Performance Analysis of TD-CDMA 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. To get the better performance of system the combination of TDMA and CDMA that is Time Division Code Division Multiple Access (TD-CDMA) is used in the communication system. In this paper, different users with spreading walsh code have been used to compute the Signal to Noise Ratio (SNR).

Keywords
MUD, CDMA, MAI, SNR, BER

I. Introduction

CODE Division Multiple Access (CDMA) is a multiplexing technique in which different number of users are separated in the code domain while sharing the same time and the same frequency band [1]. It is a digital cellular technology which is used in spread-spectrum techniques. It is digitizing in multiple conversations. Multiuser Detection (MUD) is also called joint detection technique is a receiver design technology which detects required signals from interference and noisy environment [8]. There are several techniques of multiuser detection such as frequency Domain Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA). In FDMA all users are allotted at same time slot but at different frequency band. While in TDMA all users are allotted at same frequency band but they have different time slots. Where as in CDMA all users are allotted at same time slot and same frequency but the difference is that all users have a unique code which is same in transmitter and receiver for each user. Because of this CDMA is a most popular and secure technique than other multiple access techniques such as FDMA and TDMA [1-2].

In time division CDMA (TD-CDMA) which is a radio access scheme based on a combination of both TDMA and CDMA multiuser detection scheme. Due to these small arriving time differences among different user signals, a TD-CDMA system can be regarded as a quasi-synchronous CDMA system in the up-link.

In wireless multiuser communication system, near-far problem is more serious and critical. So, multiuser detection techniques help the receiver to solve this problem. In CDMA system all other signals are considered as a noise and interference signal for each other signals. Single and multi user detection systems have similar type of transmitter and receiver which increases the capacity of the system and reduces interference of the signal. It also overcomes the near-far problem of communication system.

In TD-CDMA multiuser detection system each signal has unique spreading code which is same as in transmitter and receiver. In this paper we use walsh code as spreading sequence.

II. System Model

In the Time Division –Code Division Multiple Access (TD-CDMA) system a specific code is used in transmitter and receiver. In this paper Walsh code is used as a spreading code. At first a random data input sequence is generated for K users. A Walsh code is generated for for each user [1],[4]. Walsh code is in the form of a square matrix in which last element is reversing than all other element. We assume that each user have same spreading factor. The input data stream is further modulated by QPSK modulation. The modulated sequence is spreaded by walsh code.

We assume that there are K users simultaneously active. The input data for the N data symbols for user k in a data block as a vector is represented as

$$d^{(k)} = [\, d_1^{(k)}\ d_2^{(k)} \ldots\ldots d_N^{(k)}]^T \quad (1)$$

The spreading code sequence for K users is represented as

$$c^{(k)} = [c_1^{(k)}\ c_2^{(k)} \ldots\ldots c_Q^{(k)}] \quad (2)$$

where Q is the length of spreading code sequence.

The block-diagonal spreading matrix $C^{(k)}$ corresponding to the kth code is represented as

$$C^{(k)} = I_N \otimes c^{(k)} \quad (3)$$

where I_N is the unitary square matrix of size NxN and $\otimes$ the Kronecker product. So the block diagonal matrix is represented by

$$C^{(k)} = \begin{bmatrix} c^{(k)} & & \\ & c^{(k)} & \\ & & c^{(k)} \end{bmatrix} \quad (4)$$

The input data spreading sequence is then transmitted to the receiver through the channel. The additive white Gaussian noise (AWGN) with zero mean and variance σ^2 is added to the input spreading sequence. The channel can be estimated at the base station with the aid of a mid-amble. The channel has a channel impulse response (CIR) which affects the spreading sequence. The CIR of TD-CDMA codes for k users on receive antenna is given by

$$h^{(k)} = [\, h_1^{(k)}\ h_2^{(k)} \ldots\ldots h_N^{(k)}] \quad (5)$$

The system matrix is obtained by the linear convolution of input data sequence and channel impulse response (CIR). The output system matrix can be represented by

$$H^{(k,m)} = \begin{bmatrix} h1^{(k,m)} & & & \\ h2^{(k,m)} & h1^{(k,m)} & \ddots & \\ \vdots & h2^{(k,m)} & \ddots & h1^{(k,m)} \\ hW^{(k,m)} & \vdots & \vdots & h2^{(k,m)} \\ & hW^{(k,m)} & \ddots & \vdots \\ & & & hW^{(k,m)} \end{bmatrix} \quad (6)$$

