



Review of DWDM Technology in Optical Communication

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Abstract: The cornerstone in communication technology is dense wavelength division multiplexing (DWDM). In this paper, an intensive review of the DWDM and its hardcore analysis is presented. The most exponential changes in communication engineering have taken place in the last several decades with the advent of DWDM to explore the untapped potential of unlimited bandwidth on a fiber pair. Originally applied to solve the problem of fiber saturation in long-distance networks, DWDM is becoming the leading player in all-topical network. DWDM is insensitive to bit rate and format and permits a communications network to enhance capacity without installing new fiber and at a decreased cost with much greater flexibility. DWDM installs narrowly spaced channels onto the same fiber and improve capacity on existing fiber routes by factors of 16, 32, 40, or more. DWDM has also made it feasible for new carriers to enter the contemporary market using IP-based rather than circuit-switched networks at considerably lower costs.

Keywords: DWDM, OXC, SONET, SDH

I. Introduction

In recent decades, the remarkable growth in computer and internet happenings such as communications and networking has created an exponential demand on network capacity, bandwidth and transmission rates. With this unprecedented growth in communication, majority of the carriers are inching towards maximum power consumption throughout the scale of the networks and identifying that their assessment of fiber requirements have been under judged. Different methods developed for capacity expansion: 1) placing more cables, 2) enhancing bit rates of system to multiplex multiple signals or 3) wavelength division multiplexing (WDM). Installing more cables will prove to be a viable method across metropolitan locations, since fiber is getting inexpensive and installation techniques more optimum. This method may not be the most cost cutting, if conduit space is not present or ample construction is desired. Enhancing system bit rate may not prove economical either. Many systems are speeding at SONET OC-48 rates, is costly, demands digging out all the electronics in a network, and adds multiple times the capacity, more than required. However, with the advent of optical networks and the application of DWDM technology, a very crucial benchmark is being reached in network evolution. These networks will invite scale range and intelligence to the optical sphere by assembling the intelligence and functional strength of SONET/SDH, the enormous bandwidth of DWDM and innovative networking tools to spawn a various optical transport and switching based products.

II. DWDM Components

A. Optical Transmitters/Receivers

Transmitters are one of the important DWDM components since they share the source signals which lead to multiplexing of signals. The inheritance of optical transmitters utilized in DWDM systems is extremely important to system design. Multiple optical transmitters are explored as the sources of light in a DWDM system design. Incoming electrical data bits trigger the modulation of a light stream. Lasers give birth to various pulses of light. Each light pulse has matching wavelength.

An intermediate line repeater

It is located approximately every 80 – 100 km for compensating the loss in optical power, while the signal travels along the fiber. The signal is amplified by an EDFA, which usually consists of several amplifier stages.

B. Optical Cross Connect

OXC switches optical signals from input side to output side. These type of elements are usually independent of wavelength. OXC is positioned at nodes connecting a number of fiber pairs and also back add and removal of local rush of traffic extending the bridge with the service layer.

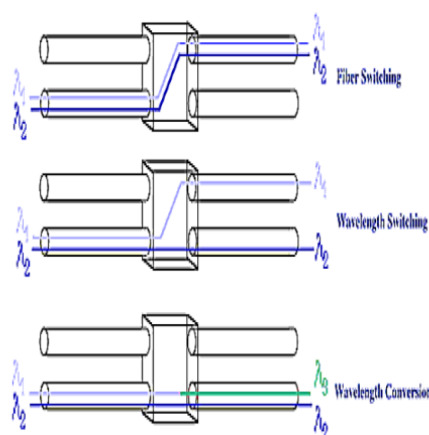


Fig. 1

C. Mux/Demux Filters

Multiple wavelengths designed by multiple transmitters and working on different fibers are assembled onto one fiber. The output end of an optical multiplexer is pointed as a composite signal. At the receiving end, an optical drop filter segregate all of the individual wavelengths of the mixed signal out to individual fibers. The individual fibers allow to pass the demultiplexed wavelengths to multiple optical receivers. The block diagram shows in figure 2 is bidirectional DWDM operation.

