Guest Editorial Airborne Communication Networks

Xianbin Cao, *Senior Member, IEEE*, Seong-Lyun Kim, *Senior Member, IEEE*, Katia Obraczka, *Fellow, IEEE*, Cheng-Xiang Wang, *Fellow, IEEE*, Dapeng Oliver Wu, *Fellow, IEEE*, and Halim Yanikomeroglu, *Fellow, IEEE*

WELCOME to the IEEE JSAC special issue on *Airborne Communication Networks*. The goal of this special issue is to disseminate the contributions in the field of airborne communication networks.

Recent advances in sensor and communication technologies have witnessed an unprecedented application increase of the airborne communication networks in both military and civilian fields. Airborne communication networks are engineered to utilize spacecrafts and/or aircrafts, which are equipped with various types of transceivers and sensors, to build seamless communication access platforms. These spacecrafts and aircrafts include satellites, airships, airplanes, Unmanned Air Vehicles (UAVs), and high/medium/low-altitude platforms (HAPs/MAPs/LAPs). Compared to terrestrial wireless networks, airborne communication networks have many distinctive features such as high dynamic network topologies and weakly connected communication links. Therefore, many standards, protocols, and design methodologies used in terrestrial wireless networks are not directly applicable to airborne communication networks. To address this, new techniques suitable for airborne communication networks need to be developed [1].

This special issue has called for papers from the entire spectrum of the research of airborne communication networks, aiming to present the latest developments in the various topics on airborne communication networks, and to provide an overall view on this important field. We were delighted to receive 68 papers spanning all research topics in airborne communication networks (see Table I). Following a thorough and very competitive review process 17 papers were accepted and are presented in this special issue. We hope that this selection of papers will highlight recent findings in airborne communication networks and contribute towards the further development of this important field.

TABLE I
AIRBORNE COMMUNICATION NETWORKS TOPICS STATISTICS

Topic and keywords	Papers
UAV communication	45
Heterogeneous airborne communication network	9
QoS and performance for airborne communication networks	29
Resource allocation for heterogeneous airborne networks	11
Dynamic networking and reconstruction of UAV communication network	15
Connectivity and robustness design and analysis of airborne communication networks	22
Coding, modulation and synchronization schemes for airborne communication networks	6
Satellite-aided UAV communication	1
Seamless integration of UAVs, near-space, and satellites networks	1

I. AIRBORNE COMMUNICATION NETWORKS

The accepted papers in this special issue cover three major areas of airborne communications networks, namely: low-altitude-platform (LAP) based communication networks, high-altitude-platform (HAP) based communication networks, and integrated airborne communication networks.

A. LAP-Based Communication Networks

The LAP-based communication networks have received extensive attention from industry and academia. A LAP equipped with a transceiver can act as an aerial base station to extend communication coverage and boost network capacity [1]. Except for acting as mobile relays or flying base stations, LAPs can be utilized as mobile-edge computing (MEC) systems. For example, in the paper "Computation rate maximization in UAV-enabled wireless powered mobile-edge computing systems" [2], the computation rate maximization problems in an unmanned aerial vehicle (UAV)-enabled MEC wireless powered system are investigated under both partial and binary computation offloading modes, subject to the

X. Cao is with the School of Electronic and Information Engineering, Beihang University, Beijing 100191, China (e-mail: xbcao@buaa.edu.cn).

S.-L. Kim is with the School of Electrical and Electronic Engineering, Yonsei University, Seoul 03722, South Korea (e-mail: slkim@yonsei.ac.kr).

K. Obraczka is with the Jack Baskin School of Engineering, University of California at Santa Cruz, Santa Cruz, CA 95064 USA (e-mail: katia@soe.ucsc.edu).

C.-X. Wang is with the School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh EH14 4AS, U.K. (e-mail: cheng-xiang.wang@hw.ac.uk).

D. O. Wu is with the Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL 32611 USA (e-mail: dpwu@ieee.org).

H. Yanikomeroglu is with the Department of Systems and Computer Engineering, Carleton University, Ottawa, ON K1S 5B6, Canada (e-mail: halim@sce.carleton.ca).

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energy harvesting causal constraint and the UAV's speed constraint. Moreover, the accepted papers describe the design of LAP-based communication networks from two major perspectives, i.e., networking and transmission.

