International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:8, No:1, 2014

Efficient Single Relay Selection Scheme for Cooperative Communication

Sung-Bok Choi, Hyun-Jun Shin, Hyoung-Kyu Song

***Abstract*—**This paper proposes a single relay selection scheme in cooperative communication. Decode-and-forward scheme is considered when a source node wants to cooperate with a single relay for data transmission. To use the proposed single relay selection scheme, the source node makes a little different pattern signal which is not complex pattern and broadcasts it. The proposed scheme does not require the channel state information between the source node and candidates of the relay during the relay selection. Therefore, it is able to be used in many fields.

***Keywords*—**Relay selection, cooperative communication, df, channel codes.

I. Introduction

MULTIPATH fading is one of the primary problems in the wireless communications. To solve this problem, many schemes have been studied. One of the solutions is diversity. Time, frequency and spatial diversity techniques are used to decline for the effect of fading. The multiple-input and multiple-output (MIMO) is the one of the schemes to make diversities. The multiple transmit and receive antennas are able to make space-time diversity. Therefore, the receiver can get more reliable signal-to-noise ratio (SNR). But, it is difficult for mobile devices to use MIMO due to size, power limitation, costs and so on. To adapt MIMO to mobile devices, a cooperative communication was proposed and has been studied in the literature with different channel and system model assumptions. Two major schemes are amplify-and-forward (AF) and decode-and-forward(DF). AF scheme amplifies the received signal and forwards the amplified signal to the destination node at the relay. Because of its simplicity, AF scheme has been adapted in many applications. DF scheme decodes the received signal, re-encodes and forwards to the destination node at the relay. Because of decoding the received signal, the effect of the noise is reduced in received signal. Therefore, DF scheme is more durable about the noise than AF scheme. Moreover, it is more powerful when the channel coding is integrated [1], [2].

When the received signal is not able to be decoded correctly, the relay transmits the wrong signal. Therefore, the destination node has difficulty in decoding correctly due to the received signal from the relay. Therefore, a selection of the good relay is one of the important issues in the cooperative communication. To overcome this problem, many researchers have been studied. One of the solutions is to compare to each instantaneous SNR at the relay [3]. In this scheme, all nodes know all information in order to calculate each SNR at each relay. Another solution is to set specific threshold. When an instantaneous SNR is higher than threshold at some relays, the source chooses this relay for cooperative communication [4]. This scheme has a difficulty in fixing the threshold because the channel is time-varying, not fixed. Besides, many schemes have been studied and proposed [5].

In this paper, the proposed scheme uses a little different pattern for the relay selection. In addition, the source node broadcasts this pattern repeatedly to choose the best relay for cooperative communication and collects the information of the candidates. The proposed scheme selects the best relay by checking this information.

This paper is organized as follows. Section II deals with the basic DF scheme system for cooperative communication. Section III deals with the proposed scheme. Section IV deals with simulation results and discussions. Section V is the conclusion.

II. Basic DF Scheme System

In this section, the basic DF scheme system is considered. Fig. 1 is the general environment. In general, a source node and many candidates such as the relay exist. The source node wants to transmit its data to a destination node. But, the channel state between the source and the destination node is not good or it is difficult for the source to transmit because it is far between the source and the destination node. Therefore, the source node tries to find the best relay for transmitting its data. Fig. 2 shows the basic DF scheme system in cooperative communication after relay selection. This system consists of two time slots such as the first time slot and the second time slot.

In the first time slot, the source node encodes the data which the source wants to transmit. In DF scheme, some channel codes are considered like convolutional codes, Reed Solomon codes, turbo codes and LDPC. By using these channel codes, the DF system is more tolerant for the effect of the noise. After the channel encoder, the source node modulates the encoded data like QPSK, 16QAM and so on. After that, the source node broadcasts the modulated data. Upon receiving broadcasted data, a selected relay demodulates it. After that, the selected relay decodes the demodulated data by using the channel codes. If decoding outcome is fail, the selected relay is idle. If decoding outcome is successful, the selected relay process re-encodes and re-modulates the decoded data.

In the second time slot, the selected relay transmits the re-modulated data to a destination node. In the destination node,

Sung-Bok Choi, Hyun-Jun Shin and Hyoung-Kyu Song are with uT Communication Research Institute, Sejong University, Seoul, Korea (corresponding author: Hyoung-Kyu Song; phone: +82-2-3408-3890; fax: +82-2-3409-4264; e-mail: songhk@sejong.ac.kr).

two data are received.

