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Performance Analysis of Multiple User Optical Code Division Multiple Access

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ABSTRACT

In this paper, we discuss and analyze an optical code division multiple access for multiple user system. Media access control implementation has been considered. For fulfilling the huge need of bandwidth services, technology tends to move to optical networks and three major optical systems come into existence. Code division of the optical network is most used and real concept interacted with users up to this time. Optical code division multiple access provides complete spectrum to each and every user for the time of accessing the channel. In the paper, we have proposed network architecture with optical encoder and decoder along with optical code translator which is supporting multiple user systems. We integrate the code translator with encoding and decoding of optical code to use the optical network at full extent and present the simulation validation results of 6 Gb/s 3-hop transmission by use of proposed architecture. Further, we have implemented experimentation with 6 users 3 Gb/s optical code division multiple access network. Through simulation structure, it is shown that the combination of encoding with EDFA in multiple user environment system provides improvement in bit error rate and also improves the multiple access interference. With increase of users in the network, MAI value increases and our proposed scheme controls interference in the network.

KEYWORDS

Optical Code Division Multiple Access; Strong Interference; Weak Interference; Bit Error Rate; Optical Encoding; Laser Diode Source; Multiple Access Interference

1. Introduction

Modern Communication is intended to achieve greater heights for providing best services to the users. Due to heavy demand of bandwidth on remote access sites, optical code division multiple access networks need to be improved. Erbium-doped fiber amplifier is very useful for providing various properties in optical communication as it provides higher level of compatibility with less loss with better gain while communication and also reduces noise parameters. EDFA process has been used for the cancellation of noise and to provide gain with couplers along with encoder and decoders in the network.

In this paper, optical networks are the main focus in context of optical code division multiple access technique based on optical networks. Optical networks face a lot of challenging tasks and issues which include the quality services to the users.

Code Division Multiplexed Access (CDMA) is a form of spread-spectrum, a family of digital communication techniques that have been used in military applications for many years. The core principle of spread-spectrum is the use of noise-like carrier waves, and bandwidth much wider than that required for simple point-to-point communication at the same data rate [1].

Optical code division multiple access (OCDMA) is one of the upcoming technologies for future multiple access networks along with WDMA and OTDMA. OCDMA is a spreading technique based on the concept of assigning codes to each user in a fiber optic communication network [2,3].

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Optical code acquisition and synchronization plays a crucial role because the degradation in the performance of the system will be dramatic when the synchronization between receiver and transmitter is not ideal [4]. In optical CDMA, each user (or station) is assigned a unique binary unipolar signature sequence as its own address. Each user sends a signature sequence, corresponding to the address of its intended destination, for a data bit one, but transmits nothing for a data bit zero [5].

Codes for OCDMA have to be unipolar, orthogonal (minimum cross-correlation) and constant weight in nature to obtain low values of the bit error rate due to multiple access interference (MAI) [3].

The process of optical CDMA is described in section 1. The brief summary of analysis of OCDMA network and brief results have been done in this section. Further multiple user architecture and proposed work have been explained in Section 2. In last Section 3, results from experimentation and discussion have been explained.

2. Multiple Hop & Multiple User Architecture

An OCDMA network can be viewed as a multiple-channel system, with each channel corresponding to a CDMA code [6,7]. Each OCDMA node is equipped with a transceiver for data transmission and detection, which encodes or decodes messages using the right code. Jaswinder *et al*. (2011) [8] provides the differential detection scheme which can reduce the multiple access interference in coherent and non-coherent for both synchronous and asynchronous optical code division multiple access networks with development of on-off keying concept. Keshavarzian *et al* (2005) [9] address the synchronization problem of an optical network using OOC codes of length *F*. The MS algorithm has two modes and an initializing part: first, *F* different shifts (or cells) in the search space are partitioned into equal-sized groups each containing *M* different shifts. Abbasali *et al* (2011) [5] provides the evaluation of Optical CDMA Systems by using the full utilization of optical encoding in presence of interference and receiver noises. The concept of optical encoding is shown in **Figure 1** below.

From the study [11,12], we have developed a scheme which also controls the multiple access interference with help of modulation, encoding, EDFA and coupler for optical networks. The basic structure for the proposed scheme has been displayed in **Figure 2** below.

As shown in **Figure 2**, the output of the optical encoder is applied to and $M \times M$ optical coupler. Based on proposed structure, probability of bit error rate and interference avoidance is provided in Equation (1) below.

3. Results and Discussion

The Concept of optical CDMA has been opted for experimentation and experimentation in this paper started with the implementation of Multiple User network with following parameters as explained in **Table 1** below. Network Simulator version 2 is used for the experimentation of OCDMA network.

