Comparisons of BER for different users in CDMA multiuser detection system

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Abstract— In wireless communication system code division multiple access (CDMA) is the most popular and secures technology in multiuser detection (MUD). MUD is an approach which uses filters for the optimization. In this paper, different users with spreading PN sequence have been used to compare the bit error rate (BER) with corresponding signal to noise ratio (SNR).

Index Terms— PN sequence, MUD, SIC, CDMA, MAI, DS-CDMA, FH-CDMA

1 INTRODUCTION

Code Division Multiple Access is a digital cellular technology which is used in spread-spectrum techniques. It is digitizing in multiple conversations. CDMA is one of the multi user detection techniques [4]. Multiuser detection (joint detection) is a receiver design technology which detects required signals from interference and noisy environment. Single user receiver is facing many problems and suffering from the many communication trouble mostly near far problems, where a near or very strong signal source may be block the signal reception of far away or weak users. This near-far problem is more serious and critical in CDMA and other wireless multi user communication systems. So, multiuser detection techniques are used for receiver to solve this problem.

In the CDMA system all users are considered as other signals for each other, it means all signals treats each user separately as a signal with other users considered as noise or multiple access interference (MAI) [2,3]. All users interfere with all other users and the interferences add to cause performance of degradation. Single and multi user spread spectrum systems have similar type of transmitter and receiver. Which reduced interference and increases the capacity of the system it also overcomes the near-far problem.

In CDMA system each user signal is in parallel using a matched filter which contains a unique spreading code used by the user. This spreading code is unique for each user and same as in transmitter and receiver which provides high security for each user The spreading sequence with unique code is designed to be uncorrelated so that the interference from all other users are shown to be a non coherent interference.

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2 MULTIPLE ACCESS TECHNIQUES

In a communication system there are three types of multiple access techniques such are classified according to their domain and division which are used by their users. Frequency division multiple access (FDMA), Time division multiple access (TDMA), and Code division multiple access (CDMA). CDMA technique is again classified in several techniques such as direct sequence CDMA, frequency hopping CDMA [1].

In the Frequency domain multiple access technique (FDMA) all users are to be allotted same time slot but they have different frequencies for each users. In Time division multiple access technique (TDMA) all users share same frequency slot but they have different time slots which is to be allotted for each user. But in Code division multiple access Technique (CDMA) all of the users have same time slot and same frequency spectrums. So each user can transmit the signals at the same time slot and allocated the entire available frequency spectrum for transmission. Code division multiple access (CDMA) is one of d most useful method of multiplexing in wireless users. In this method all users are multiplexed by distinct or unique codes. These distinct and unique codes may be PN sequence, Walsh code, Gray code, Hammered code, Gold code etc. CDMA is also known as spread spectrum multiple access (SSMA) [1, 8].

In sub techniques of CDMA such as direct sequence code division multiple access (DS-CDMA) and frequency hopping code division multiple access (FH-CDMA), DS-CDMA is one of the most popular techniques of CDMA techniques. In the DS-CDMA transmitter each user's signal is multiplied by a distinct or unique code waveform. At the receiver the detector receives a signal which is to be composed of the sum of all users' signals, superimpose in time and frequency [1]. In the convolution DS-CDMA system each user's signal is detected by correlating the entire received signal with the user's unique code waveform which is used same as in transmitter [5].

Multiple access interference (MAI) is the most important factor in communication system which degrades the capacity and performance of DS-CDMA systems. MAI is the interference between direct sequence users. The MAI caused any one user is generally small, as the number if interferers or their power increases, it allows the single user detection strategy in

which each user is detected separately without considered the other users.

3 MULTI USER DETECTION TECHNIQUES FOR CDMA

3.1 Optimum Multiuser Detection

The optimum multi user detection used matched filter detector. The optimum solution maximizes the likelihood functions for K users by choosing the random bits {b1, b2, …, bK} that minimizes the mean square error (MSE) between the estimated received signal and the actual composite received signal, which is the sum of the received signals for all K users with additive white noise, which increases exponentially with the number of users. In addition to complexity, the optimum detector requires a priori knowledge of the amplitudes of all K users [7].

