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Performance Evaluation of Invert Tree Based Interleaver with Receiver Diversity in Interleave Division Multiple Access

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Abstract

Transmitting multiple copies of signal to minimize fading effect is known as diversity. It is effectively and very commonly used in communication systems to overcome performance degradation due to interference and fading. In this paper, receiver diversity technique is used to overcome fading effect in IDMA scheme with random interleaver, tree based, and Invert tree based interleaver (ITBI). Simulation results illustrates significant performance improvement of IDMA system with receive diversity. It has been observed that ITBI gives comparable performance to that of random and tree based interleaver, however, it presents noteworthy reduction in bandwidth and memory requirement.

Keywords: Fading, Diversity, Invert Tree Based Interleaver

INTRODUCTION

Due to rapid growth in technologies and market oriented demands, mobile communication has entered in 4G stage. The distinctive features of 4G systems in comparison to 3G systems are inherited with technology of packet switched high-rate data transmission along with voice services. The ultimate user needs reliable, cheaper, secure, and low-delay voice & data services anytime and anywhere [1]. The additional features of the future wireless communications include high-speed data and the above features are imposing technical challenges on system design and stimulate various researches to work on topics related to capacity, complexity and performance of the communication systems [2-4]. Wireless communication systems are performed by sending signals through radio propagation environment. But radio propagation environment has some limitations of its performance because of natural and constructive obstacles. The parameters responsible to the sufferings of radio propagation are Path-loss, Shadowing-loss, Interference, Noise, Channel Spreading and Fading of channels [5]. The overall performance of system degraded severely due to the above problem. Fading is a major problem of wireless communication network. The reception of a signal in a channel transmitted through any type of fading channel degrades in quality if the signal level attenuation is below the expected operation region of the receiver [6]. In this situation, the received signal power is not expectedly enough comparing with signal noise and interference power for reliable reception. The solution to overcome the channel attenuation because of fading problem in channel is to increase the transmitted power adjusted to the attenuation which is called power control (PC) [7]. Using PC, the fading can't be overcome completely but the attenuation may compensate considerably. Another approach to minimize fading effect in a system is space diversity and it is effectively and commonly used to overcome degradation in performance due to interference and fading without need of extra bandwidth. If we want to get benefit from diversity technique, then we must need to combine some diversity technique to get advantage. Maximal ratio receiver combining (MRRC) diversity technique, is suitable technique to combat fading [8]. This is the best combining process used with IDMA which achieves the best performance improvement comparing to other methods. IDMA systems has less complex receiver than CDMA [5]. In this paper, MRC as diversity combining scheme is utilized to reduce fading effect in IDMA with various interleavers.

RELATED WORK:

Diversity technique is used to reduce the fading effect [8]. The effect of inter symbol interference can be mitigate by combining technique [15]. A comprehensive study of the combining methods is explained in [10]. Performance Evaluation of Maximal Ratio Receiver which combines Diversity with Prime Interleaver for is given in [11], also the performance of MRRC diversity in IDMA system using Prime Interleaver with Zigzag coding with 1:2 antennas is presented in [12]. The study of IDMA scheme in underwater fading acoustic environment with MRRC diversity is reported in [13]. Various diversity scheme for underwater IDAM communication is also reported in [14].In [15] performance of IDMA scheme with various coding scheme with receiver

diversity using random interleaver has been analyzed. It has been observed that convolution coded IDMA gives better results as related to zigzag coded IDMA. Simple diversity scheme for IDMA is presented in [16]. The performance turbo coded IDMA scheme using polarization diversity is discussed in [17]. Error-Rate (ER) performance of double space-time transmit-diversity Interleave-division multiple-access (IDMA) system using transmitter pre-processing (MUTP) for downlink communication is described in [18].The investigation of the performance of co-operative diversity aided downlink communications using multi-user transmitter preprocessing (MUTP) technique for interleave division multiple access(IDMA) scheme is shown in [19]. This paper shows analysis of MRRC diversity at the receiver side to reduce fading effect in IDMA. Simulation shows that, IDMA system gives improved performance with diversity. The performance of ITBI is found to be at same level as random and tree based interleaver. The paper is systematized as follows. Analysis of IDAM is presented in section 2. Section 3 shows MRRC diversity scheme with IDMA. Section 4 explains various interleavers. Results discussion is carried out in section 5. In section 6 conclusions are presented.

