IMPLEMENTATION OF INVESTE THE CHANNEL ADAPTATION AND INTERFERENCE FOR MULTI ANTENNA OFDM USING STBC SCHEMES

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Abstract— ***Present scenario of wireless communications channels are time varying or frequency selective especially for broadband and mobile applications. To address these challenges, a promising combination has been exploited, MIMO with OFDM, which has already been adopted such as LTE or WiMax, WLAN. With the constant demand of high spectral efficiency and high transmission speed for audio, video and internet applications, MIMO-OFDM has become the most promising technology combination for present and future wireless communications. MIMO offers spatial diversity and increase the capacity while OFDM allow systems to work in time varying or frequency selective environment. The aim of this research is to propose iterative dynamic channel estimation and signal detection techniques for MIMO-OFDM systems for fixed and mobile communications. A joint iterative scheme will be proposed for STBC-OFDM systems using orthogonal STBC at pilot subcarriers for dynamic channel estimation and this scheme will be extended for SFBC-OFDM with SFBC used for pilots. To take the advantage of the three dimensions offered by MIMO-OFDM; space, time and frequency, this research will also adapt the proposed dynamic channel estimation method to mixed STBC and SFBC MIMO-OFDM systems with pilot and data subcarriers being coded by different STBC and SFBC respectively. Due to the orthogonality of STBC and SFBC, both channel estimation and data detection become simple, as no computational intensive matrix inversion is needed.***

Indexed: Multihop routing, SFBC/STBC OFDM, LTE, WiMax, WLAN.

Manuscript received Feb, 2013.

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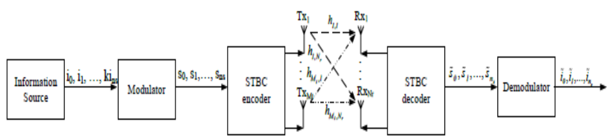
I. INTRODUCTION

Usually Multiple antennas are employed at both receiver and transmitter in a MIMO communication system to enhance channel capacity. Shannon Capacity Limit is difficult to be reached for Single Input Single Output (SISO) systems. It has been demonstrated in [34] that further increases in channel capacity can be gained by the use of MIMO systems. Under ideal propagation conditions, authors Foschini and Telatar have shown that the capacity limit grows linearly with the number of antennas. Space-time block coding (STBC) has emerged as one of the major techniques to exploit the MIMO benefit. Both spatial and temporal diversity are achieved in STBC/ SFBC. STBC/ SFBC also offer simple decoding with the use of maximum likelihood detection algorithm at the receiver for channel estimation. Other types of codes based on STBC have then emerged and are of most interest as both full rate and full diversity can be achieved contrary to the STBC where full data rate cannot be achieved for more than two transmit antennas for receiver. Those codes are known as Quasi-Orthogonal Space Time Block Codes (QOSTBC). QOSTBC has more complex decoding and therefore research is focusing on improving the complexity of the algorithm in order for the QOSTBC to be easier to implement.

Aforementioned codes are of much interest but require that channel parameters are known at the receiver to recover the transmitted data signal. Therefore, to counteract the need for channel estimation, codes based on differential modulation where the next transmitted symbol is phase shifted compared to the previously transmitted symbol, has been proposed by Tarokh et al in. Detection and demodulation is based on the same principle, the phase of the received signal is compared with the phase of the previously received signal. Such codes are called Differential Space Time Block codes (DSTBC). The most distinct feature of DSTBC is that it does not require channel estimation, similar to the case of QOSTBC.

II. PROCEDURE FOR PAPER SUBMISSION



A. *QUASI-ORTHOGONAL SPACE-TIME BLOCK CODES*

ISSN: 2278 – 1323

Full rate STBC using complex symbols in its transmission matrix Full diversity and simple decoding are the rules of orthogonal design. Quasi-Orthogonal- Space-Time Block codes (QOSTBC) which achieved full rate at the cost of higher complexity decoding. Quasi-orthogonal designs are attractive because they achieve higher code-rate than orthogonal designs and lower decoding complexity than non-orthogonal designs.
Jafarkhani's coded matrix is given as:

$$S_{4Q} = \begin{bmatrix} S_2^c(s_1,s_2) & S_2^c(s_3,s_4) \\ -S_2^{c*}(s_3,s_4) & S_2^{c*}(s_1,s_2) \end{bmatrix} = \begin{bmatrix} s_1 & s_2 & s_3 & s_4 \\ -s_2^* & s_1^* & -s_4^* & s_3^* \\ -s_3^* & -s_4^* & s_1^* & s_2^* \\ s_4 & -s_3 & -s_2 & s_1 \end{bmatrix}$$

where a matrix is the complex conjugate of the matrix as demonstrated for the matrix.

