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RESEARCH ARTICLE

PERFORMANCE ANALYSIS OF 3*4 ORTHOGONAL SPACE TIME BLOCK CODE AND TRANSMISSION ANTENNA SELECTION WITH MULTI USER DIVERSITY

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Abstract: This paper presents the average capacity and error performance of 3×4 orthogonal space time block code (OSTBC) and transmits antenna selection (TAS) with multiple antennas. In TAS scheme, we consider one transmit antenna is selected for transmit signals at the secondary transmitters and the secondary receiver applies the maximum likelihood (ML). In 3×4 OSTBC scheme, we consider three transmit antennas and four receive antennas. The experimental results shown that the average capacity and bit error rates are better performance of 3×4 OSTBC is comparing to TAS scheme. We propose a codebook design and feedback scheme that combines space-time block coding and array processing. To the best of our knowledge, this is the first scheme with quantized feedback that can achieve low-complexity de-coding and full diversity for any number of users when all users transmit

Index term- Antenna selection, cognitive radio, multiuser diversity, space-time block coding (STBC)

I. INTRODUCTION

SPACE-TIME block coding (STBC) is an efficient transmit diversity scheme to combat detrimental effects of wireless fading channels because of its simple decoding algorithm accomplishing full diversity at a radio receiver. Alamouti code is an elegant and seminal STBC design for a two-transmit-antenna system [1]. It achieves rate one, full-diversity transmission using two time slots for signals with complex constellations, which are employed in most current commercial wireless systems. The orthogonal code of Alamouti code for systems with an arbitrary number of transmit antennas [2][3]. It has been proved however, the orthogonal design for complex signals with linear decoding complexity achieving rate-one and full-diversity transmission is not available for the number of antennas more than two [2]. The system with a higher number of antennas has to either suffer from rate loss or put up with more decoding complexity. Quasi-orthogonal STBC (Q-STBC) codes are typically designed for more than two antenna systems with increased, but not exponentially, decoding complexity Recently, a lot of researches have been put into designing the STBC with full rate and full diversity for four transmit antennas [5]-[10]. For open-loop communication systems, the optimum constellation rotation proposed for QOSTBC with different improvement approaches [5]. Although a lot of partial feedback methods can be adopted to improve the closed-loop system performance [6][7][10], the major problems of such systems are high cost and high complexity due to the more feedback information. employing circulant matrix. It, therefore, is able to offer not only more flexibility but also a performance advantage over exiting methods For practical interests of the design of the closed-loop transmission schemes, it is desirable to have features such as a limited amount of feedback information, low decoding delay, low cost and simple decoding processing. In this letter, we present a novel closed-loop scenario extended from Jafarkhani's QOSTBC as well as its optimal rotated scheme for the quasi-staticat fading channels with four transmit antennas. We show that, by feeding back one bit channel information, our proposed scheme can increase the transmit diversity and reduce the self interference from adjacent symbols in QOSTBC scheme.

II. MODEL SYSTEM

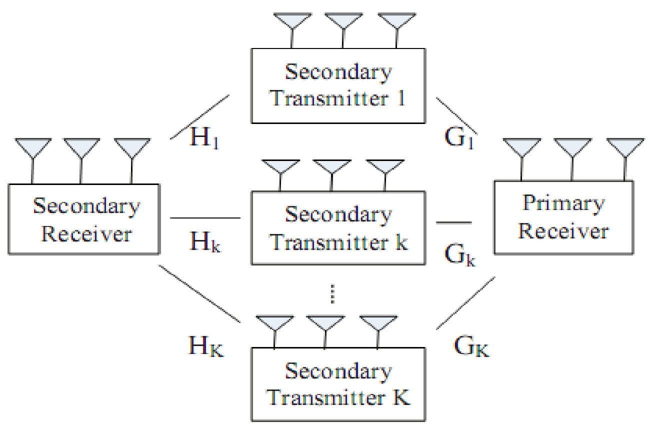


Fig 1. **Channel model of a multiuser SS OSTBC system**

So far most of the research results for SS systems focused on the single antenna case. Recently, applying the multiple-input multiple-output (MIMO) technology to cognitive radio networks has received growing interest. This paper extends the results of [4] to a more general MIMO system where every node is equipped with multiple antennas. We focus on orthogonal space-time block coding (OSTBC) and transmit antenna selection (TAS) CR systems with multi-user diversity and analyze the resulting average capacity and bit-error rate (BER) performance. It is known that TAS yields a better performance than OSTBC in a conventional down-link multiuser diversity MIMO system The outage probability, which is indicative of performance, is first derived. Then we derive a closed-form bit error rate (BER) expression for the TAS/MRC

