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Review Paper on DWDM Technology

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Abstract:
In this paper optical technologies such as Wavelength Division Multiplexing (WDM) has been studied which is used to provide high-capacity point-to-point light paths consisting of a wavelength channel carried over a succession of fibers applications DWDM system and the need of this system is discussed along with the operation of each component. As well as studied about optical ROADM scheme for routing of an individual sub channel within an all-optical OFDM superchannel. The different functions required of optical node were demonstrated using interferometric technique with the extraction, drop, and addition of individual subchannels in a ten subchannels optically aggregated signal and Coarse wavelength division multiplexing (CWDM) is a method of combining multiple signals on laser beams at various wavelengths for transmission along fiber optic cables, such that the number of channels is fewer than in dense wavelength division multiplexing (DWDM) but more than in standard wavelength division multiplexing (WDM). The objective of this paper is to summarize the basic optical networking approaches, including wavelength allocation scheme in optical networks. Dense Wavelength Division Multiplexing (DWDM) is an optical multiplexing technology which is used to increase the bandwidth of existing optical networks. The main principle on which it works is transmitting multiple signals of various wavelengths at the same time on the same optical fiber. From both technical and economic perspectives, the ability to provide potentially unlimited transmission capacity is the most obvious advantage of DWDM technology. Bandwidth aside, DWDM's most compelling technical advantages can be summarized as follows:

• Transparency—Because DWDM is physical layer architecture, it can transparently support both TDM and data formats such as ATM, Gigabit Ethernet, ESCON, and Fibre Channel with open interfaces over a common physical layer.

• Scalability—DWDM can leverage the abundance of dark fiber in many metropolitan area and enterprise networks to quickly meet demand for capacity on point-to-point links and on spans of existing SONET/SDH rings.

• Dynamic provisioning—Fast, simple, and dynamic provisioning of network connections give providers the ability to provide high-bandwidth services in days rather than months

Keywords —Optical fiber communication, Rayleigh backscattering, wavelength-division multiplexing (WDM), self-phase modulation SPM, and cross-phase modulation CPM, Coarse wavelength division multiplexing (CWDM) Reconfigurable optical add/drop multiplexers (ROADMs) .

I. INTRODUCTION

In today's networks, optical technologies such as Wavelength Division Multiplexing (WDM) are used to provide high-capacity point-to-point light paths consisting of a wavelength channel carried over a succession of fibers. The scope of optical network based services is increasing and it provides better results compared to the traditional networks like circuit switching and packet switching policies. By using optical fibers the nature of transmitting data is high and fast when compare to the above traditional approaches using copper cables, twisted pairs as a communication medium. In the optical networks the data is converted into the bits of light called photons and then transmitted over fibers which are faster than the traditional networks in which the data is converted into the electrons that travel through the copper cable. The data transmission using optical fiber is fast because photons weigh is less when compare to the weight of electrons. And further, unlike electrons, photons do not affect one another when they move in a fiber because they have no electric charge and they are not affected by stray photons outside the fiber. Light has higher frequencies and hence shorter wavelengths, and therefore more "bits" of transmission can be contained in a length of fiber versus the same length of copper. The optical fiber can carry more communications signals than the large copper cable in the background and over much longer distances. The demand for bandwidth has been increasing significantly; the network capacity has also increased and applications like Video applications (video download, video telephony), IP telephony, Multimedia applications and remote employment are the main drivers for this increased demand. Wavelength Division multiplexing an enabling technology for high-speed backbone networks are used in optical networks. The optical connection between the nodes in a network is called as light paths. A light path is established before the communication between the wavelength routers. To establish a light path the same wavelength channel should be allocated on all the links along the route. The set of established light paths are called as virtual topology and it is used to route the higher layer traffic. So, these light paths need to be set up dynamically by determining a route across the network connecting the source to the destination, and allocating a free wavelength channel on each fiber link along the chosen route.