Concept of IDMA

IDMA scheme distinguishes users by interleavers in contrast to user signature sequence in CDMA. The Figure 1 depicts blocks of transmitter and receiver of IDMA system. IDMA system proposed in [20] has been chosen here. The upper section of figure 1 is transmitter section of IDMA with G simultaneous users sharing a single channel. Let p_g denotes input data sequence of user g of M length denoted as $p_g = [p_g(1),p_g(2),.....p_g(M)]$.

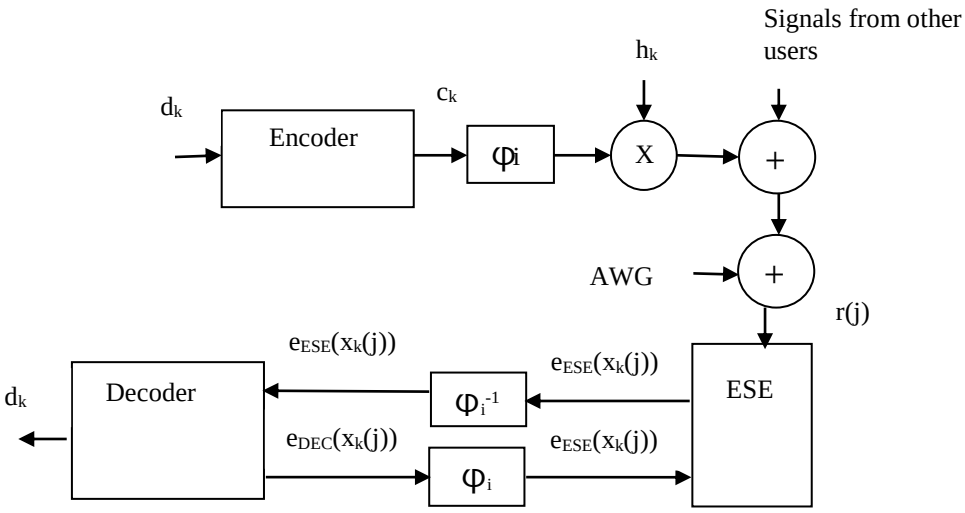

Figure 1: Transmitter and Receiver structure of IDMA[22]

This data sequence after passing through low rate encoder C, coded into chips $c_g = [c_g(1),c_g(2),.....c_g(I)]$,where I is the Chip length. Now the chips are passed through interleaver and interleaver permutes coded sequence into $x_g=[x_g(1), x_g(2).....x_g(I)]^T$. Now at the receiver data is seen as $r=[r_g(1),r_g(2)....r_g(I)]^T$. The channel is Additive White Gaussian Noise (AWGN). Received signal form G users is written as,

$$r(j) = \sum_{g=1}^{G} h_g x_g(j) + n(j) \qquad j = 1,2,3 \ldots J$$

Where h_g is channel co efficient

n(j) are noise Samples of AWGN with zero mean

The receiver is consisting of Elementary signal estimator and bank of K decoders, which are operated in iterative manner. BPSK modulation has assumed for simulation. Output of ESE and DEC are log likelihood ratio about xk(j). The outputs of the ESE are passed to the DECs for further improvement The Outputs of DECs are given back to the ESE for next iteration estimation. The process is repetitive for a predetermined multiple time and in last iteration, the DECs yield hard conclusions.

Various Interleavers in IDMA Scheme

Random Interleaver:

In case of random interleavers(RI), related interleaver must be sent with the interleaved data during the transmission. So, high amount of bandwidth is required.

Tree Based interleaver:

To minimize the problem of Computational complexity, tree based interleaver (TBI) is proposed in [21]. In this method two randomly generated interleavers called master interleavers φ1 and φ2 which are orthogonal to each other are transmitted. The structure of Tree based interleaver is shown in Figure 2, which is based on two master interleavers in a specific way. Since TBI uses two orthogonal interleavers, it suffers with the problem of extra memory requirement than MRI.

