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Transmitter Optimization for performance enhancement of MIMO

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ABSTRACT Recently, there has been an explosion of growth in research on MIMO (Multiple Input Multiple Output) systems. In this paper, space-time block coding (STBC) and spatial multiplexing MIMO techniques are considered as a means of enhancing the performance of MIMO. A hybrid 4x4 scheme is presented that combines spatial multiplexing and STBC to provide both increased throughput and diversity. Results showed that the proposed scheme can provide good performance even under correlated channels.

KEYWORDS : MIMO, Space time block coding, Spatial Multiplexing,

INTRODUCTION

For advancement of wireless communication systems, methods such as MIMO, OFDM and integrating them together as MIMO-OFDM are very useful. OFDM is used in numerous wireless transmission standards nowadays. In OFDM, high rate data stream is divided into low rate streams which are transmitted together over a number of subcarriers. A broadband and frequency-selective channel is transformed into a multiplicity of parallel narrow-band single channels by the OFDM modulation.

In this paper a hybrid 4x4 scheme is investigated that combines spatial multiplexing and STBC to provide both increased throughput and diversity to future generation STBC is a simple and attractive space time coding scheme that was proposed by Alamouti [4]. It requires only a small degree of additional complexity and is suitable for the slow fading environments of MIMO . STBC can enhance performance by exploiting spatial diversity. This is particularly useful in the case where the delay spread of the environment is low (i.e. low frequency diversity). For these reasons, STBC techniques have been examined to enhance the BER performance of MIMO. Spatial multiplexing [5] relies on transmitting independent data streams from each

transmit antenna. These data streams can be multiplexed from the incoming source stream. If N transmit and receive antennas are present then data can be sent at N-times the rate of a standard terminal. Spatial multiplexing exploits the benefits of the MIMO channel to enhance the rate at which data is sent, rather than enhancing the reliability of its detection.

I. SPACE TIME BLOCK CODING

In [4] Alamouti proposed a simple transmit diversity scheme which was generalized by Tarokh [3] to form the class of Space Time Block Codes. These codes achieve the same diversity advantage as maximal ratio receive combining. The transmit diversity scheme can be easily applied to OFDM in order to achieve a diversity gain over frequency selective fading channels [2]. Alamouti code is not a just code but technique to achieve reliability of data transmission in wireless communication. According to Alamouti code, two transmit and receive antennas are used for Space Time Block Code. For first time slot, antenna 1 and 2 simultaneously transmit symbol $-s_2^*$ and s_1^* respectively. For two consecutive time slots, received symbols can be represented as

$$[y_1 \ \ y_2] = [h_1 \ \ h_2] \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} + [n_1 \ \ n_2]$$

So each symbol has been transmitted twice and that is how data redundancy is achieved for efficient decoding at receiver. Hence, code rate is 1. Also it is assumed that channel is constant for a symbol block and changing from one block to other(*6*). Encoder consists calculation and transmitting data symbols from antennas for different time slots. For digital modulation like BPSK,QPSK, QAM, there are 2^d constellations, in which d is bits per symbol. At any time slot, 2d bits come at encoder and pick up two constellation symbols. By conjugating matrix given in (3),it has been observed that two columns (first one for S_2) become orthogonal. So detection rule at receiver converts in two separate, orthogonal issues.

II. SPATIAL MULTIPLEXING

Spatial multiplexing, also known as Bell Laboratories
Layered Space Time Architecture (BLAST), represents a direct exploitation of the available space-time resources. The first BLAST proposed in the literature is Diagonal BLAST (DBLAST [5] which has a diagonal layering space-time coding process with sequential nulling and interference cancellation decoding. One of the disadvantages of this type of structure is that with diagonal layering some space-time is wasted at the start and end of a burst. Also, it is constructed using 1-*NT* constituent codes (where *NT* represents the number of transmitting antennas), generally block codes, in order to decode each diagonal layer. This is therefore an impractical system for enhancement of 802.11a. Vertical BLAST[] overcomes this problem by using a horizontal layering space time structure that does not waste space-time resources, and does not require *NT* constituent codes. However, the major drawback of V-BLAST is that it does not utilize transmit diversity. This is solved in this study by introducing a convolutional code with a space interleaver before the data is demultiplexed, as well as exploiting the frequency diversity of OFDM.