$$P_T^k = \begin{cases} \frac{Q}{\|\mathbf{G}_k\|_F^2} & \|\mathbf{G}_k\|_F^2 > \frac{Q}{P_k} \\ P_k & \|\mathbf{G}_k\|_F^2 \leq \frac{Q}{P_k}, \end{cases}$$

it is shown that the TAS/MRC scheme can asymptotically achieve a full diversity order, although only a single transmit antenna is selected for transmission. With a specified diversity order as the system design target, the TAS/MRC scheme can deploy most of the antennas at the transmitter side with a single RF chain regardless of a potentially large number of transmit antennas. At the mobile set, the simplicity of MRC with a small number of receive antennas can be maintained. Therefore, the TAS/MRC scheme is suitable for downlink communications in cellular radio systems.

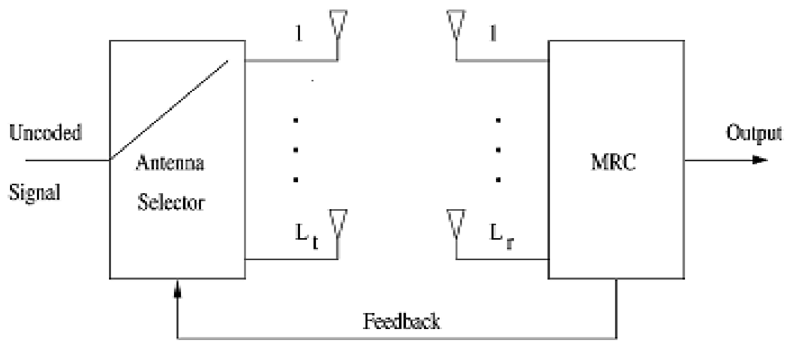
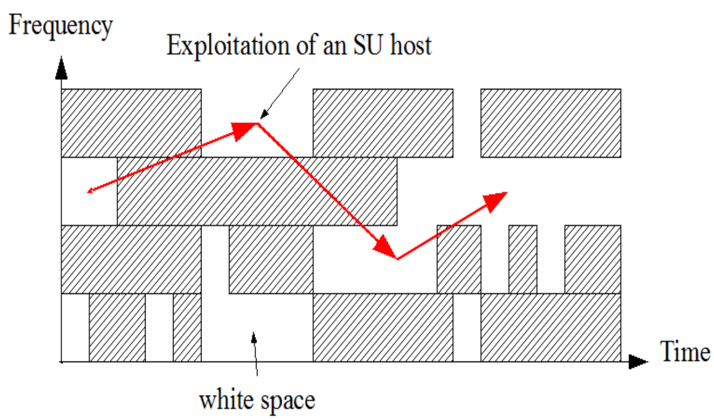


Fig 2. TRANSMIT ANTENNA SELECTION (TAS)

With a specified diversity order as the system design target, the TAS/MRC scheme can deploy most of the antennas at the transmitter side with a single RF chain regardless of a potentially large number of transmit antennas. At the mobile set, the simplicity of MRC with a small number of receive antennas can be maintained. Therefore, the TAS/MRC scheme is suitable for downlink communications in cellular radio systems. And full diversity. But the symbol rate will be reduced to one fourth of that of the space-time code. A solution to keep the symbol rate unchanged when space-time codes are used is to com-bine space-time coding and array processing.

COGNITIVE RADIO

Definition: Cognitive radio is an intelligent wireless communication system periodically monitors the radio spectrum detects occupancy in the different parts of the spectrum opportunistically communicates over white spaces The idea of CR was first presented officially in an article by Joseph Mitola and Gerald Maguire in 1999.The main function of this cognitive radio is it detects white spaces (un occupied band) in the spectrum. White space (or spectrum holes) is a band wider than 1Mhz that remains unoccupied for 10 minutes or longer CR technology enables their identification and use Secondary users jump from one white space to another.



