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Effect of Processing Gain Variation on Optical Interleave Division Multiple Access at Minimum Loss Optical Window Using Random Inter-leaver

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Abstract- **This article contains the effect of processing gain, which is efficient parameter for direct–sequence spread spectrum communication on performance of optical IDMA system. As we know the qualities of IDMA as only means for user separation, mitigates efficiently with multiple access interference (MAI) and inter symbol interference (ISI) etc. The output of optical signal at the receiver of the O-IDMA system is an important parameter and decides the performance of the system. Here the detection is analyzed using Avalanche Photodiode for O-IDMA system and analyzed. In this paper, the simulation of optical IDMA with minimum loss optical window i.e. wavelength 1553nm is used for transmission and result of probability of bit error has been observed on MATLAB. In this article processing gain which resembles to spread length is varied and result of probability of error for different number of users using random inter-leaver is observed.**

Index Terms— **Optical IDMA (O-IDMA), Inter Symbol Interference (ISI), Multiple Access Interference (MAI). Random Inter-leaver (RI), Direct Sequence Spread Spectrum (DSS), Processing gain (PG), MATLAB.**

I INTRODUCTION

Security has long been an emerging issue in wireless network especially due to its broadcast nature of communication .Most of security mechanism for wireless network depend on the intractability assumption and the corresponding computational complexity. DSSS technology possess channel bandwidth that complicates the process of decryption or decoding because narrow band massage is spread into a wideband signal.

In general communication system interleaving is known to be a way commonly used to overcome correlated channel noise as well as burst error or fading. Interleaving has been regularly used in communication system to increase the capabilities of forward error correcting codes.

The user specific inter-leaver play energetic role in the efficiency of IDMA system. Existing multiple access technique used in 1G/2G/3/G system has maximum data rate is nearly 72 Mbps [1-4]. In 4G system we must require more data rate as compared to 72 Mbps. CDMA system used frequently in wireless communication has its own limitation of multiple access interference (MAI) and inter symbol interference (ISI) multiuser detection (MUD) is also complex issue appeared specially for large number of users. To improve the problems associated in CDMA as well as MC-CDMA (multicarrier) CDMA the new technique supports the criteria of 4G systems is IDMA. IDMA make it to many structures from CDMA, in specific diversity compared to fading and moderation of the poorest case other cell user interference problem It. can be considered as a special case of direct sequence code division multiple access DS-CDMA.

In IDMA, data streams are separated by various inter-leaver instead of different spreading codes as used in DS-CDMA. The O-IDMA system proposed is a technique in which inter-leaver are used in optical channel rather than wireless channel. As we know the better performance of optical channels in terms of SNR, BER, ISI, cost as well as supports good data rate as thousands of Gbps [4-8]. In the system iterative chip by chip multiuser detection algorithm is used to reduce the complexity of MUD. Due to this it supports higher number of users .The process of rearranging the ordering of information bits in a deterministic way is called inter-leaving. The size and structure of inter-leavers play a major role in deciding the quality of communication system. There are large number of inter-leavers are designed for performing specific performances.

Random inter-leavers are the basic inter-leaver taken for analysis purpose. Effect of spreading length which basically indicates processing gain (PG) of the overall system is varying and effect of gain (PG) variation on proposed O-IDMA system with random inter-leavers are observed which gives a significant glimpes on improvement of BER of the whole system.

II SPREAD SPECTRUM COMMUNICATION

Spread spectrum communication method day back to the early fifties. Since the most basic applications, system improvements have been more evolutionary than revolutionary [5]. Like most improvements in electronic systems, these are due primarily to the availability of ever higher-speed integrated circuit components, which translate in this case to wider spread spectra. In three decades the achievable spreading factor has grown by about three orders of magnitude to the point that we are now limited more by bandwidth allocations than by technology limitations.

Spreading here refers to expansion of the bandwidth well beyond what is required to transmit digital data. Thus, a system transmitting data at a rate (R) of 100 Mb/s using approximately 100MHz of bandwidth (W) is not spread at all, while a system transmitting at 100 bits/c spread over a spectrum of about 100MHz has a factor W/R = 10^6, or 60 dB of so called processing gain.

The purpose and applicability of spread spectrum techniques is threefold: interference suppression, energy density reduction and ranging or time delay measurement. Foremost among these is the suppression of interference which may be characterized as any combination of the following: other users: intentional (hostile or unintentional), multiple access: spectrum sharing by ‘‘coordinated’’ users, multipath: self-jamming by delayed signal.

Protection contrary to in-band interference is usually called anti-jamming (A/J). This is the single most extensive application of spread spectrum communication. A similar applications is that of multiple access by numerous users who share the same spectrum in a coordinated manner, in that each employs signaling characteristics or parameters (often referred to as codes) which are distinguishable from those of all other users. One reason for using this shared spectrum, so called code-division multiple access (CDMA), is that by distinguishing signals.

