Performance Improvement of MIMO System Using OSTBC

Roopa M, B. N. Shobha

Abstract: ***In this modern communication it is very difficult to fulfill the user requirements of increase in data rate within the required band limit and transmitted power, this is the major challenge faced by the modern wireless communication. This problem is caused by the impairments like inter symbol interference (ISI), co-channel interference (CCI) and noise. This problem can be overcome by using the technology called Multiple input multiple output (MIMO). MIMO technology uses the diversity technique so that it achieves the desired reliability of available band limit of frequency spectrum with high data rate by mitigating the interference, multipath effects and signal scattering. In this paper Different space-time block coding (STBC) schemes including Alamouti's STBC for 2 transmit antennas as well as orthogonal STBC for 2 and 4 transmit antennas are explored to mitigate the CCI and maximum likelihood(ML) equalizer to mitigate ISI. Finally, using these techniques BER performance of the MIMO system using alamouti and OSTBC are implemented in MATLAB and analyzed for using BPSK under Rayleigh fading channel.***

Index Terms**:** ***CCI, ISI, MIMO, ML, STBC.***

I. Introduction

The introduction of the wireless technology has made it possible to transfer the data at very high speed with high quality. The very big challenge for communication system is to achieve high quality data at very high data rate. This problem can be minimized by applying MIMO technology. Unlike wired communication, in wireless communication, the signal reach the receiver end from multiple path and hence leads to the inter symbol interference. This inter symbol interference increases the bit error rate.

One way of effective utilization of the communication system is by making use of the frequency reuse technique, but the major drawback in this type of sharing is it does not take into account of the serviceability of the channel i.e. it leads to co-channel interference. This may occur because of two or more base stations sharing the same frequency which has a relative proximity with each other .though the designer carefully takes care to reduce the channel interferences but they fail to completely eliminate this problem of interference which in some cases becomes a dominant factor to determine the efficiency of the wireless communication system .Usually the channel can be used to provide service if its signal to noise ratio is above the threshold value on the other way we say a signal is interference limited if its co-channel interference dominates the channel noise.

Other most common type of error in a communication system is the inter symbol interferences where two or more samples or pulses overlap with each other causing a noise in the channel this is mainly caused by overlapping time periods or multipath propagation and the frequency varying non uniformly in the channel. For a wireless communication system to be efficient the noise across the channel has to be completely eliminated which in turn implies the inter symbol interferences has to be completely eliminated or minimized to the order of almost zero.

The efficiency of a wireless communication system lies in use of multiple antennas to provide a wide variety of gain increase the dependability. One of the way to achieve this is by using multiple antennas both the transmitter end as well as the receiving end which is also called a MIMO system (Multiple Input Multiple Output).

II. Literature Review

Srujana Karri, et al.[1] in their work they proposed a analyze the achievement of BER in MIMO-WiMAX system using STBC and OSTBC. With increase the demand of high data rates in recent mobile radio technology, MIMO WiMAX system is used for long distance data transmission and increase system performance as well as data rate. This MIMO-WIMAX process can be simulated by using MATLAB. This achievement can be accomplished by using Alamouti, MRC and orthogonal-Space Time Block Code(OSTBC) for different modulation schemes(QPSK, BPSK, PSK, 16-QAM) under different channel circumstances like AWGN and Rayleigh for various diversity schemes alike Alamouti(2×1), MRC(1×2), OSTBC (2×2) and OSTBC(4×1).

Ujjwal, et al.[2] in their work proposed a Multi-Channel Optimization Algorithm approach for the channel estimation of antenna in a transmission area. Here, various channel estimation techniques are considered and then optimized for improving the transmission speed and reducing the unused bandwidth. In this analysis, the technique is mainly used to schedule the time for channels. In experiments, the performance of the MIMO optimization system is evaluated and analyzed in terms of average throughput, MSE, BER and outage capacity. Furthermore, the algorithm based upon OSTBC is compared with some of the existing MCBFOA optimization algorithms in order to prove the performance. When compared to MCBFOA, the OSTBC provides the best result.

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Nam, et al.[3] In their work Proposed a correlation across transmit antennas in multiple-input multiple-output (MIMO) systems has been studied in various scenarios and has been shown to be detrimental.

Cheng, et al.[4] in their work regarding MIMO radar OFDM chirp waveform diversity design with sparse modeling and joint optimization proposed a multiple-input multiple-output radar systems, here the employed waveforms should have a large time-bandwidth.

Mohd hairi halmi, et al.[5] in their work proposed a detailed study of Orthogonal Space-Time Block Codes (OSTBC) in MIMO literature is mostly limited to conventional MIMO, i.e. MIMO systems with at most 8 transmit and 8 receive antennas. In view of the situation, this paper studies the implementation of OSTBC in Large MIMO systems. The paper presents OSTBC for transmission of real symbols that can support up to 32 transmit and 32 receive antennas. Simulation results show that real OSTBC system performance is highly dependent on the code rate of the transmission matrix as well and the number of antennas used.

