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Outdoor MIMO Wireless Communications With Alamouti's Space-Time Block Codes

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Abstract

Research on Alamouti's space-time coding algorithm upto now was primarily based on numerical simulations simplifying the transmission channel in a skill full manner. This paper purpose a simple and efficient methods to study the impact of MIMO-STBC .This paper described about channel capacity with probability of error on MIMO-STBC. In this paper we compare the simulation results with average channel capacity, SNR and probability of error by using MATLAB coding.

Keywords-MIMO, channel, STBC, Alamoutis Code, MRRC

Introduction

Overview of MIMO coding including MIMO preceding, mimo diversity coding, space time diversity coding and Alamoutis codes. MIMO stands for multiple input and multiple output. It is a system that uses several antenna at the transmitter and receiver links. In order that MIMO spatial multiplexing can be utilized, it is necessary to add coding to the different channel so that the receiver can be detect the correct data. There are various form of terminology used including space time block code-STBC,MIMO preceding, MIMO coding, and Alamouti codes.

It has come a long way since tesla , using Maxwell and Hertz's work on transmission of electromagnetic waves, demonstrated the transmission of information through a wireless medium using such waves, the second world war lead to much interest in this area , giving way to many of the theoretical foundation of communications.

Wireless networks windily use today include: cellular network wireless mesh networks (WMNs), wireless local area networks (WLANs), personal area networks (PANs) , and wireless sensor networks.

Transmit and receive diversity have emerged as effective means of achieving higher throughput in wireless communication system.

MIMO System

MIMO stands for multiple input multiple output. It is system that uses several antennas at the transmitter & receiver. Because of the invention of new technology like,portable terminal (laptop),mobile terminal and consumer devices demand on bandwidth constantly increasing & frequency spectrum is too crowded. The operator need high coverage & high capacity where as subscriber needs high quality high speed.

Before introduction of MIMO There was a popular technology called smart antenna is used to improving wireless communication in adverse propagation condition such as fading, multi-path & interference. The main idea in smart antenna is that of beam forming by which one increase the average signal noise ratio (SNR) through focusing into desire direction. The MIMO system transmits different signals from each transmit element so that the receiving antenna array receives a superposition of all the transmitted signals. All signals are transmitted from all elements once and the receiver solves a linear equation system to demodulate the message. Multiplexing (MIMO-OFDM) system is an effective solution to improve communication quality, performance, capacity, and transmission rate. MIMO-OFDM is under intensive investigation by researchers. We consider the system where the transmitter has nt antenna and the receiver has nr anteena.Let hmn be a complex number corresponding to the channel gain between transmit antenna n and the receive antenna m. If at a certain time instant complex signals {} nt x ,x,….x12 are transmitted via the nt antennas, the received signals an antenna m can be expressed as,

$$\mathbf{Ym=\sum h_{mn}x_n+em}$$

Where ym is a received signal, xn is a transmitted signal, em is a noise signal , and hm,n is a channel response in matrix form.

$$Y=hx+e$$

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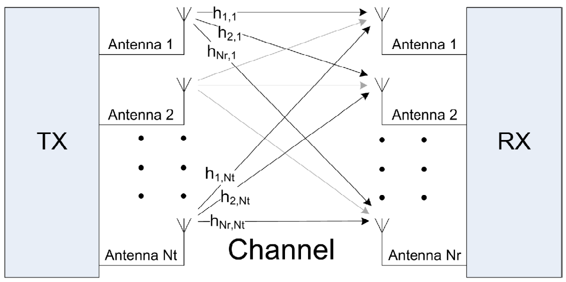


Fig.1 Block diagram of MIMO

Section A-Channel model for MIMO systems can be either simple or very complex, depending on the environment modeled and the desired accuracy.

Overview of STBC

Space time block codes are used for MIMO system to enable the transmission of multiple copies of a data stream across a number of antenna and to exploit the various received version of the data to improve the reliability of data transfer. Space time coding combines all the copies of received signal in an optimal way to extract as much information from each of them as possible.

Space time block coding uses both spatial and temporal diversity and in this way enables significant gains to be made. Space time coding involves the transmission of multiple copies of the data, This help o compensate for the channel problem such as fading and thermal noise. Although there is redundancy in the data some copies may arrive less corrupted at the receiver. When using space time block coding, the data stream is encoded in blocks prior to transmission. These data block are then distributed among the multiple antenna

(which are spaced apart to decor relate the transmission path) and the data is also spaced across time.

A space time block code is usually represented by a matrix. Each row represent a time slot and each column represent one antennas transmission over time.

There are different technique propose to mitigate multipath fading in a wireless channel.

Transmitter power control

It is assumed that the transmitter has some knowledge about the channel and it increases its power by the same level to reduce fading effect over channel. Tthis method is not practical since radiation power limitation and cost of power amplifier, and wastage in bandwidth due to feedback channel information.

