Research Paper Engineering

Implementation and Analysis of CDMA based MIMO System Using ZF and MMSE for MUD

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ABSTRACT

Future wireless communication system requires high channel capacity and error free detection. Main problem with higher channel capacity is ISI (inter symbol interference). The use of CDMA (Code Division Multiple Access) provides better solution to ISI problem. Multi-user Detection (MUD) is the intelligent estimation of transmitted bits in the presence of Multiple Access Interference (MAI). Implementation of MIMO based MUD detection in large scattering environment to achieve the goal of error free communication. Receivers proposed for above system has based on knowledge that channel static information is available at receiver. The proof of the statement is explored by comparing and analyzing MATLAB Simulated results with different no of users and varying detection algorithms such as ZF (Zero Forcing) and MMSE (Minimum Mean Square Error) by exporting MIMO technique. We compare result for AWGN (Additive white Gaussian Noise) channel.BER is measure of performance in this following research document.

Keywords :- : CDMA, MUD, MAI, MIMO, ISI, MMSE, ZF.,

I. INTRODUCTION

For high data rate wireless communications, Code Division Multiple Access (CDMA) system is one of the most promising technologies due to its high spectral capacity, robustness, frequency selective fading and low computational complexity. CDMA can be used with Multi Input Multi Output (MIMO) transceiver to increase the diversity gain and the system efficiency by exploiting spatial domain. MIMO-CDMA is considered a key technology in emerging high-data rate systems such as 4G because the CDMA system effectively provides numerous parallel channels [4].

MIMO communication uses multiple antennas at both the transmitter and receiver to exploit the spatial domain for spatial multiplexing and spatial diversity. In this paper MIMO CDMA is analyzed for PN Code and modulated with QPSK. The analysis and simulation of the MIMO CDMA system to reduce ISI and frequency selective fading is considered in two stages. The first stage involves the implementation of a system architecture model with vertical encoding, CDMA modulation demodulation. The second stage compares the SNR performance of the system for Multi user by varying various modulation techniques [3].

II. SYSTEM ARCHITECTURE

A. Code Division Multiple Access System

In order to solve channel capacity problem ,a Code Division Multiple Access (CDMA) system, several users transmit their signals simultaneously over a common channel. The receiver has knowledge of the codes of all the users. It is then required to demodulate the information symbol sequences of these users, upon reception of the sum of transmitted signals of all the users in the presence of additive noise. Conventional CDMA detectors such as matched filter and RAKE combiner are optimized for detecting the signal of a single desired user. These conventional detectors are inefficient, because the interference is treated as noise and there is no utilization of the available knowledge of spreading sequences of the interferers. The efficiency of these detectors is dependent on the cross correlation between the spreading codes of all users[5].

One approach is to employ a suitable linear transformation on the matched filter outputs. Belonging to this family are the decorrelating receiver and Minimum Mean Square Error (MMSE) detector. In these methods, the different users are made uncorrelated by a linear transformation. This linear transformation is computed by measuring all cross correlations between pairs of user codes and then inverting the resulting huge matrix of cross-correlations. Since in practical systems each user is assigned a very long pseudo noise (PN) code, each bit has essentially a random code assigned to it. Thus, in this case, the above procedure would have to be repeated for each bit in succession.

Interference Cancellation (IC) schemes contribute another variant of multi-user detection and they can be broadly divided into two categories: successive cancellation and parallel cancellation. Interference cancellation should be interpreted to mean the class of techniques that demodulate and/or decode desired information, and then use this information along with channel estimates to cancel received interference from the received signal. Lower computation and hardware related structures are the main advantages of these methods beside the main advantage of lower BER or better capacity than linear multi-user detectors. The approach successively cancels strongest users by re-encoding the decoded bits and after making an estimate of the channel, the interfering signal is recreated at the receiver and subtracted from the received waveform. In this manner successive user does not have to encounter MAI caused by initial users. One disadvantage of this scheme is the fact that a specific geometric power distribution must be assigned to the users in order that each see the same signal power to the background plus interference noise ratio. Another disadvantage of this scheme has to do with the required delay necessary to fully accomplish the IC for all the users in the system. Since the IC proceeds serially, a delay on the order of M computation stages is required to complete the job. This delay becomes intolerable for large number of users and SIC method looses its advantage.

