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DWDM in Transmission System, a Review

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Abstract: **-- Dense Wavelength Division Multiplexing (DWDM) is a key component of the world's communications infrastructure. The colossal growth in telecommunications services is possible today in part through optical networks, where DWDM systems allow much greater bandwidth over existing optical systems. DWDM is a means of achieving effective fiber-optic transmission. DWDM is a transmission technology by which we can transmit/multiplex/de-multiplex different wavelengths on a single fiber by which we can utilize maximum bandwidth via optical fiber cable. The fiber plant savings can be optimized by a factor of at least 32.**

I. INTRODUCTION

DWDM is a transmission technique used in fiber optics in which different wavelengths are transmitted over a single optical fiber. Dense meant for wavelength channels which are close to each other. The increasing demand of consumers lead to increased bandwidth and this is possible using DWDM. The data from various different sources put together on an optical fiber where each signal travels at same speed on its own light wavelength. At the receiver end every channel is de-multiplexed into original source.

Dense wavelength division multiplexing (DWDM) networks can be configured with different topologies. DWDM point-to-point network topology can be configured with or without add-drop multiplexing network. DWDM ring network topology can be configured with OADM (Optical add-drop multiplexer) nodes and a hub. Fully connected mesh network, star network and combination of point-to-point, ring and mesh networks can be configured according to the requirement. Each DWDM topology has its own requirements and based on the application, different optical components may be involved in the respective network designs.

II. DWDM TOPOLOGIES

A. POINT TO POINT TOPOLOGY

Point-to-point topology is mainly for long-haul transport that requires ultrahigh speed generally in the range of 10-40 Gbps. This topology is characterized by ultrahigh aggregate bandwidth, high signal integrity, greater reliability and fast path restoration capability. The distance between transmitter and receiver of point-to-point network may be equal to or more than hundred kilometers. Amplifiers are used along the path between transmitter and receiver and the number of amplifiers should be less than 10. Point-to-point network designed with add-drop multiplexers enables the system to add and drop channels along its path. [1].

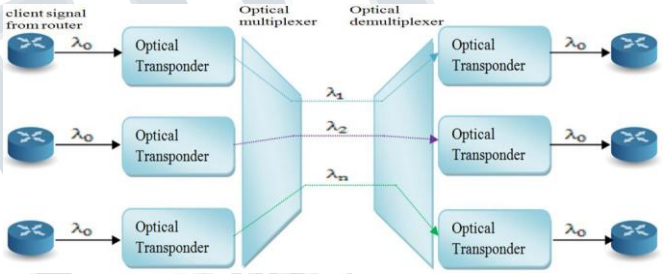

Figure 1: A point-to-point DWDM network

A point-to-point DWDM system generally termed as unidirectional DWDM system consists of two terminals connected by pair of fibers. The system consists of transponders, optical wavelength multiplexer and de-multiplexer, amplifiers and routers. The number of amplifiers placed along the fiber path depends on the length and quality of fiber. Each transponder retransmits its incoming client signal onto a particular wavelength of the channel. The optical multiplexer combines these n signals at different wavelengths together and transmits the multiplexed signal over a fiber. The multiplexed signal reaches the de-multiplexer and decomposed back into n signals at their respective wavelengths, which are retransmitted by each receiving transponder into its client signal. Client signals are generally generated by a packet switch such as a large router [2].

Explaining with an example as in Fig. 1, the top router on the left side transmits a client signal with a wavelength $\lambda 0$. This signal is converted to $\lambda 1$ using an optical transponder (OT). The $\lambda 1$ signal is combined with other wavelength signals and transmitted over the fiber to the optical de-multiplexer. The combined signal reaches optical de-multiplexer and

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decomposed into different wavelengths. Then the $\lambda 1$ signal is converted into the wavelength $\lambda 0$ when it is passed through another Optical Transponder and the $\lambda 0$ signal can be retrieved by the top router on the right side [2].

B. RING-TOPOLOGY OF DWDM NETWORKS

A DWDM ring network forms a ring configuration by a fiber which interconnects hub station and OADM's. Some systems may have only one fiber ring but in order to provide network protection it is better to have two fiber rings. A system with two fiber rings is capable of covering a local or a metropolitan area. The fiber ring in a network comprises of many

wavelength channels and nodes. The bit rate per wavelength channel lies between 622 Mbps to 10 Gbps. Figure 2 depicts a basic DWDM ring configuration network. Hub station in a ring is a source for all wavelengths that are generated and where they are managed and terminated. Hub station provides connectivity to other networks. OADM's in the ring adds and drops designated wavelength channels. OADM node may be connected with a multiplexer or a demultiplexer where it can multiplex or de-multiplex several data sources [1].

