

Special issue on 5G & B5G enabling edge computing, big data and deep learning technologies

Fifth generation (5G) mobile systems are designed to support voice, data, video, games, smart grids, smart factories, intelligent building systems (IBS), Internet of Things (IoT), cyber physical systems (CPSs), autonomous vehicles, connected vehicles, intelligent transportation systems (ITS), and much more. In addition, various novel designs for Beyond 5G (B5G) technologies are now being proposed. Two major issues arise when trying to enable these new services. One issue is that almost all interactive applications need cloud support; however, conventional mobile cloud computing approaches cannot satisfy 5G/B5G performance requirements. The second issue is that the increase in the volume of networking support units (which could reach one million units per square kilometer) radically increases the complexity, time delay, and cost of networking and storing application data. In addition, the required level of performance and complexity is expected to increase significantly more for B5G systems.

In this special issue, we attempted to select papers that solve these issues while supporting extremely high peak data rates and connection densities with minimized end-to-end (E2E) latency, edge computing, big data, and deep learning technology where edge computing enables the cloud resources to come closer to user equipment (UE) to minimize delay.

The invited paper “6G in the Sky: On-Demand Intelligence at the Edge of 3D Networks” Emilio Calvanese Strinati et al. presents an overview of an architecture for a three-dimensional (3D) version of the paradigm of providing intelligence (communication, computation, and storage, also referred to as 3C) at the network edge. The paper envisions several layers of airborne communications devices, including low-altitude platforms such as drones, high-altitude platforms such as balloons and airships, and satellites, that form the third dimension of the communications architecture where 6G will exploit satellite, aerial, and terrestrial platforms jointly to improve radio access capability and unlock the support of on-demand edge cloud services in 3D space by incorporating mobile edge computing (MEC) functionalities on aerial platforms and low orbit satellites.

The next paper titled “Performance Analysis of Local Exit for Distributed Deep Neural Networks over Cloud and Edge Computing” by Changsik Lee et al., analyzes the performance of local exit (offloading technique) in two models, namely, a single-exit model (SEM) and a multi-exit model (MEM). In edge computing, most procedures, including data collection, data processing, and service provision, are handled at edge nodes and not in the central cloud. This decreases the processing burden on the central cloud, enabling fast responses to end-device service requests in addition to reducing bandwidth consumption. However, edge nodes have restricted computing, storage, and energy resources to support computation-intensive tasks such as processing deep neural network (DNN) inference. This paper analyzes the effect of models with single and multiple local exits on DNN inference in an edge computing environment. The results suggest that a single-exit mode outperforms a multi-exit model in terms of the number of local exited samples, inference accuracy, and inference latency.

The third paper “Design of Cellular, Satellite, and Integrated Systems for 5G and Beyond” Junhyeong Kim et al. proposes architectures for 5G AgiLe and fLexible integration of SaTellite And cellulaR (5G-ALLSTAR) to develop the multi-connectivity of satellite and cellular networks for 5G and beyond. In addition, it provides an overview of recent research activities with preliminary results and a plan for the Proof of Concept of representative use cases, and explains the integration of cellular system and satellite communication promoted by 5G-ALLSTAR which is a Korea-Europe collaborative project that aims to develop Multi-Connectivity (MC) technologies that integrate cellular and satellite networks to provide seamless, reliable, ubiquitous, and broadband communication services and improve service continuity for 5G and B5G.

The analysis of the supervised learning-based spatial performance prediction (SLPP) framework for next-generation heterogeneous communication networks (HCN) is crucial for ensuring seamless network management and enhancing service experiences. The following paper “A Supervised

Learning-based Spatial Performance Prediction (SLPP) Framework for Heterogeneous Communication Networks” by Mukherjee et al., investigated a network performance prediction framework for optimizing performance and efficient resource utilization using a linear discriminant analysis (LDA)-based prediction approach. The authors' conventional LDA-based machine learning method SLPP outperforms all other approaches in terms of accuracy, performance stability, and minimal computational complexity after solving the multicollinearity issue present in the raw data.

