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IP Over DWDM

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Abstract

This paper completely deals with optical signal transmission; with encapsulation entire raw packets are converted as optical signals. Since the usage of internet and intranet are increasing day by day, the demands for bandwidth are also getting increased. In order to meet this demand, DWDM is deployed. DWDM enables service providers to accommodate consumer demand for ever-increasing amounts of bandwidth. This supports bit rates upto OC-192.

Keywords: DWDM, IP, Jumbo frame, Optical amplifier, optical multiplexer and demultiplexer.

Introduction

Since the internet traffic is growing exponentially, the need for bandwidth was also getting increased. The concept behind IP over DWDM is transmitting data packets through an optical layer using DWDM. Optical network deals with end-end delivery, without the need of electrical conversion the data packets are transmitted in optical domain. In optical network, the photonic layer is responsible to convert raw packets to an optical signal and the entire management is carried out by an photonic layer.

Need IP over DWDM

Initially IP packets cannot be transmitted directly through DWDM, the reason is IP packets are carried through Ethernet frames. Ethernet frames are electrical frames, this frames are not supported by DWDM because DWDM fully deals with optical signal. So it is necessary to provide encapsulation, then the encapsulated data is mapped onto the SONET (synchronous optical network) frame i.e. STM-16 or STM-64. SONET was used as standard interface between the physical layer and media, the service provided by the SONET was not very fast and it offers services at constant bit rate. The major disadvantage is it cannot be used in bursty internet traffic. In order to reduce the latency and to increase the bandwidth, we go for IP over DWDM.

IP Directly Over DWDM WHY?

IP supports all data like audio, video, images, videoconferencing, multimedia etc the revenue obtained through IP is very high. DWDM offers ever increasing amount of bandwidth as per the customer demand at low cost at low cost. The service provided by both the combination is very high and also it avoids the cost of SONET AND ATM equipment. There is no need of electrical conversion and it supports bit rates upto OC-192 .

Architecture of IP over DWDM

In telecommunication networks, optical layer is consider as main transmission layer, the common transmission layer above the optical layer are SONET, ATM,IP. Types of architecture exist are closed architecture and open architecture, it is shown in figure. 1. The main drawback SONET is suitable for voice and ATM is suitable for data. The advantage of using IP is, it supports audio, video, voice, multimedia etc.

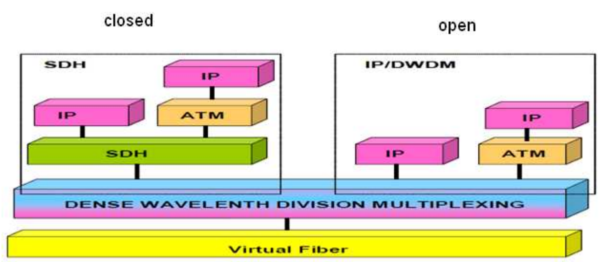

Figure. 1 Architecture

If we consider closed architecture IP cannot be directly transmitted through DWDM, because IP data's are carried by Ethernet frames and it supports only electrical transmission, and it is not possible to merge or map this IP data's directly in SDH frame. To merge the IP in SDH frame, encapsulation is must. Encapsulation is provided by point-point protocol and HDLC framing, and then the encapsulated frames are directly mapped or merged in SDH frame. This originates optical transmission in the optical layer.

Now consider the open architecture, here internet protocol data's are transmitted directly through DWDM without the need of encapsulation. The photonic layer is responsible to convert raw packets to optical signal.

5. Layer functions

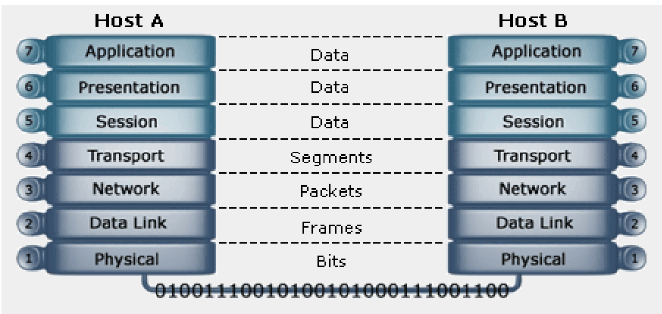

Figure. 2 Functions of layers

Functions of layers are shown in figure. 2 and it is clear that the application, presentation and session layer take the input and converts it into data, then the transport layer adds a segment header converting the data into segments, and the network layer adds a network header and convert the segments into packets.