Invert Tree based interleaver:

ITBI has already proposed in [22]. In case of ITBI generation one randomly selected master interleaver φ1 is taken initially and transmitted from BS. Now interleaver for user 2, let us say φ1' can be derived at the receiver by inverting φ1. Here φ1 and φ1'are orthogonal to each other. Interleavers for the other users are calculated using a combination of these two interleavers. For example, in case of 3rd user, the user specific Interleaver is decided with φ1 (φ1) and for the fourth user it will be φ1 (φ1'). So, we can say that, during the transmission, one interleaver along with user count must be sent to the receiver with data related to user, thus ITBI requires lesser memory compared to TBI method.

Diversity Schemes for 4G IDMA System

Diversity technique is utilized for performance improvement of fading channels. In this method, we supply multiple replica of transmitted signal to the receiver. The main idea here is that some of the signal may undergo fading channel, but some other signal may not. Majorly utilized diversity techniques are described below:

Time diversity: This diversity is realized by sending signal in the exact timeslot separated by coherence time. This technique utilizes coding of channel and interleaving to mitigate channel fading at a cost of added delay and loss of bandwidth efficiency. It is uses on slow fading channels and on the channels which is delay sensitive.

Frequency diversity: Multiple replicas of information signal are sent over several affected frequency band in this diversity [23]. Moreover, frequency hopping (FH) might be using to achieve such kind of diversity instead of sending multiple frequency replicas over different affecting frequencies.

Space diversity: Multiple resonators are used to transmit at the transmitter and/or receiver in space diversity. This technique is used to provide significant performance gain with not sacrificing any valuable bandwidth on the transmitted power resources. Spatial diversity is widely used because it is easy to implement, and it's cost effective and very simple [24].

Receiver Diversity Analysis for IDMA Scheme

Several antennas are use at the receiver to obtain diversity and employ switching and combining or selection intending to improve the quality of received signal. Since it is easier and cost effective to use multiple antennas at the base station than the terminal which is a positive manner of receive diversity. The signal from transmitting antenna travels through multipath to reach to the multiple receiving antennas related to the receiving section. These received copies of signal experience independent fading through independent paths in the channel which are further processed according to various receive diversity mechanisms. The recovered signal, thus, though receive diversity mechanism, demonstrates superior signal strength.

Maximal Ratio Receiver Combining (MRRC) Technique analysis for 4G IDMA

Figure 2 shows the arrangement for IDMA system with MRRC diversity [11]. In the MRRC combining technique, the signals from each diversity branches are added together. In such technique, diversity branches are weighted for maximum SNR. As said before we have used 1:2 antenna system, the signal is transmitted form one resonators and received with 2 receive resonator. As shown in figure after interleaving data are propagating from both channels h0 and h1. The channel can with magnitude and phase response can be modeled as,

$$h_0 = \boldsymbol{\alpha}_0 e^{i\theta_0}$$

$$h_1 = \boldsymbol{\alpha}_1 e^{i\theta_1}$$

The resulting signal after the addition of noise is

$$R_1 = h_0 x_k + n_o$$
$$R_2 = h_1 x_k + n_1 ,$$

Where n_0 is the noise and interference from antenna 1 and n_1 is the noise and interference from antenna 2.

Performance Results

Below are the simulation results to estimate the performance of IDMA with diversity. The simulation parameters for MATLAB simulations are shown in table 1.

Table 1: Selected simulation parameters

Block length	2000
Spread length	16
Iterations	15
Data length	512,1024
Transmitting Antenna	1
Receiving Antenna	2
Interleavers	RI,TBI,ITBI
Channel	Slow fading Rayleigh
Modulation	BPSK
Number of users	4

Simulation Results of IDMA With Receiver Diversity:

The comparison of amount of bandwidth required by various interleavers is shown in Figure 3. ITBI requires less bandwidth than other available interleavers due to transmission of only one interleaver during transmission [22]. Figure 4,5 and 6 shows results of IDMA with RI, TBI and ITBI with diversity. It is revealed from figure that performance of IDMA system employing MRRC diversity performs well than that of without diversity for each case. In figure 7, the parameter of data length is varied with k=512, 1024.The simulation is performed with one transmitter two receiver diversity systems. From the results, it is observed with increment in data length, the Bit Error Rate performance of the system is improving. One can also note that the performance here also improves with diversity too.

