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A Cooperative STBC Scheme Based on Superposition Modulation in Wireless Communication

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Abstract. This paper proposes a combination of space-time block codes (STBC) and superposition modulation (SM). It is aimed to obtain both high reliability and throughput. Conventional STBC can not achieve high throughput by passing the relay. The proposed scheme improves the throughput by using SM. Additionally, it can transmit signals of source and relay at the same time.

Keywords: space-time block code, superposition modulation, OFDM

1 Introduction

In wireless communication system, the attenuation and distortion of signal are occurred by multi-path fading. This problem is solved by transmitting same signal repeatedly. One of the solutions is multi-input multi-output (MIMO). The MIMO scheme transmits signals through a number of antennas in transmitter and obtains diversity gain in the receiver [1]. One of the MIMO schemes is space-time block codes (STBC) [2]. The STBC scheme obtains full rate and diversity gain. But, the MIMO scheme does not fit the present communication system using the single antenna. In order to solve this problem, cooperative communication has been proposed [3].

Cooperative communication is defined as scheme that shares the antenna of user. By using cooperative communication, user can obtain the diversity gain. Additionally, cooperative communication can obtain the high reliability such as the MIMO scheme. However, cooperative communication has low throughput because the signal is transmitted to destination through the relay. In order to solve this problem, many schemes have been proposed.

One of the schemes that improve the throughput is superposition modulation (SM) [4]. SM is modulation scheme that superimpose a number of signals. By using SM, the throughput is increased and the channel capacity is more effective than the existent modulation scheme.

In this paper, an improved cooperative communication using SM is proposed. By using SM that superimposes a number of signals, high throughput is obtained than the conventional modulation scheme.

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2 System Model

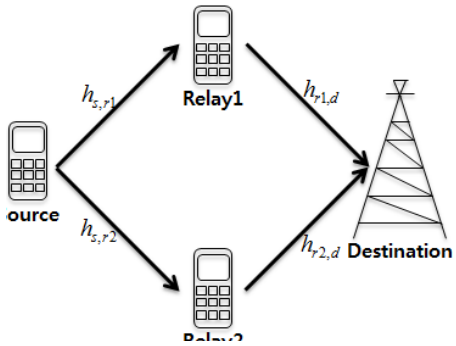

Fig. 1. Cooperative communication model.

Fig. 1 shows cooperative communication model using relays. The cooperative communication model consists of the source, two relays and destination. It is assumed that the source can not communicate with the destination directly. Namely, the source should communicate with the destination through the relay. The cooperative communication model uses STBC. STBC is one of the MIMO schemes. By using STBC, the cooperative communication model obtains full rate and diversity. The relay performs a signal process. The method of signal process is amplify-and-forward (AF) and decode-and-forward (DF) [5]. In this paper, the relay uses the DF scheme. The relay decodes and re-encodes the received signal and transmits the re-encoded signal to the destination. The DF scheme has more complexity than the AF scheme. But, the DF scheme has better performance than the AF scheme in bad channel condition.

3 Proposed Cooperative Communication Scheme

In this paper, SM that quadrature phase shift keying (QPSK) symbol is superimposed is used. The cooperative communication scheme is defined as STBC. The STBC is a scheme that obtains the diversity gain simply in the receiver. The signal of STBC is constituted such as Table 1. It is assumed that both the source and relays have the signal that they want to be transmitted. In the Table 1, x_s denotes the signal that the source wants to transmit to the destination, x_r denotes the signal that the relay wants to transmit to the destination, $\widetilde{x}$ denotes the signal performed the DF scheme in the relay and r denotes the received signal in the destination. In the first step, the source transmits the $x_{s,1}$ at time t. In the next step, the source transmits the $x_{s,2}$ at time $t+T$. Each relay receives the signal of source and performs the DF scheme. After the DF scheme, each

