A review on Security enhancement in Optical Code Division Multiple Access System

[1]Manpreet Kaur, [2] Bhawna Utreja
[1]Student, [2]Assistant Professor
[1]University College of Engineering,
[1]Punjabi University, Patiala, India

Abstract: During the past few decades, the world has seen astonishing changes in the communication system due to advancement in technologies. Communication is a significant part of our everyday life. The increase in usage of multimedia services such as voice, images data, video and data communications requires great transmission capability. In optical communication, the channel (optical fibers) plays a vital role.Here we will discuss a commun-ication system that uses optical fibers. From a security point of view, these quick developments in information services must be secured from attacks. Subsequently, network security concerns have now been increased because of the immense measure of data that streams in a communication media. The exponential development in information throughput on the Internet demands the transmission of sensitive and confidential information over the optical networks. With this development, the possible risks of security of this sensitive data additionally increased as the tapping of the signal from an optical fiber could be effectively done by utilizing then expensive hardware. OCDMA is a technique which can be used to eliminate the problem of multiple user access and traffic growth on the web in optical systems. This paper will review the concepts of OCDMA, including its components, advantages, disadvantages, and different security concerns.

Index terms **- Communication system, OCDMA, security enhancement, eavesdropping, jamming**.

I. INTRODUCTION

1.1. Communication system

In general communication system is used to transfer information over variable geographical area (varies from few kilometers to transoceanic distances). Electro-magnetic carrier waves (with frequency varying from few megahertz to hundreds of terahertz) are used to transfer data. Under the visible or infrared band in electro-magnetic spectrum, Optical Communication systems utilize high carrier frequency of about 100 THz. Optical communication, also acknowledged as optical tele-communication, is a process of using light to transmit data over remote areas. It can be achieved either visually or by using electronic devices. An optical communication arrangement uses a transmitter, that converts a message into an optical signal followed by a channel that transfers the signal to its terminus, and the receiver, that recreates the information from the established optical signal.When electronic tools are not engaged, the 'receiver' visually perceives or inferred a signal, that can be either simple (flashed in a Morse code) or complex (sequence or lights with colour codes). Optical communication can be categorised as free space and earthly communication. In Free-space optical communication, means of communication have been positioned in space, whereas in earthly communication, means as expected are limited by topography, climate and the convenience of light. We are going to provide a basic introduction to different forms of optical communication.The optical fiber is the extremely common form of channel for optical communications.The transmitters in optical fiber links are usually light-emitting diodes or laser diodes. The use of Infrared light has become more frequent than visible light since the wavelengths of infrared light rarerly weakens or scatters even on a larger distance. The signal encoding is normally basic intensity modulation. [2]

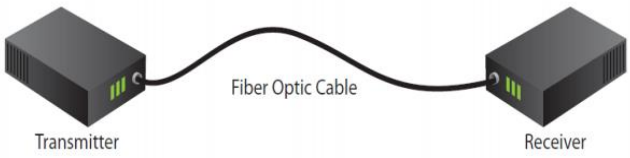

Fig 1.1: Basic Fiber Optic Transmission System

The Optical Transmitter

The optical transmitter converts an analog or digital electrical signal into a comparing optical signal. The optical signal source could either be a LED, a VCSEL, or a laser diode. The most common wavelengths used by an optical transmitter are 850nm, 1310nm, 1550nm. The optical transmitter works by the applying of an electrical signal. The optical transmitter consists of three main components which are driver circuit, a light source, and a fiber fly lead. Driver circuit guides the source of light. A light source transforms the electrical signal into the optical signal, and Fiber fly lead connects optical signal to the optical fiber.

