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Flexible Architectures for Optical Transport Nodes and Networks and ROADM Design for Mesh Optical Networks with Colorless and Directionless Specification

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***Abstract* – The network today are equipped regarding flexibility and scalability using colorless and directionless architecture of ROADM and this causes handling unpredictable demand in high bandwidth, and also supplies one to one connection and provides new services without disrupting the desired routes. In this article, using PXC and WSS at a multi-degree node, we detect C & D ROADM architectures and then examine both architectures based on their advantages. We will also discuss some of their problems. Then a kind of colorless, directionless and inimitable (CD & C) architecture is proposed that combines properties of the C & D architectures; and considered architecture is implemented practically.**

Flexibility in support of network topologies, dynamic capacity allocation automated network control, and making optical path are key components of next-generation optical transport networks. To realize this potentials, the Multiplexes ·optical remove/add with the ability to reconfigure having dynamic remove/add structures, which are within the control surfaces, and specifying the path of light are required. Architectures and different applications of ROADM including remove / add colorless, directionless, and inimitable structures are determined in this particular article .the effect of scaling data transfer rates beyond 100 gigabytes per second on architectures ROADM, has been studied. Using the GMPLS control and optical measurement methods for light paths, restoration and automated supply are explained.

***Keywords* – Colorless Directionless and Contentionless Architecture, Photonic Cross Connect (PXC), Reconfigurable Optical Add/Drop Multiplexer (ROADM), Wavelength Selective Switch (WSS).**

INTRODUCTION

Service providers, due to the rapid growth of residential and commercial bandwidth, tried to create a tool for new flow, so that increase competition among them and increase their income.

Reducing the need to re-generating light and electronic occurs using transparent ring to ring ROADM integration among metro ring networks. As a result, network operators can now go beyond the simple ring configuration and created completely meshed optical networks with redefining the resilience of the network and bring flexibility to providing new services.

Along with the development of ROADM, choosing an ideal architecture plays a very important role in realizing fast optical, flexible and dynamic network.

Fast optical mesh network requires an architecture that enhances the development of services and provide functional programs of wavelength such as Smart dynamic wavelength routing and reduce OEO operations colorless and the directionless

Architecture provides these conditions. In this paper two kinds of implementing colorless and directionless architecture based on PXC and WSS are explained.

Colorless and directionless ROADM architecture based on PXC using three-dimensional MEMS based on PXC or ROADM based on selective wavelength switches of device, WSS devices are identified by combination of splitter / combiner with multiple ports [1]. Advantages of both architectures and the problems are discussed.

In addition, a type of colorless, directionless architectural is proposed that can combine ROADMs based on PXC and WSS. Furthermore, the benefits of the above architecture and some of its practical implementation issues such as performance analysis in terms of OSNR and channel energy changes along the way, choice of subsystem technologies, cost considerations and other challenges will be discussed.

For more flexibility in wavelength routing and wavelength assignment, optical network architectures are used, yet these architectures need to support data transmission rates of 100 gigabytes per second and more.

Channel bandwidth is an important issue since the consequences of filtering along wavelength of 40 Gb / s and 100 Gb / s can be converted into a problem. Dense wave multiplex (DWDM) of nodes, has begun as linear or cyclic structures with fixed remove / add without dynamic routing of wavelengths. With the development of switches by selecting wavelength, DWDM node architectures can provide mesh configurations And wavelength routing [2].

This paper discusses the requirements for DWDM networks with complete flexibility and eliminating restrictions on the allocation wavelength. for architectures that provide this possibility, a service is required that according to resources supplied with dynamic allocation of wavelength performs and also routing through network. These architectures not only support creating flexible service, but also make it possible to reconfigure the network to optimize network use or re-establishment of link or node failures.

II. ROADM ARCHITECTURES WITH FEATURES OF COLORLESS AND DIRECTIONLESS

ROADMs are one of the critical elements of the network and play an important role in building the next generation of reconfigurable mesh optical networks. Besides the countless benefits of speed optical ROADM, flexibility of mesh networks can be developed by creating features of colorless and directionless (C & D) in ports Remove / Add of all nodes of the network. Feature colorlessness in local port remove / add refers to capabilities of adjustable in accessing transparent wavelength to all ports of DWDM. feature of directionless in the port to remove / add is related to unlock able access of transponders to all network ports of DWDM network in optical system. C & D feature of ROADM architecture facilitates efficient use of all resources of f adjustable access for required configuration the network with high-bandwidth and network architecture.

A. ROADM with features of colorlessness and directionless based on PXC

Mesh optical network consists of 7 nodes (Figure 1). Using C & D ROADM architectures based on PXC, flexibility and reconfigurability of the nodes can be provided for network dynamics.