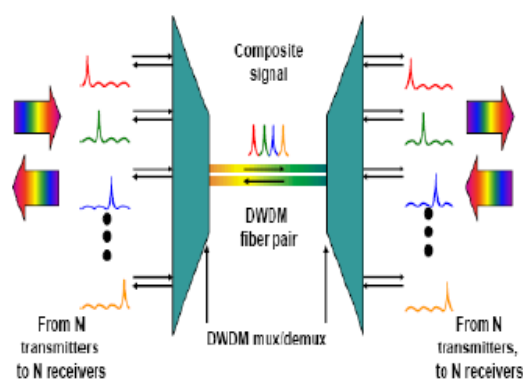


Fig. 2

D. Optical Add/Drop Multiplexers

Fig.3 presents the operation and working of a one-channel OADM. This OADM is designed and created to only add or drop optical signals with a particular range of wavelength. An incoming composite signal is divided into two components, drop and pass-through. The OADM leaves only the red optical signal stream. The dropped signal stream goes to the receiver of a client end device. The pending optical signals that go through the OADM are multiplexed with a new add signal stream. The OADM pushes a new red optical signal stream, which runs at the matched wavelength as the dropped signal.

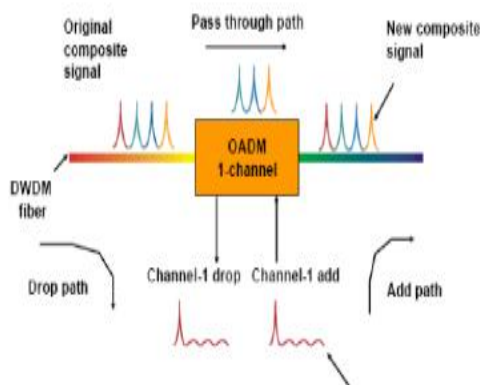


Fig. 3

E. Optical Amplifiers

Optical amplifiers (OAs) boost the amplitude or plus gain to optical signals passing on a fiber by directly trigger the photons of the signal with extra energy. They are —in-fiber devices. OAs amplify optical signals across a wide range of wavelengths.

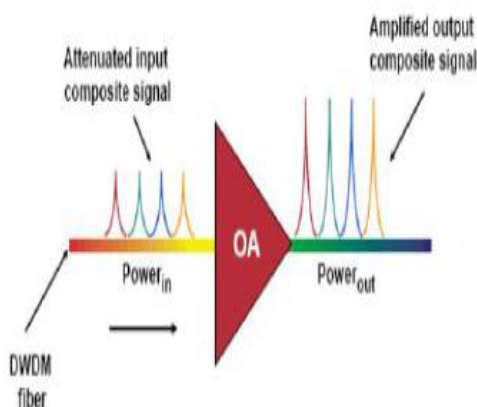


Fig. 4

F. Transponders

Transponders convert optical signals from one incoming wavelength to another outgoing wavelength suitable for DWDM applications. Within the DWDM system a transponder translates the client optical signal back to an electrical signal and then performs either 2R (reamplify, reshape) or 3R (reamplify, reshape, and retime) functions. The block diagram shows bi-directional transponder operation. A transponder is located between a client device and a DWDM system.

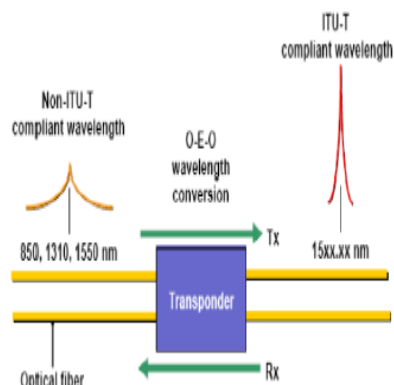


Fig. 5

G. Optical Transmission Principles

The DWDM system has an important photonic layer, which is responsible for transmission of the optical data through the network and is governed by various parameters like:-

□ **Channel Spacing:** Separation of two different signals multiplexed based on minimum frequency is known as the Channel spacing.

