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Optical Ring Architecture Using 4-Nodes WDM Add/Drop Multiplexer Based SSMF

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Abstract: *Rapidly increasing on traffic demands in network due to different service applications like broadband access, and video on demand pushing to deployment optical network. In this article, we demonstrate simulation of an architecture enabled by the optical wavelength division multiplexer-add/drop multiplexer (WDM-ADM) to introduce wavelength elimination of (O-E-O) operations, and satisfy reconfiguration requirements and to enhance network protection. Furthermore, this architecture is truly scalable in term of handling additional wavelengths or nodes with efficiently manner. This simulation can be applied on the existing optical fiber communication network with ultimately reduce the cost, and operational expenditure for overall network system. To be design, simulate, test, and verified our architecture we use the OptiSystem 7.0 Package is a license product of Optiwave Corporation (Canadian Based Company).*

1. INTRODUCTION

Rapidly growth in the demand of bandwidth need to creating the foundations and upgrading the optical network infrastructure. The network hardware has been improving along with the bit rate [1], and [2]. An optical add/drop multiplexers (OADM) are an emerging technology that can be used to reduce the number of conversions between the electrical and optical domains and frame processing time, thus, decreasing the delay of the network. The objective is the deployment of an optical network layer with the same flexibility as the equivalent synchronous digital hierarchy (SDH), because it is more economical and allows a better performance in the bandwidth utilization. OADM are the simplest passive element to introduce wavelength management capabilities by enabling the selective insertion (add), and removal (drop) of optical channels. Also, providing an access to all the wavelengths of the wavelength division multiplexer (WDM) signals with more flexibility to satisfy reconfiguration requirements and to enhance network protection [3].

The OADM, can be divided into two categories namely, static (fixed), and dynamic (reconfigurable). The former type typically enables drop and/or add predetermined channels while the latter type can provide much more flexibility, that is, channels can be added dynamically. OADM, with the ability to selectively drop and/or add individual channel or subset of wavelength(s) from the transmission system without full opto-electronic regeneration of all wavelengths makes it possible to manipulate the traffic on the wavelength basis at the optical layer [4]. By using WDM technologies , more users are allowed through each port, and high bandwidth light paths are provided for users, although the number of wavelengths that can be contained is still limited [5], and [6].

The cost is an important problem in designing and implementing any system, especially the recent business downturn puts more significant pressure on substation cost reduction while improving performance simultaneously. By elimination optical-electrical-optical (O-E-O) operations, cost reduce, and operational expenditure (OpeExp) for overall network system [7].

2. OPTICAL SWITCHING

Refer to Metcalfe’s law that the utility of growing in network proportionally to the square of the number of users connected to it[8].Unfortunately, as the number of users in a network increases, the complexity and expense of the network also increases. This leads to two competing goals of network design. The first one is, to allow communication between all network users to maximize Metcalfe’s law. The other goal is that networks must be economical; otherwise no one would use them. Electric switching domain is relatively straightforward. Network frames typically contain a header that contains the source and destination of the frame. As switching is usually done at layer two (Data Link Layer) of the open system interconnect (OSI) model, the address is usually a media access control (MAC) address. The switch reads the destination address and forwards the frame to the appropriate port on the switch based upon internal address tables.

Optical switching domain is not nearly as easy. The simplest approach is to use a series of conversions. Optical signals are generally switched by first converting the optical signal into an electric signal. The correct output address is determined by the frame header. A second conversion, this time electrical to optical is then applied to the signal before it is sent out on the correct port. This is expensive; the extra conversions and processing introduces delay and raise the cost of the switch. None-the-less, this is probably the most commonly used method of switching used today[9]. A third technique for WDM networks is to use OADMs. An OADM takes a multi-wavelength signal arriving in an input fiber, drops one or more pre-selected wavelengths from the signal, and adds one or more pre-selected wavelengths into the multi-wavelength signal that exits in an output fiber. Wavelengths carrying transit traffic pass straight through the OADM. Processing in an OADM is performed entirely in the optical domain to avoid the conversions between the electrical and optical domains. Thus, there is very little delay introduced in an OADM [10]-[13].