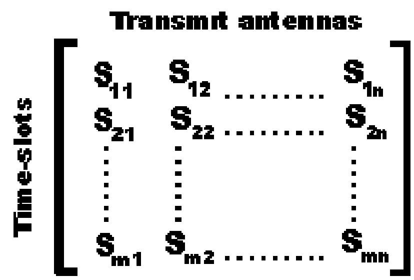
Time and frequency diversity

Both time and frequency diversity in effective due to large delay in slow varing channel and small delay spread in the channel respectively.

Antenna diversity

It is very effective technique to reduce multi-path fading. We are two types of antenna diversity technique. Receiver diversity(e.g. MRRC) and transmitter diversity (e.g. space time code) which is depend on whether the diversity is applied to transmitter or to receiver.

Recently the transmit the diversity scheme become more popular to solve multi-path fading problem which use multiple antenna at transmitter to improve reliable data transmission. Tthis scheme called combination of spatial (antenna) and temporal processing known as space time block coding (STBC).In stbc alamoutis's scheme is the most famous and popular one since the only STBC which can achieve both full diversity and full code rate for complex constellation.



Within this matrix, Sij is the modulated symbol to be transmitted in the time slot I from antenna j. There are to be T time slots and Nt transmit antenna as well as Nr received antenna. This block is usually considered to be of 'length' T.

MIMO Alamouti's Code

A particularly elegant scheme for MIMO coding was developed by Alamouti. The associated codes are often called MIMO Alamouti codes or just Alamouti codes.

The MIMO Alamouti scheme is an ingenious transmit diversity scheme for two transmit antennas that does not require transmit channel knowledge. The MIMO Alamouti code is a simple space time block code that he developed in 1998.

Alamouti's STBC

We have discussed three received diversity schemes selection combining, equal gain combining, and maximal ratio combining. All the three approaches used the antenna array at the receiver to improve the demodulation performance, Albeit with different level of complexity. Time to move to a transmit diversity scheme where the information is spread across multiple antenna at th transmitter. Let discussed a popular transmit diversity scheme called

ALAMOUTIS SPACE TIME BLOCK CODING (STBC).

The scheme is as follows:

1. Consider we have a transmission sequence, for example$\{x_1, x_2, x_3 \ldots\ldots\ldots\ldots x_n\}$

2. In normal transmission, we will be sending x_1 in the first time slot, x_2 in the second time slot, x_3 and so on.

3. However, Alamouti suggested that we group the symbols into groups of two. In the first time slot, send x_1 and x_2 from the first and second antenna. In second time slot send $-x_2^*$and x_1^* from the first and second antenna. In the third time slot send x_3 and x_4 from the first and second antenna. In fourth time slot, send $-x_4^*$ and x_3^* from the first and second antenna and so on.

4. Notice that though we are grouping two symbols, we still need two time slots to send two symbols. Hence, there is no change in the data rate.

5. This forms the simple explanation of the transmission scheme with Alamouti Space Time Block coding.

Receiver with Alamoutis STBC

In first time slot ,the received signal is,

$$y_1 = h_1 x_1 + h_2 x_2 + n_1 = [h_1 \; h_2]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + n_1$$

In second time

$$y_2 = -h_1 x_2^* + h_2 x_1^* + n_2 = [h_1 \; h_2]\begin{bmatrix} -x_2^* \\ x_1^* \end{bmatrix} + n_2$$

Where y_1, y_2 is a received symbol on the first and second time slot respectively. h_1 is a channel from 1st transmit antenna to receive antenna, h_2 is a channel from 2_{nd} **transmit to receive antenna x_1, x_2 are the transmitted symbol, and n_1, n_2 is the noise on 1st and 2nd time slot. Shown in Fig.2**

Maximal Ratio Receive Combining

It is a method used several antennas at receiver side to receive the same signal through a different propagation path and perform combining or selection and switching to improved the received signal quality. This approach practically applied only to base station to improve their reception quality because of the cost, size and power of remote unit. The channel is modeled by complex multiplicative distortion . For two receive antenna channel between the transmitter antenna and the receive antenna one is $h_1 = A_1 e^{jc2}$ and the channel between the transmitter and receiver antenna two is $h_2 = a_2\, e^{jc2}$. Noise would be add at two receiver so that the two received base band signal would be

