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Performance Analysis of Optical Code Division Multiple Access (OCDMA) System

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Abstract
With the concept of 3G & 4G services OCDMA is one of the important technologies, that provide a very high speed communication. In this technology multiple users can communicate simultaneously to transfer different kind of data. OCDMA enables the best use of available bandwidth and the spectrum to represent a cost efficient network. But in a network there is always the requirement to increase the security and the efficiency or the throughput of a multiuser communication in the OCDMA network. The proposed work is about to increase the efficiency in a Noisy channel. Here the work will be performed on impulse noised network. We are here proposing the orthogonal approach along with OCDMA to improve the throughput. We are trying to show the results in terms of noise ratio and the derived throughput. The proposed work is about to reduce this packet loss and to increase the throughput in the noisy network. To overcome this drawback and to increase the throughput we are using the concept of OFDM along with CDMA. This concept is represented as the Orthogonal CDMA.
Keywords: OCDMA, TDMA, FDMA, MATLAB

I. Introduction

Multiple accesses which uses the spread spectrum technology for transmission has become very popular in cellular radio networks. Optical code division multiple access (OCDMA) is a technique in which user uses a specific unique code rather a specific wavelength or a time slot. OCDMA uses the spread spectrum technique of code division multiple access (CDMA) combined with the optical link for transmission of data. OCDMA provides the large communication bandwidth along with the capability of secure data transmission. The key advantage of OCDMA is the multiple access technique which allows many users to share the same optical link simultaneously. This is done by giving each user a specific code which can be decoded only by the required user. OCDMA has many unique features that make it favorable data transmissions. Its characteristics make it suitable to increase the capacity and number of users in burst networks. OCDMA can accommodate a large no. of channels on a single carrier frequency. It can utilize the bandwidth effectively through coding system. OCDMA systems provide high degree of scalability and security. It provides high noise tolerance [1].

The Optical CDMA systems suffer from the problem of Multiple Access Interference (MAI) .As the number of users increase the bit error rate (BER) degrades because the effect of MAI increases. So, there is a limitation in\ number of users, as the number of users increase Signal-to-noise ratio (SNR) decrease and probability of error increase. There is a limitation of speed also in optical CDMA systems-since very short pulses are to be required within each bit time, here for it limits the bit rate for a finite pulse width transmitter.

There is also a problem of high optical splitting at encoder/decoder
[1].

Orthogonal Frequency

Orthogonal frequency will use the concept of modulation technique to transfer large amount of data using radio waves in a wireless network. As we know the radio signals can be divided into the smaller sub signals that enable the OCDMA to transfer the data in multiple data rate slots. It provides the simultaneous data transmission without any user interference [2].

1.1 Optical Code Division Multiple Access (OCDMA)

The first work in OCDMA occurred in the late 1970s in the area of fiber delay lines for signal processing. In OCDMA each channel is optically encoded with the specific code. Only an intended user with the corrected code can recover the encoded information. A proper choice of optical codes allows signals from all connected network nodes to be carried without interference between signals. Therefore, simultaneous multiple access can be achieved without a complex network protocols to coordinate data transfer among the communicating nodes [1, 3]. OCDMA Offers an interesting alternative because neither time management nor frequency management at the transmitting nodes is necessary. OCDMA can operate asynchronously and does not suffer from packet collisions; therefore very low latencies can be achieved. In contrast to TDM and WDM, in which the maximum transmission capacity is determined by the total number of time slots or wavelength channels, respectively [1, 4]. OCDMA allows flexible network design the signal quality depends on the number of active channels.

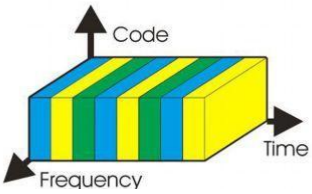


Fig. 1 Channel Usage by OCDMA

1.2. Time Division Multiple Access (TDMA)

The performance of TDMA systems is limited by the time– serial nature of the technology. Each receiver should operate at the total bit rate of the system. TDMA is a complimentary access technique to FDMA. Global Systems for Mobile communications (GSM) uses the TDMA technique. In TDMA, the entire bandwidth is available to the user but only for a finite period of time. This is illustrated in figure 2. TDMA requires careful time synchronization since users share the bandwidth in the frequency domain. Since the number of channels are less, inter channel interference is almost negligible, hence the guard time between the channels is considerably smaller. Guard time is spacing in time between the TDMA bursts. In cellular communications, when a user moves from one cell to another there is a chance that user could experience a call loss if there are no free time slots available. TDMA uses different time slots for transmission and reception. This type of duplex is referred to as Time division duplex (TDD). TDD does not require duplexers [1, 5].

