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GUEST EDITORIAL

Energy-Efficient Network Protocols and Algorithms for Wireless Sensor Networks

Wireless sensor networks have recently received tremendous attention from both academia and industry because of their promise of numerous potential applications in both civilian and military areas. A wireless sensor network consists of a large number of small sensor nodes with sensing, data processing, and communication capabilities, which are deployed in a region of interest and collaborate to accomplish a common task, such as environmental monitoring, industry process control, and military surveillance. Distinguished from traditional wireless networks, a sensor network has many unique characteristics, such as denser node deployment, higher unreliability of sensor nodes, asymmetric data transmission, and severe power, computation, and memory constraints, which present many new challenges for the development and eventual application of wireless sensor networks. In particular, sensor nodes are usually battery-powered and should operate without attendance for a relatively long period of time. In most cases, it is very difficult and even impossible to change or recharge batteries for these sensor nodes. For this reason, energy efficiency is of vital importance for the operational lifetime of a sensor network. To prolong the lifetime of a sensor network, energy efficiency must be considered in almost every aspect of sensor network design, not only at the physical layer and the link layer but also at the network and higher layers. From the networking perspective, energy efficiency must be considered in the design of various network protocols and algorithms for topology discovery, self-organization, medium access control, routing, data aggregation, fault-tolerance, etc. An energy-efficient network protocol or algorithm can provide significant power savings in individual sensor nodes and thus prolong the lifetime of the entire network. With a large amount of recent research efforts, significant research progress has been made in the design of energy-efficient network protocols and algorithms. The purpose of this special issue is to expose the readership of *Wiley International Journal of Communication System* to the latest research progress in this aspect.

In this special issue, we are pleased to present a collection of eight outstanding research papers, which cover a variety of topics in the design of energy-efficient network protocols and algorithms for wireless sensor networks.

In the first paper 'An Energy-Efficient Multipath Routing Protocol for Wireless Sensor Networks,' Lu and Wong propose a distributed multipath routing protocol to search multiple node-disjoint paths between a source node and the sink. A load balancing algorithm is also proposed to distribute traffic over the multiple paths discovered. Moreover, a comparison between the proposed routing scheme and several existing routing protocols is also presented.

In the second paper 'Efficient Delaunay-based Localized Routing for Wireless Sensor Networks,' Wang and Li study the performance of several routing protocols on localized Delaunay triangulation and propose a new routing method based on both localized Delaunay triangulation and geographic routing. The proposed routing method makes a routing decision

purely based on the position of the current node, its neighbours, and the positions of the source and the destination, and guarantees that the distance travelled by a packet is no more than a small constant factor of the minimum if the Delaunay triangulation of sensor nodes is known.

In the third paper 'Energy and Delay Trade-Off of the GTS Allocation Mechanism in IEEE 802.15.4 for Wireless Sensor Networks,' Koubaa *et al.* analyze the Guaranteed Time Slot (GTS) mechanism of the IEEE 802.15.4 protocol for time-sensitive applications and propose a methodology for setting the relevant parameters of IEEE 802.15.4-compliant wireless sensor networks that takes into account a proper trade-off between power efficiency and delay bound guarantees.

In the forth paper 'Stochastic Sleeping with Sink-Oriented Connectivity and Coverage in Large-scale Sensor Networks,' Shi and Liao propose a probabilistic cellular automaton (PCA) scheduling scheme, which does not need any node location or directional information. Different from existing probabilistic scheduling algorithms, the PCA scheduling scheme assigns a sleeping probability based on local information in one hop with no need for any global information. A topology control protocol is also proposed to schedule a node to sleep based on probabilistic cellular automaton and maintain a sink-oriented connectivity and coverage.

In the fifth paper 'Using Polynomial Regression for Data Representation in Wireless Sensor Networks,' Banerjee *et al.* propose a Tree based polynomial REGression algorithm (TREG) that addresses the problem of data compression by exploiting the spatio-temporal nature of sensor data to approximate the current values of a sensor based on the readings obtained from the sensor itself and its neighbors. The proposed TREG algorithm scales very well to sensor density and network coverage, and makes the regression process faster while maintaining acceptable error bounds.

In the sixth paper 'Energy Optimization for Chain-Based Data Gathering in Wireless Sensor Networks,' Yen *et al.* study energy optimization for chain-based data gathering and consider both inter-sensor communication and leader-BS (base station) communication. For inter-sensor communication, the notion of a virtual chain is used to optimize the energy utilization in the network. For leader-BS communication, a leader scheduling rule is proposed to minimize the energy consumption of sensor nodes.

In the seventh paper 'Timing Control for Delay-Constrained Data Aggregation in Wireless Sensor Networks,' Li *et al.* aim to address timing control for delay-constrained data aggregation and propose an Adaptive Timing Control (ATC) mechanism to determine the data aggregation time for sensor nodes. The ATC mechanism allows a node with more children to wait a longer time and thus maximizes the opportunity for data aggregation and ensures sufficient time to process the data collected from the children.

In the last paper 'A Taxonomy of Distributed Query Management Techniques for Wireless Sensor Networks,' Chatterjea and Havinga discuss the distributed query management techniques and classify the state-of-the-art techniques into four main categories: in-network processing, acquisitional query processing, cross-layer optimization and data-centric data or query dissemination. This taxonomy not only illustrates how query management techniques have advanced over the recent past years but also allows researchers to identify the relevant features in designing sensor networks for different applications.

We would like to thank all the authors who submitted their papers to this special issue. We received totally 45 submissions. Due to the limited space available for this special issue, many good papers cannot be included. We are grateful to nearly 100 reviewers for their time and efforts in carefully reviewing all the papers and providing valuable review comments. Many

thanks go to *Wiley International Journal of Communication System* for giving us the opportunity to serve the wireless networking community by putting together this special issue. We would also like to thank the Editor-in-Chief, Mohammad S. Obaidat, and all the publication staff for their support and help during the publishing process of this special issue.

It is our hope that the papers included in this special issue present a good snapshot of the latest research progress in the design of energy-efficient network protocols and algorithms for wireless sensor networks and become an important reference for researchers and practitioners in the area. Finally, we hope that the readers will find this special issue timely, informative, and stimulating.

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