

MOBILE COMMUNICATIONS AND NETWORKS



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It is our pleasure to present a rich set of papers with the objective of constructing the path to very high rate, ultra-reliable and ubiquitous mobile communications in the July 2023 issue of Mobile Communications and Networks series. The articles span a wide range of topics, including the use of machine learning for channel quality prediction, uplink time synchronization techniques for non-terrestrial networks (NTN) in 3GPP, evolution of digital terrestrial television (DTT), the integrated sensing and communications in IEEE 802.11bf, the use of high altitude platform station (HAPS) in green computing, blockchain-based network slice management, and subsequently their potential to address dynamic and unpredictable traffic demands of users in an energy-efficient manner, and finally a network architecture proposal for 6G networks to address the new requirements.

Channel quality information is critical in cellular communication to manage resources and provide services within the required quality limit. Due to the emergence of diverse applications, uses and scenarios (e.g., sensors, vehicles, IoT, massive antenna arrays, flying base stations) in 6G, with challenging channel quality need and increased channel density, the criticality and complexity of acquiring channel quality information amplify significantly. The article “Machine Learning-based Channel Quality Prediction in 6G Mobile Networks” outlines the limitations of the existing solution of obtaining channel quality information and proposes a forward-looking solution of predicting channel quality based on machine learning. The traditional approach of transmitting, measuring and reporting reference signals is not scalable for future massive deployment, as it is time, energy and resource heavy. The proposed alternative solution reduces overhead and energy consumption, as it predicts channel quality based on machine learning by finding relationship among channel characteristics and network correlation.

An important challenge for NTN is the uplink time synchronization, since the propagation delay incurred is much more than that of the terrestrial networks. The article “Uplink Time Synchronization for Non-Terrestrial Networks” presents the double-correction issue that might arise due to the two control loops proposed by 3GPP: open control (UE taking action without error information from the network) and closed control (timing advance commands to correct any residual timing error from the open loop). The authors propose potential solutions and through examples, and show how to calculate the correct delays and the timing advance using the GNSS location of the UE, the ephemeris of the satellite, and the signaled delay about the feeder link.

There is a recent trend to integrate IP-based approaches to the terrestrial broadcasting solutions. In the meantime, the Advanced Television Systems Committee (ATSC) has defined an architecture based on Broadcast Core Network (BCN), which connects the current transmitter infrastructure (Radio Access Network) to

the rest of the production and distribution assets, as well as with services at the application layer. In fact, ATSC also works towards to include its solutions within 5G defined by 3GPP. Towards this end, the authors of the article titled “Broadcast Core Network (BCN): Paving the Future Path of DTT” present a BCN architecture based on 5GC in detail and identify the additional challenges that the broadcasting industry will face to integrate the targeted services. The authors then describe a prototype developed using legacy equipment and ad-hoc software modules that are compatible with current DTT standard from ATSC.

The article “Toward Integrated Sensing and Communications in IEEE 802.11bf Wi-Fi Networks,” investigates practical implications of integrating sensing into Wi-Fi networks, which is based on the recent development in the IEEE 802.11bf Task Group in evolving the standard support of sensing capabilities through 802.11-compliant devices. The article starts with an overview of the technical enablers and algorithms for sensing at the physical, medium access control, and application layers, followed by experimental evaluations with commercial devices to provide some insights of the impact of some communication parameters on sensing performance. It also discusses the main research challenges of integrating sensing into Wi-Fi networks.

HAPS systems are promising for sustainable green operation of data centers due to the unique conditions of the naturally low atmospheric temperature that saves cooling energy and the large surface that can host solar panels covering energy requirements. The article “How to Leverage High Altitude Platforms in Green Computing?” investigates the energy-efficiency-related trade-offs within the defined operation limitations. Different deployment scenarios are analyzed in order to overcome the scalability issues of the data center-enabled HAPS architecture. Various management techniques are then discussed, in order to address workload management, network management and airship management to achieve the desired performance of the data center-enabled HAPS. A sizeable electricity cost saving is demonstrated by deploying a single data center-enabled HAPS.

Network slicing brought a new dimension in 5G and beyond to meet increasingly diverse communication needs by slicing physical network infrastructure into different logical networks. Effective slice management is key in optimizing network utilization and satisfying the key participants. The article “Make Rental Reliable: Blockchain-based Network Slice Management Framework with SLA Guarantee” proposes a blockchain-based network slice management framework consisting of a slice committee and three protocols for slice, audit, and dispute. The decentralized approach is expected to overcome the limitation of the traditional centralized approach of slice allocation. Network operators and slice tenants are the main participants, and slice allocation and Service Level Agreement (SLA) guarantee

are their main concerns respectively – both are addressed by the proposal. Other critical factors considered in the proposal are trust among the operators, billing, audit, arbitration, reports, contract and security.

The impact of information and communication technologies (ICT) on global energy consumption is increasing every year, and mobile networks (in particular, the radio access networks (RANs)) account for a significant portion of it. In the article “Sustaining Dynamic Traffic in Dense Urban Areas with High Altitude Platform Stations (HAPS),” the authors show how HAPS super macro base stations (SMBSs) can complement RANs and serve the dynamic and unpredictable traffic demands of users in densely populated areas, in an energy-efficient manner. The article provides results of simulation of a case study, to demonstrate the performance of a HAPS-SMBS compared to the conventional RAN densification method and analyses the two approaches in terms of sustainability.

The changes in the architecture will be one of the most important 6G innovations. The article “6G Architecture Design: from Overall, Logical and Networking Perspective” analyses the new requirements of the 6G network and proposes the design principles as well as a candidate architecture of 6G, termed as “3 bodies, 4 layers, 5 planes (3-4-5).” The article analyses the innovation motivations and identifies the need for technical enhancements based on the authors’ real experience of operating large 5G networks. Based on that, the corresponding logical function design is proposed, providing hints to future research directions.

As the Series Editors, we hope that the readers will enjoy reading the diverse set of topics, ranging from the channel quality prediction to the architecture of 6G networks. Overall, eight articles have been accepted for this issue. We deeply appreciate the reviewers for their high-quality, insightful, constructive, and timely reviews. We would also like to acknowledge the continuous support from the editors and staff members.

BIOGRAPHIES

WANSI CHEN [SM] (wanshic@qti.qualcomm.com) is a Sr. Director, Technology at Qualcomm Inc., where he is involved in 5G research and standardization. He is currently 3GPP TSG RAN plenary Chair appointed in April 2021. Previously, he was 3GPP TSG RAN WG1 Chair and successfully led the group to deliver both the first and the second 5G releases on time and with high quality. The highest degree that he received is a Ph.D. degree in electrical engineering from the University of Southern California, USA.

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