

Chapter 12

Energy Efficient Communication in Wireless Sensor Networks

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ABSTRACT

Longer life time is the primary goal of interest in Wireless Sensor Networks (WSNs). Communication dominates the power consumption among all the activities in WSNs. The classical sleep and wake up scheduling scheme at the application layer is believed to be one of the best power saving schemes for dense WSNs. These schemes reduce redundant transmissions, and as a result, prolong the network life time. This chapter analyzes the effect of density on inter cluster and intra cluster communication and evaluates a hybrid cross layer scheduling schemes to enhance the life time of the WSNs. In the conventional scheduling schemes at the application layer, all the nodes whose area are covered by their neighbors are put to sleep in order to prolong the life time of the WSNs. The hybrid cross layer scheme in this chapter suggests that instead of putting the redundant nodes to sleep if they are used for some other energy intensive tasks, for example the use of redundant nodes as relay stations in inter cluster communication, will be more energy efficient compare to the conventional application layer scheduling schemes in WSNs. Performance studies in the chapter indicate that the proposed communication strategy is more energy efficient than the conventional communication strategies that employ the sleep/wake up pattern at application layer.

INTRODUCTION

Wireless Sensor Networks comprise of tiny devices with a capability of sensing, communication and computation are spread over a physical environment, perhaps for a limited period of

time, with a common objective to collaborate to provide a distributed and robust sensing, storage, and communication service. These devices can be dispersed over a hostile battlefield or harsh environment to achieve a task. Wireless sensor networks have an enormous potential impact in

the future in countless fields such as military, civil, health and habitat monitoring (Werner-Allen et al., 2006), (Paek, 2005), and (Cranch, 2003). The design goals of WSNs are very different from those of conventional wireless networks, such as cellular networks and wireless ad hoc networks. In these latter the primary goal of interest is usually some aspect of quality of service such as satisfying constraints on such things as signal-to-noise ratio, bandwidth, and delay or packet loss. With WSNs, because of their often remote deployment, the major constraint is in the power supply (Akyildiz, 2002), (Chong, 2003). Then if there is an imbalance in energy consumption across the network, this can lead to the premature expiration of a specific device or devices which, in turn, will shorten the lifetime of the network (Zhao, 2005), (Arias, 2006), (Shah, 2002), (Kadayif, 2004), (Lee, 2006).

The characteristics that make WSNs different from the conventional wireless networks are its dense deployment, continuously changing topology and limited resources. The dense deployment feature of the WSNs is often exploited to achieve energy efficiency. This chapter will analyze the effect of density on the life time of the WSNs and will evaluate the potential of exploiting the density at the inter cluster and intra cluster communication and will also analyze a new hybrid cross layer scheduling scheme that uses the redundant nodes at the application layer instead of putting the nodes to sleep. Performances studies in the chapter indicate that the better way to exploit density for longer life time is to use the redundancy for inter cluster communication which is the most expensive activity in WSNs.

The Chapter is organised as follow. Section II outlines the design principles that should be kept in mind while designing a communication strategy for WSNs. Section III presents a review of cluster based routing and the dominant scheduling techniques in WSNs. Section IV presents the hybrid cross layer communication strategy

for cluster based WSNs. Section V presents the simulation results and finally section VI finally concludes the paper.

DESIGN PRINCIPLES OF COMMUNICATION STRATEGIES IN WSNs

The following issues should be considered while designing a communication protocol for WSNs.

Distributed

The communication strategy should be decentralized. Since nodes in WSNs are prone to failure. Centralized control with its limited resources is not feasible for WSNs. A hybrid scheme of centralized and distributed is more energy efficient for WSNs. For example, clustering in LEACH (Heinzelman et al., 2002) is distributed while centralized control is employed by sub dividing the network into smaller sub networks, resulting in an energy efficient distributed routing strategy. One of the advantages of the hybrid communication schemes is that changes in the network are localized and have no effect on rest of the network.

In-Network Computation

The communication protocol should try to perform computation on data wherever possible in order to minimize the number of transmissions in WSNs. The simplest network computation technique is data aggregation. Suppose a sink is periodically interested in the average temperature of the network, it will be more efficient to aggregate the temperature from the set of nodes and forward it rather than transmitting each and every node temperature measure.

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