The application of spread spectrum for ranging or location is quickly gaining in importance. In spread spectrum modulation, multiplication of two unrelated signals produces a signal whose spectrum is the convolutional of the spectra of the two component signals. Thus, if the digital data signal is comparatively narrow-band related to the spreading signal, the product signal will have nearly the spectrum of wider signal. So much for modulator. At the demodulator, the received signal is multiplied by exactly the same spreading signal. Now if the spreading signal, locally generated at the receiver, is lined up with the received spread signal, the result is original signal, and plus, possibly, some spurious higher-frequency components outside the band of the original signal, and hence easily filtered to reproduce the original data essentially undistorted. If there is every undesired signal at the receiver, on the other hand, the spreading signal will affect it just as it did the original signal at the transmitter. Thus, even if it is a narrow-band signal in the middle of the band of interest, it will be spread to the bandwidth of the spreading signal.

III PROCESSING GAIN

The undesired (jamming) signal will have a bandwidth of at least W. If its power is J watts, its average density, which is essentially uniform and can be treated as wideband noise will have

$$N_0 = J/W \quad \text{watts/Hz} \qquad (1)$$

Let the desired component of the received signal have power S watts. Thus, if the data rate is R bits/second, the received energy per bit is

$$E_b = S/R \quad \text{watts/second} \qquad (2)$$

Now it is generally recognized that digital communication system bit error rate performance is a direct function of the dimensionless ratio E_b/N_0, which for spread spectrum signals may thus be expressed as

$$E_b/N_0 = SW/JR \qquad (3)$$

And hence, the jamming power-to-signal power ratio is

$$J/S= WN_0/E_bR \qquad (4)$$

This establishes that if E_b/N_0 is the minimum bit energy-to-noise density ratio needed to support a given bit error rate, and if W/R is the ratio of spread bandwidth, also called the processing gain, then J/S is minimum tolerable jamming power-to-signal power ratio, also known as the jamming margin.

We have come this for without even specifying the features of the spreading signal. There are, in point, two different classes of spreading methods. The first is called direct-sequence or pseudo noise (PN) spread spectrum. Here the spreading is achieved by multiplication by a binary pseudorandom sequence whose symbol rate is many times the binary data bit rate. The spreading sequence symbol rate is sometimes called the chip rate.

Error-correcting coding requires redundancy, which spreads bandwidth and thus reduces available processing gain for the available bandwidth.

Reality is, in fact, just the opposite. To see that coding does not reduce the effective processing gain, let us rewrite jamming margin (4) in terms of the symbol[2] rate R_S

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and the symbol energy E_S. These are related to the bit rate and the bit energy through the code rate r, defined as the number of data bits per transmitted symbol, or the inverse of the coding expansion factor. (For example, a rate ½ coded system transmits two code symbols for each data bit). It follows that

$$R_S = R/r \quad \text{and} \quad E_S = E_b\, r \qquad (5)$$

Now if we repeat the previous dimensional argument replacing bits by symbols everywhere, we have

$$J/S = WN_0/E_b\, R_S \qquad (6)$$

But substituting the preceding definitions for symbol rate and energy, we obtain for the maximum tolerance J/S ratio

$$J/S = W\, N_0/R\, E_b \qquad (7)$$

Which gets us back to (4). This may seem like sleight of hand, but it really is not. More ever, although it will take some further reading to be convinced, we are really ahead of the game. For with coding, the required E_b/N_0 for a given level of performance (bit error rate) is actually reduced. Thus, for a given processing gain (W/R) the jamming margin is further increased by coding.

IV OPTICAL IDMA SYSTEM

In the block diagram of proposal IDMA system shown in figure, having k different users, offering single path of optical window 1550 nm. In consequence of k users having shown as $d_k= [d_k(1), d_k(ii)……d_k(N)]^w$. It all k users having converted in code length n, which is assumed to be low rate. Where length of chip is indicated by w [9-10].
The chip c_k is interleaved by a chip level interleaver 'π_k', producing a transmitting chip sequence x, $k = [x_k(1), x_k(j), …. X_k(J)]^T$. after transmitting through the channel, the bits are seen at the receiver side as $r = [r_k(1), r_k(j), …. R_k(J)]^w$. The channel opted is additive white Gaussian noise (AWGN) channel, for simulation purpose.
In receiver section, after chip matched filtering, the received signal from the k user can be written as

$$r(j) = \sum_{k=1}^{K} h_k x_k(j) + n(j), \; j = 1, 2, ….. J. \qquad (8)$$

Where h_k is the channel coefficient for user-k and {n (j)} are samples of an AWGN process with zero mean and variance $\sigma^2 = n_0/2$, we assume that the channel coefficient { h_k } are known a priori at the receiver.

