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PERFORMANCE ANALYSIS OF OPTICAL CDMA NETWORK FOR MULTIMEDIA APPLICATIONS USING HARDLIMITERS

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***Abstract*-This paper proposes the application of optical code division multiple access (OCDMA) technique. In this technique we examine the optical orthogonal codes (OOC) which are majorly used for security purpose. Application of OCDMA to Multimedia data (Audio, Video and Text) using Hard-Limiter is also implemented. The proposed system introduces Time Hopping and Power control to vary transmission Bit Rate and to control performance of transmission signal respectively. Optical Power Selector (OPS) with Hard-Limiter is proposed to improve system performance. BER is derived theoretically and numerical results are shown.**

Keywords:
Optical communications, Optical Code Division Multiple Access (OCDMA), Optical Orthogonal Code (OOC), Hard-Limiters (HL).

I. INTRODUCTION

Code Division Multiple Access (CDMA) is a "spread spectrum" technology, allowing multiple users to occupy the same frequency band at the same time. CDMA assigns unique codes to each user to distinguish it from others in the same spectrum. CDMA enables many people to share the spectrum at the same time. In Optical communication, there has been increasing interest in optical code-division multiple access (OCDMA) system due to its many attractive features such as high bandwidth, large capacity and high reliability and accommodate large numbers of simultaneous users [1]-[8]. To take the full advantage of both of the technologies, CDMA and optical fiber communication, one of the basic concepts is used where the idea is to allow several users to transmit data simultaneously over the optical fiber communication channel by simultaneously allocating the bandwidth to each user, which is multiple access. One good solution is Optical Code Division Multiple Access (OCDMA).

A typical Optical CDMA communication system [1] is best represented by an information data source, followed by a laser when the information is in electrical signal form, and an optical encoder that suits each bit of the output information into a very high rate optical sequence, that is then coupled into the single-mode fiber channel (Fig. 1). At the receiver end of the

Optical CDMA, the optical pulse sequence would be compared to a stored replica of itself (correlation process) and to a threshold
level at the comparator for the data recovery (Fig. 1).At the receiver end of the optical CDMA, the optical pulse sequence would be compared to a stored replica of itself (correlation process) and to a threshold level at the comparator for data recovery (Fig.1)

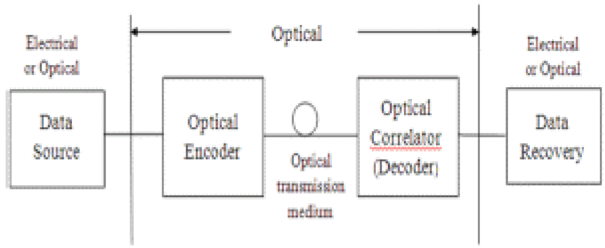

Fig 1: A fiber optic communication system using optical encoder and decoder (correlator).

A new class of codes (signature sequences), called optical orthogonal codes (OOC's), that are suitable for OCDMA is introduced. For these OOC's the desired auto and cross correlation properties are examined [1]. Main goal of OCDMA is to extract data with the desired optical pulse sequence in the presence of all other user's optical pulse sequence. We therefore need to design sequences that satisfy two conditions, namely:

- Each sequence can easily be distinguished from a shifted version of itself (auto-correlation)
- Each sequence can be easily be distinguished from (a possibly shifted version of) other sequence in the set (cross-correlation).

An (*n, w*, ,) optical orthogonal code (OOC) *C* is a family of (0,1)-sequences of length *n* and Hamming-weight (the number of "1" in each code word) *w*, and the periodic autocorrelation of each code word and the periodic cross-correlation between any two distinct code words and satisfy the following properties respectively[3]:

$$\theta_{XX}(\tau) = \sum_{i=0}^{n-1} x_i \bullet x_{i\oplus\tau} = \begin{cases} W \\ \leq \lambda_a \end{cases}$$

$$\theta_{XY}(\tau) = \sum_{i=0}^{n-1} x_i \bullet y_{i\oplus\tau} \leq \lambda_c$$

For x1, y1 ϵ {0, 1}, all integers t≠0 (mod n) and X≠Y, where OOC is denied according to the periodic correlation.

Cardinality of Constant-weight error-correcting code can be used to derive a general upper bound of the cardinality of an (n, w,) -OOC, given by

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$$\Phi(n,w,1) \leq \left\lfloor \frac{n-1}{w(w-1)} \right\rfloor \text{..........................(1)}$$

Future access networks are expected to provide Multimedia applications to a high number of users with high data rates. OCDMA would be an appropriate technique for multimedia transmission based on the assignment of a specific code to each user or each service. The different services offered were unsuccessful to provide the same quality of service QoS (characterized by the Bit Error Rate, BER), nor the same data rate (service differentiation). To perform QoS differentiation, the code weight is generally the major parameter that is to be considered.

