PRACTICAL PERSPECTIVE ON WAVELENGTH ASSIGNMENT STRATEGIES IN OPTICAL NETWORKS: A SURVEY

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Abstract: *In optical network, it is necessary to determine the route and assign a wavelength that will be used on all links along the route. This paper focuses the specific problem of wavelength assignment. Our experimental study deals with analysis of wavelength assignment strategies in optical networks. Simulation results show that first fit and random fit wavelength assignment strategies are the most practical, as these are simple to implement.*

Index terms: *Optical WDM networks, wavelength assignment, network block rate, channel utilization, throughput.*

1. INTRODUCTION

In optical WDM network, light path corresponding to a given session must travel on the same wavelength on all links from the source node to the destination node. Given the physical network structure and the required connections, the problem of setting of light paths by routing and assigning a wavelength to each connection is called Routing and Wavelength Assignment (RWA) problem. The RWA problem is an important problem in resource management networks for increasing the efficiency of wavelength-routed all-optical networks [1], [2]. Routing process has to find the route for the light path request and has to assign a wavelength that minimizes the blocking probability.

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Generally, the routes are chosen based on shortest-path sets in the routing process. The selection of the wavelength plays an important role in the performance of the algorithm and also on the overall blocking probability. So, this paper concerned only with the wavelength assignment problem and too analyzing the wavelength assignment strategies.

1.1 Routing and Wavelength Assignment

The general objective of the RWA problem is to maximize the number of established connections. Each connection request must be given a route and wavelength. Two connections requests can share the same optical link, provided a different wavelength is used. Various wavelength assignment approaches are described below:

1.1.1 First fit (FF) wavelength algorithm

First Fit chooses the available wavelength with the lowest index and assigns it to the connection request. When the request is completed, the wavelength is added back to the free wavelength set.

1.1.2 Random fit (RF) wavelength algorithm

Random fit algorithm determines which a wavelength is available and then chooses randomly amongst the available set of wavelengths. This algorithm suffers from lack of definite approach for wavelength assignment and that may not yield good results in some cases.

1.1.3 Least used (LU) wavelength algorithm

In Least used (LU) wavelength assignment, the connection request is assigned with a free wavelength that is least used in the network. If several available wavelengths share the same maximum usage, the wavelength with a specific index is chosen. There are several other wavelength assignment algorithms: Most Used, Min Product, Least Loaded, Max Sum and Relative Capacity Loss. Two of the most common methods for wavelength assignment are First Fit and Random Fit.

The goal of this paper is to have an experimental study on wavelength assignment strategies. The paper is organized as follows. Section 2 review the literature work done earlier. Section 3 presents the performance evaluation of the wavelength algorithms. Finally Section 4 concludes the paper.

2. RELATED STUDY

Light-paths are the basic building block of network architecture. Connection establishment for a session request is very important which involves selection of a route and wavelength assignment along this route. Therefore, selection of light-path involves Routing and Wavelength Assignment (RWA) problem discussed by Asuman Ozdaglar et al [3] and Jonathan Lang et al [4].

Siamak Azodolmolky et al [5] compared and presented the two classes of adaptive Quality of Transmission (QoT) aware routing and wavelength assignment algorithms with physical impairments. When networks are heavily loaded, connection requests are blocked because of poor QoT, measured by Bit-Error-Rate (BER). The reported algorithm decreases the BER and improves the fairness in blocking probability and BER without any connection drop in the network.

Ching-Fang Hsu et al [6] presented a heuristic algorithm, named Least Weighted Configuration Cost (LWCC) to solve the dynamic wavelength assignment problem in wavelength-convertible network. Simulation results show that LWCC outperforms the existing algorithm significantly in terms of blocking performance.

To solve large and scalable problem in reasonable time, RWA problem was topologically defined and the behavior of the corresponding algorithms was explained in detail by Tarek Hindam [7]. The algorithm has explained the dependence between the number of representation graphs and the shortest light-path in terms of hops.

To serve a connection request, Konstantinos Manousakis [8] developed an IA-RWA algorithm and described the mechanisms required to compute them. The IA-RWA algorithm calculates all the cost-effective and feasible light-paths for the given source-destination of the network.

Kiyo Ishii et al [9] developed the optimal wavelength assignment for concatenated ring networks which minimizes the number of wavelengths used. They also described three schemes viz., traffic separation, hierarchical switching for inter-ring traffic and restriction to only the end-node switching protection scheme. These schemes reduce the switch scale of the ring-concatenating nodes.

3. PRACTICAL PERSPECTIVE ON WAVELENGTH ASSIGNMENT

In optical WDM networks, finding physical routes and assigning wavelengths to light paths plays a vital role in the information transmission systems. Assignment of wavelengths to the connection request is depicted in figure 1:

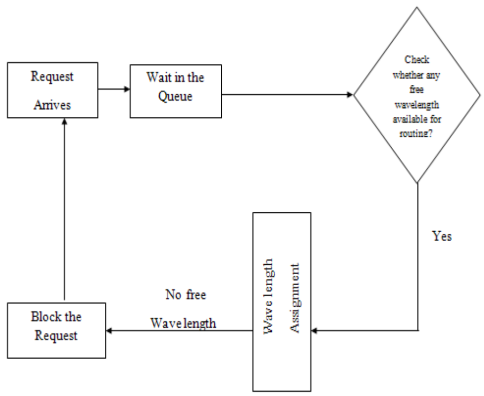

Fig 1: Architectural diagram for the wavelength assignment algorithm

In this section, various wavelength assignment approaches are discussed and their performance has been analyzed.

