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PERFORMANCE ENHANCEMENT THROUGH INCREASING NUMBER of ANTENNAS FOR ALAMOUTI AND STBC CODES IN MIMO RF SYSTEMS

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Abstract — *The objective of the paper is to take advantage of the benefits of both while avoiding their drawbacks combine transmit diversity and spatial multiplexing, thus achieving at the same time the two possible spatial gains offered by MIMO systems. Recently many researchers have been working on MIMO systems with STBC to improve the performance of system without additional bandwidth or transmit power requirements. In MIMO system, the transmitter and receiver are equipped with multiple antennas. The MIMO system provides multiple independent channels, so the channel capacity increases linearly with the number of antennas. Space-time block codes have been shown to perform well with Multiple-Input Multiple Output (MIMO) systems. The design aspect of wireless system aims at improvement in spectral efficiency and coverage area with reliable performance. This necessitates that the MIMO system must be capable to overcome data rate limitation and there must have options open for future improvement. the STBC schemes in Rayleigh fading environment using various combinations of numbers of transmit and receive antennas. The simulations results have been obtained in MATLAB.*

Keywords- *MIMO, STBC, Spatial multiplexing, Spatial Modulation, Rayleigh fading, BER, QPSK, BPSK.*

I. INTRODUCTION

MIMO has become an essential element of wireless communication standards including IEEE 802.11n (Wi-Fi), IEEE 802.11ac (Wi-Fi), HSPA+ (3G), WIMAX (4G), and Long Term Evolution(4G) [1].

There are various forms of terminology used including Space-Time Block Code – STBC, MIMO preceding MIMO coding, and Alamouti codes. Space-time block codes are used for MIMO systems to enable the transmission of multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer. Space-time coding combines all the copies of the 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 helps to compensate for the channel problems such as fading and thermal noise. Although there is redundancy in the data some copies may arrive less corrupted at the receiver.

In order that MIMO spatial multiplexing can be utilized, it is necessary to add coding to the different channels so that the receiver can detect the correct data.
When using space-time block coding, the data stream is encoded in blocks prior to transmission. These data blocks are then distributed among the multiple antennas and the data is also spaced across time.

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I will be implementing a particular scheme known as the "Alamouti scheme". It is one of the simplest multi-antenna schemes, as it uses only 2 transmit and 2 receive antennas.

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

There is speed in spatial multiplexing is high. In spatial diversity (space time block code) throughput is increasing.

A space time block code is usually represented by a matrix. Each row represents a time slot and each column represents one antenna's transmissions over time [2].

$$\begin{array}{cc} & \xrightarrow{\text{transmit antennas}} \\ \text{time-slots} \Big\downarrow & \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n_T} \\ s_{21} & s_{22} & \cdots & s_{2n_T} \\ \vdots & \vdots & & \vdots \\ s_{T1} & s_{T2} & \cdots & s_{Tn_T} \end{bmatrix} \end{array}$$

II. FUNDAMENTALS

1. Techniques for improving performance

There are two flavors of MIMO with respect to how data is transmitted across the given channel.

Aiming at improving the reliability of the system, we may choose to send same data across the different propagation (spatial) paths. This is called spatial diversity.

Aiming at improving the data rate of the system, we may choose to place different portions of the data on different propagation paths (spatial-multiplexing).

These two systems are listed below.

1. MIMO implemented using diversity techniques – provides diversity gain – Aimed at improving the reliability

2. MIMO implemented using spatial-multiplexing techniques – provides degrees of freedom or multiplexing gain – Aimed at improving the data rate of the system

2. spatial diversity:

In diversity techniques, same information is sent across independent fading channels to combat fading. When multiple copies of the same data are sent across independently fading channels, the amount of fade suffered by each copy of the data will be different. This guarantees that at-least one of the copy will suffer less fading compared to rest of the copies. Thus, the chance of properly receiving the transmitted data increases. In effect, this improves the reliability of the entire system. This also reduces the co-channel interference significantly. This technique is referred as inducing a "spatial diversity" in the communication system [4].

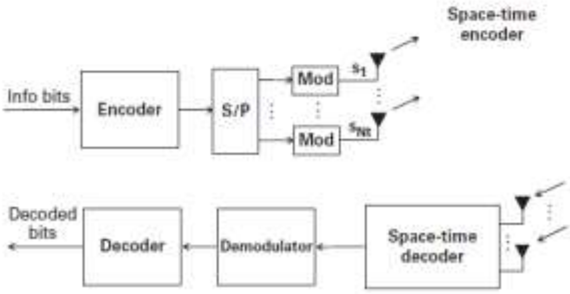

Figure 1: A MIMO system for spatial diversity

3. Spatial Multiplexing:

In spatial multiplexing, each spatial channel carries independent information, there by increasing the data rate of the system. This can be compared to Orthogonal Frequency Division Multiplexing (OFDM) technique, where, different frequency sub channels carry different parts of the modulated data. But in spatial multiplexing, if the scattering by the environment is rich enough, several independent sub channels are created in the same allocated bandwidth. Thus the multiplexing gain comes at no additional cost on bandwidth or power. using spatial multiplexing techniques to exploit multipath in order to achieve higher data rates than are possible with conventional systems having the same bandwidth

