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1-1-2013

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Published version. *International Journal of Distributed Sensor Networks*, Vol. 2013 (2013). [DOI](#).

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Editorial

Recent Advances in Energy-Efficient Sensor Networks

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Received 7 May 2013; Accepted 7 May 2013

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In the past decade, wireless sensor networks (WSNs) have attracted a great deal of research attention, as these networks have the advantage of easy deployment for a wide range of potential applications. Energy efficiency is one of the main goals of WSNs due to that sensor nodes are usually battery powered, and the battery of sensor is not always rechargeable, particularly when the network operates in inhospitable or hostile environments. This special issue on recent advances in energy-efficient WSNs is intended to provide a forum for presenting, exchanging, and discussing the most recent advances in different aspects of the energy efficiency to provide long lifetime for WSNs with emerging technologies.

Reducing energy consumption is a challenge when designing a media access control (MAC) protocol for WSNs. A major source of energy consumption in a WSN is the idle listening mode in which a node remains awake for a long time when no actual data transmission is required by the network. The paper “*Low overhead MAC protocol for low data rate wireless sensor networks*” proposes an energy-efficient, multihop MAC protocol for low data rate sensor networks called LO-MAC. It uses both duty cycling and multihop forwarding from the routing-enhanced MAC protocol (RMAC) to reduce idle listening and sleep latency, respectively. Moreover, LO-MAC exploits common characteristics of wireless communications to build several lightweight energy saving mechanisms.

Multichannel communication protocols have been developed to alleviate the effects of interference and consequently improve the network performance in WSNs requiring high bandwidth. In the paper “*Adaptive learning based scheduling in multichannel protocol for energy-efficient data-gathering*

wireless sensor networks,” the authors propose a contention-free multichannel protocol to maximize network throughput while ensuring energy-efficient operation. Arguing that routing decisions influence to a large extent the network throughput, they formulate route selection and transmission scheduling as a joint problem and propose a reinforcement-learning-based scheduling algorithm to solve it in a distributed manner.

In WSNs, clustering is widely used to support an effective mechanism in many applications, including environment monitoring, because it promises efficient energy consumption for inexpensive battery-operated sensors. In the paper “*Clustering with one-time setup for reduced energy consumption and prolonged lifetime in wireless sensor networks*,” the authors present a novel energy-efficient clustering scheme called clustering with one-time setup which removes the cluster reforming process required at every round after the first round. By removing the cluster reforming process, the number of transmissions per round can be decreased accordingly.

Clustering method for data aggregation in WSNs has attracted great attention for its high efficiency. The paper “*Energy-balanced separating algorithm for cluster-based data aggregation in wireless sensor networks*” focuses on the problem of unbalanced energy dissipation when employing the multihop routing in a cluster-based WSNs. Considering the relaying load undertaken by each cluster, they use the network topology and energy consumption to calculate a cluster radius for obtaining the intercluster energy balancing.

In the paper “*Energy-efficient self-organized clustering with splitting and merging for wireless sensor networks*,”

the authors propose an energy-efficient self-organized clustering model with splitting and merging (EECSM), which performs clustering and then splits and merges clusters for energy-efficient cluster-based routing. It uses information of the energy state of sensor nodes, in order to reduce energy consumption and maintain load balance. In addition, they have shown the validity of splitting and merging of clusters, and then compare the performance of the proposed EECSM with that of a well-known cluster-based self-organization routing protocol for WSNs.

The scarcity of spectrum has become a major bottleneck of the development of the next generation wireless communication system. Cognitive radio (CR), which allows unlicensed or secondary users (SUs) to share the spectrum with licensed or primary users (PUs), shows great promise to enhance the spectrum utilization efficiency. In the paper “*Repeated game-inspired spectrum sharing for clustering cognitive ad hoc networks*,” the authors modeled the spectrum sharing problem among multiple SUs as a repeated game. Using the game theory, which has been widely used in designing efficient spectrum sharing, the SUs can iteratively adapt their strategies in terms of requested spectrum size. They analyzed convergence condition under which the total rate revenue of SUs is maximized and the fairness of spectrum sharing. With the proposed clustering procedure and repeated game-inspired model for SUs, a significant performance improvement is achieved compared to other similar spectrum sharing algorithms.

Recently, mobility is an important factor in the design of a routing protocol for WSNs. In the paper “*A mobility-aware efficient routing scheme for mobile sensor networks*,” the authors propose a mobility-aware efficient routing, in which sensor nodes make use of mobile information to select the most appropriate routing behavior. The proposed method integrates proactive and reactive routing components efficiently using a sink cluster that consists of underlying multiple static or slow sensor nodes. The cluster provides the stable paths between less mobile entities efficiently.

In the current research inclination, hiring of biological solutions to solve and optimize different aspects of artificial system's problems has shaped into an important field with the name of bioinspired computing. In the paper “*Intelligent optimization of wireless sensor networks through bio-inspired computing: survey and future directions*,” the authors have elaborated the importance of bio-inspired algorithms for the optimal solutions of nonbiological systems. The paper leads us to differentiate between various optimization problems existing in WSNs collectively showing that hybrid and non-hybrid algorithms can efficiently optimize the problems in WSNs.

As the developments of various sensor networks, some types of sensors are required to be capable of processing mass data. For example, image sensor nodes take photos using cameras and the images are stored and processed. The paper “*Providing virtual memory support for sensor networks with mass data processing*” deals with supporting virtual memory for sensor nodes which capture and process mass data. Using the optimizing techniques for reducing VM overheads such as cache management, address translation, and secondary

storage accessing, the interesting experiments show that data processing using virtual memory can be significantly more energy-efficient than data processing using rich-resource sensor nodes.

The vehicular communication is one of vehicular ad hoc networks (VANETs) research areas using WSNs. In the paper “*An energy-efficient broadcast MAC protocol for hybrid vehicular networks*,” the authors have proposed an energy-efficient multihop relay broadcast MAC protocol, which is designed for roadside units downloading service in roadside-vehicular communication systems. The paper focuses on the MAC layer protocol in order to reduce the routing overhead of the frequent topology changes according to a vehicle's movement characteristics. It employs a rebroadcast mechanism based on a vehicle's velocity, distance, and angle from a nearby vehicle for collision-free communication.

Body sensor networks (BSNs) carry heterogeneous traffic types having diverse QoS requirements, such as delay, reliability, and throughput. In the paper “*Traffic priority and load adaptive MAC protocol for QoS provisioning in body sensor networks*,” the authors proposed a MAC protocol for QoS provisioning in BSNs and analyzed the effect of prioritizing data packets and dynamically allocating DTS with the consideration of priority and traffic load in the super frame structure of IEEE 802.15.4. The experiments show that the proposed MAC protocol can achieve higher QoS requirements with low power consumption than the state-of-the-art protocols.

The smart grid is a future power system which essentially employs WSNs for its application such as wireless meter reading and remote system monitoring. The power management for actuator gets more important, as many standard protocols such as Zigbee have already achieved significant improvement in sensor network part. The paper “*Power load distribution for wireless sensor and actuator networks in smart grid buildings*” designed an actuator operation scheduler capable of reducing peak load in power consumption of actuator tasks. The most interesting part of the paper is taking advantage of genetic algorithms. Based on the load profile specification and the task model consisting of nonpreemptive and preemptive tasks, each scheduler is encoded into a chromosome, which is an integer-valued vector. The fitness function evaluates the schedule quality by estimating the load of the peaking slot. Using the genetic algorithm, the scheduler achieves acceptable response time with significantly reduced peak load.

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