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RESEARCH ARTICLE

PERFORMANCE ANALYSIS OF 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.

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

I. INTRODUCTION

Due to the low complexity and high diversity, orthogonal space-time block coding (OSTBC) has been widely used in this decade. The diversity gain makes the transceiver with more efficiency. STBC technique can provide more benefit for mobile users with computational efficiency over the fading channel environment. Due to multiple transmit antennas requirement for the STBC system, it is found less capacity and higher error rate performance. Compared with single antenna wireless systems, Multiple Input Multiple Output (MIMO) systems have much higher capacity and reliability [1], [2]. There are several MIMO techniques which have been introduced recently. In practice, the cooperation between the secondary and primary users is loose, which results in imperfect channel state in- formation (CSI) of the interference channel. Therefore, [3][4] investigated the effect of imperfect CSI on the system capacity. 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. For instance, [5] employed multiple antennas at the secondary transmitter to manage the tradeoff between throughput and interference constraint. More recently, [6] considered the capacity limits of a multiuser multi-antenna CR network where only the base stations are equipped with multi-antennas.

In this paper is organized as follows. System model of spectrum sharing antenna in section II. Explain the TAS and OSTCBC in section III and IV. BER and capacity calculation in section V. The simulation results are presented in Section IV. Concluding remarks are made in Section V.

II. SYSTEM MODEL

We consider a spectrum sharing communication system where Gk secondary transmitters utilize a spectrum licensed to a primary user as shown in figure.1.

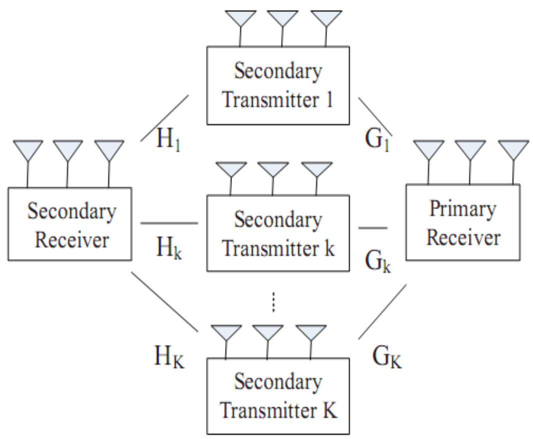

Figure.1. system model

In the spectrum sharing (SS) system, the data transmission of secondary transmitters resulting in a higher interference level than an interference temperature at the primary user is not allowed. The interference temperature represents the maximum allowable interference power level at the primary user. In the SS system, all the secondary transmitters Gk is transmit data to the target secondary receiver and calculate the maximum allowable transmit power Ptx according to αi to satisfy the interference temperature constraint at the primary user. Then, each secondary transmitter shows its transmit power Ptx to the secondary receiver so that the secondary receiver selects the best secondary transmitter in terms of the received signal-to-noise power ratio. The maximum transmitted power P^k_T at the secondary transmitter can be selected according to the rule:

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

Where ||·||F is the Frobenius norm

Pk denotes the peak power of the kth secondary transmitter.

III. TAS SCHEME

In TAS scheme uses single transmit antenna, which is high total received signal power at the receiver, is selected for uncoded transmission. This paper resides in both the average capacity and bit error rate. Based on the BER expression, it is shown that the TAS scheme can asymptotically achieve a full diversity order, although only a single transmit antenna is selected for transmission. we mainly focus on the error performance and capacity of the TAS scheme. The block diagram of TAS as shown in fig 2

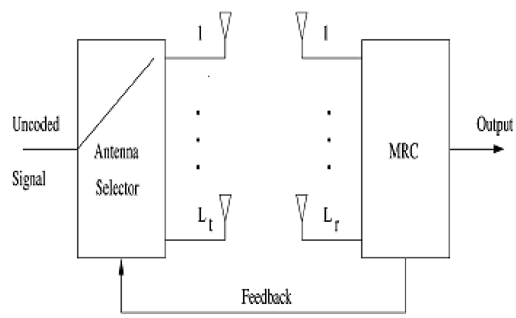

Fig.2. An TAS system.

