Comprehensive Study of Routing and Wavelength Assignment Problems in Optical Networks

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Abstract—Optical network are used widely in all types of telecommunication networks. These have capability of transmitting large amount of data across the network. It uses the light beams to transmit data over various segment. WDM is a technology that plays a vital role in bandwidth utilization. By means of this technology the bandwidth can be utilized effectively and provide a better way of communication. WDM has modify the routing process to a great extent. Routing allows that which path is to be used for the connection establishments. Wavelength assignment algorithms make use of available wavelengths in order to achieve goal of maximizing the number of optical connections. In this paper WDM and wavelength assignment algorithm has been studied and analyzed.

Keywords — Optical fiber, Wavelength Division Multiplexing, Routing, Wavelength Assignment, Wavelength Assignment algorithms.

I. INTRODUCTION

Optical fiber system are the result of continues stream of product innovations and process improvements. As the network users are increasing rapidly, demand for high bandwidth also increases, so network providers are moving towards the optical networks. These are telecommunication networks with high capacity which are based on optical technologies. Optical fiber plays an important role in information technology revolution [1]. These provides the pathways for the transmission of light for communication. An optical fiber is simple in structure and consist of glass core, cladding layer, coating buffers and outer jacket [2].

These are providing higher bandwidth for data communications. Benefits of optical networks include higher bandwidth for voice, video and data applications, light weight than other medium like copper. In these losses are low and have longer life span as compared to other medium like copper [3].

A. Wavelength Division Multiplexing

It is an important technique to exploit the huge bandwidth of the optical fiber. These are based on the concept of transmission of several light beams of different wavelength simultaneously through an optical fiber [4].

It provides enhancement in the network capacity so that traffic demands which are growing day by day can be fulfilled by the optical networks. For fulfilling this purpose available bandwidth is divided into several optical frequencies or wavelengths and sending light beams of different wavelengths simultaneously down the core of fiber, then the signals are amplified at different wavelengths regardless of their modulation speed or schemes [5].

An important aspect in optical networks is Routing and Wavelength Assignment. To establish a light path in WDM networks, it is necessary to determine the route over which the light path should be established and wavelength to be used on all the links along the routes, this is referred to RWA problem. RWA require that no two light paths on a given link may share the same wavelength [6]. Its objective is to route light paths and assign wavelength in a manner which minimize the amount of network resources that are consumed, while at the same time ensuring that no two light paths share the same wavelength on the same fiber link.

An end to end light path has to be established prior to the communication between any two nodes in optical networks. To create a path, it is require that the same wavelength be allocated or assigned on all the links along the path and approach is called as the wavelength continuity constraint [7].

There are several approaches to routing connection request. These are explained as follows:

1) Fixed Routing: This is the most basic approach to routing. In this a connection is to always choose the same fixed route for a given source destination pair. The problem with fixed routing is that it is unable to handle fault situation in which one or more links in the networks fails. This failure can be avoided by an alternative path or dynamic route must be found.

2) Fixed Alternate Routing: This approach includes that every node in the network maintain a routing table which contain an ordered list of a number of fixed routes to each destination nodes.
3) Adaptive Routing: In the adaptive routing, route from source to destination node is chosen dynamically depending on the network state. This network state is determined by the set of all connections currently in the progress [8].

B. Wavelength Assignment Algorithm

Wavelength assignment is a unique feature in wavelength routed networks. There are various algorithms used to assign the wavelength in WDM networks. These are detailed as below:

1) Random Assignment Algorithm: In this method a set of wavelengths that can be used to establish the connection is determined. A wavelength is selected randomly from the available wavelengths [7].

2) Most used: It selects the wavelength that has been mostly used in this networks. Objective of this policy is to keep more wavelengths available for calls travelling over long paths [8].

3) Least used: This type of wavelength assignment is similar to the most used algorithm except in least used algorithm the least used wavelength in the wavelength is assigned. Least Loaded wavelength assignment selects the least loaded wavelength on a most loaded link. This wavelength available on maximum number of fiber for transmission [9].

4) Wavelength conversion (Dynamic): Any incoming light path can be assigned to any wavelength on the output side. It reduces the wavelength continuity constraint [9].

5) First Fit: In this algorithm all wavelengths are numbered. When searching for available wavelength a lowered number wavelength is taken in to account before a higher number. Then first available wavelength is selected [10].

In this paper we are studying about the WDM and Wavelength assignment algorithms. Various algorithms has been used in optical networks to optimize the maximum capacity of the network. These algorithms allow to reduce the blocking probability across the network so that faster and effective communication between the nodes takes place.

II. LITERATURE SURVEY

Xuehong Sun et al. [11] has developed a new analytical technique for the performance analysis of all optical networks which use the first-fit algorithm for wavelength assignment and analyze the wavelength usage on the links to calculate the blocking probability of a source destination pair in the optical networks. It takes into account the wavelength correlation and load correlation between Links. Amit Wason et al. [12] proposed algorithm which is based on most-used wavelength assignment algorithm and suggested a mathematical model for WDM optical networks for minimization of blocking probability in optical networks. The results of proposed algorithm and model are then compared with the conventional wavelength assignment algorithms. The proposed approaches are very effective for the minimization of blocking probability in optical WDM networks.

Rajneesh Randhawa et al. [13] has proposed a new algorithm for wavelength assignment. In this paper, performance is calculated in terms of blocking probability. It has been analyzed that the newly proposed algorithm offers the least blocking probability as compared to other already developed or existing approaches. The blocking performance of wavelength division multiplexing network has been analyzed for the network having 10 nodes and for varying loads. As the load per link increases, the blocking probability also increases. The result in the shown paper shows that the performance of first-fit algorithm is better than random algorithm whereas the proposed algorithm offers the least blocking in the links of optical networks.