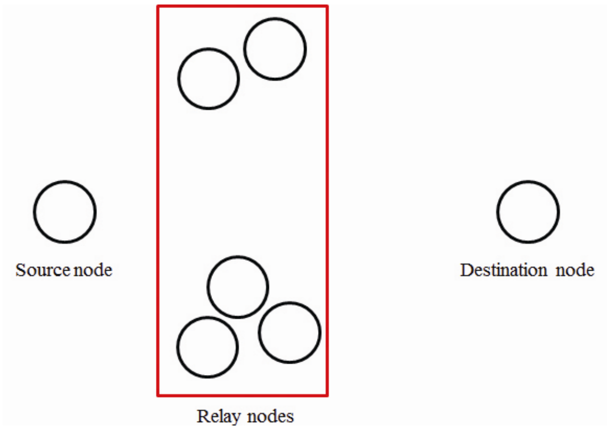

Fig. 1 General environment before the relay selection

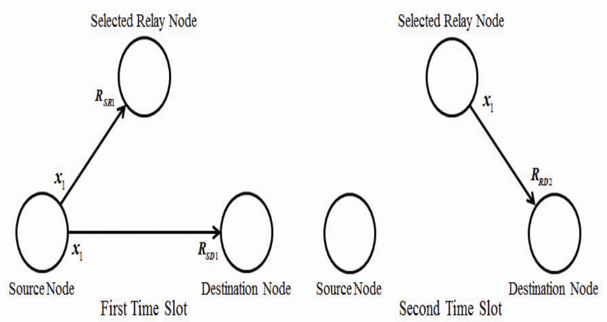

Fig. 2 Basic DF scheme system

The destination node uses maximal ratio combining (MRC) for combining them from the source node and the selected relay. The MRC process is presented as,

$$\mathbf{R}_{SD1} = \sqrt{RE_b}\mathbf{h}_{SD1}\mathbf{x}_1 + \mathbf{n}_{SD1}, \tag{1}$$

$$\mathbf{R}_{RD2} = \sqrt{RE_b}\mathbf{h}_{RD2}\mathbf{x}_1 + \mathbf{n}_{RD2}, \tag{2}$$

$$y = \mathbf{h}^*_{SD1}\mathbf{R}_{SD1} + \mathbf{h}^*_{RD2}\mathbf{R}_{RD2}, \tag{3}$$

$$\mathbf{x}_1 = \frac{\mathbf{y}}{\left|\mathbf{h}^*_{SD1}\right| + \left|\mathbf{h}^*_{RD2}\right|} \tag{4}$$

where $\mathbf{R}_{SD1}$ and $\mathbf{R}_{RD2}$ are received data from the source node and the selected relay. $\mathbf{h}$ is the complex fading channel coefficients and $\mathbf{h}^*$ is the conjugated fading channel coefficients. R is the code rate of the channel encoder, E_b is the energy per transmitted message data and $\mathbf{n}$ is zero mean additive white Gaussian noise. After MRC process, the destination node demodulates x1 and decodes. After that, the destination node is able to gain the data of the source node.

III. Proposed Scheme for Selection of the Best Relay

In this section, the proposed scheme for selection of the best relay is considered. Before transmitting the data, the source node selects the best relay among candidates of the relay.

D_{seq}	D_{seq}

Fig. 3 Data for the relay selection

In this paper, the best relay means that channel between the source and the best relay has a little effect of noise. In other words, the best relay is able to help the source node to transmit its data more reliably. If the selected relay is not best, the reliability of the received data in the destination node is reduced. Therefore, selection of the best relay is an important factor in cooperative communication.

The proposed scheme uses a characteristic of the modulation. Each modulation has a different bit error rate and symbol error rate in channel condition. According to required modulation scheme, the proposed scheme also uses required modulation scheme. Since the proposed scheme uses only modulation, the proposed scheme does not require any channel state information between the source node and candidates of the relay. The data for the relay selection is shown in Fig. 3. $\mathbf{D}_{seq}$ is the modulated data symbols. This structure consists of two data slots which have the same modulated symbols. After making this structure, the source node broadcasts this data to the candidates as the relay. After receiving this data, the candidates demodulate it and compare front demodulated $\mathbf{D}_{seq}$ with back demodulated $\mathbf{D}_{seq}$. If the channel state between the source node and any candidate is good, bit error between two demodulated $\mathbf{D}_{seq}$ is low. In other words, two demodulated $\mathbf{D}_{seq}$ are similar. If the channel state between the source node and any candidate is not good, bit error is higher than channel state of other candidates. After checking each BER in each candidate, all candidates transmit their information to the source node. The source node checks this information and selects the best relay. According to iterative number set in advance, this process is repeated to select the best relay more accurately.