Our main objective in this study is to investigate the ability of the 2D OCDMA technique to provide multimedia application in an OCDMA network. Our specification is to use an original code matrix partitioning method along with parallel mapping. This permits a high number of users to communicate simultaneously with high data rate for a multimedia transmission.

II. ANALYTICAL MODEL

We consider an asynchronous and incoherent OCDMA system using 2D codes. Each user employs an on/off keying (OOK) modulation to transmit independent and binary data upon an optical channel.

A 2D code is represented by an L*F matrix, where L is the number of wavelengths and F is the temporal code length (the bit period is sub divided in F intervals called chips). The number of chips set to '1' in the matrix corresponds to the code weight W. L and F values are chosen as low as possible, respectively in order to minimize the interference between wavelengths and to maximize the data rate. The considered MWOOC coding method imposes F to be a prime number and a minimal number of wavelengths L equal to the weight W. For multimedia applications, we consider that one user can have more than one dedicated matrix. In this case, several data are emitted in parallel and data rate can be increased.

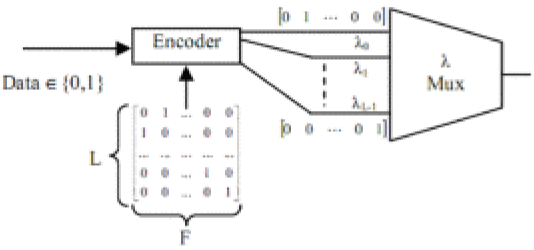

Fig 2: 2D OCDMA encoder for one user.

From this set of matrices, we aim at generating multi-weight MWOOC's. The principle is to split some matrices of dimension (LF) into lower weight matrices of dimension (F). The partition method is independent of F.

Fig2: is an example of matrix partitioning. Initial matrix of weight = 16 is split into three matrices, , and C_5^k weights respectively equals to, $W_2 = L_2 = 2$, $W_3 = L_3 = 3$, $W_4 = L_4 = 5$ and $W_5 = L_5 = 6$

Thus, as the BER depends on the weight, the four matrices, , and C_5^k corresponds to 4 different QoS.

Fig 3: Example of matrix partitioning with $L_1 = 16, L_2 = 2, L_3 = 3, L_4 = 5$ and $L_5 = 6$.

Here we consider a matrix of size (16*16)and the matrix is partitioned into 4 splits for encoding with multimedia applications. The first two rows is set to encode audio, the next 3 rows are for text, the next 5 rows for image and the last 6 rows is fixed for video.

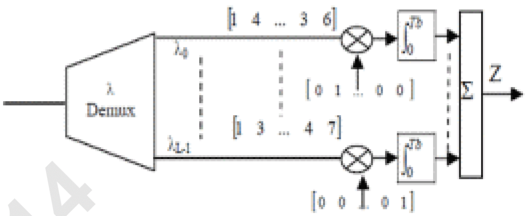

Fig 4: 2D OCDMA decoder using a CCR for one user.

At the end line, after demultiplexing the wavelengths, we first consider a Conventional Correlation Receiver (CCR) structure, making the correlation of received data with each line of the desired user code matrix. Each code matrix has one chip set to '1' per wavelength, thus the probability for two matrices with a pulse set to '1' on a same wavelength to be on the same time slot .

Performance analysis of the MultiWeight Optical Orthogonal Codes in OCDMA is done by Probability of Error/Bit When Chips Are Synchronous, which is given by

$$P_e = \frac{1}{2}\sum_{i=Th}^{N-1}\binom{N-1}{i}\left(\frac{W^2}{2L_r}\right)^i\left(1-\frac{W^2}{2L_r}\right)^{N-1-i} \text{ ....(2)}$$

where PE is the probability error and W is the code weight, N is the number of users, L is the code length and this is the threshold value.