The transmission channel

It comprises of a cable that delivers environmental and mechanical safety to the optical fibers enclosed inside. Fiber optic cable comprises one or more glass fibers that work as waveguides for the light or optical signal. These types of cables are similar to the electrical cablesin its structure, yet gives excellent security to the optical fiber within. An optical cable is commonly used for systems which requires transmitting the data over long distances in kilometers or when two or more fiber optic cables are joined.Every optical fiber acts as a discrete channel. The Optical splice is used to join two isolated optical fibers. The Optical connector is for provisional joints which are non-fixed among two separate optical fibers. Optical splitter or coupler delivers a signal to additional devices.

Receiver

The optical receiver is used at destination to receive the optical signal sent by the optical transmitter. It comprises of a photo detector, an amplifier, and a signal restorer. Photo detector transforms the optical signal into electrical signal. Amplifiers and Signal restorers are

implemented for improving the signal to noise ratio of the signal as there are probabilities of noise to be hosted in the signal because of the usage of photo detectors.The optical receiver is used to convert the light or optical signal again into an original electrical signal. The detector at the receiver side is either an avalanche-type photodiode or a PIN-sort photodiode.

1.2.Advantages of fiber optic systems

There are many advantages of optical fiber, some of them are given below:

Larger Bandwidth-Fiber optic cables offer higher data transfer rates over long distances as compared to coaxial cables. The optical carrier frequency (range 10^{13}-10^{14}Hz) provides the potential for a fiber data carrying ability.

Small size and Lightweight-An optical fiber cable is somewhat heavier than a human hair, even in one fiber contains numerous strands inside substantially lighter in weight and smaller than coaxial cables and other wire with comparative data transfer capacity.

Low interferences and crosstalk-The fiber optic cables are freefrom any electromagnetic interferences as they include lighting would not conduct electricity.

Security for optical signals-The data transferred in the form oflight, therefore, it does not radiate, and it is not easy to tap so fiber optic cables are secure communication media.

The lowrate of data loss-Optical fiber uses broad repeaters space (70 to 100 km) used for long-term communication with low losses about 0.2 dB/km.

Low Power-In optical communication systems, lower power transmitters are used instead of high voltage electrical transmitters which are required in case of copper wires. Therefore, the signals in optical fibers less degrade.

Digital signals-Optical fibers are suitable for transferring digital data used in computer networks.

1.3.Optical code division multiple access (OCDMA):

Optical CDMA is a kind of multiplexing and networking for optical communication networks and systems in which optical signals are performed by encoding and decoding information utilizing basic and low-cost optical components. Many years back, OCDMA systems have been recognized to be useful in combining the flexibility of CDMA method with unlimited data transfer speed or bandwidth of optical fiber to accomplish high-speed connection and high-qualitytransmission [3]. Optical Code Division Multiple Access is an alternate multip-lexing system to the more orthodox Time Division Multiple Access (TDMA) and Wavelength Division Multiple Access (WDMA). It has just fascinated substantial research attention since the benefits it suggests about network granularity and the suppleness in the managing of the method resources. Also, it is eye-catching for presentations where confidentiality in the communication is central, and it also has the perspective of associating IP traffic bursting and multi-protocol networks. OCDMA is grounded on distributing to the individual user of the particular code of network one. The codes are allotted to the data pulses before transmitting and at the receiver end, the users depend on correct decoding of the signal projected for them in demand to create communication, whereas rejecting all additional coded data projected for supplementary users at the similar time. Thus, every user is permitted to practice the whole accessible spectrum for all the time which was not possible in WDMA and TDMA.The different characteristics of OCDMA as compared to wireless CDMA systems are shown in the table below.

Table 1**:** Comparison of Optical CDMA with Wireless CDMA

Parameters	Wireless CDMA	Optical CDMA
Encoding/Decoding	RF Domain	Optical Domain
Spread/Dispread	Frequency Domain	Time Domain
Carrier	Micro and meter millimeter wave limited availability	4000 to 70,000 ghazi light wave
Transmission medium	Free space Large attenuation Linear	Optical fiber Low attenuation Non-Linear

1.3.1 Block Diagram of OCDMA

The purpose of Optical Code Division Multiple Access is to useradio frequency communications and huge optical bandwidth. The figure below shows the block diagram of optical code division multiple access.

