Research Paper

IMPROVING NETWORK PERFORMANCE THROUGH NOVEL RWA APPROACH IN OPTICAL NETWORKS

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ABSTRACT

The growth of internet and telecommunication systems leads to the emergence of optical networks. In optical WDM networks, data streams are transmitted along with light paths for effective data transmission. The benefit of WDM optical networks includes high performance, fault tolerance, flexibility, scalability and reduced operational and capital cost. Even though, the optical networks have numerous advantages, increasing number of data and applications increases the bandwidth demand. These limitations indulge the efficient utilization of resources in the optical fibers, which in turn results in performance degradation of the networks. In order to overcome these challenges, the light path must be routed through a path with minimum blocking probability at the same time the wavelength selection ought to be taken into account. This paper proposes a flexible load variance routing (FLVR) algorithm and a hybrid wavelength assignment (HWA) algorithm to resolve the issues in resource management. The experimental results of the proposed algorithm are measured in terms of blocking probability, throughput, average queuing delay and connection drop rate.

KEYWORDS Optical WDM networks, FLVR, HWA , Blocking probability, throughput.

1. INTRODUCTION

Optical network is a high speed telecommunication network with fiber optics as its medium and provides facilities such as routing, grooming, restoration etc. The emerging use of networking and telecommunication system needs information to be communicated at lightning speed. Modern world communication systems use optical networks as it is a low cost high bandwidth network. Earlier optical networks had fibers with a single channel which led to the underutilization of wavelengths. A solution has been devised to solve this inefficiency called the Wavelength Division Multiplexing (WDM) technology. The bandwidth constraints of the optical networks were managed by the optical WDM networks that have multiple channels in a single fiber. The users in the WDM networks transmit and receive data via light-paths that contain a large number of wavelengths. WDM has multiple channels in single fiber. The bandwidth demands are increasing due to the increasing number of applications that incorporate high speed optical networks. These demands lead to a major problem known as Routing and Wavelength Assignment (RWA) problem. In a wavelength routed WDM optical network, the converter is used to assign the wavelength to the appropriate routes. The hardware components of a system are directly proportional to the space and cost of the system. In order to reduce the cost and to address the RWA problem there are different wavelength assignment strategies discussed as follows.

First Fit (FF) Wavelength Assignment Algorithm: It numbers the wavelengths and keeps track of the free wavelengths. According to the arrival order of the connection requests, the wavelengths are allocated to them. The wavelengths with lower number are assigned frequently and wavelengths with higher number always remain unused in the free list.

Random Fit (RF) Wavelength Assignment Algorithm: It has no definite way to assign the wavelengths as it randomly assigns the wavelength for the upcoming connection request. It randomly provides good result.

Most Used (MU) Wavelength Assignment Algorithm: It assigns the wavelength that is used on the large number of fibers in the network. The wavelengths with certain index are allocated to the connection requests, when similar usage patterns are derived for most of the wavelengths.

Least Used (LU) Wavelength Assignment Algorithm: It is analogous to the MU wavelength assignment approach which in contrast chooses the least used wavelength in the network to be allocated.

Round Robin (RR) Wavelength Assignment Algorithm: It indexes the wavelength and the wavelengths are assigned to connection requests in a subsequent way. Each request utilizes them in a round robin manner. Once the free list becomes empty, the first indexed wavelength is assigned again to a new connection request.

The objective of this paper is to solve the RWA problem and to increase the network performance. The FLVR algorithm selects a path with least load and the HWA algorithm assigns the wavelengths in an efficient way. The paper is organized as follows: Section 2 reviews the traditional routing and wavelength assignment algorithms. Section 3 describes the overall description of the proposed work. Section 4 analyses the performance analysis of the proposed algorithms. Section 5 concludes the paper with the future work.

2. RELATED WORK

Sun, et al.[1] analyzed the First Fit algorithm, which was a traditional approach for wavelength assignment. It was based on First Come First Served (FCFS) basis. The wavelengths were numbered and the lower indexed wavelengths were assigned first whereas, the higher indexed wavelengths remain unused. Even though it had low computational complexity and there was no need for global information, the resources were not properly utilized. Dynamic On-line Assignment strategy uses the round robin algorithm for selecting the wavelength. The first wavelength is assigned to the first connection request. All the wavelengths are assigned to the upcoming requests, when there is no further wavelength for assignment the next request is assigned to the foremost wavelength [4]. Here the utilization is better than First Fit approach but a request may wait for a particular wavelength [10]. Static Off-line Assignment strategy is used because there is a hypothesis that blocking probability can be reduced by static assignment. Its objective is to reduce the wavelength usage. It is less complex when compared to Dynamic On-line assignment strategy [4].

