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Design and Implementation of Routing with Quality of Reliability

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Abstract: The next generation multimedia applications such as video conferencing and HDTV have upraised tremendous issues on the network design, both in bandwidth and service. According to a rapid growth of the bandwidth capacity of the WDM network, traffic loss due to a failure of the network components is becoming unacceptable. 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. It proposes a multi-objective network design problem for the traffic grooming and routing in WDM networks. A dynamic subcarrier assignment algorithm that respects quality of service by offering reduced average delay is proposed. Moreover, effective ways to improve its performance and reduce its complexity are provided. In this work, it is concentrated on the effects of bandwidth, delay and bit rate. This work discusses the improvement in blocking probably for incoming requests while performing routing by proposed algorithm and the traditional shortest path algorithm.

Keywords: Efficient Routing, Routing in Networks, shortest path, Blocking Probability.

I. INTRODUCTION

Today's communication networks, most notably the Internet, have experienced unprecedented technical change over the last years and gained on economic and societal importance. In a matter of very few years it has had a major impact in the way people communicate or do business. The popularity of the Internet has dramatically changed its original purpose, which was the provisioning of simple data transfers between universities. The multitude of sophisticated novel technologies such as real-time, near-real-time transactions, video in all its flavours and broadband data traffic has led to a disproportionate demand of bandwidth. Unlike most access networks, provider backbones (e.g. MANs, WANs) mostly run on fiber and have been upgraded consistently in terms of capacity. This is why they never severely lacked bandwidth. On the contrary, the majority of today's access networks still rely on aging twisted-pair copper infrastructures which are not optimized for packetized data traffic. As a consequence, bandwidths for broadband access technologies were increased only marginally over the last few years. Foreseeing the rapidly growing demand for multimedia services and the trend of service convergence, Wavelength-Division Multiplexing (WDM) is emerging as the most reasonable and cost effective technique to harness the theoretical bandwidth of fibers [1].

In order to meet the exploding bandwidth requirements of existing and emerging communications applications, all-networks have been gaining momentum. These networks have a tremendous bandwidth of around 50 terabits per second. However, the demand for point to point communication per application is not typically as much. Therefore, to better utilize the capabilities of all-optical networks, the bandwidth of an optical fiber is divided into multiple communication channels. Each channel corresponds to a unique wavelength. In other words, these networks employ wavelength division multiplexing [2].

The users of an optical network demand that data be sent from a source point to a destination point. These demands must be routed in most efficient way over the network. First of all, the router needs to find uncongested paths between the source and destination. Furthermore, in all optical networks router must assign a wavelength for the data while it is traveling in a link. This all-optical path, consisting of both the routing and the wavelength assignments on the route, is generally known as alight-path. The light-path is reserved for a point to point demand until it is terminated. At the termination, all the corresponding wavelengths become available on the light-path [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 travels across. 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 have wavelength 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 wavelength assignment (RWA) problem. The routing problem has been extensively researched. Several methods have been proposed to solve the RWA problem. These methods differ in their assumptions about the traffic pattern, availability of wavelength converters, and their objective functions [4].

The paper is organized as follows. In section II, we discuss related work with the wavelength allocation scheme. In Section III, It describes different approaches to implement WDM networks. In Section IV, it describes the system architecture and components of system. Section V explains the design and implementation techniques of system. In section VI, it contains the all results of the system. Finally, conclusion is given in Section VII.

II. RELATED WORK

In literature, several proposed design and management issues in routing a mixture of OC-192 and OC-768 streams in wavelength-routed optical networks. They assume that fiber links in the network are heterogeneous with respect to their transmission capability (i.e., links are designed to handle a given maximum 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 the process of finding the 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 the next generation multimedia applications such as video conferencing and HDTV have raised tremendous challenges on the 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 the 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 the 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 the challenging issues in optical networks is call blocking and it increases with the number of connection requests due to the 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 the 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. DIFFERENT APPROACHES TO IMPLEMENT WDM NETWORKS

