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TRAFFIC GROOMING IN WDM NETWORKS

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ABSTRACT

Fiber optic communication technology has brought a revolution since 1970s. This technology has rapidly replaced the copper wires, starting from the core backbone networks then gradually to the metro and now finally towards the access networks. WDM networks present concurrency by multiplexing more than one wavelength and transmit them simultaneously within the same fiber. A lightpath is an optical association, from a source to a destination over a wavelength on each intermediate link. These end to end all-optical circuits tender bandwidths equivalent to the bandwidth provided by single wavelength. Such optical networks are referred to as the wavelength division multiplexing networks We have chosen HEGONS (Heterogeneous Grooming Optical Network Simulator) as the tool for network simulations A Heterogeneous Grooming Optical Network Simulator (HEGON Supporting mixed routing & wavelength assignment algorithms and optional wavelength conversions capability on each node. Disparate many other simulators, the goal in developing. Hegons is NOT to simulate the OSI model layers as they are. These simulators mimic the behavior of say TCP/IP or GMPLS in order to provide a virtual platform for learners, developers and testers. Hegons on the other hand, targets at one thing and only one thing: The evaluation of different dynamic (RWA)Routing and Wavelength Assignment algorithms in WDM optical networks in terms of several measures such as: call jamming probability, Fairness (Variance in blocking probability), call setup time, etc.

Keywords

Modes in optical fibers, Multimode fiber, Wavelength routed WDM networks, Single-mode fibers

1.1 INTRODUCTION

Fiber optic communication technology has brought a revolution since 1970s. This technology has rapidly replaced the copper wires, starting from the core backbone networks then gradually to the metro and now finally towards the access networks. It has been widely deployed both in the developed and the developing countries. The optical communication process basically involves these steps:

- Creation of optical signals involving the use of transmitters like lasers and LEDs (light emitting diodes).
- Transmission of optical signals, through different fiber channels.
- Strengthening of optical signal along longer channels using the devices like optical amplifiers and regenerators.
- Routing or switching of optical signals using devices like optical or electrical switches and cross-connects.
- Splitting or merging of optical signals using multiplexers/de-multiplexers, splitters or couplers.
- Detecting and receiving of optical signals using Optical line terminals, photo-detectors or optical receivers, by converting them in electrical signals (using transponders) [2].

1.2 Optical fibers:

Optical fiber is a communication system in which light is used as a carrier and fiber is used as a medium. The fiber consists of an inner core material and outer cladding material which surrounds the inner core. The core and cladding are designed as, so that the light can go by through the core for a long distance before it become weak (attenuated).Figure 1.1 below shows the inner core and cladding of an optical cable [2].

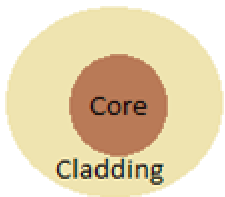

Figure 1.1 the fiber having an inner core and an outer cladding.

1.3 Modes in optical fibers:

Indeed, optical fibers have now penetrated virtually all segments of telecommunication networks [4].

- Multi-mode and
- Single mode, are two types of fibers in use.

Multimode fiber: has core of 50 to 85μm [2] and was developed in the early days. In multimode fiber, the light travels in the form of many rays in the core of the fiber and each ray takes a different path through the fiber with a different angle called mode. So each mode travels with a different speed from each other.

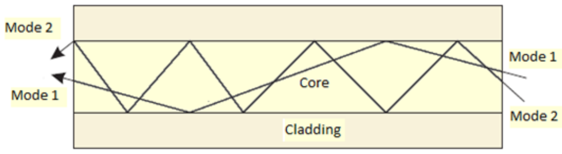

Figure 1.2 A lateral view of an optical multimode fiber.

Single-mode fibers: have small core diameter of about 8 to 10 μm and were developed in 1984 [2]. In single mode fiber, the light can travel only in one ray, that's why it is called single mode. Single mode fiber eliminates intermodal dispersion, increase bit rate and length between amplifiers and regenerator.

