Convergence of 5G Technologies, Artificial Intelligence and Cybersecurity of Networked Societies for the Cities of Tomorrow

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As many as 100 billion devices will be connected to the Internet by 2025. It has been projected that the total volume of data traffic will nearly triple between 2016 and 2021, of which about 75% will originate from non-PC devices and about 42% of all connections will be for M2M communication between over 10 billion smart objects. It is anticipated that we will witness an up to 10,000- fold growth in wireless data traffic by the year 2030. Predictions evidently indicates the skyrocketing demand on data traffic and applications for machine type communication such as self-driving vehicles, healthcare monitoring, smart cities and factories, and artificial intelligence- based personalized assistants along with traditional human-centric communications. Coexistence of human-centric and machine-type services as well as hybrids of these will make next generation wireless networks more diverse and complex.

Current wireless radio access techniques are not capable of delivering these new applications and may pose a much higher security risk than the WiFi and 4G networks did. Without novel approaches, mobile networks will grind to a halt unless more capacity is added to mobile networks. In order to better support the Internet-of-Things (IoT) applications, many technical challenges need to be overcome in 5G and beyond including network architectures, network resource allocation schemes, and advanced signal processing techniques, etc. On the other hand, in IoT systems, the hardware security assurance is a critical and emerging issue. It is reported that about 70% of IoT devices are vulnerable to cyber-attacks. In

addition, deep learning and AI techniques have been considered as promising approaches to unleash the full potential of 5G networks, IoT and cyber-physical systems.

To overcome the aforementioned challenges of emerging issues for networks of future, this special issue focuses on (but are not restricted to) the following topics: Advanced network architecture design for IoT towards 5G; IoT applications to disaster management, smart cities, smart environment, and smart agriculture; Energy-efficiency in 5G for IoT applications; 5G wireless heterogeneous networks: design and optimization; Mobility management of 5G networks for IoT applications; 5G wireless communications and networks for surveillance and management; 5G technologies: NOMA, full-duplex, massive MIMO, network planning, mmWave, URLLC; Big data and IoT data analytics; Security and privacy concerns in 5G wireless communications; Hardware forensics; Deep learning for hardware oriented cybersecurity; Machine learning for resource allocation in wireless networks; Emerging memory and computing technologies for future networks; and Advanced signal processing for future networks.

The special issue includes five high-quality papers. In the first paper entitled “Energy Efficiency of Full-Duplex Cognitive Radio in Low-Power Regimes under Imperfect Spectrum Sensing”, the authors investigate the energy efficiency (EE) of a full duplex (FD) cognitive radio (CR) system, in which the low-power regime is considered under a practical self-interference cancellation performance and imperfect spectrum sensing. In the system, the secondary user (SU) is equipped with the capacity of self-interference suppression (SIS), i.e., in an opportunistic spectrum access network. In other words, the SU can work in simultaneous transmit and sense (TS) mode to increase the channel sensing quality. By using TS mode, the sensing performance of the FD CR networks evaluated by false-alarm and miss-detection probabilities is studied and compared to the conventional half duplex (HD) CR networks using transmit only mode (TO). The results show that the Gaussian-mixture channel, which is widely used to capture the asynchronism in heterogeneous cellular

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networks, can be applied to the channel of the secondary network well in imperfect spectrum sensing scenario. Furthermore, the low-signal-to-noise-ratio (low-SNR) metrics of the minimum energy per bit and the wideband slope of the spectral efficiency curve are analytically characterized to derive the closed-form fundamental limits. This way enables us to identify the practical signaling strategies for optimal efficiency of the low-SNR regime in FD CR system. Finally, the benefit of the FD CR system over the HD CR one is demonstrated in terms of EE.

The second paper is about “Evaluating the Performance of Full-Duplex Energy Harvesting Vehicle-to-Vehicle Communication System over Double Rayleigh Fading Channels”. In this paper, the authors consider the vehicle-to-vehicle (V2V) communication system. The system is employed by full-duplex (FD) and energy harvesting (EH) techniques. All the source, relay and destination nodes are moving in the context of V2V communications. The source and the relay nodes can harvest the radio energy from a power beacon (PB) for data transmission. The exact expressions of the outage probability (OP) and symbol error probability (SEP) are derived to investigate the impacts of various parameters on the system performance. Numerical results show that the system performance is strongly impacted by the number of transmission antennas of the PB, the EH duration, the residual self-interference, and the transmission distances. In addition, there also exists an optimal EH duration and optimal distance between the source and relay nodes that can provide the best system performance. Monte-Carlo simulations are done to validate all theory analysis.

In the third paper, the authors study “A Reliable Link-adaptive Position-based Routing Protocol (RLPR) for Flying Ad hoc Network (FANET)”. To develop the conventional routing protocols of FANET in a simple network environment, i.e., using a minimum hop count criterion to find the best route between a source and a destination, the authors utilize relative speed, signal strength, and energy of the nodes along with the geographic distance towards the destination using a forwarding angle. This angle is to determine the forwarding zone that decreases the undesirable control messages in the network for route discovery. The RLPR can provide a better network performance by selecting not only the relay nodes that are in the forwarding zone towards the destination, but also the next hop with proper energy level, signal strength, and relative speed of the nodes for a higher connectivity level. The simulation results performed by network simulator (NS-2.35) are shown to investigate the benefits of the proposed RLPR over the ad hoc on-demand distance vector and the robust and reliable predictive based routing protocols in terms of control overhead message, lifetime, and search success rate.

A clustering method for table structure recognition in scanned images (ClusTi) is proposed in the fourth paper. It

is challenging in optical character recognition (OCR) for scanned paper invoices due to the variability of 19 invoice layouts, different information fields, large data tables, and low scanning quality. The table structure recognition plays an important role in accurately positioning and extracting the rows, columns, and cells. In this paper, the authors propose the ClusTi method for the recognition of the structure of tables in invoice and scanned images that can overcome the problems of existing methods such as DeepDeSRT, i.e., only deal with high-quality born-digital images (e.g., PDF) with low noise and apparent table structure. To do so, the ClusTi first removes the heavy noises from the table images using a clustering algorithm. It then extracts all the text boxes by using state-of-the-art text recognition. Finally, based on the horizontal and vertical clustering algorithm with optimized parameters, the proposed method groups the text boxes into their correct rows and columns, respectively. The results show that the ClusTi achieves an F1-score of 87.5%, 98.5%, and 94.5%, respectively. It also outperforms the DeepDeSRT with an F1-score of 91.44% on only 34 images from the ICDAR 2013 competition dataset.

Finally, the last paper is about “Meteorological and Hydrological Drought Assessment for Dong Nai River Basin, Vietnam under Climate Change”. In this paper, the authors examine future changes in meteorological, hydrological drought under the impact of climate change in Dong Nai River Basin, using Standardized Precipitation Index (SPI) and Stream flow Drought Index (SDI). The Soil and Water Assessment Tool (SWAT) is used estimate the stream flow in baseline (1980–2005) and the climate change (RCP 4.5, 2016–2035) scenarios for meteorological and hydrological calculation. The results show that 1) both types of drought tend to occur in the dry season, 2) the area is affected by meteorological and hydrological drought expanding in both baseline and RCP 4.5 scenarios, and 3) meteorological drought duration is also significantly increased, especially severely drought months. Although it slightly decreases in the hydrological drought duration, the number of months in moderately drought in the sub-basins still goes up in the climate change scenario. The findings could be useful for water shortage assessment and allocation planning in the context of climate change in the Dong Nai River Basin.

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