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IMPACT OF OPTICAL NETWORKS ON NEXT GENERATION COMMUNICATION TECHNOLOGIES

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ABSTRACT

In the field of Optical Communication, enormous developments towards Optical Networks carried out so far because of very high Bandwidth potential of Optical Fiber, First major development in the field of optical communication for transferring of digital data/bits based on Time Division Multiplexing (TDM) was Synchronous digital hierarchy (SDH)/ Synchronous optical networking (SONET) which were used for transfer multiple digital bit streams over an optical fiber by using Laser or Light Emitting Diode (LED) .SDH/SONET has a frame format to carry data with some overheads. This network is having much advantage including support to multivendor system, simple multiplexing and demultiplexing, robustness of the network etc. but having bandwidth limitations up to 10 GHZ. in the fast growing bandwidth hungry applications and demand for higher bandwidth a new multiplexing technology introduced to cope up with fast changing scenario in the field of communication known as Dense Wavelength Division Multiplexing (DWDM which is basically a Frequency Division Multiplexing (FDM) and use to enhance the capability of SDH/SONET network. a research work is proposed for making this DWDM system fully IP enabled so that less header of these layers being added and future optical network can be used more efficiently for transport of various type of traffic.

KEYWORDS: SONET/SDH, DWDM, ATM, MPLS, IP, LASER.

INTRODUCTION

Synchronous digital hierarchy (SDH) is an international standard networking principle and multiplexing technology. The main functionality of SDH as under

SYNCHRONOUS: ONE MASTER CLOCK & ALL ELEMENTS SYNCHRONISE WITH CLOCK DIGITAL: INFORMATION IN BINARY. HIERARCHY: SET OF BIT RATES IN A HIERARCHIAL ORDER.

SDH is an ITU-T standard for a high capacity telecom networks. SDH is a synchronous digital transport system, aim to provide a simple, economical and flexible infrastructure. The basis of Synchronous Digital Hierarchy (SDH) is synchronous multiplexing - data from multiple tributary sources is byte interleaved. The evolution of this system will assist in improving the economy of operability and reliability of a digital network Prior to SDH technology evolution, plesiochronous digital hierarchy is used for transfer of digital data/bits.PDH is a non standard technology and having some disadvantage given as below:-

DISADVANTAGES OF PDH

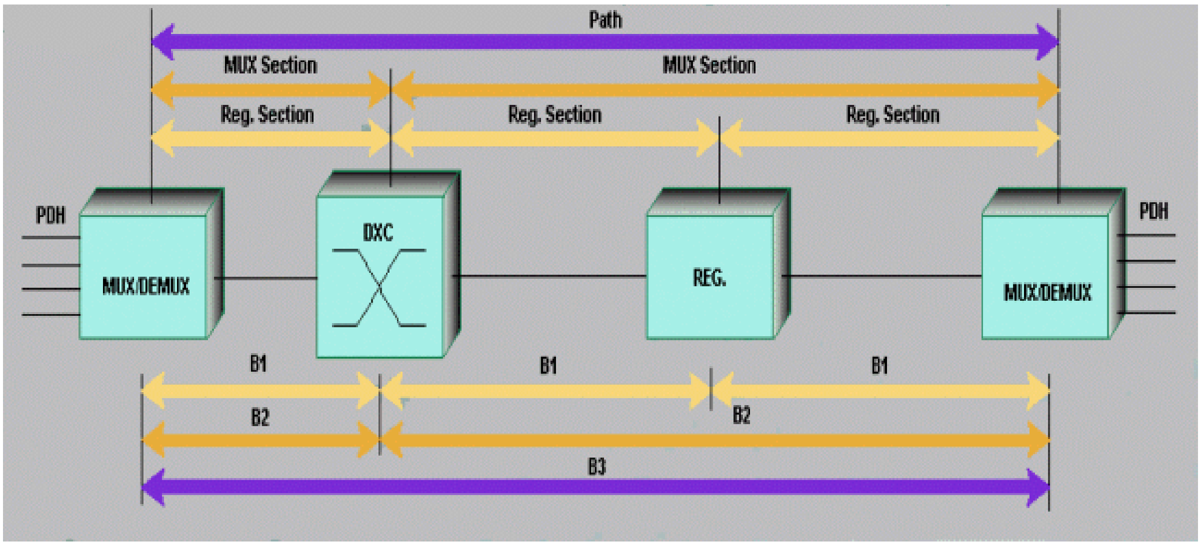
1. No common Standard
   - There are different hierarchies in use around the world.
   - Specialized interface equipment is required to inter-work the two hierarchies.
   - There is no standardized definition of PDH bit rates greater than 140 Mbit/s.
2. Homogeneity of equipment i.e. Inter vendor operability
   - The terminal equipment in a link between exchanges (fiber, coaxial etc) must come from the same vendor as every vendor used its own line coding, optical interfaces etc.
   - Very hard to interoperate.
3. Complex adds & drop function.
   - Compared with the older PDH system, it is much easier to extract and insert low-bit rate channels from or into the high-speed bit streams in SDH.

