m file] file ...
file -i [-h] file ...

DESCRIPTION
The file utility shall perform a series of tests in sequence on each specified file in an attempt to classify it:

1. If file does not exist, cannot be read, or its file status could not be determined, the output shall indicate that the file was processed, but that its type could not be determined.

2. If the file is not a regular file, its file type shall be identified. The file types directory, FIFO, socket, block special, and character special shall be identified as such. Other implementation-defined file types may also be identified. If file is a symbolic link, by default the link shall be resolved and file shall test the type of file referenced by the symbolic link. (See the -h and -i options below.)

3. If the length of file is zero, it shall be identified as an empty file.

4. The file utility shall examine an initial segment of file and shall make a guess at identifying its contents based on position-sensitive tests. (The answer is not guaranteed to be correct; see the -d, -M, and -m options below.)

5. The file utility shall examine file and make a guess at identifying its contents based on context-sensitive default system tests. (The answer is not guaranteed to be correct.)

6. The file shall be identified as a data file.

If file does not exist, cannot be read, or its file status could not be determined, the output shall indicate that the file was processed, but that its type could not be determined.

If file is a symbolic link, by default the link shall be resolved and file shall test the type of file referenced by the symbolic link.

OPTIONS
The file utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the order of the -m, -d, and -M options shall be significant.

The following options shall be supported by the implementation:

-d Apply any position-sensitive default system tests and context-sensitive default system tests to the file. This is the default if no -M or -m option is specified.

-h When a symbolic link is encountered, identify the file as a symbolic link. If -h is not specified and file is a symbolic link that refers to a nonexistent file, file shall identify the file as a symbolic link, as if -h had been specified.

-i If a file is a regular file, do not attempt to classify the type of the file further, but identify the file as specified in the STDOUT section.

-M file Specify the name of a file containing position-sensitive tests that shall be applied to a file in order to classify it (see the EXTENDED DESCRIPTION). No position-sensitive default system tests nor context-sensitive default system tests shall be applied unless the -d option is also specified.
Specify the name of a file containing position-sensitive tests that shall be applied to a file in order to classify it (see the EXTENDED DESCRIPTION).

If the −m option is specified without specifying the −d option or the −M option, position-sensitive default system tests shall be applied after the position-sensitive tests specified by the −m option. If the −M option is specified with the −d option, the −m option, or both, or the −m option is specified with the −d option, the concatenation of the position-sensitive tests specified by these options shall be applied in the order specified by the appearance of these options. If a −M or −m file option-argument is −, the results are unspecified.

OPERANDS

The following operand shall be supported:

file A pathname of a file to be tested.

STDIN

Not used.

INPUT FILES

The file can be any file type.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of file:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

In the POSIX locale, the following format shall be used to identify each operand, file specified:

"%s: %s\n", <file>, <type>

The values for <type> are unspecified, except that in the POSIX locale, if file is identified as one of the types listed in the following table, <type> shall contain (but is not limited to) the corresponding string, unless the file is identified by a position-sensitive test specified by a −M or −m option. Each space shown in the strings shall be exactly one <space>.
### Table 4-8 File Utility Output Strings

<table>
<thead>
<tr>
<th>If file is:</th>
<th>&lt;type&gt; shall contain the string:</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonexistent</td>
<td>cannot open</td>
<td></td>
</tr>
<tr>
<td>Block special</td>
<td>block special</td>
<td>1</td>
</tr>
<tr>
<td>Character special</td>
<td>character special</td>
<td>1</td>
</tr>
<tr>
<td>Directory</td>
<td>directory</td>
<td>1</td>
</tr>
<tr>
<td>FIFO</td>
<td>fifo</td>
<td>1</td>
</tr>
<tr>
<td>Socket</td>
<td>socket</td>
<td>1</td>
</tr>
<tr>
<td>Symbolic link</td>
<td>symbolic link to</td>
<td>1</td>
</tr>
<tr>
<td>Regular file</td>
<td>regular file</td>
<td>1,2</td>
</tr>
<tr>
<td>Empty regular file</td>
<td>empty</td>
<td>3</td>
</tr>
<tr>
<td>Regular file that cannot be read</td>
<td>cannot open</td>
<td>3</td>
</tr>
<tr>
<td>Executable binary</td>
<td>executable</td>
<td>4,6</td>
</tr>
<tr>
<td>ar archive library (see ar)</td>
<td>archive</td>
<td>4,6</td>
</tr>
<tr>
<td>Extended cpio format (see pax)</td>
<td>cpio archive</td>
<td>4,6</td>
</tr>
<tr>
<td>Extended tar format (see ustar in pax)</td>
<td>tar archive</td>
<td>4,6</td>
</tr>
<tr>
<td>Shell script</td>
<td>commands text</td>
<td>5,6</td>
</tr>
<tr>
<td>C-language source</td>
<td>c program text</td>
<td>5,6</td>
</tr>
<tr>
<td>FORTRAN source</td>
<td>fortran program text</td>
<td>5,6</td>
</tr>
<tr>
<td>Regular file whose type cannot be determined</td>
<td>data</td>
<td></td>
</tr>
</tbody>
</table>

#### Notes:

1. This is a file type test.
2. This test is applied only if the \(-i\) option is specified.
3. This test is applied only if the \(-i\) option is not specified.
4. This is a position-sensitive default system test.
5. This is a context-sensitive default system test.
6. Position-sensitive default system tests and context-sensitive default system tests are not applied if the \(-M\) option is specified unless the \(-d\) option is also specified.

In the POSIX locale, if file is identified as a symbolic link (see the \(-h\) option), the following alternative output format shall be used:

```
"%s: %s %s
", <file>, <type>, <contents of link>
```

If the file named by the file operand does not exist, cannot be read, or the type of the file named by the file operand cannot be determined, this shall not be considered an error that affects the exit status.

#### STDERR

The standard error shall be used only for diagnostic messages.

#### OUTPUT FILES

None.

#### EXTENDED DESCRIPTION

A file specified as an option-argument to the \(-m\) or \(-M\) options shall contain one position-sensitive test per line, which shall be applied to the file. If the test succeeds, the message field of the line shall be printed and no further tests shall be applied, with the exception that tests on immediately following lines beginning with a single ‘\(>\)’ character shall be applied.
Each line shall be composed of the following four <blank>-separated fields:

offset
An unsigned number (optionally preceded by a single \( > \) character) specifying the offset, in bytes, of the value in the file that is to be compared against the value field of the line. If the file is shorter than the specified offset, the test shall fail.

If the offset begins with the character \( > \), the test contained in the line shall not be applied to the file unless the test on the last line for which the offset did not begin with a \( > \) was successful. By default, the offset shall be interpreted as an unsigned decimal number. With a leading 0x or 0X, the offset shall be interpreted as a hexadecimal number; otherwise, with a leading 0, the offset shall be interpreted as an octal number.

type
The type of the value in the file to be tested. The type shall consist of the type specification characters \( c \), \( d \), \( f \), \( s \), and \( u \), specifying character, signed decimal, floating point, string, and unsigned decimal, respectively.

The type string shall be interpreted as the bytes from the file starting at the specified offset and including the same number of bytes specified by the value field. If insufficient bytes remain in the file past the offset to match the value field, the test shall fail.

The type specification characters \( d \), \( f \), and \( u \) can be followed by an optional unsigned decimal integer that specifies the number of bytes represented by the type. The type specification character \( f \) can be followed by an optional \( F \), \( D \), or \( L \), indicating that the value is of type \textit{float}, \textit{double}, or \textit{long double}, respectively. The type specification characters \( d \) and \( u \) can be followed by an optional \( C \), \( S \), \( I \), or \( L \), indicating that the value is of type \textit{char}, \textit{short}, \textit{int}, or \textit{long}, respectively.

The default number of bytes represented by the type specifiers \( d \), \( f \), and \( u \) shall correspond to their respective C-language types as follows. If the system claims conformance to the C-Language Development Utilities option, those specifiers shall correspond to the default sizes used in the c99 utility. Otherwise, the default sizes shall be implementation-defined.

For the type specification characters \( d \) and \( u \), the default number of bytes shall correspond to the size of a basic integer type of the implementation. For these specifier characters, the implementation shall support values of the optional number of bytes to be converted corresponding to the number of bytes in the C-language types \textit{char}, \textit{short}, \textit{int}, or \textit{long}. These numbers can also be specified by an application as the characters \( C \), \( S \), \( I \), and \( L \), respectively. The byte order used when interpreting numeric values is implementation-defined, but shall correspond to the order in which a constant of the corresponding type is stored in memory on the system.

For the type specifier \( f \), the default number of bytes shall correspond to the number of bytes in the basic double precision floating-point data type of the underlying implementation. The implementation shall support values of the optional number of bytes to be converted corresponding to the number of bytes in the C-language types \textit{float}, \textit{double}, and \textit{long double}. These numbers can also be specified by an application as the characters \( F \), \( D \), and \( L \), respectively.

All type specifiers, except for \( s \), can be followed by a mask specifier of the form \&\textit{number}. The mask value shall be AND'ed with the value of the input file before the comparison with the value field of the line is made. By default, the mask shall be interpreted as an unsigned decimal number. With a leading 0x or 0X, the mask shall be interpreted as an unsigned hexadecimal number; otherwise, with a leading
0, the mask shall be interpreted as an unsigned octal number.

The strings **byte**, **short**, **long**, and **string** shall also be supported as type fields, being interpreted as dC, dS, dl, and s, respectively.

The **value** to be compared with the value from the file.

If the specifier from the type field is s or **string**, then interpret the value as a string. Otherwise, interpret it as a number. If the value is a string, then the test shall succeed only when a string value exactly matches the bytes from the file.

If the **value** is a string, it can contain the following sequences:

**character** The backslash-escape sequences as specified in the Base Definitions volume of IEEE Std 1003.1-2001, Table 5-1, Escape Sequences and Associated Actions (\', '\a', '\b', '\f', '\n', '\r', '\t', '\v'). The results of using any other character, other than an octal digit, following the backslash are unspecified.

**octal** Octal sequences that can be used to represent characters with specific coded values. An octal sequence shall consist of a backslash followed by the longest sequence of one, two, or three octal-digit characters (01234567). If the size of a byte on the system is greater than 9 bits, the valid escape sequence used to represent a byte is implementation-defined.

By default, any value that is not a string shall be interpreted as a signed decimal number. Any such value, with a leading 0x or 0X, shall be interpreted as an unsigned hexadecimal number; otherwise, with a leading zero, the value shall be interpreted as an unsigned octal number.

If the value is not a string, it can be preceded by a character indicating the comparison to be performed. Permissible characters and the comparisons they specify are as follows:

- The test shall succeed if the value from the file equals the **value** field.
- The test shall succeed if the value from the file is less than the **value** field.
- The test shall succeed if the value from the file is greater than the **value** field.
- The test shall succeed if all of the set bits in the **value** field are set in the value from the file.
- The test shall succeed if at least one of the set bits in the **value** field is not set in the value from the file.
- The test shall succeed if the file is large enough to contain a value of the type specified starting at the offset specified.

**message** The **message** to be printed if the test succeeds. The **message** shall be interpreted using the notation for the printf formatting specification; see printf. If the **value** field was a string, then the value from the file shall be the argument for the printf formatting specification; otherwise, the value from the file shall be the argument.

**EXIT STATUS**

The following exit values shall be returned:

- Successful completion.
>0 An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

The `file` utility can only be required to guess at many of the file types because only exhaustive testing can determine some types with certainty. For example, binary data on some implementations might match the initial segment of an executable or a `tar` archive.

Note that the table indicates that the output contains the stated string. Systems may add text before or after the string. For executables, as an example, the machine architecture and various facts about how the file was link-edited may be included. Note also that on systems that recognize shell script files starting with "#!" as executable files, these may be identified as executable binary files rather than as shell scripts.

**EXAMPLES**

Determine whether an argument is a binary executable file:

```bash
file "$1" | grep −Fq executable && printf "%s is executable.\n" "$1"
```

**RATIONALITY**

The `−f` option was omitted because the same effect can (and should) be obtained using the `xargs` utility.

Historical versions of the `file` utility attempt to identify the following types of files: symbolic link, directory, character special, block special, socket, `tar` archive, `cpio` archive, SCCS archive, archive library, empty, `compress` output, `pack` output, binary data, C source, FORTRAN source, assembler source, `nroff`/`troff`/`eqn`/`tbl` source `troff` output, shell script, C shell script, English text, ASCII text, various executables, APL workspace, compiled terminfo entries, and CURSES screen images.

Only those types that are reasonably well specified in POSIX or are directly related to POSIX utilities are listed in the table.

Historical systems have used a “magic file” named `/etc/magic` to help identify file types. Because it is generally useful for users and scripts to be able to identify special file types, the `−m` flag and a portable format for user-created magic files has been specified. No requirement is made that an implementation of `file` use this method of identifying files, only that users be permitted to add their own classifying tests.

In addition, three options have been added to historical practice. The `−d` flag has been added to permit users to cause their tests to follow any default system tests. The `−i` flag has been added to permit users to test portably for regular files in shell scripts. The `−M` flag has been added to permit users to ignore any default system tests.

The IEEE Std 1003.1-2001 description of default system tests and the interaction between the `−d`, `−M`, and `−m` options did not clearly indicate that there were two types of “default system tests.” The “position-sensitive tests” determine file types by looking for certain string or binary values at specific offsets in the file being examined. These position-sensitive tests were implemented in historical systems using the magic file described above. Some of these tests are now built into the `file` utility itself on some implementations so the output can provide more detail than can be provided by magic files. For example, a magic file can easily identify a core file on most implementations, but cannot name the program file that dropped the core. A magic file could produce output such as:

```
/home/dwc/core: ELF 32-bit MSB core file SPARC Version 1
```
but by building the test into the `file` utility, you could get output such as:

```
/home/dwc/core: ELF 32-bit MSB core file SPARC Version 1, from 'testprog'
```

These extended built-in tests are still to be treated as position-sensitive default system tests even if they are not listed in `/etc/magic` or any other magic file.

The context-sensitive default system tests were always built into the `file` utility. These tests looked for language constructs in text files trying to identify shell scripts, C, FORTRAN, and other computer language source files, and even plain text files. With the addition of the `−m` and `−M` options the distinction between position-sensitive and context-sensitive default system tests became important because the order of testing is important. The context-sensitive system default tests should never be applied before any position-sensitive tests even if the `−d` option is specified before a `−m` option or `−M` option due to the high probability that the context-sensitive system default tests will incorrectly identify arbitrary text files as text files before position-sensitive tests specified by the `−m` or `−M` option would be applied to give a more accurate identification.

Leaving the meaning of `−M` — and `−m` — unspecified allows an existing prototype of these options to continue to work in a backwards-compatible manner. (In that implementation, `−M` — was roughly equivalent to `−d` in IEEE Std 1003.1-2001.)

The historical `−c` option was omitted as not particularly useful to users or portable shell scripts. In addition, a reasonable implementation of the `file` utility would report any errors found each time the magic file is read.

The historical format of the magic file was the same as that specified by the Rationale in the ISO POSIX-2: 1993 standard for the offset, value, and message fields; however, it used less precise type fields than the format specified by the current normative text. The new type field values are a superset of the historical ones.

The following is an example magic file:

```
| 0 | short | 070707 | cpio archive |
| 0 | short | 0143561 | Byte-swapped cpio archive |
| 0 | string | 070707 | ASCII cpio archive |
| 0 | long | 0177555 | Very old archive |
| 0 | short | 0177545 | Old archive |
| 0 | short | 017437 | Old packed data |
| 0 | string | \037\036 | Packed data |
| 0 | string | \377\037 | Compacted data |
| 0 | string | \037\235 | Compressed data |
| >2 byte&0x80 | >0 | Block compressed |
| >2 byte&0x1f | x | %d bits |
| 0 | string | \032\001 | Compiled Terminfo Entry |
| 0 | short | 0433 | Curses screen image |
| 0 | short | 0434 | Curses screen image |
| 0 | string | <ar> | System V Release 1 archive |
| 0 | string | !<arch>\n__.SYMDEF | Archive random library |
| 0 | string | !<arch> | Archive |
| 0 | string | ARF_BEGARF | PHIGS clear text archive |
| 0 | long | 0x137A2950 | Scalable OpenFont binary |
| 0 | long | 0x137A2951 | Encrypted scalable OpenFont binary |
```

The use of a basic integer data type is intended to allow the implementation to choose a word size commonly used by applications on that architecture.
FUTURE DIRECTIONS
None.

SEE ALSO
ar, ls, pax

CHANGE HISTORY
First released in Issue 4.

Issue 6
This utility is marked as part of the User Portability Utilities option.
Options and an EXTENDED DESCRIPTION are added as specified in the IEEE P1003.2b draft standard.
IEEE PASC Interpretations 1003.2 #192 and #178 are applied.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/25 is applied, making major changes to address ambiguities raised in defect reports.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/26 is applied, making it clear in the OPTIONS section that the −m, −d, and −M options do not comply with Guideline 11 of the Utility Syntax Guidelines.
NAME

find — find files

SYNOPSIS

find [-H | -L] path ... [operand_expression ...]

DESCRIPTION

The find utility shall recursively descend the directory hierarchy from each file specified by path, evaluating a Boolean expression composed of the primaries described in the OPERANDS section for each file encountered.

The find utility shall be able to descend to arbitrary depths in a file hierarchy and shall not fail due to path length limitations (unless a path operand specified by the application exceeds {PATH_MAX} requirements).

The find utility shall detect infinite loops; that is, entering a previously visited directory that is an ancestor of the last file encountered. When it detects an infinite loop, find shall write a diagnostic message to standard error and shall either recover its position in the hierarchy or terminate.

OPTIONS


The following options shall be supported by the implementation:

- -H

Cause the file information and file type evaluated for each symbolic link encountered on the command line to be those of the file referenced by the link, and not the link itself. If the referenced file does not exist, the file information and type shall be for the link itself. File information for all symbolic links not on the command line shall be that of the link itself.

- -L

Cause the file information and file type evaluated for each symbolic link to be those of the file referenced by the link, and not the link itself.

Specifying more than one of the mutually-exclusive options -H and -L shall not be considered an error. The last option specified shall determine the behavior of the utility.

OPERANDS

The following operands shall be supported:

- path operand is a pathname of a starting point in the directory hierarchy.

The first argument that starts with a ‘-’ or is a ‘!’ or a ‘(’, and all subsequent arguments shall be interpreted as an expression made up of the following primaries and operators. In the descriptions, wherever n is used as a primary argument, it shall be interpreted as a decimal integer optionally preceded by a plus (‘+’) or minus (‘-’) sign, as follows:

+ n More than n.

n Exactly n.

- n Less than n.

The following primaries shall be supported:

- name pattern

The primary shall evaluate as true if the basename of the filename being examined matches pattern using the pattern matching notation described in Section 2.13 (on page 62).
Utilities

find

−nouser The primary shall evaluate as true if the file belongs to a user ID for which the
getpwuid() function defined in the System Interfaces volume of
IEEE Std 1003.1-2001 (or equivalent) returns NULL.

−nogroup The primary shall evaluate as true if the file belongs to a group ID for which the
getgrgid() function defined in the System Interfaces volume of
IEEE Std 1003.1-2001 (or equivalent) returns NULL.

−xdev The primary shall always evaluate as true; it shall cause find not to continue
descending past directories that have a different device ID (st_dev, see the stat() function defined in the System Interfaces volume of IEEE Std 1003.1-2001). If any
−xdev primary is specified, it shall apply to the entire expression even if the −xdev
primary would not normally be evaluated.

−prune The primary shall always evaluate as true; it shall cause find not to descend the
current pathname if it is a directory. If the −depth primary is specified, the −prune
primary shall have no effect.

−perm [−]mode

The mode argument is used to represent file mode bits. It shall be identical in
format to the symbolic_mode operand described in chmod, and shall be interpreted
as follows. To start, a template shall be assumed with all file mode bits cleared. An
op symbol of ‘+’ shall set the appropriate mode bits in the template; ‘−’ shall
clear the appropriate bits; ‘=’ shall set the appropriate mode bits, without regard
to the contents of process’ file mode creation mask. The op symbol of ‘−’ cannot
be the first character of mode; this avoids ambiguity with the optional leading
hyphen. Since the initial mode is all bits off, there are not any symbolic modes that
need to use ‘−’ as the first character.

If the hyphen is omitted, the primary shall evaluate as true when the file
permission bits exactly match the value of the resulting template.

Otherwise, if mode is prefixed by a hyphen, the primary shall evaluate as true if at
least all the bits in the resulting template are set in the file permission bits.

−perm [−]onum

If the hyphen is omitted, the primary shall evaluate as true when the file
permission bits exactly match the value of the octal number onum and only the bits
corresponding to the octal mask 07777 shall be compared. (See the description of
the octal mode in chmod.) Otherwise, if onum is prefixed by a hyphen, the primary
shall evaluate as true if at least all of the bits specified in onum that are also set in
the octal mask 07777 are set.

−type c The primary shall evaluate as true if the type of the file is c, where c is ‘b’, ‘c’,
‘d’, ‘l’, ‘p’, ‘f’, or ‘s’ for block special file, character special file, directory,
symbolic link, FIFO, regular file, or socket, respectively.

−links n The primary shall evaluate as true if the file has n links.

−user uname The primary shall evaluate as true if the file belongs to the user uname. If uname is
a decimal integer and the getpwnam() (or equivalent) function does not return a
valid user name, uname shall be interpreted as a user ID.

−group gname The primary shall evaluate as true if the file belongs to the group gname. If gname
is a decimal integer and the getgrnam() (or equivalent) function does not return a
valid group name, gname shall be interpreted as a group ID.
The primary shall evaluate as true if the file size in bytes, divided by 512 and rounded up to the next integer, is $n$. If $n$ is followed by the character ‘c’, the size shall be in bytes.

The primary shall evaluate as true if the file access time subtracted from the initialization time, divided by 86 400 (with any remainder discarded), is $n$.

The primary shall evaluate as true if the time of last change of file status information subtracted from the initialization time, divided by 86 400 (with any remainder discarded), is $n$.

The primary shall evaluate as true if the file modification time subtracted from the initialization time, divided by 86 400 (with any remainder discarded), is $n$.

The end of the primary expression shall be punctuated by a semicolon or by a plus sign. Only a plus sign that follows an argument containing the two characters "{}" shall punctuate the end of the primary expression. Other uses of the plus sign shall not be treated as special.

If the primary expression is punctuated by a semicolon, the utility utility_name shall be invoked once for each pathname and the primary shall evaluate as true if the utility returns a zero value as exit status. A utility_name or argument containing only the two characters "{}" shall be replaced by the current pathname.

If the primary expression is punctuated by a plus sign, the primary shall always evaluate as true, and the pathnames for which the primary is evaluated shall be aggregated into sets. The utility utility_name shall be invoked once for each set of aggregated pathnames. Each invocation shall begin after the last pathname in the set is aggregated, and shall be completed before the find utility exits and before the first pathname in the next set (if any) is aggregated for this primary, but it is otherwise unspecified whether the invocation occurs before, during, or after the evaluations of other primaries. If any invocation returns a non-zero value as exit status, the find utility shall return a non-zero exit status. An argument containing only the two characters "{}" shall be replaced by the set of aggregated pathnames, with each pathname passed as a separate argument to the invoked utility in the same order that it was aggregated. The size of any set of two or more pathnames shall be limited such that execution of the utility does not cause the system’s [ARG_MAX] limit to be exceeded. If more than one argument containing only the two characters "{}" is present, the behavior is unspecified.

If a utility_name or argument string contains the two characters "{}", but not just the two characters "{}", it is implementation-defined whether find replaces those two characters or uses the string without change. The current directory for the invocation of utility_name shall be the same as the current directory when the find utility was started. If the utility_name names any of the special built-in utilities (see Section 2.14 (on page 64)), the results are undefined.

The −ok primary shall be equivalent to −exec, except that the use of a plus sign to punctuate the end of the primary expression need not be supported, and find shall request affirmation of the invocation of utility_name using the current file as an argument by writing to standard error as described in the STDERR section. If the response on standard input is affirmative, the utility shall be invoked. Otherwise, the command shall not be invoked and the value of the −ok operand shall be false.
The primary shall always evaluate as true; it shall cause the current pathname to be written to standard output.

−newer file The primary shall evaluate as true if the modification time of the current file is more recent than the modification time of the file named by the pathname file.

−depth The primary shall always evaluate as true; it shall cause descent of the directory hierarchy to be done so that all entries in a directory are acted on before the directory itself. If a −depth primary is not specified, all entries in a directory shall be acted on after the directory itself. If any −depth primary is specified, it shall apply to the entire expression even if the −depth primary would not normally be evaluated.

The primaries can be combined using the following operators (in order of decreasing precedence):

(expression ) True if expression is true.

! expression Negation of a primary; the unary NOT operator.

expression [−a] expression Conjunction of primaries; the AND operator is implied by the juxtaposition of two primaries or made explicit by the optional −a operator. The second expression shall not be evaluated if the first expression is false.

expression −o expression Alternation of primaries; the OR operator. The second expression shall not be evaluated if the first expression is true.

If no expression is present, −print shall be used as the expression. Otherwise, if the given expression does not contain any of the primaries −exec, −ok, or −print, the given expression shall be effectively replaced by:

(expression ) −print

The −user, −group, and −newer primaries each shall evaluate their respective arguments only once.

STDIN If the −ok primary is used, the response shall be read from the standard input. An entire line shall be read as the response. Otherwise, the standard input shall not be used.

INPUT FILES None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of find:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_COLLATE Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements used in the pattern matching notation for the −n option and in the extended regular expression defined for the yesexpr locale.
keyword in the LC_MESSAGES category.

- **LC_CTYPE**: This variable determines the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments), the behavior of character classes within the pattern matching notation used for the -n option, and the behavior of character classes within regular expressions used in the extended regular expression defined for the yesexpr locale keyword in the LC_MESSAGES category.

- **LC_MESSAGES**: Determine the locale for the processing of affirmative responses that should be used to affect the format and contents of diagnostic messages written to standard error.

- **XSI_NLSPATH**: Determine the location of message catalogs for the processing of LC_MESSAGES.

- **PATH**: Determine the location of the utility_name for the -exec and -ok primaries, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

### ASYNCHRONOUS EVENTS

**Default.**

### STDOUT

The -print primary shall cause the current pathnames to be written to standard output. The format shall be:

```
"%s\n", <path>
```

### STDERR

The -ok primary shall write a prompt to standard error containing at least the utility_name to be invoked and the current pathname. In the POSIX locale, the last non-blank in the prompt shall be ‘?’. The exact format used is unspecified.

Otherwise, the standard error shall be used only for diagnostic messages.

### OUTPUT FILES

None.

### EXTENDED DESCRIPTION

None.

### EXIT STATUS

The following exit values shall be returned:

- 0: All path operands were traversed successfully.
- >0: An error occurred.

### CONSEQUENCES OF ERRORS

Default.
APPLICATION USAGE

When used in operands, pattern matching notation, semicolons, opening parentheses, and closing parentheses are special to the shell and must be quoted (see Section 2.2 (on page 30)).

The bit that is traditionally used for sticky (historically 01000) is specified in the −perm primary using the octal number argument form. Since this bit is not defined by this volume of IEEE Std 1003.1-2001, applications must not assume that it actually refers to the traditional sticky bit.

EXAMPLES

1. The following commands are equivalent:
   
   find .
   
   find . −print
   
   They both write out the entire directory hierarchy from the current directory.

2. The following command:
   
   find / \( −name tmp −o −name ‘*.xx’ \) −atime +7 −exec rm {} \;
   
   removes all files named tmp or ending in .xx that have not been accessed for seven or more 24-hour periods.

3. The following command:
   
   find . −perm −o+w,+s
   
   prints (−print is assumed) the names of all files in or below the current directory, with all of the file permission bits S_ISUID, S_ISGID, and S_IWOTH set.

4. The following command:
   
   find . −name SCCS −prune −o −print
   
   recursively prints pathnames of all files in the current directory and below, but skips directories named SCCS and files in them.

5. The following command:
   
   find . −print −name SCCS −prune
   
   behaves as in the previous example, but prints the names of the SCCS directories.

6. The following command is roughly equivalent to the −nt extension to test:
   
   if [ −n "$(find file1 −prune −newer file2)" ]; then
      printf %s\n "file1 is newer than file2"
   fi

7. The descriptions of −atime, −ctime, and −mtime use the terminology n “86400 second periods (days)”. For example, a file accessed at 23:59 is selected by:
   
   find . −atime −1 −print
   
   at 00:01 the next day (less than 24 hours later, not more than one day ago); the midnight boundary between days has no effect on the 24-hour calculation.

RATIONALE

The −a operator was retained as an optional operator for compatibility with historical shell scripts, even though it is redundant with expression concatenation.
The descriptions of the ‘−‘ modifier on the mode and onum arguments to the −perm primary agree with historical practice on BSD and System V implementations. System V and BSD documentation both describe it in terms of checking additional bits; in fact, it uses the same bits, but checks for having at least all of the matching bits set instead of having exactly the matching bits set.

The exact format of the interactive prompts is unspecified. Only the general nature of the contents of prompts are specified because:

- Implementations may desire more descriptive prompts than those used on historical implementations.
- Since the historical prompt strings do not terminate with <newline>s, there is no portable way for another program to interact with the prompts of this utility via pipes.

Therefore, an application using this prompting option relies on the system to provide the most suitable dialog directly with the user, based on the general guidelines specified.

The −name file operand was changed to use the shell pattern matching notation so that find is consistent with other utilities using pattern matching.

The −size operand refers to the size of a file, rather than the number of blocks it may occupy in the file system. The intent is that the st_size field defined in the System Interfaces volume of IEEE Std 1003.1-2001 should be used, not the st_blocks found in historical implementations. There are at least two reasons for this:

1. In both System V and BSD, find only uses st_size in size calculations for the operands specified by this volume of IEEE Std 1003.1-2001. (BSD uses st_blocks only when processing the −ls primary.)

2. Users usually think of file size in terms of bytes, which is also the unit used by the ls utility for the output from the −I option. (In both System V and BSD, ls uses st_size for the −I option size field and uses st_blocks for the ls −s calculations. This volume of IEEE Std 1003.1-2001 does not specify ls −s.)

The descriptions of −atime, −ctime, and −mtime were changed from the SVID description of n “days” to “24-hour periods”. The description is also different in terms of the exact timeframe for the n case (versus the +n or −n), but it matches all known historical implementations. It refers to one 86 400 second period in the past, not any time from the beginning of that period to the current time. For example, −atime 3 is true if the file was accessed any time in the period from 72 hours to 48 hours ago.

Historical implementations do not modify "{}" when it appears as a substring of an −exec or −ok utility_name or argument string. There have been numerous user requests for this extension, so this volume of IEEE Std 1003.1-2001 allows the desired behavior. At least one recent implementation does support this feature, but encountered several problems in managing memory allocation and dealing with multiple occurrences of "{}" in a string while it was being developed, so it is not yet required behavior.

Assuming the presence of −print was added to correct a historical pitfall that plagues novice users, it is entirely upwards-compatible from the historical System V find utility. In its simplest form (find directory), it could be confused with the historical BSD fast find. The BSD developers agreed that adding −print as a default expression was the correct decision and have added the fast find functionality within a new utility called locate.

Historically, the −L option was implemented using the primary −follow. The −H and −L options were added for two reasons. First, they offer a finer granularity of control and consistency with other programs that walk file hierarchies. Second, the −follow primary always evaluated to true.
As they were historically really global variables that took effect before the traversal began, some valid expressions had unexpected results. An example is the expression `−print −o −follow`. Because `−print` always evaluates to true, the standard order of evaluation implies that `−follow` would never be evaluated. This was never the case. Historical practice for the `−follow` primary, however, is not consistent. Some implementations always follow symbolic links on the command line whether `−follow` is specified or not. Others follow symbolic links on the command line only if `−follow` is specified. Both behaviors are provided by the `−H` and `−L` options, but scripts using the current `−follow` primary would be broken if the `−follow` option is specified to work either way.

Since the `−L` option resolves all symbolic links and the `−type l` primary is true for symbolic links that still exist after symbolic links have been resolved, the command:

```
find −L −type l
```

prints a list of symbolic links reachable from the current directory that do not resolve to accessible files.

A feature of SVR4’s `find` utility was the `−exec` primary’s + terminator. This allowed filenames containing special characters (especially <newline>s) to be grouped together without the problems that occur if such filenames are piped to `xargs`. Other implementations have added other ways to get around this problem, notably a `−print0` primary that wrote filenames with a null byte terminator. This was considered here, but not adopted. Using a null terminator meant that any utility that was going to process `find`’s `−print0` output had to add a new option to parse the null terminators it would now be reading.

The "`−exec ... {} +" syntax adopted was a result of IEEE PASC Interpretation 1003.2 #210. It should be noted that this is an incompatible change to the ISO/IEC 9899:1999 standard. For example, the following command prints all files with a ‘−’ after their name if they are regular files, and a ‘+’ otherwise:

```
find / −type f −exec echo {} − ’;’ −o −exec echo {} + ’;’
```

The change invalidates usage like this. Even though the previous standard stated that this usage would work, in practice many did not support it and the standard developers felt it better to now state that this was not allowable.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Section 2.2 (on page 30), Section 2.13 (on page 62), Section 2.14 (on page 64), `chmod`, `pax`, `sh`, `test`, the System Interfaces volume of IEEE Std 1003.1-2001, `getgrgid()`, `getpwuid()`, `stat()`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

The FUTURE DIRECTIONS section is added.

**Issue 6**

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The `−perm [−]onum` primary is supported.

The `find` utility is aligned with the IEEE P1003.2b draft standard, to include processing of symbolic links and changes to the description of the `atime`, `ctime`, and `mtime` operands.
IEEE PASC Interpretation 1003.2 #210 is applied, extending the –exec operand.
NAME
fold — filter for folding lines

SYNOPSIS
fold [−bs] [−w width] [file...]

DESCRIPTION
The fold utility is a filter that shall fold lines from its input files, breaking the lines to have a maximum of width column positions (or bytes, if the −b option is specified). Lines shall be broken by the insertion of a <newline> such that each output line (referred to later in this section as a segment) is the maximum width possible that does not exceed the specified number of column positions (or bytes). A line shall not be broken in the middle of a character. The behavior is undefined if width is less than the number of columns any single character in the input would occupy.

If the <carriage-return>s, <backspace>s, or <tab>s are encountered in the input, and the −b option is not specified, they shall be treated specially:

<backspace> The current count of line width shall be decremented by one, although the count never shall become negative. The fold utility shall not insert a <newline> immediately before or after any <backspace>.

<carriage-return>
The current count of line width shall be set to zero. The fold utility shall not insert a <newline> immediately before or after any <carriage-return>.

<tab> Each <tab> encountered shall advance the column position pointer to the next tab stop. Tab stops shall be at each column position n such that n modulo 8 equals 1.

OPTIONS

The following options shall be supported:

−b Count width in bytes rather than column positions.

−s If a segment of a line contains a <blank> within the first width column positions (or bytes), break the line after the last such <blank> meeting the width constraints. If there is no <blank> meeting the requirements, the −s option shall have no effect for that output segment of the input line.

−w width Specify the maximum line length, in column positions (or bytes if −b is specified). The results are unspecified if width is not a positive decimal number. The default value shall be 80.

OPERANDS
The following operand shall be supported:

file A pathname of a text file to be folded. If no file operands are specified, the standard input shall be used.

STDIN
The standard input shall be used only if no file operands are specified. See the INPUT FILES section.
If the −b option is specified, the input files shall be text files except that the lines are not limited to (LINE_MAX) bytes in length. If the −b option is not specified, the input files shall be text files.

The following environment variables shall affect the execution of fold:

**LANG** Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

**LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), and for the determination of the width in column positions each character would occupy on a constant-width font output device.

**LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**NLSPATH** Determine the location of message catalogs for the processing of LC_MESSAGES.

The standard output shall be a file containing a sequence of characters whose order shall be preserved from the input files, possibly with inserted <newline>s.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

  0  All input files were processed successfully.

>0  An error occurred.

Default.
APPLICATION USAGE

The cut and fold utilities can be used to create text files out of files with arbitrary line lengths. The cut utility should be used when the number of lines (or records) needs to remain constant. The fold utility should be used when the contents of long lines need to be kept contiguous.

The fold utility is frequently used to send text files to printers that truncate, rather than fold, lines wider than the printer is able to print (usually 80 or 132 column positions).

EXAMPLES

An example invocation that submits a file of possibly long lines to the printer (under the assumption that the user knows the line width of the printer to be assigned by lp):

```
fold −w 132 bigfile | lp
```

RATIONALE

Although terminal input in canonical processing mode requires the erase character (frequently set to <backspace>) to erase the previous character (not byte or column position), terminal output is not buffered and is extremely difficult, if not impossible, to parse correctly; the interpretation depends entirely on the physical device that actually displays/prints/stores the output. In all known internationalized implementations, the utilities producing output for mixed column-width output assume that a <backspace> backs up one column position and outputs enough <backspace>s to return to the start of the character when <backspace> is used to provide local line motions to support underlining and emboldening operations. Since fold without the −b option is dealing with these same constraints, <backspace> is always treated as backing up one column position rather than backing up one character.

Historical versions of the fold utility assumed 1 byte was one character and occupied one column position when written out. This is no longer always true. Since the most common usage of fold is believed to be folding long lines for output to limited-length output devices, this capability was preserved as the default case. The −b option was added so that applications could fold files with arbitrary length lines into text files that could then be processed by the standard utilities. Note that although the width for the −b option is in bytes, a line is never split in the middle of a character. (It is unspecified what happens if a width is specified that is too small to hold a single character found in the input followed by a <newline>.)

The tab stops are hardcoded to be every eighth column to meet historical practice. No new method of specifying other tab stops was invented.

FUTURE DIRECTIONS

None.

SEE ALSO

cut

CHANGE HISTORY

First released in Issue 4.

Issue 6

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
fort77 — FORTRAN compiler (FORTRAN)

SYNOPSIS
FD
fort77 \[-c] \[-g] \[-L directory]... \[-O optlevel] \[-o outfile] \[-s] \[-w]
operand...

DESCRIPTION
The fort77 utility is the interface to the FORTRAN compilation system; it shall accept the full
FORTRAN-77 language defined by the ANSI X3.9-1978 standard. The system conceptually
consists of a compiler and link editor. The files referenced by operands are compiled and linked
to produce an executable file. It is unspecified whether the linking occurs entirely within the
operation of fort77; some implementations may produce objects that are not fully resolved until
the file is executed.

If the \[-c] option is present, for all pathname operands of the form file.f, the files:
$(basename pathname.f).o
shall be created or overwritten as the result of successful compilation. If the \[-c] option is not
specified, it is unspecified whether such .o files are created or deleted for the file.f operands.

If there are no options that prevent link editing (such as \[-c]) and all operands compile and link
without error, the resulting executable file shall be written into the file named by the \[-o] option
(if present) or to the file a.out. The executable file shall be created as specified in the System
Interfaces volume of IEEE Std 1003.1-2001, except that the file permissions shall be set to:
S_IRWXO | S_IRWXG | S_IRWXU
and that the bits specified by the umask of the process shall be cleared.

OPTIONS
The fort77 utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
12.2, Utility Syntax Guidelines, except that:

• The \[-L library] operands have the format of options, but their position within a list of
  operands affects the order in which libraries are searched.
• The order of specifying the multiple \[-L] options is significant.
• Conforming applications shall specify each option separately; that is, grouping option letters
  (for example, \[-cg]) need not be recognized by all implementations.

The following options shall be supported:

\[-c] Supress the link-edit phase of the compilation, and do not remove any object files
  that are produced.

\[-g] Produce symbolic information in the object or executable files; the nature of this
  information is unspecified, and may be modified by implementation-defined
  interactions with other options.

\[-s] Produce object or executable files, or both, from which symbolic and other
  information not required for proper execution using the exec family of functions
  defined in the System Interfaces volume of IEEE Std 1003.1-2001 has been removed
  (stripped). If both \[-g] and \[-s] options are present, the action taken is unspecified.

\[-o outfile] Use the pathname outfile, instead of the default a.out, for the executable file
  produced. If the \[-o] option is present with \[-c], the result is unspecified.
Utilities

−L directory Change the algorithm of searching for the libraries named in −I operands to look in the directory named by the directory pathname before looking in the usual places. Directories named in −L options shall be searched in the specified order. At least ten instances of this option shall be supported in a single fort77 command invocation. If a directory specified by a −L option contains a file named libf.a, the results are unspecified.

−O optlevel Specify the level of code optimization. If the optlevel option-argument is the digit ’0’, all special code optimizations shall be disabled. If it is the digit ’1’, the nature of the optimization is unspecified. If the −O option is omitted, the nature of the system’s default optimization is unspecified. It is unspecified whether code generated in the presence of the −O 0 option is the same as that generated when −O is omitted. Other optlevel values may be supported.

−w Suppress warnings.

Multiple instances of −L options can be specified.

OPERANDS

An operand is either in the form of a pathname or the form −l library. At least one operand of the pathname form shall be specified. The following operands shall be supported:

file.f The pathname of a FORTRAN source file to be compiled and optionally passed to the link editor. The filename operand shall be of this form if the −c option is used.

file.a A library of object files typically produced by ar, and passed directly to the link editor. Implementations may recognize implementation-defined suffixes other than .a as denoting object file libraries.

file.o An object file produced by fort77 −c and passed directly to the link editor. Implementations may recognize implementation-defined suffixes other than .o as denoting object files.

The processing of other files is implementation-defined.

−l library (The letter ell.) Search the library named:

liblibrary.a

A library is searched when its name is encountered, so the placement of a −l operand is significant. Several standard libraries can be specified in this manner, as described in the EXTENDED DESCRIPTION section. Implementations may recognize implementation-defined suffixes other than .a as denoting libraries.

STDIN

Not used.

INPUT FILES

The input file shall be one of the following: a text file containing FORTRAN source code; an object file in the format produced by fort77 −c; or a library of object files, in the format produced by archiving zero or more object files, using ar. Implementations may supply additional utilities that produce files in these formats. Additional input files are implementation-defined.

A <tab> encountered within the first six characters on a line of source code shall cause the compiler to interpret the following character as if it were the seventh character on the line (that is, in column 7).
ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of fort77:

LANG     Provide a default value for the internationalization variables that are unset or null.
          (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
           Internationalization Variables for the precedence of internationalization variables
           used to determine the values of locale categories.)

LC_ALL    If set to a non-empty string value, override the values of all the other
          internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
          characters (for example, single-byte as opposed to multi-byte characters in
          arguments and input files).

LC_MESSAGES
          Determine the locale that should be used to affect the format and contents of
          diagnostic messages written to standard error.

XSI       NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

TMPDIR    Determine the pathname that should override the default directory for temporary
          files, if any.

ASYNCHRONOUS EVENTS

Default.

STDOUT    Not used.

STDERR    The standard error shall be used only for diagnostic messages. If more than one file operand
          ending in .f (or possibly other unspecified suffixes) is given, for each such file:

          "%s: \n", <file>
          may be written to allow identification of the diagnostic message with the appropriate input file.
          This utility may produce warning messages about certain conditions that do not warrant
          returning an error (non-zero) exit value.

OUTPUT FILES

Object files, listing files, and executable files shall be produced in unspecified formats.

EXTENDED DESCRIPTION

Standard Libraries

The fort77 utility shall recognize the following −I operand for the standard library:

−I f     This library contains all functions referenced in the ANSI X3.9-1978 standard. This
          operand shall not be required to be present to cause a search of this library.

In the absence of options that inhibit invocation of the link editor, such as −c, the fort77 utility
shall cause the equivalent of a −I f operand to be passed to the link editor as the last −I operand,
causing it to be searched after all other object files and libraries are loaded.

It is unspecified whether the library libf.a exists as a regular file. The implementation may
accept as −I operands names of objects that do not exist as regular files.
Utilities

External Symbols

The FORTRAN compiler and link editor shall support the significance of external symbols up to a length of at least 31 bytes; case folding is permitted. The action taken upon encountering symbols exceeding the implementation-defined maximum symbol length is unspecified.

The compiler and link editor shall support a minimum of 511 external symbols per source or object file, and a minimum of 4095 external symbols total. A diagnostic message is written to standard output if the implementation-defined limit is exceeded; other actions are unspecified.

EXIT STATUS

The following exit values shall be returned:

0 Successful compilation or link edit.

>0 An error occurred.

CONSEQUENCES OF ERRORS

When fort77 encounters a compilation error, it shall write a diagnostic to standard error and continue to compile other source code operands. It shall return a non-zero exit status, but it is implementation-defined whether an object module is created. If the link edit is unsuccessful, a diagnostic message shall be written to standard error, and fort77 shall exit with a non-zero status.

APPLICATION USAGE

None.

EXAMPLES

The following usage example compiles xyz.f and creates the executable file foo:

fort77 -o foo xyz.f

The following example compiles xyz.f and creates the object file xyz.o:

fort77 -c xyz.f

The following example compiles xyz.f and creates the executable file a.out:

fort77 xyz.f

The following example compiles xyz.f, links it with b.o, and creates the executable a.out:

fort77 xyz.f b.o

RATIONALE

The name of this utility was chosen as fort77 to parallel the renaming of the C compiler. The name f77 was not chosen to avoid problems with historical implementations. The ANSI X3.9-1978 standard was selected as a normative reference because the ISO/IEC version of FORTRAN-77 has been superseded by the ISO/IEC 1539:1990 standard (Fortran-90).

The file inclusion and symbol definition #define mechanisms used by the c99 utility were not included in this volume of IEEE Std 1003.1-2001—even though they are commonly implemented—since there is no requirement that the FORTRAN compiler use the C preprocessor.

The –onetrip option was not included in this volume of IEEE Std 1003.1-2001, even though many historical compilers support it, because it is derived from FORTRAN-66; it is an anachronism that should not be perpetuated.

Some implementations produce compilation listings. This aspect of FORTRAN has been left unspecified because there was controversy concerning the various methods proposed for implementing it: a -V option overlapped with historical vendor practice and a naming
convention of creating files with .l suffixes collided with historical lex file naming practice.

There is no −I option in this version of this volume of IEEE Std 1003.1-2001 to specify a directory for file inclusion. An INCLUDE directive has been a part of the Fortran-90 discussions, but an interface supporting that standard is not in the current scope.

It is noted that many FORTRAN compilers produce an object module even when compilation errors occur; during a subsequent compilation, the compiler may patch the object module rather than recompiling all the code. Consequently, it is left to the implementor whether or not an object file is created.

A reference to MIL-STD-1753 was removed from an early proposal in response to a request from the POSIX FORTRAN-binding standard developers. It was not the intention of the standard developers to require certification of the FORTRAN compiler, and IEEE Std 1003.9-1992 does not specify the military standard or any special preprocessing requirements. Furthermore, use of that document would have been inappropriate for an international standard.

The specification of optimization has been subject to changes through early proposals. At one time, −O and −N were Booleans: optimize and do not optimize (with an unspecified default). Some historical practice led this to be changed to:

−O 0 No optimization.
−O 1 Some level of optimization.
−O n Other, unspecified levels of optimization.

It is not always clear whether "good code generation" is the same thing as optimization. Simple optimizations of local actions do not usually affect the semantics of a program. The −O 0 option has been included to accommodate the very particular nature of scientific calculations in a highly optimized environment; compilers make errors. Some degree of optimization is expected, even if it is not documented here, and the ability to shut it off completely could be important when porting an application. An implementation may treat −O 0 as "do less than normal" if it wishes, but this is only meaningful if any of the operations it performs can affect the semantics of a program. It is highly dependent on the implementation whether doing less than normal is logical. It is not the intent of the −O 0 option to ask for inefficient code generation, but rather to assure that any semantically visible optimization is suppressed.

The specification of standard library access is consistent with the C compiler specification. Implementations are not required to have /usr/lib/libf.a, as many historical implementations do, but if not they are required to recognize f as a token.

External symbol size limits are in normative text; conforming applications need to know these limits. However, the minimum maximum symbol length should be taken as a constraint on a conforming application, not on an implementation, and consequently the action taken for a symbol exceeding the limit is unspecified. The minimum size for the external symbol table was added for similar reasons.

The CONSEQUENCES OF ERRORS section clearly specifies the behavior of the compiler when compilation or link-edit errors occur. The behavior of several historical implementations was examined, and the choice was made to be silent on the status of the executable, or a.out, file in the face of compiler or linker errors. If a linker writes the executable file, then links it on disk with seek()s and write()s, the partially linked executable file can be left on disk and its execute bits turned off if the link edit fails. However, if the linker links the image in memory before writing the file to disk, it need not touch the executable file (if it already exists) because the link edit fails. Since both approaches are historical practice, a conforming application shall rely on the exit status of fort77, rather than on the existence or mode of the executable file.
The –g and –s options are not specified as mutually-exclusive. Historically these two options have been mutually-exclusive, but because both are so loosely specified, it seemed appropriate to leave their interaction unspecified.

The requirement that conforming applications specify compiler options separately is to reserve the multi-character option name space for vendor-specific compiler options, which are known to exist in many historical implementations. Implementations are not required to recognize, for example, –gc as if it were –g –c; nor are they forbidden from doing so. The SYNOPSIS shows all of the options separately to highlight this requirement on applications.

Echoing filenames to standard error is considered a diagnostic message because it would otherwise be difficult to associate an error message with the erring file. They are described with “may” to allow implementations to use other methods of identifying files and to parallel the description in c99.

FUTURE DIRECTIONS

A compilation system based on the ISO/IEC 1539: 1990 standard (Fortran-90) may be considered for a future version; it may have a different utility name from fort77.

SEE ALSO

ar, asa, c99, umask, the System Interfaces volume of IEEE Std 1003.1-2001, exec

CHANGE HISTORY

First released in Issue 4.

Issue 6

This utility is marked as part of the FORTRAN Development Utilities option.

The normative text is reworded to avoid use of the term “must” for application requirements.
fuser

NAME
fuser — list process IDs of all processes that have one or more files open

SYNOPSIS
fuser [ -cfu ] file ...

DESCRIPTION
The fuser utility shall write to standard output the process IDs of processes running on the local system that have one or more named files open. For block special devices, all processes using any file on that device are listed.

The fuser utility shall write to standard error additional information about the named files indicating how the file is being used.

Any output for processes running on remote systems that have a named file open is unspecified.

A user may need appropriate privilege to invoke the fuser utility.

OPTIONS
The following options shall be supported:

-c The file is treated as a mount point and the utility shall report on any files open in the file system.

-f The report shall be only for the named files.

-u The user name, in parentheses, associated with each process ID written to standard output shall be written to standard error.

OPERANDS
The following operand shall be supported:

file A pathname on which the file or file system is to be reported.

STDIN
Not used.

INPUT FILES
The user database.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of fuser:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
Utilities

fuser

**NLSPATH**
Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**
The `fuser` utility shall write the process ID for each process using each file given as an operand to standard output in the following format:

```
%d, <process_id>
```

**STDERR**
The `fuser` utility shall write diagnostic messages to standard error.
The `fuser` utility also shall write the following to standard error:

- The pathname of each named file is written followed immediately by a colon.

- For each process ID written to standard output, the character ‘c’ shall be written to standard error if the process is using the file as its current directory and the character ‘s’ shall be written to standard error if the process is using the file as its root directory.

- Implementations may write other alphabetic characters to indicate other uses of files.

- When the `−u` option is specified, characters indicating the use of the file shall be followed immediately by the user name, in parentheses, corresponding to the process’ real user ID. If the user name cannot be resolved from the process’ real user ID, the process’ real user ID shall be written instead of the user name.

When standard output and standard error are directed to the same file, the output shall be interleaved so that the filename appears at the start of each line, followed by the process ID and characters indicating the use of the file. Then, if the `−u` option is specified, the user name or user ID for each process using that file shall be written.

A `<newline>` shall be written to standard error after the last output described above for each file operand.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**
The following exit values shall be returned:

```plaintext
0 Successful completion.
>0 An error occurred.
```

**CONSEQUENCES OF ERRORS**

Default.
APPLICATION USAGE
None.

EXAMPLES
The command:

fuser -fu.

writes to standard output the process IDs of processes that are using the current directory and
writes to standard error an indication of how those processes are using the directory and the
user names associated with the processes that are using the current directory.

RATIONALE
The definition of the fuser utility follows existing practice.

FUTURE DIRECTIONS
None.

SEE ALSO
None.

CHANGE HISTORY
First released in Issue 5.
NAME

gencat — generate a formatted message catalog

SYNOPSIS

XSI

gencat catfile msgfile...

DESCRIPTION

The gencat utility shall merge the message text source file msgfile into a formatted message catalog catfile. The file catfile shall be created if it does not already exist. If catfile does exist, its messages shall be included in the new catfile. If set and message numbers collide, the new message text defined in msgfile shall replace the old message text currently contained in catfile.

OPTIONS

None.

OPERANDS

The following operands shall be supported:

catfile A pathname of the formatted message catalog. If ‘−’ is specified, standard output shall be used. The format of the message catalog produced is unspecified.

msgfile A pathname of a message text source file. If ‘−’ is specified for an instance of msgfile, standard input shall be used. The format of message text source files is defined in the EXTENDED DESCRIPTION section.

STDIN

The standard input shall not be used unless a msgfile operand is specified as ‘−’.

INPUT FILES

The input files shall be text files.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of gencat:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

The standard output shall not be used unless the catfile operand is specified as ‘−’.
The standard error shall be used only for diagnostic messages.

None.

The content of a message text file shall be in the format defined as follows. Note that the fields of a message text source line are separated by a single <blank>. Any other <blank>s are considered to be part of the subsequent field.

This line specifies the set identifier of the following messages until the next $set or end-of-file appears. The $ denotes the set identifier, which is defined as a number in the range [1, {NL_SETMAX}] (see the <limits.h> header defined in the Base Definitions volume of IEEE Std 1003.1-2001). The application shall ensure that set identifiers are presented in ascending order within a single source file, but need not be contiguous. Any string following the set identifier shall be treated as a comment. If no $set directive is specified in a message text source file, all messages shall be located in an implementation-defined default message set NL_SETD (see the <nl_types.h> header defined in the Base Definitions volume of IEEE Std 1003.1-2001).

This line deletes message set n from an existing message catalog. The $ denotes the set number [1, {NL_SETMAX}]. Any string following the set number shall be treated as a comment.

A line beginning with ‘$’ followed by a <blank> shall be treated as a comment.

The $ denotes the message identifier, which is defined as a number in the range [1, {NL_MSGMAX}] (see the <limits.h> header). The message-text shall be stored in the message catalog with the set identifier specified by the last $set directive, and with message identifier $$. If the message-text is empty, and a <blank> field separator is present, an empty string shall be stored in the message catalog. If a message source line has a message number, but neither a field separator nor message-text, the existing message with that number (if any) shall be deleted from the catalog. The application shall ensure that message identifiers are in ascending order within a single set, but need not be contiguous. The application shall ensure that the length of message-text is in the range [0, {NL_TEXTMAX}] (see the <limits.h> header).

This line specifies an optional quote character c, which can be used to surround message-text so that trailing spaces or null (empty) messages are visible in a message source line. By default, or if an empty $quote directive is supplied, no quoting of message-text shall be recognized.

Empty lines in a message text source file shall be ignored. The effects of lines starting with any character other than those defined above are implementation-defined.

Text strings can contain the special characters and escape sequences defined in the following table:
The escape sequence "\ddd" consists of backslash followed by one, two, or three octal digits, which shall be taken to specify the value of the desired character. If the character following a backslash is not one of those specified, the backslash shall be ignored.

Backslash ( '\ ' ) followed by a <newline> is also used to continue a string on the following line. Thus, the following two lines describe a single message string:

```
This line continues \
to the next line
```

which shall be equivalent to:

```
This line continues to the next line
```

EXIT STATUS
The following exit values shall be returned:

- 0 Successful completion.
- >0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Message catalogs produced by gencat are binary encoded, meaning that their portability cannot be guaranteed between different types of machine. Thus, just as C programs need to be recompiled for each type of machine, so message catalogs must be recreated via gencat.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
iconv, the Base Definitions volume of IEEE Std 1003.1-2001, <limits.h>, <nl_types.h>

CHANGE HISTORY
First released in Issue 3.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
get — get a version of an SCCS file (DEVELOPMENT)

SYNOPSIS
XSI
get [-begkmnllpst] [-c cutoff] [-i list] [-r SID] [-x list] file...

DESCRIPTION
The get utility shall generate a text file from each named SCCS file according to the specifications given by its options.

The generated text shall normally be written into a file called the g-file whose name is derived from the SCCS filename by simply removing the leading "s."

OPTIONS

The following options shall be supported:

- r SID Indicate the SCCS Identification String (SID) of the version (delta) of an SCCS file to be retrieved. The table shows, for the most useful cases, what version of an SCCS file is retrieved (as well as the SID of the version to be eventually created by delta if the -e option is also used), as a function of the SID specified.

- c cutoff Indicate the cutoff date-time, in the form:
  YY [MM [DD [HH [MM [SS]]]]]
For the YY component, values in the range [69,99] shall refer to years 1969 to 1999 inclusive, and values in the range [00,68] shall refer to years 2000 to 2068 inclusive.
Note: It is expected that in a future version of IEEE Std 1003.1-2001 the default century inferred from a 2-digit year will change. (This would apply to all commands accepting a 2-digit year as input.)
No changes (deltas) to the SCCS file that were created after the specified cutoff date-time shall be included in the generated text file. Units omitted from the date-time default to their maximum possible values; for example, -c 7502 is equivalent to -c 750228235959.
Any number of non-numeric characters may separate the various 2-digit pieces of the cutoff date-time. This feature allows the user to specify a cutoff date in the form: -c "77/2/2 9:22:25".

- e Indicate that the get is for the purpose of editing or making a change (delta) to the SCCS file via a subsequent use of delta. The -e option used in a get for a particular version (SID) of the SCCS file shall prevent further get commands from editing on the same SID until delta is executed or the j (joint edit) flag is set in the SCCS file. Concurrent use of get -e for different SIDs is always allowed.
If the g-file generated by get with a -e option is accidentally ruined in the process of editing, it may be regenerated by re-executing the get command with the -k option in place of the -e option.
SCCS file protection specified via the ceiling, floor, and authorized user list stored in the SCCS file shall be enforced when the -e option is used.

- b Use with the -e option to indicate that the new delta should have an SID in a new branch as shown in the table below. This option shall be ignored if the b flag is not present in the file or if the retrieved delta is not a leaf delta. (A leaf delta is one that
Utilities

18443 has no successors on the SCCS file tree.)

18444 Note: A branch delta may always be created from a non-leaf delta.

18445 -i list Indicate a list of deltas to be included (forced to be applied) in the creation of the
18446 generated file. The list has the following syntax:

18447 \textless list\textgreater ::= \textless range\textgreater | \textless list\textgreater , \textless range\textgreater
18448 \textless range\textgreater ::= SID | SID − SID

18449 SID, the SCCS Identification of a delta, may be in any form shown in the “SID
18450 Specified” column of the table in the EXTENDED DESCRIPTION section, except
18451 that the result of supplying a partial SID is unspecified. A diagnostic message shall
18452 be written if the first SID in the range is not an ancestor of the second SID in the
18453 range.

18454 -x list Indicate a list of deltas to be excluded (forced not to be applied) in the creation of
18455 the generated file. See the -i option for the list format.

18456 -k Suppress replacement of identification keywords (see below) in the retrieved text
18457 by their value. The -k option shall be implied by the -e option.

18458 -l Write a delta summary into an l-file.

18459 -L Write a delta summary to standard output. All informative output that normally is
18460 written to standard output shall be written to standard error instead, unless the -s
18461 option is used, in which case it shall be suppressed.

18462 -p Write the text retrieved from the SCCS file to the standard output. No g-file shall
18463 be created. All informative output that normally goes to the standard output shall
18464 go to standard error instead, unless the -s option is used, in which case it shall
18465 disappear.

18466 -s Suppress all informative output normally written to standard output. However,
18467 fatal error messages (which shall always be written to the standard error) shall
18468 remain unaffected.

18469 -m Precede each text line retrieved from the SCCS file by the SID of the delta that
18470 inserted the text line in the SCCS file. The format shall be:

18471 "\%s\t\%s\", \textless SID\textgreater, \textless text line\textgreater

18472 -n Precede each generated text line with the \%M\% identification keyword value (see
18473 below). The format shall be:

18474 "\%s\t\%s\", \textless \%M\% value\textgreater, \textless text line\textgreater

18475 When both the -m and -n options are used, the <text line> shall be replaced by the
18476 -m option-generated format.

18477 -g Suppress the actual retrieval of text from the SCCS file. It is primarily used to
18478 generate an l-file, or to verify the existence of a particular SID.

18479 -t Use to access the most recently created (top) delta in a given release (for example,
18480 -r 1), or release and level (for example, -r 1.2).

18481 OPERANDS
18482 The following operands shall be supported:

18483 file A pathname of an existing SCCS file or a directory. If file is a directory, the get
18484 utility shall behave as though each file in the directory were specified as a named
18485 file, except that non-SCCS files (last component of the pathname does not begin
with s.) and unreadable files shall be silently ignored.

If exactly one file operand appears, and it is ‘−’, the standard input shall be read; each line of the standard input is taken to be the name of an SCCS file to be processed. Non-SCCS files and unreadable files shall be silently ignored.

STDIN

The standard input shall be a text file used only if the file operand is specified as ‘−’. Each line of the text file shall be interpreted as an SCCS pathname.

INPUT FILES

The SCCS files shall be files of an unspecified format.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of get:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error, and informative messages written to standard output (or standard error, if the −p option is used).

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

TZ Determine the timezone in which the times and dates written in the SCCS file are evaluated. If the TZ variable is unset or NULL, an unspecified system default timezone is used.

ASYNCHRONOUS EVENTS

Default.

STDOUT

For each file processed, get shall write to standard output the SID being accessed and the number of lines retrieved from the SCCS file, in the following format:

"%s\n%d lines\n", <SID>, <number of lines>

If the −e option is used, the SID of the delta to be made shall appear after the SID accessed and before the number of lines generated, in the POSIX locale:

"%s\nnew delta %s\n%d lines\n", <SID accessed>, <SID to be made>, <number of lines>

If there is more than one named file or if a directory or standard input is named, each pathname shall be written before each of the lines shown in one of the preceding formats:

"\n%s:\n", <pathname>

If the −L option is used, a delta summary shall be written following the format specified below for l-files.
If the \(-i\) option is used, included deltas shall be listed following the notation, in the POSIX locale:

"Included:\n"

If the \(-x\) option is used, excluded deltas shall be listed following the notation, in the POSIX locale:

"Excluded:\n"

If the \(-p\) or \(-L\) options are specified, the standard output shall consist of the text retrieved from the SCCS file.

STDOUT

The standard error shall be used only for diagnostic messages, except if the \(-p\) or \(-L\) options are specified, it shall include all informative messages normally sent to standard output.

OUTPUT FILES

Several auxiliary files may be created by \textit{get}. These files are known generically as the \textit{g-file}, \textit{l-file}, \textit{p-file}, and \textit{z-file}. The letter before the hyphen is called the \textit{tag}. An auxiliary filename shall be formed from the SCCS filename: the application shall ensure that the last component of all SCCS filenames is of the form \textit{s.module-name}; the auxiliary files shall be named by replacing the leading \textit{s} with the tag. The \textit{g-file} shall be an exception to this scheme: the \textit{g-file} is named by removing the \textit{s} prefix. For example, for \textit{s.xyz.c}, the auxiliary filenames would be \textit{xyz.c}, \textit{l.xyz.c}, \textit{p.xyz.c}, and \textit{z.xyz.c}, respectively.

The \textit{g-file}, which contains the generated text, shall be created in the current directory (unless the \(-p\) option is used). A \textit{g-file} shall be created in all cases, whether or not any lines of text were generated by the \textit{get}. It shall be owned by the real user. If the \(-k\) option is used or implied, the \textit{g-file} shall be writable by the owner only (read-only for everyone else); otherwise, it shall be read-only. Only the real user need have write permission in the current directory.

The \textit{l-file} shall contain a table showing which deltas were applied in generating the retrieved text. The \textit{l-file} shall be created in the current directory if the \(-l\) option is used; it shall be read-only and it is owned by the real user. Only the real user need have write permission in the current directory.

Lines in the \textit{l-file} shall have the following format:

"%c%c%c∆%s\t%s∆%s\n", <\textit{code}1>, <\textit{code}2>, <\textit{code}3>,
<lID>, <\textit{date-time}>, <\textit{login}>

where the entries are:

<\textit{code}1> A <space> if the delta was applied; ‘*’ otherwise.
<\textit{code}2> A <space> if the delta was applied or was not applied and ignored; ‘*’ if the delta was not applied and was not ignored.
<\textit{code}3> A character indicating a special reason why the delta was or was not applied:
I Included.
X Excluded.
C Cut off (by a \(-c\) option).
<\textit{date-time}> Date and time (using the format of the \textit{date} utility’s \%y/\%m/\%d \%T conversion specification format) of creation.
<\textit{login}> Login name of person who created \textit{delta}.  

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The comments and MR data shall follow on subsequent lines, indented one <tab>. A blank line shall terminate each entry.

The p-file shall be used to pass information resulting from a get with a \(-e\) option along to delta. Its contents shall also be used to prevent a subsequent execution of get with a \(-e\) option for the same SID until delta is executed or the joint edit flag, \(j\), is set in the SCCS file. The p-file shall be created in the directory containing the SCCS file and the application shall ensure that the effective user has write permission in that directory. It shall be writable by owner only, and owned by the effective user. Each line in the p-file shall have the following format:

\[
\%s\Delta%s\Delta%s\%s\%s\%s\%s
\], <g-file SID>,
\<SID of new delta>, <login-name of real user>,
\<date-time>, <i-value>, <x-value>

where <i-value> uses the format "" if no \(-i\) option was specified, and shall use the format:

\[
\Delta-i%s
\], <-i option option-argument>

if a \(-i\) option was specified and <x-value> uses the format "" if no \(-x\) option was specified, and shall use the format:

\[
\Delta-x%s
\], <-x option option-argument>

if a \(-x\) option was specified. There can be an arbitrary number of lines in the p-file at any time; no two lines shall have the same new delta SID.

The z-file shall serve as a lock-out mechanism against simultaneous updates. Its contents shall be the binary process ID of the command (that is, get) that created it. The z-file shall be created in the directory containing the SCCS file for the duration of get. The same protection restrictions as those for the p-file shall apply for the z-file. The z-file shall be created read-only.
### EXTENDED DESCRIPTION

<table>
<thead>
<tr>
<th>SID*</th>
<th>−b Keyletter Used†</th>
<th>Other Conditions</th>
<th>SID Retrieved</th>
<th>SID of Delta to be Created</th>
</tr>
</thead>
<tbody>
<tr>
<td>none‡</td>
<td>no</td>
<td>R defaults to mR</td>
<td>mR.mL</td>
<td>mR.(mL+1)</td>
</tr>
<tr>
<td>none‡</td>
<td>yes</td>
<td>R defaults to mR</td>
<td>mR.mL</td>
<td>mR.mL.(mB+1).1</td>
</tr>
<tr>
<td>R</td>
<td>no</td>
<td>R &gt; mR</td>
<td>mR.mL</td>
<td>R.1***</td>
</tr>
<tr>
<td>R</td>
<td>no</td>
<td>R = mR</td>
<td>mR.mL</td>
<td>mR.(mL+1)</td>
</tr>
<tr>
<td>R</td>
<td>yes</td>
<td>R &gt; mR</td>
<td>mR.mL</td>
<td>mR.mL.(mB+1).1</td>
</tr>
<tr>
<td>R</td>
<td>yes</td>
<td>R = mR</td>
<td>mR.mL</td>
<td>mR.mL.(mB+1).1</td>
</tr>
<tr>
<td>R</td>
<td>−</td>
<td>R &lt; mR and</td>
<td>hR.mL**</td>
<td>hR.mL.(mB+1).1</td>
</tr>
<tr>
<td>R</td>
<td>−</td>
<td>Trunk successor in release ≥ R and R exists</td>
<td>R.mL</td>
<td>R.mL.(mB+1).1</td>
</tr>
<tr>
<td>R.L</td>
<td>no</td>
<td>No trunk successor</td>
<td>R.L</td>
<td>R.(L+1)</td>
</tr>
<tr>
<td>R.L</td>
<td>yes</td>
<td>No trunk successor</td>
<td>R.L</td>
<td>R.(mB+1).1</td>
</tr>
<tr>
<td>R.L</td>
<td>−</td>
<td>Trunk successor</td>
<td>R.L</td>
<td>R.(mB+1).1</td>
</tr>
<tr>
<td>R.L.B</td>
<td>no</td>
<td>No branch successor</td>
<td>R.L.B.mS</td>
<td>R.L.B.(mS+1)</td>
</tr>
<tr>
<td>R.L.B</td>
<td>yes</td>
<td>No branch successor</td>
<td>R.L.B.mS</td>
<td>R.L.B.(mB+1).1</td>
</tr>
<tr>
<td>R.L.B.S</td>
<td>no</td>
<td>No branch successor</td>
<td>R.L.B.S</td>
<td>R.L.B.(S+1)</td>
</tr>
<tr>
<td>R.L.B.S</td>
<td>yes</td>
<td>No branch successor</td>
<td>R.L.B.S</td>
<td>R.L.B.(mB+1).1</td>
</tr>
<tr>
<td>R.L.B.S</td>
<td>−</td>
<td>Branch successor</td>
<td>R.L.B.S</td>
<td>R.L.B.(mB+1).1</td>
</tr>
</tbody>
</table>

* R, L, B, and S are the release, level, branch, and sequence components of the SID, respectively; m means maximum. Thus, for example, R.mL means “the maximum level number within release R”; R.(mB+1).1 means “the first sequence number on the new branch (that is, maximum branch number plus one) of level L within release R”. Note that if the SID specified is of the form R.L, R.L.B, or R.L.B.S, each of the specified components shall exist.

** hR is the highest existing release that is lower than the specified, nonexistent, release R.

*** This is used to force creation of the first delta in a new release.

† The −b option is effective only if the b flag is present in the file. An entry of ‘−’ means “irrelevant”.

‡ This case applies if the d (default SID) flag is not present in the file. If the d flag is present in the file, then the SID obtained from the d flag is interpreted as if it had been specified on the command line. Thus, one of the other cases in this table applies.
When a g-file is generated, the creation time of deltas in the SCCS file may be taken into account. If any of these times are apparently in the future, the behavior is unspecified.

### Identification Keywords

Identifying information shall be inserted into the text retrieved from the SCCS file by replacing identification keywords with their value wherever they occur. The following keywords may be used in the text stored in an SCCS file:

- **%M%**: Module name: either the value of the m flag in the file, or if absent, the name of the SCCS file with the leading s, removed.
- **%I%**: SCCS identification (SID) (%R%.%L% or %R%.%L%.%B%.%S%) of the retrieved text.
- **%R%**: Release.
- **%L%**: Level.
- **%B%**: Branch.
- **%S%**: Sequence.
- **%D%**: Current date (YY/MM/DD).
- **%H%**: Current date (MM/DD/YY).
- **%T%**: Current time (HH:MM:SS).
- **%E%**: Date newest applied delta was created (YY/MM/DD).
- **%G%**: Date newest applied delta was created (MM/DD/YY).
- **%U%**: Time newest applied delta was created (HH:MM:SS).
- **%Y%**: Module type: value of the t flag in the SCCS file.
- **%F%**: SCCS filename.
- **%P%**: SCCS absolute pathname.
- **%Q%**: The value of the q flag in the file.
- **%C%**: Current line number. This keyword is intended for identifying messages output by the program, such as “this should not have happened” type errors. It is not intended to be used on every line to provide sequence numbers.
- **%Z%**: The four-character string "@(#)" recognizable by what.
- **%W%**: A shorthand notation for constructing what strings:
  - %W%=%Z%%M%<tab>%I%
- **%A%**: Another shorthand notation for constructing what strings:
  - %A%=%Z%%Y%%M%%I%%Z%

### EXIT STATUS

The following exit values shall be returned:

- **0**: Successful completion.
- **>0**: An error occurred.
CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Problems can arise if the system date and time have been modified (for example, put forward and then back again, or unsynchronized clocks across a network) and can also arise when different values of the TZ environment variable are used.

Problems of a similar nature can also arise for the operation of the delta utility, which compares the previous file body against the working file as part of its normal operation.

EXAMPLES

None.

RATIONALE

None.

FUTURE DIRECTIONS

The −lp option may be withdrawn in a future version.

SEE ALSO

admin, delta, prs, what

CHANGE HISTORY

First released in Issue 2.

Issue 5

A correction is made to the first format string in STDOUT.

The interpretation of the YY component of the −c cutoff argument is noted.

Issue 6

The obsolescent SYNOPSIS is removed, removing the −lp option.

The normative text is reworded to avoid use of the term “must” for application requirements.

The Open Group Corrigendum U025/5 is applied, correcting text in the OPTIONS section.

The Open Group Corrigendum U048/1 is applied.

The Open Group Interpretation PIN4C.00014 is applied.

The Open Group Base Resolution bwg2001-007 is applied as follows:

• The EXTENDED DESCRIPTION section is updated to make partial SID handling unspecified, reflecting common usage, and to clarify SID ranges.

• New text is added to the EXTENDED DESCRIPTION and APPLICATION USAGE sections regarding how the system date and time may be taken into account.

• The TZ environment variable is added to the ENVIRONMENT VARIABLES section.
NAME
getconf — get configuration values

SYNOPSIS
getconf [ -v specification ] system_var
getconf [ -v specification ] path_var pathname

DESCRIPTION
In the first synopsis form, the getconf utility shall write to the standard output the value of the variable specified by the system_var operand.

In the second synopsis form, the getconf utility shall write to the standard output the value of the variable specified by the path_var operand for the path specified by the pathname operand.

The value of each configuration variable shall be determined as if it were obtained by calling the function from which it is defined to be available by this volume of IEEE Std 1003.1-2001 or by the System Interfaces volume of IEEE Std 1003.1-2001 (see the OPERANDS section). The value shall reflect conditions in the current operating environment.

OPTIONS

The following option shall be supported:

-v specification
Indicate a specific specification and version for which configuration variables shall be determined. If this option is not specified, the values returned correspond to an implementation default conforming compilation environment.

If the command:

getconf _POSIX_V6_ILP32_OFF32

does not write "-1\n" or "undefined\n" to standard output, then commands of the form:

getconf -v POSIX_V6_ILP32_OFF32 ...

determine values for configuration variables corresponding to the POSIX_V6_ILP32_OFF32 compilation environment specified in c99, the EXTENDED DESCRIPTION.

If the command:

getconf _POSIX_V6_ILP32_OFFBIG

does not write "-1\n" or "undefined\n" to standard output, then commands of the form:

getconf -v POSIX_V6_ILP32_OFFBIG ...

determine values for configuration variables corresponding to the POSIX_V6_ILP32_OFFBIG compilation environment specified in c99, the EXTENDED DESCRIPTION.

If the command:

getconf _POSIX_V6_LP64_OFF64

does not write "-1\n" or "undefined\n" to standard output, then commands of the form:
getconf -v POSIX_V6_LP64_OFF64 ...

determine values for configuration variables corresponding to the
POSIX_V6_LP64_OFF64 compilation environment specified in c99, the
EXTENDED DESCRIPTION.

If the command:

getconf _POSIX_V6_LPBIG_OFFBIG

does not write "-1\n" or "undefined\n" to standard output, then commands of
the form:

getconf -v POSIX_V6_LPBIG_OFFBIG ...

determine values for configuration variables corresponding to the
POSIX_V6_LPBIG_OFFBIG compilation environment specified in c99, the
EXTENDED DESCRIPTION.

OPERANDS

The following operands shall be supported:

- **path_var**: A name of a configuration variable. All of the variables in the Variable column of the table in the DESCRIPTION of the `fpathconf()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001, without the enclosing braces, shall be supported. The implementation may add other local variables.

- **pathname**: A pathname for which the variable specified by `path_var` is to be determined.

- **system_var**: A name of a configuration variable. All of the following variables shall be supported:

  - The names in the Variable column of the table in the DESCRIPTION of the `sysconf()` function in the System Interfaces volume of IEEE Std 1003.1-2001, except for the entries corresponding to `_SC_CLK_TCK`, `_SC_GETGR_R_SIZE_MAX`, and `_SC_GETPW_R_SIZE_MAX`, without the enclosing braces.

  For compatibility with earlier versions, the following variable names shall also be supported:

  - `POSIX2_C_BIND`
  - `POSIX2_C_DEV`
  - `POSIX2_CHAR_TERM`
  - `POSIX2_FORT_DEV`
  - `POSIX2_FORT_RUN`
  - `POSIX2_LOCALEDEF`
  - `POSIX2_SW_DEV`
  - `POSIX2_UPE`
  - `POSIX2_VERSION`

  and shall be equivalent to the same name prefixed with an underscore. This requirement may be removed in a future version.

  - The names of the symbolic constants used as the `name` argument of the `confstr()` function in the System Interfaces volume of IEEE Std 1003.1-2001, without the `_CS_` prefix.

  - The names of the symbolic constants listed under the headings “Maximum Values” and “Minimum Values” in the description of the `<limits.h>` header in
the Base Definitions volume of IEEE Std 1003.1-2001, without the enclosing braces.

For compatibility with earlier versions, the following variable names shall also be supported:

- POSIX2_BC_BASE_MAX
- POSIX2_BC_DIM_MAX
- POSIX2_BC_SCALE_MAX
- POSIX2_BC_STRING_MAX
- POSIX2_COLL_WEIGHTS_MAX
- POSIX2_EXPR_NEST_MAX
- POSIX2_LINE_MAX
- POSIX2_RE_DUP_MAX

and shall be equivalent to the same name prefixed with an underscore. This requirement may be removed in a future version.

The implementation may add other local values.

**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of `getconf`:

- **LANG** Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH** Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

If the specified variable is defined on the system and its value is described to be available from the `confstr()` function defined in the System Interfaces volume of IEEE Std 1003.1-2001, its value shall be written in the following format:

```
"%s\n", <value>
```

Otherwise, if the specified variable is defined on the system, its value shall be written in the following format:
If the specified variable is valid, but is undefined on the system, `getconf` shall write using the following format:

```
"undefined\n"
```

If the variable name is invalid or an error occurs, nothing shall be written to standard output.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- 0 The specified variable is valid and information about its current state was written successfully.
- >0 An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

None.

**EXAMPLES**

The following example illustrates the value of `{NGROUPS_MAX}`:

```
getconf NGROUPS_MAX
```

The following example illustrates the value of `{NAME_MAX}` for a specific directory:

```
getconf NAME_MAX /usr
```

The following example shows how to deal more carefully with results that might be unspecified:

```
if value=$(getconf PATH_MAX /usr); then
  if [ "$value" = "undefined" ]; then
    echo PATH_MAX in /usr is infinite.
  else
    echo PATH_MAX in /usr is $value.
  fi
else
  echo Error in getconf.
fi
```

Note that:

```
syssconf(_SC_POSIX_C_BIND);
```

and:

```
system("getconf POSIX2_C_BIND");
```

in a C program could give different answers. The `syssconf()` call supplies a value that corresponds to the conditions when the program was either compiled or executed, depending on the
getconf implementation; the system() call to getconf always supplies a value corresponding to conditions when the program is executed.

RATIONALE

The original need for this utility, and for the confstr() function, was to provide a way of finding the configuration-defined default value for the PATH environment variable. Since PATH can be modified by the user to include directories that could contain utilities replacing the standard utilities, shell scripts need a way to determine the system-supplied PATH environment variable value that contains the correct search path for the standard utilities. It was later suggested that access to the other variables described in this volume of IEEE Std 1003.1-2001 could also be useful to applications.

This functionality of getconf would not be adequately subsumed by another command such as:

grep var /etc/conf

because such a strategy would provide correct values for neither those variables that can vary at runtime, nor those that can vary depending on the path.

Early proposal versions of getconf specified exit status 1 when the specified variable was valid, but not defined on the system. The output string "undefined" is now used to specify this case with exit code 0 because so many things depend on an exit code of zero when an invoked utility is successful.

FUTURE DIRECTIONS

None.

SEE ALSO

c99, the Base Definitions volume of IEEE Std 1003.1-2001, <limits.h>, the System Interfaces volume of IEEE Std 1003.1-2001, confstr(), pathconf(), sysconf(), system()

CHANGE HISTORY

First released in Issue 4.

Issue 5

In the OPERANDS section:

- [NL_MAX] is changed to [NL_NMAX].
- Entries beginning NL_ are deleted from the list of standard configuration variables.
- The list of variables previously marked UX is merged with the list marked EX.
- Operands are added to support new Option Groups.
- Operands are added so that getconf can determine supported programming environments.

Issue 6

The Open Group Corrigendum U029/4 is applied, correcting the example command in the last paragraph of the OPTIONS section.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- Operands are added to determine supported programming environments.

This reference page is updated for alignment with the ISO/IEC 9899:1999 standard. Specifically, new macros for c99 programming environments are introduced.

XSI marked system_var (XBS5_*) values are marked LEGACY.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/27 is applied, correcting the descriptions of `path_var` and `system_var` in the OPERANDS section.
NAME

getopts — parse utility options

SYNOPSIS

getopts optstring name [arg...]

DESCRIPTION

The getopts utility shall retrieve options and option-arguments from a list of parameters. It shall support the Utility Syntax Guidelines 3 to 10, inclusive, described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines.

Each time it is invoked, the getopts utility shall place the value of the next option in the shell variable specified by the name operand and the index of the next argument to be processed in the shell variable OPTIND. Whenever the shell is invoked, OPTIND shall be initialized to 1.

When the option requires an option-argument, the getopts utility shall place it in the shell variable OPTARG. If no option was found, or if the option that was found does not have an option-argument, OPTARG shall be unset.

If an option character not contained in the optstring operand is found where an option character is expected, the shell variable specified by name shall be set to the question-mark (’?’) character. In this case, if the first character in optstring is a colon (’:’), the shell variable OPTARG shall be set to the option character found, but no output shall be written to standard error; otherwise, the shell variable OPTARG shall be unset and a diagnostic message shall be written to standard error. This condition shall be considered to be an error detected in the way arguments were presented to the invoking application, but shall not be an error in getopts processing.

If an option-argument is missing:

• If the first character of optstring is a colon, the shell variable specified by name shall be set to the colon character and the shell variable OPTARG shall be set to the option character found.

• Otherwise, the shell variable specified by name shall be set to the question-mark character, the shell variable OPTARG shall be unset, and a diagnostic message shall be written to standard error. This condition shall be considered to be an error detected in the way arguments were presented to the invoking application, but shall not be an error in getopts processing; a diagnostic message shall be written as stated, but the exit status shall be zero.

When the end of options is encountered, the getopts utility shall exit with a return value greater than zero; the shell variable OPTIND shall be set to the index of the first non-option-argument, where the first "--" argument is considered to be an option-argument if there are no other non-option-arguments appearing before it, or the value "$#"+1 if there are no non-option-arguments; the name variable shall be set to the question-mark character. Any of the following shall identify the end of options: the special option "--", finding an argument that does not begin with a ‘‘--’, or encountering an error.

The shell variables OPTIND and OPTARG shall be local to the caller of getopts and shall not be exported by default.

The shell variable specified by the name operand, OPTIND, and OPTARG shall affect the current shell execution environment; see Section 2.12 (on page 61).

If the application sets OPTIND to the value 1, a new set of parameters can be used: either the current positional parameters or new arg values. Any other attempt to invoke getopts multiple times in a single shell execution environment with parameters (positional parameters or arg operands) that are not the same in all invocations, or with an OPTIND value modified to be a value other than 1, produces unspecified results.
OPTIONS

None.

OPERANDS

The following operands shall be supported:

optstring  A string containing the option characters recognized by the utility invoking getopt.

If a character is followed by a colon, the option shall be expected to have an
argument, which should be supplied as a separate argument. Applications should
specify an option character and its option-argument as separate arguments, but
getopt shall interpret the characters following an option character requiring
arguments as an argument whether or not this is done. An explicit null option-
argument need not be recognized if it is not supplied as a separate argument when
getopt is invoked. (See also the getopt() function defined in the System Interfaces
volume of IEEE Std 1003.1-2001.) The characters question-mark and colon shall not
be used as option characters by an application. The use of other option characters
that are not alphanumeric produces unspecified results. If the option-argument is
not supplied as a separate argument from the option character, the value in
OPTARG shall be stripped of the option character and the ‘−’.

The first character
in optstring determines how getopt behaves if an option character is not known or
an option-argument is missing.

name  The name of a shell variable that shall be set by the getopt utility to the option
character that was found.

The getopt utility by default shall parse positional parameters passed to the invoking shell
procedure. If args are given, they shall be parsed instead of the positional parameters.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of getopt:

LANG  Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI  NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

OPTIND  This variable shall be used by the getopt utility as the index of the next argument
to be processed.
ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
Whenever an error is detected and the first character in the optstring operand is not a colon (':'), a diagnostic message shall be written to standard error with the following information in an unspecified format:

- The invoking program name shall be identified in the message. The invoking program name shall be the value of the shell special parameter 0 (see Section 2.5.2 (on page 34)) at the time the getopt utility is invoked. A name equivalent to:

  basename "$0"

may be used.

- If an option is found that was not specified in optstring, this error is identified and the invalid option character shall be identified in the message.

- If an option requiring an option-argument is found, but an option-argument is not found, this error shall be identified and the invalid option character shall be identified in the message.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  An option, specified or unspecified by optstring, was found.

>0  The end of options was encountered or an error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Since getopt affects the current shell execution environment, it is generally provided as a shell regular built-in. If it is called in a subshell or separate utility execution environment, such as one of the following:

(getopts abc value "@$")
nohup getopt ...
find . -exec getopt ... \

it does not affect the shell variables in the caller’s environment.

Note that shell functions share OPTIND with the calling shell even though the positional parameters are changed. If the calling shell and any of its functions uses getopt to parse arguments, the results are unspecified.

EXAMPLES
The following example script parses and displays its arguments:
Utilities

while getopts ab: name
do
case $name in
  a) aflag=1;;
b) bflag=1
   bval="$OPTARG";;
?) printf "Usage: %s: [-a] [-b value] args
   exit 2;;
esac
done
if [ ! -z "$aflag" ]; then
  printf "Option -a specified\n"
fi
if [ ! -z "$bflag" ]; then
  printf 'Option -b "%s" specified\n' "$bval"
fi
shift $((OPTIND - 1))
printf "Remaining arguments are: %s\n" "$*"

RATIONALE
The getopts utility was chosen in preference to the System V getopt utility because getopts handles option-arguments containing <blank>s.
The OPTARG variable is not mentioned in the ENVIRONMENT VARIABLES section because it does not affect the execution of getopts; it is one of the few "output-only" variables used by the standard utilities.
The colon is not allowed as an option character because that is not historical behavior, and it violates the Utility Syntax Guidelines. The colon is now specified to behave as in the KornShell version of the getopts utility; when used as the first character in the optstring operand, it disables diagnostics concerning missing option-arguments and unexpected option characters. This replaces the use of the OPTERR variable that was specified in an early proposal.
The formats of the diagnostic messages produced by the getopts utility and the getopt() function are not fully specified because implementations with superior ("friendlier") formats objected to the formats used by some historical implementations. The standard developers considered it important that the information in the messages used be uniform between getopts and getopt(). Exact duplication of the messages might not be possible, particularly if a utility is built on another system that has a different getopt() function, but the messages must have specific information included so that the program name, invalid option character, and type of error can be distinguished by a user.
Only a rare application program intercepts a getopts standard error message and wants to parse it. Therefore, implementations are free to choose the most usable messages they can devise. The following formats are used by many historical implementations:
"%s: illegal option -- %c\n", <program name>, <option character>
"%s: option requires an argument -- %c\n", <program name>, 
  <option character>
Historical shells with built-in versions of getopt() or getopts have used different formats, frequently not even indicating the option character found in error.
FUTURE DIRECTIONS
None.

SEE ALSO
Section 2.5.2 (on page 34), the System Interfaces volume of IEEE Std 1003.1-2001, getopt()

CHANGE HISTORY
First released in Issue 4.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME

grep — search a file for a pattern

SYNOPSIS

grep [-E | -F] [-c | -l] [-q] [-insvx] -e pattern_list...
[-f pattern_file]...
[file ...]

grep [-E | -F] [-c | -l] [-q] [-insvx] [−e pattern_list]...
[−f pattern_file]...

DESCRIPTION

The grep utility shall search the input files, selecting lines matching one or more patterns; the
ones supplied to the utility are controlled by the options specified. The patterns are specified by the
−e option, −f option, or the pattern_list operand. The pattern_list’s value shall consist of one or more
patterns separated by <newline>s; the pattern_file’s contents shall consist of one or more
patterns terminated by <newline>. By default, an input line shall be selected if any pattern,
treated as an entire basic regular expression (BRE) as described in the Base Definitions volume of
IEEE Std 1003.1-2001, Section 9.3, Basic Regular Expressions, matches any part of the line
excluding the terminating <newline>; a null BRE shall match every line. By default, each selected
input line shall be written to the standard output.

Regular expression matching shall be based on text lines. Since a <newline> separates or
terminates patterns (see the −e and −f options below), regular expressions cannot contain a
<newline>. Similarly, since patterns are matched against individual lines (excluding the
terminating <newline>s) of the input, there is no way for a pattern to match a <newline> found
in the input.

OPTIONS

The grep utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

-E          Match using extended regular expressions. Treat each pattern specified as an ERE,
as described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.4,
Extended Regular Expressions. If any entire ERE pattern matches some part of an
input line excluding the terminating <newline>, the line shall be matched. A null
ERE shall match every line.

-F          Match using fixed strings. Treat each pattern specified as a string instead of a
regular expression. If an input line contains any of the patterns as a contiguous
sequence of bytes, the line shall be matched. A null string shall match every line.

-c          Write only a count of selected lines to standard output.

−e pattern_list

Specify one or more patterns to be used during the search for input. The
application shall ensure that patterns in pattern_list are separated by a <newline>.
A null pattern can be specified by two adjacent <newline>s in pattern_list. Unless
the −E or −F option is also specified, each pattern shall be treated as a BRE, as
described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic
Regular Expressions. Multiple −e and −f options shall be accepted by the grep
utility. All of the specified patterns shall be used when matching lines, but the
order of evaluation is unspecified.
Read one or more patterns from the file named by the pathname `pattern_file`. Patterns in `pattern_file` shall be terminated by a `<newline>`. A null pattern can be specified by an empty line in `pattern_file`. Unless the `-E` or `-F` option is also specified, each pattern shall be treated as a BRE, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic Regular Expressions.

Perform pattern matching in searches without regard to case; see the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.2, Regular Expression General Requirements.

(The letter ell.) Write only the names of files containing selected lines to standard output. Pathnames shall be written once per file searched. If the standard input is searched, a pathname of "(standard input)" shall be written, in the POSIX locale. In other locales, "standard input" may be replaced by something more appropriate in those locales.

Precede each output line by its relative line number in the file, each file starting at line 1. The line number counter shall be reset for each file processed.

Quiet. Nothing shall be written to the standard output, regardless of matching lines. Exit with zero status if an input line is selected.

Suppress the error messages ordinarily written for nonexistent or unreadable files. Other error messages shall not be suppressed.

Select lines not matching any of the specified patterns. If the `-v` option is not specified, selected lines shall be those that match any of the specified patterns.

Consider only input lines that use all characters in the line excluding the terminating `<newline>` to match an entire fixed string or regular expression to be matching lines.

The following operands shall be supported:

- `pattern_list` Specify one or more patterns to be used during the search for input. This operand shall be treated as if it were specified as `-e pattern_list`.
- `file` A pathname of a file to be searched for the patterns. If no `file` operands are specified, the standard input shall be used.

The standard input shall be used only if no `file` operands are specified. See the INPUT FILES section.

The input files shall be text files.

The following environment variables shall affect the execution of `grep`:

- `LANG` Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- `LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.
Utilities

**grep**

---

**LC_COLLATE**
Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.

**LC_CTYPE**
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and the behavior of character classes within regular expressions.

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**XSI NLSPATH**
Determine the location of message catalogs for the processing of **LC_MESSAGES**.

---

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
If the `-l` option is in effect, and the `-q` option is not, the following shall be written for each file containing at least one selected input line:

```
"%s\n", <file>
```

Otherwise, if more than one `file` argument appears, and `-q` is not specified, the `grep` utility shall prefix each output line by:

```
"%s:\n", <file>
```

The remainder of each output line shall depend on the other options specified:

- If the `-c` option is in effect, the remainder of each output line shall contain:
  ```
  "%d\n", <count>
  ```
- Otherwise, if `-c` is not in effect and the `-n` option is in effect, the following shall be written to standard output:
  ```
  "%d:\", <line number>
  ```
- Finally, the following shall be written to standard output:
  ```
  "%s\", <selected-line contents>
  ```

**STDERR**
The standard error shall be used only for diagnostic messages.

---

**OUTPUT FILES**
None.

---

**EXTENDED DESCRIPTION**
None.

---

**EXIT STATUS**
The following exit values shall be returned:

- 0 One or more lines were selected.
- 1 No lines were selected.
- >1 An error occurred.
CONSEQUENCES OF ERRORS

If the −q option is specified, the exit status shall be zero if an input line is selected, even if an error was detected. Otherwise, default actions shall be performed.

APPLICATION USAGE

Care should be taken when using characters in pattern_list that may also be meaningful to the command interpreter. It is safest to enclose the entire pattern_list argument in single quotes:

'. . .'  

The −e pattern_list option has the same effect as the pattern_list operand, but is useful when pattern_list begins with the hyphen delimiter. It is also useful when it is more convenient to provide multiple patterns as separate arguments.

Multiple −e and −f options are accepted and grep uses all of the patterns it is given while matching input text lines. (Note that the order of evaluation is not specified. If an implementation finds a null string as a pattern, it is allowed to use that pattern first, matching every line, and effectively ignore any other patterns.)

The −q option provides a means of easily determining whether or not a pattern (or string) exists in a group of files. When searching several files, it provides a performance improvement (because it can quit as soon as it finds the first match) and requires less care by the user in choosing the set of files to supply as arguments (because it exits zero if it finds a match even if grep detected an access or read error on earlier file operands).

EXAMPLES

1. To find all uses of the word "Posix" (in any case) in file text.mm and write with line numbers:
   
grep −i −n posix text.mm

2. To find all empty lines in the standard input:
   
grep ^$  
or:
   
grep −v.

3. Both of the following commands print all lines containing strings "abc" or "def" or both:
   
grep −E 'abc|def'
   
grep −F 'abc
def'

4. Both of the following commands print all lines matching exactly "abc" or "def":
   
grep −E '"abc$|^def$'
   
grep −F −x 'abc
def'

RATIONALE

This grep has been enhanced in an upwards-compatible way to provide the exact functionality of the historical egrep and fgrep commands as well. It was the clear intention of the standard developers to consolidate the three greps into a single command.

The old egrep and fgrep commands are likely to be supported for many years to come as implementation extensions, allowing historical applications to operate unmodified.
Historical implementations usually silently ignored all but one of multiply-specified –e and –f options, but were not consistent as to which specification was actually used.

The –b option was omitted from the OPTIONS section because block numbers are implementation-defined.

The System V restriction on using – to mean standard input was omitted.

A definition of action taken when given a null BRE or ERE is specified. This is an error condition in some historical implementations.

The –I option previously indicated that its use was undefined when no files were explicitly named. This behavior was historical and placed an unnecessary restriction on future implementations. It has been removed.

The historical BSD grep –s option practice is easily duplicated by redirecting standard output to /dev/null. The –s option required here is from System V.

The –x option, historically available only with fgrep, is available here for all of the non-obsolescent versions.

FUTURE DIRECTIONS
None.

SEE ALSO
sed

CHANGE HISTORY
First released in Issue 2.

Issue 6
The Open Group Corrigendum U029/5 is applied, correcting the SYNOPSIS.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/28 is applied, correcting the examples using the grep –F option which did not match the normative description of the –F option.
NAME
hash — remember or report utility locations

SYNOPSIS
hash [utility...]
hash -r

DESCRIPTION
The hash utility shall affect the way the current shell environment remembers the locations of utilities found as described in Section 2.9.1.1 (on page 48). Depending on the arguments specified, it shall add utility locations to its list of remembered locations or it shall purge the contents of the list. When no arguments are specified, it shall report on the contents of the list.

Utilities provided as built-ins to the shell shall not be reported by hash.

OPTIONS

The following option shall be supported:

- r Forget all previously remembered utility locations.

OPERANDS
The following operand shall be supported:

utility The name of a utility to be searched for and added to the list of remembered locations. If utility contains one or more slashes, the results are unspecified.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of hash:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

PATH Determine the location of utility, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.
ASYNCHRONOUS EVENTS

Default.

STDOUT

The standard output of hash shall be used when no arguments are specified. Its format is
unspecified, but includes the pathname of each utility in the list of remembered locations for the
current shell environment. This list shall consist of those utilities named in previous hash
invocations that have been invoked, and may contain those invoked and found through the
normal command search process.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Since hash affects the current shell execution environment, it is always provided as a shell
regular built-in. If it is called in a separate utility execution environment, such as one of the
following:

nohup hash -r
find . -type f | xargs hash

it does not affect the command search process of the caller’s environment.

The hash utility may be implemented as an alias—for example, alias -t-, in which case utilities
found through normal command search are not listed by the hash command.

The effects of hash -r can also be achieved portably by resetting the value of PATH; in the
simplest form, this can be:

PATH=":$PATH"

The use of hash with utility names is unnecessary for most applications, but may provide a
performance improvement on a few implementations; normally, the hashing process is included
by default.

EXAMPLES

None.

RATIONALE

None.

FUTURE DIRECTIONS

None.
SEE ALSO
Section 2.9.1.1 (on page 48)

CHANGE HISTORY
First released in Issue 2.
NAME
head — copy the first part of files

SYNOPSIS
head [-n number] [file...]

DESCRIPTION
The head utility shall copy its input files to the standard output, ending the output for each file at a designated point.
Copying shall end at the point in each input file indicated by the -n number option. The option-argument number shall be counted in units of lines.

OPTIONS
The following option shall be supported:

-n number The first number lines of each input file shall be copied to standard output. The application shall ensure that the number option-argument is a positive decimal integer.
When a file contains less than number lines, it shall be copied to standard output in its entirety.
This shall not be an error.
If no options are specified, head shall act as if -n 10 had been specified.

OPERANDS
The following operand shall be supported:

file A pathname of an input file. If no file operands are specified, the standard input shall be used.

STDIN
The standard input shall be used only if no file operands are specified. See the INPUT FILES section.

INPUT FILES
Input files shall be text files, but the line length is not restricted to {LINE_MAX} bytes.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of head:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
Determine the location of message catalogs for the processing of \texttt{LC\_MESSAGES}.

**ASYNCHRONOUS EVENTS**

- Default.

**STDOUT**

- The standard output shall contain designated portions of the input files.
- If multiple file operands are specified, \texttt{head} shall precede the output for each with the header:
  
  
  \begin{verbatim}
        "\n==> %s <==\n", <pathname>
  \end{verbatim}

  except that the first header written shall not include the initial <newline>.

**STDERR**

- The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

- None.

**EXTENDED DESCRIPTION**

- None.

**EXIT STATUS**

- The following exit values shall be returned:

  0   Successful completion.

  >0  An error occurred.

**CONSEQUENCES OF ERRORS**

- Default.

**APPLICATION USAGE**

- The obsolescent \texttt{−number} form is withdrawn in this version. Applications should use the \texttt{−n} \texttt{number} option.

**EXAMPLES**

- To write the first ten lines of all files (except those with a leading period) in the directory:

  
  
  \begin{verbatim}
        head * 
  \end{verbatim}

**RATIONALE**

- Although it is possible to simulate \texttt{head} with \texttt{sed} 10q for a single file, the standard developers decided that the popularity of \texttt{head} on historical BSD systems warranted its inclusion alongside \texttt{tail}.

- This standard version of \texttt{head} follows the Utility Syntax Guidelines. The \texttt{−n} option was added to this new interface so that \texttt{head} and \texttt{tail} would be more logically related.

- There is no \texttt{−c} option (as there is in \texttt{tail}) because it is not historical practice and because other utilities in this volume of IEEE Std 1003.1-2001 provide similar functionality.

**FUTURE DIRECTIONS**

- None.

**SEE ALSO**

- \texttt{sed, tail}
19457 CHANGE HISTORY
19458 First released in Issue 4.
19459 Issue 6
19460 The obsolescent -number form is withdrawn.
19461 The normative text is reworded to avoid use of the term “must” for application requirements.
19462 The DESCRIPTION is updated to clarify that when a file contains less than the number of lines requested, the entire file is copied to standard output.
NAME
iconv — codeset conversion

SYNOPSIS
iconv [−cs] −f frommap −t tomap [file ...]
icconv −f fromcode [−cs] [−t tocode] [file ...]
icconv −t tocode [−cs] [−f fromcode] [file ...]
icconv −l

DESCRIPTION
The iconv utility shall convert the encoding of characters in file from one codeset to another and write the results to standard output.

When the options indicate that charmap files are used to specify the codesets (see OPTIONS), the codeset conversion shall be accomplished by performing a logical join on the symbolic character names in the two charmaps. The implementation need not support the use of charmap files for codeset conversion unless the POSIX2_LOCALEDEF symbol is defined on the system.

OPTIONS

The following options shall be supported:
−c Omit any characters that are invalid in the codeset of the input file from the output. When −c is not used, the results of encountering invalid characters in the input stream (either those that are not characters in the codeset of the input file or that have no corresponding character in the codeset of the output file) shall be specified in the system documentation. The presence or absence of −c shall not affect the exit status of iconv.

−f fromcodeset
Identify the codeset of the input file. The implementation shall recognize the following two forms of the fromcodeset option-argument:
fromcode The fromcode option-argument must not contain a slash character. It shall be interpreted as the name of one of the codeset descriptions provided by the implementation in an unspecified format. Valid values of fromcode are implementation-defined.
frommap The frommap option-argument must contain a slash character. It shall be interpreted as the pathname of a charmap file as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.4, Character Set Description File. If the pathname does not represent a valid, readable charmap file, the results are undefined.

If this option is omitted, the codeset of the current locale shall be used.

−l Write all supported fromcode and tocode values to standard output in an unspecified format.

−s Suppress any messages written to standard error concerning invalid characters. When −s is not used, the results of encountering invalid characters in the input stream (either those that are not valid characters in the codeset of the input file or that have no corresponding character in the codeset of the output file) shall be specified in the system documentation. The presence or absence of −s shall not affect the exit status of iconv.
Utilities

iconv

Identify the codeset to be used for the output file. The implementation shall recognize the following two forms of the *tocodeset* option-argument:

- `tocode` The semantics shall be equivalent to the `-f fromcode` option.
- `tomap` The semantics shall be equivalent to the `tomap` option.

If this option is omitted, the codeset of the current locale shall be used.

If either `-f` or `-t` represents a charmap file, but the other does not (or is omitted), or both `-f` and `-t` are omitted, the results are undefined.

**OPERANDS**

The following operand shall be supported:

- `file` A pathname of an input file. If no `file` operands are specified, or if a `file` operand is `'-`', the standard input shall be used.

**STDIN**

The standard input shall be used only if no `file` operands are specified, or if a `file` operand is `'-'

**INPUT FILES**

The input file shall be a text file.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of `iconv`:

- `LANG` Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- `LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.
- `LC_CTYPE` Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments). During translation of the file, this variable is superseded by the use of the `fromcode` option-argument.
- `LC_MESSAGES` Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
- `XSI NLSPATH` Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

When the `-I` option is used, the standard output shall contain all supported `fromcode` and `tocode` values, written in an unspecified format.

When the `-I` option is not used, the standard output shall contain the sequence of characters read from the input files, translated to the specified codeset. Nothing else shall be written to the standard output.

**STDERR**

The standard error shall be used only for diagnostic messages.
iconv

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0  Successful completion.
>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The user must ensure that both charmap files use the same symbolic names for characters the
two codesets have in common.

EXAMPLES
The following example converts the contents of file mail.x400 from the ISO/IEC 6937:1994
standard codeset to the ISO/IEC 8859-1:1998 standard codeset, and stores the results in file
mail.local:
iconv -f IS6937 -t IS8859 mail.x400 > mail.local

RATIONALE
The iconv utility can be used portably only when the user provides two charmap files as option-
arguments. This is because a single charmap provided by the user cannot reliably be joined with
the names in a system-provided character set description. The valid values for fromcode and
tocode are implementation-defined and do not have to have any relation to the charmap
mechanisms. As an aid to interactive users, the –l option was adopted from the Plan 9 operating
system. It writes information concerning these implementation-defined values. The format is
unspecified because there are many possible useful formats that could be chosen, such as a
matrix of valid combinations of fromcode and tocode. The –l option is not intended for shell script
usage; conforming applications will have to use charmaps.

FUTURE DIRECTIONS
None.

SEE ALSO
gencai

CHANGE HISTORY
First released in Issue 3.

Issue 6
This utility has been rewritten to align with the IEEE P1003.2b draft standard. Specifically, the
ability to use charmap files for conversion has been added.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/29 is applied, making changes to address
inconsistencies with the iconv() function in the System Interfaces volume of
NAME
id — return user identity

SYNOPSIS
id [user]
id -G[-n] [user]
id -g[-nr] [user]
id -u[-nr] [user]

DESCRIPTION
If no user operand is provided, the id utility shall write the user and group IDs and the corresponding user and group names of the invoking process to standard output. If the effective and real IDs do not match, both shall be written. If multiple groups are supported by the underlying system (see the description of {NGROUPS_MAX} in the System Interfaces volume of IEEE Std 1003.1-2001), the supplementary group affiliations of the invoking process shall also be written.

If a user operand is provided and the process has the appropriate privileges, the user and group IDs of the selected user shall be written. In this case, effective IDs shall be assumed to be identical to real IDs. If the selected user has more than one allowable group membership listed in the group database, these shall be written in the same manner as the supplementary groups described in the preceding paragraph.

OPTIONS

The following options shall be supported:

-G Output all different group IDs (effective, real, and supplementary) only, using the format "%u\n". If there is more than one distinct group affiliation, output each such affiliation, using the format " %u", before the <newline> is output.

-g Output only the effective group ID, using the format "%u\n".

-n Output the name in the format "%s" instead of the numeric ID using the format "%u".

-r Output the real ID instead of the effective ID.

-u Output only the effective user ID, using the format "%u\n".

OPERANDS
The following operand shall be supported:

user The login name for which information is to be written.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of id:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables...}
used to determine the values of locale categories.)

**LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

**LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

**XSI** 

**NLSPATH** Determine the location of message catalogs for the processing of **LC_MESSAGES**.

### ASYNCHRONOUS EVENTS

Default.

**STDOUT** The following formats shall be used when the **LC_MESSAGES** locale category specifies the POSIX locale. In other locales, the strings *uid, gid, euid, egid*, and *groups* may be replaced with more appropriate strings corresponding to the locale.

"uid=%u(%s) gid=%u(%s)\n", <real user ID>, <user-name>,
<real group ID>, <group-name>

If the effective and real user IDs do not match, the following shall be inserted immediately before the ‘\n’ character in the previous format:

" euid=%u(%s)"

with the following arguments added at the end of the argument list:

<effective user ID>, <effective user-name>

If the effective and real group IDs do not match, the following shall be inserted directly before the ‘\n’ character in the format string (and after any addition resulting from the effective and real user IDs not matching):

" egid=%u(%s)"

with the following arguments added at the end of the argument list:

<effective group-ID>, <effective group name>

If the process has supplementary group affiliations or the selected user is allowed to belong to multiple groups, the first shall be added directly before the <newline> in the format string:

" groups=%u(%s)"

with the following arguments added at the end of the argument list:

<supplementary group ID>, <supplementary group name>

and the necessary number of the following added after that for any remaining supplementary group IDs:

","%u(%s)"

and the necessary number of the following arguments added at the end of the argument list:

<supplementary group ID>, <supplementary group name>
If any of the user ID, group ID, effective user ID, effective group ID, or supplementary/multiple group IDs cannot be mapped by the system into printable user or group names, the corresponding "(%s)" and name argument shall be omitted from the corresponding format string.

When any of the options are specified, the output format shall be as described in the OPTIONS section.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

Output produced by the −G option and by the default case could potentially produce very long lines on systems that support large numbers of supplementary groups. (On systems with user and group IDs that are 32-bit integers and with group names with a maximum of 8 bytes per name, 93 supplementary groups plus distinct effective and real group and user IDs could theoretically overflow the 2,048-byte [LINE_MAX] text file line limit on the default output case. It would take about 186 supplementary groups to overflow the 2,048-byte barrier using id −G).

This is not expected to be a problem in practice, but in cases where it is a concern, applications should consider using fold −s before postprocessing the output of id.

**EXAMPLES**

None.

**RATIONALE**

The functionality provided by the 4 BSD groups utility can be simulated using:

```
id −Gn [ user ]
```

The 4 BSD command groups was considered, but it was not included because it did not provide the functionality of the id utility of the SVID. Also, it was thought that it would be easier to modify id to provide the additional functionality necessary to systems with multiple groups than to invent another command.

The options −u, −g, −n, and −r were added to ease the use of id with shell commands substitution. Without these options it is necessary to use some preprocessor such as sed to select the desired piece of information. Since output such as that produced by:

```
id −u −n
```

is frequently wanted, it seemed desirable to add the options.
FUTURE DIRECTIONS
None.

SEE ALSO
fold, logname, who, the System Interfaces volume of IEEE Std 1003.1-2001, getgid(), getgroups(), getuid()

CHANGE HISTORY
First released in Issue 2.
NAME
ipcrm — remove an XSI message queue, semaphore set, or shared memory segment identifier

SYNOPSIS
XSI
ipcrm [ −q msgid | −Q msgkey | −s semid | −S semkey | −m shmid | −M shmkey ] ...

DESCRIPTION
The ipcrm utility shall remove zero or more message queues, semaphore sets, or shared memory segments. The interprocess communication facilities to be removed are specified by the options.

Only a user with appropriate privilege shall be allowed to remove an interprocess communication facility that was not created by or owned by the user invoking ipcrm.

OPTIONS

The following options shall be supported:
−q msgid Remove the message queue identifier msgid from the system and destroy the message queue and data structure associated with it.
−m shmid Remove the shared memory identifier shmid from the system. The shared memory segment and data structure associated with it shall be destroyed after the last detach.
−s semid Remove the semaphore identifier semid from the system and destroy the set of semaphores and data structure associated with it.
−Q msgkey Remove the message queue identifier, created with key msgkey, from the system and destroy the message queue and data structure associated with it.
−M shmkey Remove the shared memory identifier, created with key shmkey, from the system. The shared memory segment and data structure associated with it shall be destroyed after the last detach.
−S semkey Remove the semaphore identifier, created with key semkey, from the system and destroy the set of semaphores and data structure associated with it.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of ipcrm:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
ipcs, the System Interfaces volume of IEEE Std 1003.1-2001, msgctl(), semctl(), shmctl()

CHANGE HISTORY
First released in Issue 5.
NAME
ipc — report XSI interprocess communication facilities status

SYNOPSIS
XSI
ipcs [-qms] [-a | -bcopt]

DESCRIPTION
The ipcs utility shall write information about active interprocess communication facilities.
Without options, information shall be written in short format for message queues, shared
memory segments, and semaphore sets that are currently active in the system. Otherwise, the
information that is displayed is controlled by the options specified.

OPTIONS
The ipcs facility supports the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.

The ipcs utility accepts the following options:

-q Write information about active message queues.
-m Write information about active shared memory segments.
-s Write information about active semaphore sets.

If -q, -m, or -s are specified, only information about those facilities shall be written. If none of
these three are specified, information about all three shall be written subject to the following
options:

-a Use all print options. (This is a shorthand notation for -b, -c, -o, -p, and -t.)
-b Write information on maximum allowable size. (Maximum number of bytes in
messages on queue for message queues, size of segments for shared memory, and
number of semaphores in each set for semaphores.)
-c Write creator’s user name and group name; see below.
-o Write information on outstanding usage. (Number of messages on queue and total
number of bytes in messages on queue for message queues, and number of
processes attached to shared memory segments.)
-p Write process number information. (Process ID of the last process to send a
message and process ID of the last process to receive a message on message
queues, process ID of the creating process, and process ID of the last process to
attach or detach on shared memory segments.)
-t Write time information. (Time of the last control operation that changed the access
permissions for all facilities, time of the last msgsnd() and msgrcv() operations on
message queues, time of the last shmat() and shmdt() operations on shared
memory, and time of the last semop() operation on semaphores.)

OPERANDS
None.

STDIN
Not used.
INPUT FILES

- The group database
- The user database

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `ipcs`:

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**: Determine the location of message catalogs for the processing of `LC_MESSAGES`.

- **TZ**: Determine the timezone for the date and time strings written by `ipcs`. If `TZ` is unset or null, an unspecified default timezone shall be used.

ASYNCHRONOUS EVENTS

Default.

STDOUT

An introductory line shall be written with the format:

```
"IPC status from %s as of %s\n", <source>, <date>
```

where `<source>` indicates the source used to gather the statistics and `<date>` is the information that would be produced by the `date` command when invoked in the POSIX locale.

The `ipcs` utility then shall create up to three reports depending upon the `-q`, `-m`, and `-s` options. The first report shall indicate the status of message queues, the second report shall indicate the status of shared memory segments, and the third report shall indicate the status of semaphore sets.

If the corresponding facility is not installed or has not been used since the last reboot, then the report shall be written out in the format:

```
"%s facility not in system.\n", <facility>
```

where `<facility>` is `Message Queue`, `Shared Memory`, or `Semaphore`, as appropriate. If the facility has been installed and has been used since the last reboot, column headings separated by one or more spaces and followed by a `<newline>` shall be written as indicated below followed by the facility name written out using the format:

```
"%s:\n", <facility>
```

where `<facility>` is `Message Queues`, `Shared Memory`, or `Semaphores`, as appropriate. On the second and third reports the column headings need not be written if the last column headings written already provide column headings for all information in that report.
The column headings provided in the first column below and the meaning of the information in those columns shall be given in order below; the letters in parentheses indicate the options that shall cause the corresponding column to appear; “all” means that the column shall always appear. Each column is separated by one or more <space>s. Note that these options only determine what information is provided for each report; they do not determine which reports are written.

<table>
<thead>
<tr>
<th>T (all)</th>
<th>Type of facility:</th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>Message queue.</td>
</tr>
<tr>
<td>m</td>
<td>Shared memory segment.</td>
</tr>
<tr>
<td>s</td>
<td>Semaphore.</td>
</tr>
</tbody>
</table>

This field is a single character written using the format `%c`.

<table>
<thead>
<tr>
<th>ID (all)</th>
<th>The identifier for the facility entry. This field shall be written using the format <code>%d</code>.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>KEY (all)</th>
<th>The key used as an argument to <code>msgget()</code>, <code>semget()</code>, or <code>shmget()</code> to create the facility entry.</th>
</tr>
</thead>
</table>

Note: The key of a shared memory segment is changed to IPC_PRIVATE when the segment has been removed until all processes attached to the segment detach it.

This field shall be written using the format `0x%x`.

<table>
<thead>
<tr>
<th>MODE (all)</th>
<th>The facility access modes and flags. The mode shall consist of 11 characters that are interpreted as follows.</th>
</tr>
</thead>
</table>

The first character shall be:

S If a process is waiting on a `msgsnd()` operation.

− If the above is not true.

The second character shall be:

R If a process is waiting on a `msgrcv()` operation.

C or − If the associated shared memory segment is to be cleared when the first attach operation is executed.

− If none of the above is true.

The next nine characters shall be interpreted as three sets of three bits each. The first set refers to the owner’s permissions; the next to permissions of others in the user group of the facility entry, and the last to all others. Within each set, the first character indicates permission to read, the second character indicates permission to write or alter the facility entry, and the last character is a minus sign (`−`).

The permissions shall be indicated as follows:

r If read permission is granted.

w If write permission is granted.

a If alter permission is granted.

− If the indicated permission is not granted.
The first character following the permissions specifies if there is an alternate or additional access control method associated with the facility. If there is no alternate or additional access control method associated with the facility, a single <space> shall be written; otherwise, another printable character is written.

**OWNER** (all) The user name of the owner of the facility entry. If the user name of the owner is found in the user database, at least the first eight column positions of the name shall be written using the format %s. Otherwise, the user ID of the owner shall be written using the format %d.

**GROUP** (all) The group name of the owner of the facility entry. If the group name of the owner is found in the group database, at least the first eight column positions of the name shall be written using the format %s. Otherwise, the group ID of the owner shall be written using the format %d.

The following nine columns shall be only written out for message queues:

**CREATOR** (a,c) The user name of the creator of the facility entry. If the user name of the creator is found in the user database, at least the first eight column positions of the name shall be written using the format %s. Otherwise, the user ID of the creator shall be written using the format %d.

**CGROUP** (a,c) The group name of the creator of the facility entry. If the group name of the creator is found in the group database, at least the first eight column positions of the name shall be written using the format %s. Otherwise, the group ID of the creator shall be written using the format %d.

**CBYTES** (a,o) The number of bytes in messages currently outstanding on the associated message queue. This field shall be written using the format %d.

**QNUM** (a,o) The number of messages currently outstanding on the associated message queue. This field shall be written using the format %d.

**QBYTES** (a,b) The maximum number of bytes allowed in messages outstanding on the associated message queue. This field shall be written using the format %d.

**LSPID** (a,p) The process ID of the last process to send a message to the associated queue. This field shall be written using the format:

"%d", <pid>

where <pid> is 0 if no message has been sent to the corresponding message queue; otherwise, <pid> shall be the process ID of the last process to send a message to the queue.

**LRPID** (a,p) The process ID of the last process to receive a message from the associated queue. This field shall be written using the format:

"%d", <pid>

where <pid> is 0 if no message has been received from the corresponding message queue; otherwise, <pid> shall be the process ID of the last process to receive a message from the queue.

**STIME** (a,t) The time the last message was sent to the associated queue. If a message has been sent to the corresponding message queue, the hour, minute, and second of the last time a message was sent to the queue shall be written using the format %d:%2.2d:%2.2d. Otherwise, the format " no-entry" shall be written.
RTIME (a,t) The time the last message was received from the associated queue. If a
message has been received from the corresponding message queue, the hour,
minute, and second of the last time a message was received from the queue
shall be written using the format `%d:%2.2d:%2.2d`. Otherwise, the format
" no-entry" shall be written.

The following eight columns shall be only written out for shared memory segments.

CREATOR (a,c) The user of the creator of the facility entry. If the user name of the creator is
found in the user database, at least the first eight column positions of the
name shall be written using the format `%s`. Otherwise, the user ID of the
creator shall be written using the format `%d`.

CGROUP (a,c) The group name of the creator of the facility entry. If the group name of the
creator is found in the group database, at least the first eight column positions
of the name shall be written using the format `%s`. Otherwise, the group ID of
the creator shall be written using the format `%d`.

NATTACH (a,o) The number of processes attached to the associated shared memory segment.
This field shall be written using the format `%d`.

SEGSZ (a,b) The size of the associated shared memory segment. This field shall be written
using the format `%d`.

CPID (a,p) The process ID of the creator of the shared memory entry. This field shall be
written using the format `%d`.

LPID (a,p) The process ID of the last process to attach or detach the shared memory
segment. This field shall be written using the format:

"%d", <pid>

where `<pid>` is 0 if no process has attached the corresponding shared memory
segment; otherwise, `<pid>` shall be the process ID of the last process to attach
or detach the segment.

ATIME (a,t) The time the last attach on the associated shared memory segment was
completed. If the corresponding shared memory segment has ever been
attached, the hour, minute, and second of the last time the segment was
attached shall be written using the format `%d:%2.2d:%2.2d`. Otherwise, the
format " no-entry" shall be written.

DTIME (a,t) The time the last detach on the associated shared memory segment was
completed. If the corresponding shared memory segment has ever been
detached, the hour, minute, and second of the last time the segment was
detached shall be written using the format `%d:%2.2d:%2.2d`. Otherwise, the
format " no-entry" shall be written.

The following four columns shall be only written out for semaphore sets:

CREATOR (a,c) The user of the creator of the facility entry. If the user name of the creator is
found in the user database, at least the first eight column positions of the
name shall be written using the format `%s`. Otherwise, the user ID of the
creator shall be written using the format `%d`.

CGROUP (a,c) The group name of the creator of the facility entry. If the group name of the
creator is found in the group database, at least the first eight column positions
of the name shall be written using the format `%s`. Otherwise, the group ID of
the creator shall be written using the format `%d`.
NSEMS  \((a,b)\)  The number of semaphores in the set associated with the semaphore entry. This field shall be written using the format \%d.

OTIME  \((a,t)\)  The time the last semaphore operation on the set associated with the semaphore entry was completed. If a semaphore operation has ever been performed on the corresponding semaphore set, the hour, minute, and second of the last semaphore operation on the semaphore set shall be written using the format \%d:\%2.2d:\%2.2d. Otherwise, the format " no-entry" shall be written.

The following column shall be written for all three reports when it is requested:

CTIME  \((a,t)\)  The time the associated entry was created or changed. The hour, minute, and second of the time when the associated entry was created shall be written using the format \%d:\%2.2d:\%2.2d.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

0   Successful completion.

\(>0\)   An error occurred.

Default.

Things can change while \textit{ipcs} is running; the information it gives is guaranteed to be accurate only when it was retrieved.

None.

None.

None.


First released in Issue 5.

The Open Group Corrigendum U020/1 is applied, correcting the SYNOPSIS.

The Open Group Corrigenda U032/1 and U032/2 are applied, clarifying the output format.

The Open Group Base Resolution bwg98-004 is applied.
NAME
jobs — display status of jobs in the current session

SYNOPSIS
[jobs [-l] [-p] job_id ...]

DESCRIPTION
The jobs utility shall display the status of jobs that were started in the current shell environment; see Section 2.12 (on page 61).

When jobs reports the termination status of a job, the shell shall remove its process ID from the list of those “known in the current shell execution environment”; see Section 2.9.3.1 (on page 50).

OPTIONS

The following options shall be supported:

- `-l` (The letter ell.) Provide more information about each job listed. This information shall include the job number, current job, process group ID, state, and the command that formed the job.

- `-p` Display only the process IDs for the process group leaders of the selected jobs.

By default, the jobs utility shall display the status of all stopped jobs, running background jobs and all jobs whose status has changed and have not been reported by the shell.

OPERANDS
The following operand shall be supported:

- `job_id` Specifies the jobs for which the status is to be displayed. If no `job_id` is given, the status information for all jobs shall be displayed. The format of `job_id` is described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.203, Job Control Job ID.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of jobs:

- `LANG` Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- `LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.

- `LC_CTYPE` Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- `LC_MESSAGES` Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error and informative messages written to standard output.

**NSPATH** Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

**STDOUT**

If the `-p` option is specified, the output shall consist of one line for each process ID:

```
"%d
", <process ID>
```

Otherwise, if the `-l` option is not specified, the output shall be a series of lines of the form:

```
" [%d] %c %s %s
", <job-number>, <current>, <state>, <command>
```

where the fields shall be as follows:

<current> The character ‘+’ identifies the job that would be used as a default for the `fg` or `bg` utilities; this job can also be specified using the `job_id %+` or `%+`. The character ‘−’ identifies the job that would become the default if the current default job were to exit; this job can also be specified using the `job_id %−`. For other jobs, this field is a <space>. At most one job can be identified with ‘+’ and at most one job can be identified with ‘−’. If there is any suspended job, then the current job shall be a suspended job. If there are at least two suspended jobs, then the previous job also shall be a suspended job.

<job-number> A number that can be used to identify the process group to the `wait`, `fg`, `bg`, and `kill` utilities. Using these utilities, the job can be identified by prefixing the job number with ‘%’.

<state> One of the following strings (in the POSIX locale):

- **Running** Indicates that the job has not been suspended by a signal and has not exited.
- **Done** Indicates that the job completed and returned exit status zero.
- **Done(code)** Indicates that the job completed normally and that it exited with the specified non-zero exit status, `code`, expressed as a decimal number.
- **Stopped** Indicates that the job was suspended by the SIGTSTP signal.
- **Stopped (SIGTSTP)** Indicates that the job was suspended by the SIGTSTP signal.
- **Stopped (SIGSTOP)** Indicates that the job was suspended by the SIGSTOP signal.
- **Stopped (SIGTTIN)** Indicates that the job was suspended by the SIGTTIN signal.
- **Stopped (SIGTTOU)** Indicates that the job was suspended by the SIGTTOU signal.

The implementation may substitute the string **Suspended** in place of **Stopped**. If the job was terminated by a signal, the format of `<state>` is unspecified, but it shall be visibly distinct from all of the other `<state>` formats shown here and shall indicate the name or description of the signal causing the termination.
The associated command that was given to the shell.

If the −l option is specified, a field containing the process group ID shall be inserted before the <state> field. Also, more processes in a process group may be output on separate lines, using only the process ID and <command> fields.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

− 0 Successful completion.
− >0 An error occurred.

Default.

The −p option is the only portable way to find out the process group of a job because different implementations have different strategies for defining the process group of the job. Usage such as $(jobs −p) provides a way of referring to the process group of the job in an implementation-independent way.

The jobs utility does not work as expected when it is operating in its own utility execution environment because that environment has no applicable jobs to manipulate. See the APPLICATION USAGE section for bg. For this reason, jobs is generally implemented as a shell regular built-in.

None.

Both "%%" and "%+" are used to refer to the current job. Both forms are of equal validity—the "%%" mirroring "$$" and "%+" mirroring the output of jobs. Both forms reflect historical practice of the KornShell and the C shell with job control.

The job control features provided by bg, fg, and jobs are based on the KornShell. The standard developers examined the characteristics of the C shell versions of these utilities and found that differences exist. Despite widespread use of the C shell, the KornShell versions were selected for this volume of IEEE Std 1003.1-2001 to maintain a degree of uniformity with the rest of the KornShell features selected (such as the very popular command line editing features).

The jobs utility is not dependent on the job control option, as are the seemingly related bg and fg utilities because jobs is useful for examining background jobs, regardless of the condition of job control. When the user has invoked a set +m command and job control has been turned off, jobs can still be used to examine the background jobs associated with that current session. Similarly, kill can then be used to kill background jobs with kill% <background job number>.

The output for terminated jobs is left unspecified to accommodate various historical systems. The following formats have been witnessed:
1. **Killed**(*signal name*)

2. *signal name*

3. *signal name*(*coredump*)

4. *signal description – core dumped*

Most users should be able to understand these formats, although it means that applications have trouble parsing them.

The calculation of job IDs was not described since this would suggest an implementation, which may impose unnecessary restrictions.

In an early proposal, a −n option was included to “Display the status of jobs that have changed, exited, or stopped since the last status report”. It was removed because the shell always writes any changed status of jobs before each prompt.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Section 2.12 (on page 61), bg, fg, kill, wait

**CHANGE HISTORY**

First released in Issue 4.

This utility is marked as part of the User Portability Utilities option.

The JC shading is removed as job control is mandatory in this issue.
NAME

join — relational database operator

SYNOPSIS

join [-a file_number | -v file_number] [-e string] [-o list] [-t char]
       [−1 field] [−2 field] file1 file2

DESCRIPTION

The join utility shall perform an equality join on the files file1 and file2. The joined files shall be
written to the standard output.

The join field is a field in each file on which the files are compared. The join utility shall write
one line in the output for each pair of lines in file1 and file2 that have identical join fields. The
output line by default shall consist of the join field, then the remaining fields from file1, then the
remaining fields from file2. This format can be changed by using the −o option (see below). The
−a option can be used to add unmatched lines to the output. The −v option can be used to output
only unmatched lines.

The files file1 and file2 shall be ordered in the collating sequence of sort −b on the fields on which
they shall be joined, by default the first in each line. All selected output shall be written in the
same collating sequence.

The default input field separators shall be <blank>s. In this case, multiple separators shall count
as one field separator, and leading separators shall be ignored. The default output field separator
shall be a <space>.

The field separator and collating sequence can be changed by using the −t option (see below).

If the same key appears more than once in either file, all combinations of the set of remaining
fields in file1 and the set of remaining fields in file2 are output in the order of the lines
encountered.

If the input files are not in the appropriate collating sequence, the results are unspecified.

OPTIONS

The join utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

−a file_number

Produce a line for each unpairable line in file file_number, where file_number is 1 or
2, in addition to the default output. If both −a1 and −a2 are specified, all unpairable
lines shall be output.

−e string

Replace empty output fields in the list selected by −o with the string string.

−o list

Construct the output line to comprise the fields specified in list, each element of
which shall have one of the following two forms:

1. file_number.field, where file_number is a file number and field is a decimal
   integer field number

2. 0 (zero), representing the join field

The elements of list shall be either comma-separated or <blank>-separated, as
specified in Guideline 8 of the Base Definitions volume of IEEE Std 1003.1-2001,
Section 12.2, Utility Syntax Guidelines. The fields specified by list shall be written
for all selected output lines. Fields selected by list that do not appear in the input
shall be treated as empty output fields. (See the −e option.) Only specifically
requested fields shall be written. The application shall ensure that list is a single
command line argument.

-\t char
Use character char as a separator, for both input and output. Every appearance of
char in a line shall be significant. When this option is specified, the collating
sequence shall be the same as sort without the –b option.

-\v file_number
Instead of the default output, produce a line only for each unpairable line in
file_number, where file_number is 1 or 2. If both –v1 and –v2 are specified, all
unpairable lines shall be output.

-\1 field
Join on the fieldth field of file 1. Fields are decimal integers starting with 1.

-\2 field
Join on the fieldth field of file 2. Fields are decimal integers starting with 1.

OPERANDS
The following operands shall be supported:

file1, file2 A pathname of a file to be joined. If either of the file1 or file2 operands is ‘–’, the
standard input shall be used in its place.

STDIN
The standard input shall be used only if the file1 or file2 operand is ‘–’. See the INPUT FILES
section.

INPUT FILES
The input files shall be text files.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of join:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_COLLATE
Determine the locale of the collating sequence join expects to have been used when
the input files were sorted.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.
The `join` utility output shall be a concatenation of selected character fields. When the `-o` option is not specified, the output shall be:

```
"%s%s%s\n", <join field>, <other file1 fields>,
<other file2 fields>
```

If the join field is not the first field in a file, the `<other file fields>` for that file shall be:

```
<fields preceding join field>, <fields following join field>
```

When the `-o` option is specified, the output format shall be:

```
"%s\n", <concatenation of fields>
```

where the concatenation of fields is described by the `-o` option, above.

For either format, each field (except the last) shall be written with its trailing separator character. If the separator is the default (<blank>s), a single <space> shall be written after each field (except the last).

The standard error shall be used only for diagnostic messages.

None.

The following exit values shall be returned:

- **0**: All input files were output successfully.
- **>0**: An error occurred.

Default.

Pathnames consisting of numeric digits or of the form `string.string` should not be specified directly following the `-o` list.

The `-o 0` field essentially selects the union of the join fields. For example, given file `phone`:

```
!Name     Phone Number
Don       +1 123-456-7890
Hal       +1 234-567-8901
Yasushi   +2 345-678-9012
```

and file `fax`:

```
!Name     Fax Number
Don       +1 123-456-7899
Keith     +1 456-789-0122
Yasushi   +2 345-678-9011
```

(where the large expanses of white space are meant to each represent a single <tab>), the command:
join -t "<tab>" -a 1 -a 2 -e '(unknown)' -o 0,1,2,2.2 phone fax

would produce:

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone Number</th>
<th>Fax Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don</td>
<td>+1 123-456-7890</td>
<td>+1 123-456-7899</td>
</tr>
<tr>
<td>Hal</td>
<td>+1 234-567-8901</td>
<td>(unknown)</td>
</tr>
<tr>
<td>Keith</td>
<td>(unknown)</td>
<td>+1 456-789-0122</td>
</tr>
<tr>
<td>Yasushi</td>
<td>+2 345-678-9012</td>
<td>+2 345-678-9011</td>
</tr>
</tbody>
</table>

Multiple instances of the same key will produce combinatorial results. The following:

fa:
- a x
- a y
- a z

fb:
- a p

will produce:
- a x p
- a y p
- a z p

And the following:

fa:
- a b c
- a d e

fb:
- a w x
- a y z
- a o p

will produce:
- a b c w x
- a b c y z
- a b c o p
- a d e w x
- a d e y z
- a d e o p

**RATIONALE**

The -e option is only effective when used with -o because, unless specific fields are identified using -o, join is not aware of what fields might be empty. The exception to this is the join field, but identifying an empty join field with the -e string is not historical practice and some scripts might break if this were changed.

The 0 field in the -o list was adopted from the Tenth Edition version of join to satisfy international objections that the join in the base documents does not support the "full join" or "outer join" described in relational database literature. Although it has been possible to include a join field in the output (by default, or by field number using -o), the join field could not be included for an unpaired line selected by -a. The -o 0 field essentially selects the union of the join fields.

