Evolution of 5G NR MIMO Standards


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The multi-input multi-output (MIMO) technology is proven salient in cellular wireless communications standards for improving end-user experience by increasing the overall spectral efficiency. With the advent of antenna technologies such as active antennas and two-dimensional arrays, deploying base stations with tens or hundreds of antenna elements has become feasible and it is an essential component for successful deployments of 5G New Radio (NR) technologies standardized by the 3rd Generation Partnership Project (3GPP). Also included in 5G NR is the use of mmWave bands where an analog-beam-based transmission and reception paradigm, termed the beam management, poses a new set of challenges and requirements. The initial release of 5G NR, i.e., Rel-15 includes the support of high-resolution channel state information (CSI) to facilitate efficient multi-user MIMO operation, multiple transmit/receive points (multi-TRP) operation, and beam management. Such features are enabled by basic components such as reference signals for facilitating demodulation and CSI measurements, CSI reporting mechanisms for link adaptation and scheduling, transmission schemes for downlink and uplink, and control signaling. 5G NR MIMO has been enhanced in 3GPP Rel-16 and Rel-17 standards. Following the recent completion of Rel-17 standards, 5G NR MIMO would be further enhanced in Rel-18 taking into account various requests to enable new products and more flexible network deployments.

The purpose of this special issue is to discuss technical challenges and enhancements in the 3GPP standards for evolution of 5G NR MIMO technologies. This issue has four articles on various aspects of 5G NR MIMO evolution.

In the article "Enhanced Reliability and Capacity with Multi-TRP Transmission," the authors discuss the basic operation to enhance data capacity by use of multiple TRPs in both ideal and non-ideal backhaul scenarios. They also discuss other aspects such as reliability enhancement by transmission from multiple TRPs, management of beams in multi-TRP environment, support for high-speed train scenario with TRPs installed along the railroad, inter-cell multi-TRP operation, and joint CSI for multi-TRP operation.

Evolution of NR MIMO has been taking place in both of sub-6 GHz band, e.g., 3.5 GHz, and over-6 GHz band, e.g., mmWave. For the former, enhancements on CSI feedback to improve spectral efficiency with reduced overhead has been one of the most important subjects. An important subject for the latter is beam management with reduced signaling overhead and latency as well as improved link reliability in challenging scenarios. These two subjects are discussed in the article "Enhancing 5G MIMO Core Spectral Efficiency with Higher-Resolution Multi-User MIMO and Multi-Beam Operation."

Densification is a useful approach to meet the increasing requirements for communication networks such as high spectral efficiency, energy efficiency, and flexible and cost-efficient deployment. In the article "Cell-free mMIMO Support in the O-RAN Architecture: A PHY Layer Perspective for 5G and Beyond Networks," the authors discuss the cell-free network architecture and its support using the Open Radio Access Network (O-RAN) architecture that provides flexibility and intelligent control in network operation.

In the article "Enhancements on Type-II 5G New Radio Codebooks for UE Mobility Scenarios," the authors argue that the current Type-II codebooks cannot provide an adequate performance for the UEs moving with medium-to-high speeds, since the current CSI measurement and reporting is a coherence time-based approach. They propose an enhancement on Type-II codebook which is based on stationary time-based CSI measurements and reporting and exploits channel Doppler information in addition to space and delay information.

Biographies

Juho Lee [F] (juho95.lee@samsung.com) is currently a Fellow (EVP of technology) at Samsung Electronics, where he is leading research and standardization for mobile communications. He joined Samsung Electronics in 2000 and has worked on multiple generations of mobile communications, i.e., WCDMA and HSPA in 3G, LTE, LTE-Advanced, and LTE-Advanced Pro in 4G, and 5G NR technologies. His current research focus is on preparation of future technologies such as 5G evolution, e.g., 5G-Advanced in 3GPP, and 6G. He was a vice chairman of 3GPP RAN WG1 from February 2003 to August 2009 and chaired LTE/LTE-Advanced MIMO sessions. He received his Ph.D. degree in electrical engineering from Korea Advanced Institute of Science and Technology (KAIST), Korea, in 2000.

Mihai Enescu is currently a Senior Specialist, 5G Radio Standardization in Nokia, Finland. He joined Nokia in 2006 and he has been actively involved in the 3GPP standardization of several generations of mobile communication systems, i.e., LTE, LTE-Advanced, and LTE-Advanced Pro in 4G, and 5G NR technologies. His current research focus is on various physical layer topics, including MIMO, related to 5G evolution in 3GPP and 6G. He is also serving as editor of 3GPP technical specification "NR; Physical Layer procedures for data" (38.214). He received his Ph.D. in electrical engineering from Helsinki University of Technology, Finland, in 2002.

Asbjørn Grøvlen is a Principal Researcher within Standards & Technology in Business unit Networks at Ericsson and is currently Ericsson's Technical Coordinator for 3GPP RAN1 standardization. Asbjørn has been active in 3GPP standardization for 20 years working on various aspects of 3G HSDPA, 4G LTE and 5G NR. He joined Ericsson in 2014, having previously worked in 3GPP standardization for Nokia, Renesas Mobile Corporation and Broadcom. He received his M.Sc. in electrical engineering from the Norwegian Institute of Technology in 1994.

Yu Zhang [SM] received the Ph.D. degree in electrical engineering from the Beijing University of Posts and Telecommunications in 2009. From 2009 to 2013, he was a Research Staff Member with NEC Laboratories China. From 2011 to 2012, he was a Visiting Scholar at the Department of Electrical and Computer Engineering, University of California at Davis. He is currently a Senior Staff Engineer with Qualcomm Technologies, Inc. Since joining Qualcomm in 2013, he has been actively contributing to the research, development, and standardization of MIMO features for the 3GPP LTE-Advanced Pro and the 5G NR.