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AN EFFICIENT TECHNIQUE TO ENHANCE SIGNAL TRANSMISSION IN OPTICAL NETWORK

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ABSTRACT

The usage of internet medium for high speed, high performing applications and multimedia. require the communication network to be more responsive, which depends upon the transceiver parameters. This paper intends to improve the capability of the communication, using the optical network by enhancing the key parameters like SNR and data capacity of the transceiver through optimization. Thus mitigating the effects like ASE and non linear interference, and analyzing the parameters such as modulation format, launch power and channel allocation with reference to a corrected Gaussian noise model. The simulation is performed on a 20 channel network to demonstrate the effectiveness of the proposed system.

Keywords: *Optical Network, Transmittance Power, Shannon Capacity, network performance*

I. INTRODUCTION

Optical network can be defined telecommunication network of high capacity based on optical technologies and resources that facilitate routing, grooming, wavelength level restoration as well as wavelength based services. Data communication is observed by transmission of data in the form of light pulse between the sender and the receiver. The operating range depends a local-area network (LAN) or a wide-area network (WAN).It provides communication by linking metropolitan and regional areas throughout the nation, and also links international and overseas distances. It is advantageous by having the capability to provide high speed and achieving high bandwidth for operation [1]. The major resources found in a optical network system are Fiber either a Multi-mode or single-mode, light source like Laser or LED light source, Multiplexer/demultiplexer, filter, or prism, which may include Optical Add/Drop Multiplexer and Reconfigurable Optical Add/Drop Multiplexer. By means of optical switch light between the ports are directed so that the OEO conversion is not required, an Optical Splitter is used to route a signal towards different fiber paths, Optical Amplifier and Circulator and Optical Amplifier [1].the major reasons in using of optical network is its key parameters of the fiber used like capability and restoration capability. The major issues that are seen in a optical network include tedious task of joining the fiber cable, the risk of bending the cable or kinking the cable, effect of gamma rays and disturbance caused from high voltage electrical field [2].the physical impairment of optical signals transmitted can cause attenuation, cross talk and dispersion degrading the performance.[3][4].The key challenges the current industrial applications are facing is energy consumption ,transmission rate, switching throughput spectrum efficiency[5]. With emerging new internet applications that are becoming high performance and network based relying on the optical network. Evolutions of these applications have made efficiency and flexibility of the optical network more crucial and determinate [6]. Software Defined Network (SDN) allows controlling and managing functions at different layers of network, applications are allowed to control the network resources or information in different domain technology .cloud based services are extending the network to new boundaries by using sophisticated optical network technologies [7].Evolving heterogeneous network application, the diverse bandwidth fulfillment is required for which the elastic optical network is foreseen as a solution [8]. Concerns regarding the scalability current optical network and also IP based network are giving rise to new trends. One way is shifting from the current rigid network to a spectrally efficient elastic network with flexible bandwidth and adaptive spacing [9]. Advancement in optical network is giving rise to advanced transmission technique and efficient switching devices [9]. By using the concept of infrastructure as a service virtualization, optical network can be used to facilitate the sharing of physical resources to different users and applications using algorithm for both the types that include Opaque Virtual Optical Network Embedding and the transparent type instead of flexible grid elastic optical networks [10].

Rapid growth in multimedia application in years has made it a real-time and stream oriented communication. Such communication requires a high Quality Of services (QoS), which need a stream communication having a guaranteed bandwidth, delay and jitter. Integration of different media such as audio, video, images, graphics, text and data each

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having different Quality of service requirement can be carried out using optical network using different protocols to achieve high level of throughput and reliability

The paper also intends to enhance the channel capacity of the optical network. The outcome of the study is evaluated with respect to channel error and channel capacity mainly. Section 2 discusses about the related work followed by problem identification in Section 3. Section 4 discusses about the proposed system followed by the adopted research methodology in Section 5. Outcome of the study is discussed in Section 6, while Section 7 makes concluding remarks.

II. RELATED WORK

This section discusses about the existing literatures that has been carried out towards evaluation of signal efficiency in optical network.

Kim et al [11] suggests to obtain the benefits like mobility in wireless networks and the benefit of high capacity in optical networks the integration of EPON (Ethernet Passive Optical Network) and WiMax, based upon a Distributed Antenna (DA) domain, where Base Stations (BSs) are collaborated and simultaneously transmit same wireless downlink signals (specifically for multicast and broadcast services (MBSs)) to Mobile Stations (MSs) in a domain where cell coverage overlap is seen. the result based on the Performance evaluation of proposed DA-based integration architecture show the improved cost efficiency of the architecture over the Traditional Antenna (TA) (non-DA) -based integrated architecture with a same level of spectral efficiency of MSs.

Hwang et al. [12] have proposed a technique of performing channel allocation based on the QoS (Quality-of-Service) for the optical network. The studied work has highlighted on interleaved scheduling with predictive principle and thereby reducing the idle duration. The performance of the proposed system has found to have an overall better quality of system performance which through simulation is seen even if the high-priority traffic is increasing from 20%, 40%, and 60%.