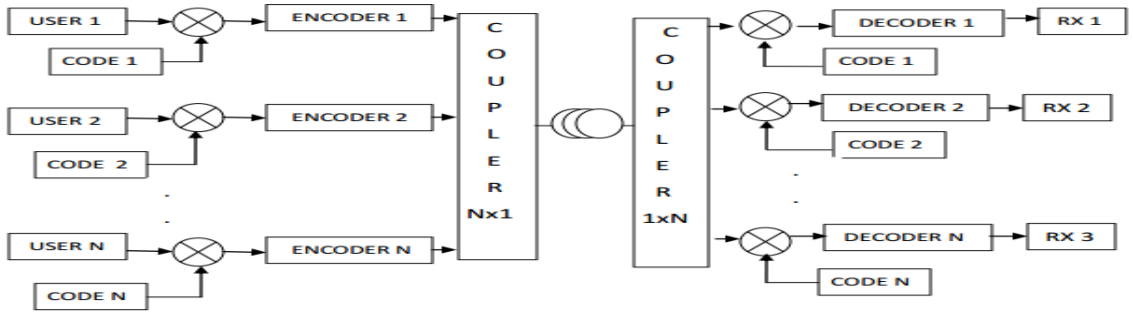

Fig1.2: Block Diagram of OCDMA

An OCDMA system for every user can be demonstrated by an information source, including the information which would be transmitted, followed by an encoder and after that a laser which converts the electrical signal to an optical pulse sequence. The receiver side uses an optical collector to get the encoded information. Numerous users transmit information simultaneously. Every user has its own codes, which is orthogonal to all other codes. The encoded information is transmitted to the N*1 star coupler,where the optical channel transmits the signalvia the optical fiber and couples to a 1*N coupler and transmits to other nodes. All encoded information is then added chip by chip and the outcome, known as the superposition, are transmitted over the channel. The separate collectors comprising of optical correlator consistently detect the

superposition of all approaching pulse transmission and obtain the information from the transmitter. Thisis obtained by the connection between the approaching signal and stored replicas of that unique sequence. The correlator will acknowledge if the approaching stream of optical pulses includes the uniquesequence and other sequences would be considered as noise. The decoding procedure is achieved by utilizing optical connection. The receiverexecutes atime correlation process to detect the particular code word. All other code words are considered as noise because of de-correlation. [3]

1.3.2. Advantages of OCDMA

The essential spectral OCDMA system has various advantageous elements:

All Optical Processing-Dissimilar to wireless CDMA, OCDMA performs the coding operations optically which is necessary for the whole PON requirement. The all optical multiplexing provides a system in channels where any combination of data rates can be carried out in a free unsynchronized manner.
Sensible division of bandwidth-Dynamic share of bandwidth hallows to add new users or deleting unsubscribed users of the network easily. OCDMA gives an approach to numerous dynamic users to share the optical bandwidth reasonably.
Full asynchronous access-OCDMA system could operate with completely asynchronous access without the need of complex and costly electronic devices and protocols. This advantage of providing asynchronous access makes OCDMA most appropriate for heavy traffic network. As there is no requirement for TDM or transient encoding, every channel works at its built-in information rate
Flexibility-The adaptability provided by the tap-and-embed nature of the optical bus together with the programmability of the trans-collectors empowers the assignments of transmission capacity and connections where they are required. Expanded flexibility of monitoring the quality of service (QoS). OCDMAs could be very flexible.
Network Control and Management-When the optical codes are designed in a way that the non-moved auto-correlation peak is vast,and the moved autocorrelation peak is limited, every receiver could operate asynchronously without the requirement for a worldwide clock signal. As the number of distinctive codes is equivalent to the number of channels on the network, so there is no requirement for a centralized node to mediate channel disputes. It is easy to add anew user on an OCDMA network by assigning a new code. Vacant codes are given to the new user. The system can be updated to support the new users if no vacant codes are available by increasing the measure of time or wavelength space spreading.

