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Design and Development of Dynamic Optimal Path Based Fault Tolerant Routing in Optical Networks

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Abstract: Wavelength Division Multiplexing (WDM) systems have increasingly been deployed to increase the capacity of optical networks. It is thus desirable to detect and locate faulty nodes to ensure the quality of service of networks. In this work, the main problem is to handle node failure and link failure in optical networks. The other problem is reliability maximization problem in the high failure probability system. To overcome this, it proposes a novel light-path routing algorithm mechanism for handling node failure & link failure in optical networks. It also proposes a mechanism of routing based on prediction to decrease the blocking probability in network. The main focus is on the design of optimized networks in which the rerouting scheme to avoid fault is as simple as possible. In this work, it works on optimal route selection in presence of large no. of faults. The new approach will provide a methodology for the Retracing of Path having good Packets with accuracy. This assessment becomes the power performance booster among the previous workout as it automatically determines the shortest path after path hopping is traced. The network performance is evaluated is terms of blocking probability. The results shows that value of blocking probability is very low ($\sim 10^{-7}$) and is reduced to zero after some time.

Keywords: Network Routing, Optical Networks, shortest path, Blocking Probability.

I. INTRODUCTION

In order to meet the exploding bandwidth requirements of existing and emerging communications applications, all-optical 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 optical networks employ wavelength division multiplexing [1].

Optical network are high-capacity telecommunication network based on optical technologies and components that provide routing, grooming and restoration at the wavelength level as well as wavelength-based services. It uses Optical Fibers for data transmission. The advantages of Optical networks can be used for long distances, easy to install and has long-term financial benefits, lasts for a long time and has a high bandwidth. Optical networks are based on the emergence of the optical layer in transport networks provide higher capacity and reduced costs for new applications such as the internet, video and multimedia interaction and advanced digital services [2].

In optical network customers are demanding more services and options and are carrying more and different types of data traffic. Optical networks provide the required bandwidth and flexibility to enable end-to-end wavelength services and meet all the high-capacity and varied needs. Optical fiber offers much higher bandwidth than conventional copper cables.

A single fiber has a potential bandwidth on the order of 50THz. Meanwhile, it has low cost, extremely low bit error rate (typically 10^{-12}, compared to 10^{-6} in copper cables), low signal attenuation and low signal distortion. In addition, optical fibers are more secure from tapping, since light does not radiate from the fiber and it is nearly impossible to tap into it secretly without being detected. As a result, it is the preferred medium for data transmission with bit rate more than a few tens of megabits per second over any distance more than one kilometre. It is also the preferred means of realizing short distance (a few meters to hundreds of meters), high-speed (gigabits per second & above) interconnection inside large systems [3].

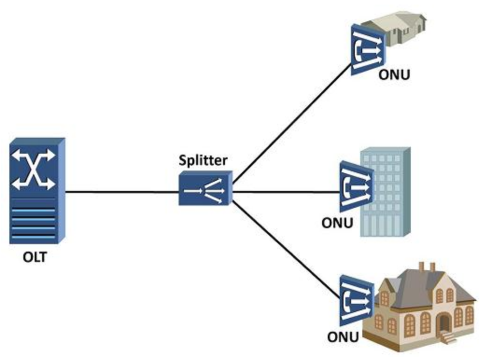

Figure 1: A Passive Optical Network

Optical-Network systems have many advantages over metallic-based communication systems. These advantages include interference, attenuation, and bandwidth characteristics. These characteristics can be classified as linear and nonlinear. Nonlinear characteristics are influenced by parameters, such as bit rates, channel spacing, and power levels.

Routing is the act of moving information across an internetwork from a source to a destination. Along the way, at least one intermediate node typically is encountered. Routing is often contrasted with bridging, which might seem to accomplish precisely the same thing to the casual observer. The primary difference between the two is that bridging occurs at Layer 2 (the link layer) of the OSI reference model, whereas routing occurs at Layer 3 (the network layer). This distinction provides routing and bridging with different information to use in the process of moving information from source to destination. Routing involves two basic activities: determining optimal routing paths and transporting information groups (typically called packets) through an internetwork.