1) Networking: The networking mechanisms can efficiently improve network resource utilization and quality-of-service (QoS) through identifying the optimal spatial locations of deployed LAPs. For example, the authors of the paper "Flight time minimization of UAV for data collection over wireless sensor networks" [3] consider a scenario where a UAV collects data from a set of sensors on a straight line. They formulate a trajectory optimization problem with an objective of minimizing the UAV's total flight time from a starting point to a destination while allowing each sensor to successfully upload a certain amount of data using a given amount of energy. Numerical results present insightful behaviors of the UAV and the sensors. The paper titled "Capacity characterization of UAV-enabled two-user broadcast channel" [4] studies fundamental capacity limits of UAV-enabled/aided multiuser communication systems. Specifically, this paper aims to characterize the capacity region of the new type of broadcast channel over a given UAV flight duration, by jointly optimizing the UAV's trajectory and transmit power/rate allocations over time, subject to the UAV's maximum speed and maximum transmit power constraints. The authors of the paper "Dual-UAV enabled secure communications joint trajectory design and user scheduling" [5] investigate a UAV-enabled secure communication system. Specifically, they maximize the minimum worst-case secrecy rate among the users within each period by jointly adjusting UAV trajectories and user scheduling under the maximum UAV speed constraints, the UAV return constraints, the UAV collision avoidance constraints, and the discrete binary constraints on user scheduling variables. In the paper "Spectrum sharing planning for full-duplex UAV relaying systems with underlaid D2D communications" [6], the authors consider the spectrum sharing planning problem for full-duplex UAV relaying systems with underlaid device-to-device (D2D) communications, where a mobile UAV employed as a full-duplex relay assists the communication link between separated nodes without direct link. The authors of the paper "Formation tracking in sparse airborne networks" [7] investigate the formation tracking problem in UAV networks. A weighted component stitching (WCS) method to find the reliable sub-components and weightily stitch their local structures to the other components by rotation and transformation is proposed for calculating the formation of the network accurately. Extensive experiments are conducted, showing the proposed method can improve the formation tracking accuracy 21% to 48% over existing state-of-the-art methods, especially in sparse, noisy UAV networks under different parameter settings. The paper "Deployment algorithms for UAV airborne networks towards on-demand coverage" [8] investigates the deployment of multiple UAVs for on-demand coverage while at the same time maintaining the connectivity among UAVs. To solve this problem, the authors propose two algorithms: a centralized deployment algorithm and a distributed motion control algorithm. The centralized algorithm is applicable to the scenario that requires minimum number of UAVs to provide desirable service for already known on-ground users. This distributed algorithm is applicable to the scenario where using given number of UAVs to cover users without users specific position information.

Besides, the paper "Rendezvous on the fly efficient neighbor discovery for autonomous UAVs" [9] investigates the neighbor discovery problem of UAVs which is a significant communication primitive for adjacent UAVs to construct a flying ad-hoc network. The paper "Cooperative UAV cluster assisted terrestrial cellular networks for ubiquitous coverage" [10] aims to analyze the coverage performance of UAV-assisted terrestrial cellular networks, where partially energy harvesting-powered caching UAVs are randomly deployed in the three-dimensional space with a minimum and maximum altitude. A novel cooperative UAV clustering scheme is proposed to offload ground mobile terminals (GMTs) from ground cellular base stations (GcBSs) to cooperative UAV clusters. The authors of the paper "Energy-efficient UAV control for effective and fair communication coverage: A deep reinforcement learning approach" [11] investigate the problem of controlling a group of UAVs to achieve certain communication coverage in a long run, while preserving their connectivity and minimizing their energy consumption. The emerging Deep Reinforcement Learning (DRL) for UAVs is leveraged to control UAVs to obtain high communication coverage and fairness, and low energy consumption.