The WDM technology transmits many signals concurrently on an optical fiber using wavelength routing a network switching node routes signals based on their wavelengths. In the near future we will likely see optical networks being widely deployed in bid to benefit from its several important advantages, including an increased usable bandwidth on optical fiber, reduced electronic processing cost, protocol transparency and efficient network component (node/link) failure handling. A WDM Optical network consists of a set of nodes and optical fiber links such that an optical fiber link connects a pair of nodes. A pair of network nodes communicate by exchanging messages over a connection path (or simply path), through a set of optical fiber links. An optical fiber supports a fixed number of wavelengths. Wavelength routing is used to establish a path, in turn the path is allocated a wavelength. A message to be sent from one node to another is referred to as a connection request (or simply a request). In WDM optical networks a request is satisfied by establishing a path between communicating nodes and allocating a wavelength to the path. Since an optical fiber supports a fixed number of wavelengths, it is possible that a wavelength may not be available to satisfy a given request, in which case it is blocked. Transmission for a blocked request is deferred to the future when a wavelength is made available through a previously allocated connection request completing its transmission.

A powerful aspect of an optical fiber communication link is that many different wavelengths carrying independent signal channels can be sent along a single fiber simultaneously. In particular, telecommunication service providers are using this feature in the low-loss 1300-to-1600-nm spectral region of optical fibers. The technology of combining a number of wavelengths onto the same fiber is known as wavelength division multiplexing or WDM [1]. Conceptually, the WDM scheme is the same as frequency-division multiplexing FDM used in microwave radio and satellite systems. Just as in FDM, the various wavelength channels or optical frequencies in WDM must be properly spaced to avoid inter channel interference. Since installing an optical fiber cable plant is both expensive and extremely time consuming, expanding the capacity of an installed network is economically attractive. Traditionally, carriers upgraded their link capacity by increasing the transmission rate. This worked well initially, with speeds eventually reaching [2]. However, when going to the next multiplexing level of 10 GB/s, one starts to encounter effects that can seriously degrade WDM network performance. Among these effects are [3]:

- Fiber chromatic dispersion, which limits the bit rate by temporally spreading a transmitted optical pulse
- Polarization mode dispersion, which arises from orthogonal polarization modes traveling at slightly different speeds owing to fiber birefringence
- Non uniform gain across the desired wavelength range in erbium-doped fiber amplifiers EDFAs
- Inelastic scattering processes such as stimulated Raman scattering SRS and SBS, which are interactions between optical signals and molecular or acoustic vibrations in a fiber
- Nonlinear processes in a fiber that arise from modulation of the refractive index of silica by intensity changes in the signal, thereby producing effects such as FWM, self-phase modulation SPM , and cross-phase modulation CPM [4]
- Fiber manufacturing and composition sometimes give rise to defects known as manufacturing defects which when employed in WDM system can lead to serious losses in the system.

II. Literature Survey

Suresh K et.al [1] this paper presented a brief survey about the existing approaches in the Routing and Wavelength Assignment (RWA) using Wavelength Division Multiplexing (WDM) and optical cross connect switches which also provides solutions for the security threats in the physical layer of optical fiber networks. Optical networks play an important role in information communication supporting both small-scale and large-scale networks through its capacity of seamless transmission of massive volume of data within a short time period. Routing in the optical networks needs to be dynamic as the wavelengths and its parameters are changing frequently. Based on the analysis carried out over the existing solutions we are proposing an equalized wavelength or power distribution using Wavelength Division Multiplexing (WDM), optical cross connect equalization at the network nodes and power equalization placement in order to prevent jamming attacks and reducing LAR with minimum cost.