The data link layer adds a frame header converting frames into bits and the MAC sub layer is converts the frame into number of bits. The physical layer is responsible for selecting the suitable medium in order to transmit the number of bits.

1. Photonic Layer

Photonic layer is responsible for converting raw packets into optical signal, and the entire management in an optical network is also carried by this layer.

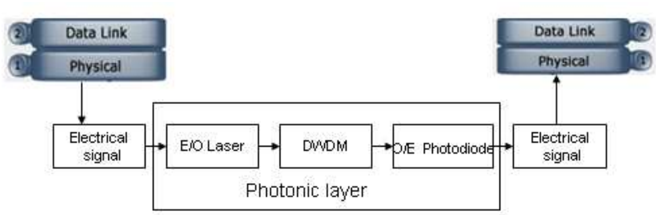

Figure. 3 Photonic layer operations

The above figure. 3 clearly explain clearly about the operation of photonic layer. The physical layer is responsible for transmitting bits through the transmission medium, those bits are electrical bits. Here we deal with optical transmission, so it is necessary to convert all electrical bits into optical signals.

At the transmitter side bits are represented as 0's and 1's, it is a voltage signal. That voltage signals are used to drive the LASER source, the source is distributed feedback laser, and it is used to produce optical power as output at some wavelength. At the receiver side an photo detector is used to convert the optical signals into electrical signal.

2. Super Jumbo Frames

Figure.4 is frame format of an jumbo frame. The preamble consists of seven bytes all of the form 10101010, and is used by the receiver to allow it to establish bit synchronization, if there is no clocking information nothing is being sent. The SFD is a single byte, 10101011, which is a frame flag, indicating the start of a frame. The source and destination address are 6 bytes, it contains the address of the sender and receiver. The length/type indicates the number of data in the frame i.e. payload, the maximum payload utilized in jumbo frame is 48 bytes to 9000 bytes. Frame check sequences are used for error detection purpose at the receiving end.

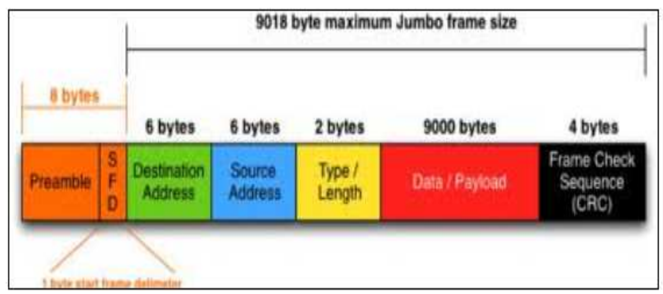

Figure. 4 Frame format

Normally IP data's are carried by an Ethernet frame, which has the maximum transmission unit as 1500 bytes. That can produce optical output signal but is not large enough to transmit over a long distance. The drawback is if any frame gets damaged or corrupted once again it has to be transmitted, so the time to process in all layers will be more because of that performance throughput gets affected. To avoid all these problems super jumbo frames are used were the maximum payload is 9000 bytes, the optical power produced by this frame is large enough to transmit over a long distance. In case of error, during retransmission the process time also get reduced, with this 99.5% throughput can be achieved .

7. DWDM System

Dense Wavelength Division Multiplexing (DWDM) is the process of multiplexing signal of

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different wavelength onto a single fiber. Through this operation, it creates many virtual fibers each capable of carrying a different signal. At its simplest, DWDM system can be viewed as a parallel set of optical channels, each using a slightly different light wavelength, but all sharing a single transmission medium. This new technical solution can increase the capacity of existing networks without the need for expensive re-cabling and can reduce the cost of network upgrades.