$$S_2^{c*}(s_0,s_1) = S_2^c(s_0^*,s_1^*) = \begin{bmatrix} s_0^* & s_1^* \\ -s_1 & s_0 \end{bmatrix}$$

Now, by using *Vi* with i=1, 2, 3, 4 representing the *i*th column, it can be seen that this orthogonality allows the calculation of the maximum likelihood decision metric which minimizes the following sum:

$$f_{14}(s_1,s_4) + f_{23}(s_2,s_3)$$

$$f_{14}(s_1,s_4) = \sum_{j=1}^{Nr}\Big[(|s_1|^2+|s_4|^2)\Big(\sum_{n_t=1}^{4}|h_{n_t,j}|^2\Big) + 2\mathcal{R}e\{(-h_{1,j}r_{1,j}^* - h_{2,j}^*r_{2,j} - h_{3,j}^*r_{3,j} - h_{4,j}r_{4,j}^*)s_1 + (-h_{4,j}r_{1,j}^* + h_{3,j}^*r_{2,j} + h_{2,j}^*r_{3,j} - h_{1,j}r_{4,j}^*)s_4 + (h_{1,j}h_{4,j}^* - h_{2,j}^*h_{3,j} - h_{2,j}h_{3,j}^* + h_{1,j}^*h_{4,j})s_1s_4^*\}\Big]$$

and

$$f_{23}(s_2,s_3) = \sum_{j=1}^{N_r}\Big[(|s_2|^2+|s_3|^2)\Big(\sum_{n_t=1}^{4}|h_{n_t,j}|^2\Big) + 2\mathcal{R}e\{(-h_{2,j}r_{1,j}^* + h_{1,j}^*r_{2,j} - h_{4,j}^*r_{3,j} + h_{3,j}r_{4,j}^*)s_2 + (-h_{3,j}r_{1,j}^* - h_{4,j}^*r_{2,j} + h_{1,j}^*r_{3,j} + h_{2,j}r_{4,j}^*)s_3 + (h_{2,j}h_{3,j}^* - h_{1,j}^*h_{4,j} - h_{1,j}h_{4,j}^* + h_{2,j}^*h_{3,j})s_2s_3^*\}\Big]$$

Where the complexity of QOSTBC systems does not grow linearly as for STBC but exponentially with the number of transmit and receive antennas.

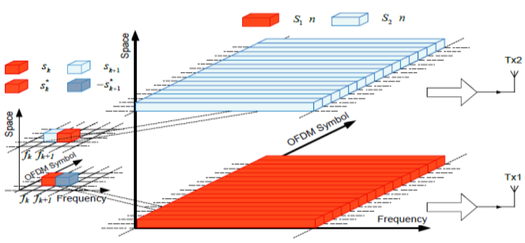


Fig. 2.2 Data Organization of SFBC-OFDM

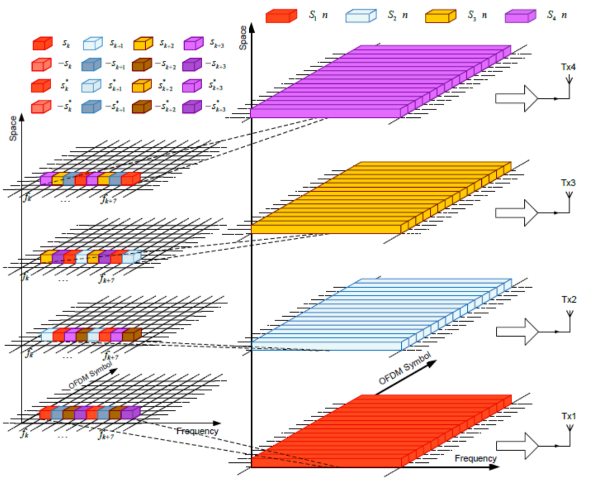


Fig. 2.3 Organization of Data Symbol for 4 Transmit Antennas SFBC-OFDM Systems

At the receiver, after the FFT operation, the received signal can be expressed as:

$$R_j = \sum_{j=1}^{Nr} H_{1,j}S_1 + H_{2,j}S_2 + H_{3,j}S_3 + H_{4,j}S_4 + N_j$$

where *Nj* is the white Gaussian noise, *Hi,j* and *Si* are the channel between the *i*-th transmit antenna and the *j*-th receive antenna and the transmitted signal from the *i*-th transmit antenna respectively. The transmitted vectors can be expressed as:

$$S_1 = [s_0, -s_1, -s_2, -s_3, s_0^*, -s_1^*, -s_2^*, -s_3^* \ldots, s_{Ns/2-4}, -s_{Ns/2-3}, -s_{Ns/2-2}, -s_{Ns/2-1}, s_{Ns/2-4}^*, -s_{Ns/2-3}^*, -s_{Ns/2-2}^*, -s_{Ns/2-1}^*]^T$$

$$S_2 = [s_1, s_0, s_3, -s_2, s_1^*, s_0^*, s_3^*, -s_2^* \ldots, s_{Ns/2-3}, s_{Ns/2-4}, s_{Ns/2-1}, -s_{Ns/2-2}, s_{Ns/2-3}^*, s_{Ns/2-4}^*, s_{Ns/2-1}^*, -s_{Ns/2-2}^*]^T$$

$$S_3 = [s_2, -s_3, s_0, s_1, s_2^*, -s_3^*, s_0^*, s_1^* \ldots, s_{Ns/2-2}, -s_{Ns/2-1}, s_{Ns/2-4}, s_{Ns/2-3}, s_{Ns/2-2}^*, -s_{Ns/2-1}^*, s_{Ns/2-4}^*, s_{Ns/2-3}^*]^T$$

$$S_4 = [s_3, s_2, -s_1, s_0, s_3^*, s_2^*, -s_1^*, s_0^* \ldots, s_{Ns/2-1}, s_{Ns/2-2}, -s_{Ns/2-3}, s_{Ns/2-4}, s_{Ns/2-1}^*, s_{Ns/2-2}^*, -s_{Ns/2-3}^*, s_{Ns/2-4}^*]^T$$

Similar to STBC-OFDM presented above in matrix equations, SFBC-OFDM for two transmit antennas Sk and S $_{k+1}$ requires two time slots to transmit the S_{2c} matrix and similar for four also. However, in contrast with STBC-OFDM, only one OFDM symbol is required as data is coded across subcarriers. The organization of the data technique is through the space, time and subcarriers. As it can be seen, symbol and are transmitted alternatively from antenna 1 while and are transmitted in a similar way from antenna.

$$\tilde{s}_k = \sum_{j=1}^{N_r}(h_{1,j,k}^*r_{j,k} + h_{2,j,k}^*r_{j,k+1} + h_{3,j,k}^*r_{j,k+2} + h_{4,j,k}^*r_{j,k+3} + h_{1,j,k}r_{j,k+4}^* + h_{2,j,k}r_{j,k+5}^* + h_{3,j,k}r_{j,k+6}^* + h_{4,j,k}r_{j,k+7}^*)$$

ISSN: 2278 – 1323

$$\tilde{s}_{k+1} = \sum_{j=1}^{N_r} (h^*_{2,j,k} r_{j,k} - h^*_{1,j,k} r_{j,k+1} - h^*_{4,j,k} r_{j,k+2} + h^*_{3,j,k} r_{j,k+3} + h_{2,j,k} r^*_{j,k+4} - h_{1,j,k} r^*_{j,k+5} - h_{4,j,k} r^*_{j,k+6} + h_{3,j,k} r^*_{j,k+7})$$

$$\tilde{s}_{k+2} = \sum_{j=1}^{N_r} (h^*_{3,j,k} r_{j,k} + h^*_{4,j,k} r_{j,k+1} - h^*_{1,j,k} r_{j,k+2} - h^*_{2,j,k} r_{j,k+3} + h_{3,j,k} r^*_{j,k+4} + h_{4,j,k} r^*_{j,k+5} - h_{1,j,k} r^*_{j,k+6} - h_{2,j,k} r^*_{j,k+7})$$

$$\tilde{s}_{k+3} = \sum_{j=1}^{N_r} (h^*_{4,j,k} r_{j,k} - h^*_{3,j,k} r_{j,k+1} + h^*_{2,j,k} r_{j,k+2} - h^*_{1,j,k} r_{j,k+3} + h_{4,j,k} r^*_{j,k+4} - h_{3,j,k} r^*_{j,k+5} + h_{2,j,k} r^*_{j,k+6} - h_{1,j,k} r^*_{j,k+7})$$