In fig.2, we consider an (Lt, 1; Lr) TAS system in flat Rayleigh fading channels. where H denote the Lr × Lt Channel matrix. The channel coefficients are the fading coefficients hi,j , $1 \le i \le Lt$, $1 \le j \le Lr$, which are modeled as independent samples of complex Gaussian random variables with a zero mean and the variance of 0.5 per dimension. An Lr × 1 vector is a column of H. It is used to denote the channel between the single selected transmit antenna and Lr receive antennas. The single selected transmit antenna is maximizes the total received signal power. In feedback channel, the value of I is available to the transmitter. It is well known that the output SNR of a maximal-ratio combiner, also referred to as post-processing SNR, is just the sum of the SNRs at different receive antennas. Therefore, the selection criterion which maximizing the instantaneous post-processing SNR. This justifies the optimality of the selection criterion. The selection criterion of maximizing the total received power has been widely adopted in the system with antenna selection

The uncoded signal x is transmitted over the single selected antenna, the received signal vector can be expressed as

$$y = hx + n$$

where h is the channel coefficients and n is the additive white Gaussian noise.

IV. OSTBC SYSYEM

OSTBCs were first introduced by Alamouti for a two transmit antenna MIMO system and, then extended to MIMO systems with more than two transmit antennas. The goal of OSTBC is to achieve the higher diversity, higher capacity and less bit error rate.

The basic concept of OSTBC is to divide the *K* transmitted symbols in a codeword into *G* independent groups that is all symbols in any group are orthogonal, such as matched filtering, while strict orthogonality among the symbols within a group is not required. At receiver, the received symbols can be separated into *G* independent groups by using maximum likelihood (ML) decoding of different groups can be performed separately and in parallel, and the ML decoding of every group can be achieved by jointly detecting only *K*/*G* complex symbols that are within the same group. In this technique can achieve full diversity and less error performance. Hence to divide the design of OSTBC into two parts, one for the decoding complexity and the other one is decoding performance or maximal symbol wise diversity of the symbols.

Let H be the channel matrix of N × M dimensions, where M is the number of the transmit antennas and N is the number of the receive antennas. In the ideal case, each path is assumed to be statistically independent from the others. Herein, consider a transmitted vector $x=[x1,x2,\ldots x_m]^T$, the vector is then transmitted via a MIMO channel characterized by the channel matrix H whose element $h_{i,j}$ is the random Gaussian complex channel coefficient between the jth transmit and ith receive antennas with zero mean and unity variance. The received vector is given by

$$\boldsymbol{r} = \boldsymbol{H}\boldsymbol{x} + \boldsymbol{n}$$

i.e.

$$\begin{pmatrix} r_1 \\ r_2^* \\ r_3^* \\ r_4 \end{pmatrix} = \begin{pmatrix} h_1 & h_2 & h_3 & h_4 \\ h_2^* & -h_1^* & h_4^* & -h_3^* \\ h_3^* & h_4^* & -h_1^* & -h_2^* \\ h_4 & h_3 & -h_2 & -h_1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2^* \\ n_3^* \\ n_4 \end{pmatrix}$$

In the above matrix, each code block consists of 4 symbols, x1, x2, Sx3 and x_4. The symbols, x1, x2, x3, x4, are transmitted from antenna 1, 2, 3 and 4 during the first time slot. n1, n2, n3, n4 are the noises of four transmit symbols and h1, h2, h3, h4 are the channel coefficients of four transmit symbols.