Parallel processing of multi-user interference simultaneously removes from each user the interference produced by the remaining users accessing the channel. In this way, each user in the system receives equal treatment insofar as the attempt is made to cancel multiple user interference. As compared with the serial processing scheme, since the IC is performed in parallel for all the users, the delay required to complete the operation is at most a few bit times. Variance and Abashing proposed a multistage detector for an asynchronous system, where the outputs from a matched filter bank were fed into a detector that performed MAI cancellation using a multistage algorithm. At each stage in the detector, the estimates of all other users from the previous stage were used for reconstructing an estimate of the MAI and this estimate was then subtracted from the interfered signal representing the wanted bit. The computational complexity of this detector was linear with respect to number of users and delay introduced was much less than serial method[1].

B. Multiple-Input Multiple-Output System Model

We consider a MIMO wireless communication system employing *M* transmit and *N* receive antennas; hence, the corresponding MIMO wireless communication channel is constituted by (N* M) propagation links. In CDMA, entire Channel is coded with PN code, which is spaced to each other such that no ISI is present. Using CDMA, the MIMO detection over frequency selective channels is transformed into MIMO detection. Therefore we focus on MIMO detection algorithms. We assume that channel matrix H is to be known for receiver only. Theoretical analysis predicts that substantial capacity gains are achievable in communication systems employing MIMO architectures. Additionally, the employment of MIMO architectures allows for efficient exploitation of the spatial diversity available in wireless MIMO environments, thus improving the system's BER, as well as further increasing the system's capacity [4].

III System Model

The system works in an indoor environment. The proposed system is a single-CDMA stream scheme capable to handle rates ranging adaptively from 64 kbps to 100 Mbps after variable-rate adaptive modulation is implemented, according to the sub-carrier SNR and target BER.

The MIMO CDMA system operates in the 17 GHz unlicensed frequency band with an available bandwidth of 200 MHz (17.1–17.3 GHz) that is divided into four 50 MHz-width channels not simultaneously selectable. CDMA with Ck(t)= 64 code is designed for each of these 50 MHz wide channels. The indoor coverage ranges from 5m for non line-of-sight to 20 m for line-of sight (LOS).

A. Transmitter

In figure I shown below is Model of Simple CDMA MIMO Transmitters. Here Data Bits from individual's users are first spreaded using their spreading code. After that each user's spreaded data is modulated using any convention modulation techniques. Vertical encoding is part of MIMO techniques here modulated signal is divided into a number of transmit antennas. After vertical encoding all users signals is sent into Rayleigh channel and addition of AWGN (additive white Gaussian noise) noise is also considered[5].

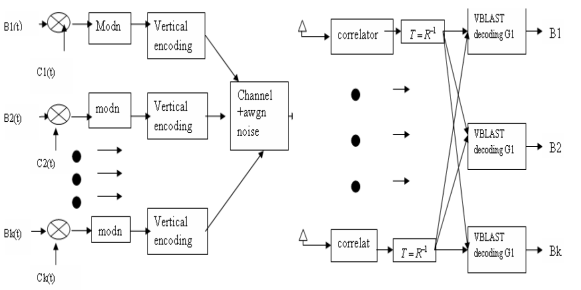

Figure I CDMA-MIMO Transmitter- Receiver

B. Receiver

Once we received the signal after the channel, first remove the cyclic extension. Each receive antennas receives data from every transmit antennas. The correlator is optional. It is used for correlation for individual users. Then the signal is passed form any operator ZF or MMSE. After Transformation of ZF signal is processed by decoding algorithms, it operates on channel matrix and all the steps of processing are performed to detect individual user signal.