Assume the sample network shown in Figure 1,is a 4-degree node A. Architecture C & D ROADM in node A consisting of PXC is based on three-dimensional micro-(3-D MEMS) that is combined with a set of sharer and selective dividers of wavelength. (Mux/DeMuxs) (Fig.2).

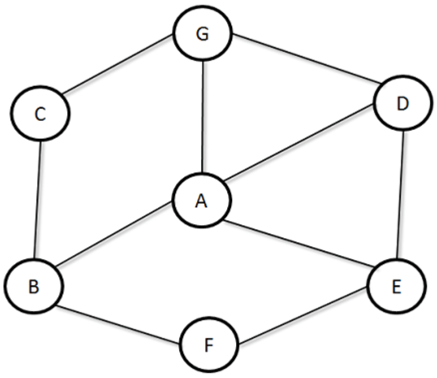

Fig.1. An example of a mesh optical network

We considered a big optical switch 320 x 320 with three dimension unlock able MEMS for core PXC having 8 fiber ports of input / output that capacity of each port is up to 40 Fiber Channel. [3] DWDM input signals are divided to seed wavelength from 4 directions using 40-channel based on array waveguide gratings divider (AWG)that get together directly in input fiber ports with array fiber blocks .by three-dimentional optical switch MEMS , light path with less wavelength waste from each fiber port in optimal fiber outlets or extra local ports can be made. [4] DWDM signals that exit from the local remove and express routes (light routes that are not node added extra ports), are multiplexed by using a 40-channel multiplexer based on AWG which are integrated in fiber output ports with an array of a block fiber.

The main advantage of C & D ROADM architectures based on PXC in multi-degree node is effectively utilizing wavelengths.

Since large optical switch based on MEMS is capable of not being locked and colorless, the same wavelengths can simultaneously carry different information and by help of multiple adjustable Transponders from/to input /output fiber ports.

This property of without argument that is provided on the removed / added place that is provided to the device C & D ROADM, makes possible effective use of wavelengths and access to resources. [5]

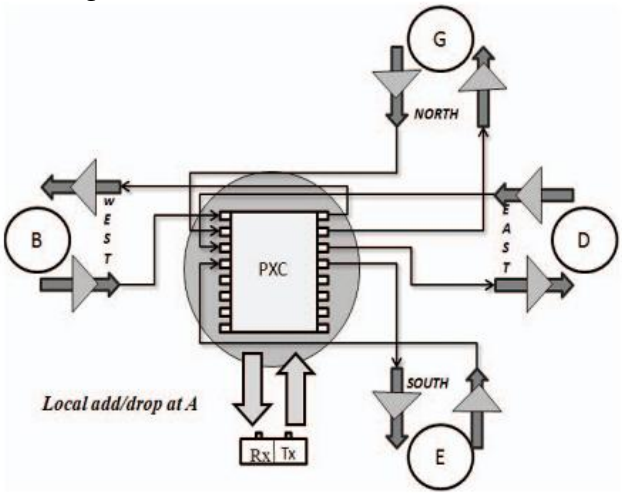

Fig.2. Colorless and directionless architecture based on PXC in 4-degree node

One of the concerns about the C & D ROADM architectures is that by increasing the number of ports N in switch Nuclear N * N, number of possible connections gets more than N2. However, with the advent of MEMS technology as the main candidate for making PXC switch with enough ports to develop nuclear transport networks [6], more PXC with more than 1,000 ports are possible[7]. On the other hand, PXCs based on MEMS whose loss of their launch is average dB 1/2 and the maximum dB4 [8] and their switching connection time is less than 10 ms [9] are available. Another limitation is that the architecture of C & D based on PXC does not supported multi-cast because it is not able to remove a given wavelength and send simultaneously the same wavelength along the Express path to other directions.

Using switching dual-core matrix in architecture C & D ROADM to provide protection scheme based on PXC in Figure 3, the secondary core is not only unnecessary but also is kept active to avoid challenges when switching services from core A to core B in the protection time of the failure of the nucleus A.

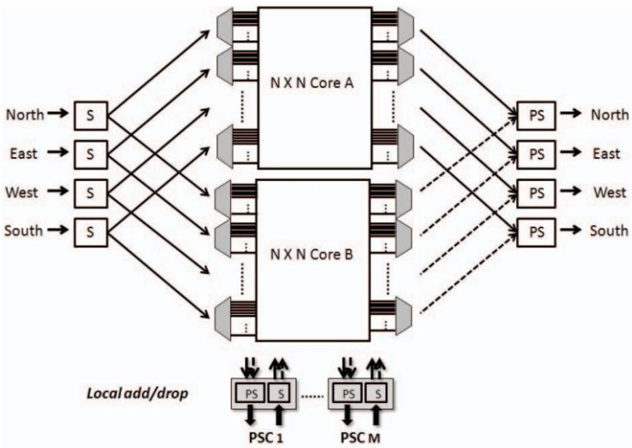

Fig.3. Protection scheme based on PXC using dual-core switching matrix in the C & D ROADM architecture

This will be done with power splitter (S) 2 * 1 that makes DWDM signals input from each input two fold and forms inputs corresponding dual core DeMux switching.

