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A review of various BER reduction techniques in MIMO-CDMA system

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Abstract— **CDMA with MIMO is very good technique beyond 3G and 4G wireless communications. CDMA with MIMO systems give large capacitive gains and good spatial diversity. Spatial diversity and spatial multiplexing are two main aspects to be taken into consideration while designing communication system. STBC block codes can be used to obtain the spatial diversity between the symbols. Space time block coding (STBC) is the most efficient method because it provides full spatial diversity and simple linear decoder. If STBC and Direct-Sequence Code-Division Multiple Access (CDMA) are combined, the performance of multiple users in a cellular network is increased. The BER performance of MIMO-CDMA system depends on its spreading strategy also. System performance can be further increased by adding coding techniques. Forward Error Correction codes can be used to that minimizes the error probability in decoding by adding the redundant bits systematically. Here review of different techniques reducing BER is presented for CDMA MIMO system.**

Keywords— **CDMA, MIMO, STBC, BER, spatial diversity, spatial multiplexing**

I. INTRODUCTION

In non-line-of-sight communication link, there are obstacles such as vehicles, trees, buildings and hills between the transmitting station and the receiving station, completely obscuring the line of sight. Even in such environments, multiple paths do exist between transmitter and receiver via a combination of reflection, diffraction and penetration. These "multi-paths" have different characteristics and are of different lengths.

Because of all these, arriving signals will have varying amplitudes and will disperse over time, and so will cause self-interference. The environment changes due to movement of obstacles such as trees or vehicles, or even changes in air pressure or ambient temperature, the nature of each path dynamically changes making situation worse. Quality of the received signal varies unpredictably because of this fading effect.

Multiple-input multiple-output (MIMO) is the use of multiple antennas at both the transmitter and receiver to improve communication performance.

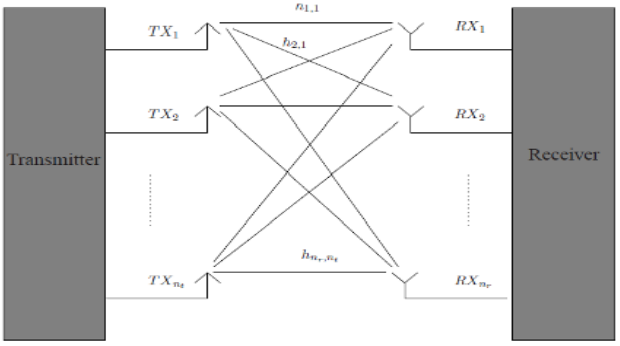

Fig. 1 MIMO model with Nt transmit antennas and Nr receive antennas

$$y = H*s + n \quad (1)$$

It is one of several forms of smart antenna technology and also promising technology for next generation wireless systems to enhance capacity and robustness of the link. MIMO provides spatial diversity which improves system performance in terms of error and spatial multiplexing which improves system capacity in terms of data rate.

The advantage is that the odds of receiving the data are massively increased. Basically, if any one path is faded, there is a high probability that the other paths are not, so the signal still gets through. The occurrence of a particular level of fade might be represented by the chance of 1 in 30 or one day in a month. When there are four separate independent paths, the probability of the same amount of fade is represented by 1 in 30^4 or 1 in 100,000 or a few minutes per year.

Code Division Multiple Access (CDMA) is a channel access method used by various radio communication technologies. CDMA is an example of multiple access, in which several transmitters can send information simultaneously

over a single communication channel.

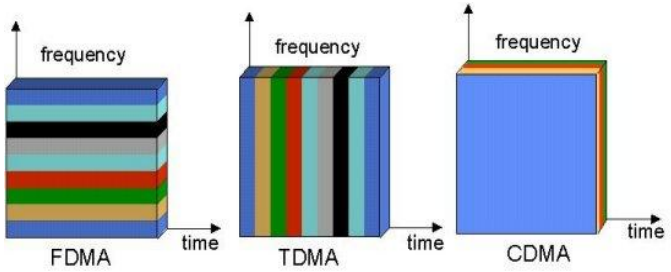

Fig 2 FDMA, TDMA and CDMA

This allows several users to share a band of frequencies. To permit this without undue interference between the users, CDMA employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code) [1]. There are several advantages of CDMA over GSM for example; it allows each user to transmit over the entire frequency spectrum all the time, security and call quality is batter comparatively. CDMA gives less radiation exposure. So CDMA is better to use in new generation wireless technology.

