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Wavelength Division Multiplexing

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Abstract— **an Optical WDM Network is composed of wavelength routing nodes interconnected by point-to-point optical fiber links in a haphazard topology. Wavelength-division multiplexing (WDM) is an effective technique to exploit the large bandwidth of optical fibers to meet the rapid growth of bandwidth demand in the Internet. WDM networks therefore have large potential to provide broadband and high-quality services, among which multicast services such as video conferencing and distance learning are becoming more and more frequent. Most telecommunication companies using WDM technologies for point to point transference. Wave length add and drop Multiplexer implies unidirectional or bidirectional traffic arrangements. For transparent mesh networking optical cross connect technology is effective. Various WDM Networks are used: broad cast and select networks, wavelength routed optical networks. Broadcast-and-select WDM network can be either single hop or multichip. A wavelength routed network composed of wavelength cross connects, interconnected by point-to-point fiber links in an arbitrary topology.**

Index Terms—**WDM, point to point network, add/drop wdm network, fiber and wave length cross connect.**

I. INTRODUCTION

1. INTRODUCTION TO WDM NETWOKS:

According to the physical technology engaged, one can identify three generations of networks (Fig. 1). Networks constructed before the appearance of optical fiber technology are the first generation of networks means networks placed on copper wire or radio. The second generation networks apply fibers in traditional architectures. The choice of fiber is because of to its large bandwidth, low error rate, reliability, availability and sustainability. Though some performance refinements can be attained by employing fibers, the performance for this generation is suffered by the maximum speed of electronics (a few gigabits per second) supplied in switches and end-nodes. This situation is called an electronics bottleneck. In order to achieve the increasing bandwidth requirements of emerging applications, totally new approaches are hired to exploit vast bandwidth available in fibers. Therefore, the third generation networks are made as all-optical to avoid the electronics bottleneck. [1].

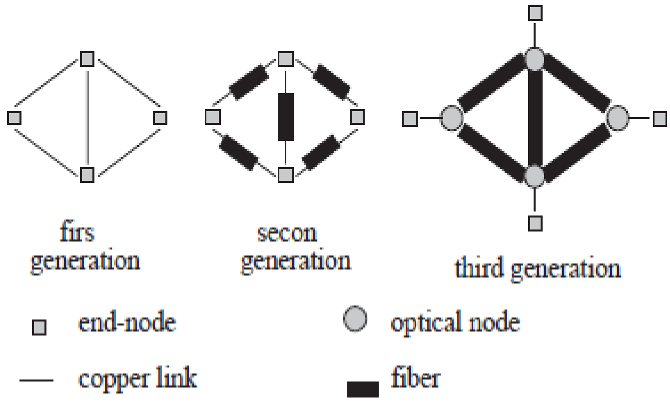


Fig.1. [1]

Exploit vast bandwidth Optical WDM networks meet the immense demand of the new world, as it possesses huge bandwidth. An Optical WDM Network is composed of wavelength routing nodes interconnected by point-to-point optical fiber links in an inconsistent topology. In WDM the optical spectrum (low loss region of fibers) is carved up into a number of smaller capability channels (Figure 2). [2].

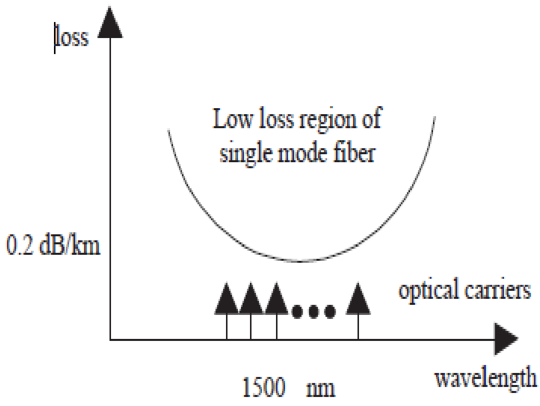


Figure 2. Wavelength Division Multiplexing

Important advantages of WDM Optical Networks are:

1. Low signal attenuation.
2. Low signal distortion.
3. Low power requirement.
4. Low material usage.
5. Small space requirements.
6. Low cost [3].