Each of the local ports remove / add is connected to dual core switching protection card (PSC) that performs tasks of switch Protection 1 * 2 (PS) and inactive Splitter (S).

III. ROADM with Features of Colorless and Directionless Based on WSS

Selective Wavelength switch (WSS) is the latest stage of evolution of ROADM technology. WSS is advanced fiber-optic modules that can select multiple DWDM wavelengths from the fiber input and converts them to the standard output fiber. WSS innovation is for the equalization of the channel dynamics (DCE) to weaken the waves are going out of output fibers. Figure 4 shows colorless and directionless architecture using modules WSS 1 * 9 and the multi-port splitter combinator at 4 degree node A in optical network mesh sample of Figure 1. [1] wavelengths that come from 4 directions , encounter with splitting energy division 8 * 1. While three of the 8 port splitter ports along three dimensions are connected to the WSS, two ports connect to the WSS to make possible local node A adding. The other ports will be used in future scaling.

WSS in add place, strengthen the wavelength that come from a different direction. Then wavelength are divided by Splitter 8 x 1, thus allow their expansion since number of incoming wavelengths may exceed the number of ports available in WSS.

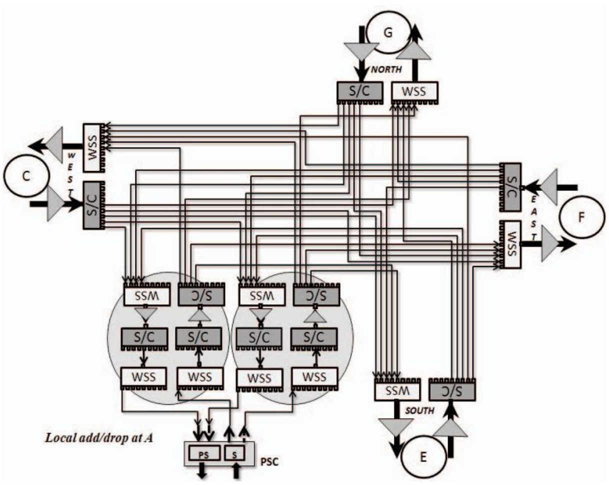

Fig.4. Colorless and directionless architecture based on WSS in 4degree node.

Then, second WSS in place, creates ports delete / add, delete / add. In order to get to remove the color feature, WSS one more time is used to strengthen the waves that emanate from node A. because of the possibility of adding wavelength in port WSS, colorless elimination can be produced. Then combinatory 8*1 causes similar expansion slot on the add side. Splitter then divides it into 8 directions to establish connections to all directions. Along any direction there is a WSS that either blocking or allowing wavelength to enter along particular direction. Thus, the wavelength added in A can be sent along any direction whereby the property of colorlessness is established performing.

ROADM colorless and directionless architecture based on WSS have has other advantages as well. Using Splitter makes wavelength that enter Node A from any direction, redirect to different nodes and at the same time be accessible at the local added. It also make possible redirecting the waves added in local node A, by placing splitter at the removal place. Thus the waves that come from different directions or stem from that node can be spread in different directions. The WSS-based ROADMs, because of scalability regarding degree of node and number of wavelengths remove / add , also provides the supply approach when needed. This advantage enables service providers to postpone the roll out of equipment, and reduce early CAPEX. Of course there is possibility of modular growth along with development of the network in different stages. Module 5 * 1.9 * 1 and 20 * 1 WSS , that will be needed by increasing the number of wavelengths in each direction in 4 degree node, are as shown in Figure 5.

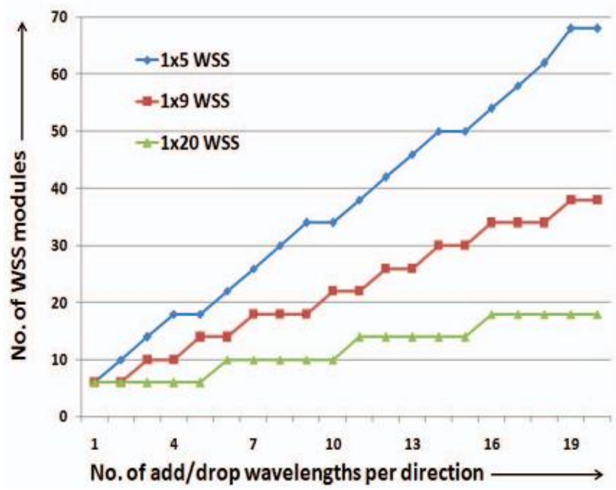

Fig.5. Number of WSS for 4 degree- node.

However, colorless and directionless ROADM architecture based on WSS, does not cause without argument remove / add.