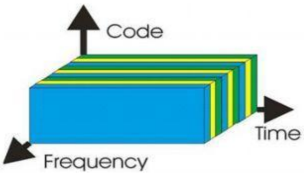


Fig. 2 Channel Usage by TDMA

1.3. Frequency Division Multiple Access (FDMA)

FDMA channels have narrow bandwidth (30 KHz) and therefore they are usually implemented in narrowband systems. Since the user has his portion of the bandwidth all the time, FDMA does not require synchronization or timing control, which makes it algorithmically simple. Even though no two users use the same frequency band at the same time, guard bands are introduced between frequency bands to minimize adjacent channel interference. Guard bands are unused frequency slots that separate neighboring channels. This leads to a waste of bandwidth. In wireless communications, FDMA achieves simultaneous transmission and reception by using Frequency division duplex (FDD). In order for both the transmitter and the receiver to operate at the same time, FDD requires duplexers. The requirement of duplexers in the FDMA system makes it expensive.

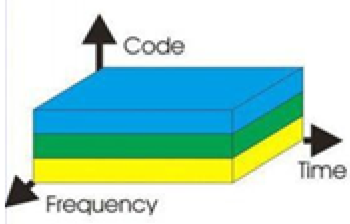


Fig. 3 Channel Usages by FDMA

1.4 Noise

Noise is a random fluctuation in an electrical signal, a characteristic of all electronic circuits. Noise generated by electronic devices varies greatly, as it can be produced by several different effects. Thermal noise is unavoidable at non- zero temperature, while other types depend mostly on device type or manufacturing quality and semiconductor defects, such as conductance fluctuations, including 1/f noise [6].

1.5 Quantification

The **Noise level** in an electronic system is typically measured as an electrical power *N* in watts or dBm, a root mean square (RMS) voltage in volts, dBμV or a mean squared error (MSE) in volts squared. Noise may also be
characterized by its probability distribution and noise spectral density *N*0(*f*) in watts per hertz. Noise power is measured in Watts or decibels (dB) relative to a standard power, usually indicated by adding a suffix after dB.

II. Objectives and Research Methodology

OCDMA provides a quality communication over the wireless network. It provides the communication in multiple users. But as the number of users in the network increases, the communication increases so there are the chances of some data loss over the network. ―In case of noisy channel the rate of data loss in the network also increases". The proposed work is about to reduce this packet loss and to increase the throughput in the noisy network. To overcome this drawback and to increase the throughput we are using the concept of OCDMA along with CDMA.
This concept is represented as the Optical CDMA.

To satisfy the orthogonally there are some rules to be satisfied:

1. The receiver and transmitter have to be entirely synchronized. In order to satisfy this requirement it is necessary to guess the same modulation frequency and the same time scale for transmission which is not really possible.
2. It is also necessary to have the best quality of the analogue transmitter and receiver part.

Following objectives have been decided for this dissertation

* To find out a MAI analysis of the OCDMA network.
* To determine optimum system parameters in the design of an OCDMA system.
* Find out the BER versus received optical power for various numbers of users with the help of m-sequences.

In this research work, we check the performance of OCDMA system in fading and noise environment .For this purposed system, we perform following steps. Generate the signal, Inclusion of Noise and Randomness, Perform the Transmission, Channel Sensing, Receive the Signal, Filter the Signal and Analysis of the Signal.

2.1 Development Environment: Matlab

For implementation part we use **MATLAB**. It stands for matrix laboratory. **MATLAB** is a high-performance langage for technical computing. It integrated computation, Noise is a random fluctuation in an electrical signal, a characteristic of all electronic circuits. Noise generated by electronic devices varies greatly, as it can be produced by several different effects. Thermal noise is unavoidable at non- zero temperature, while other types depend mostly on device visualization, and programming in an easy-to-use environment where problems and solution are expressed in familiar mathematical notation .Typical uses include Math and computation Algorithm development data acquisition Modeling, simulation, and prototyping data analysis, exploration, and visualization Scientific and engineering graphics .Application development, including graphical user interface building [7].

III. Implementation and Experimental Results

3.1Bit Error Rate (BER)

In OCDMA systems (BER) is an important parameter. It is often required as a control parameter for digital signal resource management such as hand off, call admission, and power control mechanisms. In practice, it is not easy to obtain because interference in OCDMA systems depends mostly on the number of active users in the system. Therefore simple and accurate BER measurement or estimation techniques are required [8].

