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Investigation of Various Throughput Improvement Techniques in DWDM Optical Networks (REVISED)

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ABSTRACT-When the information is transmitted over the network there are various reasons due to which there is loss of information. Some time due to congested networks the loss is more in the optical networks. As a result we need an intellectual algorithm or process which is applied to the network so that the network could overcome the congestion. In this paper, we study the various techniques applied to the optical network to improve the transmission of data in the network. This study helps us to devise a new algorithm which can be applied to the DWDM optical network. In order to develop any new algorithm it is necessary to know all the technologies which are already applied to the optical network to increase the throughput and how much improvement is being done after applying those techniques.

Keywords: Dense Wavelength Division Multiplexing (DWDM), WDM, Routing, Throughput.

I. INTRODUCTION

The optical networks using wavelength division multiplexing (WDM) could provide huge bandwidth capacity for next-generation Internet. These networks are promising candidate to meet the bandwidth demands from various emerging multimedia applications such that web applications, video on demand, multimedia conference, image access and distribution, home broadband services etc. Optical wavelength division multiplexing (WDM) networking technology has been identified as a suitable candidate for future wide area network (WAN) environments, due to its potential ability to meet rising demands of high bandwidth and low latency communication. Networking protocols and algorithms are being developed to meet the changing operational requirements in future optical networks. Simulation is used in the study and evaluation of such new protocols, and is considered a critical component of protocol design. Our goal in this paper is study various techniques that are used in the case of optical networks to improve the transmission of data. This paper presents a background for the development of new technology which could effectively be used to increase the performance of DWDM optical network.

II. WAVELENGTH DIVISION MULTIPLEXING

In optical communication, wavelength division multiplexing (WDM) is a technology which carries a number of optical carrier signals on a single fiber by using different wavelengths of laser light. This allows bidirectional communication over one standard fiber with in increased capacity. As optical network supports huge bandwidth; WDM network splits this into a number of small bandwidths optical channels. It allows multiple data stream to be transferred along a same fiber at the same time.

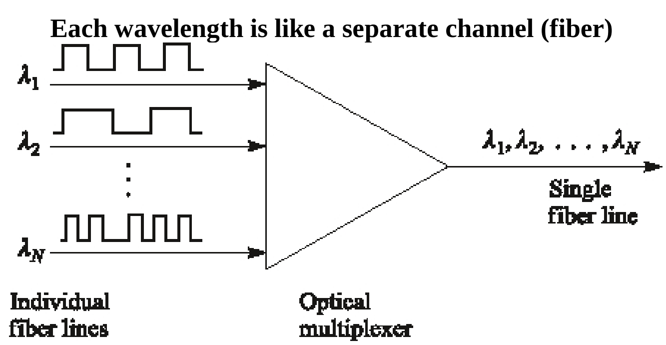

Fig 1.1 Wavelength Division Multiplexing

A WDM system uses a number of multiplexers at the transmitter end, which multiplexes more than one optical signal onto a single fiber and demultiplexers at the receiver to split them apart. Generally the transmitter consists of a laser and modulator. The light source generates an optical carrier signal at either fixed or a tunable wavelength. The receiver consists of photodiode detector which converts an optical signal to electrical signal. This new technology allows engineers to increase the capacity of network without laying more fiber. It has more security compared to other types of communication from tapping and also immune to crosstalk [1].

III. DENSE WAVELENGTH DIVISION MULTIPLEXING (DWDM)

Dense wavelength division multiplexing refers to optical signals multiplexed within the 1550nm band; so as to leverage the capabilities (and cost) of erbium doped fiber amplifiers (EDFAs), which are effective for wavelengths between approximately 1525–1565 nm (C band), or 1570–1610 nm (L band). EDFAs were originally developed to replace SONET/SDH optical-electrical-optical (OEO) regenerators. EDFAs can amplify any optical signal in their operating range, regardless of the modulated bit rate. For multi-wavelength optical signals, EDFA can amplify as many optical signals as can be multiplexed into its amplification band (though signal densities are limited by choice of modulation format). EDFAs, therefore, allow a single-channel optical link to be upgraded in bit rate by replacing only equipment at the ends of the link, while retaining the existing EDFA or series of EDFAs through a long haul route. Furthermore, single-wavelength links using EDFAs can similarly be upgraded to WDM links at reasonable cost. The EDFAs cost is thus leveraged across as many channels as can be multiplexed into the 1550 nm band.

