

Guest Editorial

Emerging Technologies

Zhisheng Niu, *Fellow, IEEE*, Kwang-Cheng Chen, *Fellow, IEEE*, S. M. Hasan, *Senior Member, IEEE*,
Latif Ladid, and Jinsong Wu, *Senior Member, IEEE*

IT is well known that communications are getting more ubiquitous and diverse and have become more interdisciplinary than before. Mobile computing, cloud computing, social networks, big data, and Internet of Things have enabled us to access, use and manage information anywhere and at any time. The communications market also began to convert into a software-defined and content-driven market, where “communication” itself is getting more invisible or, in some sense, has been integrated into other fields such as computing and social media. All these paradigm shifts have changed the rules of the games and, in fact, further expanded the scope of communications (and therefore the scope of emerging technologies). It is likely that we have been told to get our heads out of the clouds at one point in our lives. However, emerging technologies in the communications field are now forcing us to get our heads into the “cloud” and our hands on our mobile data. They have the potentials to create new industries and transform existing ones at an ever-increasing rate.

While the emerging technologies are expected to drive the growth of the information technology (IT) market, identifying them and determining out how to best leverage them are not an easy job. The main reason is that emerging technologies are in nature unknown, unproven, and risky, and are therefore difficult to be managed. As a result, IT organizations (including ComSoc) are facing with the task of not only identifying relevant emerging technologies, but also developing their organizational awareness and motivation to nurture them. In this context, the emerging technologies committee (ETC) of ComSoc should play a key role in coordinating the wide range of activities in identifying and nurturing new technology directions within and also out of ComSoc.

In this issue, some emerging fields are highlighted by 10 selected papers, which include (but not limited to) Cloud Communications and Networking, Green Communications and Computing, Social Networks, Internet of Things, and Innova-

tion and Standardization in Information and Communication Technologies. Special attention has been paid to the cross-disciplines of them. All the paper submissions are by invitation but gone through normal JSAC peer-reviewing processes. Among total 23 invited submissions, only 10 of them were finally selected, which are highlighted as below.

Cloud-based technology provides ubiquitous, scalable, and on-demand computing and storage resources across applications and services, but it may also bring extra energy consumption to end-user devices and various network elements along the path between the end user and the cloud data center. In the paper “Energy Consumption of Interactive Cloud-Based Applications” coauthored by A. Vishwanath, F. Jalali, K. Hinton, T. Alpcan, R. Ayre, and R. S. Tucker, the authors develop a power consumption model for interactive cloud services that includes the power consumption of end-user devices and the influence of the applications on the power consumption of the various network elements along the path between the user and the cloud data center. The direction with the considerations of end users is relevant to holistic system considerations of energy consumptions, which is a hot and timely topic with high importance. In the paper “Energy-Efficiency Oriented Traffic Offloading: A Brief Survey for Wireless Networks and A Learning Approach for Heterogeneous Cellular Networks” by X. Chen, J. Wu, Y. Cai, H. Zhang, and T. Chen, it provides a brief survey on existing traffic offloading techniques in wireless networks and proposes an on-line reinforcement learning framework for the problem of traffic offloading in a stochastic heterogeneous cellular network (HCN), which may effectively balance the tradeoff between the energy saving and quality of service (QoS) satisfaction of HCN via the derived centralized and decentralized learning algorithms. Such a model-free learning framework is important especially when the state space is huge. Furthermore, in the paper “Characterizing Energy-Delay Tradeoff in Hyper-Cellular Networks with Base Station Sleeping Control” coauthored by Z. Niu, X. Guo, S. Zhou, and P. R. Kumar, the authors try to answer the question “how much energy can be traded off by a tolerable delay” by characterizing the fundamental tradeoffs between energy consumption and overall delay (transmission delay + queuing delay) in a base station with sleep mode operations using vacation queuing models. Several closed-form formulas are derived to demonstrate the tradeoffs between the energy consumption and the mean delay by changing the system parameters. Numerical results reveal a very interesting result, i.e., energy-delay tradeoff does not always exist, i.e., reducing energy consumption does not always have to sacrifice delay.

Z. Niu is with Tsinghua University, Beijing 100084, China (e-mail: niuzhs@tsinghua.edu.cn).

K.-C. Chen is with National Taiwan University, Taipei 106, Taiwan (e-mail: ckc@ntu.edu.tw).