Assume the state that the end point of two different services, one of which stems from G and the other from E, is the same: node B.

Ideal colorless ROADM architecture should have flexible feature of remove / add like colorlessness, directionless and unrivaled remove / add, modular growth, etc. , so that to makes possible efficient use of resources. Although colorless and directionless ROADM architecture based on PXC, provides unrivaled delete / add, it does not support the multicast wavelengths. In the colorless and directionless ROADM architecture based on WSS, more interest will be on scalability. The architecture also supports multicast wavelengths, but is unable to secure delete / add without controversy.

ROADM colorless, directionless without controversy architecture (CD & D) can be made by combining ROADM based on PXC with WSS. (Figure 6). This architecture is similar to C & D ROADM architecture, but

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its design of the remove / add is different. In the architecture of the CD & D ROADM, PXC, WSS alternative and multiport splitter combiner are added at location remove / add. All wavelengths that come along different directions, encounter Splitter 8 x 1. Three splitter ports connect to WSS along other three directions, while the fourth port connects to one of the input ports PXC located at remove / add place. PXC output ports are connected along the direction corresponding to WSS.

Colorless, directionless ROADM architecture without controversy, not only has all the features of the ROADM based on PXC and WSS, it also consider their disadvantages. CD & D ROADM architecture have numerous benefits through support from multicast wavelength that come from a different directions and waves added over the local nodes.

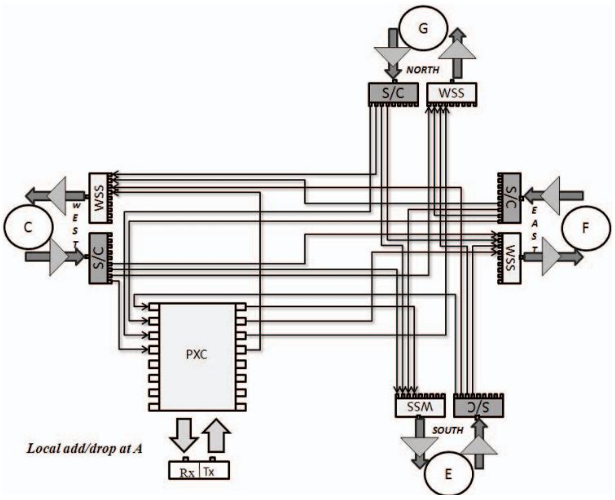

Fig.6. Colorless, directionless ROADM architecture in4 degree node.

Practical implementation of ROADM architecture

In this section, issues related to practical implementation of a colorless ROADM architecture, without controversial proposal is investigated. First, performance of ROADM architectures based in WSS and PXC is analyzed the and then the analysis of CD & C ROADM architecture is described.

Analyses conducted show that by deployment of amplifiers with reasonable interest rates, all systems within the energy framework and limitations OSNR , perform right.

On the other hand, CD & C ROADM architecture in using the instrument amplifier is an affordable and hence its OSNR performance is better.

Optical signal to noise ratio and OSNR values available in the reinforcement along a path (AEFB) for three ROADM architecture are shown in Figure 7. From this figure, we can see that OSNR performance in all three architectures in the context of minimum requirement 9dB for OSNR is acceptable. It can be seen that the CD & C ROADM architectures, compared to ROADM architectures based on PXC and WSS and for AEFB path, have better OSNR performance.

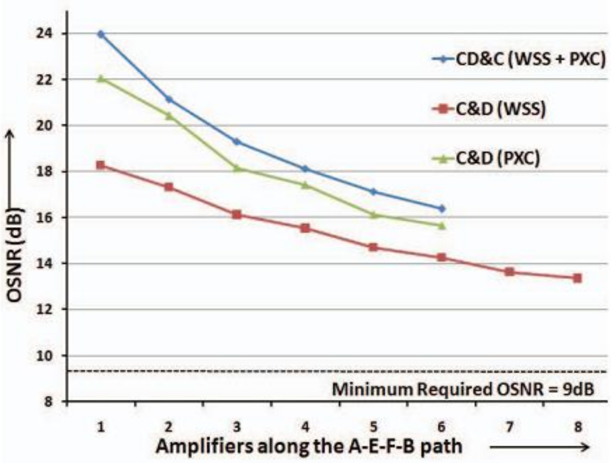

Fig.7. OSNR values in the direction of reinforcing AEFB

In the route AEFB in the sample network, proposed CD & C ROADM proposed, OSNR in amplifier that is placed immediately before node A (after reinforcing mechanism at node A) has the highest level of 24dB and amplifier just before the Node B (reinforcing mechanism r in node B) has minimum value of 16.4d that are more compared to OSNR amplifiers of node A and preamplifier of node B in ROADM architectures based on PXC and WSS.

