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STBC Generation for Multiple Antenna OFDM Systems

Neethu Krishnan[1], Mercy Mathew[2]

PG Student [CE], Dept. of ECE, BC. CAARMEL Engineering College, Pathanamthitta, Kerala, India[1]

Assistant Professor, Dept. of ECE, BC. CAARMEL Engineering College, Pathanamthitta, Kerala, India[2]

ABSTRACT: Space-time wireless technology that uses multiple antennas along with appropriate signaling and receiver techniques offers a powerful tool for improving wireless performance. Multiple antennas when used with appropriate space-time block coding (STBC) techniques can achieve huge performance gains in multipath fading wireless links. MIMO systems with multiple antenna elements at both transmitter and receiver ends are an efficient solution for future wireless communications systems. This paper describes multiple-input multiple-output (MIMO) systems using Alamouti based space-time block coding technique at the transmitter and maximal ratio combining (MRC) at the receiver. The STBC is used to encode the BPSK modulated signal before being transmitted through flat fading Rayleigh channel. At the receiving end, the received signals were combined by maximal ratio combiner and detected by Maximum-Likelihood (ML) detector. The performance of 2 x 2 MIMO system is analyzed is evaluated by using MATLAB simulation.

KEYWORDS: Space-Time Block Coding (STBC), Maximal Ratio Combining (MRC), Multiple Input Multiple Output (MIMO), OFDM

I. INTRODUCTION

OFDM enables reliable broadband communications by distributing user data across a number of closely spaced, narrowband sub channels. This arrangement makes it possible to eliminate the biggest obstacle to reliable broadband communications, intersymbol interference (ISI). ISI occurs when the overlap between consecutive symbols is large compared to the symbols' duration. Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, OFDM enables longer duration symbols.

MIMO-OFDM is the foundation for most advanced wireless local area network (Wireless LAN) and mobile broadband network standards because it achieves the greatest spectral efficiency and, therefore, delivers the highest capacity and data throughput. That is, by using multiple antennas and precoding the data, different data streams could be sent over different paths. Raleigh suggested and later proved that the processing required by MIMO at higher speeds would be most manageable using OFDM modulation, because OFDM converts a high-speed data channel into a number of parallel, lower-speed channels.

Space–time block coding is a technique used in wireless communications to transmit 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. The fact that the transmitted signal must traverse a potentially difficult environment with scattering, reflection, refraction and so on and may then be further corrupted by thermal noise in the receiver means that some of the received copies of the data will be 'better' than others. This redundancy results in a higher chance of being able to use one or more of the received copies to correctly decode the received signal. In fact, 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. In the case of STBC in particular, the data stream to be transmitted is encoded in blocks, which are distributed among spaced antennas and across time. While it is necessary to have multiple transmit antennas, it is not necessary to have multiple receive antennas, although to do so improves performance. This process of receiving diverse copies of the data is known as diversity reception.

In this paper, it proposes a simple transmit diversity using alamouti STBC to improve the signal quality on the receiver and a simple receive diversity that uses maximal ratio combining. The transmit diversity scheme can improve the error performance, data rate, or capacity of wireless communication system.

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II. SYSTEM MODEL

We consider a multiple antenna wireless communication system which is equipped with 2 transmits and 2 receive antennas. The block diagram of such a communication system is depicted in Fig 1. The binary input data stream is first modulated and mapped to a sequence of modulation symbols. After that alamouti space time encoder encode these symbols. Then these are subjected to Inverse Fast Fourier Transform (IFFT) for baseband OFDM modulation. The IFFT operation converts the frequency-domain signal to a time-domain signal. To prevent overlapping of the data at the receiver, Cyclic Prefix (CP) is inserted. Then data passed through Rayleigh fading channel.

