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Research Article

Performance Analysis for Exact and Upper Bound Capacity in DF Energy Harvesting Full-Duplex with Hybrid TPSR Protocol

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Abstract

In this paper, we investigate the full-duplex (FD) decode-and-forward (DF) cooperative relaying system, whereas the relay node can harvest energy from radiofrequency (RF) signals of the source and then utilize the harvested energy to transfer the information to the destination. Specifically, a hybrid time-power switching-based relaying method is adopted, which leverages the benefits of time-switching relaying (TSR) and power-splitting relaying (PSR) protocols. While energy harvesting (EH) helps to reduce the limited energy at the relay, full-duplex is one of the most important techniques to enhance the spectrum efficiency by its capacity of transmitting and receiving signals simultaneously. Based on the proposed system model, the performance of the proposed relaying system in terms of the ergodic capacity (EC) is analyzed. Specifically, we derive the exact closed form for upper bound EC by applying some special function mathematics. Then, the Monte Carlo simulations are performed to validate the mathematical analysis and numerical results.

1. Introduction

In the last few decades, energy harvesting (EH) has received significant attention from the researchers [1–10]. By recharging energy from surrounding sources such as solar [2], thermoelectric, wind, and radiofrequency (RF) signals, relay users can perform information forwarding without depending on external sources or battery replacement. Particularly, the RF-based EH gains great interest because it can bring energy and data simultaneously. Varshney first introduced the concept of simultaneous wireless information and power transfer (SWIPT) [1]. Then, Grover and Sahai [7] continued Varshney's work by studying the frequency-selective channel. Then, two practical SWIPT designs termed the time switching (TS) and power splitting (PS) are proposed and studied in [5]. In the TS method, the receiver can divide the total transmission time into two portions: the first one is utilized for EH, and the second one is reserved for the data reception process. In the PS method, a portion of received RF power is used for EH, and then, the rest is utilized for decoding signals.

Based on TS and PS architectures in [5], Nasir et al. [9] proposed two relaying schemes, termed the TS-based relaying (TSR) and PS-based relaying (PSR), to enable EH and information decoding at the relay node. Many works have been done to study TSR [4, 6, 10], PSR [3], and both TSR and PSR [8]. In [4], the authors investigated the secrecy performance of multihop multipath wireless sensor networks (WSNs) under the impact of EH and hardware impairment. Specifically, each relay node harvested energy from the power beacon (PB) by using TSR and then used this energy to forward the information to the next receiver. Hieu et al. in [6] studied the throughput maximization in backscatter- and cache-assisted UAV communications. Herein, a UAV was replenished by RF signals from the source, and then, it used this energy to backscatter information to the destination. Moreover, both linear EH and nonlinear EH models were considered in this work. The authors in [10] solved energy limitation and spectrum constraints for cognitive radio WSNs, whereas the secondary source and relay users were able to harvest energy from a multiantenna PB. In contrast to [4, 6, 10] that studied TSR, Tin et al. [3] considered PSR. Specifically, the authors investigated the secrecy performance of the FD PB-