6G Mobile Networks: Emerging Technologies and Applications

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Modern society has been widely benefiting from the advances in wireless technology. During the past decade, extensive research efforts have been dedicated to develop the fifth-generation (5G) wireless mobile networks. This resulted in enabling technologies for the three generic connectivity types in 5G (broadband, massive Internet-of-things connectivity and ultra-reliable low latency communication) as well as their coexistence. The final look of what will be called 5G is decided by the standardization process and it will not necessarily match the original ambitious vision of 5G. Due to this, as well as the extended time that will be required to deploy 5G ubiquitously, there are already initiatives to carry out research on 6G wireless networks. Those would have to respond to the exponential growth of mobile traffic due to AR/VR, holographic communications, V2X, autonomous driving, networked intelligence, and other, yet unknown use cases of Internet-of-Everything (IoE). These demanding use cases call for revolutionary design and novel enabling technologies on spectrum-, energy-, and cost-efficient communications for the sixth-generation (6G) mobile networks.

The primary goal of this special issue is to provide a unique opportunity to discuss the visions, key drivers, and use cases for 6G, novel physical-layer solutions, network architectures, resource allocation schemes, and their integrations with advanced enabling technologies, primarily machine learning and artificial intelligence.

There are four accepted papers in this special issue.

The first paper is entitled "Vision, Requirements and Network Architecture of 6G Mo-bile Network beyond 2030" and coauthored by Guangyi Liu, Yuhong Huang, Na Li, Jing Dong, Jing Jin, Qixing Wang, Nan Li. This paper provides the vision of the society development towards 2030, the new application scenarios, and the key performance requirements for 6G mobile communication. To compromise among the cost, capability and flexibility of the network, the features of the 6G mobile network are proposed based on the latest progress and applications of the relevant fields, namely, on-demand fulfillment, lite network, soft network, native AI and native security.

In the second paper entitled "Federated Learning for 6G Communications: Challenges, Methods, and Future Directions" and coauthored by Yi Liu, Xingliang Yuan, Zehui Xiong, Jiawen Kang, Xiaofei Wang, and Dusit Niyato, the authors introduce the integration of 6G and federated learning and provide potential federated learning applications for 6G. The key technical challenges, the corresponding federated learning methods, and open problems for future research on federated learning in the context of 6G communications are provided.

The third paper is entitled by "Spectral and Energy Efficiency of Line-of-Sight OAM-MIMO Communication Systems", and coauthored by Rui Chen, Hong Zhou, Wen-Xuan Long, and Marco Moretti. In this paper, the authors investigate the spectral efficiency (SE) and energy efficiency (EE) of a misaligned uniform concentric circle array (UCCA)-based multi-carrier multi-mode orbital angular momentum (OAM) and multiple-input multiple-output (MCMM-OAM-MIMO) system in the line-of-sight (LoS) channel. Two transceiver architectures implemented by radio

frequency (RF) analog synthesis and baseband digital synthesis are considered and analyzed.

In the fourth paper, entitled "Double-edge Intelligent Integrated Satellite Terrestrial Networks" and co-authored by Jiaxin Zhang, Xing Zhang, Peng Wang, Liangjingrong Liu, Yuanjun Wang, studies the efficient integration of satellite and terrestrial networks for 6G, and proposes double-edge intelligent integrated satellite and terrestrial networks (DILIGENT). Leveraging the boost development of multi-access edge computing (MEC) technology and artificial intelligence (AI), the framework is entitled with the systematic learning and adaptive network management of satellite and cellular networks.

We hope this special issue will provide a helpful source of references for those working in the 6G field.

Biographies

Ying-Chang Liang (F'11), is currently a Professor with the University of Electronic Science and Technology of China, China, where he leads the Center for Intelligent Networking and Communications and serves as the Deputy Director of the Artificial Intelligence Research Institute. He was a Professor with The University of Sydney, Australia, a Principal Scientist and Technical Advisor with the Institute for Infocomm Research, Singapore, and a Visiting Scholar with Stanford University, USA. His research interests include wireless networking and communications, cognitive radio, symbiotic networks, dynamic spectrum access, the Internet-of-Things, artificial intelligence, and machine learning techniques. Dr. Liang has been recognized by Thomson Reuters (now Clarivate Analytics) as a Highly Cited Researcher since 2014. He received the Prestigious Engineering Achievement Award from The Institution of Engineers, Singapore, in 2007, the Outstanding Contribution Appreciation Award from the IEEE Standards Association, in 2011, and the Recognition Award from the IEEE Communications Society Technical Committee on Cognitive Networks, in 2018. He is the recipient of numerous paper awards, including the IEEE Jack Neubauer Memorial Award, in 2014, and the IEEE Communications Society APB Outstanding Paper Award, in 2012. He is a Fellow of IEEE, and a foreign member of Academia Europaea. He is the Founding Editor-in-Chief of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS: COGNITIVE RADIO SERIES, and the Key Founder and now the Editor-in-Chief of the IEEE TRANSACTIONS ON COGNITIVE COMMUNICATIONS AND NETWORKING. He is also serving as an Associate Editor-in-Chief for China Communications. He served as the TPC Chair and Executive Co-Chair of the IEEE Globecom'17.