In WDM networks, links on the same light path must use the same wavelength, otherwise wavelength converters are required to convert signals from one wavelength to another. The use of wavelength conversion has a profound impact on the cost of multicast in WDM networks. The different approaches are:

- **Single-Hop Systems**

In a single-hop system, a message is transmitted from a source node to a destination node in one hop without being routed through different end-nodes of the network and is communicated in the optical medium al1 dong the way. Since it is infeasible to have separate transmitters and receivers for different wavelengths at dl nodes, it generally requires tunable transmitters and/or tunable receivers to provide correction on demand [12]. There are two major problems to design a good single-hop network: tuning time of transceiver and lack of efficient mechanism to establish dynamic coordination between a pair of nodes that are wishing to communicate so that at least one of the transmitters of the source node and one of the receivers of the destination node are tuned to the same wavelength to confirm transmission. Many multiple access schemes are proposed, however either they cannot satisfy the efficiency requirements, or they solely depend on rapidly tunable transceivers. However, the scalability of this network is limited to the number of supported wavelengths as it does not support reuse of wavelengths.

- **Multi-Hop Networks**

In a multi-hop system, the message from a source to a destination may have to hop through zero or more intermediate nodes. In this system, the wavelength to which a node's receiver and transmitter will be tuned generally does not change and the tuning time is not as important as in the case of a single-hop system. An important property of the multi-hop scheme is the relative independence between the logical topology and the physical topology [14]. In order to have an efficient system, the logical topology should be chosen such that either the average hop distance or the average packet delay or the maximum flow on any link must be minimal. Multi-hop systems can be of two types: irregular and regular. In an irregular multi-hop system, it is easy to address the optimal problem and it cm be optimized for arbitrary loads, but the problem is its routing complexity as it does not have regular structured node connectivity pattern. On the other hand, in regular multi-hop system, routing strategy is very simple due to its regular structured connectivity but the problem is to achieve optimal condition and generally it can be optimized for uniform loads due to its regular structure. Regular multi-hop system has received more attention because of its simple routing [10].

- Wavelength Routed Networks

Wavelength routed networks have been most commonly used in WDM networks and it is considered to be the potential candidate for the next generation of wide-area network. It is composed of some form of wavelength-selective elements at the nodes of the network. Such node makes its routing decision based on the input port and the wavelength of the signal passing through it [8]. Wavelength routing is achieved by de-multiplexing the different wavelengths from each input port and then multiplexing signals at each output port. Sometimes switches are used between de-multiplexers and multiplexers. Since another light path can reuse the same wavelength in some other part of the network, at the same time, N inputs can be interconnected to N outputs by using only N wavelengths instead of N x N wavelengths as expected in broadcast-and-select network.

IV. SYSTEM ARCHITECTURE AND ITS COMPONENTS

In optical networks, the wavelength division multiplexing technology which multiples a number of optical carrier signals into a single optical fiber using different wavelengths (colours) of a signal. Using this technique, we can join signals at the transmitter side referred as multiplexer and it splits signals at receiver side referred as de-multiplexer as shown in fig 1.

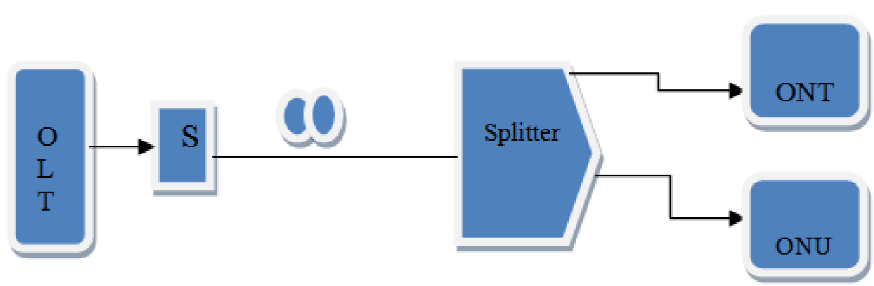

Figure 1: System Architecture of a System

The active modules in the network consist of an optical line terminal (OLT) situated at the central office, either an optical network terminal (ONT) or an optical network unit (ONU) at the far end of the network and optical amplifiers for amplification purposes [11].