GENERAL STRUCTURE OF SDH NETWORK

SDH layer has four sub layers:

- Physical layer
  - Responsible for actual transmission of bits across the fiber.
  - Define characteristics of fibers, transmitters, receivers and encoding.
- Path layer
  - Responsible for end-to-end connection between nodes.
  - Mapping PDH, ATM etc. into SDH payload.
- Multiplexer section (MS) layer
  - Multiplexes path-layer connections on single link
- Regenerator section (RS) layer
  - Responsible for segments between regenerators.

GENERAL STRUCTURE OF SDH NETWORK



Frame Format of STM-N System:-

1. The Frame structure contains 9 rows and number of columns depending upon synchronous transfer mode level (STM). In STM-1, there are 9 rows and 270 columns. The reason for 9 rows arranged in every 125 micro seconds is as follows :

For 1.544 Mbit PDH signal (North America and Japan Standard), there are 25 bytes in 125 micro second and for 2.048 Mbit per second signal, there are 32 bytes in 125 micro second. Taking some additional bytes for supervisory purposes, 27 bytes can be allotted for holding 1.544 Mbit per second signal, i.e. 9 rows x 3 columns. Similarly, for 2.048 Mbit per second signal, 36 bytes are allotted in 125 micro seconds, i.e. 9 rows x 4 columns. Therefore, it could be said 9 rows are matched to both hierarchies.

ADVANTAGES OF SDH

1. **High transmission rates**
   It allows transmission rates of up to 40 Gbit/s in modern SDH systems making SDH the most suitable technology for high speed core network, which can be considered as being the super highways in today's telecommunications networks.

2. **Multi Vendor Networking**
   Prior to 1988 international agreement on SDH all vendors used proprietary non-standard techniques for transporting information on fibre. The only way to interconnect was to convert to the copper transmission standards (G702/703/704). The cost and complexity levels were very high. SDH

provides for a standard optical interface thus allowing the inter-working of different manufacturers' equipment.

3. **High availability and capacity matching**
With SDH, network providers can react quickly and easily to the requirements of their customers. For example, leased lines can be switched in a matter of minutes. The network provider can use standardized network elements that can be controlled and monitored from a central location by means of a telecommunications network management (TMN) system