S. M. Hasan is with General Electric Global Research, Schenectady, NY 12309 USA (e-mail: hasan@research.ge.com).

L. Ladid is with University of Luxembourg, Luxembourg City, Luxembourg (e-mail: latif@ladid.lu).

J. Wu is with Universidad de Chile, Santiago 1058, Chile (e-mail: wujs@ieeecom.com).

Digital Object Identifier 10.1109/JSAC.2015.2393711

Another big trend is the convergence of communication networks and human social networks, through which more efficient communication networks can be designed along with new paradigms for services and applications. In this context, the paper “Efficient Working and Shirking in Networks” coauthored by J. Xu and M. van der Schaar develops a systematic framework for designing rating systems aimed at promoting efficient production and sharing in these networks, thereby significantly improving the social welfare of such networks. The schemes proposed operated effectively even in settings where monitoring of agent behavior is subject to significant errors. In the paper “Communication Theoretical Data Analytics” coauthored by K.-C. Chen, S.-L. Huang, L. Zheng, and H. V. Poor, with the aid of a generalized social network concept, the authors propose a new communication theoretic methodology of information-centric processing for (big) data analytics and develop a novel technology known as information coupling by using ideas from network information theory and information geometry to extract low dimensional information from high-dimensional data. This opens new insights into both big data analytics and statistical communication theory.

Another emerging technology in recent years is the so-called Internet of Things (IoT). It is predicted that more than 30 billion devices will be wirelessly connected to the Internet by 2020. But how to solve the interoperability, scalability, security and privacy issues remains as a big challenge. In the paper “Defining the stack for service delivery models and interoperability in the Internet of Things: A practical case with OpenIoT-VDK,” the authors introduce the stack for service delivery models and interoperability in the Internet of Things, which is validated in terms of functionality and adaptation at different IoT particular areas over the Virtual Development Kit (VDK). In the paper “Towards a Lightweight Authentication and Authorization Framework for Smart Objects” by J. L. Hernandez-Ramos, M. P. Pawlowski, A. J. Jara, A. F. Skarmeta Gomez, and L. Ladid, the authors propose a set of optimized lightweight authentication and authorization mechanisms for the support of smart objects along their lifecycle. The work is complete in that it presents all the essentials, namely, framework design, algorithm design, and performance evaluation of the framework. In addition, the work is closely connected to current standardization efforts in this area.

The transfer of technology from research to practice is fraught with obstacles. Therefore, the studies on the theory and methodology of innovation and standardization (I&S) in information and communication technologies are crucial, in particular in the areas of Cognitive Radio and Internet of Things. In this context, the paper “Innovation and Standardization: Oxymoron or Pleonasm” by D. Datla, S. F. Bush, and S. M. Hasan presents a very nice survey on this field, including the definitions of I&S, the relationship between I&S, popular theories of I&S for quantifying the problems and challenges encountered in understanding and studying I&S in ICT, and potential solutions to address the problems. In the paper “Meta-Cognitive Radio Engine Design,” H. Asadi, H. Volos, M. M. Marefat, and T. Bose provide an overview of how cognitive radio (CR) technology is making its way into the current wireless standards and discuss further opportunities for more

CR oriented standardization efforts. Specifically, they discuss how a cognitive engine (CE) can potentially be standardized and offer the latest innovations on metacognitive engine (meta-CE) design. Meanwhile, the paper “Enabling Spectrum Sharing via Spectrum Consumption Models” by J. A. Stine and C. E. Caicedo Bastidas proposes a spectrum consumption model (SCM) to enable dynamic spectrum access and trading, which enable better spectrum management and reuse. The topic is very timely due to the recent surge of interest of using DSA (dynamic spectrum access) to solve the issue of crowded spectrum. Also, the proposed SCMs are being standardized by IEEE.

Last but not the least, we would like to express our sincere thanks and appreciations to the anonymous reviewers for their extra-ordinary support in the face of the very tight publishing schedule. Special thanks also go to Prof. Andrea Goldsmith (former ETC chair), Prof. Muriel Medard (EiC of JSAC), Prof. Len Cimini (Director of Journals), and Prof. Sarah Kate Wilson (Vice President for Publications) in IEEE Communication Society for their initiation of this bonus issue and all the strong supports. Without the dedication of their precious time and rich experiences, this high-standard special issue would not be possible. Finally, we would also like to extend our appreciation to Prof. Sheng Zhou from Tsinghua University for his assistance during the whole preparation phase.



Zhisheng Niu (M'98–SM'99–F'12) graduated from Northern Jiaotong University (currently Beijing Jiaotong University), Beijing, China, in 1985. He received the M.E. and D.E. degrees from Toyohashi University of Technology, Toyohashi, Japan, in 1989 and 1992, respectively. After spending two years at Fujitsu Laboratories Ltd., Kawasaki, Japan, he joined with Tsinghua University, Beijing, China, in 1994, where he is now a Professor at the Department of Electronic Engineering, Deputy Dean of the School of Information Science and Technology, and

Director of Tsinghua-Hitachi Joint Lab on Environmental Harmonious ICT. He is also a Guest Chair Professor of Shandong University. His major research interests include queuing theory, traffic engineering, mobile Internet, radio resource management of wireless networks, and green communication and networks.