Advantages of fiber optic transmissions

- Very high bandwidth for carrying data.
- Very low attenuation (0.2dB/km).
- Light in weight as compared to copper, small in size and diameter which lead to low cost.
- New technologies like quantum cryptography in photonics are proposing more secure and cheaper ways for optical data transmissions.
- It is immune to electromagnetic interference and radio frequency interference, thus providing a greater safety. No cross talk and disturbance [2]

1.4 Wavelength routed WDM networks: A WDM system uses a number of multiplexers at the transmitter end, which multiplexes more than one optical pointer onto a single fiber and de-multiplexers at the receiver to split them apart. Generally the transmitter contains of a laser and modulator. The light source generates an optical carrier signal at either fixed or a tunable wavelength. The receiver contains of photodiode detector which converts an optical signal to electrical signal [3].

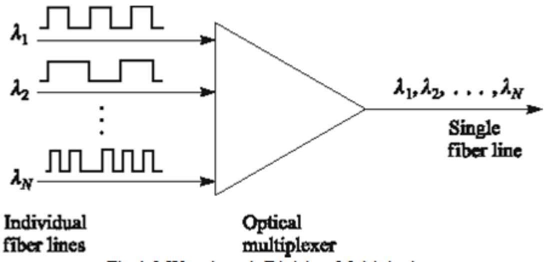

Fig 1.3 Wavelength Division Multiplexing

1.5 Wavelength continuity constraint and wavelength conversion: Wavelength conversion is a process that takes as its input; a data channel modulated on to an optical carrier with a wavelength λin and produces as its output the same data channel modulated onto an optical carrier with a different wavelength λout[2].

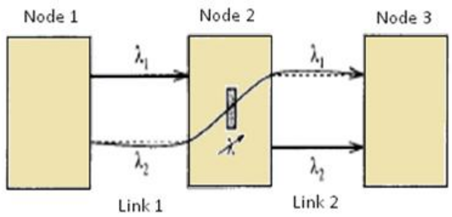

Figure 1.4 A wavelength converter at node 2, converting λ2 to λ1

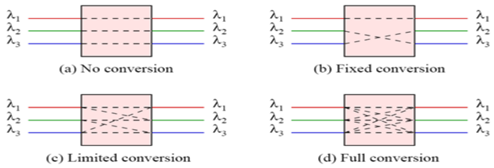

Figure 1.5 Levels of wavelength conversion

1. LITERATURE SURVEY

The research work performed in this area by different researchers is presented as follows:

Farid Farahmand et al. [1] analysed that as high capacity all-optical networks and WDM technologies advance and merge together, aggregating low speed traffic streams onto high-pace wavelengths becomes more critical. Efficient aggregation techniques, known as traffic grooming, permit higher bandwidth utilization and can reduce request blocking probability. These algorithms can also result in lower network cost in terms of electronic switching. The primary focus is on traffic grooming in WDM mesh networks with dynamic traffic patterns. Two new grooming concepts called lightpath dropping and lightpath extension are offered. These concepts are based on an substitute node architecture in which incoming optical signals can be dropped at a node, while optically continuing to the next node. Relayed on these concepts, development of several grooming algorithms and study of them under various network objectives is employed. Also, comparison of their performance with previously proposed lightpath-based grooming algorithms. throughout extensive simulation results it is shown that the proposed approaches lead to lower demand blocking probability and lower average number of logical hops when the number of transceivers per node is limited.

Shahzaan Mohammed et al. [2] analysed wavelength conversion and traffic grooming in WDM networks .Network performance improves obviously by reducing wavelength continuity constraint (using wavelength converters) and by improving the wavelength switching choices (using traffic grooming), thereby reducing the network blocking probabilities and improving network performance. Analysis of the effect of increasing number of wavelength converters and grooming devices over the network performance. Deciding the quantity and location of these devices to be used in a network is equally important. For this, the use of different placement schemes on proposed network model and assumptions is employed. The work has been done through the simulations of different device placement scenarios and the results have been analyzed using blocking probability as the performance metric. The review of the the performance of wavelength converters with different grooming devices is done. The reviews and work, correctly predict the behavior of results as demonstrated by the results of other referred literatures.

