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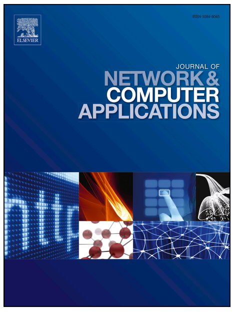

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Next-Generation RF-Powered Networks for Internet of Things: Architecture and Research Perspectives

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Abstract

Wireless power transfer technique aiming at wireless energy provision has emerged as a prominent solution to the architecture of long-term and self-sustainable wireless systems. Particularly, by integrating this approach with data communication, radio frequency (RF)-powered networks such as radio frequency identification systems have been ubiquitously deployed in recent years and are considered as one of the key components of both the Internet of Things and the Fourth Industrial Revolution. However, the lack of function diversity at end devices makes the conventional RF-powered networks merely support some simple and dull operations. In this context, various types of new devices with more intelligence and the ability of harvesting wireless power have been designed of late. Unfortunately, inevitable energy loss occurring in wireless propagation usually leads to time-consuming power transfer and network throughput degradation. Bearing this in mind, in this paper, we present a blueprint for the construction of next-generation RF-powered networks which intend to provide flexible network functions, prompt wireless power transfer, and high network throughput. Several relevant challenges and opportunities are also provided as a guidance on the formation of this new architecture-based Internet of Things.

Keywords: Internet of Things, multisource wireless power transfer, RF-powered networks

1. Introduction

As an extension of the conventional Internet which gives people the ability to interact with global information and services mainly through the World Wide Web, the Internet of Things (IoT) enables the interconnection among everyday physical objects/devices (e.g., gas meters, streetlights, and pallets) to expand the Internet's advantages into all aspects of our daily life. Nonetheless, the limitation of device battery lifetime becomes the major impediment to the construction of long-term and self-sustainable IoT world. Fortunately, wireless power transfer technique whereby a coordinator can offer devices energy via radio frequency (RF) electromagnetic waves exhibits the possibility of wireless battery charging to reduce the overhead of battery maintenance [1, 2]. Since these devices conduct energy harvesting merely based on incident RF signals, we call them as *RF-powered devices* (RPDs). Furthermore, the coordinator is typically deployed to not only transfer power but also communicate with RPDs for physical world monitoring. We call such a system as an *RF-powered network*. Radio frequency identification (RFID) systems are hitherto the only widely deployed example of RF-powered networks and they are applied in various fields such as inventory and logistics management, object tracking, and intelligent transportation systems. Such a system operating on standardized bands with the center frequencies of, for example, 13.56 MHz (i.e., high frequency – HF) and 915 MHz (i.e., ultra high frequency – UHF) typically employs a reader (coordinator) to collect the preconfigured identifiers of numerous tags/RPDs. In this context, RFID is considered as one of the most viable technologies to accelerate the formation of IoT [3, 4, 5, 6, 7, 8, 9]. However, most commodity tags merely support several lightweight and fundamental operations such as ALOHA-based channel access and identifier transmission. Moreover, they are born without any programmability and sensing capability, which imposes restrictions on the implementation of advanced functionalities. On the other hand, leveraging several pervasive signals (e.g., Wi-Fi and LTE) other than the standardized ones for energy harvesting seems to be a promising scenario.

In this context, designing a new type of RPD with more intelligence and the ability of energy harvesting in various bands has attracted growing attention from both academia and industry recently. Fig. 1 (a) illustrates a general design block diagram of an emerging RPD. The low-power microcontroller unit (MCU) providing the programmability and the power management module presiding over the energy regulation of other modules constitute the "brain" of the RPD. Particularly, when the available energy at the energy storage is determined to be insufficient, the MCU requests the coordinator for wireless power transfer and sets the RPD into energy harvesting mode. In this case, the RPD equalizes the impedances of its antenna and the remaining circuit via an impedance matching network so as to maximize the input wireless power in a certain frequency band with the center frequency of, for example, 915 MHz or 2.437 GHz (Wi-Fi channel 6). The matched RF signal is then con-

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