Editorial

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New challenges of real-time wireless sensor networks: Theory and applications

Wireless communication is steadily increasing in several applications where the main aim is to reach real-time requirements in terms of quality-of-service (QoS) parameters, bounded latency, high reliability, and dependability, particularly with the advent of HetNet architectures and context-aware environments. The last open research challenges have shown that the application requirements such as energy efficiency, security, and network adaptivity influence the real-time requirements of communication. For this reason, there is a need to disseminate, streamline, and investigate research findings coming from several different application domains. Thus, it is needed to introduce approaches, protocols, architectures, algorithms, and so on, that are able to meet the typical real-time network requirements.

The goal of special issue entitled "New Challenges of Real-Time Wireless Sensor Networks: Theory and Applications" is to report on innovative ideas and solutions for the designing of real-time wireless communication in the emerging applications era, focusing on the development, adoption, and application of wireless technology for real-time applications.

The special issue received 26 papers, but only 8 have been accepted for publication in *International Journal of Distributed Sensor Networks*.

The paper entitled "Message Passing Based Time Synchronization in Wireless Sensor Networks: A Survey" by Mohammad Ali Sarvghadi and Tat-Chee Wan presents a classification of several Message Passing based Time Synchronization (MPTS) protocols based on various metrics, such as structure formation of the network affected by the synchronization protocol, frequency of synchronization process (synchronization interval), and synchronization message overhead. Moreover, the authors propose some potential methods in order to improve the synchronization process.

The paper entitled "A Flexible and Scalable Architecture for Real-Time ANT + Sensor Data Acquisition and NoSQL Storage" by Nadeem Qaisar Mehmood, Rosario Culmone, and Leonardo Mostarda describes a system architecture based on ANT + , an open access low energy protocol, which has enabled the implementation of a healthcare monitoring system. The proposed solution is scalable and can provide further functionalities in the near future.

The paper entitled "A Performance Analysis of M2M Sensor Networks," by Jingjing Wang, Lingwei Xu, Xinli Dong, Wei Shi, and Qiuna Niu, focuses on the average symbol error probability (ASEP) and outage probability (OP) performance of mobile-to-mobile (M2M) sensor networks employing transmit antenna selection (TAS) and selection combining (SC) over N-Nakagami fading channels. The exact ASEP and closed-form OP expressions are derived for several modulation schemes, based on the moment generating function (MGF) approach, and the performance under different conditions are evaluated through numerical simulations. The results show that the number of antennas, the fading coefficient, and the number of cascaded components have an important influence on the ASEP and OP performance.

The paper entitled "A Cooperative Beamforming for Physical-Layer Security in Power-Constrained Wireless Sensor Networks with Partial Relay Selection" by Mujun Qian, Chen Liu, and Yulong Zou investigates on beamforming schemes in a cooperative wireless sensor network (WSN) for physical-layer security. The authors show that the optimal beamforming scheme should be performed along with a partial relay-selection strategy and then propose two partial relay-selection based beamforming schemes. Simulation results show that the proposed schemes combine the advantage of the all-relay-based scheme in high-power range and that of the best-relay-based scheme in low-power range.

The paper entitled "A Statistical Approach in Designing an RF-Based Human Crowd Density Estimation System" by S. Y. Fadhlullah and Widad Ismail proposes a novel technique in order to analyze Human Crowd Density values as a function of ZigBee radio frequency (RF) measurement results. Two different techniques, namely, one-way analysis of variance and design of experiment, have been employed in order to gain insight in the differences between static and dynamic crowds and to identify specific crowd properties as a function of RF parameters. The employed

methodology can provide useful information related to crowd density and identification.

The paper entitled "QoS Model of WSNs Communication in Smart Distribution Grid," by Ruju Fang, Jianping Wang, Wei Sun, and Qiyue Li, proposed a new medium access control (MAC) protocol for WSNs, aimed at differentiated QoS support according to data priorities. The proposed MAC protocol extends IEEE 802.15.4 protocol, adding a mechanism for unfair channel access to provide better QoS guarantees for more relevant data. Mathematical verifications are performed according to a proposed model based on Markov chains, allowing performance evaluation for different data priorities.

The paper entitled "Collusion-Tolerable and Efficient Privacy-Preserving Time-Series Data Aggregation Protocol" by Yongkai Li, Shubo Liu, Jun Wang, and Mengjun Liu proposes an efficient aggregation protocol capable of tolerating up to k passive adversaries who do not try to tamper the computation. The proposed protocol does not require a trusted key dealer and needs only one initialization during the whole time-series data aggregation, which provides a more computationally efficient encryption/decryption scheme, useful in scenarios in which time-aggregation series are employed.

The paper entitled "Clustering Analysis in Wireless Sensor Networks: An Ambit of Performance Metrics and Schemes Taxonomy" by Asim Zeb, A.K.M. Muzahidul Islam, Mahdi Zareei, Ishtiak Al Mamoon, Nafees Mansoor, Sabariah Baharun, Yoshiaki Katayama, and Shozo Komaki designed unique performance metrics that efficiently evaluate prominent clustering schemes and developed taxonomy for the classification of the clustering schemes. Based on performance metrics, quantitative and qualitative analyses are performed to compare the advantages and disadvantages of the algorithms.

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Mario Collotta[1], Daniel G Costa[2],
Francisco Falcone[3] and Xiangjie Kong[4]
[1]Kore University of Enna, Enna, Italy
[2]State University of Feira de Santana, Feira de Santana, Brazil
[3]Universidad Pública de Navarra, Pamplona, Spain
[4]Dalian University of Technology, Dalian, China