IV. CONCEPT OF TRAFFIC GROOMING

Given a set of connection requests, the problem of setting up light paths by routing and assigning a wavelength to each connection is called routing and wavelength assignment (RWA) problem. This problem is also defined as the traffic grooming. If we cannot setup a light path for a connection request, then it is blocked. A well designed RWA algorithm is critically important to improve the performance of DWDM networks. RWA problem can be classified into static and dynamic problems. In the static problem, the connection requests are given in advance. The objective is to minimize the total blocking probability or to have the maximum number of setting up connections. In contrast, the dynamic RWA considers the case where connection requests arrive dynamically. The dynamic RWA is performed online, it is much more challenging; therefore, heuristic algorithms are usually employed in resolving this problem.

V. RELATED WORKS

Alberto Aloisio et. al. [2] presented and discussed the performance of a complex DWDM network data transmission system that would find an application in the NEMO underwater neutrino telescope. The tests covered the qualification of a complete multipoint DWDM network consisting of transponders, fibers, passive optical filters, and an optical amplifier.

Samy Ghoniemy et. al. [3] presented modeling and design, simulation, characterization and performance evaluation of high data rate and high capacity long-haul DWMD light wave systems as well, a methodology for finding the optimum modulation format that can effectively enhance the system performance without major changes in the existing infrastructure. The performance of the exemplary system is examined using four different modulation formats: NRZ-OOK,optical duobinary, differential binary phase shift keying (NRZDBPSK),and differential quadrature phase shift keying (RZDQPSK).Simulation results show that the overall system's performance using a combination RZ-DQPSK with the LEAF based on reduced channel spacing provides a remarkable improvement over implementations based on other fiber and modulation format combinations.

Vladimir Tejkal et. al. [4] performed analysis of binary modulation formats in passive optical networks based on wavelength division multiplexing (WDM-PON). The simulations showed that CRZ is not suitable for optical link based on wavelength division multiplexing because of the broader central lobe compared with other modulation formats; also NRZ modulation gives the lowest BER in the investigated network.

C. H. Yeh et. al. [5] proposed and experimentally investigated a ring based signal remodulation WDM-PON system to mitigate RB beat noise. In the proposed network, a new ONU is designed to generate two propagating directions for downstream and upstream traffic.

Santos Kumar Das et. al. [6] proposed a QoS based OVPN framework depending on delay. The proposed framework computes wavelength dependent delay for all possible OVPN connections for a source and destination pair of a client and finally setup a qualitatively best OVPN connection and provides a guaranteed quality of service (QoS). This framework also computes the QoS for different fiber materials in order to choose the right material, which can help to improve the QoS for an OVPN connection.

Yang Qiu et. al. [7] proposed a novel scheme to perform optical multicast overlay of two independent multicast data streams on a wavelength-division-multiplexed passive optical network. By controlling a sinusoidal clock signal and an optical switch

at the optical line terminal, the delivery of the two multicast data, being carried by the generated optical tones, can be independently and flexibly controlled. Simultaneous transmissions of 10-Gb/s unicast downstream and upstream data as well as two independent 10-Gb/s multicast data are successfully demonstrated.
Alberto Aloisio et. al. [8] presented and discussed the performance of a complex DWDM network data transmission system that will find an application in the NEMO underwater neutrino telescope. The results showed a high optical power budget for values of optical power at the receiver close to the LOS state, the introduction of optical filters increased the system performance due to the reduced amount of optical noise fed to the receiver.

M. Esmaeili et. al. [9] developed a novel "risk-aware" provisioning solution for light path routing in multi-domain optical networks experiencing multiple correlated failures. The findings showed that the joint incorporation of traffic engineering and risk objectives is very effective in improving overall light path reliability.

Benyang Chen et. al. [10] proposed a wavelength optimization model according to the topology of wavelength-shared WDM-PON. With the application of this model, optimum allocation of wavelength resources can be realized and balance between performance and costs can be achieved under some conditions. Furthermore, average delay characteristics of wavelength-shared WDM-PON are simulated and analyzed. The results showed that not only the operation of network is stable but also simulation analysis is consistent with theoretical analysis and actual network situation.

Norimitsu Tsutsui et. al. [11] evaluated the performance of packet/path integrated network. The author showed that the latency is decreased to about 25% of the latency in packet switched network when the number of wavelengths is statically allocated. Next he showed that the dynamic wavelength allocation method based on queue lengths of buffer decreases the latency on various traffic loads. The results indicated the proposed method decreases the latency effectively.

Lin Xu et. al. [12] proposed, compared, and evaluated a novel remodulation scheme using the nonreciprocity of a traveling-wave electro-optic phase/amplitude modulator. This technique allows a simple and cost-effective ONU structure, which has potential for low-cost implementation via the use of silicon-photonics-based integrated receivers and modulators.

Jing Xu et. al. [13] proposed a novel WDM-PON architecture to provide symmetric bit rates and multicast overlay based on DPSK/IRZ orthogonal modulation and synchronization control. Author showed that simple and flexible multicast control could be realized at the OLT using the proposed architecture.