Anwar Alyatama et al. [14] used random and first-fit wavelength assignment approaches for presenting an analytical method and examined the blocking probabilities in wavelength division multiplexing networks. The newly developed approach viewed the WDM network as a set of different layers in which the blocked traffic in one layer is overflowed to another layer. The order of determining blocking probabilities in each layer of the network is derived from an exact approach and a matching method was used to characterize the overflow traffic from one layer to another in the networks.

Paramjeet Singh et al. [15] has analyzed commonly used routing and wavelength assignment strategies in the optical networks. In this paper we studied RWA strategies which reduces the blocking probability by reducing the number of connections rejected. All the proposed strategies use the shortest path, alternate shortest path and first fit wavelength assignment strategies giving more priority to shortest path as compared to alternate shortest path, yet differs in the combinations of the three to establish the connections. Each possible combination has been considered. This difference leads to variation in the performance as shown by the results. Performance of proposed strategies and most commonly used RWA have been evaluated in terms of blocking probability by applying on the sample network. Simulation results show that the performance of all the proposed strategies is much better than the existing strategy.
Amit Wason et al. [16] examined that the blocking probability in wavelength routed optical networks is an important aspect to measure the performance of the network. It can be affected by factors such as network topology, load on the network, number of links, algorithms used and whether wavelength conversion is available or not. A mathematical model has been proposed to reduce the blocking probability of the WDM optical network. The model can be used to evaluate the blocking performance of any network topology and it can also be useful to improve its performance of the given network topology.

Poompat Saengudomlert et al. [17] developed an on-line wavelength assignment algorithm for a wavelength-routed WDM tree network. This algorithm works dynamically and supports all k-port traffic matrices among end nodes in the network. Implementation of proposed wavelength assignment algorithm was also demonstrated using a hybrid wavelength-routed/broadcast tree with only one switching node connecting several passive broadcast sub-trees.

Abhisek Mukherjee et al. [18] proposed a new wavelength conversion algorithm in a DWDM network using online routing. In this paper we analyze that a model for the algorithm has been theoretically developed and the corresponding call connection probability has been calculated and limitation on the number of wavelength conversions has been addressed by fixing the maximum number of wavelength conversions allowed for the transmissions of a single packet over the network.

Raja Datta et al. [19] presented a wavelength assignment algorithm which was used for optical assignment of a single wavelength to single-hop traffic in a tree topology. This work was further improved for the wavelength assignment in a general graph in optical networks. This polynomial time algorithm gave an optimal solution to the routing and wavelength assignment problem in a tree topology.

Gaoxi Xiao et al. [20] studied blocking probability and proposed a set of algorithms for allocating fixed wavelength conversion in all-optical networks. A simulation-based optimization approach has been deployed in which utilization statistics of fixed wavelength conversion’s were collected from computer simulations and then optimization was performed to allocate the fixed wavelength conversion. Extensive computer simulations were conducted on regular and irregular networks under both the uniform and non-uniform traffic.

Jian Liu et al. [21] proposed two different wavelength assignment algorithms for the network.

These wavelength assignment algorithms were proposed for minimization of blocking probability of the network. In this paper we studied that in distributed light path restoration in WDM networks, different restoration operations may compete for the same wavelength on the same link. Hence they get blocked though there are still number of idle capacities on the link. In this paper, author proposed two different wavelength assignment methods within the same framework for lowering such type of blocking. Simulation results obtained show that the given approaches outperform the existing ones. It is also shown that the optimal performance cannot be guaranteed by any distributed wavelength assignment method with a predefined wavelength searching sequence.

Guangzhi Li et al. [22] studied the off-line wavelength assignment problem in star and ring networks for optical wavelength division multiplexed networks. The results showed that the ability to switch between fibers increases wavelength utilization. Additionally, the complexity of the problem was studied and several constrained versions of the problem were also considered for star and ring networks.

Jianping Wang et al. [23] studied wavelength assignment for WDM multicast network to cover the maximum number of destinations for minimizing the network cost. The computational complexity of the problem was also studied. Three heuristic algorithms were proposed and the worst-case approximation ratios for some heuristic algorithms were given. They also derive a lower bound of the minimum total wavelength cost and an upper bound of the maximum number of reached destinations. In this paper the efficiency of the proposed heuristic algorithms and the effectiveness of the derived bounds were verified by the simulation results.

Lei Guo et al. [24] has proposed a heuristic survivable algorithm named dynamic path-shared protection (DPSP) to completely protect the double-link failures in meshed Wavelength division-multiplexing (WDM) optical networks. In order to improve the performance of algorithm, focus on considering two key issues that are load balancing and resource sharing degree. Determining the trap situations and providing a solution because the trap situations may lead to high blocking probability. The result of Simulations show that, DPSP can provide complete protection for the double-link failures. DPSP not only can effectively avoid the trap situations but also is able to obtain higher resource utilization ratio and lower blocking probability.
III. CONCLUSION

In this paper we are discussing about WDM and RWA problems. WDM has been deployed over the years to enhance the faster communication in the optical networks. RWA(Routing and Wavelength assignment) problems also been studied. Various previous papers has been studied and analyzed carefully in order to determine the various strategies and methods used in WDM and RWA. In order to increase the bandwidth utilization there is requirement that blocking probability should be reduced and new approaches developed for the wavelength assignment. We have to carry out further work or refinement in the optical networks to provide faster communication medium to the network users.

REFERENCES