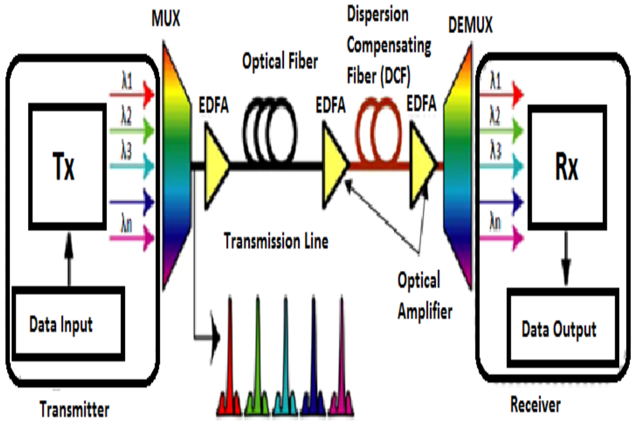
1.2 WDM Networking Evolution:

1.2.1Point to Point WDM System:

WDM technology is being established by several telecommunication companies for point-to-point communications [4]. Optical components employed in building a standard point to-point optical WDM transmission system are indicated in Figure 1 Several optical signals sent by transmitters (lasers) are combined together using a (wavelength). Multiplexer in a fiber Signals are amplified, when necessary, using amplifiers like as erbium-doped fiber amplifiers (EDFAs) to reimburse for signal attenuation [5].

Figure3.A typical point-to-point optical fiber communication link [5].

When t



the demand exceeds the capacity in existing fibers, WDM is turning out to be a more Cost-effective substitute compared to place more fibers [4].

1.2.2Wavelength Add/Drop Multiplexer (WADM):

Add and drop multiplexer is the elementary manufactural block of fiber-optic communication network constructions. It handles either unidirectional or bidirectional traffic arrangements. Amongst all, Optical Add-Drop Multiplexers (OADM) was one of the intelligent procedure for the handling of communications signals [6].

Fig. 4.Basic Add/Drop Multiplexer [6].

Time domain adds drop multiplexing is schematically visualized in Fig. 5. One (or more) channels can be dropped and one (or more) channels can be incorporated in the empty time slot(s). A organized control signal simultaneously creates a drop and through function [7].

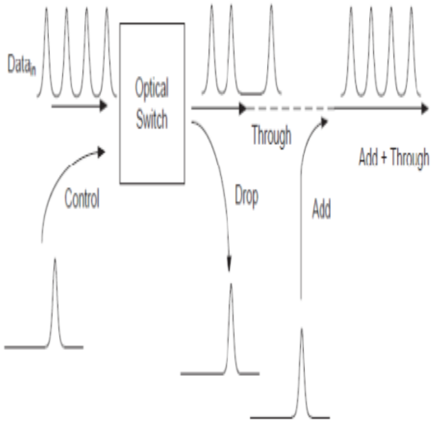


Fig. 5. Schematic Function of a Time Domain ADM with On Gate Control [7].A WDM optical add/drop (WADM) selects one or more wavelengths from a fibre and again inserts these wave lengths means add function, a very important function in WDM rings and also in point-to-point links. They can either be fixed or dynamic, either under local or network management control. Restructure able devices perform add/drop on single, a group of or all wavelengths while the remainder pass straight through the device [8].

1.2.3 Fiber and Wavelength Cross connects:

Optical cross-connects are an enabling technology for glassy mesh networking, but are better implemented in standard fashion for economic benefits. Various cross-connect constructs are assessed and found that using wavelength-selective switches offers the greatest advantages [9].In order to have a network of various wave length fiber links, we wish suitable fiber interconnection devices. These devices fall under the following three categories:

1 Passive star (see Fig. 6),
2 Passive router (see Fig. 7), and
3 Active switches (see Fig. 8).

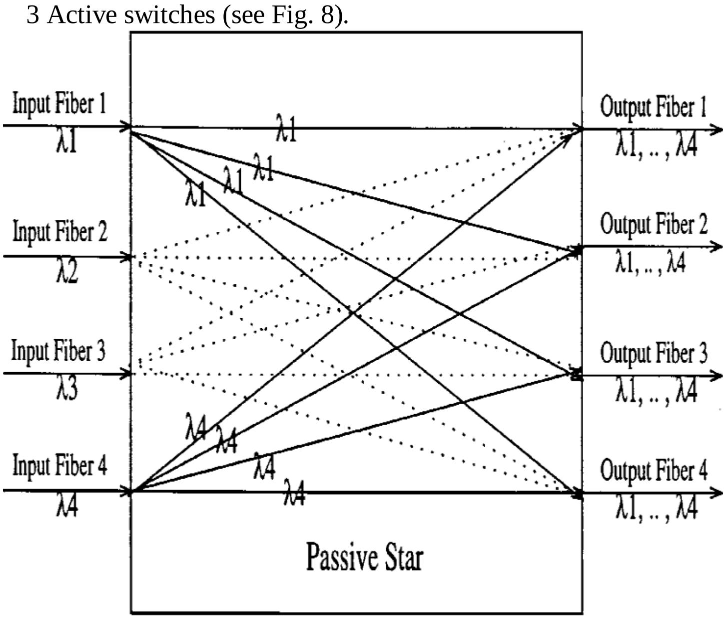


Fig. 6. A 4 x 4 passive star.

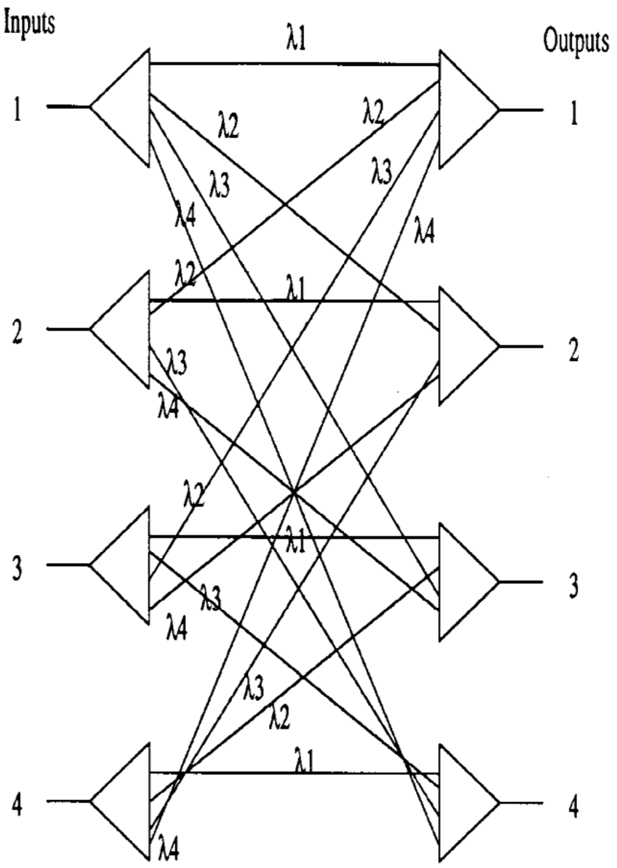


Fig.7. A 4 x 4 passive router (four wavelengths).

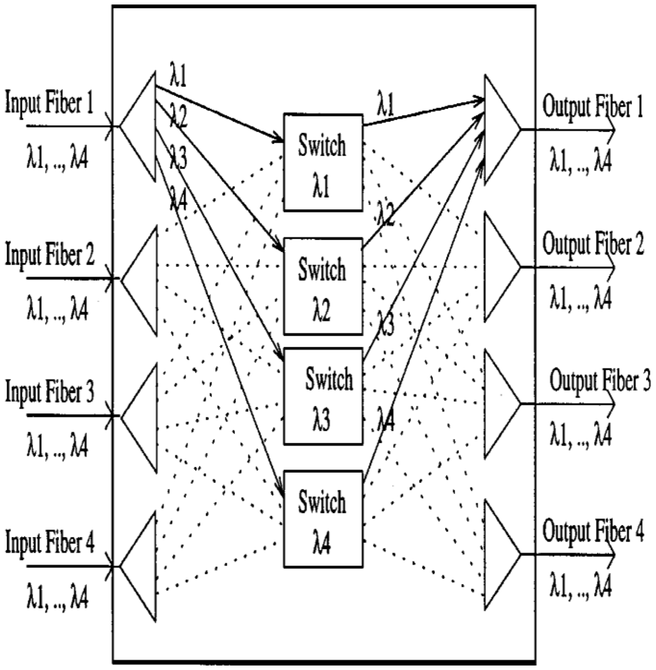


Fig.8.A4x4activeswitches(four wavelengths)[4].