Mitesh Patel, et al.[6] in their work proposed a diversity techniques used to reduce the effect of multipath fading and improve the reliability of transmission without increasing the transmitted power or sacrificing the bandwidth. In most wireless communication systems a number of diversity methods are used in order to get better performance. The focus was to compare the performance of the three techniques in terms of the complexity and improvement in SNR. In the result maximal ratio combiner gives the best result.

Abhishek Sharma, et al.[7] in their work proposed a noble method diversity technique for estimating the channel performance of mobile communication signals affected by Rayleigh multipath fading phenomena is discussed. The Alamouti scheme and Maximum ratio combining technique are evaluated here using BPSK. The use this help to combat and mitigate against Rayleigh fading channel and approach AWGN channel performance with constant transmit power. For this reason, multi-antenna MIMO channels have recently become an attractive scheme means to increase quality of wireless communications by the use of spatial diversity at both sides of the link and occupies a considerable part.

III. MIMO SYSTEM

In wireless communication system, to reduce the effect of multipath fading diversity techniques are widely used and also it improves the transmission reliability without increasing the bandwidth or transmitted power. The diversity scheme is the technique for increase the quality of the message signal in which more than one communication channels are used and each are having different characteristics. This is one of the most important technique used to reduce the co channel interference and multipath fading of the signal because each individual channels having different amount of interference.

In wireless mobile communications, diversity techniques are widely used to reduce the effect of multipath fading and improve the reliability of transmission without increasing the transmitted power or sacrificing the bandwidth. The diversity can be defined as the transmitting the multiple replicas of the signal and all signal having the same information but with some amount of correlation. In most wireless communication systems a number of diversity methods are used in order to get better performance.

Diversity scheme in wireless communication is a method for improving the quality and correctness of a message signal in which more than one communication channels which differs in their characteristics are used. This is one important scheme to battle with co channel interference and fading of the signal because individual channels results in the different amount of interference and fading and when a signal is transmitted or received with multiple versions, it is easier to combat such issues. The concept of diversity schemes in transmitted end is first came into an existence in the landmark paper of Alamouti which he published in 1998 and laid down the foundation of diversity schemes. In MISO, SIMO and MIMO systems diversity schemes are used.

Multi-Input Multi-Output (MIMO) is the combination of both Single Input Multi Output (SIMO) and Multi Input Single Output (MISO) system. The proper operation of MIMO systems requires careful design, with the encoded signals received from each transmitting antenna and the decoded signal at the receiver side. The better combination of number of transmitting and receiving antenna for MIMO systems in BPSK modulation technique that satisfy the good signal-to-noise ratio (SNR). Bit error rate (BER) is inversely proportional to the SNR values of the system. The main arguments today, for using multiple antennas when transmitting over a wireless link are: Array gain, Interference suppression, Transmitter localization, Bit rate and Data rate, Spatial diversity, Reliability, Complexity.

IV. ALAMOUTI CODE

One of the most commonly used STBC is the Alamouti code. Let two transmit antenna and one receive antenna to employ Alamouti code. To transmit *b* bits/cycle, we use a modulation scheme that maps every *b* bits to one symbol from a constellation with 2*b* symbols. From the constellation of each b bits two symbols are picked by the transmitter for a PSK constellation. For a block of 2b bits, if S_1 and S_2 are the selected symbols then at time one S_1 is transmitted from antenna one and S_2 is transmitted from antenna two. Then at time two, $-S_2^*$ and S_1^* are transmitted from antennas one and two, respectively. Therefore, the transmitted codeword is

$$C = \begin{pmatrix} S_1 & S_2 \\ -S_2^* & S_1^* \end{pmatrix} \tag{1}$$

So it is clear that encoding is done at both time and space domain. S_1^* is the conjugate of S_1 and orthogonal to S_1. Similarly, $-S_2^*$ is the negative of the conjugate of S_2 and is orthogonal to S_2. The STBC matrix is unitary. OSTBC encoding belongs to the Alamouti coding and it allows simple decoding. This STBC achieves symbol transmission rate = 1 at full diversity and has a full rank of 2. The average transmission power of this STBC is $2S_i$ through each of the two antennas.

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V. PROPOSED SYSTEM MODEL

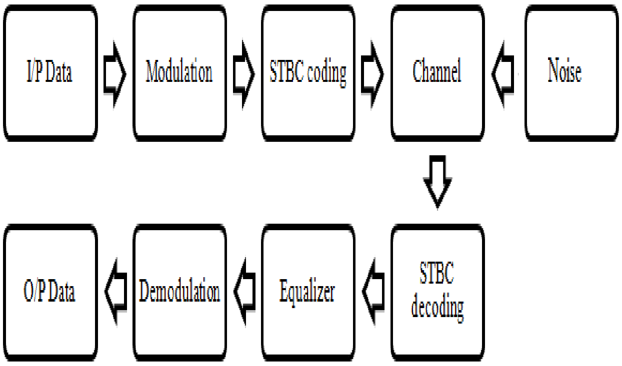

Fig. 1. Proposed system Model

The system model used in the simulation is as shown in Fig.1. MIMO systems with two transmit and two receive antennas are considered here. The input binary data is modulated according to the required scheme and then encoded using the Alamouti principle. The STBC encoded data is sent through transmitters. Various types of channels are simulated namely the AWGN channel and the flat fading Rayleigh channel. The received signals are then STBC decoded after that the equalization is done. Demodulation is then performed to calculate the estimated binary input data. Bit error rate (BER) is calculated and BER versus Signal to noise ratio (SNR) graphs are plotted.

