Guest Editorial
Wireless Communications Powered by Energy Harvesting and Wireless Energy Transfer, Part II

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THIS second of the two issues on energy harvesting wireless communications and wireless energy transfer starts with a paper by Zhang *et al.* where the authors propose a scheme, and an algorithm, for coordinating base-stations in wireless sensor networks to reduce the energy supplies required by the individual base stations. The paper shows that the proposed algorithm is asymptotically optimal, and validates its energy-efficiency through simulations and experiments. Zhang *et al.* propose the concept of an energy pattern aided simultaneous wireless information and power transfer (SWIPT) system, where in addition to power transfer, information is conveyed both by the specific receive antenna (RA) indices to which the power is delivered as well as by the particular intensity of the power assigned to that particular RA pattern. The paper characterizes the achievable rate versus power conversion trade-off bounds for this system. Ku *et al.* present an approach of computing the optimal transmission policies for solar-powered sensor nodes. Specifically, given random energy arrivals, the paper formulates a rate maximization problem for adaptive power and modulation as a Markov decision process and then proves that the optimal policy has a simple threshold structure with respect to the battery state.

Xie *et al.* study the combination of a wireless charging device and a base station for sensor data collection onto the same mobile platform. The optimization problem addressed in the paper aims to minimize the energy consumption of the overall network, making sure that no nodes run out of energy before being recharged wirelessly, and that all sensor data reach the base station. Che *et al.* use stochastic geometry to analyze wireless nodes' performance trade-off between energy harvesting and information transmission in a large-scale network. They consider scenarios with battery-free and battery-deployed wireless nodes. For both cases, a harvest-and-transmit protocol is proposed and spatial throughput is optimized given a successful information transmission probability constraint. Maso *et al.* present a new design of orthogonal frequency division multiplex (OFDM) systems with wireless power transfer, where conventional OFDM signals are superimposed with an additional signal for the dual purposes of energy transmission and interference alignment. Given the signal design, a matching receiver and a power allocation algorithm are proposed to jointly optimize the information rate and energy transfer efficiency.

Park *et al.* consider reduction of feedback overhead of transmitters in a multiple-input multiple-output (MIMO) interference channel that performs joint wireless information and energy transfer. To do so, the paper proposes a geodesic energy beamforming scheme that requires partial channel state information (CSI) at the energy access point. Additional constraints are also imposed on signaling strategies in order to reduce feedback overhead by means of geodesic information beamforming. Michalopoulos *et al.* consider a network with multiple relays in which each relay simultaneously delivers information to a designated receiver and energy to a radio frequency (RF) energy harvester. Under independent fading channels, a relay that is preferable for information transfer may not be the best relay for energy transfer. This paper investigates relay selection strategies that provide a trade-off between these two possibly conflicting objectives. Under a given energy transfer constraint, this paper identifies relay selection strategies that maximize the ergodic capacity or minimize the outage probability.

Xiong *et al.* investigate simultaneous wireless information and energy transfer to maximize the end-to-end rate for a two-hop non-regenerative MIMO-OFDM system. Relaying based on time switching and power splitting are considered and algorithms to optimize the end-to-end rate are devised. Impact of the relay location, the number of antennas and the number of subcarriers on performance are discussed. Wang *et al.* provide an optical wireless communications (OWC) receiver using a solar panel as a photodetector, which does simultaneous data transmission and energy harvesting. The paper supports the

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theoretical results with OFDM-based experiments. Gorlatova *et al.* present a large measurement dataset for kinetic energy. Based on the measurements, the paper develops practical energy allocation algorithms for wireless energy harvesting sensors targeting applications in the Internet of Things (IoT). Yang *et al.* consider a massive MIMO system with a hybrid data-and-energy access point and multiple single antenna users. The users harvest their energies from the access point transmission, and in return use the harvested energies for uplink channel estimation and information transfer. The paper defines a new metric called massive MIMO degree-of-rate-gain, and shows that the proposed system is optimal from the massive MIMO degree-of-rate-gain perspective.

Cui *et al.* consider an energy harvesting system where grid-based power is also available. The authors consider the trade-off between grid-based power usage and the resulting delay in data transmission. The paper develops an online dynamic power control scheme. Zhang *et al.* consider energy-harvesting communication systems in the context of upcoming wearable devices. For such devices, energy can be harvested through human motion. Using a mix of experiments, models, and analysis, the authors provide insights into wearable communication systems based on energy harvesting. Moradian *et al.* study a relaying scenario in a random access environment, where the relay node may cooperate by forwarding a packet sent by a source and not correctly received by its destination, while having traffic of its own. Optimal policies are derived, that minimize the average delay of source packets under constraints on the average delay of the relay's own packets, and are shown numerically to be efficient in different conditions.

Wu *et al.* consider low-power wireless sensor networks which could potentially be operated using RF energy harvesting, which in turn could be a promising way of powering these systems. The paper analyzes these networks, and obtains analytical results characterizing the average packet delay and packet loss probability of sensor transmission subject to interference from existing systems. The paper studies optimal design of energy storage capacity for such systems. Gautam *et al.* consider the trade-off between latency and availability for an energy harvesting node in a multi-hop network scenario. Different effects are modeled through a new unified framework using different time scales, e.g., a faster time scale for packet scheduling based on instantaneous queue and battery status, and a slower time scale for tracking the battery energy level using a stochastic fluid-flow model. Fernandez-Bes *et al.* study the optimal transmission policy for energy harvesting sensors, with the objective of maximizing the expected sum utility. In particular, the paper shows that, under certain conditions, the optimal policy is one in which only packets whose utility exceeds some threshold are sent. Building on this observation, the paper also proposes a model-based stochastic scheme able to approximate the optimal solution while requiring less complexity that Q-learning.

This concludes the two special issues on energy harvesting wireless communications. The comprehensive new results reported in these issues demonstrate a new but extremely active research area and point to many promising new research directions.

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