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An Improved Transmission Rate Achievement in Cooperative Communication System Based on OFDM

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Abstract. Recently, cooperative system is an interesting issue in communication systems. Single mobile antenna can have transmission diversity gain by the cooperative system as multiple input multiple output (MIMO) system. However, the most of the cooperative systems have a problem about the transmission rate loss. In this paper, hierarchical modulation is proposed in order to solve the transmission rate-loss in the cooperative system.

Keywords: cooperative scheme, OFDM, hierarchical modulation

1 Introduction

In wireless communication system, MIMO is useful system since the MIMO system has a good reliability or improved data rate by multiple antenna in transmitter and receiver. However, the MIMO system has the problems such as complexity, cost and power in mobiles by implement of the multiple antenna. The problems of MIMO is solved in the cooperative system. The cooperative scheme uses the virtual antenna array. The virtual antenna array is consisted by the mobile users that use the single antenna. The cooperative scheme can obtain the diversity gain. However, the cooperative scheme has the rate-loss by the signaling between the source and the relay [1] - [5].

In this paper, the hierarchical modulation is proposed in the cooperative system. the hierarchical modulation can transmit the two symbols at the same time and enables to selectively demodulate according to the channel condition. Although the proposed scheme has the reduction of the bit error rate (BER) performance compared with the conventional cooperative scheme, obtains the almost full transmission rate.

2 System model

Fig. 1 shows the proposed system model. The proposed system model uses one source, relay and destination. The source and the relay are mobile users using

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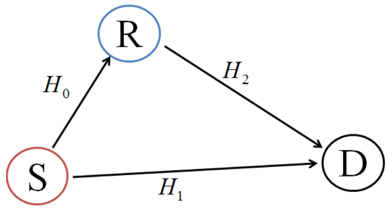

Fig. 1. The cooperative OFDM system model.

the single antenna. The system model applies the cooperative scheme based on orthogonal frequency division multiple (OFDM). Therefore, the transmission symbol of a source and a relay is consisted of orthogonal sub-carriers and the influence of channel is estimated by one-tap equalizer in receiver.

The channel coefficients are expressed as H_0, H_1 and H_2. The relay is selected to have the best channel coefficient with the source. The signals are transmitted by broadcasting. The relay retransmits the received signals by using decode and forward (DF) protocol.

3 Proposed scheme

The proposed scheme uses the 16-quadrature amplitude modulation (16-QAM)/ quadrature phase shift keying (QPSK) hierarchical modulation. The proposed scheme applies the different demodulation schemes in the relay and destination of the cooperative system by the 16-QAM/QPSK hierarchical modulation. In this paper, the source transmits the combination symbol of the successive two QPSK symbols by 16-QAM. At the first phase, the successive two QPSK symbols are expressed as follows $S(1)$ and $S(2)$ and the combination symbol is expressed as follows $S(1,2)$. Therefore, the source enables the transmission of the successive two QPSK symbols at the same time. The relay and the destination receive the $S(1,2)$. The relay demodulates the received symbol of $S(1,2)$ by 16-QAM and obtains the data for the two successive QSPK symbols of $S(1)$ and $S(2)$. The destination demodulates the the received symbol of $S(1,2)$ by QPSK and obtains the data for the first QPSK symbol of $S(1)$. At the second phase, the source transmits the combination symbol of $S(2)$ and $S(3)$ by 16-QAM and the relay re-transmits the $S(2)$ to the destination by QPSK and DF protocols. The destination receives the symbols of $S(2,3)$ and $S(2)$ from the relay and the source respectively at the same time. The destination uses the QPSK demodulation schemes. Therefore, the destination obtains the data for $S(2)$ at the second phase. This method enables to obtain the full transmission rate if the QPSK symbol is the transmission symbol in the conventional cooperative system. In the destination, the received signal at the n-th phase are generalized as follows,

$$Y(n) = S(n, n+1)H_1 + S(n)H_2 + \eta_n, \tag{1}$$

where H_1 and H_2 are the channel coefficients between the source and destination and the relay and destination respectively and η_n is additive white Gaussian noise (AWGN) in receiver. Eq. (1) is decoded as follows,

$$\tilde{S}(n) = \begin{cases} \dfrac{Y(1)}{H_1}, & n = 1 \\ \dfrac{Y(n)}{H_1 + H_2}, & n > 1. \end{cases} \tag{2}$$

4 Simulation results

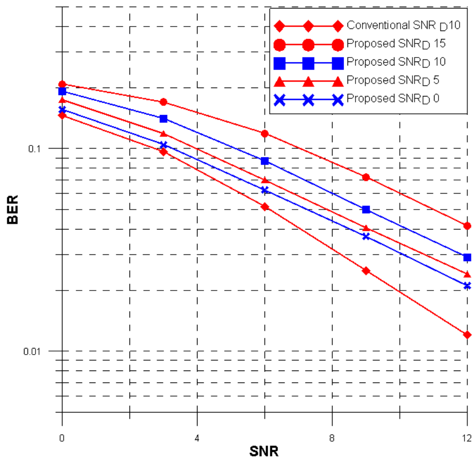

Fig. 2. BER performance of the proposed scheme according to SNR_D.

In this section, the BER performance and the throughput are expressed in Fig. 2 and Fig. 3. In the simulations, each channel is Rayleigh fading channel and the convolutional coding is used. Fast Fourier transform (FFT) size is 256 and cyclic prefix (CP) size is 64. SNR_D expresses the difference between SNR of source-relay channel and SNR of source-destination channel. Fig. 2 shows the BER performance of the proposed scheme with the conventional cooperative scheme. Fig. 3 shows the throughput of the proposed scheme for SNR_D 0, 5 and 15 [dB]. Throughput is obtained as follows,

$$T = (1 - E) \times R \times N, \tag{3}$$

where T is throughput, E is error rate, R is data rate and N is bit length.

5 Conclusion

The proposed scheme provides the method obtaining the almost full transmission rate by using hierarchical modulation although has the reduction of the BER

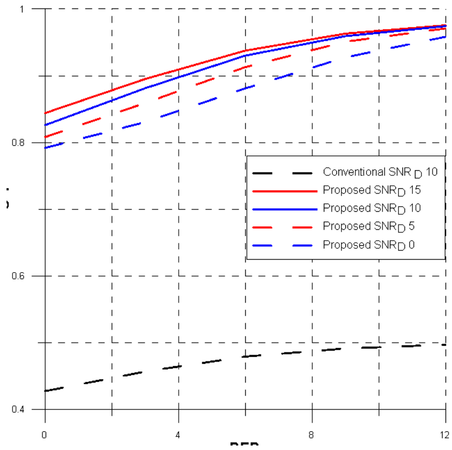

Fig. 3. Throughput of the proposed scheme according to SNR_D.

performance. However, the reduction of the BER performance can be solved by using the effective diversity schemes additionally.

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