Lifetime Maximization Relay Selection Schemes for SWIPT Networks

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Abstract

In this paper, we investigate three relay selection schemes for simultaneous wireless information and power transfer (SWIPT) networks. We proposed a energy harvesting maximization selection scheme and a weighted relay selection scheme to achieve the performance tradeoff between data transmission and energy transmission. Finally, numerical results validate our theoretical analysis.

Keywords

1. Introduction

Energy harvesting from the environment has attracted considerable attention in recent years due to the tremendous deployment increase of battery powered devices [1-3].

Compared to the conventional energy harvesting, information transmission and energy harvesting of Simultaneous wireless information and power transfer (SWIPT) system is performed simultaneously by time sharing and/or power splitting [4-6], which bring the flexibility and potential to further improve the transmission efficiency of the system. The performance limits of a relay aided MIMO broadcasting system are studied in [7]. In [8] and [9], the symbol-error rates (SERs) for DF and AF SWIPT relay systems are investigated respectively.

Lifetime Maximization Relay Selection schemes in bi-directional amplified-and-forward (AF) SWIPT relay system are considered in this paper. The power limited destination harvests energy from the wireless signal.

2. System Model

Amplify-and-forward relays aided transmission system has been considered in this paper. A source transmits signals by K amplify-and-forward relays with SWIPT to the destination. Each nodes are single antenna nodes. The best relay will be selected to maximize the lifetime of the transmission system. All channels in the system are assumed Nakagami fading.

To ensure the energy harvesting node could gain more energy, the relay selection scheme could be obtained from this point of view by maximizing the channel from relay to energy harvesting node, i.e. Energy Harvesting Maximization (EHM).

Under this scheme, the outage probability $P_{\text{out}}^{\text{EHM}}$ of the system could be obtained by the following theorem.

$$P_{\text{out}}^{\text{EHM}} = 1 - \left[1 - \left(\frac{\gamma\left(m_1, \frac{\gamma_{\text{th}}}{\theta_1^{\text{AF}}}\right)}{\Gamma(m_1)} \right)^K \right] \left(1 - \frac{\gamma\left(m_2, \frac{\gamma_{\text{th}}}{\theta_2^{\text{AF}}}\right)}{\Gamma(m_2)} \right)$$

where m_1 and m_2 are coefficients of Nakagami fading, θ_1^{AF} and θ_2^{AF} are variances of Nakagami fading, γ_{th} is the threshold, $\Gamma(.)$ and $\gamma(.,.)$ are the gamma function and lower incomplete gamma function.

Proof.

Since lifetime maximization scheme has been considered, the probability of equivalent channel between relay and destination $\| g_{i_{\text{EHM}}} \|^2 = \max_i \{ \| g_i \|^2 \}$, where g_i is the channel coefficient from ith relay node to the destination, could be expressed as:

$$P_{\| g_{i_{\text{EHM}}} \|^2}(x) = 1 - \left(\frac{\gamma\left(m_2, \frac{x}{\theta_2^{\text{AF}}}\right)}{\Gamma(m_2)} \right)^K$$

Since the channel coefficient from the source to the ith relay node h_i and g_i are independent, the outage probability could be obtained.

Furthermore, a weight factor α could be introduced to balance the signal transmission and energy transmission. Here the weighted relay selection (WRS) scheme to could be easily obtained.
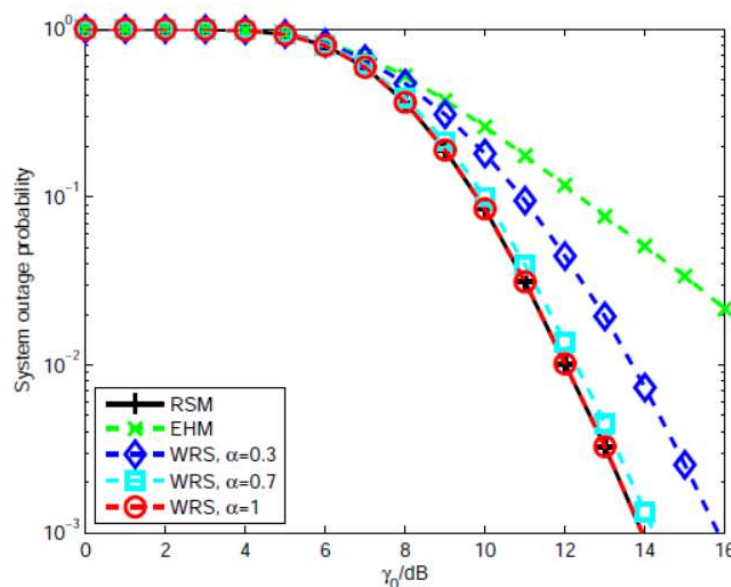
3. Simulation

Fig. 1 The comparison of system outage probability with three different relay selection schemes.
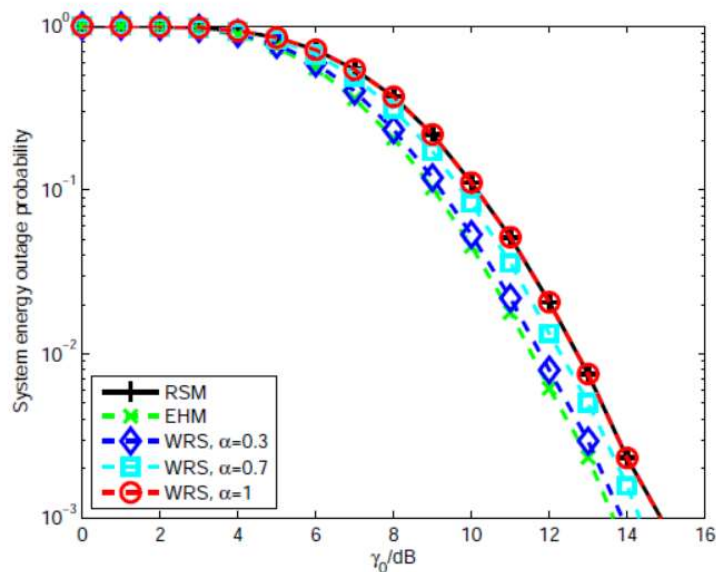
Fig. 2 The comparison of system energy outage probability with three different relay selection schemes.

In order to demonstrate the performance of the proposed scheme, simulations has been conducted. In Fig. 1 and 2, we compare the system outage probability and energy outage probability of three relay selection schemes for two-way AF SWIPT networks. Compared with other relay selection schemes, the Receive SNR Maximization (RSM) scheme could achieve the best outage performance while the EHM scheme could achieve the best energy outage performance. The proposed WRS scheme could achieve flexible tradeoff between the RSM scheme and the EHM scheme in both system outage probability and system energy outage probability by deploying different weight factors.

4. Conclusion

Relay selection schemes for SWIPT networks has been investigated for lifetime maximization. The EHM and WRS schemes are designed to improve the lifetime of the system. The simulation results validate our derivation and show that the proposed WRS scheme could achieve a flexible tradeoff between the RSM scheme and the EHM scheme by deploying different α.

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