Esa Hyytiä et al. [3] projected that with (WDM) wavelength division multiplexing several optical signals can be transferred in a single optical fiber. This technology allows more efficient use of the vast capacity of an optical fiber but also poses new network design and management problems, especially when wavelength conversion is not probable in the nodes. Routing and wavelength assignment problem in such networks is addressed. Once routes are fixed the wavelength assignment is basically a graph coloring problem. Several heuristic schemes for coloring a given graph are studied. Also an iterative algorithm for finding a reasonably good routing and wavelength assignment is represented and tested with fully connected networks.several heuristic methods for colouring a given graph are considered. Also an iterative algorithm for discovery a reasonably good routing and wavelength assignment is represented and tested with fully connected networks.

Vikas Kaushik et. al. [4] Wavelength Division Multiplexed Switching networks are important for the future transport networks. This paper evaluates the performance of various wavelength assignment algorithms and their outcome on the blocking probability of the connection request in the optical network with traffic grooming. The wavelength assignment is a single feature in wavelength routed network that distinguish them from conventional networks. The wavelength assignment algorithms are catalogue as First fit, Random fit, Most used, Least used and wavelength conversion algorithms. Simulation is done for 16 node optical ring network. The experimentation results indicate that the most used algorithms achieves compact network blocking rate with and without Traffic Grooming.

Yvan Pointurier et. al. [5] In all-optical networks with no wavelength changerss, signals are switched optically inside the nodes and therefore propagate over thousands or hundreds of kilometers with no electrical regeneration. Over such distances, physical impairments accumulate and can lead to serious signal degradation, ensuing in poor quality of transmission (QoT) as measured by signal bit-error rates. The task of Routing and Wavelength Assignment (RWA) algorithms is to accommodate incoming calls in optical networks over a route and a wavelength. RWA algorithms chunk calls if a continuous wavelength from source to destination cannot be create (wavelength blocking), or when the QoT of the call is not acceptable (QoT blocking). In this paper, an analytical method to estimate blocking probability in all-optical networks, accounting for several physical layer impairments: inter symbol interference (ISI), amplifier noise (both are static effects that only depend on the network topology only) and node crosstalk (a dynamic outcome that depends on the network status) is presented. Model was successfully validated during simulations on large scale networks with realistic physical layer parameters.

Bijoy Chand Chatterjee et. al. [6] One of the challenging issues in optical networks is call blocking and it increases with the number of connection requests due to the restricted number of wavelength channels in each fiber link. In this paper, a priority based routing and wavelength assignment method with incorporation of a traffic grooming mechanism (PRWATG) to reduce call blocking is proposed. In this scheme, the connection requests having the same source–destination (s–d) pair are groomed first to evade intermediate optical–electrical–optical conversation and then these groomed connection requests are served for routing and wavelength assignment according to their preference. The priority order of each groomed connection request is estimated relayed on type of path (direct link physical path or indirect link physical path) first and then the traffic degree. If the priority order of connection requests is estimated using these criteria, blocking of connection requests due to wavelength stability constraints can be reduced to a great extent, which will in turn lead to better performance of the network in terms of lesser blocking probability and congestion. The performance analysis of this proposed proposal is made in terms of blocking probability and congestion and compared with a similar non-priority based routing and wavelength assignment method (NPRWATG). It is seen that using the PRWATG scheme, the blocking probability and the congestion of the network are considerably reduced compared to NPRWATG. It is also seen that the performance of the projected scheme is better compared to NPRWATG when the number of connection requests increases in the network.

Jun He et. al. [7] the quality of an optical signal degrades due to physical layer impairments as it propagates from a transmitter to a receiver. As a result, the signal value at the receiver of a lightpath may not be sufficiently high, leading to increased call blocking. accordingly, an all optical network's routing and wavelength assignment algorithm must verify the quality of the lightpath prior to accepting it. In this paper, analytical expressions for the total blocking probability are imitative for first-fit wavelength assignment for networks suffering from transmission impairments. The new technique efficiently predicts the performance of wavelength selection techniques that consider either a single candidate channel or all channels for worth of transmission compliance. The analysis is also applicable to first-fit algorithms with different static channel orderings.