3.2 Linear Multiuser Detection:

Linear multiuser detectors are used to attain the better performance than optimal multi user detection. The capacity increases as the optimum detector while the complexity is reduced for this system such that it can be implemented [9]. They are simply as linear filters that attempt to suppress MAI. In these detectors, a linear transformation is applied to the soft outputs of the conventional detector to produce a better set of outputs to provide better performance. There are two most common and popular linear multiuser detectors are the decorrelating detector and the Minimum Mean Square Error (MMSE) detector. They are highly analogous to the zero-forcing and MMSE equalizers used to combat inter-symbol interference (ISI) in a single- user communication system.

3.3 Successive Interference Cancellation:

The Successive Interference Cancellation (SIC) detector is more beneficial and most popular technique than optimal multi user detector and linear multi user detector. It takes a serial approach to cancelling interference [1, 3]. Each stage of this detector such as decisions regenerates and cancel out one additional direct sequence user from the received signal. So all other remaining users have very less MAI for the next stage. The SIC detector requires only a minimal amount of additional hardware equipments and also has the potential to provide significant improvement over the conventional detectors.

4 BASIC CONCEPT OF CDMA SYSTEM

CDMA is a multiple access technique, in which several transmitters or users can send information simultaneously over a single communication channel. This allows all users to share a same band of frequencies, which permits it to be achieved without interference between the users. CDMA employs spread-spectrum technology and a special coding scheme in which each user have unique code which is same in transmitter and receiver.

There are N users in the system and the input data signals from all of these users are designated as

$$d1(t), d2(t), ..., dN(t) \quad (1)$$

The data symbols within the data signals are spread by multiplying with respective spreading sequences which may be a unique code such as PN sequence or may be other codes.

$$K1(t), K2(t), ..., KN(t) \quad (2)$$

The channel introduces delays (τ) to signals from deferent users, and the fading coefficients for the single path of each user.

After spreading the baseband signal of transmitter is given by

$$u_k(t)=\sum_{i=0}^{\infty} x_k(i)\, C_k(i) S_k(t-iT)T-\tau_k \quad (3)$$

where,

$x_k(i)$= is the ith input symbol of the kth user.

$C_k(i)$= is the real, positive channel gain.

$S_k(t)$= is the signature waveform containing the PN sequence.

τ= is the transmission delay; for synchronous CDMA,

τ= 0 for all users.

Received signal at baseband is given by-

$$Y(t)=\sum_{k-1}^{K} u_k(t)+n(t) \quad (4)$$

Where, K number of users n (t) is the complex AWGN Sampled output of the matched filter for the kth user.

This received signal is again dispread by same unique code which is to be used in transmitter. Then after demodulation process we get our output signal which is almost same as input signal. But some error occurs because of noise which present in channel. So we calculate the bit error rate (BER) for output signal. The bit error rate or bit error ratio (BER) is calculated by the number of bit errors divided by the total number of transferred bits during a particular time interval.

This is the basic concept of code division multiple access (CDMA) technique.

5 RELATION BETWEEN SNR AND BER FOR DIFFERENT USERS IN CDMA

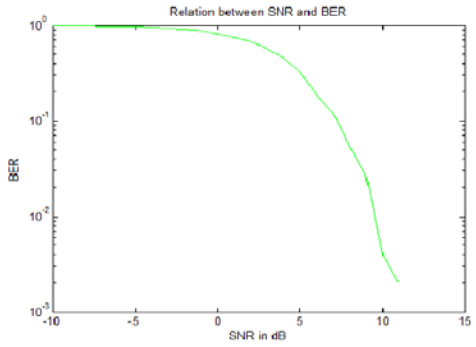
In this paper we take six users in CDMA system to provide the relation between SNR and BER. To find the relation between SNR and BER we use following steps.

At first we generate a input random data bits for different users. Then the unique PN- sequence of the each user is taken and then it is multiplied with the input data bits. When the input data bit is one then the PN-sequence is transmitted as it is and when the data bit is zero then the reverse of the PN-sequence is transmitted i.e. it inverts. After this, an additive white Gaussian noise (AWGN) is added to the channel to corrupt signal with noise. Then a threshold is applied to the received signal which compares the received signal to input signal i.e. if the signal is greater than the threshold value it is taken as 1 and if it is less than threshold value it is taken as 0. At receiver, again the summed received signal is multiplied with the same PN-sequence. Then the data bits are to be sent by the transmitter which is compared to the bits after threshold detection from this, the number of bits are obtained, that are corrupted by the noise. Then, the number of error bits is divided to the total number of output bits to get the bit error rate (BER) for the corresponding SNR (Signal-to-Noise Ratio). The graph of BER vs. SNR is plotted for six different users.