IV. Simulation Results and Discussions

In this section, the simulation results and discussions are considered. To select the best relay, the proposed scheme uses100 QPSK symbols in one $\mathbf{D}_{seq}$. The iterative number for relay selection is 100. After relay selection, the DF scheme with OFDM system is considered in cooperative communication. The number of subcarriers is 128 and 16QAM is used for data modulation. Also, channel coding is considered as convolutional codes with 1/2 code rate [6], [7]. This system assumes that channel is the independent Rayleigh fading with 7 tap delays. 4 candidates for the cooperative communication with the source node exist and each candidate has SNR gain like -5dB, -2dB, +2dB and+5dB. The SNR gain means that the difference between two channels from the source node to the destination node and from the source node to each candidate. In this simulation, the candidate which has +5dB SNR gain is the best relay.

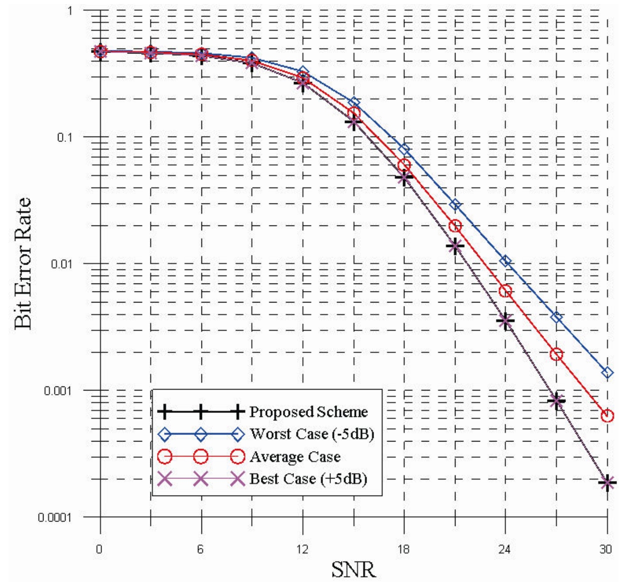

Fig. 4 BER performance for proposed scheme, worst case, average case and best case in this paper

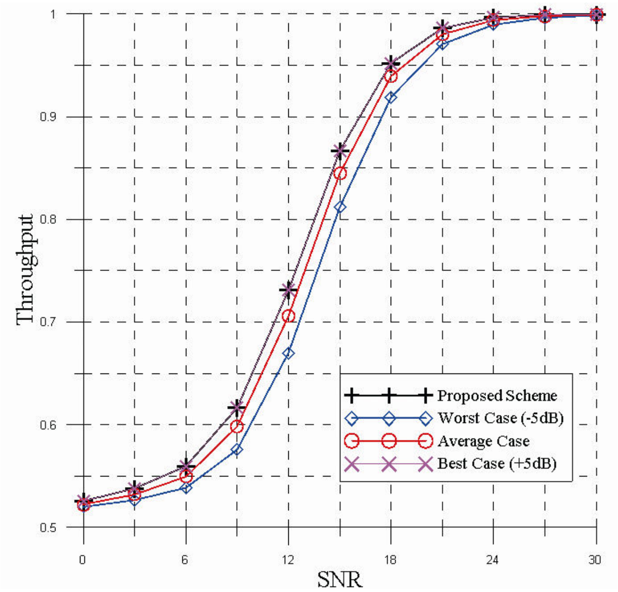

Fig. 5 Throughput for proposed scheme, worst case, average case and best case in this paper

Fig. 4 is BER performances of the proposed scheme, the worst case (-5dB), the average case and the best case (+5dB) and Fig. 5 is throughput performances. The proposed scheme is able to select the best relay for the cooperative communication due to the same BER performance and throughput with the best case.

The performance of proposed scheme depends on the data length for the relay selection. Fig. 6 shows relationship between data length for the relay selection and selection probability of each candidate as the best relay in SNR=10dB. The data length used for the relay selection is 10, 20, 50, 70, 100, 200, 300,500 and 700.