This sort of outer join was not possible with the join commands in the base documents. The -o 0 field was chosen because it is an upwards-compatible change for applications. An alternative
was considered: have the join field represent the union of the fields in the files (where they are identical for matched lines, and one or both are null for unmatched lines). This was not adopted because it would break some historical applications.

The ability to specify file2 as – is not historical practice; it was added for completeness.

The –v option is not historical practice, but was considered necessary because it permitted the writing of only those lines that do not match on the join field, as opposed to the –a option, which prints both lines that do and do not match. This additional facility is parallel with the –v option of grep.

Some historical implementations have been encountered where a blank line in one of the input files was considered to be the end of the file; the description in this volume of IEEE Std 1003.1-2001 does not cite this as an allowable case.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

awk, comm, sort, uniq

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

The obsolescent –j options and the multi-argument –o option are withdrawn in this issue.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
kill — terminate or signal processes

SYNOPSIS
kill -s signal_name pid ...
kill -l [exit_status]

XSI
kill [-signal_name] pid ...
kil [-signal_number] pid ...

DESCRIPTION
The kill utility shall send a signal to the process or processes specified by each pid operand.

For each pid operand, the kill utility shall perform actions equivalent to the kill() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 called with the following arguments:

• The value of the pid operand shall be used as the pid argument.

• The sig argument is the value specified by the -s option, --signal_number option, or the --signal_name option, or by SIGTERM, if none of these options is specified.

OPTIONS
The kill utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that in the last two SYNOPSIS forms, the --signal_number and --signal_name options are usually more than a single character.

The following options shall be supported:

-1 (The letter ell.) Write all values of signal_name supported by the implementation, if no operand is given. If an exit_status operand is given and it is a value of the ‘?’ shell special parameter (see Section 2.5.2 (on page 34) and wait) corresponding to a process that was terminated by a signal, the signal_name corresponding to the signal that terminated the process shall be written. If an exit_status operand is given and it is the unsigned decimal integer value of a signal number, the signal_name (the symbolic constant name without the SIG prefix defined in the Base Definitions volume of IEEE Std 1003.1-2001) corresponding to that signal shall be written. Otherwise, the results are unspecified.

-s signal_name
Specify the signal to send, using one of the symbolic names defined in the <signal.h> header. Values of signal_name shall be recognized in a case-independent fashion, without the SIG prefix. In addition, the symbolic name 0 shall be recognized, representing the signal value zero. The corresponding signal shall be sent instead of SIGTERM.

XSI
--signal_name
Equivalent to -s signal_name.

XSI
--signal_number
Specify a non-negative decimal integer, signal_number, representing the signal to be used instead of SIGTERM, as the sig argument in the effective call to kill(). The correspondence between integer values and the sig value used is shown in the following list.

The effects of specifying any signal_number other than those listed below are undefined.
If the first argument is a negative integer, it shall be interpreted as a \texttt{-signal\_number} option, not as a negative \texttt{pid} operand specifying a process group.

**OPERANDS**

The following operands shall be supported:

- \texttt{pid}
  
  One of the following:

  1. A decimal integer specifying a process or process group to be signaled. The process or processes selected by positive, negative, and zero values of the \texttt{pid} operand shall be as described for the \texttt{kill()} function. If process number 0 is specified, all processes in the current process group shall be signaled. For the effects of negative \texttt{pid} numbers, see the \texttt{kill()} function defined in the System Interfaces volume of IEEE Std 1003.1-2001. If the first \texttt{pid} operand is negative, it should be preceded by \texttt{"-"} to keep it from being interpreted as an option.

  2. A job control job ID (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.203, Job Control Job ID) that identifies a background process group to be signaled. The job control job ID notation is applicable only for invocations of \texttt{kill} in the current shell execution environment; see Section 2.12 (on page 61).

- \texttt{exit\_status}

  A decimal integer specifying a signal number or the exit status of a process terminated by a signal.

**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of \texttt{kill}:

- \texttt{LANG}

  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- \texttt{LC\_ALL}

  If set to a non-empty string value, override the values of all the other internationalization variables.

- \texttt{LC\_CTYPE}

  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
When the –l option is not specified, the standard output shall not be used.
When the –l option is specified, the symbolic name of each signal shall be written in the
following format:
"%s%c", <signal_name>, <separator>
where the <signal_name> is in uppercase, without the SIG prefix, and the <separator> shall be
either a <newline> or a <space>. For the last signal written, <separator> shall be a <newline>.

When both the –l option and exit_status operand are specified, the symbolic name of the
corresponding signal shall be written in the following format:
"%s\n", <signal_name>

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 At least one matching process was found for each pid operand, and the specified signal was
successfully processed for at least one matching process.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Process numbers can be found by using ps.
The job control job ID notation is not required to work as expected when kill is operating in its
own utility execution environment. In either of the following examples:
nohup kill %1 &
system("kill %1");
the kill operates in a different environment and does not share the shell’s understanding of job
numbers.

EXAMPLES
Any of the commands:
kil1 −9 100 −165
kill −s kill 100 −165
kill −s KILL 100 −165
sends the SIGKILL signal to the process whose process ID is 100 and to all processes whose
process group ID is 165, assuming the sending process has permission to send that signal to the
specified processes, and that they exist.

do not require specific signal numbers for any signal_names. Even the −signal_number option
provides symbolic (although numeric) names for signals. If a process is terminated by a signal,
its exit status indicates the signal that killed it, but the exact values are not specified. The kill −I
option, however, can be used to map decimal signal numbers and exit status values into the
name of a signal. The following example reports the status of a terminated job:

```
job
stat= $? 
if [ $stat -eq 0 ]
   then
      echo job completed successfully.
   elif [ $stat -gt 128 ]
      then
         echo job terminated by signal SIG$(kill −l $stat).
      else
         echo job terminated with error code $stat.
   fi
```

To send the default signal to a process group (say 123), an application should use a command
similar to one of the following:

```
kill −TERM −123
kill −−− −123
```

**RATIONALE**

The −l option originated from the C shell, and is also implemented in the KornShell. The C shell
output can consist of multiple output lines because the signal names do not always fit on a
single line on some terminal screens. The KornShell output also included the implementation-
defined signal numbers and was considered by the standard developers to be too difficult for
scripts to parse conveniently. The specified output format is intended not only to accommodate
the historical C shell output, but also to permit an entirely vertical or entirely horizontal listing
on systems for which this is appropriate.

An early proposal invented the name SIGNULL as a signal_name for signal 0 (used by the System
Interfaces volume of IEEE Std 1003.1-2001 to test for the existence of a process without sending it
a signal). Since the signal_name 0 can be used in this case unambiguously, SIGNULL has been
removed.

An early proposal also required symbolic signal_names to be recognized with or without the SIG
prefix. Historical versions of kill have not written the SIG prefix for the −l option and have not
recognized the SIG prefix on signal_names. Since neither applications portability nor ease-of-use
would be improved by requiring this extension, it is no longer required.

To avoid an ambiguity of an initial negative number argument specifying either a signal number
or a process group, IEEE Std 1003.1-2001 mandates that it is always considered the former by
implementations that support the XSI option. It also requires that conforming applications
always use the "−−" options terminator argument when specifying a process group, unless an
option is also specified.

The −s option was added in response to international interest in providing some form of kill that
meets the Utility Syntax Guidelines.
The job control job ID notation is not required to work as expected when *kill* is operating in its own utility execution environment. In either of the following examples:

```bash
nohup kill %1 &
system("kill %1");
```

the *kill* operates in a different environment and does not understand how the shell has managed its job numbers.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

- The Base Definitions volume of IEEE Std 1003.1-2001, `<signal.h>`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

The obsolescent versions of the SYNOPSIS are turned into non-obsolescent features of the XSI option, corresponding to a similar change in the *trap* special built-in.
NAME
lex — generate programs for lexical tasks (DEVELOPMENT)

SYNOPSIS
lex [-t][-n|-v][file ...]

DESCRIPTION
The lex utility shall generate C programs to be used in lexical processing of character input, and that can be used as an interface to yacc. The C programs shall be generated from lex source code and conform to the ISO C standard. Usually, the lex utility shall write the program it generates to the file lex.yy.c; the state of this file is unspecified if lex exits with a non-zero exit status. See the EXTENDED DESCRIPTION section for a complete description of the lex input language.

OPTIONS

The following options shall be supported:

- Suppress the summary of statistics usually written with the -v option. If no table sizes are specified in the lex source code and the -v option is not specified, then -n is implied.
- Write the resulting program to standard output instead of lex.yy.c.
- Write a summary of lex statistics to the standard output. (See the discussion of lex table sizes in Definitions in lex (on page 537).) If the -t option is specified and -n is not specified, this report shall be written to standard error. If table sizes are specified in the lex source code, and if the -n option is not specified, the -v option may be enabled.

OPERANDS
The following operand shall be supported:

file A pathname of an input file. If more than one such file is specified, all files shall be concatenated to produce a single lex program. If no file operands are specified, or if a file operand is ‘-’, the standard input shall be used.

STDIN
The standard input shall be used if no file operands are specified, or if a file operand is ‘-’. See INPUT FILES.

INPUT FILES
The input files shall be text files containing lex source code, as described in the EXTENDED DESCRIPTION section.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of lex:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_COLLATE Determine the locale for the behavior of ranges, equivalence classes, and multi-
character collating elements within regular expressions. If this variable is not set to the POSIX locale, the results are unspecified.

**LC_CTYPE**  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), and the behavior of character classes within regular expressions. If this variable is not set to the POSIX locale, the results are unspecified.

**LC_MESSAGES**  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**XSI**  **NLSPATH**  Determine the location of message catalogs for the processing of **LC_MESSAGES**.

### Asynchronous Events

**STDOUT**

If the −t option is specified, the text file of C source code output of lex shall be written to standard output.

If the −t option is not specified:

- Implementation-defined informational, error, and warning messages concerning the contents of lex source code input shall be written to either the standard output or standard error.
- If the −v option is specified and the −n option is not specified, lex statistics shall also be written to either the standard output or standard error, in an implementation-defined format. These statistics may also be generated if table sizes are specified with a ‘%’ operator in the **Definitions** section, as long as the −n option is not specified.

**STDERR**

If the −t option is specified, implementation-defined informational, error, and warning messages concerning the contents of lex source code input shall be written to the standard error.

If the −t option is not specified:

1. Implementation-defined informational, error, and warning messages concerning the contents of lex source code input shall be written to either the standard output or standard error.
2. If the −v option is specified and the −n option is not specified, lex statistics shall also be written to either the standard output or standard error, in an implementation-defined format. These statistics may also be generated if table sizes are specified with a ‘%’ operator in the **Definitions** section, as long as the −n option is not specified.

### Output Files

A text file containing C source code shall be written to **lex.yy.c**, or to the standard output if the −t option is present.

### Extended Description

Each input file shall contain lex source code, which is a table of regular expressions with corresponding actions in the form of C program fragments.

When **lex.yy.c** is compiled and linked with the lex library (using the −I1 operand with c99), the resulting program shall read character input from the standard input and shall partition it into strings that match the given expressions.
When an expression is matched, these actions shall occur:

- The input string that was matched shall be left in `yytext` as a null-terminated string; `yytext` shall either be an external character array or a pointer to a character string. As explained in Definitions in lex, the type can be explicitly selected using the `%array` or `%pointer` declarations, but the default is implementation-defined.

- The external `int yyleng` shall be set to the length of the matching string.

- The expression's corresponding program fragment, or action, shall be executed.

During pattern matching, lex shall search the set of patterns for the single longest possible match. Among rules that match the same number of characters, the rule given first shall be chosen.

The general format of lex source shall be:

```
Definitions
   %%
   Rules
   %%
UserSubroutines
```

The first "%%%" is required to mark the beginning of the rules (regular expressions and actions); the second "%%%" is required only if user subroutines follow.

Any line in the Definitions section beginning with a `<blank>` shall be assumed to be a C program fragment and shall be copied to the external definition area of the lex.yy.c file. Similarly, anything in the Definitions section included between delimiter lines containing only "{%" and "%}" shall also be copied unchanged to the external definition area of the lex.yy.c file.

Any such input (beginning with a `<blank>` or within "{%" and "%}" delimiter lines) appearing at the beginning of the Rules section before any rules are specified shall be written to lex.yy.c after the declarations of variables for the `yylex()` function and before the first line of code in `yylex()`. Thus, user variables local to `yylex()` can be declared here, as well as application code to execute upon entry to `yylex()`.

The action taken by lex when encountering any input beginning with a `<blank>` or within "{%" and "%}" delimiter lines appearing in the Rules section but coming after one or more rules is undefined. The presence of such input may result in an erroneous definition of the `yylex()` function.

Definitions in lex

Definitions appear before the first "%%%" delimiter. Any line in this section not contained between "{%" and "%}" lines and not beginning with a `<blank>` shall be assumed to define a lex substitution string. The format of these lines shall be:

```
name substitute
```

If a `name` does not meet the requirements for identifiers in the ISO C standard, the result is undefined. The string `substitute` shall replace the string `{name}` when it is used in a rule. The `name` string shall be recognized in this context only when the braces are provided and when it does not appear within a bracket expression or within double-quotes.

In the Definitions section, any line beginning with a ' %' (percent sign) character and followed by an alphanumeric word beginning with either 's' or 'S' shall define a set of start conditions.

Any line beginning with a ' %' followed by a word beginning with either 'x' or 'X' shall define a set of exclusive start conditions. When the generated scanner is in a %s state, patterns with no
state specified shall be also active; in a %x state, such patterns shall not be active. The rest of the
line, after the first word, shall be considered to be one or more <blank>-separated names of start
conditions. Start condition names shall be constructed in the same way as definition names. Start
conditions can be used to restrict the matching of regular expressions to one or more states as
described in Regular Expressions in lex (on page 539).

Implementations shall accept either of the following two mutually-exclusive declarations in the
Definitions section:

%array     Declare the type of yytext to be a null-terminated character array.
%pointer   Declare the type of yytext to be a pointer to a null-terminated character string.

The default type of yytext is implementation-defined. If an application refers to yytext outside of
the scanner source file (that is, via an extern), the application shall include the appropriate
%array or %pointer declaration in the scanner source file.

Implementations shall accept declarations in the Definitions section for setting certain internal
table sizes. The declarations are shown in the following table.

Table 4-9 Table Size Declarations in lex

<table>
<thead>
<tr>
<th>Declaration</th>
<th>Description</th>
<th>Minimum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>%p n</td>
<td>Number of positions</td>
<td>2500</td>
</tr>
<tr>
<td>%n n</td>
<td>Number of states</td>
<td>500</td>
</tr>
<tr>
<td>%a n</td>
<td>Number of transitions</td>
<td>2000</td>
</tr>
<tr>
<td>%e n</td>
<td>Number of parse tree nodes</td>
<td>1000</td>
</tr>
<tr>
<td>%k n</td>
<td>Number of packed character classes</td>
<td>1000</td>
</tr>
<tr>
<td>%o n</td>
<td>Size of the output array</td>
<td>3000</td>
</tr>
</tbody>
</table>

In the table, n represents a positive decimal integer, preceded by one or more <blank>s. The
exact meaning of these table size numbers is implementation-defined. The implementation shall
document how these numbers affect the lex utility and how they are related to any output that
may be generated by the implementation should limitations be encountered during the
execution of lex. It shall be possible to determine from this output which of the table size values
needs to be modified to permit lex to successfully generate tables for the input language. The
values in the column Minimum Value represent the lowest values conforming implementations
shall provide.

Rules in lex

The rules in lex source files are a table in which the left column contains regular expressions and
the right column contains actions (C program fragments) to be executed when the expressions
are recognized.

ERE action
ERE action
...

The extended regular expression (ERE) portion of a row shall be separated from action by one or
more <blank>s. A regular expression containing <blank>s shall be recognized under one of the
following conditions:

- The entire expression appears within double-quotes.
- The <blank>s appear within double-quotes or square brackets.
Each <blank> is preceded by a backslash character.

**User Subroutines in lex**

Anything in the user subroutines section shall be copied to `lex.yy.c` following `yylex()`.

**Regular Expressions in lex**

The `lex` utility shall support the set of extended regular expressions (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.4, Extended Regular Expressions), with the following additions and exceptions to the syntax:

- Any string enclosed in double-quotes shall represent the characters within the double-quotes as themselves, except that backslash escapes (which appear in the following table) shall be recognized. Any backslash-escape sequence shall be terminated by the closing quote. For example, "\01" represents a single string: the octal value 1 followed by the character '1'.

- The regular expression `r` shall be matched only when the program is in one of the start conditions indicated by `state`, `state1`, and so on; see Actions in lex (on page 541). (As an exception to the typographical conventions of the rest of this volume of IEEE Std 1003.1-2001, in this case `<state>` does not represent a metavariable, but the literal angle-bracket characters surrounding a symbol.) The start condition shall be recognized as such only at the beginning of a regular expression.

- The regular expression `r` shall be matched only if it is followed by an occurrence of regular expression `x` (x is the instance of trailing context, further defined below). The token returned in `yytext` shall only match `r`. If the trailing portion of `r` matches the beginning of `x`, the result is unspecified. The `r` expression cannot include further trailing context or the `\$` (match-end-of-line) operator; `x` cannot include the `\` (match-beginning-of-line) operator, nor trailing context, nor the `\$` operator. That is, only one occurrence of trailing context is allowed in a `lex` regular expression, and the `\` operator only can be used at the beginning of such an expression.

- When `name` is one of the substitution symbols from the Definitions section, the string, including the enclosing braces, shall be replaced by the substitute value. The substitute value shall be treated in the extended regular expression as if it were enclosed in parentheses. No substitution shall occur if `{name}` occurs within a bracket expression or within double-quotes.

Within an ERE, a backslash character shall be considered to begin an escape sequence as specified in the table in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation (\`, \`, \`, \`, \`, \`, \`). In addition, the escape sequences in the following table shall be recognized.

A literal \n cannot occur within an ERE; the escape sequence `\n` can be used to represent a \n. A \n shall not be matched by a period operator.
## Table 4-10  Escape Sequences in lex

<table>
<thead>
<tr>
<th>Escape Sequence</th>
<th>Description</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>\digits</td>
<td>A backslash character followed by the longest sequence of one, two, or three octal-digit characters (01234567). If all of the digits are 0 (that is, representation of the NUL character), the behavior is undefined.</td>
<td>The character whose encoding is represented by the one, two, or three-digit octal integer. If the size of a byte on the system is greater than nine bits, the valid escape sequence used to represent a byte is implementation-defined. Multi-byte characters require multiple, concatenated escape sequences of this type, including the leading '\' for each byte.</td>
</tr>
<tr>
<td>\xdigits</td>
<td>A backslash character followed by the longest sequence of hexadecimal-digit characters (01234567abcdefABCDEF). If all of the digits are 0 (that is, representation of the NUL character), the behavior is undefined.</td>
<td>The character whose encoding is represented by the hexadecimal integer.</td>
</tr>
</tbody>
</table>

**Note:** If a ’\x’ sequence needs to be immediately followed by a hexadecimal digit character, a sequence such as ”\x1”“1” can be used, which represents a character containing the value 1, followed by the character ’1’.

The order of precedence given to extended regular expressions for lex differs from that specified in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.4, Extended Regular Expressions. The order of precedence for lex shall be as shown in the following table, from high to low.

**Note:** The escaped characters entry is not meant to imply that these are operators, but they are included in the table to show their relationships to the true operators. The start condition, trailing context, and anchoring notations have been omitted from the table because of the placement restrictions described in this section; they can only appear at the beginning or ending of an ERE.
Table 4-11 ERE Precedence in lex

<table>
<thead>
<tr>
<th>Extended Regular Expression</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>collation-related bracket symbols</td>
<td>[= =] [: :) [. ..]</td>
</tr>
<tr>
<td>escaped characters</td>
<td>&lt;special character&gt;</td>
</tr>
<tr>
<td>bracket expression</td>
<td>[ ]</td>
</tr>
<tr>
<td>quoting</td>
<td>&quot;...&quot;</td>
</tr>
<tr>
<td>grouping</td>
<td>( )</td>
</tr>
<tr>
<td>definition</td>
<td>{name}</td>
</tr>
<tr>
<td>single-character RE duplication</td>
<td>* + ?</td>
</tr>
<tr>
<td>concatenation</td>
<td></td>
</tr>
<tr>
<td>interval expression</td>
<td>{m,n}</td>
</tr>
<tr>
<td>alternation</td>
<td></td>
</tr>
</tbody>
</table>

The ERE anchoring operators ‘ˆ’ and ‘$’ do not appear in the table. With lex regular expressions, these operators are restricted in their use: the ‘ˆ’ operator can only be used at the beginning of an entire regular expression, and the ‘$’ operator only at the end. The operators apply to the entire regular expression. Thus, for example, the pattern "(ˆabc)(def$)" is undefined; it can instead be written as two separate rules, one with the regular expression "ˆabc" and one with "def$", which share a common action via the special ‘|’ action (see below). If the pattern were written "ˆabc|def$", it would match either "abc" or "def" on a line by itself.

Unlike the general ERE rules, embedded anchoring is not allowed by most historical lex implementations. An example of embedded anchoring would be for patterns such as "(^[^ ] )foo( |$)" to match "foo" when it exists as a complete word. This functionality can be obtained using existing lex features:

```
^foo/[ \n]      |  /* Found foo as a separate word. */
" foo"/[ \n]    /* Found foo as a separate word. */
```

Note also that ‘$’ is a form of trailing context (it is equivalent to "/
\n") and as such cannot be used with regular expressions containing another instance of the operator (see the preceding discussion of trailing context).

The additional regular expressions trailing-context operator ‘/’ can be used as an ordinary character if presented within double-quotes, "/\n", preceded by a backslash, "\", or within a bracket expression, " [ ] ". The start-condition ‘<’ and ‘>’ operators shall be special only in a start condition at the beginning of a regular expression; elsewhere in the regular expression they shall be treated as ordinary characters.

Actions in lex

The action to be taken when an ERE is matched can be a C program fragment or the special actions described below; the program fragment can contain one or more C statements, and can also include special actions. The empty C statement ‘;’ shall be a valid action; any string in the lex.yy.c input that matches the pattern portion of such a rule is effectively ignored or skipped. However, the absence of an action shall not be valid, and the action lex takes in such a condition is undefined.

The specification for an action, including C statements and special actions, can extend across several lines if enclosed in braces:

```
ERE <one or more blanks> { program statement
                       program statement }
```
The default action when a string in the input to a `lex.yy.c` program is not matched by any expression shall be to copy the string to the output. Because the default behavior of a program generated by `lex` is to read the input and copy it to the output, a minimal `lex` source program that has just "%%" shall generate a C program that simply copies the input to the output unchanged.

Four special actions shall be available:

- **ECHO;** Write the contents of the string `yytext` on the output.
- **REJECT;** Usually only a single expression is matched by a given string in the input. `REJECT` means "continue to the next expression that matches the current input", and shall cause whatever rule was the second choice after the current rule to be executed for the same input. Thus, multiple rules can be matched and executed for one input string or overlapping input strings. For example, given the regular expressions "xyz" and "xy" and the input "xyz", usually only the regular expression "xyz" would match. The next attempted match would start after `z`. If the last action in the "xyz" rule is `REJECT`, both this rule and the "xy" rule would be executed. The `REJECT` action may be implemented in such a fashion that flow of control does not continue after it, as if it were equivalent to a `goto` to another part of `yylex()`. The use of `REJECT` may result in somewhat larger and slower scanners.
- **BEGIN** The action:

```
BEGIN newstate;
```

Switches the state (start condition) to `newstate`. If the string `newstate` has not been declared previously as a start condition in the `Definitions` section, the results are unspecified. The initial state is indicated by the digit '0' or the token `INITIAL`.

The functions or macros described below are accessible to user code included in the `lex` input. It is unspecified whether they appear in the C code output of `lex`, or are accessible only through the `-I` operand to `c99` (the `lex` library).

**int yylex(void)**

Performs lexical analysis on the input; this is the primary function generated by the `lex` utility. The function shall return zero when the end of input is reached; otherwise, it shall return non-zero values (tokens) determined by the actions that are selected.

**int yymore(void)**

When called, indicates that when the next input string is recognized, it is to be appended to the current value of `yytext` rather than replacing it; the value in `yyleng` shall be adjusted accordingly.

**int yyless(int n)**

Retains `n` initial characters in `yytext`, NUL-terminated, and treats the remaining characters as if they had not been read; the value in `yyleng` shall be adjusted accordingly.

**int input(void)**

Returns the next character from the input, or zero on end-of-file. It shall obtain input from the stream pointer `yyin`, although possibly via an intermediate buffer. Thus, once scanning has begun, the effect of altering the value of `yyin` is undefined. The character read shall be removed from the input stream of the scanner without any processing by the scanner.
int unput(int c)

Returns the character ‘c’ to the input; yytext and yyleng are undefined until the next expression is matched. The result of using unput() for more characters than have been input is unspecified.

The following functions shall appear only in the lex library accessible through the −l operand; they can therefore be redefined by a conforming application:

int yywrap(void)

Called by yylex() at end-of-file; the default yywrap() shall always return 1. If the application requires yylex() to continue processing with another source of input, then the application can include a function yywrap(), which associates another file with the external variable FILE * yyin and shall return a value of zero.

int main(int argc, char *argv[])

Calls yylex() to perform lexical analysis, then exits. The user code can contain main() to perform application-specific operations, calling yylex() as applicable.

Except for input(), unput(), and main(), all external and static names generated by lex shall begin with the prefix yy or YY.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Conforming applications are warned that in the Rules section, an ERE without an action is not acceptable, but need not be detected as erroneous by lex. This may result in compilation or runtime errors.

The purpose of input() is to take characters off the input stream and discard them as far as the lexical analysis is concerned. A common use is to discard the body of a comment once the beginning of a comment is recognized.

The lex utility is not fully internationalized in its treatment of regular expressions in the lex source code or generated lexical analyzer. It would seem desirable to have the lexical analyzer interpret the regular expressions given in the lex source according to the environment specified when the lexical analyzer is executed, but this is not possible with the current lex technology. Furthermore, the very nature of the lexical analyzers produced by lex must be closely tied to the lexical requirements of the input language being described, which is frequently locale-specific anyway. (For example, writing an analyzer that is used for French text is not automatically useful for processing other languages.)

EXAMPLES

The following is an example of a lex program that implements a rudimentary scanner for a Pascal-like syntax:

```c
{%
/* Need this for the call to atof() below. */
#include <math.h>
/* Need this for printf(), fopen(), and stdin below. */
#include <stdio.h>
%
```
DIGIT  [0-9]
ID    [a-z][a-z0-9]*

```c
printf("An integer: %s (%d)\n", yytext,
atol(yytext));
```

```c
printf("A float: %s (%g)\n", yytext,
atof(yytext));
```

```c
printf("An operator: %s\n", yytext);
```

```c
printf("Unrecognized character: %s\n", yytext);
```

```c
int main(int argc, char *argv[])
{
    ++argv, --argc; /* Skip over program name. */
    if (argc > 0)
        yyin = fopen(argv[0], "r");
    else
        yyin = stdin;
    yylex();
}
```

**RATIONALE**

Even though the `-c` option and references to the C language are retained in this description, *lex* may be generalized to other languages, as was done at one time for EFL, the Extended FORTRAN Language. Since the *lex* input specification is essentially language-independent, versions of this utility could be written to produce Ada, Modula-2, or Pascal code, and there are known historical implementations that do so.

The current description of *lex* bypasses the issue of dealing with internationalized EREs in the *lex* source code or generated lexical analyzer. If it follows the model used by *awk* (the source code is assumed to be presented in the POSIX locale, but input and output are in the locale specified by the environment variables), then the tables in the lexical analyzer produced by *lex* would interpret EREs specified in the *lex* source in terms of the environment variables specified when *lex* was executed. The desired effect would be to have the lexical analyzer interpret the EREs given in the *lex* source according to the environment specified when the lexical analyzer is executed, but this is not possible with the current *lex* technology.

The description of octal and hexadecimal-digit escape sequences agrees with the ISO C standard use of escape sequences. See the RATIONALE for *ed* for a discussion of bytes larger than 9 bits.
being represented by octal values. Hexadecimal values can represent larger bytes and multi-byte
characters directly, using as many digits as required.

There is no detailed output format specification. The observed behavior of lex under four
different historical implementations was that none of these implementations consistently
reported the line numbers for error and warning messages. Furthermore, there was a desire that
lex be allowed to output additional diagnostic messages. Leaving message formats unspecified
avoids these formatting questions and problems with internationalization.

Although the %x specifier for exclusive start conditions is not historical practice, it is believed to
be a minor change to historical implementations and greatly enhances the usability of lex
programs since it permits an application to obtain the expected functionality with fewer
statements.

The %array and %pointer declarations were added as a compromise between historical systems.
The System V-based lex copies the matched text to a yytext array. The flex program, supported in
BSD and GNU systems, uses a pointer. In the latter case, significant performance improvements
are available for some scanners. Most historical programs should require no change in porting
from one system to another because the string being referenced is null-terminated in both cases.
(The method used by flex in its case is to null-terminate the token in place by remembering the
character that used to come right after the token and replacing it before continuing on to the next
scan.) Multi-file programs with external references to yytext outside the scanner source file
should continue to operate on their historical systems, but would require one of the new
declarations to be considered strictly portable.

The description of EREs avoids unnecessary duplication of ERE details because their meanings
within a lex ERE are the same as that for the ERE in this volume of IEEE Std 1003.1-2001.

The reason for the undefined condition associated with text beginning with a <blank> or within
*% { * and % } * delimiter lines appearing in the Rules section is historical practice. Both the BSD
and System V lex copy the indented (or enclosed) input in the Rules section (except at the
beginning) to unreachable areas of the yylex() function (the code is written directly after a break
statement). In some cases, the System V lex generates an error message or a syntax error,
depending on the form of indented input.

The intention in breaking the list of functions into those that may appear in lex.yy.c versus those
that only appear in libl.a is that only those functions in libl.a can be reliably redefined by a
conforming application.

The descriptions of standard output and standard error are somewhat complicated because
historical lex implementations chose to issue diagnostic messages to standard output (unless −t
was given). IEEE Std 1003.1-2001 allows this behavior, but leaves an opening for the more
expected behavior of using standard error for diagnostics. Also, the System V behavior of
writing the statistics when any table sizes are given is allowed, while BSD-derived systems can
avoid it. The programmer can always precisely obtain the desired results by using either the −t
or −n options.

The OPERANDS section does not mention the use of − as a synonym for standard input; not all
historical implementations support such usage for any of the file operands.

A description of the translation table was deleted from early proposals because of its relatively
low usage in historical applications.

The change to the definition of the input() function that allows buffering of input presents the
opportunity for major performance gains in some applications.

The following examples clarify the differences between lex regular expressions and regular
expressions appearing elsewhere in this volume of IEEE Std 1003.1-2001. For regular expressions
of the form "r/x", the string matching r is always returned; confusion may arise when the
beginning of x matches the trailing portion of r. For example, given the regular expression
"a*b/cc" and the input "aaabcc", ytext would contain the string "aaab" on this match. But
given the regular expression "x*/xy" and the input "xxxxy", the token xxx, not xx, is returned
by some implementations because xxx matches "x*".

In the rule "ab*/bc", the "b*" at the end of r’s match into the beginning of the
trailing context, so the result is unspecified. If this rule were "ab/bc", however, the rule
matches the text "ab" when it is followed by the text "bc". In this latter case, the matching of r
cannot extend into the beginning of x, so the result is specified.

FUTURE DIRECTIONS
None.

SEE ALSO
c99, ed, yacc

CHANGE HISTORY
First released in Issue 2.

This utility is marked as part of the C-Language Development Utilities option.
The obsolescent −c option is withdrawn in this issue.
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
link — call link() function

SYNOPSIS
XSI
link file1 file2

DESCRIPTION
The link utility shall perform the function call:

link(file1, file2);

A user may need appropriate privilege to invoke the link utility.

OPTIONS
None.

OPERANDS
The following operands shall be supported:

file1 The pathname of an existing file.

file2 The pathname of the new directory entry to be created.

STDIN
Not used.

INPUT FILES
Not used.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of link:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
None.

STDERR
The standard error shall be used only for diagnostic messages.
OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
ln, unlink, the System Interfaces volume of IEEE Std 1003.1-2001, link ()

CHANGE HISTORY
First released in Issue 5.
NAME
    ln — link files

SYNOPSIS
    ln [-fs] source_file target_file
    ln [-fs] source_file ... target_dir

DESCRIPTION
    In the first synopsis form, the ln utility shall create a new directory entry (link) at the destination
    path specified by the target_file operand. If the -s option is specified, a symbolic link shall be
    created for the file specified by the source_file operand. This first synopsis form shall be assumed
    when the final operand does not name an existing directory; if more than two operands are
    specified and the final is not an existing directory, an error shall result.

    In the second synopsis form, the ln utility shall create a new directory entry (link), or if the -s
    option is specified a symbolic link, for each file specified by a source_file operand, at a destination
    path in the existing directory named by target_dir.

    If the last operand specifies an existing file of a type not specified by the System Interfaces
    volume of IEEE Std 1003.1-2001, the behavior is implementation-defined.

    The corresponding destination path for each source_file shall be the concatenation of the target
directory pathname, a slash character, and the last pathname component of the source_file. The
second synopsis form shall be assumed when the final operand names an existing directory.

    For each source_file:

    1. If the destination path exists:

       a. If the -f option is not specified, ln shall write a diagnostic message to standard error,
          do nothing more with the current source_file, and go on to any remaining source_files.

       b. Actions shall be performed equivalent to the unlink() function defined in the System
          Interfaces volume of IEEE Std 1003.1-2001, called using destination as the path
          argument. If this fails for any reason, ln shall write a diagnostic message to standard
          error, do nothing more with the current source_file, and go on to any remaining
          source_files.

    2. If the -s option is specified, ln shall create a symbolic link named by the destination path
       and containing as its pathname source_file. The ln utility shall do nothing more with
       source_file and shall go on to any remaining files.

    3. If source_file is a symbolic link, actions shall be performed equivalent to the link() function
       using the object that source_file references as the path1 argument and the destination path
       as the path2 argument. The ln utility shall do nothing more with source_file and shall go on
       to any remaining files.

    4. Actions shall be performed equivalent to the link() function defined in the System
       Interfaces volume of IEEE Std 1003.1-2001 using source_file as the path1 argument, and the
       destination path as the path2 argument.

OPTIONS
    The ln utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
    Utility Syntax Guidelines.

    The following option shall be supported:

    -f        Force existing destination pathnames to be removed to allow the link.
Create symbolic links instead of hard links.

The following operands shall be supported:

source_file A pathname of a file to be linked. If the -s option is specified, no restrictions on the type of file or on its existence shall be made. If the -s option is not specified, whether a directory can be linked is implementation-defined.

target_file The pathname of the new directory entry to be created.

target_dir A pathname of an existing directory in which the new directory entries are created.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of ln:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

XSI NLS_PATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Not used.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0 All the specified files were linked successfully.

>0 An error occurred.
CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

None.

EXAMPLES

None.

RATIONALE

Some historic versions of ln (including the one specified by the SVID) unlink the destination file, if it exists, by default. If the mode does not permit writing, these versions prompt for confirmation before attempting the unlink. In these versions the -f option causes ln not to attempt to prompt for confirmation.

This allows ln to succeed in creating links when the target file already exists, even if the file itself is not writable (although the directory must be). Early proposals specified this functionality.

This volume of IEEE Std 1003.1-2001 does not allow the ln utility to unlink existing destination paths by default for the following reasons:

- The ln utility has historically been used to provide locking for shell applications, a usage that is incompatible with ln unlinking the destination path by default. There was no corresponding technical advantage to adding this functionality.
- This functionality gave ln the ability to destroy the link structure of files, which changes the historical behavior of ln.
- This functionality is easily replicated with a combination of rm and ln.
- It is not historical practice in many systems; BSD and BSD-derived systems do not support this behavior. Unfortunately, whichever behavior is selected can cause scripts written expecting the other behavior to fail.
- It is preferable that ln perform in the same manner as the link() function, which does not permit the target to exist already.

This volume of IEEE Std 1003.1-2001 retains the -f option to provide support for shell scripts depending on the SVID semantics. It seems likely that shell scripts would not be written to handle prompting by ln and would therefore have specified the -f option.

The -f option is an undocumented feature of many historical versions of the ln utility, allowing linking to directories. These versions require modification.

Early proposals of this volume of IEEE Std 1003.1-2001 also required a -i option, which behaved like the -i options in cp and mv, prompting for confirmation before unlinking existing files. This was not historical practice for the ln utility and has been omitted.

FUTURE DIRECTIONS

None.

SEE ALSO

chmod, find, pax, rm, the System Interfaces volume of IEEE Std 1003.1-2001, link(), unlink()
The `ln` utility is updated to include symbolic link processing as defined in the IEEE P1003.2b draft standard.
NAME
locale — get locale-specific information

SYNOPSIS
locale [-a | -m]
locale [-ck] name...

DESCRIPTION
The locale utility shall write information about the current locale environment, or all public locales, to the standard output. For the purposes of this section, a public locale is one provided by the implementation that is accessible to the application.

When locale is invoked without any arguments, it shall summarize the current locale environment for each locale category as determined by the settings of the environment variables defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 7, Locale.

When invoked with operands, it shall write values that have been assigned to the keywords in the locale categories, as follows:

- Specifying a keyword name shall select the named keyword and the category containing that keyword.
- Specifying a category name shall select the named category and all keywords in that category.

OPTIONS

The following options shall be supported:

- Write information about all available public locales. The available locales shall include POSIX, representing the POSIX locale. The manner in which the implementation determines what other locales are available is implementation-defined.
- Write the names of selected locale categories; see the STDOUT section. The -c option increases readability when more than one category is selected (for example, via more than one keyword name or via a category name). It is valid both with and without the -k option.
- Write the names and values of selected keywords. The implementation may omit values for some keywords; see the OPERANDS section.
- Write names of available charmaps; see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set.

OPERANDS
The following operand shall be supported:

name The name of a locale category as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 7, Locale, the name of a keyword in a locale category, or the reserved name charmap. The named category or keyword shall be selected for output. If a single name represents both a locale category name and a keyword name in the current locale, the results are unspecified. Otherwise, both category and keyword names can be specified as name operands, in any sequence. It is implementation-defined whether any keyword values are written for the categories LC_CTYPE and LC_COLLATE.
STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of locale:

LANG

Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL

If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES

Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH

Determine the location of message catalogs for the processing of LC_MESSAGES.

The application shall ensure that the LANG, LC_*, and NLSPATH environment variables specify
the current locale environment to be written out; they shall be used if the −a option is not
specified.

ASYNCHRONOUS EVENTS

Default.

STDOUT

If locale is invoked without any options or operands, the names and values of the LANG and
LC_* environment variables described in this volume of IEEE Std 1003.1-2001 shall be written to
the standard output, one variable per line, with LANG first, and each line using the following
format. Only those variables set in the environment and not overridden by LC_ALL shall be
written using this format:

"%s=%s\n", <variable_name>, <value>

The names of those LC_* variables associated with locale categories defined in this volume of
IEEE Std 1003.1-2001 that are not set in the environment or are overridden by LC_ALL shall be
written in the following format:

"%s=""%s""\n", <variable_name>, <implied value>

The <implied value> shall be the name of the locale that has been selected for that category by the
implementation, based on the values in LANG and LC_ALL, as described in the Base Definitions

The <value> and <implied value> shown above shall be properly quoted for possible later reentry
to the shell. The <value> shall not be quoted using double-quotes (so that it can be distinguished
by the user from the <implied value> case, which always requires double-quotes).

The LC_ALL variable shall be written last, using the first format shown above. If it is not set, it
shall be written as:
If any arguments are specified:

1. If the \texttt{−a} option is specified, the names of all the public locales shall be written, each in the following format:

   \texttt{"%s
", <locale name>}

2. If the \texttt{−c} option is specified, the names of all selected categories shall be written, each in the following format:

   \texttt{"%s
", <category name>}

   If keywords are also selected for writing (see following items), the category name output shall precede the keyword output for that category.

   If the \texttt{−c} option is not specified, the names of the categories shall not be written; only the keywords, as selected by the \texttt{<name>} operand, shall be written.

3. If the \texttt{−k} option is specified, the names and values of selected keywords shall be written. If a value is non-numeric, it shall be written in the following format:

   \texttt{"%s="\"%s\"
", <keyword name>, <keyword value>}

   If the keyword was \texttt{charmap}, the name of the charmap (if any) that was specified via the \texttt{localedef −f} option when the locale was created shall be written, with the word \texttt{charmap} as \texttt{<keyword name>}.

   If a value is numeric, it shall be written in one of the following formats:

   \texttt{"%s=%d
", <keyword name>, <keyword value>}

   \texttt{"%s=%c%o
", <keyword name>, <escape character>, <keyword value>}

   \texttt{"%s=%cx%x
", <keyword name>, <escape character>, <keyword value>}

   where the \texttt{<escape character>} is that identified by the \texttt{escape_char} keyword in the current locale; see the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3, Locale Definition.

   Compound keyword values (list entries) shall be separated in the output by semicolons. When included in keyword values, the semicolon, the double-quote, the backslash, and any control character shall be preceded (escaped) with the escape character.

4. If the \texttt{−k} option is not specified, selected keyword values shall be written, each in the following format:

   \texttt{"%s
", <keyword value>}

   If the keyword was \texttt{charmap}, the name of the charmap (if any) that was specified via the \texttt{localedef −f} option when the locale was created shall be written.

5. If the \texttt{−m} option is specified, then a list of all available charmaps shall be written, each in the format:

   \texttt{"%s
", <charmap>}

   where \texttt{<charmap>} is in a format suitable for use as the option-argument to the \texttt{localedef −f} option.
STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 All the requested information was found and output successfully.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
If the LANG environment variable is not set or set to an empty value, or one of the LC_*
environment variables is set to an unrecognized value, the actual locales assumed (if any) are
implementation-defined as described in the Base Definitions volume of IEEE Std 1003.1-2001,
Chapter 8, Environment Variables.

Implementations are not required to write out the actual values for keywords in the categories
LC_CTYPE and LC_COLLATE; however, they must write out the categories (allowing an
application to determine, for example, which character classes are available).

EXAMPLES
In the following examples, the assumption is that locale environment variables are set as
follows:
LANG=locale_x
LC_COLLATE=locale_y

The command locale would result in the following output:
LANG=locale_x
LC_COLLATE=locale_y
LC_NUMERIC="locale_x"
LC_MONETARY="locale_x"
LC_MESSAGES="locale_x"
LC_ALL=

The order of presentation of the categories is not specified by this volume of

The command:
LC_ALL=POSIX locale -ck decimal_point
would produce:
LC_NUMERIC
decimal_point="."

The following command shows an application of locale to determine whether a user-supplied
response is affirmative:
if printf "%s\n" "$response" | grep -Eq "$(locale yesexpr)"
then
    affirmative processing goes here
else
    non-affirmative processing goes here
fi

RATIONALE
The output for categories LC_CTYPE and LC_COLLATE has been made implementation-defined because there is a questionable value in having a shell script receive an entire array of characters. It is also difficult to return a logical collation description, short of returning a complete localedef source.

The --m option was included to allow applications to query for the existence of charmaps. The output is a list of the charmaps (implementation-supplied and user-supplied, if any) on the system.

The --c option was included for readability when more than one category is selected (for example, via more than one keyword name or via a category name). It is valid both with and without the --k option.

The charmap keyword, which returns the name of the charmap (if any) that was used when the current locale was created, was included to allow applications needing the information to retrieve it.

FUTURE DIRECTIONS
None.

SEE ALSO
localedef, the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3, Locale Definition

CHANGE HISTORY
First released in Issue 4.

Issue 5
The FUTURE DIRECTIONS section is added.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/30 is applied, correcting an editorial error in the STDOUT section.
localedef

NAME
localedef — define locale environment

SYNOPSIS
localedef [-c] [-f charmap] [-i sourcefile] [-u code_set_name] name

DESCRIPTION
The localedef utility shall convert source definitions for locale categories into a format usable by
the functions and utilities whose operational behavior is determined by the setting of the locale
environment variables defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter
7, Locale. It is implementation-defined whether users have the capability to create new locales,
in addition to those supplied by the implementation. If the symbolic constant
POSIX2_LOCALEDEF is defined, the system supports the creation of new locales. On XSI-
conformant systems, the symbolic constant POSIX2_LOCALEDEF shall be defined.

The utility shall read source definitions for one or more locale categories belonging to the same
locale from the file named in the –i option (if specified) or from standard input.

The name operand identifies the target locale. The utility shall support the creation of public, or
generally accessible locales, as well as private, or restricted-access locales. Implementations may
restrict the capability to create or modify public locales to users with the appropriate privileges.

Each category source definition shall be identified by the corresponding environment variable
name and terminated by an END category-name statement. The following categories shall be
supported. In addition, the input may contain source for implementation-defined categories.

LC_CTYPE  Defines character classification and case conversion.

LC_COLLATE
Defines collation rules.

LC_MONETARY
Defines the format and symbols used in formatting of monetary information.

LC_NUMERIC
Defines the decimal delimiter, grouping, and grouping symbol for non-monetary
numeric editing.

LC_TIME
Defines the format and content of date and time information.

LC_MESSAGES
Defines the format and values of affirmative and negative responses.

OPTIONS
The localedef utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

–c    Create permanent output even if warning messages have been issued.

–f charmap Specify the pathname of a file containing a mapping of character symbols and
collating element symbols to actual character encodings. The format of the
charmap is described in the Base Definitions volume of IEEE Std 1003.1-2001,
Section 6.4, Character Set Description File. The application shall ensure that this
option is specified if symbolic names (other than collating symbols defined in a
collating-symbol keyword) are used. If the –f option is not present, an
implementation-defined character mapping shall be used.
localedef

The pathname of a file containing the source definitions. If this option is not present, source definitions shall be read from standard input. The format of the
inputfile is described in the Base Definitions volume of IEEE Std 1003.1-2001,
Section 7.3, Locale Definition.

Specify the name of a codeset used as the target mapping of character symbols and
collating element symbols whose encoding values are defined in terms of the

The following operand shall be supported:

name Identifies the locale; see the Base Definitions volume of IEEE Std 1003.1-2001,
Chapter 7, Locale for a description of the use of this name. If the name contains one
or more slash characters, name shall be interpreted as a pathname where the
created locale definitions shall be stored. If name does not contain any slash
characters, the interpretation of the name is implementation-defined and the locale
shall be public. This capability may be restricted to users with appropriate
privileges. (As a consequence of specifying one name, although several categories
can be processed in one execution, only categories belonging to the same locale can
be processed.)

Unless the −i option is specified, the standard input shall be a text file containing one or more
locale category source definitions, as described in the Base Definitions volume of
IEEE Std 1003.1-2001, Section 7.3, Locale Definition. When lines are continued using the escape
character mechanism, there is no limit to the length of the accumulated continued line.

The character set mapping file specified as the charmap option-argument is described in the Base
Definitions volume of IEEE Std 1003.1-2001, Section 6.4, Character Set Description File. If a locale
category source definition contains a copy statement, as defined in the Base Definitions volume
of IEEE Std 1003.1-2001, Chapter 7, Locale, and the copy statement names a valid, existing locale,
then localedef shall behave as if the source definition had contained a valid category source
definition for the named locale.

The following environment variables shall affect the execution of localedef:

Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

If set to a non-empty string value, override the values of all the other
internationalization variables.

(This variable has no affect on localedef; the POSIX locale is used for this category.)

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files). This variable has no affect on the processing of localedef
input data; the POSIX locale is used for this purpose, regardless of the value of this
variable.
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of `LC_MESSAGES`.

**ASYNCHRONOUS EVENTS**

Default.

The utility shall report all categories successfully processed, in an unspecified format.

The standard error shall be used only for diagnostic messages.

The format of the created output is unspecified. If the `name` operand does not contain a slash, the existence of an output file for the locale is unspecified.

When the `-u` option is used, the `code_set_name` option-argument shall be interpreted as an implementation-defined name of a codeset to which the ISO/IEC 10646-1:2000 standard position constant values shall be converted via an implementation-defined method. Both the ISO/IEC 10646-1:2000 standard position constant values and other formats (decimal, hexadecimal, or octal) shall be valid as encoding values within the `charmap` file. The codeset represented by the implementation-defined name can be any codeset that is supported by the implementation.

When conflicts occur between the `charmap` specification of `<code_set_name>`, `<mb_cur_max>`, or `<mb_cur_min>` and the implementation-defined interpretation of these respective items for the codeset represented by the `-u` option-argument `code_set_name`, the result is unspecified.

When conflicts occur between the `charmap` encoding values specified for symbolic names of characters of the portable character set and the implementation-defined assignment of character encoding values, the result is unspecified.

If a non-printable character in the `charmap` has a width specified that is not `-1`, `localedef` shall generate a warning.

The following exit values shall be returned:

<table>
<thead>
<tr>
<th>Exit Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No errors occurred and the locales were successfully created.</td>
</tr>
<tr>
<td>1</td>
<td>Warnings occurred and the locales were successfully created.</td>
</tr>
<tr>
<td>2</td>
<td>The locale specification exceeded implementation limits or the coded character set or sets used were not supported by the implementation, and no locale was created.</td>
</tr>
<tr>
<td>3</td>
<td>The capability to create new locales is not supported by the implementation.</td>
</tr>
<tr>
<td>&gt;3</td>
<td>Warnings or errors occurred and no output was created.</td>
</tr>
</tbody>
</table>

If an error is detected, no permanent output shall be created.

If warnings occur, permanent output shall be created if the `-c` option was specified. The following conditions shall cause warning messages to be issued:

- If a symbolic name not found in the `charmap` file is used for the descriptions of the `LC_CTYPE` or `LC_COLLATE` categories (for other categories, this shall be an error condition).
• If the number of operands to the `order` keyword exceeds the `{COLL_WEIGHTS_MAX}` limit.

• If optional keywords not supported by the implementation are present in the source.

• If a non-printable character has a width specified other than −1.

Other implementation-defined conditions may also cause warnings.

**APPLICATION USAGE**

The `charmap` definition is optional, and is contained outside the locale definition. This allows both completely self-defined source files, and generic sources (applicable to more than one codeset). To aid portability, all `charmap` definitions must use the same symbolic names for the portable character set. As explained in the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.4, Character Set Description File, it is implementation-defined whether or not users or applications can provide additional character set description files. Therefore, the `-f` option might be operable only when an implementation-defined `charmap` is named.

**EXAMPLES**

None.

**RATIONALE**

The output produced by the `localedef` utility is implementation-defined. The `name` operand is used to identify the specific locale. (As a consequence, although several categories can be processed in one execution, only categories belonging to the same locale can be processed.)

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`locale`, the Base Definitions volume of IEEE Std 1003.1-2001, Section 7.3, Locale Definition

**CHANGE HISTORY**

First released in Issue 4.

**Issue 6**

The `-u` option is added, as specified in the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
logger — log messages

SYNOPSIS
logger string ...

DESCRIPTION
The logger utility saves a message, in an unspecified manner and format, containing the string operands provided by the user. The messages are expected to be evaluated later by personnel performing system administration tasks.

It is implementation-defined whether messages written in locales other than the POSIX locale are effective.

OPTIONS
None.

OPERANDS
The following operand shall be supported:
string One of the string arguments whose contents are concatenated together, in the order specified, separated by single <space>s.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of logger:
LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error. (This means diagnostics from logger to the user or application, not diagnostic messages that the user is sending to the system administrator.)
XLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.
The standard error shall be used only for diagnostic messages.

Unspecified.

None.

The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

Default.

This utility allows logging of information for later use by a system administrator or programmer in determining why non-interactive utilities have failed. The locations of the saved messages, their format, and retention period are all unspecified. There is no method for a conforming application to read messages, once written.

A batch application, running non-interactively, tries to read a configuration file and fails; it may attempt to notify the system administrator with:

```
logger myname: unable to read file foo. [timestamp]
```

The standard developers believed strongly that some method of alerting administrators to errors was necessary. The obvious example is a batch utility, running non-interactively, that is unable to read its configuration files or that is unable to create or write its results file. However, the standard developers did not wish to define the format or delivery mechanisms as they have historically been (and will probably continue to be) very system-specific, as well as involving functionality clearly outside the scope of this volume of IEEE Std 1003.1-2001.

The text with `LC_MESSAGES` about diagnostic messages means diagnostics from `logger` to the user or application, not diagnostic messages that the user is sending to the system administrator.

Multiple `string` arguments are allowed, similar to `echo`, for ease-of-use.

Like the utilities `mailx` and `lp`, `logger` is admittedly difficult to test. This was not deemed sufficient justification to exclude these utilities from this volume of IEEE Std 1003.1-2001. It is also arguable that they are, in fact, testable, but that the tests themselves are not portable.

First released in Issue 4.
NAME
logfile — return the user's login name

SYNOPSIS
logfile

DESCRIPTION
The logfile utility shall write the user's login name to standard output. The login name shall be
the string that would be returned by the getlogin() function defined in the System Interfaces
volume of IEEE Std 1003.1-2001. Under the conditions where the getlogin() function would fail,
the logfile utility shall write a diagnostic message to standard error and exit with a non-zero
exit status.

OPTIONS
None.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of logfile:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The logfile utility output shall be a single line consisting of the user's login name:
"%s
",

STDDERR
The standard error shall be used only for diagnostic messages.
21757 **OUTPUT FILES**
21758 None.

21759 **EXTENDED DESCRIPTION**
21760 None.

21761 **EXIT STATUS**
21762 The following exit values shall be returned:
21763 0 Successful completion.
21764 >0 An error occurred.

21765 **CONSEQUENCES OF ERRORS**
21766 Default.

21767 **APPLICATION USAGE**
21768 The *logname* utility explicitly ignores the LOGNAME environment variable because environment
21769 changes could produce erroneous results.

21770 **EXAMPLES**
21771 None.

21772 **RATIONALE**
21773 The *passwd* file is not listed as required because the implementation may have other means of
21774 mapping login names.

21775 **FUTURE DIRECTIONS**
21776 None.

21777 **SEE ALSO**

21779 **CHANGE HISTORY**
21780 First released in Issue 2.
NAME
lp — send files to a printer

SYNOPSIS
lp [-c] [-d dest] [-n copies] [-msw] [-o option]... [-t title] [file...]

DESCRIPTION
The lp utility shall copy the input files to an output destination in an unspecified manner. The default output destination should be to a hardcopy device, such as a printer or microfilm recorder, that produces non-volatile, human-readable documents. If such a device is not available to the application, or if the system provides no such device, the lp utility shall exit with a non-zero exit status.

The actual writing to the output device may occur some time after the lp utility successfully exits. During the portion of the writing that corresponds to each input file, the implementation shall guarantee exclusive access to the device.

The lp utility shall associate a unique request ID with each request.

Normally, a banner page is produced to separate and identify each print job. This page may be suppressed by implementation-defined conditions, such as an operator command or one of the -o option values.

OPTIONS

The following options shall be supported:

-c Exit only after further access to any of the input files is no longer required. The application can then safely delete or modify the files without affecting the output operation. Normally, files are not copied, but are linked whenever possible. If the -c option is not given, then the user should be careful not to remove any of the files before the request has been printed in its entirety. It should also be noted that in the absence of the -c option, any changes made to the named files after the request is made but before it is printed may be reflected in the printed output. On some implementations, -c may be on by default.

-d dest Specify a string that names the destination (dest). If dest is a printer, the request shall be printed only on that specific printer. If dest is a class of printers, the request shall be printed on the first available printer that is a member of the class. Under certain conditions (printer unavailability, file space limitation, and so on), requests for specific destinations need not be accepted. Destination names vary between systems.

If -d is not specified, and neither the LPDEST nor PRINTER environment variable is set, an unspecified destination is used. The -d dest option shall take precedence over LPDEST, which in turn shall take precedence over PRINTER. Results are undefined when dest contains a value that is not a valid destination name.

-m Send mail (see mailx) after the files have been printed. By default, no mail is sent upon normal completion of the print request.

-n copies Write copies number of copies of the files, where copies is a positive decimal integer. The methods for producing multiple copies and for arranging the multiple copies when multiple file operands are used are unspecified, except that each file shall be output as an integral whole, not interleaved with portions of other files.
−o option Specify printer-dependent or class-dependent options. Several such options may be collected by specifying the −o option more than once.

−s Suppress messages from lp.

−t title Write title on the banner page of the output.

−w Write a message on the user’s terminal after the files have been printed. If the user is not logged in, then mail shall be sent instead.

**OPERANDS**

The following operand shall be supported:

**file** A pathname of a file to be output. If no file operands are specified, or if a file operand is ‘−−’, the standard input shall be used. If a file operand is used, but the −c option is not specified, the process performing the writing to the output device may have user and group permissions that differ from that of the process invoking lp.

**STDIN**

The standard input shall be used only if no file operands are specified, or if a file operand is ‘−−’. See the INPUT FILES section.

**INPUT FILES**

The input files shall be text files.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of lp:

**LANG** Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

**LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

**LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

**LC_TIME** Determine the format and contents of date and time strings displayed in the lp banner page, if any.

**LPDEST** Determine the destination. If the LPDEST environment variable is not set, the PRINTER environment variable shall be used. The −d dest option takes precedence over LPDEST. Results are undefined when −d is not specified and LPDEST contains a value that is not a valid destination name.

**XSI**

**NLSPATH** Determine the location of message catalogs for the processing of LC_MESSAGES.

**PRINTER** Determine the output device or destination. If the LPDEST and PRINTER environment variables are not set, an unspecified output device is used. The −d dest option and the LPDEST environment variable shall take precedence over PRINTER. Results are undefined when −d is not specified, LPDEST is unset, and...
PRINTER contains a value that is not a valid device or destination name.

TZ

Determine the timezone used to calculate date and time strings displayed in the \textit{lp} banner page, if any. If TZ is unset or null, an unspecified default timezone shall be used.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

The \textit{lp} utility shall write a request ID to the standard output, unless \texttt{−s} is specified. The format of the message is unspecified. The request ID can be used on systems supporting the historical \texttt{cancel} and \texttt{lpstat} utilities.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

\begin{enumerate}
\item 0 All input files were processed successfully.
\item >0 No output device was available, or an error occurred.
\end{enumerate}

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

The \texttt{pr} and \texttt{fold} utilities can be used to achieve reasonable formatting for the implementation’s default page size.

A conforming application can use one of the \texttt{file} operands only with the \texttt{−c} option or if the file is publicly readable and guaranteed to be available at the time of printing. This is because IEEE Std 1003.1-2001 gives the implementation the freedom to queue up the request for printing at some later time by a different process that might not be able to access the file.

**EXAMPLES**

\begin{enumerate}
\item To print file \texttt{file}:
\begin{verbatim}
lp −c file
\end{verbatim}
\item To print multiple files with headers:
\begin{verbatim}
pr file1 file2 | lp
\end{verbatim}
\end{enumerate}

**RATIONALE**

The \textit{lp} utility was designed to be a basic version of a utility that is already available in many historical implementations. The standard developers considered that it should be implementable simply as:

\begin{verbatim}
cat "@" > /dev/lp
\end{verbatim}

after appropriate processing of options, if that is how the implementation chose to do it and if exclusive access could be granted (so that two users did not write to the device simultaneously). Although in the future the standard developers may add other options to this utility, it should
always be able to execute with no options or operands and send the standard input to an unspecified output device.

This volume of IEEE Std 1003.1-2001 makes no representations concerning the format of the printed output, except that it must be “human-readable” and “non-volatile”. Thus, writing by default to a disk or tape drive or a display terminal would not qualify. (Such destinations are not prohibited when \texttt{d dest}, \texttt{LPDEST}, or \texttt{PRINTER} are used, however.)

This volume of IEEE Std 1003.1-2001 is worded such that a “print job” consisting of multiple input files, possibly in multiple copies, is guaranteed to print so that any one file is not intermixed with another, but there is no statement that all the files or copies have to print out together.

The \texttt{–c} option may imply a spooling operation, but this is not required. The utility can be implemented to wait until the printer is ready and then wait until it is finished. Because of that, there is no attempt to define a queuing mechanism (priorities, classes of output, and so on).

On some historical systems, the request ID reported on the STDOUT can be used to later cancel or find the status of a request using utilities not defined in this volume of IEEE Std 1003.1-2001.

Although the historical System V \texttt{lp} and BSD \texttt{lpr} utilities have provided similar functionality, they used different names for the environment variable specifying the destination printer. Since the name of the utility here is \texttt{lp}, \texttt{LPDEST} (used by the System V \texttt{lp} utility) was given precedence over \texttt{PRINTER} (used by the BSD \texttt{lpr} utility). Since environments of users frequently contain one or the other environment variable, the \texttt{lp} utility is required to recognize both. If this was not done, many applications would send output to unexpected output devices when users moved from system to system.

Some have commented that \texttt{lp} has far too little functionality to make it worthwhile. Requests have proposed additional options or operands or both that added functionality. The requests included:

- Wording requiring the output to be “hardcopy”
- A requirement for multiple printers
- Options for supporting various page-description languages

Given that a compliant system is not required to even have a printer, placing further restrictions upon the behavior of the printer is not useful. Since hardcopy format is so application-dependent, it is difficult, if not impossible, to select a reasonable subset of functionality that should be required on all compliant systems.

The term unspecified is used in this section in lieu of implementation-defined as most known implementations would not be able to make definitive statements in their conformance documents; the existence and usage of printers is very dependent on how the system administrator configures each individual system.

Since the default destination, device type, queuing mechanisms, and acceptable forms of input are all unspecified, usage guidelines for what a conforming application can do are as follows:

- Use the command in a pipeline, or with \texttt{–c}, so that there are no permission problems and the files can be safely deleted or modified.
- Limit output to text files of reasonable line lengths and printable characters and include no device-specific formatting information, such as a page description language. The meaning of “reasonable” in this context can only be answered as a quality-of-implementation issue, but it should be apparent from historical usage patterns in the industry and the locale. The \texttt{pr} and \texttt{fold} utilities can be used to achieve reasonable formatting for the default page size of the
Alternatively, the application can arrange its installation in such a way that it requires the system administrator or operator to provide the appropriate information on \textit{lp} options and environment variable values.

At a minimum, having this utility in this volume of IEEE Std 1003.1-2001 tells the industry that conforming applications require a means to print output and provides at least a command name and \textit{LPDEST} routing mechanism that can be used for discussions between vendors, application writers, and users. The use of “should” in the \texttt{DESCRIPTION} of \textit{lp} clearly shows the intent of the standard developers, even if they cannot mandate that all systems (such as laptops) have printers.

This volume of IEEE Std 1003.1-2001 does not specify what the ownership of the process performing the writing to the output device may be. If \texttt{−c} is not used, it is unspecified whether the process performing the writing to the output device has permission to read \texttt{file} if there are any restrictions in place on who may read \texttt{file} until after it is printed. Also, if \texttt{−c} is not used, the results of deleting \texttt{file} before it is printed are unspecified.

\textbf{FUTURE DIRECTIONS}

None.

\textbf{SEE ALSO}

\textit{mailx}

\textbf{CHANGE HISTORY}

First released in Issue 2.

\textbf{Issue 6}

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- In the \texttt{DESCRIPTION}, the requirement to associate a unique request ID, and the normal generation of a banner page is added.

- In the \texttt{OPTIONS} section:
  - The \texttt{−d dest} description is expanded, but references to \textit{lpstat} are removed.
  - The \texttt{−m}, \texttt{−o}, \texttt{−s}, \texttt{−t}, and \texttt{−w} options are added.

- In the \texttt{ENVIRONMENT VARIABLES} section, \texttt{LC\_TIME} may now affect the execution.

- The \texttt{STDOUT} section is added.

The normative text is reworded to avoid use of the term “must” for application requirements.

The \texttt{TZ} entry is added to the \texttt{ENVIRONMENT VARIABLES} section.
NAME
ls — list directory contents

SYNOPSIS
XSI
ls [-CFRcadilqrtul] [-H | -L] [-fgmnopsx] [file...]

DESCRIPTION
For each operand that names a file of a type other than directory or symbolic link to a directory, 
ls shall write the name of the file as well as any requested, associated information. For each 
operand that names a file of type directory, ls shall write the names of files contained within the 
directory as well as any requested, associated information. If one of the -d, -F, or -l options are 
specified, and one of the -H or -L options are not specified, for each operand that names a file of 
type symbolic link to a directory, ls shall write the name of the file as well as any requested, 
associated information. If none of the -d, -F, or -l options are specified, or the -H or -L options 
are specified, for each operand that names a file of type symbolic link to a directory, ls shall write 
the names of files contained within the directory as well as any requested, associated 
information.

If no operands are specified, ls shall write the contents of the current directory. If more than one 
operand is specified, ls shall write non-directory operands first; it shall sort directory and non-
directory operands separately according to the collating sequence in the current locale.

The ls utility shall detect infinite loops; that is, entering a previously visited directory that is an 
ancestor of the last file encountered. When it detects an infinite loop, ls shall write a diagnostic 
message to standard error and shall either recover its position in the hierarchy or terminate.

OPTIONS
The ls utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, 
Utility Syntax Guidelines.

The following options shall be supported:

-C Write multi-text-column output with entries sorted down the columns, according 
to the collating sequence. The number of text columns and the column separator 
characters are unspecified, but should be adapted to the nature of the output 
device.

-F Do not follow symbolic links named as operands unless the -H or -L options are 
specified. Write a slash (‘/’) immediately after each pathname that is a directory, 
an asterisk (‘*’) after each that is executable, a vertical bar (‘|’) after each that is 
a FIFO, and an at sign (‘@’) after each that is a symbolic link. For other file types, 
other symbols may be written.

-H If a symbolic link referencing a file of type directory is specified on the command 
line, ls shall evaluate the file information and file type to be those of the file 
referenced by the link, and not the link itself; however, ls shall write the name of 
the link itself and not the file referenced by the link.

-L Evaluate the file information and file type for all symbolic links (whether named 
on the command line or encountered in a file hierarchy) to be those of the file 
referenced by the link, and not the link itself; however, ls shall write the name of 
the link itself and not the file referenced by the link. When -L is used with -l, write 
the contents of symbolic links in the long format (see the STDOUT section).

-R Recursively list subdirectories encountered.

-a Write out all directory entries, including those whose names begin with a period 
(‘.’). Entries beginning with a period shall not be written out unless explicitly
referenced, the −a option is supplied, or an implementation-defined condition shall
cause them to be written.

-c Use time of last modification of the file status information (see <sys/stat.h> in the
System Interfaces volume of IEEE Std 1003.1-2001) instead of last modification of
the file itself for sorting (−t) or writing (−l).

-d Do not follow symbolic links named as operands unless the −H or −L options are
specified. Do not treat directories differently than other types of files. The use of −d
with −R produces unspecified results.

-xsi −f Force each argument to be interpreted as a directory and list the name found in
each slot. This option shall turn off −I, −t, −s, and −r, and shall turn on −a; the order
is the order in which entries appear in the directory.

-xsi −g The same as −l, except that the owner shall not be written.

-i For each file, write the file's file serial number (see stat() in the System Interfaces

-l (The letter ell.) Do not follow symbolic links named as operands unless the −H or
−L options are specified. Write out in long format (see the STDOUT section). When
−l (ell) is specified, −1 (one) shall be assumed.

-xsi −m Stream output format; list files across the page, separated by commas.

-xsi −n The same as −l, except that the owner's UID and GID numbers shall be written,
rather than the associated character strings.

-xsi −o The same as −l, except that the group shall not be written.

-xsi −p Write a slash (' / ') after each filename if that file is a directory.

-q Force each instance of non-printable filename characters and <tab>s to be written
as the question-mark (' ? ') character. Implementations may provide this option by
default if the output is to a terminal device.

-r Reverse the order of the sort to get reverse collating sequence or oldest first.

-xsi −s Indicate the total number of file system blocks consumed by each file displayed.
The block size is implementation-defined.

-t Sort with the primary key being time modified (most recently modified first) and
the secondary key being filename in the collating sequence.

-u Use time of last access (see <sys/stat.h>) instead of last modification of the file for
sorting (−t) or writing (−l).

-xsi −x The same as −C, except that the multi-text-column output is produced with entries
sorted across, rather than down, the columns.

-1 (The numeric digit one.) Force output to be one entry per line.

Specifying more than one of the options in the following mutually-exclusive pairs shall not be
considered an error: −C and −l (ell), −m and −l (ell), −x and −l (ell),−C and −1 (one), −H and −L,
−c and −u. The last option specified in each pair shall determine the output format.

OPERANDS

The following operand shall be supported:

file A pathname of a file to be written. If the file specified is not found, a diagnostic
message shall be output on standard error.
Utilities

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of ls:

- **COLUMNS**: Determine the user’s preferred column position width for writing multiple text-column output. If this variable contains a string representing a decimal integer, the `ls` utility shall calculate how many pathname text columns to write (see `-C`) based on the width provided. If `COLUMNS` is not set or invalid, an implementation-defined number of column positions shall be assumed, based on the implementation’s knowledge of the output device. The column width chosen to write the names of files in any given directory shall be constant. Filenames shall not be truncated to fit into the multiple text-column output.

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_COLLATE**: Determine the locale for character collation information in determining the pathname collation sequence.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments) and which characters are defined as printable (character class `print`).

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **LC_TIME**: Determine the format and contents for date and time strings written by `ls`.

- **NLSPATH**: Determine the location of message catalogs for the processing of LC_MESSAGES.

- **TZ**: Determine the timezone for date and time strings written by `ls`. If `TZ` is unset or null, an unspecified default timezone shall be used.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The default format shall be to list one entry per line to standard output; the exceptions are to terminals or when one of the `-C`, `-m`, or `-x` options is specified. If the output is to a terminal, the format is implementation-defined.

When `-m` is specified, the format used shall be:

```
"%s, %s, ...
", <filename1>, <filename2>
```

where the largest number of filenames shall be written without exceeding the length of the line.

If the `-i` option is specified, the file’s file serial number (see `<sys/stat.h>`) shall be written in the following format before any other output for the corresponding entry:
%u ", <file serial number>

If the -l option is specified without -L, the following information shall be written:

"%s %u %s %u %s %s\n", <file mode>, <number of links>,
    <owner name>, <group name>, <number of bytes in the file>,
    <date and time>, <pathname>

If the file is a symbolic link, this information shall be about the link itself and the <pathname> field shall be of the form:

"%s \%s\", <pathname of link>, <contents of link>

If both -l and -L are specified, the following information shall be written:

"%s %u %s %u %s %s\n", <file mode>, <number of links>,
    <owner name>, <group name>, <number of bytes in the file>,
    <date and time>, <pathname of link>

where all fields except <pathname of link> shall be for the file resolved from the symbolic link.

XSI The -g, -n, and -o options use the same format as -l, but with omitted items and their associated <blank>s. See the OPTIONS section.

XSI In both the preceding -l forms, if <owner name> or <group name> cannot be determined, or if -n is given, they shall be replaced with their associated numeric values using the format %u.

The <date and time> field shall contain the appropriate date and timestamp of when the file was last modified. In the POSIX locale, the field shall be the equivalent of the output of the following:

date command:

date "+%b %e %H:%M"

if the file has been modified in the last six months, or:

date "+%b %e %Y"

(where two <space>s are used between %e and %Y) if the file has not been modified in the last six months or if the modification date is in the future, except that, in both cases, the final <newline> produced by date shall not be included and the output shall be as if the date command were executed at the time of the last modification date of the file rather than the current time. When the LC_TIME locale category is not set to the POSIX locale, a different format and order of presentation of this field may be used.

If the file is a character special or block special file, the size of the file may be replaced with implementation-defined information associated with the device in question.

If the pathname was specified as a file operand, it shall be written as specified.

XSI The file mode written under the -l, -g, -n, and -o options shall consist of the following format:

"%c%s%s%c", <entry type>, <owner permissions>,
    <group permissions>, <other permissions>,
    <optional alternate access method flag>

The <optional alternate access method flag> shall be a single <space> if there is no alternate or additional access control method associated with the file; otherwise, a printable character shall be used.

The <entry type> character shall describe the type of file, as follows:

d Directory.
Utilities

ls

22163  b  Block special file.
22164  c  Character special file.
22165  l (ell)  Symbolic link.
22166  p  FIFO.
22167  –  Regular file.

Implementations may add other characters to this list to represent other implementation-defined file types.

The next three fields shall be three characters each:

<owner permissions>
Permissions for the file owner class (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.4, File Access Permissions).

<group permissions>
Permissions for the file group class.

<other permissions>
Permissions for the file other class.

Each field shall have three character positions:

1. If ‘r’, the file is readable; if ‘−’, the file is not readable.
2. If ‘w’, the file is writable; if ‘−’, the file is not writable.
3. The first of the following that applies:
   S  If in <owner permissions>, the file is not executable and set-user-ID mode is set. If in <group permissions>, the file is not executable and set-group-ID mode is set.
   s  If in <owner permissions>, the file is executable and set-user-ID mode is set. If in <group permissions>, the file is executable and set-group-ID mode is set.
   T  If in <other permissions> and the file is a directory, search permission is not granted to others, and the restricted deletion flag is set.
   t  If in <other permissions> and the file is a directory, search permission is granted to others, and the restricted deletion flag is set.
   x  The file is executable or the directory is searchable.
   –  None of the attributes of ‘S’, ‘s’, ‘T’, ‘t’, or ‘x’ applies.

   Implementations may add other characters to this list for the third character position. Such additions shall, however, be written in lowercase if the file is executable or searchable, and in uppercase if it is not.

If any of the -l, -g, -n, -o, or -s options is specified, each list of files within the directory shall be preceded by a status line indicating the number of file system blocks occupied by files in the directory in 512-byte units, rounded up to the next integral number of units, if necessary. In the POSIX locale, the format shall be:

"total %u\n", <number of units in the directory>

If more than one directory, or a combination of non-directory files and directories are written, either as a result of specifying multiple operands, or the -R option, each list of files within a directory shall be preceded by:
"\n%s:\n", <directory name>

If this string is the first thing to be written, the first <newline> shall not be written. This output shall precede the number of units in the directory.

If the −s option is given, each file shall be written with the number of blocks used by the file. Along with −C, −I, −m, or −x, the number and a <space> shall precede the filename; with −g, −I, −n, or −o, they shall precede each line describing a file.

STDOUT
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

  0  Successful completion.

  >0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Many implementations use the equal sign (‘=’) to denote sockets bound to the file system for the −F option. Similarly, many historical implementations use the ‘s’ character to denote sockets as the entry type characters for the −l option.

It is difficult for an application to use every part of the file modes field of ls −l in a portable manner. Certain file types and executable bits are not guaranteed to be exactly as shown, as implementations may have extensions. Applications can use this field to pass directly to a user printout or prompt, but actions based on its contents should generally be deferred, instead, to the test utility.

The output of ls (with the −l and related options) contains information that logically could be used by utilities such as chmod and touch to restore files to a known state. However, this information is presented in a format that cannot be used directly by those utilities or be easily translated into a format that can be used. A character has been added to the end of the permissions string so that applications at least have an indication that they may be working in an area they do not understand instead of assuming that they can translate the permissions string into something that can be used. Future issues or related documents may define one or more specific characters to be used based on different standard additional or alternative access control mechanisms.

As with many of the utilities that deal with filenames, the output of ls for multiple files or in one of the long listing formats must be used carefully on systems where filenames can contain embedded white space. Systems and system administrators should institute policies and user training to limit the use of such filenames.

The number of disk blocks occupied by the file that it reports varies depending on underlying file system type, block size units reported, and the method of calculating the number of blocks. On some file system types, the number is the actual number of blocks occupied by the file (counting indirect blocks and ignoring holes in the file); on others it is calculated based on the file size (usually making an allowance for indirect blocks, but ignoring holes).
An example of a small directory tree being fully listed with `ls -laRF a` in the POSIX locale:

```
total 11
```
```
drwxr-xr-x 3 hlj prog 64 Jul 4 12:07 ./
```
```
drwxrwxrwx 4 hlj prog 3264 Jul 4 12:09 ../
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```
drwxr-xr-x 2 hlj prog 48 Jul 4 12:07 b/
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3. The standard developers did not want to preclude future specifications that might need a way to specify more than one alternate access method.

Nonetheless, implementations providing a single alternate access method are encouraged to use ‘+’.

In an early proposal, the units used to specify the number of blocks occupied by files in a directory in an \texttt{ls} \texttt{-i} listing were implementation-defined. This was because BSD systems have historically used 1024-byte units and System V systems have historically used 512-byte units. It was pointed out by BSD developers that their system has used 512-byte units in some places and 1024-byte units in other places. (System V has consistently used 512.) Therefore, this volume of IEEE Std 1003.1-2001 usually specifies 512. Future releases of BSD are expected to consistently provide 512 bytes as a default with a way of specifying 1024-byte units where appropriate.

The \texttt{<date and time>} field in the \texttt{−i} format is specified only for the POSIX locale. As noted, the format can be different in other locales. No mechanism for defining this is present in this volume of IEEE Std 1003.1-2001, as the appropriate vehicle is a messaging system; that is, the format should be specified as a `message`.

\textbf{FUTURE DIRECTIONS}

The \texttt{-s} uses implementation-defined units and cannot be used portably; it may be withdrawn in a future version.

\textbf{SEE ALSO}


\textbf{CHANGE HISTORY}

First released in Issue 2.

\textbf{Issue 5}

A second FUTURE DIRECTION is added.

\textbf{Issue 6}

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- In the \texttt{-F} option, other symbols are allowed for other file types.

- Treatment of symbolic links is added, as defined in the IEEE P1003.2b draft standard.

- The Open Group Base Resolution bwg2001-010 is applied, adding the \texttt{t} and \texttt{t} fields as an XSI extension.
NAME

m4 — macro processor (DEVELOPMENT)

SYNOPSIS

m4 [-s] [-D name[=val]] ... [-U name] ... file...

DESCRIPTION

The m4 utility is a macro processor that shall read one or more text files, process them according to their included macro statements, and write the results to standard output.

OPTIONS

The m4 utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the order of the –D and –U options shall be significant.

The following options shall be supported:

–s Enable line synchronization output for the c99 preprocessor phase (that is, #line directives).

–D name[=val]

Define name to val or to null if =val is omitted.

–U name Undefine name.

OPERANDS

The following operand shall be supported:

file A pathname of a text file to be processed. If no file is given, or if it is ‘–’, the standard input shall be read.

STDIN

The standard input shall be a text file that is used if no file operand is given, or if it is ‘–’.

INPUT FILES

The input file named by the file operand shall be a text file.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of m4:

LANG Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.
ASYNCHRONOUS EVENTS

Default.

STDOUT

The standard output shall be the same as the input files, after being processed for macro expansion.

STDERR

The standard error shall be used to display strings with the errprint macro, macro tracing enabled by the traceon macro, the defined text for macros written by the dumpdef macro, or for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

The m4 utility shall compare each token from the input against the set of built-in and user-defined macros. If the token matches the name of a macro, then the token shall be replaced by the macro's defining text, if any, and rescanned for matching macro names. Once no portion of the token matches the name of a macro, it shall be written to standard output. Macros may have arguments, in which case the arguments shall be substituted into the defining text before it is rescanned.

Macro calls have the form:

\textit{name(arg1, arg2, \ldots, argn)}

Macro names shall consist of letters, digits, and underscores, where the first character is not a digit. Tokens not of this form shall not be treated as macros.

The application shall ensure that the left parenthesis immediately follows the name of the macro. If a token matching the name of a macro is not followed by a left parenthesis, it is handled as a use of that macro without arguments.

If a macro name is followed by a left parenthesis, its arguments are the comma-separated tokens between the left parenthesis and the matching right parenthesis. Unquoted <blank>s and <newline>s preceding each argument shall be ignored. All other characters, including trailing <blank>s and <newline>s, are retained. Commas enclosed between left and right parenthesis characters do not delimit arguments.

Arguments are positionally defined and referenced. The string "$1" in the defining text shall be replaced by the first argument. Systems shall support at least nine arguments; only the first nine can be referenced, using the strings "$1" to "$9", inclusive. The string "$0" is replaced with the name of the macro. The string "$#" is replaced by the number of arguments as a string. The string "$*" is replaced by a list of all of the arguments, separated by commas. The string "$@" is replaced by a list of all of the arguments separated by commas, and each argument is quoted using the current left and right quoting strings.

If fewer arguments are supplied than are in the macro definition, the omitted arguments are taken to be null. It is not an error if more arguments are supplied than are in the macro definition.

No special meaning is given to any characters enclosed between matching left and right quoting strings, but the quoting strings are themselves discarded. By default, the left quoting string consists of a grave accent ('\') and the right quoting string consists of an acute accent (’’'); see also the changequote macro.

Comments are written but not scanned for matching macro names; by default, the begin-comment string consists of the number sign character and the end-comment string consists of a
Utilities

The \texttt{m4} utility shall make available the following built-in macros. They can be redefined, but once this is done the original meaning is lost. Their values shall be null unless otherwise stated. In the descriptions below, the term \textit{defining text} refers to the value of the macro: the second argument to the \texttt{define} macro, among other things. Except for the first argument to the \texttt{eval} macro, all numeric arguments to built-in macros shall be interpreted as decimal values. The string values produced as the defining text of the \texttt{decr}, \texttt{divnum}, \texttt{incr}, \texttt{index}, \texttt{len}, and \texttt{sysval} built-in macros shall be in the form of a decimal-constant as defined in the C language.

\textbf{changecom} The \texttt{changecom} macro shall set the begin-comment and end-comment strings. With no arguments, the comment mechanism shall be disabled. With a single argument, that argument shall become the begin-comment string and the \texttt{<newline>} shall become the end-comment string. With two arguments, the first argument shall become the begin-comment string and the second argument shall become the end-comment string. Systems shall support comment strings of at least five characters.

\textbf{changequote} The \texttt{changequote} macro shall set the begin-quote and end-quote strings. With no arguments, the quote strings shall be set to the default values (that is, \texttt{	extquotesingle	extquotesingle}). With a single argument, that argument shall become the begin-quote string and the \texttt{<newline>} shall become the end-quote string. With two arguments, the first argument shall become the begin-quote string and the second argument shall become the end-quote string. Systems shall support quote strings of at least five characters.

\textbf{decr} The defining text of the \texttt{decr} macro shall be its first argument decremented by 1. It shall be an error to specify an argument containing any non-numeric characters.

\textbf{define} The second argument shall become the defining text of the macro whose name is the first argument.

\textbf{defn} The defining text of the \texttt{defn} macro shall be the quoted definition (using the current quoting strings) of its arguments.

\textbf{divert} The \texttt{m4} utility maintains nine temporary buffers, numbered 1 to 9, inclusive. When the last of the input has been processed, any output that has been placed in these buffers shall be written to standard output in buffer-numerical order. The \texttt{divert} macro shall divert future output to the buffer specified by its argument. Specifying no argument or an argument of 0 shall resume the normal output process. Output diverted to a stream other than 0 to 9 shall be discarded. It shall be an error to specify an argument containing any non-numeric characters.

\textbf{divnum} The defining text of the \texttt{divnum} macro shall be the number of the current output stream as a string.

\textbf{dnl} The \texttt{dnl} macro shall cause \texttt{m4} to discard all input characters up to and including the next \texttt{<newline>}.

\textbf{dumpdef} The \texttt{dumpdef} macro shall write the defined text to standard error for each of the macros specified as arguments, or, if no arguments are specified, for all macros.

\textbf{errprint} The \texttt{errprint} macro shall write its arguments to standard error.

\textbf{eval} The \texttt{eval} macro shall evaluate its first argument as an arithmetic expression, using 32-bit signed integer arithmetic. All of the C-language operators shall be supported, except for:
and all assignment operators. It shall be an error to specify any of these operators. Precedence and associativity shall be as in the ISO C standard. Systems shall support octal and hexadecimal numbers as in the ISO C standard. The second argument, if specified, shall set the radix for the result; the default is 10. The third argument, if specified, sets the minimum number of digits in the result. It shall be an error to specify the second or third argument containing any non-numeric characters.

ifdef If the first argument to the ifdef macro is defined, the defining text shall be the second argument. Otherwise, the defining text shall be the third argument, if specified, or the null string, if not.

ifelse The ifelse macro takes three or more arguments. If the first two arguments compare as equal strings (after macro expansion of both arguments), the defining text shall be the third argument. If the first two arguments do not compare as equal strings and there are three arguments, the defining text shall be null. If the first two arguments do not compare as equal strings and there are four or five arguments, the defining text shall be the fourth argument. If the first two arguments do not compare as equal strings and there are six or more arguments, the first three arguments shall be discarded and processing shall restart with the remaining arguments.

include The defining text for the include macro shall be the contents of the file named by the first argument. It shall be an error if the file cannot be read.

incr The defining text of the incr macro shall be its first argument incremented by 1. It shall be an error to specify an argument containing any non-numeric characters.

index The defining text of the index macro shall be the first character position (as a string) in the first argument where a string matching the second argument begins (zero origin), or −1 if the second argument does not occur.

len The defining text of the len macro shall be the length (as a string) of the first argument.

m4exit Exit from the m4 utility. If the first argument is specified, it is the exit code. The default is zero. It shall be an error to specify an argument containing any non-numeric characters.

m4wrap The first argument shall be processed when EOF is reached. If the m4wrap macro is used multiple times, the arguments specified shall be processed in the order in which the m4wrap macros were processed.

maketemp The defining text shall be the first argument, with any trailing ‘X’ characters replaced with the current process ID as a string.
The popdef macro shall delete the current definition of its arguments, replacing that definition with the previous one. If there is no previous definition, the macro is undefined.

The pushdef macro shall be equivalent to the define macro with the exception that it shall preserve any current definition for future retrieval using the popdef macro.

The defining text for the shift macro shall be all of its arguments except for the first one.

The sinclude macro shall be equivalent to the include macro, except that it shall not be an error if the file is inaccessible.

The defining text for the substr macro shall be the substring of the first argument beginning at the zero-offset character position specified by the second argument. The third argument, if specified, shall be the number of characters to select; if not specified, the characters from the starting point to the end of the first argument shall become the defining text. It shall not be an error to specify a starting point beyond the end of the first argument and the defining text shall be null. It shall be an error to specify an argument containing any non-numeric characters.

The syscmd macro shall interpret its first argument as a shell command line. The defining text shall be the string result of that command. No output redirection shall be performed by the m4 utility. The exit status value from the command can be retrieved using the sysval macro.

The defining text of the sysval macro shall be the exit value of the utility last invoked by the syscmd macro (as a string).

The traceon macro shall enable tracing for the macros specified as arguments, or, if no arguments are specified, for all macros. The trace output shall be written to standard error in an unspecified format.

The traceoff macro shall disable tracing for the macros specified as arguments, or, if no arguments are specified, for all macros.

The defining text of the translit macro shall be the first argument with every character that occurs in the second argument replaced with the corresponding character from the third argument.

The undefine macro shall delete all definitions (including those preserved using the pushdef macro) of the macros named by its arguments.

The undivert macro shall cause immediate output of any text in temporary buffers named as arguments, or all temporary buffers if no arguments are specified. Buffers can be undiverted into other temporary buffers. Undiverting shall discard the contents of the temporary buffer. It shall be an error to specify an argument containing any non-numeric characters.

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred

If the m4exit macro is used, the exit value can be specified by the input file.
CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The `defn` macro is useful for renaming macros, especially built-ins.

EXAMPLES
If the file `m4src` contains the lines:

```
The value of 'VER' is "VER".
ifdef('VER', '"VER" is defined to be VER., VER is not defined.)
ifelse(VER, 1, '"VER" is 'VER'.)
ifelse(VER, 2, '"VER" is 'VER'., '"VER" is not 2.)
end
```
then the command
```
m4 m4src
```
or the command:
```
m4 -U VER m4src
```
produces the output:
```
The value of VER is "VER".
VER is not defined.
VER is not 2.
end
```
The command:
```
m4 -D VER m4src
```
produces the output:
```
The value of VER is "".
VER is defined to be .
VER is not 2.
end
```
The command:
```
m4 -D VER=1 m4src
```
produces the output:
```
The value of VER is "1".
VER is defined to be 1.
VER is 1.
VER is not 2.
end
```
The command:
```
m4 -D VER=2 m4src
```
produces the output:
```
The value of VER is "2".
VER is defined to be 2.
VER is 2.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
c99

CHANGE HISTORY
First released in Issue 2.

Issue 5
The phrase “the defined text for macros written by the dumpdef macro” is added to the description of STDERR, and the description of dumpdef is updated to indicate that output is written to standard error. The description of eval is updated to indicate that the list of excluded C operators excludes unary ‘&’ and ’.’. In the description of ifdef, the phrase “and it is not defined to be zero” is deleted.

Issue 6
In the EXTENDED DESCRIPTION, the eval text is updated to include a ‘&’ character in the excepted list.
The EXTENDED DESCRIPTION of divert is updated to clarify that there are only nine diversion buffers.
The normative text is reworded to avoid use of the term “must” for application requirements.
The Open Group Base Resolution bwg2000-006 is applied.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/31 is applied, replacing the EXAMPLES section.
NAME  
mailx — process messages

SYNOPSIS

Send Mode

mailx [-s subject] address...

Receive Mode

mailx -e
mailx [-HiNn][-F][-u user]
mailx -f[-HiNn][-F][file]

DESCRIPTION

The mailx utility provides a message sending and receiving facility. It has two major modes, 
selected by the options used: Send Mode and Receive Mode.

On systems that do not support the User Portability Utilities option, an application using mailx 
shall have the ability to send messages in an unspecified manner (Send Mode). Unless the first 
character of one or more lines is tilde (‘˜’), all characters in the input message shall appear in 
the delivered message, but additional characters may be inserted in the message before it is 
retrieved.

On systems supporting the User Portability Utilities option, mail-receiving capabilities and other 
interactive features, Receive Mode, described below, also shall be enabled.

Send Mode

Send Mode can be used by applications or users to send messages from the text in standard 
input.

Receive Mode

Receive Mode is more oriented towards interactive users. Mail can be read and sent in this 
interactive mode.

When reading mail, mailx provides commands to facilitate saving, deleting, and responding to 
messages. When sending mail, mailx allows editing, reviewing, and other modification of the 
message as it is entered.

Incoming mail shall be stored in one or more unspecified locations for each user, collectively 
called the system mailbox for that user. When mailx is invoked in Receive Mode, the system 
mailbox shall be the default place to find new mail. As messages are read, they shall be marked 
to be moved to a secondary file for storage, unless specific action is taken. This secondary file is 
called the mbox and is normally located in the directory referred to by the HOME environment 
variable (see MBOX in the ENVIRONMENT VARIABLES section for a description of this file). 
Messages shall remain in this file until explicitly removed. When the -f option is used to read 
mail messages from secondary files, messages shall be retained in those files unless specifically 
removed. All three of these locations—system mailbox, mbox, and secondary file—are referred 
to in this section as simply ‘‘mailboxes’, unless more specific identification is required.

The following options shall be supported. (Only the −s subject option shall be required on all systems. The other options are required only on systems supporting the User Portability Utilities option.)

−e Test for the presence of mail in the system mailbox. The mailx utility shall write nothing and exit with a successful return code if there is mail to read.

−f Read messages from the file named by the file operand instead of the system mailbox. (See also folder.) If no file operand is specified, read messages from mbox instead of the system mailbox.

−F Record the message in a file named after the first recipient. The name is the login-name portion of the address found first on the To: line in the mail header. Overrides the record variable, if set (see Internal Variables in mailx (on page 593.).)

−H Write a header summary only.

−i Ignore interrupts. (See also ignore.)

−n Do not initialize from the system default start-up file. See the EXTENDED DESCRIPTION section.

−N Do not write an initial header summary.

−s subject Set the Subject header field to subject. All characters in the subject string shall appear in the delivered message. The results are unspecified if subject is longer than [LINE_MAX] − 10 bytes or contains a <newline>.

−u user Read the system mailbox of the login name user. This shall only be successful if the invoking user has the appropriate privileges to read the system mailbox of that user.

OPERANDS

The following operands shall be supported:

address Addressee of message. When −n is specified and no user start-up files are accessed (see the EXTENDED DESCRIPTION section), the user or application shall ensure this is an address to pass to the mail delivery system. Any system or user start-up files may enable aliases (see alias under Commands in mailx (on page 596)) that may modify the form of address before it is passed to the mail delivery system.

folder internal variable; see Internal Variables in mailx (on page 593).

file A pathname of a file to be read instead of the system mailbox when −f is specified.

The meaning of the file option-argument shall be affected by the contents of the

folder internal variable; see Internal Variables in mailx (on page 593).

STDIN

When mailx is invoked in Send Mode (the first synopsis line), standard input shall be the
message to be delivered to the specified addresses. When in Receive Mode, user commands shall be accepted from stdin. If the User Portability Utilities option is not supported, standard input lines beginning with a tilde (‘˜’) character produce unspecified results.

If the User Portability Utilities option is supported, then in both Send and Receive Modes, standard input lines beginning with the escape character (usually tilde (‘˜’)) shall affect processing as described in Command Escapes in mailx (on page 604).
When *mailx* is used as described by this volume of IEEE Std 1003.1-2001, the *file* option-
argument (see the −f option) and the *mbox* shall be text files containing mail messages,
formatted as described in the OUTPUT FILES section. The nature of the system mailbox is
unspecified; it need not be a file.

**INPUT FILES**

The following environment variables shall affect the execution of *mailx*:

- **DEAD** Determine the pathname of the file in which to save partial messages in case of
  interrupts or delivery errors. The default shall be *dead.letter* in the directory
  named by the *HOME* variable. The behavior of *mailx* in saving partial messages is
  unspecified if the User Portability Utilities option is not supported and *DEAD* is
  not defined with the value */dev/null*.

- **EDITOR** Determine the name of a utility to invoke when the *edit* (see *Commands in mailx*
  (on page 596)) or *e* (see *Command Escapes in mailx* (on page 604)) command is
  used. The default editor is unspecified. On XSI-conformant systems it is *ed*. The
  effects of this variable are unspecified if the User Portability Utilities option is not
  supported.

- **HOME** Determine the pathname of the user’s home directory.

- **LANG** Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
  Internationalization Variables for the precedence of internationalization variables
  used to determine the values of locale categories.)

- **LC_ALL** If set to a non-empty string value, override the values of all the other
  internationalization variables.

- **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as
  characters (for example, single-byte as opposed to multi-byte characters in
  arguments and input files) and the handling of case-insensitive address and
  header-field comparisons.

- **LC_TIME** Determine the format and contents of the date and time strings written by *mailx*.

**ENVIRONMENT VARIABLES**

- **LC_MESSAGES** Determine the locale that should be used to affect the format and contents of
  diagnostic messages written to standard error and informative messages written to
  standard output.

- **LISTER** Determine a string representing the command for writing the contents of the
  *folder* directory to standard output when the *folders* command is given (see
  *folders* in *Commands in mailx* (on page 596)). Any string acceptable as a
  *command_string* operand to the *sh* −c command shall be valid. If this variable is null
  or not set, the output command shall be *ls*. The effects of this variable are
  unspecified if the User Portability Utilities option is not supported.

- **MAILRC** Determine the pathname of the start-up file. The default shall be *.mailrc* in the
  directory referred to by the *HOME* environment variable. The behavior of *mailx* is
  unspecified if the User Portability Utilities option is not supported and *MAILRC* is
  not defined with the value */dev/null*.

- **MBOX** Determine a pathname of the file to save messages from the system mailbox that
  have been read. The *exit* command shall override this function, as shall saving the
  message explicitly in another file. The default shall be *mbox* in the directory
named by the HOME variable. The effects of this variable are unspecified if the User Portability Utilities option is not supported.

**NLSPATH**  Determine the location of message catalogs for the processing of LC_MESSAGES.

**PAGER**  Determine a string representing an output filtering or pagination command for writing the output to the terminal. Any string acceptable as a command_string operand to the sh -c command shall be valid. When standard output is a terminal device, the message output shall be piped through the command if the mailx internal variable crt is set to a value less the number of lines in the message; see

**Internal Variables in mailx** (on page 593). If the PAGER variable is null or not set, the paginator shall be either more or another paginator utility documented in the system documentation. The effects of this variable are unspecified if the User Portability Utilities option is not supported.

**SHELL**  Determine the name of a preferred command interpreter. The default shall be sh. The effects of this variable are unspecified if the User Portability Utilities option is not supported.

**TERM**  If the internal variable screen is not specified, determine the name of the terminal type to indicate in an unspecified manner the number of lines in a screenful of headers. If TERM is not set or is set to null, an unspecified default terminal type shall be used and the value of a screenful is unspecified. The effects of this variable are unspecified if the User Portability Utilities option is not supported.

**TZ**  This variable may determine the timezone used to calculate date and time strings written by mailx. If TZ is unset or null, an unspecified default timezone shall be used.

**VISUAL**  Determine a pathname of a utility to invoke when the visual command (see Commands in mailx (on page 596)) or \v command-escape (see Command Escapes in mailx (on page 604)) is used. If this variable is null or not set, the full-screen editor shall be vi. The effects of this variable are unspecified if the User Portability Utilities option is not supported.

### ASYNCHRONOUS EVENTS

When mailx is in Send Mode and standard input is not a terminal, it shall take the standard action for all signals.

In Receive Mode, or in Send Mode when standard input is a terminal, if a SIGINT signal is received:

1. If in command mode, the current command, if there is one, shall be aborted, and a command-mode prompt shall be written.
2. If in input mode:
   a. If ignore is set, mailx shall write "@\n", discard the current input line, and continue processing, bypassing the message-abort mechanism described in item 2b.
   b. If the interrupt was received while sending mail, either when in Receive Mode or in Send Mode, a message shall be written, and another subsequent interrupt, with no other intervening characters typed, shall be required to abort the mail message. If in Receive Mode and another interrupt is received, a command-mode prompt shall be written. If in Send Mode and another interrupt is received, mailx shall terminate with a non-zero status.

In both cases listed in item b, if the message is not empty:
 utilities
22781  i. If save is enabled and the file named by DEAD can be created, the message
22782  shall be written to the file named by DEAD. If the file exists, the message shall
22783  be written to replace the contents of the file.
22784  ii. If save is not enabled, or the file named by DEAD cannot be created, the
22785  message shall not be saved.
22786  The mailx utility shall take the standard action for all other signals.
22787  STDOUT
22788  In command and input modes, all output, including prompts and messages, shall be written to
22789  standard output.
22790  STDERR
22791  The standard error shall be used only for diagnostic messages.
22792  OUTPUT FILES
22793  Various mailx commands and command escapes can create or add to files, including the mbox,
22794  the dead-letter file, and secondary mailboxes. When mailx is used as described in this volume of
22795  IEEE Std 1003.1-2001, these files shall be text files, formatted as follows:
22796         line beginning with From<space>
22797         [one or more header-lines; see Commands in mailx (on page 596)]
22798         empty line
22799         [zero or more body lines
22800         empty line]
22801         [line beginning with From<space>...]
22802  where each message begins with the From <space> line shown, preceded by the beginning of
22803  the file or an empty line. (The From <space> line is considered to be part of the message header,
22804  but not one of the header-lines referred to in Commands in mailx (on page 596); thus, it shall not
22805  be affected by the discard, ignore, or retain commands.) The formats of the remainder of the
22806  From <space> line and any additional header lines are unspecified, except that none shall be
22807  empty. The format of a message body line is also unspecified, except that no line following an
22808  empty line shall start with From <space>; mailx shall modify any such user-entered message
22809  body lines (following an empty line and beginning with From <space>) by adding one or more
22810  characters to precede the ‘F’; it may add these characters to From <space> lines that are not
22811  preceded by an empty line.
22812  When a message from the system mailbox or entered by the user is not a text file, it is
22813  implementation-defined how such a message is stored in files written by mailx.
22814  EXTENDED DESCRIPTION
22815  The entire EXTENDED DESCRIPTION section shall apply only to implementations supporting
22816  the User Portability Utilities option.
22817  The mailx utility cannot guarantee support for all character encodings in all circumstances. For
22818  example, inter-system mail may be restricted to 7-bit data by the underlying network, 8-bit data
22819  need not be portable to non-internationalized systems, and so on. Under these circumstances, it
22820  is recommended that only characters defined in the ISO/IEC 646:1991 standard International
22821  Reference Version (equivalent to ASCII) 7-bit range of characters be used.
22822  When mailx is invoked using one of the Receive Mode synopsis forms, it shall write a page of
22823  header-summary lines (if –N was not specified and there are messages, see below), followed by
22824  a prompt indicating that mailx can accept regular commands (see Commands in mailx (on page
22825  596)); this is termed command mode. The page of header-summary lines shall contain the first
22826  new message if there are new messages, or the first unread message if there are unread
22827  messages, or the first message. When mailx is invoked using the Send Mode synopsis and
standard input is a terminal, if no subject is specified on the command line and the asksub variable is set, a prompt for the subject shall be written. At this point, mailx shall be in input mode. This input mode shall also be entered when using one of the Receive Mode synopsis forms and a reply or new message is composed using the reply, Reply, followup, Followup, or mail commands and standard input is a terminal. When the message is typed and the end of the message is encountered, the message shall be passed to the mail delivery software. Commands can be entered by beginning a line with the escape character (by default, tilde (˜)) followed by a single command letter and optional arguments. See Commands in mailx (on page 596) for a summary of these commands. It is unspecified what effect these commands will have if standard input is not a terminal when a message is entered using either the Send Mode synopsis, or the Read Mode commands reply, Reply, followup, Followup, or mail.

Note: For notational convenience, this section uses the default escape character, tilde, in all references and examples.

At any time, the behavior of mailx shall be governed by a set of environmental and internal variables. These are flags and valued parameters that can be set and cleared via the mailx set and unset commands.

Regular commands are of the form:

```
[command] [msglist] [argument ...]
```

If no command is specified in command mode, next shall be assumed. In input mode, commands shall be recognized by the escape character, and lines not treated as commands shall be taken as input for the message.

In command mode, each message shall be assigned a sequential number, starting with 1.

All messages have a state that shall affect how they are displayed in the header summary and how they are retained or deleted upon termination of mailx. There is at any time the notion of a current message, which shall be marked by a ‘>’ at the beginning of a line in the header summary. When mailx is invoked using one of the Receive Mode synopsis forms, the current message shall be the first new message, if there is a new message, or the first unread message if there is an unread message, or the first message if there are any messages, or unspecified if there are no messages in the mailbox. Each command that takes an optional list of messages (msglist) or an optional single message (message) on which to operate shall leave the current message set to the highest-numbered message of the messages specified, unless the command deletes messages, in which case the current message shall be set to the first undeleted message (that is, a message not in the deleted state) after the highest-numbered message deleted by the command, if one exists, or the first undeleted message before the highest-numbered message deleted by the command, if one exists, or to an unspecified value if there are no remaining undeleted messages. All messages shall be in one of the following states:

- **new**: The message is present in the system mailbox and has not been viewed by the user or moved to any other state. Messages in state new when mailx quits shall be retained in the system mailbox.

- **unread**: The message has been present in the system mailbox for more than one invocation of mailx and has not been viewed by the user or moved to any other state. Messages in state unread when mailx quits shall be retained in the system mailbox.

- **read**: The message has been processed by one of the following commands: "f", "m", "F", "M", copy, mbox, next, pipe, print, Print, top, type, Type, undelete. The delete, dp, and dt commands may also cause the next message to be marked as read, depending on the value of the autoprint variable. Messages that are in the system mailbox and in state read when mailx quits shall be saved in the mbox, unless the internal variable hold was set. Messages that are in the mbox or in a secondary mailbox and in state
read when mailx quits shall be retained in their current location.

The message has been processed by one of the following commands: delete, dp, dt. Messages in state deleted when mailx quits shall be deleted. Deleted messages shall be ignored until mailx quits or changes mailboxes or they are specified to the undelete command; for example, the message specification /string shall only search the subject lines of messages that have not yet been deleted, unless the command operating on the list of messages is undelete. No deleted message or deleted message header shall be displayed by any mailx command other than undelete.

The message has been processed by a preserve command. When mailx quits, the message shall be retained in its current location.

The message has been processed by one of the following commands: save or write. If the current mailbox is the system mailbox, and the internal variable keepsave is set, messages in the state saved shall be saved to the file designated by the MBOX variable (see the ENVIRONMENT VARIABLES section). If the current mailbox is the system mailbox, messages in the state saved shall be deleted from the current mailbox, when the quit or file command is used to exit the current mailbox.

The header-summary line for each message shall indicate the state of the message.

Many commands take an optional list of messages (msglist) on which to operate, which defaults to the current message. A msglist is a list of message specifications separated by <blank>s, which can include:

n Message number n.

+ The next undeleted message, or the next deleted message for the undelete command.

− The next previous undeleted message, or the next previous deleted message for the undelete command.

. The current message.

^ The first undeleted message, or the first deleted message for the undelete command.

$ The last message.

* All messages.

n-m An inclusive range of message numbers.

address All messages from address; any address as shown in a header summary shall be matchable in this form.

/string All messages with string in the subject line (case ignored).

:c All messages of type c, where c shall be one of:

d Deleted messages.

n New messages.

o Old messages (any not in state read or new).

r Read messages.

u Unread messages.
Other commands take an optional message \((message)\) on which to operate, which defaults to the current message. All of the forms allowed for \texttt{msglist} are also allowed for \texttt{message}, but if more than one message is specified, only the first shall be operated on.

Other arguments are usually arbitrary strings whose usage depends on the command involved.

**Start-Up in mailx**

At start-up time, \textit{mailx} shall take the following steps in sequence:

1. Establish all variables at their stated default values.
2. Process command line options, overriding corresponding default values.
3. Import any of the \texttt{DEAD}, \texttt{EDITOR}, \texttt{MBOX}, \texttt{LISTER}, \texttt{PAGER}, \texttt{SHELL}, or \texttt{VISUAL} variables that are present in the environment, overriding the corresponding default values.
4. Read \textit{mailx} commands from an unspecified system start-up file, unless the \texttt{-n} option is given, to initialize any internal \textit{mailx} variables and aliases.
5. Process the start-up file of \textit{mailx} commands named in the user \texttt{MAILRC} variable.

Most regular \textit{mailx} commands are valid inside start-up files, the most common use being to set up initial display options and alias lists. The following commands shall be invalid in the start-up file: \texttt{!}, \texttt{edit}, \texttt{hold}, \texttt{mail}, \texttt{preserve}, \texttt{reply}, \texttt{Reply}, \texttt{shell}, \texttt{visual}, \texttt{Copy}, \texttt{followup}, and \texttt{Followup}. Any errors in the start-up file shall either cause \textit{mailx} to terminate with a diagnostic message and a non-zero status or to continue after writing a diagnostic message, ignoring the remainder of the lines in the start-up file.

A blank line in a start-up file shall be ignored.

**Internal Variables in mailx**

The following variables are internal \textit{mailx} variables. Each internal variable can be set via the \textit{mailx} \texttt{set} command at any time. The \texttt{unset} and \texttt{set no name} commands can be used to erase variables.

In the following list, variables shown as:

\begin{verbatim}
variable
\end{verbatim}

represent Boolean values. Variables shown as:

\begin{verbatim}
variable=value
\end{verbatim}

shall be assigned string or numeric values. For string values, the rules in \textbf{Commands in mailx} (on page 596) concerning filenames and quoting shall also apply.

The defaults specified here may be changed by the implementation-defined system start-up file unless the user specifies the \texttt{-n} option.

\begin{verbatim}
allnet
append
ask, asksub
\end{verbatim}

\texttt{allnet} All network names whose login name components match shall be treated as identical. This shall cause the \texttt{msglist} message specifications to behave similarly. The default shall be \texttt{noallnet}. See also the \texttt{alternates} command and the \texttt{metoo} variable.

\texttt{append} Append messages to the end of the \texttt{mbox} file upon termination instead of placing them at the beginning. The default shall be \texttt{noappend}. This variable shall not affect the \texttt{save} command when saving to \texttt{mbox}.

\texttt{ask, asksub} Prompt for a subject line on outgoing mail if one is not specified on the command line with the \texttt{-s} option. The \texttt{ask} and \texttt{asksub} forms are synonyms; the system shall
Refer to `asksub` and `noasksub` in its messages, but shall accept `ask` and `noask` as user input to mean `asksub` and `noasksub`. It shall not be possible to set both `ask` and `noasksub`, or `noask` and `asksub`. The default shall be `asksub`, but no prompting shall be done if standard input is not a terminal.

**askbcc** Prompt for the blind copy list. The default shall be `noaskbcc`.

**askcc** Prompt for the copy list. The default shall be `noaskcc`.

**autoprint** Enable automatic writing of messages after delete and undelete commands. The default shall be `noautoprint`.

**bang** Enable the special-case treatment of exclamation marks (`'!'`) in escape command lines; see the `escape` command and **Command Escapes in mailx** (on page 604). The default shall be `nobang`, disabling the expansion of `'!'` in the command argument to the `˜!` command and the `˜<command escape`.

**cmd** Set the default command to be invoked by the pipe command. The default shall be `nocmd`.

**crt** Pipe messages having more than `number` lines through the command specified by the value of the `PAGER` variable. The default shall be `nocrt`. If it is set to null, the value used is implementation-defined.

**debug** Enable verbose diagnostics for debugging. Messages are not delivered. The default shall be `nodebug`.

**dot** When `dot` is set, a period on a line by itself during message input from a terminal shall also signify end-of-file (in addition to normal end-of-file). The default shall be `nodot`. If `ignoreeof` is set (see below), a setting of `nodot` shall be ignored and the period is the only method to terminate input mode.

**escape** Set the command escape character to be the character `'c'`. By default, the command escape character shall be tilde. If `escape` is unset, tilde shall be used; if it is set to null, command escaping shall be disabled.

**flipr** Reverse the meanings of the `R` and `r` commands. The default shall be `noflipr`.

**folder** The default directory for saving mail files. User-specified filenames beginning with a plus sign (`'+'`) shall be expanded by preceding the filename with this directory name to obtain the real pathname. If `directory` does not start with a slash (`'/'`), the contents of `HOME` shall be prefixed to it. The default shall be `nofolder`. If `folder` is unset or set to null, user-specified filenames beginning with `'+ '` shall refer to files in the current directory that begin with the literal `'+ '` character. See also `outfolder` below. The `folder` value need not affect the processing of the files named in `MBOX` and `DEAD`.

**header** Enable writing of the header summary when entering `mailx` in Receive Mode. The default shall be `header`.

**hold** Preserve all messages that are read in the system mailbox instead of putting them in the `mbox` save file. The default shall be `nohold`.

**ignore** Ignore interrupts while entering messages. The default shall be `noignore`.

**ignoreeof** Ignore normal end-of-file during message input. Input can be terminated only by entering a period (`'. '`) on a line by itself or by the `˜.` command escape. The default shall be `noignoreeof` . See also `dot` above.
indentprefix=string

A string that shall be added as a prefix to each line that is inserted into the message by the \texttt{\textasciitilde m} command escape. This variable shall default to one <tab>.

keep

When a system mailbox, secondary mailbox, or mbox is empty, truncate it to zero length instead of removing it. The default shall be nokeep.

keepsave

Keep the messages that have been saved from the system mailbox into other files in the file designated by the variable MBOX, instead of deleting them. The default shall be nokeepsave.

metoo

Suppress the deletion of the login name of the user from the recipient list when replying to a message or sending to a group. The default shall be nometoo.

onehop

When responding to a message that was originally sent to several recipients, the other recipient addresses are normally forced to be relative to the originating author’s machine for the response. This flag disables alteration of the recipients’ addresses, improving efficiency in a network where all machines can send directly to all other machines (that is, one hop away). The default shall be noonehop.

outfolder

Cause the files used to record outgoing messages to be located in the directory specified by the folder variable unless the pathname is absolute. The default shall be nooutfolder. See the record variable.

page

Insert a <form-feed> after each message sent through the pipe created by the pipe command. The default shall be nopage.

prompt=string

Set the command-mode prompt to string. If string is null or if nprompt is set, no prompting shall occur. The default shall be to prompt with the string "? ".

quiet

Refrain from writing the opening message and version when entering mailx. The default shall be noquiet.

record=file

Record all outgoing mail in the file with the pathname file. The default shall be norecord. See also outfolder above.

save

Enable saving of messages in the dead-letter file on interrupt or delivery error. See the variable DEAD for the location of the dead-letter file. The default shall be save.

screen=number

Set the number of lines in a screenful of headers for the headers and z commands. If screen is not specified, a value based on the terminal type identified by the TERM environment variable, the window size, the baud rate, or some combination of these shall be used.

sendwait

Wait for the background mailer to finish before returning. The default shall be nosendwait.

showto

When the sender of the message was the user who is invoking mailx, write the information from the To: line instead of the From: line in the header summary. The default shall be noshowto.

sign=string

Set the variable inserted into the text of a message when the \texttt{\textasciitilde a} command escape is given. The default shall be nosign. The character sequences \texttt{\textasciitilde t} and \texttt{\textasciitilde n} shall be recognized in the variable as <tab>s and <newline>s, respectively. (See also \texttt{\textasciitilde i} in Command Escapes in mailx on page 604.)

Sign=string

Set the variable inserted into the text of a message when the \texttt{\textasciitilde A} command escape is given. The default shall be noSign. The character sequences \texttt{\textasciitilde t} and \texttt{\textasciitilde n} shall
be recognized in the variable as \texttt{<tab>\textbackslash}s and \texttt{<newline>\textbackslash}s, respectively.

toplines=\texttt{number}

Set the number of lines of the message to write with the \texttt{top} command. The default shall be 5.

\textbf{Commands in mailx}

The following \texttt{mailx} commands shall be provided. In the following list, header refers to lines from the message header, as shown in the OUTPUT FILES section. Header-line refers to lines within the header that begin with one or more non-white-space characters, immediately followed by a colon and white space and continuing until the next line beginning with a non-white-space character or an empty line. Header-field refers to the portion of a header line prior to the first colon in that line.

For each of the commands listed below, the command can be entered as the abbreviation (those characters in the Synopsis command word preceding the \texttt{' ['}), the full command (all characters shown for the command word, omitting the \texttt{' ['} and \texttt{'] '}), or any truncation of the full command down to the abbreviation. For example, the \texttt{exit} command (shown as \texttt{ex[it]}) in the Synopsis can be entered as \texttt{ex}, \texttt{exi}, or \texttt{exit}.

The arguments to commands can be quoted, using the following methods:

\begin{itemize}
\item An argument can be enclosed between paired double-quotes (\texttt{""}) or single-quotes (\texttt{' '}); any white space, shell word expansion, or backslash characters within the quotes shall be treated literally as part of the argument. A double-quote shall be treated literally within single-quotes and \textit{vice versa}. These special properties of the quote marks shall occur only when they are paired at the beginning and end of the argument.
\item A backslash outside of the enclosing quotes shall be discarded and the following character treated literally as part of the argument.
\item An unquoted backslash at the end of a command line shall be discarded and the next line shall continue the command.
\end{itemize}

File names, where expected, shall be subjected to the following transformations, in sequence:

\begin{itemize}
\item If the filename begins with an unquoted plus sign, and the \texttt{folder} variable is defined (see the \texttt{folder} variable), the plus sign shall be replaced by the value of the \texttt{folder} variable followed by a slash. If the \texttt{folder} variable is unset or is set to null, the filename shall be unchanged.
\item Shell word expansions shall be applied to the filename (see Section 2.6 (on page 36)). If more than a single pathname results from this expansion and the command is expecting one file, the effects are unspecified.
\end{itemize}

\textbf{Declare Aliases}

\begin{verbatim}
 Synopsis:   a[lias] [alias [address...]]
            g[roup] [alias [address...]]
\end{verbatim}

Add the given addresses to the alias specified by \texttt{alias}. The names shall be substituted when \texttt{alias} is used as a recipient address specified by the user in an outgoing message (that is, other recipients addressed indirectly through the \texttt{reply} command shall not be substituted in this manner). Mail address alias substitution shall apply only when the alias string is used as a full address; for example, when \texttt{hlj} is an alias, \texttt{hlj@posix.com} does not trigger the alias substitution. If no arguments are given, write a listing of the current aliases to standard output. If only an \texttt{alias} argument is given, write a listing of the specified alias to standard output. These listings need not reflect the same order of addresses that were entered.
Declare Alternatives

Synopsis:   alternates name...

(See also the metoo command.) Declare a list of alternative names for the user’s login. When responding to a message, these names shall be removed from the list of recipients for the response. The comparison of names shall be in a case-insensitive manner. With no arguments, alternates shall write the current list of alternative names.

Change Current Directory

Synopsis:   cd [directory]
           ch[dir] [directory]

Change directory. If directory is not specified, the contents of HOME shall be used.

Copy Messages

Synopsis:   copy [file]
           copy [msglist] file
           C[opy] [msglist]

Copy messages to the file named by the pathname file without marking the messages as saved. Otherwise, it shall be equivalent to the save command.

In the capitalized form, save the specified messages in a file whose name is derived from the author of the message to be saved, without marking the messages as saved. Otherwise, it shall be equivalent to the Save command.

Delete Messages

Synopsis:   delete [msglist]

Mark messages for deletion from the mailbox. The deletions shall not occur until mailx quits (see the quit command) or changes mailboxes (see the folder command). If autoprint is set and there are messages remaining after the delete command, the current message shall be written as described for the print command (see the print command); otherwise, the mailx prompt shall be written.

Discard Header Fields

Synopsis:   discard [header-field...]  
            ignore [header-field...]  

Suppress the specified header fields when writing messages. Specified header-fields shall be added to the list of suppressed header fields. Examples of header fields to ignore are status and cc. The fields shall be included when the message is saved. The Print and Type commands shall override this command. The comparison of header fields shall be in a case-insensitive manner. If no arguments are specified, write a list of the currently suppressed header fields to standard output; the listing need not reflect the same order of header fields that were entered.

If both retain and discard commands are given, discard commands shall be ignored.
**Delete Messages and Display**

*Synopsis:*

```plaintext
dp [msglist]
dt [msglist]
```

Delete the specified messages as described for the `delete` command, except that the `autoprint` variable shall have no effect, and the current message shall be written only if it was set to a message after the last message deleted by the command. Otherwise, an informational message to the effect that there are no further messages in the mailbox shall be written, followed by the `mailx` prompt.

**Echo a String**

*Synopsis:*

```plaintext
ec[ho] string ...
```

Echo the given strings, equivalent to the shell `echo` utility.

**Edit Messages**

*Synopsis:*

```plaintext
e[dit] [msglist]
```

Edit the given messages. The messages shall be placed in a temporary file and the utility named by the `EDITOR` variable is invoked to edit each file in sequence. The default `EDITOR` is unspecified.

The `edit` command does not modify the contents of those messages in the mailbox.

**Exit**

*Synopsis:*

```plaintext
ex[it]
x[it]
```

Exit from `mailx` without changing the mailbox. No messages shall be saved in the `mbox` (see also `quit`).

**Change Folder**

*Synopsis:*

```plaintext
fi[le] [file]
fold[er] [file]
```

Quit (see the `quit` command) from the current file of messages and read in the file named by the pathname `file`. If no argument is given, the name and status of the current mailbox shall be written.

Several unquoted special characters shall be recognized when used as `file` names, with the following substitutions:

- `%` The system mailbox for the invoking user.
- `@user` The system mailbox for `user`.
- `#` The previous file.
- `&` The current `mbox`.
- `+file` The named file in the `folder` directory. (See the `folder` variable.)

The default file shall be the current mailbox.
Display List of Folders

Synopsis: folders

Write the names of the files in the directory set by the folder variable. The command specified by the LISTER environment variable shall be used (see the ENVIRONMENT VARIABLES section).

Follow Up Specified Messages

Synopsis: followup [message]

In the lowercase form, respond to a message, recording the response in a file whose name is derived from the author of the message. See also the save and copy commands and outfolder.

In the capitalized form, respond to the first message in the msglist, sending the message to the author of each message in the msglist. The subject line shall be taken from the first message and the response shall be recorded in a file whose name is derived from the author of the first message. See also the Save and Copy commands and outfolder.

Both forms shall override the record variable, if set.

Display Header Summary for Specified Messages

Synopsis: from [msglist]

Write the header summary for the specified messages.

Display Header Summary

Synopsis: headers [message]

Write the page of headers that includes the message specified. If the message argument is not specified, the current message shall not change. However, if the message argument is specified, the current message shall become the message that appears at the top of the page of headers that includes the message specified. The screen variable sets the number of headers per page. See also the z command.

Help

Synopsis: help [p]

Write a summary of commands.

Hold Messages

Synopsis: hold [msglist]

Mark the messages in msglist to be retained in the mailbox when mailx terminates. This shall override any commands that might previously have marked the messages to be deleted. During the current invocation of mailx, only the delete, dp, or dt commands shall remove the preserve marking of a message.
Execute Commands Conditionally

Synopsis:  \[ if \] [s|r]  
\[ mail\-commands \]  
\[ else \]  
\[ mail\-commands \]  
\[ endif \]

Execute commands conditionally, where if s executes the following mail\-commands, up to an else or endif, if the program is in Send Mode, and if r shall cause the mail\-commands to be executed only in Receive Mode.

List Available Commands

Synopsis:  l[ist]

Write a list of all commands available. No explanation shall be given.

Mail a Message

Synopsis:  m[ail] address...

Mail a message to the specified addresses or aliases.

Direct Messages to mbox

Synopsis:  mb[ox] [msglist]

Arrange for the given messages to end up in the mbox save file when mailx terminates normally. See MBOX. See also the exit and quit commands.

Process Next Specified Message

Synopsis:  n[ext] [message]

If the current message has not been written (for example, by the print command) since mailx started or since any other message was the current message, behave as if the print command was entered. Otherwise, if there is an undeleted message after the current message, make it the current message and behave as if the print command was entered. Otherwise, an informational message to the effect that there are no further messages in the mailbox shall be written, followed by the mailx prompt.

Pipe Message

Synopsis:  pi[pe] [[msglist] command]  
| [[msglist] command]

Pipe the messages through the given command by invoking the command interpreter specified by SHELL with two arguments: –c and command. (See also sh –c.) The application shall ensure that the command is given as a single argument. Quoting, described previously, can be used to accomplish this. If no arguments are given, the current message shall be piped through the command specified by the value of the cmd variable. If the page variable is set, a <form-feed> shall be inserted after each message.
Display Message with Headers

Synopsis:  \[ \text{P[rint]} \ [\text{msglist}] \]
\[ \text{T[ype]} \ [\text{msglist}] \]

Write the specified messages, including all header lines, to standard output. Override suppression of lines by the \text{discard}, \text{ignore}, and \text{retain} commands. If \text{crt} is set, the messages longer than the number of lines specified by the \text{crt} variable shall be paged through the command specified by the \text{PAGER} environment variable.

Display Message

Synopsis:  \[ \text{p[rint]} \ [\text{msglist}] \]
\[ \text{t[ype]} \ [\text{msglist}] \]

Write the specified messages to standard output. If \text{crt} is set, the messages longer than the number of lines specified by the \text{crt} variable shall be paged through the command specified by the \text{PAGER} environment variable.

Quit

Synopsis:  \[ \text{q[uit]} \]
\[ \text{end-of-file} \]

Terminate \text{mailx}, storing messages that were read in \text{mbox} (if the current mailbox is the system mailbox and unless \text{hold} is set), deleting messages that have been explicitly saved (unless \text{keepsave} is set), discarding messages that have been deleted, and saving all remaining messages in the mailbox.

Reply to a Message List

Synopsis:  \[ \text{R[eply]} \ [\text{msglist}] \]
\[ \text{R[espond]} \ [\text{msglist}] \]

Mail a reply message to the sender of each message in the \text{msglist}. The subject line shall be formed by concatenating \text{Re:<space>} (unless it already begins with that string) and the subject from the first message. If \text{record} is set to a filename, the response shall be saved at the end of that file.

See also the \text{flipr} variable.

Reply to a Message

Synopsis:  \[ \text{r[eply]} \ [\text{message}] \]
\[ \text{r[espond]} \ [\text{message}] \]

Mail a reply message to all recipients included in the header of the message. The subject line shall be formed by concatenating \text{Re:<space>} (unless it already begins with that string) and the subject from the message. If \text{record} is set to a filename, the response shall be saved at the end of that file.

See also the \text{flipr} variable.
Retain Header Fields

Synopsis: ret[ain] [header-field...]

Retain the specified header fields when writing messages. This command shall override all discard and ignore commands. The comparison of header fields shall be in a case-insensitive manner. If no arguments are specified, write a list of the currently retained header fields to standard output; the listing need not reflect the same order of header fields that were entered.

Save Messages

Synopsis: s[ave] [file]

Save the specified messages in the file named by the pathname file, or the mbox if the file argument is omitted. The file shall be created if it does not exist; otherwise, the messages shall be appended to the file. The message shall be put in the state saved, and shall behave as specified in the description of the saved state when the current mailbox is exited by the quit or file command.

In the capitalized form, save the specified messages in a file whose name is derived from the author of the first message. The name of the file shall be taken to be the author’s name with all network addressing stripped off. See also the Copy, followup, and Followup commands and outfolder variable.

Set Variables

Synopsis: se[t] [name=[string] ...] [name=number ...] [no name ...]

Define one or more variables called name. The variable can be given a null, string, or numeric value. Quoting and backslash escapes can occur anywhere in string, as described previously, as if the string portion of the argument were the entire argument. The forms name and name= shall be equivalent to name="" for variables that take string values. The set command without arguments shall write a list of all defined variables and their values. The no name form shall be equivalent to unset name.

Invoke a Shell

Synopsis: sh[ell]

Invoke an interactive command interpreter (see also SHELL).

Display Message Size

Synopsis: si[ze] [msglist]

Write the size in bytes of each of the specified messages.

Read mailx Commands From a File

Synopsis: so[urce] file

Read and execute commands from the file named by the pathname file and return to command mode.
Display Beginning of Messages

Synopsis:  to[p] [msglist]

Write the top few lines of each of the specified messages. If the toplines variable is set, it is taken as the number of lines to write. The default shall be 5.

Touch Messages

Synopsis:  tou[ch] [msglist]

Touch the specified messages. If any message in msglist is not specifically deleted nor saved in a file, it shall be placed in the mbox upon normal termination. See exit and quit.

Delete Aliases

Synopsis:  una[lias] [alias]...

Delete the specified alias names. If a specified alias does not exist, the results are unspecified.

Undelete Messages

Synopsis:  undelete [msglist]

Change the state of the specified messages from deleted to read. If autoprint is set, the last message of those restored shall be written. If msglist is not specified, the message shall be selected as follows:

- If there are any deleted messages that follow the current message, the first of these shall be chosen.
- Otherwise, the last deleted message that also precedes the current message shall be chosen.

Unset Variables

Synopsis:  unset name...

Cause the specified variables to be erased.

Edit Message with Full-Screen Editor

Synopsis:  visual [msglist]

Edit the given messages with a screen editor. Each message shall be placed in a temporary file, and the utility named by the VISUAL variable shall be invoked to edit each file in sequence. The default editor shall be vi.

The visual command does not modify the contents of those messages in the mailbox.

Write Messages to a File

Synopsis:  write [msglist] file

Write the given messages to the file specified by the pathname file, minus the message header. Otherwise, it shall be equivalent to the save command.
Scroll Header Display

Synopsis:  z [+|−]

Scroll the header display forward (if ‘+’ is specified or if no option is specified) or backward (if ‘−’ is specified) one screenful. The number of headers written shall be set by the screen variable.

Invoke Shell Command

Synopsis:  ! command

Invoke the command interpreter specified by SHELL with two arguments: −c and command. (See also sh −c.) If the bang variable is set, each unescaped occurrence of ‘!’ in command shall be replaced with the command executed by the previous ‘!’ command or ‘!’ command escape.

Null Command

Synopsis:  # comment

This null command (comment) shall be ignored by mailx.

Display Current Message Number

Synopsis:  =

Write the current message number.

Command Escapes in mailx

The following commands can be entered only from input mode, by beginning a line with the escape character (by default, tilde (‘˜’)). See the escape variable description for changing this special character. The format for the commands shall be:

<escape-character><command-char><separator>[<arguments>]

where the <separator> can be zero or more <blank>s.

In the following descriptions, the application shall ensure that the argument command (but not mailx-command) is a shell command string. Any string acceptable to the command interpreter specified by the SHELL variable when it is invoked as SHELL −c command_string shall be valid.

The command can be presented as multiple arguments (that is, quoting is not required).

Command escapes that are listed with msglist or mailx-command arguments are invalid in Send Mode and produce unspecified results.

~! command  Invoke the command interpreter specified by SHELL with two arguments: −c and command; and then return to input mode. If the bang variable is set, each unescaped occurrence of ‘!’ in command shall be replaced with the command executed by the previous ‘!’ command or ‘!’ command escape.

~.  Simulate end-of-file (terminate message input).

~: mailx-command, ~ _ mailx-command

Perform the command-level request.

~?  Write a summary of command escapes.

~A  This shall be equivalent to ‘! Sign.

~a  This shall be equivalent to ‘! sign.
~b name... Add the names to the blind carbon copy (Bcc) list.

~c name... Add the names to the carbon copy (Cc) list.

~d Read in the dead-letter file. See DEAD for a description of this file.

~e Invoke the editor, as specified by the EDITOR environment variable, on the partial message.

~f [msglist] Forward the specified messages. The specified messages shall be inserted into the current message without alteration. This command escape also shall insert message headers into the message with field selection affected by the discard, ignore, and retain commands.

~F [msglist] This shall be the equivalent of the `f command escape, except that all headers shall be included in the message, regardless of previous discard, ignore, and retain commands.

~h If standard input is a terminal, prompt for a Subject line and the To, Cc, and Bcc lists. Other implementation-defined headers may also be presented for editing. If the field is written with an initial value, it can be edited as if it had just been typed.

~i string Insert the value of the named variable, followed by a <newline>, into the text of the message. If the string is unset or null, the message shall not be changed.

~m [msglist] Insert the specified messages into the message, prefixing non-empty lines with the string in the indentprefix variable. This command escape also shall insert message headers into the message, with field selection affected by the discard, ignore, and retain commands.

~M [msglist] This shall be the equivalent of the `m command escape, except that all headers shall be included in the message, regardless of previous discard, ignore, and retain commands.

~p Write the message being entered. If the message is longer than crt lines (see Internal Variables in mailx (on page 593)), the output shall be paginated as described for the PAGER variable.

~q Quit (see the quit command) from input mode by simulating an interrupt. If the body of the message is not empty, the partial message shall be saved in the dead-letter file. See DEAD for a description of this file.

~r file, `< file, `r lcommand, `< !lcommand Read in the file specified by the pathname file. If the argument begins with an exclamation mark (` ! `), the rest of the string shall be taken as an arbitrary system command; the command interpreter specified by SHELL shall be invoked with two arguments: ~c and command. The standard output of command shall be inserted into the message.

~s string Set the subject line to string.

~t name... Add the given names to the To list.

~v Invoke the full-screen editor, as specified by the VISUAL environment variable, on the partial message.

~w file Write the partial message, without the header, onto the file named by the pathname file. The file shall be created or the message shall be appended to it if the file exists.
Exit as with `q`, except the message shall not be saved in the dead-letter file.

Pipe the body of the message through the given command by invoking the command interpreter specified by SHELL with two arguments: `-c` and `command`. If the `command` returns a successful exit status, the standard output of the command shall replace the message. Otherwise, the message shall remain unchanged. If the `command` fails, an error message giving the exit status shall be written.

EXIT STATUS
When the `-e` option is specified, the following exit values are returned:

- 0 Mail was found.
- >0 Mail was not found or an error occurred.

Otherwise, the following exit values are returned:

- 0 Successful completion; note that this status implies that all messages were sent, but it gives no assurances that any of them were actually delivered.
- >0 An error occurred.

CONSEQUENCES OF ERRORS
When in input mode (Receive Mode) or Send Mode:

- If an error is encountered processing a command escape (see Command Escapes in `mailx` (on page 604)), a diagnostic message shall be written to standard error, and the message being composed may be modified, but this condition shall not prevent the message from being sent.

- Other errors shall prevent the sending of the message.

When in command mode:

- Default.

APPLICATION USAGE
Delivery of messages to remote systems requires the existence of communication paths to such systems. These need not exist.

Input lines are limited to `{LINE_MAX}` bytes, but mailers between systems may impose more severe line-length restrictions. This volume of IEEE Std 1003.1-2001 does not place any restrictions on the length of messages handled by `mailx`, and for delivery of local messages the only limitations should be the normal problems of available disk space for the target mail file. When sending messages to external machines, applications are advised to limit messages to less than 100 000 bytes because some mail gateways impose message-length restrictions.

The format of the system mailbox is intentionally unspecified. Not all systems implement system mailboxes as flat files, particularly with the advent of multimedia mail messages. Some system mailboxes may be multiple files, others records in a database. The internal format of the messages themselves is specified with the historical format from Version 7, but only after the messages have been saved in some file other than the system mailbox. This was done so that many historical applications expecting text-file mailboxes are not broken.

