

Chapter 2.9

Level Crossing Sampling for Energy Conservation in Wireless Sensor Networks: A Design Framework

Hadi Alasti

University of North Carolina at Charlotte, USA

ABSTRACT

In pervasive computing environments, shared devices are used to perform computing tasks for specific missions. Wireless sensors are energy-limited devices with tiny storage and small computation power that may use these shared devices in pervasive computing environments to perform parts of their computing tasks. Accordingly, wireless sensors need to transmit their observations (samples) to these devices, directly or by multi-hopping through other wireless sensors. While moving the computation tasks over to the shared pervasive computing devices helps conserve the in-network energy, repeated communications to convey the samples to the pervasive computing devices depletes the sensors' battery, quickly.

In periodic sampling of the bandlimited signals, many of the consecutive samples are very similar and sometimes the signal remains unchanged over periods of time. These samples can be interpreted as redundant. For this, transmission of all of the periodic samples from all of the sensors in wireless sensor networks is wasteful. The problem becomes more challenging in large scale wireless sensor networks. Level crossing sampling in time is proposed for energy conservation in real-life application of wireless sensor networks to increase the network lifetime by avoiding the transmission of redundant samples. In this chapter, a design framework is discussed for application of level crossing sampling in wireless sensor networks. The performance of level crossing sampling for various level definition schemes are evaluated using computer simulations and experiments with real-life wireless sensors.

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INTRODUCTION

A Wireless Sensor Network (WSN) is an emerging category of wireless networks that consists of spatially distributed wireless devices equipped with sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, pollutants, etc. in various locations (Akyildiz et al, 2001). Energy conservation is one of the most challenging problems for major categories of WSN. Pervasive sensor networks have been proposed for different applications such as healthcare (Jea et al, 2007; Lin et al, 2007) and equipment health monitoring (Nasipuri et al, 2008; Alasti, 2009), when wireless sensors are cooperating with the other available computing devices in a pervasive computing task to find an appropriate solution. In applications in which the sensors should sense the signals and work as the part of pervasive computing system, energy conservation becomes more complicated.

To conserve energy, various schemes such as adaptive medium access control (MAC) (Ye & Estrin, 2004), efficient routing protocols (Trakadas et al, 2004), cross layering designs (Sichitiu, 2004), and distributed signal processing (Alasti, 2009) have been discussed. As discussed in various related work, the energy consuming operations in WSN are usually categorized in three major groups: communication, computation, and sensing. A comparative study shows that for a generation of Berkeley sensor nodes, the ratio of the required energy for single bit communication over the required energy for processing of a bit ranges from 1000 to 10000 (Zhao & Guibas, 2004). This huge ratio clearly shows that to have a WSN with longer life-time, the successful protocols, signal processing algorithms and network planning schemes should shift the network's operating mode from communication-dominant to computation-dominant mode. For instance, a considerable part of the network's energy is wasted on inefficient multi-hopping and packet collisions in the network. This energy loss may

be reduced by signal processing schemes like localized in-network information compression (Zhao & Guibas, 2004), and collaborative signal processing (Alasti, 2009; Zhao & Guibas, 2004).

Another major challenge that is critical for designing protocols and algorithms for WSNs is scalability. Network scalability is the adaptability of the network's protocols and algorithms to the variation of the node density for maintaining a defined network's quality. As also defined in (Swami et al, 2007), a network is scalable if the quality of service available to each node does not depend on the network size. As the network size increases, the higher traffic load of the network exhausts the in-network energy faster, a situation that affects the quality of service.

This chapter is focused on the application of level crossing sampling (*LCS*) for energy conservation to increase the life-time of the WSN. Transmission of the periodic samples of all of the sensors in the network with multi-hopping exhausts the in-network energy, shortly. At times, when the signal does not change significantly, sampling and transmission through the network, extravagantly wastes the in-network energy. A scheme is proposed to enable smart selection of the sampling instance, based on the instantaneous bandwidth of the signal, which effectively reduces the number of transmissions and relaying. This scheme shifts the operating mode of the network from communication dominant toward computation dominant and is energy friendly, but nonetheless needs complex algorithms and processing. *LCS* has recently received attention for energy saving in specific applications such as mobile devices (Qaisar et al, 2009). In this chapter we present the design and implementation of *LCS* based sampling in a real-life wireless sensor network. Various design issues of *LCS* are presented such as considerations for determining the number of levels, level-selection, and appropriate sampling periods that are needed for achieving higher energy efficiency without loss of useful information at wireless sensors.

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