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Implementation of both Spatial Diversity and Spatial Multiplexing Technique in MIMO-OFDMA Communication System

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Abstract

MIMO (Multiple Input Multiple Output) that use multiple antennas in transmitter and receiver is considered to be powerful technology in future wireless communication system. The major problem facing in this multipath propagation is the interference between symbols transmitted through adjacent channels. i. e. Inter Symbol Interference. This could be avoided if we use OFDMA (Orthogonal Frequency Division Multiple Access) technology. Thus MIMO combined with OFDM has got prior importance in future wireless communication system. The major properties of MIMO system involve Spatial Diversity and Spatial Multiplexing. In former case same copies of data is being transmitted in the MIMO channels while in latter case different user's data is being transmitted in the MIMO channels. In this paper, a MIMO-OFDMA system with both the advantages of Spatial Diversity and Spatial Multiplexing is suggested.

Keywords: *MIMO, OFDMA, Spatial Multiplexing, Spatial Diversity, Inter Symbol Interference*

1. Introduction

MIMO (Multiple Input Multiple Output) system using multiple antennas in both transmitter and receiver of a communication system is able to achieve high data rates and better performance compared to SISO (Single Input Single Output) systems. Here the MIMO channel will be divided into multiple sub channels and data will be transmitted through those channels [2-3, 8]. The major issue while transmitting symbols though adjacent channels is the interference between those symbols leading to Inter Symbol Interference (ISI). In order to avoid this Inter Symbol Interference (ISI), OFDMA technology is adopted in MIMO systems. Thus MIMO combined with OFDMA has become a powerful technology in future wireless communication system with high data rates and better performance that eliminates Inter Symbol Interference (ISI).

The major properties or subclasses of MIMO system are Spatial Diversity and Spatial Multiplexing. In Spatial Diversity same copies of data from single user will be transmitted through all sub channels. On the other hand in Spatial Multiplexing, different users will be sending data through the sub channels. In Spatial Diversity technique the error rate of retrieved copies will be pretty much less due to multiple copies of data [3]. Redundancies in received data reduce the error rate. In spatial multiplexing technique, since different users send data through MIMO channel the throughput and capacity of the system improves substantially [2-3].

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Thus implementing both spatial Diversity and Spatial Multiplexing in MIMO-OFDMA technology are discussed in this paper. The performance and capacity analysis is investigated as a function of SNR of the MIMO channel. In section II description of the 8X8 MIMO system designed implementing both Spatial Diversity and Spatial Multiplexing is provided. In section III Simulation results of the performance and capacity analysis are provided.

2. System Model

General system model for MIMO communication system will consist of N_t Transmitter antennas and N_r Receiver antennas. In this paper 8 X 8 MIMO system is considered with 4 users sharing the MIMO channel. All the users are allowed to send data through MIMO channel at same time slot.

3. Transmitter Model

Here a MIMO OFDMA communication with Nt Transmitter antennas and Nr Receiver antennas is considered. Each user will be sending data through MIMO channel simultaneously. Let each user's message bits be

$$\mathbf{B= \{b_0, b_1, b_2, b_3 \ldots b_{N-1}\}} \qquad \mathbf{(1)}$$

This input message sequence of each user will be mapped into BPSK modulator. BPSK modulator is chosen since it is the simplest form of phase shift keying modulation. This modulation is said to be most robust since it takes the highest level of noise distortion to make the demodulator reach in an incorrect decision. Let BPSK modulated symbols be

$$\mathbf{S= \{s_0, s_1, s_2, s_3, \ldots s_{N-1}\}} \qquad \mathbf{(2)}$$

And these modulated symbols are allowed to pass through STBC encoder which encodes BPSK symbols into Nr sequence of data

$$\mathbf{C_k= \{c_k^{(0)}, c_k^{(1)}, c_k^{(2)}, \ldots\ldots c_k^{(N_r-1)}\}} \qquad \mathbf{(3)}$$

where $C_k^{(i)}$ is the coded symbols transmitted from i^{th} antenna to the k^{th} sub channel in MIMO system. Transmission matrix for two transmit antenna using Alamounti code

$$\mathbf{G=}\begin{bmatrix} \boldsymbol{c_1} & \boldsymbol{c_2} \\ -\boldsymbol{c_1^*} & -\boldsymbol{c_2^*} \end{bmatrix} \qquad \mathbf{(4)}$$

The matrix mentioned above is for two transmitter antennas using Alamounti's code. Here in above matrix, number of columns denotes number of transmitter antennas and number of row denotes time slot at which data is being transmitted through MIMO channel. Thus for a 2X2 MIMO system at first time slot c_1 and c_2 will be transmitted through antenna 1 and antenna 2 respectively and simultaneously. At second time slot $-c_2*$ and c_1* will be transmitted from antennas 1 and 2 simultaneously. The encoded data is appended with pilot bits in the beginning. The pilot bits are known to transmitter and receiver section. It is utilized for getting channel state information in the receiver side. After appending the pilots bit Serial to parallel converter is used for making 2 strands of data. The output of Serial to Parallel converter is fed into the IFFT block for OFDM modulation. Number of subcarrier equals the number of sub channels created by the N_t X N_r MIMO system. The OFDM symbols generated are

$$\mathbf{O_k= \{o_k^{(0)}, o_k^{(1)}, o_k^{(2)}, \ldots\ldots\ldots\ldots\ldots o_k^{(Nt-1)}\}} \qquad \mathbf{(5)}$$

where $O_k^{(i)}$ denotes OFDM symbol; transmitted from i^{th} antenna through the subcarrier. In similar fashion the other users also send data through two transmitter antennas. The basic block diagram of transmitter section is shown in Figure 1.

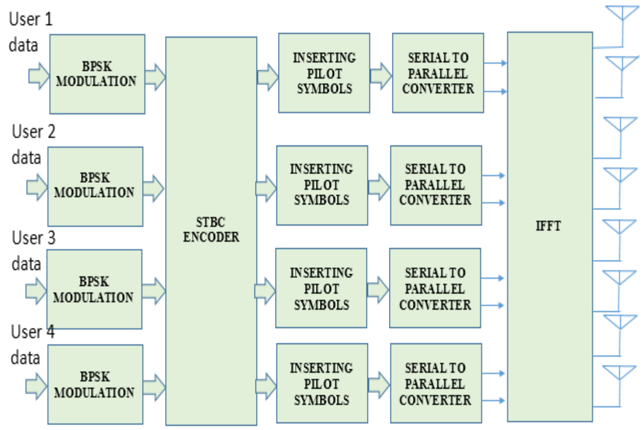

Figure 1. Transmitter Section

4. Channel Model

In this paper AWGN MIMO channel is considered. Amplitude distortion, diffraction, shadowing and reflection from the surrounding objects, which arises due to multipath propagation, will affect the data transmitted through the channel [8]. Thus, the corrupted data arriving at the receiver antennas will be with different phase, amplitude and at different time interval.

Time domain response of MIMO channel from i^{th} transmitter antenna to j^{th} receiver antenna can be modeled by the equation as follows

$$h_{i,j}(t)=\sum_{l=0}^{L-1} \propto_{i,j} (l)\delta(t-\tau_l) \quad (6)$$

where $\propto_{i,j}$ is the multipath gain coefficient. Here L denotes the number of resolvable paths in N_t X N_r MIMO system and represents the delay time in the multipath component.

5. Receiver Model

The received OFDM symbol $\{\widehat{O_K}\}$ at the receiver antenna are passed through OFDM demodulator. DFT will be performed since it mathematically similar OFDM demodulation operation. This will help to obtain encode symbols $\{\widehat{C_K}\}$ from the pilot symbols, known to both transmitter and receiver. The channel estimation is performed with the channel state information matrix. STBC decoding is performed to obtain the BPSK symbols

$$\widehat{S} =\{\widehat{S_0}, \widehat{S_1}, \widehat{S_2}, \ldots\ldots, \widehat{S_{N-1}}\} \quad (7)$$

Those symbols are passed through BPSK demodulator to obtain the bit stream

$$\widehat{B}= \{\widehat{b0},\widehat{b1},\widehat{b2}, \ldots\ldots\ \widehat{bN-1}\} \quad (8)$$

The bit stream obtained is compared with input stream for varying SNR of channel

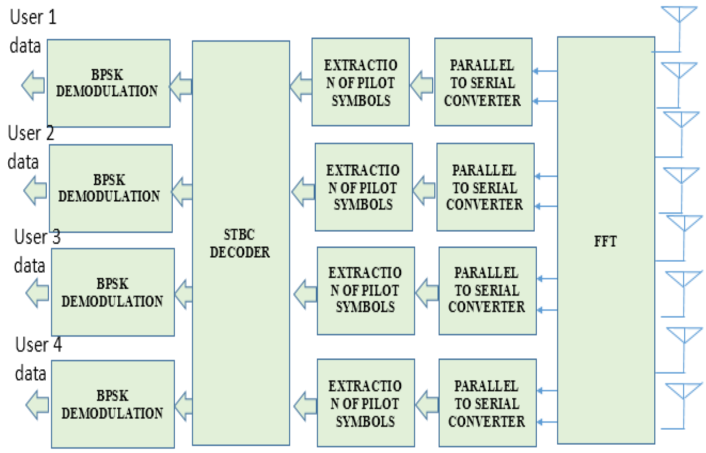

Figure 2. Receiver Section

6. Performance Analysis of MIMO-OFDMA System

Performance analysis is investigated for MIMO OFDM system with both spatial diversity and multiplexing techniques and with spatial multiplexing alone. This is measured in the form of metric like BER and SER as a function of SNR of MIMO channel. The plots obtained from simulations are show in Figure 3 BER Plot Comparison, which shows the values of BER as a function of SNR. Similarly, Figure 4 SER Plot Comparison provides the plot for SER as a function of SNR. Both the plot provides better performance for both Spatial Diversity and Spatial Multiplexing implemented system than with spatial multiplexing alone.

