Improved Transmitter Design for Downlink NOMA in Frequency-Selective Channels

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1. Introduction

Non-orthogonal multiple access (NOMA) is highly expected to increase system throughput and accommodate massive connectivity by allowing multiple users to share the same spectrum resource simultaneously [1]. For a NOMA system in frequency-selective channels, we proposed to use finite impulse response (FIR) filters at a base station (BS) to suppress inter-symbol interference (ISI) [2]. However, since ISI cannot be removed completely, the performance deteriorates when the number of antennas is small. In this paper, we propose a novel design method of FIR filters to overcome this disadvantage. In the proposed method, both ISI and inter-user interference (IUI) are suppressed by the maximization of the signal-to-noise-plus-interference ratio (SINR).

2. System Model and Filter Design

We consider a downlink NOMA system consisting of a BS, a near user UE1, and a far user UE2. The successive interference cancellation is adopted at UE1. We assume that single-carrier transmission is employed, and frequency-selective channels cause severe ISI. The BS has the perfect channel state information of all the channels. The BS is equipped with N transmit antennas and $2N$ FIR filters of degree L_w, while UEs are equipped with a single receive antenna. Then, the received signal at UEi at time k is represented as $r_i[k] = \mathbf{w}_1^H \mathbf{H}_i \mathbf{s}_1[k] + \mathbf{w}_2^H \mathbf{H}_i \mathbf{s}_2[k] + n[k]$, where $\mathbf{H}_i$ is a channel matrix from the BS to UEi, $\mathbf{w}_i$ is the impulse response of the FIR filter to suppress interference, $\mathbf{s}_i[k]$ is the transmitted symbol vector for UEi, and $n[k] \sim \mathcal{CN}(0, \sigma^2)$ is the noise at UEi. The UEs receive a multiplexed signal including IUI and ISI. Therefore, we need to jointly suppress IUI and ISI.

We consider to suppress the interference implicitly by considering a filter vector that improves each received SINR. We propose to determine $\mathbf{w} \triangleq [\mathbf{w}_1^T \mathbf{w}_2^T]^T$ by maximizing each received SINR. Now, we define the SINR at UE1 and UE2 by

$$\gamma_1 \triangleq \frac{P_1^{\mathrm{des}}(\mathbf{w})}{P_1^{\mathrm{ISI}}(\mathbf{w}) + \sigma^2}, \ \gamma_2 \triangleq \min_{j \in \{1,2\}} \frac{P_{2,j}^{\mathrm{des}}(\mathbf{w})}{P_{2,j}^{\mathrm{ISI+IUI}}(\mathbf{w}) + \sigma^2}, \quad (1)$$

where P_1^{des}, $P_{2,j}^{\mathrm{des}}$, P_1^{ISI}, and $P_{2,j}^{\mathrm{ISI+IUI}}$ represent the desired component power and interference component power of UE1, UE2, respectively. In γ_2 of (1), the case of j corresponds to the SINR of UE2 decoded at UEj. We consider maximizing the minimum SINR among UEs subject to a BS transmit power constraint:

$$\max_{\mathbf{w}} \min_{i \in \{1,2\}} \gamma_i, \quad \text{s.t.} \quad \|\mathbf{w}\|^2 \leq P, \quad (2)$$

where P is the total transmission power. We can obtain a solution of (2) by solving a feasibility problem using the second-order cone programming and the bisection method.

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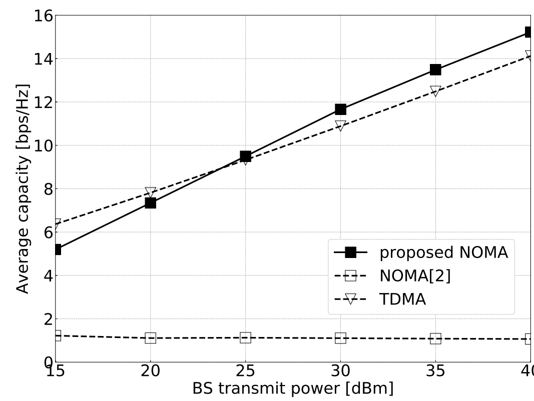

Fig. 1 Comparison with TDMA and NOMA [2].

3. Simulation Result

We compare the NOMA system using the proposed method with the conventional one [2] and a 2-slot time division multiple access (TDMA) system. System bandwidth is 4.32 MHz, $\sigma^2 = -169$ dBm/Hz, $L_w = 9$, and $N = 2$. UE1 and UE2 are randomly generated in the range of 50～250 m, 251～500 m, respectively. Multipath delayed spreads between BS and UE1 and UE2 are 1.16 μs and 1.62 μs. We ran 10^3 simulation trials. Figure 1 shows the average total capacity. The proposed NOMA system achieves a higher capacity than the TDMA system with a transmit power of 25 dBm or higher.

4. Conclusion

We showed that the proposed NOMA system, even with a small number of antennas, improves the system capacity.

References

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[2] T. Kurayama, et al., "Transmitter design ..." Proc. ITC-CSCC2020, Jun. 2020.