In other words, we allow all transmitters to send space-time codes simultaneously to keep rate one and utilize special array processing techniques to achieve low-complexity decoding and full diversity. An Alamouti encoder is designed to deal with symbols rather than bits. Therefore, the arriving bit stream is first modulated according to the chosen constellation and then pairs of modulated symbols are encoded to form a transmission matrix given by

$$S_J = \begin{bmatrix} S_1 & S_2 & S_3 & S_4 \\ -S_2 & S_1 & S_4 & S_5 \\ -S_3 & S_4 & S_1 & -S_2 \\ -S_4 & -S_3 & S_2 & S_1 \\ S^*_1 & S^*_2 & S^*_3 & S^*_4 \\ -S^*_2 & S^*_1 & S^*_4 & S^*_5 \\ -S^*_3 & S^*_4 & S^*_1 & -S^*_2 \\ -S^*_4 & -S^*_3 & S^*_2 & S^*_1 \end{bmatrix}$$

The QOSTBC achieves full rate for four transmit antennas. The columns of the transmission matrix are divided into groups. The columns in each group are not orthogonal to each other, but different groups are orthogonal to each other. In this scheme, the Alamouti code used multiple times to form the transmission matrix. The QOSTBC is represented as

$$S_J = \begin{bmatrix} S_{12} & S_{34} \\ -S_{34}^* & S_{12}^* \end{bmatrix}$$

$$S_J = \begin{bmatrix} s_1 & s_2 & s_3 & s_4 \\ -s_2^* & s_1^* & -s_4^* & s_3^* \\ -s_3^* & -s_4^* & s_1^* & s_2^* \\ s_4 & -s_3 & -s_2 & s_1 \end{bmatrix}$$

Each of them is used to decode a pair of symbols. When a constellation with *M* points is used, the required number of tests is 2*M*2 rather than the 4*M* tests required by an OSTBC with rate 1 for 4 transmit antennas. Hence, the decoding complexity is increased. But this decoding complexity is still lower than the M^4 tests required by a joint maximum likelihood decoder. The diversity gain offered by this scheme can be examined by constructing the distance matrix. It can be shown that the minimum rank of the distance matrix is two, while full rank would be 4. There is another QOSTBC which can achieve full rate but not full diversity proposed in given below

$$\begin{bmatrix} r_1 \\ r_2^* \\ r_3^* \\ r_4 \end{bmatrix} = \begin{bmatrix} h_1 & h_2 & h_3 & h_4 \\ h_2^* & -h_1^* & h_4^* & -h_3^* \\ h_3^* & h_4^* & -h_1^* & -h_2^* \\ h_4 & -h_3 & -h_2 & h_1 \end{bmatrix} . \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2^* \\ n_3^* \\ n_4 \end{bmatrix}$$

III. PERFORMANCE EVALUATION

In this section, we analyze the average capacity and error rate performance of an uplink multiuser SS OSTBC network in closed-form. For notational simplicity, let $Yk= \|Gk\|^2$ and $Uk=\|Hk\|^2$ .Then, the received SNR at the kth secondary receiver is expressed as

$$\gamma_k = \frac{Q}{RNY_k} \|\mathrm{H}_k\|_F^2 = \frac{Q}{RNY_k} U_k, \quad (1)$$

Where R denotes the code rate of STBC. In flat Rayleigh fading channels, Yk and Uk are sums of N2 squared complex Gaussian random variables and both follow the Chi-squared distribution with 2N2 degree of freedom. Thus, the probability density function (PDF) of Yk is readily given by

$$f_{Y_k}(\mathrm{y}) = \frac{1}{\Gamma(\mathrm{N}^2)}\, y^{\mathrm{N}^2-1} e^{-y} \qquad (2)$$

After collecting γk, the secondary receiver can select the target user according to the rule k = arg $\max_k$ γk.

Based on above equation, the PDF and cumulative density function (CDF) of γk are readily given by

$$f_{\gamma_k}(\gamma) = \int_0^{\infty} \frac{RN_Y}{Q} f_{U_k}\left(\frac{\gamma R N_y}{Q}\right) f_{Y_k}(\mathrm{y})\, dy \qquad (3)$$

And

$$F_{\gamma_k}(\gamma) = \frac{\Gamma(2\mathrm{N}^2)}{\Gamma^2(\mathrm{N}^2)} \left(\frac{RN}{Q}\right)^{N^2} \frac{\gamma^{N^2}}{N^2} \qquad (4)$$

IV. a) Average capacity analysis

We derive the capacity expression for a multiuser scheduling system with the single-input single-output (SISO) antenna. We assume that each user can track its channel status via, say, a downlink common pilot and correctly feed back to the base station without delay. In turn, similar to the scheduling mechanism in the modern cellular standard IS-856 [11], the base station determines to service a target user in every time slot with its full transmit power. Here, we assume that the channel variation remains constant over one time slot, but independently varies in different time slots.

