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A Survey of DWDM Networks, its Development and Future Scope in Telecommunication Domain

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ABSTRACT: Explosive information demand in the internet world is creating enormous needs for capacity expansion in the next generation telecommunication networks. It is expected that the data oriented network traffic will double every year.

Optical networks are widely regarded as the ultimate solution to the bandwidth needs of future communication systems. Optical fiber links deployed between nodes are capable to carry terabits of information but the electronic switching at the nodes limit the bandwidth of a network. Optical switches at the nodes thus overcomes this limitation. With their improved efficiency and lower costs, Optical switches provide the key to both manage the new capacity Dense Wavelength Division Multiplexing (DWDM) links as well as gain a competitive advantage for provision of new band width hungry services. However, in an optically switched network the challenge lies in overcoming signal impairment and network related parameters. In this paper, the present status, advantages and challenges and future trends in optical switches has been discussed. Today fibers are pure enough that a light signal can travel for about 80 kilometres without the need for amplification. But at some point the signal still needs to be boosted. Electronics for amplitude signal were replaced by stretches of fiber infused with ions of the rare-earth erbium.

When these erbium-doped fibers were zapped by a pump laser, the excited ions could revive a fading signal. It restores a signal without any optical to electronic conversion and can do so for very high speed signals sending tens of gigabits a second. Most importantly it can boost the power of many wavelengths simultaneously.

KEYWORDS: Switching, DWDM, SONET-SDH, PCM, Optical Fiber, Multiplexing.

I. INTRODUCTION

The revolution in high bandwidth applications and the explosive growth of the Internet, however, has created capacity demands that exceed traditional TDM limits. To meet growing demands for bandwidth, a technology called Dense Wavelength Division Multiplexing (DWDM) has been developed that multiplies the capacity of a single fiber. DWDM systems being deployed today can increase a single fiber's capacity sixteen fold, to a throughput of 40 Gb/s. The emergence of DWDM is one of the most recent and important phenomena in the development of fiber optic transmission technology. Dense wavelength-division multiplexing (DWDM) revolutionized transmission technology by increasing the capacity signal of embedded fiber. One of the major issues in the networking industry today is tremendous demand for more and more bandwidth. Before the introduction of optical networks, the reduced availability of fibers became a big problem for the network providers. However, with the development of optical networks and the use of Dense Wavelength Division Multiplexing (DWDM) technology, a new and probably a very crucial milestone is being reached in network evolution. The existing SONET/SDH network architecture is best suited for voice traffic rather than today's high-speed data traffic. To upgrade the system to handle this kind of traffic is very expensive and hence the need for the development of an intelligent all-optical network. Such a network will bring intelligence and scalability to the optical domain by combining the intelligence and functional capability of SONET/SDH, the tremendous bandwidth of DWDM and innovative networking software to spawn a variety of optical transport, switching and management related products. Fig 1 shows the basic block diagram of an optical switch.

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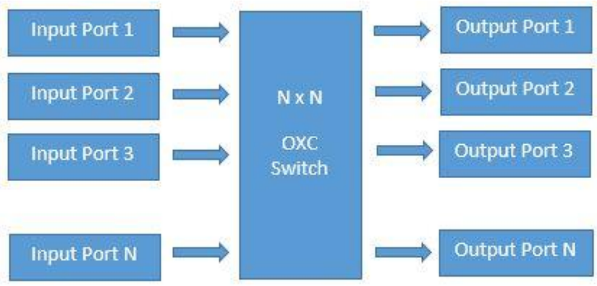

Fig 1. Block Diagram of an Optical Switch

In traditional optical fiber networks, information is transmitted through optical fiber by a single light beam. In a wavelength division multiplexing (WDM) network, the vast optical bandwidth of a fiber (approximately 30 THz corresponding to the low-loss region in a single mode optical fiber) is carved up into wavelength channels, each of which carries a data stream individually. The multiple channels of information (each having a different carrier wavelength) are transmitted simultaneously over a single fiber. The reason why this can be done is that optical beams with different wavelengths propagate without interfering with one another. When the number of wavelength channels is above 20 in a WDM system, it is generally referred to as Dense WDM or DWDM.

II. BACKGROUND

With the introduction of PCM technology in the 1960s, communications networks were gradually converted to digital technology over the next few years. To cope with the demand for ever higher bit rates, a multiplex hierarchy called the plesiochronous digital hierarchy (PDH) evolved. The bit rates start with the basic multiplex rate of 2 Mbit/s with further stages of 8, 34 and 140 Mbit/s. In North America and Japan, the primary rate is 1.5 Mbit/s. Hierarchy stages of 6 and 44 Mbit/s developed from this. Because of these very different developments, gateways between one network and another were very difficult and expensive to realize.The analog telephone signal is sampled at a bandwidth of 3.1 kHz, quantized and encoded and then transmitted at a bit rate of 64 kbit/s. A transmission rate of 2048 kbit/s results when 30 such coded channels are collected together into a frame along with the necessary signalling information. This so-called primary rate is used throughout the world.The growing demand for more bandwidth meant that more stages of multiplexing were needed throughout the world. A practically synchronous (or, to give it its proper name: plesiochronous) digital hierarchy is the result. Fig 2 shows the block diagram of a PDH system.