[2] Proposed and experimentally demonstrate a novel colorless full-duplex passive optical network (PON) access architecture optical networks (WDM-PONs), in which the mitigation of optical. Utilizing orthogonal codes and correlation receiving methods optical beat interference (OBI) noise caused by Rayleigh backscatter., the novel PON can mitigate the optical beat interference (OBI) (RB) are critical technologies [1]–[4]. RB can be regarded as noise induced by Rayleigh backscattering (RB). A pair of electrical distributed reflections over the fiber and RB noise can interfere orthogonal codes is generated and modulated at the same wave- with the upstream (US) light to impair the uplink performance length in the optical line terminal (OLT). Then, modulated optical signals are transmitted from the OLT to the optical network units [5], [6]. Characteristics of RB noise in the next-generation PON (ONUs). One of the codes is for downstream signal coding, and the (NG-PON) have been investigated [7]. The backscattering close- other is used as the upstream seed. In the ONU, the upstream sig- in noise spectrum concentrates on low frequency from 5 to nil is remodulated without erasing the downstream signal. Neither 300 MHz and broadens with light line width, launch power, and extra centralized continuous wave (CW) light sources nor gain- fiber length [8], [9]. Saturated reflective semiconductor optical amplifier is required. By using these orthogonal codes, the spectral overlap between up- The colorless ONU can be mainly realized by two kinds of stream signal and downstream signal in the full-duplex system is methods. Some methods use an extra centralized continuous reduced, which can mitigate the OBI noise significantly. The wave (CW) light source from the optical line terminal (OLT) as performance of transmission and power margin is investigated through the seed of US data, but it will increase the cost and introduce the experiments with different transmission distances. The remodulated upstream signals are recovered by correlation algorithm in the OLT In other methods, the downstream (DS) By correlation algorithm, we can get coding gain, which light is used as the seed of US remodulation after erasing the DS is important in long-reach transmissions.

Because of coding gain signal by using gain-saturated reflective semiconductor optical and the OBI noise mitigation, a link power margin of 4−10 dB can amplifier (RSOA). Then, the US data is remodulated at the be achieved for 5 Gb/s downstream and 1.25 Gb/s upstream, when same wavelength of DS by RSOA [2]. The RSOA with the transmission distance is from 20 to 70 km.

E. Kavitha et. al [3] this paper investigates the problem of dynamic wave length allocation and fairness control in WDM optical networks. A frame network topology, with a two-hop path network, is studied for three classes of traffic. Each class corresponds to a source and destination pair. For each class call-inter arrival and holding times are studied. The objective is to determine a wavelength allocation policy to maximize the weighted sum of users of all the three classes. This method is able to provide differentiated services and fairness control in the network. The problem can be formulated using markov decision process to find the optimal allocation policy.

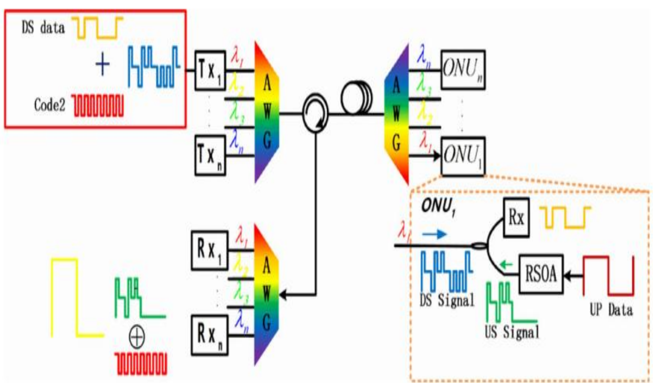

Figure 1: The principles of US remodulation scheme in the full-duplex WDM-PON.

[3] The author was presented the experimental implementation of an all-optical ROADM scheme for routing of an individual sub channel within an all-optical OFDM superchannel. The different functions required of optical node were demonstrated using interferometric technique with the extraction, drop, and addition of individual subchannels in a ten subchannels optically aggregated signal. The scheme we reported enables a fully flexible node compatible with future terabit per second superchannel transmission. In this paper, we present the implementation of a TIDE node optical gating, and thus the imperfect demultiplexing penalty for AO-OFDM superchannel with overlapping carriers. That was mitigated. Standard node functions, channel drop, extraction, and inserted- Finally, the TIDE node was completed by adding new data to were obtained whilst the signals remained fully in the the channel cleared by the extract section. For QPSK data, the optical domain. A channel was extracted through optical FFT same optical modulator was used for the original superchannel filtering, reshaped using optical gating and a second optical FFT and for the channel added, with the add channel data decor- filter and then interferometrically erased from the AO-OFDM related from the superchannel by the path length delay. Fig. 7 superchannel in a fully optical structure, allowing the insertion displays the optical spectrum for the input superchannel that was a new set of data. The scheme demonstrated here operates channel drop and the resulting superchannel with the new channel- for both single and dual quadrature formats, and clearly scales channeling added. With the assistance of the second stabilization circuit, to multi-terabit/s superchannels through the use of additional the channel suppression was maintained higher than 10 dB as sub-channels, and opens the way for guard band-free all-optical the dither based feedback loop, based on the suppression of the flexible transport.