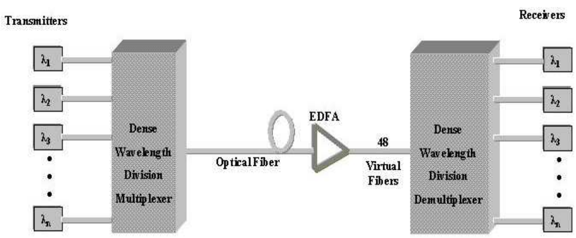

Figure. 5 DWDM Systems

DWDM performed on an optical fiber serves as the underlying carrier for the optical network. The narrow channel spacing of about 1nm characterizes the system. Fig.1 depicts the general structure of the DWDM system. The Erbium doped Fiber Amplifier (EDFA), Multiplexer and the Demultiplexer form the vital blocks of the system.

The concepts of optical fibre transmission, loss control, packet switching, network topology and synchronization play a major role in deciding the throughput of the network.

Simulation

Here we consider three types of data video, audio and images, each are transmitted at different wavelength. Sine wave is used to represent the optical signals, which are shown below. Simulation was performed at the physical layer by using .NET. This was explained step by step with the help of output produced in every stage.

a) Generating the signal

The IP packets are carried by Ethernet frames, type of Ethernet frame we preferred is super jumbo frames which has the maximum transfer unit 9000 bytes. At the physical layer data are represented as bits i.e. voltage signals. This voltage signals drives the tuneable transmitter and produce the optical power as output.

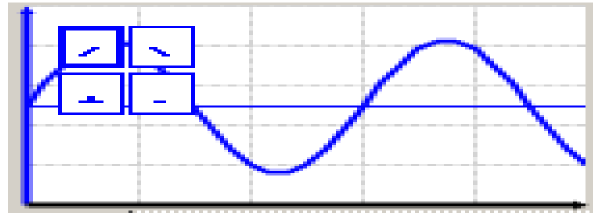

Figure. 6 (a) Audio Signal

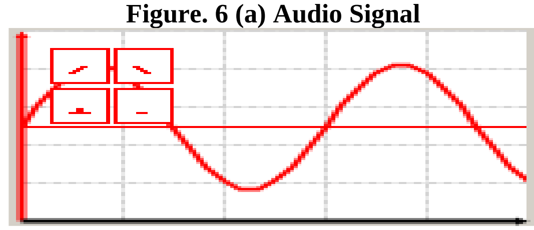

Figure. 6 (b) Video Signal

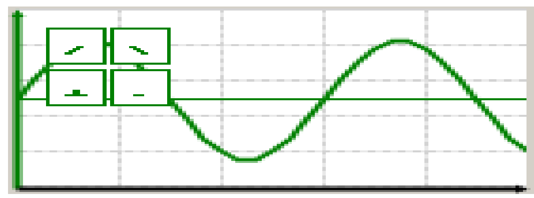

Figure. 6 (c) image Signal

The source, a solid-state laser, must provide stable light within a specific, narrow bandwidth that carries the digital data, modulated as an analog signal. Here we have taken audio, video, image for transmission through DWDM, depend upon the capacity of the data optical signals are produced. Figure 6(a) 6(b) 6(c) shows the optical signal representation of audio, video and image data.

b) Multiplexer

The transmitters are wavelength dependent, so each and every transmitter should transmit their signals in its specific wavelengths. The function performed by the multiplexer is to combine all the signals at different wavelength and are transmit through the single fiber. The simulation related to multiplexer was shown in figure. 7.