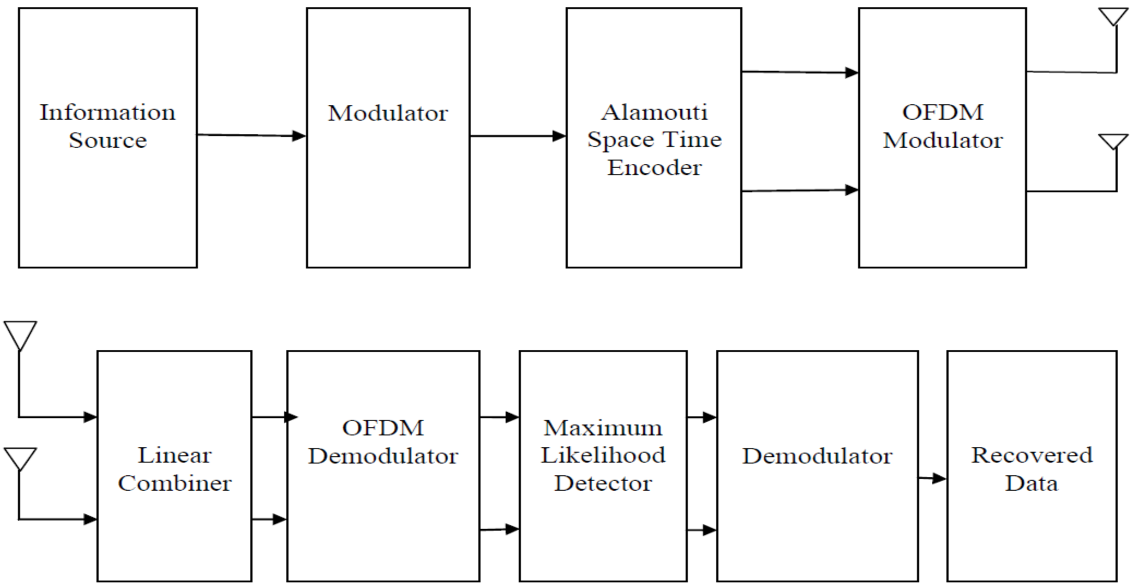

Fig 1: Alamouti space time block coded MIMO OFDM system

At the receiver basically the reverse operation to the transmitter is performed. The signal is received by two receiving antennas. The received signals are first combined by a linear combiner. After that the cyclic prefix is removed. Then the signal is demodulated by an FFT demodulator The FFT operation converts the received time-domain signal back to the frequency domain and then sent to the maximum likelihood detector where the decision rules are applied. The detected signal is then fed to the demodulator. The demodulator gives the original information which is transmitted.

III. ALAMOUTI SCHEME

Alamouti scheme is the basis of the space time coding technique. Alamouti system is one of the first space time coding schemes developed for the MIMO systems which take advantage out of the added diversity of the space direction. We can use this diversity to get a better bit error rate. At the transmitter side, a block of two symbols is taken from the source data and sent to the modulator. Afterwards, the Alamouti space-time encoder takes the two modulated symbols, in this case x_1 and x_2 creates an encoding matrix X where the symbol and are planned to be transmitted over two transmit antennas in two consecutive transmit time slots. The data are constructed as a matrix which has its rows equal to the number of the transmit antennas and its columns equal to the number of the time slots required to transmit the data. Here the symbol * represents the complex conjugate. Therefore, x_1^*, is the complex conjugate of x_1. The encoder outputs are transmitted in two consecutive transmission periods from the two transmit antennas. In the first transmission period, the signal x_1 is transmitted from antenna one and the signal x_2 is transmitted from antenna two, simultaneously. In the second transmission period, the signal $-x_2^*$ is transmitted from antenna one and the signal x_1^* is transmitted from antenna two. At the receiver side, when signals are received, they are first combined and then sent to the maximum likelihood detector where the decision rules are applied. Space-time block codes were designed to achieve the maximum diversity order for the given number of transmit and receive antennas subject to the constraint of having a simple linear decoding algorithm. This has made space-time block codes a very poplar scheme and most widely used. A block diagram of the alamouti space time encoder is shown in Fig.2.

