

Frequency Domain Equalization with Mapping of Data Onto Subcarrier Pairs In MIMO OFDM Antenna Diversity

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Abstract: This paper represents a detailed study of diversity coding for MIMO systems. Space Time Block Code (STBC) is a MIMO transmit strategy which exploits transmit diversity and high reliability. Space Time Block Codes are compared to Cyclic Delay Diversity (CDD), the comparison shows that Space Time Block Codes outperforms Cyclic Delay Diversity. In this paper Orthogonal Frequency Division Multiplexing (OFDM) for MIMO channel is proposed to mitigate Inter Symbol Interference (ISI) and enhance system capacity. Algebraic Space Time Block Codes are implemented for enhancing the throughput. The Bit Error Rate is calculated using MATLAB software for varying Signal to Noise Ratio, the experimental results shows that STBC outperforms CDD.

Keywords- MIMO, OFDM, STBC, CDD, cyclic prefix, equalization.

I. INTRODUCTION

In the first generation of analog mobile communication system it was only possible to transfer voice but it was not possible to transmit the data. The second generation could transmit data but it consumes a large bandwidth. The 3G communication has higher data rate but in future excessive data rate is required for various multimedia application,. Also the capacity of the system should also be increased. In order to meet these requirements of high data rate and high capacity there should be some

technology which can meet the requirement without need of extending the spectrum. MIMO-OFDM system combining MIMO and OFDM technology can meet the requirements. In a single carrier system, a single fade or interferer can cause the entire link to fail but in multicarrier system only small amount of subcarriers are affected. Inter symbol interference is eliminated using cyclic prefix. MIMO technology is used to increase the channel capacity. Based on studying MIMO technology and OFDM technology, the paper sets up a simple MIMO-OFDM wireless communications system, and simulates its performance using MATLAB.

II. MIMO TECHNOLOGY

A. Space Time Block Codes

The Alamouti space time coding scheme can be used to achieve diversity at the transmitter and receiver if more number of antennas are involved at the transmitter and receiver [5] . The encoder then takes a block of two modulated symbols s_1 and s_2 in each encoding operation and gives it to the transmit antennas according to the code matrix,

$$S = \begin{pmatrix} S_1 & -S_2^* \\ S_2 & S_1^* \end{pmatrix} \quad (1)$$

In Equation (1), the first column represents the first transmission period and the second column the second transmission period.

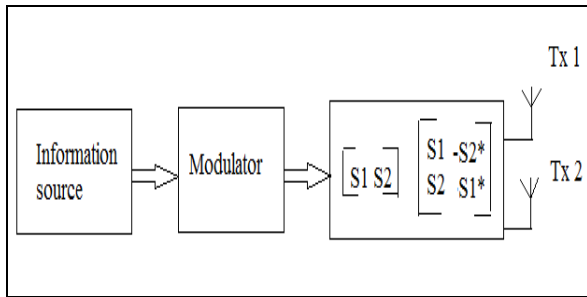


Fig.1: A Block Diagram of Alamouti Space Time Encoder

The first row corresponds to the symbols transmitted from the first antenna and the second row corresponds to the symbols transmitted from the second antenna. Elaborating further, during the first symbol period, the first antenna transmits S_1 and the second antenna transmits S_2 [1]. During the second symbol period, the first antenna transmits $-S_2^*$ and the second antenna transmits S_1^* being the complex conjugate of S_1 . This implies that we are transmitting both in space (across two antennas) and time (two transmission intervals) [3]. This is space-time coding.

$$\begin{aligned} s_1 &= [s_1, -s_2^*] \\ s_2 &= [s_2, s_1^*] \end{aligned} \quad (2)$$

In equation (2) where s_1 is the information sequence from the first antenna and s_2 is the information sequence from the second antenna. A close examination of equation (2) reveals that the sequences are orthogonal. This inner product is given by,

$$s_1 s_2 = s_1 s_2^* - s_2^* s_1 = 0 \quad (3)$$

At the receiver the signals after passing through the channel can be expressed as,

$$\begin{aligned} r_1 &= h_1 s_1 + h_2 s_2 + n_1 \\ r_2 &= -h_1 s_2^* + h_2 s_1^* + n_2 \end{aligned} \quad (4)$$

where, n_1 and n_2 are independent complex variables with zero mean and unit variance.

B. Cyclic Delay Diversity

Cyclic Delay Diversity shifts the signal in time direction and transmits these modified signal copies over separate transmitting antennas. The time shifts are inserted cyclically [6], such that no additional Inter Symbol Interference occurs. Among them, cyclic delay diversity

(CDD) is more widely adopted for single carrier and multicarrier applications as CDD can be applied to any number of transmit antennas without any rate loss or change in the receiver structure.

III. MIMO OFDM TECHNOLOGY

A. System Model

MIMO-OFDM technology takes advantage of transmitting the data with multiple antennas at the transmitter using multicarrier modulation technique.

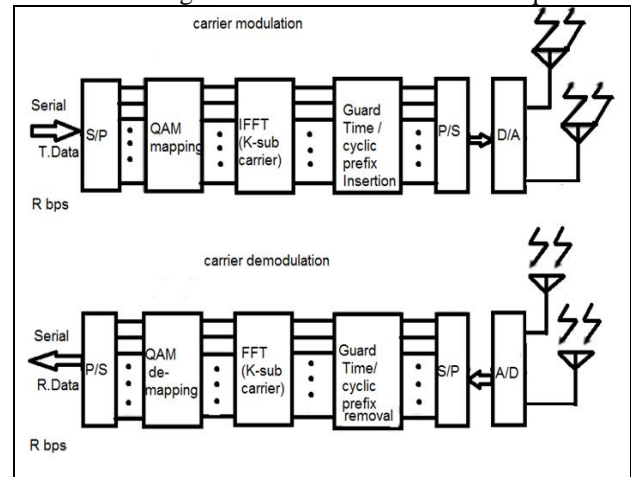


Fig. 2: MIMO OFDM System Model

1. First main component of OFDM is FFT/ IFFT which modulates a block of input QAM values onto a number of subcarriers. In the receiver, subcarriers are demodulated by FFT, which perform reverse operation of IFFT.
2. Second important feature of OFDM system is coding and interleaving.
3. The third key principle is the introduction of a cyclic prefix and zero padding as a Guard Interval to reduce interference between the symbols.

