

## Guest Editorial Preface

# Special Issue on Current Trends in Wireless Ad Hoc and Sensor Networks within the Realm of the Internet of Things

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## INTRODUCTION

The proliferation of smart devices is revolutionizing our life and work styles. Billions of physical devices or objects are envisioned to be connected. These devices will be outfitted with various kinds of sensors and actuators enabled by technologies such as embedded sensing and actuating, radio frequency identification (RFID), wireless sensor networks (WSN), real-time and semantic web services. Everyday objects are becoming online, readable and controllable via Internet. This new ecosystem of information, termed Internet of Things (IoT), will drastically change our ways to interact, behave, and reason about our surrounding. IoT is expected to become a driver in an emerging era of interconnected world through ubiquitous advanced connectivity of smart devices, systems, and services. IoT goes beyond Machine-to-Machine (M2M) communication technologies and covers a wide variety of networking protocols, a drive into an “Internet of the Future” where devices and machines (objects) learn to anticipate, communicate, and perceive in a much more effective way to respond to problems and challenges. It is a paradigm that allows networking of objects with persons, objects with objects, and also machines with machines. Objects collect, store, analyze and communicate data that concerns every useful bit of our lives. Personal data exchanged daily on the market without provoking any considerable emotion, forms a wealth of information. Access to this mass of personal data may reveal important and sensitive knowledge about a person whereabouts and private behavior. It is possible to locate virtually anything from events to persons and their belongings. The presence (or absence) of a person at home or office may be induced by studying the data related to the programming of the radiators or the motion sensors associated with the lighting system. A one’s health can be induced by analyzing data from his/her bracelet, his/her scale or even his/her connected pillow. Deduce the number of people at home could be obtained by accessing the contents of the refrigerator or counting the number of daily showers. The field of possibilities is immense covering every single aspect of our daily activities, our surrounding and our ecosystem. IoT makes it possible to assess and comprehend a wide range of phenomena relating to the state and environment of connected objects as well as the state and needs of using these objects. Such a knowledge can then be used to customize or optimize the value of various present or future activities in different areas of concern such as home and office, production, environment, system controllability, surveillance, transportation, health and medical care, localization and movement.

The advent and the realization of IoT, however, is putting the current Internet under a great pressure due to its unprecedented scale. To cope with such a bandwidth demand and complexity as well as to solve imposed challenges relating to seamless wireless access, pervasiveness, mobility support, security and privacy, efficient localization techniques, and architecture issues, new mechanisms and

architectures for the future Internet are being investigated, explored and experimented. The aim of this special issue is to answer some open questions in ad hoc and sensor networks as underlying technologies within the framework of the Internet of Things. More than twenty articles were received and double blindly reviewed, out of which five articles were selected for publication which cover topics including an efficient context aware broadcast in duty cycled WSN, an efficient low-cost localization in dense WSN, an efficient intrusion detection system for selective forwarding and clone attackers in IPv6-based WSN under Mobility, a semantic web cross road architecture for WSN, and an adaptive and hotspot aware taxi zone queuing system.

## INSIDE THIS ISSUE

The unprecedented proliferation of the Internet of Things (IoT) on different domains motivated the use of ontologies in a way similar to that used on the web. Using ontologies, things and their capabilities can be modeled in an abstract way allowing their use by non-technical people. The W3C Semantic Sensor Networks Incubator Group on semantic sensor networks provided the founding basis for the development of an IoT ecosystem. In particular, the use of a domain ontology allows to explore the data for potential hidden knowledge through data mining techniques. Following this rationale, the article “*SEMDPA: A Semantic Web Crossroad Architecture for WSNs in the Internet of Things*” proposes a new lightweight IoT architecture coined SEMDPA that supports linking sensors and other devices, as well as people via a single web by mean of a device-person-activity (DPA) crossroad ontology. This research work is part of a major project INWATERSENSE which consists of a wireless sensor network deployed in a river in Kosovo for monitoring its water quality. SEMDPA architecture is validated by means of three rich-in-semantic services: contextual data mining over WSN, semantic WSN web enablement, and linked WSN data. In addition, the authors argued that SEMDPA could be easily scalable to capture the semantics of input sensor data from other domains.