- **Optical Line Terminal**

The OLT is located in a central office and controls the bidirectional flow of information across the ODN. An OLT must be able to support transmission distances across the ODN of up to 20 km. In the downstream direction the function of an OL T is to take in voice, data, and video traffic from a long-haul or metro network and broadcast it to all the ONT modules on the ODN. In the reverse direction (upstream), an OLT accepts and distributes multiple types of voice and data traffic from the network users. A typical OLT is designed to control more than one PON gives an example of an OLT that is capable of serving four independent passive optical net-works. In this case, if there are 32 connections to each PON, the OLT can distribute information to 128 ONTs. As described OLT equipment must adhere to specific PON standards, so it can interface with ONT modules from different manufacturers. In addition, the OLT typically is located within a central office [13].

OLTs include the following features:

- A wavelength division multiplexing means for performing an electro/optical conversion of the serial data of the downstream frame and performing a wavelength division multiplexing thereof.
- An upstream frame processing means for extracting data from the wavelength division multiplexing means, searching an overhead field, delineating a slot boundary, and processing a physical layer operations administration and maintenance (PLOAM) cell and a divided slot separately.
- A control means for controlling the downstream frame processing means and the upstream frame processing means by using the variables and the timing signals from the control signal generation means [15].

- Optical Network Terminal

ONT is located directly at the customer's premises. There its purpose is to provide an optical connection to the PON on the upstream side and to interface electrically to the customer equipment on the other side. Depending on the communication requirements of the customer or block of users, the ONT typically supports a mix of telecommunication services, including various Ethernet rates, T1 orE1 (1.544 or 2.048Mbps) and DS3 or E3 (44.736 or 34.368Mbps) telephone connections, ATM interfaces (155Mbps), and digital and analog video formats. A wide variety of ONT functional designs and chassis configurations are available to accommodate the needs of various levels of demand. At the high-performance end, an ONT can aggregate, groom, and transport various types of information traffic coming from the user site and send it upstream over a single fiber PON infrastructure [17].

- **Optical Network Unit**

An ONU normally is housed in an outdoor equipment shelter. These installations include shelters located at a curb or in a centralized place within an office park. Thus, the ONU equipment must be environmentally rugged to withstand large temperature variations. The shelter for the outdoor ONU must be water-resistant, vandal-proof, ACTIVE PON MODULES 105and be able to endure high winds. In addition, there has to be a local power source to run the equipment, together with emergency battery backup. The link from the ONU to the customer's premises can be a twisted-pair copper wire, a coaxial cable, an independent optical fiber link, or a wireless connection. An alternative approach is to allow ONUs to adjust their transmitter powers such that power levels received by OLT from all ONUs become the same [20].

V. DESIGN AND IMPLEMENTATION

The routing and wavelength assignment (RWA) problem is an optical networking problem with the goal of maximizing the number of optical connections. The general objective of routing problem is to maximize the number of recognized connections. Each connection request must be given a route and wavelength. The wavelength must be consistent for entire path, unless the usage of wavelength converters is assumed. Two connections requests can share same optical link, provided a diverse wavelength is used. The bandwidth utilization is the percentage of bandwidth utilized off the total bandwidth available. Dynamic bandwidth allocation in passive optical networks presents a key issue for providing efficient and fair utilization of the PON upstream bandwidth while supporting the QoS requirements of different traffic classes. The start time and length of each transmission time slot for each ONU are scheduled using a bandwidth allocation scheme.

In order to achieve flexible sharing of bandwidth among users and high bandwidth utilization, a dynamic bandwidth allocation (DBA) scheme that can adapt to the current traffic demand is required. A failure in an optical network may result in significant data and revenue loss due to the large amount of traffic carried over optical links. To protect the network from failures, survivability may be provided through protection and restoration techniques [18].