3.1 SIMULATIONS

To analyze the performance of wavelength assignment algorithms, various performance metrics such as blocking rate, throughput and channel utilization has been considered. A 3x3 mesh network is considered for our simulation environment as shown in Figure 2.

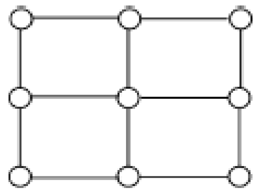

Fig 2: 9-node mesh network

3.2.1 Results and Discussion

Here, traffic load is assumed as 2MB, 4MB, 6MB, 8MB, 10MB, 12MB and 14 MB for our simulation.

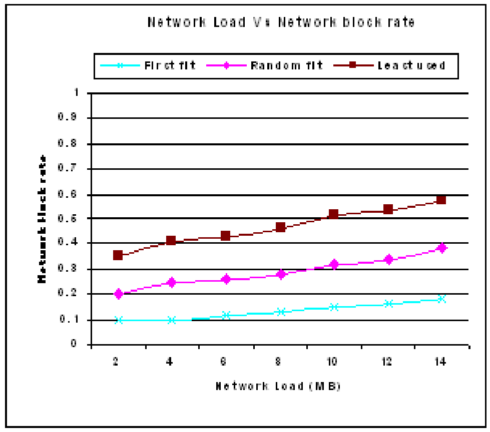

Fig 3: Variation of network block rate with load

Figure 3 depicts the network block rate with traffic load for the wavelength algorithms for various traffic loads viz., 2MB, 4MB, 6MB, 8MB, 10MB, 12MB and 14 MB. It is clearly observed from the Figure 3 that the network block rate for the FF algorithm is significantly less than the RF and LU algorithms. This reduced block rate is due to the balanced utilization of wavelengths achieved in the FF algorithm comparatively. For example, when the load is 8 MB, the network block rate with FF algorithm is only 0.12, whereas the drop rate achieved by the RF and LU wavelength algorithms are 0.28 and 0.53 respectively.

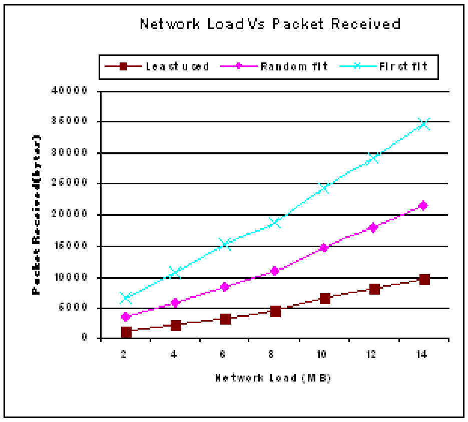

Figure 4: Variation of Packets received with load

The variation of packet received with load is presented in Figure 4 for various loading conditions. For a network load of 8 MB, it is observed that number of packets received by the FF algorithm is 18715 bytes, whereas RF and LU algorithm receives only 11520 and 5980 bytes respectively. Since the FF algorithm achieves reduced network block rate due to balanced wavelength utilization, this higher packet receiving capacity is possible than the other wavelength algorithms.

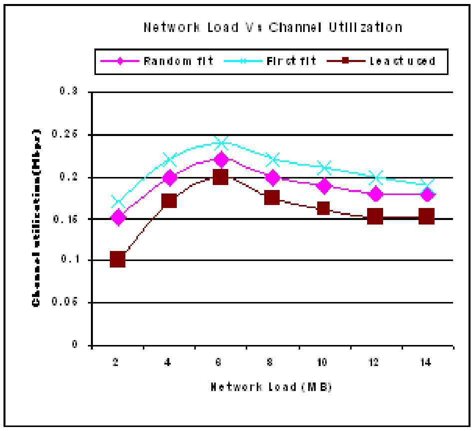

Figure 5: Variation of Channel utilization with load.

The utilization of channel for various wavelength algorithms is shown in Figure 5. For a traffic load of 8 MB, the Figure 5 shows that the FF algorithm achieves channel utilization as 0.23 Mbps, whereas RF and LU wavelength algorithms achieves only 0.2 Mbps and 0.18 Mbps respectively. From Figure 5, it is proved that FF algorithm achieves comparatively better channel utilization than the other algorithms, since all the available wavelengths are utilized uniformly.

4. CONCLUSION

In this paper, the performance of various wavelength assignment approaches has been analyzed for various performance metrics. Simulation results showed that the First fit wavelength assignment algorithm achieves reduced network block rate with increased channel utilization and throughput than the other wavelength strategies. However it yields better performance, the disadvantage of this approach is that the lower indexed wavelengths are much more used than the higher indexed wavelengths. Hence certain wavelengths are utilized very low. Since all the nodes in the network use the lower numbered wavelengths, contention for these wavelengths increases which results in higher network block rate in the network.

Furthermore, it will be concentrated to develop a round robin wavelength assignment approach to overcome the adverse effects. In this strategy, the assignment of wavelength starts with assigning the first indexed wavelength for the first requested light-path. With every subsequent request, the node chooses the next numbered wavelength and so on. In this manner, all the wavelengths can be utilized equally which reduces the blocking probability considerably.

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