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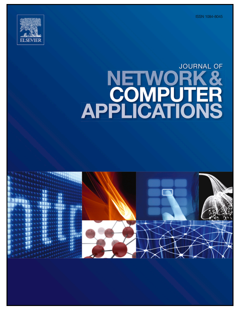

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Wireless Energy Harvesting: Empirical Results and Practical Considerations for Internet of Things

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Abstract

The continuous growth of the Internet of Things (IoT) has led to the development of different types of wireless sensors that are used for monitoring and actuation, communicating with each other and with various infrastructures through the Internet. The long-term and self-sustainable operation of these wireless sensors is a key factor when designing networks using them. To prolong the lifetime of these sensors, various approaches that are capable of harvesting the required energy from various sources have been proposed over the last few years. Wireless Energy Harvesting (WEH) technology is one of them which shows promise in terms of availability, ease of implementation, and cost. We investigate the current status of WEH technology for IoT-enabled sensors. In particular, we evaluate the energy characteristics and operation of two types of environmental wireless sensors (one based on Bluetooth Low Energy (BLE) communication and the other on the UDP protocol) that are powered by a wireless energy harvesting element and operate in the IoT environment. Our literature review on WEH for IoT revealed that despite significant advances that have been made in the design and development of wireless power harvesting elements, achieving self-sustainable wireless sensors for IoT remains a significant challenge. Finally, we also highlight some research challenges of WEH for IoT that need to be addressed in the future.

Index Terms—Energy harvesting, Internet of Things, Low power electronics, Sensor networks.

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1. Introduction

Ubiquitous computing was the third wave of computing after the mainframe and the personal computer era, and it imagined a world in which people are surrounded by large numbers of computing devices embedded in everyday objects and in the environment, having sensing and actuating capabilities and communicating with each other (Weiser, 1991). We are currently witnessing the continuous growth of the fourth wave of computing, namely, the Internet of Things, a vision of a "self-configuring, adaptive, complex network that interconnects 'things' to the Internet through the use of standard communication protocols" (Minerva et al., 2015).

The ever-increasing processing power of microelectronics, coupled with decreasing manufacturing costs, increasing power efficiency of hardware, and the rapid advances of wireless communication technologies have led to the emergence of different types of wireless sensors and Wireless Sensor Networks (WSN) which extend the Internet into physical spaces. Many large-scale WSN consist of nodes represented by "smart sensors/devices", fitted with advanced sensing functionalities, such as thermal, pressure, or acoustic, controlled by a small processor along with wireless communication capabilities (Yalgashev et al., 2016). The sensors in WSN are often placed in locations such as mobile parts (Gabay, 2014), or remote places (Harris, 2016; Sanctis et al., 2016, Muduli et al., 2018) that are often difficult to access. The locations also make the use of cables for communication or power connections difficult both from practical (large deployment and maintenance efforts) and economic perspectives. Although many types of wireless sensors have been developed over the years, they all possess the same set of fundamental functionalities which include sensing, data processing and