- **Traversing in Networks**

Graph traversal is the problem of visiting all the nodes in a particular manner, updating or checking their values along way. It is usually necessary to remember which nodes have already been explored by algorithm, so that nodes are revisited as infrequently as possible. A breadth-first search (BFS) is the technique for traversing a finite graph. BFS visits sibling nodes before visiting the child nodes. Usually a queue is used in search process. It's usually used to find shortest path from a node to another [19].

Algorithm: Breadth First Search

- create a queue Q
- enqueue v onto Q
- mark v
- **while** Q is not empty:
- t ← Q.dequeue()
- **if** t is what we are looking for:
- return t
- **for all** edges e in G.adjacentEdges(t) **do**
- o ← G.adjacentVertex(t,e)
- **if** o is not marked:
- mark o
- enqueue o onto Q
- return null
- Routing in Networks

Dijkstra's algorithm is a routing algorithm that solves the single-source problem for a network with non-negative line path costs, producing a shortest path. This algorithm calculates the shortest path using the number of optical routers as the cost function. A single probe is used to establish connection using the shortest path. The running time is cost of Dijkstra's algorithm: where m is the number of edges and n is number of routers. The running time is just endless if a predetermined path is used [19].
It computes length of the shortest path from the source to each of the remaining vertices in the graph. Breadth-first-search is an algorithm for finding shortest (link-distance) paths from a single source vertex to all other vertices. Dijkstra's algorithm uses the greedy approach to solve the single source shortest problem. It repeatedly selects from unselected vertices, vertex v adjacent to source s and declares the distance to be the actual shortest distance from s to v. The edges of v are checked to see if their destination can be reached by v followed by the relevant outgoing edges. Therefore, assume that G (V, E) is the network with E is the number of edges and the V is the number of vertices [17].

Algorithm: Shortest Path in Networks

- Assign to each node a tentative distance value: set it to zero for our initial node and to infinity for all other nodes.
- Mark all nodes unvisited. Set the first node as current. Create a set of unvisited nodes called the unvisited set consisting of all the nodes except the initial node.
- For the current node, consider all of its unvisited neighbours and calculate their tentative distances. For example, if present node A is marked with a distance of 5, and the edge connecting it with a neighbour B has length 2, then distance to B (through A) will be 5 + 2 = 7. If this distance is less than the previously recorded tentative distance of B, then replace that distance. Even though a neighbour has been examined, it is not marked as "visited" at this time, and it remains in unvisited set.
- When we are done considering all of the neighbours of the current node, mark present node as visited and remove it from the unvisited set. A visited node will never be check again.
- If the destination node has been marked visited (when planning a route between two specific nodes) or if the smallest tentative distance among the nodes in the unvisited set is infinity (when planning a complete traversal), then stop. The procedure has finished.
- Select unvisited node that is marked with the smallest tentative distance, and set it as the new "current node" then go back to step 3.

- Warshall Routing

Floyd–Warshall algorithm is a graph analysis algorithm for finding shortest paths in a weighted graph with positive or negative edge weights (but with no adverse cycles, see below) and also for finding transitive closure of a relation. A single implementation of algorithm will find the lengths (summed weights) of the shortest paths between all pairs of vertices, though it does not return details of paths themselves. The Floyd–Warshall algorithm compares all possible paths through the graph between each pair of vertices. It does so by incrementally improving an estimate on the shortest path between two vertices, until the estimate is optimal [10].

Algorithm: Warshall Routing in Networks

- let dist be a |V| × |V| array of minimum distances initialized to ∞ (infinity)
- for each vertex v
- dist[v][v] ← 0
- for each edge (u,v)
- dist[u][v] ← w(u,v)
- for k from 1 to |V|
- for i from 1 to |V|
- for j from 1 to |V|
- if dist[i][j] > dist[i][k] + dist[k][j]
- dist[i][j] ← dist[i][k] + dist[k][j]
- end if

VI. RESULTS AND DISCUSSION

- **Simulation Tool: MATLAB**

MATLAB is a high-performance language for technical computing. It mixes computation, visualization, and programming in an easy-to-use atmosphere where problems and solutions are expressed in familiar mathematical notation. It is given by fig 2.

