Guest Editorial Ultra-Wideband Wireless Communications—Theory and Applications

ULTRA-WIDEBAND (UWB) transmission has recently received increased attention in both academia and industry for multimedia applications in short-range wireless communications. It has many advantages such as high data rate, availability of low-cost transceivers, low transmit power, and low interference. UWB operates at emission levels commensurate with common digital devices such as laptops, palm pilots, and pocket calculators. The approval of UWB technology made by the Federal Communications Commission (FCC) of the United States in 2002 makes the frequency band between 3.1–10.6 GHz (7.5 GHz) available for unlicensed indoor UWB wireless communication systems. It is expected that many conventional principles and approaches used for indoor wireless communications may be reevaluated, and a new commercial sector in short-range (e.g., 10 m) wireless communications with high data rate (e.g., 400 Mb/s) may be achieved, as well as longer range communications with lower data rate (1 Mbit/s). For instance, industrial standards such as IEEE 802.15.3a (high data rate) and IEEE 802.15.4a (very low data rate) have been introduced based on UWB technology. Although R&D efforts in recent years have demonstrated that UWB radio is a promising solution for high-rate short-range wireless communications, further extensive investigation, experimentation, and development are necessary toward developing effective and efficient UWB communication systems. This Special Issue presents recent cutting edge research and state-of-the-art technology in UWB wireless communications. It is timely and valuable for future analysis, implementation, and experiments of UWB wireless communications systems.

The first 16 papers focus on UWB channel estimation, acquisition and receivers. The paper by da Silva and Milstein proposes an analytical formulation that allows for the analysis of the channel estimation in the presence of narrowband interference. The paper by Qiu *et al.* discusses per-path pulse distortion in multiuser detection for UWB communications. The paper by Chiti *et al.* proposes a punctured hopping approach suitable for time-hopping (TH)-UWB systems. The paper by Nakache and Molisch studies the design of signaling waveforms for TH impulse radio with limits on the power spectral density. The paper by Siriwongpairat *et al.* provides a performance analysis for UWB systems that successfully captures the unique multipath-rich property and multipath-clustering phenomenon of UWB channels. The paper by Dabin *et al.* develops a statistical path loss model from empirical data. The next four papers deal with transmitted reference (TR) UWB systems. The paper by Aedudodla *et al.* investigates the timing acquisition problem for TR UWB systems employing direct-sequence (DS) spreading. The paper by Xu and Sadler proposes a multiuser TR (MTR) scheme to extend TR modulation to the multiuser case, while almost doubling the data rate by allowing arbitrarily small spacing of pulse pairs. The paper by Dang *et al.* studies the signal model and receiver algorithms for a TR-UWB communication system. The paper by Franz and Mitra proposes maximum-likelihood (ML) and generalized likelihood ratio test (GLRT)-based data detection schemes for a UWB communication system. The next three papers focus on UWB timing. The paper by Onunkwo *et al.* investigates the impact of timing jitter on orthogonal frequency-division multiplexing (OFDM)-based UWB systems. The paper by Yang develops and tests timing algorithms in both data-aided and nondata-aided modes based on a synchronization criterion termed timing with dirty templates (TDTs). The paper by Ibrahim and Buehrer presents a modified framework for the analysis of UWB acquisition which accommodates multiple lock cells. The next three papers address the design issues of UWB receivers. The paper by Wu *et al.* develops a UWB receiver structure along with low-complexity timing synchronization and data demodulation schemes based on noisy templates (NTs). The paper by Pausini *et al.* shows how to reduce the effects of nonlinear intersymbol interference (ISI) and the bias term, nuisance parameters of autocorrelation receivers. The paper by Kokkalis *et al.* analyzes and evaluates the performance of multiuser TH-UWB systems employing M-ary pulse position modulation (PPM) and a correlation receiver.

