ISSN: 2664-9640

On the Outage Capacity of Amplify-and-forward Relays with Simultaneous Wireless Information and Power Transfer

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Abstract

Relay selection scheme for simultaneous wireless information and power transfer networks (SWIPT) networks has been investigated. The selection scheme has been designed under the basis of outage capacity minimization, where the outage capacity of the system has been improved after the selection. Simulation has been conducted to validate the efficiency of the proposed scheme.

Keywords

Wireless information, electricity, hair relay

1. Introduction

Relay technique in wireless networks has recently drawn significant research interests [1-3] due to its significant benefits in the throughput improvement, coverage enhancement. There are a great number of relaying strategies, i.e., amplified-and-forward (AF), decode-and-forward (DF) and compute-and-forward (CF). AF relay, one of promising technologies, has been intensively studied recently due to its simplicity and feasibility [4]. Simultaneous wireless information and power transfer (SWIPT) brings flexibility in terms of power management, which has also attracted a lot of research interest [5-9].

We investigate outage capacity minimization of amplify-and-forward relays with simultaneous wireless information and power transfer. We assume that the destination node is battery-powered which requires to harvest enough energy from the receive signal. We derive performance of the SWIPT AF system under two conventional relay selection schemes.

2. System Model

We consider an amplify-and-forward relay network which consists of one base station B, K amplify-and-forward relays R_i and one active user U. All nodes in the considered network are equipped with one signal antenna. It is assumed that there is not any power supply for the user node, which means that the node U need to harvest energy from the received signals. There is no direct link between B and U, and all nodes are working in a half-duplex mode over the same frequency band. Based on known perfect channel state information (CSI), one of relays is selected in advance before the transmission.

The channel from B to R_i and the channel from R_i to U are denoted by complex random variables h_i and g_i respectively. It is assumed that all channels are quasi-static flat Nakagami fading.

During the first slot, the source node transmits the symbol to selected relay node. If the \$i\$th relay node is selected, the receive signal at relay node could be written as

$$y_{R_i} = \sqrt{P_B} h_i x_1 + \sqrt{P_U} g_i x_2 + n_{R_i}$$

where P_B and P_U are the transmit power of the base station and user respectively, x is the transmit symbol, n_{R_i} is the noise at the \$i\$th relay which follows unit complex Gaussian

ISSN: 2664-9640

distribution, i.e. $n_{R_i} \sim CN(0,\sigma,R_i^2)$. Due to the power constraint at the relay, y_{R_i} is amplified by a factor α, where

$$\alpha_i = \frac{1}{\sqrt{P_B |h_i|^2 + P_U |g_i|^2 + \sigma_{R_i}^2}}$$

During the second slot, the relay transmits the amplified signal to end nodes. The user node splits the received signal into two part with the ratio $\rho \in [0,1)$ by the power splitter. After that, $\sqrt{1-\rho}\sqrt{P_{R_i}} g_i \alpha_i y_{R_i}$ is used for the energy harvesting circuit and $\sqrt{\rho}\sqrt{P_{R_i}} g_i \alpha_i y_{R_i}$ is used for decoding, where P_R is the transmit power of the relay node.
Considering channel reciprocity, the signal before decoding is given by

$$y_B = \sqrt{P_{R_i}} h_i^H \alpha_i y_{R_i} + n_B$$
$$y_U = \sqrt{1-\rho}\sqrt{P_{R_i}} g_i^H \alpha_i y_{R_i} + n_U$$

The harvested power and receive signal-to-noise ratio (SNR) at destination are expressed as

$$P_E = \rho P_{R_i} |g_i|^2$$
$$\gamma_B = \frac{P_{R_i} P_U |h_i|^2 |g_i|^2}{[P_B \sigma_B^2 + P_{R_i} \sigma_{R_i}^2] |h_i|^2 + P_U |g_i|^2 \sigma_B^2 + \sigma_B^2 \sigma_{R_i}^2}$$
$$\gamma_U = \frac{(1-\rho) P_{R_i} P_B |h_i|^2 |g_i|^2}{P_B |h_i|^2 \sigma_U^2 + [(1-\rho) P_{R_i} \sigma_{R_i}^2 + P_U \sigma_U^2] |g_i|^2 + \sigma_U^2 \sigma_{R_i}^2}$$

Here we introduce the max-min selection, which could be expressed as.

$$i_{\mathrm{RSM}} = \arg\max_i \min\left\{\| h_i \|^2, \| g_i \|^2\right\}$$

Using the approximation, the outage capacity of the max-min selection could be obtained..

3. Simulation

Fig. 1 shows the system outage probability of the RSM scheme. From this figure, we could see that the system outage probability is dominated by the worse link. It is observed that the analytical results tend to simulation results when the transmit SNR is large.

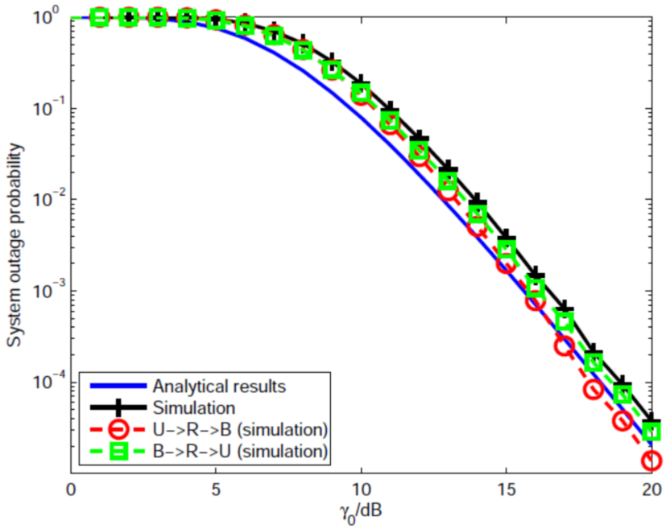

Fig. 1 The system outage probability of proposed scheme.

4. Conclusion

In this paper, we investigated the performance of AF SWIPT networks with relay selection, where the outage capacity maximization scheme has been studied. The simulation results show that the proposed scheme could improve the outage capacity performance.

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