KEY TECHNOLOGY FOR 5G NEW RADIO


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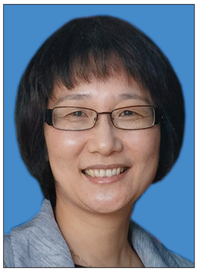
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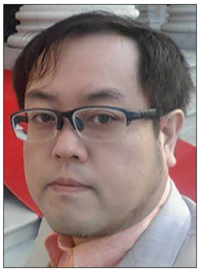
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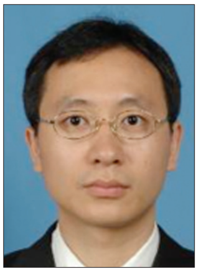
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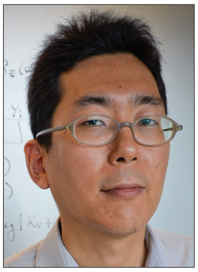
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With initial commercialization expected in 2020, fifth generation (5G) mobile communications is gathering increased interest and momentum around the world. Following discussions on the 5G vision and key requirements such as high data rate, low latency, and massive connectivity, various candidate technologies have been proposed and investigated. These new technologies include massive antenna technologies to provide beamforming gain and support increased capacity, new waveforms to flexibly accommodate various services and applications with different requirements, and new multiple access schemes to support massive connections. From a spectrum point of view, there is also increased interest in the use of spectrum above 6 GHz for 5G mobile communications.

For the past few years, the Third Generation Partnership Project (3GPP) has been studying the technologies listed above and developed a new 5G radio access technology, known as New Radio (NR). In December 2017, the 3GPP achieved a major milestone by completing the initial set of radio specifications for the non-standalone access (NSA) use case, where both 4G and 5G radios coordinate in the same device to provide necessary control and data paths. The standalone access (SA) version of the NR radio specifications are expected to be ready by the end of the first half of 2018.

The first release of NR is capable of fulfilling many of the International Telecommunication Union (ITU) requirements for International Mobile Telecommunications (IMT) for 2020. Later releases of NR will support all IMT-2020 requirements in all main usage scenarios — enhanced mobile broadband, massive machine type communications, and ultra-reliable low-latency communications — and aim to provide the first fully compliant technology. The IMT-2020 requirements include peak data rates of 20 Gb/s, user experienced data rates of 100 Mb/s, a spectrum efficiency improvement of 3×, support for up to 500 km/h mobility, 1 ms latency, a connection density of 106 devices/km^2, a network energy efficiency improvement of 100×, and an area traffic capacity of 10 Mb/s/m^2. While all these requirements need not be met simultaneously, the design of 5G networks and radio access should provide flexibility to efficiently support various applications.

The goal of this Feature Topic is to give a timely overview of the key NR technologies in terms of their design considerations, strengths, and limitations. By enabling researchers to share their viewpoints and their latest research results in this Feature Topic, we hope to feed into the 5G ecosystem development as standardization and regulatory bodies explore spectrum and access techniques for 5G.

We received very positive responses from both industry and academia to our initial Call for Papers, with a total of 34 articles submitted by leading researchers around the world. After careful review, a set of eight papers were selected.

The first article, "Spectrum for 5G: Global Status, Challenges, and Enabling Technologies" by J. Lee *et al.*, highlights the importance of harmonized mobile spectrum for 5G and lays out the current 5G spectrum situation around the world for both below and above 6GHz.

The second article, "Toward the Standardization of Non-Orthogonal Multiple Access for Next Generation Wireless Networks" by Y. Chen *et al.*, provides an overview of the state-of-the-art design of NOMA transmission based on a unified transceiver design framework, the related standardization progress, and some promising use cases in future cellular networks.

The third article, "Design of Low-Density Parity-Check Codes for 5G New Radio" by T. Richardson and S. Kudekar, describes a design philosophy of LDPC code as a new channel coding scheme for NR, which needs to address the broad requirements of 5G.

The fourth article, "Initial Access, Mobility and User-Centric Multi-Beam Operation in 5G New Radio" by J. Liu *et al.*, provides an overview of initial access and mobility mechanisms in NR, and the mechanisms that need to be designed with beamforming in mind and solutions that differ from LTE in several aspects.

The fifth article, "NR Wide Bandwidth Operations" by J. Jeon, discusses the wide bandwidths supported in NR, an important feature to support the high data rates targeted with NR. However, not all devices will support the full carrier bandwidth, and 3GPP has introduced the notion of bandwidth parts to handle this, the details of which are outlined in this article.

The last three articles introduce the recent advances in the NR MIMO technology. As the sixth article of the Feature Topic, "Modular and High-Resolution Channel State Information and Beam Management for 5G New Radio" by E. Onggosanusi *et al.* provides an overview of the latest 3GPP NR standard progress of advanced channel state information (CSI) reporting and beam management, which are two important technologies for NR MIMO performance enhancement over state-of-the-art 4G LTE. In this article, a flexible channel measurement scheme that can provide more accurate CSI acquisition and efficient beam management is introduced.

The seventh article, "Multi-Panel MIMO in 5G" by Y. Huang *et al.*, not only provides an overview on multi-panel MIMO systems in 5G, but also introduces a novel codebook design and CSI feedback approach that has been confirmed by the experimental results.

The last article, "3D MIMO: Several Observations from 32 to Massive 256 Antennas Based on Channel Measurement" by J. Zhang *et al.*, summarizes the field measurement results of the 3D-MIMO capacity for 5G NR and its dependence on bands, antenna numbers, and deployment scenario.

We wish to thank all the authors for contributing to this Feature Topic, and wish to thank the reviewers for their valuable feedback. We hope that these articles provide the readers of this magazine with a technical overview of the different technologies included in the first release of NR, as well as the technologies under consideration for future releases of NR. With 5G becoming increasingly relevant in industry and academia, and with standardization and regulatory bodies, cellular operators, and chipset and device manufacturers increasing their efforts to support new applications and requirements, this overview should be of great interest to a wide range of readers.

BIOGRAPHIES

CHARLIE JIANZHONG ZHANG [F] (jianzhong.z@samsung.com) is a VP and head of the Standards and Mobility Innovation Lab of Samsung Research America, where he leads research, prototyping, and standards for 5G cellular systems and future multimedia networks. He received his Ph.D. degree from the University of Wisconsin, Madison. From August 2009 to August 2013, he served as the Vice Chairman of the 3GPP RAN1 working group and led development of LTE and LTE-Advanced technologies such as 3D channel modeling, UL-MIMO and CoMP, and carrier aggregation for TD-LTE. Before joining Samsung, he was with Motorola from 2006 to 2007 working on 3GPP HSPA standards, and with Nokia Research Center from 2001 to 2006 working on IEEE 802.16e (WiMAX) and EDGE/CDMA receivers.

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YOSHIHISA KISHIYAMA received his B.E., M.E., and Dr. Eng. degrees from Hokkaido University, Sapporo, Japan, in 1998, 2000, and 2010, respectively. In 2000, he joined NTT DOCOMO, INC. He is currently a senior research engineer with the 5G Laboratory in NTT DOCOMO, INC., on the team to develop radio access technologies for 5G and beyond. His current research interests include massive MIMO/beamforming technologies, NOMA, radio interface design for higher frequency bands, and so on. He was a recipient of the International Telecommunication Union (ITU) Association of Japan Award in 2012.

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