Satinder Kaur al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 1, Issue 2, Sept 2014, pp. 31-36

Design & Implementation of Optical Routing with Effect on Performance Parameters

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***Abstract*— According to a rapid development of bandwidth capacity of the WDM network, traffic loss due to a failure of the network components is becoming intolerable. So, this thesis proposes an efficient routing and Bandwidth Utilization in wavelength-division-multiplexed passive optical network (WDM-PON) subject to requirements of fairness, efficiency, and cost. As networks grow in size and complexity, the amount of deception caused by a network-related outage becomes more and more significant. Several methods exist to ensure that networks can continue to provide reliable service even in the presence of faults. This paper proposes efficient routings and their effect on performance parameters in passive optical networks. The performance parameters include channel efficiency, attenuation, BER etc. The various routing algorithms are implemented on a graph network.The graph analysis is also shown between various parameters. The simulated work has been done with the help of MATLAB tool.**

***Keywords*— Passive Optical Networks, WDM-PON, routing in networks, traversing, shortest path**.

I. INTRODUCTION

An optical network connects computers (or any other device which can produce or store data in electronic form) using optical fibers. According to the physical technology working, one can classify three generations of networks, Networks built before the emergence of optical fiber technology are the first generation networks (i.e. networks based on copper wire or radio). The second generation networks employ fibers in traditional architectures. The selection of fiber is due to its large bandwidth, low error rate, reliability, accessibility, and maintainability. Although some performance improvements can be achieved by employing fibers, the performance for this generation is limited by the maximum speed of electronics (a few gigabits per second) employed in switches and end-nodes. This phenomenon is called an electronics bottleneck. In order to fulfil increasing bandwidth requirements of emerging applications, totally new approaches are active to exploit vast bandwidth (approximately 30THz in the low loss region of single mode fiber in the neighbourhood of 1500nm) available in fibers. Therefore, the third generation networks are designed as all-optical to avoid the electronics bottleneck[1].

WDM networks can also provide data transparency in which the network may accept data at any bit rate and any protocol format within limits. Data transparency may be understood through all-optical (single-hop) transmission and swapping of signals. In an all-optical network, data is transferred from source to destination in optical form without undergoing any optical to electrical conversion. Keeping the signal in optical form eliminates the "electronic bottleneck" of communications networks with electronic switching. Today, telecommunication networks are at the heart of the information society, allowing billions of people to stay in touch with each other in every part of the world, exchanging data at ever growing speeds. Over the last ten years, the amount of traffic carried by the Internet has been growing at a rate of approximately 70 to 150% per year. The growth can be expected to continue at this rate till at least the end of this decade [2].

Users of telecommunication access networks are today showing interest for the latest high-bandwidth demanding Internet applications and services such as on-line gaming, video telephony, video-on-demand, high-definition TV and peer-to-peer applications. Furthermore, many households have multiple personal computers connected to Internet all requiring a piece of bandwidth. The fast expansion of broadband telecommunication services is not only pushing the traditional copper-based access networks to the limits but requires an upgrade of access infrastructure. Fiber-To-The-Home/Building (FTTH/B) point-to-multipoint (P2MP) optical access networking is one of the most promising technological concepts that could meet this challenge, as it is evident that Digital Subscriber Line (DSL) technology is close to the end of its life cycle [4]. Deployment of FTTH/B access networks has already started in many countries [3].

In all-optical networks, there might be different types of wavelength continuity constraints. First, the network might lack wavelength conversion capabilities altogether.In this case, a light path must occupy the same wavelength on all the links it travelsacross. Second, the network might have full conversion capability at all of its nodes.In this case, the wavelength assignment will not have a material effect on the network and the problem boils down to routing. Alternatively, the network might havewavelength conversion capabilities on only a portion of its nodes.The problem of providing routes to the light-path requests and to assign a wavelength on each of the links along it is generally known as the routing and wavelengthassignment [4].

The paper is organized as follows. In section II, we discuss related work with the wavelength allocation scheme. In

Section III, It describes network topologies. In Section IV,it describesthe system architecture and analyse the different parameters of proposed system. The section V contains proposed results. Finally, conclusion is given in Section VI.