A. AWGN Channel

An AWGN channel adds white Gaussian noise to the signal that passes through it as seen in Eq.(2).

$$y = s + n \tag{2}$$

Here the received signal y is the sum of the transmitted signal, s and the noise, n.

B. Flat Fading Channel

Flat fading, or frequency non-selective fading, applies by definition to systems where the bandwidth of the transmitted signal is much smaller than the coherence bandwidth of the channel. All the frequency components of the transmitted signal within the same frame undergo the same attenuation and phase shift propagation through the channel.

$$y = Hs + n \tag{3}$$

Where, y and s are the receive and transmit signals, respectively. Here H is channel matrix and n is noise vector.

At the receiver side MLD can be achieved with only linear processing and this is the attractive feature of the OSTBC. This is a method that compares the received signal with all possible transmitted vectors and estimates s according to the Maximum Likelihood principle

VI. SIMULATION PARAMETERS AND RESULT

Standard Parameters used for simulation of MIMO system model is listed in Table.1

I. Simulation parameters for mimo system

Parameters	value
No. of Transmit antenna	2
No. of Receive antenna	2
Modulation	BPSK
Coding	STBC
Channel	Rayleigh
Noise	AWGN

A. SIMULATION RESULTS

The BER analysis of MIMO system using Alamouti and OSTBC code for BPSK under Rayleigh channel simulation results are performed by MATLAB software are shown as follow:

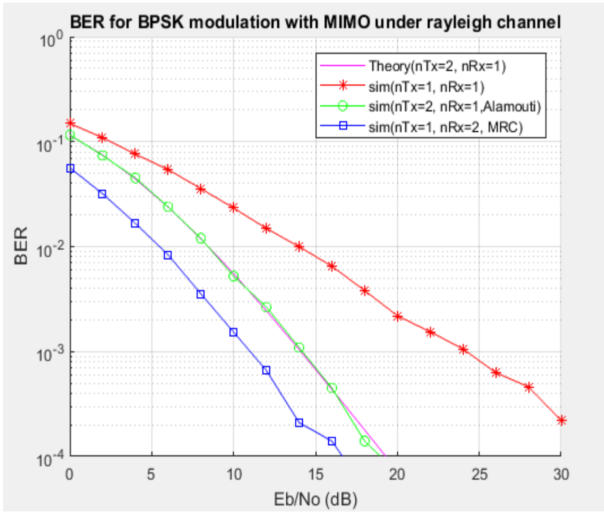

Fig.2. BER for BPSK Modulation with MIMO under Rayleigh Channel

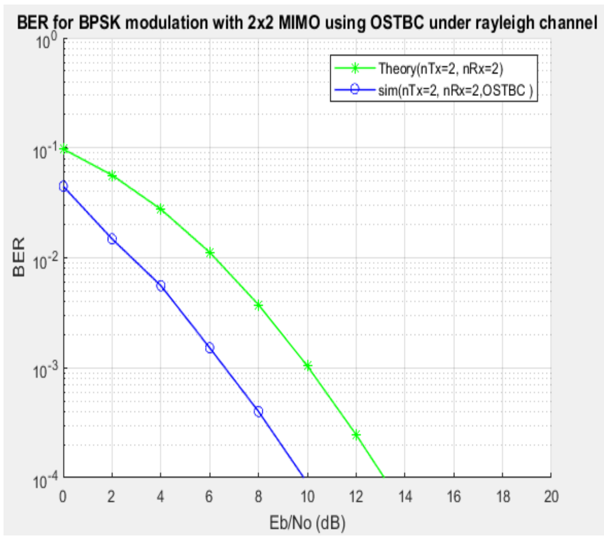

Fig.3 BER for BPSK modulation with 2x2 MIMO using OSTBC under Rayleigh channel

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Figure 2 shows the BER comparison analysis graph of different transmission techniques of MIMO system. Simulation results represents that the BER values varies from 10^{-1} to 10^{-4} and Eb/No values varies from 0 to 19 for BPSK modulation using Alamouti code under Rayleigh channel.

Figure 3 shows the BER analysis graph of 2x2 MIMO system using OSTBC. Simulation results represents that the BER values varies from 10^{-1} to 10^{-4} and Eb/No values varies from 0 to 9.8 for BPSK modulation under Rayleigh channel.

VII. CONCLUSION

In this paper, the comparative study of optimal BER in MIMO system for BPSK modulation with Alamouti code and OSTBC is represented. The BER analysis is carried out for MIMO configurations under Rayleigh fading channel. The BER performance of the system using OSTBC gives better result and it improves the Performance of the 2x2 MIMO system with the SNR 9.9 for the BER value 10^{-4} .

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