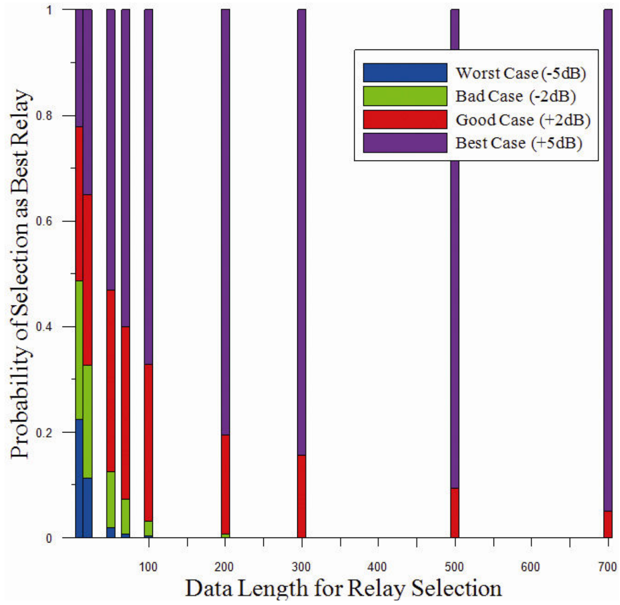

Fig. 6 Selection probability of each candidate such as best relay

In case the source node uses short data length for the relay selection, the source node has difficulty in selecting the best case as the best relay. In case the source node uses long data length for the relay selection, the source node is able to select the best case easily.

Therefore, the more data is used for the relay selection, the more source node selects the best relay. However, the more data is used for the relay selection, the more source node requires time to select the best relay.

V. Conclusion

This paper proposes the single relay selection scheme by using a characteristic of the modulation. The proposed scheme does not require any channel state information during relay selection. The simulation results show that the proposed scheme is able to select the best relay for the cooperative communication. The source node is able to select the best relay among candidates of the relay, if the data length for the relay selection is considered well. Although the simulation is only processed in DF scheme with cooperative communication, AF scheme is also adapted when the relay selection is required.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology (No. 2012-000902) and this work was supported by the IT R&D program of MTIE/KEIT [10041686, Cooperative Control Communication/Security Technology and SoC Development for Autonomous and Safe Driving System].

REFERENCES

[1] A. Nosratinia, T. E. Hunter and A. Hedayat, "Cooperative communication in wireless networks," *IEEE Commun. Mag.*, vol. 42, no. 10, pp. 74-80, Oct. 2004.

[2] K. J. Ray Liu, Ahmed K. Sadek, Weifeng Su and Andres Kwasinski, *Cooperative communications and networking*, Cambridge, 2009.

[3] Yindi Jing and Hamid Jafarkhani, "Single and multiple relay selection schemes and their achievable diversity orders," IEEE Trans. Wirel. Commun. vol. 8, no. 3, pp. 1414—1423, March 2009.

[4] A. S. Ibrahim, A. K. Sadek, W. Su and K. J. R.Liu, "Cooperative communications with relay selection: when to cooperative and whom to cooperate with?," *IEEE Trans. Wirel. Commun.* vol.7, no. 7, pp.2814-2827, July 2008.

[5] J. I. Baik, E. H. Lee and H. K. Song, "Adaptive cooperative communications with multiple antennas," *J. Electromagn. Waves Appl.*, vol. 27, no. 13, pp.1632-1639, Aug. 2013.

[6] John G. Proakis, *Digital communications*, McGraw-Hill Higher Education, 2001.

[7] Bernard Sklar, *Digital communications fundamentals and applications,* Prentice Hall PTR, 2001.

Sung-Bok Choi was born in Seoul, Korea in 1986. He received the B. S. degree in Information & Communication Engineering, Sejong University, Seoul, Korea in 2013. He is working toward to M.S. degree in the Department of information and communications engineering, Sejong University, Seoul, Korea. His research interests are in the areas of wireless communication

Hyun-Jun Shin was born in Seoul, Korea in 1986. He received the B. S. degree in Information & Communication Engineering, Sejong University, Seoul, Korea, in 2013. He is working toward to M.S. degree in the Department of information and communications engineering, Sejong University, Seoul, Korea. His research interests are in the areas of wireless communication system design and cooperative communication.

Hyoung-Kyu Song was born in Chung Cheong-Bukdo, Korea in 1967.He received B.S., M.S., and Ph.D. degrees in electronic engineering from Yonsei University, Seoul, Korea, in 1990, 1992, and 1996, respectively. From 1996 to 2000 he had been managerial engineer in Korea Electronics Technology Institute (KETI), Korea. Since 2000, he has been a professor of the Department of information and communications engineering, Sejong University, Seoul, Korea. His research interests include digital and data communications, information theory and their applications with an emphasis on mobile communications.