Proposed Experimental Algorithm for Wavelength Assignment in Optical WDM Mesh Networks

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ABSTRACT
In this paper, we analyze the wavelength assignment problem in optical WDM mesh network. Firstly the performance of Random algorithm, First-fit algorithm and Wavelength conversion is analyzed. Then new algorithm is developed from existing conversion algorithm. Proposed algorithm reserve the resources for the primary light paths and secondary light paths. Then extensive simulations are done on different networks to evaluate the performance in terms of blocking probability. Then comparison is performed for the blocking probability of various algorithms with number of links and channels are kept constant and the variation in number of load per link (in Erlangs). The results show that the proposed algorithm routing performs better than first two strategies. The performance of the modified wavelength conversion algorithms is best.

Keywords
Optical networks, Routing and Wavelength Assignment (RWA), Wavelength division multiplexing (WDM), blocking probability , lightpath

1. INTRODUCTION
All Optical Networks have become an efficient mean to fulfill the tremendous demand of bandwidth due to skyrocketed increase of internet traffic [1]. Current optical networks technically offer bandwidth demand on the order of 50Tbps within extremely low bit error rates [2]. Wavelength division multiplexing (WDM) is probably the most powerful technique to unlock the enormous bandwidth in optical fiber and thus overcome the electronic bottleneck without laying new fiber. In a WDM network several optical signals are sent on the same fibers using different wavelength channels [3]. The principle is identical to that used when we tune our television receiver to one of many TV channels. This allows bidirectional communication over one standard fiber with in increased capacity [4]. The blocking probability of a lightpath request (or a call) is an important performance measure of a wavelength-routed network. This blocking probability is affected by many factors such as network topology, traffic load, the RWA algorithm employed and whether or not wavelength conversion is available. A network equipped with the wavelength converters has a better call blocking performance than a network without wavelength converters [3].

Sitting in the heart of WDM technology is the Routing and Wavelength Assignment (RWA) problem [5]. RWA is the unique feature of WDM networks in which lightpath is implemented by selecting the path of a physical link between the source and destination edge nodes, and reserving a particular wavelength on each of these links for the lightpath. Thus for establishment of an optical connection, one must deal with both the selection of the path (Routing) and allocating the available wavelengths for the connections (Wavelength Assignment). This resulting problem is known as routing and wavelength assignment problem [6].

The RWA problem is addressed by a two step process to decrease complexity [7]:
• First, a path from the source to the destination is found using a routing algorithm,
• Second, a free wavelength on the chosen path is determined using a wavelength-assignment algorithm.

The additional complexity arises from the fact that routing and wavelength assignments are subject to the following two constraints [7]:
• Wavelength continuity constraint: A lightpath must use the same wavelength on all the links along its path from the source to the destination edge node.
• Distinct wavelength constraint: All light paths using the same link (fiber) must be allocated distinct wavelengths

If free wavelength is not available on any link the call will be blocked.
In simple terms the blocking probability can be calculated.

The number of call requests rejected
B.P = The number of call connections requested

Blocking is the key performance index in the design of an all-optical network. In simple words the connection is blocked when the network does not have sufficient resources to support a connection. Resources in our case
are the available wavelengths in the network. This parameter is dependent on the type of algorithm used to assign the wavelength for communicating nodes in the network. Thus algorithms resulting in minimum blocking have the best performance [3]. Three of the important wavelength assignment algorithms are the following:

- Random wavelength assignment [3]: In this algorithm a set of wavelengths that can be used to establish the connection is determined. After that wavelength is randomly select with uniform probability distribution from the set.

- First-fit wavelength assignment [3]: This algorithm numbers all wavelengths, so that when there is a demand for wavelengths available, those of a smaller number are considered first. The first available wavelength is then selected. This algorithm does not require global information system. Its computational cost is lower because no storage is needed to keep the network states. It works well in terms of blocking probability and fairness of allocation. This algorithm is preferred for its small overhead and low computational complexity. The objective of this allocation scheme is to minimize wavelength fragmentation.

- Wavelength conversion wavelength assignment [3]: Any incoming light-path can be assigned to any wavelength on the output side. This eliminates wavelength-continuity constraints.

Several routing algorithms are proposed in the literature of which some are represented as below:

- Static routing algorithms [7]: In the static case, the entire set of connections is known in advance, and the problem is then to set up light paths for these connections in a global fashion while minimizing network resources, such as the number of wavelengths or the number of fibers in the network. Alternatively, one may attempt to set up as many of these connections as possible for a fixed number of wavelengths. The RWA problem for static traffic is known as the Static Lightpath Establishment (SLE) problem.

- Adaptive routing algorithms [7]: In the adaptive case, connection requests arrive consecutively; a lightpath is established for each connection; and the lightpath remains in the network indefinitely.

- Dynamic routing algorithms [7]: In the dynamic case, a lightpath is set up for each connection request as it arrives, and the lightpath is released after a finite period of time. The aim in the incremental and dynamic traffic cases is to set up light paths and assign wavelengths to reduce the number of blocked connections in the network at any time. This problem is referred to as the Dynamic Lightpath Establishment (DLE) problem.

This paper is organized as follows: Section 2, covered the background. In Section 3, a simulation Setup for a wavelength-routed all-optical WDM network is being proposed. Section 4 focuses on the results and discussion, which shows simulation results for variation of blocking probability of various algorithms with respect to processing time and the variation in number of loads. The conclusions are covered in Section 5.

