A Cooperative Diversity Technique Using Precoding for OFDMA System in Wireless Communication

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\textbf{Abstract.} Cooperative communication has been broadly investigated to improve performance of wireless communication. But, most of the conventional cooperative techniques have a common problem of decreased transmission rate because the destination should receive the decodable compositions of symbols from the source and the relay. In this paper, we propose the new cooperative system which uses a feedback signal for orthogonal frequency division multiple access (OFDMA). This proposed scheme is free from the rate-loss and obtains additional diversity.

\textbf{Keywords:} Precoding, OFDMA, Cooperative communication

1 Introduction

Recently, the broadcasting system has attracted considerable attention. The digital broadcasting systems have increasingly been grown for services such as digital TV, digital radio. In recent years, many new digital services have appeared with rapid development of digital broadcasting technology. The demands for a variety of data services, additional information on TV and multimedia services are growing sharply. Moreover, some people want to control and create the broadcasting services. In order to meet these demands, many digital broadcasting systems consider an interactive wireless communication. Therefore, there are many researches for interactive digital broadcasting. One of interactive digital broadcasting techniques is digital video broadcasting for return channel terrestrial. The DVB-RCT is made by using the orthogonal frequency division multiple access (OFDMA). Since it can achieve multi-user diversity by designing the subcarrier allocation algorithm, OFDMA is regarded as a promising solution for enhancing the performance of wireless communication. To offer high reliability in wireless communication, many researchers have developed various multiple antenna techniques [1], [2]. The transmit diversity systems can be classified into open-loop

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and closed-loop. In the open-loop systems, one of precoding techniques requires a 1-bit feedback information [3], [4].

The general transmit diversity systems using the multiple antennas have problems for the cost, power and size. Solution of the problems is cooperative communication techniques. Cooperative diversity provides additional diversity. In the OFDMA uplink systems of wireless communications, the cooperative diversity is very efficient and powerful technique, since each user uses different frequency bands from each others. However, most of the introduced cooperative schemes have a common defect of decreased transmission rate because the destination should receive the decodable compositions of symbols from the source and the relay [5].

So, new cooperative technique using precoding scheme for OFDMA system is proposed. The proposed scheme can avoid rate-loss and obtains additional diversity.

2 Proposed Cooperative Scheme

We consider the cooperative OFDMA system in wireless interactive communication as shown in Fig. 1. This system is consisted of two users which have a single antenna and a base station which has a single antenna. $H_{1,2}$ and $H_{2,1}$ are inter-user channels and $H_{1,B}$ and $H_{2,B}$ are uplink channels from users to base station. Received symbols are estimated with decode and forward (DF) method [6]. In this section, proposed cooperative technique is introduced for OFDMA system. The users search the best partner among several candidates. At the time slot 1, the selected users transmit the own signal with BPSK modulation. The received signal is estimated with DF method. At the time 2, the estimated signal and own signal are recomposed. The recomposed signal is coded with feedback information and is transmitted to base station. Then, the transmitted signal is modulated with QPSK modulator. $P_m$ is defined as precoding vector for feedback information with phase flipping. The signal is normalized for the
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overall transmit power because the transmit power is equally split between two antennas. Since information for feedback is only no state change or state change, feedback variable is sufficient. The base station estimates the received symbol without additional process. The estimated signal is written as:

$$\hat{X}_{(i,j)}(l) = Y(l)/H_n.$$  \hspace{1cm} (1)

$H_n$ is the superimposed channel. Although the first time slot causes the rate-loss, the rate of the proposed scheme becomes one when $l$ is infinite.

3 Simulation Results and Discussions

To simulate the cooperative OFDMA system performance, it is assumed that each channel undergoes Rayleigh fading and is independent and identically distributed (i.i.d) random complex for multipath channel and the system is the full-duplex channel. Also, the channels are assumed to be constant during one time slot and channel state for communication link is estimated entirely at receiver. The 1st user to 2nd user link condition is an important factor to obtain the cooperative diversity. So, this simulation is considered as inter-user channel state. Fig. 2 shows the BER performance of the proposed scheme with multiple antenna schemes using cyclic delay diversity (CDD) with $2 \times 1$ in $\text{SNR}_D = 0.5$. $\text{SNR}_D$ is the difference between inter-user SNR and uplink SNR and is the relative condition of the inter-user channel. Fig. 2 shows that performance of cooperative technique is higher than $2 \times 1$ CDD.

![Fig. 2. BER performance of proposed scheme compared with CDD](image-url)
4 Conclusion

In this paper, it is proposed to cooperative scheme using precoding scheme in OFDMA system. The simulation result shows that performance of the proposed cooperative scheme obtains a diversity gain with the one antenna when SNR increases. The proposed technique can be free from the loss of transmission rate and additional diversity gain.

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