It can see that eventually packets are to be routed from a source to a destination. Such packets may need to traverse many cross-points, similar to traffic intersections in a road transportation network. Cross-points in the Internet are known as routers. A router's functions are to read the destination address marked in an incoming IP packet, to consult its internal information to identify an outgoing link to which the packet is to be forwarded, and then to forward the packet. Similar to the number of lanes and the speed limit on a road, a network link that connects two routers is limited by how much data it can transfer per unit of time, commonly referred to as the bandwidth or capacity of a link; it is generally represented by a data rate. The paper is organized as follows. In section II, we deliberate related work with the network routing and proposed algorithm scheme. In Section III, it describes the system architecture and components of system. Section IV explains the design and implementation techniques of system. In section V, it contains the all results of the system. At last, conclusion is given in Section VI.

II. RELATED WORK

Some authors studied the reliability maximization problem in wavelength division multiplexing (WDM) networks with random link failures. Reliability in these networks is defined as the probability that the logical network is connected, and it was determined by the underlying light path routing, network topologies, and the link failure probability. By introducing the notion of lexicographical ordering for light path routings, they characterized precise optimization criteria for maximum reliability in the low failure probability regime. Based on the optimization criteria, they developed light path routing algorithms that maximize the reliability, and logical topology augmentation algorithms for further improving reliability.

Some authors adopted a new framework to handle the problem in which we fix the sequence of the customer demands while trying to find the path for each demand in order to obtain more reasonable solution for the whole. Besides, a genetic algorithm using priority-based encoding combined with an efficient local search process is proposed to cover the shortage of the K-shortest path strategy which is the most widely used routing strategy in RSA but with limited search space [4].

Some proposed novel distance-adaptive optical transmission technologies to boost transceiver data rates and to enable more flexibility in the allocation of traffic flows. Traffic grooming and spectrum assignment using transceivers with fixed baud rate of 28 and 14 GB and distance-adaptive modulation formats in optical metro networks is performed [5].

Some analyzed the performance of Traffic Groomed optical networks and found that the number of wavelength channels required decreases as wavelength grooming factor increases. The grooming factor is defined as the ratio of wavelength channel capacity to the basic wavelength channel capacity. Blocking probability is plotted against the number of channels per link and it is found that as the load increases the blocking probability increases for the same number of channels per link [6].

Some authors propose a novel colourless optical transmitter based on all-optical wavelength conversion using a reflective semiconductor optical amplifier for upstream transmission in wavelength-division-multiplexed passive optical systems. The proposed optical transmitter for optical network unit is composed of an electro-absorption modulated laser, a photo-sensitive coupler and amplifier. The proposed optical transmitter is based on fast gain recovery of amplifier governed by carrier-carrier scattering and carrier-phonon relations [7].

This paper investigated problem of dynamic wavelength allocation and fairness control in WDM optical networks. A network topology, with a two-hop path network, is considered for mainly three classes of traffic. Each class corresponds to a source &destination pair. For each class call inter-arrival & holding times remain studied. The objective is to find a wavelength allocation policy to take full advantage of weighted sum of users of all the three programs. In a conventional WR network, an entire wavelength is assigned to a given connection. This can lead to inferior channel utilization when individual sessions do not need entire channel bandwidth [8].

III. SYSTEM ARCHITECTURE

Traffic grooming is the process of grouping many small telecommunications flows into larger units, which can be processed as single entities. Wavelength Division Multiplexing (WDM) systems have increasingly been deployed to increase the capacity of optical networks. These networks typically have SONET ring architecture. Nodes in such a ring use SONET Add/Drop Multiplexers (ADMs) to electronically combine lower rate streams onto a wavelength. Often the objective of grooming is minimizing the cost of the network. Fixed path routing is the simplest approach to finding a light path. The same fixed route for a given source and destination pair is always used. Typically this path is computed ahead of time using a shortest path algorithm, such as Dijkstra's Algorithm. If resources along the fixed path are in use, future connection requests will be blocked even though other paths may exist. In this approach a new fault management mechanism was proposed to deal with fault detection. It proposes a hierarchical structure to properly distribute fault management tasks among optical nodes by heavily introducing more self-managing functions.

Fault-tolerance in an optical network can be studied in terms of two system attributes: reliability and survivability. Network reliability is the ability of a system to perform its function, the lower the probability that a system will fail to perform its function, the more reliable it is. Network survivability is the ability of a network to maintain an acceptable level of performance in the presence of network failure by employing various restoration techniques. The basic principle behind a fault-tolerant system is to provide the system with redundant resources beyond the minimum requirements for normal operation. These spare resources help avoid faults.