In Figure 8, the IDMA scheme with variation in interleaver is demonstrated. The results validate the comparable performance of ITBI with other interleavers.

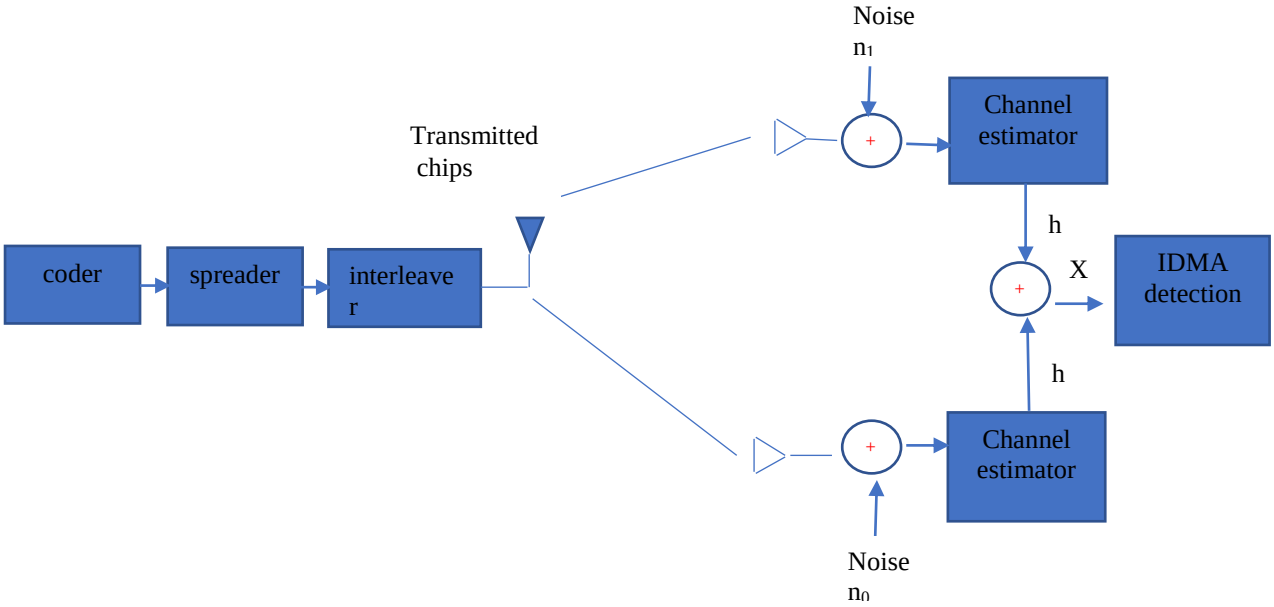

Figure 2: Maximal ratio receiver combining system with IDMA