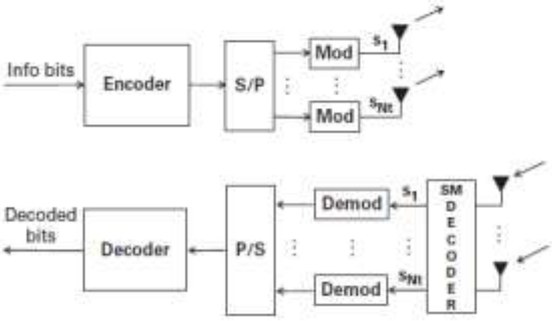

Figure 2: A MIMO system for spatial multiplexing

4. ALAMOUTI Space Time Block Code

In Space Time Block code output only depends on the current input bits. In convolution codes, the output only depends on the current input bits and on previous inputs. The convolution code may not produce the same output for a given input, because previous input is involved. The block code requires less power, to decode a block code, as compared to convolution code [6].

The Alamouti coding is described by the following matrix and Y is the encoder output, while X 1 and X2 are the input symbols. The “*” denotes the complex conjugate.

$$Y = \begin{bmatrix} X_1 & -X_2^* \\ X_2 & X_1^* \end{bmatrix}$$

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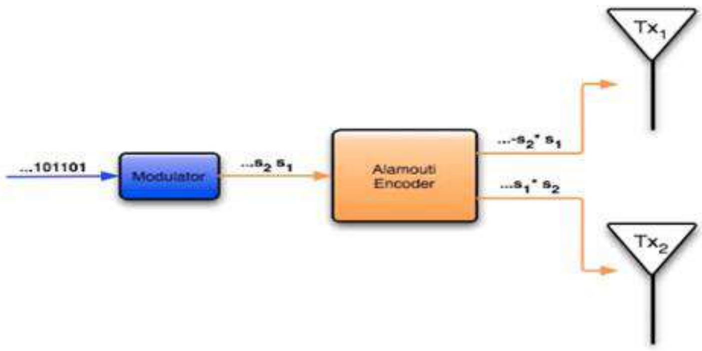

Figure 3: ALAMOUTI Space Time Block Code

The figure is a block diagram of the transmitter module in MIMO system and using the Alamouti code. The binary bits enter a modulator and are converted to “symbols”. A symbol from modulator is represented by complex numbers. This symbol can be transmitted directly in a single antenna, Single Input Single Output (SISO), system. In MIMO system the complex symbols are fed into the Alamouti encoder. The Alamouti encoder maps the symbols onto the transmitter by using the above given matrix. In this matrix, rows represent the transmit antennas, and columns represent the time. The element of the matrix tells what symbol is to be transmitted from a particular antenna. The Alamouti code works with pairs of symbols at a time. It takes two time periods to transmit the two symbols [7].

The STBC schemes in Rayleigh fading environment using various combinations of numbers of transmit and receive antennas.

III. SOFTWARE

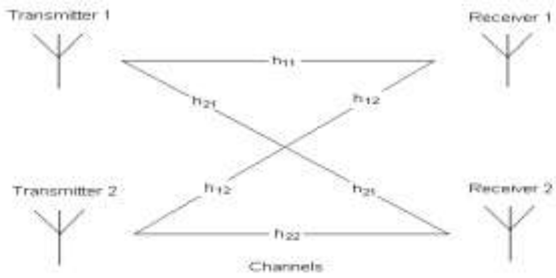

Figure 4: 2 Transmit 2 Receive (2×2) MIMO channel

In the 2×2 system in Figure there is the potential for both transmit and receive diversity. Receive diversity is when the same information is received by different antennas.

For instance the information sent from Tx1 is transmitted across channels h1,1 and h1,2, and received by both Rx1 and Rx2. Transmit diversity is when the same information is sent from multiple transmit antennas.

One possible way to achieve this is to code across multiple symbols periods. For instance, at time t antenna Tx1 could transmit the symbol s then at time t+1 antenna Tx2 would transmit the same symbol, s. The Alamouti scheme uses a method similar to this to obtain transmit diversity.

Table 1: Alamouti 2X2

	Transmitter 1	**Transmitter 2**
Time t	x_1	x_2
Time t + T	$-x_2^*$	x_1^*

$$\boldsymbol{Y} = \begin{bmatrix} y_1^2 \\ y_2^2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} -x_2^* \\ x_1^* \end{bmatrix} + \begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix}$$

Where, $\begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix}$ represents the received OFDM symbol at the first time period, for antennas 1 and 2.

