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The Study on the Transmission Structure for High Transmission Rate Based on Cooperative Communication

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Abstract

Recently, cooperative communications have been proposed that allows single antenna system in a multi user environment to share their antennas. And cooperative communications make a virtual multiple antenna transmitters that can achieve transmit diversity. But cooperative communications reduce transmission rate because the relay can re-transmit the received signals from the source. In this paper, new technique is proposed for high transmission rate based on decode-and-forward (DF) protocol. This technique adversely affects the bit error rate (BER) performance. But because transmission rate is increased, the throughput is increased.

Keywords: *STBC, DF, cooperative communication, transmission rate*

1. Introduction

Multiple-input multiple-output (MIMO) technology using multi-path provides high-throughput or reliability and increases range. But additional frequency resources are not consumed. Nowadays the high-throughput and range are facing problems. MIMO technique solves these problems. MIMO technique can achieve high-speed, spectral efficiency and wide-range. And MIMO technique has good compatibility with existing orthogonal frequency division multiplexing (OFDM) system. To achieve these advantages, sufficient spaces between antennas are required to guarantee the independence of each path. But due to size, cost, and hardware limitations, many products like a cellular phone may not be able to support multiple antennas.

Cooperative communications have been proposed to solve these problems. Cooperative communications share the antennas and make a virtual multiple antenna transmitter that can achieve transmit diversity. But cooperative communication reduces transmission rate compared with MIMO. In this paper, new transmission structure and detection techniques are proposed for high transmission rate.

2. A New Transmission Technique of the Proposed Scheme

All transmission devices of cooperative communications are comprised of source and relay. Source is the main agent of transmission. And relay helps transmission of source by using DF protocol [1]. Relay receives the transmitted signals from the source and then re-transmits by DF protocol. Therefore, relay can transmit the received signals from the source. It brings transmission rate reduction. A new technique is proposed to improve transmission rate. It is assumed that best relay is already selected.

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Table 1 is transmission structure at the source and the relay. In Table 1, column is the time slot. The relay receives the transmitted signal in previous time from the source. And the received signal is re-transmitted by rule of transmission structure. It satisfies the condition of relay. The transmission structure looks like two STBC blocks [4].

Table 1. Transmission Structure of the Proposed Scheme

Phase	1	2	3	4	5
Source	x_1	$-x_2^*$	x_3	x_4	$-x_3^*$
Relay		$\hat{x}_1^*$	$\hat{x}_2$	$\hat{x}_3$	$\hat{x}_4^*$

3. Detection Procedure of Proposed Technique

The signals are transmitted according to the proposed transmission structure. And it is arrived at the destination through the channel. Destination receives superposition signals from source and relay at each phase. Received signals at the destination can be represented as

$$y_1 = h_1 x_1 \quad (1)$$

$$y_2 = -h_1 x_2^* + h_2 \hat{x}_1^* \quad (2)$$

$$y_3 = h_1 x_3 + h_2 \hat{x}_2 \quad (3)$$

$$y_4 = h_1 x_4 + h_2 \hat{x}_3 \quad (4)$$

$$y_5 = -h_1 x_3^* + h_2 \hat{x}_4^*, \quad (5)$$

where h is channel.

It is considered that fading is constant across five phases. And it is considered that the channel is estimated perfectly at the destination.

Detection processes have two-step. In the first-step, x_3 and x_4 are decoded by STBC decoding algorithm [4]. And then, x_1 and x_2 are decoded by STBC decoding algorithm after the successive interference cancellation (SIC) [6].

3.1. STBC Decoding Algorithm

In Table 1, transmission structure of phase 3 and 4 is a typical STBC block. x_3 and x_4 are obtained by STBC decoding algorithm as following equations.

$$x_3 = \frac{(h_2^* y_4 - h_1 y_5^*)}{(h_1^2 + h_2^2)} \quad (6)$$

$$x_4 = \frac{(h_1^* y_4 + h_2 y_5^*)}{(h_1^2 + h_2^2)}. \quad (7)$$

3.2 STBC Decoding Algorithm after SIC

To make another STBC block, SIC [6] is performed by using x_3 that is obtained by first-step. SIC can be represented as

$$h_2\tilde{x}_2 = y_3 - h_1 x_3 \tag{8}$$

$$\tilde{y}_1 = y_1 + h_2\tilde{x}_2 = h_1 x_1 + h_2\tilde{x}_2 . \tag{9}$$

Using Eq. (9), the STBC block can be made using following equations.

$$\tilde{y}_1 = h_1 x_1 + h_2\tilde{x}_2 \tag{10}$$

$$y_2 = -h_1 x_2^* + h_2\hat{x}_1^* . \tag{11}$$

x_1 and x_2 can be obtained by using STBC decoding algorithm as following equations.

$$x_1 = \frac{(h_1^*\tilde{y}_1 + h_2 y_2^*)}{(h_1^2 + h_2^2)} \tag{12}$$

$$x_2 = \frac{(h_2^*\tilde{y}_1 - h_2 y_2^*)}{(h_1^2 + h_2^2)} . \tag{13}$$

4. Simulation Result

For comparison of the system performance according to increased transmission rate, define throughput G.

$$G = (1-R)\times R_t \times N , \tag{14}$$

where R is BER value, R_t is transmission rate, and N is the number of transmitted bit per one phase time. So, throughput is number of transmission success-bits per one phase time.

Figure 1 shows BER performance of proposed scheme compared conventional scheme. The BER performance of proposed scheme is about 1[dB] lower than conventional scheme. According to increased transmission rate, this result is achieved. Although BER performance is decreased, if the throughput is increased, proposed scheme is better than conventional scheme.