Muhammad et al [13] suggests a strategy to mitigate the set- up delay tolerance. Strategy is based on different scheduling strategies to assist the requests belonging to smaller set-up delay tolerance SC(Service Class), that includes fraction of the available resource is reserved, giving priority, by providing some extra paths and elevating the research space .through simulation it is seen that the overall improvement in network efficiency and network blocking performance.

Bathula et al [14] has suggests that the pre-deploying of optoelectronic generators Compared to the current practice of installing a regenerator only when a circuit needs them, service providers can swiftly provide requirements as such as bandwidth-on-demand service and fast restoration by the pre-deployment of regenerators in particular sites and comparing with the heuristic results with ILP (Integer Linear Programming) for a small-scale network topology.

Liu et al [5] demonstrates that cardinality proposed in the past supported new network architecture and applications using rapidly switching and security concerning the physical layer in optical code division(OCD) multiple entries including algebraically coded optical code having large cardinality and specific tree structure of different levels of subsets containing the codeword for adjustable code performance. Also suggests a new “translate” method of adapting “additive” Error Correction Codes (ECCs) into similar kind of optical codes is explored and expressed with four family of Reed-Solomon code. Using the weight distribution of ECCs the performance of these “tree-structured” optical codes are algebraically analyzed and verified.

Beyranvand et al [16] demonstrates a new model to enhance the performance of multiservice WDM (Wavelength Division Multiplexing) / OCDM (Optical Code Division Multiplexing)-based core networks. This scheme is based on utilizing optical (MLTT) Multi Level Transmission Technique to reduce the (MAI) Multiple Access Interference effect of OCDM. The proposed model consists of independently designed data and control plane that are separated. From the results of the proposed scheme it is evident that the data-plane aware controlling proposal, which takes in account of information in data plane, surpasses data-plane unaware algorithms in terms of average error probabilities.

Appaiah et al [17] demonstrated a technique to motivate the use of vector modulation and signal processing to enable high-data rates over MMFs (Multimode Fiber) using developments in wireless communication theory and discuss the implementation of a closed-loop system with limited channel state feedback to enable the use of precoding at the transmitter. The indications from the Experimental results suggest that vector intensity modulation and direct detection with two modulators and detectors, along with the use of limited feedback results in a 50% increase over the single laser and detector case

Perello et al [18] suggests a scheme for impairment-aware light path restoration scheme to check failure localization mechanism and an experimental demonstration on the dynamic impairment-aware restoration scheme that uses the benefits from enhanced NPOT (Network Planning and Operation Tool) features for fast light path restoration is provided. The proposed systems performance evaluation is done on a 14 nodes all optical network test bed, giving a average restoration time of 1.16 and 1.64 s for high and low priority traffic class.

Helmy et al [19] proposed a decentralized media access scheme to make the performance independent of the independent of the physical length between OLT (Optical Line Terminal) and ONUs (Optical Network Unit) for the upcoming LR-PON (Long Reach Passive Optical Network)s. In comparison to the conventional decentralized scheme here centralized control is maintained over the network, which is missed in conventional decentralized schemes, to support and manage Quality of Service(QoS) according to user service level agreements. The special requirements of emerging LR-PONs is met by this scheme by combing the decentralized media access with centralized control simulation results show 60% upstream packet can be reduced , while high throughput is maintained.

Yang et al. [20] proposed a multi-stratum resource integration (MSRI) architecture using IP and optical transport networks for Open Flow based data center interconnection. The controlling architecture is executed using multiple Open Flow controllers' collaboration through exchanging information between different controllers by MSRI. Based on the proposed architecture , a strategy to estimate service aware flow for MSRI is established .Experiments demonstrates the overall feasibility and efficiency of this architecture in optical as a service test bed in term of blocking probabilities, rate of resource allocation, and path providing latency's.

.Bhandre et al [21] proposes a strategy to reduce the effect of a ISI (Inter Symbol Interference) using optical coherent detection in metro optical network using potential electrical signal processing technique. The measured SPM(Self Phase Modulation) tolerance of NRZ-DPSK(Non Return-to-Zero Differential Phase Shift Keying) over 304 km of SSMF(Standard Single Mode Fiber) in three spans of ~100 km each is +8.8 dBm fiber launch- - power for 1.5 dB OSNR (Optical Signal To Noise Ratio) penalty.

Lee et al [22] proposes that an analytical traffic adjusting algorithm enhanced by comparing with direct bypass routing for enhancing both energy and delay capability in a high power traffic proportionality system. Additional improvement in delay performance in a low energy- traffic proportionality system is possible with hottest-first sorting policy in flow provision proportionality regime is possible with hottest-first sorting policy in flow provision. Rjeily et al. [23] analyzes the effect on the performance of cooperative Free-space Optical (FSO) networks using a novel three-stage cooperation methodology. Due to the presence of inter-relay connections closed-form expressions is derived for any number of relays using the conditional error probability in the proposed system. From the results its seen that the presence of inter-relay connections, associated with an appropriate cooperation scheme and PAS (Power Allocation Strategy), can significantly boost the performance of relay-assisted FSO systems

III. PROBLEM DESCRIPTION

In the existing system, it is seen that traditional technique for wavelength routing usually permits the mapping of requirement factor for elaborately transmit the data packets, however, such technique suffers from the issues of reducing the resources from the wavelength without considering single charecteristics of physical channel. The problems identified for the proposed study are as follows:

- Achievable gain can be impacted by the assumption of traffic demand and needs further examination.
- The gain in SNR margin is influenced by WDM (Wavelength Division Multiplexing) assignment and can be affected by attributes like physical channel characteristic, presence of nonlinearity, and routing continuity constrains.
- Transmission launch power optimization and modulation format with routing and spectral assignment is demonstrated for only simple mesh network.

