An Adaptive Cooperative Transmission Scheme According to the User Location

Chang-Hee Kang1, Hyun-Jee Yang1 and Hyuong-Kyu Song1*

1 uT Communication Research Institute, Sejong University, Seoul, Korea
kknaghea@nate.com, hjyang206@naver.com, songhk@sejong.ac.kr

Abstract. In this paper, an adaptive cooperative transmission scheme according to the user location is proposed. The proposed cooperative scheme considers the destination user location and applies cooperative scheme properly. If the destination user is located in the cell boundary, the quality of communication is degraded in the broadcasting system. In the conventional scheme, broadcasting base station and cellular base station are used to obtain high performance. However, the quality of communication is not well guaranteed and the transmission distance is increased since the destination user is far from each base station. Therefore, the adaptive transmission scheme for the user location is proposed. In the simulation results, the proposed scheme can obtain more improved performance than the conventional scheme.

Keywords: adaptive transmission, broadcasting system, cooperative transmission, improved performance.

1 Introduction

In wireless communication, the communication quality is degraded by the effect of channel fading and inter-symbol interference. The path loss according to the distance between transmitter and receiver has a bad effect on the communication quality. In order to improve the quality of the communication, multiple-input multiple-output (MIMO) systems which provide high data rate and reliable communication are studied. Since the MIMO system uses a number of antennas, the cost of the system is expensive and the complexity of the hardware is increased [1]. So, the cooperative transmission scheme is studied to resolve the problem of the MIMO system. The cooperative transmission scheme uses single antenna user and build the virtual MIMO system. In the cooperative transmission scheme, composition elements are source, destination user and relay. The relay located between source and destination user transfers the signal transmitted from the transmitter to the destination with independent path. So, the destination user received the signal additionally by using the relay [2].

The cooperative transmission scheme can obtain diversity gain since the destination user received additional signal from the relay. Also, the reliability of the communication is improved. In this paper, space time block code (STBC) scheme is adapted to improve the performance of the proposed scheme. So, the proposed scheme constructs the virtual MIMO system by cooperating with one antenna users.
The STBC scheme uses two time slots to transmit symbols from two transmission antennas. In the STBC scheme, the diversity gain is obtained since the time and space are separated [3].

The communication performance is influenced from the transmission distance between a base station and a destination user. If a destination user is distant from a base station, the performance of communication is degraded. In the conventional scheme, broadcasting base station and cellular base station are communicates with a destination user. In order to improve the performance, this paper proposes an adaptive cooperative transmission scheme using relay according to the location of a destination user. The proposed scheme can improve the quality of the communication since the relay is used with STBC scheme in the cell boundary. So, the location of a destination user is considered to improve the performance and reliable communication. In the proposed scheme, two locations are used and the cooperative transmission scheme is adaptively utilized in each location. Therefore, the propose scheme obtains more high performance than the conventional scheme in the cell boundary [4].

The remaining sections are organized as follows. Section 2 shows the system model and Section 3 represented the conventional scheme. The proposed scheme is shown in Section 4 and the simulation results are presented in the Section5. In Section 6, the conclusion of the proposed scheme is shown.

2 System Model

In this section, the system model of cooperative system is represented. The system which is based on orthogonal frequency division multiplexing (OFDM) uses the relay between a base station and a destination user. Since the use of the relay can reduce the transmission distance, the destination user is near the base station. Also, the quality of communication is improved and reliable transmission is impossible. In the conventional scheme, a destination user communicates with a broadcasting base station (BBS) and a cellular base station (CBS) and the relay is not used. On the contrary, the relay is used between BBS and a destination user and CBS and a destination user in the proposed scheme. In the proposed scheme, the use of the relay can extend the cell coverage by locating between a base station and a destination user.

The proposed scheme is based on cooperative transmission scheme. The cooperative transmission is composed of BBS, CBS and the relay and the destination user. In the cooperative transmission, the relay is selected when the channel condition is good among many users. The selected relay receives the signal to the destination user. Also, the relay and the destination user use one antenna and BBS shares channel quality information (CQI) of the destination user with CBS. In the system model of the proposed scheme, the BBS and CBS communicate with the destination user which is located in the cell boundary. So, the performance of the communication is degraded by the increase of the distance [5].

This system assumes that the transmitted signal suffers the Rayleigh fading channel which has a quasi-static characteristic. At the receiver, the signal adds additive white Gaussian noise (AWGN). The expression of the received signal can be presented as follows,
\[ z = hx + n, \quad (1) \]
where \( z \) is a received signal, \( h \) means a channel, \( x \) represents a transmitted symbol. The \( n \) is AWGN noise which has zero mean and \( \sigma^2 \) variance.

### 3 Conventional Scheme

In this section, the conventional scheme is presented. The conventional scheme is composed of the broadcasting base station is BBS, the cellular base station is CBS, and the destination user. In this system, a destination user receives the signal from BBS and CBS without relay. So, the diversity gain is obtained in this system.

![System Model](image)

**Fig. 1.** The system model of conventional transmission scheme.

Fig. 1 means the system model of the conventional cooperative transmission scheme. In the same cell coverage, BBS and CBS transmit the signal to the destination user without cooperative transmission scheme. Therefore, if the destination user is located in the cell boundary, the performance is not improved. In the conventional scheme, the OFDM symbol \( x_1 \) and \( x_2 \) are transmitted from BBS and CBS. Table 1 shows the transmitted symbol from BBS and CBS. Since BBS and CBS share their information with each other, BBS and CBS can transmit the signal at the same time.