Some new formats for messages can be expected in the future, probably including binary data, bit maps, and various multimedia objects. As described here, `mailx` is not prohibited from handling such messages, but it must store them as text files in secondary mailboxes (unless some extension, such as a variable or command line option, is used to change the stored format). Its method of doing so is implementation-defined and might include translating the data into...
The discard and ignore commands are not inverses of the retain command. The retain command discards all header-fields except those explicitly retained. The discard command keeps all header-fields except those explicitly discarded. If headers exist on the retained header list, discard and ignore commands are ignored.

**EXAMPLES**

None.

**RATIONALE**

The standard developers felt strongly that a method for applications to send messages to specific users was necessary. The obvious example is a batch utility, running non-interactively, that wishes to communicate errors or results to a user. However, the actual format, delivery mechanism, and method of reading the message are clearly beyond the scope of this volume of IEEE Std 1003.1-2001.

The intent of this command is to provide a simple, portable interface for sending messages non-interactively. It merely defines a "front-end" to the historical mail system. It is suggested that implementations explicitly denote the sender and recipient in the body of the delivered message. Further specification of formats for either the message envelope or the message itself were deliberately not made, as the industry is in the midst of changing from the current standards to a more internationalized standard and it is probably incorrect, at this time, to require either one.

Implementations are encouraged to conform to the various delivery mechanisms described in the CCITT X.400 standards or to the equivalent Internet standards, described in Internet Request for Comment (RFC) documents RFC 819, RFC 822, RFC 920, RFC 921, and RFC 1123.

Many historical systems modified each body line that started with From by prefixing the 'F' with '>'. It is unnecessary, but allowed, to do that when the string does not follow a blank line because it cannot be confused with the next header.

The edit and visual commands merely edit the specified messages in a temporary file. They do not modify the contents of those messages in the mailbox; such a capability could be added as an extension, such as by using different command names.

The restriction on a subject line being (LINE_MAX)−10 bytes is based on the historical format that consumes 10 bytes for Subject: and the trailing <newline>. Many historical mailers that a message may encounter on other systems are not able to handle lines that long, however.

Like the utilities logger and lp, mailx admittedly is difficult to test. This was not deemed sufficient justification to exclude this utility from this volume of IEEE Std 1003.1-2001. It is also arguable that it is, in fact, testable, but that the tests themselves are not portable.

When mailx is being used by an application that wishes to receive the results as if none of the User Portability Utilities option features were supported, the DEAD environment variable must be set to /dev/null. Otherwise, it may be subject to the file creations described in mailx ASYNCHRONOUS EVENTS. Similarly, if the MAILRC environment variable is not set to /dev/null, historical versions of mailx and Mail read initialization commands from a file before processing begins. Since the initialization that a user specifies could alter the contents of messages an application is trying to send, such applications must set MAILRC to /dev/null.

The description of LC_TIME uses “may affect” because many historical implementations do not or cannot manipulate the date and time strings in the incoming mail headers. Some headers found in incoming mail do not have enough information to determine the timezone in which the mail originated, and, therefore, mailx cannot convert the date and time strings into the internal form that then is parsed by routines like strftime() that can take LC_TIME settings into account.
Changing all these times to a user-specified format is allowed, but not required.

Theaginator selected when PAGER is null or unset is partially unspecified to allow the System V historical practice of using pg as the default. Bypassing the pagination function, such as by declaring that cat is the paginator, would not meet with the intended meaning of this description. However, any ‘portable user’ would have to set PAGER explicitly to get his or her preferred paginator on all systems. The paginator choice was made partially unspecified, unlike the VISUAL editor choice (mandated to be vi) because most historical pagers follow a common theme of user input, whereas editors differ dramatically.

Options to specify addresses as cc (carbon copy) or bcc (blind carbon copy) were considered to be format details and were omitted.

A zero exit status implies that all messages were sent, but it gives no assurances that any of them were actually delivered. The reliability of the delivery mechanism is unspecified and is an appropriate marketing distinction between systems.

In order to conform to the Utility Syntax Guidelines, a solution was required to the optional file option-argument to -f. By making file an operand, the guidelines are satisfied and users remain portable. However, it does force implementations to support usage such as:

```
mailx −fin mymail.box
```

The no name method of unsetting variables is not present in all historical systems, but it is in System V and provides a logical set of commands corresponding to the format of the display of options from the mailx set command without arguments.

The ask and asksub variables are the names selected by BSD and System V, respectively, for the same feature. They are synonyms in this volume of IEEE Std 1003.1-2001.

The mailx echo command was not documented in the BSD version and has been omitted here because it is not obviously useful for interactive users.

The default prompt on the System V mailx is a question mark, on BSD Mail an ampersand. Since this volume of IEEE Std 1003.1-2001 chose the mailx name, it kept the System V default, assuming that BSD users would not have difficulty with this minor incompatibility (that they can override).

The meanings of r and R are reversed between System V mailx and SunOS Mail. Once again, since this volume of IEEE Std 1003.1-2001 chose the mailx name, it kept the System V default, but allows the SunOS user to achieve the desired results using flipr, an internal variable in System V mailx, although it has not been documented in the SVID.

The indentprefix variable, the retain and unalias commands, and the ‘F and ‘M command escapes were adopted from 4.3 BSD Mail.

The version command was not included because no sufficiently general specification of the version information could be devised that would still be useful to a portable user. This command name should be used by suppliers who wish to provide version information about the mailx command.

The “‘implementation-specific (unspecified) system start-up file’” historically has been named /etc/mailx.rc, but this specific name and location are not required.

The intent of the wording for the next command is that if any command has already displayed the current message it should display a following message, but, otherwise, it should display the current message. Consider the command sequence:

```
next 3
delete 3
```
next

where the **autoprint** option was not set. The normative text specifies that the second **next** command should display a message following the third message, because even though the current message has not been displayed since it was set by the **delete** command, it has been displayed since the current message was anything other than message number 3. This does not always match historical practice in some implementations, where the command file address followed by **next** (or the default command) would skip the message for which the user had searched.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 2 (on page 29), **ed**, **ls**, **more**, **vi**

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

The description of the **EDITOR** environment variable is changed to indicate that **ed** is the default editor if this variable is not set. In previous issues, this default was not stated explicitly at this point but was implied further down in the text.

The **FUTURE DIRECTIONS** section is added.

**Issue 6**

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The **−F** option is added.
- The **allnet**, **debug**, and **sendwait** internal variables are added.
- The **C**, **ec**, **fo**, **F** and **S** **mailx** commands are added.

In the **DESCRIPTION** and **ENVIRONMENT VARIABLES** sections, text stating “**HOME directory**” is replaced by “directory referred to by the **HOME** environment variable”.

The **mailx** utility is aligned with the IEEE P1003.2b draft standard, which includes various clarifications to resolve IEEE PASC Interpretations submitted for the ISO POSIX-2:1993 standard. In particular, the changes here address IEEE PASC Interpretations 1003.2 #10, #11, #103, #106, #108, #114, #115, #122, and #129.

The normative text is reworded to avoid use of the term “must” for application requirements.

The **TZ** entry is added to the **ENVIRONMENT VARIABLES** section.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/32 is applied, applying a change to the **EXTENDED DESCRIPTION**, raised by IEEE PASC Interpretation 1003.2 #122, which was overlooked in the first version of IEEE Std 1003.1-2001.
NAME  
make — maintain, update, and regenerate groups of programs (DEVELOPMENT)

SYNOPSIS  
make [-einpqrst] [-f makefile]...[ -k ] [ -S ] [ macro=value ]...  
[ target_name... ]

DESCRIPTION  
The make utility shall update files that are derived from other files. A typical case is one where  
object files are derived from the corresponding source files. The make utility examines time  
relationships and shall update those derived files (called targets) that have modified times  
earlier than the modified times of the files (called prerequisites) from which they are derived. A  
description file (makefile) contains a description of the relationships between files, and the  
commands that need to be executed to update the targets to reflect changes in their  
prerequisites. Each specification, or rule, shall consist of a target, optional prerequisites, and  
onoptional commands to be executed when a prerequisite is newer than the target. There are two  
types of rule:

1. Inference rules, which have one target name with at least one period (’.’) and no slash  
 (’/’) 

2. Target rules, which can have more than one target name

In addition, make shall have a collection of built-in macros and inference rules that infer  
prerequisite relationships to simplify maintenance of programs.

To receive exactly the behavior described in this section, the user shall ensure that a portable  
makefile shall:

• Include the special target .POSIX

• Omit any special target reserved for implementations (a leading period followed by  
  uppercase letters) that has not been specified by this section

The behavior of make is unspecified if either or both of these conditions are not met.

OPTIONS  
The make utility shall conform to the Base Definitions Volume of IEEE Std 1003.1-2001, Section  

The following options shall be supported:

-e  Cause environment variables, including those with null values, to override macro  
    assignments within makefiles.

-f makefile  Specify a different makefile. The argument makefile is a pathname of a description  
    file, which is also referred to as the makefile. A pathname of ’-’ shall denote the  
    standard input. There can be multiple instances of this option, and they shall be  
    processed in the order specified. The effect of specifying the same option-  
    argument more than once is unspecified.

-i  Ignore error codes returned by invoked commands. This mode is the same as if the  
    special target .IGNORE were specified without prerequisites.

-k  Continue to update other targets that do not depend on the current target if a non-  
    ignored error occurs while executing the commands to bring a target up-to-date.

-n  Write commands that would be executed on standard output, but do not execute  
    them. However, lines with a plus sign (’+’) prefix shall be executed. In this mode,
Utilities

23636 lines with an at sign (’@’) character prefix shall be written to standard output.

23637 -p Write to standard output the complete set of macro definitions and target
descriptions. The output format is unspecified.

23639 -q Return a zero exit value if the target file is up-to-date; otherwise, return an exit
value of 1. Targets shall not be updated if this option is specified. However, a
makefile command line (associated with the targets) with a plus sign (’+’) prefix
shall be executed.

23643 -r Clear the suffix list and do not use the built-in rules.

23644 -S Terminate make if an error occurs while executing the commands to bring a target
up-to-date. This shall be the default and the opposite of -k.

23646 -s Do not write makefile command lines or touch messages (see -t) to standard
output before executing. This mode shall be the same as if the special target
.SILENT were specified without prerequisites.

23649 -t Update the modification time of each target as though a touch target had been
executed. Targets that have prerequisites but no commands (see Target Rules (on
page 614)), or that are already up-to-date, shall not be touched in this manner.
Write messages to standard output for each target file indicating the name of the
file and that it was touched. Normally, the makefile command lines associated with
each target are not executed. However, a command line with a plus sign (’+’) prefix
shall be executed.

23655 Any options specified in the MAKEFLAGS environment variable shall be evaluated before any
options specified on the make utility command line. If the -k and -S options are both specified
on the make utility command line or by the MAKEFLAGS environment variable, the last option
specified shall take precedence. If the -f or -p options appear in the MAKEFLAGS environment
variable, the result is undefined.

OPERANDS

The following operands shall be supported:

target_name Target names, as defined in the EXTENDED DESCRIPTION section. If no target is
specified, while make is processing the makefiles, the first target that make
encounters that is not a special target or an inference rule shall be used.

macro=value Macro definitions, as defined in Macros (on page 616).

23669 -t Update the modification time of each target as though a touch target had been
executed. Targets that have prerequisites but no commands (see Target Rules (on
page 614)), or that are already up-to-date, shall not be touched in this manner.
Write messages to standard output for each target file indicating the name of the
file and that it was touched. Normally, the makefile command lines associated with
each target are not executed. However, a command line with a plus sign (’+’) prefix
shall be executed.

Any options specified in the MAKEFLAGS environment variable shall be evaluated before any
options specified on the make utility command line. If the -k and -S options are both specified
on the make utility command line or by the MAKEFLAGS environment variable, the last option
specified shall take precedence. If the -f or -p options appear in the MAKEFLAGS environment
variable, the result is undefined.

OPERANDS

The following operands shall be supported:

target_name Target names, as defined in the EXTENDED DESCRIPTION section. If no target is
specified, while make is processing the makefiles, the first target that make
encounters that is not a special target or an inference rule shall be used.

23666 macro=value Macro definitions, as defined in Macros (on page 616).

If the target_name and macro=value operands are intermixed on the make utility command line,
the results are unspecified.

STDIN

The standard input shall be used only if the makefile option-argument is ’-’. See the INPUT
FILES section.

INPUT FILES

The input file, otherwise known as the makefile, is a text file containing rules, macro definitions,
and comments. See the EXTENDED DESCRIPTION section.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of make:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)
If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE**

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

**LC_MESSAGES**

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**MAKEFLAGS**

This variable shall be interpreted as a character string representing a series of option characters to be used as the default options. The implementation shall accept both of the following formats (but need not accept them when intermixed):

- The characters are option letters without the leading hyphens or <blank> separation used on a *make* utility command line.

- The characters are formatted in a manner similar to a portion of the *make* utility command line: options are preceded by hyphens and <blank>-separated as described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines. The *macro=value* macro definition operands can also be included. The difference between the contents of **MAKEFLAGS** and the *make* utility command line is that the contents of the variable shall not be subjected to the word expansions (see Section 2.6 (on page 36)) associated with parsing the command line values.

**NLSPATH**

Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**PROJECTDIR**

Provide a directory to be used to search for SCCS files not found in the current directory. In all of the following cases, the search for SCCS files is made in the directory **SCCS** in the identified directory. If the value of **PROJECTDIR** begins with a slash, it shall be considered an absolute pathname; otherwise, the value of **PROJECTDIR** is treated as a user name and that user’s initial working directory shall be examined for a subdirectory **src** or **source**. If such a directory is found, it shall be used. Otherwise, the value is used as a relative pathname.

If **PROJECTDIR** is not set or has a null value, the search for SCCS files shall be made in the directory **SCCS** in the current directory.

The setting of **PROJECTDIR** affects all files listed in the remainder of this utility description for files with a component named **SCCS**.

The value of the **SHELL** environment variable shall not be used as a macro and shall not be modified by defining the **SHELL** macro in a makefile or on the command line. All other environment variables, including those with null values, shall be used as macros, as defined in Macros (on page 616).

**ASYNCHRONOUS EVENTS**

If not already ignored, *make* shall trap SIGHUP, SIGTERM, SIGINT, and SIGQUIT and remove the current target unless the target is a directory or the target is a prerequisite of the special target **.PRECIOUS** or unless one of the −n, −p, or −q options was specified. Any targets removed in this manner shall be reported in diagnostic messages of unspecified format, written to standard error. After this cleanup process, if any, *make* shall take the standard action for all other signals.
The `make` utility shall write all commands to be executed to standard output unless the `−s` option was specified, the command is prefixed with an at sign, or the special target `.SILENT` has either the current target as a prerequisite or has no prerequisites. If `make` is invoked without any work needing to be done, it shall write a message to standard output indicating that no action was taken. If the `−t` option is present and a file is touched, `make` shall write to standard output a message of unspecified format indicating that the file was touched, including the filename of the file.

The standard error shall be used only for diagnostic messages.

Files can be created when the `−t` option is present. Additional files can also be created by the utilities invoked by `make`.

The `make` utility attempts to perform the actions required to ensure that the specified targets are up-to-date. A target is considered out-of-date if it is older than any of its prerequisites or if it does not exist. The `make` utility shall treat all prerequisites as targets themselves and recursively ensure that they are up-to-date, processing them in the order in which they appear in the rule. The `make` utility shall use the modification times of files to determine whether the corresponding targets are out-of-date.

After `make` has ensured that all of the prerequisites of a target are up-to-date and if the target is out-of-date, the commands associated with the target entry shall be executed. If there are no commands listed for the target, the target shall be treated as up-to-date.

A makefile can contain rules, macro definitions (see Macros (on page 616)), and comments. There are two kinds of rules: inference rules and target rules. The `make` utility shall contain a set of built-in inference rules. If the `−r` option is present, the built-in rules shall not be used and the suffix list shall be cleared. Additional rules of both types can be specified in a makefile. If a rule is defined more than once, the value of the rule shall be that of the last one specified. Macros can also be defined more than once, and the value of the macro is specified in Macros (on page 616). Comments start with a number sign (`#`) and continue until an unescaped `<newline>` is reached.

By default, the following files shall be tried in sequence: `/makefile` and `/Makefile`. If neither `/makefile` or `/Makefile` are found, other implementation-defined files may also be tried. On XSI-conformant systems, the additional files `/s.makefile`, `/SCCS/s.makefile`, `/s.Makefile`, and `/SCCS/s.Makefile` shall also be tried.

The `−f` option shall direct `make` to ignore any of these default files and use the specified argument as a makefile instead. If the `‘−’` argument is specified, standard input shall be used.

The term `makefile` is used to refer to any rules provided by the user, whether in `/makefile` or its variants, or specified by the `−f` option.

The rules in makefiles shall consist of the following types of lines: target rules, including special targets (see Target Rules (on page 614)), inference rules (see Inference Rules (on page 617)), macro definitions (see Macros (on page 616)), empty lines, and comments.

When an escaped `<newline>` (one preceded by a backslash) is found anywhere in the makefile except in a command line, it shall be replaced, along with any leading white space on the following line, with a single `<space>`. When an escaped `<newline>` is found in a command line
in a makefile, the command line shall contain the backslash, the <newline>, and the next line, except that the first character of the next line shall not be included if it is a <tab>.

**Makefile Execution**

Makefile command lines shall be processed one at a time by writing the makefile command line to the standard output (unless one of the conditions listed under '@' suppresses the writing) and executing the command(s) in the line. A <tab> may precede the command to standard output. Command execution shall be as if the makefile command line were the argument to the `system()` function. The environment for the command being executed shall contain all of the variables in the environment of `make`.

By default, when `make` receives a non-zero status from the execution of a command, it shall terminate with an error message to standard error.

Makefile command lines can have one or more of the following prefixes: a hyphen ('-'), an at sign ('@'), or a plus sign ('+'). These shall modify the way in which `make` processes the command. When a command is written to standard output, the prefix shall not be included in the output.

- If the command prefix contains a hyphen, or the –i option is present, or the special target `.IGNORE` has either the current target as a prerequisite or has no prerequisites, any error found while executing the command shall be ignored.
- @ If the command prefix contains an at sign and the `make` utility command line –n option is not specified, or the –s option is present, or the special target `.SILENT` has either the current target as a prerequisite or has no prerequisites, the command shall not be written to standard output before it is executed.
- + If the command prefix contains a plus sign, this indicates a makefile command line that shall be executed even if –n, –q, or –t is specified.

**Target Rules**

Target rules are formatted as follows:

```
target [target...] : [prerequisite...] [ ; command]
	[
		<tab>command
	]
	<tab>command
	...
```

*line that does not begin with <tab>*

Target entries are specified by a <blank>-separated, non-null list of targets, then a colon, then a <blank>-separated, possibly empty list of prerequisites. Text following a semicolon, if any, and all following lines that begin with a <tab>, are makefile command lines to be executed to update the target. The first non-empty line that does not begin with a <tab> or ‘#’ shall begin a new entry. An empty or blank line, or a line beginning with ‘#’, may begin a new entry.

Applications shall select target names from the set of characters consisting solely of periods, underscores, digits, and alphabetics from the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set). Implementations may allow other characters in target names as extensions. The interpretation of targets containing the characters ‘%’ and ‘”’ is implementation-defined.

A target that has prerequisites, but does not have any commands, can be used to add to the prerequisite list for that target. Only one target rule for any given target can contain commands.
Lines that begin with one of the following are called special targets and control the operation of `make`:

**.DEFAULT**
If the makefile uses this special target, the application shall ensure that it is specified with commands, but without prerequisites. The commands shall be used by `make` if there are no other rules available to build a target.

**.IGNORE**
Prerequisites of this special target are targets themselves; this shall cause errors from commands associated with them to be ignored in the same manner as specified by the `-i` option. Subsequent occurrences of `.IGNORE` shall add to the list of targets ignoring command errors. If no prerequisites are specified, `make` shall behave as if the `-i` option had been specified and errors from all commands associated with all targets shall be ignored.

**.POSIX**
The application shall ensure that this special target is specified without prerequisites or commands. If it appears as the first non-comment line in the makefile, `make` shall process the makefile as specified by this section; otherwise, the behavior of `make` is unspecified.

**.PRECIOUS**
Prerequisites of this special target shall not be removed if `make` receives one of the asynchronous events explicitly described in the ASYNCHRONOUS EVENTS section. Subsequent occurrences of `.PRECIOUS` shall add to the list of precious files. If no prerequisites are specified, all targets in the makefile shall be treated as if specified with `.PRECIOUS`.

**.SILENT**
Prerequisites of this special target are targets themselves; this shall cause commands associated with them not to be written to the standard output before they are executed. Subsequent occurrences of `.SILENT` shall add to the list of targets with silent commands. If no prerequisites are specified, `make` shall behave as if the `-s` option had been specified and no commands or touch messages associated with any target shall be written to standard output.

**.SUFFIXES**
Prerequisites of `.SUFFIXES` shall be appended to the list of known suffixes and are used in conjunction with the inference rules (see *Inference Rules* (on page 617)). If `.SUFFIXES` does not have any prerequisites, the list of known suffixes shall be cleared.

The special targets `.IGNORE`, `.POSIX`, `.PRECIOUS`, `.SILENT`, and `.SUFFIXES` shall be specified without commands.
Targets with names consisting of a leading period followed by the uppercase letters "POSIX" and then any other characters are reserved for future standardization. Targets with names consisting of a leading period followed by one or more uppercase letters are reserved for implementation extensions.

**Macros**

Macro definitions are in the form:

\[ string1 = \{\text{string2}\} \]

The macro named \textit{string1} is defined as having the value of \textit{string2}, where \textit{string2} is defined as all characters, if any, after the equal sign, up to a comment character (\#) or an unescaped <newline>. Any <blank>s immediately before or after the equal sign shall be ignored.

Applications shall select macro names from the set of characters consisting solely of periods, underscores, digits, and alphabetics from the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set). A macro name shall not contain an equals sign. Implementations may allow other characters in macro names as extensions.

Macros can appear anywhere in the makefile. Macro expansions using the forms $(string1)$ or $\{string1\}$ shall be replaced by \textit{string2}, as follows:

- Macros in target lines shall be evaluated when the target line is read.
- Macros in makefile command lines shall be evaluated when the command is executed.
- Macros in the string before the equals sign in a macro definition shall be evaluated when the macro assignment is made.
- Macros after the equals sign in a macro definition shall not be evaluated until the defined macro is used in a rule or command, or before the equals sign in a macro definition.

The parentheses or braces are optional if \textit{string1} is a single character. The macro $$ shall be replaced by the single character '$'. If \textit{string1} in a macro expansion contains a macro expansion, the results are unspecified.

Macro expansions using the forms $(string1[subst1=[subst2]])$ or $\{string1[subst1=[subst2]]\}$ can be used to replace all occurrences of \textit{subst1} with \textit{subst2} when the macro substitution is performed. The \textit{subst1} to be replaced shall be recognized when it is a suffix at the end of a word in \textit{string1} (where a word, in this context, is defined to be a string delimited by the beginning of the line, a <blank>, or a <newline>). If \textit{string1} in a macro expansion contains a macro expansion, the results are unspecified.

Macro expansions in \textit{string1} of macro definition lines shall be evaluated when read. Macro expansions in \textit{string2} of macro definition lines shall be performed when the macro identified by \textit{string1} is expanded in a rule or command.

Macro definitions shall be taken from the following sources, in the following logical order, before the makefile(s) are read:

1. Macros specified on the \textit{make} utility command line, in the order specified on the command line. It is unspecified whether the internal macros defined in \textbf{Internal Macros} (on page 619) are accepted from this source.

2. Macros defined by the \textit{MAKEFLAGS} environment variable, in the order specified in the environment variable. It is unspecified whether the internal macros defined in \textbf{Internal Macros} (on page 619) are accepted from this source.
3. The contents of the environment, excluding the `MAKEFLAGS` and `SHELL` variables and including the variables with null values.

4. Macros defined in the inference rules built into `make`.

Macro definitions from these sources shall not override macro definitions from a lower-numbered source. Macro definitions from a single source (for example, the `make` utility command line, the `MAKEFLAGS` environment variable, or the other environment variables) shall override previous macro definitions from the same source.

Macros defined in the makefile(s) shall override macro definitions that occur before them in the makefile(s) and macro definitions from source 4. If the `-e` option is not specified, macros defined in the makefile(s) shall override macro definitions from source 3. Macros defined in the makefile(s) shall not override macro definitions from source 1 or source 2.

Before the makefile(s) are read, all of the `make` utility command line options (except `-f` and `-p`) and `make` utility command line macro definitions (except any for the `MAKEFLAGS` macro), not already included in the `MAKEFLAGS` macro, shall be added to the `MAKEFLAGS` macro, quoted in an implementation-defined manner such that when `MAKEFLAGS` is read by another instance of the `make` command, the original macro's value is recovered. Other implementation-defined options and macros may also be added to the `MAKEFLAGS` macro. If this modifies the value of the `MAKEFLAGS` macro, or, if the `MAKEFLAGS` macro is modified at any subsequent time, the `MAKEFLAGS` environment variable shall be modified to match the new value of the `MAKEFLAGS` macro. The result of setting `MAKEFLAGS` in the Makefile is unspecified.

Before the makefile(s) are read, all of the `make` utility command line macro definitions (except the `MAKEFLAGS` macro or the `SHELL` macro) shall be added to the environment of `make`. Other implementation-defined variables may also be added to the environment of `make`.

The `SHELL` macro shall be treated specially. It shall be provided by `make` and set to the pathname of the shell command language interpreter (see `sh`). The `SHELL` environment variable shall not affect the value of the `SHELL` macro. If `SHELL` is defined in the makefile or is specified on the command line, it shall replace the original value of the `SHELL` macro, but shall not affect the `SHELL` environment variable. Other effects of defining `SHELL` in the makefile or on the command line are implementation-defined.

### Inference Rules

Inference rules are formatted as follows:

```
target:
  <tab>command
  [<tab>command]
  ...
```

`line that does not begin with <tab> or #`

The application shall ensure that the `target` portion is a valid target name (see `Target Rules` (on page 614)) of the form `.s2` or `.s1.s2` (where `.s1` and `.s2` are suffixes that have been given as prerequisites of the `.SUFFIXES` special target and `s1` and `s2` do not contain any slashes or periods.) If there is only one period in the target, it is a single-suffix inference rule. Targets with two periods are double-suffix inference rules. Inference rules can have only one target before the colon.

The application shall ensure that the makefile does not specify prerequisites for inference rules; no characters other than white space shall follow the colon in the first line, except when creating the `empty rule`, described below. Prerequisites are inferred, as described below.
Inference rules can be redefined. A target that matches an existing inference rule shall overwrite the old inference rule. An empty rule can be created with a command consisting of simply a semicolon (that is, the rule still exists and is found during inference rule search, but since it is empty, execution has no effect). The empty rule can also be formatted as follows:

rule: ;

where zero or more <blank> s separate the colon and semicolon.

The make utility uses the suffixes of targets and their prerequisites to infer how a target can be made up-to-date. A list of inference rules defines the commands to be executed. By default, make contains a built-in set of inference rules. Additional rules can be specified in the makefile.

The special target .SUFFIXES contains as its prerequisites a list of suffixes that shall be used by the inference rules. The order in which the suffixes are specified defines the order in which the inference rules for the suffixes are used. New suffixes shall be appended to the current list by specifying a .SUFFIXES special target in the makefile. A .SUFFIXES target with no prerequisites shall clear the list of suffixes. An empty .SUFFIXES target followed by a new .SUFFIXES list is required to change the order of the suffixes.

Normally, the user would provide an inference rule for each suffix. The inference rule to update a target with a suffix .s1 from a prerequisite with a suffix .s2 is specified as a target .s2.s1. The internal macros provide the means to specify general inference rules (see Internal Macros (on page 619)).

When no target rule is found to update a target, the inference rules shall be checked. The suffix of the target (.s1) to be built is compared to the list of suffixes specified by the .SUFFIXES special targets. If the .s1 suffix is found in .SUFFIXES, the inference rules shall be searched in the order defined for the first .s2.s1 rule whose prerequisite file ($*.s2) exists. If the target is out-of-date with respect to this prerequisite, the commands for that inference rule shall be executed.

If the target to be built does not contain a suffix and there is no rule for the target, the single suffix inference rules shall be checked. The single-suffix inference rules define how to build a target if a file is found with a name that matches the target name with one of the single suffixes appended. A rule with one suffix .s2 is the definition of how to build target from target.s2. The other suffix (.s1) is treated as null.

A tilde (`˜') in the above rules refers to an SCCS file in the current directory. Thus, the rule .c.˜.o would transform an SCCS C-language source file into an object file (.o). Because the .s. of the SCCS files is a prefix, it is incompatible with make's suffix point of view. Hence, the `˜' is a way of changing any file reference into an SCCS file reference.

Libraries

If a target or prerequisite contains parentheses, it shall be treated as a member of an archive library. For the lib(member.o) expression lib refers to the name of the archive library and member.o to the member name. The application shall ensure that the member is an object file with the .o suffix. The modification time of the expression is the modification time for the member as kept in the archive library; see ar. The .a suffix shall refer to an archive library. The .s2.a rule shall be used to update a member in the library from a file with a suffix .s2.
Internal Macros

The *make* utility shall maintain five internal macros that can be used in target and inference rules. In order to clearly define the meaning of these macros, some clarification of the terms *target rule*, *inference rule*, *target*, and *prerequisite* is necessary.

Target rules are specified by the user in a makefile for a particular target. Inference rules are user-specified or *make*-specified rules for a particular class of target name. Explicit prerequisites are those prerequisites specified in a makefile on target lines. Implicit prerequisites are those prerequisites that are generated when inference rules are used. Inference rules are applied to implicit prerequisites or to explicit prerequisites that do not have target rules defined for them in the makefile. Target rules are applied to targets specified in the makefile.

Before any target in the makefile is updated, each of its prerequisites (both explicit and implicit) shall be updated. This shall be accomplished by recursively processing each prerequisite. Upon recursion, each prerequisite shall become a target itself. Its prerequisites in turn shall be processed recursively until a target is found that has no prerequisites, at which point the recursion stops. The recursion shall then back up, updating each target as it goes.

In the definitions that follow, the word *target* refers to one of:

- A target specified in the makefile
- An explicit prerequisite specified in the makefile that becomes the target when *make* processes it during recursion
- An implicit prerequisite that becomes a target when *make* processes it during recursion

In the definitions that follow, the word *prerequisite* refers to one of the following:

- An explicit prerequisite specified in the makefile for a particular target
- An implicit prerequisite generated as a result of locating an appropriate inference rule and corresponding file that matches the suffix of the target

The five internal macros are:

$@

The $@ shall evaluate to the full target name of the current target, or the archive filename part of a library archive target. It shall be evaluated for both target and inference rules.

For example, in the .c.a inference rule, $@ represents the out-of-date .a file to be built. Similarly, in a makefile target rule to build *lib.a* from *file.c*, $@ represents the out-of-date *lib.a*.

$%

The $% macro shall be evaluated only when the current target is an archive library member of the form *libname*(member.o). In these cases, $@ shall evaluate to *libname* and $% shall evaluate to *member.o*. The $% macro shall be evaluated for both target and inference rules.

For example, in a makefile target rule to build *lib.a*(file.o), $% represents *file.o*, as opposed to $@, which represents *lib.a*.

$?

The $? macro shall evaluate to the list of prerequisites that are newer than the current target. It shall be evaluated for both target and inference rules.

For example, in a makefile target rule to build *prog* from *file1.o*, *file2.o*, and *file3.o*, where *prog* is not out-of-date with respect to *file1.o*, but is out-of-date with respect to *file2.o* and *file3.o*, $? represents *file2.o* and *file3.o*. 
In an inference rule, the $< macro shall evaluate to the filename whose existence allowed the inference rule to be chosen for the target. In the .DEFAULT rule, the $< macro shall evaluate to the current target name. The meaning of the $< macro shall be otherwise unspecified.

For example, in the .c.a inference rule, $< represents the prerequisite .c file.

The $* macro shall evaluate to the current target name with its suffix deleted. It shall be evaluated at least for inference rules.

For example, in the .c.a inference rule, $*.o represents the out-of-date .o file that corresponds to the prerequisite .c file.

Each of the internal macros has an alternative form. When an uppercase 'D' or 'F' is appended to any of the macros, the meaning shall be changed to the directory part for 'D' and filename part for 'F'. The directory part is the path prefix of the file without a trailing slash; for the current directory, the directory part is '._'. When the $? macro contains more than one prerequisite filename, the $(?D) and $(?F) (or ${?D} and ${?F}) macros expand to a list of directory name parts and filename parts respectively.

For the target lib(member.s.o) and the s2.a rule, the internal macros shall be defined as:

$< member.s2
$* member
$@ lib
$? member.s2
$% member.o

Default Rules

The default rules for make shall achieve results that are the same as if the following were used. Implementations that do not support the C-Language Development Utilities option may omit CC, CFLAGS, YACC, YFLAGS, LEX, LFLAGS, LDFLAGS, and the .c, .y, and .l inference rules. Implementations that do not support FORTRAN may omit FC, FFLAGS, and the .f inference rules. Implementations may provide additional macros and rules.

SPECIAL TARGETS

.SCCS_GET: sccs $(SCCSFLAGS) get $(SCCSGETFLAGS) $@

.SUFFIXES: .o .c .y .l .a .sh .f .c~ .y~ .l~ .sh~ .f~

MACROS

MAKE=make
AR=ar
ARFLAGS=-rv
YACC=yacc
YFLAGS=
LEX=lex
LFLAGS=
LDFLAGS=
CC=c99
CFLAGS=-O
FC=fort77
SINGLE SUFFIX RULES

.c:
$ (CC) $(CFLAGS) $(LDFLAGS) -o $@ $<

.f:
$ (FC) $(FFLAGS) $(LDFLAGS) -o $@ $<

.sh:
   cp $< $@
   chmod a+x $@

.c~:
$ (GET) $(GFLAGS) -p $< > $*.c
$ (CC) $(CFLAGS) $(LDFLAGS) -o $@ $*.c

.f~:
$ (GET) $(GFLAGS) -p $< > $*.f
$ (FC) $(FFLAGS) $(LDFLAGS) -o $@ $*.f

.sh~:
$ (GET) $(GFLAGS) -p $< > $*.sh
   cp $*.sh $@
   chmod a+x $@

DOUBLE SUFFIX RULES

.c.o:
$ (CC) $(CFLAGS) -c $<

.f.o:
$ (FC) $(FFLAGS) -c $<

.y.o:
$ (YACC) $(YFLAGS) $<
$ (CC) $(CFLAGS) -c y.tab.c
   rm -f y.tab.c
   mv y.tab.o $@

.l.o:
$ (LEX) $(LFLAGS) $<
$ (CC) $(CFLAGS) -c lex.yy.c
   rm -f lex.yy.c
   mv lex.yy.o $@

.y.c:
$ (YACC) $(YFLAGS) $<
   mv y.tab.c $@

.l.c:
$ (LEX) $(LFLAGS) $<
mv lex.yy.c @$

.c-o:
$(GET) $(GFLAGS) -p $< &gt; $*.c
$(CC) $(CFLAGS) -c $*.c

.f-o:
$(GET) $(GFLAGS) -p $< &gt; $*.f
$(FC) $(FFLAGS) -c $*.f

.y-o:
$(GET) $(GFLAGS) -p $< &gt; $*.y
$(YACC) $(YFLAGS) $*.y
$(CC) $(CFLAGS) -c y.tab.c
rm -f y.tab.c
mv y.tab.o @$

.l-o:
$(GET) $(GFLAGS) -p $< &gt; $*.l
$(LEX) $(LFLAGS) $*.l
$(CC) $(CFLAGS) -c lex.yy.c
rm -f lex.yy.c
mv lex.yy.o @$

.y-c:
$(GET) $(GFLAGS) -p $< &gt; $*.y
$(YACC) $(YFLAGS) $*.y
mv y.tab.c @$

.l-c:
$(GET) $(GFLAGS) -p $< &gt; $*.l
$(LEX) $(LFLAGS) $*.l
mv lex.yy.c @$

.c.a:
$(CC) -c $(CFLAGS) $<
$(AR) $(ARFLAGS) @$ $*.o
rm -f $*.o

.f.a:
$(FC) -c $(FFLAGS) $<
$(AR) $(ARFLAGS) @$ $*.o
rm -f $*.o

EXIT STATUS
When the -q option is specified, the make utility shall exit with one of the following values:
0 Successful completion.
1 The target was not up-to-date.
&gt;1 An error occurred.

When the -q option is not specified, the make utility shall exit with one of the following values:
0 Successful completion.
&gt;0 An error occurred.
CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

If there is a source file (such as ./source.c) and there are two SCCS files corresponding to it (./.source.c and ./SCCS/.source.c), on XSI-conformant systems make uses the SCCS file in the current directory. However, users are advised to use the underlying SCCS utilities (admin, delta, get, and so on) or the sccs utility for all source files in a given directory. If both forms are used for a given source file, future developers are very likely to be confused.

It is incumbent upon portable makefiles to specify the .POSIX special target in order to guarantee that they are not affected by local extensions.

The −k and −S options are both present so that the relationship between the command line, the MAKEFLAGS variable, and the makefile can be controlled precisely. If the k flag is passed in

MAKEFLAGS and a command is of the form:

$(MAKE) −S foo

then the default behavior is restored for the child make.

When the −n option is specified, it is always added to MAKEFLAGS. This allows a recursive make −n target to be used to see all of the action that would be taken to update target.

Because of widespread historical practice, interpreting a ‘#’ number sign inside a variable as the start of a comment has the unfortunate side effect of making it impossible to place a number sign in a variable, thus forbidding something like:

CFLAGS = "−D COMMENT_CHAR=‘#’"

Many historical make utilities stop chaining together inference rules when an intermediate target is nonexistent. For example, it might be possible for a make to determine that both .y.c and .c.o could be used to convert a .y to a .o. Instead, in this case, make requires the use of a .y.o rule.

The best way to provide portable makefiles is to include all of the rules needed in the makefile itself. The rules provided use only features provided by other parts of this volume of IEEE Std 1003.1-2001. The default rules include rules for optional commands in this volume of IEEE Std 1003.1-2001. Only rules pertaining to commands that are provided are needed in an implementation’s default set.

Macros used within other macros are evaluated when the new macro is used rather than when the new macro is defined. Therefore:

MACRO = value1
NEW = $(MACRO)
MACRO = value2

target:

   echo $(NEW)

would produce value2 and not value1 since NEW was not expanded until it was needed in the echo command line.

Some historical applications have been known to intermix target_name and macro=name operands on the command line, expecting that all of the macros are processed before any of the targets are dealt with. Conforming applications do not do this, although some backwards-compatibility support may be included in some implementations.

The following characters in filenames may give trouble: ‘=’, ‘:’, ‘ ’, ‘ ’, and ‘@’. For inference rules, the description of $< and $? seem similar. However, an example shows the
minor difference. In a makefile containing:

```
foo.o: foo.h
```

if `foo.h` is newer than `foo.o`, yet `foo.c` is older than `foo.o`, the built-in rule to make `foo.o` from
`foo.c` is used, with `$<$` equal to `foo.c` and ` $?` equal to `foo.h`. If `foo.c` is also newer than `foo.o`, `$<$` is
equal to `foo.c` and ` $?` is equal to `foo.h` `foo.c`.

### EXAMPLES

1. The following command:

   ```
   make
   ```

   makes the first target found in the makefile.

2. The following command:

   ```
   make junk
   ```

   makes the target `junk`.

3. The following makefile says that `pgm` depends on two files, `a.o` and `b.o`, and that they in
   turn depend on their corresponding source files (`a.c` and `b.c`), and a common file `incl.h`:

   ```
   pgm: a.o b.o
   c99 a.o b.o -o pgm
   a.o: incl.h a.c
   c99 -c a.c
   b.o: incl.h b.c
   c99 -c b.c
   ```

4. An example for making optimized `.o` files from `.c` files is:

   ```
   .c.o:
   c99 -c -O $*.c
   or:
   .c.o:
   c99 -c -O $<
   ```

5. The most common use of the archive interface follows. Here, it is assumed that the source
files are all C-language source:

   ```
   lib: lib(file1.o) lib(file2.o) lib(file3.o)
   @echo lib is now up-to-date
   ```

   The `.a` rule is used to make `file1.o`, `file2.o`, and `file3.o` and insert them into `lib`.

   The treatment of escaped `<newline>`s throughout the makefile is historical practice. For
   example, the inference rule:

   ```
   .c.o\
   ```

   works, and the macro:

   ```
   f= bar baz\
   biz
   a:
   echo ==$f==
   ```
echoes "==bar baz biz==".
If $? were:
/usr/include/stdio.h /usr/include/unistd.h foo.h
then $(?D) would be:
/usr/include /usr/include .
and $(?F) would be:
stdio.h unistd.h foo.h

6. The contents of the built-in rules can be viewed by running:
make −p −f /dev/null 2>/dev/null

RATIONALE
The make utility described in this volume of IEEE Std 1003.1-2001 is intended to provide the
means for changing portable source code into executables that can be run on an
IEEE Std 1003.1-2001-conforming system. It reflects the most common features present in
System V and BSD makes.

Historically, the make utility has been an especially fertile ground for vendor and research
organization-specific syntax modifications and extensions. Examples include:
• Syntax supporting parallel execution (such as from various multi-processor vendors, GNU,
and others)
• Additional “operators” separating targets and their prerequisites (System V, BSD, and
others)
• Specifying that command lines containing the strings "$\{MAKE\}" and "$(MAKE)" are
executed when the −n option is specified (GNU and System V)
• Modifications of the meaning of internal macros when referencing libraries (BSD and others)
• Using a single instance of the shell for all of the command lines of the target (BSD and others)
• Allowing spaces as well as tabs to delimit command lines (BSD)
• Adding C preprocessor-style “include” and “ifdef” constructs (System V, GNU, BSD, and
others)
• Remote execution of command lines (Sprite and others)
• Specifying additional special targets (BSD, System V, and most others)

Additionally, many vendors and research organizations have rethought the basic concepts of
make, creating vastly extended, as well as completely new, syntaxes. Each of these versions of
make fulfills the needs of a different community of users; it is unreasonable for this volume of
IEEE Std 1003.1-2001 to require behavior that would be incompatible (and probably inferior) to
historical practice for such a community.

In similar circumstances, when the industry has enough sufficiently incompatible formats as to
make them irreconcilable, this volume of IEEE Std 1003.1-2001 has followed one or both of two
courses of action. Commands have been renamed (cksum, echo, and pax) and/or command line
options have been provided to select the desired behavior (grep, od, and pax).

Because the syntax specified for the make utility is, by and large, a subset of the syntaxes
accepted by almost all versions of make, it was decided that it would be counter-productive to
change the name. And since the makefile itself is a basic unit of portability, it would not be
completely effective to reserve a new option letter, such as `make -P`, to achieve the portable behavior. Therefore, the special target `.POSIX` was added to the makefile, allowing users to specify “standard” behavior. This special target does not preclude extensions in the `make` utility, nor does it preclude such extensions being used by the makefile specifying the target; it does, however, preclude any extensions from being applied that could alter the behavior of previously valid syntax; such extensions must be controlled via command line options or new special targets. It is incumbent upon portable makefiles to specify the `.POSIX` special target in order to guarantee that they are not affected by local extensions.

The portable version of `make` described in this reference page is not intended to be the state-of-the-art software generation tool and, as such, some newer and more leading-edge features have not been included. An attempt has been made to describe the portable makefile in a manner that does not preclude such extensions as long as they do not disturb the portable behavior described here.

When the `–n` option is specified, it is always added to `MAKEFLAGS`. This allows a recursive `make –n target` to be used to see all of the action that would be taken to update `target`.

The definition of `MAKEFLAGS` allows both the System V letter string and the BSD command line formats. The two formats are sufficiently different to allow implementations to support both without ambiguity.

Early proposals stated that an “unquoted” number sign was treated as the start of a comment. The `make` utility does not pay any attention to quotes. A number sign starts a comment regardless of its surroundings.

The text about “other implementation-defined pathnames may also be tried” in addition to `.makefile` and `./Makefile` is to allow such extensions as `SCCS/s.Makefile` and other variations. It was made an implementation-defined requirement (as opposed to unspecified behavior) to highlight surprising implementations that might select something unexpected like `/etc/Makefile`. XSI-conformant systems also try `.s.makefile`, `SCCS/s.makefile`, `./s.Makefile`, and `SCCS/s.Makefile`.

Early proposals contained the macro `NPROC` as a means of specifying that `make` should use `n` processes to do the work required. While this feature is a valuable extension for many systems, it is not common usage and could require other non-trivial extensions to makefile syntax. This extension is not required by this volume of IEEE Std 1003.1-2001, but could be provided as a compatible extension. The macro `PARALLEL` is used by some historical systems with essentially the same meaning (but without using a name that is a common system limit value). It is suggested that implementors recognize the existing use of `NPROC` and/or `PARALLEL` as extensions to `make`.

The default rules are based on System V. The default `CC=` value is `c99` instead of `cc` because this volume of IEEE Std 1003.1-2001 does not standardize the utility named `cc`. Thus, every conforming application would be required to define `CC=c99` to expect to run. There is no advantage conferred by the hope that the makefile might hit the “preferred” compiler because this cannot be guaranteed to work. Also, since the portable makescript can only use the `c99` options, no advantage is conferred in terms of what the script can do. It is a quality-of-implementation issue as to whether `c99` is as valuable as `cc`.

The `–d` option to `make` is frequently used to produce debugging information, but is too implementation-defined to add to this volume of IEEE Std 1003.1-2001.

The `–p` option is not passed in `MAKEFLAGS` on most historical implementations and to change this would cause many implementations to break without sufficiently increased portability.
Commands that begin with a plus sign (‘+’) are executed even if the \( -n \) option is present. Based on the GNU version of `make`, the behavior of \( -n \) when the plus-sign prefix is encountered has been extended to apply to \( -q \) and \( -t \) as well. However, the System V convention of forcing command execution with \( -n \) when the command line of a target contains either of the strings \$\{MAKE\} or \$\{MAKE\} has not been adopted. This functionality appeared in early proposals, but the danger of this approach was pointed out with the following example of a portion of a makefile:

```
subdir:
  cd subdir; rm all_the_files; $(MAKE)
```

The loss of the System V behavior in this case is well-balanced by the safety afforded to other makefiles that were not aware of this situation. In any event, the command line plus-sign prefix can provide the desired functionality.

The double colon in the target rule format is supported in BSD systems to allow more than one target line containing the same target name to have commands associated with it. Since this is not functionality described in the SVID or XPG3 it has been allowed as an extension, but not mandated.

The default rules are provided with text specifying that the built-in rules shall be the same as if the listed set were used. The intent is that implementations should be able to use the rules without change, but will be allowed to alter them in ways that do not affect the primary behavior.

The best way to provide portable makefiles is to include all of the rules needed in the makefile itself. The rules provided use only features provided by other portions of this volume of IEEE Std 1003.1-2001. The default rules include rules for optional commands in this volume of IEEE Std 1003.1-2001. Only rules pertaining to commands that are provided are needed in the default set of an implementation.

One point of discussion was whether to drop the default rules list from this volume of IEEE Std 1003.1-2001. They provide convenience, but do not enhance portability of applications. The prime benefit is in portability of users who wish to type `make command` and have the command build from a `command.c` file.

The historical \texttt{MAKESHELL} feature was omitted. In some implementations it is used to let a user override the shell to be used to run `make` commands. This was confusing; for a portable `make`, the shell should be chosen by the makefile writer or specified on the `make` command line and not by a user running `make`.

The `make` utilities in most historical implementations process the prerequisites of a target in left-to-right order, and the makefile format requires this. It supports the standard idiom used in many makefiles that produce \texttt{yacc} programs; for example:

```
foo: y.tab.o lex.o main.o
    $(CC) $(CFLAGS) -o $@ t.tab.o lex.o main.o
```

In this example, if `make` chose any arbitrary order, the \texttt{lex.o} might not be made with the correct \texttt{y.tab.h}. Although there may be better ways to express this relationship, it is widely used historically. Implementations that desire to update prerequisites in parallel should require an explicit extension to `make` or the makefile format to accomplish it, as described previously.

The algorithm for determining a new entry for target rules is partially unspecified. Some historical `makes` allow blank, empty, or comment lines within the collection of commands marked by leading \texttt{<tab>}s. A conforming makefile must ensure that each command starts with a \texttt{<tab>}, but implementations are free to ignore blank, empty, and comment lines without triggering the start of a new entry.
The ASYNCHRONOUS EVENTS section includes having SIGTERM and SIGHUP, along with the more traditional SIGINT and SIGQUIT, remove the current target unless directed not to do so. SIGTERM and SIGHUP were added to parallel other utilities that have historically cleaned up their work as a result of these signals. When make receives any signal other than SIGQUIT, it is required to resend itself the signal it received so that it exits with a status that reflects the signal. The results from SIGQUIT are partially unspecified because, on systems that create core files upon receipt of SIGQUIT, the core from make would conflict with a core file from the command that was running when the SIGQUIT arrived. The main concern was to prevent damaged files from appearing up-to-date when make is rerun.

The .PRECIOUS special target was extended to affect all targets globally (by specifying no prerequisites). The .IGNORE and .SILENT special targets were extended to allow prerequisites; it was judged to be more useful in some cases to be able to turn off errors or echoing for a list of targets than for the entire makefile. These extensions to make in System V were made to match historical practice from the BSD make.

Macros are not exported to the environment of commands to be run. This was never the case in any historical make and would have serious consequences. The environment is the same as the environment to make except that MAKEFLAGS and macros defined on the make command line are added.

Some implementations do not use system() for all command lines, as required by the portable makefile format; as a performance enhancement, they select lines without shell metacharacters for direct execution by execve(). There is no requirement that system() be used specifically, but merely that the same results be achieved. The metacharacters typically used to bypass the direct execve() execution have been any of:

```
= | ^ ( ) ; & < > * ? [ ] : $ ' " \ n
```

The default in some advanced versions of make is to group all the command lines for a target and execute them using a single shell invocation; the System V method is to pass each line individually to a separate shell. The single-shell method has the advantages in performance and the lack of a requirement for many continued lines. However, converting to this newer method has caused portability problems with many historical makefiles, so the behavior with the POSIX makefile is specified to be the same as that of System V. It is suggested that the special target .ONESHELL be used as an implementation extension to achieve the single-shell grouping for a target or group of targets.

Novice users of make have had difficulty with the historical need to start commands with a <tab>. Since it is often difficult to discern differences between <tab>s and <space>s on terminals or printed listings, confusing bugs can arise. In early proposals, an attempt was made to correct this problem by allowing leading <blank>s instead of <tab>s. However, implementors reported many makefiles that failed in subtle ways following this change, and it is difficult to implement a make that unambiguously can differentiate between macro and command lines. There is extensive historical practice of allowing leading spaces before macro definitions. Forcing macro lines into column 1 would be a significant backwards-compatibility problem for some makefiles. Therefore, historical practice was restored.

The System V INCLUDE feature was considered, but not included. This would treat a line that began in the first column and contained INCLUDE <filename> as an indication to read <filename> at that point in the makefile. This is difficult to use in a portable way, and it raises concerns about nesting levels and diagnostics. System V, BSD, GNU, and others have used different methods for including files.

The System V dynamic dependency feature was not included. It would support:
Utilities

24430 \texttt{cat:} $\$$@.c
24431 
24432 that would expand to;
24433 \texttt{cat: cat.c}
24434 
24435 This feature exists only in the new version of System V \textit{make} and, while useful, is not in wide usage. This means that macros are expanded twice for prerequisites: once at makefile parse time and once at target update time.
24436 
24437 Consideration was given to adding metarules to the POSIX \textit{make}. This would make \texttt{%.o: %.c} the same as \texttt{.c.o:}. This is quite useful and available from some vendors, but it would cause too many changes to this \textit{make} to support. It would have introduced rule chaining and new substitution rules. However, the rules for target names have been set to reserve the \textquote{'}$\%$' and \textquote{'}'' characters. These are traditionally used to implement metarules and quoting of target names, respectively. Implementors are strongly encouraged to use these characters only for these purposes.
24438 
24439 A request was made to extend the suffix delimiter character from a period to any character. The metarules feature in newer \textit{makes} solves this problem in a more general way. This volume of IEEE Std 1003.1-2001 is staying with the more conservative historical definition.
24440 
24441 The standard output format for the \texttt{−p} option is not described because it is primarily a debugging option and because the format is not generally useful to programs. In historical implementations the output is not suitable for use in generating makefiles. The \texttt{−p} format has been variable across historical implementations. Therefore, the definition of \texttt{−p} was only to provide a consistently named option for obtaining \textit{make} script debugging information.
24443 
24444 Some historical implementations have not cleared the suffix list with \texttt{−r}.
24445 
24446 Implementations should be aware that some historical applications have intermixed \texttt{target\_name} and \texttt{macro=value} operands on the command line, expecting that all of the macros are processed before any of the targets are dealt with. Conforming applications do not do this, but some backwards-compatibility support may be warranted.
24448 
24449 Empty inference rules are specified with a semicolon command rather than omitting all commands, as described in an early proposal. The latter case has no traditional meaning and is reserved for implementation extensions, such as in GNU \textit{make}.
24451 
24452 FUTURE DIRECTIONS
24453 None.
24454 
24455 SEE ALSO
24457 
24458 CHANGE HISTORY
24459 First released in Issue 2.
24460 Issue 5
24461 The FUTURE DIRECTIONS section is added.
24462 Issue 6
24463 This utility is marked as part of the Software Development Utilities option.
24464 The Open Group Corrigendum U029/1 is applied, correcting a typographical error in the SPECIAL TARGETS section.
24467 In the ENVIRONMENT VARIABLES section, the \texttt{PROJECTDIR} description is updated from “otherwise, the home directory of a user of that name is examined” to “otherwise, the value of \texttt{PROJECTDIR} is treated as a user name and that user’s initial working directory is examined”.
24471

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It is specified whether the command line is related to the makefile or to the `make` command, and the macro processing rules are updated to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term "must" for application requirements.

PASC Interpretation 1003.2 #193 is applied.
NAME
man — display system documentation

SYNOPSIS
man [-k] name...

DESCRIPTION
The man utility shall write information about each of the name operands. If name is the name of a standard utility, man at a minimum shall write a message describing the syntax used by the standard utility, its options, and operands. If more information is available, the man utility shall provide it in an implementation-defined manner.

An implementation may provide information for values of name other than the standard utilities.
Standard utilities that are listed as optional and that are not supported by the implementation either shall cause a brief message indicating that fact to be displayed or shall cause a full display of information as described previously.

OPTIONS

The following option shall be supported:

-k Interpret name operands as keywords to be used in searching a utilities summary database that contains a brief purpose entry for each standard utility and write lines from the summary database that match any of the keywords. The keyword search shall produce results that are the equivalent of the output of the following command:

grep -Ei 'name
name
...'
summary-database

This assumes that the summary-database is a text file with a single entry per line; this organization is not required and the example using grep -Ei is merely illustrative of the type of search intended. The purpose entry to be included in the database shall consist of a terse description of the purpose of the utility.

OPERANDS
The following operand shall be supported:

name A keyword or the name of a standard utility. When -k is not specified and name does not represent one of the standard utilities, the results are unspecified.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of man:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and in the summary database). The value of LC_CTYPE need not affect the format of the information written about the name operands.

**LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

**PAGER** Determine an output filtering command for writing the output to a terminal. Any string acceptable as a command_string operand to the sh \( \text{−c} \) command shall be valid.

When standard output is a terminal device, the reference page output shall be piped through the command. If the PAGER variable is null or not set, the command shall be either more or another paginator utility documented in the system documentation.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT** The man utility shall write text describing the syntax of the utility name, its options and its operands, or, when \( \text{−k} \) is specified, lines from the summary database. The format of this text is implementation-defined.

**STDERR** The standard error shall be used only for diagnostic messages.

**APPLICATION USAGE**

None.

**EXAMPLES**

None.

**RATIONALE**

It is recognized that the man utility is only of minimal usefulness as specified. The opinion of the standard developers was strongly divided as to how much or how little information man should be required to provide. They considered, however, that the provision of some portable way of accessing documentation would aid user portability. The arguments against a fuller
specification were:

- Large quantities of documentation should not be required on a system that does not have excess disk space.
- The current manual system does not present information in a manner that greatly aids user portability.
- A “better help system” is currently an area in which vendors feel that they can add value to their POSIX implementations.

The –f option was considered, but due to implementation differences, it was not included in this volume of IEEE Std 1003.1-2001.

The description was changed to be more specific about what has to be displayed for a utility. The standard developers considered it insufficient to allow a display of only the synopsis without giving a short description of what each option and operand does.

The “purpose” entry to be included in the database can be similar to the section title (less the numeric prefix) from this volume of IEEE Std 1003.1-2001 for each utility. These titles are similar to those used in historical systems for this purpose.

See mailx for rationale concerning the default paginator.

The caveat in the LC_CTYPE description was added because it is not a requirement that an implementation provide reference pages for all of its supported locales on each system; changing LC_CTYPE does not necessarily translate the reference page into another language. This is equivalent to the current state of LC_MESSAGES in IEEE Std 1003.1-2001—locale-specific messages are not yet a requirement.

The historical MANPATH variable is not included in POSIX because no attempt is made to specify naming conventions for reference page files, nor even to mandate that they are files at all. On some implementations they could be a true database, a hypertext file, or even fixed strings within the man executable. The standard developers considered the portability of reference pages to be outside their scope of work. However, users should be aware that MANPATH is implemented on a number of historical systems and that it can be used to tailor the search pattern for reference pages from the various categories (utilities, functions, file formats, and so on) when the system administrator reveals the location and conventions for reference pages on the system.

The keyword search can rely on at least the text of the section titles from these utility descriptions, and the implementation may add more keywords. The term “section titles” refers to the strings such as:

man – Display system documentation
ps – Report process status

FUTURE DIRECTIONS

None.

SEE ALSO

more

CHANGE HISTORY

First released in Issue 4.
The FUTURE DIRECTIONS section is added.
NAME
mesg — permit or deny messages

SYNOPSIS
UP
mesg [y | n]

DESCRIPTION
The mesg utility shall control whether other users are allowed to send messages via write, talk, or other utilities to a terminal device. The terminal device affected shall be determined by searching for the first terminal in the sequence of devices associated with standard input, standard output, and standard error, respectively. With no arguments, mesg shall report the current state without changing it. Processes with appropriate privileges may be able to send messages to the terminal independent of the current state.

OPTIONS
None.

OPERANDS
The following operands shall be supported in the POSIX locale:

y Grant permission to other users to send messages to the terminal device.
n Deny permission to other users to send messages to the terminal device.

STDIN
Not used.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of mesg:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written (by mesg) to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
If no operand is specified, mesg shall display the current terminal state in an unspecified format.
The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

- 0 Receiving messages is allowed.
- 1 Receiving messages is not allowed.
- >1 An error occurred.

Default.

The mechanism by which the message status of the terminal is changed is unspecified. Therefore, unspecified actions may cause the status of the terminal to change after `mesg` has successfully completed. These actions may include, but are not limited to: another invocation of the `mesg` utility, login procedures; invocation of the `stty` utility, invocation of the `chmod` utility or `chmod()` function, and so on.

None.

The terminal changed by `mesg` is that associated with the standard input, output, or error, rather than the controlling terminal for the session. This is because users logged in more than once should be able to change any of their login terminals without having to stop the job running in those sessions. This is not a security problem involving the terminals of other users because appropriate privileges would be required to affect the terminal of another user.

The method of checking each of the first three file descriptors in sequence until a terminal is found was adopted from System V.

The file `/dev/tty` is not specified for the terminal device because it was thought to be too restrictive. Typical environment changes for the `n` operand are that write permissions are removed for `others` and `group` from the appropriate device. It was decided to leave the actual description of what is done as unspecified because of potential differences between implementations.

The format for standard output is unspecified because of differences between historical implementations. This output is generally not useful to shell scripts (they can use the exit status), so exact parsing of the output is unnecessary.

None.

`talk, write`
Utilities

 CHANGE HISTORY
24692 First released in Issue 2.
24693 Issue 6
24694 This utility is marked as part of the User Portability Utilities option.
NAME
mkdir — make directories

SYNOPSIS
mkdir [−p] [−m mode] dir...

DESCRIPTION
The mkdir utility shall create the directories specified by the operands, in the order specified.
For each dir operand, the mkdir utility shall perform actions equivalent to the mkdir() function
defined in the System Interfaces volume of IEEE Std 1003.1-2001, called with the following
arguments:
1. The dir operand is used as the path argument.
2. The value of the bitwise-inclusive OR of S_IRWXU, S_IRWXG, and S_IRWXO is used as
   the mode argument. (If the −m option is specified, the mode option-argument overrides this
default.)

OPTIONS
The mkdir utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
The following options shall be supported:
−m mode Set the file permission bits of the newly-created directory to the specified mode
value. The mode option-argument shall be the same as the mode operand defined
for the chmod utility. In the symbolic_mode strings, the op characters ‘+’ and ‘−’
shall be interpreted relative to an assumed initial mode of a=rwx; ‘+’ shall add
permissions to the default mode, ‘−’ shall delete permissions from the default
mode.
−p Create any missing intermediate pathname components.
For each dir operand that does not name an existing directory, effects equivalent to
those caused by the following command shall occur:
mkdir −m $(umask −S),u+wx $(dirname dir) &&
mkdir [−m mode] dir
where the −m mode option represents that option supplied to the original
invocation of mkdir, if any.
Each dir operand that names an existing directory shall be ignored without error.

OPERANDS
The following operand shall be supported:
dir A pathname of a directory to be created.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of mkdir:
LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

If set to a non-empty string value, override the values of all the other
internationalization variables.

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of \texttt{LC_MESSAGES}.

\texttt{XSI} \texttt{NLSPATH} \texttt{Determine the location of message catalogs for the processing of \texttt{LC_MESSAGES}.}

\texttt{ASYNCHRONOUS EVENTS}

\texttt{STDOUT} Default.

\texttt{STDERR} Not used.

The standard error shall be used only for diagnostic messages.

\texttt{OUTPUT FILES} None.

\texttt{EXTENDED DESCRIPTION} None.

The following exit values shall be returned:

\begin{itemize}
\item \texttt{0} All the specified directories were created successfully or the \texttt{−p} option was specified and all
\texttt{the specified directories now exist.}
\item \texttt{>0} An error occurred.
\end{itemize}

\texttt{APPLICATION USAGE}

The default file mode for directories is \texttt{a=rwx} (777 on most systems) with selected permissions
removed in accordance with the file mode creation mask. For intermediate pathname
components created by \texttt{mkdir}, the mode is the default modified by \texttt{u+wx} so that the
subdirectories can always be created regardless of the file mode creation mask; if different
ultimate permissions are desired for the intermediate directories, they can be changed
afterwards with \texttt{chmod}.

Note that some of the requested directories may have been created even if an error occurs.

\texttt{EXAMPLES} None.

\texttt{RATIONALE}

The System V \texttt{−m} option was included to control the file mode.

The System V \texttt{−p} option was included to create any needed intermediate directories and to
complement the functionality provided by \texttt{rmdir} for removing directories in the path prefix as
they become empty. Because no error is produced if any path component already exists, the \texttt{−p}
option is also useful to ensure that a particular directory exists.
The functionality of `mkdir` is described substantially through a reference to the `mkdir()` function in the System Interfaces volume of IEEE Std 1003.1-2001. For example, by default, the mode of the directory is affected by the file mode creation mask in accordance with the specified behavior of the `mkdir()` function. In this way, there is less duplication of effort required for describing details of the directory creation.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`chmod`, `rm`, `rmdir`, `umask`, the System Interfaces volume of IEEE Std 1003.1-2001, `mkdir()`

**CHANGE HISTORY**

**Issue 5**

First released in Issue 2.

The FUTURE DIRECTIONS section is added.
NAME
mkfifo — make FIFO special files

SYNOPSIS
mkfifo [-m mode] file...

DESCRIPTION
The mkfifo utility shall create the FIFO special files specified by the operands, in the order specified.
For each file operand, the mkfifo utility shall perform actions equivalent to the mkfifo() function defined in the System Interfaces volume of IEEE Std 1003.1-2001, called with the following arguments:
1. The file operand is used as the path argument.
2. The value of the bitwise-inclusive OR of S_IRUSR, S_IWUSR, S_IRGRP, S_IWGRP, S_IROTH, and S_IWOTH is used as the mode argument. (If the -m option is specified, the value of the mkfifo() mode argument is unspecified, but the FIFO shall at no time have permissions less restrictive than the -m mode option-argument.)

OPTIONS
The following option shall be supported:
-m mode Set the file permission bits of the newly-created FIFO to the specified mode value.
The mode option-argument shall be the same as the mode operand defined for the chmod utility. In the symbolic_mode strings, the op characters ‘+’ and ‘-’ shall be interpreted relative to an assumed initial mode of a=rw.

OPERANDS
The following operand shall be supported:
file A pathname of the FIFO special file to be created.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of mkfifo:
LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
Determine the location of message catalogs for the processing of LC_MESSAGES.

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
Not used.

**STDERR**
The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
The following exit values shall be returned:

- 0  All the specified FIFO special files were created successfully.
- >0  An error occurred.

**CONSEQUENCES OF ERRORS**
Default.

**APPLICATION USAGE**
None.

**EXAMPLES**
None.

**RATIONALE**
This utility was added to permit shell applications to create FIFO special files.

The **−m** option was added to control the file mode, for consistency with the similar functionality provided by the **mkdir** utility.

Early proposals included a **−p** option similar to the **mkdir** **−p** option that created intermediate directories leading up to the FIFO specified by the final component. This was removed because it is not commonly needed and is not common practice with similar utilities.

The functionality of **mkfifo** is described substantially through a reference to the **mkfifo** () function in the System Interfaces volume of IEEE Std 1003.1-2001. For example, by default, the mode of the FIFO file is affected by the file mode creation mask in accordance with the specified behavior of the **mkfifo** () function. In this way, there is less duplication of effort required for describing details of the file creation.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
**chmod**, **umask**, the System Interfaces volume of IEEE Std 1003.1-2001, **mkfifo**()

**CHANGE HISTORY**
First released in Issue 3.
NAME
more — display files on a page-by-page basis

SYNOPSIS
more [-ceisu][-n number][-p command][-t tagstring][file ...]

DESCRIPTION
The more utility shall read files and either write them to the terminal on a page-by-page basis or filter them to standard output. If standard output is not a terminal device, all input files shall be copied to standard output in their entirety, without modification, except as specified for the -s option. If standard output is a terminal device, the files shall be written a number of lines (one screenful) at a time under the control of user commands. See the EXTENDED DESCRIPTION section.

Certain block-mode terminals do not have all the capabilities necessary to support the complete more definition; they are incapable of accepting commands that are not terminated with a <newline>. Implementations that support such terminals shall provide an operating mode to more in which all commands can be terminated with a <newline> on those terminals. This mode:

- Shall be documented in the system documentation
- Shall, at invocation, inform the user of the terminal deficiency that requires the <newline> usage and provide instructions on how this warning can be suppressed in future invocations
- Shall not be required for implementations supporting only fully capable terminals
- Shall not affect commands already requiring <newline>s
- Shall not affect users on the capable terminals from using more as described in this volume of IEEE Std 1003.1-2001

OPTIONS

The following options shall be supported:

-c If a screen is to be written that has no lines in common with the current screen, or more is writing its first screen, more shall not scroll the screen, but instead shall redraw each line of the screen in turn, from the top of the screen to the bottom. In addition, if more is writing its first screen, the screen shall be cleared. This option may be silently ignored on devices with insufficient terminal capabilities.

-e By default, more shall exit immediately after writing the last line of the last file in the argument list. If the -e option is specified:

1. If there is only a single file in the argument list and that file was completely displayed on a single screen, more shall exit immediately after writing the last line of that file.

2. Otherwise, more shall exit only after reaching end-of-file on the last file in the argument list twice without an intervening operation. See the EXTENDED DESCRIPTION section.

-i Perform pattern matching in searches without regard to case; see the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.2, Regular Expression General Requirements.
Specify the number of lines per screenful. The *number* argument is a positive decimal integer. The `−n` option shall override any values obtained from any other source.

Each time a screen from a new file is displayed or redisplayed (including as a result of *more* commands; for example, `−p`), execute the *more* command(s) in the command arguments in the order specified, as if entered by the user after the first screen has been displayed. No intermediate results shall be displayed (that is, if the command is a movement to a screen different from the normal first screen, only the screen resulting from the command shall be displayed.) If any of the commands fail for any reason, an informational message to this effect shall be written, and no further commands specified using the `−p` option shall be executed for this file.

Behave as if consecutive empty lines were a single empty line.

Write the screenful of the file containing the tag named by the *tagstring* argument. See the *ctags* utility. The tags feature represented by `−t` *tagstring* and the `:t` command is optional. It shall be provided on any system that also provides a conforming implementation of *ctags*; otherwise, the use of `−t` produces undefined results.

The filename resulting from the `−t` option shall be logically added as a prefix to the list of command line files, as if specified by the user. If the tag named by the *tagstring* argument is not found, it shall be an error, and *more* shall take no further action.

If the tag specifies a line number, the first line of the display shall contain the beginning of that line. If the tag specifies a pattern, the first line of the display shall contain the beginning of the matching text from the first line of the file that contains that pattern. If the line does not exist in the file or matching text is not found, an informational message to this effect shall be displayed, and *more* shall display the default screen as if `−t` had not been specified.

If both the `−t` *tagstring* and `−p` *command* options are given, the `−t` *tagstring* shall be processed first; that is, the file and starting line for the display shall be as specified by `−t`, and then the `−p more` command shall be executed. If the line (matching text) specified by the `−t` command does not exist (is not found), no `−p more` command shall be executed for this file at any time.

Treat a `<backspace>` as a printable control character, displayed as an implementation-defined character sequence (see the EXTENDED DESCRIPTION section), suppressing backspacing and the special handling that produces underlined or standout mode text on some terminal types. Also, do not ignore a `<carriage-return>` at the end of a line.

The following operand shall be supported:

A pathname of an input file. If no *file* operands are specified, the standard input shall be used. If a *file* is `−`, the standard input shall be read at that point in the sequence.

The standard input shall be used only if no *file* operands are specified, or if a *file* operand is `−`. 

OPERANDS

STDIN

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INPUT FILES

The input files being examined shall be text files. If standard output is a terminal, standard error shall be used to read commands from the user. If standard output is a terminal, standard error is not readable, and command input is needed, more may attempt to obtain user commands from the controlling terminal (for example, /dev/tty); otherwise, more shall terminate with an error indicating that it was unable to read user commands. If standard output is not a terminal, no error shall result if standard error cannot be opened for reading.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of more:

COLUMNS Override the system-selected horizontal display line size. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables for valid values and results when it is unset or null.

EDITOR Used by the v command to select an editor. See the EXTENDED DESCRIPTION section.

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_COLLATE Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and the behavior of character classes within regular expressions.

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

LINES Override the system-selected vertical screen size, used as the number of lines in a screenful. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables for valid values and results when it is unset or null. The -n option shall take precedence over the LINES variable for determining the number of lines in a screenful.

MORE Determine a string containing options described in the OPTIONS section preceded with hyphens and <blank>-separated as on the command line. Any command line options shall be processed after those in the MORE variable, as if the command line were:

more $MORE options operands

The MORE variable shall take precedence over the TERM and LINES variables for determining the number of lines in a screenful.
TERM
Determine the name of the terminal type. If this variable is unset or null, an
unspecified default terminal type is used.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The standard output shall be used to write the contents of the input files.

STDERR
The standard error shall be used for diagnostic messages and user commands (see the INPUT
FILES section), and, if standard output is a terminal device, to write a prompting string. The
prompting string shall appear on the screen line below the last line of the file displayed in the
current screenful. The prompt shall contain the name of the file currently being examined and
shall contain an end-of-file indication and the name of the next file, if any, when prompting at
the end-of-file. If an error or informational message is displayed, it is unspecified whether it is
contained in the prompt. If it is not contained in the prompt, it shall be displayed and then the
user shall be prompted for a continuation character, at which point another message or the user
prompt may be displayed. The prompt is otherwise unspecified. It is unspecified whether
informational messages are written for other user commands.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
The following section describes the behavior of more when the standard output is a terminal
device. If the standard output is not a terminal device, no options other than −s shall have any
effect, and all input files shall be copied to standard output otherwise unmodified, at which time
more shall exit without further action.

The number of lines available per screen shall be determined by the −n option, if present, or by
examining values in the environment (see the ENVIRONMENT VARIABLES section). If neither
method yields a number, an unspecified number of lines shall be used.

The maximum number of lines written shall be one less than this number, because the screen
line after the last line written shall be used to write a user prompt and user input. If the number
of lines in the screen is less than two, the results are undefined. It is unspecified whether user
input is permitted to be longer than the remainder of the single line where the prompt has been
written.

The number of columns available per line shall be determined by examining values in the
environment (see the ENVIRONMENT VARIABLES section), with a default value as described

Lines that are longer than the display shall be folded; the length at which folding occurs is
unspecified, but should be appropriate for the output device. Folding may occur between glyphs
of single characters that take up multiple display columns.

When standard output is a terminal and −u is not specified, more shall treat <backspace>s and
<carriage-return>s specially:

- A character, followed first by a sequence of n <backspace>s (where n is the same as the
  number of column positions that the character occupies), then by n underscore characters
  (‘_’), shall cause that character to be written as underlined text, if the terminal type
  supports that. The n underscore characters, followed first by n <backspace>s, then any
  character with n column positions, shall also cause that character to be written as underlined
text, if the terminal type supports that.
• A sequence of \texttt{n <backspace>}s (where \texttt{n} is the same as the number of column positions that the previous character occupies) that appears between two identical printable characters shall cause the first of those two characters to be written as emboldened text (that is, visually brighter, standout mode, or inverse-video mode), if the terminal type supports that, and the second to be discarded. Immediately subsequent occurrences of \texttt{<backspace>/character pairs for that same character shall also be discarded. (For example, the sequence \texttt{"a\ba\ba\ba" is interpreted as a single emboldened 'a'.)}

• The \texttt{more} utility shall logically discard all other \texttt{<backspace>}s from the line as well as the character which precedes them, if any.

• A \texttt{<carriage-return>} at the end of a line shall be ignored, rather than being written as a non-printable character, as described in the next paragraph.

It is implementation-defined how other non-printable characters are written. Implementations should use the same format that they use for the \texttt{ex print} command; see the OPTIONS section within the \texttt{ed} utility. It is unspecified whether a multi-column character shall be separated if it crosses a display line boundary; it shall not be discarded. The behavior is unspecified if the number of columns on the display is less than the number of columns any single character in the line being displayed would occupy.

When each new file is displayed (or redisplayed), \texttt{more} shall write the first screen of the file. Once the initial screen has been written, \texttt{more} shall prompt for a user command. If the execution of the user command results in a screen that has lines in common with the current screen, and the device has sufficient terminal capabilities, \texttt{more} shall scroll the screen; otherwise, it is unspecified whether the screen is scrolled or redrawn.

For all files but the last (including standard input if no file was specified, and for the last file as well, if the \texttt{–e} option was not specified), when \texttt{more} has written the last line in the file, \texttt{more} shall prompt for a user command. This prompt shall contain the name of the next file as well as an indication that \texttt{more} has reached end-of-file. If the user command is \texttt{f}, \texttt{<control>-F}, \texttt{<space>, \texttt{j}, <newline>, \texttt{d}, \texttt{<control>-D}, or \texttt{s}, \texttt{more} shall display the next file. Otherwise, if displaying the last file, \texttt{more} shall exit. Otherwise, \texttt{more} shall execute the user command specified.

Several of the commands described in this section display a previous screen from the input stream. In the case that text is being taken from a non-rewindable stream, such as a pipe, it is implementation-defined how much backwards motion is supported. If a command cannot be executed because of a limitation on backwards motion, an error message to this effect shall be displayed, the current screen shall not change, and the user shall be prompted for another command.

If a command cannot be performed because there are insufficient lines to display, \texttt{more} shall alert the terminal. If a command cannot be performed because there are insufficient lines to display or a \texttt{a / command fails: if the input is the standard input, the last screen in the file may be displayed; otherwise, the current file and screen shall not change, and the user shall be prompted for another command.

The interactive commands in the following sections shall be supported. Some commands can be preceded by a decimal integer, called \texttt{count} in the following descriptions. If not specified with the command, \texttt{count} shall default to 1. In the following descriptions, \texttt{pattern} is a basic regular expression, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic Regular Expressions. The term \texttt{‘examine’} is historical usage meaning \texttt{‘open the file for viewing’}; for example, \texttt{more \texttt{foo} would be expressed as examining file \texttt{foo}.}

In the following descriptions, unless otherwise specified, \texttt{line} is a line in the \texttt{more} display, not a line from the file being examined.
In the following descriptions, the current position refers to two things:

1. The position of the current line on the screen
2. The line number (in the file) of the current line on the screen

Usually, the line on the screen corresponding to the current position is the third line on the screen. If this is not possible (there are fewer than three lines to display or this is the first page of the file, or it is the last page of the file), then the current position is either the first or last line on the screen as described later.

Help

Synopsis: h

Write a summary of these commands and other implementation-defined commands. The behavior shall be as if the more utility were executed with the -e option on a file that contained the summary information. The user shall be prompted as described earlier in this section when end-of-file is reached. If the user command is one of those specified to continue to the next file, more shall return to the file and screen state from which the h command was executed.

Scroll Forward One Screenful

Synopsis: [count]f
[count]<control>-F

Scroll forward count lines, with a default of one screenful. If count is more than the screen size, only the final screenful shall be written.

Scroll Backward One Screenful

Synopsis: [count]b
[count]<control>-B

Scroll backward count lines, with a default of one screenful (see the -n option). If count is more than the screen size, only the final screenful shall be written.

Scroll Forward One Line

Synopsis: [count]<space>
[count]j
[count]<newline>

Scroll forward count lines. The default count for the <space> shall be one screenful; for j and <newline>, one line. The entire count lines shall be written, even if count is more than the screen size.

Scroll Backward One Line

Synopsis: [count]k

Scroll backward count lines. The entire count lines shall be written, even if count is more than the screen size.
**Scroll Forward One Half Screenful**

*Synopsis:  \([count]d\)
\([count]\langle\text{control}\rangle-D\)*

Scroll forward *count* lines, with a default of one half of the screen size. If *count* is specified, it shall become the new default for subsequent *d*, \(<\text{control}\>-D\), and *u* commands.

**Skip Forward One Line**

*Synopsis:  \([count]s\)*

Display the screenful beginning with the line *count* lines after the last line on the current screen. If *count* would cause the current position to be such that less than one screenful would be written, the last screenful in the file shall be written.

**Scroll Backward One Half Screenful**

*Synopsis:  \([count]u\)
\([count]\langle\text{control}\rangle-U\)*

Scroll backward *count* lines, with a default of one half of the screen size. If *count* is specified, it shall become the new default for subsequent *d*, \(<\text{control}\>-D\), *u*, and \(<\text{control}\>-U\) commands. The entire *count* lines shall be written, even if *count* is more than the screen size.

**Go to Beginning of File**

*Synopsis:  \([count]g\)*

Display the screenful beginning with line *count*.

**Go to End-of-File**

*Synopsis:  \([count]G\)*

If *count* is specified, display the screenful beginning with the line *count*. Otherwise, display the last screenful of the file.

**Refresh the Screen**

*Synopsis:  \(r\)
\(<\text{control}\>-L\)*

Refresh the screen.

**Discard and Refresh**

*Synopsis:  \(R\)*

Refresh the screen, discarding any buffered input. If the current file is non-seekable, buffered input shall not be discarded and the *R* command shall be equivalent to the *r* command.
Mark Position

Synopsis: m\texttt{letter}

Mark the current position with the letter named by \texttt{letter}, where \texttt{letter} represents the name of one of the lowercase letters of the portable character set. When a new file is examined, all marks may be lost.

Return to Mark

Synopsis: \texttt{'}\texttt{letter}

Return to the position that was previously marked with the letter named by \texttt{letter}, making that line the current position.

Return to Previous Position

Synopsis: \texttt{'}

Return to the position from which the last large movement command was executed (where a “large movement” is defined as any movement of more than a screenful of lines). If no such movements have been made, return to the beginning of the file.

Search Forward for Pattern

Synopsis: \texttt{[count]}/[!]\texttt{pattern}<\texttt{newline}>

Display the screenful beginning with the \texttt{count}th line containing the pattern. The search shall start after the first line currently displayed. The null regular expression (\texttt{'/'} followed by a <\texttt{newline}> ) shall repeat the search using the previous regular expression, with a default \texttt{count}. If the character \texttt{'}' is included, the matching lines shall be those that do not contain the \texttt{pattern}. If no match is found for the \texttt{pattern}, a message to that effect shall be displayed.

Search Backward for Pattern

Synopsis: \texttt{[count]?/[!]\texttt{pattern}<\texttt{newline}>

Display the screenful beginning with the \texttt{count}th previous line containing the pattern. The search shall start on the last line before the first line currently displayed. The null regular expression (\texttt{'?'} followed by a <\texttt{newline}> ) shall repeat the search using the previous regular expression, with a default \texttt{count}. If the character \texttt{'}' is included, matching lines shall be those that do not contain the \texttt{pattern}. If no match is found for the \texttt{pattern}, a message to that effect shall be displayed.

Repeat Search

Synopsis: [\texttt{count}n

Repeat the previous search for \texttt{count}th line containing the last \texttt{pattern} (or not containing the last \texttt{pattern}, if the previous search was "/" or "?!").
**Repeat Search in Reverse**

**Synopsis:** `[count]N

Repeat the search in the opposite direction of the previous search for the count \text{th} line containing the last pattern (or not containing the last pattern, if the previous search was " / " or " ? ! ").

**Examine New File**

**Synopsis:** :e [filename]<newline>

Examine a new file. If the filename argument is not specified, the current file (see the :n and :p commands below) shall be re-examined. The filename shall be subjected to the process of shell word expansions (see Section 2.6 (on page 36)); if more than a single pathname results, the effects are unspecified. If filename is a number sign ('#'), the previously examined file shall be re-examined. If filename is not accessible for any reason (including that it is a non-seekable file), an error message to this effect shall be displayed and the current file and screen shall not change.

**Examine Next File**

**Synopsis:** [count]:n

Examine the next file. If a number count is specified, the count \text{th} next file shall be examined. If filename refers to a non-seekable file, the results are unspecified.

**Examine Previous File**

**Synopsis:** [count]:p

Examine the previous file. If a number count is specified, the count \text{th} previous file shall be examined. If filename refers to a non-seekable file, the results are unspecified.

**Go to Tag**

**Synopsis:** :t tagstring<newline>

If the file containing the tag named by the tagstring argument is not the current file, examine the file, as if the :e command was executed with that file as the argument. Otherwise, or in addition, display the screenful beginning with the tag, as described for the –t option (see the OPTIONS section). If the ctags utility is not supported by the system, the use of :t produces undefined results.

**Invoke Editor**

**Synopsis:** v

Invoke an editor to edit the current file being examined. If standard input is being examined, the results are unspecified. The name of the editor shall be taken from the environment variable EDITOR, or shall default to vi. If the last pathname component in EDITOR is either vi or ex, the editor shall be invoked with a –c linenumber command line argument, where linenumber is the line number of the file line containing the display line currently displayed as the first line of the screen. It is implementation-defined whether line-setting options are passed to editors other than vi and ex.

When the editor exits, more shall resume with the same file and screen as when the editor was invoked.
Utilities

Display Position

Synopsis: =
<control>-G

Write a message for which the information references the first byte of the line after the last line of
the file on the screen. This message shall include the name of the file currently being examined,
its number relative to the total number of files there are to examine, the line number in the file,
the byte number and the total bytes in the file, and what percentage of the file precedes the
current position. If more is reading from standard input, or the file is shorter than a single screen,
the line number, the byte number, the total bytes, and the percentage need not be written.

Quit

Synopsis: q
:q
ZZ

Exit more.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS

If an error is encountered accessing a file when using the :n command, more shall attempt to
examine the next file in the argument list, but the final exit status shall be affected. If an error is
encountered accessing a file via the :p command, more shall attempt to examine the previous file
in the argument list, but the final exit status shall be affected. If an error is encountered accessing
a file via the :e command, more shall remain in the current file and the final exit status shall not
be affected.

APPLICATION USAGE

When the standard output is not a terminal, only the −s filter-modification option is effective.
This is based on historical practice. For example, a typical implementation of man pipes its
output through more −s to squeeze excess white space for terminal users. When man is piped to
lp, however, it is undesirable for this squeezing to happen.

EXAMPLES

The −p allows arbitrary commands to be executed at the start of each file. Examples are:

more −p G file1 file2
Examine each file starting with its last screenful.

more −p 100 file1 file2
Examine each file starting with line 100 in the current position (usually the third line, so line
98 would be the first line written).

more −p /100 file1 file2
Examine each file starting with the first line containing the string "100" in the current
position

RATIONALE

The more utility, available in BSD and BSD-derived systems, was chosen as the prototype for the
POSIX file display program since it is more widely available than either the public-domain
program less or than pg, a pager provided in System V. The 4.4 BSD more is the model for the
features selected; it is almost fully upwards-compatible from the 4.3 BSD version in wide use and has become more amenable for vi users. Several features originally derived from various file editors, found in both less and pg, have been added to this volume of IEEE Std 1003.1-2001 as they have proved extremely popular with users.

There are inconsistencies between more and vi that result from historical practice. For example, the single-character commands h, f, b, and <space> are screen movers in more, but cursor movers in vi. These inconsistencies were maintained because the cursor movements are not applicable to more and the powerful functionality achieved without the use of the control key justifies the differences.

The tags interface has been included in a program that is not a text editor because it promotes another degree of consistent operation with vi. It is conceivable that the paging environment of more would be superior for browsing source code files in some circumstances.

The operating mode referred to for block-mode terminals effectively adds a <newline> to each Synopsis line that currently has none. So, for example, d<newline> would page one screenful.

The mode could be triggered by a command line option, environment variable, or some other method. The details are not imposed by this volume of IEEE Std 1003.1-2001 because there are so few systems known to support such terminals. Nevertheless, it was considered that all systems should be able to support more given the exception cited for this small community of terminals because, in comparison to vi, the cursor movements are few and the command set relatively amenable to the optional <newline>.

Some versions of more provide a shell escaping mechanism similar to the ex ! command. The standard developers did not consider that this was necessary in a paginator, particularly given the wide acceptance of multiple window terminals and job control features. (They chose to retain such features in the editors and mailx because the shell interaction also gives an opportunity to modify the editing buffer, which is not applicable to more.)

The −p (position) option replaces the + command because of the Utility Syntax Guidelines. In early proposals, it took a pattern argument, but historical less provided the more general facility of a command. It would have been desirable to use the same −c as ex and vi, but the letter was already in use.

The text stating “from a non-rewindable stream . . . implementations may limit the amount of backwards motion supported” would allow an implementation that permitted no backwards motion beyond text already on the screen. It was not possible to require a minimum amount of backwards motion that would be effective for all conceivable device types. The implementation should allow the user to back up as far as possible, within device and reasonable memory allocation constraints.

Historically, non-printable characters were displayed using the ARPA standard mappings, which are as follows:

1. Printable characters are left alone.
2. Control characters less than \177 are represented as followed by the character offset from the ‘@’ character in the ASCII map; for example, \007 is represented as ‘G’.
3. \177 is represented as followed by ‘?’.

The display of characters having their eighth bit set was less standard. Existing implementations use hex (0x0), octal (\000), and a meta-bit display. (The latter displayed characters with their eighth bit set as the two characters "M−", followed by the seven-bit display as described previously.) The latter probably has the best claim to historical practice because it was used with the −v option of 4 BSD and 4 BSD-derived versions of the cat utility since 1980.
No specific display format is required by IEEE Std 1003.1-2001. Implementations are encouraged to conform to historic practice in the absence of any strong reason to diverge.

FUTURE DIRECTIONS
None.

SEE ALSO
Chapter 2 (on page 29), ctags, ed, ex, vi

CHANGE HISTORY
First released in Issue 4.
The FUTURE DIRECTIONS section is added.

Issue 5
The obsolescent SYNOPSIS is removed.
The utility has been extensively reworked for alignment with the IEEE P1003.2b draft standard:
• Changes have been made as a result of IEEE PASC Interpretations 1003.2 #37 and #109.
• The more utility should be able to handle underlined and emboldened displays of characters that are wider than a single column position.
NAME
mv — move files

SYNOPSIS
mv [-fi] source_file target_file
mv [-fi] source_file... target_file

DESCRIPTION
In the first synopsis form, the mv utility shall move the file named by the source_file operand to
the destination specified by the target_file. This first synopsis form is assumed when the final
operand does not name an existing directory and is not a symbolic link referring to an existing
directory.

In the second synopsis form, mv shall move each file named by a source_file operand to a
destination file in the existing directory named by the target_dir operand, or referenced if
target_dir is a symbolic link referring to an existing directory. The destination path for each
source_file shall be the concatenation of the target directory, a single slash character, and the last
pathname component of the source_file. This second form is assumed when the final operand
names an existing directory.

If any operand specifies an existing file of a type not specified by the System Interfaces volume
of IEEE Std 1003.1-2001, the behavior is implementation-defined.

For each source_file the following steps shall be taken:

1. If the destination path exists, the -f option is not specified, and either of the following
   conditions is true:
   a. The permissions of the destination path do not permit writing and the standard input
      is a terminal.
   b. The -i option is specified.
   the mv utility shall write a prompt to standard error and read a line from standard input. If
   the response is not affirmative, mv shall do nothing more with the current source_file and
   go on to any remaining source_files.

2. The mv utility shall perform actions equivalent to the rename() function defined in the
   System Interfaces volume of IEEE Std 1003.1-2001, called with the following arguments:
   a. The source_file operand is used as the old argument.
   b. The destination path is used as the new argument.
   If this succeeds, mv shall do nothing more with the current source_file and go on to any
   remaining source_files. If this fails for any reasons other than those described for the errno
   [EXDEV] in the System Interfaces volume of IEEE Std 1003.1-2001, mv shall write a
   diagnostic message to standard error, do nothing more with the current source_file, and go
   on to any remaining source_files.

3. If the destination path exists, and it is a file of type directory and source_file is not a file of
   type directory, or it is a file not of type directory and source_file is a file of type directory,
   mv shall write a diagnostic message to standard error, do nothing more with the current
   source_file, and go on to any remaining source_files.

4. If the destination path exists, mv shall attempt to remove it. If this fails for any reason, mv
   shall write a diagnostic message to standard error, do nothing more with the current
   source_file, and go on to any remaining source_files.
5. The file hierarchy rooted in source_file shall be duplicated as a file hierarchy rooted in the destination path. If source_file or any of the files below it in the hierarchy are symbolic links, the links themselves shall be duplicated, including their contents, rather than any files to which they refer. The following characteristics of each file in the file hierarchy shall be duplicated:

- The time of last data modification and time of last access
- The user ID and group ID
- The file mode

If the user ID, group ID, or file mode of a regular file cannot be duplicated, the file mode bits S_ISUID and S_ISGID shall not be duplicated.

When files are duplicated to another file system, the implementation may require that the process invoking mv has read access to each file being duplicated.

If the duplication of the file hierarchy fails for any reason, mv shall write a diagnostic message to standard error, do nothing more with the current source_file, and go on to any remaining source_files.

If the duplication of the file characteristics fails for any reason, mv shall write a diagnostic message to standard error, but this failure shall not cause mv to modify its exit status.

6. The file hierarchy rooted in source_file shall be removed. If this fails for any reason, mv shall write a diagnostic message to the standard error, do nothing more with the current source_file, and go on to any remaining source_files.

**OPTIONS**


The following options shall be supported:

- **−f**  Do not prompt for confirmation if the destination path exists. Any previous occurrence of the −i option is ignored.
- **−i**  Prompt for confirmation if the destination path exists. Any previous occurrence of the −f option is ignored.

Specifying more than one of the −f or −i options shall not be considered an error. The last option specified shall determine the behavior of mv.

**OPERANDS**

The following operands shall be supported:

- **source_file**  A pathname of a file or directory to be moved.
- **target_file**  A new pathname for the file or directory being moved.
- **target_dir**  A pathname of an existing directory into which to move the input files.

**STDIN**

The standard input shall be used to read an input line in response to each prompt specified in the STDERR section. Otherwise, the standard input shall not be used.

**INPUT FILES**

The input files specified by each source_file operand can be of any file type.
ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `mv`:

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_COLLATE**: Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements used in the extended regular expression defined for the `yesexpr` locale keyword in the `LC_MESSAGES` category.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), the behavior of character classes used in the extended regular expression defined for the `yesexpr` locale keyword in the `LC_MESSAGES` category.

- **LC_MESSAGES**: Determine the locale for the processing of affirmative responses that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLS PATH**: Determine the location of message catalogs for the processing of `LC_MESSAGES`.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Not used.

STDERR

Prompts shall be written to the standard error under the conditions specified in the DESCRIPTION section. The prompts shall contain the destination pathname, but their format is otherwise unspecified. Otherwise, the standard error shall be used only for diagnostic messages.

OUTPUT FILES

The output files may be of any file type.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

- **0**: All input files were moved successfully.
- **>0**: An error occurred.

CONSEQUENCES OF ERRORS

If the copying or removal of `source_file` is prematurely terminated by a signal or error, `mv` may leave a partial copy of `source_file` at the source or destination. The `mv` utility shall not modify both `source_file` and the destination path simultaneously; termination at any point shall leave either `source_file` or the destination path complete.
APPLICATION USAGE

Some implementations mark for update the st_ctime field of renamed files and some do not. Applications which make use of the st_ctime field may behave differently with respect to renamed files unless they are designed to allow for either behavior.

EXAMPLES

If the current directory contains only files a (of any type defined by the System Interfaces volume of IEEE Std 1003.1-2001), b (also of any type), and a directory c:

```
mv a b c
mv c d
```
results with the original files a and b residing in the directory d in the current directory.

RATIONALE

Early proposals diverged from the SVID and BSD historical practice in that they required that when the destination path exists, the −f option is not specified, and input is not a terminal, mv fails. This was done for compatibility with cp. The current text returns to historical practice. It should be noted that this is consistent with the rename() function defined in the System Interfaces volume of IEEE Std 1003.1-2001, which does not require write permission on the target.

For absolute clarity, paragraph (1), describing the behavior of mv when prompting for confirmation, should be interpreted in the following manner:

```
if (exists AND (NOT f_option) AND
 ((not_writable AND input_is_terminal) OR i_option))
```

The −i option exists on BSD systems, giving applications and users a way to avoid accidentally unlinking files when moving others. When the standard input is not a terminal, the 4.3 BSD mv deletes all existing destination paths without prompting, even when −i is specified; this is inconsistent with the behavior of the 4.3 BSD cp utility, which always generates an error when the file is unwritable and the standard input is not a terminal. The standard developers decided that use of −i is a request for interaction, so when the destination path exists, the utility takes instructions from whatever responds to standard input.

The rename() function is able to move directories within the same file system. Some historical versions of mv have been able to move directories, but not to a different file system. The standard developers considered that this was an annoying inconsistency, so this volume of IEEE Std 1003.1-2001 requires directories to be able to be moved even across file systems. There is no −R option to confirm that moving a directory is actually intended, since such an option was not required for moving directories in historical practice. Requiring the application to specify it sometimes, depending on the destination, seemed just as inconsistent. The semantics of the rename() function were preserved as much as possible. For example, mv is not permitted to "rename" files to or from directories, even though they might be empty and removable.

Historic implementations of mv did not exit with a non-zero exit status if they were unable to duplicate any file characteristics when moving a file across file systems, nor did they write a diagnostic message for the user. The former behavior has been preserved to prevent scripts from breaking; a diagnostic message is now required, however, so that users are alerted that the file characteristics have changed.

The exact format of the interactive prompts is unspecified. Only the general nature of the contents of prompts are specified because implementations may desire more descriptive prompts than those used on historical implementations. Therefore, an application not using the −f option or using the −i option relies on the system to provide the most suitable dialog directly with the user, based on the behavior specified.
When `mv` is dealing with a single file system and `source_file` is a symbolic link, the link itself is moved as a consequence of the dependence on the `rename()` functionality, per the DESCRIPTION. Across file systems, this has to be made explicit.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`cp`, `ln`, the System Interfaces volume of IEEE Std 1003.1-2001, `rename()`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

The `mv` utility is changed to describe processing of symbolic links as specified in the IEEE P1003.2b draft standard.

The APPLICATION USAGE section is added.
newgrp

NAME
newgrp — change to a new group

SYNOPSIS
newgrp [-l] [group]

DESCRIPTION
The newgrp utility shall create a new shell execution environment with a new real and effective
group identification. Of the attributes listed in Section 2.12 (on page 61), the new shell execution
environment shall retain the working directory, file creation mask, and exported variables from
the previous environment (that is, open files, traps, unexported variables, alias definitions, shell
functions, and set options may be lost). All other aspects of the process environment that are
preserved by the exec family of functions defined in the System Interfaces volume of
IEEE Std 1003.1-2001 shall also be preserved by newgrp; whether other aspects are preserved is
unspecified.

A failure to assign the new group identifications (for example, for security or password-related
reasons) shall not prevent the new shell execution environment from being created.

The newgrp utility shall affect the supplemental groups for the process as follows:

- On systems where the effective group ID is normally in the supplementary group list (or
  whenever the old effective group ID actually is in the supplementary group list):
  - If the new effective group ID is also in the supplementary group list, newgrp shall change
    the effective group ID.
  - If the new effective group ID is not in the supplementary group list, newgrp shall add the
    new effective group ID to the list, if there is room to add it.

- On systems where the effective group ID is not normally in the supplementary group list (or
  whenever the old effective group ID is not in the supplementary group list):
  - If the new effective group ID is in the supplementary group list, newgrp shall delete it.
  - If the old effective group ID is not in the supplementary list, newgrp shall add it if there is
    room.

Note: The System Interfaces volume of IEEE Std 1003.1-2001 does not specify whether the effective
group ID of a process is included in its supplementary group list.

With no operands, newgrp shall change the effective group back to the groups identified in the
user’s user entry, and shall set the list of supplementary groups to that set in the user’s group
database entries.

If a password is required for the specified group, and the user is not listed as a member of that
group in the group database, the user shall be prompted to enter the correct password for that
group. If the user is listed as a member of that group, no password shall be requested. If no
password is required for the specified group, it is implementation-defined whether users not
listed as members of that group can change to that group. Whether or not a password is
required, implementation-defined system accounting or security mechanisms may impose
additional authorization restrictions that may cause newgrp to write a diagnostic message and
suppress the changing of the group identification.

OPTIONS
The newgrp utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
The following option shall be supported:

-1  (The letter ell.) Change the environment to what would be expected if the user actually logged in again.

**OPERANDS**

The following operand shall be supported:

- **group** A group name from the group database or a non-negative numeric group ID. Specifies the group ID to which the real and effective group IDs shall be set. If *group* is a non-negative numeric string and exists in the group database as a group name (see *getgrnam*()), the numeric group ID associated with that group name shall be used as the group ID.

**STDIN**

Not used.

**INPUT FILES**

The file `/dev/tty` shall be used to read a single line of text for password checking, when one is required.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of *newgrp*:

- **LANG** Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **XSI** **NLSPATH** Determine the location of message catalogs for the processing of *LC_MESSAGES*.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

Not used.

**STDERR**

The standard error shall be used for diagnostic messages and a prompt string for a password, if one is required. Diagnostic messages may be written in cases where the exit status is not available. See the EXIT STATUS section.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.
EXIT STATUS
If newgrp succeeds in creating a new shell execution environment, whether or not the group identification was changed successfully, the exit status shall be the exit status of the shell. Otherwise, the following exit value shall be returned:

>0 An error occurred.

CONSEQUENCES OF ERRORS
The invoking shell may terminate.

APPLICATION USAGE
There is no convenient way to enter a password into the group database. Use of group passwords is not encouraged, because by their very nature they encourage poor security practices. Group passwords may disappear in the future.

A common implementation of newgrp is that the current shell uses exec to overlay itself with newgrp, which in turn overlays itself with a new shell after changing group. On some implementations, however, this may not occur and newgrp may be invoked as a subprocess.

The newgrp command is intended only for use from an interactive terminal. It does not offer a useful interface for the support of applications.

The exit status of newgrp is generally inapplicable. If newgrp is used in a script, in most cases it successfully invokes a new shell and the rest of the original shell script is bypassed when the new shell exits. Used interactively, newgrp displays diagnostic messages to indicate problems.

But usage such as:

```
newgrp foo
```

```
echo $?
```

is not useful because the new shell might not have access to any status newgrp may have generated (and most historical systems do not provide this status). A zero status echoed here does not necessarily indicate that the user has changed to the new group successfully. Following newgrp with the id command provides a portable means of determining whether the group change was successful or not.

EXAMPLES
None.

RATIONALE
Most historical implementations use one of the exec functions to implement the behavior of newgrp. Errors detected before the exec leave the environment unchanged, while errors detected after the exec leave the user in a changed environment. While it would be useful to have newgrp issue a diagnostic message to tell the user that the environment changed, it would be inappropriate to require this change to some historical implementations.

The password mechanism is allowed in the group database, but how this would be implemented is not specified.

The newgrp utility was retained in this volume of IEEE Std 1003.1-2001, even given the existence of the multiple group permissions feature in the System Interfaces volume of IEEE Std 1003.1-2001, for several reasons. First, in some implementations, the group ownership of a newly created file is determined by the group of the directory in which the file is created, as allowed by the System Interfaces volume of IEEE Std 1003.1-2001; on other implementations, the group ownership of a newly created file is determined by the effective group ID. On implementations of the latter type, newgrp allows files to be created with a specific group ownership. Finally, many implementations use the real group ID in accounting, and on such systems, newgrp allows the accounting identity of the user to be changed.
Utilities

newgrp

FUTURE DIRECTIONS
None.

SEE ALSO
*getgrnam()*

CHANGE HISTORY
First released in Issue 2.

Issue 6
This utility is marked as part of the User Portability Utilities option.
The obsolescent SYNOPSIS is removed.
The text describing supplemental groups is no longer conditional on \{NGROUPS_MAX\} being
greater than 1. This is because \{NGROUPS_MAX\} now has a minimum value of 8. This is a FIPS
requirement.
NAME

nice — invoke a utility with an altered nice value

SYNOPSIS

nice [-n increment] utility [argument...]

DESCRIPTION

The nice utility shall invoke a utility, requesting that it be run with a different nice value (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.239, Nice Value). With no options and only if the user has appropriate privileges, the executed utility shall be run with a nice value that is some implementation-defined quantity less than or equal to the nice value of the current process. If the user lacks appropriate privileges to affect the nice value in the requested manner, the nice utility shall not affect the nice value; in this case, a warning message may be written to standard error, but this shall not prevent the invocation of utility or affect the exit status.

OPTIONS


The following option is supported:

-n increment A positive or negative decimal integer which shall have the same effect on the execution of the utility as if the utility had called the nice() function with the numeric value of the increment option-argument.

OPERANDS

The following operands shall be supported:

utility The name of a utility that is to be invoked. If the utility operand names any of the special built-in utilities in Section 2.14 (on page 64), the results are undefined.

argument Any string to be supplied as an argument when invoking the utility named by the utility operand.

STDOUT

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of nice:

LANG Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

664 Shell and Utilities, Issue 6 — Copyright © 2001-2003, IEEE and The Open Group. All rights reserved.
Utilities

<table>
<thead>
<tr>
<th>Line</th>
<th>Text</th>
</tr>
</thead>
</table>
| 25721 | **XSI**  
| **NLS** | P A T H  
| Determine the location of message catalogs for the processing of **LC_MESSAGES**. |
| 25722 | **PATH**  
| Determine the search path used to locate the utility to be invoked. See the Base |
| 25724 | **ASYNCHRONOUS EVENTS**  
| 25725 | Default. |
| 25726 | **STDOUT**  
| 25727 | Not used. |
| 25728 | **STDERR**  
| 25729 | The standard error shall be used only for diagnostic messages. |
| 25730 | **OUTPUT FILES**  
| 25731 | None. |
| 25732 | **EXTENDED DESCRIPTION**  
| 25733 | None. |
| 25734 | **EXIT STATUS**  
| 25735 | If **utility** is invoked, the exit status of **nice** shall be the exit status of **utility**; otherwise, the **nice**  
| 25736 | utility shall exit with one of the following values: |
| 25737 | 1-125 An error occurred in the **nice** utility. |
| 25738 | 126 The utility specified by **utility** was found but could not be invoked. |
| 25739 | 127 The utility specified by **utility** could not be found. |
| 25740 | **CONSEQUENCES OF ERRORS**  
| 25741 | Default. |
| 25742 | **APPLICATION USAGE**  
| 25743 | The only guaranteed portable uses of this utility are: |
| 25744 | **nice utility**  
| 25745 | Run **utility** with the default lower nice value. |
| 25746 | **nice** − **n** **<positive integer>** **utility**  
| 25747 | Run **utility** with a lower nice value. |
| 25748 | On some implementations they have no discernible effect on the invoked utility and on some  
| 25749 | others they are exactly equivalent. |
| 25750 | Historical systems have frequently supported the **<positive integer>** up to 20. Since there is no  
| 25751 | error penalty associated with guessing a number that is too high, users without access to the  
| 25752 | system conformance document (to see what limits are actually in place) could use the historical  
| 25753 | 1 to 20 range or attempt to use very large numbers if the job should be truly low priority. |
| 25754 | The nice value of a process can be displayed using the command: |
| 25755 | **ps** − **o** **nice**  
| 25756 | The **command**, **env**, **nice**, **nohup**, **time**, and **xargs** utilities have been specified to use exit code 127 if  
| 25757 | an error occurs so that applications can distinguish “failure to find a utility” from “invoked  
| 25758 | utility exited with an error indication”. The value 127 was chosen because it is not commonly  
| 25759 | used for other meanings; most utilities use small values for “normal error conditions” and the  
| 25760 | values above 128 can be confused with termination due to receipt of a signal. The value 126 was  
| 25761 | chosen in a similar manner to indicate that the utility could be found, but not invoked. Some  
| 25762 | scripts produce meaningful error messages differentiating the 126 and 127 cases. The distinction  
| 25763 | between exit codes 126 and 127 is based on KornShell practice that uses 127 when all attempts to
**nice**

exec the utility fail with [ENOENT], and uses 126 when any attempt to exec the utility fails for any other reason.

**EXAMPLES**
None.

**RATIONALE**
Due to the text about the limits of the nice value being implementation-defined, nice is not actually required to change the nice value of the executed command; the limits could be zero differences from the system default, although the implementor is required to document this fact in the conformance document.

The 4.3 BSD version of nice does not check whether increment is a valid decimal integer. The command nice -x utility, for example, would be treated the same as the command nice --1 utility. If the user does not have appropriate privileges, this results in a “permission denied” error. This is considered a bug.

When a user without appropriate privileges gives a negative increment, System V treats it like the command nice -0 utility, while 4.3 BSD writes a “permission denied” message and does not run the utility. Neither was considered clearly superior, so the behavior was left unspecified.

The C shell has a built-in version of nice that has a different interface from the one described in this volume of IEEE Std 1003.1-2001.

The term “utility” is used, rather than “command”, to highlight the fact that shell compound commands, pipelines, and so on, cannot be used. Special built-ins also cannot be used. However, “utility” includes user application programs and shell scripts, not just utilities defined in this volume of IEEE Std 1003.1-2001.

Historical implementations of nice provide a nice value range of 40 or 41 discrete steps, with the default nice value being the midpoint of that range. By default, they lower the nice value of the executed utility by 10.

Some historical documentation states that the increment value must be within a fixed range. This is misleading; the valid increment values on any invocation are determined by the current process nice value, which is not always the default.

The definition of nice value is not intended to suggest that all processes in a system have priorities that are comparable. Scheduling policy extensions such as the realtime priorities in the System Interfaces volume of IEEE Std 1003.1-2001 make the notion of a single underlying priority for all scheduling policies problematic. Some implementations may implement the nice-related features to affect all processes on the system, others to affect just the general time-sharing activities implied by this volume of IEEE Std 1003.1-2001, and others may have no effect at all. Because of the use of “implementation-defined” in nice and renice, a wide range of implementation strategies are possible.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
Chapter 2 (on page 29), renice, the System Interfaces volume of IEEE Std 1003.1-2001, nice()

**CHANGE HISTORY**
First released in Issue 4.
This utility is marked as part of the User Portability Utilities option.

The obsolete SYNOPSIS is removed.
NAME

nl — line numbering filter

SYNOPSIS

XSI


[-s sep] [-v startnum] [-w width] [file]

DESCRIPTION

The nl utility shall read lines from the named file or the standard input if no file is named and shall reproduce the lines to standard output. Lines shall be numbered on the left. Additional functionality may be provided in accordance with the command options in effect.

The nl utility views the text it reads in terms of logical pages. Line numbering shall be reset at the start of each logical page. A logical page consists of a header, a body, and a footer section. Empty sections are valid. Different line numbering options are independently available for header, body, and footer (for example, no numbering of header and footer lines while numbering blank lines only in the body).

The starts of logical page sections shall be signaled by input lines containing nothing but the following delimiter characters:

<table>
<thead>
<tr>
<th>Line</th>
<th>Start of</th>
</tr>
</thead>
<tbody>
<tr>
<td>\ \ : :</td>
<td>Header</td>
</tr>
<tr>
<td>\ : : :</td>
<td>Body</td>
</tr>
<tr>
<td>\ : : :</td>
<td>Footer</td>
</tr>
</tbody>
</table>

Unless otherwise specified, nl shall assume the text being read is in a single logical page body.

OPTIONS

The nl utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines. Only one file can be named.

The following options shall be supported:

- **-b type**: Specify which logical page body lines shall be numbered. Recognized types and their meaning are:
  - a: Number all lines.
  - t: Number only non-empty lines.
  - n: No line numbering.
  - pstring: Number only lines that contain the basic regular expression specified in string.

  The default type for logical page body shall be t (text lines numbered).

- **-d delim**: Specify the delimiter characters that indicate the start of a logical page section. These can be changed from the default characters "\\:\:" to two user-specified characters. If only one character is entered, the second character shall remain the default character ":".

- **-f type**: Specify the same as **b type** except for footer. The default for logical page footer shall be n (no lines numbered).

- **-h type**: Specify the same as **b type** except for header. The default type for logical page header shall be n (no lines numbered).
Specify the increment value used to number logical page lines. The default shall be 1.

Specify the number of blank lines to be considered as one. For example, \(-l 2\) results in only the second adjacent blank line being numbered (if the appropriate \(-h a, -b a, or -f a\) option is set). The default shall be 1.

Specify the line numbering format. Recognized values are: \(ln\), left justified, leading zeros suppressed; \(rn\), right justified, leading zeros suppressed; \(rz\), right justified, leading zeros kept. The default format shall be \(rn\) (right justified).

Specify that numbering should not be restarted at logical page delimiters.

Specify the characters used in separating the line number and the corresponding text line. The default \(sep\) shall be a <tab>.

Specify the initial value used to number logical page lines. The default shall be 1.

Specify the number of characters to be used for the line number. The default \(width\) shall be 6.

The following operand shall be supported:

- **file**
  A pathname of a text file to be line-numbered.

The standard input is a text file that is used if no \(file\) operand is given.

The input file named by the \(file\) operand is a text file.

The following environment variables shall affect the execution of \(nl\):

- **LANG**
  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_COLLATE**
  Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.

- **LC_CTYPE**
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), the behavior of character classes within regular expressions, and for deciding which characters are in character class \(graph\) (for the \(-b t, -f t, and -h t\) options).

- **LC_MESSAGES**
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**
  Determine the location of message catalogs for the processing of \(LC_MESSAGES\).
Utilities

25892 ASYNCHRONOUS EVENTS
25893 Default.

25894 STDOUT
25895 The standard output shall be a text file in the following format:
25896 "%s%s%s", <line number>, <separator>, <input line>
25897 where <line number> is one of the following numeric formats:
25898 %6d When the rn format is used (the default; see −n).
25899 %06d When the rz format is used.
25900 %−6d When the ln format is used.
25901 <empty> When line numbers are suppressed for a portion of the page; the <separator> is also suppressed.
25903 In the preceding list, the number 6 is the default width; the −w option can change this value.

25904 STDERR
25905 The standard error shall be used only for diagnostic messages.

25906 OUTPUT FILES
25907 None.

25908 EXTENDED DESCRIPTION
25909 None.

25910 EXIT STATUS
25911 The following exit values shall be returned:
25912 0 Successful completion.
25913 >0 An error occurred.

25914 CONSEQUENCES OF ERRORS
25915 Default.

25916 APPLICATION USAGE
25917 In using the −d delim option, care should be taken to escape characters that have special meaning to the command interpreter.

25919 EXAMPLES
25920 The command:
25921 nl −v 10 −i 10 −d \!+ file1
25922 numbers file1 starting at line number 10 with an increment of 10. The logical page delimiter is "\!+". Note that the ‘!’ has to be escaped when using csh as a command interpreter because of its history substitution syntax. For ksh and sh the escape is not necessary, but does not do any harm.

25926 RATIONALE
25927 None.

25928 FUTURE DIRECTIONS
25929 None.
SEE ALSO

pr

CHANGE HISTORY

First released in Issue 2.

Issue 5

The option \([-f \text{ type}]\) is added to the SYNOPSIS. The option descriptions are presented in alphabetic order. The description of \(-\text{bt}\) is changed to “Number only non-empty lines”.

Issue 6

The obsolescent behavior allowing the options to be intermingled with the optional \textit{file} operand is removed.
NAME
nm — write the name list of an object file (DEVELOPMENT)

SYNOPSIS
nm [−APv] [−efox] [−g] [−u] [−t format] file...

DESCRIPTION
This utility shall be provided on systems that support both the User Portability Utilities option
and the Software Development Utilities option. On other systems it is optional. Certain options
are only available on XSI-conformant systems.

The nm utility shall display symbolic information appearing in the object file, executable file, or
object-file library named by file. If no symbolic information is available for a valid input file, the
nm utility shall report that fact, but not consider it an error condition.

The default base used when numeric values are written is unspecified. On XSI-conformant
systems, it shall be decimal.

OPTIONS
The nm utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

−A Write the full pathname or library name of an object on each line.

−e Write only external (global) and static symbol information.

−f Produce full output. Write redundant symbols (.text, .data, and .bss), normally
suppressed.

−g Write only external (global) symbol information.

−o Write numeric values in octal (equivalent to −t o).

−P Write information in a portable output format, as specified in the STDOUT section.

−t format Write each numeric value in the specified format. The format shall be dependent
on the single character used as the format option-argument:

d The offset is written in decimal (default).

o The offset is written in octal.

x The offset is written in hexadecimal.

−u Write only undefined symbols.

−v Sort output by value instead of alphabetically.

−x Write numeric values in hexadecimal (equivalent to −t x).

OPERANDS
The following operand shall be supported:

file A pathname of an object file, executable file, or object-file library.

STDIN
See the INPUT FILES section.
The input file shall be an object file, an object-file library whose format is the same as those produced by the ar utility for link editing, or an executable file. The nm utility may accept additional implementation-defined object library formats for the input file.

The following environment variables shall affect the execution of nm:

- **LANG** Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- **LC_ALL** If set to a non-empty string value, override the values of all the other internationalization variables.
- **LC_COLLATE** Determine the locale for character collation information for the symbol-name and symbol-value collation sequences.
- **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
- **LC_MESSAGES** Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
- **NLSPATH** Determine the location of message catalogs for the processing of LC_MESSAGES.

If symbolic information is present in the input files, then for each file or for each member of an archive, the nm utility shall write the following information to standard output. By default, the format is unspecified, but the output shall be sorted alphabetically by symbol name:

- Library or object name, if -A is specified
- Symbol name
- Symbol type, which shall either be one of the following single characters or an implementation-defined type represented by a single character:
  - A Global absolute symbol.
  - a Local absolute symbol.
  - B Global “bss” (that is, uninitialized data space) symbol.
  - b Local bss symbol.
  - D Global data symbol.
  - d Local data symbol.
  - T Global text symbol.
  - t Local text symbol.
  - U Undefined symbol.
Value of the symbol

The size associated with the symbol, if applicable

This information may be supplemented by additional information specific to the implementation.

If the −P option is specified, the previous information shall be displayed using the following portable format. The three versions differ depending on whether −t d, −t o, or −t x was specified, respectively:

- d

    "%s%s %d %d\n", <library/object name>, <name>, <type>,
    <value>, <size>

- o

    "%s%s %o %o\n", <library/object name>, <name>, <type>,
    <value>, <size>

- x

    "%s%s %x %x\n", <library/object name>, <name>, <type>,
    <value>, <size>

where <library/object name> shall be formatted as follows:

- If −A is not specified, <library/object name> shall be an empty string.

- If −A is specified and the corresponding file operand does not name a library:

    "%s: \n", <file>

- If −A is specified and the corresponding file operand names a library. In this case, <object file> shall name the object file in the library containing the symbol being described:

    "%s[%s]: \n", <file>, <object file>

If −A is not specified, then if more than one file operand is specified or if only one file operand is specified and it names a library, nm shall write a line identifying the object containing the following symbols before the lines containing those symbols, in the form:

- If the corresponding file operand does not name a library:

    "%s:\n", <file>

- If the corresponding file operand names a library; in this case, <object file> shall be the name of the file in the library containing the following symbols:

    "%s[%s]:\n", <file>, <object file>

If −P is specified, but −t is not, the format shall be as if −t x had been specified.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.
CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Mechanisms for dynamic linking make this utility less meaningful when applied to an executable file because a dynamically linked executable may omit numerous library routines that would be found in a statically linked executable.

EXAMPLES

None.

RATIONALE

Historical implementations of nm have used different bases for numeric output and supplied different default types of symbols that were reported. The \(-t\) format option, similar to that used in od and strings, can be used to specify the numeric base; \(-g\) and \(-u\) can be used to restrict the amount of output or the types of symbols included in the output.

The compromise of using \(-t\) format versus using \(-d\), \(-o\), and other similar options was necessary because of differences in the meaning of \(-o\) between implementations. The \(-o\) option from BSD has been provided here as \(-A\) to avoid confusion with the \(-o\) from System V (which has been provided here as \(-t\) and as \(-o\) on XSI-conformant systems).

The option list was significantly reduced from that provided by historical implementations.

The nm description is a subset of both the System V and BSD nm utilities with no specified default output.

It was recognized that mechanisms for dynamic linking make this utility less meaningful when applied to an executable file (because a dynamically linked executable file may omit numerous library routines that would be found in a statically linked executable file), but the value of nm during software development was judged to outweigh other limitations.

The default output format of nm is not specified because of differences in historical implementations. The \(-P\) option was added to allow some type of portable output format. After a comparison of the different formats used in SunOS, BSD, SVR3, and SVR4, it was decided to create one that did not match the current format of any of these four systems. The format devised is easy to parse by humans, easy to parse in shell scripts, and does not need to vary depending on locale (because no English descriptions are included). All of the systems currently have the information available to use this format.

The format given in nm STDOUT uses spaces between the fields, which may be any number of <blank>s required to align the columns. The single-character types were selected to match historical practice, and the requirement that implementation additions also be single characters made parsing the information easier for shell scripts.

FUTURE DIRECTIONS

None.

SEE ALSO

ar, c99

CHANGE HISTORY

First released in Issue 2.

Issue 6

This utility is marked as supported when both the User Portability Utilities option and the Software Development Utilities option are supported.
NAME
nohup — invoke a utility immune to hangups

SYNOPSIS
nohup utility [argument...]

DESCRIPTION
The nohup utility shall invoke the utility named by the utility operand with arguments supplied as the argument operands. At the time the named utility is invoked, the SIGHUP signal shall be set to be ignored.

If the standard output is a terminal, all output written by the named utility to its standard output shall be appended to the end of the file nohup.out in the current directory. If nohup.out cannot be created or opened for appending, the output shall be appended to the end of the file nohup.out in the directory specified by the HOME environment variable. If neither file can be created or opened for appending, utility shall not be invoked. If a file is created, the file's permission bits shall be set to S_IRUSR | S_IWUSR.

If the standard error is a terminal, all output written by the named utility to its standard error shall be redirected to the same file descriptor as the standard output.

OPTIONS
None.

OPERANDS
The following operands shall be supported:
utility The name of a utility that is to be invoked. If the utility operand names any of the special built-in utilities in Section 2.14 (on page 64), the results are undefined.
argument Any string to be supplied as an argument when invoking the utility named by the utility operand.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of nohup:
HOME Determine the pathname of the user's home directory; if the output file nohup.out cannot be created in the current directory, the nohup utility shall use the directory named by HOME to create the file.
LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
LC_MESSAGES Determine the locale that should be used to affect the format and contents of
Utilities

Diagnostic messages written to standard error.

XSI

NLSPATH

Determine the location of message catalogs for the processing of LC_MESSAGES.

PATH

Determine the search path that is used to locate the utility to be invoked. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

ASYNCHRONOUS EVENTS

The nohup utility shall take the standard action for all signals except that SIGHUP shall be ignored.

STDOUT

If the standard output is not a terminal, the standard output of nohup shall be the standard output generated by the execution of the utility specified by the operands. Otherwise, nothing shall be written to the standard output.

STDERR

If the standard output is a terminal, a message shall be written to the standard error, indicating the name of the file to which the output is being appended. The name of the file shall be either nohup.out or $HOME/nohup.out.

OUTPUT FILES

If the standard output is a terminal, all output written by the named utility to the standard output and standard error is appended to the file nohup.out, which is created if it does not already exist.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

126 The utility specified by utility was found but could not be invoked.

127 An error occurred in the nohup utility or the utility specified by utility could not be found.

Otherwise, the exit status of nohup shall be that of the utility specified by the utility operand.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

The command, env, nice, nohup, time, and xargs utilities have been specified to use exit code 127 if an error occurs so that applications can distinguish “failure to find a utility” from “invoked utility exited with an error indication”. The value 127 was chosen because it is not commonly used for other meanings; most utilities use small values for “normal error conditions” and the values above 128 can be confused with termination due to receipt of a signal. The value 126 was chosen in a similar manner to indicate that the utility could be found, but not invoked. Some scripts produce meaningful error messages differentiating the 126 and 127 cases. The distinction between exit codes 126 and 127 is based on KornShell practice that uses 127 when all attempts to exec the utility fail with [ENOENT], and uses 126 when any attempt to exec the utility fails for any other reason.

EXAMPLES

It is frequently desirable to apply nohup to pipelines or lists of commands. This can be done by placing pipelines and command lists in a single file; this file can then be invoked as a utility, and the nohup applies to everything in the file.
Alternatively, the following command can be used to apply `nohup` to a complex command:

```
nohup sh -c 'complex-command-line'
```

**RATIONALE**

The 4.3 BSD version ignores SIGTERM and SIGHUP, and if `.nohup.out` cannot be used, it fails instead of trying to use `$HOME/nohup.out`.

The `csh` utility has a built-in version of `nohup` that acts differently from the `nohup` defined in this volume of IEEE Std 1003.1-2001.

The term **utility** is used, rather than **command**, to highlight the fact that shell compound commands, pipelines, special built-ins, and so on, cannot be used directly. However, **utility** includes user application programs and shell scripts, not just the standard utilities.

Historical versions of the `nohup` utility use default file creation semantics. Some more recent versions use the permissions specified here as an added security precaution.

Some historical implementations ignore SIGQUIT in addition to SIGHUP; others ignore SIGTERM. An early proposal allowed, but did not require, SIGQUIT to be ignored. Several reviewers objected that `nohup` should only modify the handling of SIGHUP as required by this volume of IEEE Std 1003.1-2001.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 2 (on page 29), `sh`, the System Interfaces volume of IEEE Std 1003.1-2001, `signal()`

**CHANGE HISTORY**

First released in Issue 2.
NAME
od — dump files in various formats

SYNOPSIS
od [-v] [-A address_base] [-j skip] [-N count] [-t type_string] ...
file...

xsi
od [-bcdosx] [file] [[+]+offset[.] [b]]

DESCRIPTION
The od utility shall write the contents of its input files to standard output in a user-specified format.

OPTIONS
The od utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the order of presentation of the -t options and the -bcdosx options is significant.

The following options shall be supported:

-A address_base
Specify the input offset base. See the EXTENDED DESCRIPTION section. The application shall ensure that the address_base option-argument is a character. The characters 'd', 'o', and 'x' specify that the offset base shall be written in decimal, octal, or hexadecimal, respectively. The character 'n' specifies that the offset shall not be written.

-b
Interpret bytes in octal. This shall be equivalent to -t o1.

-c
Interpret bytes as characters specified by the current setting of the LC_CTYPE category. Certain non-graphic characters appear as C escapes: "NUL=\0", "BS=\b", "FF=\f", "NL=\n", "CR=\r", "HT=\t"; others appear as 3-digit octal numbers.

-d
Interpret words (two-byte units) in unsigned decimal. This shall be equivalent to -t u2.

-j skip
Jump over skip bytes from the beginning of the input. The od utility shall read or seek past the first skip bytes in the concatenated input files. If the combined input is not at least skip bytes long, the od utility shall write a diagnostic message to standard error and exit with a non-zero exit status.

By default, the skip option-argument shall be interpreted as a decimal number. With a leading 0x or 0X, the offset shall be interpreted as a hexadecimal number; otherwise, with a leading '0', the offset shall be interpreted as an octal number. Appending the character 'b', 'k', or 'm' to offset shall cause it to be interpreted as a multiple of 512, 1024, or 1048576 bytes, respectively. If the skip number is hexadecimal, any appended 'b' shall be considered to be the final hexadecimal digit.

-N count
Format no more than count bytes of input. By default, count shall be interpreted as a decimal number. With a leading 0x or 0X, count shall be interpreted as a hexadecimal number; otherwise, with a leading '0', it shall be interpreted as an octal number. If count bytes of input (after successfully skipping, if -j skip is specified) are not available, it shall not be considered an error; the od utility shall format the input that is available.
Utilities

Interpret words (two-byte units) in octal. This shall be equivalent to \texttt{-t o2}.

Interpret words (two-byte units) in signed decimal. This shall be equivalent to \texttt{-t d2}.

Specify one or more output types. See the EXTENDED DESCRIPTION section. The application shall ensure that the \texttt{type_string} option-argument is a string specifying the types to be used when writing the input data. The string shall consist of the type specification characters \texttt{a}, \texttt{c}, \texttt{d}, \texttt{f}, \texttt{o}, \texttt{u}, and \texttt{x}, specifying named character, character, signed decimal, floating point, octal, unsigned decimal, and hexadecimal, respectively. The type specification characters \texttt{d}, \texttt{f}, \texttt{o}, \texttt{u}, and \texttt{x} can be followed by an optional unsigned decimal integer that specifies the number of bytes to be transformed by each instance of the output type. The type specification character \texttt{f} can be followed by an optional \texttt{F}, \texttt{D}, or \texttt{L} indicating that the conversion should be applied to an item of type \texttt{float}, \texttt{double}, or \texttt{long double}, respectively. The type specification characters \texttt{d}, \texttt{o}, \texttt{u}, and \texttt{x} can be followed by an optional \texttt{C}, \texttt{S}, \texttt{I}, or \texttt{L} indicating that the conversion should be applied to an item of type \texttt{char}, \texttt{short}, \texttt{int}, or \texttt{long}, respectively. Multiple types can be concatenated within the same \texttt{type_string} and multiple \texttt{-t} options can be specified. Output lines shall be written for each type specified in the order in which the type specification characters are specified.

Write all input data. Without the \texttt{-v} option, any number of groups of output lines, which would be identical to the immediately preceding group of output lines (except for the byte offsets), shall be replaced with a line containing only an asterisk ('*').

Interpret words (two-byte units) in hexadecimal. This shall be equivalent to \texttt{-t x2}.

Multiple types can be specified by using multiple \texttt{-bcdostx} options. Output lines are written for each type specified in the order in which the types are specified.

The following operands shall be supported:

- \texttt{file} A pathname of a file to be read. If no \texttt{file} operands are specified, the standard input shall be used.

  If there are no more than two operands, none of the \texttt{-A}, \texttt{-j}, \texttt{-N}, or \texttt{-t} options is specified, and either of the following is true: the first character of the last operand is a plus sign ('+'), or there are two operands and the first character of the last operand is numeric; the last operand shall be interpreted as an offset operand on XSI-conformant systems. Under these conditions, the results are unspecified on systems that are not XSI-conformant systems.

- \texttt{[+]}\texttt{offset[.][b]} The \texttt{offset} operand specifies the offset in the file where dumping is to commence. This operand is normally interpreted as octal bytes. If '.' is appended, the offset shall be interpreted in decimal. If 'b' is appended, the offset shall be interpreted in units of 512 bytes.

The standard input shall be used only if no \texttt{file} operands are specified. See the INPUT FILES section.
INPUT FILES
The input files can be any file type.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of od:

- LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
- LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).
- LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
- LC_NUMERIC Determine the locale for selecting the radix character used when writing floating-point formatted output.
- XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT See the EXTENDED DESCRIPTION section.

STDERR The standard error shall be used only for diagnostic messages.

OUTPUT FILES None.

EXTENDED DESCRIPTION
The od utility shall copy sequentially each input file to standard output, transforming the input data according to the output types specified by the -t option or the -bcdosx options. If no output type is specified, the default output shall be as if -t oS had been specified.

The number of bytes transformed by the output type specifier c may be variable depending on the LC_CTYPE category.

The default number of bytes transformed by output type specifiers d, f, o, u, and x corresponds to the various C-language types as follows. If the c99 compiler is present on the system, these specifiers shall correspond to the sizes used by default in that compiler. Otherwise, these sizes may vary among systems that conform to IEEE Std 1003.1-2001.

- For the type specifier characters d, f, o, u, and x, the default number of bytes shall correspond to the size of the underlying implementation’s basic integer type. For these specifier characters, the implementation shall support values of the optional number of bytes to be converted corresponding to the number of bytes in the C-language types char, short, int, and long. These numbers can also be specified by an application as the characters ‘C’, ‘S’, ‘I’, and ‘L’, respectively. The implementation shall also support the values 1, 2, 4, and 8, even if it provides no C-Language types of those sizes. The implementation shall support the
decimal value corresponding to the C-language type long long. The byte order used when
interpreting numeric values is implementation-defined, but shall correspond to the order in
which a constant of the corresponding type is stored in memory on the system.

- For the type specifier character F, the default number of bytes shall correspond to the number
of bytes in the underlying implementation’s basic double precision floating-point data type.
The implementation shall support values of the optional number of bytes to be converted
corresponding to the number of bytes in the C-language types float, double, and long
double. These numbers can also be specified by an application as the characters ‘F’, ‘D’,
and ‘L’, respectively.

The type specifier character a specifies that bytes shall be interpreted as named characters from
the International Reference Version (IRV) of the ISO/IEC 646: 1991 standard. Only the least
significant seven bits of each byte shall be used for this type specification. Bytes with the values
listed in the following table shall be written using the corresponding names for those characters.

<table>
<thead>
<tr>
<th>Table 4-12 Named Characters in od</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
</tr>
<tr>
<td>\000</td>
</tr>
<tr>
<td>\004</td>
</tr>
<tr>
<td>\010</td>
</tr>
<tr>
<td>\014</td>
</tr>
<tr>
<td>\020</td>
</tr>
<tr>
<td>\024</td>
</tr>
<tr>
<td>\030</td>
</tr>
<tr>
<td>\034</td>
</tr>
<tr>
<td>\040</td>
</tr>
</tbody>
</table>

Note: The "\012" value may be written either as lf or nl.

The type specifier character c specifies that bytes shall be interpreted as characters specified by
the current setting of the LC_CTYPE locale category. Characters listed in the table in the Base
‘\f’, ‘\n’, ‘\r’, ‘\t’, ‘\v’) shall be written as the corresponding escape sequences, except
that backslash shall be written as a single backslash and a NUL shall be written as ‘\0’. Other
non-printable characters shall be written as one-three-digit octal number for each byte in the
character. If the size of a byte on the system is greater than nine bits, the format used for non-
printable characters is implementation-defined. Printable multi-byte characters shall be written
in the area corresponding to the first byte of the character; the two-character sequence "**" shall
be written in the area corresponding to each remaining byte in the character, as an
indication that the character is continued. When either the –j skip or –N count option is specified
along with the c type specifier, and this results in an attempt to start or finish in the middle of a
multi-byte character, the result is implementation-defined.

The input data shall be manipulated in blocks, where a block is defined as a multiple of the least
common multiple of the number of bytes transformed by the specified output types. If the least
common multiple is greater than 16, the results are unspecified. Each input block shall be
written as transformed by each output type, one per written line, in the order that the output
types were specified. If the input block size is larger than the number of bytes transformed by
the output type, the output type shall sequentially transform the parts of the input block, and
the output from each of the transformations shall be separated by one or more <blank>s.
If, as a result of the specification of the \(-N\) option or end-of-file being reached on the last input file, input data only partially satisfies an output type, the input shall be extended sufficiently with null bytes to write the last byte of the input.