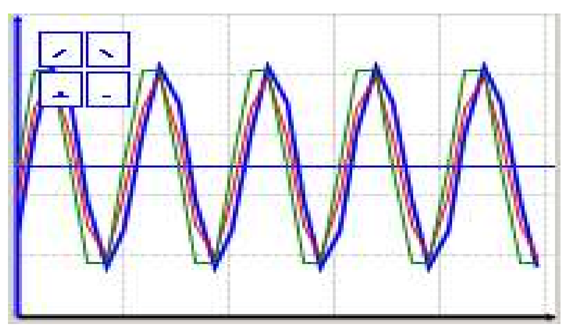

Figure. 7 Multiplexing the signals

Some inherent losses occur in the multiplexing block; the losses depend upon number of transmitters or no of users. Those losses can be controlled by varying parameters like optical power and channel spacing. The above figure. 7 shows, the optical signal produced by all transmitters are in phase with each other.

c) **Transmission Media**

The transmission media is needed to transmit the signals from one host to another host, the preferred transmission media is single mode fiber,G.652 is commonly used but it is characterized by large amount of chromatic dispersion at C (1530-1565 nm) and L (1565-1625 nm) bands, needs dispersion compensation when a system has a transmission rate exceeding 2.5 Gbps. When G.652 fiber is operating at 10 Gbps, dispersion compensation is costly so it is not used for long distance communications. So we go for dispersion shifted fiber.

G.653 fiber is a kind of dispersion shifted fiber (DSF), whose dispersion is greater than -1 ps/nm/km and less than 3.5 ps/nm/km at C and L band regions. It has the smallest amount of chromatic dispersion at C band. The maximum dispersion value for G.653 fiber is about one sixth of that for G.652 fiber. With the zero-dispersion wavelength of G.653 fiber set at 1550 nm band, systems can operate at bit rates of 20 Gbps or 40 Gbps.

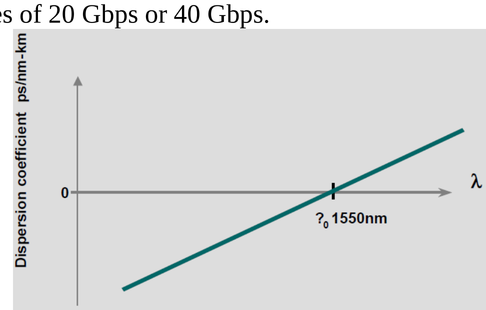

Figure. 8

Therefore, G.653 fiber is the best choice for ultra long-haul transmission over a single wavelength. Dispersion-shifted fibers have been created to take advantage of the best of both worlds: by shifting the zero-dispersion wavelength into the 1550nm band we also operate at the lowest possible attenuation.

d) Amplification

The losses occurring at the multiplexer are compensated and In order to transmit signals over long distances it is necessary to compensate for attenuation losses within the fiber.

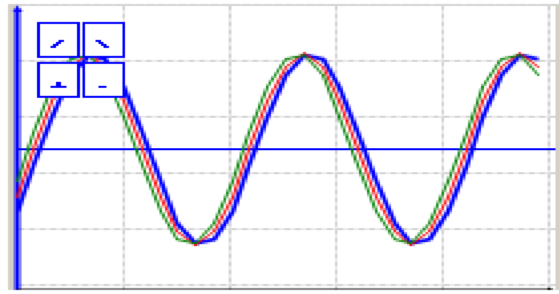

Figure.9 Optical amplification

The output of Optical amplification is shown in figure. 9 The output of optical amplification is shown in figure. Since we deal with optical network, inline amplifier is used for amplification along the transmission channel. The function performed by optical amplifier is to boost the incoming signal in order to reduce compensate the losses which occur in the signal during transmission. There are number of optical amplifier available among that the suitable simplifier is erbium doped fiber amplifier. EDFA boost the optical signal, without the need of electrical/optical (E/o) or optical to electrical (o/E) conversions. EDFA can be used in co-propagation direction and also counter propagation direction it has two pump which operate at 980nm and 1480nm. Among two pumps only 980nm is preferred. The reason is noise at this wavelength is very low compared to 1480nm. The gain also can be active up to 30dB.

e) Demultiplexer

De-multiplexing is the process of separating the signals; the output of de-multiplexer is shown in figure. 10, from the above figure the audio signal, video signal and image signal are separated and are received by the particular receiver.