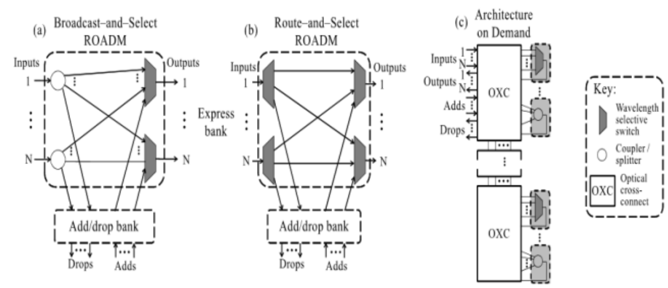

Figure 2: Optical ROADM scheme for routing of an individual sub channel within an all-optical OFDM superchannel

[4] The dramatic growth of Internet traffic is pos- emission. On the other hand, the dramatic increased in trafficking unprecedented challenges in all network segments. Moreover, its increasing heterogeneity was driving research trends in network functions virtualization and software- defined networking (SDN) to guarantee high levels of adaptability. Research trends driven by carriers requirefic heterogeneity in all network segments is requiring unprecedented levels of reconfigurability, flexibility, and reconfigurability, adaptability, and flexibility. Therefore, hardware infrastructures must be capable of playing different roles according to service and traffic requirements. In this context, reconfigurable optical add/drop multiplexers (ROADMs) are key elements since they route signals di- erectly in the optical domain. Thus, it was crucial to design offer high levels of network functions programmability ments on network functions virtualization (NFV [2]) are pushing hardware infrastructures capable of playing different roles according to service requirements. Moreover, cur- rent proposals on software-defined networking (SDN) [3] ROADMs with easy maintenance, a low manual intervention rate, and high reconfigurability, flexibility, and adapt- ability. In this work, we experimentally demonstrate our recently proposed add/drop on demand (ADoD) architecture for ROADMs in a SDN metropolitan mesh optical network test-bed with 80 dual-polarization quadrature phase-shift-keying channels at 128 Gb⁄s. In addition, we ex- by decoupling the data plane and the control plane. In this challenging context, reconfigurable optical add/ drop multiplexers (ROADMs) are key elements in the operator s optical networks since they route signals directly in the optical domain [4].

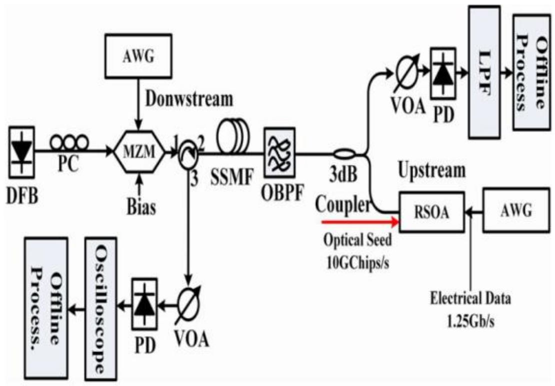

Figure 3: Experimental Setup of Remodulated DS WDM-PON System.

[5] In the optical networks the wavelength division multiplexing technology which multiples a number of optical carrier signals into a single optical fiber using different wavelengths (colors) of a signal. Here different wavelengths carrying separate signals are multiplexed by the multiplexer and then they are transmitted through a single fiber. At the receiver end, the separate signals at different wavelengths are demultiplexer by the demultiplexer and are given to separate receivers. From the receiver side also the signals can be transmitted in the same manner through the same fiber. Hence the information capacity of the fiber is increased by WDM technique. An optical wavelength demultiplexer can also be used as multiplexer