Unless \(-A\) is specified, the first output line produced for each input block shall be preceded by the input offset, cumulative across input files, of the next byte to be written. The format of the input offset is unspecified; however, it shall not contain any <blank>s, shall start at the first character of the output line, and shall be followed by one or more <blank>s. In addition, the offset of the byte following the last byte written shall be written after all the input data has been processed, but shall not be followed by any <blank>s.

If no \(-A\) option is specified, the input offset base is unspecified.

EXIT STATUS
The following exit values shall be returned:

0 All input files were processed successfully.

>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
XSI-conformant applications are warned not to use filenames starting with ‘+’ or a first operand starting with a numeric character so that the old functionality can be maintained by implementations, unless they specify one of the \(-A\), \(-j\), or \(-N\) options. To guarantee that one of these filenames is always interpreted as a filename, an application could always specify the address base format with the \(-A\) option.

EXAMPLES
If a file containing 128 bytes with decimal values zero to 127, in increasing order, is supplied as standard input to the command:

\texttt{od \(-A\ d -t \ a\)}
on an implementation using an input block size of 16 bytes, the standard output, independent of the current locale setting, would be similar to:

\begin{verbatim}
0000000 nul soh stx etx eot enq ack bel bs ht nl vt ff cr so si
0000016 dle dc1 dc2 dc3 dc4 nak syn etb can em sub esc fs gs rs us
0000032 sp ! " # $ % & ' ( ) * + - . /
0000048 0 1 2 3 4 5 6 7 8 9 : ; < = > ?
0000064 @ A B C D E F G H I J K L M N O
0000080 P Q R S T U V W X Y Z [ \ ] ^ _
0000096 ` a b c d e f g h i j k l m n o
0000112 p q r s t u v w x y z { | } ~ del
0000128
\end{verbatim}

Note that this volume of IEEE Std 1003.1-2001 allows \texttt{nl} or \texttt{If} to be used as the name for the ISO/IEC 646:1991 standard IRV character with decimal value 10. The IRV names this character \texttt{If} (line feed), but traditional implementations have referred to this character as newline (\texttt{nl}) and the POSIX locale character set symbolic name for the corresponding character is a \texttt{<newline>}.

The command:

\texttt{od \(-A\ o \ -t\ o2x2x \ -N\ 18\)}
on a system with 32-bit words and an implementation using an input block size of 16 bytes could write 18 bytes in approximately the following format:
The command:
```
od -Ad -tf -t o4 -tx4 -N 24 -j 0x15
```
on a system with 64-bit doubles (for example, IEEE Std 754-1985 double precision floating-point format) would skip 21 bytes of input data and then write 24 bytes in approximately the following format:
```
0000000 1.00000000000000e+00 1.57350000000000e+01
07774000000 00000000000 10013674121 35341217270
3ff00000 0000000 402f3851 eb851eb8
000016 1.40668230000000e+02
10030312542 04370303230
40619562 23e18698
```
```
0000024
```

**RATIONALE**

The `od` utility went through several names in early proposals, including `hd`, `xd`, and most recently `hexdump`. There were several objections to all of these based on the following reasons:

- The `hd` and `xd` names conflicted with historical utilities that behaved differently.
- The `hexdump` description was much more complex than needed for a simple dump utility.
- The `od` utility has been available on all historical implementations and there was no need to create a new name for a utility so similar to the historical `od` utility.

The original reasons for not standardizing historical `od` were also fairly widespread. Those reasons are given below along with rationale explaining why the standard developers believe that this version does not suffer from the indicated problem:

- The BSD and System V versions of `od` have diverged, and the intersection of features provided by both does not meet the needs of the user community. In fact, the System V version only provides a mechanism for dumping octal bytes and `shorts`, signed and unsigned decimal `shorts`, hexadecimal `shorts`, and ASCII characters. BSD added the ability to dump `floats`, `doubles`, named ASCII characters, and octal, signed decimal, unsigned decimal, and hexadecimal `longs`. The version presented here provides more normalized forms for dumping bytes, `shorts`, `ints`, and `longs` in octal, signed decimal, unsigned decimal, and hexadecimal; `float`, `double`, and `long double`; and named ASCII as well as current locale characters.
- It would not be possible to come up with a compatible superset of the BSD and System V flags that met the requirements of the standard developers. The historical default `od` output is the specified default output of this utility. None of the option letters chosen for this version of `od` conflict with any of the options to historical versions of `od`.
- On systems with different sizes for `short`, `int`, and `long`, there was no way to ask for dumps of `ints`, even in the BSD version. Because of the way options are named, the name space could not be extended to solve these problems. This is why the `-t` option was added (with type specifiers more closely matched to the `printf()` formats used in the rest of this volume of
IEEE Std 1003.1-2001) and the optional field sizes were added to the c, e, o, u, and x type specifiers. It is also one of the reasons why the historical practice was not mandated as a required obsolete form of od. (Although the old versions of od are not listed as an obsolescent form, implementations are urged to continue to recognize the older forms for several more years.) The a, c, e, o, and x types match the meaning of the corresponding format characters in the historical implementations of od except for the default sizes of the fields converted. The d format is signed in this volume of IEEE Std 1003.1-2001 to match the printf( ) notation. (Historical versions of od used d as a synonym for u in this version. The System V implementation uses a for signed decimal; BSD uses i for signed decimal and a for null-terminated strings.) Other than d and u, all of the type specifiers match format characters in the historical BSD version of od.

The sizes of the C-language types char, short, int, long, float, double, and long double are used even though it is recognized that there may be zero or more than one compiler for the C language on an implementation and that they may use different sizes for some of these types. (For example, one compiler might use 2 bytes shorts, 2 bytes ints, and 4 bytes longs, while another compiler (or an option to the same compiler) uses 2 bytes shorts, 4 bytes ints, and 4 bytes longs.) Nonetheless, there has to be a basic size known by the implementation for these types, corresponding to the values reported by invocations of the getconf utility when called with system_var operands {CHAR_MAX}, {SHORT_MAX}, {INT_MAX}, and {ULONG_MAX} for the types char, short, int, and long, respectively. There are similar constants required by the ISO C standard, but not required by the System Interfaces volume of IEEE Std 1003.1-2001 or this volume of IEEE Std 1003.1-2001. They are {FLT_MANT_DIG}, {DBL_MANT_DIG}, and {LDBL_MANT_DIG} for the types float, double, and long double, respectively. If the optional c99 utility is provided by the implementation and used as specified by this volume of IEEE Std 1003.1-2001, these are the sizes that would be provided. If an option is used that specifies different sizes for these types, there is no guarantee that the od utility is able to interpret binary data output by such a program correctly.

This volume of IEEE Std 1003.1-2001 requires that the numeric values of these lengths be recognized by the od utility and that symbolic forms also be recognized. Thus, a conforming application can always look at an array of unsigned long data elements using od -t ul.

- The method of specifying the format for the address field based on specifying a starting offset in a file unnecessarily tied the two together. The -A option now specifies the address base and the -S option specifies a starting offset.
- It would be difficult to break the dependence on U.S. ASCII to achieve an internationalized utility. It does not seem to be any harder for od to dump characters in the current locale than it is for the ed or sed I commands. The c type specifier does this without difficulty and is completely compatible with the historical implementations of the c format character when the current locale uses a superset of the ISO/IEC 646:1991 standard as a codeset. The a type specifier (from the BSD a format character) was left as a portable means to dump ASCII (or more correctly ISO/IEC 646:1991 standard (IRV)) so that headers produced by pax could be deciphered even on systems that do not use the ISO/IEC 646:1991 standard as a subset of their base codeset.

The use of "***" as an indication of continuation of a multi-byte character in c specifier output was chosen based on seeing an implementation that uses this method. The continuation bytes have to be marked in a way that is not ambiguous with another single-byte or multi-byte character.

An early proposal used -S and -n, respectively, for the -j and -N options eventually selected. These were changed to avoid conflicts with historical implementations.
The original standard specified \texttt{−t o2} as the default when no output type was given. This was changed to \texttt{−t oS} (the length of a \texttt{short}) to accommodate a supercomputer implementation that historically used 64 bits as its default (and that defined shorts as 64 bits). This change should not affect conforming applications. The requirement to support lengths of 1, 2, and 4 was added at the same time to address an historical implementation that had no two-byte data types in its C compiler.

The use of a basic integer data type is intended to allow the implementation to choose a word size commonly used by applications on that architecture.

**FUTURE DIRECTIONS**

All option and operand interfaces marked as extensions may be withdrawn in a future version.

**SEE ALSO**

c99, sed

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

In the description of the \texttt{−c} option, the phrase “This is equivalent to \texttt{−t c}.” is deleted.

The FUTURE DIRECTIONS section is modified.

**Issue 6**

The \texttt{od} utility is changed to remove the assumption that \texttt{short} was a two-byte entity, as per the revisions in the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/33 is applied, correcting the examples which used an undefined \texttt{−n} option, which should have been \texttt{−N}.
NAME
paste — merge corresponding or subsequent lines of files

SYNOPSIS
paste [-s] [-d list] file...

DESCRIPTION
The paste utility shall concatenate the corresponding lines of the given input files, and write the resulting lines to standard output.

The default operation of paste shall concatenate the corresponding lines of the input files. The <newline> of every line except the line from the last input file shall be replaced with a <tab>.

If an end-of-file condition is detected on one or more input files, but not all input files, paste shall behave as though empty lines were read from the files on which end-of-file was detected, unless the −s option is specified.

OPTIONS

The following options shall be supported:

- −d list
  Unless a backslash character appears in list, each character in list is an element specifying a delimiter character. If a backslash character appears in list, the backslash character and one or more characters following it are an element specifying a delimiter character as described below. These elements specify one or more delimiters to use, instead of the default <tab>, to replace the <newline> of the input lines. The elements in list shall be used circularly; that is, when the list is exhausted the first element from the list is reused. When the −s option is specified:
  - The last <newline> in a file shall not be modified.
  - The delimiter shall be reset to the first element of list after each file operand is processed.

When the −s option is not specified:
  - The <newline>s in the file specified by the last file operand shall not be modified.
  - The delimiter shall be reset to the first element of list each time a line is processed from each file.

If a backslash character appears in list, it and the character following it shall be used to represent the following delimiter characters:

\n <newline>.
\t <tab>.
\\  Backslash character.
\0  Empty string (not a null character). If ‘\0’ is immediately followed by the character ‘x’, the character ‘X’, or any character defined by the LC_CTYPE digit keyword (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 7, Locale), the results are unspecified.

If any other characters follow the backslash, the results are unspecified.

- −s
  Concatenate all of the lines of each separate input file in command line order. The <newline> of every line except the last line in each input file shall be replaced with
the <tab>, unless otherwise specified by the −d option.

OPERANDS

The following operand shall be supported:

file A pathname of an input file. If ‘−’ is specified for one or more of the files, the
standard input shall be used; the standard input shall be read one line at a time,
circularly, for each instance of ‘−’. Implementations shall support pasting of at
least 12 file operands.

STDIN

The standard input shall be used only if one or more file operands is ‘−’. See the INPUT FILES
section.

INPUT FILES

The input files shall be text files, except that line lengths shall be unlimited.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of paste:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Concatenated lines of input files shall be separated by the <tab> (or other characters under the
control of the −d option) and terminated by a <newline>.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.
CONSEQUENCES OF ERRORS

If one or more input files cannot be opened when the −s option is not specified, a diagnostic message shall be written to standard error, but no output is written to standard output. If the −s option is specified, the paste utility shall provide the default behavior described in Section 1.11 (on page 20).

APPLICATION USAGE

When the escape sequences of the list option-argument are used in a shell script, they must be quoted; otherwise, the shell treats the ‘\’ as a special character.

Conforming applications should only use the specific backslash escaped delimiters presented in this volume of IEEE Std 1003.1-2001. Historical implementations treat ‘\x’, where ‘x’ is not in this list, as ‘x’, but future implementations are free to expand this list to recognize other common escapes similar to those accepted by printf and other standard utilities.

Most of the standard utilities work on text files. The cut utility can be used to turn files with arbitrary line lengths into a set of text files containing the same data. The paste utility can be used to create (or recreate) files with arbitrary line lengths. For example, if file contains long lines:

```
cut −b 1-500 −n file > file1
cut −b 501- −n file > file2
```

creates file1 (a text file) with lines no longer than 500 bytes (plus the <newline>) and file2 that contains the remainder of the data from file. Note that file2 is not a text file if there are lines in file that are longer than 500 + [LINE_MAX] bytes. The original file can be recreated from file1 and file2 using the command:

```
paste −d "\0" file1 file2 > file
```

The commands:

```
paste −d "\0" ...
paste −d "" ...
```

are not necessarily equivalent; the latter is not specified by this volume of IEEE Std 1003.1-2001 and may result in an error. The construct ‘\0’ is used to mean “no separator” because historical versions of paste did not follow the syntax guidelines, and the command:

```
paste −d"" ...
```

could not be handled properly by getopt().

EXAMPLES

1. Write out a directory in four columns:

```
ls | paste −−−−
```

2. Combine pairs of lines from a file into single lines:

```
paste −s −d "\t\n" file
```

RATIONALE

None.

FUTURE DIRECTIONS

None.
SEE ALSO
Section 1.11 (on page 20), cut, grep, pr

CHANGE HISTORY
First released in Issue 2.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
patch — apply changes to files

SYNOPSIS
patch [−bNR][c|e|n][−d dir][−D define][−i patchfile]
[−o outfile][−p num][−r rejectfile][file]

DESCRIPTION
The patch utility shall read a source (patch) file containing any of the three forms of difference
(diff) listings produced by the diff utility (normal, context, or in the style of ed) and apply those
differences to a file. By default, patch shall read from the standard input.

The patch utility shall attempt to determine the type of the diff listing, unless overruled by a −c,
−e, or −n option.

If the patch file contains more than one patch, patch shall attempt to apply each of them as if they
came from separate patch files. (In this case, the application shall ensure that the name of the
patch file is determinable for each diff listing.)

OPTIONS
The patch utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

−b Save a copy of the original contents of each modified file, before the differences are
applied, in a file of the same name with the suffix .orig appended to it. If the file
already exists, it shall be overwritten; if multiple patches are applied to the same
file, the .orig file shall be written only for the first patch. When the −o outfile option
is also specified, file.orig shall not be created but, if outfile already exists,
outfile.orig shall be created.

−c Interpret the patch file as a context difference (the output of the utility diff when
the −c or −C options are specified).

−d dir Change the current directory to dir before processing as described in the
EXTENDED DESCRIPTION section.

−D define Mark changes with one of the following C preprocessor constructs:

#define define
...
#undef

#define
...
#undef

optionally combined with the C preprocessor construct #else. If the patched file is
processed with the C preprocessor, where the macro define is defined, the output
shall contain the changes from the patch file; otherwise, the output shall not
contain the patches specified in the patch file.

−e Interpret the patch file as an ed script, rather than a diff script.

−i patchfile Read the patch information from the file named by the pathname patchfile, rather
than the standard input.
(The letter ell.) Cause any sequence of <blank>s in the difference script to match any sequence of <blank>s in the input file. Other characters shall be matched exactly.

Interpret the script as a normal difference.

Ignore patches where the differences have already been applied to the file; by default, already-applied patches shall be rejected.

Instead of modifying the files (specified by the file operand or the difference listings) directly, write a copy of the file referenced by each patch, with the appropriate differences applied, to outfile. Multiple patches for a single file shall be applied to the intermediate versions of the file created by any previous patches, and shall result in multiple, concatenated versions of the file being written to outfile.

For all pathnames in the patch file that indicate the names of files to be patched, delete num pathname components from the beginning of each pathname. If the pathname in the patch file is absolute, any leading slashes shall be considered the first component (that is, −p 1 shall remove the leading slashes). Specifying −p 0 shall cause the full pathname to be used. If −p is not specified, only the basename (the final pathname component) shall be used.

Reverse the sense of the patch script; that is, assume that the difference script was created from the new version to the old version. The −R option cannot be used with ed scripts. The patch utility shall attempt to reverse each portion of the script before applying it. Rejected differences shall be saved in swapped format. If this option is not specified, and until a portion of the patch file is successfully applied, patch attempts to apply each portion in its reversed sense as well as in its normal sense. If the attempt is successful, the user shall be prompted to determine whether the −R option should be set.

Override the default reject filename. In the default case, the reject file shall have the same name as the output file, with the suffix .rej appended to it; see Patch Application (on page 694).

The following operand shall be supported:

file A pathname of a file to patch.

See the INPUT FILES section.

Input files shall be text files.

The following environment variables shall affect the execution of patch:

Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

If set to a non-empty string value, override the values of all the other internationalization variables.
Utilities

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

LC_TIME  Determine the locale for recognizing the format of file timestamps written by the diff utility in a context-difference input file.

ASYNCHRONOUS EVENTS

Default.

STDOUT  Not used.

STDERR  The standard error shall be used for diagnostic and informational messages.

OUTPUT FILES  The output of the patch utility, the save files (.orig suffixes), and the reject files (.rej suffixes) shall be text files.

EXTENDED DESCRIPTION

A patch file may contain patching instructions for more than one file; filenames shall be determined as specified in Filename Determination (on page 694). When the -b option is specified, for each patched file, the original shall be saved in a file of the same name with the suffix .orig appended to it.

For each patched file, a reject file may also be created as noted in Patch Application (on page 694). In the absence of a -r option, the name of this file shall be formed by appending the suffix .rej to the original filename.

Patch File Format

The patch file shall contain zero or more lines of header information followed by one or more patches. Each patch shall contain zero or more lines of filename identification in the format produced by diff -c, and one or more sets of diff output, which are customarily called hunks.

The patch utility shall recognize the following expression in the header information:

Index: pathname

The file to be patched is named pathname.

If all lines (including headers) within a patch begin with the same leading sequence of <blank>s, the patch utility shall remove this sequence before proceeding. Within each patch, if the type of difference is context, the patch utility shall recognize the following expressions:

*** filename timestamp

The patches arose from filename.

--- filename timestamp

The patches should be applied to filename.

Each hunk within a patch shall be the diff output to change a line range within the original file.

The line numbers for successive hunks within a patch shall occur in ascending order.
Filename Determination

If no file operand is specified, `patch` shall perform the following steps to determine the filename to use:

1. If the type of diff is context, the `patch` utility shall delete pathname components (as specified by the `-p` option) from the filename on the line beginning with "***", then test for the existence of this file relative to the current directory (or the directory specified with the `-d` option). If the file exists, the `patch` utility shall use this filename.

2. If the type of diff is context, the `patch` utility shall delete the pathname components (as specified by the `-p` option) from the filename on the line beginning with "---", then test for the existence of this file relative to the current directory (or the directory specified with the `-d` option). If the file exists, the `patch` utility shall use this filename.

3. If the header information contains a line beginning with the string `Index:`, the `patch` utility shall delete pathname components (as specified by the `-p` option) from this line, then test for the existence of this file relative to the current directory (or the directory specified with the `-d` option). If the file exists, the `patch` utility shall use this filename.

4. If an SCCS directory exists in the current directory, `patch` shall attempt to perform a `get -e SCCS/s.filename` command to retrieve an editable version of the file. If the file exists, the `patch` utility shall use this filename.

5. The `patch` utility shall write a prompt to standard output and request a filename interactively from the controlling terminal (for example, `/dev/tty`).

Patch Application

If the `-c`, `-e`, or `-n` option is present, the `patch` utility shall interpret information within each hunk as a context difference, an ed difference, or a normal difference, respectively. In the absence of any of these options, the `patch` utility shall determine the type of difference based on the format of information within the hunk.

For each hunk, the `patch` utility shall begin to search for the place to apply the patch at the line number at the beginning of the hunk, plus or minus any offset used in applying the previous hunk. If lines matching the hunk context are not found, `patch` shall scan both forwards and backwards at least 1 000 bytes for a set of lines that match the hunk context.

If no such place is found and it is a context difference, then another scan shall take place, ignoring the first and last line of context. If that fails, the first two and last two lines of context shall be ignored and another scan shall be made. Implementations may search more extensively for installation locations.

If no location can be found, the `patch` utility shall append the hunk to the reject file. The rejected hunk shall be written in context-difference format regardless of the format of the patch file. If the input was a normal or ed-style difference, the reject file may contain differences with zero lines of context. The line numbers on the hunks in the reject file may be different from the line numbers in the patch file since they shall reflect the approximate locations for the failed hunks in the new file rather than the old one.

If the type of patch is an ed diff, the implementation may accomplish the patching by invoking the ed utility.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.
One or more lines were written to a reject file.

An error occurred.

**CONSEQUENCES OF ERRORS**

Patches that cannot be correctly placed in the file shall be written to a reject file.

**APPLICATION USAGE**

The `−R` option does not work with `ed` scripts because there is too little information to reconstruct the reverse operation.

The `−p` option makes it possible to customize a patch file to local user directory structures without manually editing the patch file. For example, if the filename in the patch file was:

```
/curds/whey/src/blurfl/blurfl.c
```

Setting `−p 0` gives the entire pathname unmodified; `−p 1` gives:

```
curds/whey/src/blurfl/blurfl.c
```

without the leading slash, `−p 4` gives:

```
blurfl/blurfl.c
```

and not specifying `−p` at all gives:

```
blurfl.c
```

**EXAMPLES**

None.

**RATIONALE**

Some of the functionality in historical `patch` implementations was not specified. The following documents those features present in historical implementations that have not been specified.

A deleted piece of functionality was the `′+′` pseudo-option allowing an additional set of options and a patch file operand to be given. This was seen as being insufficiently useful to standardize.

In historical implementations, if the string "Prereq:" appeared in the header, the `patch` utility would search for the corresponding version information (the string specified in the header, delimited by `<blank>`s or the beginning or end of a line or the file) anywhere in the original file. This was deleted as too simplistic and insufficiently trustworthy a mechanism to standardize.

For example, if:

```
Prereq: 1.2
```

were in the header, the presence of a delimited 1.2 anywhere in the file would satisfy the prerequisite.

The following options were dropped from historical implementations of `patch` as insufficiently useful to standardize:

- `−b`
  
  The `−b` option historically provided a method for changing the name extension of the backup file from the default `.orig`. This option has been modified and retained in this volume of IEEE Std 1003.1-2001.

- `−F`
  
  The `−F` option specified the number of lines of a context diff to ignore when searching for a place to install a patch.

- `−f`
  
  The `−f` option historically caused `patch` not to request additional information from the user.
The `−r` option historically provided a method of overriding the extension of the reject file from the default `.rej`.

The `−s` option historically caused `patch` to work silently unless an error occurred.

The `−x` option historically set internal debugging flags.

In some file system implementations, the saving of a `.orig` file may produce unwanted results. In the case of 12, 13, or 14-character filenames (on file systems supporting 14-character maximum filenames), the `.orig` file overwrites the new file. The reject file may also exceed this filename limit. It was suggested, due to some historical practice, that a tilde (`˜`) suffix be used instead of `.orig` and some other character instead of the `.rej` suffix. This was rejected because it is not obvious to the user which file is which. The suffixes `.orig` and `.rej` are clearer and more understandable.

The `−b` option has the opposite sense in some historical implementations—do not save the `.orig` file. The default case here is not to save the files, making `patch` behave more consistently with the other standard utilities.

The `−w` option in early proposals was changed to `−l` to match historical practice.

The `−N` option was included because without it, a non-interactive application cannot reject previously applied patches. For example, if a user is piping the output of `diff` into the `patch` utility, and the user only wants to patch a file to a newer version non-interactively, the `−N` option is required.

Changes to the `−l` option description were proposed to allow matching across `<newline>`s in addition to just `<blank>`s. Since this is not historical practice, and since some ambiguities could result, it is suggested that future developments in this area utilize another option letter, such as `−L`.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`ed`, `diff`

**CHANGE HISTORY**

First released in Issue 4.

**Issue 5**

The FUTURE DIRECTIONS section is added.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The description of the `−D` option and the steps in `Filename Determination` (on page 694) are changed to match historical practice as defined in the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/34 is applied, clarifying the way that the `patch` utility performs `ifdef` selection for the `−D` option.
NAME
pathchk — check pathnames

SYNOPSIS
pathchk [−p] pathname...

DESCRIPTION
The pathchk utility shall check that one or more pathnames are valid (that is, they could be used
to access or create a file without causing syntax errors) and portable (that is, no filename
truncation results). More extensive portability checks are provided by the −p option.

By default, the pathchk utility shall check each component of each pathname operand based on the
underlying file system. A diagnostic shall be written for each pathname operand that:

• Is longer than {PATH_MAX} bytes (see Pathname Variable Values in the Base Definitions
volume of IEEE Std 1003.1-2001, Chapter 13, Headers, <limits.h>)
• Contains any component longer than {NAME_MAX} bytes in its containing directory
• Contains any component in a directory that is not searchable
• Contains any character in any component that is not valid in its containing directory

The format of the diagnostic message is not specified, but shall indicate the error detected and
the corresponding pathname operand.

It shall not be considered an error if one or more components of a pathname operand do not exist
as long as a file matching the pathname specified by the missing components could be created
that does not violate any of the checks specified above.

OPTIONS
The pathchk utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following option shall be supported:

−p Instead of performing checks based on the underlying file system, write a
diagnostic for each pathname operand that:

• Is longer than {_POSIX_PATH_MAX} bytes (see Minimum Values in the Base
Definitions volume of IEEE Std 1003.1-2001, Chapter 13, Headers, <limits.h>)
• Contains any component longer than {_POSIX_NAME_MAX} bytes
• Contains any character in any component that is not in the portable filename
character set

OPERANDS
The following operand shall be supported:

pathname A pathname to be checked.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of pathchk:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**NLSPATH**

Determine the location of message catalogs for the processing of `LC_MESSAGES`.

### ASYNCHRONOUS EVENTS

**STDOUT**

Not used.

**STDERR**

The standard error shall be used only for diagnostic messages.

### OUTPUT FILES

**None.**

### EXTENDED DESCRIPTION

**None.**

### EXIT STATUS

The following exit values shall be returned:

- **0**: All `pathname` operands passed all of the checks.
- **>0**: An error occurred.

### CONSEQUENCES OF ERRORS

**Default.**

### APPLICATION USAGE

The `test` utility can be used to determine whether a given pathname names an existing file; it does not, however, give any indication of whether or not any component of the pathname was truncated in a directory where the `_POSIX_NO_TRUNC` feature is not in effect. The `pathchk` utility does not check for file existence; it performs checks to determine whether a pathname does exist or could be created with no pathname component truncation.

The `noclobber` option in the shell (see the `set` special built-in) can be used to atomically create a file. As with all file creation semantics in the System Interfaces volume of IEEE Std 1003.1-2001, it guarantees atomic creation, but still depends on applications to agree on conventions and cooperate on the use of files after they have been created.

### EXAMPLES

To verify that all pathnames in an imported data interchange archive are legitimate and unambiguous on the current system:

```
pax -f archive | sed -e '/ == .*/s///' | xargs pathchk
if [ $? -eq 0 ]
  then
    pax -r -f archive
```
else
    echo Investigate problems before importing files.
    exit 1
fi

To verify that all files in the current directory hierarchy could be moved to any system
conforming to the System Interfaces volume of IEEE Std 1003.1-2001 that also supports the `pax`
utility:

```bash
find . -print | xargs pathchk -p
if [ $? -eq 0 ]
    then
      pax -w -f archive .
    else
      echo Portable archive cannot be created.
      exit 1
fi
```

To verify that a user-supplied pathname names a readable file and that the application can create
a file extending the given path without truncation and without overwriting any existing file:

```bash
case $-
    *C*) reset="";;
    *) reset="set +C"
    set -C;;
esac

```

test -r "$path" && pathchk "$path.out" &&
    rm "$path.out" > "$path.out"

if [ $? -ne 0 ]; then
    printf "%s: %s not found or %s.out fails \n creation checks.\n" $0 "$path" "$path"
    $reset # Reset the noclobber option in case a trap
    # on EXIT depends on it.
else
    exit 1
fi

$reset

PROCESSING < "$path" > "$path.out"

The following assumptions are made in this example:

1. **PROCESSING** represents the code that is used by the application to use `$path` once it is
   verified that `$path.out` works as intended.

2. The state of the `noclobber` option is unknown when this code is invoked and should be set
   on exit to the state it was in when this code was invoked. (The `reset` variable is used in this
   example to restore the initial state.)

3. Note the usage of:
   ```bash
   rm "$path.out" > "$path.out"
   ```
   a. The `pathchk` command has already verified, at this point, that `$path.out` is not
      truncated.
   b. With the `noclobber` option set, the shell verifies that `$path.out` does not already exist
      before invoking `rm`. 
c. If the shell succeeded in creating $path.out, rm removes it so that the application can create the file again in the PROCESSING step.

d. If the PROCESSING step wants the file to exist already when it is invoked, the:

   rm "$path.out" > "$path.out"

   should be replaced with:

   > "$path.out"

   which verifies that the file did not already exist, but leaves $path.out in place for use by PROCESSING.

RATIONALE

The pathchk utility was new for the ISO POSIX-2:1993 standard. It, along with the set –C(noclobber) option added to the shell, replaces the mkttemp, validfnam, and create utilities that appeared in early proposals. All of these utilities were attempts to solve several common problems:

- Verify the validity (for several different definitions of “valid”) of a pathname supplied by a user, generated by an application, or imported from an external source.

- Atomically create a file.

- Perform various string handling functions to generate a temporary filename.

The create utility, included in an early proposal, provided checking and atomic creation in a single invocation of the utility; these are orthogonal issues and need not be grouped into a single utility. Note that the noclobber option also provides a way of creating a lock for process synchronization; since it provides an atomic create, there is no race between a test for existence and the following creation if it did not exist.

Having a function like tmpnam() in the ISO C standard is important in many high-level languages. The shell programming language, however, has built-in string manipulation facilities, making it very easy to construct temporary filenames. The names needed obviously depend on the application, but are frequently of a form similar to:

$TMPDIR/application_abbreviation$$ .suffix

In cases where there is likely to be contention for a given suffix, a simple shell for or while loop can be used with the shell noclobber option to create a file without risk of collisions, as long as applications trying to use the same filename name space are cooperating on the use of files after they have been created.

FUTURE DIRECTIONS

None.

SEE ALSO

Section 2.7 (on page 43), set (on page 86), test

CHANGE HISTORY

First released in Issue 4.
NAME
pax — portable archive interchange

SYNOPSIS
pax [-cdnv] [-H|−L] [-f archive] [−s replstr]...[pattern...]
pax −r[−cdiknuv] [-H|−L] [-f archive] [−o options]...[−p string]...
 [−s replstr]...[pattern...]
pax −w[−dituvX] [-H|−L] [−b blocksize] [−a] [−f archive] [−o options]...
 [−s replstr]...[−x format][file...]
pax −x −w[−diklntuvX] [-H|−L] [−p string]...[−s replstr]...
 [file...] directory

DESCRIPTION
The pax utility shall read, write, and write lists of the members of archive files and copy
directory hierarchies. A variety of archive formats shall be supported; see the −x format option.
The action to be taken depends on the presence of the −r and −w options. The four combinations
of −r and −w are referred to as the four modes of operation: list, read, write, and copy modes,
corresponding respectively to the four forms shown in the SYNOPSIS section.

list
In list mode (when neither −r nor −w are specified), pax shall write the names of
the members of the archive file read from the standard input, with pathnames
matching the specified patterns, to standard output. If a named file is of type
directory, the file hierarchy rooted at that file shall be listed as well.

read
In read mode (when −r is specified, but −w is not), pax shall extract the members of
the archive file read from the standard input, with pathnames matching the
specified patterns. If an extracted file is of type directory, the file hierarchy rooted
at that file shall be extracted as well. The extracted files shall be created performing
pathname resolution with the directory in which pax was invoked as the current
working directory.

If an attempt is made to extract a directory when the directory already exists, this
shall not be considered an error. If an attempt is made to extract a FIFO when the
FIFO already exists, this shall not be considered an error.
The ownership, access, and modification times, and file mode of the restored files
are discussed under the −p option.

write
In write mode (when −w is specified, but −r is not), pax shall write the contents of
the file operands to the standard output in an archive format. If no file operands are
specified, a list of files to copy, one per line, shall be read from the standard input.
A file of type directory shall include all of the files in the file hierarchy rooted at the
file.

copy
In copy mode (when both −r and −w are specified), pax shall copy the file operands
to the destination directory.

If no file operands are specified, a list of files to copy, one per line, shall be read
from the standard input. A file of type directory shall include all of the files in the
file hierarchy rooted at the file.
The effect of the copy shall be as if the copied files were written to an archive file
and then subsequently extracted, except that there may be hard links between the
original and the copied files. If the destination directory is a subdirectory of one of
the files to be copied, the results are unspecified. If the destination directory is a
file of a type not defined by the System Interfaces volume of IEEE Std 1003.1-2001, the results are implementation-defined; otherwise, it shall be an error for the file named by the directory operand not to exist, not be writable by the user, or not be a file of type directory.

In read or copy modes, if intermediate directories are necessary to extract an archive member, pax shall perform actions equivalent to the mkdir() function defined in the System Interfaces volume of IEEE Std 1003.1-2001, called with the following arguments:

- The intermediate directory used as the path argument
- The value of the bitwise-inclusive OR of S_IRWXU, S_IRWXG, and S_IRWXO as the mode argument

If any specified pattern or file operands are not matched by at least one file or archive member, pax shall write a diagnostic message to standard error for each one that did not match and exit with a non-zero exit status.

The archive formats described in the EXTENDED DESCRIPTION section shall be automatically detected on input. The default output archive format shall be implementation-defined.

A single archive can span multiple files. The pax utility shall determine, in an implementation-defined manner, what file to read or write as the next file.

If the selected archive format supports the specification of linked files, it shall be an error if these files cannot be linked when the archive is extracted. For archive formats that do not store file contents with each name that causes a hard link, if the file that contains the data is not extracted during this pax session, either the data shall be restored from the original file, or a diagnostic message shall be displayed with the name of a file that can be used to extract the data. In traversing directories, pax shall detect infinite loops; that is, entering a previously visited directory that is an ancestor of the last file visited. When it detects an infinite loop, pax shall write a diagnostic message to standard error and shall terminate.

OPTIONS
The pax utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the order of presentation of the -o, -p, and -s options is significant.

The following options shall be supported:

- Read an archive file from standard input.
- Write files to the standard output in the specified archive format.
- Append files to the end of the archive. It is implementation-defined which devices on the system support appending. Additional file formats unspecified by this volume of IEEE Std 1003.1-2001 may impose restrictions on appending.
- Block the output at a positive decimal integer number of bytes per write to the archive file. Devices and archive formats may impose restrictions on blocking. Blocking shall be automatically determined on input. Conforming applications shall not specify a blocksize value larger than 32 256. Default blocking when creating archives depends on the archive format. (See the -x option below.)
- Match all file or archive members except those specified by the pattern or file operands.
- Cause files of type directory being copied or archived or archive members of type directory being extracted or listed to match only the file or archive member itself and not the file hierarchy rooted at the file.
Utilities

Specify the pathname of the input or output archive, overriding the default standard input (in list or read modes) or standard output (write mode).

- H If a symbolic link referencing a file of type directory is specified on the command line, pax shall archive the file hierarchy rooted in the file referenced by the link, using the name of the link as the root of the file hierarchy. Otherwise, if a symbolic link referencing a file of any other file type which pax can normally archive is specified on the command line, then pax shall archive the file referenced by the link, using the name of the link. The default behavior shall be to archive the symbolic link itself.

- i Interactively rename files or archive members. For each archive member matching a pattern operand or file matching a file operand, a prompt shall be written to the file /dev/tty. The prompt shall contain the name of the file or archive member, but the format is otherwise unspecified. A line shall then be read from /dev/tty. If this line is blank, the file or archive member shall be skipped. If this line consists of a single period, the file or archive member shall be processed with no modification to its name. Otherwise, its name shall be replaced with the contents of the line. The pax utility shall immediately exit with a non-zero exit status if end-of-file is encountered when reading a response or if /dev/tty cannot be opened for reading and writing.

The results of extracting a hard link to a file that has been renamed during extraction are unspecified.

- k Prevent the overwriting of existing files.

- l (The letter ell.) In copy mode, hard links shall be made between the source and destination file hierarchies whenever possible. If specified in conjunction with -H or -L, when a symbolic link is encountered, the hard link created in the destination file hierarchy shall be to the file referenced by the symbolic link. If specified when neither -H nor -L is specified, when a symbolic link is encountered, the implementation shall create a hard link to the symbolic link in the source file hierarchy or copy the symbolic link to the destination.

- L If a symbolic link referencing a file of type directory is specified on the command line or encountered during the traversal of a file hierarchy, pax shall archive the file hierarchy rooted in the file referenced by the link, using the name of the link as the root of the file hierarchy. Otherwise, if a symbolic link referencing a file of any other file type which pax can normally archive is specified on the command line or encountered during the traversal of a file hierarchy, pax shall archive the file referenced by the link, using the name of the link. The default behavior shall be to archive the symbolic link itself.

- n Select the first archive member that matches each pattern operand. No more than one archive member shall be matched for each pattern (although members of type directory shall still match the file hierarchy rooted at that file).

- o options Provide information to the implementation to modify the algorithm for extracting or writing files. The value of options shall consist of one or more comma-separated keywords of the form:

keyword[[:]=value][,keyword[[:]=value], ...]

Some keywords apply only to certain file formats, as indicated with each description. Use of keywords that are inapplicable to the file format being processed produces undefined results.
Keywords in the options argument shall be a string that would be a valid portable
filename as described in the Base Definitions volume of IEEE Std 1003.1-2001,
Section 3.276, Portable Filename Character Set.

**Note:** Keywords are not expected to be filenames, merely to follow the same character
composition rules as portable filenames.

Keywords can be preceded with white space. The value field shall consist of zero or
more characters; within value, the application shall precede any literal comma with
a backslash, which shall be ignored, but preserves the comma as part of value. A
comma as the final character, or a comma followed solely by white space as the
final characters, in options shall be ignored. Multiple -o options can be specified; if
keywords given to these multiple -o options conflict, the keywords and values
appearing later in command line sequence shall take precedence and the earlier
shall be silently ignored. The following keyword values of options shall be
supported for the file formats as indicated:

**delete=pattern**

(Applicable only to the -x pax format.) When used in write or copy mode, pax
shall omit from extended header records that it produces any keywords
matching the string pattern. When used in read or list mode, pax shall ignore
any keywords matching the string pattern in the extended header records. In
both cases, matching shall be performed using the pattern matching notation
described in Section 2.13.1 (on page 62) and Section 2.13.2 (on page 63). For
example:

```
-o delete=security.*
```

would suppress security-related information. See pax Extended Header (on
page 714) for extended header record keyword usage.

**exthdr.name=string**

(Applicable only to the -x pax format.) This keyword allows user control over
the name that is written into the ustar header blocks for the extended header
produced under the circumstances described in pax Header Block (on page
713). The name shall be the contents of string, after the following character
substitutions have been made:

<table>
<thead>
<tr>
<th>string Includes:</th>
<th>Replaced By:</th>
</tr>
</thead>
</table>
| %d               | The directory name of the file, equivalent to the result of the
dirname utility on the translated pathname. |
| %f               | The filename of the file, equivalent to the result of the
basename utility on the translated pathname. |
| %p               | The process ID of the pax process. |
| %%               | A ' % ' character. |

Any other ' % ' characters in string produce undefined results.

If no -o exthdr.name=string is specified, pax shall use the following default
value:

```
%d/PaxHeaders.%p/%f
```

**globexthdr.name=string**

(Applicable only to the -x pax format.) When used in write or copy mode
with the appropriate options, pax shall create global extended header records
with **ustar** header blocks that will be treated as regular files by previous versions of **pax**. This keyword allows user control over the name that is written into the **ustar** header blocks for global extended header records. The name shall be the contents of string, after the following character substitutions have been made:

<table>
<thead>
<tr>
<th><strong>string</strong></th>
<th><strong>Includes:</strong></th>
<th><strong>Replaced By:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>$n$</td>
<td>An integer that represents the sequence number of the global extended header record in the archive, starting at 1.</td>
<td></td>
</tr>
<tr>
<td>$p$</td>
<td>The process ID of the <strong>pax</strong> process.</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>A ‘%’ character.</td>
<td></td>
</tr>
</tbody>
</table>

Any other ‘%’ characters in **string** produce undefined results.

If no **−o globexthdr.name=string** is specified, **pax** shall use the following default value:

$\text{TMPDIR}/\text{GlobalHead}.%p.%n$

where $\text{TMPDIR}$ represents the value of the \text{TMPDIR} environment variable. If \text{TMPDIR} is not set, **pax** shall use /tmp.

**invalid=action**

(Applicable only to the **−x pax** format.) This keyword allows user control over the action **pax** takes upon encountering values in an extended header record that, in **read** or **copy** mode, are invalid in the destination hierarchy or, in **list** mode, cannot be written in the codeset and current locale of the implementation. The following are invalid values that shall be recognized by **pax**:

— In **read** or **copy** mode, a filename or link name that contains character encodings invalid in the destination hierarchy. (For example, the name may contain embedded NULs.)

— In **read** or **copy** mode, a filename or link name that is longer than the maximum allowed in the destination hierarchy (for either a pathname component or the entire pathname).

— In **list** mode, any character string value (filename, link name, user name, and so on) that cannot be written in the codeset and current locale of the implementation.

The following mutually-exclusive values of the **action** argument are supported:

**bypass**  
In **read** or **copy** mode, **pax** shall bypass the file, causing no change to the destination hierarchy. In **list** mode, **pax** shall write all requested valid values for the file, but its method for writing invalid values is unspecified.

**rename**  
In **read** or **copy** mode, **pax** shall act as if the **−i** option were in effect for each file with invalid filename or link name values, allowing the user to provide a replacement name interactively. In **list** mode, **pax** shall behave identically to the **bypass** action.

**UTF-8**  
When used in **read**, **copy**, or **list** mode and a filename, link name, owner name, or any other field in an extended header...
record cannot be translated from the \texttt{pax} UTF-8 codeset format to the codeset and current locale of the implementation, \texttt{pax} shall use the actual UTF-8 encoding for the name.

\texttt{write} \hspace{1cm} In \texttt{read} or \texttt{copy} mode, \texttt{pax} shall write the file, translating or truncating the name, regardless of whether this may overwrite an existing file with a valid name. In \texttt{list} mode, \texttt{pax} shall behave identically to the \texttt{bypass} action.

If no \texttt{−o invalid=} option is specified, \texttt{pax} shall act as if \texttt{−oinvalid=bypass} were specified. Any overwriting of existing files that may be allowed by the \texttt{−oinvalid=} actions shall be subject to permission (\texttt{−p}) and modification time (\texttt{−u}) restrictions, and shall be suppressed if the \texttt{−k} option is also specified.

\texttt{linkdata} \hspace{1cm} (Applicable only to the \texttt{−x pax} format.) In \texttt{write} mode, \texttt{pax} shall write the contents of a file to the archive even when that file is merely a hard link to a file whose contents have already been written to the archive.

\texttt{listopt=}\texttt{format} \hspace{1cm} This keyword specifies the output format of the table of contents produced when the \texttt{−v} option is specified in \texttt{list} mode. See \texttt{List Mode Format Specifications} (on page 709). To avoid ambiguity, the \texttt{listopt=}\texttt{format} shall be the only or final \texttt{keyword=}\texttt{value} pair in a \texttt{−o} option-argument; all characters in the remainder of the option-argument shall be considered part of the format string. When multiple \texttt{−olistopt=}\texttt{format} options are specified, the format strings shall be considered a single, concatenated string, evaluated in command line order.

\texttt{times} \hspace{1cm} (Applicable only to the \texttt{−x pax} format.) When used in \texttt{write} or \texttt{copy} mode, \texttt{pax} shall include \texttt{atime}, \texttt{ctime}, and \texttt{mtime} extended header records for each file. See \texttt{pax Extended Header File Times} (on page 717).

In addition to these keywords, if the \texttt{−x pax} format is specified, any of the keywords and values defined in \texttt{pax Extended Header} (on page 714), including implementation extensions, can be used in \texttt{−o} option-arguments, in either of two modes:

\texttt{keyword=}\texttt{value} \hspace{1cm} When used in \texttt{write} or \texttt{copy} mode, these keyword/value pairs shall be included at the beginning of the archive as \texttt{typeflag g} global extended header records. When used in \texttt{read} or \texttt{list} mode, these keyword/value pairs shall act as if they had been at the beginning of the archive as \texttt{typeflag g} global extended header records.

\texttt{keyword:=value} \hspace{1cm} When used in \texttt{write} or \texttt{copy} mode, these keyword/value pairs shall be included as records at the beginning of a \texttt{typeflag x} extended header for each file. (This shall be equivalent to the equal-sign form except that it creates no \texttt{typeflag g} global extended header records.) When used in \texttt{read} or \texttt{list} mode, these keyword/value pairs shall act as if they were included as records at the end of each extended header; thus, they shall override any global or file-specific extended header record keywords of the same names. For example, in the command:
pax -r -o "
gname:=mygroup,
" <archive

the group name will be forced to a new value for all files read from the
archive.

The precedence of -o keywords over various fields in the archive is described in
pax Extended Header Keyword Precedence (on page 717).

-p string
Specify one or more file characteristic options (privileges). The string option-
argument shall be a string specifying file characteristics to be retained or discarded
on extraction. The string shall consist of the specification characters a, e, m, o, and
p. Other implementation-defined characters can be included. Multiple
characteristics can be concatenated within the same string and multiple -p options
can be specified. The meaning of the specification characters are as follows:

a Do not preserve file access times.

e Preserve the user ID, group ID, file mode bits (see the Base Definitions volume
of IEEE Std 1003.1-2001, Section 3.168, File Mode Bits), access time,
modification time, and any other implementation-defined file characteristics.

m Do not preserve file modification times.

o Preserve the user ID and group ID.

p Preserve the file mode bits. Other implementation-defined file mode attributes
may be preserved.

In the preceding list, "preserve" indicates that an attribute stored in the archive
shall be given to the extracted file, subject to the permissions of the invoking
process. The access and modification times of the file shall be preserved unless
otherwise specified with the -p option or not stored in the archive. All attributes
that are not preserved shall be determined as part of the normal file creation action
(see Section 1.7.1.4 (on page 4)).

If neither the e nor the o specification character is specified, or the user ID and
group ID are not preserved for any reason, pax shall not set the S_ISUID and
S_ISGID bits of the file mode.

If the preservation of any of these items fails for any reason, pax shall write a
diagnostic message to standard error. Failure to preserve these items shall affect
the final exit status, but shall not cause the extracted file to be deleted.

If file characteristic letters in any of the string option-arguments are duplicated or
conflict with each other, the ones given last shall take precedence. For example, if
-p e m is specified, file modification times are preserved.

-s replstr
Modify file or archive member names named by pattern or file operands according
to the substitution expression replstr, using the syntax of the ed utility. The
concepts of "address" and "line" are meaningless in the context of the pax utility,
and shall not be supplied. The format shall be:

-s /old/new/[gp]

where as in ed, old is a basic regular expression and new can contain an ampersand,
\n (where n is a digit) backreferences, or subexpression matching. The old string
shall also be permitted to contain <newline>s.
Any non-null character can be used as a delimiter (‘/’ shown here). Multiple −s expressions can be specified; the expressions shall be applied in the order specified, terminating with the first successful substitution. The optional trailing ‘g’ is as defined in the ed utility. The optional trailing ‘p’ shall cause successful substitutions to be written to standard error. File or archive member names that substitute to the empty string shall be ignored when reading and writing archives.

−t When reading files from the file system, and if the user has the permissions required by utime() to do so, set the access time of each file read to the access time that it had before being read by pax.

−u Ignore files that are older (having a less recent file modification time) than a pre-existing file or archive member with the same name. In read mode, an archive member with the same name as a file in the file system shall be extracted if the archive member is newer than the file. In write mode, an archive file member with the same name as a file in the file system shall be superseded if the file is newer than the archive member. If −a is also specified, this is accomplished by appending to the archive; otherwise, it is unspecified whether this is accomplished by actual replacement in the archive or by appending to the archive. In copy mode, the file in the destination hierarchy shall be replaced by the file in the source hierarchy or by a link to the file in the source hierarchy if the file in the source hierarchy is newer.

−v In list mode, produce a verbose table of contents (see the STDOUT section). Otherwise, write archive member pathnames to standard error (see the STDERR section).

−x format Specify the output archive format. The pax utility shall support the following formats:

- cpio The cpio interchange format; see the EXTENDED DESCRIPTION section. The default blocksize for this format for character special archive files shall be 5120. Implementations shall support all blocksize values less than or equal to 32256 that are multiples of 512.

- pax The pax interchange format; see the EXTENDED DESCRIPTION section. The default blocksize for this format for character special archive files shall be 5120. Implementations shall support all blocksize values less than or equal to 32256 that are multiples of 512.

- ustar The tar interchange format; see the EXTENDED DESCRIPTION section. The default blocksize for this format for character special archive files shall be 10240. Implementations shall support all blocksize values less than or equal to 32256 that are multiples of 512.

Implementation-defined formats shall specify a default block size as well as any other block sizes supported for character special archive files.

Any attempt to append to an archive file in a format different from the existing archive format shall cause pax to exit immediately with a non-zero exit status.

In copy mode, if no −x format is specified, pax shall behave as if −xpax were specified.

−X When traversing the file hierarchy specified by a pathname, pax shall not descend into directories that have a different device ID (st_dev; see the System Interfaces volume of IEEE Std 1003.1-2001, stat()).
The options that operate on the names of files or archive members (−c, −i, −n, −s, −u, and −v) shall interact as follows. In read mode, the archive members shall be selected based on the user-specified pattern operands as modified by the −c, −n, and −u options. Then, any −s and −i options shall modify, in that order, the names of the selected files. The −v option shall write names resulting from these modifications.

In write mode, the files shall be selected based on the user-specified pathnames as modified by the −n and −u options. Then, any −s and −i options shall modify, in that order, the names of these selected files. The −v option shall write names resulting from these modifications.

If both the −u and −n options are specified, pax shall not consider a file selected unless it is newer than the file to which it is compared.

List Mode Format Specifications

In list mode with the −o listopt=format option, the format argument shall be applied for each selected file. The pax utility shall append a <newline> to the listopt output for each selected file. The format argument shall be used as the format string described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation, with the exceptions 1. through 5. defined in the EXTENDED DESCRIPTION section of printf, plus the following exceptions:

6. The sequence (keyword) can occur before a format conversion specifier. The conversion argument is defined by the value of keyword. The implementation shall support the following keywords:

   — Any of the Field Name entries in Table 4-13 (on page 718) and Table 4-15 (on page 721).
   The implementation may support the cpio keywords without the leading c_ in addition to the form required by Table 4-16 (on page 722).

   — Any keyword defined for the extended header in pax Extended Header (on page 714).

   — Any keyword provided as an implementation-defined extension within the extended header defined in pax Extended Header (on page 714).

For example, the sequence "%(charset)s" is the string value of the name of the character set in the extended header.

The result of the keyword conversion argument shall be the value from the applicable header field or extended header, without any trailing NULs.

All keyword values used as conversion arguments shall be translated from the UTF-8 encoding to the character set appropriate for the local file system, user database, and so on, as applicable.

7. An additional conversion specifier character, T, shall be used to specify time formats. The T conversion specifier character can be preceded by the sequence (keyword=subformat), where subformat is a date format as defined by date operands. The default keyword shall be mtime and the default subformat shall be:

   %b %e %H:%M %Y

8. An additional conversion specifier character, M, shall be used to specify the file mode string as defined in ls Standard Output. If (keyword) is omitted, the mode keyword shall be used. For example, %.1M writes the single character corresponding to the <entry type> field of the ls −l command.

9. An additional conversion specifier character, D, shall be used to specify the device for block or special files, if applicable, in an implementation-defined format. If not applicable, and (keyword) is specified, then this conversion shall be equivalent to % (keyword) u. If not
applicable, and \textit{(keyword)} is omitted, then this conversion shall be equivalent to \texttt{<space>}.

10. An additional conversion specifier character, \texttt{F}, shall be used to specify a pathname. The \texttt{F} conversion character can be preceded by a sequence of comma-separated keywords:

\begin{verbatim}
(keyword[,keyword] ...) \end{verbatim}

The values for all the keywords that are non-null shall be concatenated together, each separated by a \texttt{'}\texttt{/}'. The default shall be \texttt{(path)} if the keyword \texttt{path} is defined; otherwise, the default shall be \texttt{(prefix,name)}.

11. An additional conversion specifier character, \texttt{L}, shall be used to specify a symbolic line expansion. If the current file is a symbolic link, then \texttt{%L} shall expand to:

\begin{verbatim}
"%s \rightarrow %s", <value of keyword>, <contents of link> \end{verbatim}

Otherwise, the \texttt{%L} conversion specification shall be the equivalent of \texttt{%F}.

**OPERANDS**

- \texttt{directory} The destination directory pathname for \texttt{copy} mode.
- \texttt{file} A pathname of a file to be copied or archived.
- \texttt{pattern} A pattern matching one or more pathnames of archive members. A pattern must be given in the name-generating notation of the pattern matching notation in Section 2.13 (on page 62), including the filename expansion rules in Section 2.13.3 (on page 63). The default, if no \texttt{pattern} is specified, is to select all members in the archive.

**STDIN**

In \texttt{write} mode, the standard input shall be used only if no \texttt{file} operands are specified. It shall be a text file containing a list of pathnames, one per line, without leading or trailing \texttt{<blank>}s.

In \texttt{list} and \texttt{read} modes, if \texttt{−f} is not specified, the standard input shall be an archive file.

Otherwise, the standard input shall not be used.

**INPUT FILES**

The input file named by the \texttt{archive} option-argument, or standard input when the archive is read from there, shall be a file formatted according to one of the specifications in the EXTENDED DESCRIPTION section or some other implementation-defined format.

The file \texttt{/dev/tty} shall be used to write prompts and read responses.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of \texttt{pax}:

- \texttt{LANG} Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- \texttt{LC_ALL} If set to a non-empty string value, override the values of all the other internationalization variables.
- \texttt{LC_COLLATE} Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements used in the pattern matching expressions for the \texttt{pattern} operand, the basic regular expression for the \texttt{−s} option, and the extended regular expression defined for the \texttt{yesexpr} locale keyword in the \texttt{LC_MESSAGES}
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), the behavior of character classes used in the extended regular expression defined for the `yesexpr` locale keyword in the `LC_MESSAGES` category, and pattern matching.

`LC_MESSAGES` Determine the locale for the processing of affirmative responses that should be used to affect the format and contents of diagnostic messages written to standard error.

`LC_TIME` Determine the format and contents of date and time strings when the `−v` option is specified.

`NLSPATH` Determine the location of message catalogs for the processing of `LC_MESSAGES`.

`TMPDIR` Determine the pathname that provides part of the default global extended header record file, as described for the `−o globexthdr=` keyword in the OPTIONS section.

`TZ` Determine the timezone used to calculate date and time strings when the `−v` option is specified. If `TZ` is unset or null, an unspecified default timezone shall be used.

**ASYNCHRONOUS EVENTS**

`STDOUT` Default.

In `write` mode, if `−f` is not specified, the standard output shall be the archive formatted according to one of the specifications in the EXTENDED DESCRIPTION section, or some other implementation-defined format (see `−x format`).

In `list` mode, when the `−olistopt=fmt` has been specified, the selected archive members shall be written to standard output using the format described under List Mode Format Specifications (on page 709). In `list` mode without the `−olistopt=fmt` option, the table of contents of the selected archive members shall be written to standard output using the following format:

```
%s
```

If the `−v` option is specified in `list` mode, the table of contents of the selected archive members shall be written to standard output using the following formats.

For pathnames representing hard links to previous members of the archive:

```
%s==%s
```

For all other pathnames:

```
%s
```

where `ls −l listing>` shall be the format specified by the `ls` utility with the `−l` option. When writing pathnames in this format, it is unspecified what is written for fields for which the underlying archive format does not have the correct information, although the correct number of `<blank>-separated fields shall be written.

In `list` mode, standard output shall not be buffered more than a line at a time.
If −v is specified in read, write, or copy modes, pax shall write the pathnames it processes to the standard error output using the following format:

"%s
", <pathname>

These pathnames shall be written as soon as processing is begun on the file or archive member, and shall be flushed to standard error. The trailing <newline>, which shall not be buffered, is written when the file has been read or written.

If the −s option is specified, and the replacement string has a trailing ‘p’, substitutions shall be written to standard error in the following format:

"%s∆>∆%s
", <original pathname>, <new pathname>

In all operating modes of pax, optional messages of unspecified format concerning the input archive format and volume number, the number of files, blocks, volumes, and media parts as well as other diagnostic messages may be written to standard error.

In all formats, for both standard output and standard error, it is unspecified how non-printable characters in pathnames or link names are written.

When pax is in read mode or list mode, using the −xpax archive format, and a filename, link name, owner name, or any other field in an extended header record cannot be translated from the pax UTF-8 codeset format to the codeset and current locale of the implementation, pax shall write a diagnostic message to standard error, shall process the file as described for the −o invalid=option, and then shall process the next file in the archive.

In read mode, the extracted output files shall be of the archived file type. In copy mode, the copied output files shall be the type of the file being copied. In either mode, existing files in the destination hierarchy shall be overwritten only when all permission (−p), modification time (−u), and invalid-value (−oinvalid=) tests allow it.

In write mode, the output file named by the −f option-argument shall be a file formatted according to one of the specifications in the EXTENDED DESCRIPTION section, or some other implementation-defined format.

### EXTENDED DESCRIPTION

#### pax Interchange Format

A pax archive tape or file produced in the −xpax format shall contain a series of blocks. The physical layout of the archive shall be identical to the ustar format described in ustar Interchange Format (on page 717). Each file archived shall be represented by the following sequence:

- An optional header block with extended header records. This header block is of the form described in pax Header Block (on page 713), with a typeflag value of x or g. The extended header records, described in pax Extended Header (on page 714), shall be included as the data for this header block.
- A header block that describes the file. Any fields in the preceding optional extended header shall override the associated fields in this header block for this file.
- Zero or more blocks that contain the contents of the file.

At the end of the archive file there shall be two 512-byte blocks filled with binary zeros, interpreted as an end-of-archive indicator.
A schematic of an example archive with global extended header records and two actual files is shown in Figure 4-1. In the example, the second file in the archive has no extended header preceding it, presumably because it has no need for extended attributes.

```
| ustar Header [typeflag=g]                  | Global Extended Header |
| Global Extended Header Data               |                       |
| ustar Header [typeflag=x]                 | File 1: Extended Header is included |
| Extended Header Data                      | File 2: No Extended Header is included |
| ustar Header [typeflag=0]                 | End of Archive Indicator |
| Data for File 1                           |                         |
| ustar Header [typeflag=0]                 |                         |
| Data for File 2                           |                         |
| Block of binary zeros                     |                         |
| Block of binary zeros                     |                         |
```

**Figure 4-1** pax Format Archive Example

**pax Header Block**

The **pax** header block shall be identical to the **ustar** header block described in **ustar Interchange Format** on page 717, except that two additional **typeflag** values are defined:

- **x** Represents extended header records for the following file in the archive (which shall have its own **ustar** header block). The format of these extended header records shall be as described in **pax Extended Header** on page 714.

- **g** Represents global extended header records for the following files in the archive. The format of these extended header records shall be as described in **pax Extended Header** on page 714. Each value shall affect all subsequent files that do not override that value in their own extended header record and until another global extended header record is reached that provides another value for the same field. The **typeflag g** global headers should not be used with interchange media that could suffer partial data loss in transporting the archive.

For both of these types, the **size** field shall be the size of the extended header records in octets. The other fields in the header block are not meaningful to this version of the **pax** utility. However, if this archive is read by a **pax** utility conforming to the ISO POSIX-2:1993 standard, the header block fields are used to create a regular file that contains the extended header records as data. Therefore, header block field values should be selected to provide reasonable file access to this regular file.
A further difference from the ustar header block is that data blocks for files of typeflag 1 (the digit one) (hard link) may be included, which means that the size field may be greater than zero. Archives created by pax −o linkdata shall include these data blocks with the hard links.

pax Extended Header

A pax extended header contains values that are inappropriate for the ustar header block because of limitations in that format: fields requiring a character encoding other than that described in the ISO/IEC 646:1991 standard, fields representing file attributes not described in the ustar header, and fields whose format or length do not fit the requirements of the ustar header. The values in an extended header add attributes to the following file (or files; see the description of the typeflag g header block) or override values in the following header block(s), as indicated in the following list of keywords.

An extended header shall consist of one or more records, each constructed as follows:

"%d %s=%s\n", <length>, <keyword>, <value>

The extended header records shall be encoded according to the ISO/IEC 10646-1:2000 standard (UTF-8). The <length> field, <blank>, equals sign, and <newline> shown shall be limited to the portable character set, as encoded in UTF-8. The <keyword> and <value> fields can be any UTF-8 characters. The <length> field shall be the decimal length of the extended header record in octets, including the trailing <newline>.

The <keyword> field shall be one of the entries from the following list or a keyword provided as an implementation extension. Keywords consisting entirely of lowercase letters, digits, and periods are reserved for future standardization. A keyword shall not include an equals sign. (In the following list, the notations “file(s)” or “block(s)” is used to acknowledge that a keyword affects the following single file after a typeflag x extended header, but possibly multiple files after typeflag g. Any requirements in the list for pax to include a record when in write or copy mode shall apply only when such a record has not already been provided through the use of the −o option. When used in copy mode, pax shall behave as if an archive had been created with applicable extended header records and then extracted.)

- atime
  - The file access time for the following file(s), equivalent to the value of the st_atime member of the stat structure for a file, as described by the stat() function. The access time shall be restored if the process has the appropriate privilege required to do so. The format of the <value> shall be as described in pax Extended Header File Times (on page 717).

- charset
  - The name of the character set used to encode the data in the following file(s). The entries in the following table are defined to refer to known standards; additional names may be agreed on between the originator and recipient.
The encoding is included in an extended header for information only; when `pax` is used as described in IEEE Std 1003.1-2001, it shall not translate the file data into any other encoding. The **BINARY** entry indicates unencoded binary data.

When used in **write** or **copy** mode, it is implementation-defined whether `pax` includes a **charset** extended header record for a file.

<table>
<thead>
<tr>
<th><strong>&lt;value&gt;</strong></th>
<th><strong>Formal Standard</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO-IRA8859Δ8Δ1999</td>
<td>ISO/IEC 8859-8: 1999</td>
</tr>
<tr>
<td>ISO-IRA10646Δ2000ΔUTF-8</td>
<td>ISO/IEC 10646, UTF-8 encoding</td>
</tr>
<tr>
<td>BINARY</td>
<td>None.</td>
</tr>
</tbody>
</table>

The pathnamen of a link being created to another file, of any type, previously archived. This record shall override the **pathname** field in the following **ustar** header block(s). The following **ustar** header block shall determine the type of link created.
If `typeflag` of the following header block is 1, it shall be a hard link. If `typeflag` is 2, it shall be a symbolic link and the `linkpath` value shall be the contents of the symbolic link. The `pax` utility shall translate the name of the link (contents of the symbolic link) from the UTF-8 encoding to the character set appropriate for the local file system. When used in `write` or `copy` mode, `pax` shall include a `linkpath` extended header record for each link whose pathname cannot be represented entirely with the members of the portable character set other than NUL.

`mtime` The file modification time of the following file(s), equivalent to the value of the `st_mtime` member of the `stat` structure for a file, as described in the `stat()` function.

This record shall override the `mtime` field in the following header block(s). The modification time shall be restored if the process has the appropriate privilege required to do so. The format of the `<value>` shall be as described in `pax Extended Header File Times` (on page 717).

`path` The pathname of the following file(s). This record shall override the `name` and `prefix` fields in the following header block(s). The `pax` utility shall translate the pathname of the file from the UTF-8 encoding to the character set appropriate for the local file system.

When used in `write` or `copy` mode, `pax` shall include a `path` extended header record for each file whose pathname cannot be represented entirely with the members of the portable character set other than NUL.

`realtime.any` The keywords prefixed by "realtime." are reserved for future standardization.

`security.any` The keywords prefixed by "security." are reserved for future standardization.

`size` The size of the file in octets, expressed as a decimal number using digits from the ISO/IEC 646:1991 standard. This record shall override the `size` field in the following header block(s). When used in `write` or `copy` mode, `pax` shall include a `size` extended header record for each file with a size value greater than 8,589,934,591 (octal 77,777,777,777).

`uid` The user ID of the file owner, expressed as a decimal number using digits from the ISO/IEC 646:1991 standard. This record shall override the `uid` field in the following header block(s). When used in `write` or `copy` mode, `pax` shall include a `uid` extended header record for each file whose owner ID is greater than 2,097,151 (octal 7,777,777).

`uname` The owner of the following file(s), formatted as a user name in the user database.

This record shall override the `uid` and `uname` fields in the following header block(s), and any `uid` extended header record. When used in `read`, `copy`, or `list` mode, `pax` shall translate the name from the UTF-8 encoding in the header record to the character set appropriate for the user database on the receiving system. If any of the UTF-8 characters cannot be translated, and if the `−invalid=` UTF-8 option is not specified, the results are implementation-defined. When used in `write` or `copy` mode, `pax` shall include a `uname` extended header record for each file whose user name cannot be represented entirely with the letters and digits of the portable character set.

If the `<value>` field is zero length, it shall delete any header block field, previously entered extended header value, or global extended header value of the same name.

If a keyword in an extended header record (or in a `−o` option-argument) overrides or deletes a corresponding field in the `ustar` header block, `pax` shall ignore the contents of that header block field.
Unlike the *ustar* header block fields, NULs shall not delimit `<value>s; all characters within the `<value>` field shall be considered data for the field. None of the length limitations of the *ustar* header block fields in Table 4-13 (on page 718) shall apply to the extended header records.

**pax Extended Header Keyword Precedence**

This section describes the precedence in which the various header records and fields and command line options are selected to apply to a file in the archive. When *pax* is used in *read* or *list* modes, it shall determine a file attribute in the following sequence:

1. If `−odelete=keyword-prefix` is used, the affected attributes shall be determined from step 7., if applicable, or ignored otherwise.
2. If `−okeyword:=` is used, the affected attributes shall be ignored.
3. If `−okeyword:=value` is used, the affected attribute shall be assigned the value.
4. If there is a `typeflag x` extended header record, the affected attribute shall be assigned the `<value>`. When extended header records conflict, the last one given in the header shall take precedence.
5. If `−okeyword=value` is used, the affected attribute shall be assigned the value.
6. If there is a `typeflag g` global extended header record, the affected attribute shall be assigned the `<value>`. When global extended header records conflict, the last one given in the global header shall take precedence.
7. Otherwise, the attribute shall be determined from the *ustar* header block.

**pax Extended Header File Times**

The *pax* utility shall write an `mtime` record for each file in *write* or *copy* modes if the file’s modification time cannot be represented exactly in the *ustar* header logical record described in the *ustar Interchange Format*. This can occur if the time is out of *ustar* range, or if the file system of the underlying implementation supports non-integer time granularities and the time is not an integer. All of these time records shall be formatted as a decimal representation of the time in seconds since the Epoch. If a period (‘.’) decimal point character is present, the digits to the right of the point shall represent the units of a subsecond timing granularity, where the first digit is tenths of a second and each subsequent digit is a tenth of the previous digit. In *read* or *copy* mode, the *pax* utility shall truncate the time of a file to the greatest value that is not greater than the input header file time. In *write* or *copy* mode, the *pax* utility shall output a time exactly if it can be represented exactly as a decimal number, and otherwise shall generate only enough digits so that the same time shall be recovered if the file is extracted on a system whose underlying implementation supports the same time granularity.

**ustar Interchange Format**

A *ustar* archive tape or file shall contain a series of logical records. Each logical record shall be a fixed-size logical record of 512 octets (see below). Although this format may be thought of as being stored on 9-track industry-standard 12.7 mm (0.5 in) magnetic tape, other types of transportable media are not excluded. Each file archived shall be represented by a header logical record that describes the file, followed by zero or more logical records that give the contents of the file. At the end of the archive file there shall be two 512-octet logical records filled with binary zeros, interpreted as an end-of-archive indicator.

The logical records may be grouped for physical I/O operations, as described under the `−blocksize` and `−x ustar` options. Each group of logical records may be written with a single operation equivalent to the `write()` function. On magnetic tape, the result of this write shall be a
single tape physical block. The last physical block shall always be the full size, so logical records after the two zero logical records may contain undefined data.

The header logical record shall be structured as shown in the following table. All lengths and offsets are in decimal.

Table 4-13 ustar Header Block

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Octet Offset</th>
<th>Length (in Octets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>mode</td>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>uid</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>gid</td>
<td>116</td>
<td>8</td>
</tr>
<tr>
<td>size</td>
<td>124</td>
<td>12</td>
</tr>
<tr>
<td>mtime</td>
<td>136</td>
<td>12</td>
</tr>
<tr>
<td>chksum</td>
<td>148</td>
<td>8</td>
</tr>
<tr>
<td>typeflag</td>
<td>156</td>
<td>1</td>
</tr>
<tr>
<td>linkname</td>
<td>157</td>
<td>100</td>
</tr>
<tr>
<td>magic</td>
<td>257</td>
<td>6</td>
</tr>
<tr>
<td>version</td>
<td>263</td>
<td>2</td>
</tr>
<tr>
<td>uname</td>
<td>265</td>
<td>32</td>
</tr>
<tr>
<td>gname</td>
<td>297</td>
<td>32</td>
</tr>
<tr>
<td>devmajor</td>
<td>329</td>
<td>8</td>
</tr>
<tr>
<td>devminor</td>
<td>337</td>
<td>8</td>
</tr>
<tr>
<td>prefix</td>
<td>345</td>
<td>155</td>
</tr>
</tbody>
</table>

All characters in the header logical record shall be represented in the coded character set of the ISO/IEC 646: 1991 standard. For maximum portability between implementations, names should be selected from characters represented by the portable filename character set as octets with the most significant bit zero. If an implementation supports the use of characters outside of slash and the portable filename character set in names for files, users, and groups, one or more implementation-defined encodings of these characters shall be provided for interchange purposes.

However, the pax utility shall never create filenames on the local system that cannot be accessed via the procedures described in IEEE Std 1003.1-2001. If a filename is found on the medium that would create an invalid filename, it is implementation-defined whether the data from the file is stored on the file hierarchy and under what name it is stored. The pax utility may choose to ignore these files as long as it produces an error indicating that the file is being ignored.

Each field within the header logical record is contiguous; that is, there is no padding used. Each character on the archive medium shall be stored contiguously.

The fields magic, uname, and gname are character strings each terminated by a NUL character. The fields name, linkname, and prefix are NUL-terminated character strings except when all characters in the array contain non-NUL characters including the last character. The version field is two octets containing the characters "00" (zero-zero). The typeflag contains a single character. All other fields are leading zero-filled octal numbers using digits from the ISO/IEC 646: 1991 standard IRV. Each numeric field is terminated by one or more <space> or NUL characters.

The name and the prefix fields shall produce the pathname of the file. A new pathname shall be formed, if prefix is not an empty string (its first character is not NUL), by concatenating prefix (up to the first NUL character), a slash character, and name; otherwise, name is used alone. In either case, name is terminated at the first NUL character. If prefix begins with a NUL character, it shall be ignored. In this manner, pathnames of at most 256 characters can be supported. If a pathname
does not fit in the space provided, `pax` shall notify the user of the error, and shall not store any
part of the file—header or data—on the medium.

The `linkname` field, described below, shall not use the `prefix` to produce a pathname. As such, a
`linkname` is limited to 100 characters. If the name does not fit in the space provided, `pax` shall
notify the user of the error, and shall not attempt to store the link on the medium.

The `mode` field provides 12 bits encoded in the ISO/IEC 646:1991 standard octal digit
representation. The encoded bits shall represent the following values:

<table>
<thead>
<tr>
<th>Bit Value</th>
<th>IEEE Std 1003.1-2001 Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00 000</td>
<td>S_ISUID</td>
<td>Set UID on execution.</td>
</tr>
<tr>
<td>00 002</td>
<td>S_ISGID</td>
<td>Set GID on execution.</td>
</tr>
<tr>
<td>01 000</td>
<td>&lt;reserved&gt;</td>
<td>Reserved for future standardization.</td>
</tr>
<tr>
<td>00 400</td>
<td>S_IRUSR</td>
<td>Read permission for file owner class.</td>
</tr>
<tr>
<td>00 200</td>
<td>S_IWUSR</td>
<td>Write permission for file owner class.</td>
</tr>
<tr>
<td>00 100</td>
<td>S_IXUSR</td>
<td>Execute/search permission for file owner class.</td>
</tr>
<tr>
<td>00 040</td>
<td>S_IRGRP</td>
<td>Read permission for file group class.</td>
</tr>
<tr>
<td>00 020</td>
<td>S_IWGRP</td>
<td>Write permission for file group class.</td>
</tr>
<tr>
<td>00 010</td>
<td>S_IXGRP</td>
<td>Execute/search permission for file group class.</td>
</tr>
<tr>
<td>00 004</td>
<td>S_IROTH</td>
<td>Read permission for file other class.</td>
</tr>
<tr>
<td>00 002</td>
<td>S_IWOTH</td>
<td>Write permission for file other class.</td>
</tr>
<tr>
<td>00 001</td>
<td>S_IXOTH</td>
<td>Execute/search permission for file other class.</td>
</tr>
</tbody>
</table>

When appropriate privilege is required to set one of these mode bits, and the user restoring the
files from the archive does not have the appropriate privilege, the mode bits for which the user
does not have appropriate privilege shall be ignored. Some of the mode bits in the archive
format are not mentioned elsewhere in this volume of IEEE Std 1003.1-2001. If the
implementation does not support those bits, they may be ignored.

The `uid` and `gid` fields are the user and group ID of the owner and group of the file, respectively.

The `size` field is the size of the file in octets. If the `typeflag` field is set to specify a file to be of type
1 (a link) or 2 (a symbolic link), the `size` field shall be specified as zero. If the `typeflag` field is set to
specify a file of type 5 (directory), the `size` field shall be interpreted as described under the
definition of that record type. No data logical records are stored for types 1, 2, or 5. If the `typeflag`
field is set to 3 (character special file), 4 (block special file), or 6 (FIFO), the meaning of the `size`
field is unspecified by this volume of IEEE Std 1003.1-2001, and no data logical records shall be
stored on the medium. Additionally, for type 6, the `size` field shall be ignored when reading. If
the `typeflag` field is set to any other value, the number of logical records written following the
header shall be `(size+511)/512`, ignoring any fraction in the result of the division.

The `mtime` field shall be the modification time of the file at the time it was archived. It is the
ISO/IEC 646:1991 standard representation of the octal value of the modification time obtained
from the `stat()` function.

The `chksum` field shall be the ISO/IEC 646:1991 standard IRV representation of the octal value of
the simple sum of all octets in the header logical record. Each octet in the header shall be treated
as an unsigned value. These values shall be added to an unsigned integer, initialized to zero, the
precision of which is not less than 17 bits. When calculating the checksum, the `chksum` field is
treated as if it were all spaces.

The `typeflag` field specifies the type of file archived. If a particular implementation does not
recognize the type, or the user does not have appropriate privilege to create that type, the file
shall be extracted as if it were a regular file if the file type is defined to have a meaning for the
size field that could cause data logical records to be written on the medium (see the previous
description for size). If conversion to a regular file occurs, the pax utility shall produce an error
indicating that the conversion took place. All of the typeflag fields shall be coded in the
ISO/IEC 646:1991 standard IRV:

0 Represents a regular file. For backwards-compatibility, a typeflag value of binary zero
('\0') should be recognized as meaning a regular file when extracting files from the
archive. Archives written with this version of the archive file format create regular files
with a typeflag value of the ISO/IEC 646: 1991 standard IRV '\0'.

1 Represents a file linked to another file, of any type, previously archived. Such files are
identified by each file having the same device and file serial number. The linked-to
name is specified in the linkname field with a NUL-character terminator if it is less than
100 octets in length.

2 Represents a symbolic link. The contents of the symbolic link shall be stored in the
linkname field.

3, 4 Represent character special files and block special files respectively. In this case the
devmajor and devminor fields shall contain information defining the device, the format
of which is unspecified by this volume of IEEE Std 1003.1-2001. Implementations may
map the device specifications to their own local specification or may ignore the entry.

5 Specifies a directory or subdirectory. On systems where disk allocation is performed on
a directory basis, the size field shall contain the maximum number of octets (which may
be rounded to the nearest disk block allocation unit) that the directory may hold. A size
field of zero indicates no such limiting. Systems that do not support limiting in this
manner should ignore the size field.

6 Specifies a FIFO special file. Note that the archiving of a FIFO file archives the existence
of this file and not its contents.

7 Reserved to represent a file to which an implementation has associated some high-
performance attribute. Implementations without such extensions should treat this file
as a regular file (type 0).

A-Z The letters 'A' to 'Z', inclusive, are reserved for custom implementations. All other
values are reserved for future versions of IEEE Std 1003.1-2001.

Attempts to archive a socket using ustar interchange format shall produce a diagnostic message.
Handling of other file types is implementation-defined.

The magic field is the specification that this archive was output in this archive format. If this field
contains ustar (the five characters from the ISO/IEC 646:1991 standard IRV shown followed by
NUL), the uname and gname fields shall contain the ISO/IEC 646:1991 standard IRV
representation of the owner and group of the file, respectively (truncated to fit, if necessary).
When the file is restored by a privileged, protection-preserving version of the utility, the user
and group databases shall be scanned for these names. If found, the user and group IDs
contained within these files shall be used rather than the values contained within the uid and gid
fields.
**cpio Interchange Format**

The octet-oriented cpio archive format shall be a series of entries, each comprising a header that describes the file, the name of the file, and then the contents of the file.

An archive may be recorded as a series of fixed-size blocks of octets. This blocking shall be used only to make physical I/O more efficient. The last group of blocks shall always be at the full size.

For the octet-oriented cpio archive format, the individual entry information shall be in the order indicated and described by the following table; see also the `<cpio.h>` header.

### Table 4-15 Octet-Oriented cpio Archive Entry

<table>
<thead>
<tr>
<th>Header Field Name</th>
<th>Length (in Octets)</th>
<th>Interpreted as</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>c_magic</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_dev</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_ino</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_mode</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_uid</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_gid</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_nlink</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_rdev</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_mtime</code></td>
<td>11</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_namesize</code></td>
<td>6</td>
<td>Octal number</td>
</tr>
<tr>
<td><code>c_filesize</code></td>
<td>11</td>
<td>Octal number</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filename Field Name</th>
<th>Length</th>
<th>Interpreted as</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>c_name</code> (<code>c_namesize</code>)</td>
<td></td>
<td>Pathname string</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>File Data Field Name</th>
<th>Length</th>
<th>Interpreted as</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>c_filedata</code> (<code>c_filesize</code>)</td>
<td></td>
<td>Data</td>
</tr>
</tbody>
</table>

**cpio Header**

For each file in the archive, a header as defined previously shall be written. The information in the header fields is written as streams of the ISO/IEC 646: 1991 standard characters interpreted as octal numbers. The octal numbers shall be extended to the necessary length by appending the ISO/IEC 646: 1991 standard IRV zeros at the most-significant-digit end of the number; the result is written to the most-significant digit of the stream of octets first. The fields shall be interpreted as follows:

- **c_magic**: Identify the archive as being a transportable archive by containing the identifying value "070707".
- **c_dev, c_ino**: Contains values that uniquely identify the file within the archive (that is, no files contain the same pair of `c_dev` and `c_ino` values unless they are links to the same file). The values shall be determined in an unspecified manner.
- **c_mode**: Contains the file type and access permissions as defined in the following table.
Table 4-16: Values for cpio c_mode Field

<table>
<thead>
<tr>
<th>File Permissions Name</th>
<th>Value</th>
<th>Indicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_IRUSR</td>
<td>000 400</td>
<td>Read by owner</td>
</tr>
<tr>
<td>C_IWUSR</td>
<td>000 200</td>
<td>Write by owner</td>
</tr>
<tr>
<td>C_IXUSR</td>
<td>000 100</td>
<td>Execute by owner</td>
</tr>
<tr>
<td>C_IREGRP</td>
<td>000 040</td>
<td>Read by group</td>
</tr>
<tr>
<td>C_IWRGRP</td>
<td>000 020</td>
<td>Write by group</td>
</tr>
<tr>
<td>C_IXGRP</td>
<td>000 010</td>
<td>Execute by group</td>
</tr>
<tr>
<td>C_IROTH</td>
<td>000 004</td>
<td>Read by others</td>
</tr>
<tr>
<td>C_IWOTH</td>
<td>000 002</td>
<td>Write by others</td>
</tr>
<tr>
<td>C_IXOTH</td>
<td>000 001</td>
<td>Execute by others</td>
</tr>
<tr>
<td>C_ISUID</td>
<td>004 000</td>
<td>Set uid</td>
</tr>
<tr>
<td>C_ISGID</td>
<td>002 000</td>
<td>Set gid</td>
</tr>
<tr>
<td>C_ISVTX</td>
<td>001 000</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>File Type Name</th>
<th>Value</th>
<th>Indicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_ISDIR</td>
<td>040 000</td>
<td>Directory</td>
</tr>
<tr>
<td>C_ISFIFO</td>
<td>010 000</td>
<td>FIFO</td>
</tr>
<tr>
<td>C_ISREG</td>
<td>0100 000</td>
<td>Regular file</td>
</tr>
<tr>
<td>C_ISLNK</td>
<td>0120 000</td>
<td>Symbolic link</td>
</tr>
<tr>
<td>C_ISBLK</td>
<td>060 000</td>
<td>Block special file</td>
</tr>
<tr>
<td>C_ISCHR</td>
<td>020 000</td>
<td>Character special file</td>
</tr>
<tr>
<td>C_ISSOCK</td>
<td>0140 000</td>
<td>Socket</td>
</tr>
<tr>
<td>C_ISCTG</td>
<td>0110 000</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

Directories, FIFOs, symbolic links, and regular files shall be supported on a system conforming to this volume of IEEE Std 1003.1-2001; additional values defined previously are reserved for compatibility with existing systems. Additional file types may be supported; however, such files should not be written to archives intended to be transported to other systems.

- **c_uid**: Contains the user ID of the owner.
- **c_gid**: Contains the group ID of the group.
- **c_nlink**: Contains the number of links referencing the file at the time the archive was created.
- **c_rdev**: Contains implementation-defined information for character or block special files.
- **c_mtime**: Contains the latest time of modification of the file at the time the archive was created.
- **c_namesize**: Contains the length of the pathname, including the terminating NUL character.
- **c_filesize**: Contains the length of the file in octets. This shall be the length of the data section following the header structure.
**pax**

**cpio Filename**

The `c_name` field shall contain the pathname of the file. The length of this field in octets is the value of `c_namesize`.

If a filename is found on the medium that would create an invalid pathname, it is implementation-defined whether the data from the file is stored on the file hierarchy and under what name it is stored.

All characters shall be represented in the ISO/IEC 646:1991 standard IRV. For maximum portability between implementations, names should be selected from characters represented by the portable filename character set as octets with the most significant bit zero. If an implementation supports the use of characters outside the portable filename character set in names for files, users, and groups, one or more implementation-defined encodings of these characters shall be provided for interchange purposes. However, the `pax` utility shall never create filenames on the local system that cannot be accessed via the procedures described previously in this volume of IEEE Std 1003.1-2001. If a filename is found on the medium that would create an invalid filename, it is implementation-defined whether the data from the file is stored on the local file system and under what name it is stored. The `pax` utility may choose to ignore these files as long as it produces an error indicating that the file is being ignored.

**cpio File Data**

Following `c_name`, there shall be `c_filesize` octets of data. Interpretation of such data occurs in a manner dependent on the file. If `c_filesize` is zero, no data shall be contained in `c_filedata`.

When restoring from an archive:

- If the user does not have the appropriate privilege to create a file of the specified type, `pax` shall ignore the entry and write an error message to standard error.
- Only regular files have data to be restored. Presuming a regular file meets any selection criteria that might be imposed on the format-reading utility by the user, such data shall be restored.
- If a user does not have appropriate privilege to set a particular mode flag, the flag shall be ignored. Some of the mode flags in the archive format are not mentioned elsewhere in this volume of IEEE Std 1003.1-2001. If the implementation does not support those flags, they may be ignored.

**cpio Special Entries**

FIFO special files, directories, and the trailer shall be recorded with `c_filesize` equal to zero. For other special files, `c_filesize` is unspecified by this volume of IEEE Std 1003.1-2001. The header for the next file entry in the archive shall be written directly after the last octet of the file entry preceding it. A header denoting the filename TRAILER!!! shall indicate the end of the archive; the contents of octets in the last block of the archive following such a header are undefined.

**EXIT STATUS**

The following exit values shall be returned:

0  All files were processed successfully.

>0  An error occurred.
CONSEQUENCES OF ERRORS

If `pax` cannot create a file or a link when reading an archive or cannot find a file when writing an archive, or cannot preserve the user ID, group ID, or file mode when the `-p` option is specified, a diagnostic message shall be written to standard error and a non-zero exit status shall be returned, but processing shall continue. In the case where `pax` cannot create a link to a file, `pax` shall not, by default, create a second copy of the file.

If the extraction of a file from an archive is prematurely terminated by a signal or error, `pax` may have only partially extracted the file or (if the `-n` option was not specified) may have extracted a file of the same name as that specified by the user, but which is not the file the user wanted. Additionally, the file modes of extracted directories may have additional bits from the S_IRWXU mask set as well as incorrect modification and access times.

APPLICATION USAGE

The `-p` (privileges) option was invented to reconcile differences between historical `tar` and `cpio` implementations. In particular, the two utilities use `-m` in diametrically opposed ways. The `-p` option also provides a consistent means of extending the ways in which future file attributes can be addressed, such as for enhanced security systems or high-performance files. Although it may seem complex, there are really two modes that are most commonly used:

- `-p e` "Preserve everything". This would be used by the historical superuser, someone with all the appropriate privileges, to preserve all aspects of the files as they are recorded in the archive. The `e` flag is the sum of `o` and `p`, and other implementation-defined attributes.

- `-p p` "Preserve" the file mode bits. This would be used by the user with regular privileges who wished to preserve aspects of the file other than the ownership. The file times are preserved by default, but two other flags are offered to disable these and use the time of extraction.

The one pathname per line format of standard input precludes pathnames containing `<newline>`s. Although such pathnames violate the portable filename guidelines, they may exist and their presence may inhibit usage of `pax` within shell scripts. This problem is inherited from historical archive programs. The problem can be avoided by listing filename arguments on the command line instead of on standard input.

It is almost certain that appropriate privileges are required for `pax` to accomplish parts of this volume of IEEE Std 1003.1-2001. Specifically, creating files of type block special or character special, restoring file access times unless the files are owned by the user (the `-t` option), or preserving file owner, group, and mode (the `-p` option) all probably require appropriate privileges.

In read mode, implementations are permitted to overwrite files when the archive has multiple members with the same name. This may fail if permissions on the first version of the file do not permit it to be overwritten.

The `cpio` and `ustar` formats can only support files up to 8 589 934 592 bytes (8 * 2^30) in size.

EXAMPLES

The following command:

```
pax -w -f /dev/rmt/1m
```

copies the contents of the current directory to tape drive 1, medium density (assuming historical System V device naming procedures—the historical BSD device name would be `/dev/rmt9`).

The following commands:
mkdir newdir

pax -rw olddir newdir

copy the olddir directory hierarchy to newdir.

pax -r -s '"/usr/*'," -f a.pax

reads the archive a.pax, with all files rooted in /usr in the archive extracted relative to the current directory.

Using the option:

-o listopt="%M %t(ctime)T %d(size)D "

overrides the default output description in Standard Output and instead writes:

-rw-rw-— Jan 12 15:53 1492 /usr/foo/bar

Using the options:

-o listopt='%L
\%t(size)D\n%.7'
-o listopt='%(name)s\n\%t(ctime)T\n\t'

overrides the default output description in Standard Output and instead writes:

/usr/foo/bar -> /tmp 1492
/usr/fo
Jan 12 1991
Jan 31 15:53

RATIONALE

The pax utility was new for the ISO POSIX-2: 1993 standard. It represents a peaceful compromise between advocates of the historical tar and cpio utilities.

A fundamental difference between cpio and tar was in the way directories were treated. The cpio utility did not treat directories differently from other files, and to select a directory and its contents required that each file in the hierarchy be explicitly specified. For tar, a directory matched every file in the file hierarchy it rooted.

The pax utility offers both interfaces; by default, directories map into the file hierarchy they root. The -d option causes pax to skip any file not explicitly referenced, as cpio historically did. The tar -style behavior was chosen as the default because it was believed that this was the more common usage and because tar is the more commonly available interface, as it was historically provided on both System V and BSD implementations.

The data interchange format specification in this volume of IEEE Std 1003.1-2001 requires that processes with “appropriate privileges” shall always restore the ownership and permissions of extracted files exactly as archived. If viewed from the historic equivalence between superuser and “appropriate privileges”, there are two problems with this requirement. First, users running as superusers may unknowingly set dangerous permissions on extracted files. Second, it is needlessly limiting, in that superusers cannot extract files and own them as superuser unless the archive was created by the superuser. (It should be noted that restoration of ownerships and permissions for the superuser, by default, is historical practice in cpio, but not in tar.) In order to avoid these two problems, the pax specification has an additional “privilege” mechanism, the -p option. Only a pax invocation with the privileges needed, and which has the -p option set using the e specification character, has the “appropriate privilege” to restore full ownership and permission information.

Note also that this volume of IEEE Std 1003.1-2001 requires that the file ownership and access permissions shall be set, on extraction, in the same fashion as the creat() function when provided.
with the mode stored in the archive. This means that the file creation mask of the user is applied to the file permissions.

Users should note that directories may be created by `pax` while extracting files with permissions that are different from those that existed at the time the archive was created. When extracting sensitive information into a directory hierarchy that no longer exists, users are encouraged to set their file creation mask appropriately to protect these files during extraction.

The table of contents output is written to standard output to facilitate pipeline processing.

An early proposal had hard links displaying for all pathnames. This was removed because it complicates the output of the case where `−v` is not specified and does not match historical `cpio` usage. The hard-link information is available in the `−v` display.

The description of the `−l` option allows implementations to make hard links to symbolic links. IEEE Std 1003.1-2001 does not specify any way to create a hard link to a symbolic link, but many implementations provide this capability as an extension. If there are hard links to symbolic links when an archive is created, the implementation is required to archive the hard link in the archive (unless `−H` or `−L` is specified). When in `read` mode and in `copy` mode, implementations supporting hard links to symbolic links should use them when appropriate.

The archive formats inherited from the POSIX.1-1990 standard have certain restrictions that have been brought along from historical usage. For example, there are restrictions on the length of pathnames stored in the archive. When `pax` is used in `copy(−rw)` mode (copying directory hierarchies), the ability to use extensions from the `−xpax` format overcomes these restrictions.

The default blocksize value of 5120 bytes for `cpio` was selected because it is one of the standard block-size values for `cpio`, set when the `−B` option is specified. (The other default block-size value for `cpio` is 512 bytes, and this was considered to be too small.) The default block value of 10240 bytes for `tar` was selected because that is the standard block-size value for BSD `tar`. The maximum block size of 32256 bytes (215–512 bytes) is the largest multiple of 512 bytes that fits into a signed 16-bit tape controller transfer register. There are known limitations in some historical systems that would prevent larger blocks from being accepted. Historical values were chosen to improve compatibility with historical scripts using `dd` or similar utilities to manipulate archives. Also, default block sizes for any file type other than character special file has been deleted from this volume of IEEE Std 1003.1-2001 as unimportant and not likely to affect the structure of the resulting archive.

Implementations are permitted to modify the block-size value based on the archive format or the device to which the archive is being written. This is to provide implementations with the opportunity to take advantage of special types of devices, and it should not be used without a great deal of consideration as it almost certainly decreases archive portability.

The intended use of the `−n` option was to permit extraction of one or more files from the archive without processing the entire archive. This was viewed by the standard developers as offering significant performance advantages over historical implementations. The `−n` option in early proposals had three effects; the first was to cause special characters in patterns to not be treated specially. The second was to cause only the first file that matched a pattern to be extracted. The third was to cause `pax` to write a diagnostic message to standard error when no file was found matching a specified pattern. Only the second behavior is retained by this volume of IEEE Std 1003.1-2001, for many reasons. First, it is in general not acceptable for a single option to have multiple effects. Second, the ability to make pattern matching characters act as normal characters is useful for parts of `pax` other than file extraction. Third, a finer degree of control over the special characters is useful because users may wish to normalize only a single special character in a single filename. Fourth, given a more general escape mechanism, the previous behavior of the `−n` option can be easily obtained using the `−s` option or a `sed` script. Finally,
writing a diagnostic message when a pattern specified by the user is unmatched by any file is useful behavior in all cases.

In this version, the −n was removed from the copy mode synopsis of pax; it is inapplicable because there are no pattern operands specified in this mode.

There is another method than pax for copying subtrees in IEEE Std 1003.1-2001 described as part of the cp utility. Both methods are historical practice: cp provides a simpler, more intuitive interface, while pax offers a finer granularity of control. Each provides additional functionality to the other; in particular, pax maintains the hard-link structure of the hierarchy while cp does not.

It is the intention of the standard developers that the results be similar (using appropriate option combinations in both utilities). The results are not required to be identical; there seemed insufficient gain to applications to balance the difficulty of implementations having to guarantee that the results would be exactly identical.

A single archive may span more than one file. It is suggested that implementations provide informative messages to the user on standard error whenever the archive file is changed.

The −d option (do not create intermediate directories not listed in the archive) found in early proposals was originally provided as a complement to the historic −d option of cpio. It has been deleted.

The −s option in early proposals specified a subset of the substitution command from the ed utility. As there was no reason for only a subset to be supported, the −s option is now compatible with the current ed specification. Since the delimiter can be any non-null character, the following usage with single spaces is valid:

```
pax −s " foo bar " . . .
```

The −t description is worded so as to note that this may cause the access time update caused by some other activity (which occurs while the file is being read) to be overwritten.

The default behavior of pax with regard to file modification times is the same as historical implementations of tar. It is not the historical behavior of cpio.

Because the −i option uses /dev/tty, utilities without a controlling terminal are not able to use this option.

The −y option, found in early proposals, has been deleted because a line containing a single period for the −i option has equivalent functionality. The special lines for the −i option (a single period and the empty line) are historical practice in cpio.

In early drafts, a −echarmap option was included to increase portability of files between systems using different coded character sets. This option was omitted because it was apparent that consensus could not be formed for it. In this version, the use of UTF-8 should be an adequate substitute.

The −k option was added to address international concerns about the dangers involved in the character set transformations of −e (if the target character set were different from the source, the filenames might be transformed into names matching existing files) and also was made more general to protect files transferred between file systems with different {NAME_MAX} values (truncating a filename on a smaller system might also inadvertently overwrite existing files). As stated, it prevents any overwriting, even if the target file is older than the source. This version adds more granularity of options to solve this problem by introducing the −oinvalid= option—specifically the UTF-8 action. (Note that an existing file that is named with a UTF-8 encoding is still subject to overwriting in this case. The −k option closes that loophole.)

Some of the file characteristics referenced in this volume of IEEE Std 1003.1-2001 might not be supported by some archive formats. For example, neither the tar nor cpio formats contain the
file access time. For this reason, the e specification character has been provided, intended to cause all file characteristics specified in the archive to be retained.

It is required that extracted directories, by default, have their access and modification times and permissions set to the values specified in the archive. This has obvious problems in that the directories are almost certainly modified after being extracted and that directory permissions may not permit file creation. One possible solution is to create directories with the mode specified in the archive, as modified by the umask of the user, with sufficient permissions to allow file creation. After all files have been extracted, pax would then reset the access and modification times and permissions as necessary.

The list-mode formatting description borrows heavily from the one defined by the printf utility. However, since there is no separate operand list to get conversion arguments, the format was extended to allow specifying the name of the conversion argument as part of the conversion specification.

The T conversion specifier allows time fields to be displayed in any of the date formats. Unlike the ls utility, pax does not adjust the format when the date is less than six months in the past. This makes parsing the output more predictable.

The D conversion specifier handles the ability to display the major/minor or file size, as with ls, by using %−8(size)D.

The L conversion specifier handles the ls display for symbolic links.

Conversion specifiers were added to generate existing known types used for ls.

**pax Interchange Format**

The new POSIX data interchange format was developed primarily to satisfy international concerns that the ustar and cpio formats did not provide for file, user, and group names encoded in characters outside a subset of the ISO/IEC 646:1991 standard. The standard developers realized that this new POSIX data interchange format should be very extensible because there were other requirements they foresaw in the near future:

- Support international character encodings and locale information
- Support security information (ACLs, and so on)
- Support future file types, such as realtime or contiguous files
- Include data areas for implementation use
- Support systems with words larger than 32 bits and timers with subsecond granularity

The following were not goals for this format because these are better handled by separate utilities or are inappropriate for a portable format:

- Encryption
- Compression
- Data translation between locales and codesets
- inode storage

The format chosen to support the goals is an extension of the ustar format. Of the two formats previously available, only the ustar format was selected for extensions because:

- It was easier to extend in an upwards-compatible way. It offered version flags and header block type fields with room for future standardization. The cpio format, while possessing a more flexible file naming methodology, could not be extended without breaking some
theoretical implementation or using a dummy filename that could be a legitimate filename.

- Industry experience since the original "tar wars" fought in developing the ISO POSIX-1 standard has clearly been in favor of the ustar format, which is generally the default output format selected for pax implementations on new systems.

The new format was designed with one additional goal in mind: reasonable behavior when an older tar or pax utility happened to read an archive. Since the POSIX.1-1990 standard mandated that a "format-reading utility" had to treat unrecognized typeflag values as regular files, this allowed the format to include all the extended information in a pseudo-regular file that preceded each real file. An option is given that allows the archive creator to set up reasonable names for these files on the older systems. Also, the normative text suggests that reasonable file access values be used for this ustar header block. Making these header files inaccessible for convenient reading and deleting would not be reasonable. File permissions of 600 or 700 are suggested.

The ustar typeflag field was used to accommodate the additional functionality of the new format rather than magic or version because the POSIX.1-1990 standard (and, by reference, the previous version of pax), mandated the behavior of the format-reading utility when it encountered an unknown typeflag, but was silent about the other two fields.

Early proposals of the first revision to IEEE Std 1003.1-2001 contained a proposed archive format that was based on compatibility with the standard for tape files (ISO 1001, similar to the format used historically on many mainframes and minicomputers). This format was overly complex and required considerable overhead in volume and header records. Furthermore, the standard developers felt that it would not be acceptable to the community of POSIX developers, so it was later changed to be a format more closely related to historical practice on POSIX systems.

The prefix and name split of pathnames in ustar was replaced by the single path extended header record for simplicity.

The concept of a global extended header (typeflag g) was controversial. If this were applied to an archive being recorded on magnetic tape, a few unreadable blocks at the beginning of the tape could be a serious problem; a utility attempting to extract as many files as possible from a damaged archive could lose a large percentage of file header information in this case. However, if the archive were on a reliable medium, such as a CD-ROM, the global extended header offers considerable potential size reductions by eliminating redundant information. Thus, the text warns against using the global method for unreliable media and provides a method for implanting global information in the extended header for each file, rather than in the typeflag g records.

No facility for data translation or filtering on a per-file basis is included because the standard developers could not invent an interface that would allow this in an efficient manner. If a filter, such as encryption or compression, is to be applied to all the files, it is more efficient to apply the filter to the entire archive as a single file. The standard developers considered interfaces that would invoke a shell script for each file going into or out of the archive, but the system overhead in this approach was considered to be too high.

One such approach would be to have filter= records that give a pathname for an executable. When the program is invoked, the file and archive would be open for standard input/output and all the header fields would be available as environment variables or command-line arguments. The standard developers did discuss such schemes, but they were omitted from IEEE Std 1003.1-2001 due to concerns about excessive overhead. Also, the program itself would need to be in the archive if it were to be used portably.

There is currently no portable means of identifying the character set(s) used for a file in the file system. Therefore, pax has not been given a mechanism to generate charset records automatically. The only portable means of doing this is for the user to write the archive using the
`-ocharset=string` command line option. This assumes that all of the files in the archive use the same encoding. The “implementation-defined” text is included to allow for a system that can identify the encodings used for each of its files.

The table of standards that accompanies the charset record description is acknowledged to be very limited. Only a limited number of character set standards is reasonable for maximal interchange. Any character set is, of course, possible by prior agreement. It was suggested that EBCDIC be listed, but it was omitted because it is not defined by a formal standard. Formal standards, and then only those with reasonably large followings, can be included here, simply as a matter of practicality. The `<value>`s represent names of officially registered character sets in the format required by the ISO 2375: 1985 standard.

The normal comma or `<blank>`-separated list rules are not followed in the case of keyword options to allow ease of argument parsing for `getopts`.

Further information on character encodings is in *pax Archive Character Set Encoding/Decoding* (on page 732).

The standard developers have reserved keyword name space for vendor extensions. It is suggested that the format to be used is:

```
VENDOR.keyword
```

where `VENDOR` is the name of the vendor or organization in all uppercase letters. It is further suggested that the keyword following the period be named differently than any of the standard keywords so that it could be used for future standardization, if appropriate, by omitting the `VENDOR` prefix.

The `<length>` field in the extended header record was included to make it simpler to step through the records, even if a record contains an unknown format (to a particular `pax`) with complex interactions of special characters. It also provides a minor integrity checkpoint within the records to aid a program attempting to recover files from a damaged archive.

There are no extended header versions of the `devmajor` and `devminor` fields because the unspecified format `ustar` header field should be sufficient. If they are not, vendor-specific extended keywords (such as `VENDOR.devmajor`) should be used.

Device and `i`-number labeling of files was not adopted from `cpio`; files are interchanged strictly on a symbolic name basis, as in `ustar`.

Just as with the `ustar` format descriptions, the new format makes no special arrangements for multi-volume archives. Each of the `pax` archive types is assumed to be inside a single POSIX file and splitting that file over multiple volumes (diskettes, tape cartridges, and so on), processing their labels, and mounting each in the proper sequence are considered to be implementation details that cannot be described portably.

The `pax` format is intended for interchange, not only for backup on a single (family of) systems. It is not as densely packed as might be possible for backup:

- It contains information as coded characters that could be coded in binary.
- It identifies extended records with name fields that could be omitted in favor of a fixed-field layout.
- It translates names into a portable character set and identifies locale-related information, both of which are probably unnecessary for backup.

The requirements on restoring from an archive are slightly different from the historical wording, allowing for non-monolithic privilege to bring forward as much as possible. In particular, attributes such as “high performance file” might be broadly but not universally granted while...
set-user-ID or chown() might be much more restricted. There is no implication in
IEEE Std 1003.1-2001 that the security information be honored after it is restored to the file
hierarchy, in spite of what might be improperly inferred by the silence on that topic. That is a
topic for another standard.

Links are recorded in the fashion described here because a link can be to any file type. It is
desirable in general to be able to restore part of an archive selectively and restore all of those
files completely. If the data is not associated with each link, it is not possible to do this.
However, the data associated with a file can be large, and when selective restoration is not
needed, this can be a significant burden. The archive is structured so that files that have no
associated data can always be restored by the name of any link name of any link, and the user
may choose whether data is recorded with each instance of a file that contains data. The format
permits mixing of both types of links in a single archive; this can be done for special needs, and
pax is expected to interpret such archives on input properly, despite the fact that there is no pax
option that would force this mixed case on output. (When −o linkdata is used, the output must
contain the duplicate data, but the implementation is free to include it or omit it when −o
linkdata is not used.)

The time values are included as extended header records for those implementations needing
more than the eleven octal digits allowed by the ustar format. Portable file timestamps cannot be
negative. If pax encounters a file with a negative timestamp in copy or write mode, it can reject
the file, substitute a non-negative timestamp, or generate a non-portable timestamp with a
leading ‘−’. Even though some implementations can support finer file-time granularities than
seconds, the normative text requires support only for seconds since the Epoch because the
ISO POSIX-1 standard states them that way. The ustar format includes only mtime; the new
format adds atime and ctime for symmetry. The atime access time restored to the file system will
be affected by the −p a and −p e options. The ctime creation time (actually inode modification
time) is described with ‘appropriate privilege’ so that it can be ignored when writing to the file
system. POSIX does not provide a portable means to change file creation time. Nothing is
intended to prevent a non-portable implementation of pax from restoring the value.

The gid, size, and uid extended header records were included to allow expansion beyond the
sizes specified in the regular tar header. New file system architectures are emerging that will
exhaust the 12-digit size field. There are probably not many systems requiring more than 8 digits
for user and group IDs, but the extended header values were included for completeness,
allowing overrides for all of the decimal values in the tar header.

The standard developers intended to describe the effective results of pax with regard to file
ownerships and permissions; implementations are not restricted in timing or sequencing the
restoration of such, provided the results are as specified.

Much of the text describing the extended headers refers to use in “write or copy modes”. The
copy mode references are due to the normative text: “The effect of the copy shall be as if the
copied files were written to an archive file and then subsequently extracted . . .”. There is
certainly no way to test whether pax is actually generating the extended headers in copy mode,
but the effects must be as if it had.
There is a need to exchange archives of files between systems of different native codesets. Filenames, group names, and user names must be preserved to the fullest extent possible when an archive is read on the receiving platform. Translation of the contents of files is not within the scope of the `pax` utility.

There will also be the need to represent characters that are not available on the receiving platform. These unsupported characters cannot be automatically folded to the local set of characters due to the chance of collisions. This could result in overwriting previous extracted files from the archive or pre-existing files on the system.

For these reasons, the codeset used to represent characters within the extended header records of the `pax` archive must be sufficiently rich to handle all commonly used character sets. The fields requiring translation include, at a minimum, filenames, user names, group names, and link pathnames. Implementations may wish to have localized extended keywords that use non-portable characters.

The standard developers considered the following options:

- The archive creator specifies the well-defined name of the source codeset. The receiver must then recognize the codeset name and perform the appropriate translations to the destination codeset.
- The archive creator includes within the archive the character mapping table for the source codeset used to encode extended header records. The receiver must then read the character mapping table and perform the appropriate translations to the destination codeset.
- The archive creator translates the extended header records in the source codeset into a canonical form. The receiver must then perform the appropriate translations to the destination codeset.

The approach that incorporates the name of the source codeset poses the problem of codeset name registration, and makes the archive useless to `pax` archive decoders that do not recognize that codeset.

Because parts of an archive may be corrupted, the standard developers felt that including the character map of the source codeset was too fragile. The loss of this one key component could result in making the entire archive useless. (The difference between this and the global extended header decision was that the latter has a workaround—duplicating extended header records on unreliable media—but this would be too burdensome for large character set maps.)

Both of the above approaches also put an undue burden on the `pax` archive receiver to handle the cross-product of all source and destination codesets.

To simplify the translation from the source codeset to the canonical form and from the canonical form to the destination codeset, the standard developers decided that the internal representation should be a stateless encoding. A stateless encoding is one where each codepoint has the same meaning, without regard to the decoder being in a specific state. An example of a stateful encoding would be the Japanese Shift-JIS; an example of a stateless encoding would be the ISO/IEC 646: 1991 standard (equivalent to 7-bit ASCII).

For these reasons, the standard developers decided to adopt a canonical format for the representation of file information strings. The obvious, well-endorsed candidate is the ISO/IEC 10646-1:2000 standard (based in part on Unicode), which can be used to represent the characters of virtually all standardized character sets. The standard developers initially agreed upon using UCS2 (16-bit Unicode) as the internal representation. This repertoire of characters provides a sufficiently rich set to represent all commonly-used codesets.
However, the standard developers found that the 16-bit Unicode representation had some problems. It forced the issue of standardizing byte ordering. The 2-byte length of each character made the extended header records twice as long for the case of strings coded entirely from historical 7-bit ASCII. For these reasons, the standard developers chose the UTF-8 defined in the ISO/IEC 10646-1:2000 standard. This multi-byte representation encodes UCS2 or UCS4 characters reliably and deterministically, eliminating the need for a canonical byte ordering. In addition, NUL octets and other characters possibly confusing to POSIX file systems do not appear, except to represent themselves. It was realized that certain national codesets take up more space after the encoding, due to their placement within the UCS range; it was felt that the usefulness of the encoding of the names outweighs the disadvantage of size increase for file, user, and group names.

The encoding of UTF-8 is as follows:

<table>
<thead>
<tr>
<th>UCS4 Hex Encoding</th>
<th>UTF-8 Binary Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000-0000007F</td>
<td>0xxxxxxx</td>
</tr>
<tr>
<td>00000080-000007FF</td>
<td>110xxxxx 10xxxxxx</td>
</tr>
<tr>
<td>00000800-0000FFFF</td>
<td>1110xxxx 10xxxxxx 10xxxxxx</td>
</tr>
<tr>
<td>00010000-001FFFFF</td>
<td>11110xxx 10xxxxxx 10xxxxxx 10xxxxxx</td>
</tr>
<tr>
<td>00200000-03FFFFFF</td>
<td>111110xx 10xxxxxx 10xxxxxx 10xxxxxx 10xxxxxx</td>
</tr>
<tr>
<td>04000000-7FFFFFFF</td>
<td>1111110x 10xxxxxx 10xxxxxx 10xxxxxx 10xxxxxx 10xxxxxx</td>
</tr>
</tbody>
</table>

where each ‘x’ represents a bit value from the character being translated.

**ustar Interchange Format**

The description of the ustar format reflects numerous enhancements over pre-1988 versions of the historical tar utility. The goal of these changes was not only to provide the functional enhancements desired, but also to retain compatibility between new and old versions. This compatibility has been retained. Archives written using the old archive format are compatible with the new format.

Implementors should be aware that the previous file format did not include a mechanism to archive directory type files. For this reason, the convention of using a filename ending with slash was adopted to specify a directory on the archive.

The total size of the name and prefix fields have been set to meet the minimum requirements for {PATH_MAX}. If a pathname will fit within the name field, it is recommended that the pathname be stored there without the use of the prefix field. Although the name field is known to be too small to contain {PATH_MAX} characters, the value was not changed in this version of the archive file format to retain backwards-compatibility, and instead the prefix was introduced. Also, because of the earlier version of the format, there is no way to remove the restriction on the linkname field being limited in size to just that of the name field.

The size field is required to be meaningful in all implementation extensions, although it could be zero. This is required so that the data blocks can always be properly counted.

It is suggested that if device special files need to be represented that cannot be represented in the standard format, that one of the extension types (A-Z) be used, and that the additional information for the special file be represented as data and be reflected in the size field.

Attempting to restore a special file type, where it is converted to ordinary data and conflicts with an existing filename, need not be specially detected by the utility. If run as an ordinary user, pax should not be able to overwrite the entries in, for example, /dev in any case (whether the file is converted to another type or not). If run as a privileged user, it should be able to do so, and it would be considered a bug if it did not. The same is true of ordinary data files and similarly
named special files; it is impossible to anticipate the needs of the user (who could really intend
to overwrite the file), so the behavior should be predictable (and thus regular) and rely on the
protection system as required.

The value 7 in the typeflag field is intended to define how contiguous files can be stored in a
ustar archive. IEEE Std 1003.1-2001 does not require the contiguous file extension, but does
define a standard way of archiving such files so that all conforming systems can interpret these
file types in a meaningful and consistent manner. On a system that does not support extended
file types, the pax utility should do the best it can with the file and go on to the next.

The file protection modes are those conventionally used by the ls utility. This is extended
beyond the usage in the ISO POSIX-2 standard to support the “shared text” or “sticky” bit. It is
intended that the conformance document should not document anything beyond the existence
of and support of such a mode. Further extensions are expected to these bits, particularly with
overloading the set-user-ID and set-group-ID flags.

cpio Interchange Format

The reference to appropriate privilege in the cpio format refers to an error on standard output;
the ustar format does not make comparable statements.

The model for this format was the historical System V cpio-c data interchange format. This
model documents the portable version of the cpio format and not the binary version. It has the
flexibility to transfer data of any type described within IEEE Std 1003.1-2001, yet is extensible to
transfer data types specific to extensions beyond IEEE Std 1003.1-2001 (for example, contiguous
files). Because it describes existing practice, there is no question of maintaining upwards-
compatibility.

cpio Header

There has been some concern that the size of the c_ino field of the header is too small to handle
those systems that have very large inode numbers. However, the c_ino field in the header is used
strictly as a hard-link resolution mechanism for archives. It is not necessarily the same value as
the inode number of the file in the location from which that file is extracted.

The name c_magic is based on historical usage.

cpio Filename

For most historical implementations of the cpio utility, [PATH_MAX] octets can be used to
describe the pathname without the addition of any other header fields (the NUL character
would be included in this count). [PATH_MAX] is the minimum value for pathname size,
documented as 256 bytes. However, an implementation may use c_namesize to determine the
exact length of the pathname. With the current description of the <cpio.h> header, this
pathname size can be as large as a number that is described in six octal digits.

Two values are documented under the c_mode field values to provide for extensibility for known
file types:

0110 000 Reserved for contiguous files. The implementation may treat the rest of the
information for this archive like a regular file. If this file type is undefined, the
implementation may create the file as a regular file.

This provides for extensibility of the cpio format while allowing for the ability to read old
archives. Files of an unknown type may be read as “regular files” on some implementations. On
a system that does not support extended file types, the pax utility should do the best it can with
the file and go on to the next.
FUTURE DIRECTIONS

None.

SEE ALSO
Chapter 2 (on page 29), cp, ed, getopts, ls, printf, the Base Definitions volume of IEEE Std 1003.1-2001, <cpio.h>, the System Interfaces volume of IEEE Std 1003.1-2001, chown(), creat(), mkdir(), mkfifo(), stat(), utime(), write()

CHANGE HISTORY
First released in Issue 4.

Issue 5
A note is added to the APPLICATION USAGE indicating that the cpio and tar formats can only support files up to 8 gigabytes in size.

Issue 6
The pax utility is aligned with the IEEE P1003.2b draft standard:

- Support has been added for symbolic links in the options and interchange formats.
- A new format has been devised, based on extensions to ustar.
- References to the “extended” tar and cpio formats derived from the POSIX.1-1990 standard have been changed to remove the “extended” adjective because this could cause confusion with the extended tar header added in this revision. (All references to tar are actually to ustar.)

The TZ entry is added to the ENVIRONMENT VARIABLES section.

IEEE PASC Interpretation 1003.2 #168 is applied, clarifying that mkdir() and mkfifo() calls can ignore an [EEXIST] error when extracting an archive.

IEEE PASC Interpretation 1003.2 #180 is applied, clarifying how extracted files are created when in read mode.

IEEE PASC Interpretation 1003.2 #181 is applied, clarifying the description of the −t option.

IEEE PASC Interpretation 1003.2 #195 is applied.

IEEE PASC Interpretation 1003.2 #206 is applied, clarifying the handling of links for the −H, −L, and −l options.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/35 is applied, adding the process ID of the pax process into certain fields. This change provides a method for the implementation to ensure that different instances of pax extracting a file named /a/b/foo will not collide when processing the extended header information associated with foo.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/36 is applied, changing −x B to −x pax in the OPTIONS section.
NAME
pr — print files

SYNOPSIS
pr [+page] [-column] [-adFmrt] [-e[char] [gap]] [-h header] [-i[char] [gap]]
pr [-l lines] [-n[char] [width]] [-o offset] [-s[char] [width]] [-fp]
pr [file...]

DESCRIPTION
The pr utility is a printing and pagination filter. If multiple input files are specified, each shall be
read, formatted, and written to standard output. By default, the input shall be separated into 66-
line pages, each with:
• A 5-line header that includes the page number, date, time, and the pathname of the file
• A 5-line trailer consisting of blank lines

If standard output is associated with a terminal, diagnostic messages shall be deferred until the
pr utility has completed processing.

When options specifying multi-column output are specified, output text columns shall be of
equal width; input lines that do not fit into a text column shall be truncated. By default, text
columns shall be separated with at least one <blank>.

OPTIONS
The pr utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines, except that: the page option has a ‘+’ delimiter; page and column can
be multi-digit numbers; some of the option-arguments are optional; and some of the option-
arguments cannot be specified as separate arguments from the preceding option letter. In
particular, the –s option does not allow the option letter to be separated from its argument, and
the options –e, –i, and –n require that both arguments, if present, not be separated from the
option letter.

The following options shall be supported. In the following option descriptions, column, lines,
offset, page, and width are positive decimal integers; gap is a non-negative decimal integer.

+page Begin output at page number page of the formatted input.

–column Produce multi-column output that is arranged in column columns (the default shall
be 1) and is written down each column in the order in which the text is received
from the input file. This option should not be used with –m. The options –e and –i
shall be assumed for multiple text-column output. Whether or not text columns
are produced with identical vertical lengths is unspecified, but a text column shall
never exceed the length of the page (see the –l option). When used with –t, use the
minimum number of lines to write the output.

–a Modify the effect of the –column option so that the columns are filled across the
page in a round-robin order (for example, when column is 2, the first input line
heads column 1, the second heads column 2, the third is the second line in column
1, and so on).

–d Produce output that is double-spaced; append an extra <newline> following every
<newline> found in the input.

–e[char][gap]
Expand each input <tab> to the next greater column position specified by the
formula \( n \times gap + 1 \), where \( n \) is an integer > 0. If gap is zero or is omitted, it shall
default to 8. All <tab>s in the input shall be expanded into the appropriate number
of <space>s. If any non-digit character, char, is specified, it shall be used as the
input <tab>.

-f Use a <form-feed> for new pages, instead of the default behavior that uses a sequence of <newline>s. Pause before beginning the first page if the standard output is associated with a terminal.

-F Use a <form-feed> for new pages, instead of the default behavior that uses a sequence of <newline>s.

-h header Use the string header to replace the contents of the file operand in the page header.

-i[char][gap] In output, replace multiple <space>s with <tab>s wherever two or more adjacent <space>s reach column positions gap+1, 2* gap+1, 3* gap+1, and so on. If gap is zero or is omitted, default tab settings at every eighth column position shall be assumed. If any non-digit character, char, is specified, it shall be used as the output <tab>.

-l lines Override the 66-line default and reset the page length to lines. If lines is not greater than the sum of both the header and trailer depths (in lines), the pr utility shall suppress both the header and trailer, as if the -t option were in effect.

-m Merge files. Standard output shall be formatted so the pr utility writes one line from each file specified by a file operand, side by side into text columns of equal fixed widths, in terms of the number of column positions. Implementations shall support merging of at least nine file operands.

-n[char][width] Provide width-digit line numbering (default for width shall be 5). The number shall occupy the first width column positions of each text column of default output or each line of -m output. If char (any non-digit character) is given, it shall be appended to the line number to separate it from whatever follows (default for char is a <tab>).

-o offset Each line of output shall be preceded by offset <space>s. If the -o option is not specified, the default offset shall be zero. The space taken is in addition to the output line width (see the -w option below).

-p Pause before beginning each page if the standard output is directed to a terminal (pr shall write an <alert> to standard error and wait for a <carriage-return> to be read on /dev/tty).

-r Write no diagnostic reports on failure to open files.

-s[char] Separate text columns by the single character char instead of by the appropriate number of <space>s (default for char shall be <tab>).

-t Write neither the five-line identifying header nor the five-line trailer usually supplied for each page. Quit writing after the last line of each file without spacing to the end of the page.

-w width Set the width of the line to width column positions for multiple text-column output only. If the -w option is not specified and the -s option is not specified, the default width shall be 72. If the -w option is not specified and the -s option is specified, the default width shall be 512.

For single column output, input lines shall not be truncated.
The following operand shall be supported:

- `file`: A pathname of a file to be written. If no `file` operands are specified, or if a `file` operand is `−−`, the standard input shall be used.

The standard input shall be used only if no `file` operands are specified, or if a `file` operand is `−−`. See the INPUT FILES section.

The input files shall be text files.

The file `/dev/tty` shall be used to read responses required by the `−p` option.

The following environment variables shall affect the execution of `pr`:

- `LANG`: Provide a default value for the internationalization variables that are unset or null. See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, for the precedence of internationalization variables used to determine the values of locale categories.
- `LC_ALL`: If set to a non-empty string value, override the values of all the other internationalization variables.
- `LC_CTYPE`: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and which characters are defined as printable (character class `print`). Non-printable characters are still written to standard output, but are not counted for the purpose for column-width and line-length calculations.
- `LC_MESSAGES`: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
- `LC_TIME`: Determine the format of the date and time for use in writing header lines.
- `NLSPATH`: Determine the location of message catalogs for the processing of `LC_MESSAGES`.
- `TZ`: Determine the timezone used to calculate date and time strings written in header lines. If `TZ` is unset or null, an unspecified default timezone shall be used.

If `pr` receives an interrupt while writing to a terminal, it shall flush all accumulated error messages to the screen before terminating.

The `pr` utility output shall be a paginated version of the original file (or files). This pagination shall be accomplished using either `<form-feed>`s or a sequence of `<newline>`s, as controlled by the `−F` or `−f` option. Page headers shall be generated unless the `−t` option is specified. The page headers shall be of the form:

```

%s %s Page %d

```

In the POSIX locale, the `<output of date>` field, representing the date and time of last modification of the input file (or the current date and time if the input file is standard input), shall be equivalent to the output of the following command as it would appear if executed at the given time:
Utilities

pr

28747  \texttt{\texttt{date \"+\%b \%e \%H:\%M \%Y\"}}
28748  without the trailing \texttt{<newline>}, if the page being written is from standard input. If the page
28749  being written is not from standard input, in the POSIX locale, the same format shall be used, but
28750  the time used shall be the modification time of the file corresponding to \texttt{file} instead of the current
28751  time. When the \texttt{LC\_TIME} locale category is not set to the POSIX locale, a different format and
28752  order of presentation of this field may be used.
28753  If the standard input is used instead of a \texttt{file} operand, the \texttt{<file>} field shall be replaced by a null
28754  string.
28755  If the \texttt{\hyphen{h}} option is specified, the \texttt{<file>} field shall be replaced by the \texttt{header} argument.
28756
28757  STDERR
28758  The standard error shall be used for diagnostic messages and for alerting the terminal when \texttt{\hyphen{p}}
28759  is specified.
28760
28761  OUTPUT FILES
28762  None.
28763
28764  EXTENDED DESCRIPTION
28765  None.
28766
28767  EXIT STATUS
28768  The following exit values shall be returned:
28769  \begin{itemize}
28770  \item 0  Successful completion.
28771  \item >0  An error occurred.
28772  \end{itemize}
28773
28774  CONSEQUENCES OF ERRORS
28775  Default.
28776
28777  APPLICATION USAGE
28778  None.
28779
28780  EXAMPLES
28781  \begin{enumerate}
28782  \item Print a numbered list of all files in the current directory:
28783  \texttt{ls \texttt{\hyphen{a}} | \texttt{pr \hyphen{n \hyphen{h}} \"Files in \$(pwd)\."}}
28784  \item Print \texttt{file1} and \texttt{file2} as a double-spaced, three-column listing headed by \texttt{\"file list\"}:
28785  \texttt{pr \texttt{\hyphen{3d \hyphen{h}} \"file list\" file1 file2}}
28786  \item Write \texttt{file1} on \texttt{file2}, expanding tabs to columns 10, 19, 28, \ldots:
28787  \texttt{pr \texttt{\hyphen{e9 \hyphen{t}} <file1 >file2}}
28788  \end{enumerate}
28789
28790  RATIONALE
28791  This utility is one of those that does not follow the Utility Syntax Guidelines because of its
28792  historical origins. The standard developers could have added new options that obeyed the
28793  guidelines (and marked the old options obsolescent) or devised an entirely new utility; there are
28794  examples of both actions in this volume of IEEE Std 1003.1-2001. Because of its widespread use
28795  by historical applications, the standard developers decided to exempt this version of \texttt{pr} from
28796  many of the guidelines.
28797  Implementations are required to accept option-arguments to the \texttt{\hyphen{h}}, \texttt{\hyphen{l}}, \texttt{\hyphen{o}}, and \texttt{\hyphen{w}} options
28798  whether presented as part of the same argument or as a separate argument to \texttt{pr}, as suggested by
28799  the Utility Syntax Guidelines. The \texttt{\hyphen{n}} and \texttt{\hyphen{s}} options, however, are specified as in historical
28800  practice because they are frequently specified without their optional arguments. If a \texttt{<blank>}

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were allowed before the option-argument in these cases, a file operand could mistakenly be interpreted as an option-argument in historical applications.

The text about the minimum number of lines in multi-column output was included to ensure that a best effort is made in balancing the length of the columns. There are known historical implementations in which, for example, 60-line files are listed by pr -2 as one column of 56 lines and a second of 4. Although this is not a problem when a full page with headers and trailers is produced, it would be relatively useless when used with -t.

Historical implementations of the pr utility have differed in the action taken for the -f option. BSD uses it as described here for the -F option; System V uses it to change trailing <newline>s on each page to a <form-feed> and, if standard output is a TTY device, sends an <alert> to standard error and reads a line from /dev/tty before the first page. There were strong arguments from both sides of this issue concerning historical practice and as a result the -F option was added. XSI-conformant systems support the System V historical actions for the -f option.

The <output of date> field in the -l format is specified only for the POSIX locale. As noted, the format can be different in other locales. No mechanism for defining this is present in this volume of IEEE Std 1003.1-2001, as the appropriate vehicle is a message catalog; that is, the format should be specified as a "message".

FUTURE DIRECTIONS
None.

SEE ALSO
expand, lp

CHANGE HISTORY
First released in Issue 2.

Issue 6
The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

• The -p option is added.

The normative text is reworded to avoid use of the term "must" for application requirements.
NAME
printf — write formatted output

SYNOPSIS
printf format [argument ...]

DESCRIPTION
The printf utility shall write formatted operands to the standard output. The argument operands shall be formatted under control of the format operand.

OPTIONS
None.

OPERANDS
The following operands shall be supported:

format A string describing the format to use to write the remaining operands. See the EXTENDED DESCRIPTION section.

argument The strings to be written to standard output, under the control of format. See the EXTENDED DESCRIPTION section.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of printf:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

LC_NUMERIC Determine the locale for numeric formatting. It shall affect the format of numbers written using the e, E, f, g, and G conversion specifier characters (if supported).

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
See the EXTENDED DESCRIPTION section.
The standard error shall be used only for diagnostic messages.

None.

The format operand shall be used as the format string described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation with the following exceptions:

1. A <space> in the format string, in any context other than a flag of a conversion specification, shall be treated as an ordinary character that is copied to the output.

2. A ‘Δ’ character in the format string shall be treated as a ‘Δ’ character, not as a <space>.

3. In addition to the escape sequences shown in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation (‘\’’, ‘\a’, ‘\b’, ‘\f’, ‘\n’, ‘\x’, ‘\t’, ‘\v’), "\ddd", where ddd is a one, two, or three-digit octal number, shall be written as a byte with the numeric value specified by the octal number.

4. The implementation shall not precede or follow output from the d or u conversion specifiers with <blank>s not specified by the format operand.

5. The implementation shall not precede output from the o conversion specifier with zeros not specified by the format operand.

6. The e, E, f, g, and G conversion specifiers need not be supported.

7. An additional conversion specifier character, b, shall be supported as follows. The argument shall be taken to be a string that may contain backslash-escape sequences. The following backslash-escape sequences shall be supported:
   - The escape sequences listed in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation (‘\’’, ‘\a’, ‘\b’, ‘\f’, ‘\n’, ‘\x’, ‘\t’, ‘\v’), which shall be converted to the characters they represent
   - "\0ddd", where ddd is a zero, one, two, or three-digit octal number that shall be converted to a byte with the numeric value specified by the octal number
   - ‘\c’, which shall not be written and shall cause printf to ignore any remaining characters in the string operand containing it, any remaining string operands, and any additional characters in the format operand

8. For each conversion specification that consumes an argument, the next argument operand shall be evaluated and converted to the appropriate type for the conversion as specified below.

9. The format operand shall be reused as often as necessary to satisfy the argument operands. Any extra c or s conversion specifiers shall be evaluated as if a null string argument were supplied; other extra conversion specifications shall be evaluated as if a zero argument were supplied. If the format operand contains no conversion specifications and argument operands are present, the results are unspecified.
10. If a character sequence in the format operand begins with a ‘%’ character, but does not
form a valid conversion specification, the behavior is unspecified.

The argument operands shall be treated as strings if the corresponding conversion specifier is b, c, or s; otherwise, it shall be evaluated as a C constant, as described by the ISO C standard, with
the following extensions:

- A leading plus or minus sign shall be allowed.

- If the leading character is a single-quote or double-quote, the value shall be the numeric
  value in the underlying codeset of the character following the single-quote or double-quote.

If an argument operand cannot be completely converted into an internal value appropriate to
the corresponding conversion specification, a diagnostic message shall be written to standard
error and the utility shall not exit with a zero exit status, but shall continue processing any
remaining operands and shall write the value accumulated at the time the error was detected to
standard output.

It is not considered an error if an argument operand is not completely used for a c or s
conversion or if a string operand’s first or second character is used to get the numeric value of a
character.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

The floating-point formatting conversion specifications of printf() are not required because all
arithmetic in the shell is integer arithmetic. The awk utility performs floating-point calculations
and provides its own printf function. The bc utility can perform arbitrary-precision floating-
point arithmetic, but does not provide extensive formatting capabilities. (This printf utility
cannot really be used to format bc output; it does not support arbitrary precision.)
Implementations are encouraged to support the floating-point conversions as an extension.

Note that this printf utility, like the printf() function defined in the System Interfaces volume of
IEEE Std 1003.1-2001 on which it is based, makes no special provision for dealing with multi-
byte characters when using the %c conversion specification or when a precision is specified in a
%b or %s conversion specification. Applications should be extremely cautious using either of
these features when there are multi-byte characters in the character set.

No provision is made in this volume of IEEE Std 1003.1-2001 which allows field widths and
precisions to be specified as ‘*’ since the ‘*’ can be replaced directly in the format operand
using shell variable substitution. Implementations can also provide this feature as an extension
if they so choose.

Hexadecimal character constants as defined in the ISO C standard are not recognized in the
format operand because there is no consistent way to detect the end of the constant. Octal
character constants are limited to, at most, three octal digits, but hexadecimal character
constants are only terminated by a non-hex-digit character. In the ISO C standard, the "##"
concatenation operator can be used to terminate a constant and follow it with a hexadecimal
character to be written. In the shell, concatenation occurs before the printf utility has a chance to
parse the end of the hexadecimal constant.
The \%b conversion specification is not part of the ISO C standard; it has been added here as a portable way to process backslash escapes expanded in string operands as provided by the echo utility. See also the APPLICATION USAGE section of echo (on page 333) for ways to use printf as a replacement for all of the traditional versions of the echo utility.

If an argument cannot be parsed correctly for the corresponding conversion specification, the printf utility is required to report an error. Thus, overflow and extraneous characters at the end of an argument being used for a numeric conversion shall be reported as errors.

**EXAMPLES**

To alert the user and then print and read a series of prompts:

```c
printf "Please fill in the following:  Name: 
read name
printf "Phone number: 
read phone
```

To read out a list of right and wrong answers from a file, calculate the percentage correctly, and print them out. The numbers are right-justified and separated by a single <tab>. The percentage is written to one decimal place of accuracy:

```c
while read right wrong ; do
    percent=$(echo "scale=1;($right*100)/($right+$wrong)" | bc)
    printf "%2d right\t%2d wrong\t(%s\%)\n" \
    $right $wrong $percent
done < database_file
```

The command:

```c
printf "%5d%4d\n" 1 21 321 4321 54321
```

produces:

```
  1 21
3214321
54321 0
```

Note that the format operand is used three times to print all of the given strings and that a ' 0 ' was supplied by printf to satisfy the last %4d conversion specification.

The printf utility is required to notify the user when conversion errors are detected while producing numeric output; thus, the following results would be expected on an implementation with 32-bit twos-complement integers when %d is specified as the format operand:

<table>
<thead>
<tr>
<th>Argument</th>
<th>Standard Output</th>
<th>Diagnostic Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>5a</td>
<td>5</td>
<td>printf: &quot;5a&quot; not completely converted</td>
</tr>
<tr>
<td>99999999999</td>
<td>2147483647</td>
<td>printf: &quot;99999999999&quot; arithmetic overflow</td>
</tr>
<tr>
<td>-9999999999</td>
<td>-2147483648</td>
<td>printf: &quot;-9999999999&quot; arithmetic overflow</td>
</tr>
<tr>
<td>ABC</td>
<td>0</td>
<td>printf: &quot;ABC&quot; expected numeric value</td>
</tr>
</tbody>
</table>

The diagnostic message format is not specified, but these examples convey the type of information that should be reported. Note that the value shown on standard output is what would be expected as the return value from the strtol() function as defined in the System Interfaces volume of IEEE Std 1003.1-2001. A similar correspondence exists between %u and strtoul() and %e, %f, and %g (if the implementation supports floating-point conversions) and strtod().
In a locale using the ISO/IEC 646: 1991 standard as the underlying codeset, the command:

```
printf "%d\n" 3 +3 -3 \'3\' "'+3" "'\3"
```

produces:

3  Numeric value of constant 3
3  Numeric value of constant 3
−3 Numeric value of constant −3
51 Numeric value of the character ‘3’ in the ISO/IEC 646: 1991 standard codeset
43 Numeric value of the character ‘+’ in the ISO/IEC 646: 1991 standard codeset
45 Numeric value of the character ‘−’ in the ISO/IEC 646: 1991 standard codeset

Note that in a locale with multi-byte characters, the value of a character is intended to be the value of the equivalent of the `wchar_t` representation of the character as described in the System Interfaces volume of IEEE Std 1003.1-2001.