Path length based wavelength assignment algorithm divides the wavelengths into two sets. The first set contains lower indexed wavelengths and the second set contains higher indexed wavelengths. Wavelengths are assigned based on the path length of connection request. If the length of the connection request is less than the predefined path length, it is assigned to set one else to set two. Still the higher indexed wavelengths are utilized improperly as it again uses the FF strategy in both sets [7]. Artificial Bee Colony (ABC) algorithm for RWA problem is an approach based on biological and natural process that uses a greedy technique for appropriate wavelength assignment. However greedy technique leads to the algorithm complexity [8]. Improper wavelength assignment makes the connection requests to wait for a long time which in turn increases the blocking probability. Dinesh Arora et al proposed a new mathematical model to minimize the blocking probability using Erlang's formula [9].

Multi-objective Genetic (MOG) algorithm is also an intelligent approach based on the coloring of chromosomes, which aims at minimizing the number of used wavelengths. Impairment Aware – Routing and Wavelength Assignment (IA-RWA) is a problem that occurs during searching or optimum routing path and wavelength assignment. MOG algorithm gives a solution to this issue and is best suited for large population whereas, blocking ratio increases for sparse population [5]. Multilevel Feedback Queue Wavelength assignment (MFWA) algorithm consists of multiple queues. Each queue incorporates different assignment strategies. It was designed for balanced wavelength utilization. Still it suffers from queue overhead as it has multiple queues [6]. Fixed Routing Intelligent Wavelength and Timeslot Re-assignment Algorithm uses Dijkstra's algorithm for routing and uses FF for wavelength assignment. Fixed routing is used for routing whereas alternate path is not considered. The fixed routes are only taken into account whereas shortest path is not considered and it is a NP hard problem hence complex [2]. A Hybrid Adaptive Load Shifting Approach for Fault Recovery in Optical WDM Networks was proposed for multipath routing and load shifting but lacks in wavelength assignment [10].

This paper focus on the problem of routing and wavelength assignment (RWA) which determines the routes and assignment of wavelengths to the lightpaths, using the available number of wavelengths.

2.1 Flexible Load Variance Routing algorithm

Flexible Load Variance algorithm is proposed for routing the connection request with lowest blocking probability. The connection requests are routed through a light path having lowest load and blocking probability. The blocking probability and load of each light path is calculated and they are sorted. A look up table is maintained by listing the light paths with their corresponding load and blocking probability.

For each source and destination pair there will be a primary lightpath and a set of alternate lightpaths. The maximum threshold load of the primary lightpath is calculated and the current load of the primary path is calculated. Before selection of the path, both of the loads are compared and the request is routed along the lightpath having least load using Flexible Load Variance Routing Algorithm.

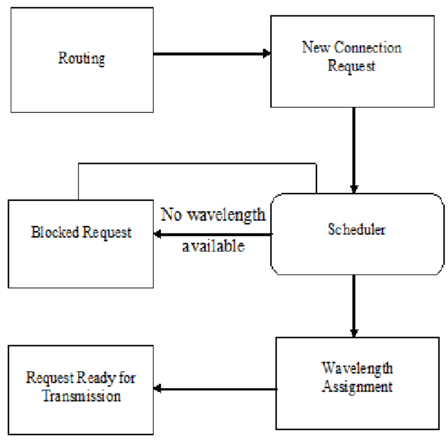

Figure 1: Flow diagram of the proposed system

LEXIBLE LOAD VARIANCE ROUTING ALGORITHM

Step 1: The n number of lighpaths across the source and sink is considered as $LP_1, LP_2, \ldots LP_k$. The blocking probability and load of each paths are sorted in an orderly manner. The main or primary path is termed as LP_1, whereas, others are considered as the secondary light paths.

Step 2: The load of the primary path at a time t is termed as $Load_{LP1}$.

Step 3: The maximum load on the primary path is $Load_{maxL1}$, which is the highest threshold value and is given by $Load_{maxL1} = CP_{tL1}$;
where, CP_{tL1} is the total available channel capacity of the path L_1.

Step 4: The extra loads in the primary path that is to be transferred to the secondary paths is termed $Load_{shift}$.
if $Load_{LP1} > Load_{maxL1}$, then
i) $d = Load_{LP1} - Load_{maxL1}$;
ii) $Load_{shift} = (Load_{LP1} / 2)+d$;
iii) $Load_{LP1} = Load_{LP1} - Load_{shift}$
iv) $Load_{LP1} = Load_{LP1} + Load_{shift}$
v) if $Load_{LP1} > Load_{max}$,then
Repeat i;
vi) end if;
where $Load_{max}$ is the maximum load in the network.