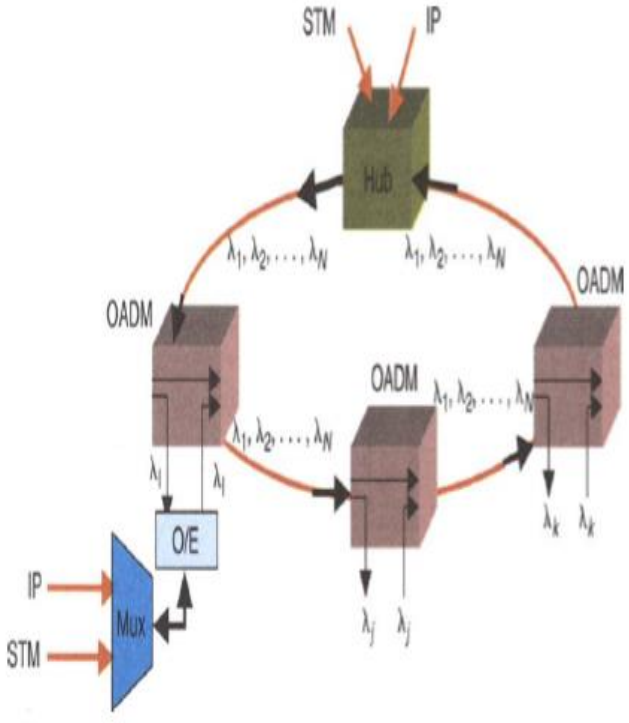

Figure2: A DWDM ring network

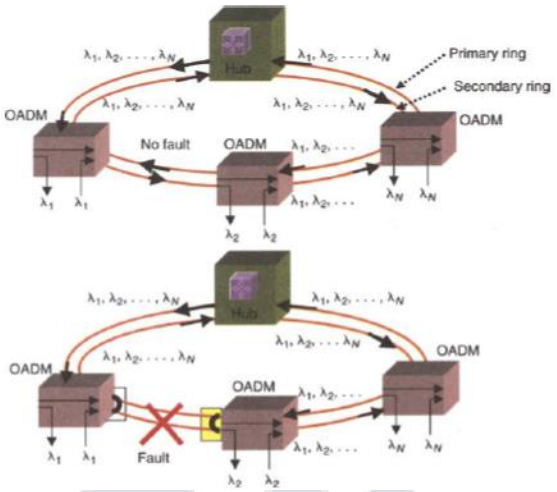

Figure 3: DWDM ring network topology to detect faults

Sometimes there might be some faults on the ring like broken fiber, faulty port unit and inoperable node. For an efficient system, DWDM networks must be able to detect faults on the ring and should isolate a fault. The DWDM system can do this well and offers continuous transmission service with minimum interruption possible. DWDM ring network topology with two fibers rings, rotating and counter rotating ring can execute fault avoidance greatly. These two rings in general referred as primary and secondary ring (figure 3). Whenever a fault occurs in a ring, the adjacent OADM avoid the fault by rerouting the traffic via a U-turn optical crossconnect (OXC) as depicted in the figure 3. When the fault is resolved, the ring network gets back to its normal state [1].

C. MESH TOPOLOGY

There is a continuous evolution in network designs and it leads to design Mesh network topology. Compared to point-to-point and ring network, mesh network is the most robust topology. This is because of system configuration with optical cross connects and switches. Mesh network requires very few fibers for carrying the same amount of traffic. Mesh and ring topologies can be joined by point-to-point links as depicted in Figure 4[4].

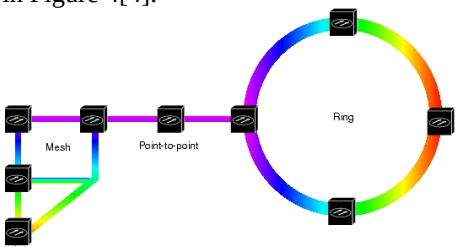

Figure 4: Mesh, Point-to-Point, and Ring Architectures

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III. DWDM SYSTEM WORKING

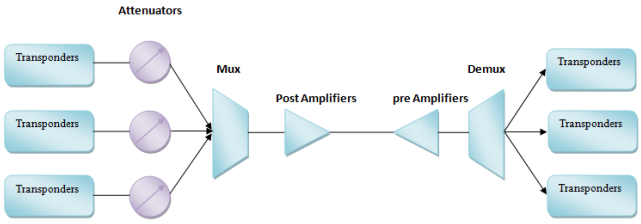
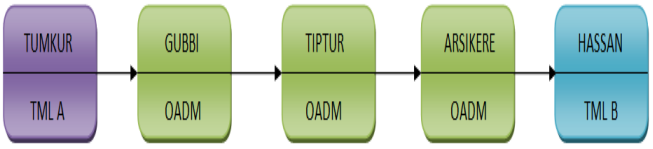


Figure 5: DWDM system

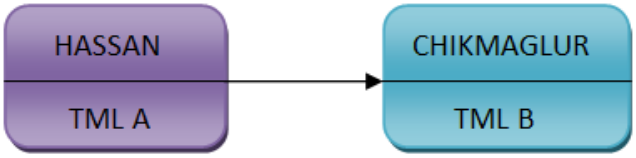
Figure 5 shows the DWDM system. Transponder placed at the transmitter side accepts input which may be of the form single-mode or multimode laser pulse. The source to generate input to the transponder can be a physical media, solid state laser or a router. The transponder signal wavelength is mapped to a DWDM wavelength and reaches the multiplexer. DWDM wavelengths from the transponder are multiplexed with signals from the direct interface to form a composite optical signal which is launched into the fiber. The post-amplifier placed after multiplexer boosts the strength of the optical signal. Additional Optical amplifiers can be used along the fiber span according to the necessity. A pre-amplifier boosts the signal before it reaches the de-multiplexer where it is de-multiplexed into individual DWDM wavelengths [3].