Further consideration is needed for smaller networks or the ones utilizing adaptive modulation and coding so as to smooth the transition between SNR requirements of different modulation and the impact of the correction in Gaussian noise model.

IV. PROPOSED SYSTEM

The prime aim of the proposed system is to improve the gains in SNR (Signal to Noise Ratio) and data capacity by properly optimizing transceiver parameters. In order to accomplish the above mentioned goal, following objectives are set:

- Improving the bandwidth of optical network
- Error free transmission for all routing and re-routing under all condition.
- Controlling power requirement and satisfying the SNR for long point-to-point transmission.
- Complete utilization of network resources to achieve high data throughput and improve quality of service.
- The problems identified in the proposed system are as follows:
- The assumptions made on traffic demand can have significant effect on the achievable gain and thus needs further examination.
- WDM (Wavelength Division Multiplexing) has influence on the gain SNR margin and can be affected by attributes like physical channel characteristic, presence of nonlinearity and routing continuity constrains.

In case of smaller networks or the kind of networks making use of the adaptive modulation mechanism and coding, in order to achieve a smooth transition between SNR requirements of different modulation and effect of the correction in Gaussian noise model will require further analysis and consideration in accomplishing the objective. The approach used in the study is empirical in nature with simplified usage of SNR.

V. RESEARCH METHODOLOGY

Considering the polarization multiplexed transmission system where the symbol SNR is limited by ASE (Amplified Spontaneous Emission) noise and non linear interference the Gaussian noise model of non linear interference is modeled in the proposed system. An uncompensated source of additive white noise is considered as the nonlinear interference between DWDM (Dense Wavelength Division Multiplexing) channels caused by the arbitrary alteration in refractive indexes of optical fiber and combines incoherently with additive white noise with ASE. The proposed system uses a simple Gaussian Noise model with assumption that it modestly estimates the nonlinear interference noise and allows for network optimization. The transmission loss is assumed to be fully compensated by using EDFA (Erbium Doped fiber Amplifier). The system uses non-linear transmission model used for point-to-point optical transmission link. The symbol SNR, SNR_n of the n^{th} DWDM channel is given by

$$SNR_n = \frac{R_i}{T_{ASE_{in}}} + T_{NLI_{in}} \quad (1)$$

In the above equation, R_i is Received signal power, T_{ASE} is ASE Noise Power, $T_{NLI,in}$ is the linear interference noise power within the receiver filter bandwidth all on the n^{th} DWDM channel. ASE noise power is given by

$$T_{ASE,i=}10^{NF/10}\, h\nu R\textstyle\sum_k 10 \quad (2)$$

Effective Receiver noise of the bandwidth used is equal to the symbol Rate R considering the assumption that the overall noise spectrum is white dominated by ASE and SNR is maximized by implementing an ideal matched filter in the receiver. NON linear interference noise T_{NLin} on the n^{th} channel due to SPM and XPM can be written.

$$T_{NLin}=R_i \textstyle\sum H_{pq}^2 \quad (3)$$

Where R is the channel launch power and the summation q is the overall 80 channel, H_{pq} is the accumulated efficiency factor of the nonlinear interference on the i^{th} channel caused by the q^{th} interfering channel. Efficiency factor H_{pq} depends on the frequency spacing between channels p & q the linear and nonlinear Transmission properties of the optical fiber.

Route Optimization

Considering a link comprising of a stretch of length 80km having transmission fiber parameters. the loss estimated at the transmitter and receiver nodes is 7.25 db due to patching connections compensated by an internal EDFA and DWDM multiplexers and patching connections compensated by an internal EDFA .All the EDFAs are assumed to have a noise figure of 5db.the link is assumed to support 20 channels on 50ghz fixed grid at a symbol rate of 28 Gbaud. The two strategies considered for launch power are:

- In the first strategy the launch power is equal to all channels

- In second strategy the launch power of individual channels are optimized to improve the flat symbol SNR of all the channels.

Using Newton-Raphson method the individual channel powers has been optimized iteratively while required SNR is increased to a maximum beyond which no solution to the power optimization is available. For each channel under two capacity optimization strategies. In first strategy the overall network capacity is calculated using the Shannon capacity equation where b is the metric.

$$b=[SNR_i+1]$$

In second strategy used for capacity optimization, capacity maximization is achieved using PM-MQAM.its found that by re distribution of launch power between channels minimum symbol SNR is improved capacity of the link can be increased by optimizing launch power in order to achieve a symbol SNR adapted to a modulation format. Extending link model to a simple 3-node network