The next five papers deal with UWB networking and routing. The paper by Zhang *et al.* develops a mobility-assisted secure localization scheme and proposes a location-based scheme to enable secure authentication for UWB sensor networks. The paper by Xiao *et al.* investigates the optimal acknowledgment (ACK) mechanisms for the IEEE 802.15.3. The following three papers focus on routing issues. The paper by Wu *et al.* addresses the throughput optimization problem in multihop UWB networks by jointly considering network topology formation and routing. The paper by Abdrabou and Zhuang presents a position-based quality-of-service (QoS) routing scheme for UWB mobile ad hoc networks. The paper by Shi *et al.* investigates a cross-layer optimization approach with joint consideration of link-layer scheduling, power control, and network-layer routing.

The subsequent ten papers discuss UWB systems and implementation. The paper by Li *et al.* studies a code-spread and chip-interleaved TH UWB system. The paper by Wang *et al.* proposes a new circuit modeling methodology that handles omnidirectional small antennas. The paper by Zhang *et al.* investigates multiple pulse waveforms adaptation in order to

Digital Object Identifier 10.1109/JSAC.2005.863805

achieve the cognitive UWB radio. The paper by Liu proposes a multicode continuous-wave UWB signaling scheme that employs chirp waveforms. The paper by Gezici *et al.* considers impulse radio systems with multiple types of UWB pulses, where different types of pulses can be used in different frames by different users. The paper by Ridolfi and Win provides a general approach to the spectra evaluation of complicated UWB signals. The paper by Richardson *et al.* investigates the application of UWB radio in vehicle environments by exploring the characteristics of UWB channels within a vehicle. The paper by Li *et al.* studies the performance of UWB radio communications systems employing phase-shift keying (PSK) modulation and fully saturated power amplifiers through additive white Gaussian noise (AWGN) channel or Rayleigh-fading channel. The paper by Wang and Dong proposes a time-division multiple-access (TDMA) scheme for the binary phase-shift keying (BPSK) modulated single carrier block transmission with frequency-domain equalization (SC-FDE) over UWB channels. The paper by Fort *et al.* proposes a simple statistical channel model and a practical implementation useful for evaluating UWB body area communication systems.

ACKNOWLEDGMENT

We have received a total of 97 high-quality submissions, and 31 papers have been selected for inclusion in this Special Issue. The Guest Editors and Reviewers made great effort to review all papers. The Guest Editors would like to thank all the authors who responded to the call for papers, regardless of whether their paper has been included in this Special Issue or not due to space limitations. The Guest Editors would also like to acknowledge the contribution of many experts who participated in the review process and provided helpful suggestions to the authors on improving the content and presentation of their papers. The advice and support from Dr. L. B. Milstein, Senior Editor, IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, and Dr. N. Maxemchuk, Editor-in-Chief, IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, are greatly appreciated.

XUEMIN (SHERMAN) SHEN, *Guest Editor*
University of Waterloo
Department of Electrical and Computer Engineering
Waterloo, ON N2L 3G1, Canada

MOHSEN GUIZANI, *Guest Editor*
Western Michigan University
Department of Computer Science
Kalamazoo, MI 49008 USA

HSIAO-HWA CHEN, *Guest Editor*
National Sun Yat-Sen University
Institute of Communications Engineering
Kaohsiung 804, Taiwan

ROBERT CAIMING QIU, *Guest Editor*
Tennessee Technological University
Center for Manufacturing Research
Department of Electrical and Computer Engineering
Cookeville, TN 38505 USA

ANDREAS F. MOLISCH, *Guest Editor*
Mitsubishi Electric Research Laboratories
Cambridge, MA 02139 USA
Also at Lund University
S-221 00 Lund, Sweden

L. B. MILSTEIN, *J-SAC Board Representative*

Xuemin (Sherman) Shen (M'97–SM'02) received the B.Sc. degree from Dalian Maritime University, Dalian, China, in 1982, and the M.Sc. and Ph.D. degrees from Rutgers University, Piscataway, NJ, in 1987 and 1990, respectively, all in electrical engineering.

Currently, he is with the Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, ON, Canada, where he is a Professor and the Associate Chair for Graduate Studies. His research focuses on mobility and resource management in interconnected wireless/wireline networks, UWB wireless communications systems, wireless security, and ad hoc and sensor networks. He is a coauthor of two books, and has published more than 200 papers and book chapters in wireless communications and networks, control, and filtering.