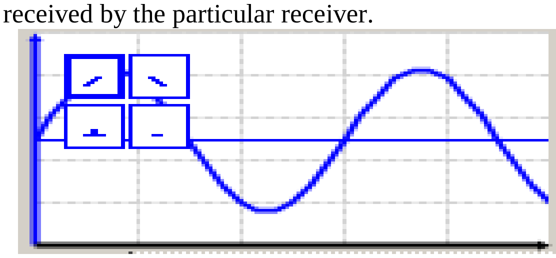

Figure. 10(a) Audio signal

Figure .10(a) represents the audio signal, the audio signal transmitted at the transmitter is received after amplification without any distortion.

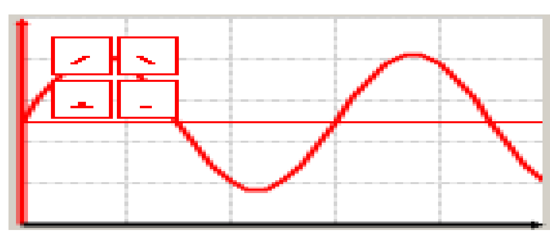

Figure. 10(b) Video signal

Figure .10(b) represents the video signal, the signal transmitted at particular wavelength is received at the receiver.

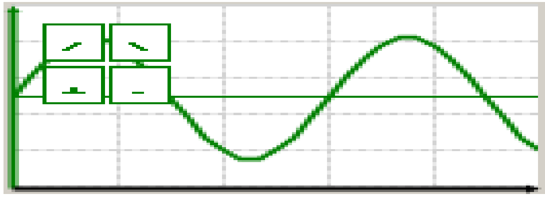

Figure. 10(c) Image signal

Figure .10(a) represents the image signal; the multiplexed signals can be separated by using the prism or optical grating. Normally prism are used to separate the signals along the fiber which propagate at different wavelength can be separated. During de-multiplexing also some losses will occur those losses are compensated by using post amplifier; it is placed in front of the receiver. The transmitters are wavelength dependent but the receivers are not wavelength dependent.

Conclusions

The performance analysis of this paper deals with throughput load and delay, our main objective is to obtain maximum throughput. Initially we use fast Ethernet or gigabit Ethernet frame to carry the data, these frames have the maximum transfer unit as 1500 bytes. The throughput obtained by using this frame is 72% only its not enough so we use super jumbo frames, it has the maximum transfer unit 9000 bytes, throughput obtain through this frame is 99.5%.

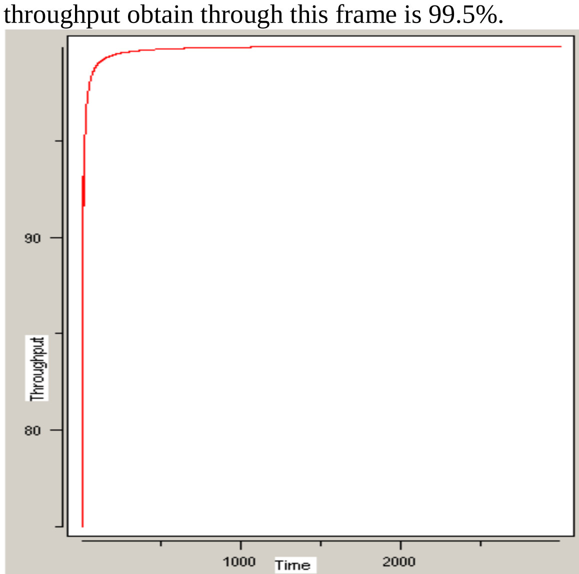

Figure. 11

From the above figure. 11 the maximum throughput achieved is ~100% i.e. 99.5% this is achieved because the retransmission rate, loss of frame during transmission was reduced, the super jumbo frame is a four times bigger than the fast Ethernet frames. So by increasing the maximum transmission unit in a frame very high throughput was achieved.

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