# SECURITY AND WIRELESS COMMUNICATION NETWORKS

Dear readers,
 In this issue of *IEEE Wireless Communications Magazine*, we are pleased to present you a special issue on "Advances in Security and Privacy Techniques in Emerging Wireless Networks" with a collection of 11 articles. We are also very glad to present you 10 articles accepted from the open call.

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Wireless communication technologies are ubiquitous nowadays, most of the smart devices have combined cellular, Wi-Fi, bluetooth connections, etc. These technologies have been developed for many years, nonetheless they are still being enhanced. At the same time, security is one of the most important topics that needs to be addressed for the deployment of emerging wireless communication networks. Security for communication networks encompasses integrity, authentication, confidentiality and nonrepudiation of both user and management information. Unlike wired communication networks that have some degree of physical security, physical security in wireless communication networks is difficult to achieve on wireless links because of the broadcast nature, and therefore security attacks on information flow are the most widespread. Modification of information is possible because of the nature of the channel and the mobility of nodes. The radio channel is harsh and subject to interference, fading, multipath, and high error rates. As a result, packet losses are common even without security threats. An opponent can make use of these natural impairments to modify information and render the information unavailable.

Wireless security is one of the most important topics today and attracting more and more attention from industry, research, and academia. There is a need to explore the frontier research results to protect the security in emerging wireless communications with the emphasis on both theories and practice to promote the fast and stable development of wireless communication networks. This special issue focuses on the recent advances and new challenges to security and privacy techniques in various wireless communication networks, including security and privacy in mobile wireless networks, wireless IoT, wireless ad hoc and sensor networks, wireless mesh networks, large-scale wireless networks, and cloud and fog/edge computing. Thanks to the guest editors, X. Lin, X. Du, M. Guizani, C.-K. Chu, and Y. Yu, who have done an excellent job in editing this special issue for our readers. Please stay tuned for new developments in this research area of wireless security and privacy and read more about the editorial and the papers in this special issue.

In addition to the 11 articles in the special issue, we have also included 10 accepted open call articles in this issue.

The first article, "Ten Challenges in Advancing Machine Learning Technologies towards 6G" by N. Kato *et al.*, introduces 10 emerging challenges of enabling intelligent machine learning into the future 6G network in terms of communication, networking, and computing perspectives. The article aims to summarize the possible research challenges and the potential research directions.

The second article, "Strategies and Demonstration to Support Multiple Wireless Protocols with a Single RF Front-end" by M. Mohamed *et al.*, proposes a new approach for spectrum sharing with a hardware implementation to support the coexistence of Wi-Fi, LTE, and ZigBee in the congested 2.4 GHz band using a single RF front-end. A detection method is developed to resample the preambles of both Wi-Fi and ZigBee to the LTE sampling rate to avoid continuous resampling of the received signal. Further processing steps such as synchronization and demodulation for each protocol are presented. Measurement results are provided to demonstrate the techniques showing a low symbol error rate tested over the air in a laboratory environment with interference.

In the third article, "Creating Efficient Blockchains for the Internet of Things by Coordinated Satellite-Terrestrial Networks", H. Wei *et al.* identify the key factors affecting the efficiency of blockchain for Internet of Things applications. Unlike most existing solutions that handle this from the computing perspective, the authors consider the problem from the communication perspective. They propose a coordinated satellite-terrestrial network to create efficient blockchains. They also derive a network scheduling strategy for the proposed architecture. Simulation results demonstrate that the proposed system can support blockchains for higher efficiency.

Q. Li *et al.*, in the fourth article, "Subcarrier Index Modulation for Future Wireless Networks: Principles, Applications, and Challenges", introduce the generic framework of subcarrier index modulation (SIM) and its specific representatives. The potential applications of SIM are then investigated in a variety of scenarios, including cognitive radio, relay networks, downlink multiuser communications, and physical layer security. The authors also discuss the challenges and possible research directions in SIM and its applications.

In the fifth article, "Quantum Machine Learning: Recent Advances and Outlook", W. O'Quinn *et al.* review the literature of existing platforms and important issues of quantum machine learning. They further provide a discussion to the emerging field of quantum machine learning and recent advances and problems that are yet to be solved.