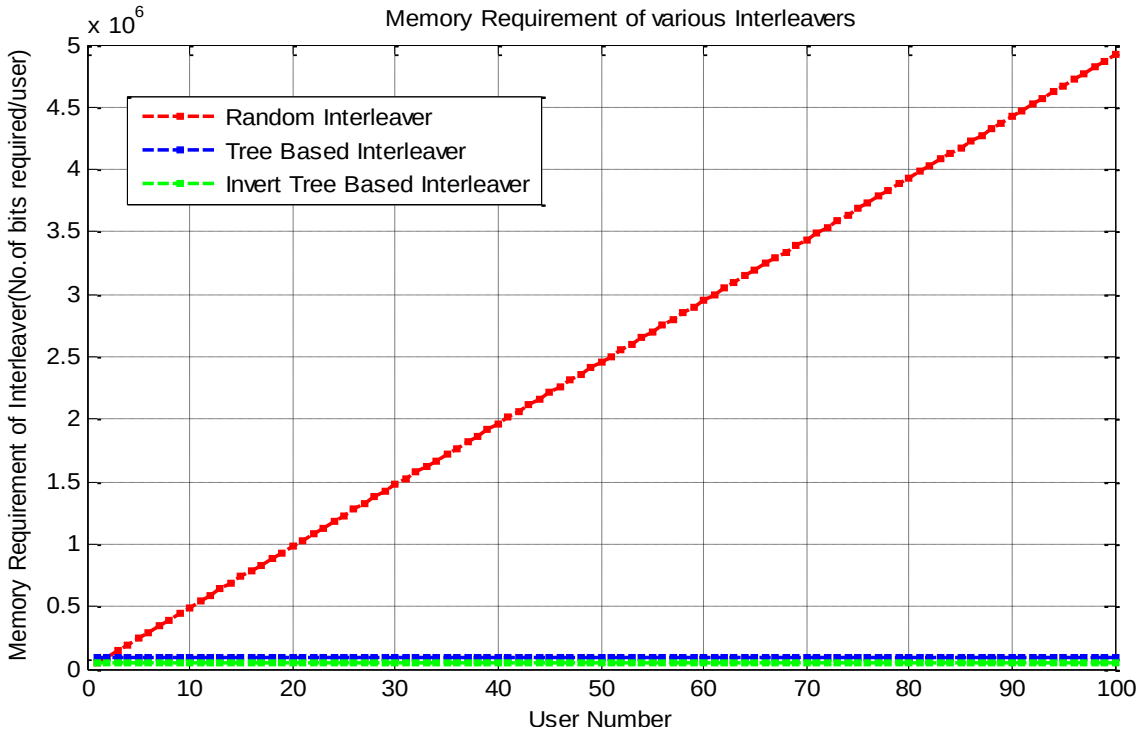

Figure 3: Bandwidth requirement by various interleavers

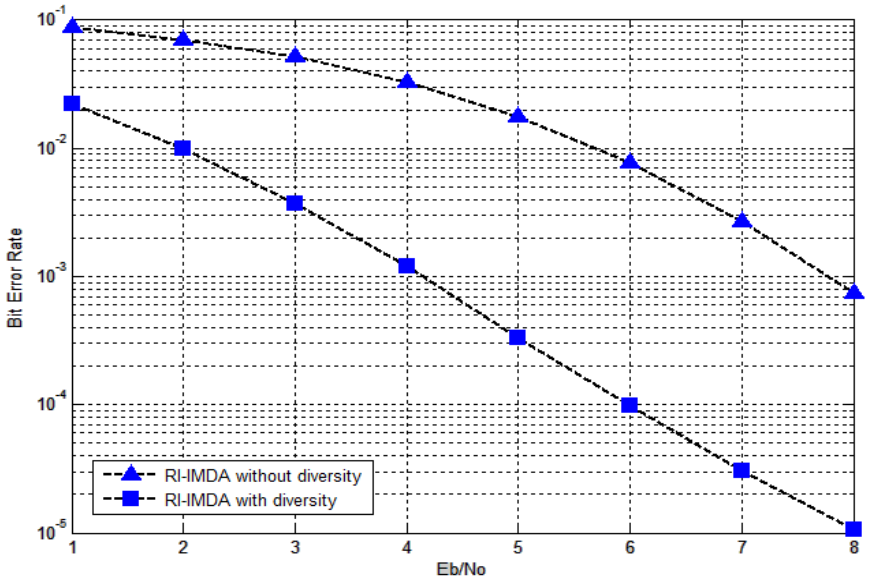

Figure 4: Performance of Random Interleaver with 1Transmitter and 2 Receive Antenna, MRRC diversity Technique

