Special Issue on Practical Physical Layer Techniques for 4G Systems & Beyond

Guest Editorial

If one looks at the last thirty years and measures the rate at which technological innovation is impacting human life, then it can be safely concluded that we are living in extremely exciting times. Wide-spread adoption of Internet triggered an information revolution that has changed the human society in fundamental ways. Subsequent development of cellular communication systems and the resulting ubiquity of cellphones enabled people to communicate while on the go, and within a decade, "anytime-anywhere" communications has become a normal service for majority of people in both developed and developing nations. Ever increasing penetration of smart phones, tablets etc. in mass markets has given users a taste of "anywhere-ubiquitous" access to information & entertainment, and this too will soon become a must have, commodity service for everyone.

Meeting these growing user demands requires next generation cellular networks to have vastly improved spectral efficiencies and coverage. Thus there is a constant need for fundamental as well as applied research on the components and algorithms for forthcoming 4G systems and beyond. The aim of this special issue is to collect and present a set of cutting edge research contributions that would hopefully be representative of the wide spectrum of on-going activities on the Physical layer front for these next generation cellular systems.

To this end, we have identified nine high-quality publications after a thorough peer-review process. The papers can broadly be divided into three categories. The first category groups contributions that present system level performance analysis of PHY techniques that have been recently proposed in the research literature. This category is quite important from a practical point of view because it tries to vet theoretically promising techniques by quantifying their real impact on a deployed system through simulations. Any research idea that aspires to be part of a 4G standard has to pass through such system level evaluations. The second category focuses on resource management algorithms and mechanisms for LTE/OFDMA systems. The selected papers either present algorithms extending state of the art, or provide a better understanding of existing interference coordination mechanisms in LTE. The third category consists of papers aiming to improve the power efficiency of cellular networks. The accepted contributions range from a paper proposing new power efficient PHY coding techniques, to a forward looking article comparing the efficiency or relay assisted networks versus user cooperation, and culminate with an invited survey article on green communications. In the paragraphs that follow, we will briefly summarize the basic ideas presented in each paper from this issue.

The first three papers evaluate multi-user (MU) multiple-input multiple-output (MIMO) technique in the context of cellular networks. The first paper, "System-Level Impact of Multi-User Diversity in SISO and MIMO-based Cellular Systems" by R. Pupala, L.J. Greenstein, and D.G. Daut, considers several parameters in wireless multi-cell systems and evaluate their impacts on aggregate throughputs with different schedulers. This work attempts to quantify the benefits of multiuser diversity and excess degrees of freedom from multiple receive antennas. The second paper "Downlink System Throughput Statistics for Various MEA Configurations" by R. Pupala, Y. Yuan, Q. Bi, and L.J. Greenstein, investigates the merit in modifying a SISO link with added antenna elements at one or both ends. Practical considerations such as channel estimation overhead are considered to evaluate relative merits of various multi-antenna configurations. The third paper "Coverage Analysis for Multiuser MIMO Broadcast Systems" by L.C. Wang and C.J. Yeh, investigates the diversity gain and coverage of zero-forcing beamforing (ZFB) and zero-forcing dirty paper coding (ZF-DPC) techniques with/without the consideration of multiuser scheduling for multiuser MIMO broadcast channels. The proposed work shows that the use of multiuser scheduling can act as soft coverage enhancement technique without requiring additional transmit power.

Next three papers focus on resource management algorithms and mechanisms for LTE/OFDMA systems. In the fourth paper, "A Practical Resource Allocation Approach for Interference Management in LTE Uplink Transmission" by L. Li, G. Wu, H. Xu, G. Li and X. Feng, the authors propose a novel resource allocation method for LTE uplink to reduce inter-cell interference. This paper investigates joint power control and resource allocation techniques for LTE uplink and proposes an efficient way to improve system performance, especially for cell edge users. In the next paper "Impact of CSI on Radio Resource Management Techniques for the OFDMA Downlink" by L. Sivridis, X. Wang and J. Choi, the authors propose sub-carrier allocation algorithm for OFDMA downlink. This work improves upon a previously known algorithm by reallocating the subcarriers of users who will not be able to meet their quality of service (QoS) requirements. The sixth paper "Understanding Static Inter-Cell Interference Coordination Mechanisms in LTE" by A. Mills, D.R. Lister, and M.D. Vos, considers modulation and coding scheme (MCS) based soft frequency reuse issue in cellular systems. Based on this metric the paper challenges the idea that cell edge users should have a high reuse factor.