The signal which will be transmitted is obtained by the multiplying the system matrix sequence to the data input sequence and channel impulse response sequence. When the output signal is transmitted to the receiver through the channel a additive white gaussian noise (AWGN) is added to the output sequence. So the received signal is represented by

$$x^{(m)} = \sum_{k=1}^{K} H^{(k,m)} \cdot C^{(k)} \cdot d^{(k)} + n^{(m)} \quad (7)$$

if

$$B^{(k,m)} = H^{(k,m)} \cdot C^{(k)} \quad (8)$$

Then the received signal is represented by

$$B^{(k,m)} = H^{(k,m)} \cdot C^{(k)} \quad (9)$$

where $x^{(m)}$ is the received signal which will be received on receiver.

Further on receiver same inverse process is applied to the received signal. At first the received signal is despreaded by the same walsh code which used in the transmitter. This despreaded signal is demodulated by using QPSK demodulation. After this all process we get the output signal which is approximately equal to the input signal.

The input and output signal is not perfectly same and equal because of noise and interferences which is known as Multiple Access Interference (MAI). There is some error present in the output signal. To overcome the problem of this Multiple Access Interference (MAI) we use the matched filter and minimum mean square error- zero forcing algorithm (MMSE-ZF).

III. Simulation Results

In the Time Division-Code Division Multiple Access (TD-CDMA) communication system walsh code is used as a spreading spectrum same as in transmitter and receiver which gives the high security in communication system.

The output signal is not perfectly matched as input signal at receiver end because of some noise and interferences which is called Multiple Access Interference (MAI) so some errors are generated due to this noise. The signal to noise ratio (SNR) is calculated of the received signal to noise signal. To determine the errors of this signal we calculate the Bit Error Rate (BER). 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).

In a wireless communication system the performance of a signal is determined by the signal to noise ratio. If the signal to noise ratio is in the range of 12dB-25dB, approximately, then received signal is perfect for communication.

In this paper we have calculated the Signal to Noise Ratio (SNR) is approximately 13.98 dB.

According to this SNR value we calculate the Bit Error Rate (BER) for this received signal to check the performance of the TD-CDMA system.

The simulated data which shows the relation between SNR and BER is given in Table 1.

Table 1: Relation Between Snr and Ber of Td-Cdma System

SNR	BER
0 db	0.0769
1 db	0.1538
2 db	0.2302
3 db	0.3077
4 db	0.3846
5 db	0.4615
6 db	0.5385
7 db	0.6151
8 db	0.6923
9 db	0.8462
10 db	0.9231

According to this table the simulation results of TD-CDMA system is plotted on the graph which shows the relation between SNR and BER.

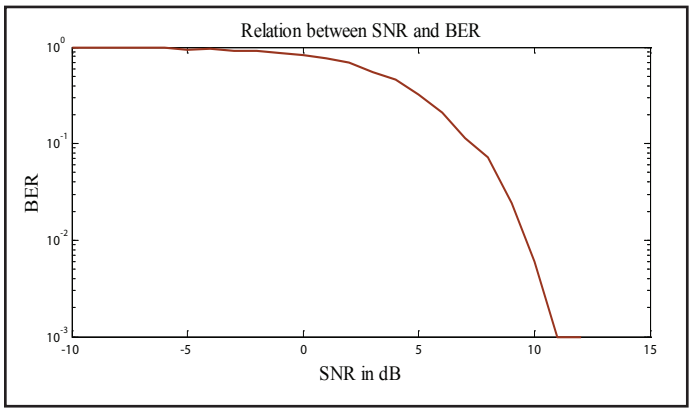

Fig. 1: Relation Between SNR and BER in TD-CDMA System

IV. Conclusion

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 multiuser detection system. To get better performance of wireless communication system we use TD-CDMA multi user detection system. The performance of output signal is described by the Signal to Noise Ratio (SNR) and Bit Error Rate (BER). In the TD-CDMA the SNR in dB of signal is better than signals of other multiple access techniques.

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