2) Transmission: To enable the LAP-based communication networks to provide high-speed and reliable data transmission, the support from transmission mechanisms is crucial. The paper "Network-coded multiple access on unmanned aerial vehicle" [12] presents the first network-coded multiple access (NCMA) downlink system on UAV. NCMA makes joint use of physical layer network coding (PNC) and multiuser decoding (MUD) together with a new superposition coding scheme, referred to as NCMA-based superposition coding, to achieve high NOMA throughput under an equal power allocation. The paper "Regularized zero-forcing precoding aided adaptive coding and modulation for large-scale antenna array based air-to-air communications" [13] proposes a regularized zero-forcing transmit precoding (RZF-TPC) aided and distance-based adaptive coding and modulation (ACM) scheme to support aeronautical communication applications, by exploiting the high spectral efficiency of large-scale antenna arrays and link adaption. Moreover, the authors of the paper "Channel modeling and parameter optimization for hovering UAV-based free-space optical links" [14] address accurate channel modeling to assess the benefits of UAV-based deployment for free-space optical communication links. The proposed model considers the joint effect of atmospheric turbulence along with position and angle-of-arrival fluctuations. Besides, the high accuracy of the proposed analytical models is verified by comparing numerically solved and Monte-Carlo simulation results in terms of link outage probability.

B. HAP-Based Communication Networks

In contrast to LAPs, HAPs have a larger footprint and longer communication persistence. HAP-based communication networks also have a bright future in providing mobile communications and broadband wireless access services [1]. For instance, the paper "Air-ground integrated vehicular network slicing with content pushing and caching" [15] proposes an Air-Ground Integrated Vehicular Network (AGIVEN) architecture, where the aerial HAPs proactively push contents to vehicles through large-area broadcast while the ground roadside units (RSUs) provide high-rate unicast services on demand. To efficiently manage the multi-dimensional heterogeneous resources, a service-oriented network slicing approach is introduced, where the AGIVEN is virtually divided into multiple slices and each slice supports a specific application with guaranteed quality of service (QoS).

C. Integrated Airborne Communication Networks

The integration concept is significant for airborne communication networks. The integration cannot only complement pre-existing airborne communication infrastructures, but also improve services provided by airborne communication networks [1]. The authors of the paper "Investigation on the UAV-to-satellite optical communication systems" [16] construct a theoretical model of a UAV-to-satellite optical communication system. Specifically, this paper analyzes the Doppler effect, the pointing error effect, and the atmospheric turbulence effect on the communication performance based on a theoretical study and numerical simulations. Their numerical results can provide data references for practical system designs. Besides, the paper "Heterogeneous statistical QoS provisioning over airborne mobile wireless networks" [17] formulates an optimization problem to maximize the aggregate effective capacity subject to heterogeneous statistical delay-bounded QoS requirements for both downlink and uplink transmissions based airborne mobile wireless networks groups (AMWNGs) in Airborne mobile wireless networks (AMWNs). Moreover, this paper solves the aggregate effective capacity maximization problems and derives the optimal heterogeneous statistical QoS-driven power allocation schemes for AMWNs.

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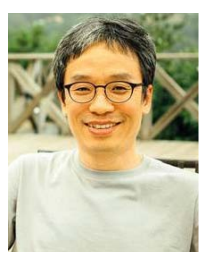
Xianbin Cao (M'08–SM'10) is currently the Dean and a Professor with the School of Electronic and Information Engineering, Beihang University, Beijing, China. His current research interests include intelligent transportation systems, airspace transportation management, and intelligent computation.

He currently serves as an Associate Editor of the IEEE TRANSACTIONS ON NETWORK SCIENCE AND ENGINEERING and *Neurocomputing*.



Seong-Lyun Kim was an Assistant Professor of radio communication systems with the Department of Signals, Sensors and Systems, Royal Institute of Technology (KTH), Stockholm, Sweden. He was also a Visiting Professor with the Control Engineering Group, Helsinki University of Technology (now Aalto), Finland, the KTH Center for Wireless Systems, Sweden, and the Graduate School of Informatics, Kyoto University, Japan. He is currently a Professor with the School of Electrical and Electronic Engineering, Yonsei University, Seoul, South Korea, the Head of the Robotic and Mobile Network Laboratory and the Center for Flexible Radio. He is also co-directing the H2020 EUK PriMO-5G Project, and leading Smart Factory TF of 5G Forum, South Korea. His research interests include radio resource management, information theory in wireless networks, collective intelligence, and robotic networks. He served as a technical committee member or a chair for various conferences, and an Editorial Board Member for the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, the IEEE COMMUNICATIONS LETTERS, *Control Engineering Practice* (Elsevier), *ICT Express* (Elsevier), and the *Journal of Communications and Network*. He served as the Leading Guest Editor for the IEEE WIRELESS COMMUNICATIONS and the IEEE NETWORK FOR WIRELESS COMMUNICATIONS IN NETWORKED ROBOTICS. He also consulted various companies in the area of wireless systems both in South Korea and abroad.