Considering as an example, BSNL, Hassan, a public sector enterprise which is providing telecom services and network management under Central Government Department of Telecom Services (DTS) and Department of Telecom Operations (DTO). Here, DWDM systems are being maintained by a transmission division. DWDM systems of 2.5G and 10G capacity are used here. 2.5G DWDM system has 32 transponders (lambdas/channels) in which each channel which caters for STM-16/2.5Gbps client signal bandwidth. Similarly, 10G DWDM system has 40 transponders (lambdas/channels) in each channel caters for STM-64/10Gbps client signal bandwidth. Here are some depictions regarding BSNL connectivity to many places from Hassan with 2.5G and 10G system. DWDM system consisting of OADM's and OLA's (Optical Line Amplifier) providing services between two terminals. Service is providing from Hassan, one of the terminals and it is connected to some distant place which is referring here as other terminal. Many cities are connected between these two terminals (TML in figures referring to terminal) There are many networks from Hassan using 2.5G DWDM system viz.,

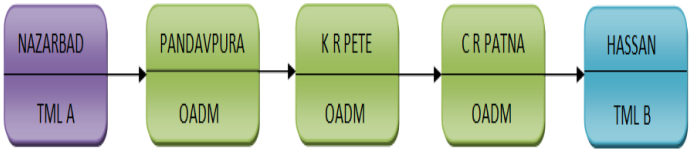
A). Hassan to Tumkur



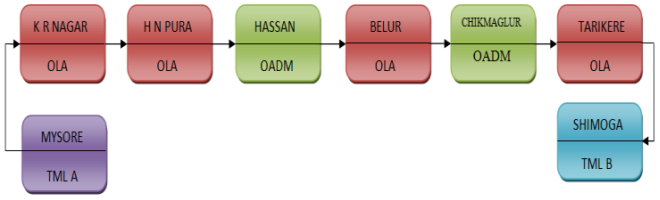
B). Hassan to Chikmaglur



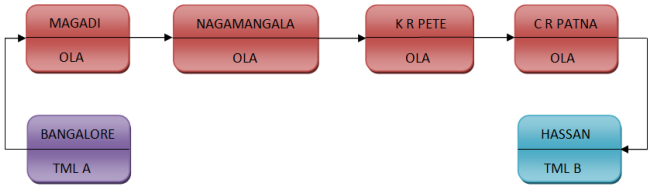
C). Mysore Nazarbad to Hassan



There are also 10G DWDM Networks from Hassan.
A). Mysore to Shimoga



B). Bangalore to Hassan



IV. ADVANTAGES OF DWDM

1. Bit rate independency and different network topologies of the system made it more flexible and the best choice for transmission system in communication.

2. The system works so well even for long haul transmission and is able to transmit the signal to a distance of 300km before reaching the first regenerator.

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3. The system is more reliable because of data transparency and for having the capacity of unlimited data transmission capacity with multi data transmission network [7].

4. DWDM can transparently support time-division multiplexing (TDM) and data formats like Asynchronous transfer mode (ATM), Gigabit Ethernet, Enterprise system connection (ESCON) and fiber channel with open interfaces over a common physical layer [5].

V. DISADVANTAGES OF DWDM

1. In some cases, amplifiers are used along the fiber length. This increases cost of the system.

2. Small variation in the fiber shape which occurs during manufacturing process leads to polarization dispersion which causes distortion of the signal which in turn minimizes the bandwidth of the fiber.

3. Different wavelengths traveling at different speed leads to chromatic dispersion which slightly affects the system performance [7].

VI. APPLICATIONS OF DWDM SYSTEM

1. DWDM system has its applications in various fields like sensor networks, tele spectroscopic process control networks, remote radar networks, telecommunication services of longer distance and Metropolitan Area Networks (MAN).

2. DWDM has its applications in utilizing the already existing thin fiber plants.

3. DWDM system can be seen where the system needs efficient transmission system and greater bandwidth availability [7].

CONCLUSION

DWDM system working and topologies have been discussed. Bandwidth availability of DWDM has made it the best choice in the transmission system. Many advantages of DWDM make it ideal technology for communication systems. The loss that generally occurs in this system is attenuation loss and it can be overcome using optical amplifiers. DWDM can work well even for long distance transmission. So, it is concluded that DWDM must be chosen for future communication.

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