**RATIONALE**

The `printf` utility was added to provide functionality that has historically been provided by `echo`. However, due to irreconcilable differences in the various versions of `echo` extant, the version has few special features, leaving those to this new `printf` utility, which is based on one in the Ninth Edition system.

The EXTENDED DESCRIPTION section almost exactly matches the `printf()` function in the ISO C standard, although it is described in terms of the file format notation in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 5, File Format Notation.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`awk`, `bc`, `echo`, the System Interfaces volume of IEEE Std 1003.1-2001, `printf()`

**CHANGE HISTORY**

First released in Issue 4.
NAME
prs — print an SCCS file (DEVELOPMENT)

SYNOPSIS
prs [-a][-d dataspec][-r[SID]] file...
prs [ -e | -l ] -c cutoff [-d dataspec] file...
prs [ -e | -l ] -r[SID][-d dataspec] file...

DESCRIPTION
The prs utility shall write to standard output parts or all of an SCCS file in a user-supplied format.

OPTIONS
The prs utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the \(-r\) option has an optional option-argument. This optional option-argument cannot be presented as a separate argument. The following options shall be supported:

-\(\text{-d dataspec}\) Specify the output data specification. The \(\text{dataspec}\) shall be a string consisting of SCCS file data keywords (see Data Keywords (on page 747)) interspersed with optional user-supplied text.

-\(\text{-r[SID]}\) Specify the SCCS identification string (SID) of a delta for which information is desired. If no \(\text{SID}\) option-argument is specified, the SID of the most recently created delta shall be assumed.

-\(\text{-e}\) Request information for all deltas created earlier than and including the delta designated via the \(-r\) option or the date-time given by the \(-c\) option.

-\(\text{-l}\) Request information for all deltas created later than and including the delta designated via the \(-r\) option or the date-time given by the \(-c\) option.

-\(\text{-c cutoff}\) Indicate the \(\text{cutoff}\) date-time, in the form:

\[YY[MM[DD[HH[MM[SS]]]]]]\]

For the \(YY\) component, values in the range \([69,99]\) shall refer to years 1969 to 1999 inclusive, and values in the range \([00,68]\) shall refer to years 2000 to 2068 inclusive.

Note: It is expected that in a future version of IEEE Std 1003.1-2001 the default century inferred from a 2-digit year will change. (This would apply to all commands accepting a 2-digit year as input.)

No changes (deltas) to the SCCS file that were created after the specified \(\text{cutoff}\) date-time shall be included in the output. Units omitted from the date-time default to their maximum possible values; for example, \(-c 7502\) is equivalent to \(-c 750228235959\).

-\(\text{-a}\) Request writing of information for both removed—that is, \(\text{delta type}=R\) (see \(\text{rmdel}\))—and existing—that is, \(\text{delta type}=D\),—deltas. If the \(-a\) option is not specified, information for existing deltas only shall be provided.

OPERANDS
The following operand shall be supported:

\(\text{file}\) A pathname of an existing SCCS file or a directory. If \(\text{file}\) is a directory, the \(\text{prs}\) utility shall behave as though each file in the directory were specified as a named file, except that non-SCCS files (last component of the pathname does not begin with \(s.\)) and unreadable files shall be silently ignored.
Utilities

If exactly one file operand appears, and it is ’−’, the standard input shall be read; each line of the standard input shall be taken to be the name of an SCCS file to be processed. Non-SCCS files and unreadable files shall be silently ignored.

The standard input shall be a text file used only when the file operand is specified as ’−’. Each line of the text file shall be interpreted as an SCCS pathname.

Any SCCS files displayed are files of an unspecified format.

The following environment variables shall affect the execution of prs:

LANG Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

The standard output shall be a text file whose format is dependent on the data keywords specified with the −d option.

Data Keywords

Data keywords specify which parts of an SCCS file shall be retrieved and output. All parts of an SCCS file have an associated data keyword. A data keyword may appear in a dataspec multiple times.

The information written by prs shall consist of:

1. The user-supplied text
2. Appropriate values (extracted from the SCCS file) substituted for the recognized data keywords in the order of appearance in the dataspec

The format of a data keyword value shall either be simple (’S’), in which keyword substitution is direct, or multi-line (’M’).

User-supplied text shall be any text other than recognized data keywords. A <tab> shall be specified by ’\t’ and <newline> by ’\n’. When the −r option is not specified, the default dataspec shall be:

: PN : : \n\n
and the following *dataspec* shall be used for each selected delta:

```plaintext
:DT: \t:DL:\nMRs:\n:MR: COMMENTS: \n:C:
```

### SCCS File Data Keywords

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Data Item</th>
<th>File Section</th>
<th>Value</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>:Dt:</td>
<td>Delta information</td>
<td>Delta Table</td>
<td>See below*</td>
<td>S</td>
</tr>
<tr>
<td>:DL:</td>
<td>Delta line statistics</td>
<td></td>
<td>mmmm***</td>
<td>S</td>
</tr>
<tr>
<td>:Li:</td>
<td>Lines inserted by Delta</td>
<td></td>
<td>mmmm***</td>
<td>S</td>
</tr>
<tr>
<td>:Ld:</td>
<td>Lines deleted by Delta</td>
<td></td>
<td>mmmm***</td>
<td>S</td>
</tr>
<tr>
<td>:Lu:</td>
<td>Lines unchanged by Delta</td>
<td></td>
<td>mmmm***</td>
<td>S</td>
</tr>
<tr>
<td>:DT:</td>
<td>Delta type</td>
<td></td>
<td>D or R</td>
<td>S</td>
</tr>
<tr>
<td>:I:</td>
<td>SCCS ID string (SID)</td>
<td></td>
<td>See below**</td>
<td>S</td>
</tr>
<tr>
<td>:R:</td>
<td>Release number</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:L:</td>
<td>Level number</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:B:</td>
<td>Branch number</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:S:</td>
<td>Sequence number</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:D:</td>
<td>Date delta created</td>
<td></td>
<td>:Dy:/Dm:/Dd:</td>
<td>S</td>
</tr>
<tr>
<td>:Dm:</td>
<td>Month delta created</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:Dd:</td>
<td>Day delta created</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:T:</td>
<td>Time delta created</td>
<td></td>
<td>:Th::Tm::Ts:</td>
<td>S</td>
</tr>
<tr>
<td>:Th:</td>
<td>Hour delta created</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:Tm:</td>
<td>Minutes delta created</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:Ts:</td>
<td>Seconds delta created</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:P:</td>
<td>Programmer who created Delta</td>
<td></td>
<td>logname</td>
<td>S</td>
</tr>
<tr>
<td>:DS:</td>
<td>Delta sequence number</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:DP:</td>
<td>Predecessor Delta sequence number</td>
<td></td>
<td>mmmm</td>
<td>S</td>
</tr>
<tr>
<td>:DI:</td>
<td>Sequence number of deltas</td>
<td></td>
<td>:Dn:/Dx:/Dg:</td>
<td>S</td>
</tr>
<tr>
<td>:Dn:</td>
<td>Deltas included (sequence #)</td>
<td></td>
<td>:DS: :DS:...</td>
<td>S</td>
</tr>
<tr>
<td>:Dx:</td>
<td>Deltas excluded (sequence #)</td>
<td></td>
<td>:DS: :DS:...</td>
<td>S</td>
</tr>
<tr>
<td>:Dg:</td>
<td>Deltas ignored (sequence #)</td>
<td></td>
<td>:DS: :DS:...</td>
<td>S</td>
</tr>
<tr>
<td>:MR:</td>
<td>MR numbers for delta</td>
<td></td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:C:</td>
<td>Comments for delta</td>
<td></td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:UN:</td>
<td>User names</td>
<td>User Names</td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:FL:</td>
<td>Flag list</td>
<td>Flags</td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:Y:</td>
<td>Module type flag</td>
<td></td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:MF:</td>
<td>MR validation flag</td>
<td></td>
<td>yes or no</td>
<td>S</td>
</tr>
<tr>
<td>:MP:</td>
<td>MR validation program name</td>
<td></td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:KF:</td>
<td>Keyword error, warning flag</td>
<td></td>
<td>yes or no</td>
<td>S</td>
</tr>
<tr>
<td>:KV:</td>
<td>Keyword validation string</td>
<td></td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:BF:</td>
<td>Branch flag</td>
<td></td>
<td>yes or no</td>
<td>S</td>
</tr>
<tr>
<td>:J:</td>
<td>Joint edit flag</td>
<td></td>
<td>yes or no</td>
<td>S</td>
</tr>
<tr>
<td>:LK:</td>
<td>Locked releases</td>
<td></td>
<td>:R:...</td>
<td>S</td>
</tr>
<tr>
<td>:Q:</td>
<td>User-defined keyword</td>
<td></td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:M:</td>
<td>Module name</td>
<td></td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>Keyword</td>
<td>Data Item</td>
<td>File Section</td>
<td>Value</td>
<td>Format</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------</td>
<td>--------------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>:FB:</td>
<td>Floor boundary</td>
<td>&quot;</td>
<td>:R:</td>
<td>S</td>
</tr>
<tr>
<td>:CB:</td>
<td>Ceiling boundary</td>
<td>&quot;</td>
<td>:R:</td>
<td>S</td>
</tr>
<tr>
<td>:Ds:</td>
<td>Default SID</td>
<td>&quot;</td>
<td>:I:</td>
<td>S</td>
</tr>
<tr>
<td>:ND:</td>
<td>Null delta flag</td>
<td>&quot;</td>
<td>yes or no</td>
<td>S</td>
</tr>
<tr>
<td>:FD:</td>
<td>File descriptive text</td>
<td>Comments</td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:BD:</td>
<td>Body</td>
<td>Body</td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:GB:</td>
<td>Gotten body</td>
<td></td>
<td>text</td>
<td>M</td>
</tr>
<tr>
<td>:W:</td>
<td>A form of what string</td>
<td>N/A</td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:A:</td>
<td>A form of what string</td>
<td>N/A</td>
<td>@(#)</td>
<td>S</td>
</tr>
<tr>
<td>:Z:</td>
<td>what string delimiter</td>
<td>N/A</td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:F:</td>
<td>SCCS filename</td>
<td>N/A</td>
<td>text</td>
<td>S</td>
</tr>
<tr>
<td>:PN:</td>
<td>SCCS file pathname</td>
<td>N/A</td>
<td>text</td>
<td>S</td>
</tr>
</tbody>
</table>


** :R: :L: :B: :S: if the delta is a branch delta (:BF:= =yes)

*** :R: :L: if the delta is not a branch delta (:BF:= =no)

*** The line statistics are capped at 99,999. For example, if 100,000 lines were unchanged in a certain revision, :Lu: shall produce the value 99,999.

STDOUT

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

None.

EXAMPLES

1. The following example:

   prs -d "User Names for :F: are:\n:UN:" s.file

   might write to standard output:

   User Names for s.file are:

   xyz

   abc

2. The following example:
prs

prs -d "Delta for pgm :M: :I: - :D: By :P:" -r s.file
might write to standard output:

> Delta for pgm main.c: 3.7 - 77/12/01 By cas

3. As a special case:

prs s.file
might write to standard output:

> s.file:
> <blank line>
> D 1.1 77/12/01 00:00:00 cas 1 000000/000000/000000
> MRs:
> b178-12345
> b179-54321
> COMMENTS:
> this is the comment line for s.file initial delta
> <blank line>
for each delta table entry of the D type. The only option allowed to be used with this
special case is the -a option.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
admin, delta, get, what

CHANGE HISTORY
First released in Issue 2.

Issue 5
The phrase “in which keyword substitution is followed by a <newline>” is deleted from the end
of the second paragraph of Data Keywords (on page 747).
The interpretation of the YY component of the -c cutoff argument is noted.

Issue 6
The normative text is reworded to emphasize the term “shall” for implementation requirements.
The Open Group Base Resolution bwg2001-007 is applied, updating the table in STDOUT with a
note that line statistics are capped at 99 999 for the :Li, :Ld, :Lu, and :DL keywords.
The Open Group Interpretation PIN4C.00009 is applied.
NAME

ps — report process status

SYNOPSIS

ps [-aA] [-defl] [-G grouplist] [-o format] ... [-p proclist] [-t termlist]

[[-U userlist] [-g grouplist] [-n namelist] [-u userlist]]

DESCRIPTION

The ps utility shall write information about processes, subject to having the appropriate privileges to obtain information about those processes.

By default, ps shall select all processes with the same effective user ID as the current user and the same controlling terminal as the invoker.

OPTIONS


The following options shall be supported:

-a Write information for all processes associated with terminals. Implementations may omit session leaders from this list.

-A Write information for all processes.

-d Write information for all processes, except session leaders.

-e Write information for all processes. (Equivalent to -A.)

-f Generate a full listing. (See the STDOUT section for the contents of a full listing.)

-g grouplist Write information for processes whose session leaders are given in grouplist. The application shall ensure that the grouplist is a single argument in the form of a <blank> or comma-separated list.

-G grouplist Write information for processes whose real group ID numbers are given in grouplist. The application shall ensure that the grouplist is a single argument in the form of a <blank> or comma-separated list.

-l Generate a long listing. (See STDOUT for the contents of a long listing.)

-n namelist Specify the name of an alternative system namelist file in place of the default. The name of the default file and the format of a namelist file are unspecified.

-o format Write information according to the format specification given in format. This is fully described in the STDOUT section. Multiple -o options can be specified; the format specification shall be interpreted as the <space>-separated concatenation of all the format option-arguments.

-p proclist Write information for processes whose process ID numbers are given in proclist. The application shall ensure that the proclist is a single argument in the form of a <blank> or comma-separated list.

-t termlist Write information for processes associated with terminals given in termlist. The application shall ensure that the termlist is a single argument in the form of a <blank> or comma-separated list. Terminal identifiers shall be given in an implementation-defined format. On XSI-conformant systems, they shall be given in one of two forms: the device's filename (for example, tty04) or, if the device's filename starts with tty, just the identifier following the characters tty (for
example, "04").

XSI

−u userlist Write information for processes whose user ID numbers or login names are given in userlist. The application shall ensure that the userlist is a single argument in the form of a <blank> or comma-separated list. In the listing, the numerical user ID shall be written unless the −f option is used, in which case the login name shall be written.

−U userlist Write information for processes whose real user ID numbers or login names are given in userlist. The application shall ensure that the userlist is a single argument in the form of a <blank> or comma-separated list.

With the exception of −o format, all of the options shown are used to select processes. If any are specified, the default list shall be ignored and ps shall select the processes represented by the inclusive OR of all the selection-criteria options.

OPERANDS

None.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of ps:

COLUMNS Override the system-selected horizontal display line size, used to determine the number of text columns to display. See the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables for valid values and results when it is unset or null.

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

LC_TIME Determine the format and contents of the date and time strings displayed.

XSI

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

TZ Determine the timezone used to calculate date and time strings displayed. If TZ is unset or null, an unspecified default timezone shall be used.
### ASYNCHRONOUS EVENTS

Default.

### STDOUT

When the −o option is not specified, the standard output format is unspecified.

On XSI-conformant systems, the output format shall be as follows. The column headings and descriptions of the columns in a ps listing are given below. The precise meanings of these fields are implementation-defined. The letters ’f’ and ’l’ (below) indicate the option (full or long) that shall cause the corresponding heading to appear; all means that the heading always appears. Note that these two options determine only what information is provided for a process; they do not determine which processes are listed.

<table>
<thead>
<tr>
<th>Column</th>
<th>Width</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>(l)</td>
<td>Flags (octal and additive) associated with the process.</td>
</tr>
<tr>
<td>S</td>
<td>(l)</td>
<td>The state of the process.</td>
</tr>
<tr>
<td>UID</td>
<td>(f,l)</td>
<td>The user ID number of the process owner; the login name is printed under the −f option.</td>
</tr>
<tr>
<td>PID</td>
<td>(all)</td>
<td>The process ID of the process; it is possible to kill a process if this datum is known.</td>
</tr>
<tr>
<td>PPID</td>
<td>(f,l)</td>
<td>The process ID of the parent process.</td>
</tr>
<tr>
<td>C</td>
<td>(f,l)</td>
<td>Processor utilization for scheduling.</td>
</tr>
<tr>
<td>PRI</td>
<td>(l)</td>
<td>The priority of the process; higher numbers mean lower priority.</td>
</tr>
<tr>
<td>NI</td>
<td>(l)</td>
<td>Nice value; used in priority computation.</td>
</tr>
<tr>
<td>ADDR</td>
<td>(l)</td>
<td>The address of the process.</td>
</tr>
<tr>
<td>SZ</td>
<td>(l)</td>
<td>The size in blocks of the core image of the process.</td>
</tr>
<tr>
<td>WCHAN</td>
<td>(l)</td>
<td>The event for which the process is waiting or sleeping; if blank, the process is running.</td>
</tr>
<tr>
<td>STIME</td>
<td>(f)</td>
<td>Starting time of the process.</td>
</tr>
<tr>
<td>TTY</td>
<td>(all)</td>
<td>The controlling terminal for the process.</td>
</tr>
<tr>
<td>TIME</td>
<td>(all)</td>
<td>The cumulative execution time for the process.</td>
</tr>
<tr>
<td>CMD</td>
<td>(all)</td>
<td>The command name; the full command name and its arguments are written under the −f option.</td>
</tr>
</tbody>
</table>

A process that has exited and has a parent, but has not yet been waited for by the parent, shall be marked **defunct**.

Under the option −f, ps tries to determine the command name and arguments given when the process was created by examining memory or the swap area. Failing this, the command name, as it would appear without the option −f, is written in square brackets.

The −o option allows the output format to be specified under user control.

The application shall ensure that the format specification is a list of names presented as a single argument, <blank> or comma-separated. Each variable has a default header. The default header can be overridden by appending an equals sign and the new text of the header. The rest of the characters in the argument shall be used as the header text. The fields specified shall be written in the order specified on the command line, and should be arranged in columns in the output. The field widths shall be selected by the system to be at least as wide as the header text (default or overridden value). If the header text is null, such as −o user=, the field width shall be at least as wide as the default header text. If all header text fields are null, no header line shall be written.

The following names are recognized in the POSIX locale:
The real user ID of the process. This shall be the textual user ID, if it can be obtained and the field width permits, or a decimal representation otherwise.

The effective user ID of the process. This shall be the textual user ID, if it can be obtained and the field width permits, or a decimal representation otherwise.

The real group ID of the process. This shall be the textual group ID, if it can be obtained and the field width permits, or a decimal representation otherwise.

The effective group ID of the process. This shall be the textual group ID, if it can be obtained and the field width permits, or a decimal representation otherwise.

The decimal value of the process ID.

The decimal value of the parent process ID.

The decimal value of the process group ID.

The ratio of CPU time used recently to CPU time available in the same period, expressed as a percentage. The meaning of "recently" in this context is unspecified. The CPU time available is determined in an unspecified manner.

The size of the process in (virtual) memory in 1024 byte units as a decimal integer.

The decimal value of the nice value of the process; see nice.

In the POSIX locale, the elapsed time since the process was started, in the form:

\[ [ \text{dd}−] \text{hh} : \text{mm} : \text{ss} \]

where \( \text{dd} \) shall represent the number of days, \( \text{hh} \) the number of hours, \( \text{mm} \) the number of minutes, and \( \text{ss} \) the number of seconds. The \( \text{dd} \) field shall be a decimal integer. The \( \text{hh}, \text{mm}, \) and \( \text{ss} \) fields shall be two-digit decimal integers padded on the left with zeros.

In the POSIX locale, the cumulative CPU time of the process in the form:

\[ [ \text{dd}−] \text{hh} : \text{mm} : \text{ss} \]

The \( \text{dd}, \text{hh}, \text{mm}, \) and \( \text{ss} \) fields shall be as described in the etime specifier.

The name of the controlling terminal of the process (if any) in the same format used by the who utility.

The name of the command being executed (argv[0] value) as a string.

The command with all its arguments as a string. The implementation may truncate this value to the field width; it is implementation-defined whether any further truncation occurs. It is unspecified whether the string represented is a version of the argument list as it was passed to the command when it started, or is a version of the arguments as they may have been modified by the application. Applications cannot depend on being able to modify their argument list and having that modification be reflected in the output of ps.

Any field need not be meaningful in all implementations. In such a case a hyphen (‘−’) should be output in place of the field value.

Only comm and args shall be allowed to contain <blank>s; all others shall not. Any implementation-defined variables shall be specified in the system documentation along with the default header and indicating whether the field may contain <blank>s.

The following table specifies the default header to be used in the POSIX locale corresponding to each format specifier.
Table 4-17  Variable Names and Default Headers in ps

<table>
<thead>
<tr>
<th>Format Specifier</th>
<th>Default Header</th>
<th>Format Specifier</th>
<th>Default Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>args</td>
<td>COMMAND</td>
<td>ppid</td>
<td>PPID</td>
</tr>
<tr>
<td>comm</td>
<td>COMMAND</td>
<td>rgroup</td>
<td>RGROUP</td>
</tr>
<tr>
<td>etime</td>
<td>ELAPSED</td>
<td>ruser</td>
<td>RUSER</td>
</tr>
<tr>
<td>group</td>
<td>GROUP</td>
<td>time</td>
<td>TIME</td>
</tr>
<tr>
<td>nice</td>
<td>NI</td>
<td>tty</td>
<td>TT</td>
</tr>
<tr>
<td>pcpu</td>
<td>%CPU</td>
<td>user</td>
<td>USER</td>
</tr>
<tr>
<td>pgid</td>
<td>PGID</td>
<td>vsz</td>
<td>VSZ</td>
</tr>
<tr>
<td>pid</td>
<td>PID</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0   Successful completion.
>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Things can change while ps is running; the snapshot it gives is only true for an instant, and might not be accurate by the time it is displayed.

The args format specifier is allowed to produce a truncated version of the command arguments. In some implementations, this information is no longer available when the ps utility is executed.

If the field width is too narrow to display a textual ID, the system may use a numeric version. Normally, the system would be expected to choose large enough field widths, but if a large number of fields were selected to write, it might squeeze fields to their minimum sizes to fit on one line. One way to ensure adequate width for the textual IDs is to override the default header for a field to make it larger than most or all user or group names.

There is no special quoting mechanism for header text. The header text is the rest of the argument. If multiple header changes are needed, multiple -o options can be used, such as:

ps -o "user=User Name" -o pid=Process\ ID

On some implementations, especially multi-level secure systems, ps may be severely restricted and produce information only about child processes owned by the user.

EXAMPLES
The command:

ps -o user,pid,ppid=MOM -o args

writes at least the following in the POSIX locale:

USER PID MOM COMMAND
helene 34 12 ps -o uid,pid,ppid=MOM -o args
The contents of the **COMMAND** field need not be the same in all implementations, due to possible truncation.

**RATIONALE**

There is very little commonality between BSD and System V implementations of *ps*. Many options conflict or have subtly different usages. The standard developers attempted to select a set of options for the base standard that were useful on a wide range of systems and selected options that either can be implemented on both BSD and System V-based systems without breaking the current implementations or where the options are sufficiently similar that any changes would not be unduly problematic for users or implementors.

It is recognized that on some implementations, especially multi-level secure systems, *ps* may be nearly useless. The default output has therefore been chosen such that it does not break historical implementations and also is likely to provide at least some useful information on most systems.

The major change is the addition of the format specification capability. The motivation for this invention is to provide a mechanism for users to access a wider range of system information, if the system permits it, in a portable manner. The fields chosen to appear in this volume of IEEE Std 1003.1-2001 were arrived at after considering what concepts were likely to be both reasonably useful to the "average" user and had a reasonable chance of being implemented on a wide range of systems. Again it is recognized that not all systems are able to provide all the information and, conversely, some may wish to provide more. It is hoped that the approach adopted will be sufficiently flexible and extensible to accommodate most systems. Implementations may be expected to introduce new format specifiers.

The default output should consist of a short listing containing the process ID, terminal name, cumulative execution time, and command name of each process.

The preference of the standard developers would have been to make the format specification an operand of the *ps* command. Unfortunately, BSD usage precluded this.

At one time a format was included to display the environment array of the process. This was deleted because there is no portable way to display it.

The **−A** option is equivalent to the BSD **−g** and the SVID **−e**. Because the two systems differed, a mnemonic compromise was selected.

The **−a** option is described with some optional behavior because the SVID omits session leaders, but BSD does not.

In an early proposal, format specifiers appeared for priority and start time. The former was not defined adequately in this volume of IEEE Std 1003.1-2001 and was removed in deference to the defined nice value; the latter because elapsed time was considered to be more useful.

In a new BSD version of *ps*, a **−O** option can be used to write all of the default information, followed by additional format specifiers. This was not adopted because the default output is implementation-defined. Nevertheless, this is a useful option that should be reserved for that purpose. In the **−o** option for the POSIX Shell and Utilities *ps*, the format is the concatenation of each **−o**. Therefore, the user can have an alias or function that defines the beginning of their desired format and add more fields to the end of the output in certain cases where that would be useful.

The format of the terminal name is unspecified, but the descriptions of *ps*, *talk*, *who*, and *write* require that they all use the same format.

The **pcpu** field indicates that the CPU time available is determined in an unspecified manner. This is because it is difficult to express an algorithm that is useful across all possible machine
architectures. Historical counterparts to this value have attempted to show percentage of use in
the recent past, such as the preceding minute. Frequently, these values for all processes did not
add up to 100%. Implementations are encouraged to provide data in this field to users that will
help them identify processes currently affecting the performance of the system.

FUTURE DIRECTIONS
None.

SEE ALSO
kill, nice, renice

CHANGE HISTORY
First released in Issue 2.

Issue 6
This utility is marked as part of the User Portability Utilities option.
The normative text is reworded to avoid use of the term “must” for application requirements.
The TZ entry is added to the ENVIRONMENT VARIABLES section.
NAME
pwd — return working directory name

SYNOPSIS
pwd [-L | -P]

DESCRIPTION
The `pwd` utility shall write to standard output an absolute pathname of the current working
directory, which does not contain the filenames dot or dot-dot.

OPTIONS
The `pwd` utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported by the implementation:

- `-L` If the `PWD` environment variable contains an absolute pathname of the current
directory that does not contain the filenames dot or dot-dot, `pwd` shall write this
pathname to standard output. Otherwise, the `-L` option shall behave as the `-P`
option.

- `-P` The absolute pathname written shall not contain filenames that, in the context of
the pathname, refer to files of type symbolic link.

If both `-L` and `-P` are specified, the last one shall apply. If neither `-L` nor `-P` is specified, the `pwd`
utility shall behave as if `-L` had been specified.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of `pwd`:

- `LANG` Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

- `LC_ALL` If set to a non-empty string value, override the values of all the other
internationalization variables.

- `LC_MESSAGES` Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

- `NLSPATH` Determine the location of message catalogs for the processing of `LC_MESSAGES`.

- `PWD` If the `-P` option is in effect, this variable shall be set to an absolute pathname of the
current working directory that does not contain any components that specify
symbolic links, does not contain any components that are dot, and does not
contain any components that are dot-dot. If an application sets or unsets the value
of `PWD`, the behavior of `pwd` is unspecified.
Utilities

pwd

ASYNCHRONOUS EVENTS
29541 Default.

STDOUT
29542 The `pwd` utility output is an absolute pathname of the current working directory:
29543 "\%s\n", <directory pathname>

STDERR
29544 The standard error shall be used only for diagnostic messages.

OUTPUT FILES
29545 None.

EXTENDED DESCRIPTION
29546 None.

EXIT STATUS
29552 The following exit values shall be returned:
29553 0 Successful completion.
29555 >0 An error occurred.

CONSEQUENCES OF ERRORS
29557 If an error is detected, output shall not be written to standard output, a diagnostic message shall
29558 be written to standard error, and the exit status is not zero.

APPLICATION USAGE
29560 None.

EXAMPLES
29561 None.

RATIONALE
29564 Some implementations have historically provided `pwd` as a shell special built-in command.
29565 In most utilities, if an error occurs, partial output may be written to standard output. This does
29566 not happen in historical implementations of `pwd`. Because `pwd` is frequently used in historical
29567 shell scripts without checking the exit status, it is important that the historical behavior is
29568 required here; therefore, the CONSEQUENCES OF ERRORS section specifically disallows any
29569 partial output being written to standard output.

FUTURE DIRECTIONS
29570 None.

SEE ALSO
29573 `cd`, the System Interfaces volume of IEEE Std 1003.1-2001, `getcwd()`

CHANGE HISTORY
29575 First released in Issue 2.
29576 Issue 6
29577 The `-P` and `-L` options are added to describe actions relating to symbolic links as specified in the
29578 IEEE P1003.2b draft standard.
NAME
qalter — alter batch job

SYNOPSIS
qalter [-a date_time] [-A account_string] [-c interval] [-e path_name]
        [h hold_list] [-j join_list] [-k keep_list] [-l resource_list]
        [-m mail_options] [-M mail_list] [-N name] [-o path_name]
        [-p priority] [-r y|n] [-S path_name_list] [-u user_list]
        job_identifier ...

DESCRIPTION
The attributes of a batch job are altered by a request to the batch server that manages the batch job. The qalter utility is a user-accessible batch client that requests the alteration of the attributes of one or more batch jobs.

The qalter utility shall alter the attributes of those batch jobs, and only those batch jobs, for which a batch job_identifier is presented to the utility.

The qalter utility shall alter the attributes of batch jobs in the order in which the batch job_identifiers are presented to the utility.

If the qalter utility fails to process a batch job_identifier successfully, the utility shall proceed to process the remaining batch job_identifiers, if any.

For each batch job_identifier for which the qalter utility succeeds, each attribute of the identified batch job shall be altered as indicated by all the options presented to the utility.

For each identified batch job for which the qalter utility fails, the utility shall not alter any attribute of the batch job.

For each batch job that the qalter utility processes, the utility shall not modify any attribute other than those required by the options and option-arguments presented to the utility.

The qalter utility shall alter batch jobs by sending a Modify Job Request to the batch server that manages each batch job. At the time the qalter utility exits, it shall have modified the batch job corresponding to each successfully processed batch job_identifier. An attempt to alter the attributes of a batch job in the RUNNING state is implementation-defined.

OPTIONS

The following options shall be supported by the implementation:

-a date_time  Redefine the time at which the batch job becomes eligible for execution.

    The date_time argument shall be in the same form and represent the same time as for the touch utility. The time so represented shall be set into the Execution_Time attribute of the batch job. If the time specified is earlier than the current time, the -a option shall have no effect.

-A account_string
    Redefine the account to which the resource consumption of the batch job should be charged.

    The syntax of the account_string option-argument is unspecified.

The qalter utility shall set the Account_Name attribute of the batch job to the value of the account_string option-argument.
Redefine whether the batch job should be checkpointed, and if so, how often.

The `qalter` utility shall accept a value for the interval option-argument that is one of the following:

- `n` No checkpointing is to be performed on the batch job (NO_CHECKPOINT).
- `s` Checkpointing is to be performed only when the batch server is shut down (CHECKPOINT_AT_SHUTDOWN).
- `c` Automatic periodic checkpointing is to be performed at the `Minimum_Cpu_Interval` attribute of the batch queue, in units of CPU minutes (CHECKPOINT_AT_MIN_CPU_INTERVAL).

`c=minutes` Automatic periodic checkpointing is to be performed every `minutes` of CPU time, or every `Minimum_Cpu_Interval` minutes, whichever is greater. The `minutes` argument shall conform to the syntax for unsigned integers and shall be greater than zero.

An implementation may define other checkpoint intervals. The conformance document for an implementation shall describe any alternative checkpoint intervals, how they are specified, their internal behavior, and how they affect the behavior of the utility.

The `qalter` utility shall set the `Checkpoint` attribute of the batch job to the value of the `interval` option-argument.

Redefine the path to be used for the standard error stream of the batch job.

The `qalter` utility shall accept a value for the `path_name` option-argument that conforms to the syntax of the `path_name` element defined in the System Interfaces volume of IEEE Std 1003.1-2001, which can be preceded by a host name element of the form `hostname:`.

If the `path_name` option-argument constitutes an absolute pathname, the `qalter` utility shall set the `Error_Path` attribute of the batch job to the value of the `path_name` option-argument, including the host name element, if present.

If the `path_name` option-argument constitutes a relative pathname and no host name element is specified, the `qalter` utility shall set the `Error_Path` attribute of the batch job to the value of the absolute pathname derived by expanding the `path_name` option-argument relative to the current directory of the process that executes the `qalter` utility.

If the `path_name` option-argument constitutes a relative pathname and a host name element is specified, the `qalter` utility shall set the `Error_Path` attribute of the batch job to the value of the option-argument without expansion.

If the `path_name` option-argument does not include a host name element, the `qalter` utility shall prefix the pathname in the `Error_Path` attribute with `hostname:`, where `hostname` is the name of the host upon which the `qalter` utility is being executed.

Redefine the types of holds, if any, on the batch job. The `qalter` `−h` option shall accept a value for the `hold_list` option-argument that is a string of alphanumeric characters in the portable character set.

The `qalter` utility shall accept a value for the `hold_list` option-argument that is a string of one or more of the characters ‘u’, ‘s’, or ‘o’, or the single character
'n'. For each unique character in the hold_list option-argument, the qalter utility shall add a value to the Hold_Types attribute of the batch job as follows, each representing a different hold type:

- **u** USER
- **s** SYSTEM
- **o** OPERATOR

If any of these characters are duplicated in the hold_list option-argument, the duplicates shall be ignored. An existing Hold_Types attribute can be cleared by the hold type:

- **n** NO_HOLD

The qalter utility shall consider it an error if any hold type other than ‘n’ is combined with hold type ‘n’. Strictly conforming applications shall not repeat any of the characters ‘u’, ‘s’, ‘o’, or ‘n’ within the hold_list option-argument. The qalter utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters. An implementation may define other hold types. The conformance document for an implementation shall describe any additional hold types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

```
−j join_list
```

Redefine which streams of the batch job are to be merged. The qalter −j option shall accept a value for the join_list option-argument that is a string of alphanumeric characters in the portable character set.

The qalter utility shall accept a join_list option-argument that consists of one or more of the characters ‘e’ and ‘o’, or the single character ‘n’.

All of the other batch job output streams specified shall be merged into the output stream represented by the character listed first in the join_list option-argument.

For each unique character in the join_list option-argument, the qalter utility shall add a value to the Join_Path attribute of the batch job as follows, each representing a different batch job stream to join:

- **e** The standard error of the batch job (JOIN_STD_ERROR).
- **o** The standard output of the batch job (JOIN_STD_OUTPUT).

An existing Join_Path attribute can be cleared by the join type:

- **n** NO_JOIN

If ‘n’ is specified, then no files are joined. The qalter utility shall consider it an error if any join type other than ‘n’ is combined with join type ‘n’.

Strictly conforming applications shall not repeat any of the characters ‘e’, ‘o’, or ‘n’ within the join_list option-argument. The qalter utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters.

An implementation may define other join types. The conformance document for an implementation shall describe any additional batch job streams, how they are specified, their internal behavior, and how they affect the behavior of the utility.

```
−k keep_list
```

Redefine which output of the batch job to retain on the execution host.
The `qalter -k` option shall accept a value for the `keep_list` option-argument that is a string of alphanumeric characters in the portable character set.

The `qalter` utility shall accept a `keep_list` option-argument that consists of one or more of the characters 'e', 'o', or the single character 'n'.

For each unique character in the `keep_list` option-argument, the `qalter` utility shall add a value to the `Keep_Files` attribute of the batch job as follows, each representing a different batch job stream to keep:

- e  The standard error of the batch job (KEEP_STD_ERROR).
- o  The standard output of the batch job (KEEP_STD_OUTPUT).

If both 'e' and 'o' are specified, then both files are retained. An existing `Keep_Files` attribute can be cleared by the keep type:

- n  NO_KEEP

If 'n' is specified, then no files are retained. The `qalter` utility shall consider it an error if any keep type other than 'n' is combined with keep type 'n'.

Strictly conforming applications shall not repeat any of the characters 'e', 'o', or 'n' within the `keep_list` option-argument. The `qalter` utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters. An implementation may define other keep types. The conformance document for an implementation shall describe any additional keep types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

`-l resource_list`

Redefine the resources that are allowed or required by the batch job.

The `qalter` utility shall accept a `resource_list` option-argument that conforms to the following syntax:

```
resource=value[,,resource=value,,...]
```

The `qalter` utility shall set one entry in the value of the `Resource_List` attribute of the batch job for each resource listed in the `resource_list` option-argument.

Because the list of supported resource names might vary by batch server, the `qalter` utility shall rely on the batch server to validate the resource names and associated values. See Section 3.3.3 (on page 123) for a means of removing `keyword=value` (and `value@keyword`) pairs and other general rules for list-oriented batch job attributes.

`-m mail_options`

Redefine the points in the execution of the batch job at which the batch server is to send mail about a change in the state of the batch job.

The `qalter -m` option shall accept a value for the `mail_options` option-argument that is a string of alphanumeric characters in the portable character set.

The `qalter` utility shall accept a value for the `mail_options` option-argument that is a string of one or more of the characters 'e', 'b', and 'a', or the single character 'n'. For each unique character in the `mail_options` option-argument, the `qalter` utility shall add a value to the `Mail_Users` attribute of the batch job as follows, each representing a different time during the life of a batch job at which to send mail:

- e  MAIL_AT_EXIT
b  MAIL_AT_BEGINNING

a  MAIL_AT_ABORT

If any of these characters are duplicated in the mail_options option-argument, the duplicates shall be ignored.

An existing Mail_Points attribute can be cleared by the mail type:

n  NO_MAIL

If ‘n’ is specified, then mail is not sent. The qalter utility shall consider it an error if any mail type other than ‘n’ is combined with mail type ‘n’. Strictly conforming applications shall not repeat any of the characters ‘e’, ‘b’, ‘a’, or ‘n’ within the mail_options option-argument. The qalter utility shall permit the repetition of characters but shall not assign additional meaning to the repeated characters.

An implementation may define other mail types. The conformance document for an implementation shall describe any additional mail types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

-M mail_list  Redefine the list of users to which the batch server that executes the batch job is to send mail, if the batch server sends mail about the batch job.

The syntax of the mail_list option-argument is unspecified. If the implementation of the qalter utility uses a name service to locate users, the utility shall accept the syntax used by the name service.

If the implementation of the qalter utility does not use a name service to locate users, the implementation shall accept the following syntax for user names:

mail_address[,mail_address,...]

The interpretation of mail_address is implementation-defined.

The qalter utility shall set the Mail_Users attribute of the batch job to the value of the mail_list option-argument.

-N name  Redefine the name of the batch job.

The qalter –N option shall accept a value for the name option-argument that is a string of up to 15 alphanumeric characters in the portable character set where the first character is alphabetic.

The syntax of the name option-argument is unspecified.

The qalter utility shall set the Job_Name attribute of the batch job to the value of the name option-argument.

-o path_name  Redefine the path for the standard output of the batch job.

The qalter utility shall accept a path_name option-argument that conforms to the syntax of the path_name element defined in the System Interfaces volume of IEEE Std 1003.1-2001, which can be preceded by a host name element of the form hostname:

If the path_name option-argument constitutes an absolute pathname, the qalter utility shall set the Output_Path attribute of the batch job to the value of the path_name option-argument.
If the `path_name` option-argument constitutes a relative pathname and no host name element is specified, the `qalter` utility shall set the `Output_Path` attribute of the batch job to the absolute pathname derived by expanding the `path_name` option-argument relative to the current directory of the process that executes the `qalter` utility.

If the `path_name` option-argument constitutes a relative pathname and a host name element is specified, the `qalter` utility shall set the `Output_Path` attribute of the batch job to the value of the `path_name` option-argument without any expansion of the pathname.

If the `path_name` option-argument does not include a host name element, the `qalter` utility shall prefix the pathname in the `Output_Path` attribute with `hostname:`, where `hostname` is the name of the host upon which the `qalter` utility is being executed.

−p priority
Redefine the priority of the batch job.

The `qalter` utility shall accept a value for the `priority` option-argument that conforms to the syntax for signed decimal integers, and which is not less than −1 024 and not greater than 1 023.

The `qalter` utility shall set the `Priority` attribute of the batch job to the value of the `priority` option-argument.

−r y | n
Redefine whether the batch job is rerunnable.

If the value of the option-argument is ‘y’, the `qalter` utility shall set the `Rerunable` attribute of the batch job to TRUE.

If the value of the option-argument is ‘n’, the `qalter` utility shall set the `Rerunable` attribute of the batch job to FALSE.

The `qalter` utility shall consider it an error if any character other than ‘y’ or ‘n’ is specified in the option-argument.

−S path_name_list
Redefine the shell that interprets the script at the destination system.

The `qalter` utility shall accept a `path_name_list` option-argument that conforms to the following syntax:

```
pathname[@host][]
```

The `qalter` utility shall accept only one pathname that is missing a corresponding host name. The `qalter` utility shall allow only one pathname per named host.

The `qalter` utility shall add a value to the `Shell_Path_List` attribute of the batch job for each entry in the `path_name_list` option-argument. See Section 3.3.3 (on page 123) for a means of removing `keyword=value` (and `value@keyword`) pairs and other general rules for list-oriented batch job attributes.

−u user_list
Redefine the user name under which the batch job is to run at the destination system.

The `qalter` utility shall accept a `user_list` option-argument that conforms to the following syntax:

```
username[@host][]
```

The `qalter` utility shall accept only one user name that is missing a corresponding host name. The `qalter` utility shall accept only one user name per named host.
The `qalter` utility shall add a value to the `User_List` attribute of the batch job for each entry in the `user_list` option-argument. See Section 3.3.3 (on page 123) for a means of removing `keyword=value` (and `value@keyword`) pairs and other general rules for list-oriented batch job attributes.

**OPERANDS**

The `qalter` utility shall accept one or more operands that conform to the syntax for a batch `job_identifier` (see Section 3.3.1 (on page 122)).

**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of `qalter`:

- **LANG**
  
  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**
  
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**
  
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **LOGNAME**
  
  Determine the login name of the user.

- **TZ**
  
  Determine the timezone used to interpret the `date-time` option-argument. If TZ is unset or null, an unspecified default timezone shall be used.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

None.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- **0** Successful completion.
- **>0** An error occurred.
CONSEQUENCES OF ERRORS

In addition to the default behavior, the **qalter** utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job **job_identifier** does not exist on the server. Whether or not the **qalter** utility attempts to locate the batch job on other batch servers is implementation-defined.

APPLICATION USAGE

None.

EXAMPLES

None.

RATIONALE

The **qalter** utility allows users to change the attributes of a batch job.

As a means of altering a queued job, the **qalter** utility is superior to deleting and requeuing the batch job insofar as an altered job retains its place in the queue with some traditional selection algorithms. In addition, the **qalter** utility is both shorter and simpler than a sequence of **qdel** and **qsub** utilities.

The result of an attempt on the part of a user to alter a batch job in a RUNNING state is implementation-defined because a batch job in the RUNNING state will already have opened its output files and otherwise performed any actions indicated by the options in effect at the time the batch job began execution.

The options processed by the **qalter** utility are identical to those of the **qsub** utility, with a few exceptions: −V, −v, and −q. The −V and −v are inappropriate for the **qalter** utility, since they capture potentially transient environment information from the submitting process. The −q option would specify a new queue, which would largely negate the previously stated advantage of using **qalter**; furthermore, the **qmove** utility provides a superior means of moving jobs.

Each of the following paragraphs provides the rationale for a **qalter** option.

Additional rationale concerning these options can be found in the rationale for the **qsub** utility.

The −a option allows users to alter the date and time at which a batch job becomes eligible to run.

The −A option allows users to change the account that will be charged for the resources consumed by the batch job. Support for the −A option is mandatory for conforming implementations of **qalter**, even though support of accounting is optional for servers. Whether or not to support accounting is left to the implementor of the server, but mandatory support of the −A option assures users of a consistent interface and allows them to control accounting on servers that support accounting.

The −c option allows users to alter the checkpointing interval of a batch job. A checkpointing system, which is not defined by IEEE Std 1003.1-2001, allows recovery of a batch job at the most recent checkpoint in the event of a crash. Checkpointing is typically used for jobs that consume expensive computing time or must meet a critical schedule. Users should be allowed to make the tradeoff between the overhead of checkpointing and the risk to the timely completion of the batch job; therefore, this volume of IEEE Std 1003.1-2001 provides the checkpointing interval option. Support for checkpointing is optional for servers.

The −e option allows users to alter the name and location of the standard error stream written by a batch job. However, the path of the standard error stream is meaningless if the value of the **Join_Path** attribute of the batch job is TRUE.

The −h option allows users to set the hold type in the **Hold_Types** attribute of a batch job. The **qhold** and **qrls** utilities add or remove hold types to the **Hold_Types** attribute, respectively. The −h
option has been modified to allow for implementation-defined hold types.

The \texttt{−j} option allows users to alter the decision to join (merge) the standard error stream of the batch job with the standard output stream of the batch job.

The \texttt{−l} option allows users to change the resource limits imposed on a batch job.

The \texttt{−m} option allows users to modify the list of points in the life of a batch job at which the designated users will receive mail notification.

The \texttt{−M} option allows users to alter the list of users who will receive notification about events in the life of a batch job.

The \texttt{−N} option allows users to change the name of a batch job.

The \texttt{−o} option allows users to alter the name and path to which the standard output stream of the batch job will be written.

The \texttt{−P} option allows users to modify the priority of a batch job. Support for priority is optional for batch servers.

The \texttt{−r} option allows users to alter the rerunability status of a batch job.

The \texttt{−S} option allows users to change the name and location of the shell image that will be invoked to interpret the script of the batch job. This option has been modified to allow a list of shell name and locations associated with different hosts.

The \texttt{−u} option allows users to change the user identifier under which the batch job will execute.

The \texttt{job_identifier} operand syntax is provided so that the user can differentiate between the originating and destination (or executing) batch server. These may or may not be the same. The \texttt{server_name} portion identifies the originating batch server, while the \texttt{@server} portion identifies the destination batch server.

Historically, the \texttt{qalter} utility has been a component of the Network Queuing System (NQS), the existing practice from which this utility has been derived.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 3 on page 101, \texttt{qdel}, \texttt{qhold}, \texttt{qmove}, \texttt{qrls}, \texttt{qsub}, \texttt{touch}

**CHANGE HISTORY**


**Issue 6**

The \texttt{TZ} entry is added to the \texttt{ENVIRONMENT VARIABLES} section.

IEEE PASC Interpretation 1003.2 #182 is applied, clarifying the description of the \texttt{−a} option.
NAME
qdel — delete batch jobs

SYNOPSIS
BE qdel job_identifier ...

DESCRIPTION
A batch job is deleted by sending a request to the batch server that manages the batch job. A
batch job that has been deleted is no longer subject to management by batch services.
The qdel utility is a user-accessible client of batch services that requests the deletion of one or
more batch jobs.
The qdel utility shall request a batch server to delete those batch jobs for which a batch
job_identifier is presented to the utility.
The qdel utility shall delete batch jobs in the order in which their batch job_identifiers are
presented to the utility.
If the qdel utility fails to process any batch job_identifier successfully, the utility shall proceed to
process the remaining batch job_identifiers, if any.
The qdel utility shall delete each batch job by sending a Delete Job Request to the batch server that
manages the batch job.
The qdel utility shall not exit until the batch job corresponding to each successfully processed
batch job_identifier has been deleted.

OPTIONS
None.

OPERANDS
The qdel utility shall accept one or more operands that conform to the syntax for a batch
job_identifier (see Section 3.3.1 (on page 122)).

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of qdel:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
Determine the login name of the user.

ASYNCHRONOUS EVENTS
Default.

STDOUT
An implementation of the qdel utility may write informative messages to standard output.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS
In addition to the default behavior, the qdel utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job_identifier does not exist on the server. Whether or not the qdel utility waits to output the diagnostic message while attempting to locate the job on other servers is implementation-defined.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The qdel utility allows users and administrators to delete jobs.

The qdel utility provides functionality that is not otherwise available. For example, the kill utility of the operating system does not suffice. First, to use the kill utility, the user might have to log in on a remote node, because the kill utility does not operate across the network. Second, unlike qdel, kill cannot remove jobs from queues. Lastly, the arguments of the qdel utility are job identifiers rather than process identifiers, and so this utility can be passed the output of the qselect utility, thus providing users with a means of deleting a list of jobs.

Because a set of jobs can be selected using the qselect utility, the qdel utility has not been complicated with options that provide for selection of jobs. Instead, the batch jobs to be deleted are identified individually by their job identifiers.

Historically, the qdel utility has been a component of NQS, the existing practice on which it is based. However, the qdel utility defined in this volume of IEEE Std 1003.1-2001 does not provide an option for specifying a signal number to send to the batch job prior to the killing of the process; that capability has been subsumed by the qsig utility.

A discussion was held about the delays of networking and the possibility that the batch server may never respond, due to a down router, down batch server, or other network mishap. The DESCRIPTION records this under the words “fails to process any job identifier”. In the broad sense, the network problem is also an error, which causes the failure to process the batch job.
Utilities

FUTURE DIRECTIONS
None.

SEE ALSO
Chapter 3 (on page 101), kill, qselect, qsig

CHANGE HISTORY

Issue 6
The LC_TIME and TZ entries are removed from the ENVIRONMENT VARIABLES section.
NAME
qhold — hold batch jobs

SYNOPSIS
BE
qhold [-h hold_list] job_identifier ...

DESCRIPTION
A hold is placed on a batch job by a request to the batch server that manages the batch job. A
batch job that has one or more holds is not eligible for execution. The qhold utility is a user-
ablessible client of batch services that requests one or more types of hold to be placed on one or
more batch jobs.

The qhold utility shall place holds on those batch jobs for which a batch job_identifier is presented
to the utility.

The qhold utility shall place holds on batch jobs in the order in which their batch job_identifiers
are presented to the utility. If the qhold utility fails to process any batch job_identifier successfully,
the utility shall proceed to process the remaining batch job_identifiers, if any.

The qhold utility shall place holds on each batch job by sending a Hold Job Request to the batch
server that manages the batch job.

The qhold utility shall not exit until holds have been placed on the batch job corresponding to
each successfully processed batch job_identifier.

OPTIONS
The qhold utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following option shall be supported by the implementation:

-h hold_list  Define the types of holds to be placed on the batch job.

The qhold -h option shall accept a value for the hold_list option-argument that is a
string of alphanumeric characters in the portable character set (see the Base

The qhold utility shall accept a value for the hold_list option-argument that is a
string of one or more of the characters 'u', 's', or 'o', or the single character
'n'.

For each unique character in the hold_list option-argument, the qhold utility shall
add a value to the Hold_Types attribute of the batch job as follows, each
representing a different hold type:

u  USER
s  SYSTEM
o  OPERATOR

If any of these characters are duplicated in the hold_list option-argument, the
duplicates shall be ignored.

An existing Hold_Types attribute can be cleared by the following hold type:

n  NO_HOLD

The qhold utility shall consider it an error if any hold type other than 'n' is
combined with hold type 'n'.
Strictly conforming applications shall not repeat any of the characters ‘u’, ‘s’, ‘o’, or ‘n’ within the *hold_list* option-argument. The *qhold* utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters.

An implementation may define other hold types. The conformance document for an implementation shall describe any additional hold types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

If the -h option is not presented to the *qhold* utility, the implementation shall set the *Hold_Types* attribute to USER.

**OPERANDS**

The *qhold* utility shall accept one or more operands that conform to the syntax for a batch *job_identifier* (see Section 3.3.1 (on page 122)).

**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of *qhold*:

- **LANG**
  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **LOGNAME**
  Determine the login name of the user.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

None.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.
EXIT STATUS
The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

CONSEQUENCES OF ERRORS
In addition to the default behavior, the qhold utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job_identifier does not exist on the server. Whether or not the qhold utility waits to output the diagnostic message while attempting to locate the job on other servers is implementation-defined.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The qhold utility allows users to place a hold on one or more jobs. A hold makes a batch job ineligible for execution.

The qhold utility has options that allow the user to specify the type of hold. Should the user wish to place a hold on a set of jobs that meet a selection criteria, such a list of jobs can be acquired using the qselect utility.

The -h option allows the user to specify the type of hold that is to be placed on the job. This option allows for USER, SYSTEM, OPERATOR, and implementation-defined hold types. The USER and OPERATOR holds are distinct. The batch server that manages the batch job will verify that the user is authorized to set the specified hold for the batch job.

Mail is not required on hold because the administrator has the tools and libraries to build this option if he or she wishes.

Historically, the qhold utility has been a part of some existing batch systems, although it has not traditionally been a part of the NQS.

FUTURE DIRECTIONS
None.

SEE ALSO
Chapter 3 (on page 101), qselect

CHANGE HISTORY

Issue 6
The LC_TIME and TZ entries are removed from the ENVIRONMENT VARIABLES section.
NAME
qmove — move batch jobs

SYNOPSIS
BE
qmove destination job_identifier ...

DESCRIPTION
To move a batch job is to remove the batch job from the batch queue in which it resides and
instantiate the batch job in another batch queue. A batch job is moved by a request to the batch
server that manages the batch job. The qmove utility is a user-accessible batch client that requests
the movement of one or more batch jobs.

The qmove utility shall move those batch jobs, and only those batch jobs, for which a batch
job_identifier is presented to the utility.

The qmove utility shall move batch jobs in the order in which the corresponding batch
job_identifiers are presented to the utility.

If the qmove utility fails to process a batch job_identifier successfully, the utility shall proceed to
process the remaining batch job_identifiers, if any.

The qmove utility shall move batch jobs by sending a Move Job Request to the batch server that
manages each batch job. The qmove utility shall not exit before the batch jobs corresponding to all
successfully processed batch job_identifiers have been moved.

OPTIONS
None.

OPERANDS
The qmove utility shall accept one operand that conforms to the syntax for a destination (see
Section 3.3.2 (on page 123)).

The qmove utility shall accept one or more operands that conform to the syntax for a batch
job_identifier (see Section 3.3.1 (on page 122)).

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of qmove:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
LOGNAME Determine the login name of the user.

ASYNCHRONOUS EVENTS
Default.

STDOUT None.

STDERR The standard error shall be used only for diagnostic messages.

OUTPUT FILES None.

EXTENDED DESCRIPTION None.

EXIT STATUS
The following exit values shall be returned:
0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
In addition to the default behavior, the qmove utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job_identifier does not exist on the server. Whether or not the qmove utility waits to output the diagnostic message while attempting to locate the job on other servers is implementation-defined.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The qmove utility allows users to move jobs between queues.

The alternative to using the qmove utility—deleting the batch job and requeuing it—entails considerably more typing.

Since the means of selecting jobs based on attributes has been encapsulated in the qselect utility, the only option of the qmove utility concerns authorization. The −u option provides the user with the convenience of changing the user identifier under which the batch job will execute. Minimalism and consistency have taken precedence over convenience; the −u option has been deleted because the equivalent capability exists with the −u option of the qalter utility.

FUTURE DIRECTIONS
None.

SEE ALSO
Chapter 3 (on page 101), qalter, qselect

CHANGE HISTORY
The _LC_TIME_ and _TZ_ entries are removed from the **ENVIRONMENT VARIABLES** section.
NAME
qmsg — send message to batch jobs

SYNOPSIS
qmsg [-E] [-O] message_string job_identifier ...

DESCRIPTION
To send a message to a batch job is to request that a server write a message string into one or more output files of the batch job. A message is sent to a batch job by a request to the batch server that manages the batch job. The qmsg utility is a user-accessible batch client that requests the sending of messages to one or more batch jobs.

The qmsg utility shall write messages into the files of batch jobs by sending a Job Message Request to the batch server that manages the batch job. The qmsg utility shall not directly write the message into the files of the batch job.

The qmsg utility shall send a Job Message Request for those batch jobs, and only those batch jobs, for which a batch job_identifier is presented to the utility.

The qmsg utility shall send Job Message Requests for batch jobs in the order in which their batch job_identifiers are presented to the utility.

If the qmsg utility fails to process any batch job_identifier successfully, the utility shall proceed to process the remaining batch job_identifiers, if any.

The qmsg utility shall not exit before a Job Message Request has been sent to the server that manages the batch job that corresponds to each successfully processed batch job_identifier.

OPTIONS

The following options shall be supported by the implementation:

- **-E** Specify that the message is written to the standard error of each batch job.
  The qmsg utility shall write the message into the standard error of the batch job.

- **-O** Specify that the message is written to the standard output of each batch job.
  The qmsg utility shall write the message into the standard output of the batch job.

If neither the -O nor the -E option is presented to the qmsg utility, the utility shall write the message into an implementation-defined file. The conformance document for the implementation shall describe the name and location of the implementation-defined file. If both the -O and the -E options are presented to the qmsg utility, then the utility shall write the messages to both standard output and standard error.

OPERANDS
The qmsg utility shall accept a minimum of two operands, message_string and one or more batch job_identifiers.

The message_string operand shall be the string to be written to one or more output files of the batch job followed by a <newline>. If the string contains <blank>s, then the application shall ensure that the string is quoted. The message_string shall be encoded in the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set).

All remaining operands are batch job_identifiers that conform to the syntax for a batch job_identifier (see Section 3.3.1 (on page 122)).
Utilities

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of qmsg:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

LOGNAME Determine the login name of the user.

ASYNCHRONOUS EVENTS
Default.

STDOUT
None.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS
In addition to the default behavior, the qmsg utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job_identifier does not exist on the server. Whether or not the qmsg utility waits to output the diagnostic message while attempting to locate the job on other servers is implementation-defined.
qmsg

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The qmsg utility allows users to write messages into the output files of running jobs. Users, including operators and administrators, have a number of occasions when they want to place messages in the output files of a batch job. For example, if a disk that is being used by a batch job is showing errors, the operator might note this in the standard error stream of the batch job.

The options of the qmsg utility provide users with the means of placing the message in the output stream of their choice. The default output stream for the message—if the user does not designate an output stream—is implementation-defined, since many implementations will provide, as an extension to this volume of IEEE Std 1003.1-2001, a log file that shows the history of utility execution.

If users wish to send a message to a set of jobs that meet a selection criteria, the qselect utility can be used to acquire the appropriate list of job identifiers.

The –E option allows users to place the message in the standard error stream of the batch job.

The –O option allows users to place the message in the standard output stream of the batch job.

Historically, the qmsg utility is an existing practice in the offerings of one or more implementors of an NQS-derived batch system. The utility has been found to be useful enough that it deserves to be included in this volume of IEEE Std 1003.1-2001.

FUTURE DIRECTIONS
None.

SEE ALSO
Chapter 3 (on page 101), qselect

CHANGE HISTORY

Issue 6
The LC_TIME and TZ entries are removed from the ENVIRONMENT VARIABLES section.
NAME
qrerun — rerun batch jobs

SYNOPSIS
BE
    qrerun job_identifier ...

DESCRIPTION
To rerun a batch job is to terminate the session leader of the batch job, delete any associated
checkpoint files, and return the batch job to the batch queued state. A batch job is rerun by a
request to the batch server that manages the batch job. The qrerun utility is a user-accessible
batch client that requests the rerunning of one or more batch jobs.

The qrerun utility shall rerun those batch jobs for which a batch job_identifier is presented to the
utility.

The qrerun utility shall rerun batch jobs in the order in which their batch job_identifiers are
presented to the utility.

If the qrerun utility fails to process any batch job_identifier successfully, the utility shall proceed
to process the remaining batch job_identifiers, if any.

The qrerun utility shall rerun batch jobs by sending a Rerun Job Request to the batch server that
manages each batch job.

For each successfully processed batch job_identifier, the qrerun utility shall have rerun the
corresponding batch job at the time the utility exits.

OPTIONS
None.

OPERANDS
The qrerun utility shall accept one or more operands that conform to the syntax for a batch
job_identifier (see Section 3.3.1 (on page 122)).

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of qrerun:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
Determine the login name of the user.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

None.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- **0**  Successful completion.
- **>0**  An error occurred.

**CONSEQUENCES OF ERRORS**

In addition to the default behavior, the `qrerun` utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch `job_identifier` does not exist on the server. Whether or not the `qrerun` utility waits to output the diagnostic message while attempting to locate the job on other servers is implementation-defined.

**APPLICATION USAGE**

None.

**EXAMPLES**

None.

**RATIONALE**

The `qrerun` utility allows users to cause jobs in the running state to exit and rerun.

The `qrerun` utility is a new utility, *vis-a-vis* existing practice, that has been defined in this volume of IEEE Std 1003.1-2001 to correct user-perceived deficiencies in the existing practice.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 3 (on page 101)

**CHANGE HISTORY**


**Issue 6**

The `LC_TIME` and `TZ` entries are removed from the ENVIRONMENT VARIABLES section.
NAME
qrls — release batch jobs

SYNOPSIS
BE

DESCRIPTION
A batch job might have one or more holds, which prevent the batch job from executing. A batch
job from which all the holds have been removed becomes eligible for execution and is said to
have been released. A batch job hold is removed by sending a request to the batch server that
manages the batch job. The qrls utility is a user-accessible client of batch services that requests
holds be removed from one or more batch jobs.

The qrls utility shall remove one or more holds from those batch jobs for which a batch
job_identifier is presented to the utility.

The qrls utility shall remove holds from batch jobs in the order in which their batch job_identifiers
are presented to the utility.

If the qrls utility fails to process a batch job_identifier successfully, the utility shall proceed to
process the remaining batch job_identifiers, if any.

The qrls utility shall remove holds on each batch job by sending a Release Job Request to the batch
server that manages the batch job.

The qrls utility shall not exit until the holds have been removed from the batch job
corresponding to each successfully processed batch job_identifier.

OPTIONS
The qrls utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following option shall be supported by the implementation:

-h hold_list  Define the types of holds to be removed from the batch job.

The qrls -h option shall accept a value for the hold_list option-argument that is a
string of alphanumeric characters in the portable character set (see the Base

The qrls utility shall accept a value for the hold_list option-argument that is a string
of one or more of the characters ‘u’, ‘s’, or ‘o’, or the single character ‘n’.

For each unique character in the hold_list option-argument, the qrls utility shall add
a value to the Hold_Types attribute of the batch job as follows, each representing a
different hold type:

u  USER
s  SYSTEM
o  OPERATOR

If any of these characters are duplicated in the hold_list option-argument, the
duplicates shall be ignored.

An existing Hold_Types attribute can be cleared by the following hold type:

n  NO_HOLD
The qrls utility shall consider it an error if any hold type other than ‘n’ is combined with hold type ‘n’.

Strictly conforming applications shall not repeat any of the characters ‘u’, ‘s’, ‘o’, or ‘n’ within the hold_list option-argument. The qrls utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters.

An implementation may define other hold types. The conformance document for an implementation shall describe any additional hold types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

If the –h option is not presented to the qrls utility, the implementation shall remove the USER hold in the Hold_Types attribute.

**OPERANDS**

The qrls utility shall accept one or more operands that conform to the syntax for a batch job_identifier (see Section 3.3.1 (on page 122)).

**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of qrls:

- **LANG**
  Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **LOGNAME**
  Determine the login name of the user.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

None.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.
EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS

In addition to the default behavior, the qrls utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job_identifier does not exist on the server. Whether or not the qrls utility waits to output the diagnostic message while attempting to locate the job on other servers is implementation-defined.

APPLICATION USAGE

None.

EXAMPLES

None.

RATIONALE

The qrls utility allows users, operators, and administrators to remove holds from jobs.

The qrls utility does not support any job selection options or wildcard arguments. Users may acquire a list of jobs selected by attributes using the qselect utility. For example, a user could select all of their held jobs.

The -h option allows the user to specify the type of hold that is to be removed. This option allows for USER, SYSTEM, OPERATOR, and implementation-defined hold types. The batch server that manages the batch job will verify whether the user is authorized to remove the specified hold for the batch job. If more than one type of hold has been placed on the batch job, a user may wish to remove only some of them.

Mail is not required on release because the administrator has the tools and libraries to build this option if required.

The qrls utility is a new utility vis-a-vis existing practice; it has been defined in this volume of IEEE Std 1003.1-2001 as the natural complement to the qhold utility.

FUTURE DIRECTIONS

None.

SEE ALSO

Chapter 3 (on page 101), qhold, qselect

CHANGE HISTORY


Issue 6

The LC_TIME and TZ entries are removed from the ENVIRONMENT VARIABLES section.
NAME
qselect — select batch jobs

SYNOPSIS
qselect [-a [op]date_time] [-A account_string] [-c [op]interval]
       [-h hold_list] [-l resource_list] [-N name] [-p [op]priority]
       [-q destination] [-r y|n] [-s states] [-u user_list]

DESCRIPTION
To select a set of batch jobs is to return the batch job_ids for each batch job
that meets a list of selection criteria. A set of batch jobs is selected by a request
to a batch server. The qselect utility is a user-accessible batch client that requests
the selection of batch jobs.

Upon successful completion, the qselect utility shall have returned a list of zero or more batch
job_ids that meet the criteria specified by the options and option-arguments presented to
the utility.

The qselect utility shall select batch jobs by sending a Select Jobs Request to a batch server. The
qselect utility shall not exit until the server replies to each request generated.

For each option presented to the qselect utility, the utility shall restrict the set of selected batch
jobs as described in the OPTIONS section.

The qselect utility shall not restrict selection of batch jobs except by authorization and as required
by the options presented to the utility.

When an option is specified with a mandatory or optional op component to the option-
argument, then op shall specify a relation between the value of a certain batch job attribute and
the value component of the option-argument. If an op is allowable on an option, then the
description of the option letter indicates the op as either mandatory or optional. Acceptable
strings for the op component, and the relation the string indicates, are shown in the following
list:

.eq. The value represented by the attribute of the batch job is equal to the value represented
by the option-argument.
.ge. The value represented by the attribute of the batch job is greater than or equal to the
value represented by the option-argument.
.gt. The value represented by the attribute of the batch job is greater than the value
represented by the option-argument.
.lt. The value represented by the attribute of the batch job is less than the value
represented by the option-argument.
.le. The value represented by the attribute of the batch job is less than or equal to the value
represented by the option-argument.
.ne. The value represented by the attribute of the batch job is not equal to the value
represented by the option-argument.

OPTIONS
The qselect utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported by the implementation:

-a [op]date_time
Restrict selection to a specific time, or a range of times.
The `qselect` utility shall select only batch jobs for which the value of the `Execution_Time` attribute is related to the Epoch equivalent of the local time expressed by the value of the `date_time` component of the option-argument in the manner indicated by the value of the `op` component of the option-argument.

The `qselect` utility shall accept a `date_time` component of the option-argument that conforms to the syntax of the `time` operand of the `touch` utility.

If the `op` component of the option-argument is not presented to the `qselect` utility, the utility shall select batch jobs for which the `Execution_Time` attribute is equal to the `date_time` component of the option-argument.

When comparing times, the `qselect` utility shall use the following definitions for the `op` component of the option-argument:

- `.eq.` The time represented by value of the `Execution_Time` attribute of the batch job is equal to the time represented by the `date_time` component of the option-argument.
- `.ge.` The time represented by value of the `Execution_Time` attribute of the batch job is after or equal to the time represented by the `date_time` component of the option-argument.
- `.gt.` The time represented by value of the `Execution_Time` attribute of the batch job is after the time represented by the `date_time` component of the option-argument.
- `.lt.` The time represented by value of the `Execution_Time` attribute of the batch job is before the time represented by the `date_time` component of the option-argument.
- `.le.` The time represented by value of the `Execution_Time` attribute of the batch job is before or equal to the time represented by the `date_time` component of the option-argument.
- `.ne.` The time represented by value of the `Execution_Time` attribute of the batch job is not equal to the time represented by the `date_time` component of the option-argument.

The `qselect` utility shall accept the defined character strings for the `op` component of the option-argument.

`-A account_string` Restrict selection to the batch jobs charging a specified account.

The `qselect` utility shall select only batch jobs for which the value of the `Account_Name` attribute of the batch job matches the value of the `account_string` option-argument.

The syntax of the `account_string` option-argument is unspecified.

`-c [op]interval` Restrict selection to batch jobs within a range of checkpoint intervals.

The `qselect` utility shall select only batch jobs for which the value of the `Checkpoint` attribute relates to the value of the `interval` component of the option-argument in the manner indicated by the value of the `op` component of the option-argument.

If the `op` component of the option-argument is omitted, the `qselect` utility shall select batch jobs for which the value of the `Checkpoint` attribute is equal to the value
of the *interval* component of the option-argument.

When comparing checkpoint intervals, the `qselect` utility shall use the following definitions for the *op* component of the option-argument:

- **.eq.** The value of the *Checkpoint* attribute of the batch job equals the value of the *interval* component of the option-argument.
- **.ge.** The value of the *Checkpoint* attribute of the batch job is greater than or equal to the value of the *interval* component option-argument.
- **.gt.** The value of the *Checkpoint* attribute of the batch job is greater than the value of the *interval* component option-argument.
- **.lt.** The value of the *Checkpoint* attribute of the batch job is less than the value of the *interval* component option-argument.
- **.le.** The value of the *Checkpoint* attribute of the batch job is less than or equal to the value of the *interval* component option-argument.
- **.ne.** The value of the *Checkpoint* attribute of the batch job does not equal the value of the *interval* component option-argument.

The `qselect` utility shall accept the defined character strings for the *op* component of the option-argument.

The ordering relationship for the values of the interval option-argument is defined to be:

```
'n' .gt. 's' .gt. 'c=minutes' .ge. 'c'
```

When comparing *Checkpoint* attributes with an interval having the value of the single character 'u', only equality or inequality are valid comparisons.

```
-h hold_list  Restrict selection to batch jobs that have a specific type of hold.
```

The `qselect` utility shall select only batch jobs for which the value of the *Hold_Types* attribute matches the value of the *hold_list* option-argument.

The `qselect -h` option shall accept a value for the *hold_list* option-argument that is a string of alphanumeric characters in the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set).

The `qselect` utility shall accept a value for the *hold_list* option-argument that is a string of one or more of the characters 'u', 's', or 'o', or the single character 'n'.

Each unique character in the *hold_list* option-argument of the `qselect` utility is defined as follows, each representing a different hold type:

- **u** USER
- **s** SYSTEM
- **o** OPERATOR

If any of these characters are duplicated in the *hold_list* option-argument, the duplicates shall be ignored.

The `qselect` utility shall consider it an error if any hold type other than 'n' is combined with hold type 'n'.
Strictly conforming applications shall not repeat any of the characters ‘u’, ‘s’, ‘o’, or ‘n’ within the hold_list option-argument. The qselect utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters.

An implementation may define other hold types. The conformance document for an implementation shall describe any additional hold types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

```
−l resource_list
```

Restrict selection to batch jobs with specified resource limits and attributes.

The qselect utility shall accept a resource_list option-argument with the following syntax:

```
resource_name op value [,,resource_name op value,, ...]
```

When comparing resource values, the qselect utility shall use the following definitions for the op component of the option-argument:

- **.eq.** The value of the resource of the same name in the Resource_List attribute of the batch job equals the value of the value component of the option-argument.
- **.ge.** The value of the resource of the same name in the Resource_List attribute of the batch job is greater than or equal to the value of the value component of the option-argument.
- **.gt.** The value of the resource of the same name in the Resource_List attribute of the batch job is greater than the value of the value component of the option-argument.
- **.lt.** The value of the resource of the same name in the Resource_List attribute of the batch job is less than the value of the value component of the option-argument.
- **.ne.** The value of the resource of the same name in the Resource_List attribute of the batch job does not equal the value of the value component of the option-argument.
- **.le.** The value of the resource of the same name in the Resource_List attribute of the batch job is less than or equal to the value of the value component of the option-argument.

When comparing the limit of a Resource_List attribute with the value component of the option-argument, if the limit, the value, or both are non-numeric, only equality or inequality are valid comparisons.

The qselect utility shall select only batch jobs for which the values of the resource_names listed in the resource_list option-argument match the corresponding limits of the Resource_List attribute of the batch job.

Limits of resource_names present in the Resource_List attribute of the batch job that have no corresponding values in the resource_list option-argument shall not be considered when selecting batch jobs.

```
−N name
```

Restrict selection to batch jobs with a specified name.

The qselect utility shall select only batch jobs for which the value of the Job_Name attribute matches the value of the name option-argument. The string specified in
the `name` option-argument shall be passed, uninterpreted, to the server. This allows an implementation to match “wildcard” patterns against batch job names.

An implementation shall describe in the conformance document the format it supports for matching against the `Job_Name` attribute.

```
-p [op]priority
```

Restrict selection to batch jobs of the specified priority or range of priorities.

The `qselect` utility shall select only batch jobs for which the value of the `Priority` attribute of the batch job relates to the value of the `priority` component of the option-argument in the manner indicated by the value of the `op` component of the option-argument.

If the `op` component of the option-argument is omitted, the `qselect` utility shall select batch jobs for which the value of the `Priority` attribute of the batch job is equal to the value of the `priority` component of the option-argument.

When comparing priority values, the `qselect` utility shall use the following definitions for the `op` component of the option-argument:

- `.eq.`: The value of the `Priority` attribute of the batch job equals the value of the `priority` component of the option-argument.
- `.ge.`: The value of the `Priority` attribute of the batch job is greater than or equal to the value of the `priority` component option-argument.
- `.gt.`: The value of the `Priority` attribute of the batch job is greater than the value of the `priority` component option-argument.
- `.lt.`: The value of the `Priority` attribute of the batch job is less than the value of the `priority` component option-argument.
- `.le.`: The value of the `Priority` attribute of the batch job is less than or equal to the value of the `priority` component option-argument.
- `.ne.`: The value of the `Priority` attribute of the batch job does not equal the value of the `priority` component option-argument.

```
-q destination
```

Restrict selection to the specified batch queue or server, or both.

The `qselect` utility shall select only batch jobs that are located at the destination indicated by the value of the `destination` option-argument.

The destination defines a batch queue, a server, or a batch queue at a server.

The `qselect` utility shall accept an option-argument for the `-q` option that conforms to the syntax for a destination. If the `-q` option is not presented to the `qselect` utility, the utility shall select batch jobs from all batch queues at the default batch server.

If the option-argument describes only a batch queue, the `qselect` utility shall select only batch jobs from the batch queue of the specified name at the default batch server. The means by which `qselect` determines the default server is implementation-defined.

If the option-argument describes only a batch server, the `qselect` utility shall select batch jobs from all the batch queues at that batch server.

If the option-argument describes both a batch queue and a batch server, the `qselect` utility shall select only batch jobs from the specified batch queue at the specified
Utilities

qselect

30786 server.
30787 -r y | n  Restrict selection to batch jobs with the specified rerunability status.
30788 The qselect utility shall select only batch jobs for which the value of the Rerunnable attribute of the batch job matches the value of the option-argument.
30789
30790 The qselect utility shall accept a value for the option-argument that consists of either the single character ‘y’ or the single character ‘n’. The character ‘y’ represents the value TRUE, and the character ‘n’ represents the value FALSE.
30791
30792 -s states  Restrict selection to batch jobs in the specified states.
30793 The qselect utility shall accept an option-argument that consists of any combination of the characters ‘e’, ‘q’, ‘r’, ‘t’, ‘w’, ‘h’, and ‘t’.
30794 Conforming applications shall not repeat any character in the option-argument.
30795 The qselect utility shall permit the repetition of characters in the option-argument, but shall not assign additional meaning to repeated characters.
30796 The qselect utility shall interpret the characters in the states option-argument as follows:
30797 e  Represents the EXITING state.
30798 q  Represents the QUEUED state.
30799 r  Represents the RUNNING state.
30800 t  Represents the TRANSITING state.
30801 h  Represents the HELD state.
30802 w  Represents the WAITING state.
30803 For each character in the states option-argument, the qselect utility shall select batch jobs in the corresponding state.
30804
30805 -u user_list  Restrict selection to batch jobs owned by the specified user names.
30806 The qselect utility shall select only the batch jobs of those users specified in the user_list option-argument.
30807 The qselect utility shall accept a user_list option-argument that conforms to the following syntax:
30808 username[@host] [,,username[@host],,, ...]
30809
30810 The qselect utility shall accept only one user name that is missing a corresponding host name. The qselect utility shall accept only one user name per named host.

30811 OPERANDS
30812 None.
30813 STDIN
30814 Not used.
30815 INPUT FILES
30816 None.
ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `qselect`:

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **LOGNAME**: Determine the login name of the user.

- **TZ**: Determine the timezone used to interpret the `date-time` option-argument. If `TZ` is unset or null, an unspecified default timezone shall be used.

ASYNCHRONOUS EVENTS

Default.

STDOUT

The `qselect` utility shall write zero or more batch `job_identifiers` to standard output.

The `qselect` utility shall separate the batch `job_identifiers` written to standard output by white space.

The `qselect` utility shall write batch `job_identifiers` in the following format:

```
sequence_number.server_name@server
```

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

- `0` Successful completion.

- `>0` An error occurred.

CONSEQUENCES OF ERRORS

Default.
APPLICATION USAGE

None.

EXAMPLES

The following example shows how a user might use the qselect utility in conjunction with the qdel utility to delete all of his or her jobs in the queued state without affecting any jobs that are already running:

```
qdel $(qselect -s q)
```

or:

```
qselect -s q || xargs qdel
```

RATIONALE

The qselect utility allows users to acquire a list of job identifiers that match user-specified selection criteria. The list of identifiers returned by the qselect utility conforms to the syntax of the batch job identifier list processed by a utility such as qmove, qdel, and qrls. The qselect utility is thus a powerful tool for causing another batch system utility to act upon a set of jobs that match a list of selection criteria.

The options of the qselect utility let the user apply a number of useful filters for selecting jobs. Each option further restricts the selection of jobs. Many of the selection options allow the specification of a relational operator. The FORTRAN-like syntax of the operator—that is, "\lt\"—was chosen rather than the C-like "\lt\" meta-characters.

The -a option allows users to restrict the selected jobs to those that have been submitted (or altered) to wait until a particular time. The time period is determined by the argument of this option, which includes both a time and an operator—it is thus possible to select jobs waiting until a specific time, jobs waiting until after a certain time, or those waiting for a time before the specified time.

The -A option allows users to restrict the selected jobs to those that have been submitted (or altered) to charge a particular account.

The -c option allows users to restrict the selected jobs to those whose checkpointing interval falls within the specified range.

The -l option allows users to select those jobs whose resource limits fall within the range indicated by the value of the option. For example, a user could select those jobs for which the CPU time limit is greater than two hours.

The -N option allows users to select jobs by job name. For instance, all the parts of a task that have been divided in parallel jobs might be given the same name, and thus manipulated as a group by means of this option.

The -q option allows users to select jobs in a specified queue.

The -r option allows users to select only those jobs with a specified rerun criteria. For instance, a user might select only those jobs that can be rerun for use with the qrerun utility.

The -s option allows users to select only those jobs that are in a certain state.

The -u option allows users to select jobs that have been submitted to execute under a particular account.

The selection criteria provided by the options of the qselect utility allow users to select jobs based on all the appropriate attributes that can be assigned to jobs by the qsub utility.

Historically, the qselect utility has not been a part of existing practice; it is an improvement that has been introduced in this volume of IEEE Std 1003.1-2001.
FUTURE DIRECTIONS
None.

SEE ALSO
qdel, qrerun, qrls, qselect, qsub, touch, Chapter 3 (on page 101)

CHANGE HISTORY
NAME
qsig — signal batch jobs

SYNOPSIS
BE
qsig [-s signal] job_identifier ...

DESCRIPTION
To signal a batch job is to send a signal to the session leader of the batch job. A batch job is signaled by sending a request to the batch server that manages the batch job. The qsig utility is a user-accessible batch client that requests the signaling of a batch job.

The qsig utility shall signal those batch jobs for which a batch job_identifier is presented to the utility. The qsig utility shall not signal any batch jobs whose batch job_identifiers are not presented to the utility.

The qsig utility shall signal batch jobs in the order in which the corresponding batch job_identifiers are presented to the utility. If the qsig utility fails to process a batch job_identifier successfully, the utility shall proceed to process the remaining batch job_identifiers, if any.

The qsig utility shall signal batch jobs by sending a Signal Job Request to the batch server that manages the batch job.

For each successfully processed batch job_identifier, the qsig utility shall have received a completion reply to each Signal Job Request sent to a batch server at the time the utility exits.

OPTIONS

The following option shall be supported by the implementation:

-s signal  Define the signal to be sent to the batch job.

The qsig utility shall accept a signal option-argument that is either a symbolic signal name or an unsigned integer signal number (see the POSIX.1-1990 standard, Section 3.3.1.1). The qsig utility shall accept signal names for which the SIG prefix has been omitted.

If the signal option-argument is a signal name, the qsig utility shall send that name.

If the signal option-argument is a number, the qsig utility shall send the signal value represented by the number.

If the -s option is not presented to the qsig utility, the utility shall send the signal SIGTERM to each signaled batch job.

OPERANDS
The qsig utility shall accept one or more operands that conform to the syntax for a batch job_identifier (see Section 3.3.1 (on page 122)).

STDIN
Not used.

INPUT FILES
None.
ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of qsig:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

LOGNAME Determine the login name of the user.

ASYNCHRONOUS EVENTS
Default.

STDOUT
An implementation of the qsig utility may write informative messages to standard output.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS
In addition to the default behavior, the qsig utility shall not be required to write a diagnostic message to standard error when the error reply received from a batch server indicates that the batch job_identifier does not exist on the server. Whether or not the qsig utility waits to output the diagnostic message while attempting to locate the batch job on other servers is implementation-defined.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The qsig utility allows users to signal batch jobs.
A user may be unable to signal a batch job with the kill utility of the operating system for a number of reasons. First, the process ID of the batch job may be unknown to the user. Second,
the processes of the batch job may be on a remote node. However, by virtue of communication between batch nodes, the \texttt{qsig} utility can arrange for the signaling of a process.

Because a batch job that is not running cannot be signaled, and because the signal may not terminate the batch job, the \texttt{qsig} utility is not a substitute for the \texttt{qdel} utility.

The options of the \texttt{qsig} utility allow the user to specify the signal that is to be sent to the batch job.

The \texttt{−s} option allows users to specify a signal by name or by number, and thus override the default signal. The POSIX.1-1990 standard defines signals by both name and number.

The \texttt{qsig} utility is a new utility, \textit{vis-a-vis} existing practice; it has been defined in this volume of IEEE Std 1003.1-2001 in response to user-perceived shortcomings in existing practice.

\textbf{FUTURE DIRECTIONS}

None.

\textbf{SEE ALSO}

Chapter 3 (on page 101), \texttt{kill}, \texttt{qdel}

\textbf{CHANGE HISTORY}


\textbf{Issue 6}

The \texttt{LC\_TIME} and \texttt{TZ} entries are removed from the \texttt{ENVIRONMENT VARIABLES} section.
NAME
qstat — show status of batch jobs

SYNOPSIS
BE
qstat [-f] job_identifier ...
qstat -Q [-f] destination ...
qstat -B [-f] server_name ...

DESCRIPTION
The status of a batch job, batch queue, or batch server is obtained by a request to the server. The qstat utility is a user-accessible batch client that requests the status of one or more batch jobs, batch queues, or servers, and writes the status information to standard output.

For each successfully processed batch job_identifier, the qstat utility shall display information about the corresponding batch job.

For each successfully processed destination, the qstat utility shall display information about the corresponding batch queue.

For each successfully processed server name, the qstat utility shall display information about the corresponding server.

The qstat utility shall acquire batch job status information by sending a Job Status Request to a batch server. The qstat utility shall acquire batch queue status information by sending a Queue Status Request to a batch server. The qstat utility shall acquire server status information by sending a Server Status Request to a batch server.

OPTIONS

The following options shall be supported by the implementation:

-f Specify that a full display is produced.
   The minimum contents of a full display are specified in the STDOUT section.
   Additional contents and format of a full display are implementation-defined.

-Q Specify that the operand is a destination.
   The qstat utility shall display information about each batch queue at each destination identified as an operand.

-B Specify that the operand is a server name.
   The qstat utility shall display information about each server identified as an operand.

OPERANDS
If the -Q option is presented to the qstat utility, the utility shall accept one or more operands that conform to the syntax for a destination (see Section 3.3.2 (on page 123)).

If the -B option is presented to the qstat utility, the utility shall accept one or more server_name operands.

If neither the -B nor the -Q option is presented to the qstat utility, the utility shall accept one or more operands that conform to the syntax for a batch job_identifier (see Section 3.3.1 (on page 122)).
**STDIN**

Not used.

**INPUT FILES**

None.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of qstat:

- **HOME**: Determine the pathname of the user’s home directory.
- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.
- **LC_COLLATE**: Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.
- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).
- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
- **LC_NUMERIC**: Determine the locale for selecting the radix character used when writing floating-point formatted output.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

If an operand presented to the qstat utility is a batch job_identifier and the −f option is not specified, the qstat utility shall display the following items on a single line, in the stated order, with white space between each item, for each successfully processed operand:

- The batch job_identifier
- The batch job name
- The Job_OWNER attribute
- The CPU time used by the batch job
- The batch job state
- The batch job location

If an operand presented to the qstat utility is a batch job_identifier and the −f option is specified, the qstat utility shall display the following items for each successfully processed operand:

- The batch job_identifier
- The batch job name
- The `Job_Owner` attribute
- The execution user ID
- The CPU time used by the batch job
- The batch job state
- The batch job location
- Additional implementation-defined information, if any, about the batch job or batch queue

If an operand presented to the `qstat` utility is a destination, the `-Q` option is specified, and the `-f` option is not specified, the `qstat` utility shall display the following items on a single line, in the stated order, with white space between each item, for each successfully processed operand:

- The batch queue name
- The maximum number of batch jobs that shall be run in the batch queue concurrently
- The total number of batch jobs in the batch queue
- The status of the batch queue
- For each state, the number of batch jobs in that state in the batch queue and the name of the state
- The type of batch queue (execution or routing)

If the operands presented to the `qstat` utility are destinations, the `-Q` option is specified, and the `-f` option is specified, the `qstat` utility shall display the following items for each successfully processed operand:

- The batch queue name
- The maximum number of batch jobs that shall be run in the batch queue concurrently
- The total number of batch jobs in the batch queue
- The status of the batch queue
- For each state, the number of batch jobs in that state in the batch queue and the name of the state
- The type of batch queue (execution or routing)
- Additional implementation-defined information, if any, about the batch queue

If the operands presented to the `qstat` utility are batch server names, the `-B` option is specified, and the `-f` option is not specified, the `qstat` utility shall display the following items on a single line, in the stated order, with white space between each item, for each successfully processed operand:

- The batch server name
- The maximum number of batch jobs that shall be run in the batch queue concurrently
- The total number of batch jobs managed by the batch server
- The status of the batch server
- For each state, the number of batch jobs in that state and the name of the state

If the operands presented to the `qstat` utility are server names, the `-B` option is specified, and the `-f` option is specified, the `qstat` utility shall display the following items for each successfully processed operand:
The qstat utility allows users to display the status of jobs and list the batch jobs in queues.

The operands of the qstat utility may be either job identifiers, queues (specified as destination identifiers), or batch server names. The \(-Q\) and \(-B\) options, or absence thereof, indicate the nature of the operands.

The other options of the qstat utility allow the user to control the amount of information displayed and the format in which it is displayed. Should a user wish to display the status of a set of jobs that match a selection criteria, the qselect utility may be used to acquire such a list.

The \(-f\) option allows users to request a “full” display in an implementation-defined format.

Historically, the qstat utility has been a part of the NQS and its derivatives, the existing practice on which it is based.

**APPLICATION USAGE**

None.

**EXAMPLES**

None.

**RATIONALE**

The qstat utility allows users to display the status of jobs and list the batch jobs in queues.

The operands of the qstat utility may be either job identifiers, queues (specified as destination identifiers), or batch server names. The \(-Q\) and \(-B\) options, or absence thereof, indicate the nature of the operands.

The other options of the qstat utility allow the user to control the amount of information displayed and the format in which it is displayed. Should a user wish to display the status of a set of jobs that match a selection criteria, the qselect utility may be used to acquire such a list.

The \(-f\) option allows users to request a “full” display in an implementation-defined format.

Historically, the qstat utility has been a part of the NQS and its derivatives, the existing practice on which it is based.

**FUTURE DIRECTIONS**

None.
SEE ALSO

Chapter 3 (on page 101), qselect

CHANGE HISTORY


Issue 6

IEEE PASC Interpretation 1003.2 #191 is applied, removing the following ENVIRONMENT VARIABLES listed as affecting qstat: COLUMNS, LINES, LOGNAME, TERM, and TZ.

The LC_TIME entry is also removed from the ENVIRONMENT VARIABLES section.
Utilities

qsub

NAME
qsub — submit a script

SYNOPSIS
qsub [-a date_time] [-A account_string] [c interval]
[−C directive_prefix] [−e path_name] [−h] [−j join_list] [−k keep_list]
[−m mail_options] [−M mail_list] [−N name]
[−o path_name] [−p priority] [−q destination] [−r y|n]
[−S path_name_list] [−u user_list] [−v variable_list] [−V]
[−z] [script]

DESCRIPTION
To submit a script is to create a batch job that executes the script. A script is submitted by a
request to a batch server. The qsub utility is a user-accessible batch client that submits a script.

Upon successful completion, the qsub utility shall have created a batch job that will execute the
submitted script.

The qsub utility shall submit a script by sending a Queue Job Request to a batch server.

The qsub utility shall place the value of the following environment variables in the Variable_List
attribute of the batch job: HOME, LANG, LOGNAME, PATH, MAIL, SHELL, and TZ. The name
of the environment variable shall be the current name prefixed with the string PBS_O_

Note: If the current value of the HOME variable in the environment space of the qsub utility is
/aa/bb/cc, then qsub shall place PBS_O_HOME=/aa/bb/cc in the Variable_List attribute of the
batch job.

In addition to the variables described above, the qsub utility shall add the following variables
with the indicated values to the variable list:

PBS_O_WORKDIR The absolute path of the current working directory of the qsub utility
process.

PBS_O_HOST The name of the host on which the qsub utility is running.

OPTIONS
The qsub utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported by the implementation:

−a date_time Define the time at which a batch job becomes eligible for execution.

The qsub utility shall accept an option-argument that conforms to the syntax of the
time operand of the touch utility.
Table 4-18 Environment Variable Values (Utilities)

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Value at qsub Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBS_O_HOME</td>
<td>HOME</td>
</tr>
<tr>
<td>PBS_O_HOST</td>
<td>Client host name</td>
</tr>
<tr>
<td>PBS_O_LANG</td>
<td>LANG</td>
</tr>
<tr>
<td>PBS_O_LOGNAME</td>
<td>LOGNAME</td>
</tr>
<tr>
<td>PBS_O_PATH</td>
<td>PATH</td>
</tr>
<tr>
<td>PBS_O_MAIL</td>
<td>MAIL</td>
</tr>
<tr>
<td>PBS_O_SHELL</td>
<td>SHELL</td>
</tr>
<tr>
<td>PBS_O_TZ</td>
<td>TZ</td>
</tr>
<tr>
<td>PBS_O_WORKDIR</td>
<td>Current working directory</td>
</tr>
</tbody>
</table>

Note: The server that initiates execution of the batch job will add other variables to the batch job’s environment; see Section 3.2.2.1 (on page 106).

The qsub utility shall set the Execution_Time attribute of the batch job to the number of seconds since the Epoch that is equivalent to the local time expressed by the value of the date_time option-argument. The Epoch is defined in the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.149, Epoch.

If the −a option is not presented to the qsub utility, the utility shall set the Execution_Time attribute of the batch job to a time (number of seconds since the Epoch) that is earlier than the time at which the utility exits.

−A account_string

Define the account to which the resource consumption of the batch job should be charged.

The syntax of the account_string option-argument is unspecified.

The qsub utility shall set the Account_Name attribute of the batch job to the value of the account_string option-argument.

If the −A option is not presented to the qsub utility, the utility shall omit the Account_Name attribute from the attributes of the batch job.

−c interval

Define whether the batch job should be checkpointed, and if so, how often.

The qsub utility shall accept a value for the interval option-argument that is one of the following:

n No checkpointing shall be performed on the batch job (NO_CHECKPOINT).

s Checkpointing shall be performed only when the batch server is shut down (CHECKPOINT_AT_SHUTDOWN).

c Automatic periodic checkpointing shall be performed at the Minimum_Cpu_Interval attribute of the batch queue, in units of CPU minutes (CHECKPOINT_AT_MIN_CPU_INTERVAL).

c=minutes Automatic periodic checkpointing shall be performed every minutes of CPU time, or every Minimum_Cpu_Interval minutes, whichever is greater. The minutes argument shall conform to the syntax for unsigned integers and shall be greater than zero.

The qsub utility shall set the Checkpoint attribute of the batch job to the value of the interval option-argument.
If the \texttt{−c} option is not presented to the \texttt{qsub} utility, the utility shall set the \texttt{Checkpoint} attribute of the batch job to the single character ‘\texttt{u}’ (CHECKPOINT_UNSPECIFIED).

\textbf{–C directive\_prefix}

Define the prefix that declares a directive to the \texttt{qsub} utility within the script.

The \texttt{directive\_prefix} is not a batch job attribute; it affects the behavior of the \texttt{qsub} utility.

If the \texttt{−C} option is presented to the \texttt{qsub} utility, and the value of the \texttt{directive\_prefix} option-argument is the null string, the utility shall not scan the script file for directives. If the \texttt{−C} option is not presented to the \texttt{qsub} utility, then the value of the \texttt{PBS\_DPREFIX} environment variable is used. If the environment variable is not defined, then \#PBS encoded in the portable character set is the default.

\textbf{–e path\_name}

Define the path to be used for the standard error stream of the batch job.

The \texttt{qsub} utility shall accept a \texttt{path\_name} option-argument which can be preceded by a host name element of the form \texttt{hostname:}.

If the \texttt{path\_name} option-argument constitutes an absolute pathname, the \texttt{qsub} utility shall set the \texttt{Error\_Path} attribute of the batch job to the value of the \texttt{path\_name} option-argument.

If the \texttt{path\_name} option-argument constitutes a relative pathname and no host name element is specified, the \texttt{qsub} utility shall set the \texttt{Error\_Path} attribute of the batch job to the value of the absolute pathname derived by expanding the \texttt{path\_name} option-argument relative to the current directory of the process executing \texttt{qsub}.

If the \texttt{path\_name} option-argument constitutes a relative pathname and a host name element is specified, the \texttt{qsub} utility shall set the \texttt{Error\_Path} attribute of the batch job to the value of the \texttt{path\_name} option-argument without expansion. The host name element shall be included.

If the \texttt{path\_name} option-argument does not include a host name element, the \texttt{qsub} utility shall prefix the pathname with \texttt{hostname:}, where \texttt{hostname} is the name of the host upon which the \texttt{qsub} utility is being executed.

If the \texttt{−e} option is not presented to the \texttt{qsub} utility, the utility shall set the \texttt{Error\_Path} attribute of the batch job to the host name and path of the current directory of the submitting process and the default filename.

The default filename for standard error has the following format:

\texttt{job\_name.e\_sequence\_number}

\textbf{–h}

Specify that a USER hold is applied to the batch job.

The \texttt{qsub} utility shall set the value of the \texttt{Hold\_Types} attribute of the batch job to the value \texttt{USER}.

If the \texttt{−h} option is not presented to the \texttt{qsub} utility, the utility shall set the \texttt{Hold\_Types} attribute of the batch job to the value \texttt{NO\_HOLD}.

\textbf{–j join\_list}

Define which streams of the batch job are to be merged. The \texttt{qsub} \texttt{−j} option shall accept a value for the \texttt{join\_list} option-argument that is a string of alphanumeric characters in the portable character set (see the Base Definitions volume of...
The **qsub** utility shall accept a *join_list* option-argument that consists of one or more of the characters 'e' and 'o', or the single character 'n'.

All of the other batch job output streams specified will be merged into the output stream represented by the character listed first in the *join_list* option-argument.

For each unique character in the *join_list* option-argument, the **qsub** utility shall add a value to the *Join_Path* attribute of the batch job as follows, each representing a different batch job stream to join:

- **e** The standard error of the batch job (JOIN_STD_ERROR).
- **o** The standard output of the batch job (JOIN_STD_OUTPUT).

An existing *Join_Path* attribute can be cleared by the following join type:

- **n** NO_JOIN

If 'n' is specified, then no files are joined. The **qsub** utility shall consider it an error if any join type other than 'n' is combined with join type 'n'.

Strictly conforming applications shall not repeat any of the characters 'e', 'o', or 'n' within the *join_list* option-argument. The **qsub** utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters.

An implementation may define other join types. The conformance document for an implementation shall describe any additional batch job streams, how they are specified, their internal behavior, and how they affect the behavior of the utility.

If the −j option is not presented to the **qsub** utility, the utility shall set the value of the *Join_Path* attribute of the batch job to NO_JOIN.

**–k keep_list** Define which output of the batch job to retain on the execution host.

The **qsub** −k option shall accept a value for the *keep_list* option-argument that is a string of alphanumeric characters in the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set).

The **qsub** utility shall accept a *keep_list* option-argument that consists of one or more of the characters 'e' and 'o', or the single character 'n'.

For each unique character in the *keep_list* option-argument, the **qsub** utility shall add a value to the *Keep_Files* attribute of the batch job as follows, each representing a different batch job stream to keep:

- **e** The standard error of the batch job (KEEP_STD_ERROR).
- **o** The standard output of the batch job (KEEP_STD_OUTPUT).

If both 'e' and 'o' are specified, then both files are retained. An existing *Keep_Files* attribute can be cleared by the following keep type:

- **n** NO_KEEP

If 'n' is specified, then no files are retained. The **qsub** utility shall consider it an error if any keep type other than 'n' is combined with keep type 'n'.

Strictly conforming applications shall not repeat any of the characters 'e', 'o', or 'n' within the *keep_list* option-argument. The **qsub** utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters.

An existing *Keep_Files* attribute can be cleared by the following keep type:
An implementation may define other keep types. The conformance document for an implementation shall describe any additional keep types, how they are specified, their internal behavior, and how they affect the behavior of the utility. If the \(-k\) option is not presented to the \texttt{qsub} utility, the utility shall set the \texttt{Keep\_Files} attribute of the batch job to the value NO\_KEEP.

\textbf{\texttt{\-m mail\_options}}

Define the points in the execution of the batch job at which the batch server that manages the batch job shall send mail about a change in the state of the batch job.

The \texttt{qsub \-m} option shall accept a value for the \texttt{mail\_options} option-argument that is a string of alphanumeric characters in the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set).

The \texttt{qsub} utility shall accept a value for the \texttt{mail\_options} option-argument that is a string of one or more of the characters \texttt{\textasciitilde{e}}, \texttt{\textasciitilde{b}}, and \texttt{\textasciitilde{a}}, or the single character \texttt{\textasciitilde{n}}.

For each unique character in the \texttt{mail\_options} option-argument, the \texttt{qsub} utility shall add a value to the \texttt{Mail\_Points} attribute of the batch job as follows, each representing a different time during the life of a batch job at which to send mail:

\begin{itemize}
  \item \texttt{e} MAIL\_AT\_EXIT
  \item \texttt{b} MAIL\_AT\_BEGINNING
  \item \texttt{a} MAIL\_AT\_ABORT
\end{itemize}

If any of these characters are duplicated in the \texttt{mail\_options} option-argument, the duplicates shall be ignored.

An existing \texttt{Mail\_Points} attribute can be cleared by the following mail type:

\begin{itemize}
  \item \texttt{n} NO\_MAIL
\end{itemize}

If \texttt{n} is specified, then mail is not sent. The \texttt{qsub} utility shall consider it an error if any mail type other than \texttt{n} is combined with mail type \texttt{n}.

Strictly conforming applications shall not repeat any of the characters \texttt{\textasciitilde{e}}, \texttt{\textasciitilde{b}}, \texttt{\textasciitilde{a}}, or \texttt{\textasciitilde{n}} within the \texttt{mail\_options} option-argument.

The \texttt{qsub} utility shall permit the repetition of characters, but shall not assign additional meaning to the repeated characters. An implementation may define other mail types. The conformance document for an implementation shall describe any additional mail types, how they are specified, their internal behavior, and how they affect the behavior of the utility.

If the \texttt{\-m} option is not presented to the \texttt{qsub} utility, the utility shall set the \texttt{Mail\_Points} attribute to the value \texttt{MAIL\_AT\_ABORT}.

\textbf{\texttt{\-M mail\_list}}

Define the list of users to which a batch server that executes the batch job shall send mail, if the server sends mail about the batch job.

The syntax of the \texttt{mail\_list} option-argument is unspecified.

If the implementation of the \texttt{qsub} utility uses a name service to locate users, the utility should accept the syntax used by the name service.

If the implementation of the \texttt{qsub} utility does not use a name service to locate users, the implementation should accept the following syntax for user names:
The interpretation of `mail_address` is implementation-defined.

The `qsub` utility shall set the `Mail_Users` attribute of the batch job to the value of the `mail_list` option-argument.

If the `-M` option is not presented to the `qsub` utility, the utility shall place only the user name and host name for the current process in the `Mail_Users` attribute of the batch job.

```
−N name
```

Define the name of the batch job.

The `qsub` `-N` option shall accept a value for the `name` option-argument that is a string of up to 15 alphanumeric characters in the portable character set (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 6.1, Portable Character Set) where the first character is alphabetic.

The `qsub` utility shall set the value of the `Job_Name` attribute of the batch job to the value of the `name` option-argument.

If the `-N` option is not presented to the `qsub` utility, the utility shall set the `Job_Name` attribute of the batch job to the name of the script argument from which the directory specification if any, has been removed.

If the `-N` option is not presented to the `qsub` utility, and the script is read from standard input, the utility shall set the `Job_Name` attribute of the batch job to the value STDIN.

```
−o path_name
```

Define the path for the standard output of the batch job.

The `qsub` utility shall accept a `path_name` option-argument that conforms to the syntax of the `path_name` element defined in the System Interfaces volume of IEEE Std 1003.1-2001, which can be preceded by a host name element of the form `hostname:`.

If the `path_name` option-argument constitutes an absolute pathname, the `qsub` utility shall set the `Output_Path` attribute of the batch job to the value of the `path_name` option-argument without expansion.

If the `path_name` option-argument constitutes a relative pathname and no host name element is specified, the `qsub` utility shall set the `Output_Path` attribute of the batch job to the pathname derived by expanding the value of the `path_name` option-argument relative to the current directory of the process executing the `qsub`.

If the `path_name` option-argument constitutes a relative pathname and a host name element is specified, the `qsub` utility shall set the `Output_Path` attribute of the batch job to the value of the `path_name` option-argument without expansion.

If the `path_name` option-argument does not specify a host name element, the `qsub` utility shall prefix the hostname with `hostname:`; where `hostname` is the name of the host upon which the `qsub` utility is executing.

If the `-o` option is not presented to the `qsub` utility, the utility shall set the `Output_Path` attribute of the batch job to the host name and path of the current directory of the submitting process and the default filename.

The default filename for standard output has the following format:
Utilities

job_name.sequence_number

-p priority Define the priority the batch job should have relative to other batch jobs owned by the batch server.

The qsub utility shall set the Priority attribute of the batch job to the value of the priority option-argument.

If the −p option is not presented to the qsub utility, the value of the Priority attribute is implementation-defined.

The qsub utility shall accept a value for the priority option-argument that conforms to the syntax for signed decimal integers, and which is not less than −1 024 and not greater than 1 023.

-q destination Define the destination of the batch job.

The destination is not a batch job attribute; it determines the batch server, and possibly the batch queue, to which the qsub utility batch queues the batch job.

The qsub utility shall submit the script to the batch server named by the destination option-argument or the server that owns the batch queue named in the destination option-argument.

The qsub utility shall accept an option-argument for the −q option that conforms to the syntax for a destination (see Section 3.3.2 (on page 123)).

If the −q option is not presented to the qsub utility, the qsub utility shall submit the batch job to the default destination. The mechanism for determining the default destination is implementation-defined.

-r y | n Define whether the batch job is rerunnable.

If the value of the option-argument is y, the qsub utility shall set the Rerunable attribute of the batch job to TRUE.

If the value of the option-argument is n, the qsub utility shall set the Rerunable attribute of the batch job to FALSE.

If the −r option is not presented to the qsub utility, the utility shall set the Rerunable attribute of the batch job to TRUE.

-S path_name_list Define the pathname to the shell under which the batch job is to execute.

The qsub utility shall accept a path_name_list option-argument that conforms to the following syntax:

pathname[@host] [,,pathname[@host], , . . .]

The qsub utility shall allow only one pathname for a given host name. The qsub utility shall allow only one pathname that is missing a corresponding host name.

The qsub utility shall add a value to the Shell_Path_List attribute of the batch job for each entry in the path_name_list option-argument.

If the −S option is not presented to the qsub utility, the utility shall set the Shell_Path_List attribute of the batch job to the null string.

The conformance document for an implementation shall describe the mechanism used to set the default shell and determine the current value of the default shell.
An implementation shall provide a means for the installation to set the default shell to the login shell of the user under which the batch job is to execute. See Section 3.3.3 (on page 123) for a means of removing keyword=value (and value@keyword) pairs and other general rules for list-oriented batch job attributes.

- **u user_list**  
Define the user name under which the batch job is to execute.

The qsub utility shall accept a user_list option-argument that conforms to the following syntax:

```
username[@host],[,username[@host],...]
```

The qsub utility shall accept only one user name that is missing a corresponding host name. The qsub utility shall accept only one user name per named host.

The qsub utility shall add a value to the User_List attribute of the batch job for each entry in the user_list option-argument.

If the -u option is not presented to the qsub utility, the utility shall set the User_List attribute of the batch job to the user name from which the utility is executing. See Section 3.3.3 (on page 123) for a means of removing keyword=value (and value@keyword) pairs and other general rules for list-oriented batch job attributes.

- **v variable_list**  
Add to the list of variables that are exported to the session leader of the batch job.

A variable_list is a set of strings of either the form <variable> or <variable=value>, delimited by commas.

If the -v option is presented to the qsub utility, the utility shall also add, to the environment Variable_List attribute of the batch job, every variable named in the environment variable_list option-argument and, optionally, values of specified variables.

If a value is not provided on the command line, the qsub utility shall set the value of each variable in the environment Variable_List attribute of the batch job to the value of the corresponding environment variable for the process in which the utility is executing; see Table 4-18 (on page 804).

A conforming application shall not repeat a variable in the environment variable_list option-argument.

The qsub utility shall not repeat a variable in the environment Variable_List attribute of the batch job. See Section 3.3.3 (on page 123) for a means of removing keyword=value (and value@keyword) pairs and other general rules for list-oriented batch job attributes.

- **V**  
Specify that all of the environment variables of the process are exported to the context of the batch job.

The qsub utility shall place every environment variable in the process in which the utility is executing in the list and shall set the value of each variable in the attribute to the value of that variable in the process.

- **z**  
Specify that the utility does not write the batch job_identifier of the created batch job to standard output.

If the -z option is presented to the qsub utility, the utility shall not write the batch job_identifier of the created batch job to standard output.
If the \texttt{-z} option is not presented to the \texttt{qsub} utility, the utility shall write the identifier of the created batch job to standard output.

**OPERANDS**

The \texttt{qsub} utility shall accept a \texttt{script} operand that indicates the path to the script of the batch job.

If the \texttt{script} operand is not presented to the \texttt{qsub} utility, or if the operand is the single-character string \texttt{‘-’}, the utility shall read the script from standard input.

If the script represents a partial path, the \texttt{qsub} utility shall expand the path relative to the current directory of the process executing the utility.

**STDIN**

The \texttt{qsub} utility reads the script of the batch job from standard input if the script operand is omitted or is the single character \texttt{‘-’}.

**INPUT FILES**

In addition to binding the file indicated by the \texttt{script} operand to the batch job, the \texttt{qsub} utility reads the script file and acts on directives in the script.

**ENVIRONMENT VARIABLES**

The following environment variables shall affect the execution of \texttt{qsub}:

- **\texttt{LANG}**
  
  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **\texttt{LC_ALL}**
  
  If set to a non-empty string value, override the values of all the other internationalization variables.

- **\texttt{LC_CTYPE}**
  
  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- **\texttt{LC_MESSAGES}**
  
  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **\texttt{LOGNAME}**
  
  Determine the login name of the user.

- **\texttt{PBS_DPREFIX}**
  
  Determine the default prefix for directives within the script.

- **\texttt{SHELL}**
  
  Determine the pathname of the preferred command language interpreter of the user.

- **\texttt{TZ}**
  
  Determine the timezone used to interpret the \texttt{date-time} option-argument. If \texttt{TZ} is unset or null, an unspecified default timezone shall be used.

**ASYNCHRONOUS EVENTS**

Once created, a batch job exists until it exits, aborts, or is deleted.

After a batch job is created by the \texttt{qsub} utility, batch servers might route, execute, modify, or delete the batch job.

**STDOUT**

The \texttt{qsub} utility writes the batch \texttt{job_identifier} assigned to the batch job to standard output, unless the \texttt{-z} option is specified.
STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

Script Preservation

The qsub utility shall make the script available to the server executing the batch job in such a way that the server executes the script as it exists at the time of submission.

The qsub utility can send a copy of the script to the server with the Queue Job Request or store a temporary copy of the script in a location specified to the server.

Option Specification

A script can contain directives to the qsub utility.

The qsub utility shall scan the lines of the script for directives, skipping blank lines, until the first line that begins with a string other than the directive string; if directives occur on subsequent lines, the utility shall ignore those directives.

Lines are separated by a <newline>. If the first line of the script begins with "#!" or a colon (':'), then it is skipped. The qsub utility shall process a line in the script as a directive if and only if the string of characters from the first non-white-space character on the line until the first <space> or <tab> on the line match the directive prefix. If a line in the script contains a directive and the final characters of the line are backslash ('\') and <newline>, then the next line shall be interpreted as a continuation of that directive.

The qsub utility shall process the options and option-arguments contained on the directive prefix line using the same syntax as if the options were input on the qsub utility.

The qsub utility shall continue to process a directive prefix line until after a <newline> is encountered. An implementation may ignore lines which, according to the syntax of the shell that will interpret the script, are comments. An implementation shall describe in the conformance document the format of any shell comments that it will recognize.

If an option is present in both a directive and the arguments to the qsub utility, the utility shall ignore the option and the corresponding option-argument, if any, in the directive.

If an option that is present in the directive is not present in the arguments to the qsub utility, the utility shall process the option and the option-argument, if any.

In order of preference, the qsub utility shall select the directive prefix from one of the following sources:

- If the −C option is presented to the utility, the value of the directive_prefix option-argument
- If the environment variable PBS_DPREFIX is defined, the value of that variable
- The four-character string "#PBS" encoded in the portable character set

If the −C option is present in the script file it shall be ignored.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.
An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
The `qsub` utility allows users to create a batch job that will process the script specified as the operand of the utility.

The options of the `qsub` utility allow users to control many aspects of the queuing and execution of a batch job.

The `−a` option allows users to designate the time after which the batch job will become eligible to run. By specifying an execution time, users can take advantage of resources at off-peak hours, synchronize jobs with chronologically predictable events, and perhaps take advantage of off-peak pricing of computing time. For these reasons and others, a timing option is existing practice on the part of almost every batch system, including NQS.

The `−A` option allows users to specify the account that will be charged for the batch job. Support for account is not mandatory for conforming batch servers.

The `−C` option allows users to prescribe the prefix for directives within the script file. The default prefix "#PBS" may be inappropriate if the script will be interpreted with an alternate shell, as specified by the `−S` option.

The `−c` option allows users to establish the checkpointing interval for their jobs. A checkpointing system, which is not defined by this volume of IEEE Std 1003.1-2001, allows recovery of a batch job at the most recent checkpoint in the event of a crash. Checkpointing is typically used for jobs that consume expensive computing time or must meet a critical schedule. Users should be allowed to make the tradeoff between the overhead of checkpointing and the risk to the timely completion of the batch job; therefore, this volume of IEEE Std 1003.1-2001 provides the checkpointing interval option. Support for checkpointing is optional for batch servers.

The `−e` option allows users to redirect the standard error streams of their jobs to a non-default path. For example, if the submitted script generally produces a great deal of useless error output, a user might redirect the standard error output to the null device. Or, if the file system holding the default location (the home directory of the user) has too little free space, the user might redirect the standard error stream to a file in another file system.

The `−h` option allows users to create a batch job that is held until explicitly released. The ability to create a held job is useful when some external event must complete before the batch job can execute. For example, the user might submit a held job and release it when the system load has dropped.

The `−j` option allows users to merge the standard error of a batch job into its standard output stream, which has the advantage of showing the sequential relationship between output and error messages.

The `−m` option allows users to designate those points in the execution of a batch job at which mail will be sent to the submitting user, or to the account(s) indicated by the `−M` option. By requesting mail notification at points of interest in the life of a job, the submitting user, or other designated users, can track the progress of a batch job.
The `−N` option allows users to associate a name with the batch job. The job name in no way affects the processing of the batch job, but rather serves as a mnemonic handle for users. For example, the batch job name can help the user distinguish between multiple jobs listed by the `qstat` utility.

The `−o` option allows users to redirect the standard output stream. A user might, for example, wish to redirect to the null device the standard output stream of a job that produces copious yet superfluous output.

The `−P` option allows users to designate the relative priority of a batch job for selection from a queue.

The `−q` option allows users to specify an initial queue for the batch job. If the user specifies a routing queue, the batch server routes the batch job to another queue for execution or further routing. If the user specifies a non-routing queue, the batch server of the queue eventually executes the batch job.

The `−r` option allows users to control whether the submitted job will be rerun if the controlling batch node fails during execution of the batch job. The `−r` option likewise allows users to indicate whether or not the batch job is eligible to be rerun by the `qrerun` utility. Some jobs cannot be correctly rerun because of changes they make in the state of databases or other aspects of their environment. This volume of IEEE Std 1003.1-2001 specifies that the default, if the `−r` option is not presented to the utility, will be that the batch job cannot be rerun, since the result of rerunning a non-rerunnable job might be catastrophic.

The `−S` option allows users to specify the program (usually a shell) that will be invoked to process the script of the batch job. This option has been modified to allow a list of shell names and locations associated with different hosts.

The `−u` option is useful when the submitting user is authorized to use more than one account on a given host, in which case the `−u` option allows the user to select from among those accounts. The option-argument is a list of user-host pairs, so that the submitting user can provide different user identifiers for different nodes in the event the batch job is routed. The `−u` option provides a lot of flexibility to accommodate sites with complex account structures. Users that have the same user identifier on all the hosts they are authorized to use will not need to use the `−u` option.

The `−V` option allows users to export all their current environment variables, as of the time the batch job is submitted, to the context of the processes of the batch job.

The `−v` option allows users to export specific environment variables from their current process to the processes of the batch job.

The `−z` option allows users to suppress the writing of the batch job identifier to standard output. The `−z` option is an existing NQS practice that has been standardized.

Historically, the `qsub` utility has served the batch job-submission function in the NQS system, the existing practice on which it is based. Some changes and additions have been made to the `qsub` utility in this volume of IEEE Std 1003.1-2001, `vis-a-vis` NQS, as a result of the growing pool of experience with distributed batch systems.

The set of features of the `qsub` utility as defined in this volume of IEEE Std 1003.1-2001 appears to incorporate all the common existing practice on potentially conforming platforms.

**Future Directions**

None.
SEE ALSO
Chapter 3 (on page 101), qrerun, qstat, touch

CHANGE HISTORY

Issue 6
The -l option has been removed as there is no portable description of the resources that are allowed or required by the batch job.
NAME
read — read a single line from standard input

SYNOPSIS
read [-r] var...

DESCRIPTION
The read utility shall read a single line from standard input.

By default, unless the -r option is specified, backslash ('\') shall act as an escape character, as
described in Section 2.2.1 (on page 30). If standard input is a terminal device and the invoking
shell is interactive, read shall prompt for a continuation line when:

- The shell reads an input line ending with a backslash, unless the -r option is specified.
- A here-document is not terminated after a <newline> is entered.

The line shall be split into fields as in the shell (see Section 2.6.5 (on page 42)); the first field shall
be assigned to the first variable var, the second field to the second variable var, and so on. If
there are fewer var operands specified than there are fields, the leftover fields and their
intervening separators shall be assigned to the last var. If there are fewer fields than vars, the
remaining vars shall be set to empty strings.

The setting of variables specified by the var operands shall affect the current shell execution
environment; see Section 2.12 (on page 61). If it is called in a subshell or separate utility
execution environment, such as one of the following:

(read foo)
nohup read ...
find . -exec read ... \;

it shall not affect the shell variables in the caller's environment.

OPTIONS
The read utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following option is supported:

-r Do not treat a backslash character in any special way. Consider each backslash to
be part of the input line.

OPERANDS
The following operand shall be supported:

var The name of an existing or nonexisting shell variable.

STDIN
The standard input shall be a text file.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of read:

IFS Determine the internal field separators used to delimit fields; see Section 2.5.3 (on
page 34).

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

If set to a non-empty string value, override the values of all the other
internationalization variables.

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

Provide the prompt string that an interactive shell shall write to standard error
when a line ending with a backslash is read and the −r option was not specified, or
if a here-document is not terminated after a <newline> is entered.

Default.

Not used.

The standard error shall be used for diagnostic messages and prompts for continued input.

None.

None.

The following exit values shall be returned:

0 Successful completion.

>0 End-of-file was detected or an error occurred.

Default.

The −r option is included to enable read to subsume the purpose of the line utility, which is not

The results are undefined if an end-of-file is detected following a backslash at the end of a line
when −r is not specified.

The following command:

while read −r xx yy
do
    printf "%s %s\n" "$yy" "$xx"
done < input_file

prints a file with the first field of each line moved to the end of the line.
The `read` utility historically has been a shell built-in. It was separated off into its own utility to take advantage of the richer description of functionality introduced by this volume of IEEE Std 1003.1-2001.

Since `read` affects the current shell execution environment, it is generally provided as a shell regular built-in. If it is called in a subshell or separate utility execution environment, such as one of the following:

- `(read foo)`
- `nohup read ...
- `find . -exec read ... \;`

it does not affect the shell variables in the environment of the caller.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 2 (on page 29)

**CHANGE HISTORY**

First released in Issue 2.
NAME
renice — set nice values of running processes

SYNOPSIS
renice −n increment [−g | −p | −u] ID ...

DESCRIPTION
The renice utility shall request that the nice values (see the Base Definitions volume of
IEEE Std 1003.1-2001, Section 3.239, Nice Value) of one or more running processes be changed.
By default, the applicable processes are specified by their process IDs. When a process group is
specified (see −g), the request shall apply to all processes in the process group.
The nice value shall be bounded in an implementation-defined manner. If the requested
increment would raise or lower the nice value of the executed utility beyond implementation-
defined limits, then the limit whose value was exceeded shall be used.
When a user is reniced, the request applies to all processes whose saved set-user-ID matches the
user ID corresponding to the user.
Regardless of which options are supplied or any other factor, renice shall not alter the nice values
of any process unless the user requesting such a change has appropriate privileges to do so for
the specified process. If the user lacks appropriate privileges to perform the requested action, the
utility shall return an error status.
The saved set-user-ID of the user’s process shall be checked instead of its effective user ID when
renice attempts to determine the user ID of the process in order to determine whether the user
has appropriate privileges.

OPTIONS
The renice utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
The following options shall be supported:
−g Interpret all operands as unsigned decimal integer process group IDs.
−n increment Specify how the nice value of the specified process or processes is to be adjusted.
The increment option-argument is a positive or negative decimal integer that shall
be used to modify the nice value of the specified process or processes.
Positive increment values shall cause a lower nice value. Negative increment values
may require appropriate privileges and shall cause a higher nice value.
−p Interpret all operands as unsigned decimal integer process IDs. The −p option is
the default if no options are specified.
−u Interpret all operands as users. If a user exists with a user name equal to the
operand, then the user ID of that user is used in further processing. Otherwise, if
the operand represents an unsigned decimal integer, it shall be used as the numeric
user ID of the user.

OPERANDS
The following operands shall be supported:
ID A process ID, process group ID, or user name/user ID, depending on the option
selected.
31835 **STDIN**
31836 Not used.

31837 **INPUT FILES**
31838 None.

31839 **ENVIRONMENT VARIABLES**
31840 The following environment variables shall affect the execution of `renice`:

31841 `LANG` Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

31842 `LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.

31843 `LC_CTYPE` Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

31844 `LC_MESSAGES` Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

31845 `XSI NLSPATH` Determine the location of message catalogs for the processing of `LC_MESSAGES`.

31846 **ASYNCHRONOUS EVENTS**
31847 Default.

31848 **STDOUT**
31849 Not used.

31850 **STDERR**
31851 The standard error shall be used only for diagnostic messages.

31852 **OUTPUT FILES**
31853 None.

31854 **EXTENDED DESCRIPTION**
31855 None.

31856 **EXIT STATUS**
31857 The following exit values shall be returned:

31858 0 Successful completion.

31859 >0 An error occurred.

31860 **CONSEQUENCES OF ERRORS**
31861 Default.
**APPLICATION USAGE**

None.

**EXAMPLES**

1. Adjust the nice value so that process IDs 987 and 32 would have a lower nice value:

   ```
   renice -n 5 -p 987 32
   ```

2. Adjust the nice value so that group IDs 324 and 76 would have a higher nice value, if the user has the appropriate privileges to do so:

   ```
   renice -n -4 -g 324 76
   ```

3. Adjust the nice value so that numeric user ID 8 and user sas would have a lower nice value:

   ```
   renice -n 4 -u 8 sas
   ```

Useful nice value increments on historical systems include 19 or 20 (the affected processes run only when nothing else in the system attempts to run) and any negative number (to make processes run faster).

**RATIONALE**

The gid, pid, and user specifications do not fit either the definition of operand or option-argument. However, for clarity, they have been included in the OPTIONS section, rather than the OPERANDS section.

The definition of nice value is not intended to suggest that all processes in a system have priorities that are comparable. Scheduling policy extensions such as the realtime priorities in the System Interfaces volume of IEEE Std 1003.1-2001 make the notion of a single underlying priority for all scheduling policies problematic. Some implementations may implement the nice-related features to affect all processes on the system, others to affect just the general time-sharing activities implied by this volume of IEEE Std 1003.1-2001, and others may have no effect at all. Because of the use of “implementation-defined” in nice and renice, a wide range of implementation strategies are possible.

Originally, this utility was written in the historical manner, using the term “nice value”. This was always a point of concern with users because it was never intuitively obvious what this meant. With a newer version of renice, which used the term “system scheduling priority”, it was hoped that novice users could better understand what this utility was meant to do. Also, it would be easier to document what the utility was meant to do. Unfortunately, the addition of the POSIX realtime scheduling capabilities introduced the concepts of process and thread scheduling priorities that were totally unaffected by the nice/renice utilities or the nice() / setpriority() functions. Continuing to use the term “system scheduling priority” would have incorrectly suggested that these utilities and functions were indeed affecting these realtime priorities. It was decided to revert to the historical term “nice value” to reference this unrelated process attribute.

Although this utility has use by system administrators (and in fact appears in the system administration portion of the BSD documentation), the standard developers considered that it was very useful for individual end users to control their own processes.

**FUTURE DIRECTIONS**

None.
31912 **SEE ALSO**
31913 *nice*

31914 **CHANGE HISTORY**
31915 First released in Issue 4.

31916 **Issue 5**
31917 In the SYNOPSIS, an ellipsis is added to the −u option in all three obsolescent forms.

31918 **Issue 6**
31919 This utility is marked as part of the User Portability Utilities option.
31920 The APPLICATION USAGE section is added.
31921 The obsolescent forms of the SYNOPSIS are removed.
31922 Text previously conditional on POSIX_SAVED_IDS is mandatory in this issue. This is a FIPS requirement.
NAME
 rm — remove directory entries

SYNOPSIS
 rm [-fiRr] file...

DESCRIPTION
 The rm utility shall remove the directory entry specified by each file argument.

If either of the files dot or dot-dot are specified as the basename portion of an operand (that is, the final pathname component), rm shall write a diagnostic message to standard error and do nothing more with such operands.

For each file the following steps shall be taken:

1. If the file does not exist:
   a. If the –f option is not specified, rm shall write a diagnostic message to standard error.
   b. Go on to any remaining files.

2. If file is of type directory, the following steps shall be taken:
   a. If neither the –R option nor the –r option is specified, rm shall write a diagnostic message to standard error, do nothing more with file, and go on to any remaining files.
   b. If the –f option is not specified, and either the permissions of file do not permit writing and the standard input is a terminal or the –i option is specified, rm shall write a prompt to standard error and read a line from the standard input. If the response is not affirmative, rm shall do nothing more with the current file and go on to any remaining files.
   c. For each entry contained in file, other than dot or dot-dot, the four steps listed here (1 to 4) shall be taken with the entry as if it were a file operand. The rm utility shall not traverse directories by following symbolic links into other parts of the hierarchy, but shall remove the links themselves.
   d. If the –i option is specified, rm shall write a prompt to standard error and read a line from the standard input. If the response is not affirmative, rm shall do nothing more with the current file, and go on to any remaining files.

3. If file is not of type directory, the –f option is not specified, and either the permissions of file do not permit writing and the standard input is a terminal or the –i option is specified, rm shall write a prompt to the standard error and read a line from the standard input. If the response is not affirmative, rm shall do nothing more with the current file and go on to any remaining files.

4. If the current file is a directory, rm shall perform actions equivalent to the rmdir() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 called with a pathname of the current file used as the path argument. If the current file is not a directory, rm shall perform actions equivalent to the unlink() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 called with a pathname of the current file used as the path argument.

   If this fails for any reason, rm shall write a diagnostic message to standard error, do nothing more with the current file, and go on to any remaining files.

The rm utility shall be able to descend to arbitrary depths in a file hierarchy, and shall not fail due to path length limitations (unless an operand specified by the user exceeds system

The following options shall be supported:

- `-f` Do not prompt for confirmation. Do not write diagnostic messages or modify the exit status in the case of nonexistent operands. Any previous occurrences of the `−i` option shall be ignored.

- `-i` Prompt for confirmation as described previously. Any previous occurrences of the `-f` option shall be ignored.

- `-R` Remove file hierarchies. See the DESCRIPTION.

- `-r` Equivalent to `-R`.

The following operand shall be supported:

- `file` A pathname of a directory entry to be removed.

The standard input shall be used to read an input line in response to each prompt specified in the STDOUT section. Otherwise, the standard input shall not be used.

None.

The following environment variables shall affect the execution of `rm`:

- `LANG` Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- `LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.

- `LC_COLLATE` Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements used in the extended regular expression defined for the `yesexpr` locale keyword in the `LC_MESSAGES` category.

- `LC_CTYPE` Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments) and the behavior of character classes within regular expressions used in the extended regular expression defined for the `yesexpr` locale keyword in the `LC_MESSAGES` category.

- `LC_MESSAGES` Determine the locale for the processing of affirmative responses that should be used to affect the format and contents of diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of `LC_MESSAGES`.

...
Utilities

rm

32010 ASYNCHRONOUS EVENTS
32011 Default.

32012 STDOUT
32013 Not used.

32014 STDERR
32015 Prompts shall be written to standard error under the conditions specified in the DESCRIPTION
32016 and OPTIONS sections. The prompts shall contain the file pathname, but their format is
32017 otherwise unspecified. The standard error also shall be used for diagnostic messages.

32018 OUTPUT FILES
32019 None.

32020 EXTENDED DESCRIPTION
32021 None.

32022 EXIT STATUS
32023 The following exit values shall be returned:
32024 0 All of the named directory entries for which rm performed actions equivalent to the rmdir() or unlink() functions were removed.
32025 >0 An error occurred.

32027 CONSEQUENCES OF ERRORS
32028 Default.

32029 APPLICATION USAGE
32030 The rm utility is forbidden to remove the names dot and dot-dot in order to avoid the
32031 consequences of inadvertently doing something like:
32032 rm -r .*
32033 Some implementations do not permit the removal of the last link to an executable binary file that
32034 is being executed; see the [EBUSY] error in the unlink() function defined in the System Interfaces
32035 volume of IEEE Std 1003.1-2001. Thus, the rm utility can fail to remove such files.
32036 The -i option causes rm to prompt and read the standard input even if the standard input is not
32037 a terminal, but in the absence of -i the mode prompting is not done when the standard input is
32038 not a terminal.

32039 EXAMPLES
32040 1. The following command:
32041 rm a.out core
32042 removes the directory entries: a.out and core.
32043
32044 2. The following command:
32045 rm -Rf junk
32046 removes the directory junk and all its contents, without prompting.

32046 RATIONALE
32047 For absolute clarity, paragraphs (2b) and (3) in the DESCRIPTION of rm describing the behavior
32048 when prompting for confirmation, should be interpreted in the following manner:
32049
32049 if ((NOT f_option) AND
32050 ((not_writable AND input_is_terminal) OR i_option))
The exact format of the interactive prompts is unspecified. Only the general nature of the contents of prompts are specified because implementations may desire more descriptive prompts than those used on historical implementations. Therefore, an application not using the −f option, or using the −i option, relies on the system to provide the most suitable dialog directly with the user, based on the behavior specified.

The −r option is historical practice on all known systems. The synonym −R option is provided for consistency with the other utilities in this volume of IEEE Std 1003.1-2001 that provide options requesting recursive descent through the file hierarchy.

The behavior of the −f option in historical versions of rm is inconsistent. In general, along with “forcing” the unlink without prompting for permission, it always causes diagnostic messages to be suppressed and the exit status to be unmodified for nonexistent operands and files that cannot be unlinked. In some versions, however, the −f option suppresses usage messages and system errors as well. Suppressing such messages is not a service to either shell scripts or users.

It is less clear that error messages regarding files that cannot be unlinked (removed) should be suppressed. Although this is historical practice, this volume of IEEE Std 1003.1-2001 does not permit the −f option to suppress such messages.

When given the −r and −i options, historical versions of rm prompt the user twice for each directory, once before removing its contents and once before actually attempting to delete the directory entry that names it. This allows the user to “prune” the file hierarchy walk. Historical versions of rm were inconsistent in that some did not do the former prompt for directories named on the command line and others had obscure prompting behavior when the −i option was specified and the permissions of the file did not permit writing. The POSIX Shell and Utilities rm differs little from historic practice, but does require that prompts be consistent.

Historical versions of rm were also inconsistent in that prompts were done to both standard output and standard error. This volume of IEEE Std 1003.1-2001 requires that prompts be done to standard error, for consistency with cp and mv, and to allow historical extensions to rm that provide an option to list deleted files on standard output.

The rm utility is required to descend to arbitrary depths so that any file hierarchy may be deleted. This means, for example, that the rm utility cannot run out of file descriptors during its descent (that is, if the number of file descriptors is limited, rm cannot be implemented in the historical fashion where one file descriptor is used per directory level). Also, rm is not permitted to fail because of path length restrictions, unless an operand specified by the user is longer than {PATH_MAX}.

The rm utility removes symbolic links themselves, not the files they refer to, as a consequence of the dependence on the unlink() functionality, per the DESCRIPTION. When removing hierarchies with −r or −R, the prohibition on following symbolic links has to be made explicit.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

rm, rmdir, the System Interfaces volume of IEEE Std 1003.1-2001, remove(), rmdir(), unlink()
Text is added to clarify actions relating to symbolic links as specified in the IEEE P1003.2b draft standard.
rmdel

NAME
rmdel — remove a delta from an SCCS file (DEVELOPMENT)

SYNOPSIS
XSI
rmdel -r SID file...

DESCRIPTION
The rmdel utility shall remove the delta specified by the SID from each named SCCS file. The delta to be removed shall be the most recent delta in its branch in the delta chain of each named SCCS file. In addition, the application shall ensure that the SID specified is not that of a version being edited for the purpose of making a delta; that is, if a p-file (see get) exists for the named SCCS file, the SID specified shall not appear in any entry of the p-file.

Removal of a delta shall be restricted to:

1. The user who made the delta
2. The owner of the SCCS file
3. The owner of the directory containing the SCCS file

OPTIONS

The following option shall be supported:

- SID
  Specify the SCCS identification string (SID) of the delta to be deleted.

OPERANDS
The following operand shall be supported:

file
A pathname of an existing SCCS file or a directory. If file is a directory, the rmdel utility shall behave as though each file in the directory were specified as a named file, except that non-SCCS files (last component of the pathname does not begin with s.) and unreadable files shall be silently ignored.

If exactly one file operand appears, and it is ‘-‘, the standard input shall be read; each line of the standard input is taken to be the name of an SCCS file to be processed. Non-SCCS files and unreadable files shall be silently ignored.