- Using the same transmission parameters as above
- To every added, dropped or passed signal through the central add- drop node is assumed to have a 14db loss with addition to launch and receive nodes.
- In initial state the DWDM channel allocations are grouped such that the group of 20 channel's of the first half traversing the entire network and the second half group of 20 channels being dropped and with added 20 channels added at the central node. The ASE noise accumulated for the signal passing the longest path from node a to node b is 10.8*10-3mW.accumulated maximum nonlinear interference efficiency at the centre channel Sm is 13.3*10-3mW-2.optimized flat launch power R is 0.74mW(-1.3dBm),providing a minimum symbol SNR of 16.6db.
- By re-distribution of launch power from shorter to longer lengths in combination of correct wavelength allocation.
- Optimization of modulation format for a specific connection based on its symbol SNR, bandwidth required for shorter connection has been reduced making more bandwidth for longer connections increasing the overall network throughput.
- Network optimization mesh
- Using a 14 node NSF mesh network Possible capacity gain is understood through optimization of the transmitter power and modulation format .
- The link length Z(km) calculated from the great circle distance between the nodes ZGC(km)
- The aim for this network is to improve the throughput by optimizing routing and channel allocation.
- Overall objective is to improve the throughput of the network and analyze it and compare its variation to fixed modulation format compared to the modulation format adapted to the signal quality.
- The link length LCG(km) is calculated from the great circle distance between the nodes.
- LGC(km)

L=

Using the latitude and longitude great circle distance between the nodes is calculated of the nodes using the haversine formula

$$\text{Arcsin}=(\sqrt{\sin^2}\,(\frac{\phi_1-\phi_2}{2})+\cos(\phi_1)\cos(\phi_2)\sin^2(\frac{\lambda_1-\lambda_2}{2})$$

- L_{GC}=2r
- Where r represents radius of the earth considered as 6367 km and ϕ and λ is the latitude and longitude of the nodes.
- In process of maximizing the network throughput a routing and wavelength assignment problem is usually encountered based on the traffic demand.
- Optimization of information capacity of a route is not possible without the final routing solution since it does not include the information of how many channels are interacting with the links.

- The shorter characteristic traffic distances have larger gains as they utilize the higher order modulation in shorter distance in a better way. where the SNR is high.
- Larger gains in the network throughput can be obtained by maintaining the number of connections and adapting their modulation format since the shorter connections dominate the gains changing the traffic profile.

VI. RESULT ANALYSIS

The proposed system is implemented in MATLAB on 32 bit machine. In order to evaluate the outcomes of the proposed system, the performance parameters considered are i) Signal quality, ii) launch Power, iii) Channel Error, and iv) Channel Capacity. The implementation of the proposed system is carried out considering the normal optical traffic system from transmitting node to receiving node. Channel capacity is one of the important parameter considered for the study which is considered to be bandwidth of the maximum order modulation (8→16→32→64 QAM). The accomplished outcomes of the proposed study are as shown below:

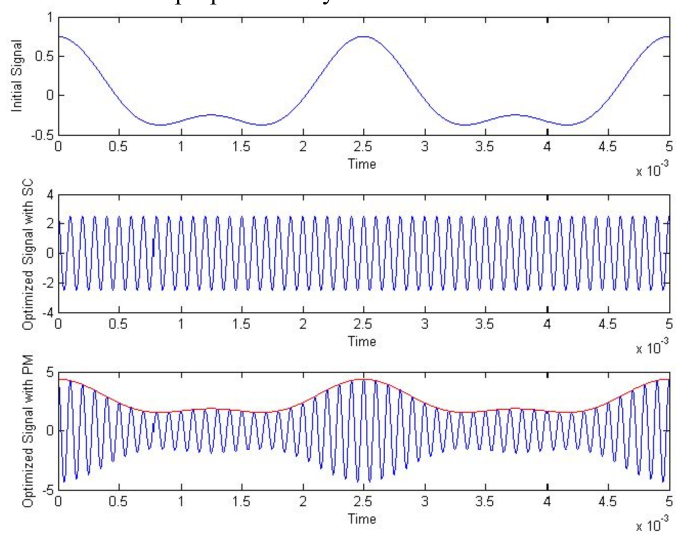

Figure 1 Analysis of Signal

Figure 1 shows the outcome of the study with respect to the quality of the signal being transmitted from the sender node. A closer look into the initial signal with respect to increasing time shows a normalized optical signal. Now the problem statement considered here is – how to enhance the normalized signal on same range of time to encapsulate maximum number of transmitting data. This part of the optimization of the signal quality is done by increasing the channel capacity of the light path by adopting the best efficient polarized multiplexing method using QAM modulation schemes. The system also allows the model to assign a specific symbol SNR for a specifically selected channel launch power distribution. Finally, the power of each channel is enhanced to attain a best symbol SNR. Therefore, the system is able to allocate the best launch power that ensure the best retention of the signal transmission quality and thereby act as a best associate module for optical amplifier, whose task of amplification is now found reduced. This outcome is in agreement with the transmission of the heavier multimedia files and streamlining the real-time applications over optical network that seriously requires to retain the best quality of the signal. Hence, adoption of polarized multiplexing technique and different versions of modulations can ensure that optimal signal quality is generated at the end. Using 20 channels of optical network, the system can now ensure minimal loss of signals during broadcasting. Therefore, enhancement of power leads to enhanced signal and minimal symbol SNR.