$Y_1 = h_1 x_1 + n_1$

$Y_2 = h_2 x_1 + n_2$

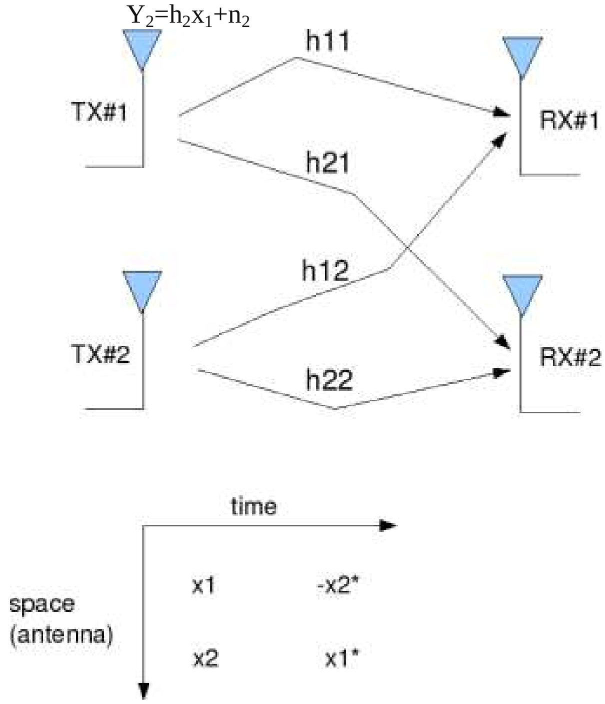


Fig.2 Transmit 2 receive Alamoutis STBC

Where x_1 the signal sent from transmitter ,n_1 and n_2 represent complex noise which is assumed to be Gaussian distributed with zero mean.

Simulations

Simulations are done in MATLAB using the Rayleigh channel model described in section A. We modulate using BPSK, QPSK,,4-QAM,16-QAM, gray mapping constellation. For is sample , blocks of 10^4 symbols are simulated until at least 100 bit error are obtain. Both the MATLAB simulation source code and the data collected from the simulation are available at [2].

Results & Analysis

Keeping all other variables the same , the result obtained for BPSK, and QPSK are nearly identical , and we there for present data for QPSK and omit that of BPSK, since the data is nearly identical.

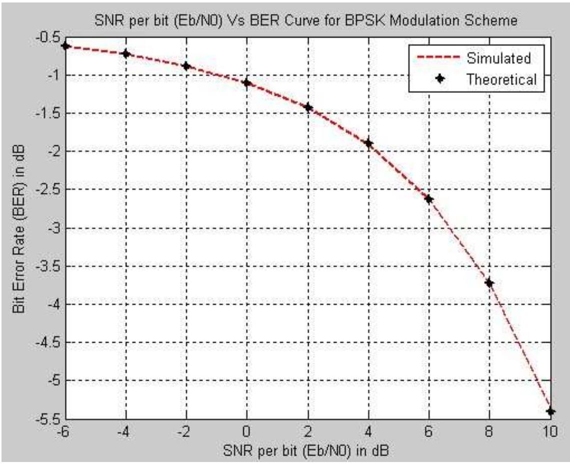


Fig.3 Bit error rate versus SNR for BPSK

We compare ,the simulated results are and therotical result are same .shown in fig. 3

In fig. 4 We comparing the BER Vs E_b /N_o (dB) by using BPSK & Diff.enc BPSK two modulation techniques.BPSK modulation results are better than Diff.enc BPSK.

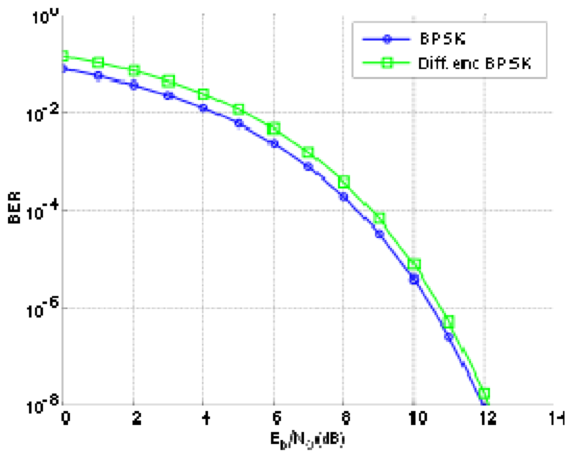


Fig.4 BER versus E_b /N_0 (dB) of BPSK & Diff.enc BPSK

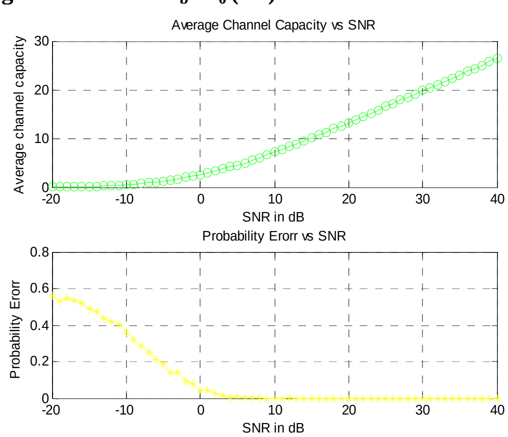


Fig .5 compare with avg channel capacity Vs SNR & probality of error.

Conclusion

We have implemented a MIMO transmission system in hardware ,utilizing alamouti space-time coding using monopole antennas with a spacing as small as B/2.Simulated results channl capacity and SNR both are increasing and probality of errors are decreasing.compare the both results on 0db SNR are same.The conclusion of this paper improving the efficiency of wireless communication systems.

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