He has been an active volunteer for various academic societies, including Director for Conference Publications (2010–11) and Director for Asia-Pacific Board (2008–09) of IEEE Communication Society, Membership Development Coordinator (2009–10) of IEEE Region 10, Councilor of IEICE-Japan (2009–11), and Council Member of the Chinese Institute of Electronics (2006–11). He is now a Distinguished Lecturer (2012–13) of IEEE Communication Society, Standing Committee Member of both Communication Science and Technology Committee under the Ministry of Industry and Information Technology of China and the Chinese Institute of Communications (CIC), Vice Chair of the Information and Communication Network Committee of the Chinese Institute of Communications (CIC), Editor of *IEEE Wireless Communication Magazine*, and Associate Editor-in-Chief of IEEE/CIC joint publication *China Communications*. He received the Outstanding Young Researcher Award from Natural Science Foundation of China in 2009. He is a Fellow IEICE.



Kwang-Cheng Chen (S'82–M'83–SM'93–F'07) received the B.S. degree from the National Taiwan University in 1983, and the M.S. and Ph.D. degrees from the University of Maryland, College Park, MD, USA, in 1987 and 1989, respectively, all in electrical engineering. From 1987 to 1998, he worked with SSE, COMSAT, IBM Thomas J. Watson Research Center, and National Tsing Hua University, in mobile communications and networks. Since 1998, he has been with National Taiwan University, Taipei, Taiwan, ROC, and is the Distinguished Professor and

Associate Dean for academic affairs in the College of Electrical Engineering and Computer Science, National Taiwan University. His recent research interests include wireless communications, network science, and data analytics. He has been actively involved in the organization of various IEEE conferences as General/TPC/Chair/Co-Chair and has served in editorships with a few IEEE journals. He also actively participates in and has contributed essential technology to various IEEE 802, Bluetooth, and LTE and LTE-A wireless standards. He has received a number of awards such as the 2011 IEEE COMSOC WTC Recognition Award, 2014 IEEE Jack Neubauer Memorial Award and 2014 IEEE COMSOC AP Outstanding Paper Award.



S. M. Hasan (S'01–M'09–SM'14) received the Bachelors degree from Bangladesh University of Engineering and Technology (BUET) in 2002, the Masters degree from the University of Tennessee at Knoxville, Knoxville, TN, USA, in 2005, and the Ph.D. degree from Virginia Tech in 2009, all in the area of electrical engineering. He is a Lead Engineer and Project Leader at GE Global Research Center in Niskayuna, NY, USA. He is also an Adjunct Assistant Professor at Bradley Department of Electrical & Computer Engineering, Virginia

Tech. His current research interests are wireless systems design, multi band radio design, medical body area network, applied signal processing, software defined radio, and cognitive radio. In recognition for his novel Ph.D. research, he received the William Bazy Fellowship from the Microwave Journal in 2007. He actively participates in various professional activities in the wireless communications area. He is a Senior Member of IEEE. Currently he is serving as the Chair of IEEE Emerging Technologies Subcommittee on Innovation and Standards for Information and Communications Technologies (ISICT).



Latif Ladid holds the following positions: President of IPv6 Forum, Emeritus Trustee of Internet Society, Board Member of IPv6 Ready & Enabled Logos Program, and Board Member of World Summit Award. He is a Research Fellow at the University of Luxembourg "Security & Trust" (SnT) on multiple European Commission Next Generation Technologies IST Projects. He is also a Member of 3GPP PCG, 3GPP2 PCG, Chair of IEEE ComSoc IoT and 5G subcommittees, Member of UN Strategy Council, member of IEC Executive Committee, and member of the Future Internet Forum EU Member States, representing Luxembourg.



Jinsong Wu (SM'11) is the Founder and Founding Chair of Technical Committee on Green Communications and Computing (TCGCC), IEEE Communications Society, which was established in 2011 as an official Technical Subcommittee (TSCGCC) and elevated as TCGCC in 2013. He is the Founder and Series Editor on Green Communication and Computing networks in *IEEE Communications Magazine*. He is Associate Editor of *IEEE Communications Surveys & Tutorials*, Associate Editor of IEEE SYSTEMS JOURNAL, Associate Editor of IEEE ACCESS, and

Editor of *KSI Transactions on Internet and Information Systems*. He has served as co-leading Guest Editor of the Special Issue on Green Communications, Computing, and Systems in the IEEE SYSTEMS JOURNAL, Associate Editor of the Special Section on Big Data for Green Communications and Computing in IEEE ACCESS, Guest Editor of Special Issue on Green Communications in *Elsevier Computer Networks*, the leading Guest Editor of the Feature Topics Issue on Context-Aware Networking and Communications in the *IEEE Communications Magazine*, Guest Editor of the Special Issue on Smart Backhauling and Fronthauling for 5G Networks in *IEEE Wireless Communications*, Guest Editor of the Special Issue on Mobile Clouds in IEEE TRANSACTIONS ON CLOUD COMPUTING. He was the leading Editor and a co-author of the comprehensive book, entitled *Green Communications: Theoretical Fundamentals, Algorithms, and Applications* (CRC Press, 2012).