***3.2 Binary Phase Shift Keying* (BPSK)**

This is one of the most efficient modulation methods. In this scheme modulation of data is performed by changing the phase of the particular signal. It uses finite number of distinct signals to represent digital data. It modulates 1bit/symbol. BPSK is most robust of all schemes as it takes highest level of noise or distortion [7].

***3.3 Normalized Signal-Noise Ratio(*SNR)**

The noise performance and hence the signal to noise ratio is a key parameter for any radio receiver. The signal to noise ratio or SNR as it is often termed is a measure of the sensitivity performance of a receiver. This is of prime importance in all applications from simple broadcast receivers to those used in cellular or wireless communications as well as in fixed or mobile radio communications, two way radio communications systems, satellite radio and more.

3.4.Random Number Generated Function (RAND)

Random numbers are essential for computer simulations of real-life events, such as weather or many other reactions. To pick the next weather or other event, the computer generates a sequence of numbers, called random numbers or Pseudorandom numbers.

MATLAB provides the random number generator *rand*. Each call to *rand* returns a uniformly distributed pseudorandom floating point number between 0 and 1. Evaluate the following command several times to observe the generation of different random numbers.

r = rand (m, n)

3.5. Kalman Filter

Kalman filter is a set of mathematical equations that provides an efficient computational (recursive) means to estimate the state of a process, in a way that minimizes the mean of the squared error. The filter is very powerful in several aspects: it supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modeled system is unknown [9].

The Basic Idea of a Kalman Filter

Noisy data in = hopefully less noisy data out

3.6 Steps for implementation

2.1.1 Generate the Signal

When working with OCDMA spectrum, first of all we would generate the signal. For this we would need to specify Channel Length, number of sub-carriers. Then we would distribute the whole signal among these sub-carriers for parallel transmission. The next step is to define the interference to be included in the form of noise, Channel noise etc. In our work we are randomly generating the Spectrum using rand () command of MATLAB. OCDMA blocks are divided into J identical sub blocks such that:

$$M = N / J$$

Where N = no. of carriers
J = no. of sub-blocks
M = size of each sub-block

3.6.1 Inclusion of Noise and Randomness

In this work, we would include two factors: Noise and randomness. We would include different intensity of noise in different sub-carriers and would show the change in error rate as the signal passes through the channels. Another factor included for variation is randomness.

3.6.2 Perform the Transmission

Here, firstly describe the number of Primary users and Secondary users for our scheme. Use 5 Primary users and 65 Secondary users per channel. For transmission signals from different sub-carriers are converted into digital form before transmission and are send in the combination of 0's and 1's (bits) simultaneously.

3.6.3 Channel Sensing

In between transmission and receiving of the signal, channel sensing would be done. For this purpose we have generated an array of clock timer for sensing purpose.

3.6.4. Receive the Signal

At receiver side, signal is received as combination of even and odd waveforms collectively and parallel.

3.6.5. Filter the Signal

Next step is to filter the signal using low pass filter and Kalman filtering method to improve the signal further.

3.6.6. Analysis of the Signal

The signal is then analyzed sensing time and throughput.

3.7 Channel

In order to transmit, it is significant to simulate the channel. Wireless channels are impaired by fading and noise.

3.7.1. Fading

This channel is affected by Rayleigh fading due to Doppler Effect. The simulation of Rayleigh fading channel was done by Smith's model.

3.7.2. Gaussian and Jammer Noise

This channel is affected by Gaussian and jammer noise. It is very easy to simulate noise in Matlab. The ―rand command was used to generate normally distributed noise.