Since any redundancy introduced in the system to make it fault-tolerant increases the system cost, it is very important to determine the right type and extent of spare resources to maximize the reliability while maintaining a moderate cost. Spare resources for every possible scenario are not a feasible solution since it would be prohibitively expensive.

Therefore, it is a challenge for network planners and engineers to maintain a satisfactory level of survivability with minimum cost. Different users need different level of survivability depending on an application's cost, service, and performance requirements, optimizing some attributes at the expense of others. A single network scheme may not be a satisfactory solution to al1 users. Therefore, the aim of a network designer is to combine several restoration techniques to meet different demand requirements and to realize a simple, efficient, fast, cost-effective fault-tolerant optical network.

Network restoration technique can be protection switching, rerouting, or self-healing. in protection switching, the new route is known in advance depending on the equipment residing in either the connecting or terminating points of the path. In rerouting, the new route is generally not known in advance and it is established depending on the network resources available at the point of failure.

In self-healing, the new route is not known in advance. The new route is established depending on the network elements and resources available at that point of failure and is not controlled by the Operating System. Self-healing allows reconfiguration of a network around failures quickly without disturbing the calls that are not affected by the network failures. It requires redundant facilities and intelligence in the network.

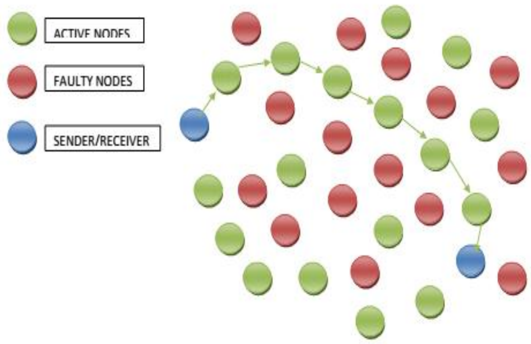

Figure 2: Proposed Optimal Path Prediction Scenario

Some reconfiguration techniques do not require any spare resources and eliminate the faulty component and run the system on the remaining resources with degraded performances.

A. Approaches to Implement Optical Networks

1. 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 connection on demand. 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.

In a broadcast-select network, the inputs from al1 transmitting nodes are combined in a star coupler and broadcast to al1 end-nodes. It can be implemented in different ways depending on the tunability of lasers and the receivers: tunable laser and fixed receiver, fixed laser and tunable receiver, fixed laser and fixed receiver, and tunable laser and tunable receiver. If the input lasers are made tuned to fixed wavelengths and the output receivers are tuned to fixed wavelengths, the number of users will be limited but a control channel is not required.

2. 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. In order to have an efficient system, the logical topology should be chosen such that either the

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average hop distance or the average packet delay or the maximum flow on any link must be minimal. Another important issue is the simplicity of routing.

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. Another disadvantage of complete regular structure includes the number of nodes that it can support will be a discrete set of integers, instead of an arbitrary integers. Regular multi-hop system has received more attention because of its simple routing.

B. Faults in Optical Network

There are mainly three types of faults: channel fault, link fault, and node fault.

1. Channel Fault
A channel fault occurs when a single wavelength channel on a link between two nodes has failed due to the failure of the laser or receiver for that wavelength channel, or due to cable disconnections. This fault can be managed by routing the traffic to a spare channel on the same physical link and bypassing the faulty channel.

2. Link Fault
A link fault occurs due to fiber cut or due to noise, jitter etc. and can be managed by using a bundle of protection fibers in addition to the working fiber. The performance or survivability is limited by the number of links in each bundle. Another way of solving this problem is by providing a "loopback" mechanism within each node on the same working fiber.

3. Node Fault
A node fault occurs due to power outages or catastrophic failure resulting in an entire network node failure. It is complicated to handle since when this fault occurs, a part of the conversion capability of the network as a whole is lost and leaves an open circuit and can result in deadlock of al1 routing networks. One solution is to introduce redundancy in the internal connections of the networks rather than in the connections of nodes. In the case of multiple failures, the solution is a "firewall" that can prevent deadlock spreading in the network. This can be achieved by a simple device that time out if a packet passing through it stay longer than a specified time.

IV. DESIGN AND IMPLEMENTATION

Routing is act of moving information across an internetwork from a source to a destination. Along the way, at least one midway node typically is encountered. Routing is frequently contrasted with bridging, which might seem to achieve precisely same thing to the casual observer. Routing involves two basic activities: determining optimal routing paths and transporting information groups (typically called packets) through an internetwork. In context of routing procedure, the latter of these is referred to as packet switching. Although packet transferring is relatively straightforward, path determination can be very composite. Routing protocols use metrics to evaluate what path will be best for a packet to travel [8].