1.3 WDM Network Constructions:

1.3.1 Broadcast and Select Networks:

Broadcast and Select Networks are depend on the easiest all-optical organization that enables WDM [1]. A broadcast-and-select WDM network can be either singlehop or multihop .In a single-hop network for communication process, the transmitter of the source (sending) node and the recipient of the destination (receiving) node must be set to the same wavelength while the period of the transmission [10]. In a broadcast-and-select network for unicast transmission, the node at source end selects an appropriate wavelength λp and broadcasts the data to be tranferred to all end nodes in the network taking the wavelength λp. The receiver at the destination end node must be set to the wavelength λp while the receivers at all other end nodes are set to wavelengths different from λp. The final result is that the data is observed and processed only at the destination node [3].

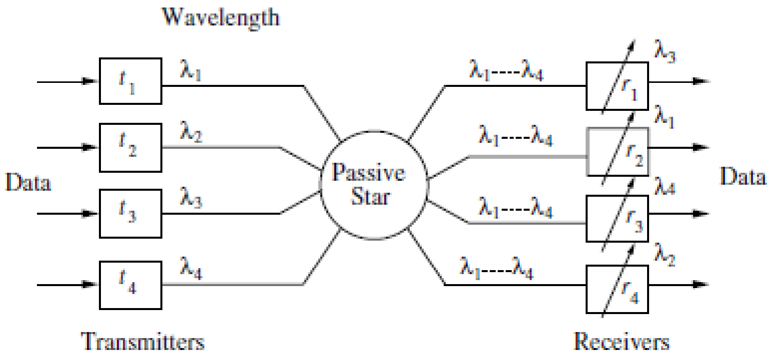


Fig. 9 A broadcast-and-select network [3].

1.3.2 Wavelength-Routed Optical Networks:

A wavelength routed network consists of wavelength cross connects, correlated by point-to-point fiber links in an inconsistent topology. In a wavelength routed network, a message is remit from one node to another node using a wavelength continuous path called a light path, without demanding Optical–Electronic–Optical (OEO) conversion thus minimize delay due to OEO conversion and buffering [2].

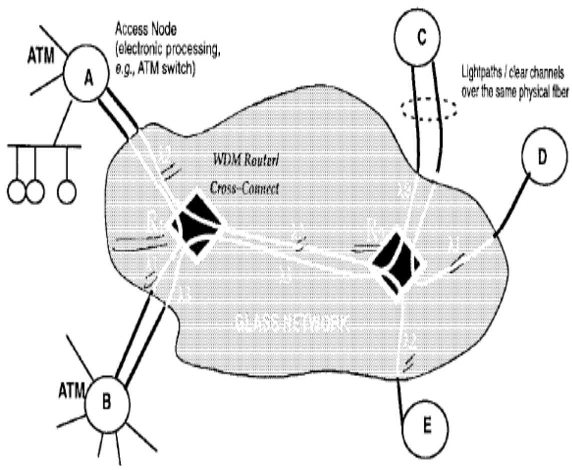


Fig.10. All-optical wavelength routing network architecture [11].

1.4**Blocking Probability:** To fulfill the request of bandwidth required for the services such as transmission of audio, video and data using video on request etc, the WDM optical network plays an important part in optical networks. Thus, with the help of WDM technology, it is manageable to transmit traffic on various wavelengths within the same optical fiber simultaneously. Since the data rate increases at fast rate so in order to meet the efficient utilization of the fiber capacity WDM(wavelength division multiplexing) network came into layout to meet the demands of high bit rate. WDM enables the efficient utilization of optical fiber by dividing its tremendous bandwidth into a set of disarrange wavelength bands, which are referred as wavelengths [12]
In networks using full wavelength conversion, a call is handled if on all the links on its path there is at least one free

Wavelength. With no wavelength conversion, a call is accepted on a path if there occur at least one wavelength which is simultaneously free on all the links of that path. This constraint is called as the *wavelength continuity constraint*. It means a call can be blocked still if there are free wavelengths should not the similar one on all the links. Therefore, having full wavelength conversion is beneficial in that it decreases the blocking probability [13].

TRAFFIC GROOMING:

It is a term used to describe the optimization of capacity utilization in data communication systems by using cross connections of conversions between different communication systems or layers inside the same system. Major advantages of traffic grooming are minimize network cost improved network performance. Traffic grooming is the process of combining small telecommunications flows into one larger units. suppose, if a network handling time-division multiplexing (TDM) and wavelength-division multiplexing (WDM) both, two flows which are approching for a common node can be settled on the same wavelength, that allowing them to be dropped by a lone optical add-drop multiplexer. The role of grooming is minimizing the cost of the network[14].

