Editorial

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1 Introduction

Wireless sensor networks are being utilised in such diverse areas such as environmental monitoring, healthcare, logistics, military and surveillance. The number of applications has grown rapidly in recent years and it is still growing, despite the stringent, and, quite often, conflicting requirements that such networks must satisfy. Those requirements cover a wide range of constraints and challenges, from purely theoretical ones (e.g. the sensors are often deployed or scattered in a given area without the knowledge of their precise physical position) to highly practical (e.g. the sensors should operate on battery power, often for prolonged periods of time and without human intervention, using resource-constrained chips with limited computational capabilities). Furthermore, the range of required data rates varies from a few bytes per second, in forestry and agriculture, to perhaps tens of kilobytes per second, for surveillance and military applications. The burstiness of the traffic also varies within wide limits.

On account of this complexity, considerable research effort in both academia and industry deals with various aspects of wireless sensor networks. This special issue of the *International Journal of Sensor Networks* presents recent developments in sensor network design and deployment through a selection of nine papers, which present viable solutions for some of the important challenges in this area. The papers deal with MAC protocol issues, routing, localisation and data collection and aggregation, as seen from the following.

The requirements of wireless sensor networks, most notably the absence of a fixed infrastructure, distributed and self-organised processing and energy conservation, necessitate the development of sensor network-specific MAC layer protocols. This problem is addressed in the paper by Liu and Elhanany, where reinforcement learning is used as a vehicle to allow individual sensor nodes to gain knowledge about the nodes in their vicinity. The resulting distributed, self-organising optimisation scheme, labelled RL-MAC, attains better energy efficiency and throughput maximisation than other similar schemes, especially under high traffic load conditions.

A different approach is undertaken in the paper by Nguyen and Kumar, where the emphasis is put on adaptive management of alternating periods in which the sensor nodes are asleep and awake, respectively. Again, the proposed scheme relies on distributed, self-organising sleep management to deliver the protocol which minimises idle listening (and, in addition, maximises energy efficiency) while striving to preserve the overall network throughput as much as possible.

The problems of medium access control in environments with mobility-enabled sensor devices are the focus of the paper by Ali and Uzmi. In particular, the issues related to energy efficiency have to be reevaluated in cases where nodes are allowed not only to join or leave the network, but also to move freely in space. Since transmission collisions are the single most important source of inefficiency, the novel scheme, labelled MMAC, ensures collision avoidance through transmission scheduling based on traffic information and mobility patterns. Simulation results show that MMAC performs similar to other MAC protocols in static networks, and clearly outperforms them in dynamic networks with highly mobile nodes.

Yet another angle on the problems of medium access control is presented in the paper by Moh, Kim and Moh, where the energy efficiency of the MAC protocol. The protocol they propose is called Distributed Power Scheduling, it is distributed and self-organised, and it integrates data aggregation and activity scheduling in the MAC layer. The enhancements incorporated into the DPS protocol lead to over 20% improvement in energy efficiency, while maintaining the throughput and packet delays within prescribed limits. The performance of the new protocol is analysed in detail, and formal expressions for duty cycle and packet latency bounds are derived.

Routing in wireless sensor networks is also subject to numerous constraints which are not often found in common wireless networks, let alone in traditional wired networks. The most important among these constraints are related to the source-to-destination distance, energy levels of all the nodes on the packet path, individual node location, and the presence of, as well as knowledge about, the holes – segments of physical space without active sensor nodes. The paper by Sha, Du and Shi provides a comprehensive analysis of those constraints, and then discusses the design of a novel routing algorithm that takes all those constraints into account. The proposed algorithm, labelled WEAR, compares favourably to the well-known GEAR and GPSR algorithms in terms of effectiveness and energy efficiency.

Two papers deal with problems of topology and localisation. The paper by Vivekanandan and Wong focuses on localisation of individual sensor nodes using a variant of the well known MultiDimensional Scaling (MDS) approach with mild additional constraints. The new approach is shown to provide reduced position estimation error with respect to the traditional MDS approach, in both hop-based and range-based scenarios that use the same number of anchor nodes.

The paper by Chen, Kuo and Chao proposes a novel method to build and maintain topology information using logical tree in Virtual Polar Coordinate Space. This information relates source and destination nodes, thus providing convenient foundation upon which routing of packets can be undertaken. Furthermore, the issues related to maintenance of the topology information in highly mobile environments are discussed, and a solution based on a fuzzy logic approach is described.

The last group of papers deals with issues of data collection and aggregation, which is the main objective of wireless sensor networks.

The paper by Huang, Jan and Yang describes a novel data collection mechanism where the sensors are organised in a ring-like logical structure. The authors present an optimised ring construction algorithm which is shown to outperform both cluster- and chain-based schemes in terms of both battery (and network) lifetime and energy-delay product. Optionally, the ring can be modified to include several layers which facilitates concurrent activities; this scheme performs better than the equivalent two- and three-level chain-based schemes.

The paper by Solis and Obraczka discusses in-network data aggregation in the context of various trade-offs that need to be made to achieve effective and energy-efficient operation. In particular, they study the influence of timing constraints on the accuracy and freshness of different approaches to data aggregation. The proposed approach, based on the concept of cascading timers, provides good results even under the conditions of packet loss due to noise and interference present at the physical link.

We wish to thank both authors and reviewers for their hard work and the effort they have invested in producing this Special Issue. We would also like to express our sincere gratitude to the Editor-In-Chief, Professor Yang Xiao, for extending this opportunity as well as for his continuous support and guidance.