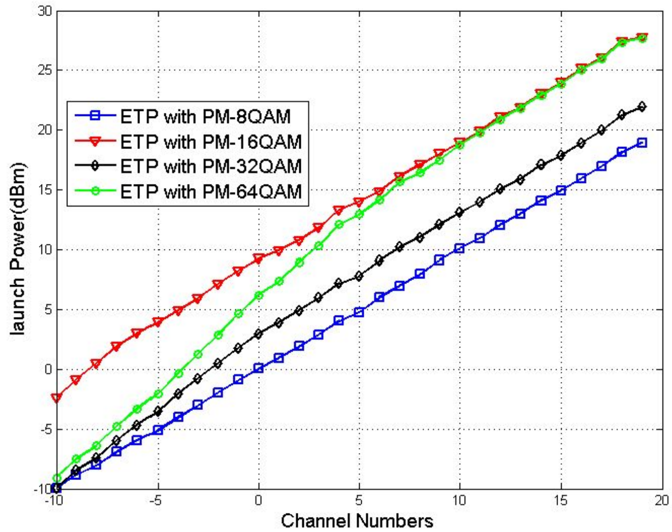

Figure 2 Analysis the Launch Power

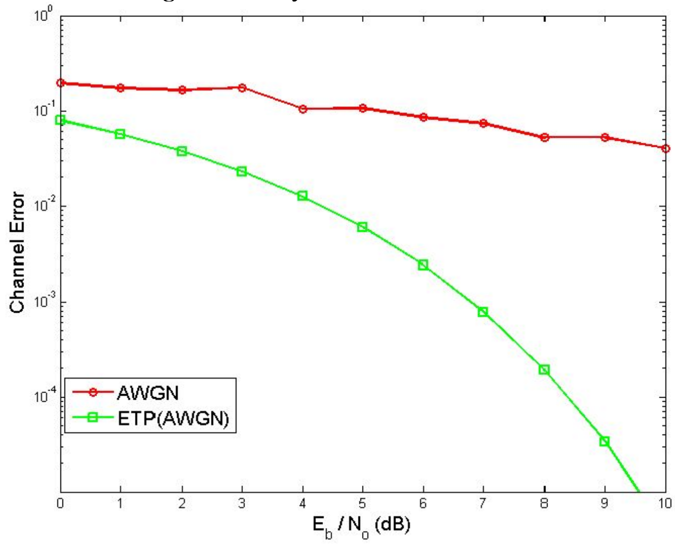

Figure 3 Analysis of Channel Error

Fig.2 shows the analysis of the Launch power. The curve of the proposed system is highlighted as ETP of enhancing transmittance power. The outcome shows that increase in level of modulation has diminished launch power for the transmitter. The single route of the light path adopts the transmittance powers that were enhanced to improve the reduced rate of SNR with the interleaved channel assignment between the shorter and longer haul optical connectivity. The outcome shows that adoption of PM-16QAM results in 27 dBm of launch power which is somewhat equivalent to PM-64QAM. However, curve for PM-32QAM is more than launch power using PM-8QAM. The outcome shows that the proposed model gives a flexibility of using QAM levels based on the situation of the traffic and it also infers that transmittance power can be controlled by enhanced the modulation scheme and multiplexing scheme. Fig.3 shows the analysis of the channel error where the evaluation is done with the existing system and standard AWGN. The outcome shows that AWGN with proposed system offers higher reduction in channel error as compared to the conventional AWGN.

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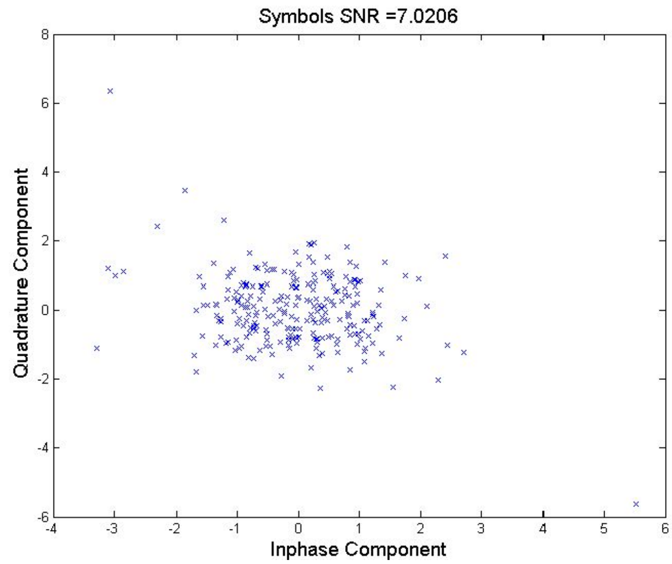