II. RELATED WORK

In literature, several proposed design and management subjects in routing a mixture of OC-192 and OC-768 streams in wavelength-routed optical networks. They assume that fiber links in network are heterogeneous with respect to their transmission capability (i.e., links are designed to handle a given extreme bit-rate imposed by regenerator spacing). They investigate the issues of routing connection demands of various bit-rate requirements in such heterogeneous networks. In this environment, we introduce routing of multi rate traffic problem. The RMT problem is informally defined as process of finding best routing which maximizes the total bandwidth carried in network, for a set of sessions, within a given TDM equipment budget. They proposed a two-phase optimization scheme [5].

Authors proposed that next generation multimedia applications such as video conferencing and HDTV have raised tremendous challenges on network design, both in bandwidth and service. As wavelength-division-multiplexing (WDM) networks have emerged as a promising candidate for future networks with huge bandwidth, supporting efficient multicast in WDM networks becomes eminent. Different from IP layer, the cost of multicast at WDM layer involves not only bandwidth cost, but also wavelength conversion cost and light splitting cost. It is well known that optimal multicast problem in WDM networks is NP-hard [7].

Another proposed the connection-assignment problem for a time-division-multiplexed (TDM) wavelength-routed (WR) optical wavelength-division-multiplexing (WDM) network. In a conventional network, an entire wavelength is assigned to a given connection (or session). This can lead to lesser channel utilization when individual sessions do not need entire channel bandwidth. This paper reflects a TDM-based approach to reduce this inefficiency, where several connections are multiplexed onto each wavelength channel. The resultant network is a TDM-based network where wavelength bandwidth is partitioned into fixed-length time slots organized as a fixed-length frame. Provisioning a link in such a network involves determining a time-slot assignment, in addition to route and wavelength [6].

Some proposed that One of challenging issues in optical networks is call blocking and it increases with number of connection requests due to limited number of wavelength channels in each fiber link. In this paper, they propose a priority based routing and wavelength assignment scheme with incorporation of a traffic grooming mechanism to reduce call blocking. In this scheme, connection requests having the same source–destination pair are groomed first to avoid intermediate optical–electrical–optical conversation and then these groomed connection requests are served for routing and wavelength assignment according to their precedence order. The priority order of each groomed connection request is estimated based on type of path first and then traffic volume. If priority order of connection requests is estimated using these standards, blocking of connection requests due to wavelength continuity constraints can be reduced to a great extent, which will in turn lead to improved performance of the network in terms of lower blocking probability and congestion [9].

III. NETWORK TOPOLOGIES

The topology of the network defines how nodes of the network communicate with one another over physical media. Each is used in exact network types. There are five major topologies in use today: Bus, Star, Ring, Tree, and Mesh. Each topology has its own strengths and weaknesses.

1. With Bus topology, all workstations is connected directly to the main backbone that carries data. Traffic generated by any computer will travel across backbone and be received by all workstations. However biggest disadvantage is that the entire network shuts down if there is a break in the main cable and it is difficult to identify the problem in such an event.

2. The Star or Hub topology is one of most common network topologies found in most offices and home networks. It has become very widespread in contrast to the bus type, because of cost and comfort of troubleshooting. A star topology consists of a point-to-point connection to a central connection, generally a hub or a Switch. The disadvantage of using this topology is that because each computer is connected to a central hub or switch, if this device fails, whole network fails.

3. In a ring network, every device has exactly two neighbours for communication purposes. All messages travel through a ring in same direction (effectively either clockwise or counter clockwise. The ring topology has many of same problems as the bus topology, in that it can be difficult to troubleshoot and a single break can disable the whole network. Rings are found in some office buildings or school campuses and in MANs.

4. A tree topology combines characteristics of linear bus and star topologies. It contains of groups of star-configured workstations connected to a linear bus backbone cable. Tree topologies allow for expansion of an existing network. Its main drawback is that if the backbone line breaks, the entire segment goes down. A Passive Optical Network (PON) is the best example of a network with a tree topology. Trees can also be multi hop if splitting nodes process the signal.

