Distributed Diagnostics on the Grid: DAME

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Project Partners

• EPSRC Funded, £3.2 Million, 3 years, commenced Jan 2002.
• UK pilot project for e-Science (£120 million programme)
• 4 Universities:
  – University of York, Dept of Computer Science
  – University of Sheffield, Dept of Automatic Control and Systems Engineering
  – University of Oxford, Dept of Engineering Science
  – University of Leeds, School of Computing and School of Mechanical Engineering
• Industrial Partners:
  – Rolls-Royce
  – Data Systems and Solutions
  – Cybula Ltd
Operational Scenario

- Engine flight data
  - London Airport
  - New York Airport
  - Diagnostics Centre
  - Maintenance Centre
  - Airline office

- European data center
- American data center
DAME Grid Challenges

• Building a demonstration system as proof of concept for Grid technology in the aerospace diagnostic domain.

• Two primary Grid challenges:
  – Management of large, distributed and heterogeneous data repositories;
  – Rapid data mining and analysis of fault data;

• Other key (commercial) issues:
  – Remote, secure access to flight data and other operational data and resources;
  – Management of distributed users and resources;
  – Quality of Service issues (and Service Level Agreements)
The Data

- Each flight could produce up to 1GB of vibration data
- This is archived in distributed data repositories (EDS)
Demonstrator Objectives

The DAME demonstration system will provide a diagnosis workbench (portal) which brings together a suite of analysis services via Grid technology;

- Provides access to a range of analysis tools for the engine diagnosis process
- Will act as central control point for automated workflows
- Manages issues of distributed diagnosis team and virtual organisations
- Manages issues of security and user roles.
DAME Service Overview

DAME Diagnostics Portal

Grid Services Management

Modelling/Simulation

Case Based Reasoning

Decision Support

QUOTE

The Grid

Data-Mining

AURA-G

Raw Engine Data

Service Data

Operational Data

Parts Data

Vibration Shaft Speed Fuel Flow

Novel Data

Distributed Aircraft Maintenance Environment - DAME
White Rose Grid Distribution

Distributed Aircraft Maintenance Environment - DAME

York
Data Mining Services

- AURA-G Database
  - GT3 Service Simulates arrival & storage of QUOTE data
- Zmod Viewer
  - GT3 Service Browser based data viewer for zmod files
- DataStore-G
  - GT3 Service Browser based GUI to DAME services
- Collaboration tools
  - GT3 Service Toolkit for multi-user collaboration

Sheffield
Modeling & Decision Support

- EngineModel-G
  - GT3 Service BD25 Engine model wrapped as Grid Service
- CBRAnalysis-G
  - GT3 Service CBR advisor

Leeds
Grid Middleware Services

- Workflow
  - Browser based workflow tool
  - Compliant with Resource Broker
- XTO-G
  - GT3 Service XTO plug-ins via a Grid Service
- Security
  - GT3 Security Service Proxy-Management
- DataVisualiser
  - GT3 Service Jchart Viewer for viewing XTO output
- Resource Broker
  - GT3 Service Schedule workflow tasks on WRG resource

Oxford
Engine Data Store

- Engine Data Database

DAME
- DAME GUI
- AURA-G
- Zmod Viewer
- DataStore-G
- Collaboration tools
- DAME Sign-on Portal
- GT3 Service
- GT3 Security Service
- GT3 Workflow
- GT3 Resource Broker
- GT3 Engine Model
- GT3 DataStore
- GT3 Collaboration Toolset

DAME Workbench

Distributed Aircraft Maintenance Environment - DAME
- The AURA correlation matrix technology is used for rapid pattern matching;
- Two-tier Grid Service architecture.
  - First tier hosts a generic AURA service
  - Second tier containing application specific code
- Clients interact directly with the second tier, allowing application developers to abstract away from the pattern match domain.
AURA Technology

Correlation Matrix Memory (CMM).
- Scalable high-performance.
- Family of generic techniques.
- Wide range of data types.
- Large volumes of data.
- Find exact and near-matches.
AURA Grid Deployment

Time Series Input Pattern

GRID ENABLED QUERY SERVICE

Matched Records

GRID

Data Node: Location 1

Encoding

AURA-G

EDS

Data Node: Location 2

Encoding

AURA-G

EDS

Data Node: Location n

Encoding

AURA-G

EDS
Data Node Detail

Distributed Aircraft Maintenance Environment - DAME

Other Pattern Matching Nodes

DAME Pattern Matching Node

Pattern Matching Control

AURA-G

AURA Encoder

Back-check

Catalogue

CMMs

Tracked Orders
Case Based Reasoning

CBR service is provided via a Grid service interface to a commercial CBR package;

A *Service Factory* supports the creation of multiple CBR instances

- Permits many CBR processes to be executed in parallel from a single service access point

CBR provides decision support for fault ranking and workflow advice;
GSI enabled engine performance simulation for different flight operational conditions and requirements, e.g. Idle, Take-off, Climb.

The Factory Service can generate a group of engine simulation instances for different client requirements.

Both Transport Level and Message Level Security are implemented to protect the secure sensitive engine model and user data.
Signal Processing Services

- Grid based deployment of the vibration analysis algorithms:
  - Provides:
    - Opportunity for finer grain analysis;
    - More powerful algorithms;
    - Testing environment for development of new algorithms;

![Graph showing vibration analysis results](image)
• Services are managed at the portal via a Workflow Engine
• Workflow Engine provides management of manual and automated workflows.
• Also handles certification and role management
Commercial Drivers

• Security of services, process and data are critical:
  – Investigating optimal security architecture based on emerging GT services
  – Security is tightly coupled to role definition and user access rights
  – Complex cross border, cross domain issues;

• Quality of Service aspects are major commercial driver:
  – Investigating mechanisms for service level agreements

• Both of the above underpinned by detailed dependability analysis
Brokering and SLA’s

• Brokerage system is used for job allocation on available Grid resource
• Due to commercial application domain, broker should also demonstrate capability to manage QoS issues, and specifically Service Level Agreements (SLA’s)
• Integrates with GGF Grid Economic Architecture
Dependability Issues

• Contribute to the GRID community dependability and security studies, where possible.
• Provide dependability and security analysis to support the ultimate deployment of DAME as a working engine diagnosis environment.
• If possible, provide a basis (identify good practices) for dependability and security analysis for the deployment of DAME as a working diagnosis environment for other domains e.g. medical.
• Dependability analysis has meant need for business process analysis, asset identification, risk identification.
Dependability Issues, cont

Distributed Aircraft Maintenance Environment - DAME

Airline / Maintenance Contractor (at Airport)
- Download Engine Data
- Perform Minor Repair
- Local Diagnosis
- Maintenance Engineer (ME)
- DAME Diagnosis
- Request advice from MA
- Upload Engine Data
- Update Engine Record
- Return overhauled engine to service

Remote / Distributed Tools and Services
- Distributed Aircraft Maintenance Environment (DAME) - Miscellaneous Providers.
  - Engine Data Center (EDC) - DS&S
  - Service Data Manager (SDM) - RR

Engine Manufacturer (RR)
- Information / request for advice
- Investigate using tools
- Provide Diagnosis / Prognosis / Advice
- Update Engine Records
- Remote / Distributed Tools and Services

Domain Expert (DE) - engine expert
- Information / request for advice
- Investigate using tools
- Provide Diagnosis / Prognosis / Advice
- Update Engine Records
- Request advice from ME

Maintenance Analyst (MA) - maintenance expert
- Information / request for advice
- Investigate using tools
- Provide Diagnosis / Prognosis / Advice
- Update Engine Records

Data Center (DS&S)
- Information / request for advice
- Investigate using tools
- Provide Diagnosis / Prognosis / Advice
- Update Engine Records
- Request advice from DE

Engine Maintenance Repair and Overhaul (MRO) Facility (RR / Contractor)
- Information / request for advice
- Investigate using tools
- Provide Diagnosis / Prognosis / Advice
- Update Engine Records
- Request advice from DE

Return overhauled engine to service
Future Work

- Addition of workflow ‘creator’ in the portal, for flexible workflow configuration;
- Further analysis of dependability properties, including detailed studies on timeliness properties and security issues;
- Larger scale database deployment, and SRB integration;
- Further development of Grid monitoring services as basis for SLA and brokering;
- Continued development of data mining (AURA) capability;
Thanks…

The development team:

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Further info: http://www.cs.york.ac.uk/dame