In the receiver side for multiuser detection we have used elementary signal estimator, APP and $SDEC_s$ having variable iterative mechanisms.

The obtained outputs of various components used in receiver are based on LLR_S. Which is expressed as

$$e(x_k(j)) = \log\left(\frac{P\,(x_k(j)=+1)}{P\,(x_k(j)=-1)}\right) \quad \text{for all } k, j. \qquad (9)$$

The produced LLR are further classified in two ways, one which is produced by PSE and another which is generated by DEC.
For special case of random interleave ….the mechanism based on chip by chip type u (j)
r (j) = $h_k\, x_k(j)$ +

$$r(j) = h_k x_k(j) + \xi_k(j), \qquad (10)$$

where,

$$\xi_k(j) = r(j) - h_k x_k(j) = \sum_{k' \neq k} h_{k'} x_{k'}(j) + n(j)$$

……………………………………………….. (11)

where,
$\xi_k(j)$ is the distortion (including interference-plus-noise) in $r(j)$ with respect to user-k.
The concept and ethics involved in CBC has shown in [2], the function of ESEB and APP decoders are based on users. The obtained values of LLRS for both SDEC and ESEB are shown in the expression.

$$e_{SDEC}\,(x_k(j)) = 2h_k \frac{r(j) - E(r(j)) + h_k E(x_k(j))}{Var(r_j) - |h_k| Var(x_k(j))}$$

……….(12)

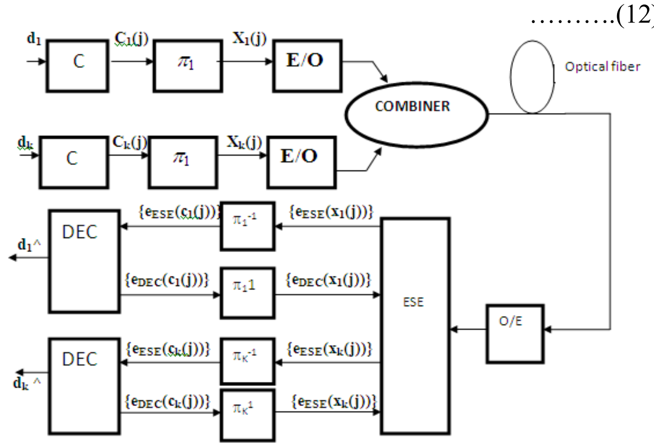

Figure1. Optical IDMA Transmitter and Receiver Structure

V RANDOM INTER-LEAVER

Interleaving is the mechanism of rearranging the ordering of data sequence in one to one deterministic format [11-12]. The basic role of an inter-leaver is to construct a block long code from small memory convolutional codes as long codes can approach the Shannon capacity limit. Secondary it spreads burst errors.

The inter-leavers provides scrambled information data to the second component encoder and de-correlates inputs to the two component decoder so that an iterative suboptimum decoding algorithm based on uncorrelated information exchange between the two component decoder can be applied. The final role of the inter-leaver is to break low weight input sequence and hence increases the code free hamming distance or reduce the number of code words with small distances in the code distance spectrum.

User Specific inter-leavers can be generated independently and randomly. The transmitter and receiver need to store or communicate many bits in order to agree upon an inter-leaver. It provides very good results in terms of BER (Bit Error Rate). The only disadvantage of random inter-leaver is that it suffers from the problem of large memory requirement which is undesirable.

The Random Inter-leaver rearranges the elements of its input vector using a random permutation. The incoming data is rearranged using a series of generated permuter indices.

A permuter is essentially a device that generates pseudo-random permutation of given memory addresses. The data is arranged according to the pseudo-random order of memory addresses.

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VI SIMULATION RESULT AND DISCUSSION

In this paper the simulation of optical IDMA with minimum loss optical window i.e. wavelength 1553nm is used for transmission and result of probability of bit error has been observed on MATLAB. Here processing gain which resembles to spread length is varied and result for different number of users using random inter-leaver is observed.

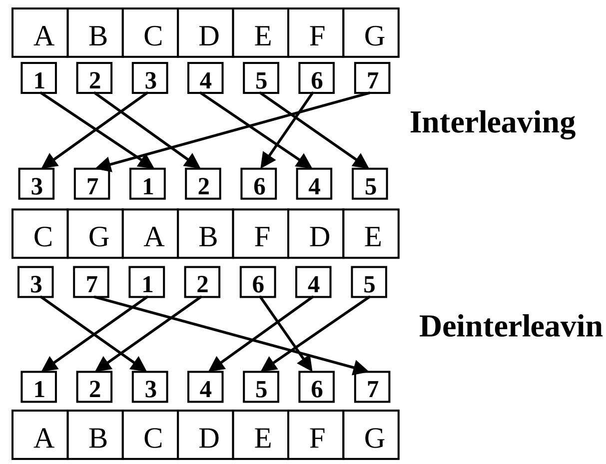

Figure 2: Random Inter-leaver

Figure 3 is plotted between probability of bit error versus number of users taking spread length (Sl) =16 and data length (m) = 512 bits. Number of users varies from 40 to 100. Varying data length doubles that is 1024 again a graph between Pe versus number of users is plotted. In figure 4 the parameter processing gain that is spread length is changed. It is selected as sl = 32 and the graphs between Pe versus number of users are plotted for data length 512 and 1024 respectively.