K. PotouIn et. al. [8] In a wavelength-routed optical network, the signal remains in the optical domain over the whole route (lightpath) from source to destination node. Thus, while propagating through the network, the signal value may degrade as it encounters physical impairments. In this paper, the establishment of new connections in that a network in the presence of amplifier optical power constraints is studied. In particular, a multi-cost Impairment Aware Online RWA (IA-RWA) algorithm is extended to include amplifier power constraints. The absolute algorithm accounts not only for the channel utilization in the network but also for the amplifiers' possible saturation, which modify as new connections are established or released, in order to calculate the noise variances that communicate to physical impairments on the links. It was found that when these effects are taken into account the two algorithms attain similar performance when the amplifiers operate in the linear region. In the case, however, where the amplifiers are saturated, the absolute algorithm exhibits better performance compared with the previously projected algorithm, in terms of blocking probability and frequency of re-routings required.

Yvan Pointurier et. Al. [9] In all-optical networks with no wavelength converters, signals are switched optically inside the nodes and therefore broadcast over hundreds or thousands of kilo-meters with no electrical regeneration. Over such distances, physical impairments, such as inter-symbol interference (ISI), amplifier noise, and leaks within nodes (cross-talk), accumulate and can guide to serious signal degradation, resulting in poor quality of transmission (QoT) as measured by signal bit-error rates. The role of (RWA) routing and wavelength assignment algorithms is to accommodate incoming calls in optical networks over a way and a wavelength. RWA algorithms block calls if a continuous wavelength from the source to the destination cannot be create (wavelength blocking) or when the QoT of the call is not acceptable (QoT blocking). Evaluating RWA algorithms via simulations is probable but time consuming, and hence analytical methods are needed. Wavelength blocking has been studied rationally in the past, but QoT blocking has never been analytically modelled to our knowledge. In this paper, an analytical method to estimate blocking probability in all-optical networks, accounting for physical layer impairments is presented. The physical layer model includes ISI and noise, two static effects that only depend on the network topology, and also cross-talk, which relayed on the network state. Simulations on three different topologies with various numbers of channels, demonstrating small- to large-scale networks, show that this technique is suitable for quick and accurate dimensioning of all-optical networks: the precision of the blocking rates computed with the analytical method, taking only seconds or minutes to run, is the alike as that of simulations, which take hours to run.

2. PROPOSED WORK

2.1 Problem Formulation

Since the data rate increases at rapid rate so in order to meet the efficient utilization of the fibre capability WDM(wavelength division multiplexing) network came into scenario to meet the demand of high bit rate. WDM enables the proficient utilization of optical fibre by dividing its tremendous bandwidth into a set of disjoint wavelength bands, which are referred as wavelengths.The major problems of heterogeneous WDM networks include:

(I) determining the virtual topology that consists of all nodes based on lightpath assignments;
(2) Routing the connection requests across the networks based on current network states, such as available bandwidth of a lightpath;
(3) Implementing different grooming policies and rules.

2.2 Proposed Work

In our proposed work we focused on a comparative analysis of optical mesh networks consisting of 8, 12 and 16 nodes and analyzed their performance in terms of blocking probability with the help of various algorithms, for all these mesh networks wavelength is seven and traffic is varied from 0-9. We have used the sparse wavelength technique for the assignment of wavelength in mesh network. Blocking probability is an important estimation of performance in all these networks. In order to minimize the blocking probability, RWA algorithm should be selected carefully, because these algorithms not only give the information about the availability of the path between source and destination but also give information about the location and numbers of the converters

3. RESULTS AND ANALYSIS

3.1 Simulation Environment: The parameters used for simulation are fixed wavelength and variable traffic. The mesh topologies with 8, 12 and 16 nodes are used on these three mesh networks. We have fixed the wavelength as 7 and traffic load varies from 0 to 9. Both the matrix link capacities and arrival rate matrix are dependent upon the numbers of nodes for eight nodes its [8][8] and for twelve nodes its [12][12] similarly for sixteen nodes its [16][16]. Here the total traffic blocked, average blocking probability, overall blocking probability and average of average blocking probability of algorithms such as first fit, random fit, most used, least used has been analyzed for these three scenario.

