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Intitulée

Efficient data aggregation management in WSN

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Abstract

Wireless sensor networks (WSN) is becoming a very important research area, especially with recent advances in embedded systems and wireless communications. A WSN is composed of one or multiple base-stations and a set of sensor nodes deployed in an area called *sensing field.* It is designed to gather data from the network to the base-station (or sink) using hop-by-hop communication. Sensor nodes are severely resource-constrained, with limited processing power, storage, bandwidth, and battery energy. They can be used in many applications, such as monitoring unreachable and hostile areas. Replacing these batteries requires network redeployment, which can be a very expensive process. Energy limitation is the main concern of any WSN application. The communication between nodes is the greedy factor for the energy consumption. One important mechanism to save energy and increase the throughput is in-network data aggregation, which is often pursued to remove redundancy and correlate the data en-route to the base-station. In-network data aggregation removes redundancy, as well as unnecessary data forwarding. Therefore, hence cuts on the energy used in communications. Unfortunately, while aggregation eliminates redundancy, it makes data integrity verification more complicated since each node in the network can manipulate the data of the others. The harsh conditions that the nodes operate in and the limited on-board energy supply make them susceptible to failure. Moreover, the recent applications consider, in addition to energy efficiency, the data latency and accuracy as important factors. When in-network data aggregation is used, each node should wait a predefined time to receive data from all its predecessors. This has a negative impact on the application with delay constraint. For this reason, an efficient data aggregation protocol, in addition to the energy saving, should ensure the network reliability, reduce the time latency and prevent the attackers from falsifying the aggregate values.

This thesis focuses on the efficiency of in-network data aggregation management in terms of integrity control, reliability and time latency. First of all, the control integrity of in-network data aggregation are considered. A new protocol have been proposed that provides control integrity for aggregation in wireless sensor networks. The proposed protocol is based on two hops verification mechanism of data integrity. The proposed solution is essentially different from existing solutions in that it does not require referring to the base-station for verifying and detecting faulty aggregated readings. It thus provides a totally distributed scheme to guarantee data integrity. The numerical analysis and simulation results show that the proposed protocol yields significant savings in energy consumption while preserving data integrity, and outperforms comparable solutions with respect to some important performances criteria. Moreover, the thesis considers also the network reliability and data latency. We have proposed a set of solutions that take into account network reliability and data latency when aggregating data from the network nodes.

We have studied the problem of data aggregation scheduling in wireless sensor networks (WSNs) to minimize time latency. Prior work on this problem has adopted a sequential approach, in which a tree-based structure is used as an input for the scheduling algorithm. As the scheduling performance mainly depends on the supplied aggregation tree, such an approach cannot guarantee optimal performance. To address this problem, we have proposed three solutions, called DAS-ST, DAS-UT and DAS-MC. They intertwine the tree construction and MAC scheduling. These solutions apply a new parent selection criterion that helps to reduce the data latency. In contrast to DAS-ST and DAS-UT, DAS-MC reduces the data latency in disseminating aggregated data to the base-station over multi-frequency radio links. The thesis proposes also a general hardware-in-the-loop framework for validating data aggregation schemes on WSNs. The framework factors in practical issues such as clock synchronization, the interaction between the layers of the communication protocol stack, and the sensor node hardware. This thesis is also factored with the problem of network reliability with minimal data latency and then two

protocols, called RTAD and RMSA, are proposed. The aim is to form an aggregation tree such that there are k disjoint paths from each node to the base-station and, to find a collision-free schedule for node transmissions so that the aggregated data reaches the base-station in minimal time. The proposed solutions intertwine the formation of multi-path structure and the allocation of time slots to nodes, and assign parents to the individual nodes in order to maximize time slot reuse. RMSA also reduces the latency in disseminating aggregated data to the base-station over multi-frequency radio links. Simulations and numerical analysis results show that our protocols outperform the base-line approaches in terms of latency, reliability, and network lifetime.

Contents