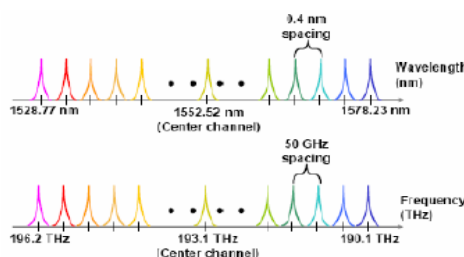


Fig. 7

□ **Signal Direction:** A fiber based on optical design assists in inflow of signal in duplex. DWDM system design based on two categories - Unidirectional, Bi-directional.

□ **Signal Trace:** Detection of a signal reaches the desired destination at the other end is called signal trace. This directs the light signal through the whole network via plugging in extra information on a wavelength, using an electrical.

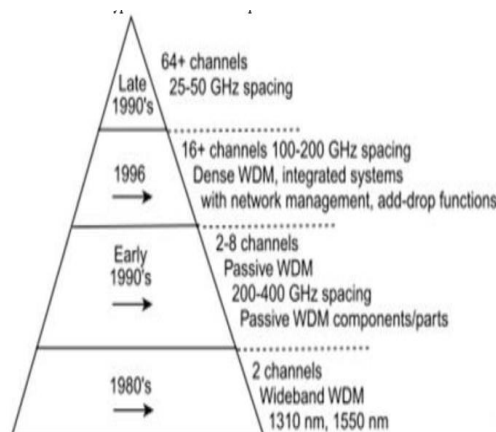


Fig. 8

III. DWDM Architecture

DWDM architecture is explained as below:

The transponder acknowledges the input as standard single-mode or multimode laser pulse. The wavelength of the transponder input signal is mapped to a DWDM wavelength. A post-amplifier boosts the strength of the optical signal as it leaves the multiplexer.

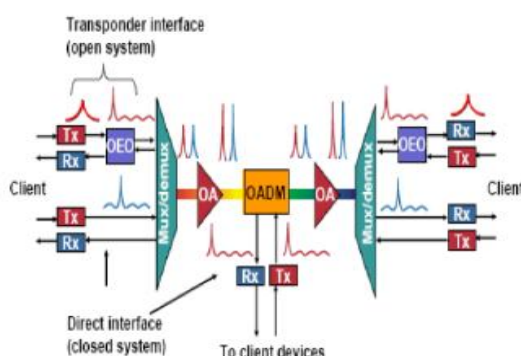


Fig. 9

IV. Attenuation

Attenuation is the process of the reduction in signal level measured in dB.

- **Fiber Loss**

Impurities in optical fiber absorb energy from a passing light signal.

- **Splicing & Connectors Loss**

Optical loop found in fiber splices and connectors fetches or deflects energy from a passing light signal.

- **Insertion Loss**

Loss encountered when multiple optical signals are multiplexed together or when a multiplexed signal is demultiplexed.

V. Dispersion

It is the expansion of a signal as it browses the fiber. It gateways to the signal distortion which bounded the horizon of the fiber.

VI. Conclusion

In this research, authors presented different dynamics of DWDM and its contemporary advancements. In-depth study of different DWDM frameworks are also provided. It is bench-marked that DWDM will revolutionized communication innovative networks, In opposite, the current coupling architectural design and advanced protocols will contribute to the incoming DWDM based benchmarks. Because of the advance switching based design and bandwidth presence via DWDM. The coupling of all the components attached to a DWDM framework is oxygen to the architecture design of the system. From transmitter end to receiver end, the

magnitude and quality of entire optical signal range must be consistent. Amplifiers based on optical design enhances the domain of DWDM systems by eliminating losses by spreading of attenuation. Compensation devices based on dispersion can reduce the intensity of dispersion of a specific range, hence optimize the length of transmission capacity.

