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Review of DWDM Technology Development and its Future Aspects

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ABSTRACT

This contribution gives a brief review of Dense Wavelength Division Multiplexing (DWDM) architecture. DWDM transmission system have been used in commercial networks to transmit data over long distances. DWDM is most advantageous technique to reduce transport cost per bit and operating cost with the capability of more bits per second transmission over long distances with intelligent network flexibility and performance monitoring feature

Keywords: DWDM network, rainbow effect, photodetectors, Avalnche Photodiode, optical networks

INTRODUCTION

Nonlinear effects arising from reduced channel spacing and increased number of channels will be one of the major impairments in future wavelength-division-multiplexing.(DWDM) systems[1].The bandwidth demands for recent Optical Fiber communication and telecommunication networks are rapidly increasing worldwide. Reasons are increasing number of users in communication networks and development of new service with higher bandwidth requirements leading to an exploding growth especially of data traffic. A photonic network[6] represents a promising way to cope with demands.

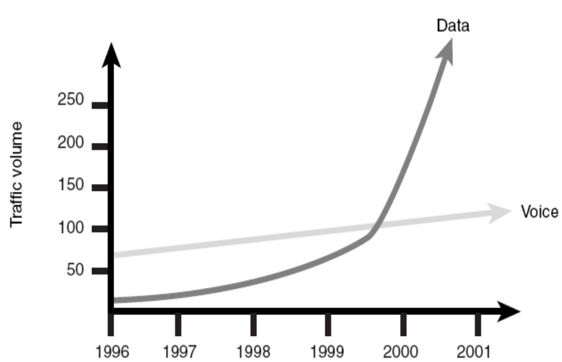

Fig- 1 Traffic Growth

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Already today, optical point to point links are used in many networks and real optical networks are already becoming apparent. There is 300% growth per year in internet traffic, while traditional voice traffic growth at a compound annual rate of only about 13% as shown in fig-1.Wave Length Division Multiplexing (WDM) is an answer to all these problems. In WDM system each of wavelengths is launched in to the fiber and the signal are demultiplexed at the receiving end. WDM carries each input signal independently of the others. This means that each channel has its own dedicated bandwidth; all signals arrive at the same time, rather than being broken up and carried in time slots as in TDM. Wavelength Division Multiplexing (WDM) can be more efficiently utilized by closing the spacing between the wavelengths and therefore its capacity is getting increased by many times, this technique is known as Dense Wavelength Division Multiplexing (DWDM). [8]

Advancement in fiber optics closely tied the use of specific regions on the optical spectrum where optical attenuation is low. These regions are called windows. In early stages it operated around 850 nm, known as first window. The second window was developed at 1310 nm, third window in C band at 1550 nm, fourth window in L band at 1625 nm. From both technical and economic perspective, the ability to provide potentially unlimited transmission capacity is the most obvious advantage of DWDM technology. Not only current investment in fiber plant can be utilized efficiently by the use of DWDM but also it can be optimized many times by the current rate.[5]

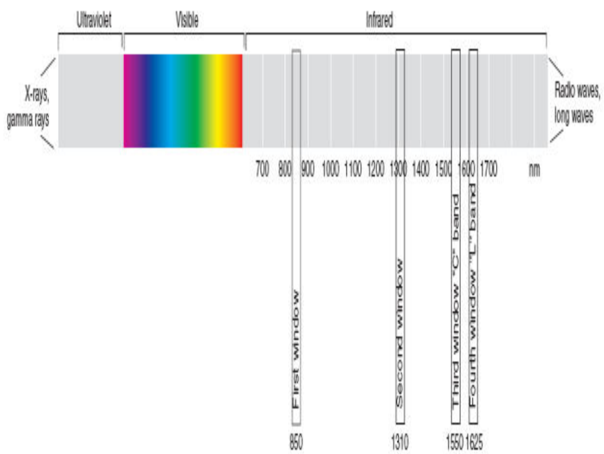

Fig- 2 Wavelength Regions

In early stages of WDM, two widely spaced wavelengths in 1310nm and 1550 nm regions were used, sometimes called as wideband WDM. In the second generation of WDM, narrowband WDM in which two to eight channels were used,these channels are now spaced at an interval of about 400 GHZ in 1550 nm window as shown in fig- 2. The furthermore advancement in WDM technology lead to DWDM technology with 16 to 40 channels, spacing from 100 GHZ to 200 GHZ. Later stages of DWDM evolved with the capability of 64 to 160 channels, densely packed at 50 GHZ to 25 GHZ intervals.[2]

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Table No. 1

S.No.	Generation of DWDM	No. of Channels	Spacing Between channels
1	I Generation	16 to 40	100 - 200GHZ
2	II Generation	64 to160	50-25 GHZ

This advancement in technology can be seen as an increase in the number of wavelengths accompanied by a decrease in the spacing of wavelengths. Along with this advantage the system becomes more flexible from configuration and capability point of view.

DWDM Network Architecture

Various component and sub-system are necessary to realize photonic networks as shown in fig. 3.