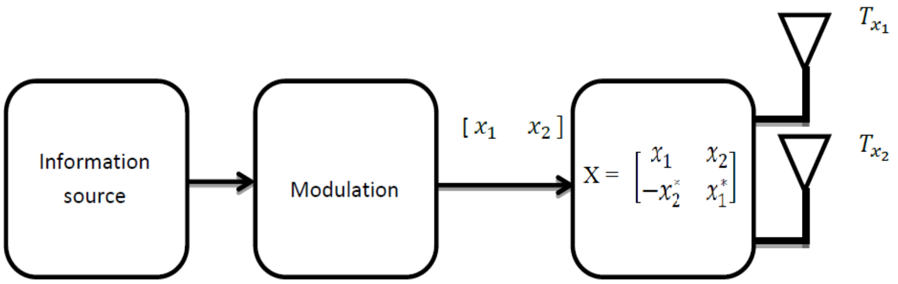

Fig. 2: Alamouti Space-Time Encoder.

IV. OFDM

OFDM is an efficient technique for transmitting data over frequency selective channels. The main idea behind OFDM is to divide a broadband frequency channel in to a few narrowband sub-channels. By making all sub-channels narrowband, they experience almost flat fading, which makes equalization very simple. To obtain a high spectral efficiency the frequency response of the sub-channels are overlapping and orthogonal, hence the name OFDM. This orthogonality can be completely maintained, even though the signal passes through a time dispersive channel, by introducing a cyclic prefix. There are several versions of OFDM but we focus on systems using such a cyclic prefix.

A cyclic prefix is a copy of the last part of the OFDM symbol which is prepended to the transmitted symbol. This makes the transmitted signals periodic, which plays a decisive roll in avoiding intersymbol and inter carrier interference Two difficulties arise when the signal is transmitted over a dispersive channel. One difficulty is that channel dispersion destroys the orthogonality between subcarriers and causes inter carrier interference (ICI). In addition, a system may transmit multiple OFDM symbols in a series so that a dispersive channel causes intersymbol interference (ISI) between successive OFDM symbols. The insertion of a silent guard period between successive OFDM symbols would avoid ISI in a dispersive environment but it does not avoid the loss of the subcarrier orthogonality. To avoid Inter Symbol Interference (ISI) due to the channel delay spread, a few Cyclic Prefix (CP) symbols are inserted in the block. Basically, the last samples of the block are duplicated in front of the block as the cyclic prefix. This cyclic prefix both preserves the orthogonality of the subcarriers and prevents ISI between successive OFDM symbols. Though the CP slightly reduces spectral capacity by consuming a small percentage of the available bandwidth, the elimination of ISI makes it an exceedingly worthwhile tradeoff. These cyclic prefix samples are removed at the receiver. Then, a Fast Fourier Transform (FFT) is utilized at the receiver to recover the block of received symbols.

V. MAXIMAL RATIO COMBINING

The Fig. 3 shows maximal ratio combining scheme with two transmit and two receive antennas. In maximal ratio combining (MRC), the signals received from multiple paths are weighted according to their individual signal voltage to noise power ratios and then summed.

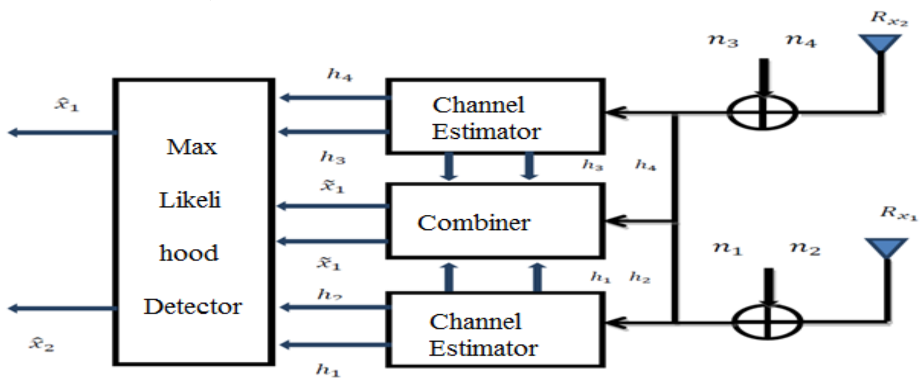

Fig. 3: MRC scheme with two transmit and two receive antennas.

