PERFORMANCE ANALYSIS OF IDMA SCHEME USING DIFFERENT CODING TECHNIQUES WITH RECEIVER DIVERSITY USING RANDOM INTERLEAVER

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ABSTRACT
In this paper performance analysis of IDMA systems is determined using different coding techniques. In this paper we use a receiver diversity approach which is useful in combating the fading in the IDMA scheme. In the transmitter section a single antenna is used where as in the receiver section two antennas are used. A comparative study has been performed between convolutional coding and zigzag coding with and without receiver diversity. Use of receiver diversity improves the bit error performance of the IDMA scheme. Random interleaver has been used in this paper.

Keywords: Convolutional coding, IDMA, MATLAB, random interleaver, receiver diversity, zigzag coding.

1. INTRODUCTION
In the last three decade the wireless communication is on demand among the society leading to extensive growth in technology. Due to the growth in technology in wireless communication demand for bandwidth also has been increased. Different techniques have been studied to improve the bandwidth, efficiency and increase the number of users that can be accommodated within each cell [1]. Existing multiple access technique that are used in 1G/2G/3G systems are basically suitable for voice communication only. These systems do not provide high data rate transmission which is important feature of 4G system. 3G systems provide the data rate of around 3.6-7.2 Mbps however 4G provides the data rate up to 100 Mbps for high mobility and up to 1 Gbps for low mobility [2,4].

CDMA scheme as it offers better bandwidth and efficiency than both schemes that is TDMA and FDMA. It offers robust performance due to its unique feature of processing gain, dynamic channel sharing, large coverage etc. Therefore CDMA is widely used in 3G technology. But there are many problems with CDMA. It is mainly limited by multiple access interference (MAI), as well as intersymbol interference (ISI)[2,3]. The computational cost and complexity of multiuser detection are also one of the main disadvantages of CDMA. Therefore we switch to a new multiple access technique which combat the disadvantages of CDMA. This technique is known as INTERLEAVE DIVISION MULTIPLE ACCESS (IDMA).Interleave division multiple access is the technique in which interleaver are used as the only means for user separation.

2. OVERVIEW OF IDMA SCHEME
Among the existing multiple techniques most commonly used scheme in the world is the Interleave division multiple access can be considered as a special case of direct sequence- code division multiple access. IDMA exhibits excellent bit error rate (BER) performance, spectrum usability, and low complexity of the receiver. It can also effectively deal with the intersymbol interference and reduce interference between the cells. IDMA provides very high gain. Interleave division multiple access is the technique in which interleavers are used as the only means for user separation. Thus in this technique users are distinguished by users specific chip level interleavers instead of signatures as in the case of conventional CDMA system[5]. This scheme allows a low complexity multiple user detection technique which is applicable to the systems with large number of users in multipath channels. The spreading process is carried out before interleaving in the transmitter part of IDMA. This spreading process can be same for all users. Performance of code division multiple access (CDMA) systems is mainly limited by multiple access interference (MAI) and inter-symbol interference (ISI). A code division multiple access system share the same transmission media so that signals from different users are superimposed causing the multiple access interference (MAI) problem. Multiple access interference (MAI) is a factor which limits the capacity and the performance of DS-CDMA systems. MAI refers to the interference between direct sequences users. Thus to combat disadvantages of conventional
CDMA in second and third-generation cellular mobile communications, IDMA is proposed as a new spread spectrum technique.

IDMA TRANSMITTER AND RECEIVER

The structure of a transmitter and a receiver for an IDMA system with \( K \) simultaneous users is demonstrated in Figure.

2.1 TRANSMITTER SECTION

The upper part of the figure shows the transmitter section of IDMA scheme whereas lower part of the figure shows the receiver section of IDMA. Input data sequence that are given by the \( K \) users are \( d_1, d_2, \ldots, d_K \) represented by \( d_k = [d_1, d_2, \ldots, d_K] \).

Fig.1 Transmitting and receiving scheme of IDMA system

In the transmitter section firstly the input data sequences are passed through an Encoder at the rate \( R \) using low rate code \( C \). Then it is passed through a spreader where each user has assigned a common signature sequence \( S_k \) having length \( S \). The spreader for the users spreads a coded bit to a chip sequence (i.e., it transmits either \( S_k \) or \( -S_k \) to represent one bit. The spreading operation expands the bandwidth.