Single-link fault tolerance is very useful; however the occurrence of multiple-link failures is not uncommon in a practical network. It might happen that two or more distinct physical links may be routed via the same common duct or physical channel. Such commonality might be only for a few hundred meters or less, but if any damage happens to this physical duct, it will cause simultaneous logical failures in two or more distinct logical links. Multiple-link failures can also arise out of independent overlapping sequential link failures. For example, a fiber cut occurring as the result of an excavation necessitates that fiber be repaired, which is hardly a quick process. In the meantime, an unrelated fiber may also fail, thus creating a sequential multiple-link failure scenario not provisioned for in the original network design. Detection of faulty nodes can be achieved by two mechanisms i.e. self-detection (or passive-detection) and active-detection. In self-detection, optical nodes are required to periodically monitor their path, and identify the potential failure. In this scheme, we consider the link failure as a main cause of node sudden death. A node is termed as failing when its packet drops below the threshold value. This requires no recovery steps. Self-detection is considered as a local computational process of optical nodes, and requires less in-network communication to conserve the packets. In addition, it also reduces the response delay of the management system towards the potential failure of sensor nodes.

To efficiently detect the node sudden death, our fault management system employed an active detection mode. In this approach, the message of updating the node residual battery is applied to track the existence of optical nodes. In active detection, if link gets failed that shows the connecting node is failed hence packets gets lost and signal is blocked. It causes the increase in blocking probability of system. In proposed approach, the status of failure nodes gets stored in a cell and when packet reaches the adjacent node of failure node, it gets the status of that failure node. Hence it changes its path immediately so blocking probability gets reduced. This is called in-cell update cycle. The update message consists of node ID and location information.If the cell does not receive an update from any node then it sends an instant message to the node acquiring about its status .If cell manager does not receive the acknowledgement in a given time, it then declares the node faulty and passes this information to the remaining nodes in the cell. The adjacent nodes only concentrate on its cell members and only inform the group manager for further assistant if the network performance of its small region has been in a critical level.

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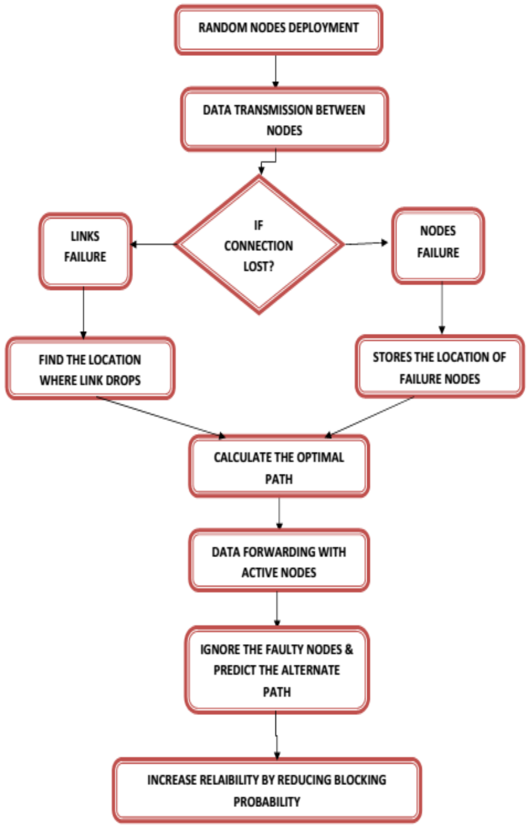

Figure 3: Proposed System Model

Fixed alternate routing is an extension of fixed path routing. Instead of having just one fixed route for a given source and destination pair, several routes are stored. The probes can be sent in a serial or parallel fashion. For each connection request, the source node attempts to find a connection on each of the paths. If all of the paths fail, then the connection is blocked. If multiple paths are available, only one of them would be utilized. The major issue with both fixed path routing and fixed alternate routing is that neither algorithm takes into account the current state of the network. If the predetermined paths are not available, the connection request will become blocked even though other paths may exist.

V. RESULTS AND DISCUSSION

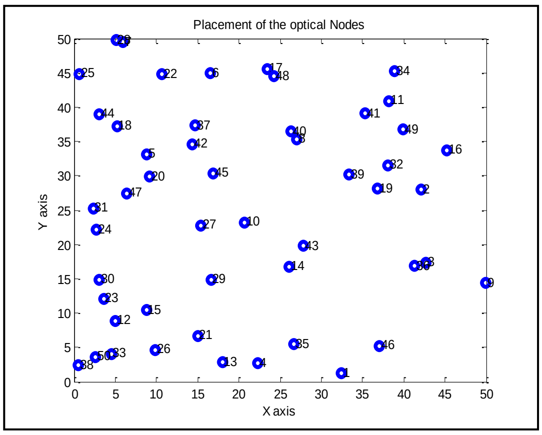

Figure 3: Placement of Nodes in Network

Fault tolerance in optical networks is an important design consideration. The forfeiture of data and revenue due to the loss of even a single fiber is staggering, not to mention the magnitude of loss due to multiple simultaneous or sequential fiber failures. The motivation of the proposed work is to provide a strategy for protecting WDM optical networks against all types of multiple-link failures using prediction based routing.

The figure 4.8 describes the network failure probability in case of node and link failures. The graph shows that as the no. of failure nodes increases, network failure probability also increases. This value is very high and it must be reduced. So, it proposes a system that can handle these faults and also reducing probability as shown in figure 4.9. The results shows that value of blocking probability is very low ($\sim10^{-7}$) and is reduced to zero after some time. The calculation can be approximated based on known probabilities regarding certain aspects of transmission technology, for instance, the type of physical link, the node characteristics, the geographical distribution of the network segments, etc.

Blocking probability is simply the ratio of total number of calls blocked to the total number of calls expressed in percentage. Minimum blocking is always desired condition for provisioning. It is clear that if the nodes have a smaller transmission radius then the interference constraints on each hop are fewer but the calls hop through many links to reach the destination. The proposed result shows the response of network failure probability with no. of nodes in network. The results indicate that constraining sub-graph routing to a path actually improves the blocking probability.

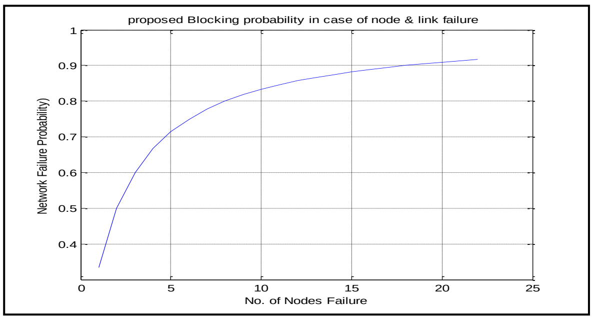

Figure 4: Blocking Probability in case of Node & Link failure

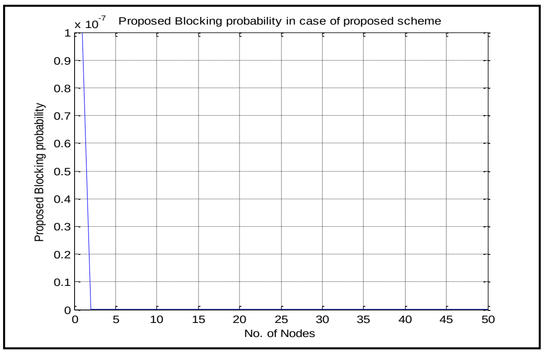

Figure 5: Proposed Blocking Probability in case of Proposed Routing

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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. It shows that as the no. of nodes increases with increase in number of servers having same energy, the blocking probability gets decreased and vice-versa. If the path on a sub-graph is distinctly different from the base network, the request has to traverse through links that a different request regularly utilizes. If a request cannot find the necessary resources available on such critical links, it is blocked with a higher frequency. If, however, each sub-graph is required to route each connection in the same way the base network does if the same path exists, the sub-graph utilization of critical links more closely resembles that of the base network. This increases the likelihood that an arbitrary request is accepted on all sub-graphs, and consequently accepted in the base network. This phenomenon is referred to as sub-graph shadowing.

VI. CONCLUSION

In this work, the main problem is to handle node failure and link failure in optical networks. The other problem is reliability maximization problem in the high failure probability system. To overcome this, it proposes a novel light-path routing algorithm mechanism for handling node failure and link failure in optical networks. So, this paper investigated the error handling routing schemes and bandwidth utilization problem in WDM networks. In proposed scheme, it predicts the location of failure nodes so that it may retrace the path without affecting by faulty nodes present in the system. It proposes a system that can handle these faults and also reducing probability as shown in results. It covers shortest path mechanism to transfer data from sender to receiver. It provides a path hoping mechanism for compare the results. The new approach will provide a methodology for the Retracing of Path having good Packets with accuracy. In the actual results, the value of blocking probability is 0.01 initially for 20 nodes. As no. of nodes increases, the blocking probability is reduced to 10^{-6} erlang. But in proposed results of 50 nodes, initial blocking probability is about 10^{-7} and reduced to zero as no. of nodes increases. In proposed scheme, the blocking probability gets reduced to almost zero that shows the reliability of proposed system.

REFFERENCES

[1]. Lee, Kayi Lee, “Maximizing Reliability in WDM Networks through Light path Routing”, IEEE Transactions on Networking, Vol. 22, No. 4, pp. 1830–1845, August 2014.

[2]. Buttaboni, M. Andrade, and M. Tornatore, “A Multi-Threaded Dynamic Bandwidth and Wavelength Allocation Scheme With Void Filling for Long Reach WDM/TDM PONs”, Journal of Light-wave Technology, pp. 4-10, Vol. 31, No. 8, April 15, 2013.

[3]. Rottondi, M. Tornatore, G. Gavioli “Traffic Grooming And Spectrum Assignment For coherent Transceivers In Metro-Flexible Networks” IEEE Photonics Technology Letters, pp. 100-106, Vol. 25, issue 2, 2013.

[4]. Cuda, R. M. Indre, E. Rouzic, and J. Roberts, “Building a Low-Energy Transparent Optical Wide Area Network with Multi-paths”, Journal of Optical Communication, pp. 58-63, Vol. 5, No. 1, 2013.

[5]. Zhang, M.Leenheer, A.Morea, B. Mukherjee, “A Survey on OFDM-Based Elastic Core Optical Networking”, IEEE Communications Surveys & Tutorials, pp. 110-118, Vol. 15, No. 1, 2013.

[6]. Hwang and A. Tannyliem, “A Hybrid Scalable Peer-To-Peer IP-Based Multimedia Services Architecture In Ethernet Passive Optical Networks” Journal of Lightwave Technology, pp. 156-165, Vol. 31, issue 2, 2013.

[7]. Yoshima, Y. Tanaka, N. Kataoka, N. Wada, J. Nakagawa, and K. Kitayama, “Full-Duplex, Extended-Reach 10G-TDMOCDM-PON System Without En/Decoder at ONU”, Journal of Light-wave Technology, pp. 180-190, Vol. 31, No. 1, 2013.

[8]. Qazwini, “Colorless Optical Transmitter for Upstream WDM PON Based on Wavelength Conversion” Journal of Lightwave Technology, Pp. 487–494, Vol. 31, issue 6, 2013.

[9]. Pagès, S. Spadaro and G. Junyent, “Strategies for Virtual Optical Network Allocation”, IEEE Communications Letters, Pp. 48–54, Vol. 16, issue. 2, 2012.

[10]. Kantarci, H. T. Mouftah, “Bandwidth Distribution Solutions for Performance Enhancement in Long-Reach Passive Optical Networks”, IEEE Communications Surveys & Tutorials, Pp. 87–94, Vol. 14, No. 3, 2012.

[11]. Chatterjee, Nityanandasarma, And P. Sahu, “Priority Based Routing and Wavelength assignment With Traffic Grooming For optical Networks”, Journal of Optical Communications, pp. 45-54, Vol. 4, issue 6, 2012.

[12]. Wang, W. Wei, W. Zhang, H. Jiang, “Optimal Wavelength Scheduling For Hybrid WDM/TDM Passive Optical Networks”, Journal of Optical Communications, Pp. 489–498, Vol. 3, issue 6, 2012.

[13]. Zhang, M. Leenheer, and B. Mukherjee “Optical Traffic Grooming In OFDM-Based elastic Optical Networks” Journal of Optical Communications, Vol. 4, 2012.

[14]. Kanonakis, E. Giacoumidis. “Physical-Layer-Aware Mac Schemes For Dynamic subcarrier Assignment In OFDM-PON Networks” Journal of Lightwave Technology, Vol. 30, issue 12, 2012

[15]. Charbonneau, V. M. Vokkarane, “Survey Of Advance Reservation Routing and wavelength Assignment In Wavelength-Routed WDM Networks” .IEEE Communications Surveys & Tutorials, Vol. 14, issue 4, 2012.