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COMBINATION OF SM & STBC FOR MIMO COMMUNICATIONS: PEFRMANCE EVALUTION OF GLSTC TO IMPROVE DIVERSITY & MULTIPLEXING GAIN

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Abstract- As MIMO system can provide two types of gains so that most current research focuses on designing schemes to extract either maximal diversity gain or maximal spatial multiplexing gain. MIMO can achieve sufficiently high data-rate using SM technique, which transmit independent stream over different transmitting antennas simultaneously. So, channel capacity increases linearly with minimum number of transmitting and receiving antennas. However, Due to channel impairments such as multipath propagation, the capacity of wireless channels cannot be fully exploited. Hence SM MIMO detectors are evaluated on flat fading channel, but in real time environment channel is highly time-varying and frequency selective. OFDM is an efficient technique to combat the ISI in frequency selective channel. So this paper introduces GLSTC technique to overcome the above problem. Here GLSTC technique is a trade-off technique between multiplexing gain and diversity gain is evaluated. This GLSTC technique combines both SM and STBC techniques to achieve both higher bit rate and better quality simultaneously rather than SM MIMO detectors.
Keywords –MIMO System, Group layers space-time coding (GLSTC), SM-spatial Multiplexing, STBC-Space-time block code, ISI- Inter Symbol Interference.

I. INTRODUCTION

The basic definition of diversity is the presence of a wide range of variation in the qualities or attributes under discussion. For wireless links, this translates to having a number of copies of the desired signal at the receiver which varies in terms of signal to noise ratio (SNR). In practice however, all forms of diversity schemes cannot be implemented because of the nature of the channel available and of the signaling employed. For instance, a slow fading channel that has a long coherence time cannot support temporal diversity with practical interleaving depths. Similarly, frequency diversity is not feasible when the coherence bend with of the channel is comparable to the signal bandwidth. However, irrespective of the channel characteristics, space diversity can always be efficiently implemented as long as the antenna elements are sufficiently placed apart, so as to have uncorrelated fading channels at the transmitter and/or receiver. Another attractive feature is the fact that unlike time and frequency diversity, space-diversity does not introduce any loss in bandwidth efficiency. Most current research focuses on designing schemes to extract either maximal diversity gain or maximal spatial multiplexing gain. There are

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also schemes which switch between the two modes, depending on the instantaneous channel condition [9].

However, maximizing one type of gain may not necessarily maximize the other. For example, it was observed in [2] that the coding structure from the orthogonal designs for STBC, while achieving the full diversity gain, reduces the achievable spatial multiplexing gain. In fact, each of the two design goals addresses only one aspect of the problem. This makes it difficult to compare the performance between diversity-based and multiplexing based schemes. So, it is better to combine both the scheme which provides fundamental trade-off between these two types of gain. In [7] it is shown that for a given MIMO channel, both gains can in fact be achieved but there is a fundamental trade –off between how much of each type of gain can be extracted by any particular scheme. It is proved in [2] that a complex orthogonal design and the corresponding space-time block code which provides full diversity and full transmission rate is not possible for more than two antennas (see [2,Theorem 5.4.2]).

For the specific cases of three and four transmit antennas [2] also proposed codes with ¾ of the full transmission rate. In [5] a different strategy for designing space –time block codes was proposed. Here rate 1 codes that provide half of the maximum possible diversity for three and four transmit antennas were presented. However, this approach does not come close to yielding the rate $r_s=N_T$ provided by SM. Conversely, SM suffers from performance issues due to the low diversity order. As mentioned earlier the maximum diversity order achievable by V-BLAST is > N_{R-} N_T+1, < N_R with a constraint of $N_R \geq N_T$. Different methodologies were proposed in [1] which aimed at improving the diversity order of the first decoded layer by transmitting signals using a lower modulation level such as QPSK or 8-PSK. Work presented in [4], [5] and [10] is geared towards sacrificing either diversity gain to improve spatial multiplexing gain, or sacrifice spatial multiplexing gain to improve diversity gain. In other words, the desire has been to obtain a suitable rate diversity trade-off.

II. PROPOSED ALGORITHM

A. System Model

SM technique for data rate maximization and STBC technique of diversity maximization is used, now we combine both of them to achieve dual gains. In this scheme transmit stream is partitioned different into groups and then each group STC is applied so called as Group layers space-time coding (GLSTC). In STBC and SM combined transmission strategy and a detector that contains a group receiver followed by space-time decoder as shown in fig. 1.