Figure 4 Quadrature components for SNR=7.0206

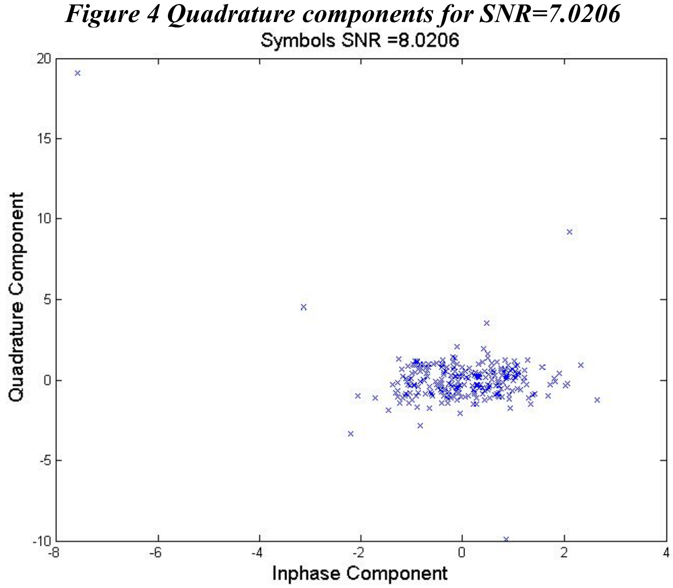

Figure 5 Quadrature components for SNR=8.0206

Fig.4-13 exhibits the behavior of the quadrature component for the proposed study with respect to increasing in-phase components. The study outcome shows that with an increase of SNR, the in-phase components become much sparser, which finally results in arrangement of quadrature components as shown in Fig.13. Hence, it can be said that proposed system offers better retention of signal quality with the increasing modulation techniques using QAM in optical network.