4.2 : end if;

2.2 Hybrid Wavelength assignment algorithm

The connection request requests the scheduler for wavelength assignment. The scheduler determines the wavelength to be assigned for the connection request. The requests are sorted based on the priority of their transmission. The request should not wait for any particular wavelength so priority based round robin algorithm is being combined for the development of the novel wavelength assignment algorithm.

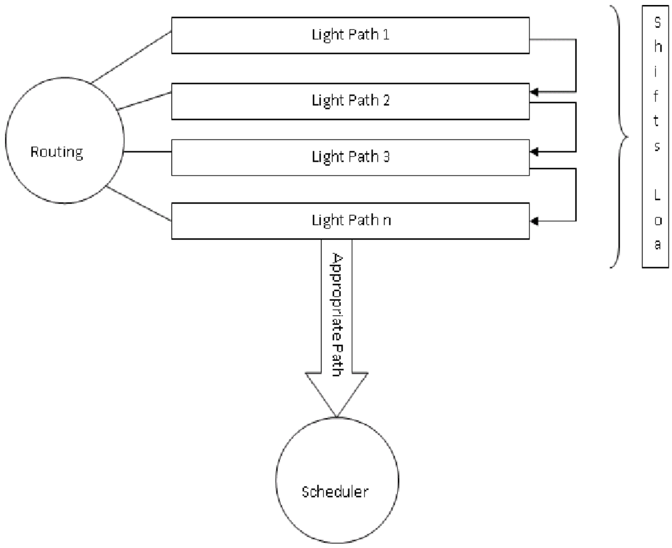

Figure 2: FLVR Algorithm

HYBRID WAVELENGTH ASSIGNMENT ALGORITHM

Consider two registers Average Time (AT) register and Remaining Time (RT) register.

- Average Time (AT) register – It consists of the average time of each cycle of transmission.
- Remaining Time (RT) register – It consists of the remaining time after each cycle gets complete.

Step 1: Each lightpath consists of a set of wavelengths $\lambda_1, \lambda_2, \ldots, \lambda_n$. Each λ has different channel capacity.

Step 2: The connection requests (CR) are queued based on the priority. The time required to transmit each CR is predefined.

Step 3: The λs are sorted based on its channel capacity. Higher the channel capacity; faster the transmission.

Step 4: The average time register AT is assigned its initial value by

$$AT = \frac{CRT\ \max + CRT\ \min}{2}$$

where CRT is the Connection Request Time.

Step 5: The connection requests are assigned to the λs of sorted order. Transmission takes place until the average time is reached.

Step 6: Once all the CRs in the queue has completed one cycle of transmission, the registers are updated.

RT = Total time of each CR - Transmitted time of each CR

Step 7: The connection requests those completed their transmission time are removed from the ready queue. The assigned λ is moved to the free list.

Step 8: Now, the CRs are sorted based on their RT. AT is updated by

$$AT = \frac{CRT\ new\ max + CRT\ newmin}{2}$$

Step 9: Repeat 5,6,7 until the ready queue becomes empty.

4. PERFORMANCE ANALYSIS

In this section, the performance of the proposed methodology is compared using ns-2 simulator by patching Optical WDM network simulator (Owns). A mesh topology with 14-nodes is shown in Figure 3.

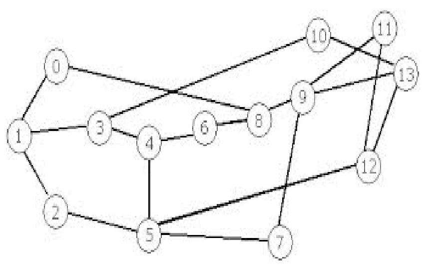

Figure 3: NSF-Net with 14 nodes

The simulation parameters are shown in Table 1. The comparison of end-to-end delay, blocking probability, channel utilization probability and packets received with traffic load is performed to analyze the network. In our initial experiment, we vary the load as 2, 4, 6, 8 … 14MB.

Table 1: Simulation Parameters

Topology	Mesh
Routing Algorithm	FLVR algorithm
Total No. of nodes	14
Link Wavelength Number	8
Link Delay	10 ms
Link utilization sample interval	0.5 ms
Traffic Arrival Rate	0.5Mb
Traffic Holding Time	0.2 ms
Packet Size	500 bytes
No.of Session-traffics	5
Max Requests Number	50
Wavelength Algorithm	HWA

The Variation of blocking probability with traffic load for the proposed FLVR algorithm with respect to the existing static and dynamic routing algorithms is shown in Figure 4. It is noted from the Figure 4 that the blocking probability for FLVR algorithm is less, when compared to the existing algorithms. This improvement is due to the shifting of load from the overloaded path to the least loaded path. When the load is 8 MB, the blocking probability with FLVR algorithm is only 0.34, whereas the blocking probabilities of static and dynamic algorithms, are 0.48 and 0.87 respectively.