The channel is estimated using optimal linear minimum mean square error algorithm. In optimal minimum mean square error the channel is estimated by averaging the transmitted data. B. Algebraic Space Time Block Codes

The Alamouti code for MIMO system with 2 transmitter antennas and 1 receiver antenna have full rate and full diversity of 2. The Alamouti code have the full diversity

for MIMO system with 2 transmitter antennas and 2 receiver antennas, but no full rate. To achieve full rate and full diversity STBC for MIMO we go for Algebraic Space Time Block Codes. This technique is used for achieving full rate along with full diversity.

IV. SIMULATION RESULTS

Figure 3 shows the simulation of Bit Error Rate performance for Alamouti STBC scheme and Cyclic Delay Diversity for 2x1 system. The result shows that Alamouti Scheme shows higher performance than Cyclic Delay Diversity. Figure 4 shows the Bit Error Rate performance of Algebraic Space Time Block Codes for 2x2 systems. The transmission from T1 to R1 shows better performance. Throughput analysis for Alamouti Space Time Block Codes, Cyclic Delay Diversity, Algebraic STBC are shown in figure 5. Algebraic STBC achieves the highest throughput.

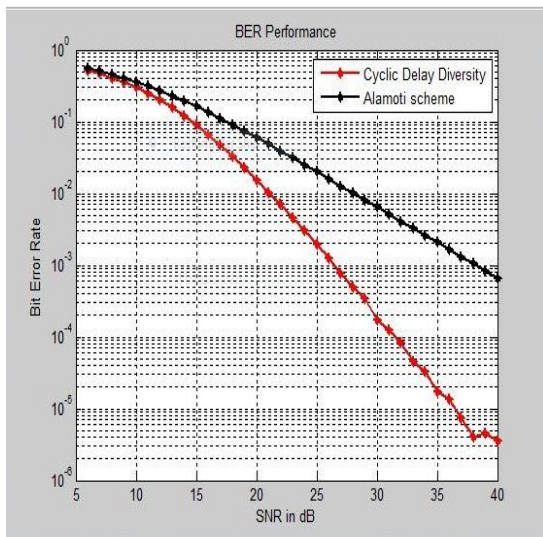


Fig.3: BER performance for Alamouti STBC scheme and Cyclic Delay Diversity for $N_t=2, N_r=1$

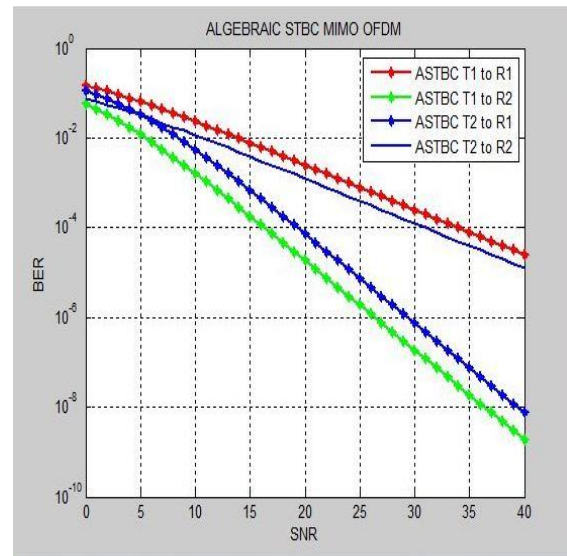


Fig.4: BER performance of Algebraic space time block codes for 2x2 MIMO

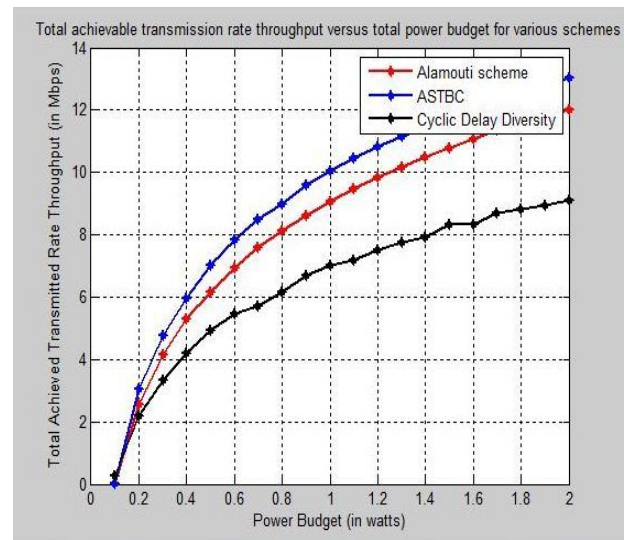


Fig. 5: Throughput Analysis for various diversity schemes

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V. CONCLUSION AND FUTURE WORK

By using different transmit diversity techniques and equalization techniques, parameters like SNR and throughput are calculated. Increasing the SNR increases the channel capacity. Using the algebraic STBC technique with MIMO OFDM increases the transmission rate. Future work is continued with various receiver diversity techniques

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