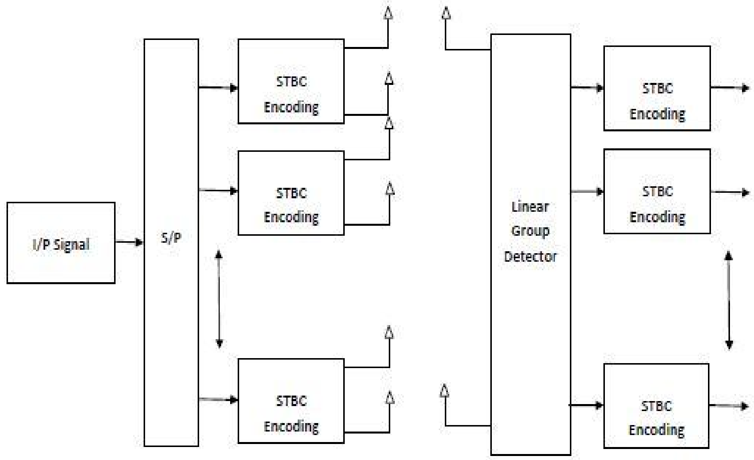

Fig. 1 Combined Transmission Scheme and Decoder Structure for GLSTC.

The MIMO communication link consist of M_T transmit antennas and M_R receive antennas ($M_R \geq M_T$). The channel propagation coefficients between each pair of transmit antenna and receive antenna are assumed to be CN (0, 1), constant over a block of symbols period, and change from block to block independently.

We use a $M_R \times M_T$ matrix **H** to desire the channel. It is assumed that perfect channel state information (CSI) is only known at the receiver. Since the number of the antenna is even ,if every two transmit antenna are considered as a group, the channel matrix can be seen as a collection of $M_R \times 2$ matrix group, h_k ,$k \in [1, M_T/2]$:

$$H= [h_1, h_2, \ldots\ldots, h_{NT/2}] \qquad [1]$$

During two symbol periods, a sequence of symbols are transmitted and multiplexed. Every two symbols are grouped and modulated by a 2×2 space –time encoder and the k-th space-time coded block is given by:

$$\mathbf{S_k} = \begin{bmatrix} s_{2k-1} & S^*_{2k} \\ s_{2k} & -S^*_{2k-1} \end{bmatrix} \qquad [2]$$

The $M_T/2$ space-time coded blocks are transmitted in parallel and the received signal is given by

$$y=HS + n \qquad [3]$$

$$y = \sum_{k=1}^{N_{T/}2} h_k s_k + n \qquad [4]$$

Where $S= [s_1, s_2, \ldots\ldots, s_{MT/2}]^T$ has dimension $M_T \times 2$ and n is the $M_R \times 2$ dimensional noise matrix whose entries are assumed i.i.d complex Gaussian with zero mean and variance of σ_n^2.

B. Detection of GLSTC

In the Aamouti's code and SM combined system, the detector consist of two steps: the first is the introduction of the group receiver that separates the filtered version of the time bocks; in the second step, space-time decoder for Aamouti's code is used to estimate the signal from the output Zero-forcing group receiver.

ZF criteria as group receiver to separate out different streams came from independent group from transmitter. The ZF group receiver is described as a matrix of dimension $M_R \times M_T$, that makes the channel matrix block diagonal, i.e.,

$$W_{ZF}H = \text{diag}\,[H_{1,}\ H_{2,}\ \ldots\ldots, H_{MT/2}] \quad [5]$$

Each block on the main diagonal of the combined matrix of ZF group receiver and channel matrix has dimension 2×2, which is the virtual channel of the corresponding space-time coded block.

$$W^{ZF} = \mathbf{H}^{-1},$$

$$H_1 = \ldots.. = H_{NT/2} = \mathbf{I_2} \quad [6]$$

The virtual channel matrix of the space-time coded block is not unique and depends on the decomposition of the original channel matrix, of a 4×4 channel matrix decomposed as

$$H = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \quad [7]$$

In order to make the channel matrix block diagonal, the ZF group receiver takes the following form:

$$W^{ZF} = \begin{bmatrix} B^{-1} & -D^{-1} \\ A^{-1} & -C^{-1} \end{bmatrix} \quad [8]$$

So that,

$$W^{ZF}H = \begin{bmatrix} B^{-1}A - D^{-1}C & 0_2 \\ 0_2 & A^{-1}B - B^{-1}D \end{bmatrix} \quad [9]$$

Separating the signal corresponding to all groups, the STBC decoding of each signal is performed to recover the desired signal.

III. SIMULATION AND RESULT

For a GLSTC system, we consider a MIMO system with four transmit antenna and four receiver antennas.