Y. Shachaf et. al. [14] proposed a scalable access network architecture, which is experimentally evaluated to demonstrate gradual deployment of time and wavelength-division multiplexed passive optical networks in a single-platform with minor changes in fiber infrastructure. This is achieved by the application of dynamic coarse-fine grooming to route multiple reflective optical network units of either time or wavelength-multiplexed PONs collectively through coarse pass band of an arrayed waveguide grating.
A.D.Kora et. al. [15] presented a generalized analytical model of error probability in passive optical network (PON) in which optical orthogonal codes (OOC) and (dense) wavelength division multiplexing (WDM) have been considered. Low cost deployment of these networks is determined by several parameters characterizing this system such as optic transmitters with a relatively large spectrum. The work evaluates the relationship between a network using OOC and WDM parameters in crosstalk situation.

Pham Tien Dat et. al. [16] presented a successful significant attempt to study and characterize the simultaneous transmission of multiple RF signals in actual operational environment using an advanced DWDM RoFSO system. The system can be considered as an easy, cost effective means to build a feasible and universal platform for ubiquitous communication.

Yuki Okamura et. al. [17] evaluated the performance of packet multiplexing with three flow aggregation strategies in multiwavelength optical packet networks. The results showed flow aggregation based on destination AS can increase bandwidth utilization most efficiently.

Amornrat Jirattigalachote et. al. [18] proposed a novel Impairment Constraint Based Routing algorithm with differentiation of service based on Bit Error Rate (BER) of a light path provisioned for each connection request. In this work BER is considered as a routing constraint that corresponds to the signal quality requirement of connection requests. Simulation results indicated a significant improvement in blocking probabilities compared to the shortest path and impairment-aware best-path (IABP) approaches.

Jun He et. al. [19] proposed a new heuristic offline wavelength ordering algorithm to wisely allocate the wavelengths to calls/requests in order to minimize crosstalk due to adjacent wavelength power leaking through the WDM demultiplexers.

The work showed that this technique not only alleviates the effects of physical impairments, but also decreases the latency in QoS-aware algorithms, over a wide range of network parameters.

Arvind Kumar Sharda1 et. al. [20] proposed one user, two user, four user and eight user FWM based DWDM systems at 2.5Gbps bit rate. The designed system exploits FWM's property and uses all the wavelengths for transmitting data. The designed system provides no wastage of wavelengths like in case of wavelength converters. It has been designed addressing the problem of wastage of wavelengths with wavelength converters and how this wastage can be prevented. The work showed that BER increases while quality factor and received power decrease as there is increase in number of users and optical fiber distance.

T.L Vinh et. al. [21] worked on the problem of dynamic survivable routing in WDM networks with single link failure model. The model generated was to find the ways to dynamically determine a protection cycle (i.e. two link disjoint paths between a node pair) to establish a dependable light path with back up path sharing. The authors used a genetic algorithm (GA) based survivable routing algorithm; which allowed to improve the blocking performances.
Yuxiang Zhai et. al. [22] investigated the impact of physical layer on the blocking probability and vulnerability ratio under two different dedicated path protection schemes: dark backup and lit backup.Simulation results showed that QoT aware HQ outperforms SP in terms of blocking probability and vulnerability ratio in a certain traffic load range in both backup dark and lit protection schemes.

Hu et. al. [23] proposed a wavelength routing scheme with no service interruption in all optical network with survivable traffic grooming capability. The proposed scheme allows two routes: one for active path, and another for backup path. The proposed scheme is called survivable traffic grooming wavelength retuning (STGWR). The throughput can be increased to some extent in all optical networks using this scheme.
Ge Nong et. al. [24] proposed an efficient Medium Access Control (MAC) protocol called iCSMA/CD for improving the efficiencies of optical Wavelength Division Multiplexing (WDM) networks. The proposed protocol for an optical WDM ring network with each node equipped with a wavelength tuneable transmitter and a wavelength fixed receiver is more intelligent in predicting the occupation status of each individual channel, which in turn yields a better system performance in terms of delay and throughput. The simulation results showed that the protocol has significant impacts on improving the system performance.

Weifa Liang et. al. [25] proposed an algorithm for realizing all-to-all routing such that the routing is fault tolerant and both node load and link load are well balanced. The results showed that the proposed approach produces clear routing paths, requires fewer wavelengths, and can easily incorporate load balancing.

VI. CONCLUSION

In this paper, the various techniques of throughput improvement and their effect on the performance of DWDM optical networks has been studied. A brief introduction of DWDM Network has been given and a review of the network performance in accordance with the various algorithms has been studied. DWDM is important technology used in today's communication systems. It has better features than other types of communication with client satisfaction. In this paper we have studied what different types of modulation schemes have effect on the performance of DWDM optical network.

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