Figure 2: MATLAB Tool

- **Graphical User Interface**

In computing graphical user interface is a type of user interface that allows users to interact with electronic devices using images rather than text commands.

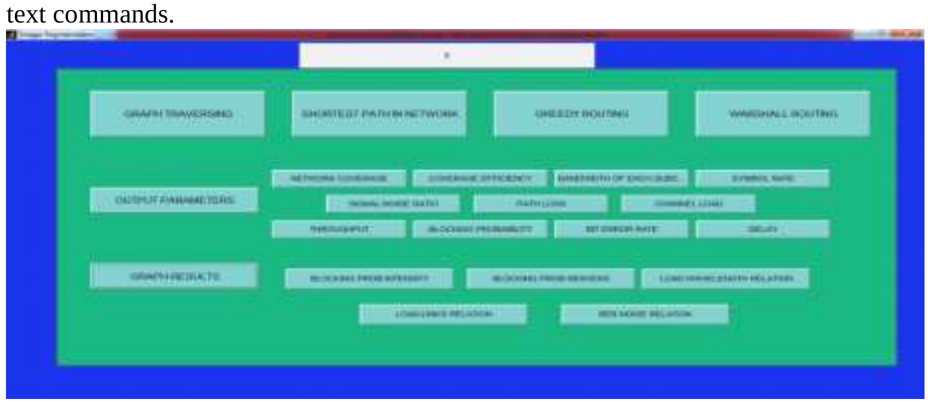

Figure 3: Proposed GUI

A GUI represents information and actions available to a user through graphical icons and visual indicators such as secondary notation, as opposite to text-based interfaces, typed command tags or text navigation. The actions are usually done through direct manipulation of the graphical elements. The proposed GUI is given by fig 3.

- **Graph Traversing**

The most fundamental graph problem is to traverse every edge and vertex in a graph in a systematic way. BFS visits the sibling nodes before visiting child nodes. Usually a queue is used in search process as shown in fig 4. It's usually used to find the shortest path from a node to another.

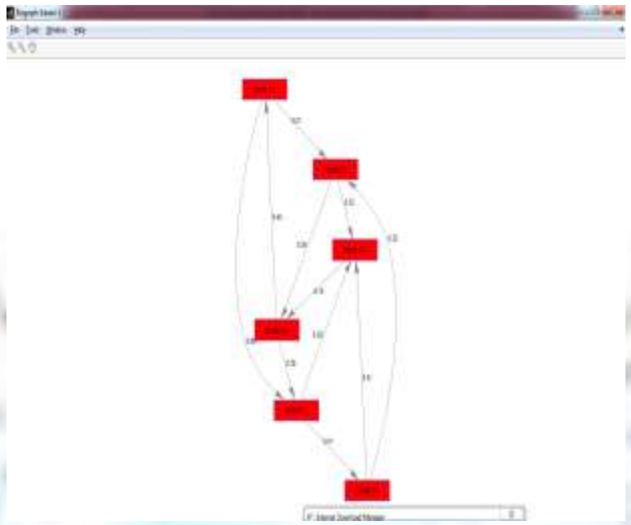

Figure 4: Traversing in Networks

- **Routing in Network**

Dijkstra's algorithm is applied to automatically find directions between physical locations, such as driving instructions on websites like Map-quest or Google Maps.