The performance of MIMO-CDMA with comparison to conventional code division multiple access (CDMA) system has been analysed in[2].

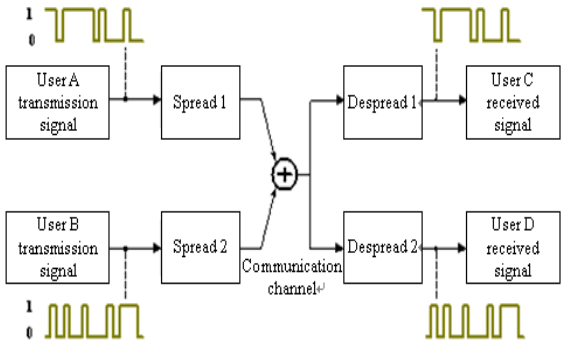

Fig 3 MIMO CDMA model

The simulations models are simulated with different number of antenna which are two transmit-two receive (2Tx2Rx) and four transmit-four receive (4Tx4Rx). The simulation results shows that the BER performance of MIMO-CDMA with 2 transmit and 2 receive antennas is improved by 43% and improved by 63% it 4 transmit and 4 received antennas are used compared to conventional CDMA. Capacity of MIMO-CDMA with 2 transmit and 2 receive antennas is improved by 50% and improved by 75% it 4 transmit and four receive antennas are used compared to conventional CDMA [2].

Further techniques should be used at transmitter and/or receiver to reduce error and improve system performance. In this paper, different techniques proposed in different papers are reviewed for CDMA-MIMO system.

II. RELATED WORK

Recently, there are a large number of research papers on use of multiple input multiple output (MIMO) in CDMA transmission to reduce multipath fading and provide spatial diversity. Among them, space time spreading (STS) and space time block coding (STBC) are the most efficient method because it provides full spatial diversity and simple linear decoder. If space–time block coding (STBC) and direct-sequence code-division multiple access (DS-CDMA) are combined, the performance of multiple users in a cellular network is increased.

Many research papers propose different ways to increase system performance by reducing BER.

This paper includes review of following different techniques which are used in different papers

- FEC codes
- Different spreading strategies

A. FEC codes

Error will be introduced in data when high-speed binary data is transmitted over a communication link via twisted-pair wires, coaxial cable, fiber optic cable, magnetic tape or radio/air link. Incorrect data is received because these errors produce changes in the data's binary bit pattern caused by interference, fading, distortions, noise, or equipment malfunctions. The number of bit errors that occur for a given number of bits transmitted is referred to as the bit error rate (BER). Channel coding techniques can be used to reduce BER. Channel coding technique involves error detection and correction in which extra bits (redundant bits) are added to the message data characters at the

transmitter to permit error detection or correction at the receiver

Error Detection and Error Correction Codes are majorly categorized as follows:

1) Error Detection Codes:

- Parity Check codes.
- ARC: Arithmetic Redundancy Check codes.
- Cyclic Redundancy Check codes.

2) Block Error Correction Codes:

- Hamming linear block error correcting codes.
- BCH (Bose-Chaudhuri-Hocquenghem) cyclic block codes.
- Reed-Solomon cyclic block codes.
- Turbo Product Codes (TCP).

3) Convolutional Error Correction Code:

- Tradition, Viterbi Decoding.
- Turbo Convolutional Code (TCC).
- Low Density Parity Check Code.

4) Concatenated Error Correction Codes: Inner/Outer codes.

