5G Wireless Communication Networks: Challenges in Security and Privacy


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Dear Readers: First, I would like to introduce you to the new members recently joining the Editorial Board of *IEEE Wireless Communications*: Sastri Kota as the Column Editor for Book Reviews; Feng Ye as the Column Editor for Scanning the Literature; and Tao Chen, Wen-Long Chin, Gabor Fodor, Bin Hu, Khoa Le, Balasubramaniam Natarajan, Yongpeng Wu, and Nan Zhao as Technical Editors. Welcome aboard! I would also thank those who have served their editor terms most recently: Satyajayant Misra, Pan Li, Han-Chieh Chao, Periklis Chatzimisios, Stanley Kuang-Hao Liu, Weixiao Meng, Mohammad S. Obaidat, Kui Ren, Joel Rodrigues, Athanasios V. Vasilakos, Yonggang Wen, and Sherali Zeadally. Thanks everyone again for your time and dedication to *IEEE Wireless Communications*!

With the current impact factor 11.391, our magazine is doing very well. I would like to make sure that we can keep up our reputation and make it even better in the years to come. Having a strong Editorial Board is so critical to the continuing success of *IEEE Wireless Communications*.

In this issue we are pleased to present a special issue on "Challenges and Novel Solutions for 5G Network Security, Privacy and Trust" with a collection of five articles. In this issue, we are also very glad to present 14 articles accepted from the open call.

Fifth generation (5G) wireless communication networks are the next generation mobile wireless systems beyond the current 4G/International Mobile Telecommunications Advance Systems. Not only enhanced mobile broadband communications but also ultra-reliable low-latency communications and massive machine-type communications are supported by 5G wireless networks. New architecture and advanced technologies are applied in 5G wireless networks to support different use cases. New security issues and advanced performance requirements are raised by various use cases and advanced technologies. Moreover, privacy concerns escalate due to the large amount of personal information that is transmitted over 5G wireless networks. The 5G wireless system is not only an evolution of the legacy 4G networks, but also a system with many new service capabilities, related to our daily life and industry applications. To support these new service capabilities, 5G wireless networks integrate many new technologies, which can potentially bring security vulnerabilities. Moreover, strict performance requirements for certain applications cannot be satisfied with the current security solutions. For instance, vehicular communications over 5G require extremely low latency and IoT applications demand low overhead. The goal of 5G wireless network security is to provide security services to 5G wireless systems while retaining the high performance emblematic of 5G technology. Since 4G security architectures may not be satisfactory for 5G networks, new security architectures are needed to ensure the efficiency and flexibility of security and privacy in 5G wireless networks.

Security and privacy for 5G wireless networks 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 5G wireless networks 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 challenges and novel solutions for 5G network security and privacy, including attack and threat detection, trust models, new security frameworks and architectures, security management, access control, information sharing and data protection, big data security and analytics, physical layer security, privacy preservation and enhancement, and secure 5G network protocols.

Thanks to the guest editors, W. Mazurczyk, P. Bisson, R. P. Jover, K. Nakao, and K. Cabaj, who did an excellent job editing this special issue for our readers. Please stay tuned for new developments in this research area of 5G wireless security and privacy and read more about the editorial and the papers in this special issue.

In addition to the five articles in the special issue, we have also included 14 articles accepted from the open call.

The first article, "UAV-Aided Cellular Communications with Deep Reinforcement Learning Against Jamming" by X. Lu *et al.*, proposes a deep reinforcement learning based UAV relay algorithm to choose the relay power to help cellular systems resist jamming attacks. The authors have proved that this scheme enables a UAV to achieve optimal performance such as the BER and the energy consumption without knowing the network topology, the message generation model, the server computation model and the jamming model of the cellular system.

The second article, "Map-based Millimeter-Wave Channel Models: An Overview, Data for B5G Evaluation and Machine Learning" by Y.-G. Lim *et al.*, provides an overview of map-based mm-Wave channel models and guidelines of the categorization of map-based channel parameters. The authors explain why map-based channel models are necessary for researchers trying to evaluate novel technologies in the mm-Wave range. They share the measurement data and the map-based channel parameters, which can model new link types and have user-specific characteristics. As a use case of the proposed channel model, they evaluate a machine-learning-based beam-selection algorithm that exploits power delay profiles through the shared database and a geometry-based stochastic channel model.

In the third article, "A Framework for MEC-Enhanced Small-Cell HetNet with Massive MIMO," C. Wang *et al.* propose a framework for a multi-access edge computing (MEC)-enhanced heterogeneous network with massive multiple-input multiple-output and small cells that is employed to mitigate interference, increase throughput, alleviate backhaul capacity pressure, and reduce signaling overhead. The authors design the information-centric transmission mechanism and discuss possible signal processing and transmission modes. They also demonstrate that channel state information can be pooled at a centralized MEC server, and precoding may be carried out cooperatively among cells to reduce intra-cell and inter-cell interference. A smart caching scheme is proposed to proactively cache content at appropriate base stations in anticipation of the best transmission mode to be used, thereby reducing latency from content retrieval.

E. De Carvalho *et al.*, in the fourth article, "Non-Stationarities in Extra-Large Scale Massive MIMO," demonstrate that massive MIMO systems behave differently in large-scale regimes due to spatial non-stationarity. In the large-scale regime, with arrays of around 50 wavelengths, the terminals see the whole array, but non-stationarities occur because different regions of the array

see different propagation paths. At even larger dimensions, which the authors call the extra-large scale regime, terminals see a portion of the array and inside the first type of non-stationarities might occur. The authors show that the non-stationarity properties of the massive MIMO channel change several important MIMO design aspects.