STDIN
The standard input shall be a text file used only when the file operand is specified as ‘-‘. Each line of the text file shall be interpreted as an SCCS pathname.

INPUT FILES
The SCCS files shall be files of unspecified format.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of rmdel:

LANG
Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other internationalization variables.
Determines the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
The SCCS files shall be files of unspecified format. During processing of a file, a temporary x-file,
as described in admin, may be created and deleted; a locking z-file, as described in get, may be
created and deleted.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
admin, delta, get, prs

CHANGE HISTORY
First released in Issue 2.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
   rmdir — remove directories

SYNOPSIS
   rmdir [-p] dir...

DESCRIPTION
   The rmdir utility shall remove the directory entry specified by each dir operand.

   For each dir operand, the rmdir utility shall perform actions equivalent to the rmdir() function
called with the dir operand as its only argument.

   Directories shall be processed in the order specified. If a directory and a subdirectory of that
directory are specified in a single invocation of the rmdir utility, the application shall specify the
subdirectory before the parent directory so that the parent directory will be empty when the
rmdir utility tries to remove it.

OPTIONS
   The rmdir utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

   The following option shall be supported:

   -p     Remove all directories in a pathname. For each dir operand:

   1. The directory entry it names shall be removed.

   2. If the dir operand includes more than one pathname component, effects
equivalent to the following command shall occur:

      rmdir -p $(dirname dir)

OPERANDS
   The following operand shall be supported:

   dir     A pathname of an empty directory to be removed.

STDIN
   Not used.

INPUT FILES
   None.

ENVIRONMENT VARIABLES
   The following environment variables shall affect the execution of rmdir:

   LANG     Provide a default value for the internationalization variables that are unset or null.
            (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
            Internationalization Variables for the precedence of internationalization variables
            used to determine the values of locale categories.)

   LC_ALL   If set to a non-empty string value, override the values of all the other
            internationalization variables.

   LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
            characters (for example, single-byte as opposed to multi-byte characters in
            arguments).

   LC_MESSAGES   Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
Utilities

rmdir

**NLSPATH**

Determine the location of message catalogs for the processing of *LC_MESSAGES*.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

Not used.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- 0 Each directory entry specified by a *dir* operand was removed successfully.
- >0 An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

The definition of an empty directory is one that contains, at most, directory entries for dot and dot-dot.

**EXAMPLES**

If a directory *a* in the current directory is empty except it contains a directory *b* and *a/b* is empty except it contains a directory *c*:

```
rmdir -p a/b/c
```

removes all three directories.

**RATIONALE**

On historical System V systems, the *−p* option also caused a message to be written to the standard output. The message indicated whether the whole path was removed or whether part of the path remained for some reason. The STDERR section requires this diagnostic when the entire path specified by a *dir* operand is not removed, but does not allow the status message reporting success to be written as a diagnostic.

The *rmdir* utility on System V also included a *−s* option that suppressed the informational message output by the *−p* option. This option has been omitted because the informational message is not specified by this volume of IEEE Std 1003.1-2001.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

*r*, *rm*, *remove()* , *rmdir()* , *unlink()*

**CHANGE HISTORY**

First released in Issue 2.
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
sact — print current SCCS file-editing activity (DEVELOPMENT)

SYNOPSIS
sact file...

DESCRIPTION
The sact utility shall inform the user of any impending deltas to a named SCCS file by writing a
list to standard output. This situation occurs when get −e has been executed previously without
a subsequent execution of delta, unget, or sccs unedit.

OPTIONS
None.

OPERANDS
The following operand shall be supported:

file A pathname of an existing SCCS file or a directory. If file is a directory, the sact
utility shall behave as though each file in the directory were specified as a named
file, except that non-SCCS files (last component of the pathname does not begin
with s.) and unreadable files shall be silently ignored.

If exactly one file operand appears, and it is ‘−’, the standard input shall be read;
each line of the standard input shall be taken to be the name of an SCCS file to be
processed. Non-SCCS files and unreadable files shall be silently ignored.

STDIN
The standard input shall be a text file used only when the file operand is specified as ‘−’. Each
line of the text file shall be interpreted as an SCCS pathname.

INPUT FILES
Any SCCS files interrogated are files of an unspecified format.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of sact:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.
The output for each named file shall consist of a line in the following format:

```
"%sΔ%sΔ%sΔ%sΔ%s\n", <SID>, <new SID>, <login>, <date>, <time>
```

- `<SID>` Specifies the SID of a delta that currently exists in the SCCS file to which changes are made to make the new delta.
- `<new SID>` Specifies the SID for the new delta to be created.
- `<login>` Contains the login name of the user who makes the delta (that is, who executed a `get` for editing).
- `<date>` Contains the date that `get -e` was executed, in the format used by the `prs :D:` data keyword.
- `<time>` Contains the time that `get -e` was executed, in the format used by the `prs :T:` data keyword.

If there is more than one named file or if a directory or standard input is named, each pathname shall be written before each of the preceding lines:

```
"\n%s:\n", <pathname>
```

The standard error shall be used only for optional informative messages concerning SCCS files with no impending deltas, and for diagnostic messages.

None.

None.

The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

Default.

None.

None.

None.

None.

`delta, get, sccs, unget`
CHANGE HISTORY
First released in Issue 2.
NAME
sccs — front end for the SCCS subsystem (DEVELOPMENT)

SYNOPSIS
xsi
sccs [-r] [-d path] [-p path] command [options...][operands...]

DESCRIPTION
The sccs utility is a front end to the SCCS programs. It also includes the capability to run set-user-id to another user to provide additional protection.

The sccs utility shall invoke the specified command with the specified options and operands. By default, each of the operands shall be modified by prefixing it with the string "SCCS/s.".

The command can be the name of one of the SCCS utilities in this volume of IEEE Std 1003.1-2001 (admin, delta, get, prs, rmdel, sact, unget, val, or what) or one of the pseudo-utilities listed in the EXTENDED DESCRIPTION section.

OPTIONS
The sccs utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that options operands are actually options to be passed to the utility named by command. When the portion of the command:
command [options ...] [operands ...]
is considered, all of the pseudo-utilities used as command shall support the Utility Syntax Guidelines. Any of the other SCCS utilities that can be invoked in this manner support the Guidelines to the extent indicated by their individual OPTIONS sections.

The following options shall be supported preceding the command operand:

-d path A pathname of a directory to be used as a root directory for the SCCS files. The default shall be the current directory. The -d option shall take precedence over the PROJECTDIR variable. See -p.

-p path A pathname of a directory in which the SCCS files are located. The default shall be the SCCS directory.

The -p option differs from the -d option in that the -d option-argument shall be prefixed to the entire pathname and the -p option-argument shall be inserted before the final component of the pathname. For example:
sccs -d /x -p y get a/b
converts to:
get /x/a/y/s.b
This allows the creation of aliases such as:
alias syssccs="sccs -d /usr/src"
which is used as:
syssccs get cmd/who.c

-r Invoke command with the real user ID of the process, not any effective user ID that the sccs utility is set to. Certain commands (admin, check, clean, diffs, info, rmdel, and tell) cannot be run set-user-ID by all users, since this would allow anyone to change the authorizations. These commands are always run as the real user.
OPERANDS
The following operands shall be supported:

command  An SCCS utility name or the name of one of the pseudo-utilities listed in the
EXTENDED DESCRIPTION section.

options   An option or option-argument to be passed to command.

operands  An operand to be passed to command.

STDIN
See the utility description for the specified command.

INPUT FILES
See the utility description for the specified command.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of sccs:

LANG     Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL   If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES   Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

PROJECTDIR Provide a default value for the −d path option. If the value of PROJECTDIR begins with a slash, it shall be considered an absolute pathname; otherwise, the value of PROJECTDIR is treated as a user name and that user’s initial working directory shall be examined for a subdirectory src or source. If such a directory is found, it shall be used. Otherwise, the value shall be used as a relative pathname.

Additional environment variable effects may be found in the utility description for the specified command.

ASYNCHRONOUS EVENTS
Default.

STDOUT
See the utility description for the specified command.

STDERR
See the utility description for the specified command.

OUTPUT FILES
See the utility description for the specified command.
EXTENDED DESCRIPTION

The following pseudo-utilities shall be supported as command operands. All options referred to
in the following list are values given in the options operands following command.

check  Equivalent to info, except that nothing shall be printed if nothing is being edited, and a
non-zero exit status shall be returned if anything is being edited. The intent is to have
this included in an “install” entry in a makefile to ensure that everything is included
into the SCCS file before a version is installed.

clean  Remove everything from the current directory that can be recreated from SCCS files,
but do not remove any files being edited. If the -b option is given, branches shall be
ignored in the determination of whether they are being edited; this is dangerous if
branches are kept in the same directory.

create Create an SCCS file, taking the initial contents from the file of the same name. Any
options to admin are accepted. If the creation is successful, the original files shall be
renamed by prefixing the basenames with a comma. These renamed files should be
removed after it has been verified that the SCCS files have been created successfully.

delget  Perform a delta on the named files and then get new versions. The new versions shall
have ID keywords expanded and shall not be editable. Any -m, -p, -r, -s, and -y
options shall be passed to delta, and any -b, -c, -e, -i, -k, -l, -s, and -x options shall be
passed to get.

deledit Equivalent to delget, except that the get phase shall include the -e option. This option
is useful for making a checkpoint of the current editing phase. The same options shall
be passed to delta as described above, and all the options listed for get above except -e
shall be passed to edit.

diffs  Write a difference listing between the current version of the files checked out for
editing and the versions in SCCS format. Any -r, -c, -i, -x, and -t options shall be
passed to get; any -l, -s, -e, -f, -h, and -b options shall be passed to diff. A -C option
shall be passed to diff as -c.

edit  Equivalent to get -e.

fix  Remove the named delta, but leave a copy of the delta with the changes that were in it.
It is useful for fixing small compiler bugs, and so on. The application shall ensure that it
is followed by a -r SID option. Since fix does not leave audit trails, it should be used
carefully.

info  Write a listing of all files being edited. If the -b option is given, branches (that is, SIDs
with two or fewer components) shall be ignored. If a -u user option is given, then only
files being edited by the named user shall be listed. A -U option shall be equivalent to
-ub<current user>.

print  Write out verbose information about the named files, equivalent to sccs prs.

tell  Write a <newline>-separated list of the files being edited to standard output. Takes the
-b, -u, and -U options like info and check.

unedit This is the opposite of an edit or a get -e. It should be used with caution, since any
changes made since the get are lost.

EXIT STATUS

The following exit values shall be returned:

0  Successful completion.
>0 An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

Many of the SCCS utilities take directory names as operands as well as specific filenames. The pseudo-utilities supported by SCCS are not described as having this capability, but are not prohibited from doing so.

**EXAMPLES**

1. To get a file for editing, edit it and produce a new delta:

   sccs get -e file.c

   ex file.c

   sccs delta file.c

2. To get a file from another directory:

   sccs -p /usr/src/sccs/s. get cc.c

   or:

   sccs get /usr/src/sccs/s.cc.c

3. To make a delta of a large number of files in the current directory:

   sccs delta *.c

4. To get a list of files being edited that are not on branches:

   sccs info -b

5. To delta everything being edited by the current user:

   sccs delta $(sccs tell -U)

6. In a makefile, to get source files from an SCCS file if it does not already exist:

   SRCS = <list of source files>

   $(SRCS):

   sccs get $(REL) @

**RATIONALE**

SCCS and its associated utilities are part of the XSI Development Utilities option within the XSI extension.

SCCS is an abbreviation for Source Code Control System. It is a maintenance and enhancement tracking tool. When a file is put under SCCS, the source code control system maintains the file and, when changes are made, identifies and stores them in the file with the original source code and/or documentation. As other changes are made, they too are identified and retained in the file.

Retrieval of the original and any set of changes is possible. Any version of the file as it develops can be reconstructed for inspection or additional modification. History data can be stored with each version, documenting why the changes were made, who made them, and when they were made.
FUTURE DIRECTIONS
None.

SEE ALSO
admin, delta, get, make, prs, rmdel, sact, unget, val, what

CHANGE HISTORY
First released in Issue 4.

Issue 6
In the ENVIRONMENT VARIABLES section, the PROJECTDIR description is updated from “otherwise, the home directory of a user of that name is examined” to “otherwise, the value of PROJECTDIR is treated as a user name and that user’s initial working directory is examined”.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
sed — stream editor

SYNOPSIS
sed [-n] script[file...]
sed [-n][-e script][−f script_file][file...]  

DESCRIPTION
The sed utility is a stream editor that shall read one or more text files, make editing changes according to a script of editing commands, and write the results to standard output. The script shall be obtained from either the script operand string or a combination of the option-arguments from the −e script and −f script_file options.

OPTIONS
The sed utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the order of presentation of the −e and −f options is significant.

The following options shall be supported:
−e script Add the editing commands specified by the script option-argument to the end of the script of editing commands. The script option-argument shall have the same properties as the script operand, described in the OPERANDS section.
−f script_file Add the editing commands in the file script_file to the end of the script.
−n Suppress the default output (in which each line, after it is examined for editing, is written to standard output). Only lines explicitly selected for output are written.

Multiple −e and −f options may be specified. All commands shall be added to the script in the order specified, regardless of their origin.

OPERANDS
The following operands shall be supported:
file A pathname of a file whose contents are read and edited. If multiple file operands are specified, the named files shall be read in the order specified and the concatenation shall be edited. If no file operands are specified, the standard input shall be used.
script A string to be used as the script of editing commands. The application shall not present a script that violates the restrictions of a text file except that the final character need not be a <newline>.

STDIN
The standard input shall be used only if no file operands are specified. See the INPUT FILES section.

INPUT FILES
The input files shall be text files. The script_files named by the −f option shall consist of editing commands.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of sed:
LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
**LC_ALL**  If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_COLLATE**  Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements within regular expressions.

**LC_CTYPE**  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), and the behavior of character classes within regular expressions.

**LC_MESSAGES**  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**XSI**  

**NLSPATH**  Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**ASYNCHRONOUS EVENTS**

**STDOUT**

The input files shall be written to standard output, with the editing commands specified in the script applied. If the `−n` option is specified, only those input lines selected by the script shall be written to standard output.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

The output files shall be text files whose formats are dependent on the editing commands given.

**EXTENDED DESCRIPTION**

The **script** shall consist of editing commands of the following form:

```
[address[, address]] function
```

where **function** represents a single-character command verb from the list in **Editing Commands in sed** (on page 843), followed by any applicable arguments.

The command can be preceded by `<blank>`s and/or semicolons. The function can be preceded by `<blank>`s. These optional characters shall have no effect.

In default operation, **sed** cyclically shall append a line of input, less its terminating `<newline>`, into the pattern space. Normally the pattern space will be empty, unless a **D** command terminated the last cycle. The **sed** utility shall then apply in sequence all commands whose addresses select that pattern space, and at the end of the script copy the pattern space to standard output (except when the **−n** is specified) and delete the pattern space. Whenever the pattern space is written to standard output or a named file, **sed** shall immediately follow it with a `<newline>`.

Some of the editing commands use a hold space to save all or part of the pattern space for subsequent retrieval. The pattern and hold spaces shall each be able to hold at least 8 192 bytes.
Addresses in sed

An address is either a decimal number that counts input lines cumulatively across files, a ' $' character that addresses the last line of input, or a context address (which consists of a BRE, as described in Regular Expressions in sed, preceded and followed by a delimiter, usually a slash).

An editing command with no addresses shall select every pattern space.

An editing command with one address shall select each pattern space that matches the address.

An editing command with two addresses shall select the inclusive range from the first pattern space that matches the first address through the next pattern space that matches the second. (If the second address is a number less than or equal to the line number first selected, only one line shall be selected.) Starting at the first line following the selected range, sed shall look again for the first address. Thereafter, the process shall be repeated. Omitting either or both of the address components in the following form produces undefined results:

```
[address[, address]]
```

Regular Expressions in sed

The sed utility shall support the BREs described in the Base Definitions volume of IEEE Std 1003.1-2001, Section 9.3, Basic Regular Expressions, with the following additions:

- In a context address, the construction "\cBRE", where c is any character other than backslash or <newline>, shall be identical to "'/BRE/'". If the character designated by c appears following a backslash, then it shall be considered to be that literal character, which shall not terminate the BRE. For example, in the context address "\xabc\xdefx", the second x stands for itself, so that the BRE is "abc\xdef".

- The escape sequence ' \
' shall match a <newline> embedded in the pattern space. A literal <newline> shall not be used in the BRE of a context address or in the substitute function.

- If an RE is empty (that is, no pattern is specified) sed shall behave as if the last RE used in the last command applied (either as an address or as part of a substitute command) was specified.

Editing Commands in sed

In the following list of editing commands, the maximum number of permissible addresses for each function is indicated by [0addr], [1addr], or [2addr], representing zero, one, or two addresses.

The argument text shall consist of one or more lines. Each embedded <newline> in the text shall be preceded by a backslash. Other backslashes in text shall be removed, and the following character shall be treated literally.

The r and w command verbs, and the w flag to the s command, take an optional rfile (or wfile) parameter, separated from the command verb letter or flag by one or more <blank>s; implementations may allow zero separation as an extension.

The argument rfile or the argument wfile shall terminate the editing command. Each wfile shall be created before processing begins. Implementations shall support at least ten wfile arguments in the script; the actual number (greater than or equal to 10) that is supported by the implementation is unspecified. The use of the wfile parameter shall cause that file to be initially created, if it does not exist, or shall replace the contents of an existing file.

The b, r, s, t, w, y, and : command verbs shall accept additional arguments. The following synopses indicate which arguments shall be separated from the command verbs by a single
The `a` and `r` commands schedule text for later output. The text specified for the `a` command, and the contents of the file specified for the `r` command, shall be written to standard output just before the next attempt to fetch a line of input when executing the `N` or `n` commands, or when reaching the end of the script. If written when reaching the end of the script, and the `−n` option was not specified, the text shall be written after copying the pattern space to standard output. The contents of the file specified for the `r` command shall be as of the time the output is written, not the time the `r` command is applied. The text shall be output in the order in which the `a` and `r` commands were applied to the input.

Command verbs other than `{`, `a`, `b`, `c`, `i`, `t`, `w`, `;`, and `#` can be followed by a semicolon, optional `<blank>`s, and another command verb. However, when the `s` command verb is used with the `w` flag, following it with another command in this manner produces undefined results.

A function can be preceded by one or more `!` characters, in which case the function shall be applied if the addresses do not select the pattern space. Zero or more `<blank>`s shall be accepted before the first `!` character. It is unspecified whether `<blank>`s can follow a `!` character, and conforming applications shall not follow a `!` character with `<blank>`s.

```
[2addr] { function
  ... 
}  
[1addr]a\ 
  text  
[2addr]b [label]  
  Branch to the : function bearing the label. If label is not specified, branch to the end of the script. The implementation shall support labels recognized as unique up to at least 8 characters; the actual length (greater than or equal to 8) that shall be supported by the implementation is unspecified. It is unspecified whether exceeding a label length causes an error or a silent truncation.
[2addr]c\  
  text  
[2addr]d  
[2addr]D  
[2addr]g  
[2addr]G  
[2addr]h  
[2addr]H
```

Write text to standard output as described previously.

Delete the pattern space. With a 0 or 1 address or at the end of a 2-address range, place `text` on the output and start the next cycle.
Delete the pattern space and start the next cycle.
Delete the initial segment of the pattern space through the first `<newline>` and start the next cycle.
Replace the contents of the pattern space by the contents of the hold space.
Append to the pattern space a `<newline>` followed by the contents of the hold space.
Replace the contents of the hold space with the contents of the pattern space.
Append to the hold space a `<newline>` followed by the contents of the pattern space.
Write text to standard output.

(The letter ell.) Write the pattern space to standard output in a visually unambiguous form. The characters listed in the Base Definitions volume of IEEE Std 1003.1-2001, Table 5-1, Escape Sequences and Associated Actions (‘\a’, \b’, ‘\f’, ‘\r’, ‘\t’, \v’) shall be written as the corresponding escape sequence; the ‘\n’ in that table is not applicable. Non-printable characters not in that table shall be written as one three-digit octal number (with a preceding backslash) for each byte in the character (most significant byte first). If the size of a byte on the system is greater than 9 bits, the format used for non-printable characters is implementation-defined.

Long lines shall be folded, with the point of folding indicated by writing a backslash followed by a <newline>; the length at which folding occurs is unspecified, but should be appropriate for the output device. The end of each line shall be marked with a ‘$’.

Write the pattern space to standard output if the default output has not been suppressed, and replace the pattern space with the next line of input, less its terminating <newline>.

If no next line of input is available, the n command verb shall branch to the end of the script and quit without starting a new cycle.

Append the next line of input, less its terminating <newline>, to the pattern space, using an embedded <newline> to separate the appended material from the original material. Note that the current line number changes.

If no next line of input is available, the N command verb shall branch to the end of the script and quit without starting a new cycle or copying the pattern space to standard output.

Write the pattern space to standard output.

Write the pattern space, up to the first <newline>, to standard output.

Branch to the end of the script and quit without starting a new cycle.

Copy the contents of rfile to standard output as described previously. If rfile does not exist or cannot be read, it shall be treated as if it were an empty file, causing no error condition.

Substitute the replacement string for instances of the BRE in the pattern space. Any character other than backslash or <newline> can be used instead of a slash to delimit the BRE and the replacement. Within the BRE and the replacement, the BRE delimiter itself can be used as a literal character if it is preceded by a backslash.

The replacement string shall be scanned from beginning to end. An ampersand (‘&’) appearing in the replacement shall be replaced by the string matching the BRE. The special meaning of ‘&’ in this context can be suppressed by preceding it by a backslash. The characters ‘\n’, where n is a digit, shall be replaced by the text matched by the corresponding backreference expression. The special meaning of ‘\n’ where n is a digit in this context, can be suppressed by preceding it by a backslash. For each other backslash (‘\’) encountered, the following character shall lose its special meaning (if any). The meaning of a ‘\’ immediately followed
by any character other than ’&’, ’\’, a digit, or the delimiter character used for
this command, is unspecified.

A line can be split by substituting a <newline> into it. The application shall escape
the <newline> in the replacement by preceding it by a backslash. A substitution
shall be considered to have been performed even if the replacement string is
identical to the string that it replaces. Any backslash used to alter the default
meaning of a subsequent character shall be discarded from the BRE or the
replacement before evaluating the BRE or using the replacement.

The value of flags shall be zero or more of:

- **n**: Substitute for the n-th occurrence only of the BRE found within the
  pattern space.
- **g**: Globally substitute for all non-overlapping instances of the BRE
  rather than just the first one. If both g and n are specified, the results
  are unspecified.
- **p**: Write the pattern space to standard output if a replacement was
  made.
- **w wfile**: Write. Append the pattern space to wfile if a replacement was made.
  A conforming application shall precede the wfile argument with one
  or more <blank>s. If the w flag is not the last flag value given in a
  concatenation of multiple flag values, the results are undefined.

- [2addr]t [label]
  Test. Branch to the : command verb bearing the label if any substitutions have been
  made since the most recent reading of an input line or execution of a t. If label is
  not specified, branch to the end of the script.

- [2addr]w wfile
  Append (write) the pattern space to wfile.

- [2addr]x
  Exchange the contents of the pattern and hold spaces.

- [2addr]/string1/string2/
  Replace all occurrences of characters in string1 with the corresponding characters
  in string2. If a backslash followed by an ’n’ appear in string1 or string2, the two
  characters shall be handled as a single <newline>. If the number of characters in
  string1 and string2 are not equal, or if any of the characters in string1 appear more
  than once, the results are undefined. Any character other than backslash or
  <newline> can be used instead of slash to delimit the strings. If the delimiter is not
  n, within string1 and string2, the delimiter itself can be used as a literal character if
  it is preceded by a backslash. If a backslash character is immediately followed by a
  backslash character in string1 or string2, the two backslash characters shall be
  counted as a single literal backslash character. The meaning of a backslash
  followed by any character that is not ’n’, a backslash, or the delimiter character is
  undefined.

- [0addr]:label
  Do nothing. This command bears a label to which the b and t commands branch.

- [1addr]=
  Write the following to standard output:

  "%d\n", <current line number>

- [0addr]
  Ignore this empty command.
Ignore the ‘#’ and the remainder of the line (treat them as a comment), with the single exception that if the first two characters in the script are "#n", the default output shall be suppressed; this shall be the equivalent of specifying −n on the command line.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.
>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Regular expressions match entire strings, not just individual lines, but a <newline> is matched by ‘\n’ in a sed RE; a <newline> is not allowed by the general definition of regular expression in IEEE Std 1003.1-2001. Also note that ‘\n’ cannot be used to match a <newline> at the end of an arbitrary input line; <newline>s appear in the pattern space as a result of the N editing command.

EXAMPLES
This sed script simulates the BSD cat −s command, squeezing excess blank lines from standard input.

```
sed −n '  # Write non-empty lines.
/./ {  
  p
  d
}
# Write a single empty line, then look for more empty lines.
/^$/ p
# Get next line, discard the held <newline> (empty line),
# and look for more empty lines.
:Empty
/^$/ {  
  N
  s/.///
  b Empty
}
# Write the non-empty line before going back to search
# for the first in a set of empty lines.
  p
',
```

RATIONALE
This volume of IEEE Std 1003.1-2001 requires implementations to support at least ten distinct wfiles, matching historical practice on many implementations. Implementations are encouraged to support more, but conforming applications should not exceed this limit.

The exit status codes specified here are different from those in System V. System V returns 2 for garbled sed commands, but returns zero with its usage message or if the input file could not be opened. The standard developers considered this to be a bug.
The manner in which the I command writes non-printable characters was changed to avoid the
historical backspace-overstrike method, and other requirements to achieve unambiguous output
were added. See the RATIONALE for ed for details of the format chosen, which is the same as
that chosen for sed.

This volume of IEEE Std 1003.1-2001 requires implementations to provide pattern and hold
spaces of at least 8192 bytes, larger than the 4000 bytes spaces used by some historical
implementations, but less than the 20,480 bytes limit used in an early proposal. Implementations
are encouraged to allocate dynamically larger pattern and hold spaces as needed.

The requirements for acceptance of <blank>s and <space>s in command lines has been made
more explicit than in early proposals to describe clearly the historical practice and to remove
collision about the phrase “protect initial blanks [sic] and tabs from the stripping that is done
on every script line” that appears in much of the historical documentation of the sed utility
description of text. (Not all implementations are known to have stripped <blank>s from text
lines, although they all have allowed leading <blank>s preceding the address on a command
line.)

The treatment of ‘#’ comments differs from the SVID which only allows a comment as the first
line of the script, but matches BSD-derived implementations. The comment character is treated
as a command, and it has the same properties in terms of being accepted with leading <blank>s;
the BSD implementation has historically supported this.

Early proposals required that a script_file have at least one non-comment line. Some historical
implementations have behaved in unexpected ways if this were not the case. The standard
developers considered that this was incorrect behavior and that application developers should
not have to avoid this feature. A correct implementation of this volume of IEEE Std 1003.1-2001
shall permit script_files that consist only of comment lines.

Early proposals indicated that if −e and −f options were intermixed, all −e options were
processed before any −f options. This has been changed to process them in the order presented
because it matches historical practice and is more intuitive.

The treatment of the p flag to the s command differs between System V and BSD-based systems
when the default output is suppressed. In the two examples:

```
  echo a | sed 's/a/A/p'
  echo a | sed −n 's/a/A/p'
```

this volume of IEEE Std 1003.1-2001, BSD, System V documentation, and the SVID indicate that
the first example should write two lines with A, whereas the second should write one. Some
System V systems write the A only once in both examples because the p flag is ignored if the −n
option is not specified.

This is a case of a diametrical difference between systems that could not be reconciled through
the compromise of declaring the behavior to be unspecified. The SVID/BSD/System V
documentation behavior was adopted for this volume of IEEE Std 1003.1-2001 because:

- No known documentation for any historic system describes the interaction between the p
flag and the −n option.
- The selected behavior is more correct as there is no technical justification for any interaction
between the p flag and the −n option. A relationship between −n and the p flag might imply
that they are only used together, but this ignores valid scripts that interrupt the cyclical
nature of the processing through the use of the D, d, q, or branching commands. Such scripts
rely on the p suffix to write the pattern space because they do not make use of the default
output at the “bottom” of the script.
• Because the –n option makes the p flag unnecessary, any interaction would only be useful if
sed scripts were written to run both with and without the –n option. This is believed to be
unlikely. It is even more unlikely that programmers have coded the p flag expecting it to be
unnecessary. Because the interaction was not documented, the likelihood of a programmer
discovering the interaction and depending on it is further decreased.

• Finally, scripts that break under the specified behavior produce too much output instead of
too little, which is easier to diagnose and correct.

The form of the substitute command that uses the n suffix was limited to the first 512 matches in
an early proposal. This limit has been removed because there is no reason an editor processing
lines of [LINE_MAX] length should have this restriction. The command s/a/A/2047 should be
able to substitute the 2 047th occurrence of a on a line.

The b, t, and : commands are documented to ignore leading white space, but no mention is
made of trailing white space. Historical implementations of sed assigned different locations to
the labels ‘x’ and "x ". This is not useful, and leads to subtle programming errors, but it is
historical practice, and changing it could theoretically break working scripts. Implementors are
encouraged to provide warning messages about labels that are never used or jumps to labels
that do not exist.

Historically, the sed ! and } editing commands did not permit multiple commands on a single
line using a semicolon as a command delimiter. Implementations are permitted, but not
required, to support this extension.

FUTURE DIRECTIONS
None.

SEE ALSO
awk, ed, grep

CHANGE HISTORY
First released in Issue 2.

Issue 5
The FUTURE DIRECTIONS section is added.

Issue 6
The following new requirements on POSIX implementations derive from alignment with the
Single UNIX Specification:

• Implementations are required to support at least ten wfile arguments in an editing command.

The EXTENDED DESCRIPTION is changed to align with the IEEE P1003.2b draft standard.

IEEE PASC Interpretation 1003.2 #190 is applied.

IEEE PASC Interpretation 1003.2 #203 is applied, clarifying the meaning of the backslash escape
sequences in a replacement string for a BRE.
NAME

sh — shell, the standard command language interpreter

SYNOPSIS

```
sh [−abCefhimnuvx] [−o option] [+abCefhimnuvx] [+o option] [command_file [argument...]]
sh −c [−abCefhimnuvx] [−o option] [+abCefhimnuvx] [+o option] command_string
sh −s [−abCefhimnuvx] [−o option] [+abCefhimnuvx] [+o option] [argument]
```

DESCRIPTION

The sh utility is a command language interpreter that shall execute commands read from a
command line string, the standard input, or a specified file. The application shall ensure that the
commands to be executed are expressed in the language described in Chapter 2 (on page 29).
Pathname expansion shall not fail due to the size of a file.
Shell input and output redirections have an implementation-defined offset maximum that is
established in the open file description.

OPTIONS

The sh utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines, with an extension for support of a leading plus sign (‘+’) as noted
below.
The −a, −b, −C, −e, −f, −m, −n, −o option, −u, −v, and −x options are described as part of the set
utility in Section 2.14 (on page 64). The option letters derived from the set special built-in shall
also be accepted with a leading plus sign (‘+’) instead of a leading hyphen (meaning the reverse
case of the option as described in this volume of IEEE Std 1003.1-2001).
The following additional options shall be supported:

```
−c Read commands from the command_string operand. Set the value of special
parameter 0 (see Section 2.5.2 (on page 34)) from the value of the command_name
operand and the positional parameters ($1, $2, and so on) in sequence from the
remaining argument operands. No commands shall be read from the standard
input.
−i Specify that the shell is interactive; see below. An implementation may treat
specifying the −i option as an error if the real user ID of the calling process does
not equal the effective user ID or if the real group ID does not equal the effective
group ID.
−s Read commands from the standard input.
```

If there are no operands and the −c option is not specified, the −s option shall be assumed.
If the −i option is present, or if there are no operands and the shell’s standard input and standard
error are attached to a terminal, the shell is considered to be interactive.

OPERANDS

The following operands shall be supported:

```
−  A single hyphen shall be treated as the first operand and then ignored. If both ‘−’
and "−−" are given as arguments, or if other operands precede the single hyphen,
the results are undefined.
argument The positional parameters ($1, $2, and so on) shall be set to arguments, if any.
```
command_file

The pathname of a file containing commands. If the pathname contains one or more slash characters, the implementation attempts to read that file; the file need not be executable. If the pathname does not contain a slash character:

- The implementation shall attempt to read that file from the current working directory; the file need not be executable.
- If the file is not in the current working directory, the implementation may perform a search for an executable file using the value of PATH, as described in Section 2.9.1.1 (on page 48).

Special parameter 0 (see Section 2.5.2 (on page 34)) shall be set to the value of command_file. If sh is called using a synopsis form that omits command_file, special parameter 0 shall be set to the value of the first argument passed to sh from its parent (for example, argv[0] for a C program), which is normally a pathname used to execute the sh utility.

command_name

A string assigned to special parameter 0 when executing the commands in command_string. If command_name is not specified, special parameter 0 shall be set to the value of the first argument passed to sh from its parent (for example, argv[0] for a C program), which is normally a pathname used to execute the sh utility.

command_string

A string that shall be interpreted by the shell as one or more commands, as if the string were the argument to the system() function defined in the System Interfaces volume of IEEE Std 1003.1-2001. If the command_string operand is an empty string, sh shall exit with a zero exit status.

STDIN

The standard input shall be used only if one of the following is true:

- The –s option is specified.
- The –c option is not specified and no operands are specified.
- The script executes one or more commands that require input from standard input (such as a read command that does not redirect its input).

See the INPUT FILES section.

When the shell is using standard input and it invokes a command that also uses standard input, the shell shall ensure that the standard input file pointer points directly after the command it has read when the command begins execution. It shall not read ahead in such a manner that any characters intended to be read by the invoked command are consumed by the shell (whether interpreted by the shell or not) or that characters that are not read by the invoked command are not seen by the shell. When the command expecting to read standard input is started asynchronously by an interactive shell, it is unspecified whether characters are read by the command or interpreted by the shell.

If the standard input to sh is a FIFO or terminal device and is set to non-blocking reads, then sh shall enable blocking reads on standard input. This shall remain in effect when the command completes.

INPUT FILES

The input file shall be a text file, except that line lengths shall be unlimited. If the input file is empty or consists solely of blank lines or comments, or both, sh shall exit with a zero exit status.
ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of sh:

ENV

This variable, when and only when an interactive shell is invoked, shall be subjected to parameter expansion (see Section 2.6.2 (on page 37)) by the shell, and the resulting value shall be used as a pathname of a file containing shell commands to execute in the current environment. The file need not be executable. If the expanded value of ENV is not an absolute pathname, the results are unspecified. ENV shall be ignored if the real and effective user IDs or real and effective group IDs of the process are different.

FCEDIT

This variable, when expanded by the shell, shall determine the default value for the \texttt{-e editor option}'s editor option-argument. If FCEDIT is null or unset, \texttt{ed} shall be used as the editor. This volume of IEEE Std 1003.1-2001 specifies the effects of this variable only for systems supporting the User Portability Utilities option.

HISTFILE

Determine a pathname naming a command history file. If the HISTFILE variable is not set, the shell may attempt to access or create a file \texttt{.sh_history} in the directory referred to by the HOME environment variable. If the shell cannot obtain both read and write access to, or create, the history file, it shall use an unspecified mechanism that allows the history to operate properly. (References to history “file” in this section shall be understood to mean this unspecified mechanism in such cases.) An implementation may choose to access this variable only when initializing the history file; this initialization shall occur when \texttt{fc} or \texttt{sh} first attempt to retrieve entries from, or add entries to, the file, as the result of commands issued by the user, the file named by the ENV variable, or implementation-defined system start-up files. Implementations may choose to disable the history list mechanism for users with appropriate privileges who do not set HISTFILE; the specific circumstances under which this occurs are implementation-defined. If more than one instance of the shell is using the same history file, it is unspecified how updates to the history file from those shells interact. As entries are deleted from the history file, they shall be deleted oldest first. It is unspecified when history file entries are physically removed from the history file. This volume of IEEE Std 1003.1-2001 specifies the effects of this variable only for systems supporting the User Portability Utilities option.

HISTSIZE

Determine a decimal number representing the limit to the number of previous commands that are accessible. If this variable is unset, an unspecified default greater than or equal to 128 shall be used. The maximum number of commands in the history list is unspecified, but shall be at least 128. An implementation may choose to access this variable only when initializing the history file, as described under HISTFILE. Therefore, it is unspecified whether changes made to HISTSIZE after the history file has been initialized are effective.

HOME

Determine the pathname of the user's home directory. The contents of HOME are used in tilde expansion as described in Section 2.6.1 (on page 37). This volume of IEEE Std 1003.1-2001 specifies the effects of this variable only for systems supporting the User Portability Utilities option.

IFS

(Input Field Separators.) A string treated as a list of characters that shall be used for field splitting and to split lines into words with the \texttt{read} command. See Section 2.6.5 (on page 42). If IFS is not set, the shell shall behave as if the value of IFS were \texttt{<space>, <tab>, and <newline>}. Implementations may ignore the value of IFS in the environment at the time \texttt{sh} is invoked, treating IFS as if it were not set.
Utilities

LANG  Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other internationalization variables.

LC_COLLATE  Determine the behavior of range expressions, equivalence classes, and multi-character collating elements within pattern matching.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), which characters are defined as letters (character class alpha), and the behavior of character classes within pattern matching.

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

MAIL  Determine a pathname of the user’s mailbox file for purposes of incoming mail notification. If this variable is set, the shell shall inform the user if the file named by the variable is created or if its modification time has changed. Informing the user shall be accomplished by writing a string of unspecified format to standard error prior to the writing of the next primary prompt string. Such check shall be performed only after the completion of the interval defined by the MAILCHECK variable after the last such check. The user shall be informed only if MAIL is set and MAILPATH is not set. This volume of IEEE Std 1003.1-2001 specifies the effects of this variable only for systems supporting the User Portability Utilities option.

MAILCHECK  Establish a decimal integer value that specifies how often (in seconds) the shell shall check for the arrival of mail in the files specified by the MAILPATH or MAIL variables. The default value shall be 600 seconds. If set to zero, the shell shall check before issuing each primary prompt. This volume of IEEE Std 1003.1-2001 specifies the effects of this variable only for systems supporting the User Portability Utilities option.

MAILPATH  Provide a list of pathnames and optional messages separated by colons. If this variable is set, the shell shall inform the user if any of the files named by the variable are created or if any of their modification times change. (See the preceding entry for MAIL for descriptions of mail arrival and user informing.) Each pathname can be followed by ‘%’ and a string that shall be subjected to parameter expansion and written to standard error when the modification time changes. If a ‘%’ character in the pathname is preceded by a backslash, it shall be treated as a literal ‘%’ in the pathname. The default message is unspecified.

The MAILPATH environment variable takes precedence over the MAIL variable. This volume of IEEE Std 1003.1-2001 specifies the effects of this variable only for systems supporting the User Portability Utilities option.

NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

PATH  Establish a string formatted as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables, used to effect command interpretation; see Section 2.9.1.1 (on page 48).
This variable shall represent an absolute pathname of the current working directory. Assignments to this variable may be ignored unless the value is an absolute pathname of the current working directory and there are no filename components of dot or dot-dot.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

See the STDERR section.

**STDERR**

Except as otherwise stated (by the descriptions of any invoked utilities or in interactive mode), standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

See Chapter 2. The following additional capabilities are supported on systems supporting the User Portability Utilities option.

**Command History List**

When the `sh` utility is being used interactively, it shall maintain a list of commands previously entered from the terminal in the file named by the `HISTFILE` environment variable. The type, size, and internal format of this file are unspecified. Multiple `sh` processes can share access to the file for a user, if file access permissions allow this; see the description of the `HISTFILE` environment variable.

**Command Line Editing**

When `sh` is being used interactively from a terminal, the current command and the command history (see `fc`) can be edited using `vi`-mode command line editing. This mode uses commands, described below, similar to a subset of those described in the `vi` utility. Implementations may offer other command line editing modes corresponding to other editing utilities.

The command `set -o vi` shall enable `vi`-mode editing and place `sh` into `vi` insert mode (see Command Line Editing (vi-mode) (on page 855)). This command also shall disable any other editing mode that the implementation may provide. The command `set +o vi` disables `vi`-mode editing.

Certain block-mode terminals may be unable to support shell command line editing. If a terminal is unable to provide either edit mode, it need not be possible to `set -o vi` when using the `sh` on this terminal.

In the following sections, the characters `erase`, `interrupt`, `kill`, and `end-of-file` are those set by the `stty` utility.
33127 Command Line Editing (vi-mode)

33128 In vi editing mode, there shall be a distinguished line, the edit line. All the editing operations
33129 which modify a line affect the edit line. The edit line is always the newest line in the command
33130 history buffer.

33131 With vi-mode enabled, sh can be switched between insert mode and command mode.

33132 When in insert mode, an entered character shall be inserted into the command line, except as
33133 noted in vi Line Editing Insert Mode. Upon entering sh and after termination of the previous
33134 command, sh shall be in insert mode.

33135 Typing an escape character shall switch sh into command mode (see vi Line Editing Command
33136 Mode (on page 856)). In command mode, an entered character shall either invoke a defined
33137 operation, be used as part of a multi-character operation, or be treated as an error. A character
33138 that is not recognized as part of an editing command shall terminate any specific editing
33139 command and shall alert the terminal. Typing the interrupt character in command mode shall
33140 cause sh to terminate command line editing on the current command line, reissue the prompt on
33141 the next line of the terminal, and reset the command history (see fc) so that the most recently
33142 executed command is the previous command (that is, the command that was being edited when
33143 it was interrupted is not reentered into the history).

33144 In the following sections, the phrase “move the cursor to the beginning of the word” shall mean
33145 “move the cursor to the first character of the current word” and the phrase “move the cursor to
33146 the end of the word” shall mean “move the cursor to the last character of the current word”. The
33147 phrase “beginning of the command line” indicates the point between the end of the prompt
33148 string issued by the shell (or the beginning of the terminal line, if there is no prompt string) and
33149 the first character of the command text.

33150 vi Line Editing Insert Mode

33151 While in insert mode, any character typed shall be inserted in the current command line, unless
33152 it is from the following set.

33153 <newline> Execute the current command line. If the current command line is not empty, this
33154 line shall be entered into the command history (see fc).

33155 erase Delete the character previous to the current cursor position and move the current
33156 cursor position back one character. In insert mode, characters shall be erased from
33157 both the screen and the buffer when backspacing.

33158 interrupt Terminate command line editing with the same effects as described for
33159 interrupting command mode; see Command Line Editing (vi-mode).

33160 kill Clear all the characters from the input line.

33161 <control>-V Insert the next character input, even if the character is otherwise a special insert
33162 mode character.

33163 <control>-W Delete the characters from the one preceding the cursor to the preceding word
33164 boundary. The word boundary in this case is the closer to the cursor of either the
33165 beginning of the line or a character that is in neither the blank nor punct character
33166 classification of the current locale.

33167 end-of-file Interpreted as the end of input in sh. This interpretation shall occur only at the
33168 beginning of an input line. If end-of-file is entered other than at the beginning of the
33169 line, the results are unspecified.
<ESC>  Place sh into command mode.

**vi Line Editing Command Mode**

In command mode for the command line editing feature, decimal digits not beginning with 0 that precede a command letter shall be remembered. Some commands use these decimal digits as a count number that affects the operation.

The term *motion command* represents one of the commands:

- `<space>` 0 b F l W ^ $ ; E f T w | , B e h t

If the current line is not the edit line, any command that modifies the current line shall cause the content of the current line to replace the content of the edit line, and the current line shall become the edit line. This replacement cannot be undone (see the u and U commands below). The modification requested shall then be performed to the edit line. When the current line is the edit line, the modification shall be done directly to the edit line.

Any command that is preceded by *count* shall take a count (the numeric value of any preceding decimal digits). Unless otherwise noted, this count shall cause the specified operation to repeat by the number of times specified by the count. Also unless otherwise noted, a *count* that is out of range is considered an error condition and shall alert the terminal, but neither the cursor position, nor the command line, shall change.

The terms *word* and *bigword* are used as defined in the *vi* description. The term *save buffer* corresponds to the term *unnamed buffer* in *vi*.

The following commands shall be recognized in command mode:

- `<newline>` Execute the current command line. If the current command line is not empty, this line shall be entered into the command history (see *fc*).
- `<control>-L` Redraw the current command line. Position the cursor at the same location on the redrawn line.
- `#` Insert the character ‘#’ at the beginning of the current command line and treat the resulting edit line as a comment. This line shall be entered into the command history; see *fc*.
- `=` Display the possible shell word expansions (see Section 2.6 (on page 36)) of the bigword at the current command line position.
  
  **Note:** This does not modify the content of the current line, and therefore does not cause the current line to become the edit line.

These expansions shall be displayed on subsequent terminal lines. If the bigword contains none of the characters ‘?’ , ‘*‘, or ‘[‘, an asterisk (‘*‘) shall be implicitly assumed at the end. If any directories are matched, these expansions shall have a ‘/‘ character appended. After the expansion, the line shall be redrawn, the cursor repositioned at the current cursor position, and sh shall be placed in command mode.

- `\` Perform pathname expansion (see Section 2.6.6 (on page 42)) on the current bigword, up to the largest set of characters that can be matched uniquely. If the bigword contains none of the characters ‘?’ , ‘*‘, or ‘[‘, an asterisk (‘*‘) shall be implicitly assumed at the end. This maximal expansion then shall replace the original bigword in the command line, and the cursor shall be placed after this expansion. If the resulting bigword completely and uniquely matches a directory, a ‘/‘ character shall be inserted directly after the bigword. If some other file is completely matched, a single <space> shall be inserted after the bigword. After
this operation, sh shall be placed in insert mode.

* Perform pathname expansion on the current bigword and insert all expansions into the command to replace the current bigword, with each expansion separated by a single <space>. If at the end of the line, the current cursor position shall be moved to the first column position following the expansions and sh shall be placed in insert mode. Otherwise, the current cursor position shall be the last column position of the first character after the expansions and sh shall be placed in insert mode. If the current bigword contains none of the characters ‘?’, ‘*’, or ‘[’, before the operation, an asterisk shall be implicitly assumed at the end.

@letter Insert the value of the alias named _letter. The symbol letter represents a single alphabetic character from the portable character set; implementations may support additional characters as an extension. If the alias _letter contains other editing commands, these commands shall be performed as part of the insertion. If no alias _letter is enabled, this command shall have no effect.

[count]* Convert, if the current character is a lowercase letter, to the equivalent uppercase letter and vice versa, as prescribed by the current locale. The current cursor position then shall be advanced by one character. If the cursor was positioned on the last character of the line, the case conversion shall occur, but the cursor shall not advance. If the ‘˜’ command is preceded by a count, that number of characters shall be converted, and the cursor shall be advanced to the character position after the last character converted. If the count is larger than the number of characters after the cursor, this shall not be considered an error; the cursor shall advance to the last character on the line.

[count]. Repeat the most recent non-motion command, even if it was executed on an earlier command line. If the previous command was preceded by a count, and no count is given on the ‘.’ command, the count from the previous command shall be included as part of the repeated command. If the ‘.’ command is preceded by a count, this shall override any count argument to the previous command. The count specified in the ‘.’ command shall become the count for subsequent ‘.’ commands issued without a count.

[number]v Invoke the vi editor to edit the current command line in a temporary file. When the editor exits, the commands in the temporary file shall be executed and placed in the command history. If a number is included, it specifies the command number in the command history to be edited, rather than the current command line.

[count]l (ell)
[count]<space> Move the current cursor position to the next character position. If the cursor was positioned on the last character of the line, the terminal shall be alerted and the cursor shall not be advanced. If the count is larger than the number of characters after the cursor, this shall not be considered an error; the cursor shall advance to the last character on the line.

[count]h Move the current cursor position to the countth (default 1) previous character position. If the cursor was positioned on the first character of the line, the terminal shall be alerted and the cursor shall not be moved. If the count is larger than the number of characters before the cursor, this shall not be considered an error; the cursor shall move to the first character on the line.

[count]w Move to the start of the next word. If the cursor was positioned on the last character of the line, the terminal shall be alerted and the cursor shall not be
Utilities

advanced. If the count is larger than the number of words after the cursor, this shall
not be considered an error; the cursor shall advance to the last character on the
line.

[count]W Move to the start of the next bigword. If the cursor was positioned on the last
count character of the line, the terminal shall be alerted and the cursor shall not be
advanced. If the count is larger than the number of bigwords after the cursor, this
shall not be considered an error; the cursor shall advance to the last character on
the line.

[count]e Move to the end of the current word. If at the end of a word, move to the end of
the next word. If the cursor was positioned on the last character of the line, the
terminal shall be alerted and the cursor shall not be advanced. If the count is larger
than the number of words after the cursor, this shall not be considered an error; the
cursor shall advance to the last character on the line.

[count]E Move to the end of the current bigword. If at the end of a bigword, move to the
end of the next bigword. If the cursor was positioned on the last character of the,line, the terminal shall be alerted and the cursor shall not be advanced. If the count
is larger than the number of bigwords after the cursor, this shall not be considered
an error; the cursor shall advance to the last character on the line.

[count]b Move to the beginning of the current word. If at the beginning of a word, move to
the beginning of the previous word. If the cursor was positioned on the first
character of the line, the terminal shall be alerted and the cursor shall not be
moved. If the count is larger than the number of words preceding the cursor, this
shall not be considered an error; the cursor shall return to the first character on the
line.

[count]B Move to the beginning of the current bigword. If at the beginning of a bigword,
moves to the beginning of the previous bigword. If the cursor was positioned on the
first character of the line, the terminal shall be alerted and the cursor shall not be
moved. If the count is larger than the number of bigwords preceding the cursor,
this shall not be considered an error; the cursor shall return to the first character on
the line.

^ Move the current cursor position to the first character on the input line that is not a
<blank>.

$ Move to the last character position on the current command line.

0 (Zero.) Move to the first character position on the current command line.

[count] Move to the countth character position on the current command line. If no number
is specified, move to the first position. The first character position shall be
numbered 1. If the count is larger than the number of characters on the line, this
shall not be considered an error; the cursor shall be placed on the last character on
the line.

[count]fc Move to the first occurrence of the character ’c’ that occurs after the current
cursor position. If the cursor was positioned on the last character of the line, the
terminal shall be alerted and the cursor shall not be advanced. If the character ’c’
does not occur in the line after the current cursor position, the terminal shall be
alerted and the cursor shall not be moved.

[count]Fc Move to the first occurrence of the character ’c’ that occurs before the current
cursor position. If the cursor was positioned on the first character of the line, the
terminal shall be alerted and the cursor shall not be moved. If the character ’c’
does not occur in the line before the current cursor position, the terminal shall be
alerted and the cursor shall not be moved.

[count]tc  Move to the character before the first occurrence of the character ‘c’ that occurs
after the current cursor position. If the cursor was positioned on the last character
of the line, the terminal shall be alerted and the cursor shall not be advanced. If the
character ‘c’ does not occur in the line after the current cursor position, the
terminal shall be alerted and the cursor shall not be moved.

[count]Tc  Move to the character after the first occurrence of the character ‘c’ that occurs
before the current cursor position. If the cursor was positioned on the first
character of the line, the terminal shall be alerted and the cursor shall not be
moved. If the character ‘c’ does not occur in the line before the current cursor
position, the terminal shall be alerted and the cursor shall not be moved.

[count];  Repeat the most recent f, F, t, or T command. Any number argument on that
previous command shall be ignored. Errors are those described for the repeated
command.

[count],  Repeat the most recent f, F, t, or T command. Any number argument on that
previous command shall be ignored. However, reverse the direction of that
command.

a  Enter insert mode after the current cursor position. Characters that are entered
shall be inserted before the next character.

A  Enter insert mode after the end of the current command line.

i  Enter insert mode at the current cursor position. Characters that are entered shall
be inserted before the current character.

I  Enter insert mode at the beginning of the current command line.

R  Enter insert mode, replacing characters from the command line beginning at the
current cursor position.

[count]emotion  Delete the characters between the current cursor position and the cursor position
that would result from the specified motion command. Then enter insert mode
before the first character following any deleted characters. If count is specified, it
shall be applied to the motion command. A count shall be ignored for the following
motion commands:

0  ^  $  c

If the motion command is the character ‘c’, the current command line shall be
cleared and insert mode shall be entered. If the motion command would move the
current cursor position toward the beginning of the command line, the character
under the current cursor position shall not be deleted. If the motion command
would move the current cursor position toward the end of the command line, the
character under the current cursor position shall be deleted. If the count is larger
than the number of characters between the current cursor position and the end of
the command line toward which the motion command would move the cursor,
this shall not be considered an error; all of the remaining characters in the
aforementioned range shall be deleted and insert mode shall be entered. If the
motion command is invalid, the terminal shall be alerted, the cursor shall not be
moved, and no text shall be deleted.
Delete from the current character to the end of the line and enter insert mode at the new end-of-line.

Clear the entire edit line and enter insert mode.

Replace the current character with the character ‘c’. With a number count, replace the current and the following count–1 characters. After this command, the current cursor position shall be on the last character that was changed. If the count is larger than the number of characters after the cursor, this shall not be considered an error; all of the remaining characters shall be changed.

Append a <space> after the current character position and then append the last bigword in the previous input line after the <space>. Then enter insert mode after the last character just appended. With a number count, append the countth bigword in the previous line.

Delete the character at the current cursor position and place the deleted characters in the save buffer. If the cursor was positioned on the last character of the line, the character shall be deleted and the cursor position shall be moved to the previous character (the new last character). If the count is larger than the number of characters after the cursor, this shall not be considered an error; all the characters from the cursor to the end of the line shall be deleted.

Delete the character before the current cursor position and place the deleted characters in the save buffer. The character under the current cursor position shall not change. If the cursor was positioned on the first character of the line, the terminal shall be alerted, and the X command shall have no effect. If the line contained a single character, the X command shall have no effect. If the line contained no characters, the terminal shall be alerted and the cursor shall not be moved. If the count is larger than the number of characters before the cursor, this shall not be considered an error; all the characters from before the cursor to the beginning of the line shall be deleted.

Delete the characters between the current cursor position and the character position that would result from the motion command. A number count repeats the motion command count times. If the motion command would move toward the beginning of the command line, the character under the current cursor position shall not be deleted. If the motion command is d, the entire current command line shall be cleared. If the count is larger than the number of characters between the current cursor position and the end of the command line toward which the motion command would move the cursor, this shall not be considered an error; all of the remaining characters in the aforementioned range shall be deleted. The deleted characters shall be placed in the save buffer.

Delete all characters from the current cursor position to the end of the line. The deleted characters shall be placed in the save buffer.

Yank (that is, copy) the characters from the current cursor position to the position resulting from the motion command into the save buffer. A number count shall be applied to the motion command. If the motion command would move toward the beginning of the command line, the character under the current cursor position shall not be included in the set of yanked characters. If the motion command is y, the entire current command line shall be yanked into the save buffer. The current cursor position shall be unchanged. If the count is larger than the number of
Yank the characters from the current cursor position to the end of the line into the save buffer. The current character position shall be unchanged.

33413  \[\text{count}\]P  Put a copy of the current contents of the save buffer before the current cursor position. The current cursor position shall be moved to the last character put from the save buffer. A count shall indicate how many copies of the save buffer shall be put.

33417  u  Undo the last command that changed the edit line. This operation shall not undo the copy of any command line to the edit line.

33419  U  Undo all changes made to the edit line. This operation shall not undo the copy of any command line to the edit line.

33422  \[\text{count}\]k  Set the current command line to be the count th previous command line in the shell command history. If count is not specified, it shall default to 1. The cursor shall be positioned on the first character of the new command. If a k or − command would retreat past the maximum number of commands in effect for this shell (affected by the HISTSIZE environment variable), the terminal shall be alerted, and the command shall have no effect.

33425  \[\text{count}\]+  Set the current command line to be the count th next command line in the shell command history. If count is not specified, it shall default to 1. The cursor shall be positioned on the first character of the new command. If a j or + command advances past the edit line, the current command line shall be restored to the edit line and the terminal shall be alerted.

33434  \[\text{number}\]G  Set the current command line to be the oldest command line stored in the shell command history. With a number number, set the current command line to be the command line number in the history. If command line number does not exist, the terminal shall be alerted and the command line shall not be changed.

Move backwards through the command history, searching for the specified pattern, beginning with the previous command line. Patterns use the pattern matching notation described in Section 2.13 (on page 62), except that the ‘ˆ’ character shall have special meaning when it appears as the first character of pattern. In this case, the ‘ˆ’ is discarded and the characters after the ‘ˆ’ shall be matched only at the beginning of a line. Commands in the command history shall be treated as strings, not as filenames. If the pattern is not found, the current command line shall be unchanged and the terminal is alerted. If it is found in a previous line, the current command line shall be set to that line and the cursor shall be set to the first character of the new command line.
If *pattern* is empty, the last non-empty pattern provided to / or ? shall be used. If there is no previous non-empty pattern, the terminal shall be alerted and the current command line shall remain unchanged.

```
pattern
```

Move forwards through the command history, searching for the specified pattern, beginning with the next command line. Patterns use the pattern matching notation described in Section 2.13 (on page 62), except that the ‘ˆ’ character shall have special meaning when it appears as the first character of *pattern*. In this case, the ‘ˆ’ is discarded and the characters after the ‘ˆ’ shall be matched only at the beginning of a line. Commands in the command history shall be treated as strings, not as filenames. If the pattern is not found, the current command line shall be unchanged and the terminal alerted. If it is found in a following line, the current command line shall be set to that line and the cursor shall be set to the first character of the new command line.

If *pattern* is empty, the last non-empty pattern provided to / or ? shall be used. If there is no previous non-empty pattern, the terminal shall be alerted and the current command line shall remain unchanged.

**n**

Repeat the most recent / or ? command. If there is no previous / or ?, the terminal shall be alerted and the current command line shall remain unchanged.

**N**

Repeat the most recent / or ? command, reversing the direction of the search. If there is no previous / or ?, the terminal shall be alerted and the current command line shall remain unchanged.

### EXIT STATUS

The following exit values shall be returned:

- **0** The script to be executed consisted solely of zero or more blank lines or comments, or both.
- **1-125** A non-interactive shell detected a syntax, redirection, or variable assignment error.
- **127** A specified *command_file* could not be found by a non-interactive shell.

Otherwise, the shell shall return the exit status of the last command it invoked or attempted to invoke (see also the *exit* utility in Section 2.14 (on page 64)).

### CONSEQUENCES OF ERRORS

See Section 2.8.1 (on page 46).

### APPLICATION USAGE

Standard input and standard error are the files that determine whether a shell is interactive when –i is not specified. For example:

```
sh > file
```

and:

```
sh 2> file
```

create interactive and non-interactive shells, respectively. Although both accept terminal input, the results of error conditions are different, as described in Section 2.8.1 (on page 46); in the second example a redirection error encountered by a special built-in utility aborts the shell.

A conforming application must protect its first operand, if it starts with a plus sign, by preceding it with the "--" argument that denotes the end of the options.
Applications should note that the standard PATH to the shell cannot be assumed to be either /bin/sh or /usr/bin/sh, and should be determined by interrogation of the PATH returned by getconf PATH, ensuring that the returned pathname is an absolute pathname and not a shell built-in.

For example, to determine the location of the standard sh utility:

```bash
command -v sh
```

On some implementations this might return:

```
/usr/xpg4/bin/sh
```

Furthermore, on systems that support executable scripts (the "#!" construct), it is recommended that applications using executable scripts install them using `getconf −v` to determine the shell pathname and update the "#!" script appropriately as it is being installed (for example, with `sed`). For example:

```bash
# # Installation time script to install correct POSIX shell pathname # # Get list of paths to check # Sifs=$IFS # IFS=: # $(getconf PATH)
IFS=$Sifs
# # Check each path for 'sh'
for i in $@
do
   if [ -f ${i}/sh ];
      then
         Pshell=${i}/sh
      fi
   done

# # This is the list of scripts to update. They should be of the # form '{name}.source' and will be transformed to '{name}'. # Each script should begin:
# # # !INSTALLSHELLPATH -p
scripts="a b c"
# # Transform each script
for i in ${scripts}
do
   sed -e "s|INSTALLSHELLPATH|${Pshell}|" < ${i}.source > ${i}
done
```
**EXAMPLES**

1. Execute a shell command from a string:
   
   ```
   sh -c "cat myfile"
   ```

2. Execute a shell script from a file in the current directory:
   
   ```
   sh my_shell_cmds
   ```

**RATIONALE**

The `sh` utility and the `set` special built-in utility share a common set of options.

The KornShell ignores the contents of `IFS` upon entry to the script. A conforming application cannot rely on importing `IFS`. One justification for this, beyond security considerations, is to assist possible future shell compilers. Allowing `IFS` to be imported from the environment prevents many optimizations that might otherwise be performed via dataflow analysis of the script itself.

The text in the STDIN section about non-blocking reads concerns an instance of `sh` that has been invoked, probably by a C-language program, with standard input that has been opened using the `O_NONBLOCK` flag; see `open()` in the System Interfaces volume of IEEE Std 1003.1-2001. If the shell did not reset this flag, it would immediately terminate because no input data would be available yet and that would be considered the same as end-of-file.

The options associated with a restricted shell (command name `rsh` and the `-r` option) were excluded because the standard developers considered that the implied level of security could not be achieved and they did not want to raise false expectations.

On systems that support set-user-ID scripts, a historical trapdoor has been to link a script to the name `-i`. When it is called by a sequence such as:

```
sh -
```

or by:

```
#! usr/bin/sh -
```

the historical systems have assumed that no option letters follow. Thus, this volume of IEEE Std 1003.1-2001 allows the single hyphen to mark the end of the options, in addition to the use of the regular `--` argument, because it was considered that the older practice was so pervasive. An alternative approach is taken by the KornShell, where real and effective user/group IDs must match for an interactive shell; this behavior is specifically allowed by this volume of IEEE Std 1003.1-2001.

**Note:** There are other problems with set-user-ID scripts that the two approaches described here do not resolve.

The initialization process for the history file can be dependent on the system start-up files, in that they may contain commands that effectively preempt the user’s settings of `HISTFILE` and `HISTSIZE`. For example, function definition commands are recorded in the history file, unless the `set -o nolog` option is set. If the system administrator includes function definitions in some system start-up file called before the `ENV` file, the history file is initialized before the user gets a chance to influence its characteristics. In some historical shells, the history file is initialized just after the `ENV` file has been processed. Therefore, it is implementation-defined whether changes made to `HISTFILE` after the history file has been initialized are effective.

The default messages for the various `MAIL`-related messages are unspecified because they vary across implementations. Typical messages are:
"you have mail\n"

or:

"you have new mail\n"

It is important that the descriptions of command line editing refer to the same shell as that in IEEE Std 1003.1-2001 so that interactive users can also be application programmers without having to deal with programmatic differences in their two environments. It is also essential that the utility name sh be specified because this explicit utility name is too firmly rooted in historical practice of application programs for it to change.

Consideration was given to mandating a diagnostic message when attempting to set vi-mode on terminals that do not support command line editing. However, it is not historical practice for the shell to be cognizant of all terminal types and thus be able to detect inappropriate terminals in all cases. Implementations are encouraged to supply diagnostics in this case whenever possible, rather than leaving the user in a state where editing commands work incorrectly.

In early proposals, the KornShell-derived emacs mode of command line editing was included, even though the emacs editor itself was not. The community of emacs proponents was adamant that the full emacs editor not be standardized because they were concerned that an attempt to standardize this very powerful environment would encourage vendors to ship strictly conforming versions lacking the extensibility required by the community. The author of the original emacs program also expressed his desire to omit the program. Furthermore, there were a number of historical systems that did not include emacs, or included it without supporting it, but there were very few that did not include and support vi. The shell emacs command line editing mode was finally omitted because it became apparent that the KornShell version and the editor being distributed with the GNU system had diverged in some respects. The author of emacs requested that the POSIX emacs mode either be deleted or have a significant number of unspecified conditions. Although the KornShell author agreed to consider changes to bring the shell into alignment, the standard developers decided to defer specification at that time. At the time, it was assumed that convergence on an acceptable definition would occur for a subsequent draft, but that has not happened, and there appears to be no impetus to do so. In any case, implementations are free to offer additional command line editing modes based on the exact models of editors their users are most comfortable with.

Early proposals had the following list entry in vi Line Editing Insert Mode (on page 855):

\ If followed by the erase or kill character, that character shall be inserted into the input line.

Otherwise, the backslash itself shall be inserted into the input line.

However, this is not actually a feature of sh command line editing insert mode, but one of some historical terminal line drivers. Some conforming implementations continue to do this when the stty iexten flag is set.

FUTURE DIRECTIONS

None.

SEE ALSO

Chapter 2 (on page 29), cd, echo, exit, fc, pwd, read, set, stty, test, umask, vi, the System Interfaces volume of IEEE Std 1003.1-2001, dup(), exec, exit(), fork(), open(), pipe(), signal(), system(), ulimit(), umask(), wait()
Issue 5

The FUTURE DIRECTIONS section is added.

Text is added to the DESCRIPTION for the Large File Summit proposal.

Issue 6

The Open Group Corrigendum U029/2 is applied, correcting the second SYNOPSIS.

The Open Group Corrigendum U027/3 is applied, correcting a typographical error.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The option letters derived from the set special built-in are also accepted with a leading plus sign (`+`).

- Large file extensions are added:
  - Pathname expansion does not fail due to the size of a file.
  - Shell input and output redirections have an implementation-defined offset maximum that is established in the open file description.

In the ENVIRONMENT VARIABLES section, the text “user’s home directory” is updated to “directory referred to by the HOME environment variable”.

Descriptions for the ENV and PWD environment variables are included to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
  sleep — suspend execution for an interval

SYNOPSIS
  sleep time

DESCRIPTION
  The sleep utility shall suspend execution for at least the integral number of seconds specified by
  the time operand.

OPTIONS
  None.

OPERANDS
  The following operand shall be supported:

  time  A non-negative decimal integer specifying the number of seconds for which to
        suspend execution.

STDIN
  Not used.

INPUT FILES
  None.

ENVIRONMENT VARIABLES
  The following environment variables shall affect the execution of sleep:

  LANG    Provide a default value for the internationalization variables that are unset or null.
           (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
           Internationalization Variables for the precedence of internationalization variables
           used to determine the values of locale categories.)

  LC_ALL  If set to a non-empty string value, override the values of all the other
           internationalization variables.

  LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
           characters (for example, single-byte as opposed to multi-byte characters in
           arguments).

  LC_MESSAGES  Determine the locale that should be used to affect the format and contents of
               diagnostic messages written to standard error.

  XSI NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
  If the sleep utility receives a SIGALRM signal, one of the following actions shall be taken:

  1.  Terminate normally with a zero exit status.

  2.  Effectively ignore the signal.

  3.  Provide the default behavior for signals described in the ASYNCHRONOUS EVENTS
      section of Section 1.11 (on page 20). This could include terminating with a non-zero exit
      status.

  The sleep utility shall take the standard action for all other signals.
sleep

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 The execution was successfully suspended for at least time seconds, or a SIGALRM signal was received. See the ASYNCHRONOUS EVENTS section.

>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
The sleep utility can be used to execute a command after a certain amount of time, as in:

(sleep 105; command) &

or to execute a command every so often, as in:

while true
do
    command
    sleep 37
done

RATIONALE
The exit status is allowed to be zero when sleep is interrupted by the SIGALRM signal because most implementations of this utility rely on the arrival of that signal to notify them that the requested finishing time has been successfully attained. Such implementations thus do not distinguish this situation from the successful completion case. Other implementations are allowed to catch the signal and go back to sleep until the requested time expires or to provide the normal signal termination procedures.

As with all other utilities that take integral operands and do not specify subranges of allowed values, sleep is required by this volume of IEEE Std 1003.1-2001 to deal with time requests of up to 2 147 483 647 seconds. This may mean that some implementations have to make multiple calls to the delay mechanism of the underlying operating system if its argument range is less than this.

FUTURE DIRECTIONS
None.

SEE ALSO
wait, the System Interfaces volume of IEEE Std 1003.1-2001, alarm(), sleep()
CHANGE HISTORY

First released in Issue 2.
NAME
sort — sort, merge, or sequence check text files

SYNOPSIS
sort [-m] [-o output] [-bdfinru] [-t char] [-k keydef]... [file...]
sort -c [-bdfinru] [-t char] [-k keydef] [file]

DESCRIPTION
The sort utility shall perform one of the following functions:
1. Sort lines of all the named files together and write the result to the specified output.
2. Merge lines of all the named (presorted) files together and write the result to the specified
   output.
3. Check that a single input file is correctly presorted.

Comparisons shall be based on one or more sort keys extracted from each line of input (or, if no
sort keys are specified, the entire line up to, but not including, the terminating <newline>), and
shall be performed using the collating sequence of the current locale.

OPTIONS
The sort utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
12.2, Utility Syntax Guidelines, and the -k keydef option should follow the -b, -d, -f, -i, -n, and
-r options.

The following options shall be supported:
-c Check that the single input file is ordered as specified by the arguments and the
collating sequence of the current locale. No output shall be produced; only the exit
code shall be affected.
-m Merge only; the input file shall be assumed to be already sorted.
-o output Specify the name of an output file to be used instead of the standard output. This
file can be the same as one of the input files.
-u Unique: suppress all but one in each set of lines having equal keys. If used with
the -c option, check that there are no lines with duplicate keys, in addition to
checking that the input file is sorted.

The following options shall override the default ordering rules. When ordering options appear
independent of any key field specifications, the requested field ordering rules shall be applied
globally to all sort keys. When attached to a specific key (see -k), the specified ordering options
shall override all global ordering options for that key.
-d Specify that only <blank>s and alphanumeric characters, according to the current
setting of LC_CTYPE, shall be significant in comparisons. The behavior is
undefined for a sort key to which -i or -n also applies.
-f Consider all lowercase characters that have uppercase equivalents, according to
the current setting of LC_CTYPE, to be the uppercase equivalent for the purposes
of comparison.
-i Ignore all characters that are non-printable, according to the current setting of
LC_CTYPE.
-n Restrict the sort key to an initial numeric string, consisting of optional <blank>s,
optional minus sign, and zero or more digits with an optional radix character and
thousands separators (as defined in the current locale), which shall be sorted by
Utilities

33771 arithmetic value. An empty digit string shall be treated as zero. Leading zeros and
33772 signs on zeros shall not affect ordering.

33773 -r Reverses the sense of comparisons.

33774 The treatment of field separators can be altered using the options:

33775 -b Ignore leading <blank>s when determining the starting and ending positions of a
33776 restricted sort key. If the -b option is specified before the first -k option, it shall be
33777 applied to all -k options. Otherwise, the -b option can be attached independently
33778 to each -k field_start or field_end option-argument (see below).

33779 -t char Use char as the field separator character; char shall not be considered to be part of a
33780 field (although it can be included in a sort key). Each occurrence of char shall be
33781 significant (for example, <char><char> delimits an empty field). If -t is not
33782 specified, <blank>s shall be used as default field separators; each maximal non-
33783 empty sequence of <blank>s that follows a non-<blank> shall be a field separator.

33784 Sort keys can be specified using the options:

33785 -k keydef The keydef argument is a restricted sort key field definition. The format of this
33786 definition is:

33787 field_start[type] [, field_end[type]]

33788 where field_start and field_end define a key field restricted to a portion of the line
33789 (see the EXTENDED DESCRIPTION section), and type is a modifier from the list of
33790 characters 'b', 'd', 'f', 'i', 'n', 'r'. The 'b' modifier shall behave like the
33791 -b option, but shall apply only to the field_start or field_end to which it is attached.
33792 The other modifiers shall behave like the corresponding options, but shall apply
33793 only to the key field to which they are attached; they shall have this effect if
33794 specified with field_start, field_end, or both. If any modifier is attached to a
33795 field_start or to a field_end, no option shall apply to either. Implementations shall
33796 support at least nine occurrences of the -k option, which shall be significant in
33797 command line order. If no -k option is specified, a default sort key of the entire
33798 line shall be used.

33799 When there are multiple key fields, later keys shall be compared only after all
33800 earlier keys compare equal. Except when the -u option is specified, lines that
33801 otherwise compare equal shall be ordered as if none of the options -d, -f, -i, -n, or
33802 -k were present (but with -r still in effect, if it was specified) and with all bytes in
33803 the lines significant to the comparison. The order in which lines that still compare
33804 equal are written is unspecified.

OPERANDS

33805 The following operand shall be supported:

33807 file A pathname of a file to be sorted, merged, or checked. If no file operands are
33808 specified, or if a file operand is '-', the standard input shall be used.

33809 STDIN

33810 The standard input shall be used only if no file operands are specified, or if a file operand is '-'.
33811 See the INPUT FILES section.

INPUT FILES

33812 The input files shall be text files, except that the sort utility shall add a <newline> to the end of a
33813 file ending with an incomplete last line.
ENIRONMENT VARIABLES

The following environment variables shall affect the execution of sort:

LANG   Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_COLLATE  Determine the locale for ordering rules.

LC_CTYPE   Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files) and the behavior of character classification for the −b,
−d, −f, −i, and −n options.

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

LC_NUMERIC  Determine the locale for the definition of the radix character and thousands
separator for the −n option.

XSI NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Unless the −o or −c options are in effect, the standard output shall contain the sorted input.

STDERR

The standard error shall be used for diagnostic messages. A warning message about correcting
an incomplete last line of an input file may be generated, but need not affect the final exit status.

OUTPUT FILES

If the −o option is in effect, the sorted input shall be written to the file output.

EXTENDED DESCRIPTION

The notation:

−k field_start[.first_character][,field_end[.first_character]]

shall define a key field that begins at field_start and ends at field_end inclusive, unless field_start
falls beyond the end of the line or after field_end, in which case the key field is empty. A missing
field_end shall mean the last character of the line.

A field comprises a maximal sequence of non-separating characters and, in the absence of option
−t, any preceding field separator.

The field_start portion of the keydef option-argument shall have the form:

field_number[.first_character]

Fields and characters within fields shall be numbered starting with 1. The field_number and
first_character pieces, interpreted as positive decimal integers, shall specify the first character to
be used as part of a sort key. If first_character is omitted, it shall refer to the first character of the
The field_end portion of the keydef option-argument shall have the form:

```
field_number[.last_character]
```

The field_number shall be as described above for field_start. The last_character piece, interpreted as a non-negative decimal integer, shall specify the last character to be used as part of the sort key. If last_character evaluates to zero or .last_character is omitted, it shall refer to the last character of the field specified by field_number.

If the -b option or b type modifier is in effect, characters within a field shall be counted from the first non-<blank> in the field. (This shall apply separately to first_character and last_character.)

**EXIT STATUS**

The following exit values shall be returned:

- 0 All input files were output successfully, or -c was specified and the input file was correctly sorted.
- 1 Under the -c option, the file was not ordered as specified, or if the -c and -u options were both specified, two input lines were found with equal keys.
- >1 An error occurred.

**APPLICATION USAGE**

The default value for -t, <blank>, has different properties from, for example, -t"<space>". If a line contains:

```
<space><space>foo
```

the following treatment would occur with default separation as opposed to specifically selecting a <space>:

<table>
<thead>
<tr>
<th>Field</th>
<th>Default</th>
<th>-t &quot;&lt;space&gt;&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;&lt;space&gt;&quot;</td>
<td>empty</td>
</tr>
<tr>
<td>2</td>
<td>empty</td>
<td>empty</td>
</tr>
<tr>
<td>3</td>
<td>empty</td>
<td>foo</td>
</tr>
</tbody>
</table>

The leading field separator itself is included in a field when -t is not used. For example, this command returns an exit status of zero, meaning the input was already sorted:

```
sort -c -k 2 <<eof
y<tab>b
x<space>a
eof
```

(assuming that a <tab> precedes the <space> in the current collating sequence). The field separator is not included in a field when it is explicitly set via -t. This is historical practice and allows usage such as:

```
sort -t "|" -k 2n <<eof
Atlanta|425022|Georgia
Birmingham|284413|Alabama
Columbia|100385|South Carolina
eof
```
where the second field can be correctly sorted numerically without regard to the non-numeric field separator.

The wording in the OPTIONS section clarifies that the \texttt{–b}, \texttt{–d}, \texttt{–f}, \texttt{–i}, \texttt{–n}, and \texttt{–r} options have to come before the first sort key specified if they are intended to apply to all specified keys. The way it is described in this volume of IEEE Std 1003.1-2001 matches historical practice, not historical documentation. The results are unspecified if these options are specified after a \texttt{–k} option.

The \texttt{–f} option might not work as expected in locales where there is not a one-to-one mapping between an uppercase and a lowercase letter.

\textbf{EXAMPLES}

1. The following command sorts the contents of \texttt{infile} with the second field as the sort key:

   \begin{verbatim}
   sort –k 2,2 infile
   \end{verbatim}

2. The following command sorts, in reverse order, the contents of \texttt{infile1} and \texttt{infile2}, placing the output in \texttt{outfile} and using the second character of the second field as the sort key (assuming that the first character of the second field is the field separator):

   \begin{verbatim}
   sort –r –o outfile –k 2.2,2.2 infile1 infile2
   \end{verbatim}

3. The following command sorts the contents of \texttt{infile1} and \texttt{infile2} using the second non-\texttt{<blank>} of the second field as the sort key:

   \begin{verbatim}
   sort –k 2.2b,2.2b infile1 infile2
   \end{verbatim}

4. The following command prints the System V password file (user database) sorted by the numeric user ID (the third colon-separated field):

   \begin{verbatim}
   sort –t: –k 3,3n /etc/passwd
   \end{verbatim}

5. The following command prints the lines of the already sorted file \texttt{infile}, suppressing all but one occurrence of lines having the same third field:

   \begin{verbatim}
   sort –um –k 3.1,3.0 infile
   \end{verbatim}

\textbf{RATIONALE}

Examples in some historical documentation state that options \texttt{–um} with one input file keep the first in each set of lines with equal keys. This behavior was deemed to be an implementation artifact and was not standardized.

The \texttt{–z} option was omitted; it is not standard practice on most systems and is inconsistent with using \texttt{sort} to sort several files individually and then merge them together. The text concerning \texttt{–z} in historical documentation appeared to require implementations to determine the proper buffer length during the sort phase of operation, but not during the merge.

The \texttt{–y} option was omitted because of non-portability. The \texttt{–M} option, present in System V, was omitted because of non-portability in international usage.

An undocumented \texttt{–T} option exists in some implementations. It is used to specify a directory for intermediate files. Implementations are encouraged to support the use of the \textit{TMPDIR} environment variable instead of adding an option to support this functionality.

The \texttt{–k} option was added to satisfy two objections. First, the zero-based counting used by \texttt{sort} is not consistent with other utility conventions. Second, it did not meet syntax guideline requirements.

Historical documentation indicates that “setting \texttt{–n} implies \texttt{–b}”. The description of \texttt{–n} already states that optional leading \texttt{<blank>}s are tolerated in doing the comparison. If \texttt{–b} is enabled,
rather than implied, by \texttt{−n}, this has unusual side effects. When a character offset is used in a
column of numbers (for example, to sort modulo 100), that offset is measured relative to the
most significant digit, not to the column. Based upon a recommendation from the author of the
original \texttt{sort} utility, the \texttt{−b} implication has been omitted from this volume of
\cite{Std1003.1-2001}, and an application wishing to achieve the previously mentioned side
effects has to code the \texttt{−b} flag explicitly.

\textbf{FUTURE DIRECTIONS}

None.

\textbf{SEE ALSO}

\texttt{comm}, \texttt{join}, \texttt{uniq}, the System Interfaces volume of IEEE Std 1003.1-2001, \texttt{toupper()}.

\textbf{CHANGE HISTORY}

First released in Issue 2.

\textbf{Issue 6}

IEEE PASC Interpretation 1003.2 #174 is applied, updating the DESCRIPTION of comparisons.

IEEE PASC Interpretation 1003.2 #168 is applied.
NAME  
split — split files into pieces

SYNOPSIS

split [-l line_count] [-a suffix_length] [file[name]]

split -b n[k|m] [-a suffix_length] [file[name]]

DESCRIPTION

The split utility shall read an input file and write one or more output files. The default size of each output file shall be 1000 lines. The size of the output files can be modified by specification of the -b or -l options. Each output file shall be created with a unique suffix. The suffix shall consist of exactly suffix_length lowercase letters from the POSIX locale. The letters of the suffix shall be used as if they were a base-26 digit system, with the first suffix to be created consisting of all 'a' characters, the second with a 'b' replacing the last 'a', and so on, until a name of all 'z' characters is created. By default, the names of the output files shall be 'x', followed by a two-character suffix from the character set as described above, starting with "aa", "ab", "ac", and so on, and continuing until the suffix "zz", for a maximum of 676 files.

If the number of files required exceeds the maximum allowed by the suffix length provided, such that the last allowable file would be larger than the requested size, the split utility shall fail after creating the last file with a valid suffix; split shall not delete the files it created with valid suffixes. If the file limit is not exceeded, the last file created shall contain the remainder of the input file, and may be smaller than the requested size.

OPTIONS


The following options shall be supported:

-a suffix_length
Use suffix_length letters to form the suffix portion of the filenames of the split file. If -a is not specified, the default suffix length shall be two. If the sum of the name operand and the suffix_length option-argument would create a filename exceeding [NAME_MAX] bytes, an error shall result; split shall exit with a diagnostic message and no files shall be created.

-b n
Split a file into pieces n bytes in size.

-b nk
Split a file into pieces n*1 024 bytes in size.

-b nm
Split a file into pieces n*1 048 576 bytes in size.

-l line_count
Specify the number of lines in each resulting file piece. The line_count argument is an unsigned decimal integer. The default is 1000. If the input does not end with a <newline>, the partial line shall be included in the last output file.

OPERANDS

The following operands shall be supported:

file
The pathname of the ordinary file to be split. If no input file is given or file is '−', the standard input shall be used.

name
The prefix to be used for each of the files resulting from the split operation. If no name argument is given, 'x' shall be used as the prefix of the output files. The combined length of the basename of prefix and suffix_length cannot exceed [NAME_MAX] bytes. See the OPTIONS section.
STDIN

See the INPUT FILES section.

INPUT FILES

Any file can be used as input.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of `split`:

LANG

Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL

If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

XSI

NLSPATH

Determine the location of message catalogs for the processing of `LC_MESSAGES`.

ASYNCHRONOUS EVENTS

Default.

STDOUT

Not used.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

The output files contain portions of the original input file; otherwise, unchanged.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS

Default.
**APPLICATION USAGE**

None.

**EXAMPLES**

In the following examples foo is a text file that contains 5000 lines.

1. Create five files, xaa, xab, xac, xad, and xae:
   
   ```bash
   split foo
   ```

2. Create five files, but the suffixed portion of the created files consists of three letters, xaaa, xaab, xaac, xaad, and xae:
   
   ```bash
   split -a 3 foo
   ```

3. Create three files with four-letter suffixes and a supplied prefix, bar_aaaa, bar_aaab, and bar_aaac:
   
   ```bash
   split -a 4 -l 2000 foo bar_
   ```

4. Create as many files as are necessary to contain at most 20*1024 bytes, each with the default prefix of x and a five-letter suffix:
   
   ```bash
   split -a 5 -b 20k foo
   ```

**RATIONALE**

The -b option was added to provide a mechanism for splitting files other than by lines. While most uses of the -b option are for transmitting files over networks, some believed it would have additional uses.

The -a option was added to overcome the limitation of being able to create only 676 files.

Consideration was given to deleting this utility, using the rationale that the functionality provided by this utility is available via the csplit utility (see csplit). Upon reconsideration of the purpose of the User Portability Extension, it was decided to retain both this utility and the csplit utility because users use both utilities and have historical expectations of their behavior. Furthermore, the splitting on byte boundaries in split cannot be duplicated with the historical csplit.

The text “split shall not delete the files it created with valid suffixes” would normally be assumed, but since the related utility, csplit, does delete files under some circumstances, the historical behavior of split is made explicit to avoid misinterpretation.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

csplit

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The APPLICATION USAGE section is added.

The obsolescent SYNOPSIS is removed.
NAME
strings — find printable strings in files

SYNOPSIS
strings [-a][-t format][-n number][file...]

DESCRIPTION
The strings utility shall look for printable strings in regular files and shall write those strings to standard output. A printable string is any sequence of four (by default) or more printable characters terminated by a <newline> or NUL character. Additional implementation-defined strings may be written; see localedef.

OPTIONS
The following options shall be supported:

-a  Scan files in their entirety. If -a is not specified, it is implementation-defined what portion of each file is scanned for strings.

-n number  Specify the minimum string length, where the number argument is a positive decimal integer. The default shall be 4.

-t format  Write each string preceded by its byte offset from the start of the file. The format shall be dependent on the single character used as the format option-argument:

d  The offset shall be written in decimal.
o  The offset shall be written in octal.
x  The offset shall be written in hexadecimal.

OPERANDS
The following operand shall be supported:

file  A pathname of a regular file to be used as input. If no file operand is specified, the strings utility shall read from the standard input.

STDIN  See the INPUT FILES section.

INPUT FILES
The input files named by the utility arguments or the standard input shall be regular files of any format.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of strings:

LANG  Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and to identify printable strings.
**Strings**

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**XSI NLSPATH**
Determine the location of message catalogs for the processing of LC_MESSAGES.

**Asynchronous Events**

**Default.**

**STDOUT**
Strings found shall be written to the standard output, one per line.

When the **−t** option is not specified, the format of the output shall be:

```
"%s", <string>
```

With the **−to** option, the format of the output shall be:

```
"%o %s", <byte offset>, <string>
```

With the **−tx** option, the format of the output shall be:

```
"%x %s", <byte offset>, <string>
```

With the **−td** option, the format of the output shall be:

```
"%d %s", <byte offset>, <string>
```

**STDERR**
The standard error shall be used only for diagnostic messages.

**Output Files**

None.

**Extended Description**

None.

**Exit Status**
The following exit values shall be returned:

- 0 Successful completion.
- >0 An error occurred.

**Consequences of Errors**

Default.

**Application Usage**
By default the data area (as opposed to the text, “bss”, or header areas) of a binary executable file is scanned. Implementations document which areas are scanned.

Some historical implementations do not require NUL or <newline> terminators for strings to permit those languages that do not use NUL as a string terminator to have their strings written.

**Examples**

None.

**Rationale**
Apart from rationalizing the option syntax and slight difficulties with object and executable binary files, strings is specified to match historical practice closely. The **−a** and **−n** options were introduced to replace the non-conforming – and **−number** options.

The **−o** option historically means different things on different implementations. Some use it to mean “offset in decimal”, while others use it as ”offset in octal”. Instead of trying to decide which
way would be least objectionable, the −t option was added. It was originally named −O to mean
‘offset’, but was changed to −t to be consistent with od.

The ISO C standard function isprint() is restricted to a domain of unsigned char. This volume of
IEEE Std 1003.1-2001 requires implementations to write strings as defined by the current locale.

FUTURE DIRECTIONS
None.

SEE ALSO
localedef, nm

CHANGE HISTORY
First released in Issue 4.

Issue 6
This utility is marked as part of the User Portability Utilities option.
The obsolescent SYNOPSIS is removed.
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
strip — remove unnecessary information from executable files (DEVELOPMENT)

SYNOPSIS
strip file...

DESCRIPTION
The strip utility shall remove from executable files named by the file operands any information
the implementor deems unnecessary for execution of those files. The nature of that information
is unspecified. The effect of strip shall be similar to the use of the -s option to c99 or fort77.

OPTIONS
None.

OPERANDS
The following operand shall be supported:
file A pathname referring to an executable file.

STDIN
Not used.

INPUT FILES
The input files shall be in the form of executable files successfully produced by any compiler
defined by this volume of IEEE Std 1003.1-2001.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of strip:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI_NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.
The `strip` utility shall produce executable files of unspecified format.

The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

The behavior of `strip` is said to be the same as the `−s` option to a compiler. While the end result is essentially the same, it is not required to be identical.
NAME

stty — set the options for a terminal

SYNOPSIS

stty [ -a | -g ]

stty operands

DESCRIPTION

The stty utility shall set or report on terminal I/O characteristics for the device that is its standard input. Without options or operands specified, it shall report the settings of certain characteristics, usually those that differ from implementation-defined defaults. Otherwise, it shall modify the terminal state according to the specified operands. Detailed information about the modes listed in the first five groups below are described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface. Operands in the Combination Modes group (see Combination Modes (on page 889)) are implemented using operands in the previous groups. Some combinations of operands are mutually-exclusive on some terminal types; the results of using such combinations are unspecified.

Typical implementations of this utility require a communications line configured to use the termios interface defined in the System Interfaces volume of IEEE Std 1003.1-2001. On systems where none of these lines are available, and on lines not currently configured to support the termios interface, some of the operands need not affect terminal characteristics.

OPTIONS


The following options shall be supported:

- Write to standard output all the current settings for the terminal.
- Write to standard output all the current settings in an unspecified form that can be used as arguments to another invocation of the stty utility on the same system. The form used shall not contain any characters that would require quoting to avoid word expansion by the shell; see Section 2.6 (on page 36).

OPERANDS

The following operands shall be supported to set the terminal characteristics.

Control Modes

- Enable (disable) parity generation and detection. This shall have the effect of setting (not setting) PARENB in the termios c_cflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.
- Select odd (even) parity. This shall have the effect of setting (not setting) PARODD in the termios c_cflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.
- Select character size, if possible. This shall have the effect of setting CS5, CS6, CS7, and CS8, respectively, in the termios c_cflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.
- Set terminal baud rate to the number given, if possible. If the baud rate is set to zero, the modem control lines shall no longer be asserted. This shall have
the effect of setting the input and output `termios` baud rate values as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`ispeed number` Set terminal input baud rate to the number given, if possible. If the input baud rate is set to zero, the input baud rate shall be specified by the value of the output baud rate. This shall have the effect of setting the input `termios` baud rate values as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`ospeed number` Set terminal output baud rate to the number given, if possible. If the output baud rate is set to zero, the modem control lines shall no longer be asserted. This shall have the effect of setting the output `termios` baud rate values as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`hupcl` (–`hupcl`) Stop asserting modem control lines (do not stop asserting modem control lines) on last close. This shall have the effect of setting (not setting) HUPCL in the `termios c_cflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`hup` (–`hup`) Equivalent to `hupcl` (–`hupcl`).

`cstopb` (–`cstopb`) Use two (one) stop bits per character. This shall have the effect of setting (not setting) CSTOPB in the `termios c_cflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`cread` (–`cread`) Enable (disable) the receiver. This shall have the effect of setting (not setting) CREAD in the `termios c_cflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`clocal` (–`clocal`) Assume a line without (with) modem control. This shall have the effect of setting (not setting) CLOCAL in the `termios c_cflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

It is unspecified whether `stty` shall report an error if an attempt to set a Control Mode fails.

**Input Modes**

`ignbrk` (–`ignbrk`) Ignore (do not ignore) break on input. This shall have the effect of setting (not setting) IGNBRK in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`brkint` (–`brkint`) Signal (do not signal) INTR on break. This shall have the effect of setting (not setting) BRKINT in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`ignpar` (–`ignpar`) Ignore (do not ignore) bytes with parity errors. This shall have the effect of setting (not setting) IGNPAR in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

`parmkrk` (–`parmkrk`) Mark (do not mark) parity errors. This shall have the effect of setting (not setting) PARMRK in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.
inpck (−inpck) Enable (disable) input parity checking. This shall have the effect of setting (not setting) INPCK in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

istrip (−istrip) Strip (do not strip) input characters to seven bits. This shall have the effect of setting (not setting) ISTrip in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

inlcr (−inlcr) Map (do not map) NL to CR on input. This shall have the effect of setting (not setting) INLCR in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

igncr (−igncr) Ignore (do not ignore) CR on input. This shall have the effect of setting (not setting) IGNCR in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

icrnl (−icrnl) Map (do not map) CR to NL on input. This shall have the effect of setting (not setting) ICRNL in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

ixon (−ixon) Enable (disable) START/STOP output control. Output from the system is stopped when the system receives STOP and started when the system receives START. This shall have the effect of setting (not setting) IXON in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

ixany (−ixany) Allow any character to restart output. This shall have the effect of setting (not setting) IXANY in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

ixoff (−ixoff) Request that the system send (not send) STOP characters when the input queue is nearly full and START characters to resume data transmission. This shall have the effect of setting (not setting) IXOFF in the `termios c_iflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

Output Modes

opost (−opost) Post-process output (do not post-process output; ignore all other output modes). This shall have the effect of setting (not setting) OPOST in the `termios c_oflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

ocrnl (−ocrnl) Map (do not map) CR to NL on output. This shall have the effect of setting (not setting) OCRNL in the `termios c_oflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

onocr (−onocr) Do not (do) output CR at column zero. This shall have the effect of setting (not setting) ONOCR in the `termios c_oflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

onlret (−onlret) The terminal newline key performs (does not perform) the CR function. This shall have the effect of setting (not setting) ONLRET in the `termios c_oflag` field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ofill (−ofill)</td>
<td>Use fill characters (use timing) for delays. This shall have the effect of setting (not setting) OFILL in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>ofdel (−ofdel)</td>
<td>Fill characters are DELs (NULs). This shall have the effect of setting (not setting) OFDEL in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>cr0 cr1 cr2 cr3</td>
<td>Select the style of delay for CRs. This shall have the effect of setting CRDLY to CR0, CR1, CR2, or CR3, respectively, in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>nl0 nl1</td>
<td>Select the style of delay for NL. This shall have the effect of setting NLDLY to NL0 or NL1, respectively, in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>cr0 cr1 cr2 cr3</td>
<td>Select the style of delay for CRs. This shall have the effect of setting CRDLY to CR0, CR1, CR2, or CR3, respectively, in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>tabs (−tabs)</td>
<td>Synonym for <code>tab0</code> (tab3).</td>
</tr>
<tr>
<td>bs0 bs1</td>
<td>Select the style of delay for backspaces. This shall have the effect of setting BSDLY to BS0 or BS1, respectively, in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>ff0 ff1</td>
<td>Select the style of delay for form-feeds. This shall have the effect of setting FFDLY to FF0 or FF1, respectively, in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>vt0 vt1</td>
<td>Select the style of delay for vertical-tabs. This shall have the effect of setting VTDLY to VT0 or VT1, respectively, in the <em>termios</em> <code>c_oflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
</tbody>
</table>

**Local Modes**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>isig (−isig)</td>
<td>Enable (disable) the checking of characters against the special control characters INTR, QUIT, and SUSP. This shall have the effect of setting (not setting) ISIG in the <em>termios</em> <code>c_lflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>ican (−ican)</td>
<td>Enable (disable) canonical input (ERASE and KILL processing). This shall have the effect of setting (not setting) ICAN in the <em>termios</em> <code>c_lflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
<tr>
<td>iexten (−iexten)</td>
<td>Enable (disable) any implementation-defined special control characters not currently controlled by ican, isig, ixon, or ixoff. This shall have the effect of setting (not setting) IEXTEN in the <em>termios</em> <code>c_lflag</code> field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.</td>
</tr>
</tbody>
</table>
Utilities


**echo** (−echo)  Echo back (do not echo back) every character typed. This shall have the effect of setting (not setting) ECHO in the termios c_lflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

**echoe** (−echoe)  The ERASE character visually erases (does not erase) the last character in the current line from the display, if possible. This shall have the effect of setting (not setting) ECHOE in the termios c_lflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

**echok** (−echok)  Echo (do not echo) NL after KILL character. This shall have the effect of setting (not setting) ECHOK in the termios c_lflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

**echonl** (−echonl)  Echo (do not echo) NL, even if echo is disabled. This shall have the effect of setting (not setting) ECHONL in the termios c_lflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

**noflsh** (−noflsh)  Disable (enable) flush after INTR, QUIT, SUSP. This shall have the effect of setting (not setting) NOFLSH in the termios c_lflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

**tostop** (−tostop)  Send SIGTTOU for background output. This shall have the effect of setting (not setting) TOSTOP in the termios c_lflag field, as defined in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

**Special Control Character Assignments**

<control>-character string  
Set <control>-character to string. If <control>-character is one of the character sequences in the first column of the following table, the corresponding Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface control character from the second column shall be recognized. This has the effect of setting the corresponding element of the termios c_cc array (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 13, Headers, <termios.h>).
set the current terminal characteristics to the saved settings. Saved settings are:

<table>
<thead>
<tr>
<th>Control Character</th>
<th>c_cc Subscript</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eof</td>
<td>VEOF</td>
<td>EOF character</td>
</tr>
<tr>
<td>eol</td>
<td>VEOL</td>
<td>EOL character</td>
</tr>
<tr>
<td>erase</td>
<td>VERASE</td>
<td>ERASE character</td>
</tr>
<tr>
<td>intr</td>
<td>VINTR</td>
<td>INTR character</td>
</tr>
<tr>
<td>kill</td>
<td>VKILL</td>
<td>KILL character</td>
</tr>
<tr>
<td>quit</td>
<td>VQUIT</td>
<td>QUIT character</td>
</tr>
<tr>
<td>susp</td>
<td>VSUSP</td>
<td>SUSP character</td>
</tr>
<tr>
<td>start</td>
<td>VSTART</td>
<td>START character</td>
</tr>
<tr>
<td>stop</td>
<td>VSTOP</td>
<td>STOP character</td>
</tr>
</tbody>
</table>

The two-character sequence "^c" or the string "undef", if it is in effect for the device; if "^c" is not in effect for the device, it shall be treated as an error. In the POSIX locale, if "^c" is a two-character sequence beginning with circumflex ("^c"), and the second character is one of those listed in the "^c" column of the following table, the control character shall be set to the corresponding character value in the Value column of the table.

<table>
<thead>
<tr>
<th>^c Value</th>
<th>^c Value</th>
<th>^c Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a, A</td>
<td>&lt;SOH&gt;</td>
<td>w, W</td>
</tr>
<tr>
<td>b, B</td>
<td>&lt;ETX&gt;</td>
<td>x, X</td>
</tr>
<tr>
<td>c, C</td>
<td>&lt;SO&gt;</td>
<td>y, Y</td>
</tr>
<tr>
<td>d, D</td>
<td>&lt;Si&gt;</td>
<td>z, Z</td>
</tr>
<tr>
<td>e, E</td>
<td>&lt;DLE&gt;</td>
<td>[</td>
</tr>
<tr>
<td>f, F</td>
<td>&lt;DC1&gt;</td>
<td>\</td>
</tr>
<tr>
<td>g, G</td>
<td>&lt;DC2&gt;</td>
<td>]</td>
</tr>
<tr>
<td>h, H</td>
<td>&lt;DC3&gt;</td>
<td>^</td>
</tr>
<tr>
<td>i, I</td>
<td>&lt;DC4&gt;</td>
<td>_</td>
</tr>
<tr>
<td>j, J</td>
<td>&lt;NAK&gt;</td>
<td>?</td>
</tr>
<tr>
<td>k, K</td>
<td>&lt;VT&gt;</td>
<td>v, V</td>
</tr>
</tbody>
</table>

- **min number**: Set the value of MIN to number. MIN is used in non-canonical mode input processing (icanon).
- **time number**: Set the value of TIME to number. TIME is used in non-canonical mode input processing (icanon).

## Combination Modes
- **saved settings**: Set the current terminal characteristics to the saved settings produced by the -g option.
- **evenp or parity**: Enable parenb and cs7; disable parodd.
- **oddp**: Enable parenb, cs7, and parodd.
--parity, --evenp, or --oddp
Disable parenb, and set cs8.

raw (--raw or cooked)
Enable (disable) raw input and output. Raw mode shall be equivalent to setting:

```
stty cs8 erase ^- kill ^- intr ^- \nquit ^- eof ^- eol ^- --post -inpck
```

nl (--nl)
Disable (enable) icrnl. In addition, --nl unsets inlcr and igncr.

ek
Reset ERASE and KILL characters back to system defaults.

sane
Reset all modes to some reasonable, unspecified, values.

STDIN
Although no input is read from standard input, standard input shall be used to get the current terminal I/O characteristics and to set new terminal I/O characteristics.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of stty:

LANG
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE
This variable determines the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments) and which characters are in the class print.

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NILSPATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
If operands are specified, no output shall be produced.
If the --g option is specified, stty shall write to standard output the current settings in a form that can be used as arguments to another instance of stty on the same system.
If the --a option is specified, all of the information as described in the OPERANDS section shall be written to standard output. Unless otherwise specified, this information shall be written as <space>-separated tokens in an unspecified format, on one or more lines, with an unspecified number of tokens per line. Additional information may be written.
If no options or operands are specified, an unspecified subset of the information written for the --a option shall be written.
If speed information is written as part of the default output, or if the \texttt{−a} option is specified and if the terminal input speed and output speed are the same, the speed information shall be written as follows:

\texttt{"speed \%d baud;", <speed>}

Otherwise, speeds shall be written as:

\texttt{"ispeed \%d baud; ospeed \%d baud;", <ispeed>, <ospeed>}

In locales other than the POSIX locale, the word \texttt{baud} may be changed to something more appropriate in those locales.

If control characters are written as part of the default output, or if the \texttt{−a} option is specified, control characters shall be written as:

\texttt{"%s = %s;", <control-character name>, <value>}

where <value> is either the character, or some visual representation of the character if it is non-printable, or the string \texttt{undef} if the character is disabled.

\textbf{STDERR}

The standard error shall be used only for diagnostic messages.

\textbf{OUTPUT FILES}

None.

\textbf{EXTENDED DESCRIPTION}

None.

\textbf{EXIT STATUS}

The following exit values shall be returned:

\begin{itemize}
  \item \texttt{0} The terminal options were read or set successfully.
  \item \texttt{>0} An error occurred.
\end{itemize}

\textbf{CONSEQUENCES OF ERRORS}

Default.

\textbf{APPLICATION USAGE}

The \texttt{−g} flag is designed to facilitate the saving and restoring of terminal state from the shell level. For example, a program may:

\begin{verbatim}
saveterm="$(stty −g)"     # save terminal state
stty (new settings)     # set new state
...                      # ...
stty $saveterm            # restore terminal state
\end{verbatim}

Since the format is unspecified, the saved value is not portable across systems.

Since the \texttt{−a} format is so loosely specified, scripts that save and restore terminal settings should use the \texttt{−g} option.

\textbf{EXAMPLES}

None.

\textbf{RATIONALE}

The original \textit{stty} description was taken directly from System V and reflected the System V terminal driver \texttt{termio}. It has been modified to correspond to the terminal driver \texttt{termios}.

Output modes are specified only for XSI-conformant systems. All implementations are expected to provide \textit{stty} operands corresponding to all of the output modes they support.
The `stty` utility is primarily used to tailor the user interface of the terminal, such as selecting the preferred ERASE and KILL characters. As an application programming utility, `stty` can be used within shell scripts to alter the terminal settings for the duration of the script.

The `termios` section states that individual disabling of control characters is possible through the option `_POSIX_VDISABLE`. If enabled, two conventions currently exist for specifying this: System V uses "^~", and BSD uses `undef`. Both are accepted by `stty` in this volume of IEEE Std 1003.1-2001. The other BSD convention of using the letter `'u'` was rejected because it conflicts with the actual letter `'u'`, which is an acceptable value for a control character.

Early proposals did not specify the mapping of "^c" to control characters because the control characters were not specified in the POSIX locale character set description file requirements. The control character set is now specified in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 3, Definitions so the historical mapping is specified. Note that although the mapping corresponds to control-character key assignments on many terminals that use the ISO/IEC 646: 1991 standard (or ASCII) character encodings, the mapping specified here is to the control characters, not their keyboard encodings.

Since `termios` supports separate speeds for input and output, two new options were added to specify each distinctly.

Some historical implementations use standard input to get and set terminal characteristics; others use standard output. Since input from a login TTY is usually restricted to the owner while output to a TTY is frequently open to anyone, using standard input provides fewer chances of accidentally (or maliciously) altering the terminal settings of other users. Using standard input also allows `stty -a` and `stty -g` output to be redirected for later use. Therefore, usage of standard input is required by this volume of IEEE Std 1003.1-2001.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 2 (on page 29), the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface, `<termios.h>`

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

The description of `tabs` is clarified.

The `FUTURE DIRECTIONS` section is added.

**Issue 6**

The legacy items `iuccl`(`-iuccl`), `xcase`, `olcuc`(`-olcuc`), `lcase`(`-lcase`), and `LCASE`(`-LCASE`) are removed.

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/37 is applied, applying IEEE PASC Interpretation 1003.2 #133, fixing an error in the OPERANDS section for the Combination Modes `nl`(`-nl`).

---

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NAME

tabs — set terminal tabs

SYNOPSIS

tabs [ −n | −a | −a2 | −c | −c2 | −c3 | −f | −p | −s | −u ] [+m[n]] [ −T type ]

tabs [ −T type ] [ +[n] ] n1[,n2,...]

DESCRIPTION

The tabs utility shall display a series of characters that first clears the hardware terminal tab settings and then initializes the tab stops at the specified positions and optionally adjusts the margin.

The phrase “tab-stop position N” shall be taken to mean that, from the start of a line of output, tabbing to position N shall cause the next character output to be in the (N+1)th column position on that line. The maximum number of tab stops allowed is terminal-dependent.

It need not be possible to implement tabs on certain terminals. If the terminal type obtained from the TERM environment variable or −T option represents such a terminal, an appropriate diagnostic message shall be written to standard error and tabs shall exit with a status greater than zero.

OPTIONS

The tabs utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except for various extensions: the options −a2, −c2, and −c3 are multi-character.

The following options shall be supported:

−n Specify repetitive tab stops separated by a uniform number of column positions, n, where n is a single-digit decimal number. The default usage of tabs with no arguments shall be equivalent to tabs−8. When −0 is used, the tab stops shall be cleared and no new ones set.

−a 1,10,16,36,72
Assembler, applicable to some mainframes.

−a2 1,10,16,40,72
Assembler, applicable to some mainframes.

−c 1,8,12,16,20,55
COBOL, normal format.

−c2 1,6,10,14,49
COBOL, compact format (columns 1 to 6 omitted).

−c3 1,6,10,14,18,22,26,30,34,38,42,46,50,54,58,62,67
COBOL compact format (columns 1 to 6 omitted), with more tabs than −c2.

−f 1,7,11,15,19,23
FORTRAN

−p 1,5,9,13,17,21,25,29,33,37,41,45,49,53,57,61
PL/1

−s 1,10,55
SNOBOL

−u 1,12,20,44
Assembler, applicable to some mainframes.
OPERANDS
The following operand shall be supported:

\[ n1[,n2,\ldots] \]

A single command line argument that consists of tab-stop values separated using
either commas or <blank>s. The application shall ensure that the tab-stop values
are positive decimal integers in strictly ascending order. If any number (except the
first one) is preceded by a plus sign, it is taken as an increment to be added to the
previous value. For example, the tab lists 1,10,20,30 and 1,10,+10,+10 are
considered to be identical.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of \texttt{tabs}:

\texttt{LANG}
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

\texttt{LC_ALL}
If set to a non-empty string value, override the values of all the other
internationalization variables.

\texttt{LC_CTYPE}
Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

\texttt{LC_MESSAGES}
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

\texttt{NLSPATH}
Determine the location of message catalogs for the processing of \texttt{LC_MESSAGES}.

\texttt{TERM}
Determine the terminal type. If this variable is unset or null, and if the \texttt{–T} option is
not specified, an unspecified default terminal type shall be used.

ASYNCHRONOUS EVENTS
Default.

STDOUT
If standard output is a terminal, the appropriate sequence to clear and set the tab stops may be
written to standard output in an unspecified format. If standard output is not a terminal,
undefined results occur.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.
EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
This utility makes use of the terminal’s hardware tabs and the stty tabs option.

This utility is not recommended for application use.

Some integrated display units might not have escape sequences to set tab stops, but may be set by internal system calls. On these terminals, tabs works if standard output is directed to the terminal; if output is directed to another file, however, tabs fails.

EXAMPLES
None.

RATIONALE
Consideration was given to having the tput utility handle all of the functions described in tabs.

However, the separate tabs utility was retained because it seems more intuitive to use a command named tabs than tput with a new option. The tput utility does not support setting or clearing tabs, and no known historical version of tabs supports the capability of setting arbitrary tab stops.

The System V tabs interface is very complex; the version in this volume of IEEE Std 1003.1-2001 has a reduced feature list, but many of the features omitted were restored as XSI extensions even though the supported languages and coding styles are primarily historical.

There was considerable sentiment for specifying only a means of resetting the tabs back to a known state—presumably the “standard” of tabs every eight positions. The following features were omitted:

• Setting tab stops via the first line in a file, using −f. Since even the SVID has no complete explanation of this feature, it is doubtful that it is in widespread use.

In an early proposal, a −t tablist option was added for consistency with expand; this was later removed when inconsistencies with the historical list of tabs were identified.

Consideration was given to adding a −p option that would output the current tab settings so that they could be saved and then later restored. This was not accepted because querying the tab stops of the terminal is not a capability in historical terminfo or termcap facilities and might not be supported on a wide range of terminals.

FUTURE DIRECTIONS
None.

SEE ALSO
expand, stty, tput, unexpand
34754 CHANGE HISTORY
34755 First released in Issue 2.
34756 Issue 6
34757 This utility is marked as part of the User Portability Utilities option.
34758 The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
tail — copy the last part of a file

SYNOPSIS
tail [-f] [-c number| -n number][file]

DESCRIPTION
The tail utility shall copy its input file to the standard output beginning at a designated place.
Copying shall begin at the point in the file indicated by the -c number or -n number options. The option-argument number shall be counted in units of lines or bytes, according to the options -n and -c. Both line and byte counts start from 1.
Tails relative to the end of the file may be saved in an internal buffer, and thus may be limited in length. Such a buffer, if any, shall be no smaller than {LINE_MAX}*10 bytes.

OPTIONS
The following options shall be supported:

-c number The application shall ensure that the number option-argument is a decimal integer whose sign affects the location in the file, measured in bytes, to begin the copying:

<table>
<thead>
<tr>
<th>Sign</th>
<th>Copying Starts</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Relative to the beginning of the file.</td>
</tr>
<tr>
<td>-</td>
<td>Relative to the end of the file.</td>
</tr>
<tr>
<td>none</td>
<td>Relative to the end of the file.</td>
</tr>
</tbody>
</table>

The origin for counting shall be 1; that is, -c +1 represents the first byte of the file, -c -1 the last.

-f If the input file is a regular file or if the file operand specifies a FIFO, do not terminate after the last line of the input file has been copied, but read and copy further bytes from the input file when they become available. If no file operand is specified and standard input is a pipe, the -f option shall be ignored. If the input file is not a FIFO, pipe, or regular file, it is unspecified whether or not the -f option shall be ignored.

-n number This option shall be equivalent to -c number, except the starting location in the file shall be measured in lines instead of bytes. The origin for counting shall be 1; that is, -n +1 represents the first line of the file, -n -1 the last.

If neither -c nor -n is specified, -n 10 shall be assumed.

OPERANDS
The following operand shall be supported:

file A pathname of an input file. If no file operands are specified, the standard input shall be used.

STDIN
The standard input shall be used only if no file operands are specified. See the INPUT FILES section.
INPUT FILES
If the −c option is specified, the input file can contain arbitrary data; otherwise, the input file shall be a text file.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of tail:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

XSI_NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT The designated portion of the input file shall be written to standard output.

STDERR The standard error shall be used only for diagnostic messages.

OUTPUT FILES None.

EXTENDED DESCRIPTION None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The −c option should be used with caution when the input is a text file containing multi-byte characters; it may produce output that does not start on a character boundary.

Although the input file to tail can be any type, the results might not be what would be expected on some character special device files or on file types not described by the System Interfaces volume of IEEE Std 1003.1-2001. Since this volume of IEEE Std 1003.1-2001 does not specify the block size used when doing input, tail need not read all of the data from devices that only perform block transfers.
EXAMPLES

The -f option can be used to monitor the growth of a file that is being written by some other process. For example, the command:

tail -f fred

prints the last ten lines of the file fred, followed by any lines that are appended to fred between the time tail is initiated and killed. As another example, the command:

tail -f -c 15 fred

prints the last 15 bytes of the file fred, followed by any bytes that are appended to fred between the time tail is initiated and killed.

RATIONALE

This version of tail was created to allow conformance to the Utility Syntax Guidelines. The historical -b option was omitted because of the general non-portability of block-sized units of text. The -c option historically meant "characters", but this volume of IEEE Std 1003.1-2001 indicates that it means "bytes". This was selected to allow reasonable implementations when multi-byte characters are possible; it was not named -b to avoid confusion with the historical -b.

The origin of counting both lines and bytes is 1, matching all widespread historical implementations.

The restriction on the internal buffer is a compromise between the historical System V implementation of 4096 bytes and the BSD 32768 bytes.

The -f option has been implemented as a loop that sleeps for 1 second and copies any bytes that are available. This is sufficient, but if more efficient methods of determining when new data are available are developed, implementations are encouraged to use them.

Historical documentation indicates that tail ignores the -f option if the input file is a pipe (pipe and FIFO on systems that support FIFOs). On BSD-based systems, this has been true; on System V-based systems, this was true when input was taken from standard input, but it did not ignore the -f flag if a FIFO was named as the file operand. Since the -f option is not useful on pipes and all historical implementations ignore -f if no file operand is specified and standard input is a pipe, this volume of IEEE Std 1003.1-2001 requires this behavior. However, since the -f option is useful on a FIFO, this volume of IEEE Std 1003.1-2001 also requires that if standard input is a FIFO or a FIFO is named, the -f option shall not be ignored. Although historical behavior does not ignore the -f option for other file types, this is unspecified so that implementations are allowed to ignore the -f option if it is known that the file cannot be extended.

This was changed to the current form based on comments noting that -c was almost never used without specifying a number and that there was no need to specify -1 if -n number was given.

FUTURE DIRECTIONS

None.

SEE ALSO

head

CHANGE HISTORY

First released in Issue 2.

Issue 6

The obsolescent SYNOPSIS lines and associated text are removed.

The normative text is reworded to avoid use of the term "must" for application requirements.
NAME

talk — talk to another user

SYNOPSIS

```
talk address [terminal]
```

DESCRIPTION

The `talk` utility is a two-way, screen-oriented communication program.
When first invoked, `talk` shall send a message similar to:

```
Message from <unspecified string>
talk: connection requested by your_address
talk: respond with: talk your_address
```

to the specified `address`. At this point, the recipient of the message can reply by typing:

```
talk your_address
```

Once communication is established, the two parties can type simultaneously, with their output displayed in separate regions of the screen. Characters shall be processed as follows:

- Typing the alert character shall alert the recipient’s terminal.
- Typing `<control>-L` shall cause the sender’s screen regions to be refreshed.
- Typing the erase and kill characters shall affect the sender’s terminal in the manner described by the `termios` interface in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.
- Typing the interrupt or end-of-file characters shall terminate the local `talk` utility. Once the `talk` session has been terminated on one side, the other side of the `talk` session shall be notified that the `talk` session has been terminated and shall be able to do nothing except exit.
- Typing characters from `LC_CTYPE` classifications `print` or `space` shall cause those characters to be sent to the recipient’s terminal.
- When and only when the `stty iexten` local mode is enabled, the existence and processing of additional special control characters and multi-byte or single-byte functions shall be implementation-defined.
- Typing other non-printable characters shall cause implementation-defined sequences of printable characters to be sent to the recipient’s terminal.

Permission to be a recipient of a `talk` message can be denied or granted by use of the `mesg` utility.
However, a user’s privilege may further constrain the domain of accessibility of other users’ terminals. The `talk` utility shall fail when the user lacks the appropriate privileges to perform the requested action.

Certain block-mode terminals do not have all the capabilities necessary to support the simultaneous exchange of messages required for `talk`. When this type of exchange cannot be supported on such terminals, the implementation may support an exchange with reduced levels of simultaneous interaction or it may report an error describing the terminal-related deficiency.

OPTIONS

None.
OPERANDS
The following operands shall be supported:

address  The recipient of the talk session. One form of address is the <user name>, as returned by the who utility. Other address formats and how they are handled are unspecified.

terminal  If the recipient is logged in more than once, the terminal argument can be used to indicate the appropriate terminal name. If terminal is not specified, the talk message shall be displayed on one or more accessible terminals in use by the recipient. The format of terminal shall be the same as that returned by the who utility.

STDIN
Characters read from standard input shall be copied to the recipient’s terminal in an unspecified manner. If standard input is not a terminal, talk shall write a diagnostic message and exit with a non-zero status.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of talk:

LANG  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files). If the recipient’s locale does not use an LC_CTYPE equivalent to the sender’s, the results are undefined.

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

XSI_NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

TERM  Determine the name of the invoker’s terminal type. If this variable is unset or null, an unspecified default terminal type shall be used.

ASYNCHRONOUS EVENTS
When the talk utility receives a SIGINT signal, the utility shall terminate and exit with a zero status. It shall take the standard action for all other signals.

STDOUT
If standard output is a terminal, characters copied from the recipient’s standard input may be written to standard output. Standard output also may be used for diagnostic messages. If standard output is not a terminal, talk shall exit with a non-zero status.

STDERR
None.
OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0  Successful completion.
>0  An error occurred or talk was invoked on a terminal incapable of supporting it.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Because the handling of non-printable, non-space characters is tied to the stty description of iexten, implementation extensions within the terminal driver can be accessed. For example, some implementations provide line editing functions with certain control character sequences.

EXAMPLES
None.

RATIONALE
The write utility was included in this volume of IEEE Std 1003.1-2001 since it can be implemented on all terminal types. The talk utility, which cannot be implemented on certain terminals, was considered to be a “better” communications interface. Both of these programs are in widespread use on historical implementations. Therefore, both utilities have been specified.

All references to networking abilities (talking to a user on another system) were removed as being outside the scope of this volume of IEEE Std 1003.1-2001.

Historical BSD and System V versions of talk terminate both of the conversations when either user breaks out of the session. This can lead to adverse consequences if a user unwittingly continues to enter text that is interpreted by the shell when the other terminates the session. Therefore, the version of talk specified by this volume of IEEE Std 1003.1-2001 requires both users to terminate their end of the session explicitly.

Only messages sent to the terminal of the invoking user can be internationalized in any way:

- The original “Message from <unspecified string> …” message sent to the terminal of the recipient cannot be internationalized because the environment of the recipient is as yet inaccessible to the talk utility. The environment of the invoking party is irrelevant.
- Subsequent communication between the two parties cannot be internationalized because the two parties may specify different languages in their environment (and non-portable characters cannot be mapped from one language to another).
- Neither party can be required to communicate in a language other than C and/or the one specified by their environment because unavailable terminal hardware support (for example, fonts) may be required.

The text in the STDOUT section reflects the usage of the verb “display” in this section; some talk implementations actually use standard output to write to the terminal, but this volume of IEEE Std 1003.1-2001 does not require that to be the case.

The format of the terminal name is unspecified, but the descriptions of ps, talk, who, and write require that they all use or accept the same format.
The handling of non-printable characters is partially implementation-defined because the details
of mapping them to printable sequences is not needed by the user. Historical implementations,
for security reasons, disallow the transmission of non-printable characters that may send
commands to the other terminal.

FUTURE DIRECTIONS
None.

SEE ALSO
msg, stty, who, write, the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General
Terminal Interface

CHANGE HISTORY
First released in Issue 4.

Issue 6
This utility is marked as part of the User Portability Utilities option.
NAME
te — duplicate standard input

SYNOPSIS
tee [-ai][file...]

DESCRIPTION
The tee utility shall copy standard input to standard output, making a copy in zero or more files.
The tee utility shall not buffer output.
If the −a option is not specified, output files shall be written (see Section 1.7.1.4 (on page 4).

OPTIONS
The tee utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.
The following options shall be supported:
−a Append the output to the files.
−i Ignore the SIGINT signal.

OPERANDS
The following operands shall be supported:
file A pathname of an output file. Processing of at least 13 file operands shall be supported.

STDIN
The standard input can be of any type.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of tee:
LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).
LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default, except that if the −i option was specified, SIGINT shall be ignored.
STDOUT

The standard output shall be a copy of the standard input.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

If any file operands are specified, the standard input shall be copied to each named file.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

  0  The standard input was successfully copied to all output files.

  >0  An error occurred.

CONSEQUENCES OF ERRORS

If a write to any successfully opened file operand fails, writes to other successfully opened file operands and standard output shall continue, but the exit status shall be non-zero. Otherwise, the default actions specified in Section 1.11 (on page 20) apply.

APPLICATION USAGE

The tee utility is usually used in a pipeline, to make a copy of the output of some utility.

The file operand is technically optional, but tee is no more useful than cat when none is specified.

EXAMPLES

Save an unsorted intermediate form of the data in a pipeline:

  ... | tee unsorted | sort > sorted

RATIONALE

The buffering requirement means that tee is not allowed to use ISO C standard fully buffered or line-buffered writes. It does not mean that tee has to do 1-byte reads followed by 1-byte writes.

It should be noted that early versions of BSD ignore any invalid options and accept a single ‘−’ as an alternative to −i. They also print a message if unable to open a file:

  "tee: cannot access %s\n", <pathname>

Historical implementations ignore write errors. This is explicitly not permitted by this volume of IEEE Std 1003.1-2001.

Some historical implementations use O_APPEND when providing append mode; others use the lseek() function to seek to the end-of-file after opening the file without O_APPEND. This volume of IEEE Std 1003.1-2001 requires functionality equivalent to using O_APPEND; see Section 1.7.1.4 (on page 4).

FUTURE DIRECTIONS

None.

SEE ALSO

Chapter 1 (on page 1), cat, the System Interfaces volume of IEEE Std 1003.1-2001, lseek()

CHANGE HISTORY

First released in Issue 2.
IEEE PASC Interpretation 1003.2 #168 is applied.
NAME
   test — evaluate expression

SYNOPSIS
   test [expression]
   [ [expression] ]

DESCRIPTION
   The test utility shall evaluate the expression and indicate the result of the evaluation by its exit
   status. An exit status of zero indicates that the expression evaluated as true and an exit status of
   1 indicates that the expression evaluated as false.

   In the second form of the utility, which uses " [] " rather than test, the application shall ensure
   that the square brackets are separate arguments.

OPTIONS
   The test utility shall not recognize the " -- " argument in the manner specified by guideline 10 in
   No options shall be supported.

OPERANDS
   The application shall ensure that all operators and elements of primaries are presented as
   separate arguments to the test utility.

   The following primaries can be used to construct expression:

      -b file   True if file exists and is a block special file.
      -c file   True if file exists and is a character special file.
      -d file   True if file exists and is a directory.
      -e file   True if file exists.
      -f file   True if file exists and is a regular file.
      -g file   True if file exists and its set-group-ID flag is set.
      -h file   True if file exists and is a symbolic link.
      -L file   True if file exists and is a symbolic link.
      -n string True if the length of string is non-zero.
      -p file   True if file is a FIFO.
      -r file   True if file exists and is readable. True shall indicate that permission to read from
                 file will be granted, as defined in Section 1.7.1.4 (on page 4).
      -S file   True if file exists and is a socket.
      -s file   True if file exists and has a size greater than zero.
      -t file_descriptor
                 True if the file whose file descriptor number is file_descriptor is open and is
                 associated with a terminal.
      -u file   True if file exists and its set-user-ID flag is set.
      -w file   True if file exists and is writable. True shall indicate that permission to write from
                 file will be granted, as defined in Section 1.7.1.4 (on page 4).
−x file  True if file exists and is executable. True shall indicate that permission to execute file will be granted, as defined in Section 1.7.1.4 (on page 4). If file is a directory, true shall indicate that permission to search file will be granted.

−z string  True if the length of string string is zero.

string  True if the string string is not the null string.

s1 = s2  True if the strings s1 and s2 are identical.

s1 != s2  True if the strings s1 and s2 are not identical.

n1 −eq n2  True if the integers n1 and n2 are algebraically equal.

n1 −ne n2  True if the integers n1 and n2 are not algebraically equal.

n1 −gt n2  True if the integer n1 is algebraically greater than the integer n2.

n1 −ge n2  True if the integer n1 is algebraically greater than or equal to the integer n2.

n1 −lt n2  True if the integer n1 is algebraically less than the integer n2.

n1 −le n2  True if the integer n1 is algebraically less than or equal to the integer n2.

XSI expression1 −a expression2  True if both expression1 and expression2 are true. The −a binary primary is left associative. It has a higher precedence than −o.

XSI expression1 −o expression2  True if either expression1 or expression2 is true. The −o binary primary is left associative.

With the exception of the −h file and −L file primaries, if a file argument is a symbolic link, test shall evaluate the expression by resolving the symbolic link and using the file referenced by the link.

These primaries can be combined with the following operators:

! expression  True if expression is false.

(expression )  True if expression is true. The parentheses can be used to alter the normal precedence and associativity.

The primaries with two elements of the form:

−primary_operator primary_operand

are known as unary primaries. The primaries with three elements in either of the two forms:

primary_operand −primary_operator primary_operand

primary_operand primary_operator primary_operand

are known as binary primaries. Additional implementation-defined operators and primary_operators may be provided by implementations. They shall be of the form −operator where the first character of operator is not a digit.

The algorithm for determining the precedence of the operators and the return value that shall be generated is based on the number of arguments presented to test. (However, when using the "[...]" form, the right-bracket final argument shall not be counted in this algorithm.)

In the following list, $1, $2, $3, and $4 represent the arguments presented to test:

0 arguments:  Exit false (1).
Utilities

1 argument: Exit true (0) if $1 is not null; otherwise, exit false.

2 arguments:
• If $1 is ‘!’, exit true if $2 is null, false if $2 is not null.
• If $1 is a unary primary, exit true if the unary test is true, false if the unary test is false.
• Otherwise, produce unspecified results.

3 arguments:
• If $2 is a binary primary, perform the binary test of $1 and $3.
• If $1 is ‘!’, negate the two-argument test of $2 and $3.
• If $1 is ‘((' and $3 is ‘) ’), perform the unary test of $2.
• Otherwise, produce unspecified results.

4 arguments:
• If $1 is ‘!’, negate the three-argument test of $2, $3, and $4.
• If $1 is ‘((' and $4 is ‘) ’), perform the two-argument test of $2 and $3.
• Otherwise, the results are unspecified.

>4 arguments: The results are unspecified.

On XSI-conformant systems, combinations of primaries and operators shall be evaluated using the precedence and associativity rules described previously. In addition, the string comparison binary primaries ‘=’ and ‘! =’ shall have a higher precedence than any unary primary.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of test:

LANG
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.
STDOUT
Not used.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  expression evaluated to true.
1  expression evaluated to false or expression was missing.
>1  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Scripts should be careful when dealing with user-supplied input that could be confused with
primaries and operators. Unless the application writer knows all the cases that produce input to
the script, invocations like:

test "$1" −a "$2"

should be written as:

test "$1" && test "$2"

to avoid problems if a user supplied values such as $1 set to ‘!’ and $2 set to the null string.
That is, in cases where maximal portability is of concern, replace:

test expr1 −a expr2

with:

test expr1 && test expr2

and replace:

test expr1 −o expr2

with:

test expr1 || test expr2

but note that, in test, −a has higher precedence than −o while "&&" and "||" have equal
precedence in the shell.

Parentheses or braces can be used in the shell command language to effect grouping.
Parentheses must be escaped when using sh; for example:

test \( expr1 −a expr2 \) −o expr3

This command is not always portable outside XSI-conformant systems. The following form can
be used instead:
The two commands:

```bash
test "$1"
test ! "$1"
```

could not be used reliably on some historical systems. Unexpected results would occur if such a string expression were used and $1 expanded to ‘!’, ‘(’, or a known unary primary. Better constructs are:

```bash
test -n "$1"
test -z "$1"
```

respectively.

Historical systems have also been unreliable given the common construct:

```bash
test "$response" = "expected string"
```

One of the following is a more reliable form:

```bash
test "X$response" = "Xexpected string"
test "expected string" = "$response"
```

Note that the second form assumes that expected string could not be confused with any unary primary. If expected string starts with ‘−’, ‘(’, ‘!’, or even ‘=’, the first form should be used instead. Using the preceding rules without the XSI marked extensions, any of the three comparison forms is reliable, given any input. (However, note that the strings are quoted in all cases.)

Because the string comparison binary primaries, ‘=’ and "!=", have a higher precedence than any unary primary in the greater than 4 argument case, unexpected results can occur if arguments are not properly prepared. For example, in:

```bash
test -d $1 -o -d $2
```

If $1 evaluates to a possible directory name of ‘=’, the first three arguments are considered a string comparison, which shall cause a syntax error when the second -d is encountered. One of the following forms prevents this; the second is preferred:

```bash
test \( -d "$1" \) -o \( -d "$2" \)
test -d "$1" || test -d "$2"
```

Also in the greater than 4 argument case:

```bash
test "$1" = "bat" -a "$2" = "ball"
```

syntax errors occur if $1 evaluates to ‘(’ or ‘!’. One of the following forms prevents this; the third is preferred:

```bash
test "X$1" = "Xbat" -a "X$2" = "Xball"
test "$1" = "bat" && test "$2" = "ball"
test "X$1" = "Xbat" && test "X$2" = "Xball"
```

**EXAMPLES**

1. Exit if there are not two or three arguments (two variations):

```bash
if [ $# -ne 2 -a $# -ne 3 ]; then exit 1; fi
if [ $# -lt 2 -o $# -gt 3 ]; then exit 1; fi
```
2. Perform a `mkdir` if a directory does not exist:
   ```bash
   test ! -d tempdir && mkdir tempdir
   ```

3. Wait for a file to become non-readable:
   ```bash
   while test -r thefile
do
   sleep 30
done
echo '"thefile" is no longer readable'
   ```

4. Perform a command if the argument is one of three strings (two variations):
   ```bash
   if [ "$1" = "pear" ] || [ "$1" = "grape" ] || [ "$1" = "apple" ]
   then
command
fi
case "$1" in
  pear|grape|apple) command ;;
esac
   ```

RATIONALE

The KornShell-derived conditional command (double bracket `[[ ]]`) was removed from the shell command language description in an early proposal. Objections were raised that the real problem is misuse of the `test` command (`[]`), and putting it into the shell is the wrong way to fix the problem. Instead, proper documentation and a new shell reserved word (!) are sufficient.

Tests that require multiple `test` operations can be done at the shell level using individual invocations of the `test` command and shell logicals, rather than using the error-prone `-o` flag of `test`.

XSI-conformant systems support more than four arguments.

XSI-conformant systems support the combining of primaries with the following constructs:

- `expression1 -a expression2`
  True if both `expression1` and `expression2` are true.

- `expression1 -o expression2`
  True if at least one of `expression1` and `expression2` are true.

- `( expression )`
  True if `expression` is true.

In evaluating these more complex combined expressions, the following precedence rules are used:

- The unary primaries have higher precedence than the algebraic binary primaries.
- The unary primaries have lower precedence than the string binary primaries.
- The unary and binary primaries have higher precedence than the unary `string` primary.
- The `!` operator has higher precedence than the `-a` operator, and the `-a` operator has higher precedence than the `-o` operator.
- The `-a` and `-o` operators are left associative.
- The parentheses can be used to alter the normal precedence and associativity.
The BSD and System V versions of \(-f\) are not the same. The BSD definition was:

\[-f \text{file} \quad \text{True if file exists and is not a directory.}\]

The SVID version (true if the file exists and is a regular file) was chosen for this volume of IEEE Std 1003.1-2001 because its use is consistent with the \(-b, -c, -d,\) and \(-p\) operands (file exists and is a specific file type).

The \(-e\) primary, possessing similar functionality to that provided by the C shell, was added because it provides the only way for a shell script to find out if a file exists without trying to open the file. Since implementations are allowed to add additional file types, a portable script cannot use:

\[
\text{test} \quad -b \text{foo} \quad -o \quad -c \text{foo} \quad -o \quad -d \text{foo} \quad -o \quad -f \text{foo} \quad -o \quad -p \text{foo}
\]

to find out if \text{foo} is an existing file. On historical BSD systems, the existence of a file could be determined by:

\[
\text{test} \quad -f \text{foo} \quad -o \quad -d \text{foo}
\]

but there was no easy way to determine that an existing file was a regular file. An early proposal used the KornShell \(-a\) primary (with the same meaning), but this was changed to \(-e\) because there were concerns about the high probability of humans confusing the \(-a\) primary with the \(-a\) binary operator.

The following options were not included in this volume of IEEE Std 1003.1-2001, although they are provided by some implementations. These operands should not be used by new implementations for other purposes:

\[-k \text{file} \quad \text{True if file exists and its sticky bit is set.}\]
\[-C \text{file} \quad \text{True if file is a contiguous file.}\]
\[-V \text{file} \quad \text{True if file is a version file.}\]

The following option was not included because it was undocumented in most implementations, has been removed from some implementations (including System V), and the functionality is provided by the shell (see Section 2.6.2 (on page 37).

\[-l \text{string} \quad \text{The length of the string string.}\]

The \(-b, -c, -g, -p, -u,\) and \(-x\) operands are derived from the SVID; historical BSD does not provide them. The \(-k\) operand is derived from System V; historical BSD does not provide it.