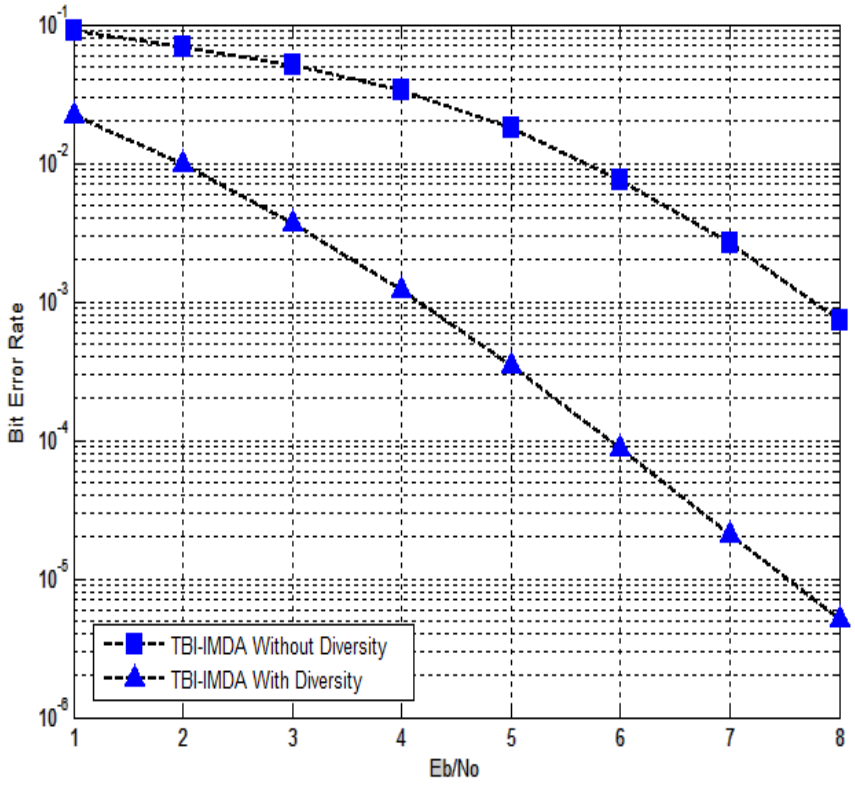

Figure 5: Performance comparison of TBI with and without MRRC diversity Technique