5. Mesh topologies involve the concept of routes. Unlike each of preceding topologies, messages sent on a mesh network can take any of several possible paths from source to destination. This provides a great improvement in performance and reliability, however complexity and exertion of implementation increases geometrically as the number of nodes on the network increases. For example, a three or four node mesh net is relatively easy to realize, whereas it is impractical to set up a full mesh network of 100 nodes. The number of interconnections would be so high and expensive that it is not practical. Mesh networks are not used much in LANs but are used in Wide Area Networks (WANs) where reliability is important and the number of sites being connected together is fairly small. A mesh may also be logically configured to be a concatenation of rings. The past decade has witnessed significant developments in the area of optical networking.

Such advanced technologies as wavelength-division multiplexing (WDM), optical amplification, optical path routing (using wavelength converting, optical cross-connect), wavelength add-drop multiplexer (OADM), and high-speed switching have found their way into the wide-area network (WAN), resulting in a substantial increase of the telecommunications backbone capacity and greatly improved reliability At same time, enterpriseNetworks nearly universally converged on 100-Mbps or 1000-Mbps Fast Ethernet architecture.

IV. SYSTEM ARCHITECTURE AND PARAMETERS

A. *System Architecture*

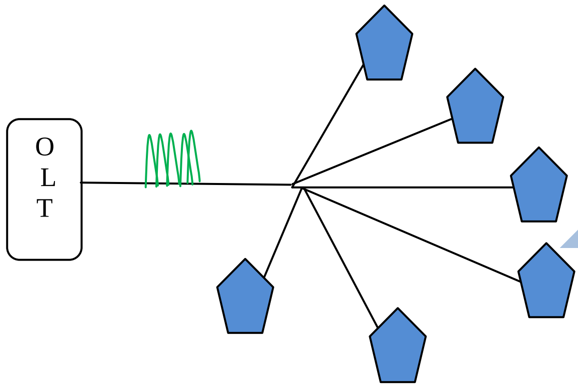

Figure 1: Proposed System Architecture

The PON is a technology viewed by many as an attractive solution to the first-mile problem. A PON reduces number of optical transceivers, central office terminations, and fiber placement. A PON is a point-to-multipoint (P2MP) optical network with no active elements in the signal's path from source to destination. The only inner elements used in a PON are passive optical components, such as fiber, joints, and splitters.

An access network based on a single fiber PON only requires N+1 transceivers and L km of fiber Fig. 1. In a PON, transmissions are performed between an Optical Line Terminal (OLT) and Optical Network Units (ONUs). The OLT resides in the CO and connects the optical access network to the metropolitan area network (MAN) or wide area network (WAN), also known as backbone or long-haul network. The ONU is situated either at end-user location (FTTH and FTTB) or at the curb, resulting in a fiber-to-the-curb (FTTC) architecture. Developments in PON in recent years include Ethernet PON (EPON), ATM-PON (APON, based on ATM), Broadband-PON (BPON, based on APON adding support for WDM and higher bandwidth), Gigabit-PON (GPON, an evolution of BPON supporting higher rates and multiple layer-2 protocols) and wavelength division multiplexing PON (WDM-PON).

Measuring bandwidth utilization can give administrators pertinent information as to how network resources are used. Without comprehensive insight into traffic flow type and bandwidth utilization, it is not possible to guarantee proper spreading of bandwidth between applications. For occasion, business-critical applications might not receive sufficient bandwidth, while applications like video running and torrent downloading can take over bandwidth. By checking bandwidth utilization, it is probable to determine the no. of users, applications and hosts taking up critical bandwidth, as well as in classifying access of unofficial applications.