3. EXPERIMENT SETUP

The implemented network was simulated, tested, and verified using the OptiSystem 7.0 Package. The main layout system setup are shown in Fig. 1. Functionality of the WDM-ADM is demonstrated using experimental network in Fig. 2 was used through the experiment. Four nodes (subsystem) each of them have a one input and four outputs, and contains these components (WDM-ADM with frequency (193.1THz), optical attenuator with attenuation (3.8dB) to attenuate optical signals, merge optical signal bands to merges multiple sampled signals into one signal, positive intrinsic negative (PIN) was used to detect an optical signal and convert it to an electrical signal, 4th order low pass Bessel filter with cutoff frequency (0.75*Bitrate), Pseudo-Random Bit Sequence Generator (PRBS), Non-return-to- zero generator (NRZ), Continuous Wave Laser with frequency (193.1 THz) and power with (3dBm), Mach-Zehnder Modulator to modulate an electrical signal on an optical signal, and 2-Forks as passive component), and ring control with iteration loops, an ideal Erbium Doped Fiber Amplifier (EDFA) which is concerned with the values of gain and noise figure, these two values are fairly straightforward, as the gain is set to compensate for power loss in fiber, meanwhile the gain and noise figure are set to (10dB and 4dB) respectively, 4-spans Standard Single Mode Fiber (SSMF) with (12.5km) for each the SSMF it has a step index profile. It is characterized by a large dispersion and a moderate loss. The most common fiber, which complies with ITU-T recommendation G.652, has a typical chromatic dispersion (CD) of around (17ps/nm/km at 1550nm) and loss of around (0.2dB/km). SSMF is attractive because of its moderate loss. In addition it is well adopted to WDM transmission because of its high resistance to nonlinear effects. This is mainly a result of the large CD, which reduces interaction between channels. The Bandwidth is set to 10Gbps, as sequence length equal to (128bits), sample per bit is (64), and number of samples is (8192). By the way, the system architecture was monitored through bit error (BER) analyzer, optical spectrum analyzer (OSA), and oscilloscope visualizer.

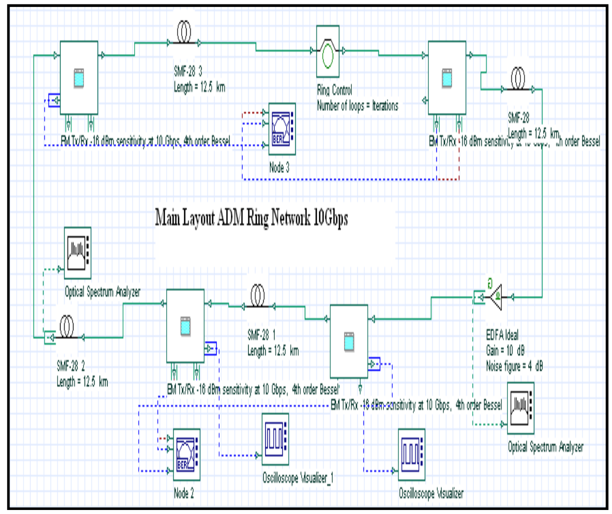

Fig. 1: Main layout ADM network.

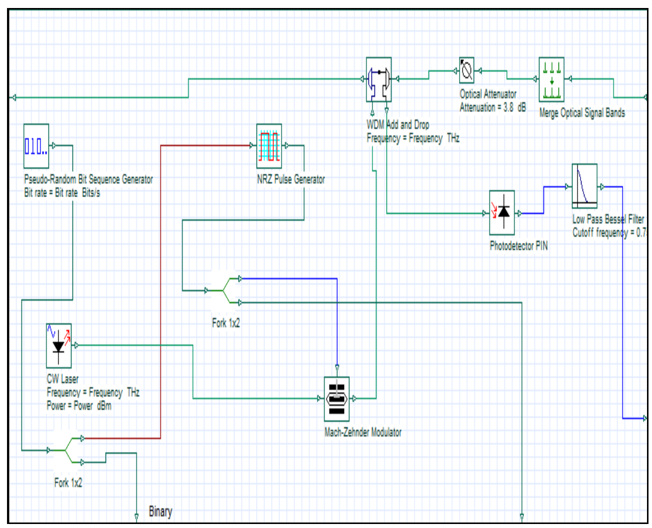

Fig. 2: Show The Subsystem For Each Node.