Thus a coding sequence is generated which is represented as

\[
C_K = [c_K(1), c_K(2), \ldots, c_K(j)]^T
\]

Where, \( j \) is the Frame length.

Sequence is passed through an interleaver. This interleaver permutes the coded sequence to produce \( X_K = [x_K(1), x_K(2), \ldots, x_K(j)]^T \). After interleaving process the \( X_K \) is transmitted over multiple access channels.

2.2 RECEIVER SECTION

In the multiuser detection technique of IDMA, the receiver consists of an Elementary Signal estimator (ESE) and a posteriori probability (APP) decoder (DEC). The received signal from different users from multiple access channels can be written as

\[
R_j = \sum h_k x_k(j) + n(j), \quad j = 1, 2, 3, \ldots, j \quad (1)
\]

Where

- \( n(j) \) – Samples of a zero mean additive white Gaussian noise (AWGN) with variance \( \sigma^2 = \text{N}_0/2 \).
- \( X_k(j) \) is the \( j \)th chip transmitted by the \( K \)th user, the channel coefficient for the \( k \)th user.
- \( h_k \) is the channel coefficient of the user \( K \).

In the receiver section of IDMA system, the detector deploys a chip by chip detection strategy. The elementary signal estimator (ESE) exchanges the information with a posteriori decoder (DEC)\[8\]. \( e(x_K(j)) \) denotes the extrinsic information about \( x_K(j) \). Further it can be discriminated as \( e_{\text{ESE}}(x_K(j)) \) and \( e_{\text{DEC}}(x_K(j)) \) depending on whether it is generated by elementary signal estimator or decoder. The input of elementary signal estimator are \( [r(j)] \) and \( [e_{\text{DEC}}(x_K(j))] \) and the output of the ESE is the extrinsic information \( [e_{\text{ESE}}(x_K(j))] \) about \( (x_K(j)) \). The output of the ESE that is \( [e_{\text{ESE}}(x_K(j))] \) is first applied to Deinterleaver of the \( K \)th user. This extrinsic information generated by ESE (after deinterleaving) is used as a priori information in the \( K \)th DEC for user \( K \)[8,11].

Then output of the \( K \)th DEC (after interleaving) is the updated extrinsic information \( [e_{\text{DEC}}(x_K(j))] \). This procedure is repeated a number of times until a hard decision \( \{d'_K\} \) on the information bits \( \{d_K\} \). The output of elementary signal estimator is defined by the logarithm likelihood ratio (LLR).

\[
P(r_l / x_K(j) = +1, h) = e(x_K(j)) = \log[P(r_l / x_K(j) = -1, h)] \quad \text{for all } k, j \quad (2)
\]

CBC ALGORITHM USED IN MUD

Step 1:- First of all set \( [e_{\text{DEC}}(x_K(j))] = 0 \), for all \( K, j \).

Step 2:- Estimation of the mean and variance of the transmitted signal \( x_K \).

\[
E(x_K(j)) = \text{tanh}(e_{\text{DEC}}(x_K(j)))/2, \quad \text{for all } K, j \quad (3)
\]

\[
\text{Var}(x_K(j)) = 1 - (E(x_K(j)))^2, \quad \text{for all } K, j \quad (4)
\]

Where, \( E(\cdot) \) and \( \text{Var}(\cdot) \) shows the mean and the variance respectively.
Step 3:- Estimation of the mean and variance of the received signal.

\[ E(r(j)) = \sum h_k E(x_k(j)) \text{, for all } j \]  
\[ \text{Var}(r(j)) = \sum |h_k|^2 \text{Var}(x_k(j)) + \sigma^2 \text{, for all } j \]  

Step 4:- Generation of LLR-

\[ E_{\text{ESE}}(x_k(j)) = 2h_k \frac{R(j)-E(r(j))+h_k E(x_k(j))}{\text{Var}(r(j)) - |h_k|^2 \text{Var}(x_k(j))} \]  

3. CODING TECHNIQUES

Zigzag coding- In coding theory, the zigzag code comes under the family of linear error correcting code. These codes are introduced by Ping, Huang & Phamdo (2001). These codes partition the input data into segments of fixed size, and adding sequence of check bits to the data, where each check bit is the exclusive or of the bits in a single segment and of the previous check bit in the sequence. The code rate is high: \( J/(J + 1) \) where \( J \) is the number of bits per segment[12]. Its worst-case ability to correct transmission errors is very limited: in the worst case it can only detect a single bit error and cannot correct any errors. However, it works better in the soft-decision model of decoding: its regular structure allows the task of finding a maximum-likelihood decoding or an a posteriori probability decoding to be performed in constant time per input bit.