The channel is demonstrated by N_r x N_t matrix (N_r is number of receivers and N_t is number of transmitters):

$$H = \begin{pmatrix} h_{1,1} h_{1,2} \ldots\ldots h_{1,N_t} \\ h_{2,1} h_{2,2} \ldots\ldots h_{2,N_t} \\ \vdots \quad \vdots \quad \quad \vdots \\ h_{N_r,1} h_{N_r,2} \ldots h_{N_r,N_t} \end{pmatrix}$$

where each term $h_{a,b}$ shows phase shift and attenuation between b^{th} transmitter and a^{th} receiver. With assumption of spatially independent Rayleigh channel and independent and identically distributed (i.i.d.) AWGN noise symbols with mean zero and variance N_0, received signal is represented by

$y = Hx + n$

III. THE HYBRID ALGORITHM

This section presents a hybrid algorithm [5] that combines spatial multiplexing and space time block coding techniques to achieve both enhanced throughput and packet error rate performance. Both a 4x2 and a 4x4 configuration will be examined. Figure 1 shows a block diagram of the proposed architecture for the 4x2 configuration. As described in the previous sections, results showed that not all of the antennas should be used for only spatial multiplexing or only diversity. We will apply this method for an OFDM based system, and the transmitted streams will be interleaved for additional diversity as described in Section IV. For example, if we assume the 4x2 configuration in Figure 1, there are *K*= 2 streams, and each stream goes to a STBC scheme and is transmitted over *N*=2 antennas. Hence the terminal has *KxN*=4 transmit antennas and a minimum of *K*= 2 receive antennas are required to detect the streams employing ZF techniques. The above configuration provides double the throughput (similar to 2x2 spatial multiplexing) and a diversity order of 2.

The received signal at time t,

$y1 = h_{11}{}^{*}x_1 + h_{12}{}^{*}x_2 - h_{13}x_2{}^{*} + h_{14}x_1{}^{*} + n_1$

$y2 = h_{21}{}^{*}x_1 + h_{22}{}^{*}x_2 - h_{23}x_2{}^{*} + h_{24}x_1{}^{*} + n_2$

$y3 = h_{31}{}^{*}x_1 + h_{32}{}^{*}x_2 - h_{33}x_2{}^{*} + h_{34}x_1{}^{*} + n_3$

$y4 = h_{41}{}^{*}x_1 + h_{42}{}^{*}x_2 - h_{43}x_2{}^{*} + h_{44}x_1{}^{*} + n_4$

Where y1, y2, y3, y4 are receive symbols, h is a channel matrix, and x1, x2, x2*, -x1* are transmitted symbols , and n1, n2, n3, n4 noise symbol.

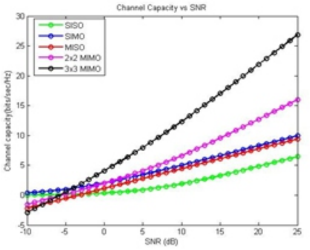

Figure 1. Channel Capacity Comparison for different antenna schemes

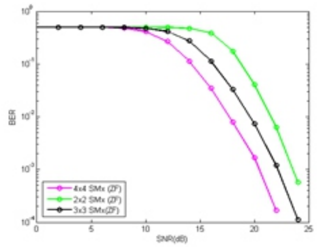

Figure 2. comparison between different transmitting antenna in spatial multiplexing (MIMO).

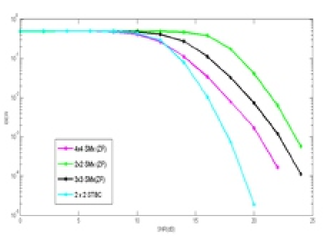

Figure 3. MIMO STBC v/s Spatial Multiplexing

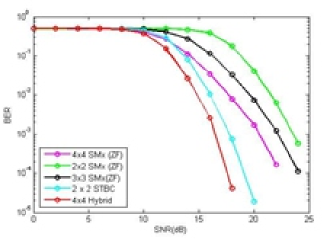

Figure 4. Hybrid results compared with STBC and spatial multiplexing

I. RESULTS

Simulation has been done on MATLAB software to Compare the channel Capacity of different antenna schemes. As shown in fig -1 as the number of antenna increases in MIMO the capacity of MIMO will increases. Next in fig -2 shows comparison between different transmitting antenna in spatial multiplexing (MIMO). Spatial multiplexing is best choice for the applications where speed or data transmission rate is having primary importance than BER. Fig -3 shows BER significantly less in STBC as compared spatial multiplexing. Spatial multiplexing gives higher throughput, gives twice data rate. Fig -4 shows the result of hybrid with compared to different antennas of spatial multiplexing (zero forcing equalizer) and spatial diversity (2Tx, 2Rx). Hybrid gives better result than other techniques

II. CONCLUSION

In this paper a hybrid 4x4 scheme was investigated for MIMO. This scheme combines spatial multiplexing and STBC to provide both increased throughput and diversity. Performance results for MIMO employing the hybrid MIMO technique were presented for both a 4x2 and a 4x4 configuration employing ZF detection. Bit Error Rate and throughput performance results under different channel conditions showed that the hybrid algorithm

can provide enhanced performance relative to a standard spatial multiplexing approach. It was shown that the proposed scheme can provide double the throughput of a 2x2 spatial multiplexing system at low SNR values.

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