The remaining three papers focus on power-efficient system architectures and PHY techniques for cellular systems. The paper "Power-efficient Irregular Repeat-Accumulate Encoded BICM-ID for 16-ary Signal Constellations" by W.K. Han, S. Y. L. Goff, B. Sharif, and A. J. Al-Dweik presents novel results on the application of bit-interleaved coded modulation (BICM) along with irregular repeat accumulate and low-density parity-check codes to improve bit error rate

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(BER) performance over Rayleigh fading channels. The next paper "Dedicated-Relay vs. User Cooperation in Time-Duplexed Multiaccess Networks" by L. Shankar, G. Kramer, and N. Mandayam, investigates the performance trade-offs of cooperation in a multi-user uplink network. Two basic modes of cooperation are considered: user cooperation, in which users forward each other's messages, and dedicated relaying, in which a single dedicated relay forwards users' messages. This work explores whether user cooperation or dedicated relaying is more energy efficient, as measured by outage probability versus total transmit and processing power. Environmental impact and power usage are major concerns for next generation networks. An He et al., provide a survey of energy efficient advances in renewable and alternative energy resources for base stations in the ninth paper "Green Communications: A Call for Power Efficient Wireless Systems". This paper is of tutorial nature and presents an interesting overview of technology and economics that could affect green communication systems.

We feel that this special issue succeeds in its attempt to give readers an insight into on-going activities on fundamental as well as applied research on the Physical layer algorithms and system level design for forthcoming 4G systems and beyond. We would like to thank all the authors who submitted their work for consideration for this issue, and the reviewers for their timely and constructive feedback. We also thank the staff at the JCM Academy Publisher for their help in handling the manuscripts. Lastly, we would like to extend our sincere appreciation to Dr. Linda Xie, Editor of the Journal of Communications, for her great support, and Dr. Haohong Wang, Editor-in-Chief of the Journal of Communications for providing us the opportunity to organize this special issue.

Guest Editors

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Sudhanshu Gaur (M'02 – SM'10) received his Bachelor of Technology degree in Instrumentation Engineering from the Indian Institute of Technology (IIT), Kharagpur in 2000. He obtained his Master's degree from Virginia Tech in 2003 and PhD from Georgia Institute of Technology in 2008, both in Electrical & Computer Engineering.

From 2005 onwards, he has been working at Hitachi's wireless research lab in Santa Clara and is currently a Principal Research Engineer. He leads physical layer research and system design targeting LTE-Advanced standardization and is actively involved in RAN1 activities in 3GPP. Earlier he led a project on HD video transmission over WiFi and was also involved with IEEE 802.11aa standardization. Previously, he had also worked in GPRS MAC design at Sasken Communication Technologies, Bangalore. His research activities span MIMO signal processing, interference management, multiple access protocols, and performance analysis of cellular systems. He holds several US patents, and has authored several peer-reviewed publications in wireless communications.

Geoffrey Ye Li received his B.S.E. and M.S.E. degrees in 1983 and 1986, respectively, from the Department of Wireless Engineering, Nanjing Institute of Technology, Nanjing, China, and his Ph.D. degree in 1994 from the Department of Electrical Engineering, Auburn University, Alabama.

He was a Teaching Assistant and then a Lecturer with Southeast University, Nanjing, China, from 1986 to 1991, a Research and Teaching Assistant with Auburn University, Alabama, from 1991 to 1994, and a Post-Doctoral Research Associate with the University of Maryland at College Park, Maryland, from 1994 to 1996. He was with AT&T Labs - Research at Red Bank, New Jersey, as a Senior and then a Principal Technical Staff Member from 1996 to 2000. Since 2000, he has been with the School of Electrical and Computer Engineering at Georgia Institute of Technology as an Associate and then a Full Professor. He is also holding the Cheung Kong Scholar title at the University of Electronic Science and Technology of China since March 2006.