Receiver Diversity In IDMA Scheme

Receiver diversity is used to have the optimum value of signal to noise ratio SNIR. In this technique the diversity branches are weighted for maximum SNIR. The block diagram of the receiver diversity is shown in the figure given below.

![Receiver Diversity Block Diagram](image)

Fig 2 Receiver diversity in the receiver section of IDMA

The receiver diversity is shown in the figure 2[1]. Here \( d_k \) is the input data sequence for the \( k^{th} \) user. The input data is firstly applied to the forward error correcting code FEC and then output of the encoder is passed through the spreader where each user has assigned a common signature sequences \( S_k \) having length \( S \). The spreader for the users spreads a coded bit to a chip sequence (i.e. transmit either \( S_k \) or \( -S_k \) to represent one bit). The spreading operation expands the bandwidth.

The spreading operation expands the bandwidth.

1 transmit and 2 receive antenna are used in the case of receiver diversity, then channel coefficient between transmit antenna and the first received antenna is \( h_0 \) and between the transmit antenna and second receive antenna is denoted by \( h_1 \). The channel can be modelled having magnitude and phase response [13].

\[ h_0 = a_0 e^{j \theta_0} \]  
\[ h_1 = a_1 e^{j \theta_1} \]  

Noise can be added at both the receiver. The resulting received signals are

\[ R_0 = h_0 x_k + n_0 \]  
\[ R_1 = h_1 x_k + n_1 \]  

Where, \( n_0 \) and \( n_1 \) represents the noise and interference at both the receiver separately.

Now the Receiver combining scheme for two branches MRRC can be written as

\[ X_k = h_0 R_0 + h_1 R_1 \]  

Now this output of maximal ratio receiver combiner can fed to the detector for the proper estimation of transmitted signal \( x_k \).

4. RESULTS AND PERFORMANCE ANALYSIS
Figure 3 depicts bit error rate of the Zigzag coded IDMA without receiver diversity. In Fig. 4, data length taken is 128 bits with 150 bits as block length and 8 as spread length. Iterations used for turbo processing is taken to be 13.

Figure 4 depicts bit error rate of the Zigzag coded IDMA with receiver diversity. In Fig. 4, data length taken is 128 bits with 150 block length and 8 as spread length. Iterations used for turbo processing is taken to be 13.

Figure 4 depicts bit error rate of the Zigzag coded IDMA with receiver diversity. In Fig. 4, data length taken is 128 bits with 150 block length and 8 as spread length. Iterations used for turbo processing is taken to be 13.

Figure 4 Performance analysis of zigzag coded IDMA with receiver diversity

Figure 5 depicts bit error rate of the Convolutional coded IDMA without receiver diversity. In Fig. 5, data length taken is 128 bits with 150 blocks and 8 as spread length. Iterations used for turbo processing is taken to be 13.

Figure 5 Performance of a convolution coded IDMA system without Receiver diversity

Figure 6 depicts bit error rate of the Convolution coded IDMA with receiver diversity. In Fig. 6 data length taken is 128 bits with 150 block and 8 as spread length. Iterations used for turbo processing is taken to be 13.

Figure 6 Performance analysis of a convolution coded IDMA with receiver diversity

Figure 7 shows a Comparative analysis between the different techniques shown above. It shows that using diversity at the receiver side improves the performance of the system.

Figure 7 A comparative analysis between zigzag and convolution coded IDMA using BPSK signaling

5. CONCLUSION

From the above results we can conclude that the IDMA system using receiver diversity performs better than the simply coded system. Here for the analysis of the IDMA scheme parameter BER bit error rate is used. IDMA with suitable diversity technique can generate fruitful results in the area of wireless communication. We can also
conclude that convolution coded IDMA gives better results as compared to the zigzag coded IDMA. Since IDMA inherits all the merits of DS-CDMA in addition to its own advantages, existing CDMA systems may be enhanced by IDMA systems and study can also enhanced to Multiple input and multiple output (MIMO) antenna system to improve the diversity order and hence the performance of IDMA communication system.

REFERENCES
Books:

Journal Papers:


