



Performance Improvement of Combined Array Processing for High Data Rate in Time Varying Channel Wireless Environment

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Abstract— Orthogonal space-time block code (OSTBC) designs for four-user MIMO X channels are used to finalize full diversity while the inter-user interference is eliminated by the group of zero-forcing receivers of channel codes for better data speed and stability for wireless environment. The use of multiple transmitters and receivers as an alternative to single one can help out to recover consistency without any concatenation in the bandwidth expenditure. This paper expedites the reduction in encoding and decoding complexity by partitioning antennas at the transmitter into small groups that is single space-time codes, to transmit source information from every cluster of antennas. At the receiver structure is derived to provide full diversity and coding gain above encoded systems. This mixture of array processing at the receiver and coding techniques for multiple transmit antennas can provide truthfully and extremely raised data rate communication over narrowband wireless channels. A improvement of this fundamental structure begin to a multilayered space-time architecture which summarizes and enhances upon the layered space-time architecture.

Keywords— Orthogonal Space Time Block coding, MIMO, diversity, decoding complexity, combined array processing

I. INTRODUCTION

The demands for the capacity in wireless environment are increasing exponentially, thanks to the speed in the utilization of mobile telephone, Internet and multimedia services all over the world. However, there is a limitation on the available radio spectrum and a heavy increase in communication spectral efficiency is important for the capacity demands. Band limited wireless channels are initially like narrow pipes, which do not allow quick flow of data. Development in coding with reference to a one antenna link have reached a state all the way through the use of turbo and low density parity check codes, the present effort is thus partial towards the use of multiple antenna links. In fact it is now installed that the capacity of a multichannel system is more superior to that of a single. Channel communication system. In fact, as long as the number of receive antennas is more than equal to the number of transmit antennas the capacity rises almost linearly with the number of transmit antennas, assuming final propagation.

In MIMO system at the transmitter and at the receiver in a wireless communication link allow a new dimension in uniform communication, which can expand the system performance physically. The concept behind MIMO is that the transmit antennas at one end and the receive antennas at the other end are “connected and combined” in such a way that the quality (the bit error rate (BER), or the data rate) for each user is developed. The basic idea in MIMO transmission is space-time signal processing in which signal processing in time is complemented by signal processing in the spatial dimension by using multiple, spatially distributed antennas at both link ends.

The purpose of antenna arrays at the transmitter and receiver to form a multi-input multi-output (MIMO) system has emerged as a powerful technique to improve the information rates and reliability of wireless links at low cost. High data rate wireless communication systems are becoming more and more desirable for universal personal [2]. Physical limitations on wireless channels present a primary technical challenge to reliable communication. Bandwidth limitations, propagation loss, time variance, noise, interference, and multipath fading construct the wireless channel a narrow pipe that does not easily accommodate the flow of data. Additional challenges come from power limitation in addition to the size and speed of devices in wireless portables.

Multiple transmit antennas at both the base and remote stations increases the capacity of wireless channels and information theory provides trials of this increase. The standard approach to exploit this capacity is linear processing at the receiver or extensions thereof [1].

Transmit diversity has been explored and includes the delay diversity scheme of the space-time codes which provide the best possible tradeoffs between constellation size, data rate, diversity gain, and trellis complexity[15]. Space-time codes combine signal processing at the receiver with coding techniques appropriate to multiple transmit antennas, and

this approach provides significant gain over and. To reduce encoding and decoding complexity by partitioning antennas at the transmitter into tiny groups, and using individual space–time codes to transmit information from each group of antennas. [11]. Thus space–time codes are decoded at the receiver by making use of linear processing technique which helps to suppress signals transmitted by other groups of antennas by treating them as intervention. A simple receiver arrangement is consequent that provides diversity and coding gain over encoded systems. This mixture of array processing at the receiver and coding techniques for multiple transmit antennas can provide reliable and very high data rate communication over narrowband wireless channels. An enhancement of this fundamental structure gives rise to a multilayered space–time architecture that both generalizes and improves upon the layered space–time architecture proposed by Foschini. A mixture of space–time coding at the transmitter and array processing at the receiver accomplishes high data rates.

II. THE COMMUNICATION MODEL

This model shows an adaptive orthogonal space-time block code (OSTBC) transceiver system over a multiple-input multiple-output (MIMO) channel. The system uses a variable number of transmit and receive antennas. In any frame, the system operates with one, two, three or four transmit or receive antennas. The number of the transmit and receive antennas are adaptive and change either manually or according to an adaptation algorithm, based on the difference between target and actual frame-error rates of the overall system. OSTBCs are attractive techniques for MIMO wireless communications. They exploit full spatial diversity order and employ symbol-wise maximum likelihood (ML) decoding. The OSTBC Combiner block at the receiver side provides soft information of the symbols that the system transmits, which can be utilized for decoding or demodulation of an outer code. The Bernoulli Binary Generator block produces the information source for this simulation. The block generates a frame of random bits. The Frame length parameter determines the length of the output frame.

The QPSK Modulator block modulates the message data from the Bernoulli Binary Generator to a quaternary PSK constellation. The output is a baseband representation of the modulated signal with an output size equal to half of the Bernoulli Binary Generator block output size, as every two input bits produce one modulated symbol. The MIMO Channel block simulates the frequency-flat Rayleigh fading MIMO channel from the N_t transmit antennas to the N_r receive antennas. The block is configured as a spatially independent 4×4 MIMO channel with transmit and receive antenna selection. The Sample rate (Hz) parameter is set to $2e6/3$ that is calculated based on the frame length, code rates and model sample time. The Maximum Doppler shift (Hz) parameter is set to 100. The block uses this value so the MIMO channel behaves like a quasi-static fading channel, i.e., it keeps relatively constant during one code block transmission and varies along multiple blocks.

The first input to this block is an $(N_s \times N_t)$ variable-size matrix, where the number of columns (N_t) corresponds to the number of selected transmit antennas and the number of rows (N_s) corresponds to the number of orthogonal code samples that the system transmits over each transmit antenna in a frame. The second and third inputs to this block are (1×4) fixed-size binary row vectors to indicate that the first N_t transmit and N_r receive antennas are being selected for the current frame transmission, respectively. The first output of this block is an $(N_s \times N_r)$ variable-size channel output matrix. The second output of this block is an $(N_s \times 1 \times 4 \times 4)$ variable-size channel gain array with NaN values for those unselected transmit-receive antenna pairs. The first input of this block is the first output of the MIMO Channel block. The second input of this block is the noise variance calculated from the number of transmits antennas (N_t) and the Signal to noise ratio (SNR) value, where the MIMO channel normalization has been taken into account.

The OSTBC Combiner block combines the received signal $rxSig$ with the channel state information (CSI) $chEst$ to output the estimates of the modulated symbols. The input signal $rxSig$ is an $(N_s \times N_r)$ variable-size matrix and the input signal $chEst$ is an $(N_s \times 1 \times 4 \times 4)$ variable-size array. In this example, the CSI is assumed perfectly known at the receiver side. This block is a MATLAB Function block that uses the `comm.OSTBCCombinerSystem` object to implement the combining algorithm for the selected transmit and receive antennas. The QPSK Demodulator block demodulates the output of the OSTBC Combiner that is the recovered modulated signal using the quaternary phase shift keying method. The input is a baseband representation of the modulated signal with an input size equal to half of that of the Bernoulli Binary Generator block, as everyone input symbol produces two output bits. The Frame Error Rate (FER) Calculation subsystem compares the decoded bits with the original source bits per frame to detect errors and dynamically updates the FER along the simulation. The output of this subsystem is a three-element vector containing the FER, the number of error frames observed, and the number of frames processed. This vector is from the Error Rate Calculation block and also saved as a MATLAB workspace variable `FER Data` to ease the simulation for multiple SNR values

The OSTBC Encoder block encodes the information symbols from the QPSK Modulator by using either the Alamouti code for two transmit antennas or other generalized complex orthogonal codes for three or four transmit antennas. The number of transmit antennas is given to this block as an input. The output of this block is an $(N_s \times N_t)$ variable-size matrix, where the number of columns (N_t) corresponds to the number of transmit antennas and the number of rows (N_s) corresponds to the number of orthogonal code samples transmitted over each transmit antenna in a frame. This block is a MATLAB Function block that uses the `comm.OSTBCEncoderSystem` object to implement the encoding algorithm for selected transmit antennas.

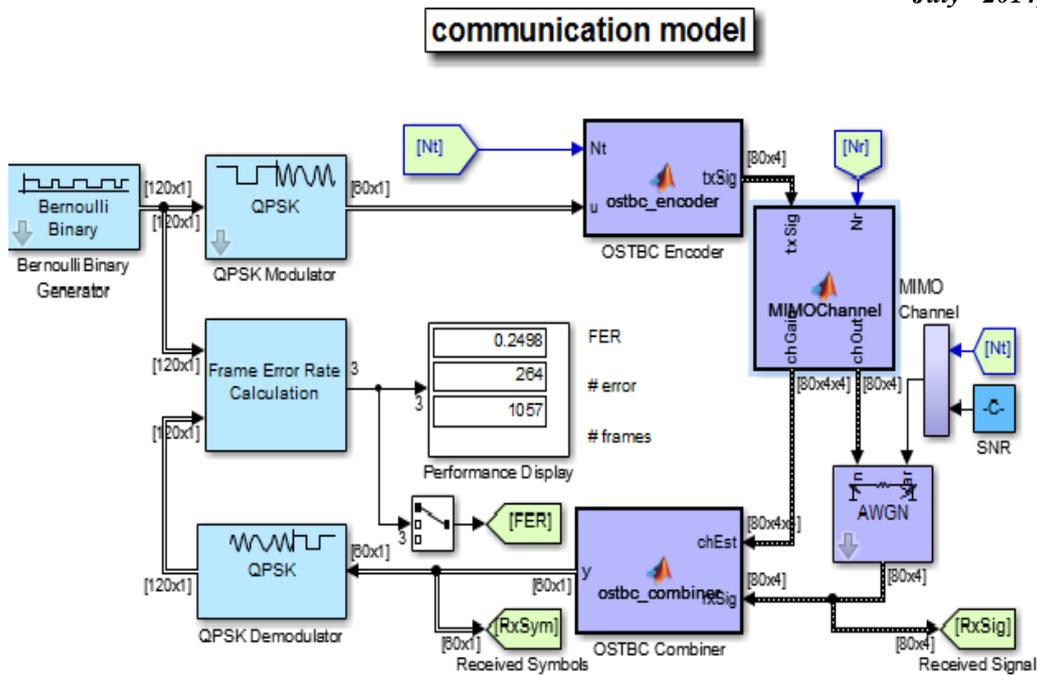


Fig 1. Communication model

III. MAXIMUM RATIO COMBINING

In Maximum Ratio combining, the technique used to merge each signal branch is multiplied by a weight factor which is proportional to the signal amplitude. Thus branches with strong signal are further amplified, while weak signals are attenuated. The following steps are involved which comprises of,

- 1) The signals from each channel are added together.
- 2) The gain of each channel is made relative to the rms signal level and inversely proportional to the mean square noise level in that channel.
- 3) Diverse proportionality constants are used for each channel.

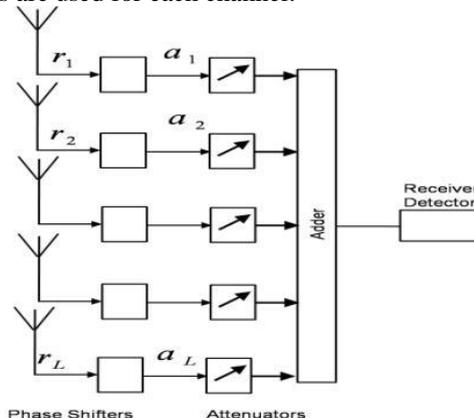


Fig. 2. Maximum Ratio Combining Diversity Scheme

Maximal-ratio combining is the optimum combiner for independent AWGN channel. It is a linear combining method, in which various signal inputs are individually weighted and added together to get an output signal which is shown in Fig 1

IV. ZERO FORCING DETECTION TECHNIQUE

Spatially multiplexed MIMO systems can transmit data at a higher data at a higher speed than MIMO system using antenna diversity techniques, spatial demultiplexing using antenna detection at the receiver side is a challenging task for SM MIMO systems. Consider the $N_R \times N_T$ MIMO system in fig. Let H denote a channel matrix with its $(j, i)^{th}$ entry h_{ji} for the channel gain between the i^{th} transmit antenna and the corresponding received signals are represented by

$$x = [x_1, x_2, \dots, x_{N_T}]^T \text{ and } y = [y_1, y_2, \dots, y_{N_R}]^T$$

where x_i and y_j denote the transmit signal from the i^{th} transmit antenna and received signal at the j^{th} receive antenna. Let z_j indicates the white Gaussian noise with a variance at j^{th} receive antenna and h_i denote the i^{th} column vector of the channel matrix H . The $N_R \times N_T$ MIMO system is represented as

$$y = H_x + z$$

$$= h_1 x_1 + h_2 x_2 + \dots + h_{N_r} x_{N_r} + z$$

Where $z = [z_1, z_2, \dots, z_{N_r}]^T$

V. LINEAR SIGNAL DETECTION METHOD

Linear signal detection method treats all transmitted signals as interferences except for the desired stream from the target transmit antenna. Therefore, interference signals from other transmit antennas are minimized or nullified in the course of detecting the desired from each antenna the effect of the channel is inverted by a weight matrix W such that

$$\tilde{x} = [\tilde{x}_1 \tilde{x}_2 \dots \tilde{x}_{N_r}]^T = W_y$$

$$\tilde{x}_{ML} = \arg \min_{x \in C^{N_r}} \|y - H_x\|^2$$

$$\|y - H_x\|^2$$

The standard linear detection methods include the zero-forcing (ZF) technique and the minimum mean square error (MMSE) technique.

VI. ZF SIGNAL DETECTOR

Zero forcing technique is a method in which the interference get nullified by following weight matrix

$$W_{ZF} = (H^H H)^{-1} H^H$$

Where $(.)^H$ = Hermitian transpose operation

$$\tilde{x}_{ZF} = W_{ZF} y$$

$$= x + (H^H H)^{-1} H^H z$$

$$= x + \tilde{z}_{ZF}$$

Where $\tilde{z}_{ZF} = W_{ZF} z = (H^H H)^{-1} H^H z$

Error performance is directly connected to the power of \tilde{z}_{ZF} (i.e., $\|\tilde{z}_{ZF}\|_2^2$)

$$\|\tilde{z}_{ZF}\|_2^2 = \|(H^H H)^{-1} H^H z\|^2$$

$$= \|(V \Sigma^{-2} V^H)^{-1} V \Sigma U^H z\|^2$$

$$= \|V \Sigma^{-1} U^H z\|^2$$

VII. SIMULATION RESULTS

To view data graphically, open the display window by double-clicking the Signal Visualization icon. This subsystem generates a figure that helps visualize the effect of varying the number of transmit or receive antennas on the overall frame-error rate of the system. The plots within the display window show: The frame error rate as a function of time The number of transmit and receive antennas in the current frame Scatter plots of the received signal before and after the OSTBC Combiner. The plot of the OSTBC Combiner output indicates the system is recovering a signal with a QPSK constellation. Colour Legend The model uses colours at the top level of the hierarchy to help you distinguish blocks that play different roles. Light Blue colour code represents blocks, or subsystems composed of blocks, from the Communications System Toolbox™. Light Green colour code denotes blocks involved in signal routing, measurements and displays.

Blue colour code represents blocks you can use to set different parameters of the model. Purple colour code represents blocks that use MATLAB Function blocks with System objects. You can examine, edit or change the System object configurations that characterize the operations of these blocks. When you load this model, you create a variable called 'adaptivemimo' in the MATLAB workspace. This variable is a MATLAB structure containing five fields. By modifying any of these fields (FrameLen, SNR, TargetFER, MaxNumErrs, MaxNumFrames), you can explore the effects of different parameter settings on the simulation duration and numerical results. These five fields correspond to parameters used in this model, i.e., (Frame length, Signal to noise ratio (SNR), Target frame error rate Maximum number of errors and Maximum number of frames) respectively. You can set different values for these five parameters, by double-clicking the sub-system found in the top portion of the model, called Model Parameters, and typing your desired parameters values directly in the dialog boxes.

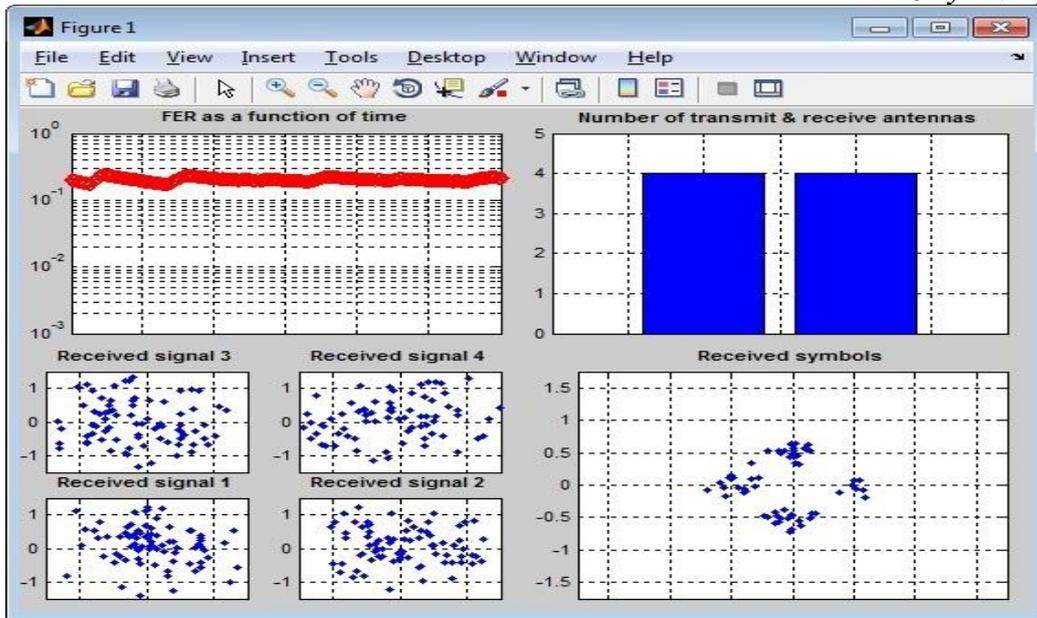


Fig.3 Graph of FER vs time

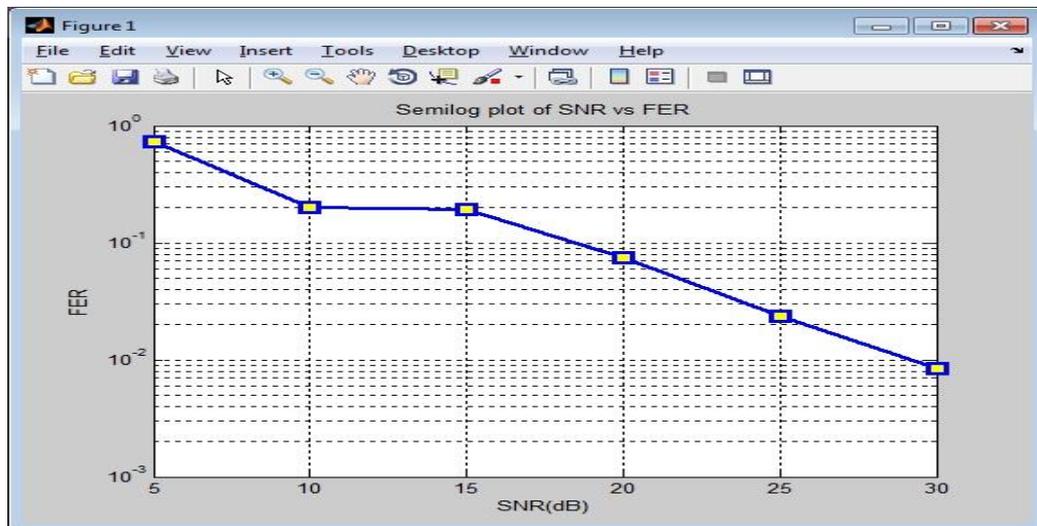


Fig.4 Graph of SNR vs FER

VIII. CONCLUSION

In this research work, proposed a full-diversity STBC design criterion for four-user MIMO X channels when the group ZF receiver is utilized to eliminate inter-user interference. Based on the design criterion, the proposed STBC approaches code rate of one symbol per channel use. Simulation results were presented to show that proposed STBCs achieved full diversity under the group ZF receiver. As SNR is increased and FER is decreased the interference is suppressed and data rate gates high.

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