5G MmWave Small Cell Networks: Architecture, Self-Organization, and Management


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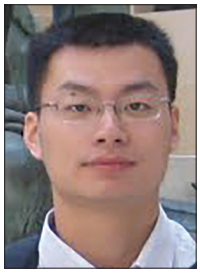
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To meet the demand of fast growing data rates, fifth generation (5G) millimeter-wave (mmWave) small cell networks (SCNs) have recently gained surging research interest worldwide. MmWave SCN is not a simple upgrade of its low-frequency predecessor by just adding additional spectrum or equipping advanced radio technologies. To fully release the potential, one has to rethink from the system and architecture levels down to the physical implementation level.

The mmWave SCN combines various enhancements to aggregate more spectrum and infrastructure nodes, specifically by adopting mmWave spectrum, massive multiple-input multiple-output (MIMO), and network densification. The availability of broad spectrum makes mmWave the ideal candidate for achieving the gigabit-level data traffic and ultra-low latency required in 5G. Other advantages of mmWave include the applicability of massive antenna arrays due to the millimeter wavelength, the capability of pencil-beam transmissions after beamforming, and thus limited interference and improved security. As a result, the mmWave SCN naturally possesses properties from dense SCN and mmWave, including ultra-high data rate support, flexible deployment and management, rich available spectral resources, and so on.

The motivation of this Special Issue is to invite peers to contribute to the state-of-the-art knowledge with their technical insights regarding mmWave SCNs. The Call for Papers received worldwide responses with a large number of high-quality submissions. Due to space limitations, we were able to select only nine papers, best aligned with this Special Issue.

The nine accepted articles fulfill the goal of outlining the main research directions and shaping the future works. The article "All Technologies Work Together for Good: A Glance at Future Mobile Networks" concentrates on the benefits and challenges of simultaneously operating a number of potential 5G technologies, including mmWave, massive MIMO, non-orthogonal multiple access (NOMA), small cells, and so on. The article "Toward the Coexistence of 5G MmWave Networks with Incumbent Systems Beyond 70 GHz" investigates the deployment of 5G systems at the e-band (71–76 GHz, 81–86 GHz) and highlights the coexistence with incumbent fixed stations. The article "Energy-Efficient Power Allocation with Interference Mitigation in MmWave-Based Fog Radio Access Networks" presents an integrated architecture of 5G mmWave and fog radio access networks with the goal of maximal energy efficiency. In order to overcome the increasing complexity and overheads in 5G networks, the article "Computationally Intelligent Techniques for Resource Management in MmWave Small Cell Networks" highlights the concept of computational intelligence, mainly including game theory and optimization routines, to perform efficient resource management. The article "Millimeter-Wave Small Cells: Base Station Discovery, Beam Alignment, and System Design Challenges" studies some fundamental problems in the design of 5G mmWave small cells, such as beamforming transmission of reference signals in achieving efficient BS discovery. The article "On the Secrecy Capacity of 5G MmWave Small Cell Networks" investigates those challenges from the perspectives of physical layer security, in the ensemble of mmWave, small cell, MIMO, NOMA, and so on. The article "Evaluation Metrics and Simulation Tools for 5G Millimeter-Wave Networks" investigates the emulation and assessment process for 5G mmWave spectrum sharing. The article "Capacity Enhancement for 5G Networks Using MmWave Aerial Base Station: Self-Organizing Architecture and Approach" resorts to a self-organizing network (SON)-based architecture to control multiple mmWave aerial base stations for capacity enhancement. From a general perspective of 5G SON for 5G mmWave SCN, the article "Revolution of Self-Organizing Network for 5G MmWave Small Cell Management: From Reactive to Proactive" claims that the legacy SON design philosophy will no longer be suitable for the mmWave small cell system, and a revolution is demanded to adapt to the new radio and new network.

This Special Issue provides a comprehensive overview of the development of mmWave SCNs. As the research is still in its burgeoning stage, we hope that this Special Issue will not

only serve as a valuable reference, but also encourage more readers of *IEEE Wireless Communications* to contribute their efforts in this area.

Finally, we would like to express our gratitude to all the authors for their generous submissions and all reviewers for their timely and professional reviews. We also acknowledge the support of the Editor-in-Chief of *IEEE Wireless Communications* and the help provided by the publication staff.

Biographies

Bo Rong (bo.rong@ieee.org) is a research scientist at Communications Research Centre, Ottawa, Canada. He has authored and coauthored more than 100 technical papers in major journals and conferences, as well as books and book chapters in the areas of wireless networking and communications. His research interests include modeling, simulation, and performance analysis of next-generation mobile networks.

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George K. Karagiannidis [F] is currently a professor in the Electrical and Computer Engineering Department and director of the Digital Telecommunications Systems and Networks Laboratory, Aristotle University of Thessaloniki, Greece. From 2012 to 2015 he was the Editor-in Chief of *IEEE Communications Letters*. He is a highly cited authors across all areas of eectrical engineering, recognized as a 2015, 2016, and 2017 Thomson Reuters Highly-Cited Researcher.

Chenwei Wang received his Ph.D. in electrical and computer engineering from the University of California, Irvine, in December 2012. Since 2013, he has been a research engineer in the Mobile Network Technology Group of DOCOMO Innovations Inc., Palo Alto, California. His research interests include wireless communications and networks, machine learning, and big data. He was a recipient of the 2017 IEEE GLOBECOM Best Paper Award, the 2016 IEICE Best Tutorial Paper Award, and the 2014 IEEE Signal Processing Society Young Author Best Paper Award.