Optical CDMA Signal System

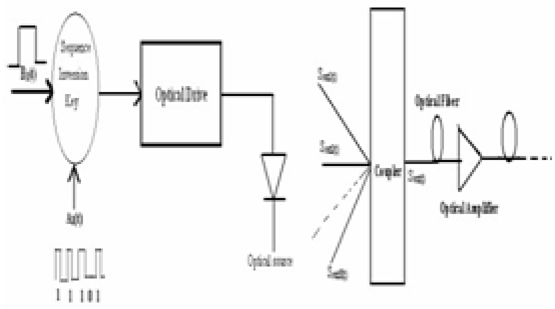


Fig..4 Transmitter of Optical CDMA

Process Flow Charts

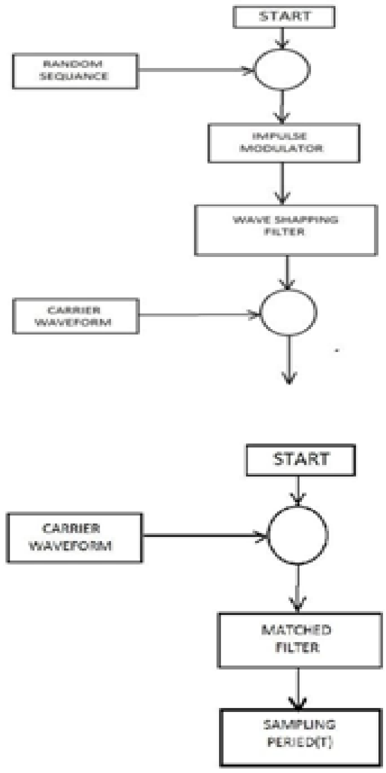


Fig.5 OCDMA with BPSK Signaling Modulation And Demodulation

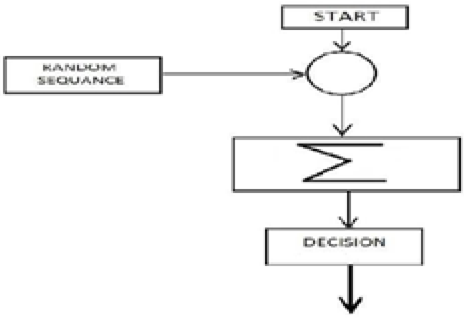


Fig. 6 Analysis of Generated Signal

Parameters for Simulation Test

TABLEI

Parameter	Values
Users	10 Primary users 75 Secondary users
Codeword allocation:	Uniform random
Wavelength	10,000 nm
Number of Blocks Generated	100
Normalized Sampling Frequency	5-10 MHz
Number of input samples	200
Channel bandwidth	5,10,20,30 MHz
Downlink RF channel structure	Direct spread
Frame length	10 ms/20 ms (optional)
Spreading modulation	BPSK (uplink/downlink)
Data modulation	BPSK (uplink/downlink)
Power control	Open and fast closed loop (1.6 kHz)
Carrier spacing	5 kHz
Bandwidth	20 nm
Power	16 dBm
Filter	Kalman
Random function	Rand (Matlab)
Modulation Scheme	1/2 BPSK

Modules For Simulations

The simulation consists of Some files. The main file is mainbinary.m which includes the main binary function code and calls to different other files and functions. This makes the programming code simple and understandable.

Generat Fading

>> Fading.m

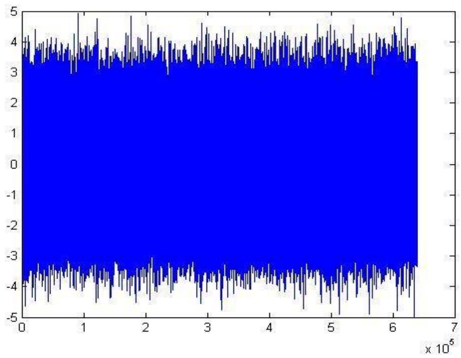
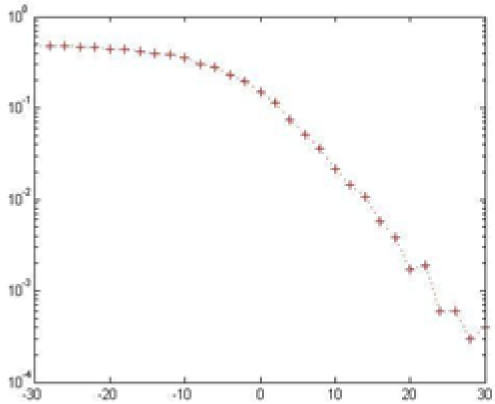
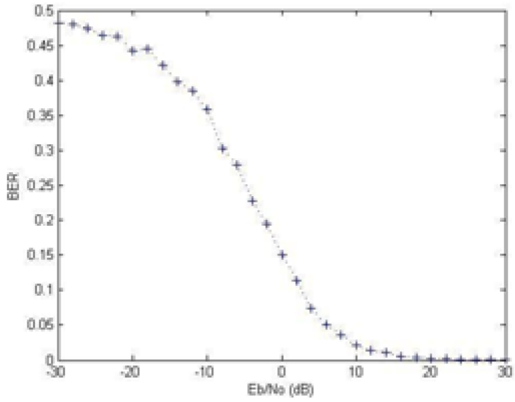