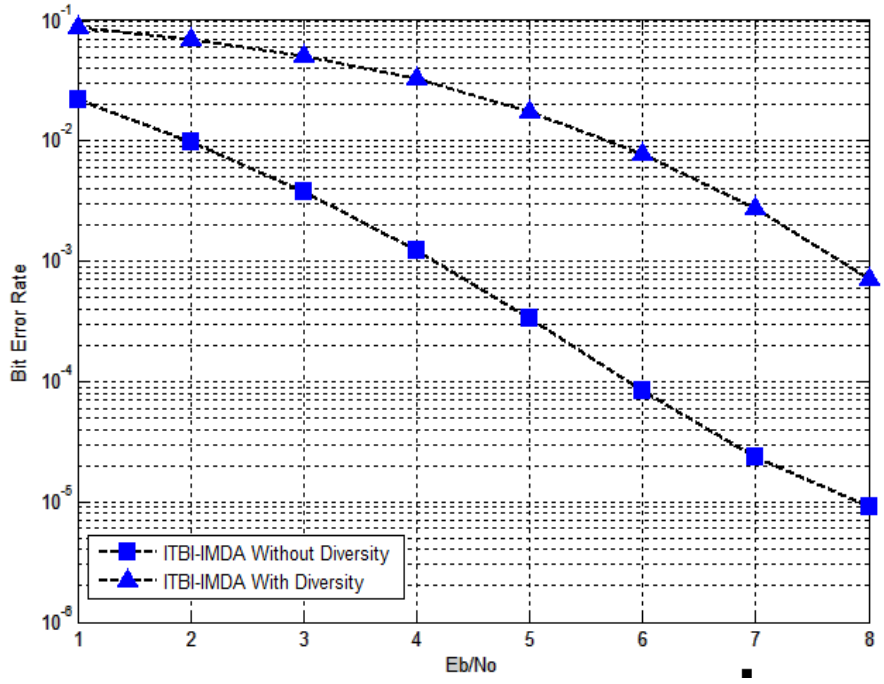

Figure 6: Performance of ITBI with and without MRRC diversity Technique

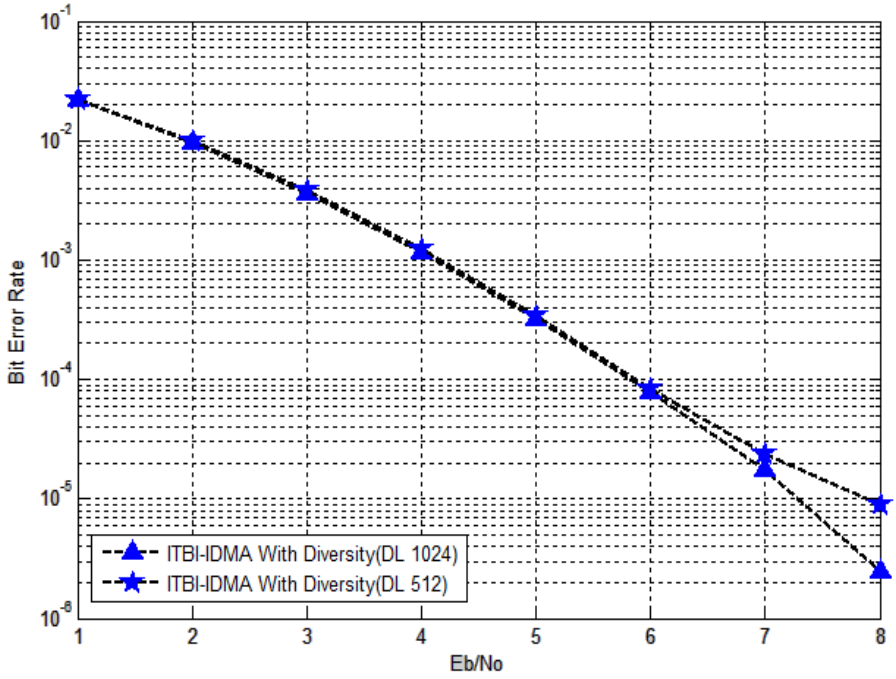

Figure 7: Performance comparison at different data length Invert Tree based Interleaver with MRRC Diversity

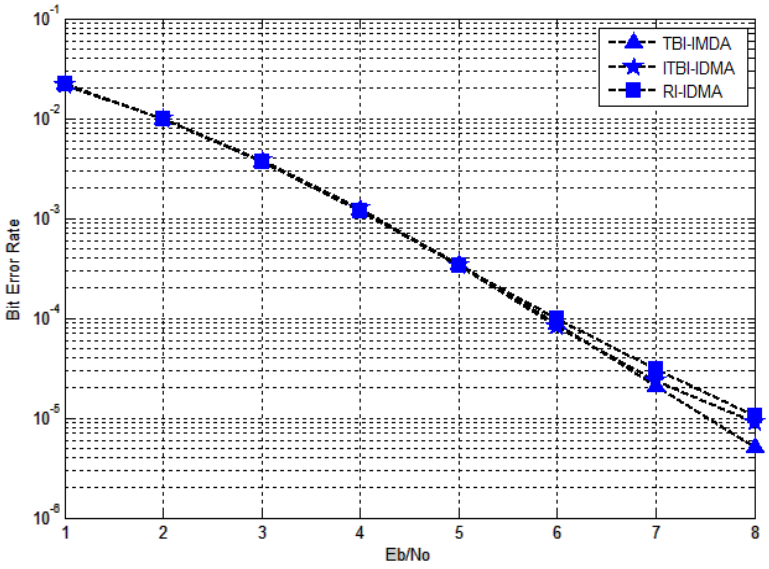

Figure 8: Performance comparison of RI, TBI&ITBI with MRRC Diversity at data length=512 bits

CONCLUSIONS

IDMA system has been simulated incorporating maximal-ratio combining technique for multiple interleavers. This system is compared with IDMA without inclusion of MRCC technique. Based on simulation results it is validated that IDMA having MRCC diversity technique has improved performance. In addition, it is observed that as data length increases, the performance of IDMA system gets significantly improved. From presented simulations it can be concluded that system with ITBI gives similar BER performance irrespective of diversity, but it has noteworthy improvement in terms of bandwidth and memory requirements.

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