For the probability calculation of bit error rate for optical encoding process, we have considered variables selected randomly as M^E and M^D *i.e.* $Q_{ME\,MD}(i, j)$. Where Q is representing probability factor for interference between two different codes for OCDMA system with weight W and length L is usually equal to Q, Q and $1-3Q$, respectively. Therefore $Q_{ME\,MD}(i, j)$ distribution along with parameters $X-1$ and $(Q, Q, 1-3Q)$ are described by:

$$Q_{ME\,MD}(i,j) = \frac{(X-1)!}{i!\,j!\left(X-1-(i+j)\right)!} Q^{i+j} (1-3Q)^{X-1-(i+j)} \quad (1)$$

Where the approx. value of probability Q has been provided for final solution.

The simulation scenario used for the experimentation is shown in **Figure 3**.

The performance of the OCDMA network has been judged through bit error rate and multiple access interference. Bit error rate is calculated for 30 users in **Figure 4**, for 60 users in **Figure 5**, for 120 users in **Figure 6**, for 240 users in **Figure 7**. Multiple access interference has shown in **Figure 8**. The proposed work provides variation with increase in the number of users in the network. The variation has been shown in term of graphs with bit error rate and access interference.

Implementation shows that the bit error rate increases as increase of users. Normal OCDMA network provides high bit error rate as compared to proposed OCDMA

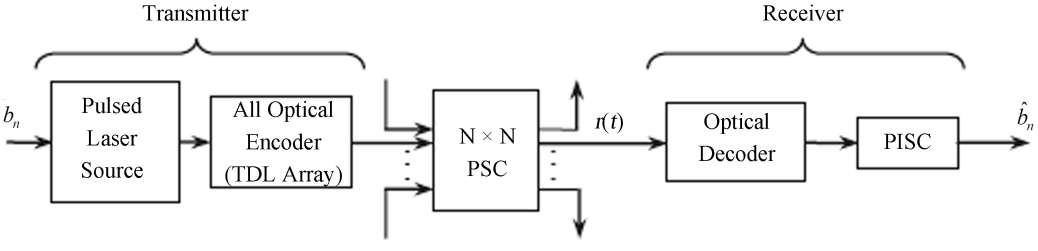

Figure 1. Model of OCDMA with Optical Encoding [10].

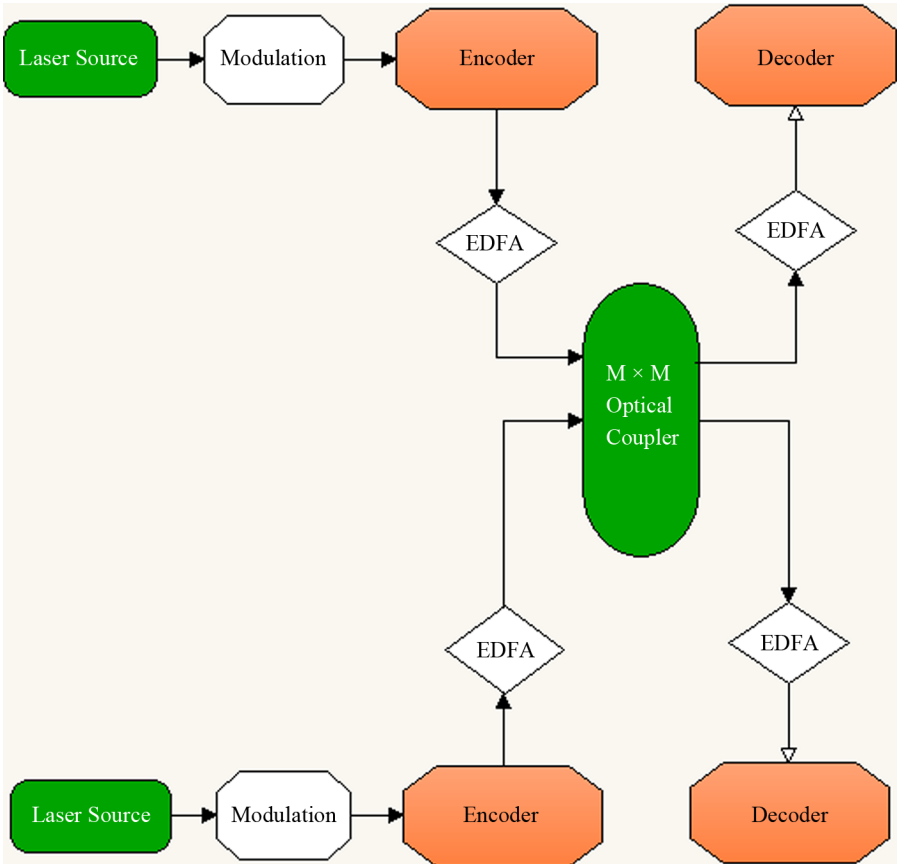

Figure 2. Node Architecture of Multiple User and Multi Hop concept.