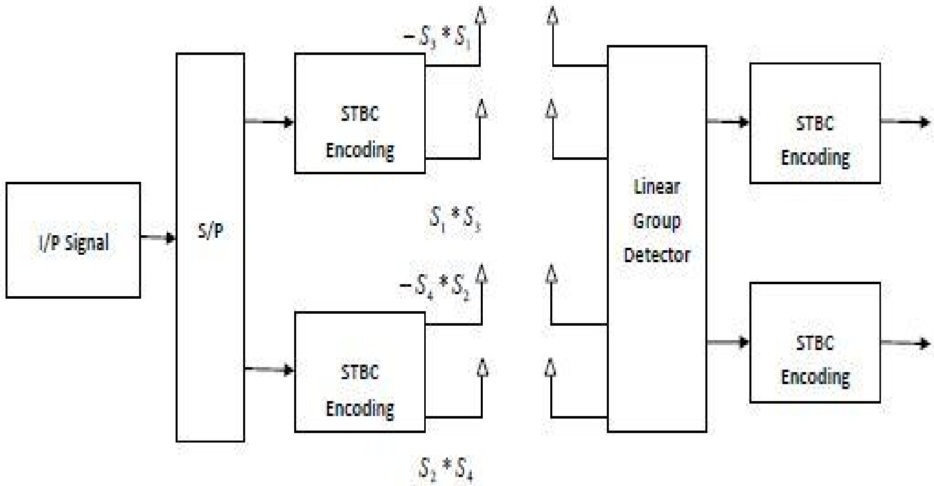

Fig. 2 GLSTC with Four Transmitting and Four Receiving Antennas

As shown in fig.2 as the transmitter side input signal is divided into two groups and STBC encoding is perform, in each group two symbols are transmitted in two time slots. The channel remains constant for this two time slots and then changed in the next pair of symbols. So, this scheme transmits four different symbols in the two time slots, means effectively double data rate. Moreover it also provides same diversity gain as provided by almouti scheme means double. We can achieve both gains simultaneously using this scheme.