1.3.3 Disadvantages of OCDMA
Despite being an excellent technology, there are as yet several disadvantages which restrict its wide scale use. Following are some of the main disadvantages: One of the limitations of OCDMA utilizing a coded pulse sequence is that when the number of users increases, the code length must be expanded to keep up a similar execution.
Cost-The greatest obstruction to the wide scale usage of OCDMA is cost. Expense not just influences OCDMA but other multiple access schemes, for example, WDMA likewise experiences a similar issue. They are additionally restricted by the requirement for costly optical equipment. The requirement for all optical encoding/deciphering equipment and broadband light source for OCDMA creates it much costly. [19]

Multiple Access Interference (MAI)-The OCDMA networks suffersfrom different concurrent users. When the number of synchronous user increases, the BER corrupts in due to the impact of MAIs increments [11-16]. A basic limitation of OCDMA systems is the decrease of throughput when numerous users are at the same time attempting to transfer over a common medium, in this way creating an extreme jam at high network loads. Moreover, regardless of the possi-bility that the obtained optical power is sufficiently wide i.e. if the impact of noise is little, the impact of MAIs is steady as the power of the transferred pulse is equivalent among all users. Transmitted light pulses by various users may overlap. [19]

1.4 Security Concerns of OCDMA System-The sensitive security data for example military transactions, medical records, financial transactions, intellectual property, etc., that is to be securely transferred, is completed through the internet. The physical transmitter of the web is, for the most part, the optical fiber which constitutes high speed, and large capacity worldwide optical networks. To shield the web from security attacks, different security conventions and components are usedin various layers of the network stack. The physical layer security in photonic network rests an open zone of exploration as an extra security layer in transmission frameworks. The physical layer is the lowermost layer in the OSI model. OCDMA has been deliberated as a good contender to give optical layer security because if multiple codes work simultaneously, it would be almost difficult to get any important data from the information signal. Despite that, the xtended modernity of optical tapping devices situated out in the open, and private optical networks as of now permit unreasonable access to all communications and data traveling in any fiber portion. As we know signal security is very important issue in some fields like in military etc. so to prevent the signal from unauthorized attacks so many techniques are used. The security issues are in OCDMA network are described below: [1]

1.4.1. Data Confidentiality against Eavesdropping-Confidentiality guarantees that only the proposed collectors of data really get data, and no one else. Eavesdropping is the illegal real-time intervention of a secretive communication like a phone call, video confe-rence, instant message, or fax communication [10] [18-19] .Signal Eavesdropping a danger to the signal confidentiality that could becompromised to different points. It is a demons-tration of secretly tuning into a private discussion. It should be possible over phone lines, email, texting and different strategies for communication as private. In the most doubtful scenario, an interceptor can specifically read the data. [14] The information that two specific individuals are communicating may likewise compromise confidentiality. Some data is accessible to potential opponents just by watching the traffic patterns. The objective of eavesdropping is to accomplish some private information that must be kept secret during the trans-mission. The confidential information might contain the region, private key, open key, or additionally passwords of the nodes. Such information is extremely essential to the security condition of the nodes, and it must be kept secure from unapproved access.
Confidentiality has been one of the significant security issues in OCDMA networks as a result of the simplicity of eavesdropping regardless of the optical pulse in OCDMA being encoded into noise, such as signal by the optical encoder as per a unique optical code. Eavesd-ropping in the optical code division multiplexing system can be defined as an intercepting of the signal when it is in the process of transfer, and receiving of the sensitive information by the interference of signals which can collect the data traveling through the medium of the optical cable. Eavesdropping operations generally have three principal elements:

Pickup Device-A device such as a microphone, a video camera which picks up audio or video and maybe images and transforms to electrical impulses. The device may be fitted so that it uses electrical power previously available in the target area which can eliminate the need for periodic admission to the area to change batteries. Small microphones can be joined with miniature amplifiers that can help in filtering background noise

.

