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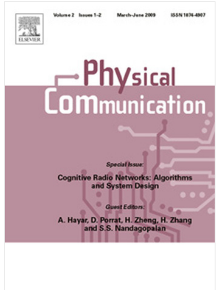

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Integrated Wireless Communications and Wireless Power Transfer: An Overview

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Abstract

As an important application of the fifth generation (5G) mobile communication systems, Internet of Things (IoT) has attracted worldwide research interests. Since most of the communication devices in IoT are powered by batteries, these devices always have limited operation time. Wireless power transfer (WPT) technology, which can transfer power over a wireless medium (without any wires), can avoid the need to manually replace or recharge the batteries of the wireless devices in IoT. For electromagnetic (EM) radiation-based WPT, since radio-frequency (RF) signals that transport energy can at the same time be used for wireless communications, integrated wireless communications and WPT becomes a new research area which has attracted great research interests. In this paper, we first introduce two main research paradigms for integrated wireless communications and WPT, i.e., simultaneous wireless information and power transfer (SWIPT) and wireless-powered communication network (WPCN). Then we provide an overview of the state-of-the-art of both SWIPT and WPCN, respectively. Finally, we point out the new and challenging future research direction.

Keywords: Wireless power transfer, Simultaneous wireless information and power transfer, Wireless-powered communication network

1. Introduction

Mobile Internet and Internet of things (IoT) are the two main drivers for the fifth generation (5G) mobile communication systems and have attracted worldwide research interests [1]. Since most of the wireless communication devices in IoT are powered by batteries, these devices always have limited operation time. In order to extend the lifetime of the IoT, the common way is by replacing or recharging the batteries, which is usually inconvenient, costly, and sometimes dangerous (e.g., in toxic environments) or even infeasible (e.g., for implanted medical devices). As a more convenient and safer approach, energy harvesting (EH) communication systems, where communication devices harvest energy from the environment, have received much attention. However, conventional EH communication systems, which use renewable energy sources such as solar or wind, may not be practical in some situations because most of the renewable energy sources are time-varying, uncontrollable, and not available indoors. To overcome those limitations, wireless power transfer (WPT), which can transmit energy over a wireless medium, has been considered as a viable solution for supplying energy.

The idea of WPT was first conceived and experimented by Nicola Tesla in the 1890s. However, this area had not received much attention due to the low energy transfer efficiency until recently. In general, there are two kinds of WPT approaches. Traditional WPT can be carried out using the near-field electromagnetic (EM) induction (e.g., inductive coupling, capacitive coupling), but it is only for short-distance applications (less than a meter). As the microwave technologies had a series of breakthroughs including the high-power microwave generators and the invention of rectifying antennas (rectennas), which can efficiently convert the radio-frequency (RF) signals to a direct current (DC) signal by integrating with a rectifier (e.g., diode), WPT can be carried out using far-field EM radiation (i.e., RF signals) for long-range (up to a few kilometers) applications.

For EM radiation-based WPT, since RF signals that transport energy can at the same time be used for wireless communications, integrated wireless communications and WPT becomes a new research area which has attracted great research interests. There are two main research paradigms for integrated wireless communications and WPT. One direction of research is called simultaneous wireless information and power transfer (SWIPT), which refers to using the same RF signal to transmit both energy that will be harvested at the receiver and information that will be decoded by the receiver. In [2], Varshney investigated a point-to-point single-antenna SWIPT system for narrowband additive white Gaussian noise (AWGN) channel from an information-theoretic perspective. This work was later extended to frequency-selective AWGN channels in [3]. It

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