Design and Performance investigation of multiuser OCDMA network

Parambir Singh, Manoj Kumar, Anurag Sharma

Abstract-Optical Code Division Multiple Access (OCDMA) combines the large bandwidth of the fiber medium with the flexibility of the CDMA technique to achieve high speed connectivity. This paper presents the simulation module for OCDMA transmission and reception. The proposed network permits large number of users to communicate at high data rate. This paper describes a technology demonstrator for an incoherent optical code-division multiple-access scheme based on wavelength/time codes. The system supports 36 users operating at 10 Gsymbols/s/user while maintaining bit-error rate (BER) < 10-12 for the correctly decoded signal. Experiments support simulations which show that coherent beat noise, occurring between the signal and multiple access interference, ultimately limits system performance.

Keywords-OCDMA; EDFA; SNR; BER; OC; FTTH;

1. INTRODUCTION

In next generation access networks, a symmetric multi-Gigabit Fiber-to-the-home (FTTH) service is required to meet the demands of future applications such as peer-to-peer, which includes video on demand, videoconferencing, high-definition TV (HD-TV), and voice over IP [1]. Optical code division multiple access (OCDMA) allows multiple users to share the same transmission media by assigning different optical codes (OCs) to different users,OCDMA is a promising aspirant for a new-generation broadband multiple access technique with unique features of full asynchronous transmission, low latency access, and soft capacity on demand as well as optical layer security [1], [3]. OCDMA schemes are categorized as implementing the code through the optical field and relying through time slots and wavelengths with reliance on incoherent detection as shown in figure 1.

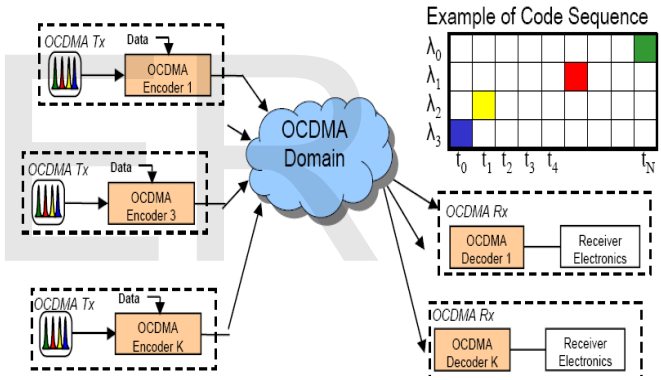

Figure 1.Multiuser OCDMA Network

Coherent schemes are susceptible to coherent beat noise that occurs when the correctly decoded signal temporally overlaps with the Multiple Access Interference (MAI) from other users [1].Signals from different encoders are coupled and each decoder receives the sum of the encoded signals. If a given encoder transmits a signal, only the decoder with the same code is capable of recovering it. Unwanted signals appear as noise to the decoder and are called multiple-access interference (MAI). MAI is the principal source of noise in OCDMA and is the limiting factor to system performance. In a well designed OCDMA network where MAI is over come, users can successfully communicate asynchronously regardless of network traffic [7].

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2. SYSTEM MODEL

Transmitter section of 36 users of OCDMA network is shown in figure 2. Here we have demonstrated an incoherent OCDMA system based on a wavelength-time spreading coding technique. The two dimensional wavelength/time (W/T) codes have been designed by using six wavelengths and six time slot in the system. Six mode locked laser have been used to create a WDM multi-frequency light source i.e. carrier signal. This carrier signal is used to modulate the PRBS data of the user. After modulation an encoder is used for encoding the signal. The wavelength range from 1550 nm to1552 nm, with 0.4 nm wavelength spacing. The PRBS data generator is used to generate random data of 26-pattern length. An electrical NRZ signal generator is used to convert digital data into electrical signal. A Mach-Zehnder LiNbO3 modulator modulates the multiplexed 6 wavelengths according to the NRZ electrical data.

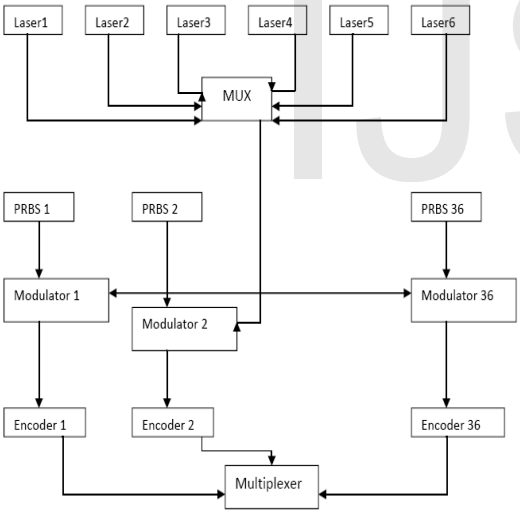

Figure 2: 36 users OCDMA Transmitter

The modulated signals are distributed to the respective encoders, which have been assigned a unique W/T code respective to each encoder. In an encoder three optical filters and six shift signals are used to produce the encoded bit stream. The optFil is used to filter out one spectral wavelength and then the shiftSig is used to produce a pulse at specified chip. The placement of the delay lines arrays and the amount of each delay are dictated by the specifies of the user signatures. The combiner combines six of the displaced pulses to from an encoded signal.

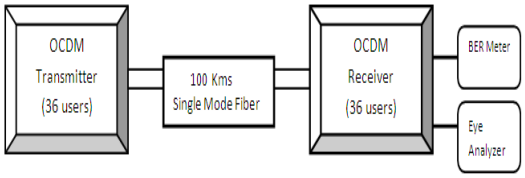

Figure 3: Block diagram of 36 user's point to point OCDMA network

The encoded data from all users are multiplexed and then pass through 100 kms span of fiber. The decoder tuned to the same structure as the corresponding encoder but with negative delays as compared to encoder, providing delays in terms of integer multiples of chip times. The decoded signal finally arrives at optical receiver.

The eye diagram analyzer has been used to take the plot of eye diagram. Bit error rate values for different users have been taken from BER meter as shown in figure 3. Figure shows block diagram of 36 user OCDMA network.

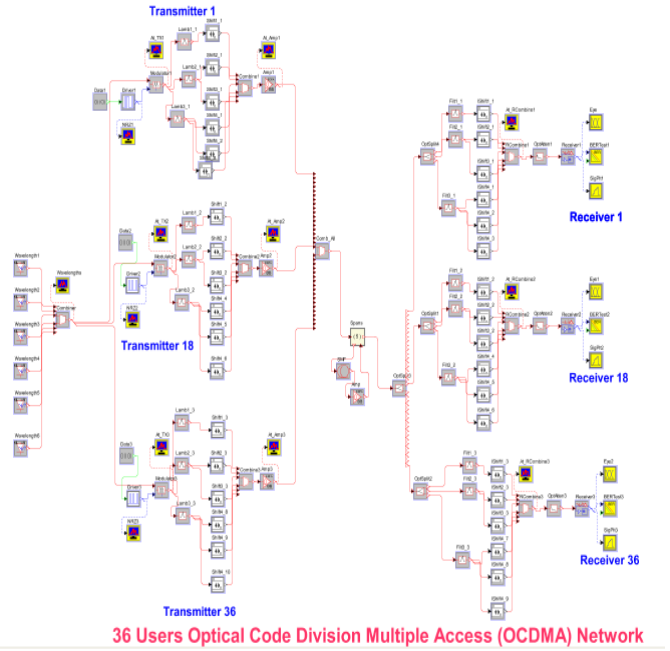

Figure 4.Simulation Set up

Figure 4 shows the actual simulation OPTSIM setup for 36 users OCDMA network. For the transmission of data, first of all, data is applied to the generator which converts the data stream {0, 1} to the pulse waveform by optical source. This output is modulated with the WDM optical signal which is produced by multiplexing multiple MLM laser input and generating the output signal which include the entire input WDM optical signal.This signal is fed to encoder,which consists of three filters and six time delay blocks.Filters filter out the desired wavwlength and each wavelength is time delayed according to spanning ruler to create a different code for different user. Now again the signals are combined through 36/1 multiplexer and then amplified to specific level this whole process is called encoding .Output of multiplexer is transmitted through single stream over long distance single mode fiber. Signal now enters the fiber link in which span and the length of the fiber is defined. This link is consisting of single mode fiber and amplifiers in which changing length will result in use of extra amplifiers and spans. The output of span enters the optical splitter l/36 which divides the signal stream to 36 data signals. Output of the optical splitter again enters an optical splitter which splits the signals to the no of wavelength generated by MLM laser. For receiving the desired signal the splitter's output enters the filter model which filter out the signal whose peak power exceed the user specified drop Fil-

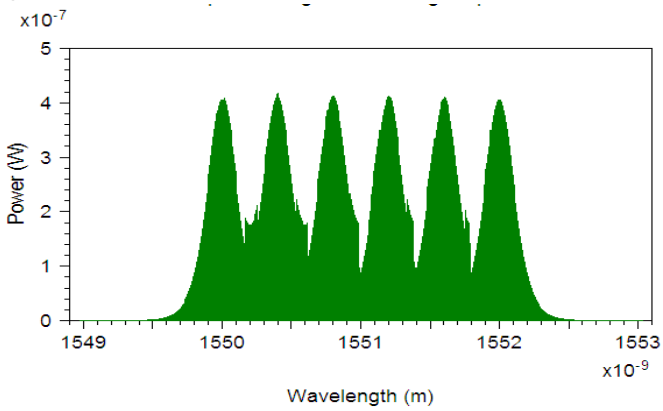

Figure 5 Wavelength Spectrums for 10Gbps

tered output is again passed through time delay block which has same magnitude but with negative sign to cancel the effect,this whole procedure is called decoding. For convenience only three transmitter and receiver i.e. user 1, 18, 36 are used in simulation setup and comparison is based on eye diagram and BER.

3.SIMULATION RESULTS

The wavelength spectrum for 10Gbps system is depicted in figure 5, which is using multiplot. Each code is designed using three wave length as seen in figure 6.

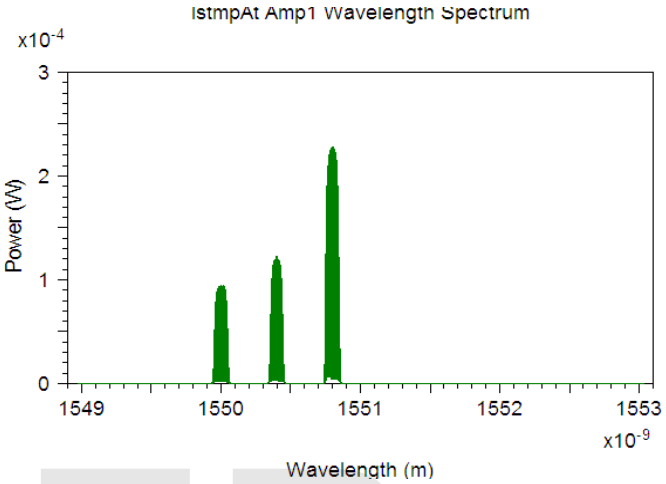

Figure 6 Spectrum Analyzer output at encoder

From Eye diagrams shown in figure 5 to 9, it can be analyzed that as the no of users increase from 1 to 18 the multiple access interference increases but it is in acceptable limits. It is further concluded that as the no of users increases from 18 to 36 the signal amplitude starts diminishing. The amplitude of the signal is decreases with increases the no. of users. For 1 user the maximum amplitude of the signal is 12V, which degrades for 36 users. It is evident that the multiple access interference exists along with the original signal, which restricts to increase the no. of users.

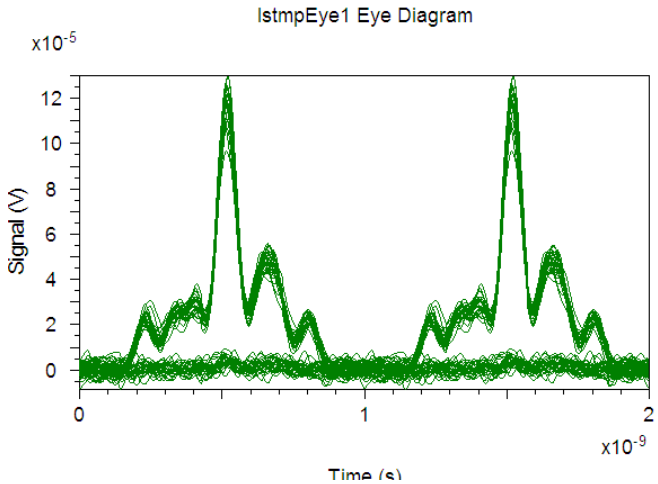

Figure 7 Eye diagram for 1 user

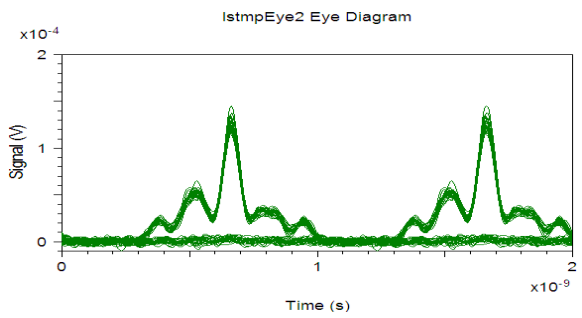

Figure 8 Eye diagram for 1 user when 18 users are present

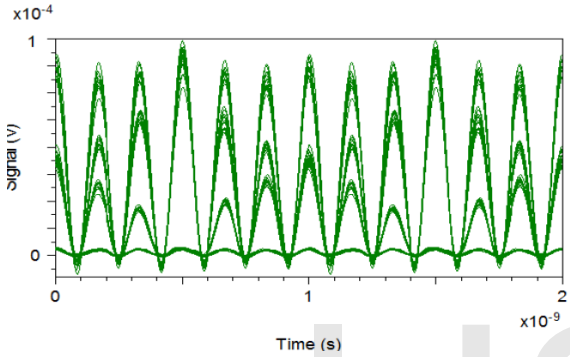

Figure 9 Eye diagram for 36 users

Table 1 shows BER comparison viz in the first part of the table, when there is only one user BER of that user is 1.91e-48.As the number of users increased from 1 to 18, BER of the first user degrades to 1.33e-26 and 18th user has BER of 1.75e-20.Similarly if the number of users are further increased 36 BER of user1 is 1.31e-12.This is due to MAI effect that degrades the performance as the number of users increases.

USER	BER
1	1.91e-48

USER	BER
1	1.33e-26
18	1.75e-28

USER	BER
1	1.61e-12
18	1.42e-16
36	1.71e-18

Table1: Simulataneous multiuser BER Comparison

4. CONCLUSION

The Optical CDMA system had been designed using these W/T matrix code and WDM type components. A computer simulation using OPTSIM simulation software was used to access the propagation of these codes at high data rates, over a long span fiber. The optical CDMA system had been designed for 10Gbps data rate. A comparative BER and Eye Diagram analysis of high speed OCDMA system for asynchronous concurrent communication of multiple users had been done. The architecture has been proposed for a number of users with different values of received power and different value of BER has been calculated. Results shows that the present system can accommodate 36 users for permissible bit error rate of 10-12. The current OCDMA system is designed for Metropolitan Area Network (MAN) which can further be extended for long haul transmission by using optical amplifier to overcome transmission losses and other similar improvements in the system design.

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