Improved Beamforming Design for Full-Duplex Relay-Assisted Cooperative NOMA

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1. Introduction

Non-orthogonal multiple access (NOMA) is a practical solution to improve the spectral efficiency of a downlink multi-user system by accommodating multiple users on the same frequency. Relay-assisted cooperative NOMA (RA-CNOMA) is known to be effective when there is no direct link between a base station (BS) and a user due to obstacles. To further improve the spectral efficiency, the RA-CNOMA using a full-duplex (FD) relay was studied [1]. The main challenge of the FD-RA-CNOMA is to suppress self-interference (SI) and inter-user interference (IUI). We focus on beamforming (BF) at the relay, which has been adopted in [2]. However, the authors in [2] did not consider the mitigation of IUI from a relay to a near user. In this paper, we propose a BF design at the relay to overcome this issue. In the proposed BF design, both SI and IUI are suppressed to improve the system performance.

2. System Model and BF Design

We consider a downlink RA-CNOMA system supporting two users where the near user U1 directly communicates with the BS. In contrast, the far user U2 requires the assistance of a FD relay employing decode-and-forward (DF) protocol. Successive interference cancellation (SIC) is adopted U1. We assume that the BS, U1, and U2 are equipped with a single antenna, and the relay is equipped with N_{T} transmit antennas and N_{R} receive antennas. Let $d_{i,j}$ and $\mathbf{h}_{i,j}$ denote the distance and channel coefficient between nodes $i \in$ {b (BS), r (relay)} and $j \in$ {1 (U1), 2 (U2), r}, respectively.

With perfect SIC, U1 first decodes the symbol of U2, then subtracts it from the received signal to detect the symbol of U1. At the relay, the symbol of U2 is decoded and then transmit it to U2. The transmitted signal is also received at the relay and U1, and they are regarded as SI and IUI, respectively. To suppress both the SI and IUI, we propose to design the transmit and receive BF vectors $\mathbf{w}_{\mathrm{t}} \in \mathbb{C}^{N_{\mathrm{T}}\times 1}$ and $\mathbf{w}_{\mathrm{r}} \in \mathbb{C}^{N_{\mathrm{R}}\times 1}$ by solving the following problems in order:

$$\max_{\mathbf{w}_{\mathrm{t}}} \ |\mathbf{h}_{\mathrm{r2}}^{\mathrm{T}}\mathbf{w}_{\mathrm{t}}|^2, \ \ \text{s.t. } \mathbf{h}_{\mathrm{r1}}^{\mathrm{T}}\mathbf{w}_{\mathrm{t}} = 0, \|\mathbf{w}_{\mathrm{t}}\| = 1. \quad (1)$$

$$\max_{\mathbf{w}_{\mathrm{r}}} \ |\mathbf{w}_{\mathrm{r}}^{\mathrm{H}}\mathbf{h}_{\mathrm{br}}|^2, \ \ \text{s.t. } \mathbf{w}_{\mathrm{r}}^{\mathrm{H}}\mathbf{h}_{\mathrm{rr}}\mathbf{w}_{\mathrm{t}} = 0, \|\mathbf{w}_{\mathrm{r}}\| = 1. \quad (2)$$

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3. Simulation Result

We compare the FD-RA-CNOMA system using the proposed method with the transmit zero-forcing (TZF) method in [2]. The transmission bandwidth is 1.0 MHz. The carrier frequency is 2.0 GHz, and the noise power spectral density is −169 dBm/Hz. The path loss model $-128.1 - 37.6\log(d_{i,j})$ dB is used. Distances $d_{b1}, d_{br}, d_{r1}, d_{r2}$ are 0.1 km, 0.15 km, 0.18 km, 0.15 km, respectively. We set the power allocation coefficient $\alpha_1 = 0.1, \alpha_2 = 0.9$ for U1 and U2, respectively. Quality-of-service (QoS) requirements at U1 and U2 are both 1.0 bps/Hz. The transmit power at BS and relay is 30 dBm, $N_{\mathrm{T}} = N_{\mathrm{R}} = 2$, and the SI cancellation at the relay is −80 dB. We ran 10^6 simulation trials. Figure 1 shows outage probability (OP) and average achieved sum rate (SR). OP is the probability that the rate of U1 or U2 falls below a QoS requirement. The performance of the proposed BF method is not affected by the IUI cancellation level and is superior to the TZF method.

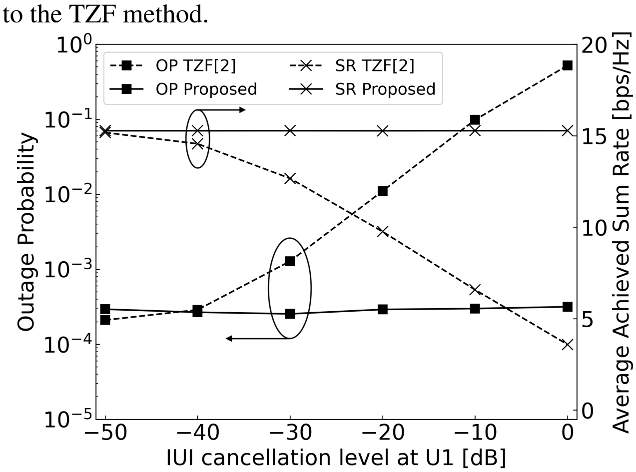

Fig. 1 Performance comparison.

4. Conclusion

We proposed a BF design method for FD-RA-CNOMA, which can improve the outage probability and sum rate over the conventional method.

References

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[2] Z. Mobini, et al., "Beamforming design ...," IEEE Trans. Wireless Commun., vol. 18, no. 6, pp. 3295–3311, Jun. 2019.