Figure 2 shows throughput of proposed scheme compared conventional scheme. According to the result, throughput of proposed scheme is increased about 30[bpp] than conventional scheme, where [bpp] is bits per phase.

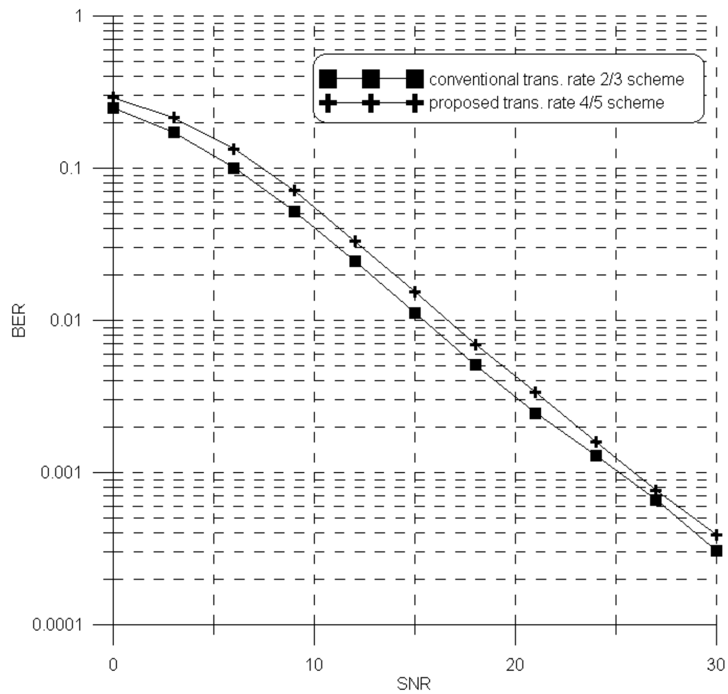

Figure 1. BER Performance of Proposed Scheme Compared with Conventional Scheme

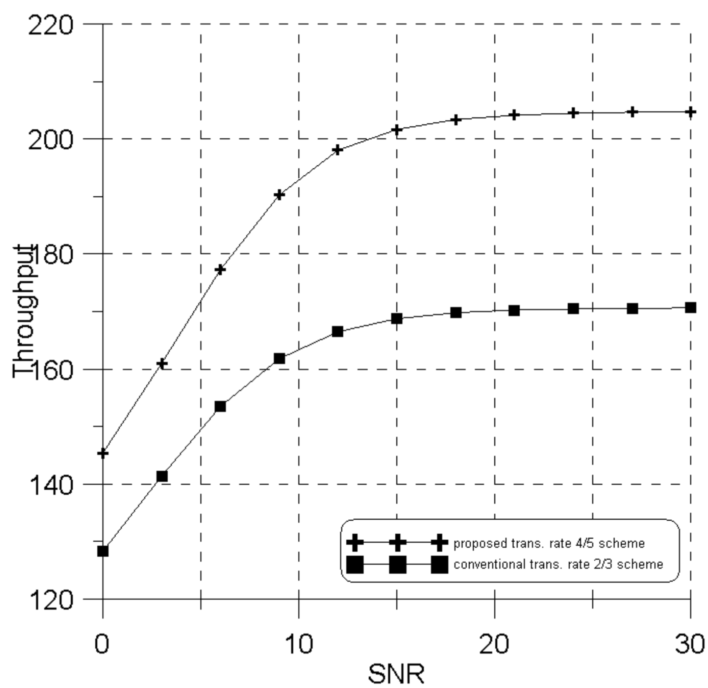

Figure 2. Throughput of Proposed Scheme Compared with Conventional Scheme

5. Conclusion

The rising demand of reliability and speed makes cooperative communication research. Cooperative communication can achieve higher reliability than the general communication. But cooperative communication reduces transmission rate. Transmission rate is decreased from 1 to 2/3. It has a bad effect of the throughput. In this paper, this problem is solved. Transmission rate is increased by proposed transmission structure. As a result, transmission rate is increased from 2/3 to 4/5. And although the BER performance is a little bad, overall throughput is increased about 30[bpp]. Proposed scheme can achieve high-throughput without additional hardware. Therefore, in order to achieve high-throughput, proposed scheme should be used.

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References

[1] A. Nostratinia, T. E. Hunter and A. Hedayat, "Cooperative Communication in Wireless Networks", IEEE Communications Magazine, vol. 42, **(2004)**, pp. 74-80.

[2] A. Sendonaris, E. Erkip and B. Aazhang, "User Cooperation Diversity", Part I, System Description, IEEE Transactions on Communications, vol. 51, **(2003)**, pp. 1927-1938.

[3] A. Sendonaris, E. Erkip and B. Aazhang, "User Cooperation Diversity", Part II, Implementation Aspects and Performance Analysis, IEEE Transactions on Communications, vol. 51, **(2003)**, pp. 1939-1948.

[4] S. M. Alamouti, "A Simple Transmit Diversity Technique for Wireless Communication", IEEE Journal on Selected Areas in Communications, vol. 16, **(1998)**, pp. 1451-1458.

[5] J. -S. Yoon, S. -Y. Yeo, J. H. Kim and H. -K. Song, "Cooperative Transmission Technique Using Space Time Delay Code in OFDMA Uplink System", IEICE Transactions on Communications, vol. E90-B, **(2007)**, pp. 1270-1273.

[6] C. Mun, "Transmit-antenna Selection for Spatial Multiplexing with Ordered Successive Interference Cancellation", IEEE Transactions on Communications, vol. 54, **(2006)**, pp. 423-429.

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