EURASIP Journal on Applied Signal Processing 2005:3, 249–251

Editorial

Maria-Gabriella Di Benedetto

Infocom Department, School of Engineering, University of Rome La Sapienza, Via Eudossiana 18, 00184 Rome, Italy
Email: dibenedetto@newyork.ing.uniroma1.it

Thomas Kaiser

Department of Communication Systems, Faculty of Engineering, University of Duisburg-Essen, 47048 Duisburg, Germany
Email: thomas.kaiser@uni-duisburg.de

Norbert Schmidt

Department of Information and Communication Systems, IMST GmbH, 47475 Kamp-Lintfort, Germany
Email: schmidt@imst.de

Ultra-wideband (UWB) radio is emerging worldwide as a particularly appealing transmission technique for applications requiring either high bit rates over short ranges or low bit rates over medium-to-long ranges, that is, scenarios that favor compliance with the severe power constraints imposed by regulatory bodies under the coexistence principle. The high-bit-rate/short-range case includes wireless personal area networks (WPANs) for multimedia traffic, cable replacement such as wireless universal serial bus (USB), and wearable devices, for example, wireless Hi-Fi headphones. The low-bit-rate/medium-to-long-range case applies to long-range sensor networks such as indoor/outdoor distributed surveillance systems, non-real-time data applications, for example, e-mail and instant messaging, and in general all data transfers compatible with a transmission rate in the order of 1 Mbps over several tens of meters. In this light, the moment seems appropriate for taking a snapshot of the state of the art in UWB methods and technologies. The aim of this special issue is to present recent research in UWB systems and technology from several points of view. After a tutorial on UWB, we classified the further 16 contributions into five major categories, namely, antennas and propagation, multiple antenna systems, system analysis, parameter estimation and synchronization, and implementations.

The invited tutorial by Scholtz et al. covers multiple aspects of UWB, starting from history via regulations, antenna design, link budget analysis, propagation, pulse shaping, and finishing with receiver architectures and circuits. Several challenges for designing a complete UWB transmission link are highlighted and first solutions are substantiated by real data and simulations.

The next three papers of the issue are related to antennas and propagation. The first paper by Xu et al. presents an approach for multiuser channel estimation based on the introduction of a pulse-rate discrete-time system model. The proposed method applies blind multiuser channel estimation on the basis of first- and second-order statistics of received signals. In the paper by Menouniet al., typical statistics are modeled based on the method of eigendecomposition. The model is furthermore supported by measurements to verify it in realistic environments. Both line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios are covered in the examinations. The last paper on antennas and propagation by Sörgel and Wiesbeck focuses on the characterization of several known types of antennas with regard to the very special characteristics like "ringing" which are of interest for UWB system implementation. The paper first gives a mathematical introduction. In the second part of the paper, measurements and analysis for several UWB antenna types are shown.

Though belonging to "beyond UWB" challenges, three papers are devoted to UWB combined with multiple antennas. In the contribution by H. Zhang and Gulliver, receive diversity of time-hopping UWB is investigated in terms of error probability and capacity for AWGN channels. Besides conventional modulation schemes, namely, pulse amplitude modulation (PAM) and pulse-position modulation (PPM), results are also given for multiuser environments. The second paper by Sibille studies MIMO diversity to further improve the performance of a UWB link, for example, enlargement of the link margin by extra gain at the receiver. An SNR gain almost independent of the modulation schemes (PAM, PPM, and DS-CDMA) and proportional to the number of transmit antennas multiplied with the number of receive antennas has been observed under moderate channel conditions. Beam switching is proposed so as to reduce complexity. The last paper on UWB-MIMO by Siriwongpairat, et al. proposes a combination of space-time coding with a RAKE receiver to simultaneously exploit spatial and multipath diversity. UWB-SISO and UWB-MIMO are compared in terms of diversity and coding gain and an upper bound for the average pairwise error probability (PEP) in case of Nakagami frequency-selective channels has been derived.

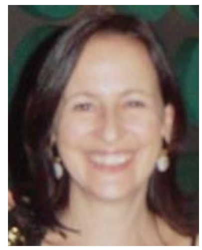
The following five papers are dedicated to system concepts, analysis, and performance. In the paper by Nuño-Barrau and Páez-Borrallo, new methods for system simulation are studied and applied to a frequency-hopping UWB system concept. The approach includes a multipath indoor channel model and derives system performance parameters based on this propagation channel. The next paper by Durisi and Benedetto compares the performance of coherent detections schemes versus noncoherent concepts in terms of BER under the assumption of realistic propagation channel models. In the paper by Abreu et al., a jitter-robust extension of orthogonal Hermite polynoms for pulse shaping in AWGN channels is proposed. The approach relies on a transform from the convolutional jitter channel model into a multiplicative matrix model, leading to a generalized eigendecomposition problem. The auto- and cross-correlation functions of the jitter-robust pulses are given and compared to conventional ones. The next contribution by Gerrits et al. proposes a mixed analog and digital frequency modulation (FM) with constant envelope UWB transmission for low- and medium-bit-rate WPAN systems. The performance of this approach in AWGN or multipath channels and for narrowband interferers is investigated. Further validation of double FM in praxis is achieved by a hardware demonstrator. The final paper on system concepts by Molisch et al. suggests a low-complexity time-hopping impulse radio system for high data rate transmission. The approach is multiuser capable, all-baseband with symbol rate sampling, and obeys the FCC spectral mask requirements.