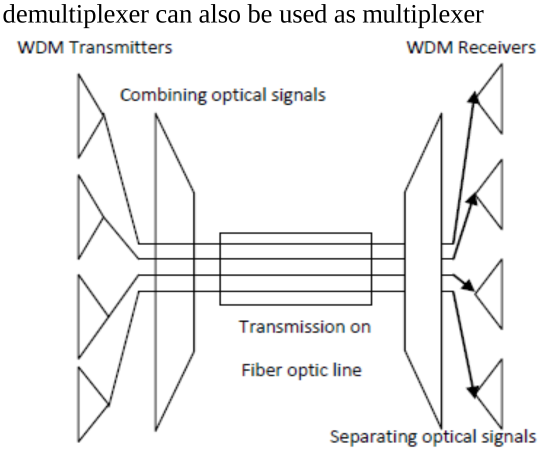

Figure 4:Wavelength Division Multiplexing

Turza K. et al [8] presented the possibility of time and frequency (T&F) distribution in two generations of dense wavelength-division-multiplexing (DWDM) networks: the older one, equipped with dispersion compensation fiber (DCF) modules, and the newest, without in-line chromatic dispersion compensation (dedicated for coherent signals). The results of transmission in the newest DWDM systems architecture, dedicated for coherent transmission, were surprisingly good. Allan deviation of frequency transfer was 10−16 for averaging longer than 104 s, and TDEV was below 15 ps. Hence, it was proved from these results that the DWDM alien wavelength service can be used for high-demanding applications like cesium fountains comparisons. Results achieved for the former version of DWDM were about one magnitude worse for a long-term comparison, but it can still be useful for less demanding applications.

Poliak J. et al [9] discussed the proof of-concept demonstration of optical DWDM under worst case atmospheric channel conditions for satellite communications in geostationary orbit. The highest-to-date throughput of 1.72 Tbit/s was transmitted over 10.45 km distance with passive transmitter pointing and active receiver tracking with active single-mode fiber coupling. This throughput was achieved by modulating 40 DWDM channels with uncoded 43.01824Gbit/s rate per channel. Furthermore, direct bit-error-rate and signal fluctuations measurements were carried out to assess the link performance. No forward error correction was used. Finally, in each DWDM channel BER values between error-free and BER = 0.5 were achieved, with median BER of 4.4 • 10−7. The normalized variance of the received optical power varied between 0.1 and 3.6.This demonstration served as a basis for development of active single-mode fiber coupling, turbulent channel characterization and future use of DWDM technology for satellite communications.

Nagarajan R. et al [10] discussed the nature of and requirements for data center interconnect. Then a demonstration was done on a switch-pluggable, 4.5 W, 100 Gbit/s, silicon photonics-based, PAM4, QSFP-28 module to transport Ethernet data directly over DWDM for layer 2/3 connection between switches at data centers up to 120 km apart, thereby eliminating the need for a separate optical transport layer. The module, based on the direct detect modulation format of much reduced complexity, power and cost compared to the coherent systems that are currently being deployed for this application.

Jiang W. et al [11] demonstrated a one-span 100-km transmission of 64Gbaud/DP-16QAM signal using a state-of-the-art In P-based coherent transmitter and receiver, a 1-sample/symbol DAC without pulse shaping, and a 1.25-sample/symbol ADC/DSP to achieve 400 Gb/s per λ over 100km SSMF. Furthermore, the greatly reduced sampling rate should enable a low complexity,low cost, and low power DSP for the 400 Gb/s per λ DCI DWDM or grey links.

Morais R. M. et al [12] evaluated the effectiveness of various machine learning models used to predict the quality of transmission (QoT) of an un established light path, speeding up the process of light path provisioning. Moreover, three network scenarios were proposed to efficiently generate the knowledge data base used to train the models as well as an overview of the most used machine learning models. The considered models were: K-nearest neighbors, logistic regression, support vector machines, and artificial neural networks. It was proved by the results that all machine learning models were able to correctly predict the QoT of more than90%ofthelightpaths. Furthermore, the artificial neural networks proved to be the model achieving the best generalization, with accuracies in the order of 99%. Moreover, ANNs for regression predicted the residual mar gin with average error smaller than 0.4 dB and misclassifications for only a few light paths with residual margin near 0 dB.