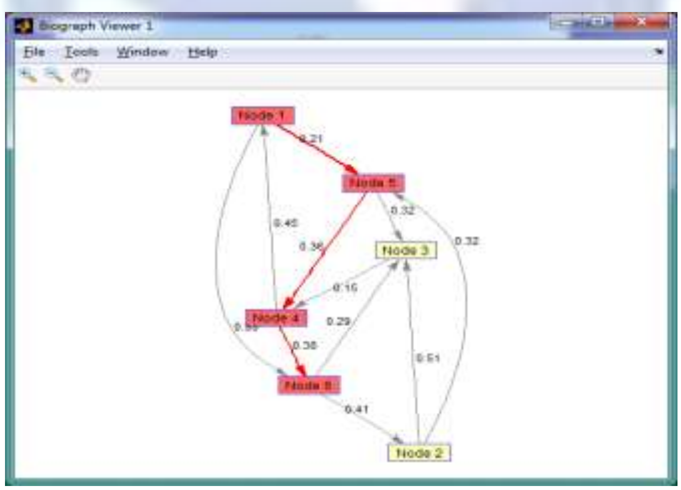

Figure 5: Routing in Networks

In a networking or communication applications, Dijkstra's algorithm has been used for solving the min-delay path problem (which is the shortest path problem). For example in data network routing, the goal is to find the path for data packets to go through a switching network with minimal delay. It is also used for solving a variety of shortest path problems arising in plant and facility layout, robotics, transportation, and VLSI design. The shortest path is shown in fig 5.

- Effect of Input Parameters

Table 1: Effect of Noise Power on Output Parameters

Parameter	$No = 20$	$No = 30$	$No = 40$
BER	0.39	0.40	0.42

Table 2: Effect of Servers on Output Parameters

Parameters	$m = 7$	$m = 8$	$m = 9$
B.P	0.79	0.88	1) 0.9

- Effect on Blocking Probability

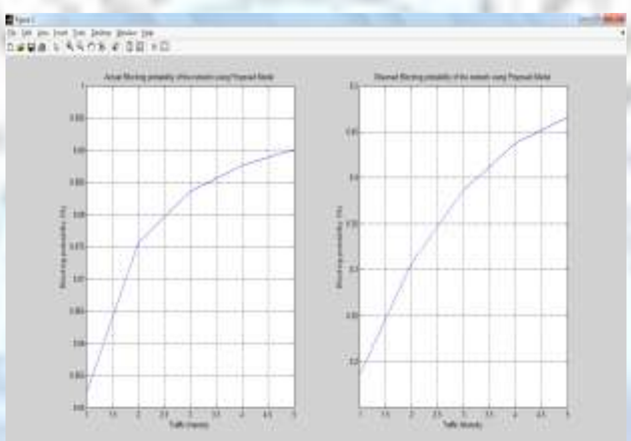

Figure 6: Blocking Probability-Intensity Relation

It provides a relation between blocking probability with traffic intensity. As traffic increases, blocking probability started increasing in exponential way and vice versa. Blocking Probability signifies 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 as shown in fig 6.

- BER-Noise Relation

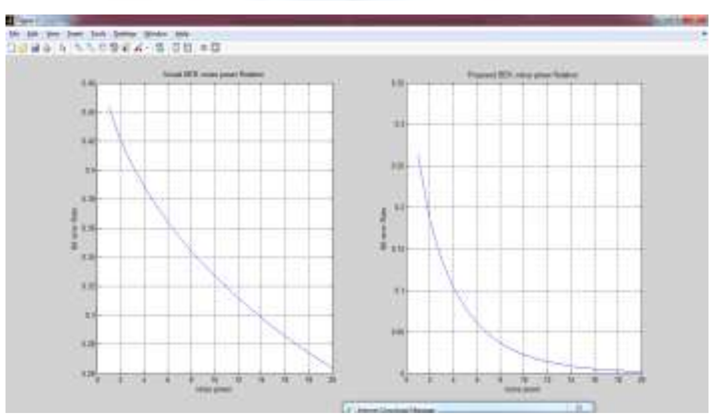

Figure 7: BER-Noise Relation

- The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit-less performance measure quantity. The graph shows the relation between bit error rate and noise power. As noise increases, BER decreases exponentially and vice-versa as shown in fig 5.7.

CONCLUSION

This paper investigated the routing and bandwidth utilization problem in WDM networks. It assigns upstream bandwidth in rectangles trying to minimize the average delay 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 improved by increasing the capacity of system. The capacity of the system can be increased by increasing the number of users without disturbing the working of another user. The simulation results show that the proposed algorithm improves the network cost compared to a simple placement heuristic.

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