Identifying appropriate subsystem technology selecting Switching Subsystem for the PXC in CD & C architecture plays an important role. Over the past few years various technology came that some of them were fast and others slow. Some are suitable for small scale, while others offered a lot of inputs and outputs. [10]. Switches based on crystal did not have liquid moving component, but required careful design because any minor flaws in their construction waste will be significantly associated with great waste. Despite the rapid switching of the switch based on the bubble, maximum size of switch was 32 x 32. Thermal-optical waveguides have still faster switching . MEMS devices are very large number of moving parts, so these devices are not reliable. In addition, the devices were vulnerable to vibration and shock and vibration-free environment therefore needed.

Despite these difficulties, the ability to create more than 1,000 MEMS-based switches and outlet ports with the ability to balance the use of space has led to many fans. Especially MEMS switches due to the low loss and low wavelength dependence of the same set up as well as various operational conditions, provides more flexibility in network design. It also minimizes switches degradation to optical signal noise ratio caused primarily by interference, polarization dependent loss (PDL) polarization mode, and randomly dispersion.

Investigating the transmission node architectures

When DWDM technology entered optical transmission networks, its main function was to increase capacity so that a fiber can transfer more sync optics network (SONET) or Synchronous Digital Hierarchy networks (SDH). Although the network SONET / SDH has mainly ring structure, but DWDM nodes were are as a point to point technology between nodes a way that many rings SONET / SDH could have a common fiber. The only thing

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that was needed was to be done was multiplex and de - multiplex wavelengths at each node. Figure 8-A shows an example of the multiplex and De multiplex point to point where four linear DWDM nodes are connected by four devices to form a ring.

To add flexibility, DWDM networks are used as linear and ring multi-node configurations. When a wave reaches a node, it can be determined that the wavelength stays in the node or goes to the next node. Channels that pass the node are called quick channels. In addition, the current wavelengths can be added to DWDM flow at intermediate nodes. It introduces the concept of remove / add wavelength in nodes that are called remove / add OADM optical multiplexers. Using the remove / Add wavelength function, specific wavelengths can be added to predefined network configurations or subtracted from it. However, the practice of adding or deleting channel is static and for correcting add or delete locations in channels, manually configuration is needed. Figure 8 (b) shows a DWDM ring with the ability to remove / add .

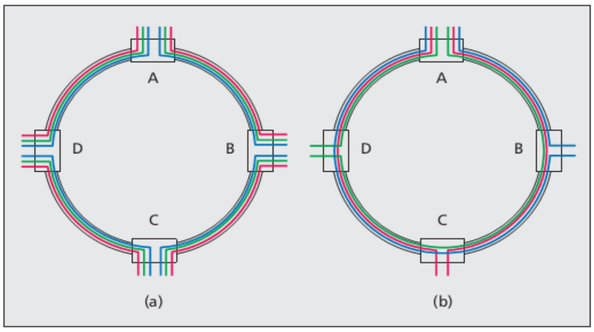


Fig.8. main functions of DWDM: a) making multiplex / demultiplex, b) delete add.

When the wavelength flexibility enters network, the optical path of a channel is not necessarily limited to linear or ring configurations. Instead, as long as the transmission distance did not matter, wavelength could access any virtual nodes in network using switching performance. Thus, using this new function, the network, at least in the wavelength is like a mesh. Considering network as a mesh, each node within the network instead of acting s as a stopping point on track, serves as a connection point. In this case, the concept of rank (degree) entered ROADM networks. Each degree represents the direction in which a node is connected to another node. Figure 9 illustrates general architecture of a ROADM with four degrees.

After introducing the major applications of multi-degree ROADM, technology has progressed to increase agility of wavelength and overcome the challenges of future networks. Agility wavelength is important for color, and remove / add. A Service is defined as a colorless , so that wavelength can be determined based software controle and is not fixed by physical port, remove / add on ROADM. Colorlessness is created by a source wavelength adjustable and using the delete / add structure that is not dependent to color. remove / add structures of wavelength are usually associated with a particular direction of ROADM. When a wavelength be added to one direction or removed from it(based on monitoring software), it is called directionless. Architecture with no competition makes this possibility that on a single remove / add structure have multiple copies of a wavelength. In the implementation of colorless, directionless, and without competition ROADM, a service can have its own color and direction on condition that this color of wavelengths exists on the network for that direction. Figure 9- (b) shows four-degree ROADM node, colorless, directionless, and without competition ROADM.

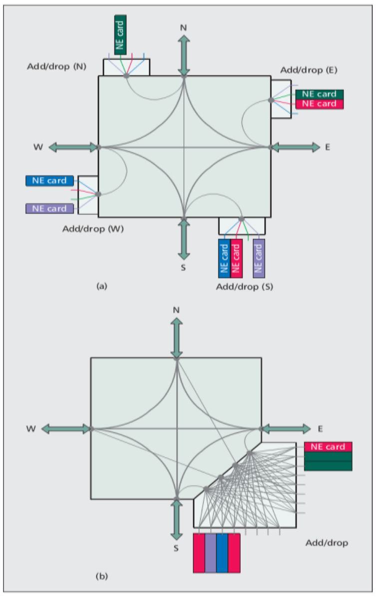


Fig.9. Architectures of - a) original design ROADM, b) plan of colorless plan, directionless, and with no competition ROADM.

