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 transmit 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 information (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](image)

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 $P_T^k$ at the secondary transmitter can be selected according to the rule:

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

Where $\|\cdot\|_F$ 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.

\[ y = hx + n \]

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

IV. OSTBC SYSTEM

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 $N \times M$ 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 $x=[x_1,x_2,\ldots,x_m]^T$, the vector is then transmitted via a MIMO channel characterized by the channel matrix $H$ whose element $h_{ij}$ is the random Gaussian complex channel coefficient between the $j$th transmit and $i$th receive antennas with zero mean and unity variance. The received vector is given by

$$r = Hx + n$$

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, $x_1, x_2, x_3$ and $x_4$. The symbols, $x_1$, $x_2$, $x_3$, $x_4$, are transmitted from antenna 1, 2, 3 and 4 during the first time slot. $n_1, n_2, n_3, n_4$ are the noises of four transmit symbols and $h_1, h_2, h_3, h_4$ 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

$$\text{arg min}_{\{x_i\}_{i=1}^4 \in \mathcal{S}} \left[ f_{1,4}(x_1,x_4) + f_{2,3}(x_2,x_3) \right] = \text{arg min}_{x_1, x_4 \in \mathcal{S}} f_{1,4}(x_1,x_4) + \text{arg min}_{x_2, x_3 \in \mathcal{S}} f_{2,3}(x_2,x_3)$$

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

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

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

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

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,

\[ BER = \frac{\text{number of bits in error}}{\text{total number of bits sent}}. \]

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.
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.

REFERENCES