Dusit Niyato (M'09-SM'15-F'17), is currently a professor in the School of Computer Science and Engineering, at Nanyang Technological University, Singapore. He received B.Eng. from King Mongkuts Institute of Technology Ladkrabang (KMITL), Thailand in 1999 and Ph.D. in Electrical and Computer Engineering from the University of Manitoba, Canada in 2008. His research interests are in the area of energy harvesting for wireless communication, Internet of Things (IoT) and sensor networks.

Erik G. Larsson (Fellow, IEEE), received the Ph.D. degree from Uppsala University, Uppsala, Sweden, in 2002. He is currently a Professor of Communication Systems at Linköping University (LiU) in Linköping, Sweden. He was with the KTH Royal Institute of Technology in Stockholm, Sweden, the George Washington University, USA, the University of Florida, USA, and Ericsson Research, Sweden. His main professional interests are within the areas of wireless communications and signal processing. He coauthored Space-Time Block Coding for Wireless Communications (Cambridge University Press, 2003) and Fundamentals of Massive MIMO (Cambridge University Press, 2016). He is co-inventor of 19 issued U.S. patents. Currently he is an editorial board member of the IEEE Signal Processing Magazine, and a member of the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS steering committee. He served as a Chair of the IEEE Signal Processing Society SPCOM technical committee (2015–2016), Chair of the IEEE WIRELESS COMMUNICATIONS LETTERS steering committee (2014–2015), General respectively Technical Chair of the Asilomar SSC conference (2015, 2012), Technical Co-Chair of the IEEE Communication Theory Workshop (2019), and a member of the IEEE Signal Processing Society Awards Board (2017–2019). He was an Associate Editor for, among others, the IEEE TRANSACTIONS ON COMMUNICATIONS (2010–2014) and the IEEE TRANSACTIONS ON SIGNAL PROCESSING (2006–2010). Prof. Larsson received the IEEE Signal Processing Magazine Best Column Award twice, in 2012 and 2014, the IEEE ComSoc Stephen O. Rice Prize in Communications Theory in 2015, the IEEE ComSoc Leonard G. Abraham Prize in 2017, the IEEE ComSoc Best Tutorial Paper Award in 2018, and the IEEE ComSoc Fred W. Ellersick Prize in 2019.

Petar Popovski (S'97--A'98--M'04--SM'10--F'16), is a Professor at Aalborg University, where he is heading the section on Connectivity. He received his Dipl. Ing and M. Sc. degrees in communication engineering from the University of Sts. Cyril and Methodius in Skopje and the Ph.D. degree from Aalborg University in 2005. He is a Fellow of IEEE, has over 300 publications in journals, conference proceedings, and edited books and he was featured in the list of Highly Cited Researchers 2018, compiled by Web of Science. He holds over 30 patents and patent applications. He received an ERC Consolidator Grant (2015), the Danish Elite Researcher award (2016), IEEE Fred W. Ellersick prize (2016), IEEE Stephen O. Rice prize (2018) and the Technical Achievement Award from the IEEE Technical Committee on Smart Grid Communications. He is currently a Steering Committee Member of IEEE SmartGridComm and IEEE Transactions on Green Communications and Networking. He previously served as a Steering Committee Member of the IEEE INTERNET OF THINGS JOURNAL. He is currently an Area Editor of the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS. Prof. Popovski was the General Chair for IEEE SmartGridComm 2018 and IEEE Communication Theory Workshop 2019. From 2019, he is also a Member-at-Large of the Board of Governors of the IEEE Communications Society. His research interests are in the area of wireless communication, communication theory and Internet of Things. In 2020 he published the book "Wireless Connectivity: An Intuitive and Fundamental Guide".