His general research interests include statistical signal processing and telecommunications, with emphasis on OFDM and MIMO techniques, cross-layer optimization, and signal processing issues in cognitive radios. In these areas, he has published over 200 papers in refereed journals or conferences and two books, 20 of which are with over 100 Google citations. He has over 20 patents granted or filed. He once served or is currently serving as an editor, a member of editorial board, and a guest editor for over 10 technical journals. He organized and chaired many international conferences, including technical program vice-chair of *IEEE ICC'03* and co-chair of *IEEE SPARC'11*. He has been awarded an IEEE Fellow for his contributions to *signal processing for wireless communications* since 2006, selected as a *Distinguished Lecturer* for 2009 - 2010 by *IEEE Communications Society*, and won 2010 *IEEE Communications Society* Stephen O. Rice Prize Paper Award in the field of communications theory.

Li-Chun Wang (M'96 – SM'06 – F'11) received the B.S. degree from National Chiao Tung University, Taiwan, R. O. C. in 1986, the M.S. degree from National Taiwan University in 1988, and the Ms. Sci. and Ph. D. degrees from the Georgia Institute of Technology , Atlanta, in 1995, and 1996, respectively, all in electrical engineering.

From 1990 to 1992, he was with the Telecommunications Laboratories of the Ministry of Transportations and Communications in Taiwan (currently the Telecom Labs of Chunghwa Telecom Co.). In 1995, he was affiliated with Bell Northern Research of Northern Telecom, Inc., Richardson, TX. From 1996 to 2000, he was with AT&T Laboratories, where he was a Senior Technical Staff Member in the Wireless Communications Research Department. In August 2000, he has joined the Department of Electrical Engineering of National Chiao Tung University in Taiwan and has been promoted to the full professor since 2005. His current research interests are in the areas of radio resource management and cross-layer optimization techniques for wireless systems, heterogeneous wireless network design, and cloud computing for mobile applications.

He was elected to the IEEE Fellow grade in 2011 for his contributions in cellular architectures and radio resource management in wireless networks. Dr. Wang was a co-recipient (with Gordon L. Stüber and Chin-Tau Lea) of the 1997 IEEE Jack Neubauer Best Paper Award for his paper "Architecture Design, Frequency Planning, and Performance Analysis for a Microcell/Macrocell Overlaying System," IEEE Transactions on Vehicular Technology, vol. 46, no. 4, pp. 836-848, 1997. He has published over 180 journal and international conference papers. He served as an Associate Editor for the IEEE Trans. on Wireless Communications from 2001 to 2005, the Guest Editor of Special Issue on "Mobile Computing and Networking" for IEEE Journal on Selected Areas in Communications in 2005 and on "Radio Resource Management and Protocol Engineering in Future IEEE Broadband Networks" for IEEE Wireless Communications Magazine in 2006. He is holding nine US patents.

Neelesh B. Mehta received his Bachelor of Technology degree in Electronics and Communications Engineering from the Indian Institute of Technology (IIT), Madras in 1996, and his M.S. and PhD degrees in Electrical Engineering from the California Institute of Technology, Pasadena, CA, USA in 1997 and 2001, respectively. He is now an Assistant Professor at the Dept. of Electrical Communication Engineering, Indian Institute of Science (IISc), Bangalore, India. Before joining IISc, he has held research scientist positions in the Wireless Systems Research group in AT&T Laboratories, NJ, USA, Broadcom Corp., NJ, USA and Mitsubishi Electric Research Laboratories (MERL), MA, USA.

His research includes work on link adaptation, multiple access protocols, system-level performance analysis of cellular systems, MIMO and antenna selection, and cooperative communications. He was also actively involved in radio access network physical layer (RAN1) standardization activities in 3GPP. He has served on several TPCs. He was a TPC co-chair for WISARD 2010 and 2011 workshops, National Conference on Communications (NCC) 2011, the Transmission technologies track of VTC 2009 (Fall), the Frontiers of Networking and Communications symposium of Chinacom 2008, and the tutorials co-chair for SPCOM 2010. He is an Editor of the IEEE Transactions on Wireless Communications and an executive committee member of the IEEE Bangalore Section and the Bangalore chapter of the IEEE Signal Processing Society.