In the fifth article, "Bankruptcy Problem in Network Sharing: Fundamentals, Applications and Challenges," A. Antonopoulos *et al*. discuss the potential applications of the bankruptcy problem in mobile communications. For the similarities of the bankruptcy problem with the sharing of limited resources in 5G wireless networks, the authors try to identify new research lines that will foster 5G network sharing. They introduce the intuition behind the bankruptcy problem along with a set of proposed solutions. They focus on the telecommunications domain, quoting a list of possible applications that includes a broad range of emerging techniques and concepts, from energy and spectrum sharing to UAVs and MEC use cases. They highlight the challenges and open issues for the smooth application of the bankruptcy problem in wireless networks in concluding the paper.

In the sixth article, "Dimming Techniques of Visible Light Communications for Human-Centric Illumination Networks: State-of-the-Art, Challenges, and Trends," T. Wang *et al*. review the current research progress in the dimming techniques of VLC for human-centric illumination network. The authors provide comprehensive comparisons and discussions of the state-of-the-art solutions from a multidimensional perspective. They also discuss the challenges and the future research trends. They believe that the dimming strategies will cover not only the physical layer but also the higher layers to further improve the system efficiency and enhance the users' experience. With continuing efforts from academia and industry, it is expected VLC will play a much more important role in post 5G or even 6G wireless communication systems.

In the seventh article, "The Collective Advantage for Advancing Communications and Intelligence," R. Li *et al*. highlight the collective intelligence among connected beings and things, which harnesses the advancement in communications technology and AI and is assumed to emerge in the B5G era. Following that, the authors propose the IEML as the communicating language among multiple agents to augment human intelligence and discuss the advantages and potential applications of IEML to advance communications. They demonstrate the achievement by collective intelligent agents through simple indirect communications and show the effectiveness of collective intelligence to boost intelligence.

In the eighth article, "Edge Intelligence for Mission Cognitive Wireless Emergency Networks," L. Wang *et al*. present a hierarchical architecture for wireless emergency communications, which consists of remote cloud servers, edge servers, and end devices. Four functionality modules are introduced under the framework of mission cognitive edge intelligence for typical applications in emergency scenarios, supported by various edge-assisted technologies. The effectiveness of the proposed approaches is demonstrated via detailed case studies.

In the ninth article, "Compression and Acceleration of Neural Networks for Communications," J. Guo *et al*. investigate how to compress and accelerate the neural networks (NNs) in communication systems. After introducing the deployment challenges for DL-based communication algorithms, the authors discuss several representative NN compression and acceleration techniques. Two case studies for multiple-input-multiple-output (MIMO) communications, including DL-based channel state information feedback and signal detection, are presented to show the feasibility and potential of these techniques. They identify the challenges on NN compression and acceleration in DL-based communications and provide a guideline for future research.

In the 10th article, "A Speculative Study on 6G," F. Tariq *et al*. provide an expert view on the most trending research directions that have the potential to shape the 6G mobile technologies. Although the development of 6G is in an early stage and it is expected that some ideas will only emerge in later years, this article takes an approach to speculate on the possible enabling technologies and the elements in 6G, and describes the features beyond the capability of 5G.

In the 11th article, "Intelligent Task Offloading in Vehicular Edge Computing Networks," H. Guo *et al*. propose an SDN-enhanced vehicular edge computing network, in which the data and information throughout the entire network can be collected and centrally managed. The authors study the task offloading problem with the goal of minimizing processing delay in such a scenario, and propose an intelligent task offloading scheme, i.e., a deep Q learning based scheme. Numerical results and analysis demonstrate that the proposed scheme can achieve better performance compared to the traditional offloading schemes.

In the 12th article, "Deep Learning for Wireless Communications: An Emerging Interdisciplinary Paradigm," L. Dai *et al.* provide an overview of a pair of dominant methodologies of using DL for wireless communications. The first one is DL-based architecture design, which breaks the classical model-based block design rule of wireless communications in the past decades; the second is DL-based algorithm design, which is illustrated by several examples in a series of typical techniques conceived for 5G and beyond. The authors discuss the principles, key features, and performance gains, as well as open problems and future research opportunities, highlighting the interplay between DL and wireless communications.

In the 13th article, "Proximate Device Discovery for D2D Communication in LTE Advanced: Challenges and Approaches," H. Wu *et al*. give an overview of D2D Communications in LTE Advanced for the fundamentals of peer discovery, including basic concepts, application scenarios, associated requirements, along with the current standardization progress. They survey the key challenges and open issues in the design of device discovery signals and device discovery protocols for D2D communication in centralized and distributed scenarios, respectively. They also discuss the possible approaches to address these challenges.

In the 14th and last article, "Massive Access for Future Wireless Communication Systems," Y. Wu *et al*. study the significance of massive access as a key enabling technology for future beyond 5G wireless networks. The authors demonstrate that there are fundamental challenges ahead for the practical implementation of massive access wireless communication, e.g., when it comes to common codebook coding, realization of low complexity processing algorithms, sporadic and small payload traffic of users, and synchronization protocols. It provides both academia and industry a promising research potential and many new research problems.

I hope you will enjoy reading the articles in this issue. Please stay safe and healthy. Have a nice summer!

Biography

Yi Qian [M'95, SM'07, F'19] received a Ph.D. degree in electrical engineering from Clemson University in 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 IEEE International Conference on Communications 2018. 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 IEEE Vehicular Technology Society. He is currently a Distinguished Lecturer for IEEE Communications Society.