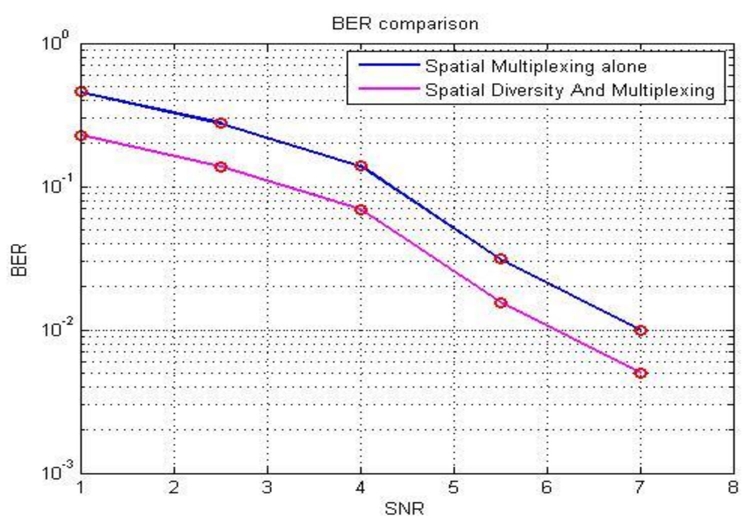

Figure 3. BER Plot Comparison

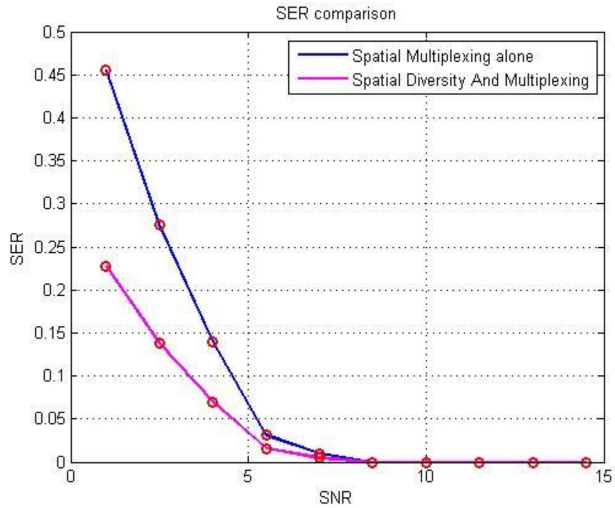

Figure 4. SER Plot Comparison

7. Capacity Analysis of MIMO-OFDMA System

Here MIMO channel capacity per unit bandwidth and throughput is investigated as a function of SNR. MIMO OFDM system with spatial diversity alone and with both spatial diversity and multiplexing techniques is compared for its spectral efficiency. The Figure 6 demonstrates the spectral efficiency of MIMO-OFDMA communication system with spatial diversity alone and with both spatial diversity and spatial multiplexing. The plots obtained from simulations are show in Figure.5 Throughput Plot Comparison, which shows the values of Throughput as a function of SNR. Similarly, Figure.6 Spectral Efficiency Plot Comparison provides the plot for Spectral Efficiency as a function of SNR. Both the plot provides better performance for both Spatial Diversity and Spatial Multiplexing implemented system than with spatial multiplexing alone.

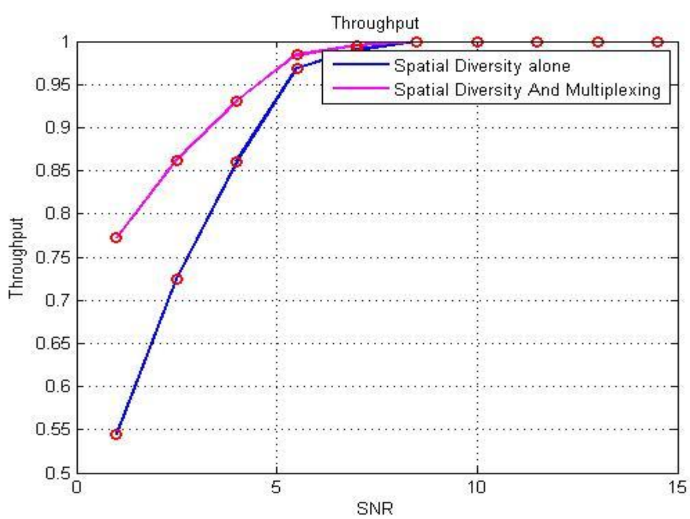

Figure 5. Throughput Plot Comparison

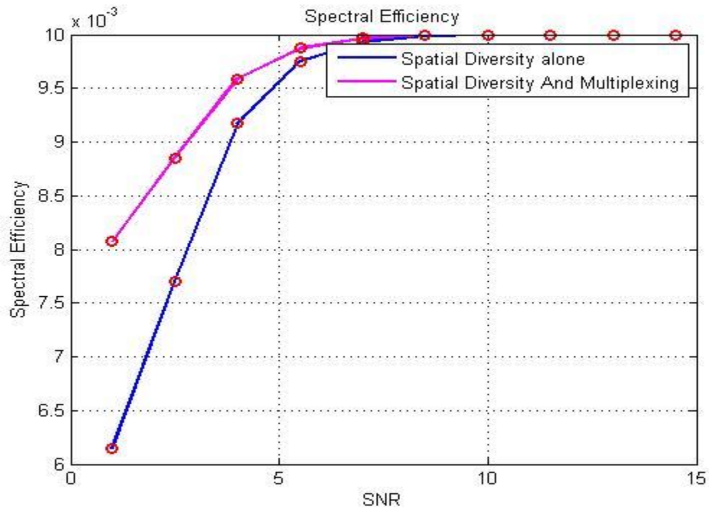

Figure 6. Spectral Efficiency Plot Comparison

8. Conclusion

In this paper the performance of the MIMO-OFDMA system under AWGN channel is evaluated. Here the performance and capacity of the system with spatial diversity alone and with both spatial diversity and spatial multiplexing are investigated for metrics like throughput and spectral efficiency as a function of SNR. Similarly, performance and capacity of the system with spatial multiplexing alone and with both spatial diversity and spatial multiplexing are investigated for metrics like BER and SER as a Function of SNR. From the analysis it is found that Spatial Multiplexing and Spatial Diversity implemented system is showing better performance metric compared to with that of spatial multiplexing alone or spatial diversity alone

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