The scheduling policy considered in this paper is to select a target user k according to the following rule:

$$k^* = \arg\max_k \frac{\gamma_k}{\tilde{\gamma}_k} \quad \ldots.(5)$$

We have

$$f_{\gamma_{\max}}(\alpha, \beta, K) = K p_\gamma(\gamma)\,[P_\gamma(\gamma)]^{K-1} \qquad (6)$$

the link capacity between the base station and the target user then can be written as

$$C_{\text{link}}^{k^*} = \int_0^{\infty} \log_2(1+\gamma) f_{\text{link}}^{k^*}(\gamma)\, d\gamma. \qquad (7)$$

Then the system capacity is expressed by

$$C_{\text{sys}} = \sum_{k^*=1}^{K} C_{\text{link}}^{k^*} p_{k^*}. \quad \ldots(8)$$

For the Rayleigh fading case ( ) with -fold multi-user diversity is simplified to

$$C_{\text{sys}} = K \log_2(e) \times \sum_{k=0}^{K-1} (-1)^k \binom{K-1}{k} \frac{e^{(k+1)/\Omega}}{k+1} \cdot E_1\left(\frac{k+1}{\Omega}\right). \quad (9)$$

For the single-user case , multiuser diversity gain vanishes and (18) reduces to (20), shown at the bottom of the page, which is identical to the link capacity of the Nakagami fading channel with optimal rate control

$$C_{\text{sys}} = \log_2(e) e^{1/\Omega} E_1\left(\frac{1}{\Omega}\right). \quad \ldots(10)$$

When m is not restricted to an integer, can be also efficiently computed with the help of the orthogonal Laguerre polynomial as follows:

$$C_{\text{sys}} \simeq \frac{K \log_2(e)}{\Gamma(\alpha)} \sum_{i=1}^{N_L} w_i \ln\left(1 + \frac{z_i}{\beta}\right) \left[\tilde{\Gamma}(\alpha, z_i)\right]^{K-1} z_i^{\alpha-1} \quad (11)$$

IV. b) Bit Error Rate (BER) analysis

The **bit error rate** or **bit error ratio** (**BER**) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage. Bit error rate is a key parameter that is used in assessing systems that transmit digital data from one location to another. BER is applicable to radio data links, Ethernet, as well as fiber optic data systems. When data is transmitted over a data link, there is a possibility of errors being introduced into the system. If this is so, the integrity of the system may be compromised. As a result, it is necessary to assess the performance of the system, and BER provides an ideal way in which this can be achieved. BER assesses the full end to end performance of a system including the transmitter, receiver and the medium between the two. BER is defined as the rate at which errors occur in a transmission system. In simple form,

$$\text{Bit Error Rate, BER} = \frac{\text{Number of errors}}{\text{Total number of bits sent}}$$

BER comparison between BPSK and differentially encoded BPSK with gray-coding operating in white noise. In a noisy channel, the BER is often expressed as a function of the normalized carrier-to-noise ratio measure denoted Eb/N0, (energy per bit to noise power spectral density ratio), or Es/N0 (energy per modulation symbol to noise spectral density).For example, in the case of QPSK modulation and AWGN channel, the BER as function of the Eb/N0 is given by

$$\text{BER} = \frac{1}{2} \operatorname{erfc}(\sqrt{E_b/N_0}) \quad \ldots(12)$$

Usually plot the BER curves to describe the functionality of a digital communication system. In optical communication, BER(dB) vs. Received Power(dBm) is usually used; while in wireless communication, BER(dB) vs. SNR(dB) is used .Measuring the bit error ratio helps people choose

the appropriate SSS codes. Since most such codes correct only bit-flips, but not bit-insertions or bit-deletions, the Hamming distance metric is the appropriate way to measure the number of bit errors. Many FEC coders also continuously measure the current BER.