WAVELENGTH ASSIGNMENT ALGORITHMS ARE AS DEFINED:

First fit (FF) wavelength algorithm:

In this technique first the free wavelengths of traffic matrix are organized in non decreasing order. FF method always selects the lowest indexed wavelength from the list of free wavelengths and assigns it to the connection demand. When this demand is completed the wavelength is added back to the free wavelength group.

Random fit (RF) wavelength algorithm:

In this algorithm, a group of free wavelengths on particular path is to be found. RF algorithm deduces which wavelengths are present and then choose the wavelength randomly amongst the available set of free wavelengths.

Most used (MU) and least used (LU) wavelength algorithm:

In mostly used algorithm, when the request for connection is made it get to be assigned by the wavelength which is using on the largest number of fibers in the network.LU(Least used) wavelength assignment is same to the most used algorithm except in LU algorithm the least used wavelength in the wavelength is allocated [12].

II. LITERATURE SURVEY

Parul Kaushik (2001) a survey of latest literature on all optical networking is showed. Starts from multiplexing techniques and topological properties, network design and performance problems are reviewed. Particular attention is devoted to WDM (Wavelength Division Multiplexing) networks. Dynamic and Static solutions of the routing and wavelength assignment (RWA) problem are inspected. Issues of current research are outlined.

Vitthal J. Gond et al.(2010) The fast development of telecommunication networks is carry by user requests for new applications and advances in technologies. The volatile growth of the internet traffic is due to its use for collecting the information, transmission, multimedia application, entertainment, etc. Those applications are imposing a immense need for bandwidth capacity on telecommunication network. The establishment of fiber optics had proved to meet the vast demand of bandwidth. This requirement can be match by all optical network which is capable of transmitting extensive data at very high speed, around 50 Tbps (Tera bits per seconds).A wavelength conversion technique is discussed in this paper to lessened the blocking probability in wavelength routed networks. It is notice that the blocking probability of traffic demand decreases as the wavelength conversion factor increases. We explore the possibility for network with various sizes with variation in wavelength per link. In this study the evaluation of wavelength routed optical network with various number of wavelength converters, various traffic types are accomplished and results are showing that the blocking probability is least with 50% - 60% wavelength changeable nodes. Wavelength convertible nodes more than 60% are not showing extra effect on reduction in blocking probability relatively it results in increase in overall cost of network.

Parul Kaushik(2015) This paper throws light on what Optical Networks are actually capable of and what expansions have been made in terms of the higher bandwidth provided by them in an adaptable way, when and where needed. How optical fibres have been largly applied now days in all types of communication networks. So many ways of increasing the potential by using the WDM (Wavelength Division Multiplexing) technique. A concise survey on the recent growth on flexible optical networking. This paper concerns with the estimation of the performance of WDM networks**.**

Biswanath Mukherjee et al. (2000) While optical-transmission techniques have been researched for several time, optical networking studies have been conducted only over the past couple of years. The field has fully grown enormously over this time: many papers and Ph.D. study have been produced, a number of prototypes and test environment have been built, a lot of books have been written, a large number of startups have been generated, and optical WDM technology is being employed in the marketplace at a very fast rate. The objective of this paper is to conclude the basic optical-networking methods, clear report on the WDM classified strategies of two major U.S. carriers, and summarize the current research and development trends on WDM optical networks.

Ahmed Riad BORSALI et al.(2012) In this paper, we investigate the quality of the transmission of every channel for a WDM(Wavelength Division Multiplexed) system with a 640 GB/s data rate (16 x 40 GB/s) having RZ modulation for different channel spacing**.**

Devendra Kr.Tripathi et al.(2014) Optical multiplexing is the key function of a WDM network and best method for data transport networks. WDM networks designed as rings/mesh along with Optical Add-Drop Multiplexers encourage added flexibility, simplicity and augment the spectral productivity. Further enhancement achieved with Reconfigurable OADM architectures, growing rapidly besides with automatic network management, let the transport network to acclimatize with dynamically deviating environment and flexibly reacted to the transport network changes. It allows single or many wavelengths to be added and/or dropped from a transport fiber not requiring optical-to-electrical-to-optical domain translation. Currently ROADM technology has transfigures optical networking and an indivisible part of modern optical communication giving huge bandwidth for data transport at minimum cost. In this view the article presents complete study for countless generations of