V. Performance Analysis

A MIMO CDMA architecture that significantly increases the achievable bit rate of the system as well as decreases the Co-channel Interference has been studied and analyzed.

The conditions under which this CDMA MIMO model is presented are :

- Modulation techniques are used for the information signal.
- The length of the spreading code is 8.
- Each information/data bit has a period of T.
- Each chip has a period of T_C.
- The pulse shape is rectangular and has amplitude of 1± for the information signal.
- The pulse shape for each chip of the spreading code is also rectangular, having amplitude of.
- All the users are transmitting at the same bit rate.
- The system operates in single cell environment.

The parameters are

- Modulation Techniques
  - o QPSK
- Number of Users
  - o 2-Users
  - o 4-Users
  - o 8-Users
  - o 16-Users
- Types of Pseudo-Random Code
  - o PN codes

Simulation results are shown the effectiveness of the considered System. We analyzed SNR performance of QPSK based on CDMA- MIMO systems for different users with same transmitted power using PN code for ZF and MMSE. SNR Performance is showed in Figure II and III for QPSK(ZF) and QPSK (MMSE) respectively. As can be seen, increasing number of user, bit error rate goes down and increase performance. Another interesting note is the fact that for ZF, the BER seem to go down very far compare to MMSE, despite a high SNR. This is because for higher order QPSK systems, there must be some channel inversion at the receiver to allow for proper decoding. This unfortunately amplifies the noise as well as the signal.

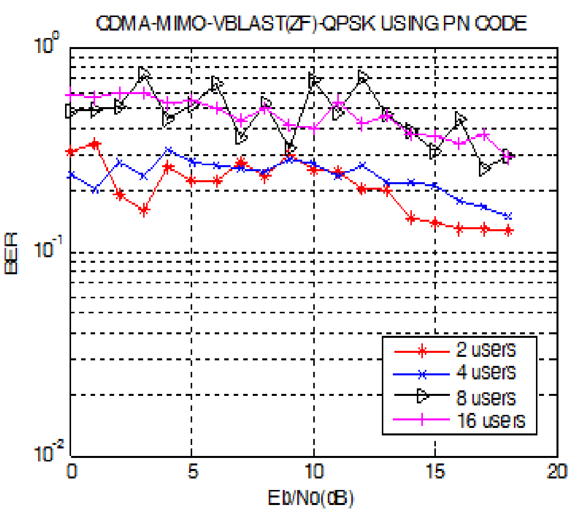

Figure II CDMA –MIMO System Performance Comparison for MUD for QPSK using PN Coder (for)ZF

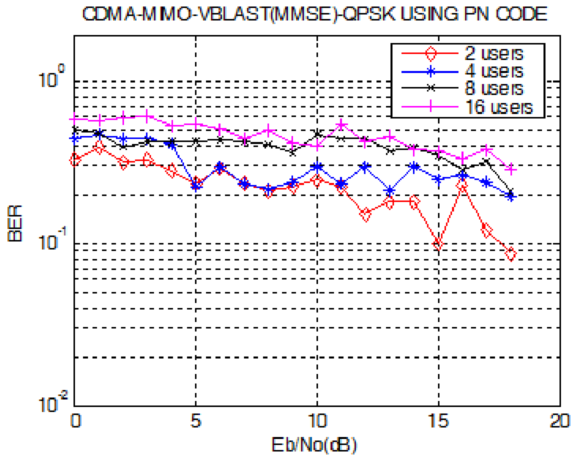

Figure III CDMA –MIMO System Performance Comparison for MUD for QPSK using PN Coder (for MMSE)

As can be seen, for QPSK bit error rate is nearly higher as number of user increased.

CONCLUSION

In this paper, Two linear multi-user detection techniques ZF (Zero forcing) and MMSE (Minimum Mean Square Error) have been implemented in Matlab 7.0 CDMA based system,

From the simulation results of BER vs Eb/No for varying users from 1 to 64 we have seen that the Performance of the MMSE algorithm is better than ZF algorithm because of desired symbols, MAI and noise terms are de-correlated by a wiener estimator.

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