Optimization of Spare Capacity in Survivable WDM Networks[1]

H.W. Chong and Sam Kwong

Department of Computer Science
City University of Hong Kong, 83 Tatchee Avenue, Hong Kong
Chonghw@cs.city.edu.hk, Cssamk@cityu.edu.hk

Abstract. A network with restoration capability requires spare capacity to be used in the case of failure. Optimization of spare capacity is to find the minimum amount of spare capacity for the network to survive from network component failures. In this paper, this problem is investigated for wavelength division multiplexing (WDM) mesh networks without wavelength conversion. We propose a hybrid genetic algorithm approach (GA) for the problem. Simulated Annealing (SA) and Tabu Search (TS) are also applied to this problem for comparison purpose. Simulation results show very favorable results for the Genetic Algorithm approach.

1 The Proposed Algorithm

In this paper, we are primarily concerned with the restoration at the optical layer. The discussion is limited to wavelength-continuity optical WDM mesh network with static traffic. Given a network topology, a traffic demand consisting of the connections to be established, and set of alternate routes for each connection request, Our objective is to find sets of primary lightpaths and backup lightpaths such that the sum of working and backup capacity usage can be minimized while a set of customer traffic demands can still be satisfied and the traffic is 100% restorable under the constraint to be immune against a single link failure. Our algorithms will use path-based restoration method and backup multiplexing to improve the channel utilization.

To minimize the spare capacity, we will optimize both routing and wavelength assignment, this combinatorial problem is usually called Routing and Wavelength Assignment (*RWA*) problem and it is known to be NP-complete. For the routing problem, we employ the alternate routing approach. For each connection request, a set of candidate routes is precomputed off-line, our algorithms will select the primary routes and backup routes that can optimize the total capacity usage. For the wavelength assignment problem, we reduce it to a graph-coloring problem and the nodes are assigned colors in the order found by our algorithms. The *RWA* problem is divided into two sub-problems in this paper but our proposed GA will solve these two these Sub-problems simultaneously.

Figure 1 shows the structure of a chromosome, the chromosome consists of three parts.

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[1] This work is supported by City University Strategic Grant 7001337.

E. Cantú-Paz et al. (Eds.): GECCO 2003, LNCS 2724, pp. 2396–2397, 2003.

Part one is a set of working routes for connection requests, part two is a set of backup routes for connection requests and part three is the wavelength assignment order for each route. Since the structure of the chromosome is divided into three parts and each part codes different sub-problem, we design different type of crossover operation for different part of chromosome. One-point crossover and two-point crossover operations are applied to part 1 and part 2 of the chromosome, after that, uniform order-based crossover operation is applied to part 3 of the chromosome. Similar to crossover operation, we design different mutation operator for different part of chromosome structure. For the mutation on part 1 and 2 of chromosome, we need to select a working route and its corresponding backup route before mutation is implemented, and then a new working route and backup route are found to replace the current routes in the selected chromosome. After performing mutation on part 1 and 2 of chromosome structure, we will apply scramble sublist mutation [1] to the third part of chromosome structure.

2 Experimental Results

We conduct experiment to study the performance of proposed GA. For benchmarking purpose, SA and TS are also applied to the problem as well. The three approaches are applied on the network shown in figure 2. A performance comparison between GA, SA and TS is shown in the chart. From the result, we can find that GA approach clearly outperforms SA and TS approaches. Also, TS approach is the poorest of the three. Therefore, GA approach is recommended to be the best choice for solving the spare capacity allocation problem arising in the design of survivable WDM mesh network with static traffic.

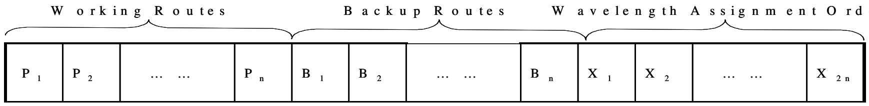
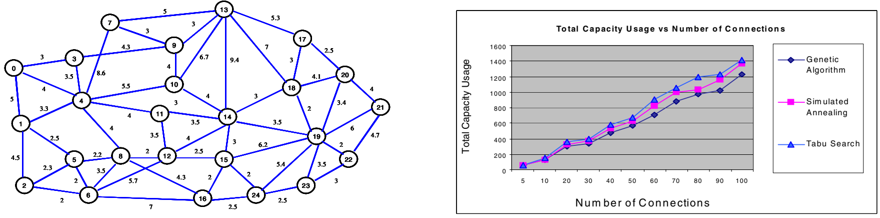


Fig. 1. Structure of a chromosome



Simulation Network

Comparison of the results of GA, SA and TS in simulation network

Fig. 2. Simulation network and results

Reference

1. Davis, L.: Handbook of genetic algorithms. 1991, New York: Van Nostrand Reinhold