Table 3.1 Probability distribution for different algorithms for 8 nodes mesh network

Algorithm	Total blocked	Average blocking probability	Overall blocking probability	Averge of average blocking probability
First fit	5	0.00031482	3.17E-04	8.84E-05
Random Fit	3	1.89E-04	1.90E-04	5.28E-05
Most used	4	0.000253713	0.000254	1.62E-04

Performance for the eight nodes mesh network in terms of blocking performance shown from figure 3.1 to 3.4

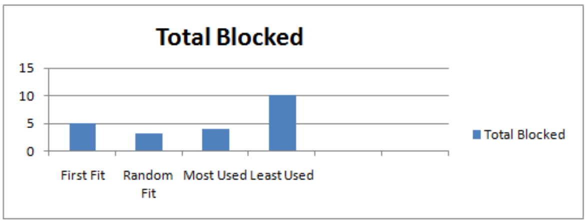

Figure 3.1 Total blocked

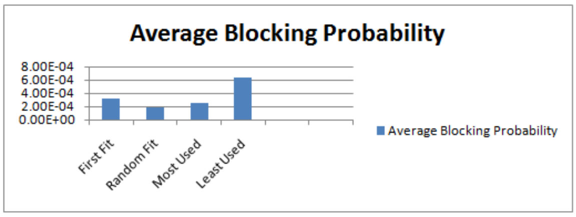

Figure 3.2 Avg. Blocking Probability

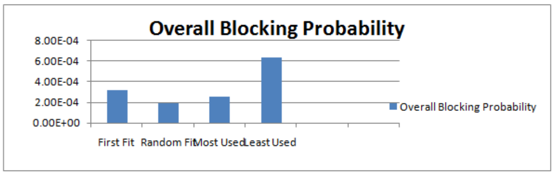

Figure 3.3 Overall Blocking Probability

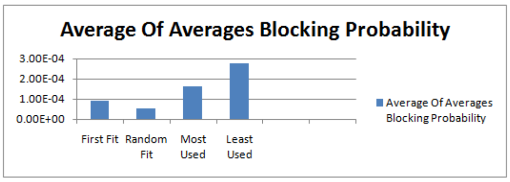

Figure 3.4 Avg. of Avg. Blocking Probability

Performance for 12 node mesh network for the fixed wavelength and varying traffic .

Table 3.2 Probability distribution for different algorithms for 12 node mesh network

Algorithm	Total blocked	Average blocking probability	Overall blocking probability	Averge of average blocking probability
First fit	23	5.97E-04	5.96E-04	1.75E-04
Random Fit	27	7.01E-04	7.00E-04	2.63E-04
Most used	17	0.000440954	0.00044	1.63E-04
Least Used	36	9.33E-04	9.32E-04	3.56E-04

Performance for 12 nodes mesh network shown below form figure3.5 to figure 3.8

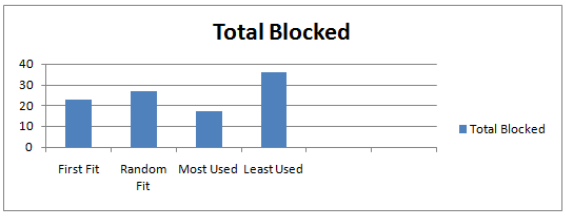

Figure 3.5 Total blocked

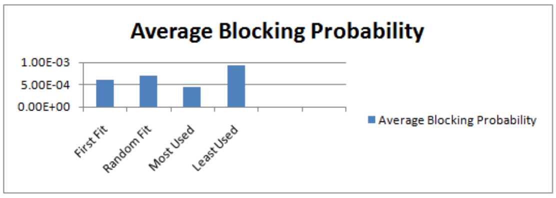

Figure 3.6 Avg. Blocking Probability

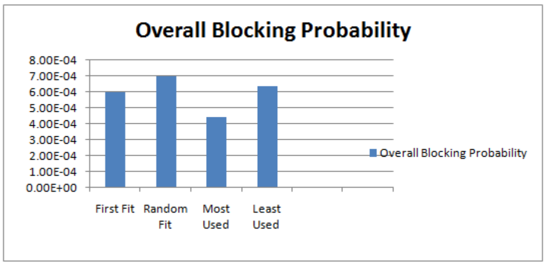

Figure 3.7 Overall Blocking Probability

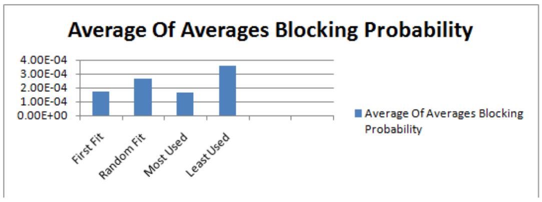

Figure 3.8 Avg of Avg. Blocking Probability

Table 5.3 Probability distribution for sixteen nodes mesh network.