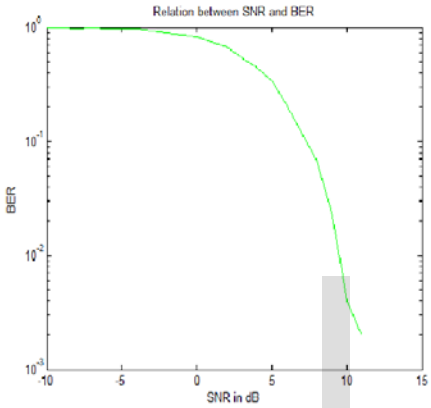
In the next section, i.e. simulation results, results from each user are shown in the figures. Relation between SNR and BER are shown for each user.

6 SIMULATION RESULTS

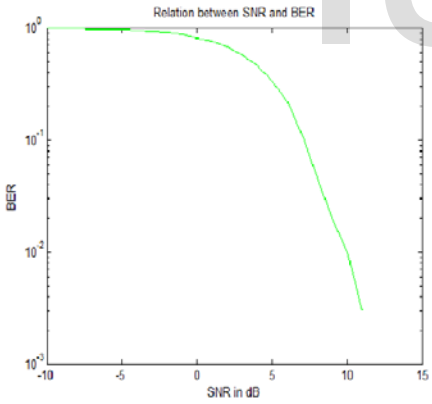
USER 1:



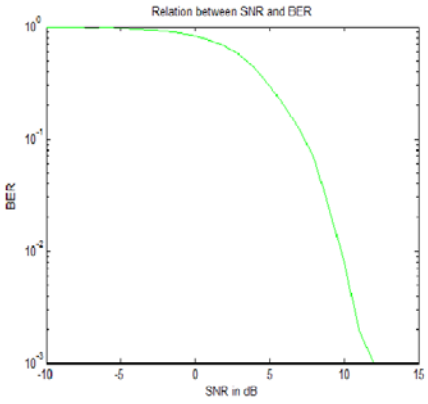
USER 2:



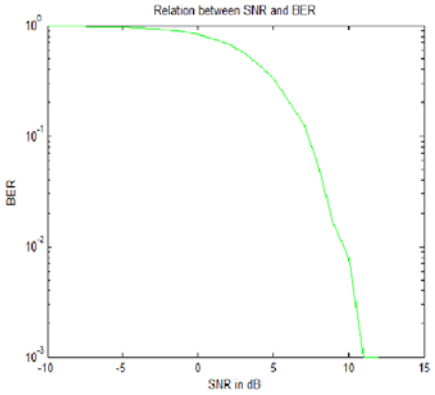
USER 3:



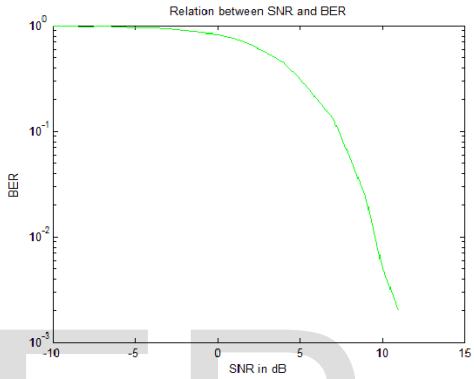
USER 4:



USER 5:



USER 6:



These are the graphical representations of the relation between the SNR and BER for six different users in CDMA system.

Further we can use many techniques to overcome the problem of interference which is normally occurred in the communication system.

CONCLUSIONS

There are various techniques for multiple access such as FDMA, TDMA and CDMA. As discussed earlier that, CDMA is more better and secure technique than others. It is a multi user detection technique which is to be used widely in communication system. A unique spreading code is used which is same in transmitter and receiver, so the error generates in received signal is much less than other techniques of wireless communication.

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