III. SYSTEM MODEL

In this section, we introduce OPS and hard limiter in OCDMA systems with time hopping and power control. The BER is also derived for the system with the OPS and the hard limiter. In the system described optical signals from users are additionally coupled, which causes interference to degrade the system performance. One device to reduce the effect of the interference is an

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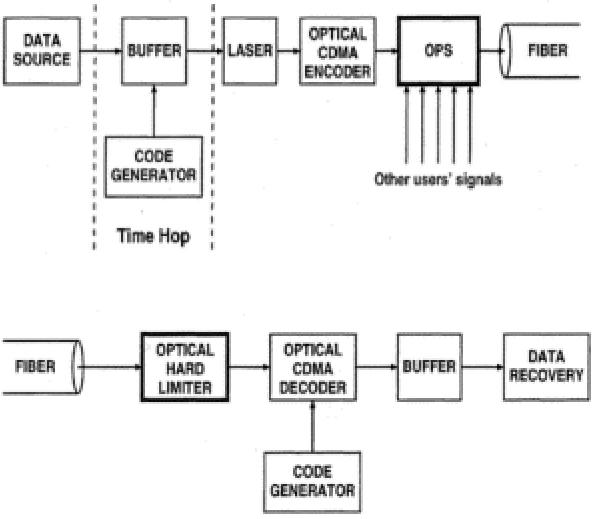

Fig 5: OCDMA system with the OPS and Hard-limiter

hard limiter followed by correlator in the receiver. In the proposed multilevel system with power control, the instantaneous cumulative signals from low-power users result in interference for high-power users even in the use of the hard limiter. This fact implies that the transmission with the minimum required signal would improve the system performance in the power-controlled OCDMA. The minimum required optical power for the multilevel system is the instantaneous maximum power among users. The transmission with the minimum required power followed by the receiver hard limiter results in the minimum interference

RESULTS

From the discussion made above we obtained the results based on the performance analysis of Optical CDMA with analysis of Bit Error Rate is shown

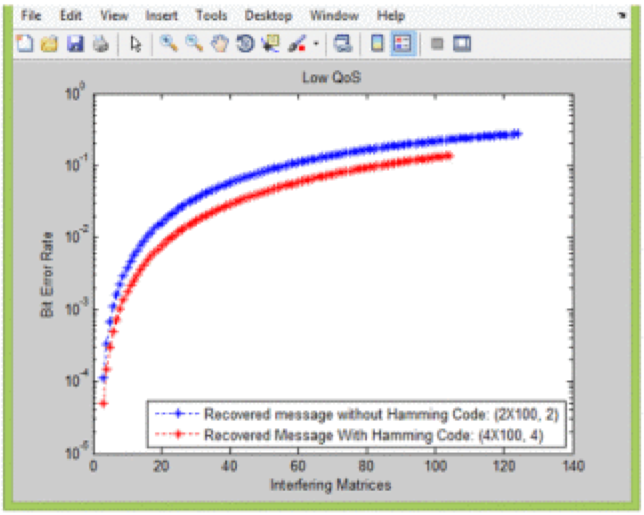

Fig 6: Representation of Bit Error Rate with N users with hardlimiters

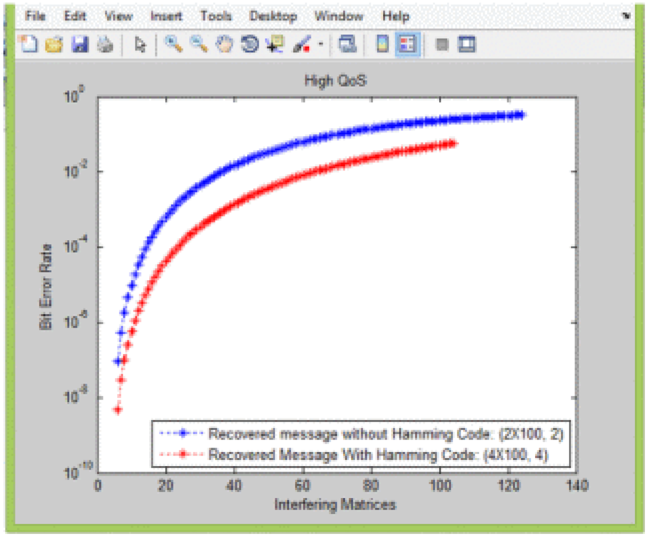

Fig 7: Representation of Bit Error Rate with N users with hardlimiters with High QOS

CONCULSION

In this paper, a new class of signature sequences, called "optical Orthogonal codes" is used which satisfies auto and cross correlation properties required for OCDMA. A method to provide multimedia access in an Optical CDMA network is been presented. Generation of 2D multiweight codes with constant length, from a 2D coding method based on MWOOC, is determined providing several Qualities of Service. The data rate differentiation is made by allocating several codes per user. The theoretical error probability expression has been established considering multimedia transmission when a conventional correlation receiver is used with and without hard limiting function.

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