Three papers are focusing on the estimation of parameters and synchronization issues. The paper by Xu et al. is dedicated to multiuser scenarios. Based on a method for channel estimation, optimal receivers for multiuser detection are derived and their performance is analysed. A more theoretical approach is presented in the paper written by J. Zhang et al., where theoretical thresholds for several performance parameters are derived and presented. The performance bounds are analyzed for Gaussian channels as well as in the case of multipath propagation conditions. In the contribution by Tian and L. Wu, low-complexity timing synchronizers are introduced for use with correlation-based receiver types. The performance of these synchronization algorithms is studied in a multipath environment.

Last but no least, the two remaining papers focus on some aspects of implementation. The implementation of the correlation algorithm is a crucial topic for coherent UWB systems. The paper by Tu et al. presents an implementation of a correlator which may be used for UWB implementations in the frequency band from 3 GHz to 10 GHz. The correlator is characterized by frequency-domain and time-domain analysis via simulations. In the last contribution by Christensen, the adaptive linear minimum mean square error criterion is exploited for joint synchronization, channel estimation, and multiuser detection of a single-band DS-CDMA UWB radio link. In order to reduce the receiver's complexity, a nonrecursive least-squares algorithm is developed with similar beneficial performance known from a recursive least-squares approach.

We thank the authors, the reviewers, the publisher, and the Editor-in-Chief for their efforts. We also hope that this special issue will stimulate further research on UWB communications.

Maria-Gabriella Di Benedetto
Thomas Kaiser
Norbert Schmidt



Maria-Gabriella Di Benedetto obtained her Ph.D. degree in telecommunications in 1987 from the University of Rome La Sapienza, Italy. In 1991, she joined the faculty of the School of Engineering, the University of Rome La Sapienza, where currently she is a Full Professor of telecommunications at the Infocom Department. She has held visiting positions at the Massachusetts Institute of Technology, the University of California, Berkeley, and the University of Paris XI, France. In 1994, she received the Mac Kay Professorship Award from the University of California, Berkeley. Her research interests include speech analysis and synthesis, and digital communication systems. From 1995 to 2000, she directed four European projects for the design of UMTS. Since 2000, she has been active in fostering the development of ultra-wideband (UWB) telecommunication systems in Europe. She is currently the Director for Infocom of two European IST projects of the 5th European Union Framework Program (Whyless.com and UCAN), and of two integrated projects (IP) within the 6th European Union Framework Program (PULSERS and Liaison). The four mentioned projects are aimed at the design and implementation of UWB systems. Her research group also participates in the European Union Network of Excellence on Hybrid System Modeling and Control (HYCON). She recently completed together with Guerino Giancola a book *Understanding Ultra Wide Band Radio Fundamentals* on UWB from radio to the network, which was published in June 2004 by Prentice Hall.

Thomas Kaiser received the Diploma degree from the Ruhr-University Bochum in 1991, the Ph.D. degree in 1995 with distinction, and the second Ph.D. degree in 2000 (so-called Habilitation) from Gerhard-Mercator-University Duisburg, all in electrical engineering. From 1995 to 1996, he spent a research leave at the University of Southern California, Los Angeles, grant-aided by the German Academic Exchange Service. From April 2000 to March 2001, he was Head of the Department of Communication Systems, Gerhard-Mercator-

University Duisburg, and from April 2001 to March 2002, he was Head of the Department of Wireless Chips & Systems (WCS), Fraunhofer Institute of Microelectronic Circuits and Systems. Now he is with the Department of Communication Systems and Coleader of the Smart Antenna Research Team (SmART) at the University of Duisburg-Essen. Dr. Kaiser published more than 75 papers in international journals and conferences and is the coeditor of the forthcoming books *UWB Communication Systems—A Comprehensive Overview*, *Smart Antennas—State of the Art* (to appear in EURASIP Book Series on Signal Processing and Communications by the end of 2004), and *UWB Communications* (to appear by Wiley in 2005). He belongs to the Editorial Board of EURASIP Journal on Applied Signal Processing (JASP) and the Advisory Board of a European multiantenna project. He is involved in several national and international projects, and chaired and cochaired three special sessions on multiantenna implementation issues. He is the Guest Editor of three EURASIP JASP special issues and technical program committee member of several international conferences. His current research interest focuses on applied signal processing with emphasis on multiantenna systems, especially its applicability to ultra-wideband (UWB) systems and on implementation issues.

Norbert Schmidt received his M.S. degree in electrical engineering from the Gerhard-Mercator-University Duisburg in 1991. Since 1993, he is with IMST GmbH, Germany, mainly being involved in research and development of future radio communication systems. His expertise are in system theory and implementation, digital signal processing, and system implementations. Since 1997, he is heading the Section *Mobile Radio Systems*, Department of Information and Communication Systems. Norbert Schmidt is involved in several national and international research projects studying ultra-wideband (UWB) systems and technology since 1999 (Whyless.com, EUROPCOM) and is now involved in the implementation phase for UWB demonstration systems.