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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: THE PLETHORA OF RESEARCH IN INTERNET OF THINGS (IOT)

The plethora of research, standardization and developments in Internet of Things (IoT) has increased enormously in recent years. This is due to the vast scope of IoT. Internet of Things refers to the worldwide network of interconnected objects, which allow people or things to be connected anytime, anyplace, with anything and anyone, using any path, any network and any service. The objects have different characteristics: mobile or static, with or without energy constraint, different computation and storage capabilities, equipped with different communication technologies and sensors, etc.

The application areas of IoT are numerous, ranging from smart cities to vehicular networks and from cyber physical systems, smart grids to green Internet of Things. This special section discusses the most recent advances in the interdisciplinary research areas encompassing the Internet of Things domain. This Special Section in IEEE ACCESS presents fifteen contributions classified into six hot topics: 1) Cloud, SDN, and global infrastructure, 2) Cellular IoT and M2M Networks, 3) Security, trust and privacy in IoT, 4) Heterogeneous and coexistence at MAC and upper layers, 5) Internet of Things and Smart Grid, and 6) Social networking with IoT.

I. CLOUD, SDN, AND GLOBAL INFRASTRUCTUR

Cloud computing is extending to IoT with different applications such as: vehicular communication [item 1) in the Appendix], smart cities [item 2) in the Appendix], e-health [item 3) in the Appendix], etc. In this Special Section, Wan *et al.* [item 4) in the Appendix] describe the basic concepts and development processes of cloud robotics and the overall architecture of these systems. The major driving forces behind the development of cloud robotics are carefully analyzed from the point of view of cloud computing, big data, open source resources, robot cooperative learning, and network connectivity. Zhou *et al.* [item 5) in the Appendix] propose another contribution based on Software Defined Networks (SDN) for wireless sensor and actuator networks (WSAN). They study the application framework and relevant methods for applying the SDN approach in a WSAN, with the objective of improving network's efficiency and scalability. In addition, they explore the relevant challenges and mechanisms for effective system management from many aspects, including mobility, energy saving, reliability maintenance, and topology construction.

Finally, Bader *et al.* [item 19) in the Appendix] propose to introduce the empowerment of front-end IoT devices to support the back-end network in fulfilling end-user applications requirements mainly by means of improved connectivity and efficient network management. The authors use the concept of software-defined architecture for a new conceptual framework to smartly manage the different devices with new features for IoT administrators as well as end users.

II. CELLULAR IOT AND M2M NETWORK

The communication between objects in IoT can be ensured through the cellular networks where the network resources are shared between User cellular equipment and M2M communications [item 6) in the Appendix]. The main issue in this topic is to give answers to this question: how to efficiently share radio resources between Machine-Type Communication (MTC) and cellular user equipment (CUE)? Recently some contributions are proposed in literatures [item 24) in the Appendix], [item 6) in the Appendix]. In this Special Section, Nessa *et al.* [item 7) in the Appendix] propose to use clustering approach to group MTC nodes into clusters with one Cluster Head (CH) for each cluster in LTE-A. In order to reduce the impact of CHs' mobility, the authors propose a rateless-coded-incremental-relay selection (RCIRS) algorithm based on greedy techniques to guarantee the required data rate with a minimum cost. The main idea is to use non-CH nodes as relays between neighboring CHs. In addition, they develop both source-feedback and non-source-feedback based fountain coded cooperative communication protocols with different relay selection methods under Rayleigh fading channel.

Another contribution proposed by Mishra *et al.* [item 8) in the Appendix] consists in a device-centric scheme for relay selection in a dynamic network scenario of 5G. The key point is to reduce the involvement of the base station in the communication between devices. In addition, they propose a new relay selection scheme for scenarios, where the devices have more than one device (relay) in common. The proposed relay selection scheme is based on several parameters, including signal-to-noise ratio (SNR), signal-to-interference plus noise ratio, residual battery power, buffer space, and reliability; this provides more reliable and efficient communications.

Radwan *et al.* [item 9) in the Appendix] discuss low cost innovative networking scenario, which can be built using not

only available 4G technologies but also the 5G paradigm when deployed. The authors analyze the envisioned scenario, show how it can be built on expected 5G technologies trends, presents preliminary results that show the benefits gained from such deployment, and, finally, details the foreseen open research challenges that need to be addressed.

Similarly, Balasubramanya *et al.* [item 10) in the Appendix] focus on Machine Type Communications (MTC) in the Long Term Evolution (LTE)/LTE-Advanced (LTE-A) standards. They show that an accurate estimation and compensation of the residual Carrier Frequency Offset (CFO) at the base-station (eNB) results in a reduction in energy consumption for MTC devices in low coverage. For robust and accurate CFO estimation in low coverage, the authors propose a Maximum Likelihood (ML) based CFO estimation technique that works for data and/or pilot repetitions in LTE/LTE-A uplink.

