User Fairness Power Allocation in OFDMA-based Wireless Powered Communication Network

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1. Introduction

Wireless powered communication network (WPCN) has attracted attention as low-power communication system because they can supply power wirelessly to communication terminals [1]. We have previously proposed a transceiver design method based on sum-rate maximization for OFDMA-based full-duplex WPCN [2] and shown its superiority to the half-duplex WPCN. However, since it does not take the rate fairness among users into consideration, users with poor channel conditions were less likely to be allocated available resources. In this paper, we propose a proportional fairness-based power allocation method that aims to simultaneously achieve user fairness and high sum rate.

2. System Model and Power Allocation Method

We consider an OFDMA-based WPCN consisting of an energy transmitter (ET) with M_T antennas, K users, and an information receiver (IR). ET transmits energy signals to the users using N sub-bands. The users harvest the energy from the received signal and simultaneously transmit information data to IR using the allocated sub-bands. Due to the full-duplex operation of the users, IR experiences the interference from ET. Then, the purpose of the transceiver design is to find the beamformer and power allocation at ET and the sub-band and power allocation at the users to improve the sum rate while enhancing user fairness.

Here we focus on user fairness power allocation $\mathbf{P}_E = [P_1^E \ \cdots \ P_N^E]$ where P_n^E is the allocated power on the nth sub-band of the transmitted signal at ET. We assume that the interference suffered by IR from ET can be effectively suppressed by appropriately setting the beamforming at ET [2]. The transmit power of each user depends on the transmit power of ET and thus is represented as $P_{n,k}^U(\mathbf{P}_E)$. Then, the transmission rate of the k-th user is expressed as $R_k(\mathbf{P}_E) = \sum_{n\in\mathcal{N}_k} \log_2\left(1 + P_{n,k}^U(\mathbf{P}_E)\|g_{n,k}\|^2/\sigma_z^2\right)$, where $\mathcal{N}_k$ is the set of sub-bands allocated to the k-th user, $g_{n,k}$ is the channel gain that k-th user experiences on n-th sub-band, and σ_z^2 is the noise power. The proportional fairness-based power allocation problem can be expressed as

$$\max_{\mathbf{P}_E} \sum_{k=1}^{K} \log\{R_k(\mathbf{P}_E)\} \quad \text{s.t} \sum_{n=1}^{N} P_n^E \leq P_{\max}, \tag{1}$$

where $P_{\max}$ is the total transmit power constraint of ET. Since this problem (1) is convex, it can be efficiently solved by existing convex software packages.

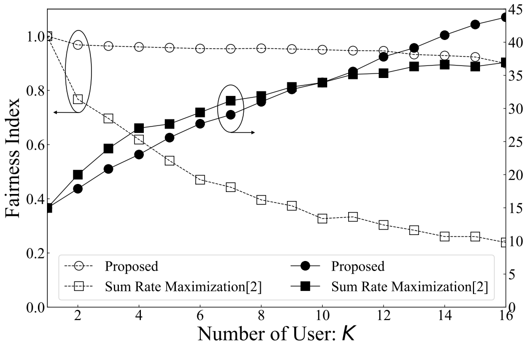

Fig. 1 Comparison with conventional WPCN [2].

3. Simulation Result

In the simulation, we set $M_T = 5$, $N = 16$, $P_{\max} = 40$ dBm, $\sigma_z^2 = -90$ dBm. The coordinates of ET and IR were $(-6\text{m}, 0\text{m})$ and $(6\text{m}, 0\text{m})$. The users were randomly generated in a 3m radius circle centered on the origin. We applied the beamforming method based on maximizing SINR at IR. Also, we applied the user fairness sub-band allocation method [3] based on the max-min criterion. For simplicity, we considered equal power allocation at the users. We compared the WPCN based on the proposed power allocation with the WPCN based on the sum rate maximization [2]. Figure 1 shows the sum rate and fairness index defined by $(\sum_{k=1}^{K} R_k)^2/(K\sum_{k=1}^{K} R_k^2)$. It can be seen that the proposed method can achieve a higher sum rate than [2] for $K \geq 10$ while maintaining high fairness index.

4. Conclusion

We proposed a proportional fairness-based power allocation method and showed that the proposed method achieves a high sum rate while maintaining fairness.

References

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