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The amplitudes and phases of the data signals received are adjusted with the help of digital signal processing in such a way that signal addition leads to gain in the S/N ratio and hence to a better bit error rate. Maximal ratio combining produces an output SNR equal to the sum of individual SNR. Thus it has an advantage of producing an output with an acceptable SNR even when none of the individual signals are themselves acceptable. The output of the receivers is linearly combined in MRC to maximize the instantaneous SNR. The optimum decoder based on likelihood function is known as ML decoder. The ML decoder is not necessarily optimum in the case where the input or code sequences are not equally likely, however it is considered as the best feasible decoding rule. In ML receiver, input symbols are code word spanning space and time where number of code words is finite. In this detection technique, testing is done for all possible code words and then one which best fits the received signal based on the ML criterion is selected for the estimation of code word that was really transmitted.

VI. RESULT AND DISCUSSION

Here we study the performance of alamouti space time block coded MIMO OFDM with 2 transmits and 2 receive antennas. The bit error rate is plotted with respect to the different values of SNR. It is found that the BER performance of the system decreases with the increase in signal to noise ratio. The Fig. 4 shows that BER of alamouti space time block coded MIMO.

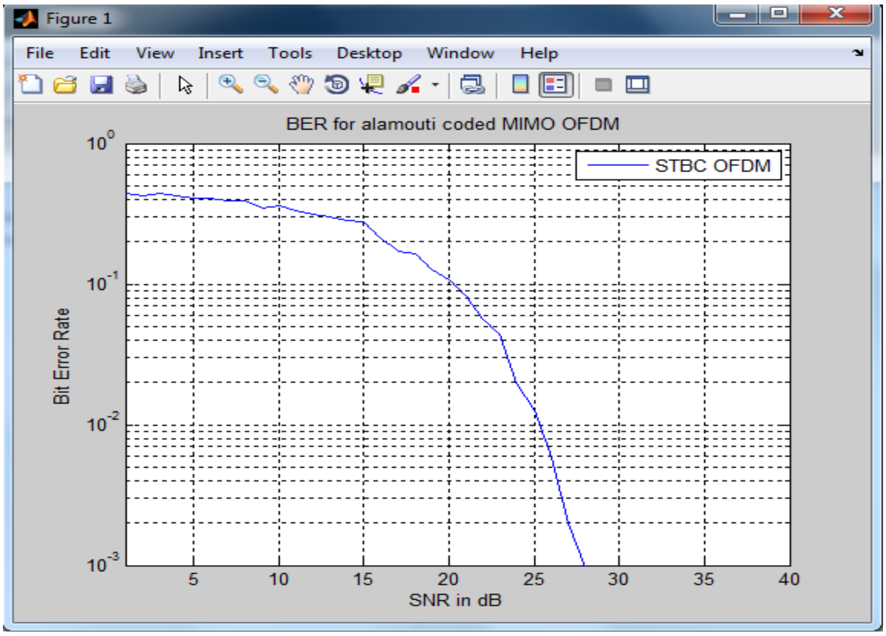

Fig. 4: BER of alamouti coded MIMO OFDM

VII. CONCLUSION

This paper analyses multiple-input multiple-output (MIMO) systems using Alamouti based space-time block coding technique at the transmitter and maximal ratio combining (MRC) at the receiver. The alamouti scheme is good coding technique for the data transmission by minimizing the error. The alamouti STBC has gained much attention as an effective transmit diversity scheme to provide reliable transmission with high peak data rates to increase the capacity of wireless communication system. At the receiving end, the signals received from multiple paths are weighted and summed in accordance with MRC scheme which provides maximum performance improvement by maximizing the SNR of the MIMO-OFDM system.The 2x 2 MIMO system achieved good performance shown better bit error performance. That is bit error rate also gets reduced. The simulation results are performed in terms of BER & SNR. It is found that the BER performance of the system decreases with the increase in signal to noise ratio. From the simulation result, it is clear that the proposed MIMO OFDM system concatenated with Alamouti STBC and MRC diversity provides maximum SNR improvement with minimum BER.

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