A Study on Energy Harvesting Wireless Sensor Networks

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Abstract

Wireless sensor networks offer an attractive solution to several environments, security, and process monitoring problems. However, one barrier for their full adoption is the need to provide electrical power over extended periods of time without the need of dedicated wiring. Energy harvesting offers good solutions to this problem in several applications. This paper surveys the energy requirements of typical sensor network nodes and summarizes the future research work in the field of energy harvesting resource allocation in wireless sensor networks.

1. Introduction

Sensor networks are designed from a group of sensing nodes which communicate with each other, usually through wireless channels, in order to gather spatially distributed data from their surroundings. Such networks have the potential to deliver better quality data as compared to small numbers of individual sensors in applications such as environmental monitoring, process monitoring, surveillance and security [1] [7]. In wireless technology, wireless sensor networks (WSNs) may be considered as the wave of a revolution. They promise to have substantial beneficial impacts on numerous of aspects of our human existence. These benefits include efficient utilization of resources, good understanding of the human behavior, engineering and natural systems, and increased security and safety. Ubiquitous computing also has some possible negative environmental impacts, mainly in physical waste and energy consumption [2].

In order to be efficient and cost effective in many applications, the sensor nodes must be low maintenance and low cost. This presents challenges in terms of sensor standardization, packaging for survival in strict environments and, especially, the efficient supply and utilization of power. Though the performance of battery technology is steadily improving and the power requirements of electronics are commonly dropping, these are not keeping pace with the growing demands of many WSN applications. To overcome these challenges, there has been considerable attention in the development of systems able of extracting suitable electrical energy from existing environmental sources. Such sources include thermal gradients, vibration, ambient light and other forms of motion.

The power requirements for nodes in sensor networks are discussed in Chapter 2, and the wireless sensor networks in Chapter 3. Chapter 4 discuss some of the important future research directions.

2. Power Requirements for Nodes in Sensor Network

The power used by a network node can be divided between the several functions it has to perform. Many authors have described the structure of a common sensor network node [3]. The main elements are illustrated in Figure 1. We observed that not all of these elements would be present in every node. The power requirement of an individual element based on the particular application and so it is difficult to generalize about which portions of the node consume the maximum power. For instance, it is usually the case that actuators, if present, consume a huge proportion of the total power. Also, consumption depends on the working mode of a device such as to reduce consumption whether it utilizes sleep mode and how frequently it receives and transmits data. Correal and Patwari [4] considered the division of power consumption in a common node and concluded that communication functions consumed a huge proportion of total power. The same paper defined the design issues regarding the development of a highly energy efficient module architecture for embedded WSN; start with device technology and progressing up to the application layer. The roadmap introduced is claimed to be generic across the field of WSNs.

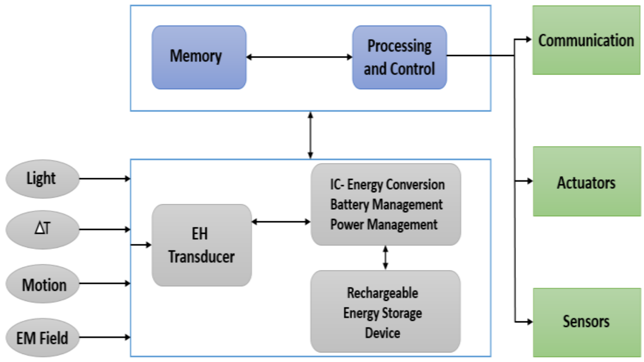

Figure 1. Wireless sensor network node with energy harvesting device

3. Wireless Sensor Networks(WSNs)

Research in energy harvesting (EH) WSNs has attracted much attention in current years due to their broad spectrum of applications. One of the vital issues in WSNs is to accomplish high energy efficiency since sensor nodes are commonly powered by batteries with limited stored energy that cannot be easily replaced or recharged. Advances in EH and storage methods open new challenges for the researchers. These enhancements are also creating a lot of interest for WSNs manufacturing. Though, optimization of EH-WSN performance needs to pay thoughtful efforts on the development of effective resource allocation methods [8]. In static resource allocation methods, decisions are made only once at the starting of a long period, while in dynamic resource allocation methods, decisions are made in each time slot.

A constrained optimization framework for choosing active sensor nodes and assigning power usage in spatially unrelated fading channels for several epochs is proposed in [5]. The authors consider a cooperative network of WSN via orthogonal signaling technique. Yao et al. in [6] present a technique which permits the EH-WSN to adaptively control source coding rates by selecting the most valuable data packets for transmission. The packet selection approach is optimized by mutually considering the transmission energy cost parameters and the multimedia distortion reduction. The authors assumed that the total working time may be divided into different time segments. In each segment, the overall problem has been formulated as a packet selection problem in consideration of the mathematical reliability of constraints and energy neutrality. They also, on the assumption that wireless communication environment is stable for a short period of optimization time, the source node, you need to always send a data packet to each segment.

In [9], energy allocation method by using the DP has been proposed for a finite data buffer and EH sensor nodes of the rechargeable battery and Fi. Maora. Compare the performance of the their approach shows that to achieve a high throughput than discussed in [10]. MAX-UTILITY called epochs based rate allocation algorithm, the utility of all applications are designed to maximize, and it is introduced in [11]. Algorithm proposed in this work is old, fast and has the time complexity of O (N3) for the N nodes. In the network model, node, it has been organized as a data collection tree with a collection tree protocol. As a function of the packet rate, it offers any node is acquired utility ne author de Fi. Using a novel energy management policy, another work on maximizing the total channel throughput has been discussed in [12]. This approach, instead of calculating the energy balance, uses the current observation recovered energy to the amount of energy that can be future recovery predict. Houla. Further, while maintaining a stable queue data at an energy neutral state under different channel characteristics in the adaptive, these policies, said to be able to achieve maximum channel throughput of the sensor node.

4. Discussion

Based on our survey, we summarize some of the important research directions in EH-WSN:

- The EH communication research should pay attention to application specific scenarios. The assumptions should be accurate and in line with the state of the art technology existing for implementation.
- The collaboration of data queues in cognitive radio networks with energy queues open up several new research questions about the optimality of resource allocation and stability analysis and involves investigation via complex analysis tools.
- Interference can be used as a source of

energy. Interference alignment approaches have been applied successfully to solve several communication problems recently and have many potentials for research in the EH-WSN area.

5. Conclusion

This paper surveys the literature in the emerging field of energy harvesting wireless sensors network communications. We summarized the outline the key areas for future research. Energy harvesting in WNS is a promising research area that addresses the issue of limited network lifetime period for energy-constrained wireless networks.

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