Performance Enhancement Scheme Using Hierarchical Modulation in Cooperative Communication

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Abstract. In this paper, a decode-and-forward cooperative communication system using hierarchical modulation (HM) to improve bit error probability (BER) performance is proposed. A HM symbol has high priority (HP) and low priority (LP) data streams that have different levels of BER. In the proposed scheme, all decoded symbols are treated as HP symbol by suitable design for cooperative communication. Consequently, the proposed scheme makes it possible to obtain equal BER performance in both streams. Simulation result shows that the proposed scheme provides better BER performance than conventional cooperative communication scheme in same rate.

Keywords: cooperative communications, decode-and-forward, hierarchical modulation.

1 Introduction

Cooperative communication is emerging as a countermeasure of multiple-input multiple-output (MIMO) system. Cooperative communication techniques have been investigated to improve reliability of data by transmission of same data from different location. But it has to have two time slot (TS) for one signal transmission, due to TS for retransmission of partner’s signal called cooperation phase. The retransmission scheme is optional. Among them, decode-and-forward (DF) cooperation scheme has been widely studied [1], [2]. Also HM has been studied in [3]–[5]. In this paper, a new transmission scheme for cooperative communication using HM is proposed. Simulation result shows that the BER performance of the proposed scheme is better than that of the conventional scheme.

2 Scheme Description

The considered wireless OFDM system is that there are two users who communicate with same destination by cooperative communication and transmission is

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divided by TS. Each user transmits OFDM symbols to partner and destination. Throughout this paper, notation \( s, h \) and \( n \) denote symbol, channel coefficient and complex Gaussian additive noise with zero mean and variance of \( \sigma^2 \). Also \( i, (i=0,1,2,...) \) denotes TS sequence and is used with other notation. \( h_i \) is modeled as independent and identically distributed (i.i.d) for different \( i \).

In the proposed transmission scheme with two cooperating users, two symbols in symbol frames of two users are concatenated as a superimposed HM symbol. Mapping to constellation of a HM symbol is determined by priority of each of symbols. The method of allocation of HP and LP streams in the proposed scheme depends on user who wants to generate symbol. Always own stream is put in the position of HP.

The proposed scheme has to have initial stage to successive transmission. Table 1 shows form of transmitted symbols according to TS. As explained, the proposed HM-based cooperation scheme is differentiated from former HM schemes. It uses LP mapping as retransmission of partner’s data.

### 3 Simulation Result and Discussion

The error performance of proposed scheme is evaluated and compared with conventional cooperative scheme. In order to compare the performance differences of the conventional scheme with proposed schemes, perfect equalization and synchronization are assumed. Convolutional code with a rate 1/2 with generator \((13,17)\) is applied. Lastly, users-destination channel signal to noise ratio (SNR) is same each other and inter-user channel SNR is 10dB higher. Fig. 1 shows the BER performance of conventional scheme and proposed scheme in Rayleigh fading channel. The scheme with a novel transmitter design has better BER performance than conventional scheme about 0.3dB at \(10^{-3}\). So the proposed scheme can operate in less power consumption to achieve target performance with same rate for conventional scheme.

Table 1. The comparison of transmission schemes. Each capital alphabet represents two information bits and notation \( s^{A(m)} \) and \( s^{B(m)} \), \((m = 1, 2, 3,...)\) denote symbol sequence of user1 and user2, respectively. Underline and (·) denote HP mapping and regenerated symbol from received signal, respectively.

<table>
<thead>
<tr>
<th>TS</th>
<th>User1</th>
<th>User2</th>
<th>Proposed Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(s^{A(1)}s^{A(2)})</td>
<td>(s^{B(1)}s^{B(2)})</td>
<td>(s^{A(1)}) initial stage</td>
</tr>
<tr>
<td>1</td>
<td>(s^{B(1)}s^{B(2)})</td>
<td>(s^{A(1)}s^{A(2)})</td>
<td>(s^{B(1)}) initial stage</td>
</tr>
<tr>
<td>2</td>
<td>(s^{A(1)}s^{A(2)})</td>
<td>(s^{B(2)}s^{A(1)})</td>
<td>(s^{A(2)}s^{B(1)})</td>
</tr>
<tr>
<td>3</td>
<td>(s^{B(2)}s^{A(1)})</td>
<td>(s^{A(2)}s^{B(1)})</td>
<td>(s^{B(3)}s^{A(2)})</td>
</tr>
<tr>
<td>4</td>
<td>(s^{A(3)}s^{A(4)})</td>
<td>(s^{B(4)}s^{A(3)})</td>
<td>(s^{B(4)}s^{A(3)})</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
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<td>...</td>
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</table>
In this paper, a new transmission scheme with HM in cooperative communication is proposed to improve BER performance. The simulation result demonstrates that the proposed scheme is about 0.3dB better than the reference scheme with same data rate. The proposed scheme does not use LP part of symbol for decoding. If effective decoding scheme with LP is applied, the proposed scheme can obtain more diversity than conventional scheme.

Acknowledgment. This work was supported by the IT R&D program of MKE/KEIT [10039988]. And 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. 2010-0015785).

References