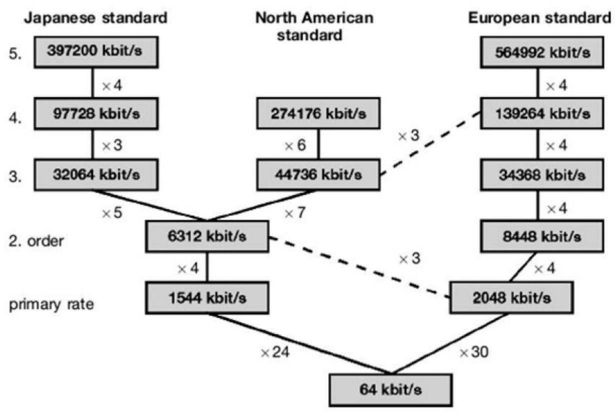

Fig 2. Block Diagram of a PDH System

Traditionally, digital transmission systems and hierarchies have been based on multiplexing signals which are plesiochronous (running at almost the same speed). Also, various parts of the world use different hierarchies which lead to problems of international interworking; for example, between those countries using 1.544 Mbit/s systems (U.S.A.

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and Japan) and those using the 2.048 Mbit/s system.SDH is an ITU-T standard for a high capacity telecom network. SDH is a synchronous digital transport system, aim to provide a simple, economical and flexible telecom infrastructure. The basis of Synchronous Digital Hierarchy (SDH) is synchronous multiplexing – data from multiple tributary sources is byte interleaved. Along with the development of S.D.H, the development of WDM began in the late 1980s using the two widely spaced wavelengths in the 1310 nm and 1550 nm (or 850 nm and 1310 nm) regions, sometimes called wideband WDM. The early 1990s saw a second generation of WDM, sometimes called narrowband WDM, in which two to eight channels were used. These channels were now spaced at an interval of about 400 GHz in the 1550-nm window. By the mid 1990s, dense WDM (DWDM) systems were emerging with 16 to 40 channels and spacing from 100 to 200 GHz. By the late 1990s DWDM systems had evolved to the point where they were capable of 64 to 160 parallel channels, densely packed at 50 or even 25 GHz intervals.

III. OPTICAL SWITCHING AND DWDM BASIC FUNCTION

Based on different applications, WDM optical switching networks can be categorized into two connection models: the wavelength-based model and the fiber-link-based model, depending on whether a single device attached to the switching network occupies a single input/output wavelength or a single input/output fiber link. Under the wavelength-based model, each device occupies one wavelength on an input/output fiber link of a WDM optical switching network.
Under the fiber-link-based model, each device occupies an entire input/ output fiber link (with multiple wavelength channels) of a WDM optical switching network. These two models are used in different types of applications. In the former each device could be an independent, simple device that needs only one communication channel, and in the latter each device could be a more sophisticated one with multiple input/output channels, such as a network processor capable of handling concurrent, independent packet flows, for example, MMC Networks NP3400 processor and Motorola's Cport network processor. Also, some hybrid models are possible, e.g. adopting the wavelength-based model on the network input side and the fiber-link-based model on the network output side. As can be expected, a switching network with wavelength-based model has stronger connection capabilities than that with fiber-link-based model, but it has higher hardware cost. In addition, the communication patterns realizable by an optical switching network can be categorized into permutation (one-to-one), multicast (one-to-many) and so on.[1]

DWDM stands for Dense Wavelength Division Multiplexing, an optical technology used to increase Band width over existing fiber optic backbones. Dense wavelength division multiplexing systems allow many discrete transports channels by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber. In effect, one fiber is transformed into multiple virtual fibers. So, if 32 STM-16 signals had to be multiplexed into one fiber, it would increase the carrying capacity of that fiber from 2.5Gb/s to 80 Gb/s. Currently, because of DWDM, single fibers have been able to transmit data at speeds up to 400Gb/s.

A key advantage to DWDM is that it is protocol and bit rate-independent. DWDM-based networks can transmit data in SDH, IP, ATM and Ethernet etc. Therefore, DWDM-based networks can carry different types of traffic at different speeds over an optical channel. DWDM is a core technology in an optical transport network. Dense WDM common spacing may be 200,100, 50, or 25 GHz with channel count reaching up to 128 or more channels at distances of several thousand kilometres with amplification and regeneration along such a route. Fig 3 shows the basic block diagram of a DWDM system.