Transmission Link-The electrical impulses generated by pickup device necessarily be conveyed to the listening post which can be achieved by a transmission through radio frequency or by using wire. Available wires might include the active telephone line, unused telephone or electrical wire, or ungrounded electrical conduits.

Listening Post-It is a safe area where the signals can be watched, logged, or retransferred to a new area for handling.

1.4.1.1. Types of Eavesdropper

The various types of eavesdroppers are described below:

Simple Energy Detector-It comprises of a simple photo detector. It essentially detects the energy in a specified bit period by securing bit interval synchronization from the encoded information. When the energy is available in a specific bit period, the bit "1" get transferred else bit "0" get transferred. It is therefore called simple power detector incorporating the received power over the whole bit period to discover regardless of whether energy is available in that bit period.

Differential eavesdropper-It comprises of DPSK demodulator along with a balanced photo detector. Mach-Zehnder interferometer (MZI) is a DPSK demodulator with the one-bit delay in one arm. The balanced detector comprises of two photo detectors with the subtractor. Differential identification identifies the distinction between two encoded signals to get the transferred signal. Thus, the resultant signal is made by the distinctive combinations of the back to back bits.

1.4.2. Signal Availability against Jamming -Availability is considered as when a node must maintain its capacity to provide all the considered services irrespective of its security state. It implies that data transmitted is not "lost" or damaged in transit. Physical infrastructure damage attacks the availability of signal by damaging the transmission connection amongst trans-mitter and receiver. One more way that troubles the availability of signal in the network is signal jamming. Jamming signs could lower debase the performance of the OCDMA framework significantly as per availability of the signal. Jamming is completed by infusing an interference signal at a similar frequency band or sub-band using the transmitter so as to original signal totally obscures by interference. The expression "jamming" is utilized to depict the utilization of attack signals trying to corrupt or disturb communication, despite that; "interference" is utilized to characterize unintentional strategies for the interruption. Unintentional jamming emerges when an operator transfers on a busy frequency without reviewing that it is as of now being used, or without having the capacity to access stations on the same frequency. Intentional jamming is the overwhelming of authorized network signals through the jammer signals.

1.4.2.1 Different Jamming Schemes in OCDMA

Various jamming schemes in OCDMA are pulse jamming and partial band jamming. Both jamming schemes attack signals since they have similar frequencies like data signals

Pulse Jamming-In Pulse jamming, the pulses are similar to the signal pulses of OCDMA authorized the user and it is a high power jammer. It could increase its rapid jamming level through pulsed jamming when there is no output power to the jammer to jam. It transmits high power pulses for a small amount of time yet over the whole user's data transfer capacity.

Partial band jammer-As the name proposes, it covers just a bit of the user's bandwidth rather than user's whole bandwidth. In this jamming scheme, the jamming signal comprises of pulses of spectrally flat noise which covers the partial bandwidth of the signal.

II. LITERATURE REVIEW

Summit Gupta et al. proposed a design of an optical code division multiple access for enhancing the security against the eavesdropper. In this paper two users performed the switching position of pulse and pulse spectrum of the code which varies from group to group. This technique has better performance and also minimizes the code length of code design. The result indicated that the probability of information detection from the single pulse of code orthe whole code shows more satisfactory response than the ZCC(Zero cross co-relation)code. this research depicts comparsion of other code with ZCC code. The performance of proposed technique is analyzed with the help of the simulation software and mathematical analysis [1].