B. *Proposed Parameters*

The bandwidth utilization is the percentage of bandwidth utilized off the total bandwidth available. Let B be the total bandwidth of channel and N be the total no. of nodes present, then bandwidth of each subcarrier is given by (1):

$$B.W(Subcarrier) = \frac{B}{N} \quad (1)$$

Symbol rate (also known as baud or modulation rate) is the number of symbol changes (waveform changes or signalling events) made to the transmission medium per second. In the case of a line code, the symbol rate is the pulse rate in pulses/second. It is represented as Ts in (2):

$$Ts = \frac{N}{B} \quad (2)$$

The optical signal-to-noise ratio (OSNR) is the key performance parameter in optical networks that predicts the bit error rate (BER) of the system. The OSNR is obtained by measuring the total signal power in the channel pass band and the noise power (ASE noise) in the gaps between the optical channels. It is defined as the ratio of signal power to the noise power. It is given by (3):

$$SNR = \frac{Psignal}{Pnoise} \quad (3)$$

If d is no. of dead nodes and L is the no. of inactive nodes then coverage efficiency is given by (4):

$$Efficiency = \frac{(N-d-L)}{N-d} \quad (4)$$

C. *Proposed Algorithm*

1. *Interface Graphic User Interface with MATLAB.*
2. *Set input parameters to desired value.*
3. *(For traversing the graph)*
   a) *Set the weights between nodes.*
   b) *Create a sparse matrix.*
   c) *Traverse the graph by BFS technique*
4. *(For fixed Routing)*
   a) *Set the weights between nodes.*
   b) *Create a sparse matrix using these weights.*
   c) *Find shortest path between these nodes.*
5. *(For greedy routing)*
   a) *Enter total no. of nodes.*
   b) *Enter the weight between these nodes.*
   c) *Enter source and destination node.*
   d) *Find the total cost between source and destination node.*
6. *(For warshall Routing)*
   a) *Enter the adjacent matrix.*
   b) *Find the path matrix and then calculated total distance matrix.*
7. *After routings, estimate performance parameters like signal to noise ratio, path loss, and channel load, blocking probability, bit error rate and delay.*

8. *Find the relation between blocking probability and intensity, load and wavelength and BER-Noise etc.*
9. *Calculate effect of wavelength and bandwidth on various parameters.*

V. RESULTS

A. *Simulation Environment*

MATLAB has developed over a period of years from many users. In university environments, it is regular instructional tool for preliminary and advanced courses in mathematics, engineering, and science. In industry, MATLAB is tool of choice for high productivity research, development, and analysis. MATLAB features a family of add-on application precise solutions called toolboxes. Very important to most users of MATLAB, toolboxes permit you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) those gatherings of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems.

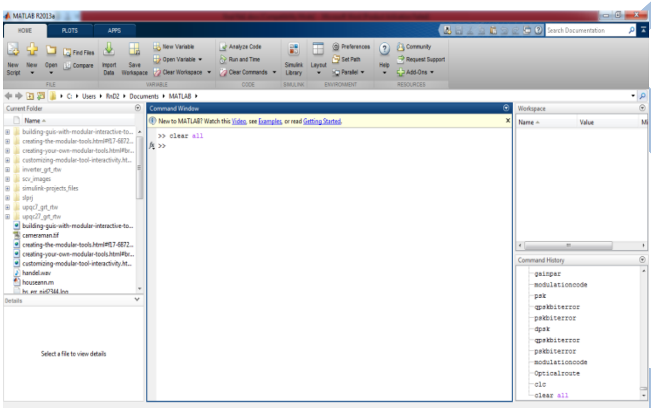

Figure 2: MATLAB Tool

Figure 3: Proposed Graphical User Interface

Fig 3 shows input parameters, output parameters, routing in networks and graphical results. Click on buttons provided to see the results. The proposed GUI is shown in figure 3. It contains various routing techniques and performance parameters and their effect on network.

B. Input Optical Parameters

Table 1 show the various input parameters used by this proposed network. We can alter these values depends upon performance of network.

Table 1:Input Optical Parameters

Input Parameters	Value
Total Bandwidth	100 MHz
Wavelength	100 µm
Total Nodes	6
Dead nodes	1
Inactive Nodes	1
Transmit Power	120 dB
Attenuation	0.1 dB
Energy	100 DB
Noise Power	10 DB
No. of links	6
Mean Service Rate	8 DB
No. of Servers	6
No. of Signals	5
Expected Blockage	1

C.Graph Traversing

The most important graph problem is to traverse every edge and vertex in a graph in a systematic way. BFS visits sibling nodes before visiting child nodes. Frequently a queue is used in search process. It's usually used to find shortest path from a node to another. Breadth-first search explores nodes of a graph in increasing distance away from some initial vertex.