On historical BSD systems, \text{test} \(-w \text{directory}\) always returned false because \text{test} tried to open the directory for writing, which always fails.

Some additional primaries newly invented or from the KornShell appeared in an early proposal as part of the conditional command ([[]]): \text{s1 > s2}, \text{s1 < s2}, \text{str = pattern}, \text{str ! = pattern}, \text{f1 -nt f2}, \text{f1 -ot f2}, \text{and f1 -ef f2}. They were not carried forward into the \text{test} utility when the conditional command was removed from the shell because they have not been included in the \text{test} utility built into historical implementations of the \text{sh} utility.

The \(-t \text{file_descriptor}\) primary is shown with a mandatory argument because the grammar is ambiguous if it can be omitted. Historical implementations have allowed it to be omitted, providing a default of 1.

**FUTURE DIRECTIONS**

None.
SEE ALSO
Section 1.7.1.4 (on page 4), *find*

CHANGE HISTORY
First released in Issue 2.

**Issue 5**
The FUTURE DIRECTIONS section is added.

**Issue 6**
The \( -h \) operand is added for symbolic links, and access permission requirements are clarified for the \( -r, -w, \) and \( -x \) operands to align with the IEEE P1003.2b draft standard.
The normative text is reworded to avoid use of the term “must” for application requirements.
The \( -L \) and \( -S \) operands are added for symbolic links and sockets.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/38 is applied, adding XSI margin marking and shading to a line in the OPERANDS section referring to the use of parentheses as arguments to the *test* utility.
NAME

time — time a simple command

SYNOPSIS

    time [-p] utility [argument...]

DESCRIPTION

The time utility shall invoke the utility named by the utility operand with arguments supplied as the argument operands and write a message to standard error that lists timing statistics for the utility. The message shall include the following information:

- The elapsed (real) time between invocation of utility and its termination.
- The User CPU time, equivalent to the sum of the tms_utime and tms_cutime fields returned by the times() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 for the process in which utility is executed.
- The System CPU time, equivalent to the sum of the tms_stime and tms_cstime fields returned by the times() function for the process in which utility is executed.

The precision of the timing shall be no less than the granularity defined for the size of the clock tick unit on the system, but the results shall be reported in terms of standard time units (for example, 0.02 seconds, 00:00:00.02, 1m33.75s, 365.21 seconds), not numbers of clock ticks.

When time is used as part of a pipeline, the times reported are unspecified, except when it is the sole command within a grouping command (see Section 2.9.4.1 (on page 52)) in that pipeline. For example, the commands on the left are unspecified; those on the right report on utilities a and c, respectively:

    time a | b | c  { time a } | b | c
    a | b | time c  a | b | (time c)

OPTIONS


The following option shall be supported:

    -p  Write the timing output to standard error in the format shown in the STDERR section.

OPERANDS

The following operands shall be supported:

    utility  The name of a utility that is to be invoked. If the utility operand names any of the special built-in utilities in Section 2.14 (on page 64), the results are undefined.

    argument  Any string to be supplied as an argument when invoking the utility named by the utility operand.

STDIN

Not used.

INPUT FILES

None.
ENVIROMENT VARIABLES
The following environment variables shall affect the execution of *time*:

**LANG**
Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

**LC_ALL**
If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE**
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic and informative messages written to standard error.

**LC_NUMERIC**
Determine the locale for numeric formatting.

**XSI**

**NLSPATH**
Determine the location of message catalogs for the processing of *LC_MESSAGES*.

**PATH**
Determine the search path that shall be used to locate the utility to be invoked; see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
The standard error shall be used to write the timing statistics. If *-p* is specified, the following format shall be used in the POSIX locale:

```
"real %f\nuser %f\nsys %f\n", <real seconds>, <user seconds>,
<system seconds>
```

where each floating-point number shall be expressed in seconds. The precision used may be less than the default six digits of %f, but shall be sufficiently precise to accommodate the size of the clock tick on the system (for example, if there were 60 clock ticks per second, at least two digits shall follow the radix character). The number of digits following the radix character shall be no less than one, even if this always results in a trailing zero. The implementation may append white space and additional information following the format shown here.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
If the *utility* utility is invoked, the exit status of *time* shall be the exit status of *utility*; otherwise, the *time* utility shall exit with one of the following values:

1-125 An error occurred in the *time* utility.
The utility specified by utility was found but could not be invoked.

The utility specified by utility could not be found.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The command, env, nice, nohup, time, and xargs utilities have been specified to use exit code 127 if an error occurs so that applications can distinguish “failure to find a utility” from “invoked utility exited with an error indication”. The value 127 was chosen because it is not commonly used for other meanings; most utilities use small values for “normal error conditions” and the values above 128 can be confused with termination due to receipt of a signal. The value 126 was chosen in a similar manner to indicate that the utility could be found, but not invoked. Some scripts produce meaningful error messages differentiating the 126 and 127 cases. The distinction between exit codes 126 and 127 is based on KornShell practice that uses 127 when all attempts to exec the utility fail with [ENOENT], and uses 126 when any attempt to exec the utility fails for any other reason.

EXAMPLES
It is frequently desirable to apply time to pipelines or lists of commands. This can be done by placing pipelines and command lists in a single file; this file can then be invoked as a utility, and the time applies to everything in the file.

Alternatively, the following command can be used to apply time to a complex command:

```
time sh -c 'complex-command-line'
```

RATIONALE
When the time utility was originally proposed to be included in the ISO POSIX-2: 1993 standard, questions were raised about its suitability for inclusion on the grounds that it was not useful for conforming applications, specifically:

- The underlying CPU definitions from the System Interfaces volume of IEEE Std 1003.1-2001 are vague, so the numeric output could not be compared accurately between systems or even between invocations.
- The creation of portable benchmark programs was outside the scope this volume of IEEE Std 1003.1-2001.

However, time does fit in the scope of user portability. Human judgement can be applied to the analysis of the output, and it could be very useful in hands-on debugging of applications or in providing subjective measures of system performance. Hence it has been included in this volume of IEEE Std 1003.1-2001.

The default output format has been left unspecified because historical implementations differ greatly in their style of depicting this numeric output. The -p option was invented to provide scripts with a common means of obtaining this information.

In the KornShell, time is a shell reserved word that can be used to time an entire pipeline, rather than just a simple command. The POSIX definition has been worded to allow this implementation. Consideration was given to invalidating this approach because of the historical model from the C shell and System V shell. However, since the System V time utility historically has not produced accurate results in pipeline timing (because the constituent processes are not all owned by the same parent process, as allowed by POSIX), it did not seem worthwhile to break historical KornShell usage.

The term utility is used, rather than command, to highlight the fact that shell compound commands, pipelines, special built-ins, and so on, cannot be used directly. However, utility
includes user application programs and shell scripts, not just the standard utilities.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
Chapter 2 (on page 29), **sh**, the System Interfaces volume of IEEE Std 1003.1-2001, **times()**

**CHANGE HISTORY**
First released in Issue 2.

**Issue 6**
This utility is marked as part of the User Portability Utilities option.
touch — change file access and modification times

SYNOPSIS

    touch [-acm] [ -r ref_file | -t time ] file...

DESCRIPTION

The touch utility shall change the modification times, access times, or both of files. The
modification time shall be equivalent to the value of the st_mtime member of the stat structure
for a file, as described in the System Interfaces volume of IEEE Std 1003.1-2001; the access time
shall be equivalent to the value of st_atime.

The time used can be specified by the -t time option-argument, the corresponding time fields of
the file referenced by the -r ref_file option-argument, or the date_time operand, as specified in the
following sections. If none of these are specified, touch shall use the current time (the value
returned by the equivalent of the time() function defined in the System Interfaces volume of

For each file operand, touch shall perform actions equivalent to the following functions defined
in the System Interfaces volume of IEEE Std 1003.1-2001:

  1. If file does not exist, a creat() function call is made with the file operand used as the path
     argument and the value of the bitwise-inclusive OR of S_IRUSR, S_IWUSR, S_IRGRP,
     S_IWGRP, S_IROTH, and S_IWOTH used as the mode argument.

  2. The utime() function is called with the following arguments:

     a. The file operand is used as the path argument.

     b. The utimbuf structure members actime and modtime are determined as described in
        the OPTIONS section.

OPTIONS

The touch utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

-a  Change the access time of file. Do not change the modification time unless -m is
     also specified.

-c  Do not create a specified file if it does not exist. Do not write any diagnostic
     messages concerning this condition.

-m  Change the modification time of file. Do not change the access time unless -a is
     also specified.

-r ref_file  Use the corresponding time of the file named by the pathname ref_file instead of
              the current time.

-t time    Use the specified time instead of the current time. The option-argument shall be a
decimal number of the form:

            [ [CC] YY] MMDDhhmm[ . SS]

where each two digits represents the following:

    MM    The month of the year [01,12].
    DD    The day of the month [01,31].

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The hour of the day [00,23].

The minute of the hour [00,59].

The first two digits of the year (the century).

The second two digits of the year.

The second of the minute [00,60].

Both CC and YY shall be optional. If neither is given, the current year shall be assumed. If YY is specified, but CC is not, CC shall be derived as follows:

<table>
<thead>
<tr>
<th>If YY is:</th>
<th>CC becomes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[69,99]</td>
<td>19</td>
</tr>
<tr>
<td>[00,68]</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: It is expected that in a future version of IEEE Std 1003.1-2001 the default century inferred from a 2-digit year will change. (This would apply to all commands accepting a 2-digit year as input.)

The resulting time shall be affected by the value of the TZ environment variable. If the resulting time value precedes the Epoch, touch shall exit immediately with an error status. The range of valid times past the Epoch is implementation-defined, but it shall extend to at least the time 0 hours, 0 minutes, 0 seconds, January 1, 2038, Coordinated Universal Time. Some implementations may not be able to represent dates beyond January 18, 2038, because they use signed int as a time holder.

The range for SS is [00,60] rather than [00,59] because of leap seconds. If SS is 60, and the resulting time, as affected by the TZ environment variable, does not refer to a leap second, the resulting time shall be one second after a time where SS is 59. If SS is not given a value, it is assumed to be zero.

If neither the −a nor −m options were specified, touch shall behave as if both the −a and −m options were specified.

The following operands shall be supported:

file A pathname of a file whose times shall be modified.

Not used.

None.

The following environment variables shall affect the execution of touch:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

 LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in


Utilities

touch

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

Determine the timezone to be used for interpreting the time option-argument. If TZ is unset or null, an unspecified default timezone shall be used.

Default.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

0  The utility executed successfully and all requested changes were made.

>0  An error occurred.

The interpretation of time is taken to be seconds since the Epoch (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 4.14, Seconds Since the Epoch). It should be noted that implementations conforming to the System Interfaces volume of IEEE Std 1003.1-2001 do not take leap seconds into account when computing seconds since the Epoch. When SS=60 is used, the resulting time always refers to 1 plus seconds since the Epoch for a time when SS=59.

Although the -t time option-argument specifies values in 1969, the access time and modification time fields are defined in terms of seconds since the Epoch (00:00:00 on 1 January 1970 UTC). Therefore, depending on the value of TZ when touch is run, there is never more than a few valid hours in 1969 and there need not be any valid times in 1969.

One ambiguous situation occurs if -t time is not specified, -r ref_file is not specified, and the first operand is an eight or ten-digit decimal number. A portable script can avoid this problem by using:

touch -- file

or:

touch ./file

in this case.
EXAMPLES
None.

RATIONALE
The functionality of touch is described almost entirely through references to functions in the System Interfaces volume of IEEE Std 1003.1-2001. In this way, there is no duplication of effort required for describing such side effects as the relationship of user IDs to the user database, permissions, and so on.

There are some significant differences between the touch utility in this volume of IEEE Std 1003.1-2001 and those in System V and BSD systems. They are upwards-compatible for historical applications from both implementations:

1. In System V, an ambiguity exists when a pathname that is a decimal number leads the operands; it is treated as a time value. In BSD, no time value is allowed; files may only be touched to the current time. The -t time construct solves these problems for future conforming applications (note that the -t option is not historical practice).

2. The inclusion of the century digits, CC, is also new. Note that a ten-digit time value is treated as if YY, and not CC, were specified. The caveat about the range of dates following the Epoch was included as recognition that some implementations are not able to represent dates beyond 18 January 2038 because they use signed int as a time holder.

The -r option was added because several comments requested this capability. This option was named -f in an early proposal, but was changed because the -f option is used in the BSD version of touch with a different meaning.

At least one historical implementation of touch incremented the exit code if -c was specified and the file did not exist. This volume of IEEE Std 1003.1-2001 requires exit status zero if no errors occur.

FUTURE DIRECTIONS
Applications should use the -r or -t options.

SEE ALSO
date, the System Interfaces volume of IEEE Std 1003.1-2001, creat(), time(), utime(), the Base Definitions volume of IEEE Std 1003.1-2001, <sys/stat.h>

CHANGE HISTORY
First released in Issue 2.

Issue 6
The obsolescent date_time operand is removed.

The Open Group Corrigendum U027/1 is applied. This extends the range of valid time past the Epoch to at least the time 0 hours, 0 minutes, 0 seconds, January 1, 2038, Coordinated Universal Time. This is a new requirement on POSIX implementations.

The range for seconds is changed from [00,61] to [00,60] to align with the ISO/IEC 9899:1999 standard, and to allow for positive leap seconds.
NAME
tput — change terminal characteristics

SYNOPSIS
up
tput [−T type] operand...

DESCRIPTION
The tput utility shall display terminal-dependent information. The manner in which this information is retrieved is unspecified. The information displayed shall clear the terminal screen, initialize the user’s terminal, or reset the user’s terminal, depending on the operand given. The exact consequences of displaying this information are unspecified.

OPTIONS

The following option shall be supported:

−T type  Indicate the type of terminal. If this option is not supplied and the TERM variable is unset or null, an unspecified default terminal type shall be used. The setting of type shall take precedence over the value in TERM.

OPERANDS
The following strings shall be supported as operands by the implementation in the POSIX locale:

clear  Display the clear-screen sequence.
init  Display the sequence that initializes the user’s terminal in an implementation-defined manner.
reset  Display the sequence that resets the user’s terminal in an implementation-defined manner.

If a terminal does not support any of the operations described by these operands, this shall not be considered an error condition.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of tput:

LANG  Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES  Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
**tput**

Utilities

35739 XSI **NLSPATH** Determine the location of message catalogs for the processing of `LC_MESSAGES`.

35740 **TERM** Determine the terminal type. If this variable is unset or null, and if the `-T` option is not specified, an unspecified default terminal type shall be used.

35742 **ASYNCHRONOUS EVENTS**

35743 Default.

35744 **STDOUT**

35745 If standard output is a terminal device, it may be used for writing the appropriate sequence to clear the screen or reset or initialize the terminal. If standard output is not a terminal device, undefined results occur.

35748 **STDERR**

35749 The standard error shall be used only for diagnostic messages.

35750 **OUTPUT FILES**

35751 None.

35752 **EXTENDED DESCRIPTION**

35753 None.

35754 **EXIT STATUS**

35755 The following exit values shall be returned:

35756 0  The requested string was written successfully.

35757 1  Unspecified.

35758 2  Usage error.

35759 3  No information is available about the specified terminal type.

35760 4  The specified operand is invalid.

35761 >4  An error occurred.

35762 **CONSEQUENCES OF ERRORS**

35763 If one of the operands is not available for the terminal, `tput` continues processing the remaining operands.

35765 **APPLICATION USAGE**

35766 The difference between resetting and initializing a terminal is left unspecified, as they vary greatly based on hardware types. In general, resetting is a more severe action.

35768 Some terminals use control characters to perform the stated functions, and on such terminals it might make sense to use `tput` to store the initialization strings in a file or environment variable for later use. However, because other terminals might rely on system calls to do this work, the standard output cannot be used in a portable manner, such as the following non-portable constructs:

35773 `ClearVar='tput clear'`

35774 `tput reset | mailx -s "Wake Up" ddg`

35775 **EXAMPLES**

35776 1. Initialize the terminal according to the type of terminal in the environmental variable `TERM`. This command can be included in a `.profile` file.

35777 `tput init`

35778

35779 2. Reset a 450 terminal.
tput -T 450 reset

**RATIONALE**

The list of operands was reduced to a minimum for the following reasons:

- The only features chosen were those that were likely to be used by human users interacting with a terminal.
- Specifying the full `terminfo` set was not considered desirable, but the standard developers did not want to select among operands.
- This volume of IEEE Std 1003.1-2001 does not attempt to provide applications with sophisticated terminal handling capabilities, as that falls outside of its assigned scope and intersects with the responsibilities of other standards bodies.

The difference between resetting and initializing a terminal is left unspecified as this varies greatly based on hardware types. In general, resetting is a more severe action.

The exit status of 1 is historically reserved for finding out if a Boolean operand is not set. Although the operands were reduced to a minimum, the exit status of 1 should still be reserved for the Boolean operands, for those sites that wish to support them.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`stty`, `tabs`

**CHANGE HISTORY**

First released in Issue 4.

This utility is marked as part of the User Portability Utilities option.
NAME
tr — translate characters

SYNOPSIS
tr [-c | -C] string1 string2
tr -s [-c | -C] string1
tr -d [-c | -C] string1
tr -ds [-c | -C] string1 string2

DESCRIPTION
The tr utility shall copy the standard input to the standard output with substitution or deletion of selected characters. The options specified and the string1 and string2 operands shall control translations that occur while copying characters and single-character collating elements.

OPTIONS

The following options shall be supported:
-c Complement the set of values specified by string1. See the EXTENDED DESCRIPTION section.
-C Complement the set of characters specified by string1. See the EXTENDED DESCRIPTION section.
-d Delete all occurrences of input characters that are specified by string1.
-s Replace instances of repeated characters with a single character, as described in the EXTENDED DESCRIPTION section.

OPERANDS
The following operands shall be supported:

string1, string2
Translation control strings. Each string shall represent a set of characters to be converted into an array of characters used for the translation. For a detailed description of how the strings are interpreted, see the EXTENDED DESCRIPTION section.

STDIN
The standard input can be any type of file.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of tr:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_COLLATE Determine the locale for the behavior of range expressions and equivalence classes.
Utilities

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments) and the behavior of character classes.

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**xsi** NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

The tr output shall be identical to the input, with the exception of the specified transformations.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

None.

**EXTENDED DESCRIPTION**

The operands string1 and string2 (if specified) define two arrays of characters. The constructs in the following list can be used to specify characters or single-character collating elements. If any of the constructs result in multi-character collating elements, tr shall exclude, without a diagnostic, those multi-character elements from the resulting array.

Any character not described by one of the conventions below shall represent itself.

Octal sequences can be used to represent characters with specific coded values. An octal sequence shall consist of a backslash followed by the longest sequence of one, two, or three-octal-digit characters (01234567). The sequence shall cause the value whose encoding is represented by the one, two, or three-digit octal integer to be placed into the array. If the size of a byte on the system is greater than nine bits, the valid escape sequence used to represent a byte is implementation-defined. Multi-byte characters require multiple, concatenated escape sequences of this type, including the leading ‘\’ for each byte.

The backslash-escape sequences in the Base Definitions volume of IEEE Std 1003.1-2001, Table 5-1, Escape Sequences and Associated Actions (‘\’, ‘\a’, ‘\b’, ‘\f’, ‘\n’, ‘\r’, ‘\t’, ‘\v’) shall be supported. The results of using any other character, other than an octal digit, following the backslash are unspecified.

In the POSIX locale, this construct shall represent the range of collating elements between the range endpoints (as long as neither endpoint is an octal sequence of the form ‘\octal’), inclusive, as defined by the collation sequence. The characters or collating elements in the range shall be placed in the array in ascending collation sequence. If the second endpoint precedes the starting endpoint in the collation sequence, it is unspecified whether the range of collating elements is empty, or this construct is treated as invalid. In locales other than the POSIX locale, this construct has unspecified behavior.

If either or both of the range endpoints are octal sequences of the form ‘\octal’, this shall represent the range of specific coded values between the two range endpoints, inclusive.
[\texttt{class:}] Represents all characters belonging to the defined character class, as defined by the current setting of the \texttt{LC\_CTYPE} locale category. The following character class names shall be accepted when specified in \texttt{string1}:

\begin{verbatim}
alnum blank digit lower punct upper
alpha cntrl graph print space xdigit
\end{verbatim}

XSI

\texttt{xsi}

In addition, character class expressions of the form \texttt{[name:]\}} shall be recognized in those locales where the \texttt{name} keyword has been given a \texttt{charclass} definition in the \texttt{LC\_CTYPE} category.

When both the \texttt{−d} and \texttt{−s} options are specified, any of the character class names shall be accepted in \texttt{string2}. Otherwise, only character class names \texttt{lower} or \texttt{upper} are valid in \texttt{string2} and then only if the corresponding character class (\texttt{upper} and \texttt{lower}, respectively) is specified in the same relative position in \texttt{string1}. Such a specification shall be interpreted as a request for case conversion. When \texttt{[lower:]} appears in \texttt{string1} and \texttt{[upper:]} appears in \texttt{string2}, the arrays shall contain the characters from the \texttt{toupper} mapping in the \texttt{LC\_CTYPE} category of the current locale. When \texttt{[upper:]} appears in \texttt{string1} and \texttt{[lower:]} appears in \texttt{string2}, the arrays shall contain the characters from the \texttt{tolower} mapping in the \texttt{LC\_CTYPE} category of the current locale. The first character from each mapping pair shall be in the array for \texttt{string1} and the second character from each mapping pair shall be in the array for \texttt{string2} in the same relative position.

Except for case conversion, the characters specified by a character class expression shall be placed in the array in an unspecified order.

If the name specified for \texttt{class} does not define a valid character class in the current locale, the behavior is undefined.

\[\texttt{equiv=}\]

Represents all characters or collating elements belonging to the same equivalence class as \texttt{equiv}, as defined by the current setting of the \texttt{LC\_COLLATE} locale category. An equivalence class expression shall be allowed only in \texttt{string1}, or in \texttt{string2} when it is being used by the combined \texttt{−d} and \texttt{−s} options. The characters belonging to the equivalence class shall be placed in the array in an unspecified order.

\texttt{[x\^{n}]} Represents \texttt{n} repeated occurrences of the character \texttt{x}. Because this expression is used to map multiple characters to one, it is only valid when it occurs in \texttt{string2}. If \texttt{n} is omitted or is zero, it shall be interpreted as large enough to extend the \texttt{string2}-based sequence to the length of the \texttt{string1}-based sequence. If \texttt{n} has a leading zero, it shall be interpreted as an octal value. Otherwise, it shall be interpreted as a decimal value.

When the \texttt{−d} option is not specified:

- Each input character found in the array specified by \texttt{string1} shall be replaced by the character in the same relative position in the array specified by \texttt{string2}. When the array specified by \texttt{string2} is shorter than the one specified by \texttt{string1}, the results are unspecified.

- If the \texttt{−C} option is specified, the complements of the characters specified by \texttt{string1} (the set of all characters in the current character set, as defined by the current setting of \texttt{LC\_CTYPE}, except for those actually specified in the \texttt{string1} operand) shall be placed in the array in ascending collation sequence, as defined by the current setting of \texttt{LC\_COLLATE}.

- If the \texttt{−c} option is specified, the complement of the values specified by \texttt{string1} shall be placed in the array in ascending order by binary value.
Because the order in which characters specified by character class expressions or equivalence class expressions is undefined, such expressions should only be used if the intent is to map several characters into one. An exception is case conversion, as described previously.

When the \(-d\) option is specified:

- Input characters found in the array specified by \(string1\) shall be deleted.
- When the \(-C\) option is specified with \(-d\), all characters except those specified by \(string1\) shall be deleted. The contents of \(string2\) are ignored, unless the \(-s\) option is also specified.
- When the \(-c\) option is specified with \(-d\), all values except those specified by \(string1\) shall be deleted. The contents of \(string2\) shall be ignored, unless the \(-s\) option is also specified.
- The same string cannot be used for both the \(-d\) and the \(-s\) option; when both options are specified, both \(string1\) (used for deletion) and \(string2\) (used for squeezing) shall be required.

When the \(-s\) option is specified, after any deletions or translations have taken place, repeated sequences of the same character shall be replaced by one occurrence of the same character, if the character is found in the array specified by the last operand. If the last operand contains a character class, such as the following example:

```
tr -s ’[:space:]’
```

the last operand’s array shall contain all of the characters in that character class. However, in a case conversion, as described previously, such as:

```
tr -s ’[:upper:]’ ’[:lower:]’
```

the last operand’s array shall contain only those characters defined as the second characters in each of the `toupper` or `tolower` character pairs, as appropriate.

An empty string used for \(string1\) or \(string2\) produces undefined results.

**EXIT STATUS**

The following exit values shall be returned:

- 0 All input was processed successfully.
- >0 An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

If necessary, \(string1\) and \(string2\) can be quoted to avoid pattern matching by the shell.

If an ordinary digit (representing itself) is to follow an octal sequence, the octal sequence must use the full three digits to avoid ambiguity.

When \(string2\) is shorter than \(string1\), a difference results between historical System V and BSD systems. A BSD system pads \(string2\) with the last character found in \(string2\). Thus, it is possible to do the following:

```
tr 0123456789 d
```

which would translate all digits to the letter ‘\(d\)’. Since this area is specifically unspecified in this volume of IEEE Std 1003.1-2001, both the BSD and System V behaviors are allowed, but a conforming application cannot rely on the BSD behavior. It would have to code the example in the following way:

```
tr 0123456789 ’[d*]’
```
It should be noted that, despite similarities in appearance, the string operands used by \texttt{tr} are not regular expressions.

Unlike some historical implementations, this definition of the \texttt{tr} utility correctly processes NUL characters in its input stream. NUL characters can be stripped by using:

\begin{verbatim}
tr -d \000
\end{verbatim}

**EXAMPLES**

1. The following example creates a list of all words in \texttt{file1} one per line in \texttt{file2}, where a word is taken to be a maximal string of letters.

   \begin{verbatim}
   tr -cs "[:alpha:]" "[\n*]" <file1 >file2
   \end{verbatim}

2. The next example translates all lowercase characters in \texttt{file1} to uppercase and writes the results to standard output.

   \begin{verbatim}
   tr "[:lower:]" "[:upper:]" <file1
   \end{verbatim}

3. This example uses an equivalence class to identify accented variants of the base character \texttt{'e'} in \texttt{file1}, which are stripped of diacritical marks and written to \texttt{file2}.

   \begin{verbatim}
   tr "=[e=]" e <file1 >file2
   \end{verbatim}

**RATIONALE**

In some early proposals, an explicit option \enquote{-n} was added to disable the historical behavior of stripping NUL characters from the input. It was considered that automatically stripping NUL characters from the input was not correct functionality. However, the removal of \enquote{-n} in a later proposal does not remove the requirement that \texttt{tr} correctly process NUL characters in its input stream. NUL characters can be stripped by using \texttt{tr -d \000}.

Historical implementations of \texttt{tr} differ widely in syntax and behavior. For example, the BSD version has not needed the bracket characters for the repetition sequence. The \texttt{tr} utility syntax is based more closely on the System V and XPG3 model while attempting to accommodate historical BSD implementations. In the case of the short \texttt{string2} padding, the decision was to UNSPECIFY the behavior and preserve System V and XPG3 scripts, which might find difficulty with the BSD method. The assumption was made that BSD users of \texttt{tr} have to make accommodations to meet the syntax defined here. Since it is possible to use the repetition sequence to duplicate the desired behavior, whereas there is no simple way to achieve the System V method, this was the correct, if not desirable, approach.

The use of octal values to specify control characters, while having historical precedents, is not portable. The introduction of escape sequences for control characters should provide the necessary portability. It is recognized that this may cause some historical scripts to break.

An early proposal included support for multi-character collating elements. It was pointed out that, while \texttt{tr} does employ some syntactical elements from REs, the aim of \texttt{tr} is quite different; ranges, for example, do not have a similar meaning (\enquote{any of the chars in the range matches\textquoteright}, versus \enquote{translate each character in the range to the output counterpart\textquoteright}). As a result, the previously included support for multi-character collating elements has been removed. What remains are ranges in current collation order (to support, for example, accented characters), character classes, and equivalence classes.

In XPG3 the \texttt{[class]} and \texttt{[equiv]} conventions are shown with double brackets, as in RE syntax. However, \texttt{tr} does not implement RE principles; it just borrows part of the syntax. Consequently, \texttt{[class]} and \texttt{[equiv]} should be regarded as syntactical elements on a par with \texttt{[x*n]}, which is not an RE bracket expression.
The standard developers will consider changes to tr that allow it to translate characters between different character encodings, or they will consider providing a new utility to accomplish this.

On historical System V systems, a range expression requires enclosing square-brackets, such as:

```
tr '[a-z]' '[A-Z]'
```

However, BSD-based systems did not require the brackets, and this convention is used here to avoid breaking large numbers of BSD scripts:

```
tr a-z A-Z
```

The preceding System V script will continue to work because the brackets, treated as regular characters, are translated to themselves. However, any System V script that relied on "a-z" representing the three characters 'a', '-', and 'z' have to be rewritten as "az-".

The ISO POSIX-2:1993 standard had a −c option that behaved similarly to the −C option, but did not supply functionality equivalent to the −c option specified in IEEE Std 1003.1-2001. This meant that historical practice of being able to specify tr −d\200−\377 (which would delete all bytes with the top bit set) would have no effect because, in the C locale, bytes with the values octal 200 to octal 377 are not characters.

The earlier version also said that octal sequences referred to collating elements and could be placed adjacent to each other to specify multi-byte characters. However, it was noted that this caused ambiguities because tr would not be able to tell whether adjacent octal sequences were intending to specify multi-byte characters or multiple single byte characters. IEEE Std 1003.1-2001 specifies that octal sequences always refer to single byte binary values.

FUTURE DIRECTIONS
None.

SEE ALSO
sed

CHANGE HISTORY
First released in Issue 2.

Issue 6
The −C operand is added, and the description of the −c operand is changed to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.
true

NAME
true — return true value

SYNOPSIS
true

DESCRIPTION
The true utility shall return with exit code zero.

OPTIONS
None.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
None.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.

STDERR
Not used.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
Zero.

CONSEQUENCES OF ERRORS
None.

APPLICATION USAGE
This utility is typically used in shell scripts, as shown in the EXAMPLES section. The special built-in utility : is sometimes more efficient than true.

EXAMPLES
This command is executed forever:

while true
do
command
done
The `true` utility has been retained in this volume of IEEE Std 1003.1-2001, even though the shell special built-in `:` provides similar functionality, because `true` is widely used in historical scripts and is less cryptic to novice script readers.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`false`, Section 2.9 (on page 47)

**CHANGE HISTORY**

First released in Issue 2.

**Issue 6**

IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/39 is applied, replacing the terms "None" and "Default" from the STDERR and EXIT STATUS sections, respectively, with terms as defined in Section 1.11 (on page 20).
NAME
tsort — topological sort

SYNOPSIS
XSI
tsort [file]

DESCRIPTION
The tsort utility shall write to standard output a totally ordered list of items consistent with a
partial ordering of items contained in the input.

The application shall ensure that the input consists of pairs of items (non-empty strings)
separated by <blank>s. Pairs of different items indicate ordering. Pairs of identical items
indicate presence, but not ordering.

OPTIONS
None.

OPERANDS
The following operand shall be supported:

file    A pathname of a text file to order. If no file operand is given, the standard input
        shall be used.

STDIN
The standard input shall be a text file that is used if no file operand is given.

INPUT FILES
The input file named by the file operand is a text file.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of tsort:

LANG    Provide a default value for the internationalization variables that are unset or null.
        (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
        Internationalization Variables for the precedence of internationalization variables
        used to determine the values of locale categories.)

LC_ALL  If set to a non-empty string value, override the values of all the other
        internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
        characters (for example, single-byte as opposed to multi-byte characters in
        arguments and input files).

LC_MESSAGES
        Determine the locale that should be used to affect the format and contents of
        diagnostic messages written to standard error.

NLSPATH  Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The standard output shall be a text file consisting of the order list produced from the partially
ordered input.
STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0  Successful completion.
>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The LC_COLLATE variable need not affect the actions of *tsort*. The output ordering is not lexicographic, but depends on the pairs of items given as input.

EXAMPLES
The command:

```bash
tsort <<EOF
abccde
gg
fgef
hh
EOF
```
produces the output:

```
a
b
c
d
e
f
g
h
```

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
None.

CHANGE HISTORY
First released in Issue 2.

Issue 6
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
tty — return user’s terminal name

SYNOPSIS
tty

DESCRIPTION
The tty utility shall write to the standard output the name of the terminal that is open as
standard input. The name that is used shall be equivalent to the string that would be returned by
the ttyname() function defined in the System Interfaces volume of IEEE Std 1003.1-2001.

OPTIONS
The tty utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.

OPERANDS
None.

STDOUT
While no input is read from standard input, standard input shall be examined to determine
whether or not it is a terminal, and, if so, to determine the name of the terminal.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of tty:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error and informative messages written to
standard output.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
If standard input is a terminal device, a pathname of the terminal as specified by the ttyname()
function defined in the System Interfaces volume of IEEE Std 1003.1-2001 shall be written in the
following format:
"%s
", <terminal name>
Otherwise, a message shall be written indicating that standard input is not connected to a
terminal. In the POSIX locale, the tty utility shall use the format:
"not a tty\n"

STDOUT
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:
0 Standard input is a terminal.
1 Standard input is not a terminal.
>1 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
This utility checks the status of the file open as standard input against that of an
implementation-defined set of files. It is possible that no match can be found, or that the match
found need not be the same file as that which was opened for standard input (although they are
the same device).

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
The System Interfaces volume of IEEE Std 1003.1-2001, isatty(), ttyname()

CHANGE HISTORY
First released in Issue 2.

Issue 5
The SYNOPSIS is changed to indicate two forms of the command, with the second form marked
as obsolete. This is a clarification and does not change the functionality published in previous
issues.

Issue 6
The obsolescent -s option is removed.
NAME
  type — write a description of command type

SYNOPSIS
  xsi  type name...

DESCRIPTION
  The *type* utility shall indicate how each argument would be interpreted if used as a command
  name.

OPTIONS
  None.

OPERANDS
  The following operand shall be supported:

  name  A name to be interpreted.

STDIN
  Not used.

INPUT FILES
  None.

ENVIRONMENT VARIABLES
  The following environment variables shall affect the execution of *type*:

  LANG  Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
  Internationalization Variables for the precedence of internationalization variables
  used to determine the values of locale categories.)

  LC_ALL  If set to a non-empty string value, override the values of all the other
           internationalization variables.

  LC_CTYPE  Determine the locale for the interpretation of sequences of bytes of text data as
            characters (for example, single-byte as opposed to multi-byte characters in
            arguments).

  LC_MESSAGES
            Determine the locale that should be used to affect the format and contents of
            diagnostic messages written to standard error.

  NLSPATH  Determine the location of message catalogs for the processing of *LC_MESSAGES*.

  PATH  Determine the location of name, as described in the Base Definitions volume of
        IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

ASYNCHRONOUS EVENTS
  Default.

STDOUT
  The standard output of *type* contains information about each operand in an unspecified format.
  The information provided typically identifies the operand as a shell built-in, function, alias, or
  keyword, and where applicable, may display the operand’s pathname.
### STDERR
The standard error shall be used only for diagnostic messages.

### OUTPUT FILES
None.

### EXTENDED DESCRIPTION
None.

### EXIT STATUS
The following exit values shall be returned:

- **0**: Successful completion.
- **>0**: An error occurred.

### CONSEQUENCES OF ERRORS
Default.

### APPLICATION USAGE
Since `type` must be aware of the contents of the current shell execution environment (such as the lists of commands, functions, and built-ins processed by `hash`), it is always provided as a shell regular built-in. If it is called in a separate utility execution environment, such as one of the following:

- `nohup type writer`
- `find . -type f | xargs type`

it might not produce accurate results.

### EXAMPLES
None.

### RATIONALE
None.

### FUTURE DIRECTIONS
None.

### SEE ALSO
`command`, `hash`

### CHANGE HISTORY
First released in Issue 2.
ulimit — set or report file size limit

SYNOPSIS
ulimit [-f] [blocks]

DESCRIPTION
The ulimit utility shall set or report the file-size writing limit imposed on files written by the shell and its child processes (files of any size may be read). Only a process with appropriate privileges can increase the limit.

OPTIONS

The following option shall be supported:

-f Set (or report, if no blocks operand is present), the file size limit in blocks. The -f option shall also be the default case.

OPERANDS
The following operand shall be supported:

blocks The number of 512-byte blocks to use as the new file size limit.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of ulimit:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The standard output shall be used when no blocks operand is present. If the current number of blocks is limited, the number of blocks in the current limit shall be written in the following format:
Utilities

ulimit

"%d\n", <number of 512-byte blocks>

If there is no current limit on the number of blocks, in the POSIX locale the following format shall be used:

"unlimited\n"

STDOUT

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0   Successful completion.

>0   A request for a higher limit was rejected or an error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Since ulimit affects the current shell execution environment, it is always provided as a shell regular built-in. If it is called in a separate utility execution environment, such as one of the following:

nohup ulimit -f 10000

env ulimit 10000

it does not affect the file size limit of the caller's environment.

Once a limit has been decreased by a process, it cannot be increased (unless appropriate privileges are involved), even back to the original system limit.

EXAMPLES

Set the file size limit to 51200 bytes:

ulimit -f 100

RATIONALE

None.

FUTURE DIRECTIONS

None.

SEE ALSO

The System Interfaces volume of IEEE Std 1003.1-2001, ulimit()

CHANGE HISTORY

First released in Issue 2.
NAME
   umask — get or set the file mode creation mask

SYNOPSIS
   umask [−S] [mask]

DESCRIPTION
   The umask utility shall set the file mode creation mask of the current shell execution
   environment (see Section 2.12 (on page 61)) to the value specified by the mask operand. This
   mask shall affect the initial value of the file permission bits of subsequently created files. If umask
   is called in a subshell or separate utility execution environment, such as one of the following:

      (umask 002)
      nohup umask ...
      find . −exec umask ... \;

   it shall not affect the file mode creation mask of the caller's environment.

   If the mask operand is not specified, the umask utility shall write to standard output the value of
   the invoking process' file mode creation mask.

OPTIONS
   The umask utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

   The following option shall be supported:

   −S
   Produce symbolic output.

   The default output style is unspecified, but shall be recognized on a subsequent invocation of
   umask on the same system as a mask operand to restore the previous file mode creation mask.

OPERANDS
   The following operand shall be supported:

   mask
   A string specifying the new file mode creation mask. The string is treated in the
   same way as the mode operand described in the EXTENDED DESCRIPTION
   section for chmod.

   For a symbolic_mode value, the new value of the file mode creation mask shall be
   the logical complement of the file permission bits portion of the file mode specified
   by the symbolic_mode string.

   In a symbolic_mode value, the permissions op characters '+' and '-' shall be
   interpreted relative to the current file mode creation mask; '+' shall cause the bits
   for the indicated permissions to be cleared in the mask; '-' shall cause the bits for
   the indicated permissions to be set in the mask.

   The interpretation of mode values that specify file mode bits other than the file
   permission bits is unspecified.

   In the octal integer form of mode, the specified bits are set in the file mode creation
   mask.

   The file mode creation mask shall be set to the resulting numeric value.

   The default output of a prior invocation of umask on the same system with no
   operand also shall be recognized as a mask operand.
STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of umask:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
When the mask operand is not specified, the umask utility shall write a message to standard
output that can later be used as a umask mask operand.

If −S is specified, the message shall be in the following format:

"u=%s,g=%s,o=%s\n", <owner permissions>, <group permissions>,
<other permissions>

where the three values shall be combinations of letters from the set [r, w, x]; the presence of a
letter shall indicate that the corresponding bit is clear in the file mode creation mask.

If a mask operand is specified, there shall be no output written to standard output.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 The file mode creation mask was successfully changed, or no mask operand was supplied.

>0 An error occurred.
CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Since umask affects the current shell execution environment, it is generally provided as a shell regular built-in.

In contrast to the negative permission logic provided by the file mode creation mask and the octal number form of the mask argument, the symbolic form of the mask argument specifies those permissions that are left alone.

EXAMPLES
Either of the commands:

umask a=rx,ug+w
umask 002

sets the mode mask so that subsequently created files have their S_IWOTH bit cleared.

After setting the mode mask with either of the above commands, the umask command can be used to write out the current value of the mode mask:

$ umask
0002

(The output format is unspecified, but historical implementations use the octal integer mode format.)

$ umask -S
u=rwx,g=rwx,o=rx

Either of these outputs can be used as the mask operand to a subsequent invocation of the umask utility.

Assuming the mode mask is set as above, the command:

umask g-w

sets the mode mask so that subsequently created files have their S_IWGRP and S_IWOTH bits cleared.

The command:

umask -- -w

sets the mode mask so that subsequently created files have all their write bits cleared. Note that mask operands -r, -w, -x or anything beginning with a hyphen, must be preceded by "--" to keep it from being interpreted as an option.

RATIONALE
Since umask affects the current shell execution environment, it is generally provided as a shell regular built-in. If it is called in a subshell or separate utility execution environment, such as one of the following:

(umask 002)
nohup umask ...
find . -exec umask ... \\;

it does not affect the file mode creation mask of the environment of the caller.

The description of the historical utility was modified to allow it to use the symbolic modes of chmod. The -s option used in early proposals was changed to -S because -s could be confused
with a symbolic_mode form of mask referring to the S_ISUID and S_ISGID bits.

The default output style is implementation-defined to permit implementors to provide migration to the new symbolic style at the time most appropriate to their users. A \texttt{-o} flag to force octal mode output was omitted because the octal mode may not be sufficient to specify all of the information that may be present in the file mode creation mask when more secure file access permission checks are implemented.

It has been suggested that trusted systems developers might appreciate ameliorating the requirement that the mode mask “affects” the file access permissions, since it seems access control lists might replace the mode mask to some degree. The wording has been changed to say that it affects the file permission bits, and it leaves the details of the behavior of how they affect the file access permissions to the description in the System Interfaces volume of IEEE Std 1003.1-2001.

\textbf{FUTURE DIRECTIONS}

None.

\textbf{SEE ALSO}

Chapter 2 (on page 29), \texttt{chmod}, the System Interfaces volume of IEEE Std 1003.1-2001, \texttt{umask()}.

\textbf{CHANGE HISTORY}

First released in Issue 2.

\textbf{Issue 6}

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

\textbullet{} The octal mode is supported.
NAME
unalias — remove alias definitions

SYNOPSIS
up
unalias alias-name ...
unalias -a

DESCRIPTION
The unalias utility shall remove the definition for each alias name specified. See Section 2.3.1 (on page 32). The aliases shall be removed from the current shell execution environment; see Section 2.12 (on page 61).

OPTIONS

The following option shall be supported:

-a Remove all alias definitions from the current shell execution environment.

OPERANDS
The following operand shall be supported:

alias-name The name of an alias to be removed.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of unalias:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
Not used.
STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.

EXTENDED DESCRIPTION

None.

EXIT STATUS

The following exit values shall be returned:

0    Successful completion.

>0    One of the alias-name operands specified did not represent a valid alias definition, or an error occurred.

CONSEQUENCES OF ERRORS

Default.

APPLICATION USAGE

Since unalias affects the current shell execution environment, it is generally provided as a shell regular built-in.

EXAMPLES

None.

RATIONALE

The unalias description is based on that from historical KornShell implementations. Known differences exist between that and the C shell. The KornShell version was adopted to be consistent with all the other KornShell features in this volume of IEEE Std 1003.1-2001, such as command line editing.

The -a option is the equivalent of the unalias * form of the C shell and is provided to address security concerns about unknown aliases entering the environment of a user (or application) through the allowable implementation-defined predefined alias route or as a result of an ENV file. (Although unalias could be used to simplify the "secure" shell script shown in the command rationale, it does not obviate the need to quote all command names. An initial call to unalias -a would have to be quoted in case there was an alias for unalias.)

FUTURE DIRECTIONS

None.

SEE ALSO

Chapter 2 (on page 29), alias

CHANGE HISTORY

First released in Issue 4.

Issue 6

This utility is marked as part of the User Portability Utilities option.
NAME
uname — return system name

SYNOPSIS
uname [-snrvma]

DESCRIPTION
By default, the uname utility shall write the operating system name to standard output. When
options are specified, symbols representing one or more system characteristics shall be written
to the standard output. The format and contents of the symbols are implementation-defined. On
systems conforming to the System Interfaces volume of IEEE Std 1003.1-2001, the symbols
written shall be those supported by the uname() function as defined in the System Interfaces

OPTIONS
The uname utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

-a Behave as though all of the options -mnrsv were specified.
-m Write the name of the hardware type on which the system is running to standard
output.
-n Write the name of this node within an implementation-defined communications
network.
-r Write the current release level of the operating system implementation.
-s Write the name of the implementation of the operating system.
-v Write the current version level of this release of the operating system
implementation.

If no options are specified, the uname utility shall write the operating system name, as if the -s
option had been specified.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of uname:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).
Utilities

uname

36681  **LC_MESSAGES**
36682  Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
36683
36684  **XSI**  **NLSPATH**  Determine the location of message catalogs for the processing of **LC_MESSAGES**.

36685  **ASYNCHRONOUS EVENTS**
36686  Default.

36687  **STDOUT**
36688  By default, the output shall be a single line of the following form:
36689        "%s
", <sysname>
36690  If the −a option is specified, the output shall be a single line of the following form:
36691        "%s %s %s %s %s\n", <sysname>, <nodename>, <release>,
36692            <version>, <machine>
36693  Additional implementation-defined symbols may be written; all such symbols shall be written at
36694  the end of the line of output before the <newline>.
36695  If options are specified to select different combinations of the symbols, only those symbols shall
36696  be written, in the order shown above for the −a option. If a symbol is not selected for writing, its
36697  corresponding trailing <blank>s also shall not be written.

36698  **STDERR**
36699  The standard error shall be used only for diagnostic messages.

36700  **OUTPUT FILES**
36701  None.

36702  **EXTENDED DESCRIPTION**
36703  None.

36704  **EXIT STATUS**
36705  The following exit values shall be returned:
36706        0  The requested information was successfully written.
36707        >0  An error occurred.

36708  **CONSEQUENCES OF ERRORS**
36709  Default.

36710  **APPLICATION USAGE**
36711  Note that any of the symbols could include embedded <space>s, which may affect parsing
36712  algorithms if multiple options are selected for output.
36713  The node name is typically a name that the system uses to identify itself for inter-system
36714  communication addressing.

36715  **EXAMPLES**
36716  The following command:
36717        uname −sr
36718  writes the operating system name and release level, separated by one or more <blank>s.
It was suggested that this utility cannot be used portably since the format of the symbols is implementation-defined. The POSIX.1 working group could not achieve consensus on defining these formats in the underlying `uname()` function, and there was no expectation that this volume of IEEE Std 1003.1-2001 would be any more successful. Some applications may still find this historical utility of value. For example, the symbols could be used for system log entries or for comparison with operator or user input.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

The System Interfaces volume of IEEE Std 1003.1-2001, `uname()`

**CHANGE HISTORY**

First released in Issue 2.
The *uncompress* utility shall restore files to their original state after they have been compressed using the *compress* utility. If no files are specified, the standard input shall be uncompressed to the standard output. If the invoking process has appropriate privileges, the ownership, modes, access time, and modification time of the original file shall be preserved.

This utility shall support the uncompressing of any files produced by the *compress* utility on the same implementation. For files produced by *compress* on other systems, *uncompress* supports 9 to 14-bit compression (see *compress*, `−b`); it is implementation-defined whether values of `−b` greater than 14 are supported.

The following options shall be supported:

- `−c` Write to standard output; no files are changed.
- `−f` Do not prompt for overwriting files. Except when run in the background, if `−f` is not given the user shall be prompted as to whether an existing file should be overwritten. If the standard input is not a terminal and `−f` is not given, *uncompress* shall write a diagnostic message to standard error and exit with a status greater than zero.
- `−v` Write messages to standard error concerning the expansion of each file.

The following operand shall be supported:

- `file` A pathname of a file. If `file` already has the `.Z` suffix specified, it shall be used as the input file and the output file shall be named `file` with the `.Z` suffix removed. Otherwise, `file` shall be used as the name of the output file and `file` with the `.Z` suffix appended shall be used as the input file.

The standard input shall be used only if no `file` operands are specified, or if a `file` operand is `−`.

Input files shall be in the format produced by the *compress* utility.

The following environment variables shall affect the execution of *uncompress*:

- `LANG` Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
- `LC_ALL` If set to a non-empty string value, override the values of all the other internationalization variables.
uncompress

Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

Default.

When there are no file operands or the –c option is specified, the uncompressed output is written
to standard output.

Prompts shall be written to the standard error output under the conditions specified in the
DESCRIPTION and OPTIONS sections. The prompts shall contain the file pathname, but their
format is otherwise unspecified. Otherwise, the standard error output shall be used only for
diagnostic messages.

Output files are the same as the respective input files to compress.

None.

The following exit values shall be returned:

Successful completion.

An error occurred.

The input file remains unmodified.

The limit of 14 on the compress –b bits argument is to achieve portability to all systems (within
the restrictions imposed by the lack of an explicit published file format). Some implementations
based on 16-bit architectures cannot support 15 or 16-bit uncompression.

None.

None.

None.

compress, zcat

First released in Issue 4.
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
unexpand — convert spaces to tabs

SYNOPSIS
unexpand [-a] [-t tablist][file...]

DESCRIPTION
The unexpand utility shall copy files or standard input to standard output, converting <blank>s at the beginning of each line into the maximum number of <tab>s followed by the minimum number of <space>s needed to fill the same column positions originally filled by the translated <blank>s. By default, tabstops shall be set at every eighth column position. Each <backspace> shall be copied to the output, and shall cause the column position count for tab calculations to be decremented; the count shall never be decremented to a value less than one.

OPTIONS

The following options shall be supported:

- a
  In addition to translating <blank>s at the beginning of each line, translate all sequences of two or more <blank>s immediately preceding a tab stop to the maximum number of <tab>s followed by the minimum number of <space>s needed to fill the same column positions originally filled by the translated <blank>s.

- t tablist
  Specify the tab stops. The application shall ensure that the tablist option-argument is a single argument consisting of a single positive decimal integer or multiple positive decimal integers, separated by <blank>s or commas, in ascending order. If a single number is given, tabs shall be set tablist column positions apart instead of the default 8. If multiple numbers are given, the tabs shall be set at those specific column positions.

  The application shall ensure that each tab-stop position N is an integer value greater than zero, and the list shall be in strictly ascending order. This is taken to mean that, from the start of a line of output, tabbing to position N shall cause the next character output to be in the (N+1)th column position on that line. When the -t option is not specified, the default shall be the equivalent of specifying -t 8 (except for the interaction with -a, described below).

No <space>-to-<tab> conversions shall occur for characters at positions beyond the last of those specified in a multiple tab-stop list.

When -t is specified, the presence or absence of the -a option shall be ignored; conversion shall not be limited to the processing of leading <blank>s.

OPERANDS
The following operand shall be supported:

file  A pathname of a text file to be used as input.

STDIN
See the INPUT FILES section.
The input files shall be text files.

The following environment variables shall affect the execution of `unexpand`:

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files), the processing of <tab>s and <space>s, and for the determination of the width in column positions each character would occupy on an output device.

- **LC_MESSAGES**: Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**: Determine the location of message catalogs for the processing of **LC_MESSAGES**.

The standard output shall be equivalent to the input files with the specified <space>-to-<tab> conversions.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

None.

Default.
One non-intuitive aspect of *unexpand* is its restriction to leading spaces when neither *-a* nor *-t* is specified. Users who always want to convert all spaces in a file can easily alias *unexpand* to use the *-a* or *-t* option.

### Rationale

On several occasions, consideration was given to adding a *-t* option to the *unexpand* utility to complement the *-t* in *expand* (see *expand*). The historical intent of *unexpand* was to translate multiple `<blank>`s into tab stops, where tab stops were a multiple of eight column positions on most UNIX systems. An early proposal omitted *-t* because it seemed outside the scope of the User Portability Utilities option; it was not described in any of the base documents. However, hard-coding tab stops every eight columns was not suitable for the international community and broke historical precedents for some vendors in the FORTRAN community, so *-t* was restored in conjunction with the list of valid extension categories considered by the standard developers. Thus, *unexpand* is now the logical converse of *expand*.

### Future Directions

None.

### See Also

*expand*, *tabs*

### Change History

First released in Issue 4.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The definition of the *LC_CTYPE* environment variable is changed to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
unget — undo a previous get of an SCCS file (DEVELOPMENT)

SYNOPSIS
xsi unget [-ns][r SID] file...

DESCRIPTION
The unget utility shall reverse the effect of a get −e done prior to creating the intended new delta.

OPTIONS

The following options shall be supported:

−r SID
Uniquely identify which delta is no longer intended. (This would have been specified by get as the new delta.) The use of this option is necessary only if two or more outstanding get commands for editing on the same SCCS file were done by the same person (login name).

−s
Suppress the writing to standard output of the intended delta’s SID.

−n
Retain the file that was obtained by get, which would normally be removed from the current directory.

OPERANDS
The following operands shall be supported:

file
A pathname of an existing SCCS file or a directory. If file is a directory, the unget utility shall behave as though each file in the directory were specified as a named file, except that non-SCCS files (last component of the pathname does not begin with s.) and unreadable files shall be silently ignored.

If exactly one file operand appears, and it is ‘−’, the standard input shall be read; each line of the standard input shall be taken to be the name of an SCCS file to be processed. Non-SCCS files and unreadable files shall be silently ignored.

STDIN
The standard input shall be a text file used only when the file operand is specified as ‘−’. Each line of the text file shall be interpreted as an SCCS pathname.

INPUT FILES
Any SCCS files processed shall be files of an unspecified format.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of unget:

LANG
Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

Determine the location of message catalogs for the processing of LC_MESSAGES.

Default.

The standard output shall consist of a line for each file, in the following format:

"%s
", <SID removed from file>

If there is more than one named file or if a directory or standard input is named, each pathname shall be written before each of the preceding lines:

"\n%s:\n", <pathname>

The standard error shall be used only for diagnostic messages.

Any SCCS files updated shall be files of an unspecified format. During processing of a file, a locking z-file, as described in get, and a q-file (a working copy of the p-file), may be created and deleted. The p-file and g-file, as described in get, shall be deleted.

None.

The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

None.

None.

None.

None.

None.

First released in Issue 2.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
uniq — report or filter out repeated lines in a file

SYNOPSIS
uniq [-c|-d|-u] [-f fields] [-s char] [input_file [output_file]]

DESCRIPTION
The uniq utility shall read an input file comparing adjacent lines, and write one copy of each
input line on the output. The second and succeeding copies of repeated adjacent input lines shall
not be written.
Repeated lines in the input shall not be detected if they are not adjacent.

OPTIONS
The uniq utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section
The following options shall be supported:
-c Precede each output line with a count of the number of times the line occurred in
the input.
-d Suppress the writing of lines that are not repeated in the input.
-f fields Ignore the first fields fields on each input line when doing comparisons, where
fields is a positive decimal integer. A field is the maximal string matched by the
basic regular expression:

[[[:blank:]]*[^[:blank:]]]*
If the fields option-argument specifies more fields than appear on an input line, a
null string shall be used for comparison.
-s chars Ignore the first chars characters when doing comparisons, where chars shall be a
positive decimal integer. If specified in conjunction with the -f option, the first
chars characters after the first fields fields shall be ignored. If the chars option-
argument specifies more characters than remain on an input line, a null string shall
be used for comparison.
-u Suppress the writing of lines that are repeated in the input.

OPERANDS
The following operands shall be supported:
input_file A pathname of the input file. If the input_file operand is not specified, or if the
input_file is '-', the standard input shall be used.
output_file A pathname of the output file. If the output_file operand is not specified, the
standard output shall be used. The results are unspecified if the file named by
output_file is the file named by input_file.

STDIN
The standard input shall be used only if no input_file operand is specified or if input_file is '-'.
See the INPUT FILES section.

INPUT FILES
The input file shall be a text file.
EVENVIRONMENT VARIABLES

The following environment variables shall affect the execution of uniq:

LANG
Provide a default value for the internationalization variables that are unset or null.

(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL
If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_COLLATE
Determine the locale for ordering rules.

LC_CTYPE
Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files) and which characters constitute a <blank> in the
current locale.

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

XSI_NLSPATH
Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS

Default.

STDOUT
The standard output shall be used only if no output_file operand is specified. See the OUTPUT
FILES section.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
If the −c option is specified, the output file shall be empty or each line shall be of the form:

"%d %s", <number of duplicates>, <line>

otherwise, the output file shall be empty or each line shall be of the form:

"%s", <line>

EXTENDED DESCRIPTION

None.

EXIT STATUS
The following exit values shall be returned:

0 The utility executed successfully.

>0 An error occurred.

CONSEQUENCES OF ERRORS

Default.
APPLICATION USAGE

The sort utility can be used to cause repeated lines to be adjacent in the input file.

EXAMPLES

The following input file data (but flushed left) was used for a test series on uniq:

```
#01 foo0 bar0 foo1 bar1
#02 bar0 foo1 bar1 foo0
#03 foo0 bar0 foo1 bar1
#04
#05 foo0 bar0 foo1 bar1
#06 foo0 bar0 foo1 bar1
#07 bar0 foo1 bar1 foo0
```

What follows is a series of test invocations of the uniq utility that use a mixture of uniq options against the input file data. These tests verify the meaning of adjacent. The uniq utility views the input data as a sequence of strings delimited by \n. Accordingly, for the fields\th member of the sequence, uniq interprets unique or repeated adjacent lines strictly relative to the fields+1th member.

1. This first example tests the line counting option, comparing each line of the input file data starting from the second field:

```
uniq -c -f 1 uniq_0I.t
1 #01 foo0 bar0 foo1 bar1
1 #02 bar0 foo1 bar1 foo0
1 #03 foo0 bar0 foo1 bar1
1 #04
2 #05 foo0 bar0 foo1 bar1
1 #07 bar0 foo1 bar1 foo0
```

The number ‘2’, prefixing the fifth line of output, signifies that the uniq utility detected a pair of repeated lines. Given the input data, this can only be true when uniq is run using the –f 1 option (which shall cause uniq to ignore the first field on each input line).

2. The second example tests the option to suppress unique lines, comparing each line of the input file data starting from the second field:

```
uniq -d -f 1 uniq_0I.t
#05 foo0 bar0 foo1 bar1
```

3. This test suppresses repeated lines, comparing each line of the input file data starting from the second field:

```
uniq -u -f 1 uniq_0I.t
#01 foo0 bar0 foo1 bar1
#02 bar0 foo1 bar1 foo0
#03 foo0 bar0 foo1 bar1
#04
#07 bar0 foo1 bar1 foo0
```

4. This suppresses unique lines, comparing each line of the input file data starting from the third character:

```
uniq -d -s 2 uniq_0I.t
```

In the last example, the uniq utility found no input matching the above criteria.
RATIONALE
Some historical implementations have limited lines to be 1080 bytes in length, which does not meet the implied [LINE_MAX] limit.

FUTURE DIRECTIONS
None.

SEE ALSO
comm, sort

CHANGE HISTORY
First released in Issue 2.

Issue 6
The obsolescent SYNOPSIS and associated text are removed.
The normative text is reworded to avoid use of the term “must” for application requirements.
IEEE Std 1003.1-2001/Cor 1-2002, item XCU/TC1/D6/40 is applied, adding LC_COLLATE to the ENVIRONMENT VARIABLES section, and changing “the application shall ensure that” in the OUTPUT FILES section.
NAME
unlink — call the unlink() function

SYNOPSIS
unlink file

DESCRIPTION
The unlink utility shall perform the function call:
unlink(file);
A user may need appropriate privilege to invoke the unlink utility.

OPTIONS
None.

OPERANDS
The following operands shall be supported:
file The pathname of an existing file.

STDIN
Not used.

INPUT FILES
Not used.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of unlink:
LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.
LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).
LC_MESSAGES
Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.
NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
None.

STDERR
The standard error shall be used only for diagnostic messages.
unlink

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0  Successful completion.
>0  An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
link, rm, the System Interfaces volume of IEEE Std 1003.1-2001, unlink()

CHANGE HISTORY
First released in Issue 5.
NAME
uucp — system-to-system copy

SYNOPSIS
XSI
uucp [-Cdfjr] [-n user] source-file... destination-file

DESCRIPTION
The uucp utility shall copy files named by the source-file argument to the destination-file argument. The files named can be on local or remote systems.

The uucp utility cannot guarantee support for all character encodings in all circumstances. For example, transmission data may be restricted to 7 bits by the underlying network, 8-bit data and filenames need not be portable to non-internationalized systems, and so on. Under these circumstances, it is recommended that only characters defined in the ISO/IEC 646:1991 standard International Reference Version (equivalent to ASCII) 7-bit range of characters be used, and that only characters defined in the portable filename character set be used for naming files.

The protocol for transfer of files is unspecified by IEEE Std 1003.1-2001.

Typical implementations of this utility require a communications line configured to use the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface, but other communications means may be used. On systems where there are no available communications means (either temporarily or permanently), this utility shall write an error message describing the problem and exit with a non-zero exit status.

OPTIONS

The following options shall be supported:

-c Do not copy local file to the spool directory for transfer to the remote machine (default).

-C Force the copy of local files to the spool directory for transfer.

-d Make all necessary directories for the file copy (default).

-f Do not make intermediate directories for the file copy.

-j Write the job identification string to standard output. This job identification can be used by uustat to obtain the status or terminate a job.

-m Send mail to the requester when the copy is completed.

-n user Notify user on the remote system that a file was sent.

-r Do not start the file transfer; just queue the job.

OPERANDS
The following operands shall be supported:

destination-file, source-file
A pathname of a file to be copied to, or from, respectively. Either name can be a pathname on the local machine, or can have the form:

system-name!pathname
where system-name is taken from a list of system names that uucp knows about.

The destination system-name can also be a list of names such as:
in which case, an attempt is made to send the file via the specified route to the
destination. Care should be taken to ensure that intermediate nodes in the route
are willing to forward information.

The shell pattern matching notation characters ‘?', '*', and "[..]" appearing
in pathname shall be expanded on the appropriate system.

Pathnames can be one of:

1. An absolute pathname.

2. A pathname preceded by `user where user is a login name on the specified
   system and is replaced by that user's login directory. Note that if an invalid
   login is specified, the default is to the public directory (called PUBDIR; the
   actual location of PUBDIR is implementation-defined).

3. A pathname preceded by `~/destination where destination is appended to
   PUBDIR.
   
   *Note:* This destination is treated as a filename unless more than one file is being
   transferred by this request or the destination is already a directory. To
   ensure that it is a directory, follow the destination with a ‘/’. For
   example, `~/dan/` as the destination makes the directory PUBDIR/dan if it
   does not exist and puts the requested files in that directory.

4. Anything else shall be prefixed by the current directory.

If the result is an erroneous pathname for the remote system, the copy shall fail. If
the destination-file is a directory, the last part of the source-file name shall be used.

The read, write, and execute permissions given by uucp are implementation-
defined.

**STDIN**
Not used.

**INPUT FILES**
The files to be copied are regular files.

**ENVIRONMENT VARIABLES**
The following environment variables shall affect the execution of uucp:

- **LANG**
  Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
  Internationalization Variables for the precedence of internationalization variables
  used to determine the values of locale categories.)

- **LC_ALL**
  If set to a non-empty string value, override the values of all the other
  internationalization variables.

- **LC_COLLATE**
  Determine the locale for the behavior of ranges, equivalence classes, and multi-
  character collating elements within bracketed filename patterns.

- **LC_CTYPE**
  Determine the locale for the interpretation of sequences of bytes of text data as
  characters (for example, single-byte as opposed to multi-byte characters in
  arguments and input files) and the behavior of character classes within bracketed
  filename patterns (for example, "'[[[:lower:]]]*'".).
Determine the locale that should be used to affect the format and contents of the diagnostic messages written to standard error, and informative messages written to standard output.

Determine the location of message catalogs for the processing of \texttt{LC\_MESSAGES}.

\textbf{ASYNCHRONOUS EVENTS}

\textbf{STDOUT}

Not used.

\textbf{STDERR}

The standard error shall be used only for diagnostic messages.

\textbf{OUTPUT FILES}

The output files (which may be on other systems) are copies of the input files.

If \texttt{−m} is used, mail files are modified.

\textbf{EXTENDED DESCRIPTION}

None.

The following exit values shall be returned:

\begin{itemize}
  \item 0 \hspace{1em} Successful completion.
  \item >0 \hspace{1em} An error occurred.
\end{itemize}

\textbf{CONSEQUENCES OF ERRORS}

Default.

\textbf{APPLICATION USAGE}

The domain of remotely accessible files can (and for obvious security reasons usually should) be severely restricted.

Note that the \texttt{!' '} character in addresses has to be escaped when using \texttt{csh} as a command interpreter because of its history substitution syntax. For \texttt{ksh} and \texttt{sh} the escape is not necessary, but may be used.

As noted above, shell metacharacters appearing in pathnames are expanded on the appropriate system. On an internationalized system, this is done under the control of local settings of \texttt{LC\_COLLATE} and \texttt{LC\_CTYPE}. Thus, care should be taken when using bracketed filename patterns, as collation and typing rules may vary from one system to another. Also be aware that certain types of expression (that is, equivalence classes, character classes, and collating symbols) need not be supported on non-internationalized systems.

\textbf{EXAMPLES}

None.

\textbf{RATIONALE}

None.

\textbf{FUTURE DIRECTIONS}

None.
SEE ALSO
mailx, uudecode, uustat, uux

CHANGE HISTORY
First released in Issue 2.

Issue 6
The LC_TIME and TZ entries are removed from the ENVIRONMENT VARIABLES section.
The UN margin codes and associated shading are removed from the −C, −f, −j, −n, and −r
options in response to The Open Group Base Resolution bwg2001-003.
NAME
uudecode — decode a binary file

SYNOPSIS
uudecode [-o outfile] [file]

DESCRIPTION
The uudecode utility shall read a file, or standard input if no file is specified, that includes data
created by the uuencode utility. The uudecode utility shall scan the input file, searching for data
compatible with one of the formats specified in uuencode, and attempt to create or overwrite the
file described by the data (or overridden by the -o option). The pathname shall be contained in
the data or specified by the -o option. The file access permission bits and contents for the file to
be produced shall be contained in that data. The mode bits of the created file (other than
standard output) shall be set from the file access permission bits contained in the data; that is,
other attributes of the mode, including the file mode creation mask (see umask), shall not affect
the file being produced.

If the pathname of the file to be produced exists, and the user does not have write permission on
that file, uudecode shall terminate with an error. If the pathname of the file to be produced exists,
and the user has write permission on that file, the existing file shall be overwritten.

If the input data was produced by uuencode on a system with a different number of bits per byte
than on the target system, the results of uudecode are unspecified.

OPTIONS
The uudecode utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001,
Section 12.2, Utility Syntax Guidelines.

The following option shall be supported by the implementation:

-o outfile A pathname of a file that shall be used instead of any pathname contained in the
input data. Specifying an outfile option-argument of /dev/stdout shall indicate
standard output.

OPERANDS
The following operand shall be supported:

file The pathname of a file containing the output of uuencode.

STDIN
See the INPUT FILES section.

INPUT FILES
The input files shall be files containing the output of uuencode.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of uudecode:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments and input files).
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**NLSPATH** Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**ASYNCHRONOUS EVENTS**

Default.

**STDOUT**

If the file data header encoded by **uuencode** is − or /dev/stdout, or the −o /dev/stdout option overrides the file data, the standard output shall be in the same format as the file originally encoded by uuencode. Otherwise, the standard output shall not be used.

**STDERR**

The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**

The output file shall be in the same format as the file originally encoded by uuencode.

**EXTENDED DESCRIPTION**

None.

**EXIT STATUS**

The following exit values shall be returned:

- 0 Successful completion.
- >0 An error occurred.

**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

The user who is invoking uuencode must have write permission on any file being created.

The output of uuencode is essentially an encoded bit stream that is not cognizant of byte boundaries. It is possible that a 9-bit byte target machine can process input from an 8-bit source, if it is aware of the requirement, but the reverse is unlikely to be satisfying. Of course, the only data that is meaningful for such a transfer between architectures is generally character data.

**EXAMPLES**

None.

**RATIONALE**

Input files are not necessarily text files, as stated by an early proposal. Although the uuencode output is a text file, that output could have been wrapped within another file or mail message that is not a text file.

The −o option is not historical practice, but was added at the request of WG15 so that the user could override the target pathname without having to edit the input data itself.

In early drafts, the [−o outfile] option-argument allowed the use of − to mean standard output. The symbol − has only been used previously in IEEE Std 1003.1-2001 as a standard input indicator. The developers of the standard did not wish to overload the meaning of − in this manner. The /dev/stdout concept exists on most modern systems. The /dev/stdout syntax does not refer to a new special file. It is just a magic cookie to specify standard output.
FUTURE DIRECTIONS
None.

SEE ALSO
umask, uuencode

CHANGE HISTORY
First released in Issue 4.

Issue 6
This utility is marked as part of the User Portability Utilities option.
The \texttt{-o outfile} option is added, as specified in the IEEE P1003.2b draft standard.
The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
uuencode — encode a binary file

SYNOPSIS
uuencode [-m] [file] decode_pathname

DESCRIPTION
The uuencode utility shall write an encoded version of the named input file, or standard input if no file is specified, to standard output. The output shall be encoded using one of the algorithms described in the STDOUT section and shall include the file access permission bits (in chmod octal or symbolic notation) of the input file and the decode_pathname, for re-creation of the file on another system that conforms to this volume of IEEE Std 1003.1-2001.

OPTIONS

The following option shall be supported by the implementation:

-m Encode the output using the MIME Base64 algorithm described in STDOUT. If -m is not specified, the historical algorithm described in STDOUT shall be used.

OPERANDS
The following operands shall be supported:

decode_pathname
The pathname of the file into which the uudecode utility shall place the decoded file. Specifying a decode_pathname operand of /dev/stdout shall indicate that uuencode is to use standard output. If there are characters in decode_pathname that are not in the portable filename character set the results are unspecified.

file A pathname of the file to be encoded.

STDIN
See the INPUT FILES section.

INPUT FILES
Input files can be files of any type.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of uuencode:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.
uuencode Base64 Algorithm

The standard output shall be a text file (encoded in the character set of the current locale) that begins with the line:

"begin-base64\%s\%s\n", <mode>, <decode_pathname>

and ends with the line:

"====\n"

In both cases, the lines shall have no preceding or trailing <blank>s.

The encoding process represents 24-bit groups of input bits as output strings of four encoded characters. Proceeding from left to right, a 24-bit input group shall be formed by concatenating three 8-bit input groups. Each 24-bit input group then shall be treated as four concatenated 6-bit groups, each of which shall be translated into a single digit in the Base64 alphabet. When encoding a bit stream via the Base64 encoding, the bit stream shall be presumed to be ordered with the most-significant bit first. That is, the first bit in the stream shall be the high-order bit in the first byte, and the eighth bit shall be the low-order bit in the first byte, and so on. Each 6-bit group is used as an index into an array of 64 printable characters, as shown in Table 4-21.

<table>
<thead>
<tr>
<th>Value</th>
<th>Encoding</th>
<th>Value</th>
<th>Encoding</th>
<th>Value</th>
<th>Encoding</th>
<th>Value</th>
<th>Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A</td>
<td>17</td>
<td>R</td>
<td>34</td>
<td>i</td>
<td>51</td>
<td>z</td>
</tr>
<tr>
<td>1</td>
<td>B</td>
<td>18</td>
<td>S</td>
<td>35</td>
<td>j</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>19</td>
<td>T</td>
<td>36</td>
<td>k</td>
<td>53</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>20</td>
<td>U</td>
<td>37</td>
<td>l</td>
<td>54</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>E</td>
<td>21</td>
<td>V</td>
<td>38</td>
<td>m</td>
<td>55</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>22</td>
<td>W</td>
<td>39</td>
<td>n</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>G</td>
<td>23</td>
<td>X</td>
<td>40</td>
<td>o</td>
<td>57</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>H</td>
<td>24</td>
<td>Y</td>
<td>41</td>
<td>p</td>
<td>58</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>I</td>
<td>25</td>
<td>Z</td>
<td>42</td>
<td>q</td>
<td>59</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>J</td>
<td>26</td>
<td>a</td>
<td>43</td>
<td>r</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>K</td>
<td>27</td>
<td>b</td>
<td>44</td>
<td>s</td>
<td>61</td>
<td>9</td>
</tr>
<tr>
<td>11</td>
<td>L</td>
<td>28</td>
<td>c</td>
<td>45</td>
<td>t</td>
<td>62</td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>29</td>
<td>d</td>
<td>46</td>
<td>u</td>
<td>63</td>
<td>/</td>
</tr>
<tr>
<td>13</td>
<td>N</td>
<td>30</td>
<td>e</td>
<td>47</td>
<td>v</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>O</td>
<td>31</td>
<td>f</td>
<td>48</td>
<td>(pad)</td>
<td></td>
<td>=</td>
</tr>
<tr>
<td>15</td>
<td>P</td>
<td>32</td>
<td>g</td>
<td>49</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Q</td>
<td>33</td>
<td>h</td>
<td>50</td>
<td>y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The character referenced by the index shall be placed in the output string.

The output stream (encoded bytes) shall be represented in lines of no more than 76 characters each. All line breaks or other characters not found in the table shall be ignored by decoding software (see uudecode).

Special processing shall be performed if fewer than 24 bits are available at the end of a message or encapsulated part of a message. A full encoding quantum shall always be completed at the
end of a message. When fewer than 24 input bits are available in an input group, zero bits shall be added (on the right) to form an integral number of 6-bit groups. Output character positions that are not required to represent actual input data shall be set to the character ‘=’. Since all Base64 input is an integral number of octets, only the following cases can arise:

1. The final quantum of encoding input is an integral multiple of 24 bits; here, the final unit of encoded output shall be an integral multiple of 4 characters with no ‘=’ padding.

2. The final quantum of encoding input is exactly 16 bits; here, the final unit of encoded output shall be three characters followed by one ‘=’ padding character.

3. The final quantum of encoding input is exactly 8 bits; here, the final unit of encoded output shall be two characters followed by two ‘=’ padding characters.

A terminating "====" evaluates to nothing and denotes the end of the encoded data.

uuencode Historical Algorithm

The standard output shall be a text file (encoded in the character set of the current locale) that begins with the line:

"begin%s%s\n" <mode>, <decode_pathname>

and ends with the line:

"end\n"

In both cases, the lines shall have no preceding or trailing <blank>s.

The algorithm that shall be used for lines in between begin and end takes three octets as input and writes four characters of output by splitting the input at six-bit intervals into four octets, containing data in the lower six bits only. These octets shall be converted to characters by adding a value of 0x20 to each octet, so that each octet is in the range [0x20,0x5F], and then it shall be assumed to represent a printable character in the ISO/IEC 646: 1991 standard encoded character set. It then shall be translated into the corresponding character codes for the codeset in use in the current locale. (For example, the octet 0x41, representing ‘A’, would be translated to ‘A’ in the current codeset, such as 0xc1 if it were EBCDIC.)

Where the bits of two octets are combined, the least significant bits of the first octet shall be shifted left and combined with the most significant bits of the second octet shifted right. Thus the three octets A, B, C shall be converted into the four octets:

\[
\begin{align*}
0x20 + ((A >> 2) \& 0x3F) & \\
0x20 + (((A << 4) | ((B >> 4) \& 0xF)) \& 0x3F) & \\
0x20 + (((B << 2) | ((C >> 6) \& 0x3)) \& 0x3F) & \\
0x20 + (C) & \\
\end{align*}
\]

These octets then shall be translated into the local character set.

Each encoded line contains a length character, equal to the number of characters to be decoded plus 0x20 translated to the local character set as described above, followed by the encoded characters. The maximum number of octets to be encoded on each line shall be 45.

STDERR

The standard error shall be used only for diagnostic messages.

OUTPUT FILES

None.
EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
The file is expanded by 35 percent (each three octets become four, plus control information)
causing it to take longer to transmit.

Since this utility is intended to create files to be used for data interchange between systems with
possibly different codesets, and to represent binary data as a text file, the ISO/IEC 646: 1991
standard was chosen for a midpoint in the algorithm as a known reference point. The output
from uuencode is a text file on the local system. If the output were in the ISO/IEC 646: 1991
standard codeset, it might not be a text file (at least because the <newline>s might not match),
and the goal of creating a text file would be defeated. If this text file was then carried to another
machine with the same codeset, it would be perfectly compatible with that system's uudecode. If
it was transmitted over a mail system or sent to a machine with a different codeset, it is assumed
that, as for every other text file, some translation mechanism would convert it (by the time it
reached a user on the other system) into an appropriate codeset. This translation only makes
sense from the local codeset, not if the file has been put into a ISO/IEC 646: 1991 standard
representation first. Similarly, files processed by uuencode can be placed in pax archives,
terminated with other text files in the same codeset.

EXAMPLES
None.

RATIONALE
A new algorithm was added at the request of the international community to parallel work in
RFC 2045 (MIME). As with the historical uuencode format, the Base64 Content-Transfer-Encoding
is designed to represent arbitrary sequences of octets in a form that is not humanly readable. A
65-character subset of the ISO/IEC 646: 1991 standard is used, enabling 6 bits to be represented
per printable character. (The extra 65th character, '═', is used to signify a special processing
function.)

This subset has the important property that it is represented identically in all versions of the
ISO/IEC 646: 1991 standard, including US ASCII, and all characters in the subset are also
represented identically in all versions of EBCDIC. The historical uuencode algorithm does not
share this property, which is the reason that a second algorithm was added to the ISO POSIX-2
standard.

The string "====" was used for the termination instead of the end used in the original format
because the latter is a string that could be valid encoded input.

In an early draft, the −m option was named −b (for Base64), but it was renamed to reflect its
relationship to the RFC 2045. A −u was also present to invoke the default algorithm, but since
this was not historical practice, it was omitted as being unnecessary.

See the RATIONALE section in uudecode for the derivation of the /dev/stdout symbol.
**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`chmod`, `mailx`, `uudecode`

**CHANGE HISTORY**

First released in Issue 4.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The Base64 algorithm and the ability to output to `/dev/stdout` are added as specified in the IEEE P1003.2b draft standard.
NAME
uustat — uucp status inquiry and job control

SYNOPSIS
XSI
uustat [ −q| −k jobid| −r jobid]
uustat [ −s system] [ −u user]

DESCRIPTION
The uustat utility shall display the status of, or cancel, previously specified uucp requests, or provide general status on uucp connections to other systems.

When no options are given, uustat shall write to standard output the status of all uucp requests issued by the current user.

Typical implementations of this utility require a communications line configured to use the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface, but other communications means may be used. On systems where there are no available communications means (either temporarily or permanently), this utility shall write an error message describing the problem and exit with a non-zero exit status.

OPTIONS

The following options shall be supported:

−q Write the jobs queued for each machine.

−k jobid Kill the uucp request whose job identification is jobid. The application shall ensure that the killed uucp request belongs to the person invoking uustat unless that user has appropriate privileges.

−r jobid Rejuvenate jobid. The files associated with jobid are touched so that their modification time is set to the current time. This prevents the cleanup program from deleting the job until the jobs modification time reaches the limit imposed by the program.

−s system Write the status of all uucp requests for remote system system.

−u user Write the status of all uucp requests issued by user.

OPERANDS
None.

STDIN
Not used.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of uustat:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)
If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE**
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error, and informative messages written to standard output.

**NLSPATH**
Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
The standard output shall consist of information about each job selected, in an unspecified format. The information shall include at least the job ID, the user ID or name, and the remote system name.

**STDERR**
The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
The following exit values shall be returned:

0  Successful completion.

>0  An error occurred.

**CONSEQUENCES OF ERRORS**
Default.

**APPLICATION USAGE**
None.

**EXAMPLES**
None.

**RATIONALE**
None.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
**uucp**

**CHANGE HISTORY**
First released in Issue 2.
The normative text is reworded to avoid use of the term “must” for application requirements.

The LC_TIME and TZ entries are removed from the ENVIRONMENT VARIABLES section.

The UN margin code and associated shading are removed from the −q option in response to The Open Group Base Resolution bwg2001-003.
NAME
uux — remote command execution

SYNOPSIS
XSI
uux [-np] command-string
uux [-jnp] command-string

DESCRIPTION
The uux utility shall gather zero or more files from various systems, execute a shell pipeline (see Section 2.9 (on page 47)) on a specified system, and then send the standard output of the command to a file on a specified system. Only the first command of a pipeline can have a system-name! prefix. All other commands in the pipeline shall be executed on the system of the first command.

The following restrictions are applicable to the shell pipeline processed by uux:

- In gathering files from different systems, pathname expansion shall not be performed by uux. Thus, a request such as:
  uux "c99 remays!"/*.c"
  would attempt to copy the file named literally *.c to the local system.
- The redirection operators ">>", "<<", "|", and ">>&" shall not be accepted. Any use of these redirection operators shall cause this utility to write an error message describing the problem and exit with a non-zero exit status.
- The reserved word ! cannot be used at the head of the pipeline to modify the exit status. (See the command-string operand description below.)
- Alias substitution shall not be performed.

A filename can be specified as for uucp; it can be an absolute pathname, a pathname preceded by -name (which is replaced by the corresponding login directory), a pathname specified as ~/dest (dest is prefixed by the public directory called PUBDIR; the actual location of PUBDIR is implementation-defined), or a simple filename (which is prefixed by uux with the current directory). See uucp for the details.

The execution of commands on remote systems shall take place in an execution directory known to the uucp system. All files required for the execution shall be put into this directory unless they already reside on that machine. Therefore, the application shall ensure that non-local filenames (without path or machine reference) are unique within the uux request.

The uux utility shall attempt to get all files to the execution system. For files that are output files, the application shall ensure that the filename is escaped using parentheses.

The remote system shall notify the user by mail if the requested command on the remote system was disallowed or the files were not accessible. This notification can be turned off by the -n option.

Typical implementations of this utility require a communications line configured to use the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface, but other communications means may be used. On systems where there are no available communications means (either temporarily or permanently), this utility shall write an error message describing the problem and exit with a non-zero exit status.

The uux utility cannot guarantee support for all character encodings in all circumstances. For example, transmission data may be restricted to 7 bits by the underlying network, 8-bit data and
filenames need not be portable to non-internationalized systems, and so on. Under these circumstances, it is recommended that only characters defined in the ISO/IEC 646:1991 standard International Reference Version (equivalent to ASCII) 7-bit range of characters be used and that only characters defined in the portable filename character set be used for naming files.

OPTIONS

The following options shall be supported:

- \( p \) Make the standard input to \textit{uux} the standard input to the \textit{command-string}.

- \( j \) Write the job identification string to standard output. This job identification can be used by \textit{uustat} to obtain the status or terminate a job.

- \( n \) Do not notify the user if the command fails.

OPERANDS
The following operand shall be supported:

- \textit{command-string}

A string made up of one or more arguments that are similar to normal command arguments, except that the command and any filenames can be prefixed by \textit{system-name}!. A null \textit{system-name} shall be interpreted as the local system.

STDIN
The standard input shall not be used unless the ‘\( -p \)’ or ‘\( -p \)’ option is specified; in those cases, the standard input shall be made the standard input of the \textit{command-string}.

INPUT FILES
Input files shall be selected according to the contents of \textit{command-string}.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of \textit{uux}:

- \textit{LANG}

Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- \textit{LC_ALL}

If set to a non-empty string value, override the values of all the other internationalization variables.

- \textit{LC_CTYPE}

Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

- \textit{LC_MESSAGES}

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

- \textit{NLSPATH}

Determine the location of message catalogs for the processing of \textit{LC_MESSAGES}.

ASYNCHRONOUS EVENTS
Default.
STDOUT
The standard output shall not be used unless the \(-j\) option is specified; in that case, the job
identification string shall be written to standard output in the following format:

\(\%s\backslash n, <jobid>\)

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
Output files shall be created or written, or both, according to the contents of \texttt{command-string}.
If \(-n\) is not used, mail files shall be modified following any command or file-access failures on
the remote system.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

\begin{itemize}
  \item 0 Successful completion.
  \item >0 An error occurred.
\end{itemize}

CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Note that, for security reasons, many installations limit the list of commands executable on
behalf of an incoming request from \texttt{uux}. Many sites permit little more than the receipt of mail
via \texttt{uux}.

Any characters special to the command interpreter should be quoted either by quoting the entire
\texttt{command-string} or quoting the special characters as individual arguments.

As noted in \texttt{uucp}, shell pattern matching notation characters appearing in pathnames are
expanded on the appropriate local system. This is done under the control of local settings of
\texttt{LC_COLLATE} and \texttt{LC_CTYPE}. Thus, care should be taken when using bracketed filename
patterns, as collation and typing rules may vary from one system to another. Also be aware that
certain types of expression (that is, equivalence classes, character classes, and collating symbols)
need not be supported on non-internationalized systems.

EXAMPLES

\begin{enumerate}
  \item The following command gets \texttt{file1} from system \texttt{a} and \texttt{file2} from system \texttt{b}, executes \texttt{diff} on
    the local system, and puts the results in \texttt{file.diff} in the local \texttt{PUBDIR} directory. (\texttt{PUBDIR} is
    the \texttt{uucp} public directory on the local system.)
    \begin{verbatim}
    uux "!diff a!/usr/file1 b!/a4/file2 >!~file.diff"
    \end{verbatim}
  \item The following command fails because \texttt{uux} places all files copied to a system in the same
    working directory. Although the files \texttt{xyz} are from two different systems, their filenames
    are the same and conflict.
    \begin{verbatim}
    uux "!diff a!/usr1/xyz b!/usr2/xyz >!~/xyz.diff"
    \end{verbatim}
  \item The following command succeeds (assuming \texttt{diff} is permitted on system \texttt{a}) because the file
    local to system \texttt{a} is not copied to the working directory, and hence does not conflict with
    the file from system \texttt{c}.
\end{enumerate}
uux "a!diff a!/usr/xyz c!/usr/xyz >˜/xyz.diff"

**RATIONALE**
None.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
Chapter 2 (on page 29), uucp, uuencode, uustat

**CHANGE HISTORY**
First released in Issue 2.

**Issue 6**
The obsolescent SYNOPSIS is removed.
The normative text is reworded to avoid use of the term “must” for application requirements.
The UN margin code and associated shading are removed from the −j option in response to The Open Group Base Resolution bwg2001-003.
NAME
val — validate SCCS files (DEVELOPMENT)

SYNOPSIS
val –
val [-m name][-r SID][-y type] file...

DESCRIPTION
The val utility shall determine whether the specified file is an SCCS file meeting the characteristics specified by the options.

OPTIONS
The val utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2, Utility Syntax Guidelines, except that the usage of the ‘−’ operand is not strictly as intended by the guidelines (that is, reading options and operands from standard input).

The following options shall be supported:

−m name Specify a name, which is compared with the SCCS %M% keyword in file; see get.

−r SID Specify a SID (SCCS Identification String), an SCCS delta number. A check shall be made to determine whether the SID is ambiguous (for example, −r 1 is ambiguous because it physically does not exist but implies 1.1, 1.2, and so on, which may exist) or invalid (for example, −r 1.0 or −r 1.1.0 are invalid because neither case can exist as a valid delta number). If the SID is valid and not ambiguous, a check shall be made to determine whether it actually exists.

−s Silence the diagnostic message normally written to standard output for any error that is detected while processing each named file on a given command line.

−y type Specify a type, which shall be compared with the SCCS %Y% keyword in file; see get.

OPERANDS
The following operands shall be supported:

file A pathname of an existing SCCS file. If exactly one file operand appears, and it is ‘−’, the standard input shall be read: each line shall be independently processed as if it were a command line argument list. (However, the line is not subjected to any of the shell word expansions, such as parameter expansion or quote removal.)

STDIN
The standard input shall be a text file used only when the file operand is specified as ‘−’.

INPUT FILES
Any SCCS files processed shall be files of an unspecified format.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of val:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
Utilities

val

3785    LC_TYPE    Determine the locale for the interpretation of sequences of bytes of text data as
3786    characters (for example, single-byte as opposed to multi-byte characters in
3787    arguments and input files).

3788    LC_MESSAGES    Determine the locale that should be used to affect the format and contents of
3789    diagnostic messages written to standard error, and informative messages written
3790    to standard output.

3792    NLSPATH    Determine the location of message catalogs for the processing of LC_MESSAGES.

3793    ASYNCHRONOUS EVENTS
3794    Default.

3795    STDOUT
3796    The standard output shall consist of informative messages about either:
3797            1. Each file processed
3798            2. Each command line read from standard input
3799    If the standard input is not used, for each file operand yielding a discrepancy, the output line
3800    shall have the following format:
3801        "\%s: %s\n", <pathname>, <unspecified string>
3802    If standard input is used, a line of input shall be written before each of the preceding lines for
3803    files containing discrepancies:
3804        "\%s:\n", <input line>

3795    STDERR
3796    Not used.

3797    OUTPUT FILES
3798    None.

3799    EXTENDED DESCRIPTION
3800    None.

3801    EXIT STATUS
3802    The 8-bit code returned by val shall be a disjunction of the possible errors; that is, it can be
3803    interpreted as a bit string where set bits are interpreted as follows:

3804    0x80 = Missing file argument.
3805    0x40 = Unknown or duplicate option.
3806    0x20 = Corrupted SCCS file.
3807    0x10 = Cannot open file or file not SCCS.
3808    0x08 = SID is invalid or ambiguous.
3809    0x04 = SID does not exist.
3810    0x02 = %Y%, −y mismatch.
3811    0x01 = %M%, −m mismatch.

3812    Note that val can process two or more files on a given command line and can process multiple
3813    command lines (when reading the standard input). In these cases an aggregate code shall be
3814    returned: a logical OR of the codes generated for each command line and file processed.
CONSEQUENCES OF ERRORS
Default.

APPLICATION USAGE
Since the `val` exit status sets the 0x80 bit, shell applications checking "$?" cannot tell if it terminated due to a missing file argument or receipt of a signal.

EXAMPLES
In a directory with three SCCS files—`s.x` (of t type “text”), `s.y`, and `s.z` (a corrupted file)—the following command could produce the output shown:

```
val - <<EOF
-y source s.x
-m y s.y
s.z
EOF

-s.x: %Y%, -y mismatch
-s.z: corrupted SCCS file
```

RATIONALE
None.

FUTURE DIRECTIONS
None.

SEE ALSO
`admin`, `delta`, `get`, `prs`

CHANGE HISTORY
First released in Issue 2.

Issue 6
The Open Group Corrigendum U025/4 is applied, correcting a typographical error in the EXIT STATUS.
NAME

vi — screen-oriented (visual) display editor

SYNOPSIS

vi [-rR] [-c command] [-t tagstring] [-w size] [file ...]

DESCRIPTION

This utility shall be provided on systems that both support the User Portability Utilities option and define the POSIX2_CHAR_TERM symbol. On other systems it is optional.

The vi (visual) utility is a screen-oriented text editor. Only the open and visual modes of the editor are described in IEEE Std 1003.1-2001; see the line editor ex for additional editing capabilities used in vi. The user can switch back and forth between vi and ex and execute ex commands from within vi.

This reference page uses the term edit buffer to describe the current working text. No specific implementation is implied by this term. All editing changes are performed on the edit buffer, and no changes to it shall affect any file until an editor command writes the file.

When using vi, the terminal screen acts as a window into the editing buffer. Changes made to the editing buffer shall be reflected in the screen display; the position of the cursor on the screen shall indicate the position within the editing buffer.

Certain terminals do not have all the capabilities necessary to support the complete vi definition. When these commands cannot be supported on such terminals, this condition shall not produce an error message such as "not an editor command" or report a syntax error. The implementation may either accept the commands and produce results on the screen that are the result of an unsuccessful attempt to meet the requirements of this volume of IEEE Std 1003.1-2001 or report an error describing the terminal-related deficiency.

OPTIONS


The following options shall be supported:

- c command See the ex command description of the -c option.
- r See the ex command description of the -r option.
- R See the ex command description of the -R option.
- t tagstring See the ex command description of the -t option.
- w size See the ex command description of the -w option.

OPERANDS

See the OPERANDS section of the ex command for a description of the operands supported by the vi command.

STDIN

If standard input is not a terminal device, the results are undefined. The standard input consists of a series of commands and input text, as described in the EXTENDED DESCRIPTION section.

If a read from the standard input returns an error, or if the editor detects an end-of-file condition from the standard input, it shall be equivalent to a SIGHUP asynchronous event.
INPUT FILES
See the INPUT FILES section of the ex command for a description of the input files supported by the vi command.

ENVIRONMENT VARIABLES
See the ENVIRONMENT VARIABLES section of the ex command for the environment variables that affect the execution of the vi command.

ASYNCHRONOUS EVENTS
See the ASYNCHRONOUS EVENTS section of the ex for the asynchronous events that affect the execution of the vi command.

STDOUT
If standard output is not a terminal device, undefined results occur.
Standard output may be used for writing prompts to the user, for informational messages, and for writing lines from the file.

STDERR
If standard output is not a terminal device, undefined results occur.
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
See the OUTPUT FILES section of the ex command for a description of the output files supported by the vi command.

EXTENDED DESCRIPTION
If the terminal does not have the capabilities necessary to support an unspecified portion of the vi definition, implementations shall start initially in ex mode or open mode. Otherwise, after initialization, vi shall be in command mode; text input mode can be entered by one of several commands used to insert or change text. In text input mode, <ESC> can be used to return to command mode; other uses of <ESC> are described later in this section; see Terminate Command or Input Mode (on page 996).

Initialization in ex and vi
See Initialization in ex and vi (on page 358) for a description of ex and vi initialization for the vi utility.

Command Descriptions in vi
The following symbols are used in this reference page to represent arguments to commands.

buffer
See the description of buffer in the EXTENDED DESCRIPTION section of the ex utility; see Command Descriptions in ex (on page 368).

In open and visual mode, when a command synopsis shows both [buffer] and [count] preceding the command name, they can be specified in either order.

count
A positive integer used as an optional argument to most commands, either to give a repeat count or as a size. This argument is optional and shall default to 1 unless otherwise specified.

The Synopsis lines for the vi commands <control>-G, <control>-L, <control>-R, <control>-], %, &, *, D, m, M, Q, u, U, and ZZ do not have count as an optional argument. Regardless, it shall not be an error to specify a count to these commands, and any specified count shall be ignored.
motion An optional trailing argument used by the !, <, >, c, d, and y commands, which is used to indicate the region of text that shall be affected by the command. The motion can be either one of the command characters repeated or one of several other vi commands (listed in the following table). Each of the applicable commands specifies the region of text matched by repeating the command; each command that can be used as a motion command specifies the region of text it affects.

Commands that take motion arguments operate on either lines or characters, depending on the circumstances. When operating on lines, all lines that fall partially or wholly within the text region specified for the command shall be affected. When operating on characters, only the exact characters in the specified text region shall be affected. Each motion command specifies this individually.

When commands that may be motion commands are not used as motion commands, they shall set the current position to the current line and column as specified.

The following commands shall be valid cursor motion commands:

- <apostrophe> (jH)
- <carriage-return> ($kL)
- <comma> ([% l M)
- <control>-H (n N)
- <control>-N (T T)
- <control>-P (w W)
- <grave accent> (^b B)
- <newline> (+ e E)
- <space> (| f F)
- <zero> (/h G)

Any count that is specified to a command that has an associated motion command shall be applied to the motion command. If a count is applied to both the command and its associated motion command, the effect shall be multiplicative.

The following symbols are used in this section to specify locations in the edit buffer:

- current character: The character that is currently indicated by the cursor.
- end of a line: The point located between the last non-
newline> (if any) and the terminating <newline> of a line. For an empty line, this location coincides with the beginning of the line.
- end of the edit buffer: The location corresponding to the end of the last line in the edit buffer.

The following symbols are used in this section to specify command actions:

- bigword: In the POSIX locale, vi shall recognize four kinds of bigwords:
  1. A maximal sequence of non-
blank>s preceded and followed by <blank>s or the beginning or end of a line or the edit buffer
  2. One or more sequential blank lines
  3. The first character in the edit buffer
  4. The last non-
newline> in the edit buffer
word  In the POSIX locale, `vi` shall recognize five kinds of words:

1. A maximal sequence of letters, digits, and underscores, delimited at both ends by:
   - Characters other than letters, digits, or underscores
   - The beginning or end of a line
   - The beginning or end of the edit buffer

2. A maximal sequence of characters other than letters, digits, underscores, or `<blank>`s, delimited at both ends by:
   - A letter, digit, underscore
   - `<blank>`s
   - The beginning or end of a line
   - The beginning or end of the edit buffer

3. One or more sequential blank lines

4. The first character in the edit buffer

5. The last non-<newline> in the edit buffer

section boundary

A section boundary is one of the following:

1. A line whose first character is a `<form-feed>`

2. A line whose first character is an open curly brace (`{` `}`)

3. A line whose first character is a period and whose second and third characters match a two-character pair in the `sections` edit option (see `ed`)

4. A line whose first character is a period and whose only other character matches the first character of a two-character pair in the `sections` edit option, where the second character of the two-character pair is a `<space>`

5. The first line of the edit buffer

6. The last line of the edit buffer if the last line of the edit buffer is empty or if it is a `]` or `}` command; otherwise, the last non-<newline> of the last line of the edit buffer

paragraph boundary

A paragraph boundary is one of the following:

1. A section boundary

2. A line whose first character is a period and whose second and third characters match a two-character pair in the `paragraphs` edit option (see `ed`)

3. A line whose first character is a period and whose only other character matches the first character of a two-character pair in the `paragraphs` edit option, where the second character of the two-character pair is a `<space>`

4. One or more sequential blank lines

remembered search direction

See the description of `remembered search direction` in `ed`. 
sentence boundary

A sentence boundary is one of the following:

1. A paragraph boundary

2. The first non-<blank> that occurs after a paragraph boundary

3. The first non-<blank> that occurs after a period (', '), exclamation mark ('!', '), or question mark ('?', '), followed by two <space>s or the end of a line; any number of closing parenthesis (')'), closing brackets ('['), double quote ('"'), or single quote ('''') characters can appear between the punctuation mark and the two <space>s or end-of-line

In the remainder of the description of the vi utility, the term “buffer line” refers to a line in the edit buffer and the term “display line” refers to the line or lines on the display screen used to display one buffer line. The term “current line” refers to a specific “buffer line”.

If there are display lines on the screen for which there are no corresponding buffer lines because they correspond to lines that would be after the end of the file, they shall be displayed as a single tilde ('˜') character, plus the terminating <newline>. The last line of the screen shall be used to report errors or display informational messages. It shall also be used to display the input for “line-oriented commands” (/, ?, :, and !). When a line-oriented command is executed, the editor shall enter text input mode on the last line on the screen, using the respective command characters as prompt characters. (In the case of the ! command, the associated motion shall be entered by the user before the editor enters text input mode.) The line entered by the user shall be terminated by a <newline>, a non-<control>-V-escaped <carriage-return>, or unescaped <ESC>. It is unspecified if more characters than require a display width minus one column number of screen columns can be entered.

If any command is executed that overwrites a portion of the screen other than the last line of the screen (for example, the ex suspend or ! commands), other than the ex shell command, the user shall be prompted for a character before the screen is refreshed and the edit session continued.

<tab>s shall take up the number of columns on the screen set by the tabstop edit option (see ed), unless there are less than that number of columns before the display margin that will cause the displayed line to be folded; in this case, they shall only take up the number of columns up to that boundary.

The cursor shall be placed on the current line and relative to the current column as specified by each command described in the following sections.

In open mode, if the current line is not already displayed, then it shall be displayed.

In visual mode, if the current line is not displayed, then the lines that are displayed shall be expanded, scrolled, or redisplayed to cause an unspecified portion of the current line to be displayed. If the screen is redrawn, no more than the number of display lines specified by the value of the window edit option shall be displayed (unless the current line cannot be completely displayed in the number of display lines specified by the window edit option) and the current line shall be positioned as close to the center of the displayed lines as possible (within the constraints imposed by the distance of the line from the beginning or end of the edit buffer). If the current line is before the first line in the display and the screen is scrolled, an unspecified portion of the current line shall be placed on the first line of the display. If the current line is after the last line in the display and the screen is scrolled, an unspecified portion of the current line shall be placed on the last line of the display.

In visual mode, if a line from the edit buffer (other than the current line) does not entirely fit into the lines at the bottom of the display that are available for its presentation, the editor may
choose not to display any portion of the line. The lines of the display that do not contain text
from the edit buffer for this reason shall each consist of a single ‘@’ character.

In visual mode, the editor may choose for unspecified reasons to not update lines in the display
to correspond to the underlying edit buffer text. The lines of the display that do not correctly
correspond to text from the edit buffer for this reason shall consist of a single ‘@’ character
(plus the terminating <newline>), and the <control>-R command shall cause the editor to
update the screen to correctly represent the edit buffer.

Open and visual mode commands that set the current column set it to a column position in the
display, and not a character position in the line. In this case, however, the column position in the
display shall be calculated for an infinite width display; for example, the column related to a
character that is part of a line that has been folded onto additional screen lines will be offset from
the display line column where the buffer line begins, not from the beginning of a particular
display line.

The display cursor column in the display is based on the value of the current column, as follows,
with each rule applied in turn:

1. If the current column is after the last display line column used by the displayed line, the
display cursor column shall be set to the last display line column occupied by the last non-
<newline> in the current line; otherwise, the display cursor column shall be set to the
current column.

2. If the character of which some portion is displayed in the display line column specified by
the display cursor column requires more than a single display line column:
   a. If in text input mode, the display cursor column shall be adjusted to the first display
      line column in which any portion of that character is displayed.
   b. Otherwise, the display cursor column shall be adjusted to the last display line
      column in which any portion of that character is displayed.

The current column shall not be changed by these adjustments to the display cursor column.

If an error occurs during the parsing or execution of a vi command:

- The terminal shall be alerted. Execution of the vi command shall stop, and the cursor (for
  example, the current line and column) shall not be further modified.

- Unless otherwise specified by the following command sections, it is unspecified whether an
  informational message shall be displayed.

- Any partially entered vi command shall be discarded.

- If the vi command resulted from a map expansion, all characters from that map expansion
  shall be discarded, except as otherwise specified by the map command (see ed).

- If the vi command resulted from the execution of a buffer, no further commands caused by
  the execution of the buffer shall be executed.
Page Backwards

Synopsis: \([\text{count}] \; <\text{control}>-\text{B}\)

If in open mode, the <control>-B command shall behave identically to the \(z\) command.
Otherwise, if the current line is the first line of the edit buffer, it shall be an error.

If the \textit{window} edit option is less than 3, display a screen where the last line of the display shall
be some portion of:

\[(\text{current first line}) - 1\]

otherwise, display a screen where the first line of the display shall be some portion of:

\[(\text{current first line}) - \text{count} \times ((\text{window edit option}) - 2)\]

If this calculation would result in a line that is before the first line of the edit buffer, the first line
of the display shall display some portion of the first line of the edit buffer.

\textit{Current line}: If no lines from the previous display remain on the screen, set to the last line of the
display; otherwise, set to \((\text{line} - \text{the number of new lines displayed on this screen})\).

\textit{Current column}: Set to non-\texttt{<blank>}. 

Scroll Forward

Synopsis: \([\text{count}] \; <\text{control}>-\text{D}\)

If the current line is the last line of the edit buffer, it shall be an error.

If no \texttt{count} is specified, \texttt{count} shall default to the \texttt{count} associated with the previous <control>-D
or <control>-U command. If there was no previous <control>-D or <control>-U command, \texttt{count}
shall default to the value of the \texttt{scroll} edit option.

If in open mode, write lines starting with the line after the current line, until \texttt{count} lines or the
last line of the file have been written.

\textit{Current line}: If the current line + \texttt{count} is past the last line of the edit buffer, set to the last line of
the edit buffer; otherwise, set to the current line + \texttt{count}.

\textit{Current column}: Set to non-\texttt{<blank>}. 

Scroll Forward by Line

Synopsis: \([\text{count}] \; <\text{control}>-\text{E}\)

Display the line \texttt{count} lines after the last line currently displayed.

If the last line of the edit buffer is displayed, it shall be an error. If there is no line \texttt{count} lines
after the last line currently displayed, the last line of the display shall display some portion of
the last line of the edit buffer.

\textit{Current line}: Unchanged if the previous current character is displayed; otherwise, set to the first
line displayed.

\textit{Current column}: Unchanged.
Page Forward

Synopsis:  \([\text{count}] \langle\text{control}\rangle-F\)

If in open mode, the \(<\text{control}\>-F\) command shall behave identically to the \(z\) command. Otherwise, if the current line is the last line of the edit buffer, it shall be an error.

If the \texttt{window} edit option is less than 3, display a screen where the first line of the display shall be some portion of:

\[(\text{current last line}) + 1\]

otherwise, display a screen where the first line of the display shall be some portion of:

\[(\text{current first line}) + \text{count} \times ((\text{window edit option}) - 2)\]

If this calculation would result in a line that is after the last line of the edit buffer, the last line of the display shall display some portion of the last line of the edit buffer.

\texttt{Current line}: If no lines from the previous display remain on the screen, set to the first line of the display; otherwise, set to (line + the number of new lines displayed on this screen).

\texttt{Current column}: Set to non-\texttt{<\text{blank}>}.

Display Information

Synopsis:  \(<\text{control}>-G\)

This command shall be equivalent to the \texttt{ex file} command.

Move Cursor Backwards

Synopsis:  \([\text{count}] \langle\text{control}\rangle-H\)

\(\text{count}\) \texttt{h}

the current erase character (see \texttt{stty})

If there are no characters before the current character on the current line, it shall be an error. If there are less than \texttt{count} previous characters on the current line, \texttt{count} shall be adjusted to the number of previous characters on the line.

If used as a motion command:

1. The text region shall be from the character before the starting cursor up to and including the \texttt{count}th character before the starting cursor.

2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

\texttt{Current line}: Unchanged.

\texttt{Current column}: Set to \((\text{column} - \text{the number of columns occupied by count characters ending with the previous current column})\).
Move Down

Synopsis: \[\text{count} \text{ newline}\]

38267 \[\text{count} \text{ control J}\]
38268 \[\text{count} \text{ control M}\]
38269 \[\text{count} \text{ control N}\]
38270 \[\text{count} \text{ j}\]
38271 \[\text{count} \text{ carriage-return}\]
38272 \[\text{count} +\]

If there are less than \text{count} lines after the current line in the edit buffer, it shall be an error.

If used as a motion command:

1. The text region shall include the starting line and the next \text{count} – 1 lines.

2. Any text copied to a buffer shall be in line mode.

If not used as a motion command:

\text{Current line:} Set to \text{current line} + \text{count}.

\text{Current column:} Set to non-\text{blank} for the \text{carriage-return}, \text{control-M}, and + commands; otherwise, unchanged.

Clear and Redisplay

Synopsis: \text{control -L}

If in open mode, clear the screen and redisplay the current line. Otherwise, clear and redisplay the screen.

\text{Current line:} Unchanged.

\text{Current column:} Unchanged.

Move Up

Synopsis: \[\text{count} \text{ control P}\]

38289 \[\text{count} \text{ k}\]
38290 \[\text{count} \text{ -}\]

If there are less than \text{count} lines before the current line in the edit buffer, it shall be an error.

If used as a motion command:

1. The text region shall include the starting line and the previous \text{count} lines.

2. Any text copied to a buffer shall be in line mode.

If not used as a motion command:

\text{Current line:} Set to \text{current line} – \text{count}.

\text{Current column:} Set to non-\text{blank} for the – command; otherwise, unchanged.
**Redraw Screen**

*Synopsis:* \( <\text{control}>-R \)

If any lines have been deleted from the display screen and flagged as deleted on the terminal using the @ convention (see the beginning of the EXTENDED DESCRIPTION section), they shall be redisplayed to match the contents of the edit buffer.

It is unspecified whether lines flagged with @ because they do not fit on the terminal display shall be affected.

*Current line:* Unchanged.

*Current column:* Unchanged.

**Scroll Backward**

*Synopsis:* \([\text{count}] <\text{control}>-U\)

If the current line is the first line of the edit buffer, it shall be an error.

If no \(\text{count}\) is specified, \(\text{count}\) shall default to the \(\text{count}\) associated with the previous \(<\text{control}>-D\) or \(<\text{control}>-U\) command. If there was no previous \(<\text{control}>-D\) or \(<\text{control}>-U\) command, \(\text{count}\) shall default to the value of the scroll edit option.

*Current line:* If \(\text{count}\) is greater than the current line, set to 1; otherwise, set to the current line – \(\text{count}\).

*Current column:* Set to non-<blank>.

**Scroll Backward by Line**

*Synopsis:* \([\text{count}] <\text{control}>-Y\)

Display the line \(\text{count}\) lines before the first line currently displayed.

If the current line is the first line of the edit buffer, it shall be an error. If this calculation would result in a line that is before the first line of the edit buffer, the first line of the display shall display some portion of the first line of the edit buffer.

*Current line:* Unchanged if the previous current character is displayed; otherwise, set to the first line displayed.

*Current column:* Unchanged.

**Edit the Alternate File**

*Synopsis:* \(<\text{control}>\hat{\text{e}}\)

This command shall be equivalent to the \texttt{ex edit} command, with the alternate pathname as its argument.

**Terminate Command or Input Mode**

*Synopsis:* \( <\text{ESC}>\)

If a partial vi command (as defined by at least one, non-\(\text{count}\) character) has been entered, discard the \(\text{count}\) and the command character(s).

Otherwise, if no command characters have been entered, and the \(<\text{ESC}>\) was the result of a map expansion, the terminal shall be alerted and the \(<\text{ESC}>\) character shall be discarded, but it shall not be an error.
Otherwise, it shall be an error.

Current line: Unchanged.

Current column: Unchanged.

**Search for tagstring**

**Synopsis:** `<control>-[]`

If the current character is not a word or `<blank>`, it shall be an error.

This command shall be equivalent to the `ex tag` command, with the argument to that command defined as follows.

If the current character is a `<blank>`:

1. Skip all `<blank>`s after the cursor up to the end of the line.
2. If the end of the line is reached, it shall be an error.

Then, the argument to the `ex tag` command shall be the current character and all subsequent characters, up to the first non-word character or the end of the line.

**Move Cursor Forward**

**Synopsis:** `[count] <space>`

If there are less than `count` non-<newline>s after the cursor on the current line, `count` shall be adjusted to the number of non-<newline>s after the cursor on the line.

If used as a motion command:

1. If the current or `count`th character after the cursor is the last non-<newline> in the line, the text region shall be comprised of the current character up to and including the last non-<newline> in the line. Otherwise, the text region shall be from the current character up to, but not including, the `count`th character after the cursor.
2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

If there are no non-<newline>s after the current character on the current line, it shall be an error.

Current line: Unchanged.

Current column: Set to the last column that displays any portion of the `count`th character after the current character.

**Replace Text with Results from Shell Command**

**Synopsis:** `[count] ! motion shell-commands <newline>

If the motion command is the `!` command repeated:

1. If the edit buffer is empty and no `count` was supplied, the command shall be the equivalent of the `ex read !` command, with the text input, and no text shall be copied to any buffer.
2. Otherwise:
   a. If there are less than `count`–1 lines after the current line in the edit buffer, it shall be an error.
b. The text region shall be from the current line up to and including the next count −1 lines.

Otherwise, the text region shall be the lines in which any character of the text region specified by the motion command appear.

Any text copied to a buffer shall be in line mode.

This command shall be equivalent to the ex ! command for the specified lines.

### Move Cursor to End-of-Line

**Synopsis:** \([\text{count}] \$\)

It shall be an error if there are less than (count −1) lines after the current line in the edit buffer.

If used as a motion command:

1. If count is 1:
   a. It shall be an error if the line is empty.
   b. Otherwise, the text region shall consist of all characters from the starting cursor to the last non-<newline> in the line, inclusive, and any text copied to a buffer shall be in character mode.

2. Otherwise, if the starting cursor position is at or before the first non-<blank> in the line, the text region shall consist of the current and the next count −1 lines, and any text saved to a buffer shall be in line mode.

3. Otherwise, the text region shall consist of all characters from the starting cursor to the last non-<newline> in the line that is count −1 lines forward from the current line, and any text copied to a buffer shall be in character mode.

If not used as a motion command:

**Current line:** Set to the current line + count −1.

**Current column:** The current column is set to the last display line column of the last non-<newline> in the line, or column position 1 if the line is empty.

The current column shall be adjusted to be on the last display line column of the last non-<newline> of the current line as subsequent commands change the current line, until a command changes the current column.

### Move to Matching Character

**Synopsis:** \(%\)

If the character at the current position is not a parenthesis, bracket, or curly brace, search forward in the line to the first one of those characters. If no such character is found, it shall be an error.

The matching character shall be the parenthesis, bracket, or curly brace matching the parenthesis, bracket, or curly brace, respectively, that was at the current position or that was found on the current line.

Matching shall be determined as follows, for an open parenthesis:

1. Set a counter to 1.

2. Search forwards until a parenthesis is found or the end of the edit buffer is reached.
3. If the end of the edit buffer is reached, it shall be an error.
4. If an open parenthesis is found, increment the counter by 1.
5. If a close parenthesis is found, decrement the counter by 1.
6. If the counter is zero, the current character is the matching character.

Matching for a close parenthesis shall be equivalent, except that the search shall be backwards, from the starting character to the beginning of the buffer, a close parenthesis shall increment the counter by 1, and an open parenthesis shall decrement the counter by 1.

Matching for brackets and curly braces shall be equivalent, except that searching shall be done for open and close brackets or open and close curly braces. It is implementation-defined whether other characters are searched for and matched as well.

If used as a motion command:
1. If the matching cursor was after the starting cursor in the edit buffer, and the starting cursor position was at or before the first non-<blank> non-<newline> in the starting line, and the matching cursor position was at or after the last non-<blank> non-<newline> in the matching line, the text region shall consist of the current line to the matching line, inclusive, and any text copied to a buffer shall be in line mode.
2. If the matching cursor was before the starting cursor in the edit buffer, and the starting cursor position was at or after the last non-<blank> non-<newline> in the starting line, and the matching cursor position was at or before the first non-<blank> non-<newline> in the matching line, the text region shall consist of the current line to the matching line, inclusive, and any text copied to a buffer shall be in line mode.
3. Otherwise, the text region shall consist of the starting character to the matching character, inclusive, and any text copied to a buffer shall be in character mode.

If not used as a motion command:
Current line: Set to the line where the matching character is located.
Current column: Set to the last column where any portion of the matching character is displayed.

Repeat Substitution

Synopsis: &

Repeat the previous substitution command. This command shall be equivalent to the ex & command with the current line as its addresses, and without options, count, or flags.

Return to Previous Context at Beginning of Line

Synopsis: 'character

It shall be an error if there is no line in the edit buffer marked by character.

If used as a motion command:
1. If the starting cursor is after the marked cursor, then the locations of the starting cursor and the marked cursor in the edit buffer shall be logically swapped.
2. The text region shall consist of the starting line up to and including the marked line, and any text copied to a buffer shall be in line mode.

If not used as a motion command:
Current line: Set to the line referenced by the mark.
Current column: Set to non-<blank>.

Return to Previous Context

Synopsis: ‘ character

It shall be an error if the marked line is no longer in the edit buffer. If the marked line no longer contains a character in the saved numbered character position, it shall be as if the marked position is the first non-<blank>.

If used as a motion command:

1. It shall be an error if the marked cursor references the same character in the edit buffer as the starting cursor.
2. If the starting cursor is after the marked cursor, then the locations of the starting cursor and the marked cursor in the edit buffer shall be logically swapped.
3. If the starting line is empty or the starting cursor is at or before the first non-<blank> non-
   <newline> of the starting line, and the marked cursor line is empty or the marked cursor references the first character of the marked cursor line, the text region shall consist of all lines containing characters from the starting cursor to the line before the marked cursor line, inclusive, and any text copied to a buffer shall be in line mode.
4. Otherwise, if the marked cursor line is empty or the marked cursor references a character at or before the first non-<blank> non-
   <newline> of the marked cursor line, the region of text shall be from the starting cursor to the last non-
   <newline> of the line before the marked cursor line, inclusive, and any text copied to a buffer shall be in character mode.
5. Otherwise, the region of text shall be from the starting cursor (inclusive), to the marked cursor (exclusive), and any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Set to the line referenced by the mark.
Current column: Set to the last column in which any portion of the character referenced by the mark is displayed.

Return to Previous Section

Synopsis: [count] [[    ]]

Move the cursor backward through the edit buffer to the first character of the previous section boundary, count times.

If used as a motion command:

1. If the starting cursor was at the first character of the starting line or the starting line was empty, and the first character of the boundary was the first character of the boundary line, the text region shall consist of the current line up to and including the line where the countth next boundary starts, and any text copied to a buffer shall be in line mode.
2. If the boundary was the last line of the edit buffer or the last non-
   <newline> of the last line of the edit buffer, the text region shall consist of the last character in the edit buffer up to and including the starting character, and any text saved to a buffer shall be in character mode.
3. Otherwise, the text region shall consist of the starting character up to but not including the first character in the count th next boundary, and any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Set to the line where the count th next boundary in the edit buffer starts.

Current column: Set to the last column in which any portion of the first character of the count th next boundary is displayed, or column position 1 if the line is empty.

Move to Next Section

Synopsis: \[\text{count}\]

Move the cursor forward through the edit buffer to the first character of the next section boundary, count times.

If used as a motion command:

1. If the starting cursor was at the first character of the starting line or the starting line was empty, and the first character of the boundary was the first character of the boundary line, the text region shall consist of the current line up to and including the line where the count th previous boundary starts, and any text copied to a buffer shall be in line mode.

2. If the boundary was the first line of the edit buffer, the text region shall consist of the first character in the edit buffer up to but not including the starting character, and any text copied to a buffer shall be in character mode.

3. Otherwise, the text region shall consist of the first character in the count th previous section boundary up to but not including the starting character, and any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Set to the line where the count th previous boundary in the edit buffer starts.

Current column: Set to the last column in which any portion of the first character of the count th previous boundary is displayed, or column position 1 if the line is empty.

Move to First Non-<blank> Position on Current Line

Synopsis: ^

If used as a motion command:

1. If the line has no non-<blank> non-<newline>s, or if the cursor is at the first non-<blank> non-<newline> of the line, it shall be an error.

2. If the cursor is before the first non-<blank> non-<newline> of the line, the text region shall be comprised of the current character, up to, but not including, the first non-<blank> non-<newline> of the line.

3. If the cursor is after the first non-<blank> non-<newline> of the line, the text region shall be from the character before the starting cursor up to and including the first non-<blank> non-<newline> of the line.

4. Any text copied to a buffer shall be in character mode.

If not used as a motion command:
Utilities

Current line: Unchanged.
Current column: Set to non-<blank>.

Current and Line Above
Synopsis: \[count\] _
If there are less than count −1 lines after the current line in the edit buffer, it shall be an error.
If used as a motion command:
1. If count is less than 2, the text region shall be the current line.
2. Otherwise, the text region shall include the starting line and the next count −1 lines.
3. Any text copied to a buffer shall be in line mode.
If not used as a motion command:
Current line: Set to current line + count −1.
Current column: Set to non-<blank>.

Move Back to Beginning of Sentence
Synopsis: \[count\] (Move backward to the beginning of a sentence. This command shall be equivalent to the [[ command, with the exception that sentence boundaries shall be used instead of section boundaries.

Move Forward to Beginning of Sentence
Synopsis: \[count\] )
Move forward to the beginning of a sentence. This command shall be equivalent to the ]] command, with the exception that sentence boundaries shall be used instead of section boundaries.

Move Back to Preceding Paragraph
Synopsis: \[count\] {Move back to the beginning of the preceding paragraph. This command shall be equivalent to the [ [command, with the exception that paragraph boundaries shall be used instead of section boundaries.

Move Forward to Next Paragraph
Synopsis: \[count\] }
Move forward to the beginning of the next paragraph. This command shall be equivalent to the ] ] command, with the exception that paragraph boundaries shall be used instead of section boundaries.
Move to Specific Column Position

Synopsis: \[ \text{count} \]

For the purposes of this command, lines that are too long for the current display and that have been folded shall be treated as having a single, 1-based, number of columns.

If there are less than \text{count} columns in which characters from the current line are displayed on the screen, \text{count} shall be adjusted to be the last column in which any portion of the line is displayed on the screen.

If used as a motion command:

1. If the line is empty, or the cursor character is the same as the character on the \text{count}th column of the line, it shall be an error.
2. If the cursor is before the \text{count}th column of the line, the text region shall be comprised of the current character, up to but not including the character on the \text{count}th column of the line.
3. If the cursor is after the \text{count}th column of the line, the text region shall be from the character before the starting cursor up to and including the character on the \text{count}th column of the line.
4. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Unchanged.

Current column: Set to the last column in which any portion of the character that is displayed in the \text{count} column of the line is displayed.

Reverse Find Character

Synopsis: \[ \text{count} \]

If the last \text{F}, \text{f}, \text{T}, or \text{t} command was \text{F}, \text{f}, \text{T}, or \text{t}, this command shall be equivalent to an \text{f}, \text{F}, \text{t}, or \text{T} command, respectively, with the specified \text{count} and the same search character.

If there was no previous \text{F}, \text{f}, \text{T}, or \text{t} command, it shall be an error.

Repeat

Synopsis: \[ \text{count} \]

Repeat the last \text{!}, \text{<}, \text{>}, \text{A}, \text{C}, \text{D}, \text{I}, \text{J}, \text{O}, \text{P}, \text{R}, \text{S}, \text{X}, \text{Y}, \text{a}, \text{c}, \text{d}, \text{i}, \text{o}, \text{p}, \text{r}, \text{s}, \text{x}, \text{y}, \text{~} command. It shall be an error if none of these commands have been executed. Commands (other than commands that enter text input mode) executed as a result of map expansions, shall not change the value of the last repeatable command.

Repeated commands with associated motion commands shall repeat the motion command as well; however, any specified \text{count} shall replace the \text{count}(s) that were originally specified to the repeated command or its associated motion command.

If the motion component of the repeated command is \text{f}, \text{F}, \text{t}, or \text{T}, the repeated command shall not set the remembered search character for the ; and , commands.

If the repeated command is \text{p} or \text{P}, and the buffer associated with that command was a numeric buffer named with a number less than 9, the buffer associated with the repeated command shall be set to be the buffer named by the name of the previous buffer logically incremented by 1.
If the repeated character is a text input command, the input text associated with that command is repeated literally:

- Input characters are neither macro or abbreviation-expanded.
- Input characters are not interpreted in any special way with the exception that `<newline>`, `<carriage-return>`, and `<control>-T` behave as described in Input Mode Commands in vi (on page 1022).

**Current line**: Set as described for the repeated command.

**Current column**: Set as described for the repeated command.

### Find Regular Expression

**Synopsis**: `/`

If the input line contains no non-<newline>s, it shall be equivalent to a line containing only the last regular expression encountered. The enhanced regular expressions supported by vi are described in Regular Expressions in ex (on page 391).

Otherwise, the line shall be interpreted as one or more regular expressions, optionally followed by an address offset or a `vi z` command.

If the regular expression is not the last regular expression on the line, or if a line offset or `vi z` command is specified, the regular expression shall be terminated by an unescaped ‘/’ character, which shall not be used as part of the regular expression. If the regular expression is not the first regular expression on the line, it shall be preceded by zero or more <blank>s, a semicolon, zero or more <blank>s, and a leading ‘/’ character, which shall not be interpreted as part of the regular expression. It shall be an error to precede any regular expression with any characters other than these.

Each search shall begin from the character after the first character of the last match (or, if it is the first search, after the cursor). If the `wrapscan` edit option is set, the search shall continue to the character before the starting cursor character; otherwise, to the end of the edit buffer. It shall be an error if any search fails to find a match, and an informational message to this effect shall be displayed.

An optional address offset (see Addressing in ex (on page 361)) can be specified after the last regular expression by including a trailing ‘/’ character after the regular expression and specifying the address offset. This offset will be from the line containing the match for the last regular expression specified. It shall be an error if the line offset would indicate a line address less than 1 or greater than the last line in the edit buffer. An address offset of zero shall be supported. It shall be an error to follow the address offset with any other characters than <blank>s.

If not used as a motion command, an optional `z` command (see Redraw Window (on page 1021)) can be specified after the last regular expression by including a trailing ‘/’ character after the regular expression, zero or more <blank>s, a ‘z’, zero or more <blank>s, an optional new window edit option value, zero or more <blank>s, and a location character. The effect shall be as if the `z` command was executed after the `/` command. It shall be an error to follow the `z` command with any other characters than <blank>s.

The remembered search direction shall be set to forward.

If used as a motion command:

1. It shall be an error if the last match references the same character in the edit buffer as the starting cursor.
Utilities

2. If any address offset is specified, the last match shall be adjusted by the specified offset as described previously.

3. If the starting cursor is after the last match, then the locations of the starting cursor and the last match in the edit buffer shall be logically swapped.

4. If any address offset is specified, the text region shall consist of all lines containing characters from the starting cursor to the last match line, inclusive, and any text copied to a buffer shall be in line mode.

5. Otherwise, if the starting line is empty or the starting cursor is at or before the first non-<blank> non-<newline> of the starting line, and the last match line is empty or the last match starts at the first character of the last match line, the text region shall consist of all lines containing characters from the starting cursor to the line before the last match line, inclusive, and any text copied to a buffer shall be in line mode.

6. Otherwise, if the last match line is empty or the last match begins at a character at or before the first non-<blank> non-<newline> of the last match line, the region of text shall be from the current cursor to the last non-<newline> of the line before the last match line, inclusive, and any text copied to a buffer shall be in character mode.

7. Otherwise, the region of text shall be from the current cursor (inclusive), to the first character of the last match (exclusive), and any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: If a match is found, set to the last matched line plus the address offset, if any; otherwise, unchanged.

Current column: Set to the last column on which any portion of the first character in the last matched string is displayed, if a match is found; otherwise, unchanged.

Move to First Character in Line

Synopsis: 0 (zero)

Move to the first character on the current line. The character '0' shall not be interpreted as a command if it is immediately preceded by a digit.

If used as a motion command:

1. If the cursor character is the first character in the line, it shall be an error.

2. The text region shall be from the character before the cursor character up to and including the first character in the line.

3. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Unchanged.

Current column: The last column in which any portion of the first character in the line is displayed, or if the line is empty, unchanged.
Execute an ex Command

Synopsis:  :

Execute one or more ex commands.

If any portion of the screen other than the last line of the screen was overwritten by any ex
command (except shell), vi shall display a message indicating that it is waiting for an input from
the user, and shall then read a character. This action may also be taken for other, unspecified
reasons.

If the next character entered is a ':', another ex command shall be accepted and executed. Any
other character shall cause the screen to be refreshed and vi shall return to command mode.

Current line:  As specified for the ex command.

Current column:  As specified for the ex command.

Repeat Find

Synopsis:  [count] ;

This command shall be equivalent to the last F, f, T, or t command, with the specified count, and
with the same search character used for the last F, f, T, or t command. If there was no previous F,
f, T, or t command, it shall be an error.

Shift Left

Synopsis:  [count] < motion

If the motion command is the < command repeated:

1.  If there are less than count −1 lines after the current line in the edit buffer, it shall be an
    error.

2.  The text region shall be from the current line, up to and including the next count −1 lines.

Shift any line in the text region specified by the count and motion command one shiftwidth (see
the ex shiftwidth option) toward the start of the line, as described by the ex < command. The
unshifted lines shall be copied to the unnamed buffer in line mode.

Current line:  If the motion was from the current cursor position toward the end of the edit
buffer, unchanged. Otherwise, set to the first line in the edit buffer that is part of the text region
specified by the motion command.

Current column:  Set to non-<blank>.

Shift Right

Synopsis:  [count] > motion

If the motion command is the > command repeated:

1.  If there are less than count −1 lines after the current line in the edit buffer, it shall be an
    error.

2.  The text region shall be from the current line, up to and including the next count −1 lines.

Shift any line with characters in the text region specified by the count and motion command one
shiftwidth (see the ex shiftwidth option) away from the start of the line, as described by the ex >
command. The unshifted lines shall be copied into the unnamed buffer in line mode.
Current line: If the motion was from the current cursor position toward the end of the edit buffer, unchanged. Otherwise, set to the first line in the edit buffer that is part of the text region specified by the motion command.

Current column: Set to non-<blank>.

Scan Backwards for Regular Expression

Synopsis: ?

Scan backwards; the ? command shall be equivalent to the / command (see Find Regular Expression (on page 1004)) with the following exceptions:

1. The input prompt shall be a ‘?’.
2. Each search shall begin from the character before the first character of the last match (or, if it is the first search, the character before the cursor character).
3. The search direction shall be from the cursor toward the beginning of the edit buffer, and the wrapscan edit option shall affect whether the search wraps to the end of the edit buffer and continues.
4. The remembered search direction shall be set to backward.

Execute

Synopsis: @buffer

If the buffer is specified as @, the last buffer executed shall be used. If no previous buffer has been executed, it shall be an error.

Behave as if the contents of the named buffer were entered as standard input. After each line of a line-mode buffer, and all but the last line of a character mode buffer, behave as if a <newline> were entered as standard input.

If an error occurs during this process, an error message shall be written, and no more characters resulting from the execution of this command shall be processed.

If a count is specified, behave as if that count were entered as user input before the characters from the @ buffer were entered.

Current line: As specified for the individual commands.

Current column: As specified for the individual commands.

Reverse Case

Synopsis: [count] ~

Reverse the case of the current character and the next count −1 characters, such that lowercase characters that have uppercase counterparts shall be changed to uppercase characters, and uppercase characters that have lowercase counterparts shall be changed to lowercase characters, as prescribed by the current locale. No other characters shall be affected by this command.

If there are less than count −1 characters after the cursor in the edit buffer, count shall be adjusted to the number of characters after the cursor in the edit buffer minus 1.

For the purposes of this command, the next character after the last non-<newline> on the line shall be the next character in the edit buffer.

Current line: Set to the line including the (count−1)th character after the cursor.
Current column: Set to the last column in which any portion of the \((\text{count}−1)\)th character after the cursor is displayed.

Append

Synopsis: \([\text{count}] \ a\)

Enter text input mode after the current cursor position. No characters already in the edit buffer shall be affected by this command. A \(\text{count}\) shall cause the input text to be appended \(\text{count} − 1\) more times to the end of the input.

Current line/column: As specified for the text input commands (see Input Mode Commands in \(\text{vi}\) (on page 1022)).

Append at End-of-Line

Synopsis: \([\text{count}] \ A\)

This command shall be equivalent to the \(\text{vi}\) command:

\(\$ \ [\text{count}] \ a\)

(see Append).

Move Backward to Preceding Word

Synopsis: \([\text{count}] \ b\)

With the exception that words are used as the delimiter instead of bigwords, this command shall be equivalent to the \(\text{B}\) command.

Move Backward to Preceding Bigword

Synopsis: \([\text{count}] \ B\)

If the edit buffer is empty or the cursor is on the first character of the edit buffer, it shall be an error. If less than \(\text{count}\) bigwords begin between the cursor and the start of the edit buffer, \(\text{count}\) shall be adjusted to the number of bigword beginnings between the cursor and the start of the edit buffer.

If used as a motion command:

1. The text region shall be from the first character of the \(\text{count}\)th previous bigword beginning up to but not including the cursor character.
2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Set to the line containing the current column.

Current column: Set to the last column upon which any part of the first character of the \(\text{count}\)th previous bigword is displayed.
Change

Synopsis: [buffer] [count] c motion

If the motion command is the c command repeated:

1. The buffer text shall be in line mode.
2. If there are less than count −1 lines after the current line in the edit buffer, it shall be an error.
3. The text region shall be from the current line up to and including the next count −1 lines.

Otherwise, the buffer text mode and text region shall be as specified by the motion command.

The replaced text shall be copied into buffer, if specified, and into the unnamed buffer. If the text to be replaced contains characters from more than a single line, or the buffer text is in line mode, the replaced text shall be copied into the numeric buffers as well.

If the buffer text is in line mode:

1. Any lines that contain characters in the region shall be deleted, and the editor shall enter text input mode at the beginning of a new line which shall replace the first line deleted.
2. If the autoindent edit option is set, autoindent characters equal to the autoindent characters on the first line deleted shall be inserted as if entered by the user.

Otherwise, if characters from more than one line are in the region of text:

1. The text shall be deleted.
2. Any text remaining in the last line in the text region shall be appended to the first line in the region, and the last line in the region shall be deleted.
3. The editor shall enter text input mode after the last character not deleted from the first line in the text region, if any; otherwise, on the first column of the first line in the region.