Table 1. Signal composition for STBC

time	source	relay 1	relay 2	destination
t	$x_{s,1}$			
t+T	$x_{s,2}$			
t+2T		$\widetilde{x}_{s,1}, x_{r,1}$	$\widetilde{x}_{s,2}, x_{r,2}$	r_1
t+3T		$-(\widetilde{x}_{s,2}, x_{r,2})^*$	$(\widetilde{x}_{s,1}, x_{r,1})^*$	r_2

relay transmits the signals that signal of source and signal of relay are superimposed at time $t + 2T$ and $t + 3T$. In the destination, received signals are defined as follows:

$$\begin{aligned} r_1 &= r(t+2T) = h_{r1,d}(\widetilde{x}_{s,1}, x_{r,1}) + h_{r2,d}(\widetilde{x}_{s,2}, x_{r,2}) \\ r_2 &= r(t+3T) = -h_{r1,d}(\widetilde{x}_{s,2}, x_{r,2})^* + h_{r2,d}(\widetilde{x}_{s,1}, x_{r,1})^* \end{aligned} \tag{1}$$

where T denotes the symbol duration, $h_{r1,d}$ denotes a channel between the relay 1 and the destination, $h_{r2,d}$ denotes the channel between the relay 2 and the destination and r denotes the received signal in the destination. The received signal is detected as follows:

$$\begin{aligned} \widehat{x}_{s,1}, \widehat{x}_{r,1} &= h^*_{r1,d} r_1 + h_{r2,d} r^*_2 \\ \widehat{x}_{s,2}, \widehat{x}_{r,2} &= h^*_{r2,d} r_1 - h_{r1,d} r^*_2 \end{aligned} \tag{2}$$

where $\widehat{x}$ is estimated signal in the destination. The destination receives the superimposed signal that wants to transmit the source and relay. Therefore, the destination can receive the signal of source and relay at the same time.

4 Simulation Results and Conclusion

In the simulation, the cooperative communication system uses orthogonal frequency division multiplexing (OFDM) with subcarrier of 256. It is assumed that a channel coding is considered as convolutional codes with 1/2 code rate. It is assumed that a channel is the independent Rayleigh fading.

Fig. 2 shows BER performance used by 16QAM and the proposed scheme that superimposed QPSK symbol. Each QPSK symbol has weight of 0.8944 and 0.4472. BER performance of proposed scheme is similar to 16QAM. QPSK symbol that has large weight shows more BER performance than 16QAM. In this system, QPSK symbol that has large weight transmits the signal of source and QPSK symbol that has small weight transmits the signal of relay. Therefore, the signal of source has high reliability.

In this paper, STBC using SM is proposed. The proposed scheme superimposes two QPSK symbols. In the case of BER performance, the proposed scheme is similar to 16QAM. Additionally, the signal of source that has the large weight gains more BER performance than 16QAM. In the case of throughput, the proposed scheme is similar to 16QAM. Therefore, the proposed scheme using SM transmits the signal of source and relay at the same time. Additionally, QPSK symbol that has the large weight gains high reliability.

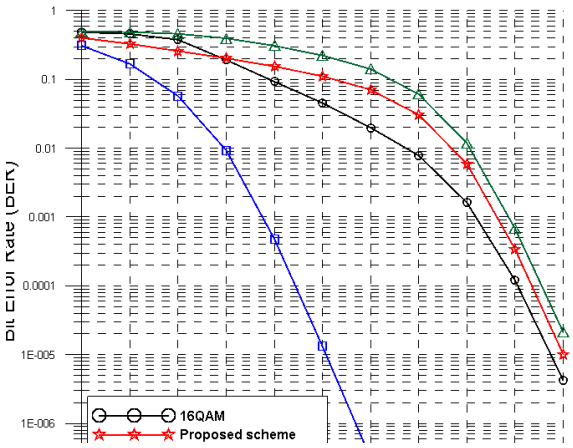

Fig. 2. BER performance of proposed cooperative communication using SM.

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