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Special Issue on Recent Advance on Mobile Sensor Systems

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The continuous growing technique of sensor networks has enabled many new applications in which mobility of sensor nodes are explored, such as sea monitoring, animal migration and patrol defense. Enabling mobility in traditional static sensor networks makes a great impact on most existing research solutions and poses a large number of research challenging issues in both communication and data management aspects, which also provide lots of opportunities that researchers can leverage the mobility feature to exploring improvement for traditional solutions and methods.

It is our great pleasure to bring you this special issue on “Recent Advance on Mobile Sensor Systems”, which aims at presenting innovative and significant research on the design, implementation, usage, and evaluation of mobile sensor systems, applications, and novel techniques.

We are deeply grateful for receiving many excellent submissions to this special issue. The review and revision processes for all papers were carried out in a rigorous and thorough manner. The accepted papers fall into various important areas of mobile WSNs, including design, architecture, simulation, routing, security, and applications of mobile WSNs.

Enrico Natalizio and Valeria Loscrí present the paper with title “Controlled Mobility in Mobile Sensor Networks: Advantages, Issues and Challenges”. They discuss the research issues and different objectives that are pursued when controlled mobility is integrated in the management architecture of a wireless sensor self-organizing network. They also identify and emphasize the advantages obtained by using controlled mobility. The features taken into account are the type of network, the objective of the research, the centralized/distributed scheme, the programmed/adaptive controlled mobility and its penetration in the network. They recognize some of the limitations in self-organizing networks when controlled mobility is used. Finally, they show a case study that proves its advantages and details the operations of controlled mobility, when it is considered as a network basic control factor, and they showed the dependencies of each step of the scheme with the protocol stack.

In the paper “Localization Algorithms of Wireless Sensor Networks: A Survey”, Guangjie Han, Huihui Xu, Trung Q. Duong, Jinfang Jiang and Takahiro Hara reclassify the localization algorithms with a new perspective based on the mobility state of landmarks and unknown nodes, namely (1) static landmarks, static nodes, (2) static landmarks, mobile nodes, (3) mobile landmarks, static nodes and (4) mobile landmarks, mobile nodes. The authors present a detailed analysis of the representative localization algorithms and summary every kind of localization algorithms in the aspect of localization accuracy, localization coverage, localization time, landmark number and energy consumption. Finally the future research directions for the localization algorithms are given in this paper.

The dynamic aspects of Mobile Wireless Sensor Network topologies raise multiple shortcomings when trying to access the medium. Especially, mobile sensors may experience long medium access delays as well as fail to synchronize with their next hop. To address these issues, Kuntz et al. in their paper titled, “Improving the Medium Access in Highly Mobile Wireless Sensor Networks”, propose the XMachiavel protocol. Their contribution relies on a fixed sensor infrastructure which takes care of routing the data between peers. On an idle channel, fixed nodes can claim the data of a mobile sensor and route it toward its destination. On a congested medium, mobile nodes can take possession of the channel initially reserved by a fixed sensor in order to fit in the communication schedule. Lastly, they give the idea that by setting the layer-2 next hop just before the effective data transmission without the need for a routing protocol, mobile nodes are more likely to reach their peer. Through the simulation analysis they provide the evidence of the effectiveness of their proposal.

In the paper “Collision Free Mobility Adaptive (CFMA) MAC for Wireless Sensor Networks”, Bilal Muhammad Khan and Falah H. Ali propose a high-throughput contention-based collision-free mobility-adaptive and energy-efficient medium

access protocol (MAC). The protocol uses a delay allocation scheme based on traffic priority at each node and avoids allocating the same backoff delay for more than one node, used for joining nodes, which resolves the major issue of control message collisions as well. It also allows nodes to determine when they can switch to sleep mode during operation whenever they are not transmitting or receiving. The performance of CFMA has been analyzed and compared with other existing mobility aware MAC protocols. The results show that it outperforms significantly the existing industrial standard of CSMA/CA as well as other mobile MAC protocols such as S-MAC, MOB-MAC, AM-MAC, MS-MAC, MD-MAC and DS-MAC protocols, at low traffic load and at high network load, including throughput, latency and energy consumption.

Abbas Nayeb and Hamid Sarbazi-Azad address the problem of determining the maximum “hello” interval preserving the connectivity of a homogeneous topology with high probability, in the paper “Optimum Hello Interval for a Connected Homogeneous Topology in Mobile Wireless Sensor Networks”. They propose an estimation method for the statistical topology lifetime (STL) to ensure the statistical connectivity with a given threshold. The estimated value of STL can be used as the optimal “hello” interval for topology reconstruction. The results obtained from a wide range of network sizes, transmission ranges, and node densities are compared with experimental results. They confirm the accuracy and applicability of the proposed method.