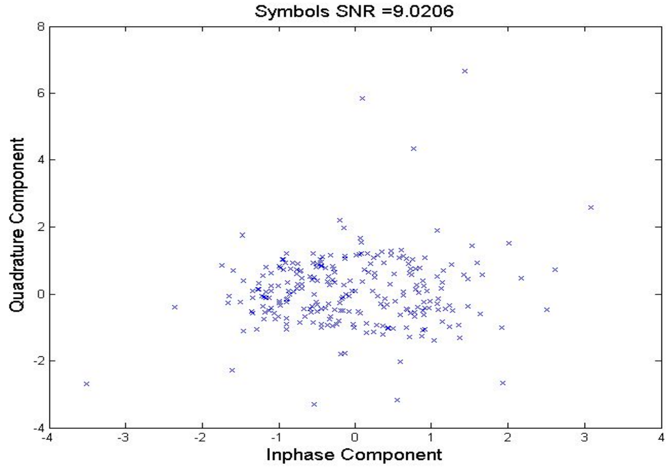

Figure 6 Quadrature components for SNR=9.0206

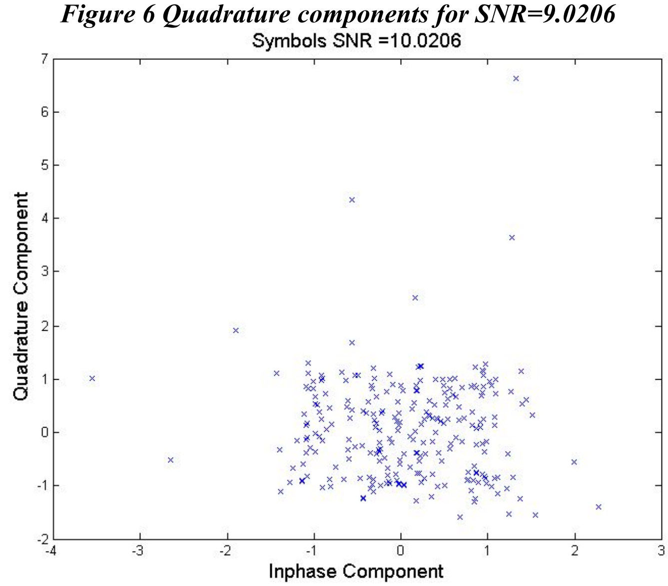

Figure 7 Quadrature components for SNR=10.0206

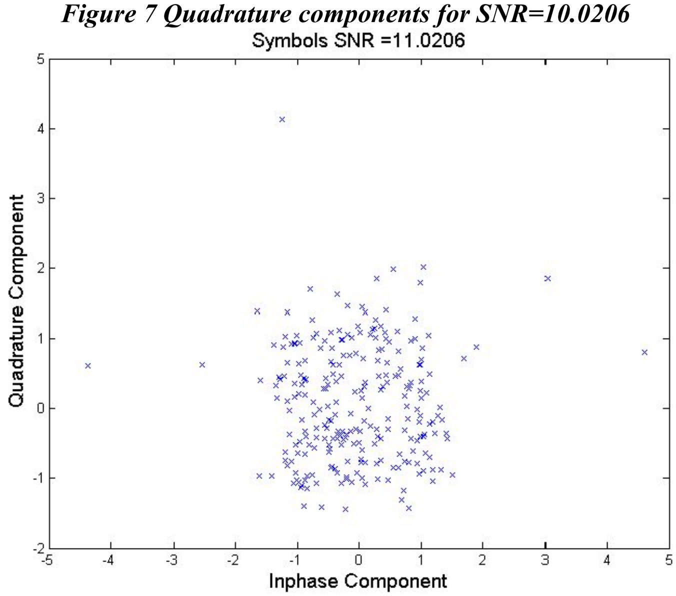

Figure 8 Quadrature components for SNR=11.0206

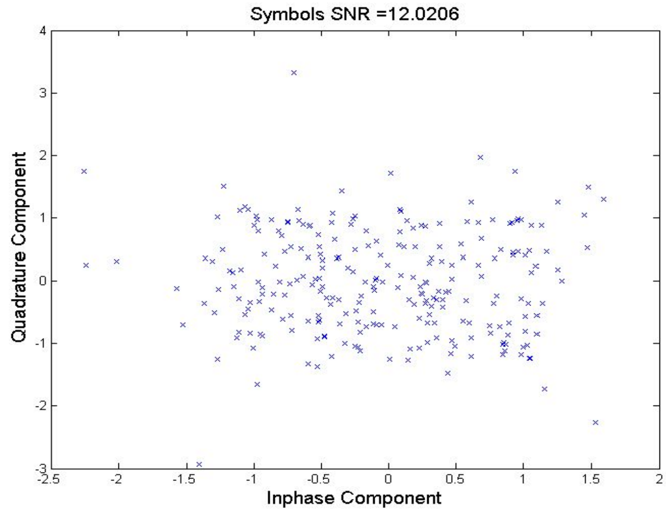

Figure 9 Quadrature components for SNR=12.0206

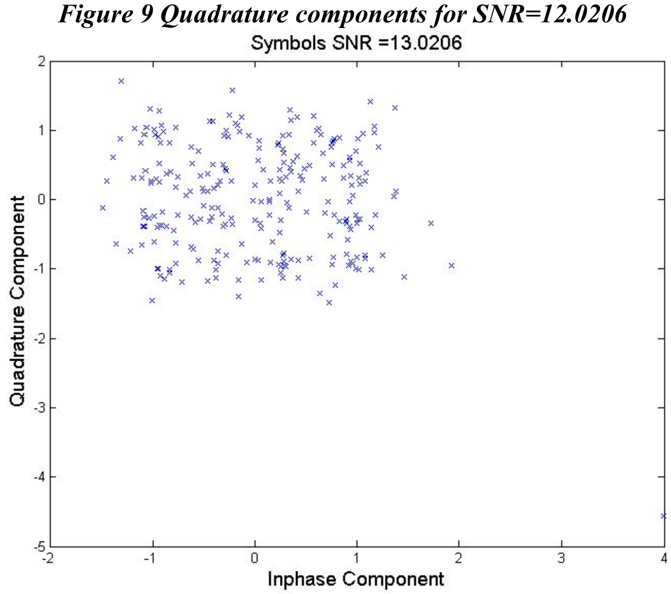

Figure 10 Quadrature components for SNR=13.0206

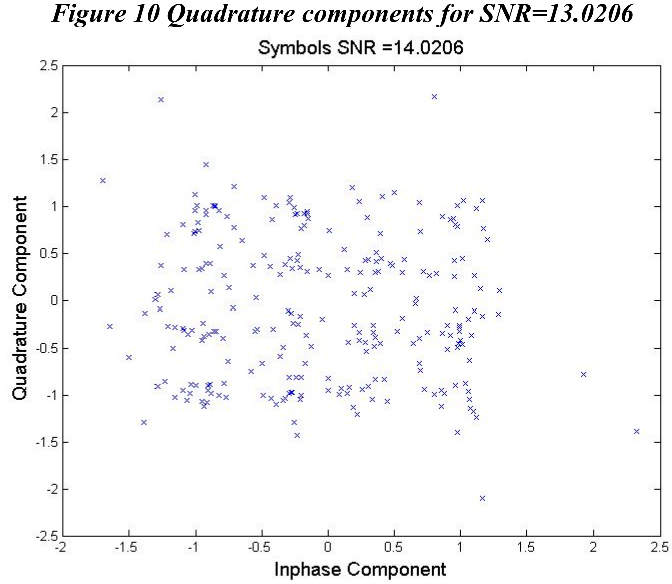

Figure 11 Quadrature components for SNR=14.0206

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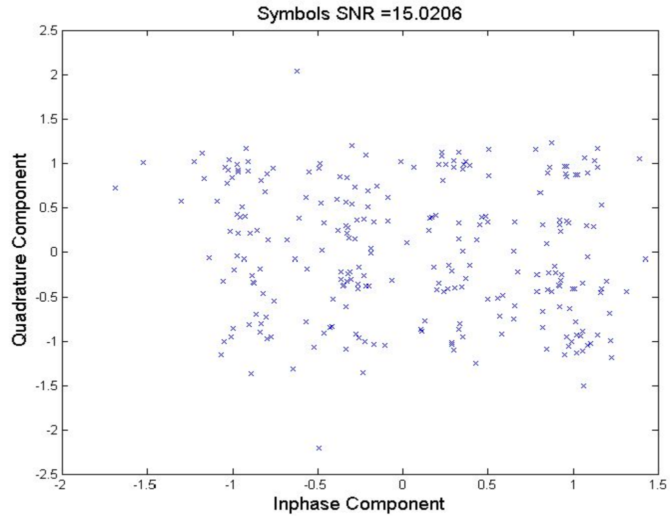