Need of New Bandwidth Highways: DWDM

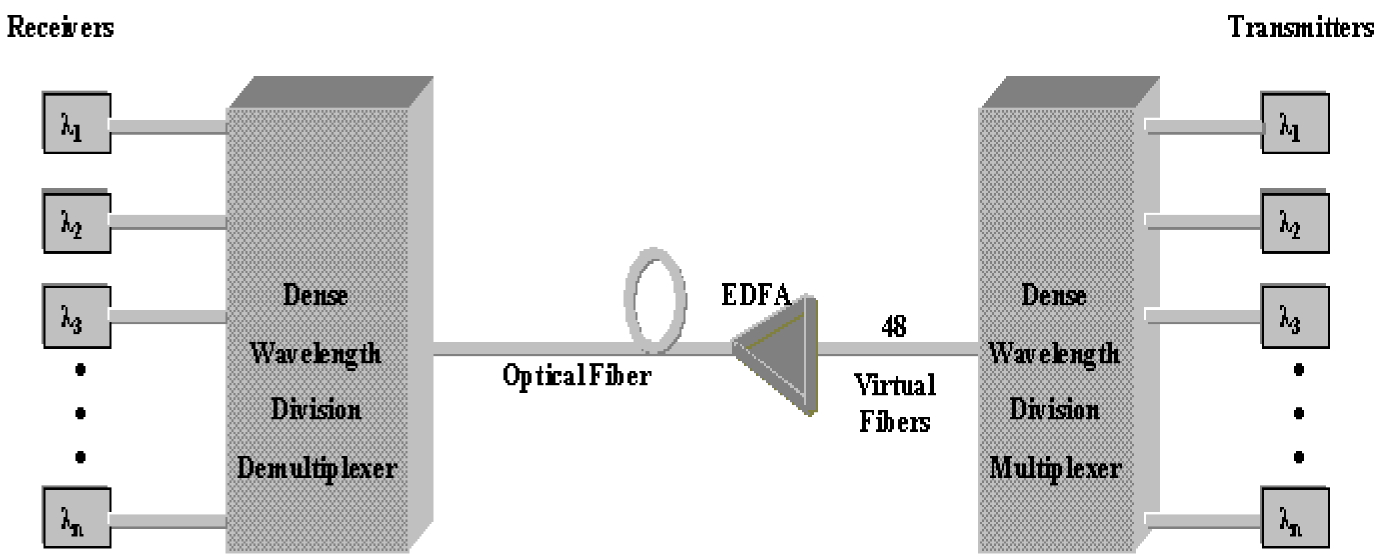
In the fast growing bandwidth hungry applications and demand for higher bandwidth a new multiplexing technology introduced to cope up with fast changing scenario in the field of communication known as Dense Wavelength Division Multiplexing (DWDM which is basically a Frequency Division Multiplexing (FDM) and use to enhance the capability of SDH/SONET network.

Dense wavelength division multiplexing (DWDM) is a technology that uses multiple lasers to transmit many wavelengths of light simultaneously over a single optical fiber. Each signal is modulated by different source data (text, voice, video, etc.) and travels within its own unique color band (wavelength). DWDM enables the existing fiber infrastructure of the telephone companies and other carriers to be dramatically increased. Vendors have announced DWDM systems that can support more than 150 wavelengths, each carrying up to 10 Gbps.

A. FUNCTIONAL DIAGRAM OF DWDM.

OPTICAL NETWORKING does not rely on electrical data processing, as in SONET/SDH. So its development is more closely tied to optics. WDM was capable to carry signals over two widely spaced wavelengths but for relatively short distance. By enabling the narrow band lasers and improved optical filters to DWDM, it was to combine more than two signals on a fiber. The flat gain optical amplifiers invention, further dramatically increased the viability of DWDM system by extending the section length of fiber transmission.

In addition to above, the improved optical fiber with lower and better optical transmission characteristics, EDFA and fiber gratings used in optical add/drop multiplexes also play an important role in development DWDM.



IMPLEMENTATION OF INTERNET PROTOCOL OVER DWDM

It is widely believed that IP provides the only convergence layer in the global and ubiquitous Internet. IP, a layer 3 protocol, is designed to address network level interoperability and routing over different subnets with different layer 2 technologies.

WDM based optical networks have been deployed not only in the back bone but also in metro, regional, and access networks.

IP over WDM will also address all levels of interoperability issues on intra and inter WDM optical networks and IP networks.