Algorithms	Total blocked	Average blocking probability	Overall blocking probability	Averge of average blocking probability
First Fit	10	0.000102198	0.000102198	3.44E-05
Random Fit	8	8.17E-05	8.17E-05	2.89E-05
Most used	11	0.000112414	0.000112416	3.78E-05
Least used	5	5.11E-05	5.11E-05	1.68E-05

The blocking performance for different algorithms is shown from figure 3.9 to figure 3.12.

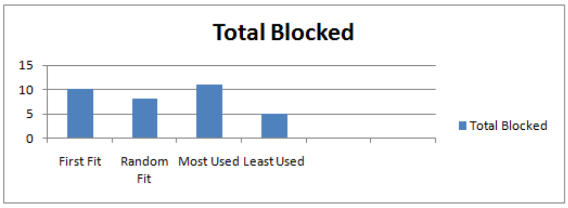

Figure 3.9 Total blocked

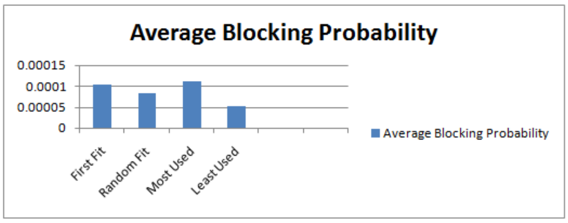

Figure 3.10 Avg. Blocking Probability

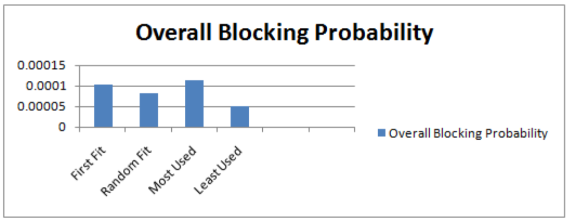

Figure 3.11 in general Blocking Probability

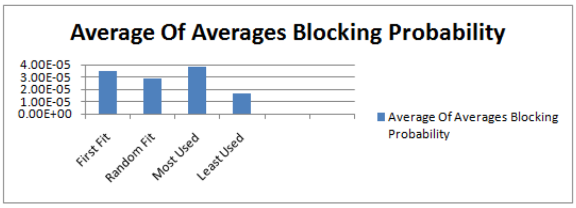

Figure 3.12 Avg. of Avg Blocking Probability

CONCLUSION AND FUTURE SCOPE

Wavelength conversion and traffic grooming have been between the most researched areas and technologies of substance in optical networking. Network performance improves considerably by relaxing the wavelength continuity constraint using wavelength converters and by advancing the wavelength utilization using traffic grooming. A simulating technique for comparative analysis of First-fit, Random, Most-used and Least-used algorithms for three optical mesh network having eight nodes , twelve nodes and sixteen nodes is presented. The simulation is carried out to obtain the probability of blocking (bp) for all algorithms and results has been analyzed. As the number of nodes increased in the network arrival rate also increased and blocking rate depends upon the assignment of wavelength and traffic adjustment. The paper employs the use of hegons simulator for analyzing blocking probabilities with fixed wavelength and varying data traffic. Simulation results are obtained for probability of blocking (bp), total blocked probability (tbp), overall blocking probability (obp), avg. blocking probability (abp) and avg. of avg. blocking probability (aabp) for each of these algorithms. The Random fit algorithm performed better for eight nodes optical mesh network ,most used algorithm performed better in twelve nodes mesh and least used performed better for sixteen nodes mesh network and without the requirement of wavelength convertors. Many research efforts have been stanch to the RWA and WA problems. However, there are still many open problems. In this section, we give a few directions for the future work.

The wavelength assignment schemes can be modified to increase the capacity of optical networks and can be proposed for fault tolerance and recovery in WDM optical networks for better performance.
Different routing protocols can be enhanced by using different wavelength assignment schemes can be used.
Working can be done on wavelength colouring problem in WDM networks.
Work can be extended for traffic grooming and colouring.
Here, we work on different algorithms where number of wavelength used in network is fixed; we can extend the work for varying wavelength.

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