2. BACKGROUND

Transmission systems using copper line are limited in bandwidth and constrained by electronic processing speed. With the advance of optical technology, copper lines are gradually replaced by optical fiber [5]. Optical transmission systems were first demonstrated commercially in 1980 at a line rate of 45 M b/s [8]. After languishing for many years as an interesting technology without a cost effective application, wavelength-division multiplexing started playing a major role in telecommunications networks in the early 1990s. This resulted from the surge in demand for high-capacity links and the limitation of the installed fiber high-rate optical signals over any substantial distance [9]. An Optical WDM Network is consists of wavelength routing nodes interconnected by point-to-point optical fiber links in an arbitrary topology. A Routing and Wavelength Assignment (RWA) algorithm selects a good route and wavelength to satisfy a connection request so as to improve the network performance [10]. The blocking probability of a light path request (or a call) is an important performance measure of a wavelength-routed network. Various works researches on routing and wavelength assignment algorithms have been done to minimize the blocking probability.

Vishal Anand and Chunming Qiao [11] focuses on the routing and wavelength assignment in wavelength-routed optical wavelength-divisioned-multiplexed networks with circuit switching using wavelength conversion. Wavelength conversion has been proposed for use in such networks to improve the efficiency. Sun et al. [5] proposes a new analytical technique for the performance analysis of all optical networks which use the first-fit algorithm for wavelength assignment. Also analyze the wavelength usage on the links to calculate the blocking probability of a source destination pair, taking into account wavelength correlation and load correlation between links. This model is accurate even in a system with large number of wavelengths. Zung et al. [12] study the routing and Wavelength-Assignment (RWA) problem in wavelength-routed optical WDM networks and they propose a new wavelength assignment scheme, called Distributed Relative Capacity Loss (DRCL), which works well in distributed-controlled networks, and demonstrate the performance of DRCL through simulation. Vitthal J. Gond and Aditya Goel [10] addressed wavelength conversion
technique to reduce the blocking probability in wavelength routed networks. It is seen that the blocking probability of traffic requests decreases as the wavelength conversion factor increases. In this work the evaluation of wavelength routed optical network with varying number of wavelength converters, different traffic types are carried out and results are shown that the blocking probability is minimum with 50% to 60% wavelength convertible nodes. Amrinder S. Arora and Suresh Subramaniam [13] addressed the problem of optimally placing a limited number of wavelength converters in mesh topologies. Two objective functions, namely, minimizing the average blocking probability and minimizing the maximum blocking probability over all routes, are considered. In the first part of the paper, they extend an earlier analytical model to compute the blocking probability on an arbitrary route in a mesh topology, given the traffic and locations of converters. Then propose heuristic algorithms to place wavelength converters, and evaluate the performance of the proposed heuristic using the analytical model. Awwad et al. [14] consider the RWA problem with traffic grooming (GRWA) for mesh networks under static and dynamic lightpath connection requests. They propose an integer linear programming (ILP) model that accurately depicts the GRWA problem. Because it is very hard to find a solution for large networks using ILP, we solve the GRWA problem by proposing two novel heuristics. The strength of the proposed heuristics stems from their simplicity, efficiency and applicability to large-scale networks. Our simulation results demonstrate that deploying traffic grooming resources on the edge of optical networks is more cost effective and results in a similar blocking performance to that obtained when distributing the grooming resources throughout the optical network domain. Keyao Zhu and Biswanath Mukherjee [22] investigate the traffic-grooming problem in a WDM-based optical mesh topology network. There objective is to improve the network throughput and study the node architecture for a WDM mesh network with traffic-grooming capability. A mathematical formulation of the traffic-grooming problem is presented in this study and several fast heuristics are also proposed and evaluated. Many mathematical models are proposed in the literature for the networks with wavelength conversion. Also, those models are complex in nature. A network which equipped the wavelength converters has a better call blocking performance than a network without wavelength converters. However, since wavelength conversion is an extremely costly technology and a burden of using expensive hardware, So that we proposed a new algorithm in which we reduce the running cost of the system.

3. SIMULATION SETUP

In this Simulation setup we vary loads per link (in Erlangs) with respect to processing time and in result of which we analyze the blocking probability for various wavelength algorithms in optical WDM mesh network. In optical networks, for information transmission system, finding physical routes and assigning wavelengths to light paths (call) plays an important role.

The architectural diagram for proposed algorithm is shown in Figure 1. According to the flow diagram of proposed algorithm our call request will be discarding only in one condition if route and wavelength will not found. Dropping probability of request call is minimum in this case so that the blocking probability will also reduced because the blocking probability is the ratio of number of call requests rejected to the total number of call connections requested. The efficiency of the system is also increased due to wavelength convertors. Wavelength conversion technology and wavelength converters play an important role in enhancing fiber utilization and in reducing the overall call blocking probability of the network.

The mesh topology with different nodes in OPNET (Optimized Network Engineering Tool) software is shown in Figure 2.
4. RESULTS AND DISCUSSION

In this section we will present the simulation result for random, first fit and proposed wavelength assignment algorithms. The number of channels and wavelengths on all the links is kept constant. In this network number of channels used is 60, number of wavelengths is 10 and number of nodes is 24. The blocking probability of all algorithms is compared and we obtain the blocking probability with the variation of load per links (in Erlangs). The simulation is carried out in OPNET modeler 14.5 software.

The above simulation results show how the blocking probability (%) increases with the number of loads. The average blocking probability of first-fit algorithm and random algorithm is always larger as compared to proposed algorithm. Figure 3- Figure 5 shows blocking probability v/s processing time for various wavelength assignment algorithms with variation in loads per link (in Erlangs).
5. CONCLUSION

The performance analysis of optical mesh network using first fit, random and proposed algorithms is based on OPNET simulation technique. After comparing the results of various algorithms having load variations with respect to processing time it is concluded that blocking probability of proposed algorithm is better than first fit and random algorithms. The results shows that as the load per link (in Erlangs) increases the blocking probability increases. The blocking probability is maximum in first-fit algorithm and the performance of the proposed algorithms is best.

REFERENCES