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An Improved Transmission Scheme Using an Extra Source in the Cooperative Communication System

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Abstract. For the quality of communication as multiple-input multiple-output (MIMO), the cooperative scheme has been widely used in the wireless communication system. One of the cooperative schemes is space-time cyclic delay diversity (STCDD). In this paper, a cooperative transmission scheme using two sources and applying STCDD is proposed. When a destination is distant from a source, the system uses two sources through relays and obtains good BER performance.

Keywords: MIMO, cooperative communication, diversity, STCDD

1 Introduction

In wireless communication, MIMO has been widely applied since MIMO provides spectral efficiency and high data rate. However, the use of multiple antennas has some disadvantages for cost, complexity and difficulty of implementation. At the terminals, implementation of multiple antennas is more difficult due to the limitation of the antenna size or high cost [1].

In order to overcome these problems in MIMO systems, cooperative communication is employed. In cooperative communication, single-input or single-output systems are operated as MIMO system without using the extra antennas at transmitter and receiver. The basic principle of cooperative communication is that single-antenna mobile device becomes a relay for other mobile device and this process creates a virtual MIMO system [2].

MIMO and virtual MIMO using the cooperative scheme obtain spatial multiplexing and spatial diversity gains. In order to obtain these gains, some schemes have been studied. One way is orthogonal space time block code (OSTBC). In OSTBC, the designed signal using orthogonal code is transmitted for the two time slots using a block code [3]. If Alamouti scheme in OSTBC is used, full diversity gain and full data rate can be obtained [4]. Another way is cyclic delay diversity (CDD) [5]. In CDD, cyclically delayed signals are transmitted by antennas with different time delays at different places. The cooperative scheme

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combining OSTBC with CDD is STCDD. STCDD has an advantage that the degradation in performance can avoid when the number of relays is more than two [6]. In this paper, the new scheme using an extra source and a relay is proposed and STCDD is applied to the proposed scheme. It is assumed that the channel state between a relay and an extra source is better than the channel state between a relay and an original source.

2 System Model

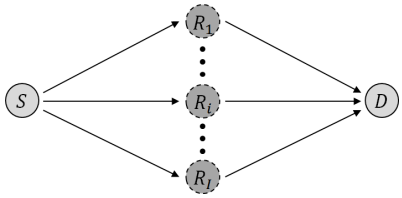

Fig. 1. Cooperative transmission relaying system.

The cooperative relaying system is explained in this section. The signal from a source S is transmitted to a relay R_i where i is $\{1, 2, ..., I\}$ and experiences the process of decode and forward (DF) protocol. the reconstructed signal by DF is retransmitted to a destination D and D demodulates the reconstructed signal by DF. The system is assumed that S, D and each relay have one antenna for transmission and reception. This system assumes that the transmitted signal from a source experiences a Rayleigh fading channel having quasi-static characteristics. A noise is regarded as a complex additive white Gaussian noise (AWGN). A received signal vector $\mathbf{Y}$ is expressed as follows,

$$\mathbf{Y} = \mathbf{HX} + \mathbf{n}, \tag{1}$$

where $\mathbf{H}$ denotes a complex channel matrix, $\mathbf{X}$ is a matrix of the complex OFDM symbols transmitted from S and $\mathbf{n}$ denotes a vector of AWGN with zero mean and σ^2 variance.

3 Proposed Cooperative Transmission Scheme

The cooperative transmission scheme uses one source and three relays in this paper. The signal is transmitted from a source to relays and the processed signal by DF at the relays is retransmitted to a destination. Since a source is assumed to have one antenna, the relays can receive only one symbol for one time slot in the conventional scheme when the OFDM symbol x_1 and x_2 are transmitted. In the proposed scheme, two symbols x_1 and x_2 can be transmitted for one time slot since two sources are used.

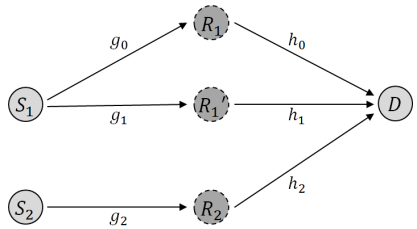

Fig. 2. Proposed cooperative transmission scheme.

The proposed cooperative system is represented in Fig. 2. The destination D can receive the signal from the source S_2 through the relay R_2. The system uses three relays and assumes that R_2 by S_2 is better than the third relay by S_1 since the good two relays by S_1 are already selected. And the proposed scheme can employ STCDD. STCDD is the scheme combining OSTBC with CDD and has good performance compared with OSTBC and CDD.

4 Simulation Results

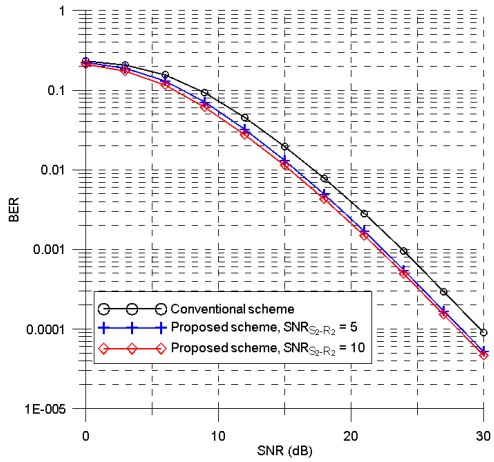

Fig. 3. BER performance of the conventional and proposed schemes.

This section shows the performances of the conventional and proposed relaying schemes. The simulation assumes that the channel is perfectly estimated, a source shares its information with other sources and relays share their channel information each other. All simulations are applied with following parameters; the fast Fourier transform (FFT) size is 256, the modulation is 16 quadrature

amplitude modulation (16QAM) and the guard interval (GI) is 64. Signals are coded by a 1/2 rate convolutional code and the constraint length is 3. The power of transmitted signals is uniformly allocated and the signals experience a 7-path Rayleigh fading. In order to equitably compare two schemes, the conventional and proposed schemes use three relays.In the simulation, the channel state between R_2 and S_2 is expressed as the SNR value. The SNR values are 5 and 10. Each case denotes $SNR_{S_2\text{-}R_2} = 5$ and $SNR_{S_2\text{-}R_2} = 10$. Fig. 3 represents the BER performances of the conventional and proposed schemes in the case $SNR_{S_2\text{-}R_2} = 5$ and $SNR_{S_2\text{-}R_2} = 10$. It is confirmed that the proposed scheme has better BER performance than with the conventional scheme.

5 Conclusions

The cooperative transmission scheme receiving the signals from two sources is proposed. In the proposed scheme, STCDD can be employed and BER performance is improved. When a destination is distant from a source, the BER performance of the proposed scheme is more improved than the conventional scheme because the system uses two sources.

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