Abstract

Wireless communication has grown explosively and significant efforts have been made for increasing the data transmission rate over a bandwidth-limited wireless channel with high reliability simultaneously causing low power consumption. One of the most prominent solutions can be regarded as the ambient Radio Frequency (RF) Energy Harvesting (EH) which is a potential green communication technology and an energy efficient approach to energize the relay devices while preventing battery drainage issue and simultaneously enabling data transmission as well.

The integration of RF Wireless Power Transfer (WPT) technology in relay-aided communication systems have led to the implementation of green communication systems. The performance of communication networks can be improved using the best relay from multiple relay communication. Two-way relaying techniques have emerged as a spectral-efficient scheme for bidirectional message exchange between two users and have shown to increase diversity capacity and thus improve the range of wireless communication.

For improved Spectral Efficiency (SE) and capacity enhancement, Non-Orthogonal Multiple Access (NOMA)-assisted cooperative network has emerged as an effective and efficient scheme to support the rigorous demands of Fifth Generation and Beyond (5G+) wireless networks. However, maintaining Energy Efficiency (EE) and sustainability in the design and operation of wireless communication systems is a major concern. Thus, the concept of energy-efficient NOMA or 'green' NOMA has been introduced in the upcoming 5G mobile network design to cater for the goal of achieving a low cost, self-sustaining, environment-friendly wireless network. Although NOMA technique is far superior to traditional multiple access ones, there is still a paucity of research contributions on investigating the security issues of NOMA with EH. Therefore, Physical Layer Security (PLS)-aware RF-powered NOMA systems have gained much interest from researchers.

An important application of WPT that plays a crucial role in time-critical applications is the time requirement for charging a battery/supercapacitor. Battery usage and recharging is challenging especially for autonomous operation of ultra-low battery-powered smart sensors in applications of Internet of Things (IoT) and Wireless Sensor Network (WSN). RF-WPT provides reliable and stable energy supply to the in-built batteries by transmission of RF energy.

Motivated by the above research trends and challenges, different relay selection strategies have been implemented with Interference-Aided (IA) EH. Moreover, new two-way relaying schemes have been developed under realistic assumptions to achieve improved

performance related to energy efficiency, secrecy capacity and harvested power. Simulations are performed in MATLAB 2022b. Additionally, Netsim v13.1 modeller tool has been used to create a virtual Industrial IoT (IIoT) scenario. To validate the proposed model, Bluetooth-enabled PowerSpot RF Wireless Power Development Module (P1110-EVAL-PS) has been utilized to charge various sensors and multiple consumer devices using the harvested RF power.

In the first instance, performance of RF-powered one-way single relay networks has been investigated. The throughput performance of a DF relay system has been studied using Hybrid TSR-PSR protocol architecture with IA-EH scheme. Next, Destination-based Jamming (DBJ) technique has been incorporated in an ideal interference-free environment to investigate the system security in the presence of an Eavesdropper (EAV). Moreover, a secure one-way communication model has been presented in an interference-limited untrusted environment.

In the second scenario, various relay selection strategies have been applied to analyse the throughput and secrecy performance of multi-relay cooperative network. The throughput analysis of a Multi-Source Multi-Antenna Cooperative Relay Network (CRN) with RF-EH has been carried out using maximum energy accumulated selection and optimal relay selection schemes in an ideal interference-free environment. Next, a generalized RF energy harvesting framework has been designed with Hybrid TSR-PSR protocol for AF, DF and hybrid AF-DF relaying schemes under the Weibull fading channel. Additionally, the security performance in multi-relay network with a friendly jammer has been evaluated.

In the third part of our research, the performance of two-way cooperative networks has been analysed. Here an energy-efficient and secure transmission scheme has been devised for bidirectional IoT relay network with energy accumulation using RF-EH in interference-limited environment. The untrusted relays accumulate the harvested energy from the surrounding RF sources and Co-Channel Interferers (CCIs) and utilize that energy to forward the confidential information to the respective destinations.

In the fourth instance, the impact of RF-EH in NOMA-assisted CRN has been shown. The performance of an autonomous and energy-efficient RF-powered Multi-Device (MD) Diamond Relay Network (DRN) in an IoT environment has been studied using an improved Adaptive NOMA (A-NOMA) protocol. Alongwith this, the secrecy performance of a two-user Cooperative NOMA network has been examined under the influence of a cluster of interferers using jamming cancellation scheme.

Finally, the impact of RF-WPT on Rechargeable Wireless Sensor Network (R-WSN) has been observed in IIoT application.