IV. Advanced Transmission Node in ROADM Design

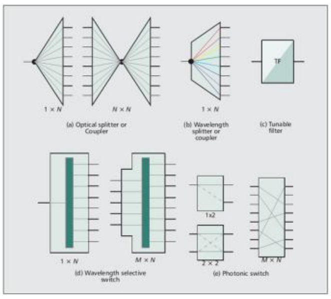
In ROADM operational design, a few basic elements are used. Although ROADM applications are different based on the design goals, but the basic building blocks are quite similar. The differences between ROADM designs show objective of design and performance. For example, the number of fiber grades or ports of remove / add supported according to the node architecture and balance between different parts is varied. Initial cost and complexity of designing affec onger-node scalability. Figure 10 shows building blocks commonly used in implementing ROADMs.

As shown in Figure 10 -a, optical splitter 1 × N distributes optical power of input port (left in the figure) between the output ports on the right side .ratio of power Division between the output ports depends on the device . ratio of power Division is designed to be in frequency range ROADM which is independent of wavelength. fiber coupler 1 × 2 is a typical divider and split ratios of 50/50 or 10/90 are common. When splitter is used in positive direction, it turn to an optical coupler. Power Loss between a pair of input and output ports in splitter configurations and coupler is equal. optical coupler N × N is a generalized example of optical coupler 1 × N. In the case of a coupler N × N, input power per port on each side of the device relative to specified distribution , have been distributed among all ports on the otherside.

As shown in Figure 10 b, wavelength divider (which is also called Multiplexer/ De0-multimplexer of wavelength) is device to separate optical channels with different wavelengths or different "colors" with minimal losses in device (device) is. For example, a tuned waveguide (AWG) is a device that can convert a group of DWDM channels in a fiber to set of separate fibers with a channels in each fiber.

For making AWG devices, Planar light wave circuit technology (PLC) is used. [11]. Thin film technology can be used for making wavelength filters, [12] though these devices have usually small ports. a divider can do combine wavelength or separate them to perform multiplex and De-multiplex. Channel separation is typically performed in a uniform optical frequency. For example, separation of channels can be 50 or 100 GHz. Because divider of wavelength is a passive device, wavelength or wavelengths allocated to each channel are fixed. An adjustable filter (as shown in Figure 10 c) is a device that allows a wavelength or range of wavelengths to pass through and blocks other wavelengths. As shown in Figure 10 d, selective switch of wavelength 1 × N (WSS) is a device that is capable of selectively passing a wavelength or wavelengths from input port to an output port. The 1 × 5 and 1 × 9 WSS are devices that are used in the designing ROADM.

Photonic switches are also a useful building block for the ROADM designs. Photonic switching, without signal conversion to electric field, performs the optical signal routing. As shown in Figure 10 e, the photon switch may have a small number of devices, such as the 1 × 2 or 2 × 2. To make photonic switches, a variety of technologies, including mechanical beam steering, spin polarization, or interference, can be used. [13] photonic switches with many ports can also be helpful for ROADM designs. For example, a photonic switch 320 × 320 with various wavelength dividers can create a flexibile remove/ add structure for a ROADM node. [14]



Most transmitters in optical transport equipment today are equipped with wave-length tunable lasers, and most receivers are equipped with broadband photo detectors. Therefore, the colored add/drop limitation is not due to transmitters or receivers but caused by the add/drop structure.

Fig.10. Common building blocks for ROADM.

Applying main ROADM

As optical transport networks move towards more meshed topology, ROADM designs compared are required to support local connections to a greater degree compared to simple networks based on ring. In Figure 11 a- a 4 ° ROADM is shown. In the original plan, channels are guided to specific degree or the delete / add wavelength.

This is done by optical splitter, wavelength splitter, and WSS. Optical splitter distributes WSS of other degrees. Wavelength splitter, divides channels between remove (drop) ports. To add a channeles, an optical coupler combvines channels an sends channels to a port on the WSS.

Applying Colorless ROADM

In a Colorless design, any wavelength can be allocated to a remove / add port. In the previous scheme, wavelengths divider of each wavelength limited each remove port to only a specific wavelength. To reconfigure the colored wavelength services, the recipient must move towards a port with related removed color. To remove this restriction, WSS can replace the splitter of wavelength, as shown in Figure 11 b, provides discolored performance. WSS is able to direct each wavelength to a specific port in remove structure. At the transmitter side,there is no need to optical coupler, because each sender sends only one wavelength and the optical coupler is not sensitive to color. When the channels are combined by a coupler, crosstalk (unwanted signal in a set of computer communication circuits or interference arises from the presence of traffic on the other channels) between the overlap channels can be problematic. Designs may need specifying ratio of remove on laser side of filtering signals for reducing bandwidth and filtering noise before colorless combination.