Dr. Shen received the Outstanding Performance Award in 2004 from the University of Waterloo, and the Premier's Research Excellence Award (PREA) in 2003 from the Province of Ontario, Canada, for demonstrated excellence of scientific and academic contributions, and the Distinguished Performance Award in 2002 from the Faculty of Engineering, University of Waterloo, for outstanding contributions in teaching, scholarship, and service. He was Technical Co-Chair for the IEEE GLOBECOM'03, ISPAN'04, QShine'05, IEEE Broadnets'05, and WirelessCom'05, and was Special Track Chair of the 2005 IFIP Networking Conference. He serves as Associate Editor for the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, *Computer Networks*, *ACM/Wireless Networks*, *Wireless Communications and Mobile Computing* (Wiley), and the *International Journal Computer and Applications*. He has also served as Guest Editor for the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, the *IEEE Wireless Communications*, and the *IEEE Communications Magazine*.

Mohsen Guizani (S'87–M'90–SM'98) received the B.S. and M.S. degrees in electrical engineering, and the M.S. and Ph.D. degrees in computer engineering from Syracuse University, Syracuse, NY, in 1984, 1986, 1987, and 1990, respectively.

He is currently a Professor and the Chair of the Computer Science Department, Western Michigan University, Kalamazoo. He currently serves on the editorial boards of six technical journals. He is the Founder and Editor-in-Chief of the *Wireless Communications and Mobile Computing Journal* published by Wiley. He is the author of four books. He guest edited a number of special issues in IEEE journals and magazines. He also served as Member, Chair, and General Chair of a number of conferences, including, ICC, GLOBECOM, INFOCOM, and VTC. He has more than 140 publications in refereed journals and conferences. He was selected as the Distinguished Speaker for the IEEE Computer Society until 2005. His research has been supported by Sprint, Telcordia, Navy, and Boeing, to name a few.

Dr. Guizani was selected as the Best Teaching Assistant for two consecutive years at Syracuse University, 1988 and 1989, respectively. He is a member of IEEE Communication Society, the IEEE Computer Society, ASEE, ACM, OSA, SCS, and Tau Beta Pi.

Hsiao-Hwa Chen (S'89–M'91–SM'00) received the B.Sc. and M.Sc. degrees from Zhejiang University, Zhejiang, China, and the Ph.D. degree from the University of Oulu, Oulu, Finland, in 1982, 1985 and 1990, respectively, all in electrical engineering.

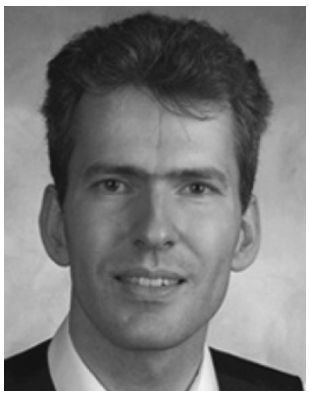
He was with the Academy of Finland for the research on spread-spectrum communications as a Research Associate from 1991 to 1993 and the National University of Singapore as a Lecturer and then a Senior Lecturer from 1992 to 1997. He joined Department of Electrical Engineering, National Chung Hsing University, Taiwan, as an Associate Professor in 1997 and was promoted to a Full Professor in 2000. In 2001, he moved to National Sun Yat-Sen University, Taiwan, as the founding Director of the Institute of Communications Engineering of the University. Under his leadership, the Institute of Communications Engineering was ranked second place in the country in terms of SCI journal publications and National Science Council funding per faculty in 2004. He has been a visiting Professor at the Department of Electrical Engineering, University of Kaiserslautern, Germany, in 1999, the Institute of Applied Physics, Tsukuba University, Japan, in 2000, and Institute of Experimental Mathematics, University of Essen, Germany, in 2002. He is an Honorary Guest Professor of Zhejiang University, China, and Shanghai Jiao-Tong University, China. He has authored or coauthored over 150 technical papers in major international journals and conferences, and four books and several book chapters in the areas of communications.