Manisha Bharti evaluated the performance of the OCDMA with the help of the simulation analysis**.** This method helps in minimizing the dispersion and increasing the security with the help of 2-code keying i**.**e**.** bipolar coding approach**.** In the analysis, Walsh-Hadamard codes exclude the code words which consists the all **"**ones**."** It will be used in the bipolar arrangementin order to ensure the successful transmission of the OCDMA signal**.** They also prevent wire tapper simultaneously in the system transmitter information for an authorized user with single authorized user at a particular instant of time**.** Single code keying approach creates the possibility that a wiretapper can easily retrieve information without any effort**.** The performance of the system evaluated for variation in fiber length in the form of Quality Factor and received optical power and values of these parameters are plotted on graphs **[**2**]**.

J. **A**. **Salehi** examined the fiber optics code division multiple access communication techniques. FO-CDMA is a technique in which the low information data rates are mapped into the very high rate address codes in order to achieve the asynchronous communication which was free of network control among many of the users. Optical orthogonal codes (OOC's) which are a new class of codes are introduced, and showed suitability for the FO-CDMA. The experimental results indicated the desired auto and cross relation properties of these codes and also the use of them in the FO-CDMA. This method also introduced the concept of the optical disk patterns represented an equivalent to representing the OOC's. For deriving the probability density functions, the optical disk patterns are used. It had been ssociated with any of the two interfering OOC's. This method also presented various interferences patterns from which the weakest and the strongest interference patterns were introduced [3].

Jen-Fa Huang proposed a system, in which each network node is allocated a group of composite signature codes which had been constructed from relatively prime lengths M-sequence component codes. In the OCDMA network, each of the nodesis initially assignedone set of composite signature codes with code periods relatively prime to other node's signature codes are configuration command from a central monitoring station. The proposed scheme has various attractive features. These features enhanced the system confidentiality, reduced the network coordination and asynchronous network coordination [4].

Gamal Attia et al.presented an advanced modulation scheme which was based on the 2-D Hybrid F-poISK with utilizing MPC as a signature sequence. the designed transceiver depends on the proposed modulated schemes could be the aim of the proposed system by considering the effects of the optical AES noise, PDs shot-noise and mainly MAL, and electronic receiver noise (i.e. LPF). In this research, BER and SNR have been derived and analyzed for the overall system. The result of the simulation indicated that the binary combination of two modulations provides the improvement in the perfor-mance of the system which can reliably and power efficiently in accommodating a greater number of simultaneous users (i.e. capacity enhancement). It also helps in supporting the system security [5].

Zhijian Si et al. proposed design of simple code-switching technique of the OCDMA communication system for the security enhancement. The technique helps in ignoring the replacement of all the encoders and decoders**.** In this research, all the users**'** codes are altered by changing the core wavelength of the laser source**.** Each of the encoder and decoder was comprised of the multiple codes which are non-overlapping in the spectrum**.** The scheme is demonstrated in a proof-of-principle trans-mission experiment **[**6**].**

Sheng Peng Wan et al. presented the new fast optical time-spreading or frequency hopping differential code division multiple access systems with the Prime or optical orthogonal codes. In this study the performance of multiple Bragg grating fiber was analyzed. Differential detection can be adopted by assigning two orthogonal codes for one of the users, and these codes help in encoding the "1" and "0" respectively.

The differential detection improves the system performance in BER and also resists the interferences like MAI without any control devices in order to evaluate the optimum decision threshold as compared to the normal direct chip detection. In this research, multiple Bragg grating fiber was also designed for the Prime/OOC codes which can be tuned from one code to another with the help of the piezoelectric device. The result declared that the proposed system has more spectral efficiency as compared to the WDM system [7].

Shilpa Jindal et al. demonstrated doubling the number of active users within GF (5) for 3D OCDMA system. In this paper, the transmission of 10 active users with the data rate up to 5 Gb/sec per user at the variable received power with acceptable Bit Error Rate is also presented with the help of newly developed 3D codes. At the variable receiver power, the performance was compared till -32 dBm in terms of Bit Error Rate, signal strength, eye diagrams, Q factor, and data rate. The results indicated that in the technique which was employed for the temporal domain, the number of the active users had been increased and signal temporal codes become doubled. These types of codes are suitable and can send the data up to the 5Gbps, 2 Gbps, and 1Gbps data rate with receiving power ranging from -26dBm to -32dBm. They are used in the applications such as radio over fiber and free space optics etc. [8].