Also, using this method, software must protect system against unwanted wavelengths allocation that interfere with channels earlier with the same wavelength. In such scheme, any degree of node has its own remove / add part. Because the structure of remove / add for each degree is unique, wavelength move to another degree requires physical movement of service to the different ports in question. This is a major limitation for designing wavelengths at the network level

Applying colorless and directionless ROADM

Directionless remove / Add Structure makes possibility of free access to a channel in any degree of ROADM and is created by connecting a delete / add structure to any degree on ROADM. It can be done by adding an optical coupler 1 × M to add structure and a 1 × M WSS to the remove structure, as shown in Figure 11 c. [15] Note that with these amendments, it is not necessary to allocated a separate remove / Add a structure to

Any degree of node. As the number of components in colorless and directionless projects increases, in most practical applications to overcome the loss of devices, an optical amplifier in the removal / addition will be required. ROADM deigns without competition, remove restrictions on the wavelength from removes / add part of ROADM node, So that a transmitter, as long as the number of channels with a wavelength is more than the number of degrees of nodes, can be allocated to any wavelength. This architecture ensures that only one node in a structured remove / add is needed. Network designing is simple, because each remove / add port can supports all colors and can be attached to any degree. There are several ways to run the function without competition. Figure 11 d shows an instance with remove / add part equipped with an M × N WSS.

Passage of 100 GB / S with adopting a flexible channel bandwidth

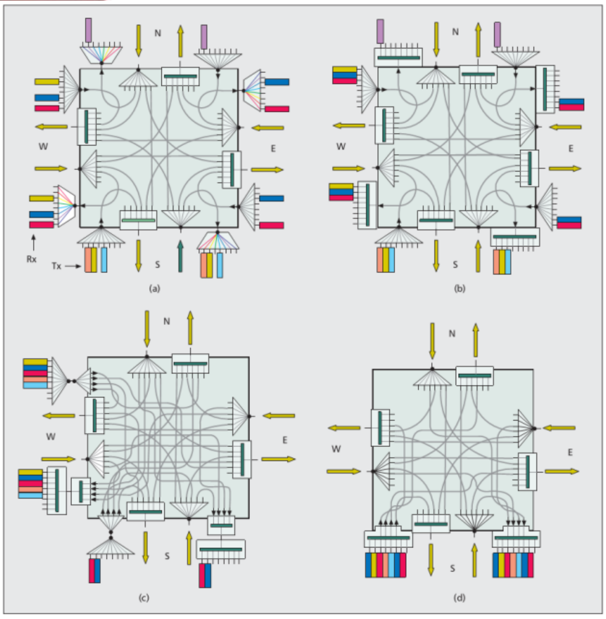


Fig.11. Examples of ROADM designs with different characteristics.

ROADM creates flexibility in the transmission of the optical channels that as defined by the International Union of Telecommunication - Telecommunication Standardization Sector (ITU-T) – have central frequencies. Based on ITU-T G.694.1, frequency of an optical channel is defined with respect to the reference frequency 193.10 THz, or a wavelength of 1552.52 nm. Frequency difference between adjacent optical channels, which is called a channel distance, can be between 5/12 and 100 GHz or more. 100 and 50 GHz are common channel distance that nowadays are commonly used in optical networks. Many adjustable lasers used in transmitters are designed to have locking mechanism of frequency and through this can adjust channel frequency with the network. As the data send rate of an optical channel is rising, advanced modulation also by successfully places channels 40 Gb / s and 100 Gb / s in channel distance of 50 GHz, which was primarily designed to channels 10 Gb / s. To put channels with high data transmission rate within small band width of channel, especially for signals 100 Gb /s, the modulation format got away from the classic connect- cut locking (on-off keying). To reduce the optical bandwidth of a channel, multi-level amplitude and phase modulation is introduced. The most common example in this regard is PMQPSK format that is commonly used for channels 100 Gb / s. [16] , since using format PMQPSK, symbol rate signal 100 Gb / s is just equal a quarter of data transmission rate , modulated signal is placed in a 50 GHz channel. Using channel distance 50 GHz for channels 100 Gb / s, optical spectral efficiency, compared with the signals supporting 10 Gb / s, increased 10 times to 2 b / s / Hz.