ROADM and their architecture and continuous development.
Ahmed Nabih et al.(2012) The OADM rely on DWDM technology is forwarding the telecommunications industry seriously closer to the development of optical networks. The OADM can be settled between two end terminals along any route and be exchanged for an optical amplifier. Commercially available OADMs permit carriers to drop and/or add up to multi channels between DWDM terminals. By employing an OADM irrespet of an optical amplifier, service providers can gain flexibility to spread revenue–generating traffic and lessen costs associated with deploying end terminals at low traffic areas with a route. The OADM is specifically best-suited for meshed or branched network classifications, as well as for ring architectures used to magnify survivability. Moreover, an optical add/drop multiplexer with adjustable bandwidth offers various potential advantages, including optical performance watching and varying bandwidth allocation. This paper has suggested OADM for high transmission bit rates and products in coming generation optical communication networks deployed on dense wavelength division multiplexing for various fiber link lengths at room temperature for best production efficiency.
Dan Marom (2004) Optical cross-connects are an enabling technology for glassy mesh networking, but are greatly implemented in modular fashion for economic benefits. Various cross-connect constructs are studied and found that using wavelength-selective switches gives the greatest advantages.
JINGYI HE et al (2004). Wavelength-division multiplexing (WDM) networks are assumed to be a promising candidate to meet the unusual increase of bandwidth needs in the Internet. In this paper, we examine the problems and techniques to multicasting in WDM networks.Specially we highlight the issues in the context of threetypesofWdmnetworks:1.broadcast-and-select,2.wavelength-routed, and 3. Optical burst-switched (OBS) WDM networks. Broadcast-and-select WDM networks are especially for WDM LANs/MANs, and are one of two single-hop or multihop. So many multicast scheduling algorithms (MSAs) are studied for single-hop networks. For multihop networks, we studied how channel sharing can be implied to effectively support multicast. In a wavelength-routed WDM network, supporting multicast guide to the MC-RWA (multicast routing and wavelength assignment) problem, which has been discussed for different frameworks, including sparse-splitting networks. We also discuss the problem of perfectly supporting multicast in optical burst-switched networks, where the above due to control packets and guard bands need to considered .
Subrata Banerjee et al.(1997) We consider the problem of drawing a logical optical network topology for a given physical topology (or fiber layout) and a stated traffic needs matrix between the end-users.Traffic between the end-users is taking in a packet-switched form and the purpose of our logical topology design is to minimize the utmost traffic on the reasoned correspondance in the logical topology. The logical connections are realized by wavelength continuous paths or light paths between end-users and they are routed via wavelength-selective routers. Note that a topology with lower maximum link crowd will allow its traffic request matrix to be scaled up by a larger factor. In the logical topology each node is stocked with a limited number of optical transceivers, hence logical connections cannot be arranged between every couple of nodes. In this paper we showing an improved lower bound for maximum congestion on any link in the logical topology. The bound is displayed to be up to 50% higher than the existing ones. An analytical model for forming the maximum and average logical connection loads for a given logical network and traffic demand matrix is also formulated, and it has been confirmed through simulation. Finally, two heuristic algorithms for constructing a logical topology that minimizes maximum logical connection congestion are presented.

Ref.No.	Tech/Method used	Parameter used	Findings
1	Different types of networks	Multifber network,limitedwavelength conversion,wavelength routers,wavelength conversions	To support packet switched traffic between all-optical local area networks, wavelength routing packet switches that are interconnected by virtual topologies over optical transport networks can be Employed.
2	Evaluation of Wavelength Routed Optical Network with Wavelength Conversion.	WDM Networks, Blocking Probability, Wavelength Conversion.	from the blocking probability point of view 32 and 64 wave lengths are proposed to be utilized in the network.
3	WDM Networks	optical networks, WDM, flexible optical networking, ONN	The establishment of lightpaths in such networks requires the implementation of control and management protocols to perform routing and wavelength assignment functions.
4	WDM optical Networks	Carrier strategies, optical communication network, research trends, wavelength routing, WDM	physical-layer impairments which may strongly influence network architectures.
5	Wave length spacing	WDM; RZ; dispersion compensating Fiber; bit error rate.	We found that more we increase the channel spacing the Quality factor increases with.
6	Optical Add and Drop Multiplexer.	(TFFs), optical transport network	It is to be developed around the future broadband