**Table 1.** Transmission sequence of the conventional scheme.

<table>
<thead>
<tr>
<th>Time slot</th>
<th>BBS</th>
<th>CBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>X1</td>
<td>X2</td>
</tr>
<tr>
<td>T2</td>
<td>X2</td>
<td>X1</td>
</tr>
</tbody>
</table>
In the conventional scheme, the destination user receives the signal from BBS and CBS, the diversity gain is obtained. However, this scheme can’t reliable transmission if the destination user is located in the cell boundary and the channel condition of the destination user is bad. As a result, the adaptive cooperative transmission scheme is proposed for the improved performance in this paper.

4 Proposed Scheme

In the broadcasting system, the BBS and CBS communicate with each other and the quality of the communication is affected by the location of the destination user. If the destination user is located in the cell boundary, the communication performance is degraded by the distance increase. Therefore, an adaptive cooperative transmission scheme for the reliable transmission is proposed in this paper.

The location (a) and (b) are used in the proposed scheme according to the two locations. Each location adapts STBC scheme of cooperative transmission scheme for reliable transmission when the destination user is located in the cell edge. In Fig. 2, the adaptive proposed schemes are represented. Also, the location (a) and (b) are using cooperative transmission scheme with relay for improved performance. In the location (a) of the Fig. 2, the destination user is located in the cell boundary of CBS. On the other hand, the destination user is located in the cell boundary of BBS in the location (b) of Fig. 2. The adaptive transmission scheme is necessary for reliable transmission since two locations have different environment of communication system. Therefore, this paper proposes an adaptive cooperative transmission scheme with relay to obtain high performance and diversity gain. Also, STBC scheme of cooperative transmission scheme is applied to improve the communication performance when the transmission distance between BBS and the destination user and between CBS and destination user is increased. So, the adaptive cooperative proposed scheme which uses relay between a base station and the destination user is obtained more good BER and throughput performance than the conventional scheme.

Fig. 2. The system model of proposed transmission scheme.
Table 2. Transmission sequence of the location (a) in proposed scheme.

<table>
<thead>
<tr>
<th>Time slot</th>
<th>BBS</th>
<th>Relay</th>
<th>CBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>X1</td>
<td>X2</td>
<td>X1</td>
</tr>
<tr>
<td>T2</td>
<td>-X2*</td>
<td>X1*</td>
<td>X2</td>
</tr>
</tbody>
</table>

Table 3. Transmission sequence of the location (b) in proposed scheme.

<table>
<thead>
<tr>
<th>Time slot</th>
<th>BBS</th>
<th>CBS</th>
<th>Relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>X1</td>
<td>X1</td>
<td>X2</td>
</tr>
<tr>
<td>T2</td>
<td>X2</td>
<td>-X1*</td>
<td>X1*</td>
</tr>
</tbody>
</table>

Table 2 expresses the transmission sequence of the adaptive cooperative transmission scheme about the location (a). Also, Table 3 expresses the transmission sequence of the adaptive cooperative transmission scheme about the location (b). In Table 2 and Table 3, the BBS and CBS transmit the OFDM symbol x1 and c2 during two time slots. X1* and X2* mean the signal suffering STBC scheme which is spatial diversity scheme. In the location (a), the BBS and the relay process the STBC scheme since the destination user is far from the BBS compared with CBS. On the other hand, since the destination user is far from the CBS compared with BBS, the CBS and the relay process the STBC scheme in the location (b).

5 Simulation Results

In this section, BER and throughput performance comparison figures are shown. The adaptive cooperative transmission scheme is compared with the conventional scheme to prove the performance improvement. In order to fair comparison, the simulation environment is applied equally in the conventional scheme and the proposed scheme. Also, it is assumed that BBS and CBS share their information of channel quality with each other. The OFDM modulated signals are transmitted and the number of subcarrier is 64. The transmitted signals use quadrature phase shift keying (QPSK) modulation and 1/2 convolutional code is also used. The 7-path Rayleigh fading channel is suffered in these simulations. Finally, the transmitted signals are detected by the minimum mean square error (MMSE).

In the simulation, the attenuation rates of the channel condition are expressed 10 and 15 decibel (dB). These two dB values mean that the channel condition between a base station and the destination user is bad since the destination user is located in the cell boundary.

Fig. 3 shows bit error rate (BER) performance of the conventional scheme and proposed scheme. The simulation graph is also expressed according to the destination user location (a) and (b) and conventional scheme. It is confirmed that the proposed scheme has higher BER performance than the conventional scheme in all locations by the simulation results.
In Fig. 4, the throughput performance is presented. In similar BER performance, the throughput performance of the proposed scheme is good compared with the conventional scheme. In other words, the adaptive cooperative transmission scheme can be obtained improved BER and throughput performance. Also, this means that the proposed scheme is more efficiently in the broadcasting system and possible the reliable transmission in the attenuation environment.

![Fig. 3. The simulation result of BER performance.](image1)

![Fig. 4. The simulation result of throughput performance.](image2)

6 Conclusion

In this paper, the adaptive cooperative transmission scheme according to the destination location is proposed in order to improve the quality of communication. The conventional scheme can obtain diversity gain since BBS and CBS transmit the
signal to the destination user at the same time. However, the performance of the conventional scheme is degraded if the distance between BBS and the destination user and CBS and the destination user is increased and the communication environment is bad. So, this paper proposes the adaptive cooperative transmission scheme with relay according to the destination user location. As a result, the improved performance is provided by proposed scheme since the relay transmits the additional signal by short transmission distance. Also, the application of the suitable transmission scheme considering two locations can obtain good performance. Therefore, the proposed scheme can do reliable communication with relay in the attenuation environment.

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