4. RESULT

The performance of our simulation network is assessed by the BER analyzer on the removed channel Fig. 3 demonstrate the BER performance between node 2, and node 3, Fig. 4 show the BER between node 1, and node 4. As we see in Fig. 4 the power penalty is (-46dBm) measured for all nodes due to cross talk induced by the leak of the signal power. Direct detection eye diagram of the drop channel for a ($5.65*10^{-6}$ and $3.74*10^{-15}$) BER. Fig. 5 shows the power (dBm) versus wavelength (nm) at gain flatness for 10dBm after EDFA. This cross talk lead to small optical signal to noise ratio (OSNR). From the wide horizontal eye opening is present no Inter Symbols Interference (ISI).

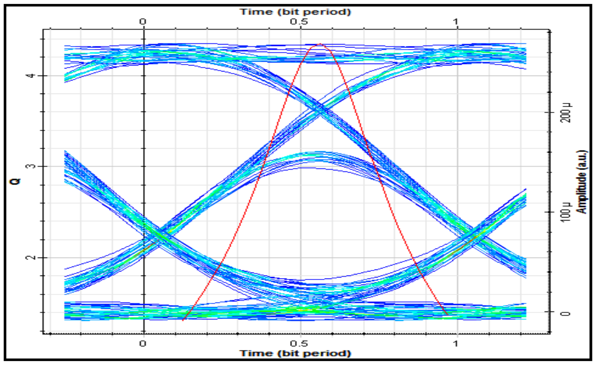

Fig. 3: BER performance between node 2, and node 3.

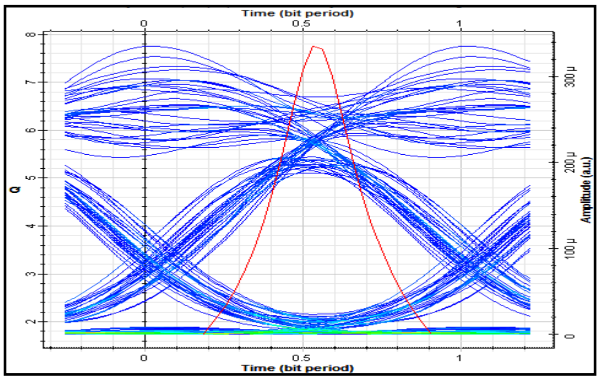

Fig. 4: BER performance between node 1, and node 4.

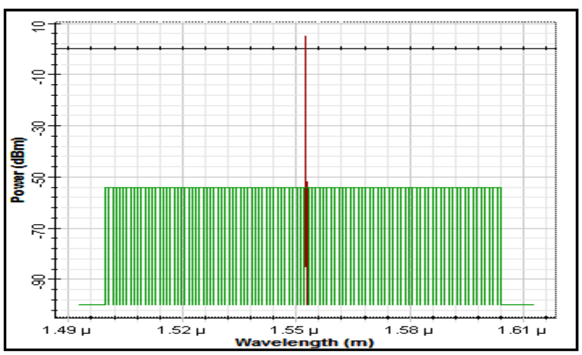

Fig. 5: Output power (red), and noise spectrum (green).

5. CONCLUSIONS

The WDM-add/drop multiplexer utilizing to support communication and distributive services. It is evaluated in ring optical network by 4-nodes. Ring configurations can be deployed with more WDM systems as Dense-WDM (DWDM). Also can be supporting any-to-any traffic, or they can have a hub station and one or more OADM nodes, or other. At any node traffic originates is terminated, managed, and connectivity with other networks. Ring architecture allow nodes on the ring to provide access to network elements such as routers, switches or servers by adding wavelength channels in the optical domain. The obtained results from our simulation by the bit error rate analyzer (BER) less than (10^{-15}), and Max Q-Factor with (4.35) that indicates the network show good performance, provide valuable features such elimination of (O-E-O) operations, and satisfy reconfiguration requirements and to enhance network. protection. Furthermore, this architecture is truly scalable in term of handling additional wavelengths or nodes with efficiently manner. This simulation can be applied on the existing optical fiber communication network with ultimately reduce the cost, and operational expenditure for overall network system.

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