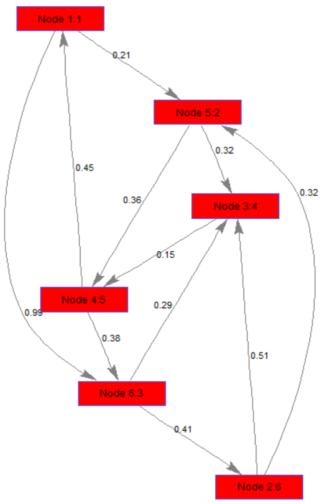

Figure 4: Graph Traversing by BFS

D. *Routing and Shortest Path Selection*

In proposed architecture, for a given concentrator node, al1 the node disjoint paths from the source to the predecessor nodes and al1 the node disjoint paths from the successor nodes to the destination cm be defined very easily. Besides this, it inherently allows a number of alternative routes for communication and its survival route graph has a very mal1 diameter, the upper limit of the number of routes to be traversed in any communication between two fault-free nodes, to avoid signal attenuation and network blocking. In this scheme, al1 the paths for every source-destination pair

are constant length paths which reduces the signal dynamics at the receiver and simplifies the receiver implementation
In order to achieve maximum efficiencies, one would need to bundle traffic onto wavelengths so that the number of wavelengths that have to be processed at each router is minimized. Dijkstra's algorithm is applied to automatically find directions between physical locations, such as driving directions on websites like Maps. In a networking or telecommunication applications, Dijkstra's algorithm has been used for solving min-delay path problem (which is the shortest path problem). For example in data network routing, the goal is to find path for data packets to go through a switching network with negligible delay.

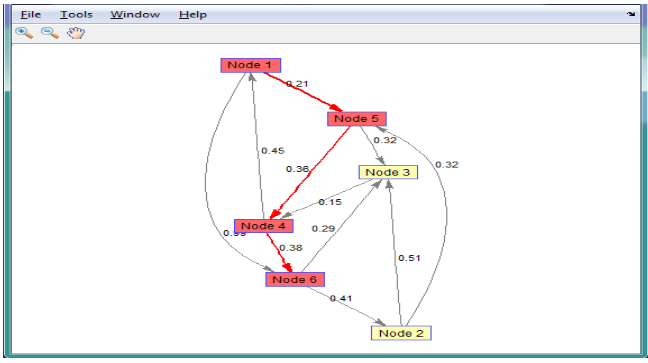

Figure 5: Shortest Route Output

```
Please enter the number of nodes less than 26 = 3
Enter Weight between [A][A] = 0
Enter Weight between [A][B] = 1
Enter Weight between [A][C] = 2
Enter Weight between [B][A] = 3
Enter Weight between [B][B] = 0
Enter Weight between [B][C] = 1
Enter Weight between [C][A] = 2
Enter Weight between [C][B] = 3
Enter Weight between [C][C] = 0
Please enter the source node = 1
Please enter the destination node = 3
```

Figure 6: Parameters Value in Greedy Routing

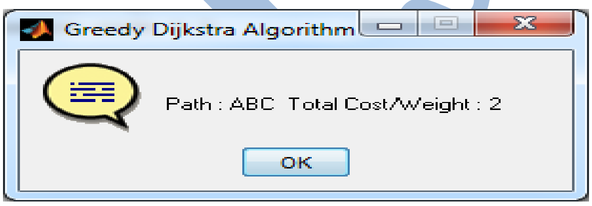

Figure 7: Output Cost by Greedy Routing

E. Estimation of Blocking Probability

To calculate blocking probability of network, it can form the probability of successful message transmission as the ratio of expected number of message entering the network to the expected number of messages arriving at sink. Click on blocking probability button to get the output as shown in figure 8.