Table 1. Parameters used in the simulation experimentation.

Parameter	Value
Input power	−3 dBm
Data Rate	6 Gbps
Number of users	6
Length of Fiber	20 km
Laser Frequency	2.6244×10^{14} Hz
Modulation Extinction Ratio	100
Dispersion	15.75 ps/nm-km
Attenuation of Fiber	0.2 dB/km

network which have low bit error rate comparatively. The initial state of the process carried slow interference cancelation which gave rise to the more bit error rate in starting seconds and after proper initiating of the proposed process bit error rate drops down and provides low error rate than normal Optical CDMA.

Implementation shows that the bit error rate increases as increase of users. Normal OCDMA network provides high bit error rate as compared to proposed OCDMA network which have low bit error rate comparatively. With increase of the users in the network, bit error rate goes high in normal Optical CDMA network as compared to proposed work. At peak intervals bit error rate provides similar results for some time and then normal network lacks cancelation of noise and suffers more error rate.

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The Multiple access interference value for proposed scheme is shown in **Figure 8**.

Figure 8 shows the high value of MAI for normal network as compared to the low value of MAI in proposed OCDMA. Approx. 10% decrease in bot bit error rate and MAI proved to be good solution.

Overall consideration of the fact of growing need of the network, gave rise to the fast communication demand through optical networks. So OCDMA is one of the best solutions available for future communication. Proposed scheme for OCDMA provides much better results than