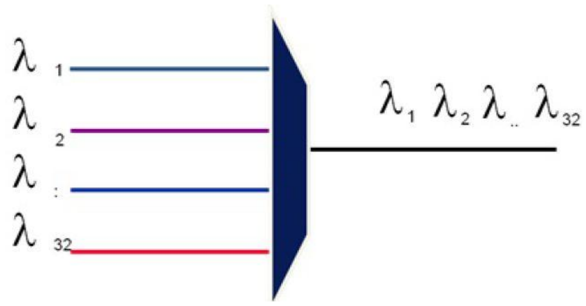

Fig 3. Block Diagram of a DWDM System

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The basic DWDM technique consists of five network elements. It consists of a transmitter (transmit transponder) which changes electrical bits to optical pulses and is frequency specific, a multiplexer/de-multiplexer which combines/separates discrete wavelengths, an amplifier which boosts signal both at receiver and transmitter side, an optical fiber (media) used to transmit the information and a receiver (receive transponder) which converts optical pulses to electrical bits. Fig 4 shows the DWDM System components.

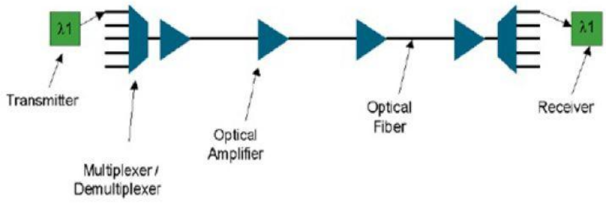

Fig 4. DWDM System Components

II.1 **Benefits of DWDM**

It increases the bandwidth (speed and distance).It doesn't require any up-gradation of the existing system in order to install it. DWDM fetches the need for next generation technologies to meet the growing demand of data needs. It is also less costly in the long run as the increased fiber capacity is automatically available, hence no upgrading is required all the time.

II.2 **Fibers Supporting DWDM**

For transmitting the DWDM signal, the conventional single mode optical fibers i.e. ITU G 652 compliant, are not completely suitable. Due to availability of Optical Amplifier working in 1550 nm region, the operating wavelengths are chosen in the C band i.e. from 1530 to 1565 nm.[2] The ITU G 652 fiber has very high dispersion in 1550 nm region, which limits the distance between repeater stations severely. ITU G 652 fiber with the high dispersion at 1550 nm, typically 18 ps/nm-km. Although, it is possible to compensate the dispersion by using dispersion compensating fibers (DCF), these DCF adds to additional optical loss. Conversely, in case of ITU G 653 fibers with zero dispersion at 1550 nm, the nonlinearities such as Four Wave Mixing (FWM) plays dominant role, rendering the fiber unsuitable for long distance transmission. A fiber that has small but non-zero amount of dispersion can minimize the non-linearity effects. The ITU G 655 compliant, Non Zero Dispersion Fibers (NZDF) has dispersion which is carefully chosen to be small enough to enable high speed transmission over long distances, but large enough to suppress FWM. With the proper use and placement of Optical Amplifiers, it is possible to have the repeater less link.

IV. DWDM BACKBONE NETWORKS

The DWDM based network structures can be divided into three classes which are simple point to point DWDM link,DWDM wavelength routing with electronic TDM (time domain multiplexing) and switching/routing backbone network and all optical DWDM network.[3]

III.1 **Point to Point DWDM Links**

In this architecture, the electronic nodes can be SONET/SDH switches, Internet routers, ATM switches, or any other type network nodes. The DWDM node consists of typically a pair of wavelength multiplexer / de-multiplexer (light wave grating devices) and a pair of optical-electrical/ electrical-optical convertors. Each wavelength channel is used to transmit one stream of data individually. The DWDM wavelength multiplexer combines all of the lightwave channels into one light beam and pumps it into one single fiber. The combined light of multiple wavelengths is separated by the demultiplexer at the receiving end. The signals carried by each wavelength channel are then converted back to the electrical domain through the O/E convertors (photodetectors). In this way, one wavelength channel can be equivalent to a traditional fibe in which one light beam is used to carry information. It is worth noting that the wavelength channels in one fiber can be used for both directions or two fibers are used with each for one direction.

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III.2 Wavelength Routing with Electronic TDM

In this structure wavelength routers are used to configure or reconfigure the network topology within the optical domain and the TDM (Time Domain Multiplexing) network nodes are used to perform multiplexing and switching in the electrical domain. This combined optical and electrical network architecture can be applied in SONET/SDH in which the electrical TDM network nodes would be SONET switches, or in the Internet in which the electrical TDM network nodes would be the Internet routers. The architecture can also be used in an ATM network where the electrical TDM network nodes would be ATM switches.