WDM optical networks can be broadly categorized into the following two classes:

1. **All-optical transmission (transparent) network:** each connection request must be assigned the same wavelength in every fiber on the allocated path. Between the transmitter node and receiver node

2. **Optical transmission (opaque) network:** a connection request may be as-signed distinct wavelengths in different optical fibres on the allocated path between the transmitter node and the receiver node.

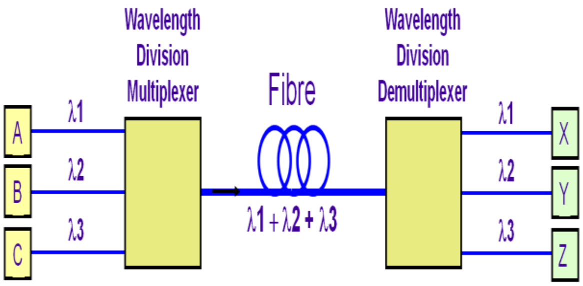

Figure 5: Dense Wavelength Division Multiplexing

- Multiple channels of information carried over the same fiber, each using an individual wavelength.
- Dense WDM is WDM utilizing closely spaced channels.
- Cost effective way of increasing capacity without replacing fiber.
- Commercial systems available with capacities of 32 channels.
- Allows new optical network topologies, for example high speed metropolitan rings.

III. CWDM

Coarse wavelength division multiplexing (CWDM) is a method of combining multiple signals on laser beams at various wavelengths for transmission along fiber optic cables, such that the number of channels is fewer than in dense wavelength division multiplexing (DWDM) but more than in standard wavelength division multiplexing (WDM).CWDM utilizes multiple wavelength spaced at 20nm. The International Telecommunication Union (ITU) specifies 18CWDM wavelengths from 1271nm to 1611nm. Transmitters, optical multiplexers and demultiplexer are at defined wavelength but they do not need to be tightly controlled which translates into lower equipment costs compared to Dense WDM

IV. ADVANTAGES

WDM:

1. Fewer wires or channels to transmit and receive data.
2. A single fiber-optic cable can handle dozens of channel, instead of using 12 cables, you only use one.

DWDM:

1. Greater fiber capacity.
2. Easier network expansion.
3. No new fiber needed.
4. Incremental cost for a new channel is low.
5. No need to replace many components such as optical amplifiers.

CWDM:

1. CWDM is a cheaper and simpler alternative to DWDM.
2. Passive components, such as multiplexers, are lower-cost.
3. CWDM components use less space on PCBs - lower cost.
4. Lasers used require less precise wavelength control.
5. It provides low insertion loss, high channel isolation, wide pass band, low temperature sensitivity and epoxy free optical path.
6. Lower power dissipation, smaller size, and less cost.

V. DISADVANTAGES OR CHALLENGES

WDM:

1. Complex transmitters and receivers.
2. They must be wideband, which means they are more expensive and possibly less reliable.

DWDM:

1. Not cost-effective for low channel numbers.
2. Fixed cost of mux/demux, transponder, other system components.
3. Introduces another element, the frequency domain, to network design and management.
4. DWDM performance monitoring and protection methodologies developing.

CWDM:

1. Number of channel is limited.
2. The CWDM-PON lacks in scalability.

VI. COCLUSION

The advantages of DWDM make this technology ideal for communication and other. The scope of optical network based services are increasing and it provides better results compared to the traditional networks like circuit switching and packet switching policies. By using optical fibers the nature of transmitting data is high and fast when compare to the above traditional approaches using copper cables, twisted pairs as a communication medium.As well as studied about optical ROADM scheme for routing of an individual sub channel within an all-optical OFDM superchannel. The different functions required of optical node were demonstrated using interferometric technique with the extraction, drop, and addition of individual subchannels in a ten subchannels optically aggregated signal and Coarse wavelength division multiplexing (CWDM) is a method of combining multiple signals on laser beams at various wavelengths for transmission along fiber optic cables, such that the number of channels is fewer than in dense wavelength division multiplexing (DWDM) but more than in standard wavelength division multiplexing (WDM).

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