Dr. Chen is a recipient of numerous Research and Teaching Awards from the National Science Council and Ministry of Education, Taiwan, from 1998 to 2001. He served as a TPC member and symposium chair of major international conferences, including IEEE VTC, IEEE ICC, and IEEE GLOBECOM. He served or is serving as the Editor or Guest Editor for the *IEEE Communications Magazine*, the the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, the *IEEE Network Magazine*, the *IEEE Wireless Communications Magazine*, the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, the *IEEE Vehicular Technology Magazine*, *Wireless Communications and Mobile Computing (WCMC) Journal*, and the *International Journal of Communication Systems*.

Robert Caiming Qiu (S'93–M'96–SM'01) received the Ph.D. degree in electrical engineering from Polytechnic University, Brooklyn, NY.

He is currently an Associate Professor in the Department of Electrical and Computer Engineering, Center for Manufacturing Research, Tennessee Technological University, Cookeville. His current interest is in wireless communication and networking systems, in particular ultra-wideband (UWB). He was Founder-CEO and President of Wiscom Technologies, Inc., manufacturing and marketing WCDMA chipsets. All the assets of Wiscom was sold to Intel in 2003. Prior to Wiscom, he worked for GTE Laboratories, Inc. (now Verizon), Waltham, MA, and Bell Laboratories, Lucent Technologies, Whippany, NJ. He has worked in wireless communications, radio propagation, digital signal processing, EM scattering, composite absorbing materials, RF microelectronics, UWB, underwater acoustics, and fiber optics. He holds over 10 U.S. patents pending in WCDMA and authored over 40 technical papers and 4 book chapters. He contributed to 3GPP and IEEE standards bodies, and delivered invited seminars to institutions including Princeton University and the U.S. Army Research Lab. His current interest is in wireless communication and networking systems, in particular, ultra-wideband (UWB).

Dr. Qiu serves as Associate Editor for the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, the *International Journal of Sensor Networks* (Inderscience), and *Wireless Communication and Mobile Computing* (Wiley). He is a Guest Book Editor for *Ultra-Wideband (UWB) Wireless Communications* (Wiley, 2005), and three Special Issues on UWB including the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS and the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY. He serves as a Member of TPC for GLOBE-COM, WCNC, and MILCOM. In addition, he served on the Advisory Board of the New Jersey Center for Wireless Telecommunications (NJCWT).



Andreas F. Molisch (S'89–M'95–SM'00–F'05) received the Dipl. Ing., Dr. techn., and Habilitation degrees from the Technical University (TU) Vienna, Vienna, Austria, in 1990, 1994, and 1999, respectively.

From 1991 to 2000, he was with the TU Vienna, becoming an Associate Professor there in 1999. From 2000 to 2002, he was with the Wireless Systems Research Department, AT&T Laboratories-Research, Middletown, NJ. Since then, he has been a Senior Principal Member of Technical Staff with Mitsubishi Electric Research Laboratories, Cambridge, MA. He is also a Professor and Chairholder for Radio Systems at Lund University, Lund, Sweden. He has authored, coauthored, or edited four books, among them the recent textbook *Wireless Communications* (Wiley-IEEE Press), 11 book chapters, some 85 journal papers, and numerous conference contributions. He has done research in the areas of SAW filters, radiative transfer in atomic vapors, atomic line filters, smart antennas, and wideband systems. His current research interests are MIMO systems, measurement and modeling of mobile radio channels, and ultra-wideband (UWB).

Dr. Molisch is the recipient of several awards. He is an Editor of the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, Coeditor of the *Journal on Wireless Communications Mobile Computing* (a recent Special Issue on MIMO and Smart Antennas), and Coeditor of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS (Special Issue on UWB). He has been member of numerous TPCs, Vice-Chair of the TPC of VTC 2005 Spring, and will be General Chair of ICUWB 2006. He has participated in the European research initiatives "COST 231," "COST 259," and "COST 273," where he was Chairman of the MIMO Channel Working Group. He is also Chairman of Commission C (signals and systems) of International Union of Radio Scientists (URSI).