$\begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$ are the noise at time slot 1 on receive antenna 1, 2 respectively.

$$\boldsymbol{Y} = \begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$$

Where, $\begin{bmatrix} y_1^2 \\ y_2^2 \end{bmatrix}$ represents the received OFDM symbol at the second time period for antennas 1 and 2.

$\begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix}$ are the noise at time slot 2 on receive antenna 1, 2 respectively.

Combining the equations at time slot 1 and 2.

$$\boldsymbol{Y} = \begin{bmatrix} y_1^1 \\ y_2^1 \\ y_1^{2*} \\ y_2^{2*} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^* & -h_{11}^* \\ h_{22}^* & -h_{21}^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \\ n_1^{2*} \\ n_2^{2*} \end{bmatrix}$$

equations can easily be combined and arranged to produce the result.

IV. RESULT ANALYSIS

The bit-error-rate (BER) versus signal-to-noise-ratio (Eb/N0 (db)) performance of STBC with nT=2 transmit diversity scheme on Rayleigh fading channel is evaluated by simulation.

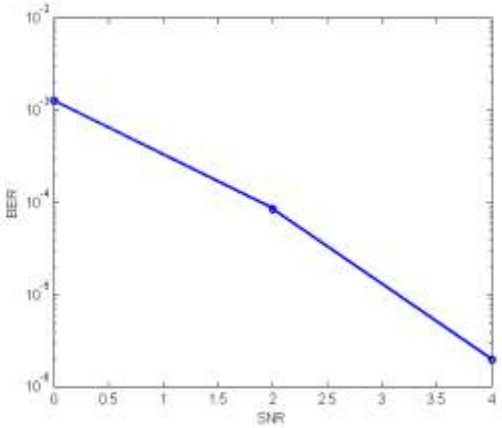

Figure 5: BER for BPSK modulation with 2Tx, 2Rx Alamouti STBC (Rayleigh Channel)

Figure 5 shows the Alamouti scheme BER versus Eb/N0 performance with coherent BPSK modulation. From the simulation result, SNR 5 db(approx).

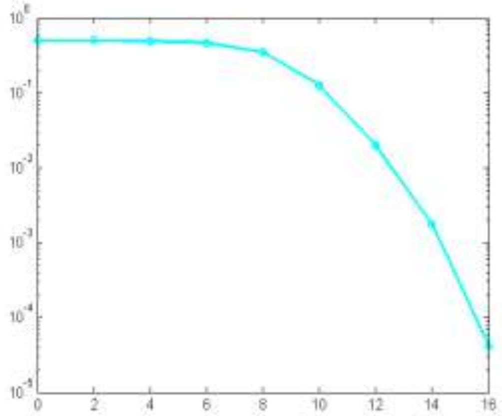

Figure 6: BER for QPSK modulation with 2Tx, 2Rx Alamouti STBC(RayleighChannel)

Also figure 6 gives the BER curves for the Alamouti scheme for QPSK modulations in Rayleigh channel.

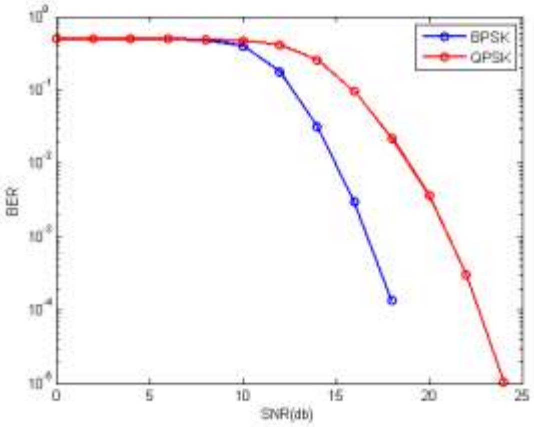

Figure 7: BPSK vs QPSK

figure 7 shows comparison of BPSK versus QPSK modulation. We observe 6 db SNR gap between BPSK and QPSK.The complete simulation work has been done in MATLAB.

V. Conclusion & Future Work

Conclusion

Hence, conclude that a basic overview of MIMO system. A basic introduction of Space-time coding was provided by presenting Almouti‘s scheme. the Almouti scheme for 2 transmit and 2 receive antenna and finally we got the estimated symbol s0 and s1.

Hence, conclude that with the results are plotted in MATLAB for different diversity scheme by using BPSK and QPSK modulation at constant SNR . this work can be extended for more than 2 transmitting antenna and can be done using different modulation schemes.

In Alamouti Space Time Block Coding with 2 transmitters and 2 receiver has around 5dB performance. the theoretical Alamouti calculation SNR is 0 to 25 db (approx.) BER plot for nTx=2, nRx=2 Maximal ratio combining, the Alamouti Space Time Block Coding has around 5dB better performance.

Future work

To take advantage of the benefits of spatial diversity and spatial multiplexing, while avoiding their drawbacks combine transmit diversity and spatial multiplexing, thus achieving at the same time the two possible spatial gains offered by MIMO systems. Reduce the interference between channel and To increase speed and throughput.

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