Otherwise:

1. If the glyph for ‘$’ is smaller than the region, the end of the region shall be marked with a ‘$’.
2. The editor shall enter text input mode, overwriting the region of text.

Current line/column: As specified for the text input commands (see Input Mode Commands in vi (on page 1022)).

Change to End-of-Line

Synopsis: [buffer] [count] C

This command shall be equivalent to the vi command:

[buffer] [count] c$

See the c command.
**Delete**

**Synopsis:** \([buffer] [count] \ d \ motion\)

If the motion command is the \(d\) command repeated:

1. The buffer text shall be in line mode.
2. If there are less than \(count\) – 1 lines after the current line in the edit buffer, it shall be an error.
3. The text region shall be from the current line up to and including the next \(count\) – 1 lines.

Otherwise, the buffer text mode and text region shall be as specified by the motion command.

If in open mode, and the current line is deleted, and the line remains on the display, an \(\text{'@'}\) character shall be displayed as the first glyph of that line.

Delete the region of text into \(buffer\), if specified, and into the unnamed buffer. If the text to be deleted contains characters from more than a single line, or the buffer text is in line mode, the deleted text shall be copied into the numeric buffers, as well.

**Current line:** Set to the first text region line that appears in the edit buffer, unless that line has been deleted, in which case it shall be set to the last line in the edit buffer, or line 1 if the edit buffer is empty.

**Current column:**

1. If the line is empty, set to column position 1.
2. Otherwise, if the buffer text is in line mode or the motion was from the cursor toward the end of the edit buffer:
   a. If a character from the current line is displayed in the current column, set to the last column that displays any portion of that character.
   b. Otherwise, set to the last column in which any portion of any character in the line is displayed.
3. Otherwise, if a character is displayed in the column that began the text region, set to the last column that displays any portion of that character.
4. Otherwise, set to the last column in which any portion of any character in the line is displayed.

**Delete to End-of-Line**

**Synopsis:** \([buffer] \ D\)

Delete the text from the current position to the end of the current line; equivalent to the \(vi\) command:

\([buffer] \ d\$\)
Move to End-of-Word

Synopsis: \([\text{count}]\) e

With the exception that words are used instead of bigwords as the delimiter, this command shall be equivalent to the E command.

Move to End-of-Bigword

Synopsis: \([\text{count}]\) E

If the edit buffer is empty it shall be an error. If less than \(\text{count}\) bigwords end between the cursor and the end of the edit buffer, \(\text{count}\) shall be adjusted to the number of bigword endings between the cursor and the end of the edit buffer.

If used as a motion command:

1. The text region shall be from the last character of the \(\text{count}\)th next bigword up to and including the cursor character.
2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Set to the line containing the current column.

Current column: Set to the last column upon which any part of the last character of the \(\text{count}\)th next bigword is displayed.

Find Character in Current Line (Forward)

Synopsis: \([\text{count}]\) f \(\text{character}\)

It shall be an error if \(\text{count}\) occurrences of the character do not occur after the cursor in the line.

If used as a motion command:

1. The text range shall be from the cursor character up to and including the \(\text{count}\)th occurrence of the specified character after the cursor.
2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Unchanged.

Current column: Set to the last column in which any portion of the \(\text{count}\)th occurrence of the specified character after the cursor appears in the line.

Find Character in Current Line (Reverse)

Synopsis: \([\text{count}]\) F \(\text{character}\)

It shall be an error if \(\text{count}\) occurrences of the character do not occur before the cursor in the line.

If used as a motion command:

1. The text region shall be from the \(\text{count}\)th occurrence of the specified character before the cursor, up to, but not including the cursor character.
2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:
Current line: Unchanged.

Current column: Set to the last column in which any portion of the \textit{count}th occurrence of the specified character before the cursor appears in the line.

\section*{Move to Line}

\textbf{Synopsis:} \[ \texttt{[\textit{count}] G} \]

If \textit{count} is not specified, it shall default to the last line of the edit buffer. If \textit{count} is greater than the last line of the edit buffer, it shall be an error.

If used as a motion command:

1. The text region shall be from the cursor line up to and including the specified line.
2. Any text copied to a buffer shall be in line mode.

If not used as a motion command:

\textit{Current line:} Set to \textit{count} if \textit{count} is specified; otherwise, the last line.

\textit{Current column:} Set to non-<blank>.

\section*{Move to Top of Screen}

\textbf{Synopsis:} \[ \texttt{[\textit{count}] H} \]

If the beginning of the line \textit{count} greater than the first line of which any portion appears on the display does not exist, it shall be an error.

If used as a motion command:

1. If in open mode, the text region shall be the current line.
2. Otherwise, the text region shall be from the starting line up to and including (the first line of the display + \textit{count} −1).
3. Any text copied to a buffer shall be in line mode.

If not used as a motion command:

If in open mode, this command shall set the current column to non-<blank> and do nothing else.

Otherwise, it shall set the current line and current column as follows.

\textit{Current line:} Set to (the first line of the display + \textit{count} −1).

\textit{Current column:} Set to non-<blank>.

\section*{Insert Before Cursor}

\textbf{Synopsis:} \[ \texttt{[\textit{count}] i} \]

Enter text input mode before the current cursor position. No characters already in the edit buffer shall be affected by this command. A \textit{count} shall cause the input text to be appended \textit{count} −1 more times to the end of the input.

\textit{Current line/column:} As specified for the text input commands (see \textit{Input Mode Commands in vi} (on page 1022)).
Insert at Beginning of Line

Synopsis: \([\text{count}] \downarrow\)

This command shall be equivalent to the \(vi\) command \("[\text{count}]i\)."

Join

Synopsis: \([\text{count}] J\)

If the current line is the last line in the edit buffer, it shall be an error.

This command shall be equivalent to the \(ex\) \(join\) command with no addresses, and an \(ex\) command \(count\) value of 1 if \(count\) was not specified or if a \(count\) of 1 was specified, and an \(ex\) command \(count\) value of \(count - 1\) for any other value of \(count\), except that the current line and column shall be set as follows.

Current line: Unchanged.

Current column: The last column in which any portion of the character following the last character in the initial line is displayed, or the last non-<newline> in the line if no characters were appended.

Move to Bottom of Screen

Synopsis: \([\text{count}] L\)

If the beginning of the line \(count\) less than the last line of which any portion appears on the display does not exist, it shall be an error.

If used as a motion command:

1. If in open mode, the text region shall be the current line.
2. Otherwise, the text region shall include all lines from the starting cursor line to (the last line of the display \(-(count - 1))\).
3. Any text copied to a buffer shall be in line mode.

If not used as a motion command:

1. If in open mode, this command shall set the current column to non-<blank> and do nothing else.
2. Otherwise, it shall set the current line and current column as follows.

Current line: Set to (the last line of the display \(-(count - 1))\).

Current column: Set to non-<blank>.

Mark Position

Synopsis: \(m\ \text{letter}\)

This command shall be equivalent to the \(ex\) \(mark\) command with the specified character as an argument.
Move to Middle of Screen

Synopsis: $M$

The middle line of the display shall be calculated as follows:

$$(\text{the top line of the display}) + (((\text{number of lines displayed}) + 1) / 2) - 1$$

If used as a motion command:

1. If in open mode, the text region shall be the current line.
2. Otherwise, the text region shall include all lines from the starting cursor line up to and including the middle line of the display.
3. Any text copied to a buffer shall be in line mode.

If not used as a motion command:

If in open mode, this command shall set the current column to non-<blank> and do nothing else.

Otherwise, it shall set the current line and current column as follows.

Current line: Set to the middle line of the display.

Current column: Set to non-<blank>.

Repeat Regular Expression Find (Forward)

Synopsis: $n$

If the remembered search direction was forward, the $n$ command shall be equivalent to the $vi /$ command with no characters entered by the user. Otherwise, it shall be equivalent to the $vi ?$ command with no characters entered by the user.

If the $n$ command is used as a motion command for the $!$ command, the editor shall not enter text input mode on the last line on the screen, and shall behave as if the user entered a single ‘!’ character as the text input.

Repeat Regular Expression Find (Reverse)

Synopsis: $N$

Scan for the next match of the last pattern given to $l$ or $?$, but in the reverse direction; this is the reverse of $n$.

If the remembered search direction was forward, the $N$ command shall be equivalent to the $vi ?$ command with no characters entered by the user. Otherwise, it shall be equivalent to the $vi l$ command with no characters entered by the user. If the $N$ command is used as a motion command for the $!$ command, the editor shall not enter text input mode on the last line on the screen, and shall behave as if the user entered a single ‘!’ character as the text input.

Insert Empty Line Below

Synopsis: $o$

Enter text input mode in a new line appended after the current line. A count shall cause the input text to be appended count −1 more times to the end of the already added text, each time starting on a new, appended line.

Current line/column: As specified for the text input commands (see Input Mode Commands in vi (on page 1022)).
## Insert Empty Line Above

**Synopsis:**

Enter text input mode in a new line inserted before the current line. A *count* shall cause the input text to be appended *count* −1 more times to the end of the already added text, each time starting on a new, appended line.

*Current line/column:* As specified for the text input commands (see **Input Mode Commands in vi** (on page 1022)).

## Put from Buffer Following

**Synopsis:**

\[[\text{buffer}] \ p\]

If no buffer is specified, the unnamed buffer shall be used.

If the buffer text is in line mode, the text shall be appended below the current line, and each line of the buffer shall become a new line in the edit buffer. A *count* shall cause the buffer text to be appended *count* −1 more times to the end of the already added text, each time starting on a new, appended line.

If the buffer text is in character mode, the text shall be appended into the current line after the cursor, and each line of the buffer other than the first and last shall become a new line in the edit buffer. A *count* shall cause the buffer text to be appended *count* −1 more times to the end of the already added text, each time starting after the last added character.

*Current line:* If the buffer text is in line mode, set the line to line +1; otherwise, unchanged.

*Current column:* If the buffer text is in line mode:

1. If there is a non-<blank> in the first line of the buffer, set to the last column on which any portion of the first non-<blank> in the line is displayed.
2. If there is no non-<blank> in the first line of the buffer, set to the last column on which any portion of the last non-<newline> in the first line of the buffer is displayed.

If the buffer text is in character mode:

1. If the text in the buffer is from more than a single line, then set to the last column on which any portion of the first character from the buffer is displayed.
2. Otherwise, if the buffer is the unnamed buffer, set to the last column on which any portion of the last character from the buffer is displayed.
3. Otherwise, set to the first column on which any portion of the first character from the buffer is displayed.

## Put from Buffer Before

**Synopsis:**

\[[\text{buffer}] \ p\]

If no buffer is specified, the unnamed buffer shall be used.

If the buffer text is in line mode, the text shall be inserted above the current line, and each line of the buffer shall become a new line in the edit buffer. A *count* shall cause the buffer text to be appended *count* −1 more times to the end of the already added text, each time starting on a new, appended line.

If the buffer text is in character mode, the text shall be inserted into the current line before the cursor, and each line of the buffer other than the first and last shall become a new line in the edit buffer. A *count* shall cause the buffer text to be appended *count* −1 more times to the end of the
already added text, each time starting after the last added character.

Current line: Unchanged.

Current column: If the buffer text is in line mode:

1. If there is a non-<blank> in the first line of the buffer, set to the last column on which any portion of that character is displayed.
2. If there is no non-<blank> in the first line of the buffer, set to the last column on which any portion of the last non-<newline> in the first line of the buffer is displayed.

If the buffer text is in character mode:

1. If the buffer is the unnamed buffer, set to the last column on which any portion of the last character from the buffer is displayed.
2. Otherwise, set to the first column on which any portion of the first character from the buffer is displayed.

Enter ex Mode

Synopsis: Q

Leave visual or open mode and enter ex command mode.

Current line: Unchanged.

Current column: Unchanged.

Replace Character

Synopsis: [count] r character

Replace the count characters at and after the cursor with the specified character. If there are less than count non-<newline>s at and after the cursor on the line, it shall be an error.

If character is <control>-V, any next character other than the <newline> shall be stripped of any special meaning and used as a literal character.

If character is <ESC>, no replacement shall be made and the current line and current column shall be unchanged.

If character is <carriage-return> or <newline>, count new lines shall be appended to the current line. All but the last of these lines shall be empty. count characters at and after the cursor shall be discarded, and any remaining characters after the cursor in the current line shall be moved to the last of the new lines. If the autoindent edit option is set, they shall be preceded by the same number of autoindent characters found on the line from which the command was executed.

Current line: Unchanged unless the replacement character is a <carriage-return> or <newline>, in which case it shall be set to line + count.

Current column: Set to the last column position on which a portion of the last replaced character is displayed, or if the replacement character caused new lines to be created, set to non-<blank>.
Replace Characters

Synopsis: \texttt{R}

Enter text input mode at the current cursor position possibly replacing text on the current line. A \emph{count} shall cause the input text to be appended \emph{count} –1 more times to the end of the input.

Current line/column: As specified for the text input commands (see Input Mode Commands in \texttt{vi} (on page 1022)).

Substitute Character

Synopsis: \texttt{[buffer] [count] s}

This command shall be equivalent to the \texttt{vi} command:

\texttt{[buffer] [count] c<space>}

Substitute Lines

Synopsis: \texttt{[buffer] [count] S}

This command shall be equivalent to the \texttt{vi} command:

\texttt{[buffer] [count] c_}

Move Cursor to Before Character (Forward)

Synopsis: \texttt{[count] t character}

It shall be an error if \emph{count} occurrences of the character do not occur after the cursor in the line.

If used as a motion command:
1. The text region shall be from the cursor up to but not including the \emph{count}th occurrence of the specified character after the cursor.
2. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

Current line: Unchanged.

Current column: Set to the last column in which any portion of the character before the \emph{count}th occurrence of the specified character after the cursor appears in the line.

Move Cursor to After Character (Reverse)

Synopsis: \texttt{[count] T character}

It shall be an error if \emph{count} occurrences of the character do not occur before the cursor in the line.

If used as a motion command:
1. If the character before the cursor is the specified character, it shall be an error.
2. The text region shall be from the character before the cursor up to but not including the \emph{count}th occurrence of the specified character before the cursor.
3. Any text copied to a buffer shall be in character mode.

If not used as a motion command:
Current line: Unchanged.

Current column: Set to the last column in which any portion of the character after the count occurrence of the specified character before the cursor appears in the line.

**Undo**

**Synopsis:** 
\( \texttt{u} \)

This command shall be equivalent to the ex undo command except that the current line and current column shall be set as follows:

Current line: Set to the first line added or changed if any; otherwise, move to the line preceding any deleted text if one exists; otherwise, move to line 1.

Current column: If undoing an ex command, set to the first non-<blank>.

Otherwise, if undoing a text input command:

1. If the command was a C, c, O, o, R, S, or s command, the current column shall be set to the value it held when the text input command was entered.
2. Otherwise, set to the last column in which any portion of the first character after the deleted text is displayed, or, if no non-<newline> follow the text deleted from this line, set to the last column in which any portion of the last non-<newline> in the line is displayed, or 1 if the line is empty.

Otherwise, if a single line was modified (that is, not added or deleted) by the u command:

1. If text was added or changed, set to the last column in which any portion of the first character added or changed is displayed.
2. If text was deleted, set to the last column in which any portion of the first character after the deleted text is displayed, or, if no non-<newline> follow the deleted text, set to the last column in which any portion of the last non-<newline> in the line is displayed, or 1 if the line is empty.

Otherwise, set to non-<blank>.

**Undo Current Line**

**Synopsis:** 
\( \texttt{U} \)

Restore the current line to its state immediately before the most recent time that it became the current line.

Current line: Unchanged.

Current column: Set to the first column in the line in which any portion of the first character in the line is displayed.

**Move to Beginning of Word**

**Synopsis:** 
\( \texttt{[count]} \texttt{w} \)

With the exception that words are used as the delimiter instead of bigwords, this command shall be equivalent to the W command.
Move to Beginning of Bigword

Synopsis: \([\texttt{count}] \texttt{w}\)

If the edit buffer is empty, it shall be an error. If there are less than \texttt{count} bigwords between the cursor and the end of the edit buffer, \texttt{count} shall be adjusted to move the cursor to the last bigword in the edit buffer.

If used as a motion command:

1. If the associated command is \texttt{c}, \texttt{count} is 1, and the cursor is on a \texttt{<blank>}, the region of text shall be the current character and no further action shall be taken.

2. If there are less than \texttt{count} bigwords between the cursor and the end of the edit buffer, then the command shall succeed, and the region of text shall include the last character of the edit buffer.

3. If there are \texttt{<blank>}s or an end-of-line that precede the \texttt{count}th bigword, and the associated command is \texttt{c}, the region of text shall be up to and including the last character before the preceding \texttt{<blank>}s or end-of-line.

4. If there are \texttt{<blank>}s or an end-of-line that precede the bigword, and the associated command is \texttt{d} or \texttt{y}, the region of text shall be up to and including the last \texttt{<blank>} before the start of the bigword or end-of-line.

5. Any text copied to a buffer shall be in character mode.

If not used as a motion command:

1. If the cursor is on the last character of the edit buffer, it shall be an error.

Current line: Set to the line containing the current column.

Current column: Set to the last column in which any part of the first character of the \texttt{count}th next bigword is displayed.

Delete Character at Cursor

Synopsis: \([\texttt{buffer}] [\texttt{count}] \texttt{x}\)

Delete the \texttt{count} characters at and after the current character into \texttt{buffer}, if specified, and into the unnamed buffer.

If the line is empty, it shall be an error. If there are less than \texttt{count} non-\texttt{<newline>}s at and after the cursor on the current line, \texttt{count} shall be adjusted to the number of non-\texttt{<newline>}s at and after the cursor.

Current line: Unchanged.

Current column: If the line is empty, set to column position 1. Otherwise, if there were \texttt{count} or less non-\texttt{<newline>}s at and after the cursor on the current line, set to the last column that displays any part of the last non-\texttt{<newline>} of the line. Otherwise, unchanged.
Delete Character Before Cursor

Synopsis: \[buffer\] [count] \ X

Delete the \textit{count} characters before the current character into \textit{buffer}, if specified, and into the unnamed buffer.

If there are no characters before the current character on the current line, it shall be an error. If there are less than \textit{count} previous characters on the current line, \textit{count} shall be adjusted to the number of previous characters on the line.

Current line: Unchanged.

Current column: Set to (current column – the width of the deleted characters).

Yank

Synopsis: \[buffer\] [count] \ y \ motion

Copy (yank) the region of text into \textit{buffer}, if specified, and into the unnamed buffer.

If the motion command is the \textit{y} command repeated:

1. The buffer shall be in line mode.
2. If there are less than \textit{count} – 1 lines after the current line in the edit buffer, it shall be an error.
3. The text region shall be from the current line up to and including the next \textit{count} – 1 lines.

Otherwise, the buffer text mode and text region shall be as specified by the motion command.

Current line: If the motion was from the current cursor position toward the end of the edit buffer, unchanged. Otherwise, set to the first line in the edit buffer that is part of the text region specified by the motion command.

Current column:

1. If the motion was from the current cursor position toward the end of the edit buffer, unchanged.
2. Otherwise, if the current line is empty, set to column position 1.
3. Otherwise, set to the last column that displays any part of the first character in the file that is part of the text region specified by the motion command.

Yank Current Line

Synopsis: \[buffer\] [count] \ Y

This command shall be equivalent to the \textit{vi} command:

\[buffer\] [count] \ y_
Utilities

Redraw Window

If in open mode, the z command shall have the Synopsis:

Synopsis: [count] z

If count is not specified, it shall default to the window edit option −1. The z command shall be equivalent to the ex z command, with a type character of = and a count of count −2, except that the current line and current column shall be set as follows, and the window edit option shall not be affected. If the calculation for the count argument would result in a negative number, the count argument to the ex z command shall be zero. A blank line shall be written after the last line is written.

Current line: Unchanged.

Current column: Unchanged.

If not in open mode, the z command shall have the following Synopsis:

Synopsis: [line] z [count] character

If line is not specified, it shall default to the current line. If line is specified, but is greater than the number of lines in the edit buffer, it shall default to the number of lines in the edit buffer.

If count is specified, the value of the window edit option shall be set to count (as described in the ex window command), and the screen shall be redrawn.

line shall be placed as specified by the following characters:

<newline>, <carriage-return>

Place the beginning of the line on the first line of the display.

. Place the beginning of the line in the center of the display. The middle line of the display shall be calculated as described for the M command.

– Place an unspecified portion of the line on the last line of the display.

+ If line was specified, equivalent to the <newline> case. If line was not specified, display a screen where the first line of the display shall be (current last line) +1. If there are no lines after the last line in the display, it shall be an error.

^ If line was specified, display a screen where the last line of the display shall contain an unspecified portion of the first line of a display that had an unspecified portion of the specified line on the last line of the display. If this calculation results in a line before the beginning of the edit buffer, display the first screen of the edit buffer.

Otherwise, display a screen where the last line of the display shall contain an unspecified portion of (current first line −1). If this calculation results in a line before the beginning of the edit buffer, it shall be an error.

Current line: If line and the ‘^’ character were specified:

1. If the first screen was displayed as a result of the command attempting to display lines before the beginning of the edit buffer: if the first screen was already displayed, unchanged; otherwise, set to (current first line −1).

2. Otherwise, set to the last line of the display.

If line and the ‘+’ character were specified, set to the first line of the display.

Otherwise, if line was specified, set to line.
Otherwise, unchanged.

Current column: Set to non-<blank>.

Exit

Synopsis: ZZ

This command shall be equivalent to the ex xit command with no addresses, trailing !, or filename (see the ex xit command).

Input Mode Commands in vi

In text input mode, the current line shall consist of zero or more of the following categories, plus the terminating <newline>:

1. Characters preceding the text input entry point
   Characters in this category shall not be modified during text input mode.

2. autoindent characters
   autoindent characters shall be automatically inserted into each line that is created in text input mode, either as a result of entering a <newline> or <carriage-return> while in text input mode, or as an effect of the command itself; for example, O or o (see the ex autoindent command), as if entered by the user.

   It shall be possible to erase autoindent characters with the <control>-D command; it is unspecified whether they can be erased by <control>-H, <control>-U, and <control>-W characters. Erasing any autoindent character turns the glyph into erase-columns and deletes the character from the edit buffer, but does not change its representation on the screen.

3. Text input characters
   Text input characters are the characters entered by the user. Erasing any text input character turns the glyph into erase-columns and deletes the character from the edit buffer, but does not change its representation on the screen.

   Each text input character entered by the user (that does not have a special meaning) shall be treated as follows:

   a. The text input character shall be appended to the last character in the edit buffer from the first, second, or third categories.

   b. If there are no erase-columns on the screen, the text input command was the R command, and characters in the fifth category from the original line follow the cursor, the next such character shall be deleted from the edit buffer. If the slowopen edit option is not set, the corresponding glyph on the screen shall become erase-columns.

   c. If there are erase-columns on the screen, as many columns as they occupy, or as are necessary, shall be overwritten to display the text input character. (If only part of a multi-column glyph is overwritten, the remainder shall be left on the screen, and continue to be treated as erase-columns; it is unspecified whether the remainder of the glyph is modified in any way.)

   d. If additional display line columns are needed to display the text input character:

      1. If the slowopen edit option is set, the text input characters shall be displayed on subsequent display line columns, overwriting any characters displayed in
those columns.

2. Otherwise, any characters currently displayed on or after the column on the
display line where the text input character is to be displayed shall be pushed
ahead the number of display line columns necessary to display the rest of the
text input character.

4. Erase-columns

Erase-columns are not logically part of the edit buffer, appearing only on the screen, and
may be overwritten on the screen by subsequent text input characters. When text input
mode ends, all erase-columns shall no longer appear on the screen.

Erase-columns are initially the region of text specified by the c command (see Change (on
page 1009)); however, erasing autoindent or text input characters causes the glyphs of the
erased characters to be treated as erase-columns.

5. Characters following the text region for the c command, or the text input entry point for all
other commands

Characters in this category shall not be modified during text input mode, except as
specified in category 3.b. for the R text input command, or as <blank>s deleted when a
newline or carriage-return is entered.

It is unspecified whether it is an error to attempt to erase past the beginning of a line that was
created by the entry of a newline or carriage-return during text input mode. If it is not an
error, the editor shall behave as if the erasing character was entered immediately after the last
text input character entered on the previous line, and all of the non-newline s on the current
line shall be treated as erase-columns.

When text input mode is entered, or after a text input mode character is entered (except as
specified for the special characters below), the cursor shall be positioned as follows:

1. On the first column that displays any part of the first erase-column, if one exists

2. Otherwise, if the slowopen edit option is set, on the first display line column after the last
character in the first, second, or third categories, if one exists

3. Otherwise, the first column that displays any part of the first character in the fifth category,
if one exists

4. Otherwise, the display line column after the last character in the first, second, or third
categories, if one exists

5. Otherwise, on column position 1

The characters that are updated on the screen during text input mode are unspecified, other than
that the last text input character shall always be updated, and, if the slowopen edit option is not
set, the current cursor character shall always be updated.

The following specifications are for command characters entered during text input mode.
Utilities

NUL

Synopsis: NUL

If the first character of the text input is a NUL, the most recently input text shall be input as if entered by the user, and then text input mode shall be exited. The text shall be input literally; that is, characters are neither macro or abbreviation expanded, nor are any characters interpreted in any special manner. It is unspecified whether implementations shall support more than 256 bytes of remembered input text.

<control>-D

Synopsis: <control>-D

The <control>-D character shall have no special meaning when in text input mode for a line-oriented command (see Command Descriptions in vi (on page 988)).

This command need not be supported on block-mode terminals.

If the cursor does not follow an autoindent character, or an autoindent character and a ‘0’ or ‘^’ character:
1. If the cursor is in column position 1, the <control>-D character shall be discarded and no further action taken.
2. Otherwise, the <control>-D character shall have no special meaning.

If the last input character was a ‘0’, the cursor shall be moved to column position 1.

Otherwise, if the last input character was a ‘^’, the cursor shall be moved to column position 1. In addition, the autoindent level for the next input line shall be derived from the same line from which the autoindent level for the current input line was derived.

Otherwise, the cursor shall be moved back to the column after the previous shiftwidth (see the ex shiftwidth command) boundary.

All of the glyphs on columns between the starting cursor position and (inclusively) the ending cursor position shall become erase-columns as described in Input Mode Commands in vi (on page 1022).

Current line: Unchanged.

Current column: Set to 1 if the <control>-D was preceded by a ‘^’ or ‘0’; otherwise, set to (column −1)−((column −2) % shiftwidth).

<control>-H

Synopsis: <control>-H

If in text input mode for a line-oriented command, and there are no characters to erase, text input mode shall be terminated, no further action shall be done for this command, and the current line and column shall be unchanged.

If there are characters other than autoindent characters that have been input on the current line before the cursor, the cursor shall move back one character.

Otherwise, if there are autoindent characters on the current line before the cursor, it is implementation-defined whether the <control>-H command is an error or if the cursor moves back one autoindent character.

Otherwise, if the cursor is in column position 1 and there are previous lines that have been input, it is implementation-defined whether the <control>-H command is an error or if it is equivalent.
to entering <control>-H after the last input character on the previous input line.

Otherwise, it shall be an error.

All of the glyphs on columns between the starting cursor position and (inclusively) the ending
cursor position shall become erase-columns as described in Input Mode Commands in vi (on
page 1022).

The current erase character (see stty) shall cause an equivalent action to the <control>-H
command, unless the previously inserted character was a backslash, in which case it shall be as
if the literal current erase character had been inserted instead of the backslash.

Current line: Unchanged, unless previously input lines are erased, in which case it shall be set to
line −1.

Current column: Set to the first column that displays any portion of the character backed up
over.

Synopsis:

<newline>
<carriage-return>
<control>-J
<control>-M

If input was part of a line-oriented command, text input mode shall be terminated and the
command shall continue execution with the input provided.

Otherwise, terminate the current line. If there are no characters other than autoindent characters
on the line, all characters on the line shall be discarded. Otherwise, it is unspecified whether the
autoindent characters in the line are modified by entering these characters.

Continue text input mode on a new line appended after the current line. If the slowopen edit
option is set, the lines on the screen below the current line shall not be pushed down, but the
first of them shall be cleared and shall appear to be overwritten. Otherwise, the lines of the
screen below the current line shall be pushed down.

If the autoindent edit option is set, an appropriate number of autoindent characters shall be
added as a prefix to the line as described by the ex autoindent edit option.

All columns after the cursor that are erase-columns (as described in Input Mode Commands in
vi (on page 1022)) shall be discarded.

If the autoindent edit option is set, all <blank>s immediately following the cursor shall be
discarded.

All remaining characters after the cursor shall be transferred to the new line, positioned after any
autoindent characters.

Current line: Set to current line +1.

Current column: Set to the first column that displays any portion of the first character after the
autoindent characters on the new line, if any, or the first column position after the last
autoindent character, if any, or column position 1.
<control>-T

Synopsis:   <control>-T

The <control>-T character shall have no special meaning when in text input mode for a line-oriented command (see Command Descriptions in vi (on page 988)).

This command need not be supported on block-mode terminals.

Behave as if the user entered the minimum number of <blank>s necessary to move the cursor forward to the column position after the next shiftwidth (see the ex shiftwidth command) boundary.

Current line: Unchanged.

Current column: Set to column + shiftwidth – ((column –1) % shiftwidth).

<control>-U

Synopsis:   <control>-U

If there are characters other than autoindent characters that have been input on the current line before the cursor, the cursor shall move to the first character input after the autoindent characters.

Otherwise, if there are autoindent characters on the current line before the cursor, it is implementation-defined whether the <control>-U command is an error or if the cursor moves to the first column position on the line.

Otherwise, if the cursor is in column position 1 and there are previous lines that have been input, it is implementation-defined whether the <control>-U command is an error or if it is equivalent to entering <control>-U after the last input character on the previous input line.

Otherwise, it shall be an error.

All of the glyphs on columns between the starting cursor position and (inclusively) the ending cursor position shall become erase-columns as described in Input Mode Commands in vi (on page 1022).

The current kill character (see stty) shall cause an equivalent action to the <control>-U command, unless the previously inserted character was a backslash, in which case it shall be as if the literal current kill character had been inserted instead of the backslash.

Current line: Unchanged, unless previously input lines are erased, in which case it shall be set to line –1.

Current column: Set to the first column that displays any portion of the last character backed up over.

<control>-V

Synopsis:   <control>-V

<control>-Q

Allow the entry of any subsequent character, other than <control>-J or the <newline>, as a literal character, removing any special meaning that it may have to the editor in text input mode. If a <control>-V or <control>-Q is entered before a <control>-J or <newline>, the <control>-V or <control>-Q character shall be discarded, and the <control>-J or <newline> shall behave as described in the <newline> command character during input mode.
For purposes of the display only, the editor shall behave as if a ‘`’ character was entered, and the cursor shall be positioned as if overwriting the ‘`’ character. When a subsequent character is entered, the editor shall behave as if that character was entered instead of the original <control>-V or <control>-Q character.

Current line: Unchanged.

Current column: Unchanged.

<control>-W

Synopsis: <control>-W

If there are characters other than autoindent characters that have been input on the current line before the cursor, the cursor shall move back over the last word preceding the cursor (including any <blank>s between the end of the last word and the current cursor); the cursor shall not move to before the first character after the end of any autoindent characters.

Otherwise, if there are autoindent characters on the current line before the cursor, it is implementation-defined whether the <control>-W command is an error or if the cursor moves to the first column position on the line.

Otherwise, if the cursor is in column position 1 and there are previous lines that have been input, it is implementation-defined whether the <control>-W command is an error or if it is equivalent to entering <control>-W after the last input character on the previous input line.

Otherwise, it shall be an error.

All of the glyphs on columns between the starting cursor position and (inclusively) the ending cursor position shall become erase-columns as described in Input Mode Commands in vi (on page 1022).

Current line: Unchanged, unless previously input lines are erased, in which case it shall be set to line -1.

Current column: Set to the first column that displays any portion of the last character backed up over.

<ESC>

Synopsis: <ESC>

If input was part of a line-oriented command:

1. If interrupt was entered, text input mode shall be terminated and the editor shall return to command mode. The terminal shall be alerted.

2. If <ESC> was entered, text input mode shall be terminated and the command shall continue execution with the input provided.

Otherwise, terminate text input mode and return to command mode.

Any autoindent characters entered on newly created lines that have no other non-<newline>s shall be deleted.

Any leading autoindent and <blank>s on newly created lines shall be rewritten to be the minimum number of <blank>s possible.

The screen shall be redisplayed as necessary to match the contents of the edit buffer.

Current line: Unchanged.
Current column:
1. If there are text input characters on the current line, the column shall be set to the last column where any portion of the last text input character is displayed.
2. Otherwise, if a character is displayed in the current column, unchanged.
3. Otherwise, set to column position 1.

EXIT STATUS
The following exit values shall be returned:
0  Successful completion.
>0  An error occurred.

CONSEQUENCES OF ERRORS
When any error is encountered and the standard input is not a terminal device file, vi shall not write the file or return to command or text input mode, and shall terminate with a non-zero exit status.
Otherwise, when an unrecoverable error is encountered it shall be equivalent to a SIGHUP asynchronous event.
Otherwise, when an error is encountered, the editor shall behave as specified in Command Descriptions in vi (on page 988).

APPLICATION USAGE
None.

EXAMPLES
None.

RATIONALE
See the RATIONALE for ex for more information on vi. Major portions of the vi utility specification point to ex to avoid inadvertent divergence. While ex and vi have historically been implemented as a single utility, this is not required by IEEE Std 1003.1-2001.

It is recognized that portions of vi would be difficult, if not impossible, to implement satisfactorily on a block-mode terminal, or a terminal without any form of cursor addressing, thus it is not a mandatory requirement that such features should work on all terminals. It is the intention, however, that a vi implementation should provide the full set of capabilities on all terminals capable of supporting them.

Historically, vi exited immediately if the standard input was not a terminal. IEEE Std 1003.1-2001 permits, but does not require, this behavior. An end-of-file condition is not equivalent to an end-of-file character. A common end-of-file character, <control>-D, is historically a vi command.

The text in the STDOUT section reflects the usage of the verb display in this section; some implementations of vi use standard output to write to the terminal, but IEEE Std 1003.1-2001 does not require that to be the case.

Historically, implementations reverted to open mode if the terminal was incapable of supporting full visual mode. IEEE Std 1003.1-2001 requires this behavior. Historically, the open mode of vi behaved roughly equivalently to the visual mode, with the exception that only a single line from the edit buffer (one "buffer line") was kept current at any time. This line was normally displayed on the next-to-last line of a terminal with cursor addressing (and the last line performed its normal visual functions for line-oriented commands and messages). In addition, some few commands behaved differently in open mode than in visual mode. IEEE Std 1003.1-2001 requires conformance to historical practice.
Historically, *ex* and *vi* implementations have expected text to proceed in the usual
European/Latin order of left to right, top to bottom. There is no requirement in
IEEE Std 1003.1-2001 that this be the case. The specification was deliberately written using
words like “before”, “after”, “first”, and “last” in order to permit implementations to support
the natural text order of the language.

Historically, lines past the end of the edit buffer were marked with single tilde (‘˜’) characters;
that is, if the one-based display was 20 lines in length, and the last line of the file was on line one,
then lines 2-20 would contain only a single ‘˜’ character.

Historically, the *vi* editor attempted to display only complete lines at the bottom of the screen (it
did display partial lines at the top of the screen). If a line was too long to fit in its entirety at the
bottom of the screen, the screen lines where the line would have been displayed were displayed
as single ‘@’ characters, instead of displaying part of the line. IEEE Std 1003.1-2001 permits, but
does not require, this behavior. Implementations are encouraged to attempt always to display a
complete line at the bottom of the screen when doing scrolling or screen positioning by buffer
lines.

Historically, lines marked with ‘@’ were also used to minimize output to dumb terminals over
slow lines; that is, changes local to the cursor were updated, but changes to lines on the screen
that were not close to the cursor were simply marked with an ‘@’ sign instead of being updated
to match the current text. IEEE Std 1003.1-2001 permits, but does not require this feature because
it is used ever less frequently as terminals become smarter and connections are faster.

**Initialization in ex and vi**

Historically, *vi* always had a line in the edit buffer, even if the edit buffer was “empty”. For
example:

1. The *ex* command = executed from visual mode wrote “1” when the buffer was empty.
2. Writes from visual mode of an empty edit buffer wrote files of a single character (a
   <newline>), while writes from *ex* mode of an empty edit buffer wrote empty files.
3. Put and read commands into an empty edit buffer left an empty line at the top of the edit
   buffer.

For consistency, IEEE Std 1003.1-2001 does not permit any of these behaviors.

Historically, *vi* did not always return the terminal to its original modes; for example, ICRNL was
modified if it was not originally set. IEEE Std 1003.1-2001 does not permit this behavior.

**Command Descriptions in vi**

Motion commands are among the most complicated aspects of *vi* to describe. With some
exceptions, the text region and buffer type effect of a motion command on a *vi* command are
described on a case-by-case basis. The descriptions of text regions in IEEE Std 1003.1-2001 are
not intended to imply direction; that is, an inclusive region from line *n* to line *n+5* is identical to
a region from line *n+5* to line *n*. This is of more than academic interest—movements to marks
can be in either direction, and, if the.wrapscan option is set, so can movements to search points.
Historically, lines are always stored into buffers in text order; that is, from the start of the edit
buffer to the end. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, command counts were applied to any associated motion, and were multiplicative
to any supplied motion count. For example, 2cw is the same as c2w, and 2c3w is the same as
c6w. IEEE Std 1003.1-2001 requires this behavior. Historically, *vi* commands that used bigwords,
words, paragraphs, and sentences as objects treated groups of empty lines, or lines that
contained only <blank>s, inconsistently. Some commands treated them as a single entity, while
others treated each line separately. For example, the \texttt{w}, \texttt{W}, and \texttt{B} commands treated groups of empty lines as individual words; that is, the command would move the cursor to each new empty line. The \texttt{e} and \texttt{E} commands treated groups of empty lines as a single word; that is, the first use would move past the group of lines. The \texttt{b} command would just beep at the user, or if done from the start of the line as a motion command, fail in unexpected ways. If the lines contained only (or ended with) \texttt{<blank>}, the \texttt{w} and \texttt{W} commands would just beep at the user, the \texttt{E} and \texttt{e} commands would treat the group as a single word, and the \texttt{B} and \texttt{b} commands would treat the lines as individual words. For consistency and simplicity of specification, IEEE Std 1003.1-2001 requires that all \textit{vi} commands treat groups of empty or blank lines as a single entity, and that movement through lines ending with \texttt{<blank>} be consistent with other movements.

Historically, \textit{vi} documentation indicated that any number of double quotes were skipped after punctuation marks at sentence boundaries; however, implementations only skipped single quotes. IEEE Std 1003.1-2001 requires both to be skipped.

Historically, the first and last characters in the edit buffer were word boundaries. This historical practice is required by IEEE Std 1003.1-2001.

Historically, \textit{vi} attempted to update the minimum number of columns on the screen possible, which could lead to misleading information being displayed. IEEE Std 1003.1-2001 makes no requirements other than that the current character being entered is displayed correctly, leaving all other decisions in this area up to the implementation.

Historically, lines were arbitrarily folded between columns of any characters that required multiple column positions on the screen, with the exception of tabs, which terminated at the right-hand margin. IEEE Std 1003.1-2001 permits the former and requires the latter. Implementations that do not arbitrarily break lines between columns of characters that occupy multiple column positions should not permit the cursor to rest on a column that does not contain any part of a character.

The historical \textit{vi} had a problem in that all movements were by buffer lines, not by display or screen lines. This is often the right thing to do; for example, single line movements, such as \texttt{j} or \texttt{k}, should work on buffer lines. Commands like \texttt{dj} or \texttt{j+, where + is a change command, only make sense for buffer lines. It is not, however, the right thing to do for screen motion or scrolling commands like \texttt{<control>-D}, \texttt{<control>-F}, and \texttt{H}. If the window is fairly small, using buffer lines in these cases can result in completely random motion; for example, \texttt{I<control>-D} can result in a completely changed screen, without any overlap. This is clearly not what the user wanted. The problem is even worse in the case of the \texttt{H}, \texttt{L}, and \texttt{M} commands—as they position the cursor at the first non-\texttt{<blank>} of the line, they may all refer to the same location in large lines, and will result in no movement at all.

In addition, if the line is larger than the screen, using buffer lines can make it impossible to display parts of the line—there are not any commands that do not display the beginning of the line in historical \textit{vi}, and if both the beginning and end of the line cannot be on the screen at the same time, the user suffers. Finally, the page and half-page scrolling commands historically moved to the first non-\texttt{<blank>} in the new line. If the line is approximately the same size as the screen, this is inadequate because the cursor before and after a \texttt{<control>-D} command will refer to the same location on the screen.

Implementations of \textit{ex} and \textit{vi} exist that do not have these problems because the relevant commands (\texttt{<control>-B}, \texttt{<control>-D}, \texttt{<control>-F}, \texttt{<control>-U}, \texttt{<control>-Y}, \texttt{<control>-E}, \texttt{H}, \texttt{L}, and \texttt{M}) operate on display (screen) lines, not (edit) buffer lines.

IEEE Std 1003.1-2001 does not permit this behavior by default because the standard developers believed that users would find it too confusing. However, historical practice has been relaxed.
For example, ex and vi historically attempted, albeit sometimes unsuccessfully, to never put part of a line on the last lines of a screen; for example, if a line would not fit in its entirety, no part of the line was displayed, and the screen lines corresponding to the line contained single ‘@’ characters. This behavior is permitted, but not required by IEEE Std 1003.1-2001, so that it is possible for implementations to support long lines in small screens more reasonably without changing the commands to be oriented to the display (instead of oriented to the buffer).

IEEE Std 1003.1-2001 also permits implementations to refuse to edit any edit buffer containing a line that will not fit on the screen in its entirety.

The display area (for example, the value of the window edit option) has historically been “grown”, or expanded, to display new text when local movements are done in displays where the number of lines displayed is less than the maximum possible. Expansion has historically been the first choice, when the target line is less than the maximum possible expansion value away. Scrolling has historically been the next choice, done when the target line is less than half a display away, and otherwise, the screen was redrawn. There were exceptions, however, in that \texttt{ex} commands generally always caused the screen to be redrawn. IEEE Std 1003.1-2001 does not specify a standard behavior because there may be external issues, such as connection speed, the number of characters necessary to redraw as opposed to scroll, or terminal capabilities that implementations will have to accommodate.

Commands that set the current line, but that do not set the current cursor value (for example, j and k) attempt to get as close as possible to the remembered column position, so that the cursor tends to restrict itself to a vertical column as the user moves around in the edit buffer.

IEEE Std 1003.1-2001 requires conformance to historical practice, requiring that the display location of the cursor on the display line be adjusted from the current column value as necessary to support this historical behavior.

Historically, only a single line (and for some terminals, a single line minus 1 column) of characters could be entered by the user for the line-oriented commands; that is, ; !, /, or ?. IEEE Std 1003.1-2001 permits, but does not require, this limitation.

Historically, “soft” errors in vi caused the terminal to be alerted, but no error message was displayed. As a general rule, no error message was displayed for errors in command execution in vi, when the error resulted from the user attempting an invalid or impossible action, or when a searched-for object was not found. Examples of soft errors included \texttt{h} at the left margin, \texttt{<control>-B} or \{ at the beginning of the file, \texttt{2G} at the end of the file, and so on. In addition, errors such as %, [ ], , ) N, n, f, F, t, and T failing to find the searched-for object were soft as well.

Less consistently, / and ? displayed an error message if the pattern was not found, /, ?, N, and n displayed an error message if no previous regular expression had been specified, and ; did not display an error message if no previous f, F, t, or T command had occurred. Also, behavior in this area might reasonably be based on a runtime evaluation of the speed of a network connection. Finally, some implementations have provided error messages for soft errors in order to assist naive users, based on the value of a verbose edit option. IEEE Std 1003.1-2001 does not list specific errors for which an error message shall be displayed. Implementations should conform to historical practice in the absence of any strong reason to diverge.
Page Backwards

The \texttt{<control>-B} and \texttt{<control>-F} commands historically considered it an error to attempt to page past the beginning or end of the file, whereas the \texttt{<control>-D} and \texttt{<control>-U} commands simply moved to the beginning or end of the file. For consistency, IEEE Std 1003.1-2001 requires the latter behavior for all four commands. All four commands still consider it an error if the current line is at the beginning (\texttt{<control>-B}, \texttt{<control>-U}) or end (\texttt{<control>-F}, \texttt{<control>-D}) of the file. Historically, the \texttt{<control>-B} and \texttt{<control>-F} commands skip two lines in order to include overlapping lines when a single command is entered. This makes less sense in the presence of a \texttt{count}, as there will be, by definition, no overlapping lines. The actual calculation used by historical implementations of the \texttt{vi} editor for \texttt{<control>-B} was:

\[
((\text{current first line}) - \text{count} \times \text{(window edit option)}) + 2
\]

and for \texttt{<control>-F} was:

\[
((\text{current first line}) + \text{count} \times \text{(window edit option)}) - 2
\]

This calculation does not work well when intermixing commands with and without counts; for example, \texttt{3<control>-F} is not equivalent to entering the \texttt{<control>-F} command three times, and is not reversible by entering the \texttt{<control>-B} command three times. For consistency with other \texttt{vi} commands that take counts, IEEE Std 1003.1-2001 requires a different calculation.

Scroll Forward

The 4BSD and System V implementations of \texttt{vi} differed on the initial value used by the \texttt{scroll} command. 4BSD used:

\[
((\text{window edit option}) + 1) / 2
\]

while System V used the value of the \texttt{scroll} edit option. The System V version is specified by IEEE Std 1003.1-2001 because the standard developers believed that it was more intuitive and permitted the user a method of setting the scroll value initially without also setting the number of lines that are displayed.

Scroll Forward by Line

Historically, the \texttt{<control>-E} and \texttt{<control>-Y} commands considered it an error if the last and first lines, respectively, were already on the screen. IEEE Std 1003.1-2001 requires conformance to historical practice. Historically, the \texttt{<control>-E} and \texttt{<control>-Y} commands had no effect in open mode. For simplicity and consistency of specification, IEEE Std 1003.1-2001 requires that they behave as usual, albeit with a single line screen.

Clear and Redisplay

The historical \texttt{<control>-L} command refreshed the screen exactly as it was supposed to be currently displayed, replacing any '@' characters for lines that had been deleted but not updated on the screen with refreshed '@' characters. The intent of the \texttt{<control>-L} command is to refresh when the screen has been accidentally overwritten; for example, by a \texttt{write} command from another user, or modem noise.
Redraw Screen

The historical \texttt{<control>-R} command redisplayed only when necessary to update lines that had been deleted but not updated on the screen and that were flagged with '@' characters. There is no requirement that the screen be in any way refreshed if no lines of this form are currently displayed. IEEE Std 1003.1-2001 permits implementations to extend this command to refresh lines on the screen flagged with '@' characters because they are too long to be displayed in the current framework; however, the current line and column need not be modified.

Search for tagstring

Historically, the first non-\texttt{<blank>} at or after the cursor was the first character, and all subsequent characters that were word characters, up to the end of the line, were included. For example, with the cursor on the leading space or on the '#' character in the text "#bar@", the tag was "#bar". On the character 'b' it was "bar", and on the 'a' it was "ar". IEEE Std 1003.1-2001 requires this behavior.

Replace Text with Results from Shell Command

Historically, the <, >, and ! commands considered most cursor motions other than line-oriented motions an error; for example, the command \texttt{>/foo<CR>} succeeded, while the command \texttt{>l} failed, even though the text region described by the two commands might be identical. For consistency, all three commands only consider entire lines and not partial lines, and the region is defined as any line that contains a character that was specified by the motion.

Move to Matching Character

Other matching characters have been left implementation-defined in order to allow extensions such as matching '<' and '>' for searching HTML, or \texttt{#ifdef}, \texttt{#else}, and \texttt{#endif} for searching C source.

Repeat Substitution

IEEE Std 1003.1-2001 requires that any \texttt{c} and \texttt{g} flags specified to the previous substitute command be ignored; however, the \texttt{r} flag may still apply, if supported by the implementation.

Return to Previous (Context or Section)

The [l, ] (,), {, and } commands are all affected by "section boundaries", but in some historical implementations not all of the commands recognize the same section boundaries. This is a bug, not a feature, and a unique section-boundary algorithm was not described for each command. One special case that is preserved is that the sentence command moves to the end of the last line of the edit buffer while the other commands go to the beginning, in order to preserve the traditional character cut semantics of the sentence command. Historically, \texttt{vi} section boundaries at the beginning and end of the edit buffer were the first non-\texttt{<blank>} on the first and last lines of the edit buffer if one exists; otherwise, the last character of the first and last lines of the edit buffer if one exists. To increase consistency with other section locations, this has been simplified by IEEE Std 1003.1-2001 to the first character of the first and last lines of the edit buffer, or the first and the last lines of the edit buffer if they are empty.

Sentence boundaries were problematic in the historical \texttt{vi}. They were not only the boundaries as defined for the section and paragraph commands, but they were the first non-\texttt{<blank>} that occurred after those boundaries, as well. Historically, the \texttt{vi} section commands were documented as taking an optional window size as a \texttt{count} preceding the command. This was not implemented in historical versions, so IEEE Std 1003.1-2001 requires that the \texttt{count} repeat the command, for consistency with other \texttt{vi} commands.
Repeat

Historically, mapped commands other than text input commands could not be repeated using the `period` command. IEEE Std 1003.1-2001 requires conformance to historical practice.

The restrictions on the interpretation of special characters (for example, `<control>-H`) in the repetition of text input mode commands is intended to match historical practice. For example, given the input sequence:

```
iab<control>-H<control>-H<control>-Hdef<escape>
```

the user should be informed of an error when the sequence is first entered, but not during a command repetition. The character `<control>-T` is specifically exempted from this restriction.

Historical implementations of `vi` ignored `<control>-T` characters that were input in the original command during command repetition. IEEE Std 1003.1-2001 prohibits this behavior.

Find Regular Expression

Historically, commands did not affect the line searched to or from if the motion command was a search (`/`, `?`, `N`, `n`) and the final position was the start/end of the line. There were some special cases and `vi` was not consistent. IEEE Std 1003.1-2001 does not permit this behavior, for consistency. Historical implementations permitted but were unable to handle searches as motion commands that wrapped (that is, due to the edit option `wrapscan`) to the original location. IEEE Std 1003.1-2001 requires that this behavior be treated as an error.

Historically, the syntax `"/RE/0"` was used to force the command to cut text in line mode. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, in open mode, a `z` specified to a search command redisplayed the current line instead of displaying the current screen with the current line highlighted. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, trailing `z` commands were permitted and ignored if entered as part of a search used as a motion command. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Execute an ex Command

Historically, `vi` implementations restricted the commands that could be entered on the colon command line (for example, `append` and `change`), and some other commands were known to cause them to fail catastrophically. For consistency, IEEE Std 1003.1-2001 does not permit these restrictions. When executing an `ex` command by entering `;`, it is not possible to enter a `<newline>` as part of the command because it is considered the end of the command. A different approach is to enter `ex` command mode by using the `vi Q` command (and later resuming visual mode with the `ex vi` command). In `ex` command mode, the single-line limitation does not exist. So, for example, the following is valid:

```
Q
s/break here/break\here/
v
```

IEEE Std 1003.1-2001 requires that, if the `ex` command overwrites any part of the screen that would be erased by a refresh, `vi` pauses for a character from the user. Historically, this character could be any character; for example, a character input by the user before the message appeared, or even a mapped character. This is probably a bug, but implementations that have tried to be more rigorous by requiring that the user enter a specific character, or that the user enter a character after the message was displayed, have been forced by user indignation back into

Shift Left (Right)

Refer to the Rationale for the ! and / commands. Historically, the < and > commands sometimes
moved the cursor to the first non-<blank> (for example if the command was repeated or with _
as the motion command), and sometimes left it unchanged. IEEE Std 1003.1-2001 does not
permit this inconsistency, requiring instead that the cursor always move to the first non-
<blank>. Historically, the < and > commands did not support buffer arguments, although some
implementations allow the specification of an optional buffer. This behavior is neither required

Execute

Historically, buffers could execute other buffers, and loops, infinite and otherwise, were
possible. IEEE Std 1003.1-2001 requires conformance to historical practice. The *buffer syntax of
ex is not required in vi, because it is not historical practice and has been used in some vi
implementations to support additional scripting languages.

Reverse Case

Historically, the " command ignored any associated count, and acted only on the characters in
the current line. For consistency with other vi commands, IEEE Std 1003.1-2001 requires that an
associated count act on the next count characters, and that the command move to subsequent
lines if warranted by count, to make it possible to modify large pieces of text in a reasonably
efficient manner. There exist vi implementations that optionally require an associated motion
command for the " command. Implementations supporting this functionality are encouraged to
base it on the tildedop edit option and handle the text regions and cursor positioning identically
to the yank command.

Append

Historically, counts specified to the A, a, I, and i commands repeated the input of the first line
count times, and did not repeat the subsequent lines of the input text. IEEE Std 1003.1-2001
requires that the entire text input be repeated count times.

Move Backward to Preceding Word

Historically, vi became confused if word commands were used as motion commands in empty
files. IEEE Std 1003.1-2001 requires that this be an error. Historical implementations of vi had a
large number of bugs in the word movement commands, and they varied greatly in behavior in
the presence of empty lines, "words" made up of a single character, and lines containing only
<blank>s. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit
this behavior.

Change to End-of-Line

Some historical implementations of the C command did not behave as described by
IEEE Std 1003.1-2001 when the $ key was remapped because they were implemented by pushing
the $ key onto the input queue and reprocessing it. IEEE Std 1003.1-2001 does not permit this
behavior. Historically, the C, S, and s commands did not copy replaced text into the numeric
buffers. For consistency and simplicity of specification, IEEE Std 1003.1-2001 requires that they
behave like their respective c commands in all respects.
Delete

Historically, lines in open mode that were deleted were scrolled up, and an @ glyph written over the beginning of the line. In the case of terminals that are incapable of the necessary cursor motions, the editor erased the deleted line from the screen. IEEE Std 1003.1-2001 requires conformance to historical practice; that is, if the terminal cannot display the ‘@’ character, the line cannot remain on the screen.

Delete to End-of-Line

Some historical implementations of the D command did not behave as described by IEEE Std 1003.1-2001 when the $ key was remapped because they were implemented by pushing the $ key onto the input queue and reprocessing it. IEEE Std 1003.1-2001 does not permit this behavior.

Join

An historical oddity of vi is that the commands J, 1J, and 2J are all equivalent. IEEE Std 1003.1-2001 requires conformance to historical practice. The vi J command is specified in terms of the ex join command with an ex command count value. The address correction for a count that is past the end of the edit buffer is necessary for historical compatibility for both ex and vi.

Mark Position

Historical practice is that only lowercase letters, plus ‘’ and ‘’, could be used to mark a cursor position. IEEE Std 1003.1-2001 requires conformance to historical practice, but encourages implementations to support other characters as marks as well.

Repeat Regular Expression Find (Forward and Reverse)

Historically, the N and n commands could not be used as motion components for the c command. With the exception of the cN command, which worked if the search crossed a line boundary, the text region would be discarded, and the user would not be in text input mode. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Insert Empty Line (Below and Above)

Historically, counts to the O and o commands were used as the number of physical lines to open, if the terminal was dumb and the slowopen option was not set. This was intended to minimize traffic over slow connections and repainting for dumb terminals. IEEE Std 1003.1-2001 does not permit this behavior, requiring that a count to the open command behave as for other text input commands. This change to historical practice was made for consistency, and because a superset of the functionality is provided by the slowopen edit option.

Put from Buffer (Following and Before)

Historically, counts to the p and P commands were ignored if the buffer was a line mode buffer, but were (mostly) implemented as described in IEEE Std 1003.1-2001 if the buffer was a character mode buffer. Because implementations exist that do not have this limitation, and because pasting lines multiple times is generally useful, IEEE Std 1003.1-2001 requires that count be supported for all p and P commands.

Historical implementations of vi were widely known to have major problems in the p and P commands, particularly when unusual regions of text were copied into the edit buffer. The standard developers viewed these as bugs, and they are not permitted for consistency and
simplicity of specification.

Historically, a P or p command (or an ex put command executed from open or visual mode) executed in an empty file, left an empty line as the first line of the file. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Replace Character

Historically, the r command did not correctly handle the erase and word erase characters as arguments, nor did it handle an associated count greater than 1 with a <carriage-return> argument, for which it replaced count characters with a single <newline>. IEEE Std 1003.1-2001 does not permit these inconsistencies.

Historically, the r command permitted the <control>-V escaping of entered characters, such as <ESC> and the <carriage-return>; however, it required two leading <control>-V characters instead of one. IEEE Std 1003.1-2001 requires that this be changed for consistency with the other text input commands of vi.

Historically, it is an error to enter the r command if there are less than count characters at or after the cursor in the line. While a reasonable and unambiguous extension would be to permit the r command on empty lines, it would require that too large a count be adjusted to match the number of characters at or after the cursor for consistency, which is sufficiently different from historical practice to be avoided. IEEE Std 1003.1-2001 requires conformance to historical practice.

Replace Characters

Historically, if there were autoindent characters in the line on which the R command was run, and autoindent was set, the first <newline> would be properly indented and no characters would be replaced by the <newline>. Each additional <newline> would replace n characters, where n was the number of characters that were needed to indent the rest of the line to the proper indentation level. This behavior is a bug and is not permitted by IEEE Std 1003.1-2001.

Undo

Historical practice for cursor positioning after undoing commands was mixed. In most cases, when undoing commands that affected a single line, the cursor was moved to the start of added or changed text, or immediately after deleted text. However, if the user had moved from the line being changed, the column was either set to the first non-<blank>, returned to the origin of the command, or remained unchanged. When undoing commands that affected multiple lines or entire lines, the cursor was moved to the first character in the first line restored. As an example of how inconsistent this was, a search, followed by an o text input command, followed by an undo would return the cursor to the location where the o command was entered, but a cw command followed by an o command followed by an undo would return the cursor to the first non-<blank> of the line. IEEE Std 1003.1-2001 requires the most useful of these behaviors, and discards the least useful, in the interest of consistency and simplicity of specification.
Yank

Historically, the **yank** command did not move to the end of the motion if the motion was in the forward direction. It moved to the end of the motion if the motion was in the backward direction, except for the `_` command, or for the **G** and `'` commands when the end of the motion was on the current line. This was further complicated by the fact that for a number of motion commands, the **yank** command moved the cursor but did not update the screen; for example, a subsequent command would move the cursor from the end of the motion, even though the cursor on the screen had not reflected the cursor movement for the **yank** command. IEEE Std 1003.1-2001 requires that all **yank** commands associated with backward motions move the cursor to the end of the motion for consistency, and specifically, to make `'` commands as motions consistent with search patterns as motions.

Yank Current Line

Some historical implementations of the **Y** command did not behave as described by IEEE Std 1003.1-2001 when the `'` key was remapped because they were implemented by pushing the `'` key onto the input queue and reprocessing it. IEEE Std 1003.1-2001 does not permit this behavior.

Redraw Window

Historically, the **z** command always redrew the screen. This is permitted but not required by IEEE Std 1003.1-2001, because of the frequent use of the **z** command in macros such as **map n nz**. for screen positioning, instead of its use to change the screen size. The standard developers believed that expanding or scrolling the screen offered a better interface for users. The ability to redraw the screen is preserved if the optional new window size is specified, and in the <control>-L and <control>-R commands.

The semantics of `z` are confusing at best. Historical practice is that the screen before the screen that ended with the specified line is displayed. IEEE Std 1003.1-2001 requires conformance to historical practice.

Historically, the **z** command would not display a partial line at the top or bottom of the screen. If the partial line would normally have been displayed at the bottom of the screen, the command worked, but the partial line was replaced with `'@` characters. If the partial line would normally have been displayed at the top of the screen, the command would fail. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, the **z** command with a line specification of `1` ignored the command. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Historically, the **z** command did not set the cursor column to the first non-<blank> for the character if the first screen was to be displayed, and was already displayed. For consistency and simplicity of specification, IEEE Std 1003.1-2001 does not permit this behavior.

Input Mode Commands in **vi**

Historical implementations of **vi** did not permit the user to erase more than a single line of input, or to use normal erase characters such as **line erase**, **word erase**, and **erase** to erase **autoindent** characters. As there exist implementations of **vi** that do not have these limitations, both behaviors are permitted, but only historical practice is required. In the case of these extensions, **vi** is required to pause at the **autoindent** and previous line boundaries.

Historical implementations of **vi** updated only the portion of the screen where the current cursor character was displayed. For example, consider the **vi** input keystrokes:
Historically, the `<tab>` would overwrite the characters "abcd" when it was displayed. Other implementations replace only the 'a' character with the `<tab>`, and then push the rest of the characters ahead of the cursor. Both implementations have problems. The historical implementation is probably visually nicer for the above example; however, for the keystrokes:

```
iabcd<escape>0C<tab>
```

the historical implementation results in the string "bcd" disappearing and then magically reappearing when the `<ESC>` character is entered. IEEE Std 1003.1-2001 requires the former behavior when overwriting erase-columns—that is, overwriting characters that are no longer logically part of the edit buffer—and the latter behavior otherwise.

Historical implementations of vi discarded the `<control>-D` and `<control>-T` characters when they were entered at places where their command functionality was not appropriate. IEEE Std 1003.1-2001 requires that the `<control>-T` functionality always be available, and that `<control>-D` be treated as any other key when not operating on `autoindent` characters.

### NUL

Some historical implementations of vi limited the number of characters entered using the NUL input character to 256 bytes. IEEE Std 1003.1-2001 permits this limitation; however, implementations are encouraged to remove this limit.

### `<control>-D`

See also Rationale for the input mode command `<newline>`. The hidden assumptions in the `<control>-D` command (and in the vi `autoindent` specification in general) is that `<space>`s take up a single column on the screen and that `<tab>`s are comprised of an integral number of `<space>`s.

### `<newline>`

Implementations are permitted to rewrite `autoindent` characters in the line when `<newline>`, `<carriage-return>`, `<control>-D`, and `<control>-T` are entered, or when the `shift` commands are used, because historical implementations have both done so and found it necessary to do so. For example, a `<control>-D` when the cursor is preceded by a single `<tab>`, with `tabstop` set to 8, and `shiftwidth` set to 3, will result in the `<tab>` being replaced by several `<space>`s.

### `<control>-T`

See also the Rationale for the input mode command `<newline>`: Historically, `<control>-T` only worked if no non-blank had yet been input in the current input line. In addition, the characters inserted by `<control>-T` were treated as `autoindent` characters, and could not be erased using normal user erase characters. Because implementations exist that do not have these limitations, and as moving to a column boundary is generally useful, IEEE Std 1003.1-2001 requires that both limitations be removed.
<control>-V

Historically, vi used "V, regardless of the value of the literal-next character of the terminal. IEEE Std 1003.1-2001 requires conformance to historical practice.

The uses described for <control>-V can also be accomplished with <control>-Q, which is useful on terminals that use <control>-V for the down-arrow function. However, most historical implementations use <control>-Q for the termios START character, so the editor will generally not receive the <control>-Q unless stty ixon mode is set to off. (In addition, some historical implementations of vi explicitly set ixon mode to on, so it was difficult for the user to set it to off.) Any of the command characters described in IEEE Std 1003.1-2001 can be made ineffective by their selection as termios control characters, using the stty utility or other methods described in the System Interfaces volume of IEEE Std 1003.1-2001.

<ESC>

Historically, SIGINT alerted the terminal when used to end input mode. This behavior is permitted, but not required, by IEEE Std 1003.1-2001.

FUTURE DIRECTIONS

None.

SEE ALSO

ed, ex, stty

CHANGE HISTORY

First released in Issue 2.

Issue 5

The FUTURE DIRECTIONS section is added.

Issue 6

This utility is marked as part of the User Portability Utilities option.

The APPLICATION USAGE section is added.

The obsolescent SYNOPSIS is removed.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The reindent command description is added.

The vi utility has been extensively rewritten for alignment with the IEEE P1003.2b draft standard.

IEEE PASC Interpretations 1003.2 #57, #62, #63, #64, #78, and #188 are applied.

IEEE PASC Interpretation 1003.2 #207 is applied, clarifying the description of the R command in a manner similar to the descriptions of other text input mode commands such as i, o, and O.

The -l option is removed.


NAME

wait — await process completion

SYNOPSIS

wait [pid...]  

DESCRIPTION

When an asynchronous list (see Section 2.9.3.1 (on page 50)) is started by the shell, the process ID of the last command in each element of the asynchronous list shall become known in the current shell execution environment; see Section 2.12 (on page 61).

If the wait utility is invoked with no operands, it shall wait until all process IDs known to the invoking shell have terminated and exit with a zero exit status.

If one or more pid operands are specified that represent known process IDs, the wait utility shall wait until all of them have terminated. If one or more pid operands are specified that represent unknown process IDs, wait shall treat them as if they were known process IDs that exited with exit status 127. The exit status returned by the wait utility shall be the exit status of the process requested by the last pid operand.

The known process IDs are applicable only for invocations of wait in the current shell execution environment.

OPTIONS

None.

OPERANDS

The following operand shall be supported:

pid One of the following:

1. The unsigned decimal integer process ID of a command, for which the utility is to wait for the termination.

2. A job control job ID (see the Base Definitions volume of IEEE Std 1003.1-2001, Section 3.203, Job Control Job ID) that identifies a background process group to be waited for. The job control job ID notation is applicable only for invocations of wait in the current shell execution environment; see Section 2.12 (on page 61). The exit status of wait shall be determined by the last command in the pipeline.

Note: The job control job ID type of pid is only available on systems supporting the User Portability Utilities option.

STDIN

Not used.

INPUT FILES

None.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of wait:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.
wait

**LC_CTYPE**
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

**LC_MESSAGES**
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**XSI**
**NLSPATH**
Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**ASYNCHRONOUS EVENTS**
Default.

**STDOUT**
Not used.

**STDERR**
The standard error shall be used only for diagnostic messages.

**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
If one or more operands were specified, all of them have terminated or were not known by the invoking shell, and the status of the last operand specified is known, then the exit status of **wait** shall be the exit status information of the command indicated by the last operand specified. If the process terminated abnormally due to the receipt of a signal, the exit status shall be greater than 128 and shall be distinct from the exit status generated by other signals, but the exact value is unspecified. (See the **kill** −I option.) Otherwise, the **wait** utility shall exit with one of the following values:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The <strong>wait</strong> utility was invoked with no operands and all process IDs known by the invoking shell have terminated.</td>
</tr>
<tr>
<td>1-126</td>
<td>The <strong>wait</strong> utility detected an error.</td>
</tr>
<tr>
<td>127</td>
<td>The command identified by the last <strong>pid</strong> operand specified is unknown.</td>
</tr>
</tbody>
</table>

**CONSEQUENCES OF ERRORS**
Default.

**APPLICATION USAGE**
On most implementations, **wait** is a shell built-in. If it is called in a subshell or separate utility execution environment, such as one of the following:

```
(wait)
nohup wait ...
find . -exec wait ... \
```

it returns immediately because there are no known process IDs to wait for in those environments.

Historical implementations of interactive shells have discarded the exit status of terminated background processes before each shell prompt. Therefore, the status of background processes was usually lost unless it terminated while **wait** was waiting for it. This could be a serious problem when a job that was expected to run for a long time actually terminated quickly with a syntax or initialization error because the exit status returned was usually zero if the requested
Utilities

wait

process ID was not found. This volume of IEEE Std 1003.1-2001 requires the implementation to keep the status of terminated jobs available until the status is requested, so that scripts like:

```bash
j1&
p1=$!
j2&
wait $p1
echo Job 1 exited with status $?
wait $!
echo Job 2 exited with status $
```

work without losing status on any of the jobs. The shell is allowed to discard the status of any process if it determines that the application cannot get the process ID for that process from the shell. It is also required to remember only (CHILD_MAX) number of processes in this way. Since the only way to get the process ID from the shell is by using the ‘! ’ shell parameter, the shell is allowed to discard the status of an asynchronous list if "$!" was not referenced before another asynchronous list was started. (This means that the shell only has to keep the status of the last asynchronous list started if the application did not reference "$!". If the implementation of the shell is smart enough to determine that a reference to "$!" was not saved anywhere that the application can retrieve it later, it can use this information to trim the list of saved information. Note also that a successful call to wait with no operands discards the exit status of all asynchronous lists.)

If the exit status of wait is greater than 128, there is no way for the application to know if the waited-for process exited with that value or was killed by a signal. Since most utilities exit with small values, there is seldom any ambiguity. Even in the ambiguous cases, most applications just need to know that the asynchronous job failed; it does not matter whether it detected an error and failed or was killed and did not complete its job normally.

EXAMPLES

Although the exact value used when a process is terminated by a signal is unspecified, if it is known that a signal terminated a process, a script can still reliably determine which signal by using kill as shown by the following script:

```bash
sleep 1000&
pid=$!
kil l -1 $pid
wait $pid
echo $pid was terminated by a SIG$(kill -1 $?) signal.
```

If the following sequence of commands is run in less than 31 seconds:

```bash
sleep 257 | sleep 31 &
jobs -l %
```

either of the following commands returns the exit status of the second sleep in the pipeline:

```bash
wait <pid of sleep 31>
wait %
```

RATIONALE

The description of wait does not refer to the waitpid() function from the System Interfaces volume of IEEE Std 1003.1-2001 because that would needlessly overspecify this interface. However, the wording means that wait is required to wait for an explicit process when it is given an argument so that the status information of other processes is not consumed. Historical implementations use the wait() function defined in the System Interfaces volume of IEEE Std 1003.1-2001 until wait() returns the requested process ID or finds that the requested
process does not exist. Because this means that a shell script could not reliably get the status of all background children if a second background job was ever started before the first job finished, it is recommended that the `wait` utility use a method such as the functionality provided by the `waitpid()` function.

The ability to wait for multiple `pid` operands was adopted from the KornShell.

This new functionality was added because it is needed to determine the exit status of any asynchronous list accurately. The only compatibility problem that this change creates is for a script like

```bash
while sleep 60 do
    job& echo Job started $(date) as $! done
```

which causes the shell to monitor all of the jobs started until the script terminates or runs out of memory. This would not be a problem if the loop did not reference "$!" or if the script would occasionally `wait` for jobs it started.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 2 (on page 29), `kill`, `sh`, the System Interfaces volume of IEEE Std 1003.1-2001, `wait()`, `waitpid()`

**CHANGE HISTORY**

First released in Issue 2.
NAME
wc — word, line, and byte or character count

SYNOPSIS
wc [-c | -m | -l] [file...]

DESCRIPTION
The *wc* utility shall read one or more input files and, by default, write the number of <newline>s,
words, and bytes contained in each input file to the standard output.
The utility also shall write a total count for all named files, if more than one input file is
specified.
The *wc* utility shall consider a word to be a non-zero-length string of characters delimited by
white space.

OPTIONS
The *wc* utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section 12.2,
Utility Syntax Guidelines.
The following options shall be supported:

- **-c** Write to the standard output the number of bytes in each input file.
- **-l** Write to the standard output the number of <newline>s in each input file.
- **-m** Write to the standard output the number of characters in each input file.
- **-w** Write to the standard output the number of words in each input file.
When any option is specified, *wc* shall report only the information requested by the specified
options.

OPERANDS
The following operand shall be supported:

- **file** A pathname of an input file. If no *file* operands are specified, the standard input
shall be used.

STDIN
The standard input shall be used only if no *file* operands are specified. See the INPUT FILES
section.

INPUT FILES
The input files may be of any type.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of *wc*:

- **LANG** Provide a default value for the internationalization variables that are unset or null.
  (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
  Internationalization Variables for the precedence of internationalization variables
  used to determine the values of locale categories.)
- **LC_ALL** If set to a non-empty string value, override the values of all the other
  internationalization variables.
- **LC_CTYPE** Determine the locale for the interpretation of sequences of bytes of text data as
  characters (for example, single-byte as opposed to multi-byte characters in
  arguments and input files) and which characters are defined as white space
  characters.
Utilities

Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

XSI NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
By default, the standard output shall contain an entry for each input file of the form:
"%d %d %d %s\n", <newlines>, <words>, <bytes>, <file>

If the −m option is specified, the number of characters shall replace the <bytes> field in this format.

If any options are specified and the −l option is not specified, the number of <newline>s shall not be written.

If any options are specified and the −w option is not specified, the number of words shall not be written.

If any options are specified and neither −c nor −m is specified, the number of bytes or characters shall not be written.

If no input file operands are specified, no name shall be written and no <blank>s preceding the pathname shall be written.

If more than one input file operand is specified, an additional line shall be written, of the same format as the other lines, except that the word total (in the POSIX locale) shall be written instead of a pathname and the total of each column shall be written as appropriate. Such an additional line, if any, is written at the end of the output.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
None.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0 Successful completion.

>0 An error occurred.

CONSEQUENCES OF ERRORS
Default.
APPLICATION USAGE

The −m option is not a switch, but an option at the same level as −c. Thus, to produce the full default output with character counts instead of bytes, the command required is:

wc −mlw

EXAMPLES

None.

RATIONALE

The output file format pseudo-printf() string differs from the System V version of wc:

"%7d%7d%7d %s\n"

which produces possibly ambiguous and unparsable results for very large files, as it assumes no number shall exceed six digits.

Some historical implementations use only <space>, <tab>, and <newline> as word separators. The equivalent of the ISO C standard isspace() function is more appropriate.

The −c option stands for "character" count, even though it counts bytes. This stems from the sometimes erroneous historical view that bytes and characters are the same size. Due to international requirements, the −m option (reminiscent of "multi-byte") was added to obtain actual character counts.

Early proposals only specified the results when input files were text files. The current specification more closely matches historical practice. (Bytes, words, and <newline>s are counted separately and the results are written when an end-of-file is detected.)

Historical implementations of the wc utility only accepted one argument to specify the options −c, −l, and −w. Some of them also had multiple occurrences of an option cause the corresponding count to be written multiple times and had the order of specification of the options affect the order of the fields on output, but did not document either of these. Because common usage either specifies no options or only one option, and because none of this was documented, the changes required by this volume of IEEE Std 1003.1-2001 should not break many historical applications (and do not break any historical conforming applications).

FUTURE DIRECTIONS

None.

SEE ALSO

cksum


CHANGE HISTORY

First released in Issue 2.
NAME
what — identify SCCS files (DEVELOPMENT)

SYNOPSIS
xsi what [-s] file...

DESCRIPTION
The what utility shall search the given files for all occurrences of the pattern that get (see get) substitutes for the %Z% keyword ("@(#) ") and shall write to standard output what follows until the first occurrence of one of the following:

" > newline \ NUL

OPTIONS

The following option shall be supported:

-s Quit after finding the first occurrence of the pattern in each file.

OPERANDS
The following operands shall be supported:

file A pathname of a file to search.

STDIN
Not used.

INPUT FILES
The input files shall be of any file type.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of what:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The standard output shall consist of the following for each file operand:

"%s:
	%s
", <pathname>, <identification string>
The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

0 Any matches were found.
1 Otherwise.

Default.

APPLICATION USAGE
The what utility is intended to be used in conjunction with the SCCS command get, which automatically inserts identifying information, but it can also be used where the information is inserted by any other means.

When the string "@(#)" is included in a library routine in a shared library, it might not be found in an a.out file using that library routine.

If the C-language program in file f.c contains:

```
char ident[] = "@(#)identification information";
```

and f.c is compiled to yield f.o and a.out, then the command:

```
what f.c f.o a.out
```

writes:

```
f.c:
  identification information
  ...

f.o:
  identification information
  ...

a.out:
  identification information
  ...
```

None.

None.

get

First released in Issue 2.
NAME
who — display who is on the system

SYNOPSIS
who [-MT]
who [-mu]-s[-bHlprt][file]
who [-MT][-abdHlprt][file]
who -q [file]
who am i
who am I

DESCRIPTION
The who utility shall list various pieces of information about accessible users. The domain of
accessibility is implementation-defined.

Based on the options given, who can also list the user’s name, terminal line, login time, elapsed
time since activity occurred on the line, and the process ID of the command interpreter for each
current system user.

OPTIONS
The who utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported. The metavariables, such as <line>, refer to fields
described in the STDOUT section.

-a   Process the implementation-defined database or named file with the -b, -d, -l, -p,
     -r, -t, -T and -u options turned on.
     -b   Write the time and date of the last reboot.
     -d   Write a list of all processes that have expired and not been respawned by the init
     system process. The <exit> field shall appear for dead processes and contain the
     termination and exit values of the dead process. This can be useful in determining
     why a process terminated.
     -H   Write column headings above the regular output.
     -l   (The letter ell.) List only those lines on which the system is waiting for someone to
     login. The <name> field shall be LOGIN in such cases. Other fields shall be the
     same as for user entries except that the <state> field does not exist.
     -m   Output only information about the current terminal.
     -p   List any other process that is currently active and has been previously spawned by
     init.
     -q   (Quick.) List only the names and the number of users currently logged on. When
     this option is used, all other options shall be ignored.
     -r   Write the current run-level of the init process.
     -s   List only the <name>, <line>, and <time> fields. This is the default case.
     -t   Indicate the last change to the system clock.
Show the state of each terminal, as described in the STDOUT section.

Write “idle time” for each displayed user in addition to any other information. The idle time is the time since any activity occurred on the user’s terminal. The method of determining this is unspecified. This option shall list only those users who are currently logged in. The <name> is the user’s login name. The <line> is the name of the line as found in the directory /dev. The <time> is the time that the user logged in. The <activity> is the number of hours and minutes since activity last occurred on that particular line. A dot indicates that the terminal has seen activity in the last minute and is therefore “current”. If more than twenty-four hours have elapsed or the line has not been used since boot time, the entry shall be marked <old>. This field is useful when trying to determine whether a person is working at the terminal or not. The <pid> is the process ID of the user’s login process.

The following operands shall be supported:

am i, am I
In the POSIX locale, limit the output to describing the invoking user, equivalent to the –m option. The am and i or I must be separate arguments.

file
Specify a pathname of a file to substitute for the implementation-defined database of logged-on users that who uses by default.

Not used.

None.

The following environment variables shall affect the execution of who:

LANG Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments).

LC_MESSAGES
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

LC_TIME Determine the locale used for the format and contents of the date and time strings.

NLS_PATH Determine the location of message catalogs for the processing of LC_MESSAGES.

TZ Determine the timezone used when writing date and time information. If TZ is unset or null, an unspecified default timezone shall be used.

Default.
The who utility shall write its default format to the standard output in an implementation-defined format, subject only to the requirement of containing the information described above.

XSI-conformant systems shall write the default information to the standard output in the following general format:

```
<name>[<state>]<line><time>[<activity>][<pid>][<comment>][<exit>]
```

The following format shall be used for the −T option:

```
"%s %c %s %s
" <name>, <terminal state>, <terminal name>,
<time of login>
```

where <terminal state> is one of the following characters:

- + The terminal allows write access to other users.
- − The terminal denies write access to other users.
- ? The terminal write-access state cannot be determined.

In the POSIX locale, the <time of login> shall be equivalent in format to the output of:

```
date +"%b %e %H:%M"
```

If the −u option is used with −T, the idle time shall be added to the end of the previous format in an unspecified format.

The standard error shall be used only for diagnostic messages.

None.

None.

The following exit values shall be returned:

- 0 Successful completion.
- >0 An error occurred.

Default.

The name init used for the system process is the most commonly used on historical systems, but it may vary.

The “domain of accessibility” referred to is a broad concept that permits interpretation either on a very secure basis or even to allow a network-wide implementation like the historical rwho.

None.

Due to differences between historical implementations, the base options provided were a compromise to allow users to work with those functions. The standard developers also considered removing all the options, but felt that these options offered users valuable functionality. Additional options to match historical systems are available on XSI-conformant
It is recognized that the `who` command may be of limited usefulness, especially in a multi-level secure environment. The standard developers considered, however, that having some standard method of determining the “accessibility” of other users would aid user portability.

No format was specified for the default `who` output for systems not supporting the XSI Extension. In such a user-oriented command, designed only for human use, this was not considered to be a deficiency.

The format of the terminal name is unspecified, but the descriptions of `ps`, `talk`, and `write` require that they use the same format.

It is acceptable for an implementation to produce no output for an invocation of `who mil`.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`mesg`

**CHANGE HISTORY**

First released in Issue 2.

This utility is marked as part of the User Portability Utilities option.

The `TZ` entry is added to the ENVIRONMENT VARIABLES section.
NAME
write — write to another user

SYNOPSIS
write user_name [terminal]

DESCRIPTION
The write utility shall read lines from the user’s standard input and write them to the terminal of another user. When first invoked, it shall write the message:

Message from sender-login-id (sending-terminal) [date]...

to user_name. When it has successfully completed the connection, the sender’s terminal shall be alerted twice to indicate that what the sender is typing is being written to the recipient’s terminal.

If the recipient wants to reply, this can be accomplished by typing:

write sender-login-id [sending-terminal]

upon receipt of the initial message. Whenever a line of input as delimited by an NL, EOF, or EOL special character (see the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface) is accumulated while in canonical input mode, the accumulated data shall be written on the other user’s terminal. Characters shall be processed as follows:

• Typing <alert> shall write the alert character to the recipient’s terminal.

• Typing the erase and kill characters shall affect the sender’s terminal in the manner described by the termios interface in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface.

• Typing the interrupt or end-of-file characters shall cause write to write an appropriate message (“EOT\n” in the POSIX locale) to the recipient’s terminal and exit.

• Typing characters from LC_CTYPE classifications print or space shall cause those characters to be sent to the recipient’s terminal.

• When and only when the stty iexten local mode is enabled, the existence and processing of additional special control characters and multi-byte or single-byte functions is implementation-defined.

• Typing other non-printable characters shall cause implementation-defined sequences of printable characters to be written to the recipient’s terminal.

To write to a user who is logged in more than once, the terminal argument can be used to indicate which terminal to write to; otherwise, the recipient’s terminal is selected in an implementation-defined manner and an informational message is written to the sender’s standard output, indicating which terminal was chosen.

Permission to be a recipient of a write message can be denied or granted by use of the mesg utility. However, a user’s privilege may further constrain the domain of accessibility of other users’ terminals. The write utility shall fail when the user lacks the appropriate privileges to perform the requested action.

OPTIONS
None.
OPERANDS
The following operands shall be supported:

user_name   Login name of the person to whom the message shall be written. The application
shall ensure that this operand is of the form returned by the who utility.

terminal   Terminal identification in the same format provided by the who utility.

STDIN
Lines to be copied to the recipient’s terminal are read from standard input.

INPUT FILES
None.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of write:

LANG   Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

LC_ALL   If set to a non-empty string value, override the values of all the other internationalization variables.

LC_CTYPE   Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files). If the recipient’s locale does not use an LC_CTYPE equivalent to the sender’s, the results are undefined.

LC_MESSAGES   Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error and informative messages written to standard output.

NLSPATH   Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
If an interrupt signal is received, write shall write an appropriate message on the recipient’s terminal and exit with a status of zero. It shall take the standard action for all other signals.

STDOUT
An informational message shall be written to standard output if a recipient is logged in more than once.

STDERR
The standard error shall be used only for diagnostic messages.

OUTPUT FILES
The recipient’s terminal is used for output.

EXTENDED DESCRIPTION
None.

EXIT STATUS
The following exit values shall be returned:

0   Successful completion.
>0   The addressed user is not logged on or the addressed user denies permission.
**CONSEQUENCES OF ERRORS**

Default.

**APPLICATION USAGE**

The `talk` utility is considered by some users to be a more usable utility on full-screen terminals.

**EXAMPLES**

None.

**RATIONALE**

The `write` utility was included in this volume of IEEE Std 1003.1-2001 since it can be implemented on all terminal types. The standard developers considered the `talk` utility, which cannot be implemented on certain terminals, to be a “better” communications interface. Both of these programs are in widespread use on historical implementations. Therefore, the standard developers decided that both utilities should be specified.

The format of the terminal name is unspecified, but the descriptions of `ps`, `talk`, `who`, and `write` require that they all use or accept the same format.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`mesg`, `talk`, `who`, the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 11, General Terminal Interface

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

The FUTURE DIRECTIONS section is added.

**Issue 6**

This utility is marked as part of the User Portability Utilities option.

The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
xargs — construct argument lists and invoke utility

SYNOPSIS
XSI
[-s size] [utility [argument...]]

DESCRIPTION
The xargs utility shall construct a command line consisting of the utility and argument operands
specified followed by as many arguments read in sequence from standard input as fit in length
and number constraints specified by the options. The xargs utility shall then invoke the
constructed command line and wait for its completion. This sequence shall be repeated until one
of the following occurs:

• An end-of-file condition is detected on standard input.

• The logical end-of-file string (see the −E eofstr option) is found on standard input after
double-quote processing, apostrophe processing, and backslash escape processing (see next
paragraph).

• An invocation of a constructed command line returns an exit status of 255.

The application shall ensure that arguments in the standard input are separated by unquoted
<blank>s, unescaped <blank>s, or <newline>s. A string of zero or more non-double-quote (""")
characters and non-<newline>s can be quoted by enclosing them in double-quotes. A string of
zero or more non-apostrophe ('') characters and non-<newline>s can be quoted by enclosing
them in apostrophes. Any unquoted character can be escaped by preceding it with a backslash.
The utility named by utility shall be executed one or more times until the end-of-file is reached
or the logical end-of-file string is found. The results are unspecified if the utility named by utility
attempts to read from its standard input.

The generated command line length shall be the sum of the size in bytes of the utility name and
each argument treated as strings, including a null byte terminator for each of these strings. The
xargs utility shall limit the command line length such that when the command line is invoked,
the combined argument and environment lists (see the exec family of functions in the System
Interfaces volume of IEEE Std 1003.1-2001) shall not exceed {ARG_MAX}−2048 bytes. Within
this constraint, if neither the −n nor the −s option is specified, the default command line length
shall be at least {LINE_MAX}.

OPTIONS
The xargs utility shall conform to the Base Definitions volume of IEEE Std 1003.1-2001, Section

The following options shall be supported:

-E eofstr Use eofstr as the logical end-of-file string. If −E is not specified, it is unspecified
whether the logical end-of-file string is the underscore character (\_\_) or the end-
of-file string capability is disabled. When eofstr is the null string, the logical end-
of-file string capability shall be disabled and underscore characters shall be taken
literally.

-I replstr Insert mode: utility is executed for each line from standard input, taking the entire
line as a single argument, inserting it in arguments for each occurrence of replstr. A
maximum of five arguments in arguments can each contain one or more instances
of replstr. Any <blank>s at the beginning of each line shall be ignored.
Constructed arguments cannot grow larger than 255 bytes. Option −x shall be
forced on.
The utility shall be executed for each non-empty number lines of arguments from standard input. The last invocation of utility shall be with fewer lines of arguments if fewer than number remain. A line is considered to end with the first <newline> unless the last character of the line is a <blank>; a trailing <blank> signals continuation to the next non-empty line, inclusive. The −L and −n options are mutually-exclusive; the last one specified shall take effect.

Invoke utility using as many standard input arguments as possible, up to number (a positive decimal integer) arguments maximum. Fewer arguments shall be used if:

• The command line length accumulated exceeds the size specified by the −s option (or [LINE_MAX] if there is no −s option).
• The last iteration has fewer than number, but not zero, operands remaining.

Prompt mode: the user is asked whether to execute utility at each invocation. Trace mode (−t) is turned on to write the command instance to be executed, followed by a prompt to standard error. An affirmative response read from /dev/tty shall execute the command; otherwise, that particular invocation of utility shall be skipped.

Invoke utility using as many standard input arguments as possible yielding a command line length less than size (a positive decimal integer) bytes. Fewer arguments shall be used if:

• The total number of arguments exceeds that specified by the −n option.
• The total number of lines exceeds that specified by the −L option.
• End-of-file is encountered on standard input before size bytes are accumulated.

Values of size up to at least [LINE_MAX] bytes shall be supported, provided that the constraints specified in the DESCRIPTION are met. It shall not be considered an error if a value larger than that supported by the implementation or exceeding the constraints specified in the DESCRIPTION is given; xargs shall use the largest value it supports within the constraints.

Enable trace mode. Each generated command line shall be written to standard error just prior to invocation.

Terminate if a command line containing number arguments (see the −n option above) or number lines (see the −L option above) will not fit in the implied or specified size (see the −s option above).

The following operands shall be supported:

utility The name of the utility to be invoked, found by search path using the PATH environment variable, described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables. If utility is omitted, the default shall be the echo utility. If the utility operand names any of the special built-in utilities in Section 2.14 (on page 64), the results are undefined.

argument An initial option or operand for the invocation of utility.

The standard input shall be a text file. The results are unspecified if an end-of-file condition is detected immediately following an escaped <newline>. 
The file /dev/tty shall be used to read responses required by the −p option.

The following environment variables shall affect the execution of xargs:

- **LANG**: Provide a default value for the internationalization variables that are unset or null. (See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

- **LC_ALL**: If set to a non-empty string value, override the values of all the other internationalization variables.

- **LC_COLLATE**: Determine the locale for the behavior of ranges, equivalence classes, and multi-character collating elements used in the extended regular expression defined for the yesexpr locale keyword in the LC_MESSAGES category.

- **LC_CTYPE**: Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files) and the behavior of character classes used in the extended regular expression defined for the yesexpr locale keyword in the LC_MESSAGES category.

- **LC_MESSAGES**: Determine the locale for the processing of affirmative responses and that should be used to affect the format and contents of diagnostic messages written to standard error.

- **NLSPATH**: Determine the location of message catalogs for the processing of LC_MESSAGES.

- **PATH**: Determine the location of utility, as described in the Base Definitions volume of IEEE Std 1003.1-2001, Chapter 8, Environment Variables.

**ASYNCHRONOUS EVENTS**

- **STDOUT**: Default.

- **STDERR**: Not used.

The standard error shall be used for diagnostic messages and the −t and −p options. If the −t option is specified, the utility and its constructed argument list shall be written to standard error, as it will be invoked, prior to invocation. If −p is specified, a prompt of the following format shall be written (in the POSIX locale):

```
"?..."
```

at the end of the line of the output from −t.
EXIT STATUS

The following exit values shall be returned:

0  All invocations of utility returned exit status zero.
1-125 A command line meeting the specified requirements could not be assembled, one or
   more of the invocations of utility returned a non-zero exit status, or some other error
   occurred.
126 The utility specified by utility was found but could not be invoked.
127 The utility specified by utility could not be found.

CONSEQUENCES OF ERRORS

If a command line meeting the specified requirements cannot be assembled, the utility cannot be
invoked, an invocation of the utility is terminated by a signal, or an invocation of the utility exits
with exit status 255, the xargs utility shall write a diagnostic message and exit without
processing any remaining input.

APPLICATION USAGE

The 255 exit status allows a utility being used by xargs to tell xargs to terminate if it knows no
further invocations using the current data stream will succeed. Thus, utility should explicitly exit
with an appropriate value to avoid accidentally returning with 255.

Note that input is parsed as lines; <blank>s separate arguments. If xargs is used to bundle output
of commands like find dir -print or ls into commands to be executed, unexpected results are
likely if any filenames contain any <blank>s or <newline>s. This can be fixed by using find to
call a script that converts each file found into a quoted string that is then piped to xargs. Note
that the quoting rules used by xargs are not the same as in the shell. They were not made
consistent here because existing applications depend on the current rules and the shell syntax is
not fully compatible with it. An easy rule that can be used to transform any string into a quoted
form that xargs interprets correctly is to precede each character in the string with a backslash.

On implementations with a large value for {ARG_MAX}, xargs may produce command lines
longer than {LINE_MAX}. For invocation of utilities, this is not a problem. If xargs is being used
to create a text file, users should explicitly set the maximum command line length with the −s
option.

The command, env, nice, nohup, time, and xargs utilities have been specified to use exit code 127 if
an error occurs so that applications can distinguish “failure to find a utility” from “invoked
utility exited with an error indication”. The value 127 was chosen because it is not commonly
used for other meanings; most utilities use small values for “normal error conditions” and the
values above 128 can be confused with termination due to receipt of a signal. The value 126 was
chosen in a similar manner to indicate that the utility could be found, but not invoked. Some
scripts produce meaningful error messages differentiating the 126 and 127 cases. The distinction
between exit codes 126 and 127 is based on KornShell practice that uses 127 when all attempts to
exec the utility fail with [ENOENT], and uses 126 when any attempt to exec the utility fails for
any other reason.

EXAMPLES

1. The following command combines the output of the parenthesised commands onto one
   line, which is then written to the end-of-file log:

   (logname; date; printf "%s
" "$0 $*" ) | xargs >>log

2. The following command invokes diff with successive pairs of arguments originally typed
   as command line arguments (assuming there are no embedded <blank>s in the elements of
   the original argument list):
printf "$s\n" "$*" | xargs -n 2 -x diff

3. In the following commands, the user is asked which files in the current directory are to be archived. The files are archived into arch; a, one at a time, or b, many at a time.

   a. ls | xargs -p -L 1 ar -r arch
   b. ls | xargs -p -L 1 | xargs ar -r arch

4. The following executes with successive pairs of arguments originally typed as command line arguments:

   echo $* | xargs -n 2 diff

5. On XSI-conformant systems, the following moves all files from directory $1 to directory $2, and echoes each move command just before doing it:

   ls $1 | xargs -I{} -t mv $1/{} $2/{}

RATIONALE

The xargs utility was usually found only in System V-based systems; BSD systems included an apply utility that provided functionality similar to xargs -n number. The SVID lists xargs as a software development extension. This volume of IEEE Std 1003.1-2001 does not share the view that it is used only for development, and therefore it is not optional.

The classic application of the xargs utility is in conjunction with the find utility to reduce the number of processes launched by a simplistic use of the find -exec combination. The xargs utility is also used to enforce an upper limit on memory required to launch a process. With this basis in mind, this volume of IEEE Std 1003.1-2001 selected only the minimal features required.

Although the 255 exit status is mostly an accident of historical implementations, it allows a utility being used by xargs to tell xargs to terminate if it knows no further invocations using the current data stream shall succeed. Any non-zero exit status from a utility falls into the 1-125 range when xargs exits. There is no statement of how the various non-zero exit status codes are accumulated by xargs. The value could be the addition of all codes, their highest value, the last one received, or a single value such as 1. Since no algorithm is arguably better than the others, and since many of the standard utilities say little more (portably) than "pass/fail", no new algorithm was invented.

Several other xargs options were withdrawn because simple alternatives already exist within this volume of IEEE Std 1003.1-2001. For example, the -i replstr option can be just as efficiently performed using a shell for loop. Since xargs calls an exec function with each input line, the -i option does not usually exploit the grouping capabilities of xargs.

The requirement that xargs never produces command lines such that invocation of utility is within 2048 bytes of hitting the POSIX exec {ARG_MAX} limitations is intended to guarantee that the invoked utility has room to modify its environment variables and command line arguments and still be able to invoke another utility. Note that the minimum {ARG_MAX} allowed by the System Interfaces volume of IEEE Std 1003.1-2001 is 4096 bytes and the minimum value allowed by this volume of IEEE Std 1003.1-2001 is 2048 bytes; therefore, the 2048 bytes difference seems reasonable. Note, however, that xargs may never be able to invoke a utility if the environment passed in to xargs comes close to using {ARG_MAX} bytes.

The version of xargs required by this volume of IEEE Std 1003.1-2001 is required to wait for the completion of the invoked command before invoking another command. This was done because historical scripts using xargs assumed sequential execution. Implementations wanting to provide parallel operation of the invoked utilities are encouraged to add an option enabling parallel invocation, but should still wait for termination of all of the children before xargs terminates normally.
The −e option was omitted from the ISO POSIX-2:1993 standard in the belief that the eofstr option-argument was recognized only when it was on a line by itself and before quote and escape processing were performed, and that the logical end-of-file processing was only enabled if a −e option was specified. In that case, a simple sed script could be used to duplicate the −e functionality. Further investigation revealed that:

- The logical end-of-file string was checked for after quote and escape processing, making a sed script that provided equivalent functionality much more difficult to write.
- The default was to perform logical end-of-file processing with an underscore as the logical end-of-file string.

To correct this misunderstanding, the −E eofstr option was adopted from the X/Open Portability Guide. Users should note that the description of the −E option matches historical documentation of the −e option (which was not adopted because it did not support the Utility Syntax Guidelines), by saying that if eofstr is the null string, logical end-of-file processing is disabled. Historical implementations of xargs actually did not disable logical end-of-file processing; they treated a null argument found in the input as a logical end-of-file string. (A null string argument could be generated using single or double quotes (" " or ""). Since this behavior was not documented historically, it is considered to be a bug.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

Chapter 2 (on page 29), echo, find, the System Interfaces volume of IEEE Std 1003.1-2001, exec

**CHANGE HISTORY**

First released in Issue 2.

**Issue 5**

A second FUTURE DIRECTION is added.

**Issue 6**

The obsolescent −e, −i, and −l options are removed.

The following new requirements on POSIX implementations derive from alignment with the Single UNIX Specification:

- The −p option is added.
- In the INPUT FILES section, the file /dev/tty is used to read responses required by the −p option.
- The STDERR section is updated to describe the −p option.
- The description of the −E option is aligned with the ISO POSIX-2: 1993 standard.
- The normative text is reworded to avoid use of the term “must” for application requirements.
NAME
yacc — yet another compiler compiler (DEVELOPMENT)

SYNOPSIS
CD
```
yacc [-dltv] [-b file_prefix] [-p sym_prefix] grammar
```

DESCRIPTION
The `yacc` utility shall read a description of a context-free grammar in `grammar` and write C source code, conforming to the ISO C standard, to a code file, and optionally header information into a header file, in the current directory. The C code shall define a function and related routines and macros for an automaton that executes a parsing algorithm meeting the requirements in Algorithms (on page 1074).

The form and meaning of the grammar are described in the EXTENDED DESCRIPTION section.

The C source code and header file shall be produced in a form suitable as input for the C compiler (see `c99`).

OPTIONS

The following options shall be supported:

`-b file_prefix` Use `file_prefix` instead of `y` as the prefix for all output filenames. The code file `y.tab.c`, the header file `y.tab.h` (created when `-d` is specified), and the description file `y.output` (created when `-v` is specified), shall be changed to `file_prefix.tab.c`, `file_prefix.tab.h`, and `file_prefix.output`, respectively.

`-d` Write the header file; by default only the code file is written. The `#define` statements associate the token codes assigned by `yacc` with the user-declared token names. This allows source files other than `y.tab.c` to access the token codes.

`-l` Produce a code file that does not contain any `#line` constructs. If this option is not present, it is unspecified whether the code file or header file contains `#line` directives. This should only be used after the grammar and the associated actions are fully debugged.

`-p sym_prefix` Use `sym_prefix` instead of `yy` as the prefix for all external names produced by `yacc`. The names affected shall include the functions `yparse()`, `yylex()`, and `yyerror()`, and the variables `yylval`, `yychar`, and `yydebug`.

(In the remainder of this section, the six symbols cited are referenced using their default names only as a notational convenience.) Local names may also be affected by the `-p` option; however, the `-p` option shall not affect `#define` symbols generated by `yacc`.

`-t` Modify conditional compilation directives to permit compilation of debugging code in the code file. Runtime debugging statements shall always be contained in the code file, but by default conditional compilation directives prevent their compilation.

`-v` Write a file containing a description of the parser and a report of conflicts generated by ambiguities in the grammar.
OPERANDS

The following operand is required:

**grammar**  
A pathname of a file containing instructions, hereafter called **grammar**, for which a parser is to be created. The format for the grammar is described in the EXTENDED DESCRIPTION section.

STDOUT

Not used.

ENVIRONMENT VARIABLES

The following environment variables shall affect the execution of **yacc**:

**LANG**  
Provide a default value for the internationalization variables that are unset or null.  
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2, Internationalization Variables for the precedence of internationalization variables used to determine the values of locale categories.)

**LC_ALL**  
If set to a non-empty string value, override the values of all the other internationalization variables.

**LC_CTYPE**  
Determine the locale for the interpretation of sequences of bytes of text data as characters (for example, single-byte as opposed to multi-byte characters in arguments and input files).

**LC_MESSAGES**  
Determine the locale that should be used to affect the format and contents of diagnostic messages written to standard error.

**NLSPATH**  
Determine the location of message catalogs for the processing of **LC_MESSAGES**.

**XSI**

The **LANG** and **LC_*** variables affect the execution of the **yacc** utility as stated. The **main()** function defined in **Yacc Library** (on page 1074) shall call:

```c
setlocale(LC_ALL, ""
```

and thus the program generated by **yacc** shall also be affected by the contents of these variables at runtime.

ASYNCHRONOUS EVENTS

Default.

STDERR

If shift/reduce or reduce/reduce conflicts are detected in **grammar**, **yacc** shall write a report of those conflicts to the standard error in an unspecified format.

Standard error shall also be used for diagnostic messages.

OUTPUT FILES

The code file, the header file, and the description file shall be text files. All are described in the following sections.
Utilities

Shell and Utilities, Issue 6 — Copyright © 2001-2003, IEEE and The Open Group. All rights reserved.
Lexical Structure of the Grammar

The <blank>s, <newline>s, and <form-feed>s shall be ignored, except that the application shall ensure that they do not appear in names or multi-character reserved symbols. Comments shall be enclosed in "/* ... */", and can appear wherever a name is valid.

Names are of arbitrary length, made up of letters, periods ('.'), underscores ('_'), and non-initial digits. Uppercase and lowercase letters are distinct. Conforming applications shall not use names beginning in yy or YY since the yacc parser uses such names. Many of the names appear in the final output of yacc, and thus they should be chosen to conform with any additional rules created by the C compiler to be used. In particular they appear in #define statements.

A literal shall consist of a single character enclosed in single-quotes (''). All of the escape sequences supported for character constants by the ISO C standard shall be supported by yacc.

The relationship with the lexical analyzer is discussed in detail below.

The application shall ensure that the NUL character is not used in grammar rules or literals.

Declarations Section

The declarations section is used to define the symbols used to define the target language and their relationship with each other. In particular, much of the additional information required to resolve ambiguities in the context-free grammar for the target language is provided here.

Usually yacc assigns the relationship between the symbolic names it generates and their underlying numeric value. The declarations section makes it possible to control the assignment of these values.

It is also possible to keep semantic information associated with the tokens currently on the parse stack in a user-defined C-language union, if the members of the union are associated with the various names in the grammar. The declarations section provides for this as well.

The first group of declarators below all take a list of names as arguments. That list can optionally be preceded by the name of a C union member (called a tag below) appearing within '<' and '>'. (As an exception to the typographical conventions of the rest of this volume of IEEE Std 1003.1-2001, in this case <tag> does not represent a metavariable, but the literal angle bracket characters surrounding a symbol.) The use of tag specifies that the tokens named on this line shall be of the same C type as the union member referenced by tag. This is discussed in more detail below.

For lists used to define tokens, the first appearance of a given token can be followed by a positive integer (as a string of decimal digits). If this is done, the underlying value assigned to it for lexical purposes shall be taken to be that number.

The following declares name to be a token:

%token [tag] name [number]... name [number]...

If tag is present, the C type for all tokens on this line shall be declared to be the type referenced by tag. If a positive integer, number, follows a name, that value shall be assigned to the token.

The following declares name to be a token, and assigns precedence to it:

%left [tag] name [number]... name [number]...
%right [tag] name [number]... name [number]...

One or more lines, each beginning with one of these symbols, can appear in this section. All tokens on the same line have the same precedence level and associativity; the lines are in order.
of increasing precedence or binding strength. %left denotes that the operators on that line are left associative, and %right similarly denotes right associative operators. If tag is present, it shall declare a C type for names as described for %token.

The following declares name to be a token, and indicates that this cannot be used associatively:

```
%nonassoc [<tag>] name [number] [name [number]]...
```

If the parser encounters associative use of this token it reports an error. If tag is present, it shall declare a C type for names as described for %token.

The following declares that union member names are non-terminals, and thus it is required to have a tag field at its beginning:

```
%type <tag> name...
```

Because it deals with non-terminals only, assigning a token number or using a literal is also prohibited. If this construct is present, yacc shall perform type checking; if this construct is not present, the parse stack shall hold only the int type.

Every name used in grammar not defined by a %token, %left, %right, or %nonassoc declaration is assumed to represent a non-terminal symbol. The yacc utility shall report an error for any non-terminal symbol that does not appear on the left side of at least one grammar rule.

Once the type, precedence, or token number of a name is specified, it shall not be changed. If the first declaration of a token does not assign a token number, yacc shall assign a token number. Once this assignment is made, the token number shall not be changed by explicit assignment.

The following declarators do not follow the previous pattern.

The following declares the non-terminal name to be the start symbol, which represents the largest, most general structure described by the grammar rules:

```
%start name
```

By default, it is the left-hand side of the first grammar rule; this default can be overridden with this declaration.

The following declares the yacc value stack to be a union of the various types of values desired:

```
%union {
    body of union (in C)
}
```

By default, the values returned by actions (see below) and the lexical analyzer shall be of type int. The yacc utility keeps track of types, and it shall insert corresponding union member names in order to perform strict type checking of the resulting parser.

Alternatively, given that at least one <tag> construct is used, the union can be declared in a header file (which shall be included in the declarations section by using a #include construct within %{ and %}), and a typedef used to define the symbol YYSTYPE to represent this union. The effect of %union is to provide the declaration of YYSTYPE directly from the yacc input.

C-language declarations and definitions can appear in the declarations section, enclosed by the following marks:

```
 %{ ... %}
```

These statements shall be copied into the code file, and have global scope within it so that they can be used in the rules and program sections.

The application shall ensure that the declarations section is terminated by the token %%. 

```
Grammar Rules in yacc

The rules section defines the context-free grammar to be accepted by the function yacc generates, and associates with those rules C-language actions and additional precedence information. The grammar is described below, and a formal definition follows.

The rules section is comprised of one or more grammar rules. A grammar rule has the form:

\[ A : \text{BODY} ; \]

The symbol A represents a non-terminal name, and BODY represents a sequence of zero or more names, literals, and semantic actions that can then be followed by optional precedence rules.

Only the names and literals participate in the formation of the grammar; the semantic actions and precedence rules are used in other ways. The colon and the semicolon are yacc punctuation.

If there are several successive grammar rules with the same left-hand side, the vertical bar ‘|’ can be used to avoid rewriting the left-hand side; in this case the semicolon appears only after the last rule. The BODY part can be empty (or empty of names and literals) to indicate that the non-terminal symbol matches the empty string.

The yacc utility assigns a unique number to each rule. Rules using the vertical bar notation are distinct rules. The number assigned to the rule appears in the description file.

The elements comprising a BODY are:

- **name, literal** These form the rules of the grammar: name is either a token or a non-terminal; literal stands for itself (less the lexically required quotation marks).

- **semantic action**

  With each grammar rule, the user can associate actions to be performed each time the rule is recognized in the input process. (Note that the word “action” can also refer to the actions of the parser—shift, reduce, and so on.)

  These actions can return values and can obtain the values returned by previous actions. These values are kept in objects of type YYSTYPE (see %union). The result value of the action shall be kept on the parse stack with the left-hand side of the rule, to be accessed by other reductions as part of their right-hand side. By using the <tag> information provided in the declarations section, the code generated by yacc can be strictly type checked and contain arbitrary information. In addition, the lexical analyzer can provide the same kinds of values for tokens, if desired.

  An action is an arbitrary C statement and as such can do input or output, call subprograms, and alter external variables. An action is one or more C statements enclosed in curly braces ‘{’ and ‘}’.

  Certain pseudo-variables can be used in the action. These are macros for access to data structures known internally to yacc.

- **$$** The value of the action can be set by assigning it to $$. If type checking is enabled and the type of the value to be assigned cannot be determined, a diagnostic message may be generated.

- **$number** This refers to the value returned by the component specified by the token number in the right side of a rule, reading from left to right; number can be zero or negative. If number is zero or negative, it refers to the data associated with the name on the parser’s stack preceding the leftmost symbol of the current rule. (That is, "$0" refers to the name immediately preceding the leftmost name in the current rule to be found on the parser’s stack and "$-1" refers to the symbol to its
left.) If `number` refers to an element past the current point in the rule, or beyond the bottom of the stack, the result is undefined. If type checking is enabled and the type of the value to be assigned cannot be determined, a diagnostic message may be generated.

\[
\text{\$<tag>number}
\]

These correspond exactly to the corresponding symbols without the `tag` inclusion, but allow for strict type checking (and preclude unwanted type conversions). The effect is that the macro is expanded to use `tag` to select an element from the YYSTYPE union (using `dataname.tag`). This is particularly useful if `number` is not positive.

\[
\text{\$<tag>}$
\]

This imposes on the reference the type of the union member referenced by `tag`. This construction is applicable when a reference to a left context value occurs in the grammar, and provides `yacc` with a means for selecting a type.

Actions can occur anywhere in a rule (not just at the end); an action can access values returned by actions to its left, and in turn the value it returns can be accessed by actions to its right. An action appearing in the middle of a rule shall be equivalent to replacing the action with a new non-terminal symbol and adding an empty rule with that non-terminal symbol on the left-hand side. The semantic action associated with the new rule shall be equivalent to the original action. The use of actions within rules might introduce conflicts that would not otherwise exist.

By default, the value of a rule shall be the value of the first element in it. If the first element does not have a type (particularly in the case of a literal) and type checking is turned on by `%type`, an error message shall result.

\[
\text{\%prec}
\]

The keyword `%prec` can be used to change the precedence level associated with a particular grammar rule. Examples of this are in cases where a unary and binary operator have the same symbolic representation, but need to be given different precedences, or where the handling of an ambiguous if-else construction is necessary. The reserved symbol `%prec` can appear immediately after the body of the grammar rule and can be followed by a token name or a literal. It shall cause the precedence of the grammar rule to become that of the following token name or literal. The action for the rule as a whole can follow `%prec`.

If a program section follows, the application shall ensure that the grammar rules are terminated by `%%`.

**Programs Section**

The `programs` section can include the definition of the lexical analyzer `yylex()`, and any other functions; for example, those used in the actions specified in the grammar rules. It is unspecified whether the programs section precedes or follows the semantic actions in the output file; therefore, if the application contains any macro definitions and declarations intended to apply to the code in the semantic actions, it shall place them within `"%\{ . . . %\}"` in the declarations section.
Input Grammar

The following input to `yacc` yields a parser for the input to `yacc`. This formal syntax takes precedence over the preceding text syntax description.

The lexical structure is defined less precisely; *Lexical Structure of the Grammar* (on page 1066) defines most terms. The correspondence between the previous terms and the tokens below is as follows.

**IDENTIFIER** This corresponds to the concept of name, given previously. It also includes literals as defined previously.

**C_IDENTIFIER** This is a name, and additionally it is known to be followed by a colon. A literal cannot yield this token.

**NUMBER** A string of digits (a non-negative decimal integer).

**TYPE, LEFT, MARK, LCURL, RCURL**

These correspond directly to `%type`, `%left`, `%%`, `%{`, and `}`.

This indicates C-language source code, with the possible inclusion of `$` macros as discussed previously.

/* Grammar for the input to yacc. */
/* Basic entries. */
/* The following are recognized by the lexical analyzer. */

```c
%token IDENTIFIER /* Includes identifiers and literals */
%token C_IDENTIFIER /* identifier (but not literal)
  followed by a :. */
%token NUMBER /* [0-9]* */
%token LEFT RIGHT NONASSOC TOKEN PREC TYPE START UNION
%token MARK /* The %% mark. */
%token LCURL /* The %{ mark. */
%token RCURL /* The %} mark. */

/* 8-bit character literals stand for themselves; */
/* tokens have to be defined for multi-byte characters. */
%start spec
%
spec : defs MARK rules tail

;
tail : MARK
{
  /* In this action, set up the rest of the file. */
}

| /* Empty; the second MARK is optional. */

; defs : /* Empty. */
  | defs def
  |
  def : START IDENTIFIER
```

{ /* Copy union definition to output. */
  LCURL
}
/* Copy C code to output file. */
RCURL
  rword tag nlist
;  
  rword : TOKEN
  | LEFT
  | RIGHT
  | NONASSOC
  | TYPE
;
  tag : /* Empty: union tag ID optional. */
  | '<' IDENTIFIER '>
;
  nlist : nmno
  | nlist nmno
;
  nmno : IDENTIFIER  /* Note: literal invalid with % type. */
  | IDENTIFIER NUMBER  /* Note: invalid with % type. */
;
/* Rule section */
rules : C_IDENTIFIER rbody prec
  | rules rule
;
rule : C_IDENTIFIER rbody prec
  | rbody prec
;
rbody : /* empty */
  | rbody IDENTIFIER
  | rbody act
;
act : '{{
  |
  /* Copy action, translate $$, and so on. */
  |
  ',
  |
  ;
  |
  /* Empty */
  |
  | PREC IDENTIFIER
  | PREC IDENTIFIER act
  | prec ';';
;
Conflicts

The parser produced for an input grammar may contain states in which conflicts occur. The conflicts occur because the grammar is not LALR(1). An ambiguous grammar always contains at least one LALR(1) conflict. The yacc utility shall resolve all conflicts, using either default rules or user-specified precedence rules.

Conflicts are either shift/reduce conflicts or reduce/reduce conflicts. A shift/reduce conflict is where, for a given state and lookahead symbol, both a shift action and a reduce action are possible. A reduce/reduce conflict is where, for a given state and lookahead symbol, reductions by two different rules are possible.

The rules below describe how to specify what actions to take when a conflict occurs. Not all shift/reduce conflicts can be successfully resolved this way because the conflict may be due to something other than ambiguity, so incautious use of these facilities can cause the language accepted by the parser to be much different from that which was intended. The description file shall contain sufficient information to understand the cause of the conflict. Where ambiguity is the reason either the default or explicit rules should be adequate to produce a working parser.

The declared precedences and associativities (see Declarations Section (on page 1066)) are used to resolve parsing conflicts as follows:

1. A precedence and associativity is associated with each grammar rule; it is the precedence and associativity of the last token or literal in the body of the rule. If the %prec keyword is used, it overrides this default. Some grammar rules might not have both precedence and associativity.

2. If there is a shift/reduce conflict, and both the grammar rule and the input symbol have precedence and associativity associated with them, then the conflict is resolved in favor of the action (shift or reduce) associated with the higher precedence. If the precedences are the same, then the associativity is used; left associative implies reduce, right associative implies shift, and non-associative implies an error in the string being parsed.

3. When there is a shift/reduce conflict that cannot be resolved by rule 2, the shift is done. Conflicts resolved this way are counted in the diagnostic output described in Error Handling.

4. When there is a reduce/reduce conflict, a reduction is done by the grammar rule that occurs earlier in the input sequence. Conflicts resolved this way are counted in the diagnostic output described in Error Handling.

Conflicts resolved by precedence or associativity shall not be counted in the shift/reduce and reduce/reduce conflicts reported by yacc on either standard error or in the description file.

Error Handling

The token error shall be reserved for error handling. The name error can be used in grammar rules. It indicates places where the parser can recover from a syntax error. The default value of error shall be 256. Its value can be changed using a %token declaration. The lexical analyzer should not return the value of error.

The parser shall detect a syntax error when it is in a state where the action associated with the lookahead symbol is error. A semantic action can cause the parser to initiate error handling by executing the macro YYERROR. When YYERROR is executed, the semantic action passes control back to the parser. YYERROR cannot be used outside of semantic actions.

When the parser detects a syntax error, it normally calls yyerror() with the character string "syntax error" as its argument. The call shall not be made if the parser is still recovering
from a previous error when the error is detected. The parser is considered to be recovering from
a previous error until the parser has shifted over at least three normal input symbols since the
last error was detected or a semantic action has executed the macro \texttt{yyerrok}. The parser shall not
call \texttt{yyerror()} when YYERROR is executed.

The macro function YYRECOVERING shall return 1 if a syntax error has been detected and the
parser has not yet fully recovered from it. Otherwise, zero shall be returned.

When a syntax error is detected by the parser, the parser shall check if a previous syntax error
has been detected. If a previous error was detected, and if no normal input symbols have been
shifted since the preceding error was detected, the parser checks if the lookahead symbol is an
endmarker (see \textit{Interface to the Lexical Analyzer}). If it is, the parser shall return with a non-
zero value. Otherwise, the lookahead symbol shall be discarded and normal parsing shall
resume.

When YYERROR is executed or when the parser detects a syntax error and no previous error has
been detected, or at least one normal input symbol has been shifted since the previous error was
detected, the parser shall pop back one state at a time until the parse stack is empty or the
current state allows a shift over \texttt{error}. If the parser empties the parse stack, it shall return with a
non-zero value. Otherwise, it shall shift over \texttt{error} and then resume normal parsing. If the parser
reads a lookahead symbol before the error was detected, that symbol shall still be the lookahead
symbol when parsing is resumed.

The macro \texttt{yyerrok} in a semantic action shall cause the parser to act as if it has fully recovered
from any previous errors. The macro \texttt{yyclearin} shall cause the parser to discard the current
lookahead token. If the current lookahead token has not yet been read, \texttt{yyclearin} shall have no
effect.

The macro YYACCEPT shall cause the parser to return with the value zero. The macro
YYABORT shall cause the parser to return with a non-zero value.

\textbf{Interface to the Lexical Analyzer}

The \texttt{yylex()} function is an integer-valued function that returns a \textit{token number}
representing the
kind of token read. If there is a value associated with the token returned by \texttt{yylex()} (see the
discussion of \texttt{tag} above), it shall be assigned to the external variable \texttt{yylval}.

If the parser and \texttt{yylex()} do not agree on these token numbers, reliable communication between
them cannot occur. For (single-byte character) literals, the token is simply the numeric value
of the character in the current character set. The numbers for other tokens can either be chosen by
\texttt{yacc}, or chosen by the user. In either case, the \texttt{#define} construct of C is used to allow \texttt{yylex()} to
return these numbers symbolically. The \texttt{#define} statements are put into the code file, and the
header file if that file is requested. The set of characters permitted by \texttt{yacc} in an identifier is larger
than that permitted by C. Token names found to contain such characters shall not be included in
the \texttt{#define} declarations.

If the token numbers are chosen by \texttt{yacc}, the tokens other than literals shall be assigned numbers
greater than 256, although no order is implied. A token can be explicitly assigned a number by
following its first appearance in the declarations section with a number. Names and literals not
defined this way retain their default definition. All token numbers assigned by \texttt{yacc} shall be
unique and distinct from the token numbers used for literals and user-assigned tokens. If
duplicate token numbers cause conflicts in parser generation, \texttt{yacc} shall report an error;
otherwise, it is unspecified whether the token assignment is accepted or an error is reported.

The end of the input is marked by a special token called the \textit{endmarker}, which has a token
number that is zero or negative. (These values are invalid for any other token.) All lexical
analyzers shall return zero or negative as a token number upon reaching the end of their input. If
the tokens up to, but excluding, the endmarker form a structure that matches the start symbol,
the parser shall accept the input. If the endmarker is seen in any other context, it shall be
considered an error.

Completing the Program

In addition to `yyparse()` and `yylex()`, the functions `yyerror()` and `main()` are required to make a
complete program. The application can supply `main()` and `yyerror()`, or those routines can be
obtained from the `yacc` library.

Yacc Library

The following functions shall appear only in the `yacc` library accessible through the `-ly` operand
to `c99`; they can therefore be redefined by a conforming application:

```c
int main(void)
    This function shall call `yyparse()` and exit with an unspecified value. Other actions within
    this function are unspecified.

int yyerror(const char *s)
    This function shall write the NUL-terminated argument to standard error, followed by a
    <newline>.
```

The order of the `-ly` and `-ll` operands given to `c99` is significant; the application shall either
provide its own `main()` function or ensure that `-ly` precedes `-ll`.

Debugging the Parser

The parser generated by `yacc` shall have diagnostic facilities in it that can be optionally enabled
at either compile time or at runtime (if enabled at compile time). The compilation of the runtime
debugging code is under the control of `YYDEBUG`, a preprocessor symbol. If `YYDEBUG` has a
non-zero value, the debugging code shall be included. If its value is zero, the code shall not be
included.

In parsers where the debugging code has been included, the external `int yydebug` can be used to
turn debugging on (with a non-zero value) and off (zero value) at runtime. The initial value of
`yydebug` shall be zero.

When `-t` is specified, the code file shall be built such that, if `YYDEBUG` is not already defined at
compile time (using the `c99 -D YYDEBUG` option, for example), `YYDEBUG` shall be set
explicitly to 1. When `-t` is not specified, the code file shall be built such that, if `YYDEBUG` is not
already defined, it shall be set explicitly to zero.

The format of the debugging output is unspecified but includes at least enough information to
determine the shift and reduce actions, and the input symbols. It also provides information
about error recovery.

Algorithms

The parser constructed by `yacc` implements an LALR(1) parsing algorithm as documented in the
literature. It is unspecified whether the parser is table-driven or direct-coded.

A parser generated by `yacc` shall never request an input symbol from `yylex()` while in a state
where the only actions other than the error action are reductions by a single rule.

The literature of parsing theory defines these concepts.
Utilities

The `yacc` utility may have several internal tables. The minimum maximums for these tables are shown in the following table. The exact meaning of these values is implementation-defined. The implementation shall define the relationship between these values and between them and any error messages that the implementation may generate should it run out of space for any internal structure. An implementation may combine groups of these resources into a single pool as long as the total available to the user does not fall below the sum of the sizes specified by this section.

### Table 4-22 Internal Limits in `yacc`

<table>
<thead>
<tr>
<th>Limit</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>{NTERMS}</td>
<td>126</td>
<td></td>
<td>Number of tokens.</td>
</tr>
<tr>
<td>{NNONTERM}</td>
<td>200</td>
<td></td>
<td>Number of non-terminals.</td>
</tr>
<tr>
<td>{NPROD}</td>
<td>300</td>
<td></td>
<td>Number of rules.</td>
</tr>
<tr>
<td>{NSTATES}</td>
<td>600</td>
<td></td>
<td>Number of states.</td>
</tr>
<tr>
<td>{MEMSIZE}</td>
<td>5200</td>
<td></td>
<td>Length of rules. The total length, in names (tokens and non-terminals), of all the rules of the grammar. The left-hand side is counted for each rule, even if it is not explicitly repeated, as specified in Grammar Rules in <code>yacc</code> (on page 1068).</td>
</tr>
<tr>
<td>{ACTSIZE}</td>
<td>4000</td>
<td></td>
<td>Number of actions. “Actions” here (and in the description file) refer to parser actions (shift, reduce, and so on) not to semantic actions defined in Grammar Rules in <code>yacc</code> (on page 1068).</td>
</tr>
</tbody>
</table>

### EXIT STATUS

The following exit values shall be returned:

- `0` Successful completion.
- `>0` An error occurred.

### CONSEQUENCES OF ERRORS

If any errors are encountered, the run is aborted and `yacc` exits with a non-zero status. Partial code files and header files may be produced. The summary information in the description file shall always be produced if the `-v` flag is present.

### APPLICATION USAGE

Historical implementations experience name conflicts on the names `yacc.tmp`, `yacc.acts`, `yacc.debug`, `y.tab.c`, `y.tab.h`, and `y.output` if more than one copy of `yacc` is running in a single directory at one time. The `-b` option was added to overcome this problem. The related problem of allowing multiple `yacc` parsers to be placed in the same file was addressed by adding a `-p` option to override the previously hard-coded `yy` variable prefix.

The description of the `-p` option specifies the minimal set of function and variable names that cause conflict when multiple parsers are linked together. `YYSTYPE` does not need to be changed. Instead, the programmer can use `-b` to give the header files for different parsers different names, and then the file with the `yylex()` for a given parser can include the header for that parser. Names such as `yyclearerr` do not need to be changed because they are used only in the actions; they do not have linkage. It is possible that an implementation has other names, either internal ones for implementing things such as `yyclearerr`, or providing non-standard features that it wants to change with `-p`. 
Unary operators that are the same token as a binary operator in general need their precedence adjusted. This is handled by the `%prec` advisory symbol associated with the particular grammar rule defining that unary operator. (See Grammar Rules in `yacc` on page 1068.) Applications are not required to use this operator for unary operators, but the grammars that do not require it are rare.

**EXAMPLES**

Access to the `yacc` library is obtained with library search operands to `c99`. To use the `yacc` library `main()`:

```c
    c99 y.tab.c -l y
```

Both the `lex` library and the `yacc` library contain `main()`. To access the `yacc main()`:

```c
    c99 y.tab.c lex.yy.c -l y -l l
```

This ensures that the `yacc` library is searched first, so that its `main()` is used.

The historical `yacc` libraries have contained two simple functions that are normally coded by the application programmer. These functions are similar to the following code:

```c
#include <locale.h>

int main(void)
{
    extern int yyparse();
    setlocale(LC_ALL, "");
    /* If the following parser is one created by lex, the application must be careful to ensure that LC_CTYPE and LC_COLLATE are set to the POSIX locale. */
    (void) yyparse();
    return (0);
}
```

```c
#include <stdio.h>

int yyerror(const char *msg)
{
    (void) fprintf(stderr, "%s\n", msg);
    return (0);
}
```

**RATIONALE**

The references in Referenced Documents (on page xxxi) may be helpful in constructing the parser generator. The referenced DeRemer and Pennello article (along with the works it references) describes a technique to generate parsers that conform to this volume of IEEE Std 1003.1-2001. Work in this area continues to be done, so implementors should consult current literature before doing any new implementations. The original Knuth article is the theoretical basis for this kind of parser, but the tables it generates are impractically large for reasonable grammars and should not be used. The “equivalent to” wording is intentional to assure that the best tables that are LALR(1) can be generated.

There has been confusion between the class of grammars, the algorithms needed to generate parsers, and the algorithms needed to parse the languages. They are all reasonably orthogonal. In particular, a parser generator that accepts the full range of LR(1) grammars need not generate a table any more complex than one that accepts SLR(1) (a relatively weak class of LR grammars) for a grammar that happens to be SLR(1). Such an implementation need not recognize the case, either; table compression can yield the SLR(1) table (or one even smaller than that) without
Utilities

recognizing that the grammar is SLR(1). The speed of an LR(1) parser for any class is dependent
more upon the table representation and compression (or the code generation if a direct parser is
generated) than upon the class of grammar that the table generator handles.

The speed of the parser generator is somewhat dependent upon the class of grammar it handles.
However, the original Knuth article algorithms for constructing LR parsers were judged by its
author to be impractically slow at that time. Although full LR is more complex than LALR(1), as
computer speeds and algorithms improve, the difference (in terms of acceptable wall-clock
execution time) is becoming less significant.

Potential authors are cautioned that the referenced DeRemer and Pennello article previously
cited identifies a bug (an over-simplification of the computation of LALR(1) lookahead sets) in
some of the LALR(1) algorithm statements that preceded it to publication. They should take the
time to seek out that paper, as well as current relevant work, particularly Aho's.

The \texttt{−b} option was added to provide a portable method for permitting \texttt{yacc} to work on multiple
separate parsers in the same directory. If a directory contains more than one \texttt{yacc} grammar, and
both grammars are constructed at the same time (by, for example, a parallel \texttt{make} program),
conflict results. While the solution is not historical practice, it corrects a known deficiency in
historical implementations. Corresponding changes were made to all sections that referenced
the filenames \texttt{y.tab.c} (now “the code file”), \texttt{y.tab.h} (now “the header file”), and \texttt{y.output} (now
“the description file”).

The grammar for \texttt{yacc} input is based on System V documentation. The textual description shows
there that the \texttt{;} is required at the end of the rule. The grammar and the implementation do not
require this. (The use of \texttt{C\_IDENTIFIER} causes a reduce to occur in the right place.)

Also, in that implementation, the constructs such as \texttt{%token} can be terminated by a semicolon,
but this is not permitted by the grammar. The keywords such as \texttt{%token} can also appear in
uppercase, which is again not discussed. In most places where \texttt{`\$'} is used, \texttt{`\'} can be
substituted, and there are alternate spellings for some of the symbols (for example, \texttt{LEFT} can
be "$<" or even "$\<").

Historically, \texttt{<tag>} can contain any characters except \texttt{>`}, including white space, in the
implementation. However, since the \texttt{tag} must reference an ISO C standard union member, in
practice conforming implementations need to support only the set of characters for ISO C
standard identifiers in this context.

Some historical implementations are known to accept actions that are terminated by a period.
Historical implementations often allow \texttt{`$'} in names. A conforming implementation does not
need to support either of these behaviors.

Deciding when to use \texttt{%prec} illustrates the difficulty in specifying the behavior of \texttt{yacc}. There
may be situations in which the \texttt{grammar} is not, strictly speaking, in error, and yet \texttt{yacc} cannot
interpret it unambiguously. The resolution of ambiguities in the grammar can in many instances
be resolved by providing additional information, such as using \texttt{%type} or \texttt{%union} declarations. It
is often easier and it usually yields a smaller parser to take this alternative when it is
appropriate.

The size and execution time of a program produced without the runtime debugging code is
usually smaller and slightly faster in historical implementations.

Statistics messages from several historical implementations include the following types of
information:

\begin{itemize}
\item \texttt{n/512} terminals, \texttt{n/300} non-terminals
\item \texttt{n/600} grammar rules, \texttt{n/1500} states
\item \texttt{n} shift/reduce, \texttt{n} reduce/reduce conflicts reported
\end{itemize}
The report of internal tables in the description file is left implementation-defined because all aspects of these limits are also implementation-defined. Some implementations may use dynamic allocation techniques and have no specific limit values to report.

The format of the `y.output` file is not given because specification of the format was not seen to enhance applications portability. The listing is primarily intended to help human users understand and debug the parser; use of `y.output` by a conforming application script would be unusual. Furthermore, implementations have not produced consistent output and no popular format was apparent. The format selected by the implementation should be human-readable, in addition to the requirement that it be a text file.

Standard error reports are not specifically described because they are seldom of use to conforming applications and there was no reason to restrict implementations.

Some implementations recognize `"{"` as equivalent to `'{'` because it appears in historical documentation. This construction was recognized and documented as obsolete as long ago as 1978, in the referenced `Yacc: Yet Another Compiler-Compiler`. This volume of IEEE Std 1003.1-2001 chose to leave it as obsolete and omit it.

Multi-byte characters should be recognized by the lexical analyzer and returned as tokens. They should not be returned as multi-byte character literals. The token `error` that is used for error recovery is normally assigned the value 256 in the historical implementation. Thus, the token value 256, which is used in many multi-byte character sets, is not available for use as the value of a user-defined token.

**FUTURE DIRECTIONS**

None.

**SEE ALSO**

`c99`, `lex`

**CHANGE HISTORY**

**Issue 5**

First released in Issue 2.

**Issue 6**

This utility is marked as part of the C-Language Development Utilities option.

Minor changes have been added to align with the IEEE P1003.2b draft standard.

The normative text is reworded to avoid use of the term "must" for application requirements.

IEEE PASC Interpretation 1003.2 #177 is applied, changing the comment on `RCURL` from the `%` token to the `\%`.
NAME
zcath — expand and concatenate data

SYNOPSIS
zcath [file...]

DESCRIPTION
The zcat utility shall write to standard output the uncompressed form of files that have been
compressed using the compress utility. It is the equivalent of uncompress -c. Input files are not
affected.

OPTIONS
None.

OPERANDS
The following operand shall be supported:

file The pathname of a file previously processed by the compress utility. If file already
has the .Z suffix specified, it is used as submitted. Otherwise, the .Z suffix is
appended to the filename prior to processing.

STDIN
The standard input shall be used only if no file operands are specified, or if a file operand is ‘−’.

INPUT FILES
Input files shall be compressed files that are in the format produced by the compress utility.

ENVIRONMENT VARIABLES
The following environment variables shall affect the execution of zcat:

LANG Provide a default value for the internationalization variables that are unset or null.
(See the Base Definitions volume of IEEE Std 1003.1-2001, Section 8.2,
Internationalization Variables for the precedence of internationalization variables
used to determine the values of locale categories.)

LC_ALL If set to a non-empty string value, override the values of all the other
internationalization variables.

LC_CTYPE Determine the locale for the interpretation of sequences of bytes of text data as
characters (for example, single-byte as opposed to multi-byte characters in
arguments).

LC_MESSAGES Determine the locale that should be used to affect the format and contents of
diagnostic messages written to standard error.

NLSPATH Determine the location of message catalogs for the processing of LC_MESSAGES.

ASYNCHRONOUS EVENTS
Default.

STDOUT
The compressed files given as input shall be written on standard output in their uncompressed
form.

STDERR
The standard error shall be used only for diagnostic messages.
**OUTPUT FILES**
None.

**EXTENDED DESCRIPTION**
None.

**EXIT STATUS**
The following exit values shall be returned:

- 0  Successful completion.
- >0  An error occurred.

**CONSEQUENCES OF ERRORS**
Default.

**APPLICATION USAGE**
None.

**EXAMPLES**
None.

**RATIONALE**
None.

**FUTURE DIRECTIONS**
None.

**SEE ALSO**
compress, uncompress

**CHANGE HISTORY**
First released in Issue 4.
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