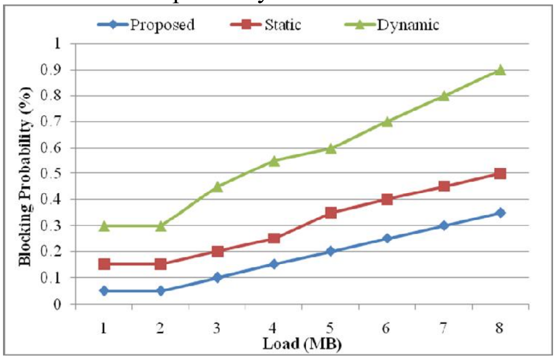

Figure 4 : Variation of blocking probability Vs traffic load

Figure 5 compares the connection drop rate of HWA algorithm with existing Multilevel Feedback Wavelength Assignment (MFWA) algorithm for various traffic loads. When compared with the MFWA, the connection drop rate for the proposed HWA algorithm is less. The connection drop rate is reduced as result of optimized utilization of wavelengths in the proposed HWA algorithm.

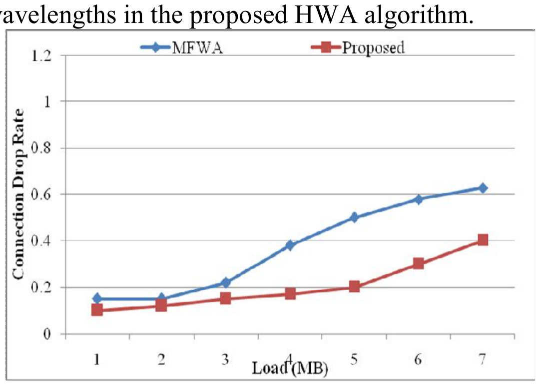

Figure 5 : Variation of Connection drop rate Vs Load

Figure 6 depicts the comparison of average queuing delay of HWA algorithm with MFWA and it is observed from the Figure 6 that the average queuing delay in HWA algorithm is less compared to MFWA algorithm. For example, when the network load is 5 MB, the average queuing delay using proposed HWA algorithm is 0.0028 ms, whereas the average queuing delay is 0.0038 ms using MFWA wavelength assignment algorithm.

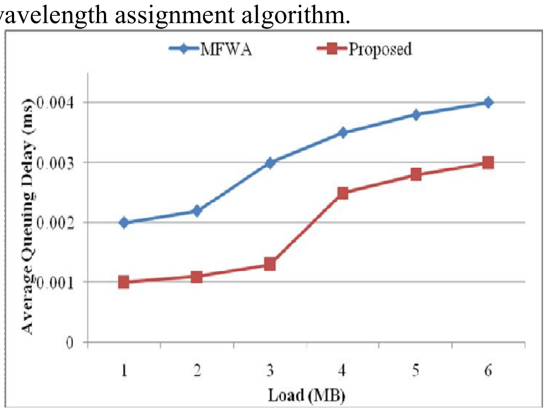

Figure 6: Average queuing delay Vs load

The comparison of the proposed HWA and the existing MFWA for the variation of throughput and load is illustrated in the Figure 7.

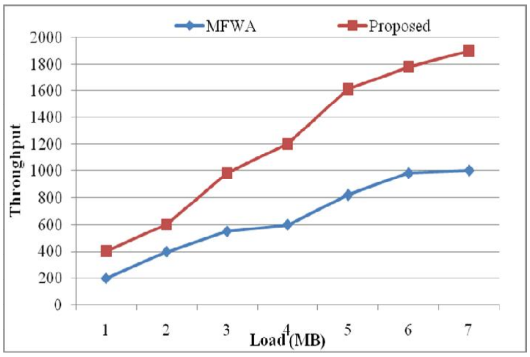

Figure 7: Variation of throughput Vs load

The throughput of HWA is drastically raised even at heavy loads, whereas the throughput of MFWA decreases under higher loads. It is seen that the HWA algorithm achieves uniform wavelength utilization, whereas the existing MFWA achieves unbalanced wavelength utilization than the suggested HWA algorithm.

5. CONCLUSION

The Flexible Load Variance Routing algorithm was developed and the connection requests are routed along the appropriate light paths with minimum blocking probability. The loads of overloaded light paths are shifted to the lightpaths with minimum load. Hence the network performance was improved by drastically reducing the blocking probability of the network. The results were simulated by comparing the traffic of the network with the blocking probability. In order to utilize the wavelength properly a hybrid wavelength assignment algorithm was proposed. As a result the connection drop rate and queuing delay was reduced and the throughput was increased. The results were simulated and compared with the results of multilevel feedback queue wavelength assignment algorithm.

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