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Relay Selection in Cooperative Diversity Systems

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Abstract. In this paper, we propose an improved relay selection scheme for single-relay decode-and-forward cooperative diversity systems, in which relays are selected according to instantaneous channel state information and a cooperative threshold is set up to eliminate some unsatisfying relays from the set of alternative relays and thus reduce the calculated amount. Simulation results show that the proposed improved relay selection scheme can achieve very high performance with low computational complexity.

Keywords: cooperative diversity; decode-and-forward; relay selection

1 Introduction

Cooperative diversity has been considered for the next generation wireless communication systems. The basic idea is that a user and its partner/partners transmit cooperatively, thus providing space diversity [1,2]. Research shows that the relay selection scheme affects the performance of a cooperative diversity system greatly. In [3], the opportunistic selection protocol is proposed and analyzed, [4] develops the worst-link-first (WLF) matching algorithm, and [5] presents cooperative regions in coded cooperative systems.

In this paper, single-relay decode-and-forward (DF) cooperative diversity systems are considered. We propose an improved relay selection scheme, in which relays are selected according to instantaneous channel state information (CSI). Simulation results show that the proposed scheme can achieve very high performance with low computational complexity.

The rest of this paper is organized as follows. Section 2 describes the transmission model. In section 3, an improved WLF relay selection scheme is proposed. The simulation results are given in Section 4. Section 5 gives the main conclusions of this paper.

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2 Transmission Model

A single-relay DF cooperative diversity system is considered. Fig. 1 shows the transmission model. h_{SD}, h_{SR} and h_{RD} denote channel fading coefficients of source to destination (S—D), source to relay (S—R) and relay to destination (R—D) links, respectively. The process of cooperative communication can be divided into two stages: in the first stage of cooperation (broadcasting stage), source transmits information to destination and relay, relay then decodes information; in the second stage of cooperation (relaying stage), relay forwards information to destination, destination combines signal transmitted from source in the first stage and signal transmitted from relay in the second stage according to maximum ratio combination method and then decodes information.

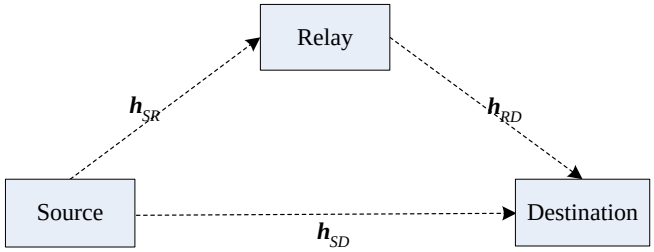

Fig. 1. Transmission model

3 Improved WLF Relay Selection Scheme

We suppose that binary phase shift keying (BPSK) modulation is adopted. We use γ_{SD}, γ_{SR} and γ_{RD} to denote the instantaneous signal to noise ratio (SNR) of S—D link, S—R link and R—D link, respectively.

It can be concluded that if we want a notable improvement of bit-error-rate (BER) performance, the following threshold for single-relay DF cooperative diversity systems should be satisfied,

$$\gamma_{SR} > \gamma_{SD} \quad . \tag{1}$$

If this cooperative threshold is not satisfied, the BER performance of a DF cooperative diversity system cannot be much better than that of direct transmission, it may be close to or even poor than the BER performance of direct transmission.

WLF matching algorithm can achieve high performance with low complexity. Its basic idea is that the user with the worse channel condition is prior to other users in choosing its partner.

We consider quasi-static and flat fading channel and select relays for users according to instantaneous CSI. A non-reciprocal scenario is considered and a special threshold, as shown in (1), is set up to avoid unnecessary cooperation and narrow the alternative relay field.

Here, we use $\mathbf{U}_{\mathbf{un}}$ to denote the set of users that haven't find their relays, and use $\mathbf{R}_{\mathbf{un}}$ to denote the set of users that haven't been selected as other users' relays. The improved WLF scheme proposed can be expressed as follows.

1) The base station (BS) selects a user i from $\mathbf{U}_{\mathbf{un}}$ with the smallest γ_{SD}.

2) The BS selects a user j from $\mathbf{R}_{\mathbf{un}}$ as the relay of user i such that the theoretical instantaneous BER is the smallest one and satisfies (1). Then delete user i from $\mathbf{U}_{\mathbf{un}}$ and delete user j from $\mathbf{R}_{\mathbf{un}}$.

3) If there is no user j in $\mathbf{R}_{\mathbf{un}}$ satisfies (1), user i will adopt direct transmission mode, and then delete user i from $\mathbf{U}_{\mathbf{un}}$.

4) Repeat 1), 2) and 3) until $\mathbf{U}_{\mathbf{un}}$ is empty.

4 Simulation Results

The simulation results are shown in Fig. 2 and Fig. 3. In the simulation, we suppose that users are uniformly distributed in a circular area, BPSK modulation is employed, the channel is Rayleigh flat-fading and AWGN channel.

Fig. 2 shows the average BERs of direct transmission and DF cooperative diversity systems with different relay selection schemes. It can be seen that the BER performances of improved WLF scheme and WLF scheme are almost same and much better than that of direct transmission and random selection.

Fig. 3 shows the average calculated amounts of relay selection for one user. The calculated amount of calculating the theoretical instantaneous BER once is assumed to be 1. It can be seen that compared to WLF scheme, the improved WLF scheme has a much lower average calculated amount.

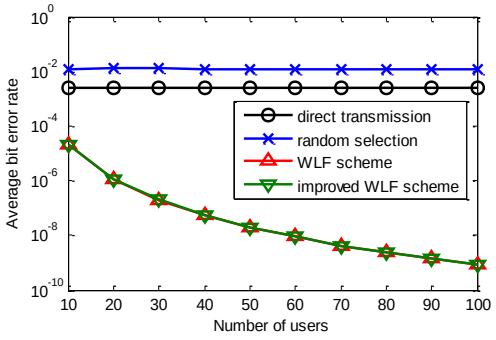

Fig. 2. Average bit error rate

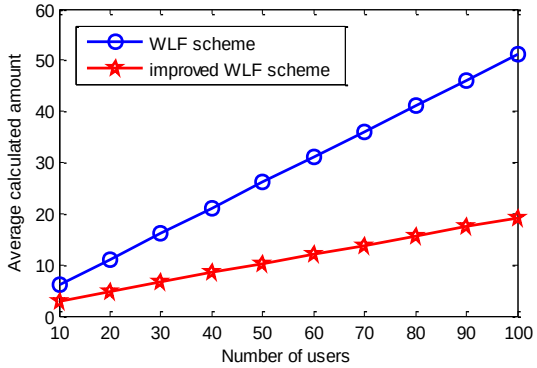

Fig. 3. Average calculated amount

5 Conclusions

In this paper, an improved relay selection scheme is proposed, which employ the cooperative threshold to reduce the number of alternative relays and thus decrease the computational complexity. Numerical simulation results show that the BER performance of the improved WLF relay selection scheme is almost the same as that of traditional WLF scheme, while it has a much lower computational complexity than WLF scheme.

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