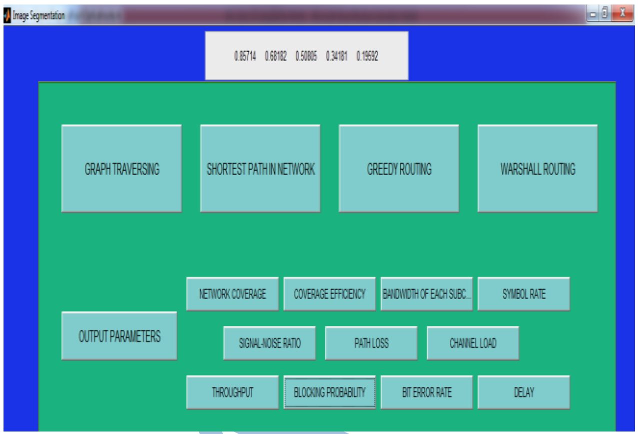

Figure 8: Blocking Probability of 5 Input Signals

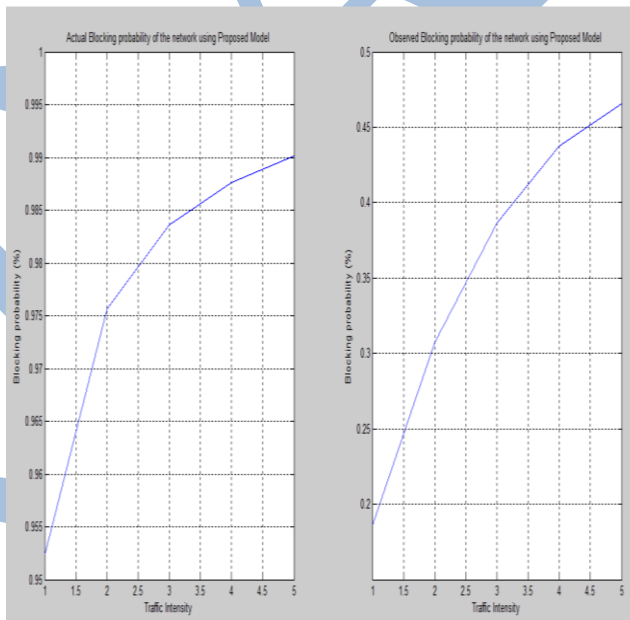

Figure 9: Blocking Probability-Traffic Intensity Relation

It provides a relation between blocking probability with traffic intensity. As no. of servers increase, blocking probability started decreases and vice versa. Blocking Probability represents in terms of percentage (%). It is represented in terms of Erlangs. First graph shows the actual relation while second shows the observed relation between them.

F. Effect on Parameters

Table 2 & 3 shows the variation of parameters with change in input values. Table 2 describes the effect of servers on blocking probability. It shows that with increase in no. of servers having same no. of signals, B.P increases and vice versa. In table 3, it shows the effect of bandwidth on output parameters.

Table 2: Effect of Servers on Output Parameters

Parameters	$m = 7$	$m = 8$	$m = 9$
Blocking Probability	*0.79*	*0.88*	*0.9*

Table 3: Effect of Bandwidth on Output Parameters

Parameters	$BW = 100$	$BW = 200$	$BW = 300$	$BW = 400$
Subcarrier B.W	*16.6*	*33.3*	*50*	*66.6*
Symbol Rate	*0.06*	*0.03*	*0.02*	*0.015*

VI. CONCLUSION

This paper investigated the routing and bandwidth utilization problem in WDM networks. It assigns bandwidth in rectangles trying to minimize the delay and blocking probability of each reservation. It is proved that the results for the transmission through the two hop networks are successful with reduced BER. The bandwidth of the system can be increased by increasing the capacity of the system. The capacity of the system can be increased by increasing the number of users without disturbing the working of another user. We know that blocking probability increases with increase in no. of servers with fixed no. of signals. Initially, the blocking probability is 0.79 having 7 no. of servers, then, it started increasing. The graph of blocking probability with traffic is also calculated. The effect of bandwidth on various parameters is also numerically studied.

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