III.3 All Optical DWDM Network

As it is seen that the electrical TDM/switching nodes can be of any kind, such as SONET/SDH switches, Internet routers, and ATM switches. This indicates that the all-optical TDM nodes in the all-optical architecture can be optical SONET/SDH switches, or all-optical ATM switches, or all-optical Internet routers. Different types of all-optical TDM/switch nodes can also be in one network, provided the protocol conversions are implemented.In fact, the optical TDM/switch node and the wavelength router in one routing site can be combined into one all-optical switching node that not only forwards packets through time domain multiplexing but also selects the light path intelligently according to the availability and traffic loads of the links.

V. DWDM ACCESS POINT NETWORKS

An overriding belief existed even in the early 1970's that optical fiber would one day make its way into the subscriber loop and be used to connect individual homes. Research on the fiber based residential access network architecture and protocols have since then become one of the major areas in the telecommunication arena. The ATM (Asynchronous Transfer Mode) based B-ISDN (Broadband Integrated Services Digital Network) architecture had been once believed to be the leading candidate for realizing the fiber-to-the-home access network. However, with the technological development of the DWDM, broadband residential access fiber network has taken another turn, which leads to a DWDM-based fiber optical network to deliver both narrowband and broadband services. DWDM-based access optical networks can be classified into two categories, passive DWDM access networks and active DWDM networks. The term of active DWDM network here refers as to the DWDM network in which the TDM (time domain multiplexing) is applied in the wavelength channels.[3]

DWDM passive optical networks (PON) use the wavelength channels to connect the users with the central office. Each service uses one wavelength channel. The early PON was developed for narrowband services, such as the PON architecture developed by British Telecom. However, recent PONs are for both broadband and narrowband services. A passive subscriber loop is attractive because it uses no active devices outside the central office (CO), except at the customer premises. Several architectures of passive optical networks have been proposed for WDM or DWDM, which include the single-star, the tree, the double star, and the star-bus.

With the increasing bandwidth capacity of DWDM technology, the bandwidth of one signal channel becomes high enough to carry several or many services even in the access environment. This leads to the thinking of applying TDM in each individual DWDM wavelength channel, resulting in the active DWDM access optical network in which TDM is used within each channel to provide integrated services. The Asynchronous Transfer Mode (ATM) has been proposed as the TDM protocol in the active DWDM access networks. With the ATM coming into the picture, the original B-ISDN (Broadband Integrated Services Digital Network) protocols are again surfacing in the access network arena. But this time, only one wavelength channel replaces the whole optical fiber in the system.

VI. CONCLUSION

The DWDM point-to-point technology has already played an important role in the backbone networks and it will continue to be installed for existing and new fiber links. However, for the all-optical DWDM network to become viable, it may still take some time till the optical processing power becomes available. This may create a time gap between the DWDM point-to-point applications and the all-optical DWDM transparent networks. In the access network

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case, it is still not clear whether the passive or the active is the leader. Although the cost barrier has been weakened through replacing the fiber by DWDM channels in the active access network architecture, the TDM devices in the system may still be too high at the present time. On the other hand, the fiber cost (along with the costs of the passive devices) in the passive architecture is probably still not cheap enough to make it ahead of the active architecture. However, the very high channel-count of DWDM may change the landscape of the access network world, and it may become even cheaper than the combined costs of twisted pair copper and coaxial cables.

REFERENCES

1. Yuanyuan Yang Department of Electrical and Computer Engineering State University of New York at Stony Brook, Stony Brook, NY 11794, USA Jianchao Wang East Isle Technologies Inc., Setauket, NY 11733, USA, 'WDM Optical Switching Networks Using Sparse Crossbars', Proceedings of IEEE INFOCOM 2004.
2. 'Technology Paper on High Capacity DWDM Networks', CommtelNetwokshttp://issuu.com/commtelnetworkspvt.ltd./docs/dwdm_technology
3. Shaowen Song, Wilfrid Laurier University, Waterloo, ON, 'An Overview of DWDM Networks', IEEE Canadian Review-Spring/ Printemps 2001.
4. J.D. Angelopoulos, et al, TDMA Multiplexing of ATM Cells in a Residential Access Super PON, IEEE Journal on Selected Areas in Communications, Vol.16, No. 7, Sep. 1998, pp.1123 - 1133.
5. P.E. Green, Jr., Optical Networking Update, IEEE Journal on Selected Areas in Communications, Vol.14, No. 5, J 1996 pp.764 - 778.
6. 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.

BIOGRAPHY

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