Efficient Data Transport in Wireless Sensor Networks

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Abstract

Providing efficient data transport is one of the uppermost objectives in the design of wireless sensor networks (WSNs) since the primary role for each sensor is to report the sensed data to the data sink(s). This thesis focuses on designing efficient data transport schemes for WSNs in the dimensions of energy consumption and time respectively. The developed schemes can be directly applied in a number of applications such as intrusion detection, target tracking, environment monitoring, etc., and can be further extended to underwater acoustic sensor networks and unmanned aerial vehicles (UAVs) networks. With the development of WSN technologies, new challenging research problems such as real-time streaming data gathering and intelligent data communication are emerging. This thesis provides useful foundation for designing next-generation data transport schemes for WSNs.

Energy is the most important resource in WSNs because sensor nodes are commonly powered by small batteries, and energy is directly related to the lifetime of nodes and the network. In this thesis, energy-efficient data transport schemes are designed for two major types of WSNs: event-driven sensor networks and time-driven sensor networks. A novel on-line routing scheme called EBGR (Energy-efficient Beaconless Geographic Routing) is designed for event-driven sensor networks characterized by dynamic network topology. The main advantage of EBGR is that it can provide energy-efficient sensor-to-sink routing without any prior neighborhood knowledge. Moreover, the total energy consumption for sensor-to-sink data delivery under EBGR has an upper bound. Time-driven sensor networks, in which all sensors periodically report the sensed data to the sink(s), have been widely used for environment monitoring applications. Unbalanced energy consumption is an inherent problem in time-driven sensor networks. An efficient data gathering scheme, called EBDG (Energy-Balanced Data Gathering), is designed to balance energy consumption for the goal of maximizing network lifetime. Combing all advantages of corona-based network division, mixed-routing and data aggregation, EBDG can prolong network lifetime by an order of magnitude compared with conventional schemes.

Time-efficient data transport is another critical issue in WSNs since the data generated by the sensor nodes may become outdated after a certain time interval. This thesis focuses on the problem of providing real-time data gathering in time-driven sensor networks. A

novel data gathering scheme based on random access is proposed with the objective to minimize the average duration for completing one round of data gathering. Fully localized solutions have been designed for both linear networks and tree networks. A simple data gathering protocol called RADG (Random Access Data Gathering) is designed. Simulation results show that RADG outperforms CSMA based schemes when the size of the data packets is small.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying.

Singed:

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Published Papers

1. Haibo Zhang and Hong Shen, Balancing Energy Consumption to Maximize Network Lifetime in Data Gathering Sensor Networks, accepted for publication at IEEE Transactions on Parallel and Distributed Systems.

2. Haibo Zhang and Hong Shen, Brief Announcement: Balancing Energy Consumption for Data Gathering in Sensor Networks, the 27th Annual ACM Symposium on Principles of Distributed Computing (PODC), 2008.

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7. Haibo Zhang and Hong Shen, Haibin Kan, Reliability-Latency Tradeoffs for Data Gathering in Random-Access Wireless Sensor Networks, the 4th International Conference on Grid and Cooperative Computing (GCC), 2005, pp. 701-712.

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1. Haibo Zhang and Hong Shen, Energy-efficient Beaconless Geographic Routing in Wireless Sensor Networks, *under second-round review*, IEEE Transactions on Paral-

lel and Distributed Systems.

2. Haibo Zhang and Hong Shen, Exploring Random Access Techniques for Data Gathering in Wireless Sensor Networks, Submitted to Wireless Communications and Mobile Computing in April 2008 .