Organizing sensors in cooperative groups can reduce the global energy consumption of the WSN, since it can reduce the number of the messages transmitted inside the WSNs. In the paper, “Saving Energy and Improving Communications using Cooperative Group-based Wireless Sensor Networks”, Jaime Lloret et al. analyze cooperative group-based WSNs and show that cooperation between groups could be used to change the direction of the alert propagation and the level of the alert in order to take the appropriate actions. They conduct simulations to give the insights on how the number of groups improves the network performance.

Cheng et al., in their paper, “Wait, Focus and Spray: Efficient Data Delivery in Wireless Sensor Networks with Ubiquitous Mobile Data Collectors”, consider a world of ubiquitous sensor networks to propose a dissemination protocol that leads to efficient data delivery from the source sensors to ubiquitous mobile data collectors (MDCs). The authors propose the Wait-Focus-Spray (WFS) data delivery scheme for wireless sensor networks with ubiquitous MDCs, the main objective of which is to balance the data delivery latency and transmission overhead. In WFS, they also propose a corresponding mechanism named ‘Probabilistic Scattered Binary Spraying’ (PSBS), to reduce the spatial redundancy when spraying data copies, which can increase the probability of meeting an MDC. Through detailed theoretical analysis and extensive simulation they show the efficiency and applicability of their proposed approach.

Xiannuan Liang et al. in their paper “Stochastic Event Capture with Single Mobile Robot in Rectangular Perimeter” consider a single robot detecting intrusions in a rectangular perimeter. The robot moving periodically along the field of interest at a varying velocity, an intrusion mode— each intrusion appear at a random point of the field of interest and then last for a random time—is analyzed. The authors define the mode of intrusion events as follows: intrusions arrive at a random point at the rectangular perimeter, and stay in the point for a random length of time. In our model, a robot is set to periodically move along a certain routine at not a constant speed but a varying one. They derive the general expression for intrusion loss probability. Under a reasonable assumption that after an intrusion happen in a random point in the rectangular perimeter, it stays at that point for a random length of time, which follows a Poisson distribution, they derive the solution on the above problem.

“Nonpreemptive Priority Scheme for the S-MAC Protocol in Multimedia Mobile Sensor Networks” by Y.S. Wong et al. proposed a simple, efficient, but yet well-performing sliding contention window control mechanism to modify the S-MAC protocol with the view of supporting multimedia application and alleviating starvation problem. Besides, the authors also provided an analytical model to study the system throughput of the proposed scheme.

Hierarchical routing and clustering mechanisms in Wireless Sensor Networks (WSNs) help to reduce the energy consumptions and the overhead created when all the sensor nodes in the network are sending information to the central data collection point. Most of the routing and clustering protocols proposed for WSNs assume that the nodes are stationary. However, in applications like habitat monitoring or search and rescue, that assumption makes those clustering mechanisms invalid, since the static nature of sensors is not real. In this paper, we propose Zone-based Routing Protocol for Mobile WSNs that considers the design aspects such as mobility of sensors, zones and routes maintenance, information update and communication between sensor nodes. Simulation results show the effectiveness and strengths of the proposed protocol such as a low routing and mobility overhead, while achieving a good performance in WSNs using small zone sizes and sensors with low speed. Simulation results also show that the proposed protocol outperforms existing LEACH-ME and LEACH-M protocols in terms of network lifetime and energy consumptions.

Xinqing and Xuemei in their work, “Evaluating the Energy Consumption of the RFID Tag Collision Resolution Protocols”, evaluate the energy consumed by both the reader and tags in a cycle for the commonly used RFID tag collision resolution protocols using theoretical analysis. The authors suggest that regarding energy consumption, for the Class-1 RFID system, the frame slotted ALOHA protocols can be used for resolving the tag collisions. Otherwise the binary query tree based protocols should be adopted.

Due to the space constraint, we can only include a limited number of papers in this special issue. We trust that the two survey papers can give readers a comprehensive overview of state-of-the-art technologies and challenges. We also believe that the

other research papers cover the further research in both theoretical and practical aspects of the relevant topics.

We would like to express our gratitude to the reviewers who provided the authors with important, timely and constructive feedbacks. We thank all authors who have submitted their papers for consideration for this issue. We also thank the staff at the Springer Telecommunication Systems for their helps in handling the manuscripts. Last but not the least, we would extend our appreciation to the Editor-in- Chief of the Journal, Prof. Bezael Gavish, for providing us this opportunity to organize this special issue.

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