WSN are considered the essential components of the IoT. The global market for sensors is growing fast and expected to double by 2020. 6LoWPAN, IPv6 over IEEE 802.15.4, stands out as the main building block for connecting the huge number of things to the internet. IEEE 802.15.4 nodes can operate in either secure mode or non-secure mode. Two security modes were defined: the Access Control List providing limited security services, and the more advanced secure mode providing confidentiality integrity, access control, and sequential freshness. However, even with authentication and encryption mechanisms, an attacker can compromise nodes and get all the keying materials. The article “*An Efficient Intrusion Detection System for Selective Forwarding and Clone Attackers in IPv6-based wireless Sensor Networks under Mobility*” argues that an intrusion detection system is necessary to detect and defend against insider attackers, especially in IPv6-based mobile WSNs. This article focused on detecting the selective forwarding and clone attacks as they constitute the most dangerous attacks. The paper presents the design, implementation, and evaluation of a novel intrusion detection system (IDS) for mobile WSNs based on IPv6 routing protocol for low power and lossy networks. The authors also argued that their proposed IDS can be extended to other attacks such as wormhole and sybil attacks.

Reducing energy consumption has been the fundamental task sought after in WSN research. In WSN, radio communications are considered the main source of energy dissipation. As such duty-cycle mechanisms, where nodes alternate between long dormant and short active periods independently of each other, have been widely deployed. This asynchronous operational pattern, however, brings new challenges to the network design. Broadcast, a task required by various applications, becomes a challenging issue as nodes uses independent wake up schedules. The article “*Context-Aware Broadcast in Duty-Cycled Wireless Sensor Networks*” proposes an efficient context aware multi-hop broadcasting protocol named E-ECAB, which combines the advantages of context awareness by considering a multi criteria and duty-cycle technique in order to optimize resources usage and satisfy application

requirements. Extensive simulations show that E-ECAB achieves a significant improvement in terms of throughput and end-to-end delay without sacrificing energy efficiency.

Localization in IoT in general and in WSN in particular is a basic fundamental service as it stands as a central building block for various applications. Existing localization approaches mainly focused on enhancing the localization accuracy. Recently a particular attention has also been given to reduce their implementation costs. To gauge the tradeoff between location accuracy and implementation cost, recursive localization approaches are being pursued as a cost-effective alternative to the more expensive localization approaches. In the recursive approach, localization information increases progressively as new nodes compute their positions and become themselves reference nodes. The article “*Low Cost Recursive Localization Scheme for High Density Wireless Sensor Networks*” discusses this tradeoff and proposes an efficient recursive localization approach. This approach is based on a novel strategy to control and maintain the distribution of new reference nodes. The lack of such a strategy leads, especially in high density networks, to wasted energy, important communication overhead and even impacts the localization accuracy. Extensive simulations show that the proposed approach reduces the energy consumption, the execution time, and the communication overhead, yet it increases the localization accuracy via an adequate distribution of reference nodes within the network.

The Internet of Vehicles (IoV) has been emerging as the integration of the Internet of Things and the mobile Internet. IoV integrates three different networks: an inter-vehicles network, an intra-vehicle network and vehicular mobile Internet. IoV supports intelligent traffic management, intelligent dynamic information service, and intelligent vehicle control. It represents a typical application of IoT technology in intelligent transportation system (ITS). Internet of Taxis (IoTx) is one promising example of IoV applications. Taxi fleets are projected to be fully automated by 2020 in virtually all large and mid-sized cities around the world. The article “*An Adaptive and Hotspot Aware Taxi Zone Queuing System on Internet of Vehicles*” proposes an adaptive and hotspot-aware taxi zone queuing system. It presents an adaptive scheme that features data collection, hotspot extraction, an adaptive zone queuing protocol, and navigation services for taxi drivers. Real data were collected from Taiwan Taxi Inc., the largest taxi company in Taiwan. Queuing zone hotspots were identified through the analysis of the collected data. To verify the feasibility of the proposed system, a prototype was implemented. Conducted experimental results are used to position and compare the proposed scheme with other existing proposals.

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