Special Issue on 5G Communications and Experimental Trials with Heterogeneous and Agile Mobile networks

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5th generation mobile networks, 5G, are the proposed next-generation communication network standards. In addition to providing more than 1 Gb per second faster speeds, 5G will be a global game changer from technological, economic, societal, and environmental perspectives by integrating multiple networks in diverse sectors for various up to date applications such as the Internet of Things (IoT), device-to-device direct communication (D2D), vehicular communications (V2X), and disaster resilient communication. Currently, millimeter-wave (mmWave) radio spectrum between 30 GHz and 300 GHz is critical for 5G rollout. Regulatory bodies around the world are now working towards opening up new spectrum bands from 6 GHz–100 GHz, and new technologies to overcome the challenges of these mmWave bands have been developed. It is envisioned that advanced 5G network infrastructure includes ultra-broadband access, high-speed backhaul and relay, softwarized flexible evolved packet core solutions for efficient system management, and satellite communications as an inherent component of 5G systems.

In this Special Issue, we attempted to select papers covering both experimental trials as well as system-oriented issues over heterogeneous and agile mobile network environments.

The invited paper "5GCHAMPION – Disruptive 5G Technologies for Roll-Out in 2018" by Emilio Calvanese Strinati et al. summarizes the 5GCHAMPION Europe-Korea collaborative project that provides fully integrated and operational disruptive 5G technologies over a global scope. This article focuses on a subset of three disruptive solutions including high-speed communications, direct satellite-UE (user equipment) communications, and softwareization over virtualized infrastructure. 5GCHAMPION technologies are developed and deployed for the 2018 PyeongChang Olympic Games in Korea. Extensive real-field experimentation for evaluating the effectiveness and performability of these 5G principal features enhances real maturity of 5G technologies and applications for large-scale 5G services.

The next paper titled "Field Measurement-Based Received Power Analysis for Directional Beamforming Millimeter-Wave Systems: Effects of Beamwidth and Beam Mis-Alignment" by Juyul Lee et al. overcomes many propagation limitations of the millimeter wave (mmWave) frequency band by using an enhanced beamforming technology. Notably, To overcome the performance variation and extra power losses of beam-based mmWave communication system caused by the width and operational methods of beamforming, they investigated and designed directional beamforming approaches in consideration of the aspect of beam width and alignment effect.

The third paper "Stochastic Channel Modeling for Railway Tunnel Scenarios at 25 GHz" by Danping He et al. tackles high-speed 5G communication scenarios for the railway system. In support of the high-speed trains, the proposed communication system is designed to handle high data rate demands with seamless connectivity over high mobility. The authors examined and modeled channel characteristics for railway tunnel scenario with both straight and curved routes. They calibrated and validated the target scenarios using a 3D ray tracing (RT) rendering technique with the "Mobile Hotspot Network (MHN)" system based measurements. Their additional RT simulation results at 25.25 GHz with 500 MHz bandwidth validate the channel characteristics models. According to the substantial experiments, they consolidated several channel parameters to a 3GPP-like stochastic channel generator to get the practical channel information, which can reproduce similar scenarios for both link and system level designs of the communication system.

The analysis of Open Loop (OL)/Transmit Power Control (TPC) parameters is crucial for efficient resource management of cellular networks. The following paper "Investigation of Open Loop Transmit Power Control

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Parameters for Homogeneous and Heterogeneous Small Cell Uplink" by Amir Haider, Rashmi Sharan Sinha, and Seung-Hoon Hwang investigates the impact of OL/TPC parameters for both homogeneous small cells and heterogeneous small/macro cells network (HetNet) environments. The authors derived a novel mathematical model to compute the transmission power at the User Equipment (UE), the reception power at eNodeB, the interference ratio in the network, and the reception signal to interference ratio.

The paper "5G Network Communications, Caching, and Computing Algorithms Based on the Two-Tier Game Model" by Sungwook Kim proposes hybrid control algorithms for the Smart Base Stations (SBSs) using communication, caching, and computing techniques. SBSs become mobile edge computing devices equipped with computing power and data storage to simultaneously offload the computation from the mobile user equipment (UE) as well as cache the data from the remote clouds. The authors used game theory to characterize competitive and cooperative interactions among the communications, caching, and computing processes. Thanks to the agile coordination among the integrated approaches and the adaptability and flexibility for the different performance requirements, the simulation results demonstrate that the proposed method outperforms existing schemes by 5%–15% regarding bandwidth utilization, access delay, and system throughput.

In the 5G era, as ultra-large content traffic such as UHD Video Streaming, Augmented Reality (AR), Virtual Reality (VR) should travel across wireless/wireline access network in mobile speeds up to 20 Gbit/s, all 5G mobile/fixed traffic has to go through the packet core network. The quasi-real-time management of these large-bandwidth consuming services requires less than 1 ms radio latency as well as the end-to-end latency of less than a few ms. Another paper by Taesang Choi et al. entitled "Agile Management and Interoperability Testing of SDN/NFV-Enriched 5G Core Networks" propose agile management of 5G core network functionalities. They designed and developed a novel solution using SDN (Software Defined Network) and NFV (Network Function Virtualization) technologies with PoC implementation targeted for PyeongChang Winter Olympics. By enhancing interoperability between two core networks, it can distribute 5G core nodes closer to cell sites. Consequently, it significantly reduces the backhaul traffic volume and latency, as mobile devices can download content immediately from a closer content server.

The final paper "28 GHz Wireless Backhaul Transceiver Characterization and Radio Link Budget" by Marko E. Leinonen et al. verifies system level calculations and theoretical link budget analysis with conductive and radiated over-the-air measurements. This paper provides an analysis of this use case from a radio engineering as well as implementation perspective. Results indicate that the implemented radio solution can achieve 2.5 Gbps data-rate on average up to the 200-meter range as the target key-performance-indicator. Furthermore, their preliminary experimental results are presented as a proof-of-concept of a wireless backhaul solution developed in the EU-KR 5GCHAMPION project, which will be showcased during the Winter Olympic Games in Rep. of Korea 2018.

The Guest Editors would like to thank all the authors, reviewers, and the editorial staff of ETRI Journal for making this special issue a success. We are most pleased to have been part of the effort in getting these high-quality technical papers timely. The new technological field of 5G communications and experimental trials will considerably impact the future wireless and mobile network research at large.

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We would like to thank all authors for their contributions. We unfortunately also had to reject some interesting contributions due to space and time limitations associated with a special issue and its natural deadlines. We are very grateful to the reviewers for their effort, and to the ETRI Journal editorial board and the editorial staff.

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