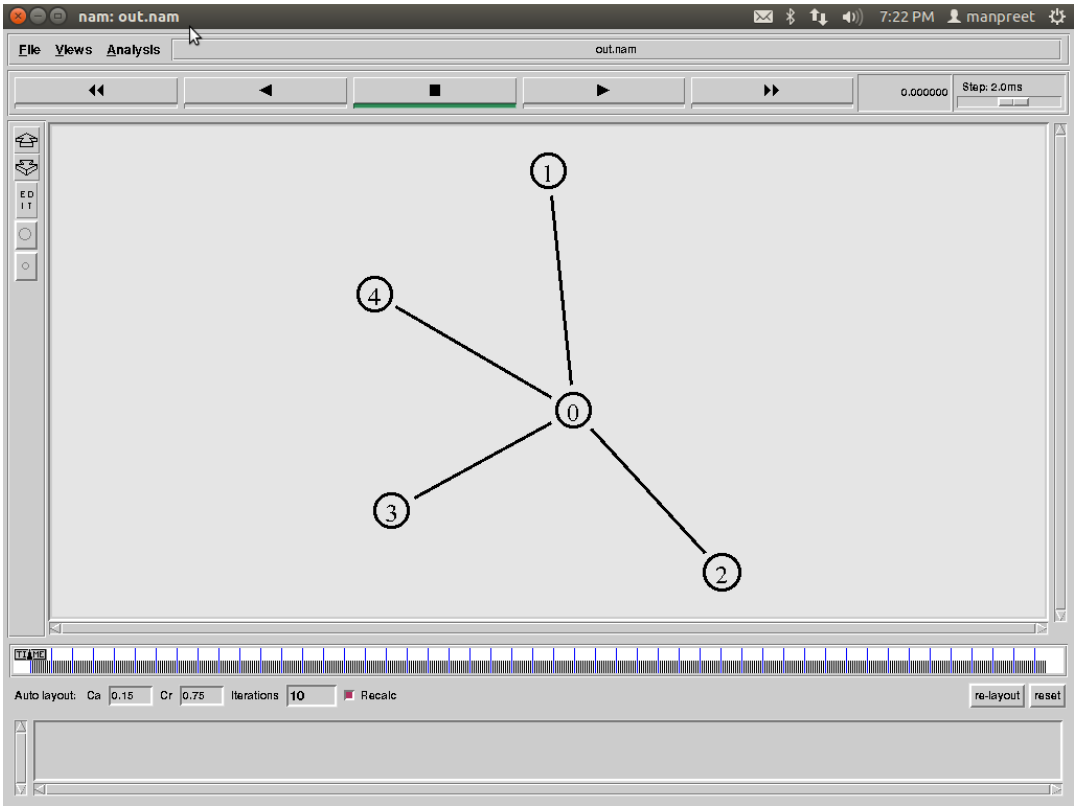

Figure 3. **Overview of network simulation used for OCDMA network.**

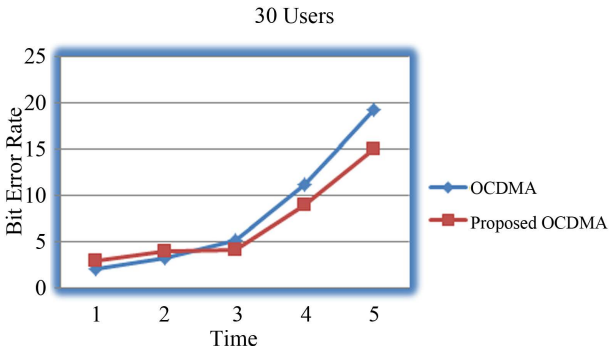

Figure 4. **Bit Error Rate for proposed OCDMA with 30 users.**

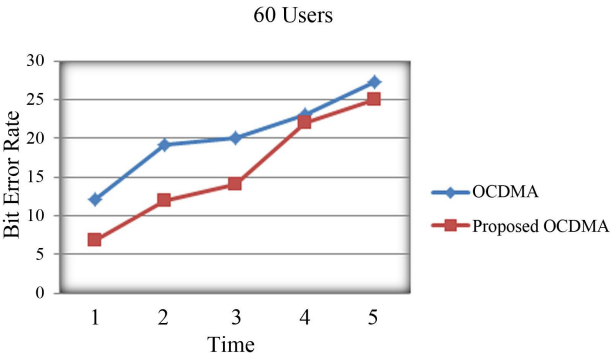

Figure 5. **Bit Error Rate for proposed OCDMA with 60 users.**

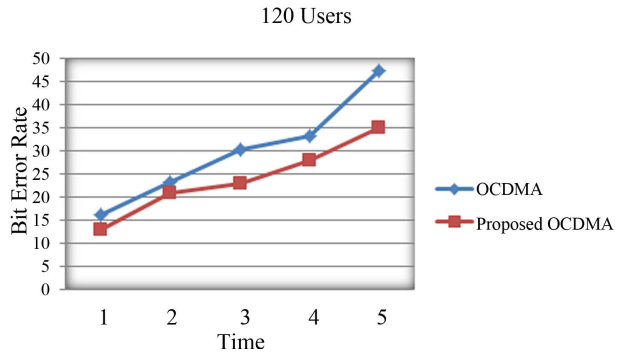

Figure 6. **Bit Error Rate for proposed OCDMA with 120 users.**

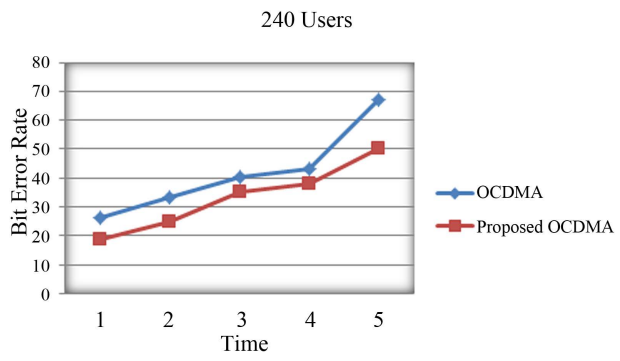

Figure 7. **Bit Error Rate for proposed OCDMA with 240 users.**

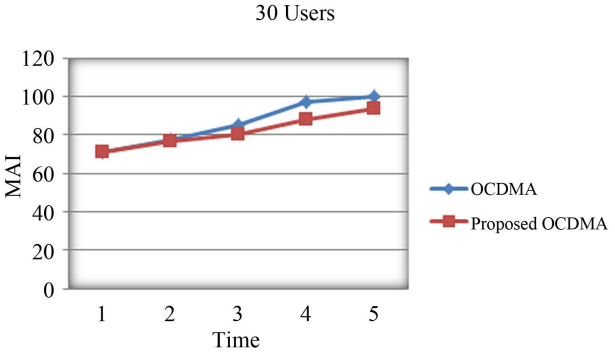

Figure 8. Multiple access interference for proposed and normal OCDMA.

the normal OCDMA network and proposed work also provides add on multiuser communication as compared to single user communication in normal OCDMA network.

4. Conclusion

This paper provides the idea of performance of multi user optical code division multiple access asynchronous networks with bit error rate and multiple access interference with the help of encoding process along with EDFA structure. Proposed scheme architecture provides less interference as compared to the normal optical code division multiple access networks. Multiple access interference is always been a limitation factor in optical CDMA networks and we have tried to refine the communication by decreasing the interference and bit error rate. Experimentation considers 6 users for the communication structure and shows similar results as suggested by interference cancellation technique with differential detection process.

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