In the sixth article, "FPGA for 5G: Re-configurable Hardware for Next Generation Communication", V. Chamola *et al.* give an overview of 5G technology and integration of various hardware and software-defined technologies to meet the requirement of future mobile communication. The authors explain how FPGA can be used to create various building blocks of 5G infrastructure. They demonstrate that the invention of hybrid computing platforms, such as the FPGA-based hardware acceleration approach, shows promise for the implementation of standalone energy efficient NFV and C-RAN architectures

C. Lin *et al.*, in the seventh article, "An SDN Architecture for AUV-based Underwater Wireless Networks to Enable Cooperative Underwater Search", employ the paradigm of Software-Defined Networking (SDN) technology and propose an SDN-based underwater cooperative searching framework for AUV-based UWNs. They propose a software-defined beaconing framework integrating two categories of defined beacons to synchronize network information and execute network operations.

In the eighth article, "Robust Spectrum Sharing in Air-Ground Integrated Networks: Opportunities and Challenges", H. Wang *et al.* study the characteristics in air-ground spectrum sharing from state uncertainties and security threats perspectives. A robust spectrum sharing framework is developed in which spectrum utilizing networks, spectrum monitoring networks, and spectrum clouds cooperatively form a cognitive dynamic close-loop control system. Furthermore,

the authors discuss the key enabling technologies for robust spectrum sharing in AGIN to tackle the issues of uncertain and unknown information. After that, an exemplary robust spectrum sharing case with location uncertainty is provided. Finally, the technical challenges and open issues ahead are presented.

In the ninth article, "QoE-based Cooperative Task Offloading with Deep Reinforcement Learning in Mobile Edge Networks", X. He *et al.* present a new cooperative task offloading mechanism to strive for lower service latency with the goal of achieving a better QoE value. The proposed scheme consists of three procedures, namely task-hub construction, task preprocessing, and task scheduling, with which the task inputs are better processed, and the mobile users are better served. To enable the offloading mechanism in complex mobile edge network scenarios, they integrate deep reinforcement learning in task scheduling. Experimental results exhibit the notable advantages of the proposed scheme, during which a higher QoE value is achieved compared with traditional offloading algorithms

In the tenth and last article, "Learning to Sense: Deep Learning for Wireless Sensing with Less Training Efforts", J. Wang *et al.* study deep learning techniques for wireless sensing applications. The authors provide a general framework for deep learning based wireless sensing systems and introduce the kernel modules of the system. They highlight two new types of deep learning networks, i.e., deep similarity evaluation networks and deep generative adversarial networks, which could accomplish the sensing task with less training efforts. They also elaborate existing challenges and point out a few future research directions.

I hope you will enjoy reading the articles in this issue of *IEEE Wireless Communications Magazine*. Please stay safe and healthy and take care. Thank you!

## BIOGRAPHY

Yi Qian [M'95, SM'07, F'19] received a Ph.D. degree in electrical engineering from Clemson University, Clemson, South Carolina. He is currently a professor in the Department of Electrical and Computer Engineering, University of Nebraska-Lincoln (UNL). Prior to joining UNL, he worked in the telecommunications industry, academia, and government. Some of his previous professional positions include serving as a senior member of scientific staff and a technical advisor at Nortel Networks, a senior systems engineer and a technical advisor at several startup companies, an assistant professor at the University of Puerto Rico at Mayaguez, and a senior researcher at the National Institute of Standards and Technology. His research interests include wireless communications and networks, and information and communication network security. More specifically, he has research and industry experience in wireless communications and networks, wireless sensor networks, vehicular communication networks, information and communication network security, smart grid communications, broadband satellite communications, optical communications, high-speed communications and networks, and Internet of Things. He was previously Chair of the IEEE Technical Committee for Communications and Information Security. He was the Technical Program Chair for the 2018 IEEE International Conference on Communications. He serves on the Editorial Boards of several international journals and magazines, including as the Editor-in-Chief for *IEEE Wireless Communications*. He was a Distinguished Lecturer for the IEEE Vehicular Technology Society. He is currently a Distinguished Lecturer for the IEEE Communications Society.