Katia Obraczka (F'14) was a Research Scientist with the USC's Information Sciences Institute and had a joint research faculty appointment at the USC's Computer Science Department. She is currently a Professor of computer engineering with the University of California at Santa Cruz (UCSC). Her lab, the Internetwork Research Group (i-NRG) at UCSC, conducts research on designing and developing protocol architectures motivated by the Internets of the future. Her research interests span the areas of computer networks, distributed systems, and Internet information systems. She has been a PI and a Co-PI in a number of projects sponsored by government agencies (e.g., NSF, DARPA, NASA, ARO, DoE, and AFOSR) and industry (e.g., Cisco, Google, and Nokia). She is currently serving as an Associate Editor for the IEEE TRANSACTIONS ON MOBILE COMPUTING and the IEEE Letters of the Computer Society.

Cheng-Xiang Wang (S'01–M'05–SM'08–F'17) has been with Heriot-Watt University, Edinburgh, U.K., since 2005, and was promoted to a Professor in 2011. In 2018, he joined Southeast University, China, as a Professor and a Thousand Talent Plan Expert. He has authored two books, one book chapter, and over 330 papers in refereed journals and conference proceedings. His current research interests include wireless channel modeling and (B)5G wireless communication networks.

Dr. Wang is a fellow of the IET and HEA. He is recognized as a Web of Science 2017 Highly Cited Researcher. He has served or is serving as a TPC Member, a TPC Chair, and a General Chair of over 80 international conferences. He received nine best paper awards from the IEEE GLOBECOM 2010, the IEEE ICCT 2011, ITST 2012, the IEEE VTC 2013, IWCMC 2015, IWCMC 2016, the IEEE/CIC ICCC 2016, and the WPMC 2016. He has served or is currently serving as an Editor for nine international journals, including the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY since 2011, the IEEE TRANSACTIONS ON COMMUNICATIONS since 2015, and the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS from 2007 to 2009. He was the Leading Guest Editor of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, Special Issue on Vehicular Communications and Networks. He is also a Guest Editor of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, Special Issue on Spectrum and Energy Efficient Design of Wireless Communication Networks and Special Issue on Airborne Communication Networks, and the IEEE TRANSACTIONS ON BIG DATA, Special Issue on Wireless Big Data.

Dapeng Oliver Wu (S'98–M'04–SM'06–F'13) is currently a Professor with the Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL, USA. His research interests are in the areas of networking, communications, signal processing, computer vision, machine learning, smart grid, and information and network security.

He has served as a member of executive committee and/or technical program committee of over 100 conferences. He was the Founding Editor-in-Chief of the *Journal of Advances in Multimedia* from 2006 to 2008, and an Associate Editor for the IEEE TRANSACTIONS ON SIGNAL AND INFORMATION PROCESSING OVER NETWORKS, the *IEEE Signal Processing Magazine*, the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, and the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY. He currently serves as the Editor-in-Chief of the IEEE TRANSACTIONS ON NETWORK SCIENCE AND ENGINEERING and an Associate Editor of the IEEE TRANSACTIONS ON COMMUNICATIONS. He is also a Guest Editor for the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, Special Issue on Cross-layer Optimized Wireless Multimedia Communications.

Halim Yanikomeroglu (F'17) is currently a Full Professor with the Department of Systems and Computer Engineering, Carleton University, Ottawa, Canada. His research interests cover many aspects of wireless networks including non-terrestrial networks. He led one of the largest pre-standards 5G industrial-academic collaborative research project funded by the Ontario Research Fund–Research Excellence program (2012–2016). His collaborative research with industry has resulted in 24 granted patents (plus about a dozen applied). He is a Distinguished Lecturer for the IEEE Communications Society and a Distinguished Speaker for the IEEE Vehicular Technology Society.