Fig. 7 Working of OCDMA Signal in Fading (Eb/No)



SNR (Eb.No)

Fig. 8 (EB/No. vs. BER) Representthe difference between Normalized SNR to Bit Error Rate in Large Scale

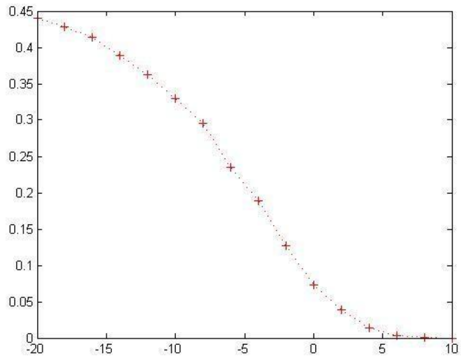


SNR (Eb.No)

Fig. 9 (EB/No. vs. BER) Representthe Difference between Normalized SNR to Bit Error Rate in Small Scale

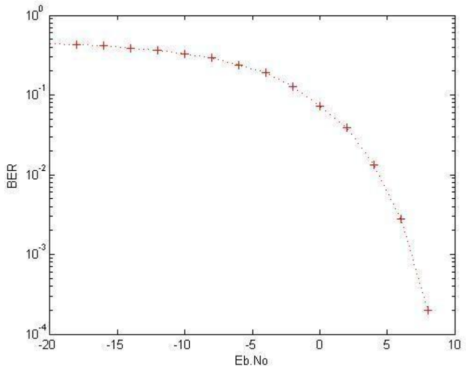
In Case of Gaussian White Noise

>>Gnosie.m



SNR (Eb.No)

Fig. 10 (EB/No. vs. BER) Represent the Difference between Normalized SNR to Bit Error Rate in Small Scale

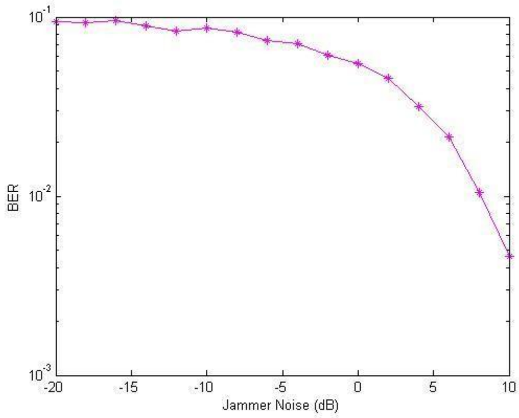


SNR (Eb.No)

Fig.11 (EB/No.vs. BER)Represent the Difference between Normalized SNRto Bit Error Rate in Larger Scale**.**

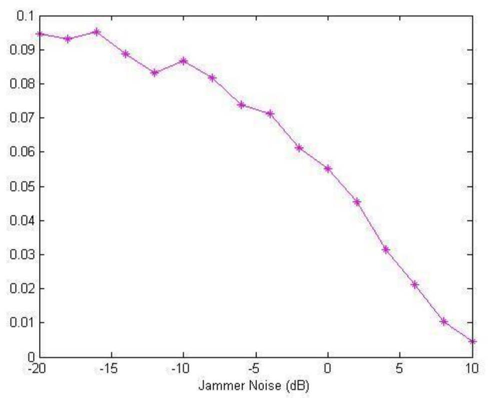
In Case of Jammer Noise

>>Jnosie.M



SNR (Eb.No)

Fig. 12 (EB/No. vs. BER) Represent the Difference between Normalized SNR to Bit Error Rate in Large Scale



SNR (Eb.No)

Fig. 13 (EB/No. vs. BER) Represent the Difference between Normalized SNR to Bit Error Rate in Small Scale

IV. Conclusion

The research work is an improvement of OCDMA with the concept of orthogonal approach. This approach is presented here to improve the network reliability in case of Noisy and the fading Channel. The system presented here, provide an enhanced throughput mechanism to provide the efficient communication over the network Here we considered the jammer noise and Gaussian white noise with MAI. We observe that a high power of optical transmission is required in order to maintain a BER number of users. We also observe the behaviour of the OCDMA system by analysis the x, y scatter diagram of OCDMA system. We observe that when the fiber length is decreased, the index of noise effect of the optical fiber increased. In addition BER performance degrades due to the noise effect in the OCDMA system.

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