- A transmitter which is precisely a LASER with stable wavelength and a multiplexer to combine the wavelengths.
- A transmission media which is typically optical fiber with flat gain amplifiers to boost the signal on span.
- A detector at receiving end such as photodetectors and optical demultiplexer using thin film filter.[4]

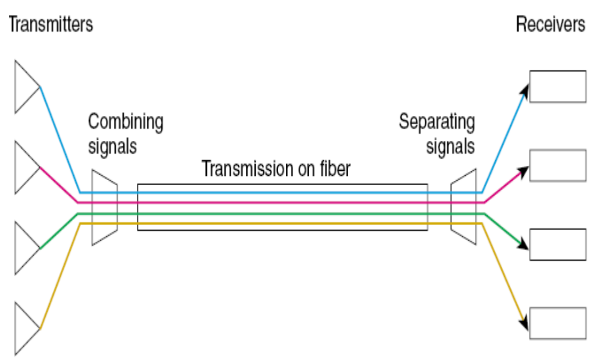

Fig-3 DWDM Network Architechitecture

At transmitter end for generating the signal semiconductor and optical lasers are used. The semiconductor lasers, monolithic Fabry-perot lasers, and distributed feedback (DFB) lasers are variety of lasers which are commonly used. The DFB lasers well suited for DWDM application as it emits a nearly monochromatic light, is capable of high speed, has a favorable signal to noise ratio, and has superior linearity. DWDM system incorporates multiplexers and demultiplexers for the purpose of combination and segregation of signals. There are some losses associated with multiplexing and demultiplexing. These loses are dependent on number of channels but can overcome by the help of optical amplifiers, which boost all the wavelengths at once without electrical conversion. Mutiplexing and demultiplexing can be done using a prism. In this technique a beam of light impinges on the surface of prism and then each wavelength is refracted differently as

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shown in fig-4. This is known as Rainbow effect. A lens then focuses each wavelength to the point where it is needed to enter in to the fiber. A different technique based on principle of diffraction and of optical interference can also be used. In this technique, light source when impinges on diffraction grating, gets diffracted at different angels. Arrayed waveguide grating (AWG) based on this principle can be used for the above stated purpose. Another approach using interference filter in device can also be used which is also known as thinfilm filters or multilayer interference filter.

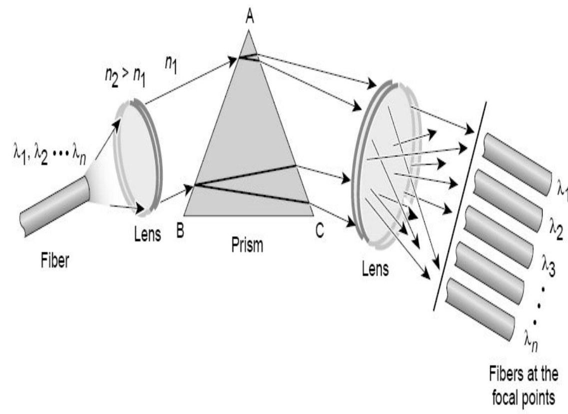

Fig- 4 Prism refraction demultiplexing

Attenuation limits the range of optical signals. So optical amplifiers are used to resolve the problem of attenuation. An optical amplifier amplifies all the wavelengths at once without optical to electrical, electrical to optical conversion. Erbium doped fiber amplifier (EDFA)[3] have the ability to provide significant amplification in all transmission window. Erbium when exited emits lights around 1.54 micrometers. It is the low loss wavelength for optical fibers used in DWDM. EDFA can provide gain of 30 dB or more and is capable of providing output power amplification of 17 dB or more. EDFA have advantage of high gain, low noise figure, wide bandwidth and high saturation output power.[9] These pictures of EDFA seem to be very attractive to support the DWDM optical networks.

Optical fiber acts as the medium for carrying the signal. Optical fiber guides the light waves with a minimum attenuation. Optical fibers recomposed of fine threads of glasses in layers, called core and cladding, that can transmit light about two third the speed of light in vacuum. Optical fiber uses principle of total internal reflection to transmit the signals. We use two types of fibers namely step index and graded index fibers. In step index fiber there is a uniform refractive index of the core while in graded index fiber the core of the fiber is graded i.e. it gradually decreases from the center of the core outward.[7] At the receiving end the signals of different wavelength are to be recovered by the photodetectors. Photodetectors are wideband devices thus optical signals are to be demultiplexed before reaching the detector. Two types of detectors are widely used namely Positive intrinsic negative (PIN) and Avalanche Photodiode (APD). APD provide gain through an amplification process one photon acting on the device releases many electrons and have higher received sensitivity and accuracy.

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Along with bandwidth considerations there are other features of DWDM that can be given as follows-

1) Transperancy- DWDM supports both TDM and data formats such as ATM, Gigabite ethrnet, ESCON and Fiber channel with open interface over a common physical layer as it is physical layer architecture.
2) Scalability- DWDM accomplishes the task to quickly meet the demand for capacity on point to point link and on spans of existing SONET/SDH rings.
3) Dynamic Provisioning- In DWDM network connection is fast, simple and dynamically provisioned which provides the ability of high bandwidth services in days rather than months.

CONCLUSION

This paper gives an overview on photonic network based on DWDM as a key technology to efficiently use of huge bandwidth available on fiber. By using graded index fiber and changing the grading of the fiber we can accommodate more number of channels on the fiber. DWDM enhances the bit rate or the data transmission thus it is widely deployed in Metropolitan Area Networks (MAN).

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