Figure 12 Quadrature components for SNR=15.0206

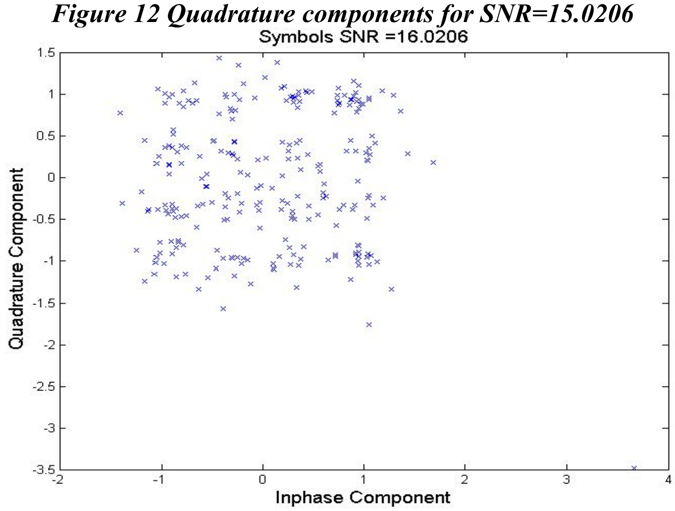

Figure 13 Quadrature components for SNR=16.0206

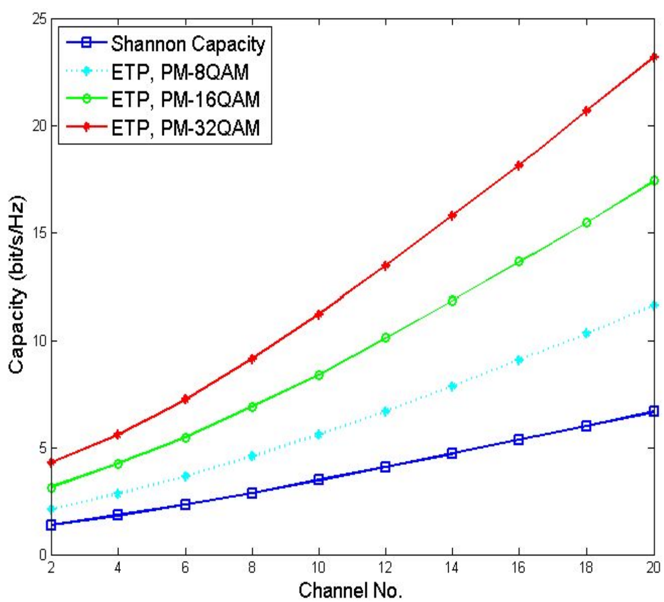

Figure 14 Analysis of Channel Capacity

Fig.14 shows the analysis of the channel capacity of the proposed system with conventional channel capacity. The outcome shows that proposed system with increasing order to QAM modulation scheme offers efficient channel capacity in comparison to the existing Shannon capacity.

The outcome of the proposed system was already compared with existing technique that is found using conventional AWGN as shown in Fig.15. There are numerous work e.g. [24][25][26][27], which has almost the similar approach, but the seemingly the outcome of the proposed study various to a large extent in comparison to the proposed study.

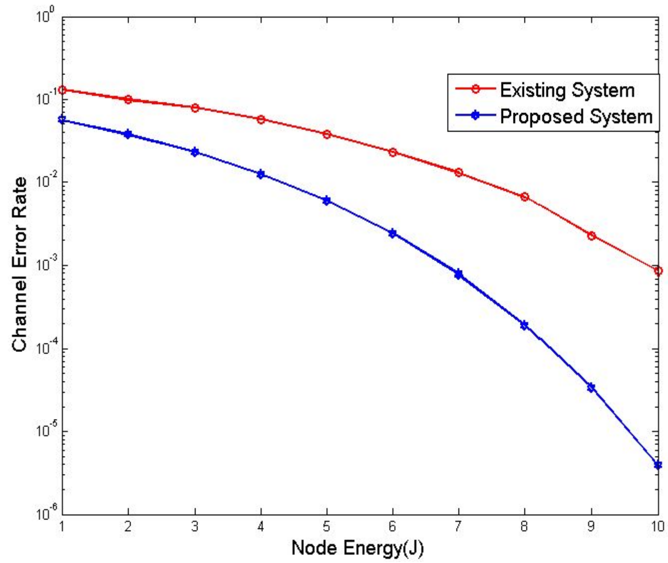

Figure 15 Comparative Performance Analysis

The outcome highlighted in Fig.15 shows that channel error rate of proposed study has been compared with majority of the modulation based technique discussed in [24][25][26][27] etc. The prime reason of better outcomes of the proposed study is its inclusion of network optimization, which is missing from the existing studies. The study performs faster computation of signal quality using Gaussian noise model along with enhancement of channel capacity highly superior than existing approaches found in literatures.

VII.CONCLUSION

The proposed architecture is applied to a 20 channel network, key parameters such as signal quality, channel error, launch power and channel allocation are analyzed. Optimization of the parameters allows improving the channel capacity and thereby accomplishes high throughput. Result analysis shows that data throughput gains are dependent on the traffic distance characteristic. Assumption on the traffic demand will have significant effect on the gain intended to achieve. Channel utilization is also dependent on various factors like physical characteristic and presence of non linearities, and also routing characteristic.

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