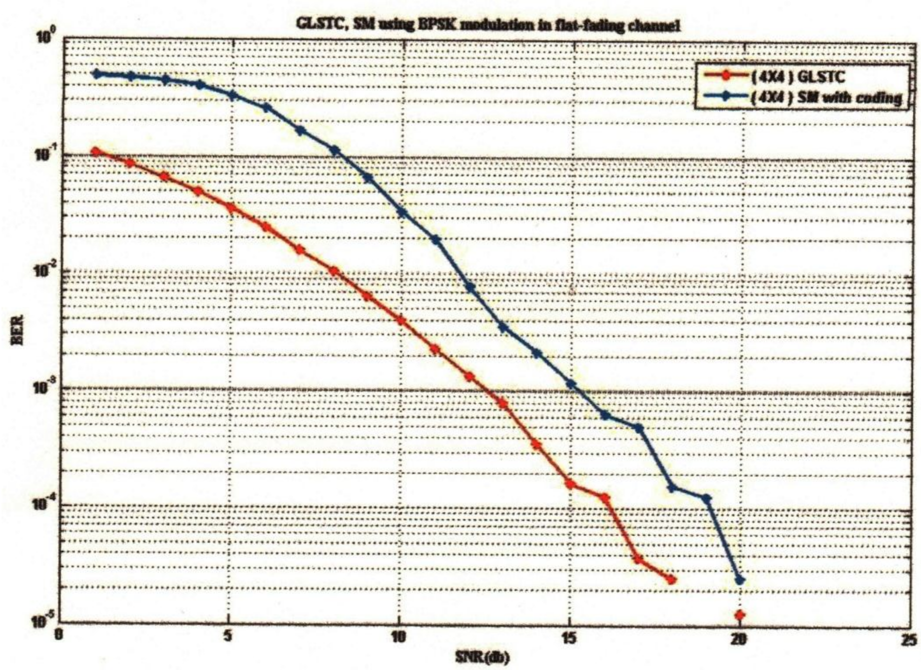

Fig 3 GSLTC 4×4 SM with Coding using BPSK Modulation

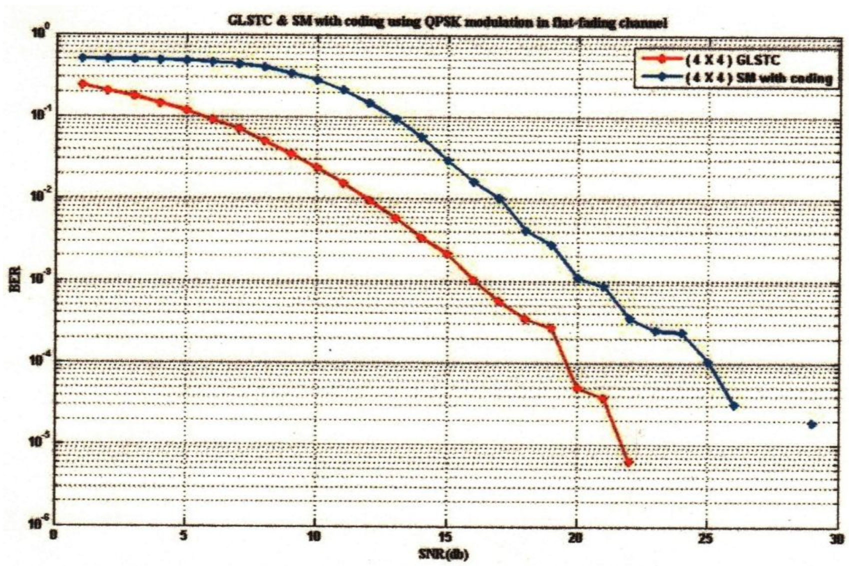

Fig 4 GSLTC 4×4 SM with Coding using QPSK Modulation

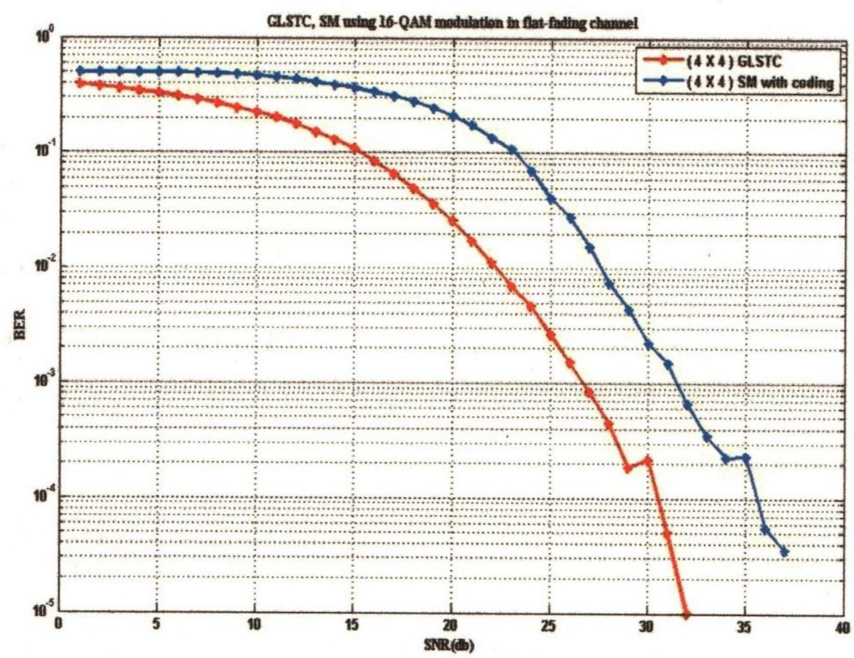

Fig 5 GSLTC 4×4 SM with Coding using 16-QAM Modulation

From the fig. 3, 4 & 5; we observe that GLSTC coding provide better compared to SM with coding for same antenna dimension.

Table 1 Comparison of GSLTC and Coded SM for Different Modulation Schemes

No.	Type of Modulation	GLSTC (4×4) SNR (dB) at $(10)^{-3}$ BER	SM with coding (4×4) SNR (dB) at $(10)^{-3}$ BER
1	BPSK	12.5	15.25

2	QPSK	16	20.4
3	16-QAM	26.7	31.5

From the comparison of GLSTC and SM with ½ convolution coding for same number of transmitter and receiver antennas. It is observed that GLSTC provides about 2.75 dB gain in performance compare to SM for same spectral efficiency. It is also observed that this improvement in performance increase with modulation order.

IV.CONCLUSION

Spectral efficiency of MIMO system can be increased with the use of SM technique. Simultaneous transmit of different data in SM suffer from MSI (Multi Stream Interference) and make detection challenging. The liner, nonlinear and ML detectors [11] of SM are compared on basis of performance and complexity. So from the result it can be seen that SM MIMO detectors combined with OFDM degrades the performance with increase in multipath and in modulation order. Finally to provide good rate-diversity trade-off combination of SM and STBC is used. So by combining the concept of SM and STBC as a GSLTC provides double rate and double diversity simultaneously.

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