ROADM networks with control level ASON / GMPLS

ROADM nodes with the ability of internal control level, automatically switched optical network (ASON), or extended GMPLS, make network performance management with operations automation for distributed software in network simpler. Mesh routing transmission nodes and colorless, directionless remove/ add, increase performance of control level by supporting dynamic regulations and returning of light paths. [17.18] However, in using control level and to maximize use of dynamic features, optical and electrical switching characteristics must be considered. For example, in optical switching, services can be independent of the rate and the format, but are impacted by physical layer requirements such as OSNR, dispersion of light, and are non-linear. About switching OTN, service are dependent on rates and formats, but are not constrained by physical requirements. Hierarchy OTN (G.709) create fixed containers of different rates and also routing for public services such as Ethernet and SONET.

Recently, standard has been upgraded to support sub slots 1.25Gb / s that support direct routing Gigabit Ethernet. Different sub slots can be combined with a trailing ODUflex to allow flexible allocation of bandwidth higher than 1.25 Gb / s. [19]

Characteristics of optical path of networks based on ROADM

To guarantee the performance of an optical channel, it is necessary that the key characteristics of the light path is chosen, are known [20-24]. Although networks based on ROADM create more flexibility in making optical paths, but require accurate identification of the optical paths in the network. When the network is working, describing the fiber parameters such as mortality, CD, and PMD is done in each area. The main characteristics of the light path and amplifier infrastructure are designed based on these data [25]. These values establish a baseline for the performance of the network, but the working values can be used to verify the performance of the network.

When the network is working, the internal software of optical path routing and values can use range loss and values CD, PMD, ONSR and Q based on the path of light to verify the performance of the newly identified route and track the performance over the life of the system.

Digital signal processing used in a coherent receiver can determine values of the optical path without the need for additional hardware for the system.

PASS BAND SHAPE for an optical channel

PASS BAND SHAPE of an optical channel in a network based on ROADM can affect performance, especially in applications where multiple nodes are in the form of a cascade [26]. As shape of ROADM pass band is not ideal, the greater the number of nodes in the cascade form, the narrower gets bandwidth. The central wavelength accuracy, temperature change, and specific form of the pass band all have role in narrowing.

For example, in an experiment, an optical path, with channel distance 50 GHz had bandwidth of approximately 45 GHz (at point 3 dB) in the first ROADM. When the signal passes from the fifth ROADM in the light path, the bandwidth decrease as 19 percent, and when passes the tenth ROADM fells to 6 percent. In the twentieth ROADM, bandwidth reduced to 31 GHz [27]. Using a cascade consisting of 20 ROADM, because of inter symbol interference, slight reduction occurs because the symbol rate signal 100 Gb / s PM-QPSK is about 28-32 Gbaud.

Group delay, and polarization dependence of an optical channel Group delay and change delay are of the most important features of an optical channel in networks based on ROADM. Group delay is mainly caused by the fibers present in the optical path, while the change delays are caused by optical components within the nodes that lie along the path of light. Chromatic dispersion of the light path is derivative of the group delay with respect to wavelength. Coherent detection using digital signal processing is capable to compensate for the large amount of dispersion in an optical path (over 2000 km of standard fiber single mode). Different Distribution values at work have been reported [28-32]. In a recently published report, group delay within optical channel of test bed DWDM based on ROADM was measured with a 1500 km optical path as shown in Figure 12 [33].

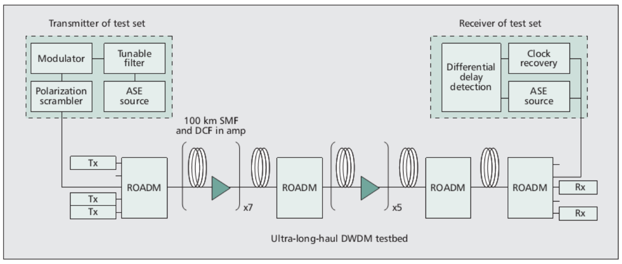


Fig.12. Group delay at work and description of pass band Conclusions

Conclusion

Today, the optical transport networks move towards dynamic structure based on the mesh, thus for optimizing the network designs flexibility of optical node is a major contributor. The architecture proposed in this paper are formed from combination of ROADM based selective switch of wavelength by optical cross-connection.

It will have advantages such as directionless remove / add , dynamic optimization of light paths of device, bridge and rolling light and will also provides reduce of wavelength conversion and subsidiary protection path in mesh optical networks, the benefits of remove / add with no controversy . This property is added to other features such as flexibility, easy prepare, modular remove / add and the need to minimal prior planning and reduces service providers' need to CAPEX and OPEX.

Multi-degree ROADMs to support mesh topologies, and colorless, directionless without competion remove / add structures, will create the necessary flexibility. With the increasing demand for capacity, flexible channel bandwidth needs to optimize access to channels with data transmission rates higher than 100 Gb / s. Guaranteed channel performance and confirm of network parameters will be possible by optical path description. finally, the most important factor in simplifying performance of the network making preparation and auto-correction, which creates a very reliable and can be generalized optical transmission network.

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