- A.Reed-Solomon Error Correction Codes/ Viterbi algorithm

These FEC codes can be applied to communication system in order to improve the system performance.

In [3], the performance of BCH correcting code is evaluated. Its performance is compared with Convolutional encoding. The system shows a consistent improvement in BER performance when add BCH coding on AWGN channel of OFDM. 16 QAM modulation scheme is used.

In [4], performance of Reed Solomon-Convolution Code (RS-CC), Convolutional Turbo Code (CTC) and Low Density Parity Check code (LDPC) FEC codes are compared for MIMO-OFDM system. Channels used are Additive White Gaussian Noise (AWGN) and Rayleigh fading channel. It is shown that CTC give a coding gain of 0.2dB and 0.25dB than its rival LDPC in AWGN and Rayleigh fading channel respectively. Here processing time is also compared for RSCC, CTC and LDPC and it is shown that CTC gives the best BER performance but is highly complex than LDPC and RS-CC. So, CTC is better if BER reduction is more concerned. Else if system complexity and processing time is more concerned, LDPC is better.

Performance of MIMO-MC-CDMA system with 2 transmit and 3 receive antennas is estimated in [5]. MC-CDMA (Multi Carrier Code Division for Multiple Access) is a multi-user and multiple access system which is formed by the combination of OFDM and CDMA. Convolution encoding scheme is used in encoder of CDMA as FEC code to reduce BER (Bit Error Rate). System is examined for 8-PSK, 16-QAM, QPSK, 32-QAM, 8-QAM and 64-QAM modulation techniques. Rayleigh fading channel is used. It is shown that BER performance is improved in QPSK modulation compared to other modulation techniques in 2*3 MIMO MC CMDA system.

B. Spreading strategies

Parity bit selected spreading sequences are introduced initially in [6] to improve bit error rate performance of MIMO-CDMA system. In a MIMO-CDMA system with permutation spreading, different spreading waveforms are selected from a set of mutually orthogonal spreading sequences for each transmit antenna instead of assigning one spreading sequence to all transmit antennas.

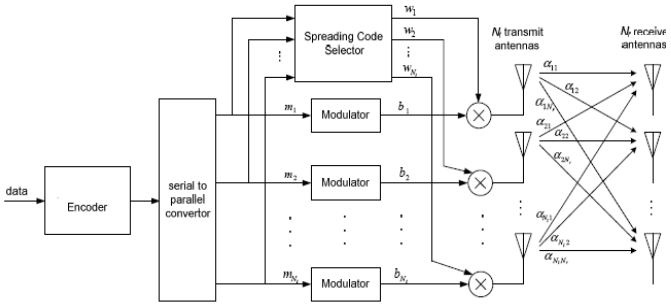

Fig. 4 MIMO-CDMA system with permutation spreading

Each block of information bits assigns a different permutation of spreading waveforms to transmit antennas [7].

In [8], soft output detector is proposed for a convolutionally encoded MIMO-CDMA system employing permutation spreading. Here considerable improvement in the performance of the system in terms of bit error rate (BER) is

achieved using soft variables as the input to an outer soft input decoder.

In [9], T-designs spreading permutations scheme was introduced later. Performance improvement in BER is obtained compared to previous block coding approach. But additional complexity is introduced

A new design method to find the permutation spreading table for SC MIMO-CDMA systems is proposed in [10]. That offers improvements in the BER performance without increasing the system complexity compared to the SC MIMO-CDMA system employing permutation spreading.

III. CONCLUSION

Because of non line of sight challenges in communication link, errors are introduced in transmitted data and so it is necessary to design techniques those can combat this fading effects. MIMO is very good technology for this because it provides spatial diversity which takes advantage of multipath propagation of signal and gives better performance. CDMA is better multiple access technology compared to others because of its so many advantages compared to other multiple access technology. So combination of CDMA and MIMO can give better communication system. Further improvements in BER performance of system can be obtained by adding different FEC codes, using different spreading strategies. Various papers proposing different BER reduction techniques are reviewed here.

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