REFERENCES

- [1] G. P. Agrawal, *Lightwave Technology: Telecommunication Systems* (Wiley, Hoboken, NJ, 2005).
- [2] G. P. Agrawal, *Lightwave Technology: Components and Devices* (Wiley, Hoboken, NJ, 2007).
- [3] G. P. Agrawal, *Fiber-Optic Communication Systems*, (Wiley, Hoboken, NJ, 2009).
- [4] R. Ramaswami and K. Sivarajan, *Optical Networks* (Morgan, San Francisco, 2009).
- [5] I. P. Kaminow, et al., "A Wideband All-Optical WDM Network", *IEEE Journal on Selected Areas in Communications*, Vol.14, No. 5, June 1996, pp. 780 - 799.)
- [6] Melián, B., Laguna, M., and Moreno, J.A., "Capacity expansion of fiber optic networks with WDM systems: Problem formulation and comparative analysis", *Computers and Operations Research*, 31(3) (2004) 461- 472.
- [7] Lu, Ying and Ersoy, Okan K., "Dense Wavelength Division Multiplexing/Demultiplexing by the method of Irregularly Sampled Zero Crossings" (2003). ECE Technical Reports. Paper 154. <http://docs.lib.purdue.edu/ecetr/154>.
- [8] Hiroshi Yoshimura et al, "Future Photonic Transport Networks Based on WDM Technologies", Volume 37, No 2, pp 74-81, February 1999.
- [9] P. V. Hatton and F. Cheston, "WDM Deployment in the Local Exchange Network", *IEEE Communications Magazine*, February 1998.
- [10] Lars Thylen, et. al., "Switching Technologies for Future Guided Wave Optical Networks: Potentials and Limitations of Photonics and Electronics", *IEEE Communications Magazine*, February 1996.
- [11] J.Anderson, J.Manchester, A.Rodriguez-Moral, M.Veeraraghavan, "Protocols and Architectures for IP Optical Networking", *Bell Labs Technical Journal*, Jan-Mar 1999.
- [12] K. C. Chan, et. al., "Application of Optical Solutions in High-Speed and Wavelength-Division-Multiplexed Light wave Communication Systems", *Journal of High Speed Networks*.
- [13] WDM: North American deployment trends: J.P. Ryan, *IEEE Comm.*, Feb '98.
- [14] J. Luciani, B. Rajagopalan, D. Awuduche, B. Cain, BilelJamoussi, DebanjanSaha, "IP Over Optical Networks - A Framework", , November 2000.
- [15] J. Luciani, B. Rajagopalan, D. Awuduche, B. Cain, BilelJamoussi, DebanjanSaha, "IP Over Optical Networks - A Framework", , November 2000.
- [16] Greg M. Bernstein, Jennifer Yates, DebanjanSaha, "IP-Centric Control and Management of Optical Transport Networks," *IEEE Communications Magazine*, October 2000.
- [17] J. R. Kiny, "Wavelength Division Multiplexing: Ultra High Speed Fiber Optics", *IEEE Internet Computing*, March-April 1998 http://www.ee.columbia.edu/~bbathula/courses/HPCN/chap04_part-3.pdf.
- [18] Victor O. K. Li, et. al., "Wavelength Conversion and Wavelength Routing for High-Efficiency All-Optical Networks: A Proposal for Research on All-Optical Networks", *Journal of High Speed Networks* 4 (1995).
- [19] Wilner, Alan, "Key limitations in WDM systems and networks", *Conference Proceedings, SPIE*, Vol. CR 71, pp. 220-245, 1999.
- [20] B.T.Doshi, S.Dravida, P.Harshavardhana, M.Qureshi, "Comparison of next-generation IP-centric transport architectures", *Bell Labs Technical Journal*, Oct-Dec 1998.
- [21] <http://www.cse.wustl.edu/~jain/cis788-99/ftp/dwdm/index.html>
- [22] <http://www.thefoa.org/tech/dwdm.htm>
- [23] <http://www.cse.wustl.edu/~jain/cis788-99/ftp/dwdm/index.html>
- [24] http://www.cse.wustl.edu/~jain/refs/opt_refs.htm