In decoding step, we are using maximum likelihood (ML) technique. ML decoding is equivalent to minimizing the metric

$M=||R-HX||^2$

As one advantage of OSTBCs, the ML decoding can be performed by minimizing two independent metrics. The ML metric can be written into two independent functions as

$$\begin{aligned} &\arg \min_{\{x_i\}_{i=1}^4 \subset \mathcal{S}} [f_{1,4}(x_1, x_4) + f_{2,3}(x_2, x_3)] \\ &= \arg \min_{x_1, x_4 \in \mathcal{S}} f_{1,4}(x_1, x_4) + \arg \min_{x_2, x_3 \in \mathcal{S}} f_{2,3}(x_2, x_3) \end{aligned}$$

The main advantages of OSTBCs can achieve full diversity gain, simple decoding algorithm, higher capacity, less computation complexity and less bit error rate compare to TAS scheme.

V. BER AND CAPACITY CALCULATION

In an additive white Gaussian noise (AWGN) channel, the exact BER of the n-th bit in M-PAM with Gray mapping is given by

$$P_M(\rho) = \frac{1}{\log_2 M} \sum_{n=1}^{\log_2 M} P_M(n; \rho).$$

We derive the capacity expression for a multiuser scheduling system with TAS scheme. The capacity of the Rayleigh fading channel as shown in below

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

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 unitless performance measure, often expressed as a percentage.

BER is defined as the rate at which errors occur in a transmission system. In simple form,

$$BER = \frac{number\ of\ bits\ in\ error}{total\ number\ of\ bits\ sent}$$

VI. RESULTS

This section describes several numerical simulation results to verify the proposed analysis. Fig. 3 shows the BER comparison between the TAS and OSTBC schemes for K = 2. It clearly shows that the 3×4 OSTBC can achieve better performance.

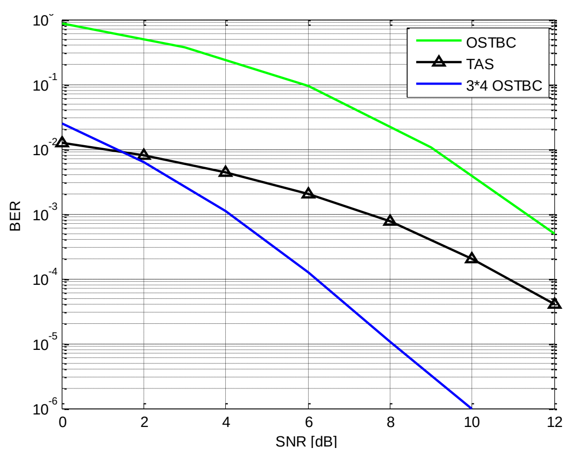

Fig.3 BER performance comparison between OSTBC and TAS SS networks with multiuser diversity

Fig. 4 shows the average Capacity 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 3×4 OSTBC scheme can achieve higher capacity.

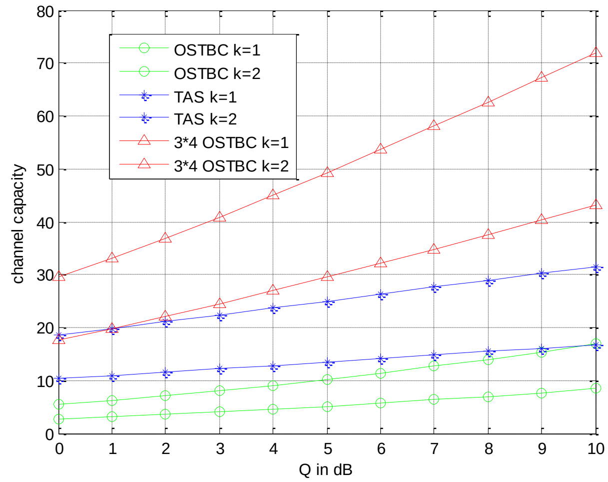

Fig.4. Capacity comparison between OSTBC and TAS SS network with multiuser diversity

VII. CONCLUSION

OSTBC and TAS techniques are proposed in this paper. In OSTBC, we consider four transmit antennas and multiple receive antennas. It has better performance in terms of average capacity, bit error rate and diversity gain. Simulation results show that the OSTBC makes a great contribution to the system performance.

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