6.1. For Un-coded IDMA, data length m=512 and m=1024, Spread Length Sl=16 and number of users, n=40 to 100:

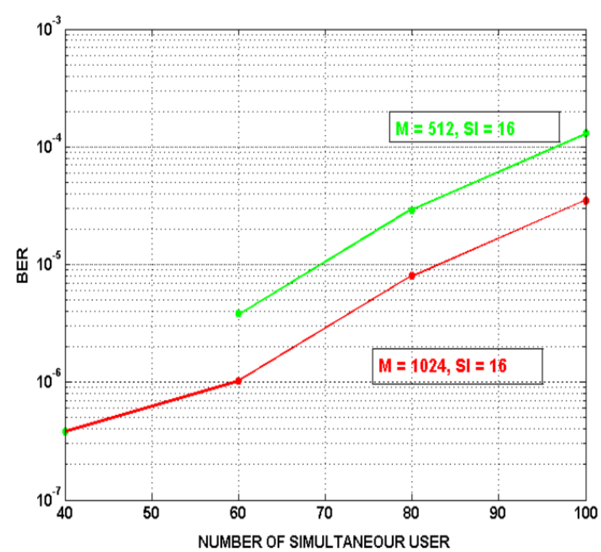

Figure 3: BER performance of un-coded Optical IDMA of Random inter-leaver m=512 and 1024 and Sl=16.

6.2 For Un-coded IDMA, data length m=512 and m=1024, Spread Length Sl=32 and number of users, n=300 to 400:

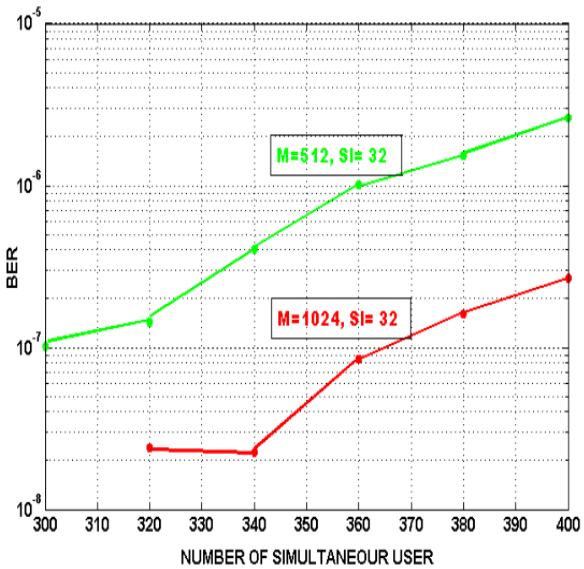

Figure 4: BER performance of un-coded Optical IDMA of Random inter-leaver m=512 and 1024 and Sl=16.

VII CONCLUSION

As we know that the spreading length resembles processing gain which is significant parameter for direct sequence spread spectrum communication. Higher the processing gain of system improves the antijam capability and security of system; it improves the jamming margin as well as reduces probability of bit error.

The results obtained from figure 3 clearly shows that by increasing number of users Pe increases rapidly from 3×10^{-7} for 40 users up to 0.3×10^{-4} for 100 users.

As data length is increases from 512 to 1024 the results were more optimistic clearly shown in the graph giving lesser Pe.

As in figure 4 where processing gain is doubled that is Sl =32 and m = 512, there is no error obtained below 300 users. The error comes 1.01×10^{-7} for 300 users and increases rapidly as user increases. Same trend obtained for Sl = 32 and m = 1024.

Since we are using here APD in place of PIN detector performance is improved, as we know the qualities of APD have high internal gain and wavelength dependent responsivity and high sensitivity characteristic. In further work by various efficiency and gain of APD we can get much improved performance of APD.

Thus it can be concluded that effect of processing gain variation improves the performance of OIDMA system. As processing gain increases the improvement in Pe obtained. We have use random inter-leaver for study due to its simplicity and easier generation property results will be more improved if tree based inter-leaver which comprises of two master random inter-leaver is used. At last we can say that due to less multiple access interference, high data rate, low ISI, and cost dependent on number of users, OIDMA is best tool for forthcoming 4G and 5G system.

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BIOGRAPHIES

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