		(OTN), fully-reconfigurable OADM (FROADMS)	communication network service needs, along with considerable decrease in the operational costs, effective interoperability and the flawless service evolution.
7	Optical Add Drop Multiplexer (OADM) Based on Dense Wavelength Division Multiplexing Technology	Next generation network, Reconfigurable All-Optical Network, add/drop multiplexer, Dynamic bandwidth allocation	Moreover the decreased fiber link length at constant of both number of transmitted channels and operating optical signal wavelength, the increased optical received signal power, and the decreased bit error rate at the receiving side
8	Hybrid solutions to optical WDM networking sub system functionalities.	WDM Optical Networking, Semiconductor Optical Amplifiers (SOAs), WDM Optical Add/Drop Multiplexers (WADMs), All-Optical Wavelength Converters/Regenerators	As the network evolves further into fully meshed architectures with dynamic optical path provisioning, all-optical wavelength converters and all-optical regenerators are key in providing a cost effective solution for multi-node, ultra high speed (> 40Gbit/s) extensive optical layer.
9	Modular Wavelength Selective Cross-Connects.	Optical cross-connects, WDM links, OADM node, hitless switching.	Optical cross-connects support high-channel-count WDM links (for efficient use of fiber-optic links and for greater number of possible wavelength routing options), enable equalization of channel power deviations (from optical amplifiers gain profile and source-link variations), allow hitless switching, and modular deployment for a pay as you grow solution.
10	Multicasting in WDM Networks	WDM, MULTICASTING IN BROADCAST-AND-SELECT WDM NETWORKS, Hybrid-Partition Scheme	multicast schemes achieve this goal of reducing the overheads of the control packets and guard bands by sharing the control packets and guard bands between unicast traffic and multicast traffic or among multiple multicast sessions.
11	LP-Based One-Hop Traffic Maximization Scheme, Link Elimination via Matching Scheme.	Lightwave/optical networks, logical topology design,minimizing maximum congestion, routing algorithm, wavelength division multiplexing (WDM), wavelength routers, wide area networks.	Results from this scheme show that shortest-path based routing is not effective in reducing maximum logical connection congestion. LP-based one-hop traffic maximization with connectivity constraint improves the maximum logical connection congestion by 5–30% over randomly chosen topology for uniform and skewed traffic patterns.
12	Various wavelength asiignment algorithm with traffic grooming	WDM Networks, Blocking Probability, First-Fit method, Random-Fit Method, most used, least used, least loaded.	The blocking probability of network depends on length of the route, free wavelengths, and number of channels
13	Blocking probability in wavelength routed all routed network with limited range wavelength conversion using traffic model	WDM Networks, blocking probability, traffic model	Using this model the performance improvement obtained by full-wavelength conversion over no-wavelength conversion can be achieved by using limited-wavelength conversion with the degree of conversion, , being only 1 or 2.
14	Placement of grooming nodes along with wavelength	WDM Networks, Blocking Probability, Traffic	The first fit,least loaded, Most loaded algorithm performs better than all other algorithms with

	convertor on blocking probability	grooming.	effective placement of grooming nodes				

III. Conclusion

Optical networking remains the most important transmission medium and has enabled the explosive growth of communications networking for many years. The introduction of WDM has also played an important role in satisfying the growing bandwidth demand over the last fe years. WDM is often a more cost-effective way to expand capacity than other alternatives, such as installing more parallel fibers or replacing current TDM systems with higher-rate systems. Therefore, point-to-point WDM links have become widespread in recent years. WDM represents the first step towards all-optical networking. Broadcast-and-select WDM networks can be either single hop or multi hop. For single-hop networks, the major issue is the design of multicast scheduling algorithms (MSAs) for contention resolution. For wavelength-routed WDM networks, the key matter is the MC-RWA (multicast routing and wavelength assignment) problem. For OBS WDM networks, the major consideration is reducing the overheads of the control packets and guard bands. Some studies discussed some multicast schemes that achieve this goal by sharing the control packets and guard bands between unicast traffic and multicast traffic or among multiple multicast sessions.ROADM (RECONFIGURABLE OPTICAL ADD AND DROP MULTIPLEXERS) diminishes the expenditure with enhanced capacity. Development of the future generation ROADM architecture depend on the growth of supporting optical components maturity, progress of integrated optics technology, upgrade capacity of the equipment and novel algorithms that will be add to development of the advanced ROADMs design.

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