III. RESULT

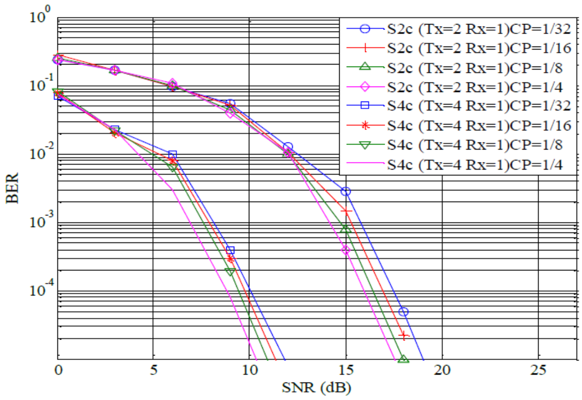


Fig. 3.1 Cyclic Prefix Performance Results of STBC-OFDM under 16QAM

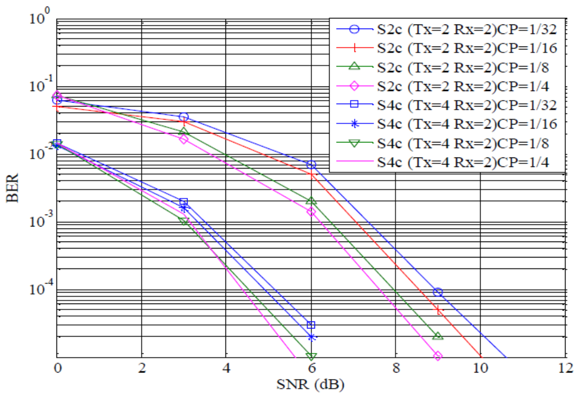


Fig. 3.2 Cyclic Prefix Performance Results of SFBC OFDM System under QPSK

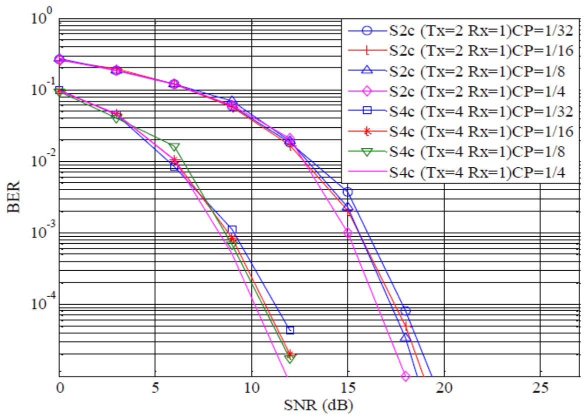


Fig. 3.3 Cyclic Prefix Performance Results of SFBC-OFDM under 16QAM

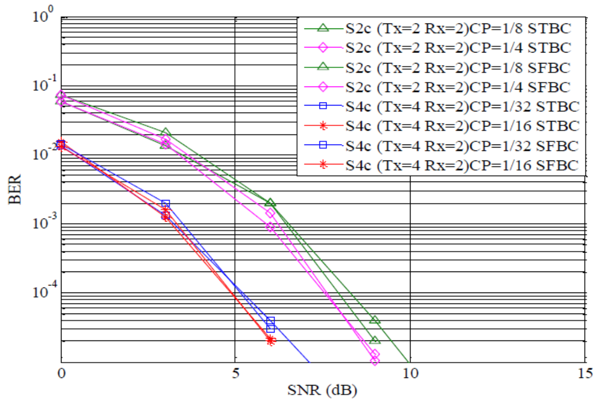


Fig. 3.4 Comparison Results between STBC-OFDM and SFBC-OFDM under QPSK

IV. CONCLUSION

In this paper, research work introduces a comprehensive investigation of OFDM and in particular MIMO-OFDM systems was conducted. Two coding schemes, STBC-OFDM and SFBC-OFDM, have been described in detail and simulation results for both schemes have been presented for different number of transmit and receive antennas and under various modulation schemes. A comparison of the 2 schemes has also been made which led to the conclusions that STBC-OFDM and SFBC-OFDM achieve similar performances. Moreover, investigation on the effect of CP on MIMO-OFDM systems was made and it has been noticed for both schemes that the BER increases as the CP length decreases.

For both STBC and SFBC scheme, similar coding has been used where symbols are coded through different OFDM symbols and different subcarriers for STBC and SFBC respectively. Moreover, in both cases, channel parameters have been assumed known at the receiver. Therefore, using known channel parameter and same type of coding; results were expected to be the same. Furthermore, the effect of CP on both schemes was expected as increasing CP reduces the BER due to the fact that CP length must be longer than the delay spread of the channel in order to ensure perfect equalization. In the future, we need to compare both schemes in Comparison Results between STBC-OFDM and SFBC-OFDM under 16QAM, and m-ary QAM formats.

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ISSN: 2278 – 1323