IV. (c)White Noise

White noise is usually applied in context of frequency domain and hence, white noise is commonly applied to a noise signal in the spectral domain. The white noise is thermal noise. Gaussian white noise is a noise with a Gaussian amplitude distribution. Gaussian white noise is a good approximation of many real-time situations and it generates mathematical traceable models. But because these models are so frequently used, the term additive has been added. Additive White Gaussian Noise (AWGN) has become a statistical tool for analysis and application in telecommunication engineering. Usually plot the BER curves to describe the functionality of a digital communication system. In optical communication, BER(dB) vs. Received Power(dBm) is usually used; while in wireless communication, BER(dB) vs. SNR(dB) is used .Measuring the bit error ratio helps people choose the appropriate forward error correction codes.

V. SIMULATION RESULTS

In this section, Fig. 1 shows the BER comparison between the TAS and OSTBC schemes for K = 2. It clearly shows that the TAS scheme can achieve better performance. This fact is in agreement with the similar result observed in traditional multiuser diversity MIMO system

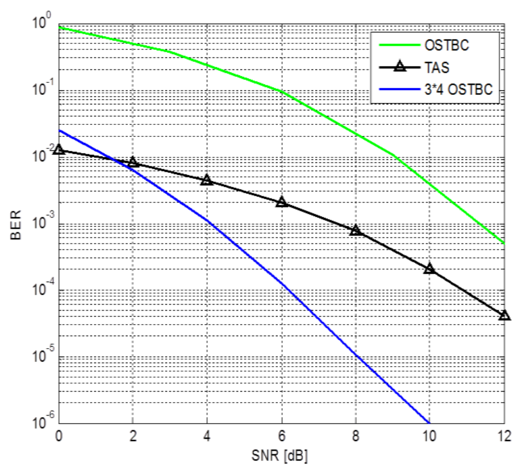


Fig.1 BER performance comparison between OSTBC and TAS SS networks with multiuser diversity

Fig. 2 shows the average throughput comparison between OSTBC and TAS in a multiuser diversity SS system with K =1, and 3. As expected, the simulation results coincide with the analytical ones, and the multiuser diversity gain can further improve the system performance. Also, we found that the TAS scheme can achieve higher capacity.. However, it should be noted that in such a system the TAS scheme requires the secondary receiver to indicate the transmitter which antenna is selected, which increases the system complexity. Therefore, there is a tradeoff between the system complexity and performance

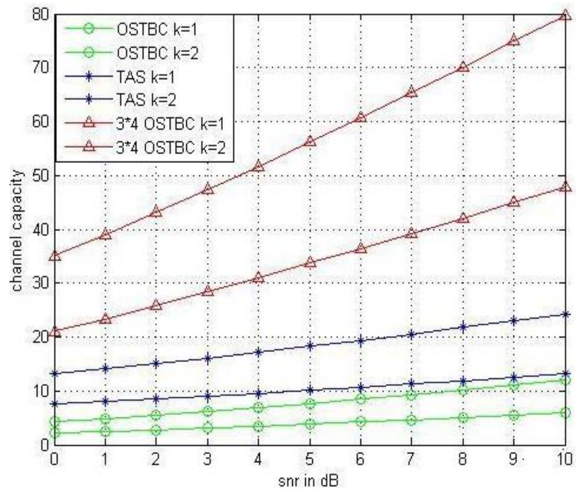


Fig.2. Capacity comparison between OSTBC and TAS SS network with multiuser diversity

VI. CONCLUSION

In this paper, we focus on orthogonal space-time block coding (OSTBC) and transmit antenna selection (TAS) CR systems with multi-user diversity and analyse the resulting average capacity and bit-error rate (BER) performance. It is known that TAS yields a better performance than OSTBC. But TAS scheme requires the secondary receiver to indicate the transmitter which antenna is selected, which increases the system complexity. Therefore, there is a trade-off between the system complexity and performance. For a comparison purpose, an analysis of the transmit antenna selection scheme is also presented. The experimental results shown that the average capacity and bit error rates are better performance of 3×4 OSTBC is comparing to TAS scheme. This paper presents the average capacity and error performance of 3×4 orthogonal space time block code (OSTBC) and transmits antenna selection (TAS) with multiple antennas. In TAS scheme, we consider one transmit antenna is selected for transmit signals at the secondary transmitters and the secondary receiver applies the maximum likelihood (ML). In 3×4 OSTBC scheme, we consider three transmit antennas and four receive antennas. The experimental results shown that the average capacity and bit error rates are better performance of 3×4 OSTBC is comparing to TAS scheme. Finally, some selected numerical results are presented to corroborate the proposed analysis,

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