Hesham A. Bakarman et al.presented the enhancement of security for spectral amplitude coding OCDMA**.** This paper investigated the eavesdropper probability of error-free code based on the hybrid code system**.** This hybrid code system combined the Enhancement Double Weight **(**EDW**)** OCDMA scheme with M-sequence codes OCDMA scheme**.** The eavesdropper taps a coded trans-mission of a specific client**.** This transmission, it also performs the necessary estimations in order to derive the transmitter's code**.** If any eavesdropper forced to tap code pulses with low SNR,then a security enhancement could be achieved**.** The SNR of 9.2 dB will be required for the eavesdropper in order to detect the encoded pulses with 50**%** probability for the hybrid system**.** It showed 3dB greater than EDW and 5dB higher than M-grouping**.** The distinction in the performance of envelope detection and eavesdropper receiver had been detected smaller, particularly at higher SNR **[**9**].**

III. FINDINGS

The table below includes a summary of some of the previous studies which have performed different research in security enhancement of OCDMA.

Table:2 Table of Literature survey

Authors and Year	**Objectives and methods**	**Results/Output**
Bharti, M. (2014)	Simulative analysis of 2 code keying in OCDMA systems **Method**: Walsh Hadamard codes	Effective to enhance the security of thesystem and provides valued parameters.
J. A. Salehi (1989)	Code division multiple access in optical fiber **Method:** Optical orthogonal codes and fiber optic signal processing techniques.	Helpful to drive the probability density functions and evaluating strongest and weakest interference between patterns.
Jen-Fa Huang(2012)	Structuring re-configurable composite signature **Method:**Dynamic signature coding scheme	Helpful to illustrate numerical designs
Attia, G. (2011)	Capacity and security enhancement in OCDMA **Method:**Hybrid frequency polarization shift keying	Approved the power efficient and provided secure communication.
Zhijian Si, and Feifei Yin, (2011)	Simple code-switching scheme for security enhancement **Method:**Simple code-switching scheme	Helpful to decodes the codes

Jindal, S. and Gupta, N.(2013)	Doubling the number of active users **Method:** 3D OCDMA code structure	Compares the performance in terms of data rate and improves the signal strength.
Hesham A. Bakarman (2010)	Security enhancement for spectral amplitude Method: Double weight optical CDMA scheme and M-Sequence codes	Detection is getting small especially at higher SNR's
Kumar, R. (2009)	Multi-dimensional codes in OCDMA **Method:**Multi -dimensional code	Easy to construct and have suitable properties
Panda, S. (2015)	Performance analysis of novel coding **Method:**MRDC code	Higher data rate transmissions and lower bit error rates

IV. CONCLUSION

Optical code division multiplexing communication has established a huge arrangement of requests in computer systems. For confident terminal to terminal application, the crucial factors such as maximizing data transmission with higher speed and at longer distance and minimizing the fiber and splice loss. There are various types of eavesdropping threats which can be worked out by improving the security of the signals. OCDMA is a technique which can be used to eliminate the problem of multiple user access and traffic growth on the web in optical systems. Improved data security is frequently said to be characteristic in OCDMA system because of its coded nature. If multiple codes work at the same time, it is practically difficult for an eavesdropper to get any important data due to multiple access interference (MAI) generated by all the communicating users and furthermore, it is hard to jam the noise such as OCDMA encoded signal.

