Spatial Correlation Code Based Data Aggregation Scheme for Maximizing Network Lifetime

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Abstract. A wireless sensor network consists of many micro-sensor nodes distributed throughout an area of interest. Each node has a limited energy supply and generates information that needs to be communicated to a sink node. The basic operation in such a network is the systematic gathering and transmission of sensed data to a base station for further processing. During data gathering, sensors have the ability to perform in-network aggregation (fusion) of data packet routes to the base station. The lifetime of such a sensor system can be defined as the time during which the sensor information is gathered from all of the sensors and combined at the base station. Given the location of the sensors, the base station and the available energy at each sensor, the main interest is to find an efficient manner in which data can be collected from the sensors and transmitted to the base station at a given rate, so as to maximize the system lifetime. A zone based data aggregation scheduling scheme is presented to accomplish this. The experimental results demonstrate that the proposed protocol significantly outperforms other methods in terms of the energy saving and system lifetime.[1]

Keywords: Data Aggregation, Maximum Network Lifetime, Scheduing Spatial Correlation, Wireless Sensor Networks, Zone.

1 Introduction

Recent advances in micro sensor technology and low power analog/digital electronics have led to the development of distributed, wireless sensor device networks [1]. In the future, it is envisioned that sensor networks will consist of hundreds of inexpensive nodes that can be readily deployed in physical environments to collect useful information (e.g. seismic, acoustic, medical and surveillance data) in a robust and autonomous manner. However, there are several obstacles that need to be overcome before this vision becomes a reality [2]. These obstacles arise from the limited energy, computing capabilities, and communication resources available to sensors. Therefore, reducing the energy consumption of such networks is the most important design consideration.

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Data aggregation has been put forward as an essential paradigm for wireless routing in sensor networks [3]. Most previous related works [4], [2] aimed to reduce the energy consumed by sensors during the process of data gathering. Directed diffusion [4] is based on a network of nodes that can coordinate their operation, in order to perform distributed sensing of an environmental phenomenon. This approach allows significant energy savings to be achieved, when intermediate nodes are employed to aggregate responses to queries. LEACH analyzes the performance of the cluster-based routing mechanism with in-network data compression [2]. In PEGASIS [10], sensors form chains so that each node transmits and receives information from a close neighbor. Gathered data moves from node to node, becomes aggregated and is eventually transmitted to the base station.

Wireless Sensor Networks (WSNs) are characterized by the dense deployment of sensor nodes that continuously observe a physical phenomenon. Due to the high density in the network topology, sensor observations are highly correlated in the space domain. These spatial correlations, along with the collaborative nature of the WSN, bring significant potential advantages for the development of efficient communication protocols well-suited for the WSN paradigm. Typical WSN applications require spatially dense sensor deployment in order to achieve satisfactory coverage [2]. As a result, multiple sensors record information about a single event in the sensor field. Due to the high density in the network topology [5], spatially proximal sensor observations are highly correlated, with the degree of correlation increasing with decreasing inter-node separation. Therefore, it may not be necessary for every sensor node to transmit its data to the sink; instead, a smaller number of sensor measurements might be adequate to communicate the event features to the sink within a certain reliability/fidelity level. There has been some research effort to study the correlation in WSN [5]. However, most of these existing studies investigated the theoretical aspects of the correlation, and they do not provide efficient networking protocols which exploit the correlation in the WSN. In a recent effort, joint routing and source coding was introduced in [6] to reduce the amount of traffic generated in dense sensor networks with spatially correlated records. While this technique reduces the number of bits transmitted; from the network point of view, the number of transmitted packets remains unchanged, whereas it could be further minimized by regulating the network access based on the spatial correlation between the sensor nodes. In this paper, the Spatial Correlation Code based data Aggregation (SCCA) scheme is proposed to maximize the network lifetime. SCCA is operated in a framework that models the spatial correlations in wireless sensor networks. The proposed protocols can significantly outperform the previous methods in terms of the energy saving and network lifetime.

The remainder of this paper is organized as follows. In Section 2, we state the problem and, in Section 3, we present the SCCA algorithm whose primary purpose is to prolong the network lifetime. In Section 4, we show the numerical results obtained using the above analytical framework. Finally, concluding remarks are discussed in Section 5.