The motivation behind IP over WDM can be summaries as follows:

- WDM optical networks can address the continuous growth of the internet traffic by exploiting the existing fibre infrastructure. The use of WDM technology can significantly increase the user of the fibre bandwidth.
- Most of the data traffic across networks is IP Nearly all the end user data application uses IP. Conventional voice traffic can also be packetized with voice over IP techniques.
- IP/WDM inherits the flexibility and the adaptability offered in the IP control protocol
- IP/WDM can achieve or aims to achieve dynamic on demand bandwidth allocation (of real time provisioning) in optical network.

The emergence of MPLS not only complements conventional IP with traffic engineering and a different quality of service capability, but also proposes a unified IP centric control plane across networks. The existence of a variety of WDM network equipment demands vendor interoperability for example opaque WADMs require specific signal formats such as SONET/SDH (Synchronous Optical Network/ Synchronous Digital Hierarchy) signals on their add/drop client interfaces. WDM interoperability requires the presence of a network layer, which is IP.

IP/WDM integration will eventually translate into an efficient optical network transport reducing the cost of IP traffic (i.e. cost per bit/mile) and increasing the utilization of the optical network.

What is IP over WDM? IP/WDM network is designated to transmit IP traffic in a WDM-enabled optical network to leverage both IP universal connectivity and massive WDM bandwidth capacity. A software controller controls the switching fabric. IP, as a network layer technology, relies on a data link layer to provide: Framing Error detection Error some of the link layer functionality is implemented in the interface, for example, the add/drop client interfaces or the pass-by physical transport interfaces.

The definition of a protocol model to efficiently and effectively implement an IP/WDM network is still an active research area. Figure 1.1 shows three possible approaches for IP over WDM. The first approach transports IP over ATM (Asynchronous Transfer Mode), then over SONET/SDH and WDM fibre. WDM is employed as a physical layer parallel transmission technology. The main advantage of this approach by using ATM is to be able to carry different types of traffic onto the same pipe with different QoS requirements.

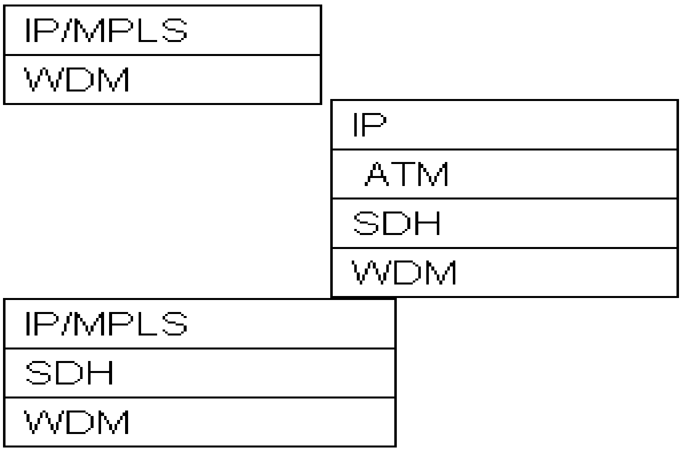


Fig. 1.1 Three Approaches for IP over WDM

IP/MPLS over SONET/SDH and WDM is the second approach in the figure. SONET/SDH provides several attractive features to this approach.

First, SONET provides a standard optical signal multiplexing hierarchy by which low-speed signals can be multiplexed into high-speed signals. Second, SONET provides a transmission frame standard. Third is the SONET network protection/restoration capability, which is completely transparent to upper layers such as the IP layer.

The third approach for IP/WDM employs IP/MPLS directly over WDM, which is the most efficient solution among the possible approaches. However, it required that the IP layer looks after path protection and restoration. It also needs a simplified framing format for transmission error handling. There are a few alternatives providing IP over WDM framing format. Several companies are developing a new framing standard known as Slim SONET/SDH, which provides similar functionality as in SONET/SDH but with modern techniques for header placement and matching frame size to packet size.

CONCLUSION

Optical Networks SDH and DWDM discussed, Impact of Fully IP enabled DWDM network carried out. It is clear that IP enabled DWDM will definitely reshape the future communication network as it has bandwidth availability which is the need of hour and routing intelligence powered with Internet Protocol.

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