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Negotiation-Based Protocols for Disseminating Information in Wireless Sensor Networks

JOANNA KULIK
MIT Laboratory for Computer Science, Cambridge, MA 02139, USA

WENDI HEINZELMAN
University of Rochester, Rochester, NY 14627, USA

HARI BALAKRISHNAN
MIT Laboratory for Computer Science, Cambridge, MA 02139, USA

Abstract. In this paper, we present a family of adaptive protocols, called SPIN (Sensor Protocols for Information via Negotiation), that efficiently disseminate information among sensors in an energy-constrained wireless sensor network. Nodes running a SPIN communication protocol name their data using high-level data descriptors, called meta-data. They use meta-data negotiations to eliminate the transmission of redundant data throughout the network. In addition, SPIN nodes can base their communication decisions both upon application-specific knowledge of the data and upon knowledge of the resources that are available to them. This allows the sensors to efficiently distribute data given a limited energy supply. We simulate and analyze the performance of four specific SPIN protocols: SPIN-PP and SPIN-EC, which are optimized for a point-to-point network, and SPIN-BC and SPIN-RL, which are optimized for a broadcast network. Comparing the SPIN protocols to other possible approaches, we find that the SPIN protocols can deliver 60% more data for a given amount of energy than conventional approaches in a point-to-point network and 80% more data for a given amount of energy in a broadcast network. We also find that, in terms of dissemination rate and energy usage, the SPIN protocols perform close to the theoretical optimum in both point-to-point and broadcast networks.

Keywords: wireless sensor networks, energy-efficient protocols, negotiation-based protocols, meta-data, information dissemination

1. Introduction

Wireless networks of sensors are likely to be widely deployed in the future because they greatly extend our ability to monitor and control the physical environment from remote locations. Such networks can greatly improve the accuracy of information obtained via collaboration among sensor nodes and online information processing at those nodes.

Wireless sensor networks improve sensing accuracy by providing distributed processing of vast quantities of sensing information (e.g., seismic data, acoustic data, high-resolution images, etc.). When networked, sensors can aggregate such data to provide a rich, multi-dimensional view of the environment. In addition, networked sensors can focus their attention on critical events pointed out by other sensors in the network (e.g., an intruder entering a building). Furthermore, networked sensors can continue to function accurately in the face of failure of individual sensors; for example, if some sensors in a network lose a piece of crucial information, other sensors may come to the rescue by providing the missing data.

Wireless sensor networks can also improve remote access to sensor data by providing *sink nodes* that connect them to other networks, such as the Internet, using wide-area wireless links. If the sensors share their observations and process these observations so that meaningful and useful information is available at the sink nodes, users can retrieve information from the sink nodes to monitor and control the environment from afar.

We, therefore, envision a future in which collections of sensor nodes form ad hoc distributed processing networks that produce easily accessible and high-quality information about the physical environment. Each sensor node operates autonomously with no central point of control in the network, and each node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication and energy resources. Compared to today's isolated sensors, tomorrow's networked sensors have the potential to perform with more accuracy, robustness and sophistication.

Several obstacles need to be overcome before this vision can become a reality. These obstacles arise from the limited energy, computational power, and communication resources available to the sensors in the network.

- *Energy.* Because wireless sensors have a limited supply of energy, energy-conserving communication protocols and computation are essential.
- *Computation.* Sensors have limited computing power and therefore may not be able to run sophisticated network protocols.
- *Communication.* The bandwidth of the wireless links connecting sensor nodes is often limited, on the order of a few