III. SECURITY, TRUST, AND PRIVACY IN IOT

The security is one of big issues that need to be faced in IoT. The large IoT' applications will impact the number of wireless connected devices which will exceed 40 billion by 2020 [item 11) in the Appendix]. As we know, more connected devices increase the vulnerabilities and possibilities of attacks. The security affects all communication layers from physical to application layers [item 12) in the Appendix]. In addition, the trust model is a key point that has direct or indirect impact on communication protocols and security [26]. Finally, the privacy is another issue that requires a particular intention in applications where personal data are collected through a network.

Sajid *et al.* [item 13) in the Appendix] focus on Cyber Physical Systems (CPS), particularly the supervisory control and data acquisition (SCADA) systems, to control and monitor the critical infrastructure (CI). They highlight the security challenges of these CIs, also provide the existing best practices and recommendations for improving and maintaining security. In addition, they describe future research directions to secure these critical CPSs and help the research community in identifying the research gaps in this regard.

In another contribution, Asplund and Nadjm-Tehrani [item 14) in the Appendix] demonstrate that despite an overall optimistic view on IoT in critical societal services, there is a lack of consensus on risks related to IoT security. They identify information security requirements that are common over different sectors, and in particular, ones that impact critical societal services, namely, and the energy, water, and health management systems. They present the results of an interview-based study where actors in these sectors were asked about their perceptions and attitudes on the security of IoT.

Hasan and Mouftah [item 15) in the Appendix] propose a trust system placement scheme for smart grid supervisory control and data acquisition (SCADA) networks. The functionalities of a trust system include firewalling and network intrusion detection. It is capable of monitoring both ingress traffic and egress traffic.

Christidis and Devetsikiotis [item 16) in the Appendix] review how blockchains mechanism works and also discuss the introduction of this mechanism in IoT. They describe how a blockchain-IoT combination: 1) facilitates the sharing of services and resources leading to the creation of a marketplace of services between devices and 2) allow us to automate in a cryptographically verifiable manner several existing, time-consuming workflows. Finally, the blockchain-IoT combination is powerful and can cause significant transformations across several industries, paving the way for new business models and novel, distributed applications.

IV. HETEROGENOUS AND COEXISTENCE AT MAC AND UPPER LAYERS

The medium access control (MAC) and routing protocols have high impact on the overall performance of IoT [item 27) in the Appendix]. That's why design these protocols has been an important area of research. Recently, many protocols and standards are proposed and the coexistence between them must be considered.

In this special section, Laya *et al.* [item 17) in the Appendix] propose an overview of the existing MAC solutions for the IoT, describing current limitations and envisioned challenges for the near future. They identify a family of simple algorithms based on distributed queuing (DQ), which can operate for an infinite number of devices generating any traffic load and pattern. In addition, the authors describe the first demo of DQ for IoT.

Another contribution proposed by Ndiah and Cherkaoui [item 18) in the Appendix] focuses on coexistence scenarios between 802.11 and 802.15.4 (ZigBee) technologies. The authors propose the use of traffic prioritization for ZigBee nodes in order to improve their performance when coexisting with IEEE 802.11 nodes. In addition, they demonstrate using analytical and network simulations that the added value of this scheme comes at the cost of negligible degradation in the performance of the 802.11 nodes.

V. INTERNET OF THINGS AND SMARG GRI

The Internet of Things (IoT) contributes to make smart grid efficient and reliable in terms of energy management, data transportation, and heterogeneous architecture [item 22) in the Appendix]–[item 24) in the Appendix]. Zhang *et al.* [item 20) in the Appendix] present a review of several economic incentive approaches used in the energy-trading control mechanisms. In addition, they investigate the energy trading in a new cloud-based vehicle-to-vehicle energy exchange scenario. Finally, they proposed an optimal contract-based electricity trading scheme, which efficiently increases the generated profit.

VI. SOCIAL NETWORKING WITH IOT

Li *et al.* [item 21) in the Appendix] show the importance of social networking paradigm in efficient data

dissemination process. In order to improve the performance of the dissemination in IoT, the social characteristics of nodes can be exploited by creating valuable relation between nodes and user interest. The authors take advantage of interest inclusion and intersection to solve the dissemination problem in a conference scenario. By constructing the structure of the Interest Tree to solely represent the relations of interest inclusion and interest intersection, they integrate vehicles' social factors into their geographical information, and introduce the concept of geo-social distance (GSD) as the basis of the proposed strategy.

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APPENDIX
RELATED WORKS

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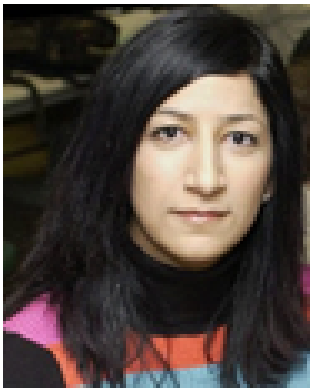

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