The paper “Combined Time Bound Optimization of Control, Communication, and Data Processing for FSO based 6G UAV Aerial Networks” by Seungwoo Seo et al. proposes flexible broadband supportive unmanned aerial vehicle (UAV)-based 6G mobile networks using free space optic (FSO) links. Big data processing, and artificial intelligence (AI) precision control technologies are considered to be highly viable options in the near future for forming an additional wireless network based on UAV aerial platforms to assist the existing fixed base stations (BSs) of a mobile radio access network (RAN). The authors propose a combined time-bound optimization scheme that can adaptively satisfy the control and communication time constraints as well as the processing time constraints in FSO-based 6G UAV aerial networks. The proposed scheme controls the relationship among the number of data flows, input data rate, number of worker nodes considering the time bounds, and the errors that occur during communication and data processing.

One of the most natural ways to meet B5G system requirements, such as ultra-high data rates, ultra-low power consumption, intelligent network operation, and all-time seamless coverage, is to expand the utilized frequency bandwidth of wireless systems. Therefore, to make the best use of limited and precious spectrum resources, spectrum sharing between satellite and cellular networks has received much interest. Another paper by Jeong Seon Yeom et al. entitled “Performance Analysis of Satellite and Terrestrial Spectrum Shared Networks with Directional Antenna” uses a stochastic geometry framework to mathematically analyze the success probability of a fixed (satellite) earth station (FES) in a satellite and terrestrial spectrum-shared network with, where the cellular downlink uses the same frequency as the satellite station (SS) downlink. Validating the success probability of the cognitive satellite-terrestrial network with directional

antennas by comparing the analytical results with extensive computer simulations, exclusive zone-based interference mitigation technique was found to significantly improve the success probability as the exclusion zone increases.

The final paper “Ultra Low Latency Services in 5G System: A Perspective from 3GPP standards” by Sunmi Jun et al. provides a clear overview of 3GPP standards for ultra-low latency service in 5G wireless systems. This paper presents a detailed survey of two standardization activities of 3GPP to ensure low latency at the network level. The authors developed a 5G system based on 3GPP Release 15 supporting MEC and the feasibility of sub-10ms end-to-end latency in the edge network.

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 pleased to have been part of the effort to obtain these high-quality technical papers in a timely manner. The new technological fields of 5G and B5G enabling edge computing, big Data & deep Learning Technologies will considerably impact future wireless and mobile network research.

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Taesang Choi received his M.S. and Ph.D. degrees in computer science and telecommunications from the University of Missouri-Kansas City, USA, in 1990 and 1995, respectively. In 1996, he joined ETRI, where he is currently a principal of research staff. He has been actively involved in the research and development of traffic engineering, traffic measurement and analysis, SDN/NFV management, and 5G network slice management. He has also actively contributed to various SDOs and open source activities, such as IETF, ITU-T, ONF, and ONOS. He is currently acting as ITU-T SG13 Question 6 Rapporteur and International IT Standardization Expert representing the Rep. of Korea.



Sejun Song received his M.S. and Ph.D. degrees in computer science and engineering from the University of Minnesota, Twin Cities, USA, in 1999 and 2001, respectively. He is an associate professor with the Department of Computer Science Electrical Engineering, University of Missouri–Kansas City, USA. He and his research team conduct research in the areas of trustworthy information and computing systems, and software, including resilient network and system management, software-defined networks, cloud computing auditability, mobile cloud computing, security, high availability, data storage, and embedded systems.



Emilio Calvanese Strinati is the 6G program and smart devices and telecommunications scientific and innovation director at the French Atomic Energy Commission's Electronics and Information Technologies Laboratory (CEA/Leti), Grenoble, France. He worked in Motorola Labs between 2003 and 2006. In 2006, he joins CEA/Leti first as research engineer, then between 2011 and 2016, he was the Smart Devices & Telecommunications European collaborative strategic programs Director. Since December 2016 he is the Smart Devices & Telecommunications Scientific and Innovation Director. In 2020, he started the new-6G CEA/Leti initiative focusing on future 6G technologies. Since 2018, he holds the French Research Director Habilitation (HDR). E. Calvanese Strinati has published around 120 papers in international conferences, journals and books chapters, given more than 150 international invited talks, keynotes, and tutorials. He is the main inventor or co-inventor of more than 60 patents. His current research interests are in the area of beyond-5G future-enabling technologies such as high-frequency communications, mobile edge computing, and distributed intelligence.



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