REFERENCES

[1] Sumit Gupta, Aditya Goel.2015.OCDMA Technique with the switching of code betweenthe users for Enhancing the Security,IEEE ICCSP.
[2] Manisha Bharti.2014.Simulative Analysis of 2-Code keying Approach using Walsh-Hadamard codes to Enhance Security and Reduce Dispersion in OCDMA system,IEEE**.**
[3] J. A. Salehi.1989.Code division multiple-access techni-ques in optical fiber networkspart I: Fundamental principles IEEE, vol. 37, no. 8, pp. 824–833.
[4] Jen-Fa Huang.2012.Structuring Reconfigurable Composite Signature Codecs to Enhance OCDMA Network Confidentiality, Chung-Yu Li, Kai-Sheng Chen, Tsing Zhang, IEEE**.**
[5] Gamal Attia.2011.Capacity and Security Enhancement in Optical CDMA Systems," National Radio Science Conference 2011, I.El Dokany,and A. Mohamed,NRSC.
[6] Zhijian Si, Feifei Yin.2011. Simple Code Switching Scheme for Security Enhancement of OCDMA Communication system," IEEE Photonics Technology Letters, Hongwei Chen, Shizhong Xie,vol.23, No. 16.
[7] Sheng Peng Wan and Yu Hu.2001.Two-Dimensional Optical CDMA Differential System with Prime/OOC Codes, IEEE PhotonicsTechnologyLetters, Vol. 13, no. 12.
[8] Shilpa Jindal, Dr. Neena Gupta.2013.Doubling the Number of Active Users within GF (5) for 3D OCDMA System,International Jornal of research review in Engineering Science and Technology Vol .2.
[9] Hesham A. Bakarman.2010.Security Enhancements for Spectral Amplitude Coding OCDMA based on Hybrid EDW/M seq. code systems, IEEE International confer-ence on computer and communication engineering.
[10] M.Ravi Kumar, S.S. Pathak, and N.B. Chakrabarti.2009.Design and analysis of three-dimensional OCDMA code families, Optical Switching and Networking Vol.6, No.4, pp.243-249.
[11] Isaac A. M. Ashour, Hesham A. Bakarman, Sahbudin Shaari and Hossam M. H.Shala.2010.Hybrid SAC/Optical CDMA-WDM overlay System for Enhan-cing Network Security, IEEE**.**
[12] Satyasen Panda,2015.Performance analysis of novel coding technique for SAC-OCDMA,"Journal of Emerging trends in computing and information sciences,vol.6.
[13] Zhensen Gao, "Stealth Transmission of Time-Domain Spectral Phase Encoded OCDMA Signal Over WDM Network," IEEE Photonics Technology Letters. vol.22, no.6, June2010.
[14] Mokhria, S. "Security Issue on Spectral – Encoded Optical OCDMA with Bipolar Coding and Modified PN Code." International Journal of Advanced Research in Computer Science and Software Engineering, 23(11), 1479-1482, 2013.
[15] Jiang, Z., Seo, D., Yang, S., Leaird, D., Roussev, R., Langrock, C., Weiner, A. "Four-user, 2.5-Gb/s, spectrally coded OCDMA system demonstration using low-power nonlinear processing." Journal of Light wave Technology, *23*(1), 143-158, 2005.
[16] Ramamurthy, B., & Mukherjee, B. "Wavelength conversion in WDM networking." IEEE Journal on Selected Areas in Communications, 16(7), *1061*-1073,1998.
[17] Sahbudin, R. K., Kamarulzaman, M., Hitam, S., Mokhtar, M., & Anas, S. B. "Performance of SAC OCDMA-FSO communication systems." Optik Interna-tional Journal for Light and Electron Optics, 124(17), 2868-2870, 2012.
[18] Fadhil, H. A., Aljunid, S., & Ahmad, R. "Perfo- rmance of random diagonal code for OCDMA systems using new spectral direct detection technique." Optical Fiber Technology, 7(1), 2010.
[19] Kaur, A., & Singh, G. "Performance comparison of various detection techniques for SAC-OCDMA system using DW and MDW code." International Conference and Workshop on Computing and Communication *(*IEMCON*)*, 4(11), 2759-2761, 2015.