

Editorial

Sofiène Affes

*Institut National de la Recherche Scientifique (INRS-EMT), Université du Québec, 800 de la Gauchetière Ouest, bureau 6900, Montreal, QC, Canada H5A 1K6
Email: affes@inrs-emt.quebec.ca*

Jacob Benesty

*Institut National de la Recherche Scientifique (INRS-EMT), Université du Québec, 800 de la Gauchetière Ouest, bureau 6900, Montreal, QC, Canada H5A 1K6
Email: benesty@inrs-emt.quebec.ca*

David Gesbert

*Institut Eurécom, 2229 route des Crêtes, BP 193, 06904 Sophia Antipolis Cedex, France
Email: david.gesbert@eurecom.fr*

Laurence Mailaender

*Bell Laboratories, Lucent Technologies, Room R-139, 791 Holmdel Road, Holmdel, NJ 07733, USA
Email: lm@lucent.com*

Mamoru Sawahashi

*Wireless Access Laboratory, Wireless Laboratories, NTT DoCoMo, 3-5 Hikarinooka, Yokosuka, Kanagawa 239-8536, Japan
Email: sawahasi@mlab.yrp.nttdocomo.co.jp*

Current research in wireless transceiver design will extend wireless system performance beyond the capabilities of third-generation (3G) systems. Yet the prospective innovative solutions that are most likely to make their shortest way to integration in a future real-world wireless system are those that take into account interaction with other subsystem components, any source of imperfection such as estimation and modeling errors, implementation feasibility and costs, software/hardware codesign issues, and so forth to the proof of concept.

This special issue has solicited original research contributions in the design of new transceiver solutions for wireless networks beyond 3G with a development and assessment approach oriented towards implementation and integration in a real-world wireless system, that is, the methodology ranging from (i) realistic link/system-level software simulation, to (ii) off-line verification and validation over channel measurements, (iii) real-time prototyping and validation, and (iv) on-air demonstration and field trials.

The papers included in this special issue address a broad range of topics such as MIMO (multiple-input multiple-output) systems, space-time coding (STC), multiuser detection and interference suppression, synchronization and

channel identification, and so forth applied in most cases to code-division multiple access (CDMA), wideband CDMA (WCDMA), high-speed downlink packet access (HSDPA), or multicarrier CDMA (MC-CDMA). A relatively large number of contributions also come from industry and hence provide an invaluable industrial perspective on current research issues in wireless. In the following, the specific contributions of the papers included in this special issue are summarized and grouped according to the adopted methodology.

Simulation-based performance evaluation with system-design approach

Maljević and Sousa introduce a new paradigm in the design of DS-CDMA receivers that mixes analog and digital processing based on a five-port device to achieve direct conversion and analog despreading with symbol-rate sampling only. They also exploit the five-port device to propose a noncoherent code-tracking scheme and a RAKE combiner for mobile terminals. Under Rayleigh fading channels, simulations suggest that the proposed receiver structures based on five-port devices offer robustness and high performance while maintaining low complexity.

Tsai et al. present the architecture of a downlink baseband transceiver for a MC-CDMA radio access under the same channel bandwidth and channel conditions as a WCDMA access. Along with subcarrier data scrambling at the transmitter, joint carrier and frequency estimation and channel estimation based on frequency-domain interpolation are presented, providing the maximum aggregate uncoded data rates of 8 and 16 Mbps in mobile and stationary multipath fading channels, respectively.

Peppas et al. propose a reconfigurable space-time coding technique for HSDPA by introducing reconfigurability at the link level using a linear processor for space-time block coding according to the antenna correlation. The paper also develops a novel link-to-system interface for realistic system-level performance evaluations. The simulation results show the performance enhancement achieved by the application of reconfigurable techniques compared to that of the conventional techniques.

Zhang et al. consider issues in the encoding of MIMO signals. They compare "joint encoding" to a per-antenna "separate encoding" that facilitates the detection and subtraction of the individual MIMO signals. When such systems are rate controlled, a link quality metric is needed that summarizes the MIMO channel capacity. They focus on the performance of these metrics in multipath channels.

Impact of channel estimation and modeling accuracy on MIMO performance

Mysore and Bajcsy study the impact of channel estimation errors and cochannel interference on the performance of a coded MIMO system. One fundamental condition for a successful integration of MIMO solutions into real-life systems is the availability of MIMO receiver algorithms that can operate under nonideal channel scenarios. In particular, the MIMO decoder typically operates with imperfect channel estimation due to finite training. One approach is to combine (turbo) coding with MIMO signaling to provide extra robustness with respect to error-prone channel estimates and other detrimental propagation effects like antenna correlation. Such aspects are investigated in this paper and new algorithms are proposed and evaluated.

Tang and Mohan study the impact of clustering on the performance of indoor MIMO systems. They propose a simple and efficient channel model which combines the statistical characteristics of signal clusters with the deterministic ray-tracing approach and validate it over on-site measurements. Their investigation reveals that the clustering of signals significantly affects the spatial correlation and the achievable indoor MIMO capacity.

Measurement-based performance evaluation

Trautwein et al. evaluate the performance of advanced MIMO transceiver designs based on channel measurements. Real-life deployments of MIMO systems are likely to be met with channel conditions featuring frequency selectivity. In this case, the turbo concept can also be put to use to help the spatial multiplexing transceiver deal with equalizing the

channel. In this paper, such turbo equalizers are further investigated in the presence of real channels. By incorporating channel sounder measurements into the physical layer simulator, the authors are able to explore the real-time dynamics of MIMO channels and their impact on MIMO link adaptation.

Hagerman et al. evaluate the performance of parallel interference cancellation (PIC) on the WCDMA uplink based on both link/system-level simulations and measurements from a prototype field trial. System-level simulations suggest an increase of 40% in capacity with limited-complexity PIC versus the conventional RAKE receiver. Additionally, measurements from a single-cell field trial confirm the increase in capacity and battery life in accordance with system-level simulations.

Cheikhrouhou et al. verify the analysis/synthesis-based design of a new wideband CDMA receiver, the spatio-temporal array receiver (STAR), by illustrating its capacity to extract accurately the channel parameters (multipath time delays and drifts, carrier frequency offset, Doppler spread, etc.) from measured data and to adapt on-line to their time evolution. They also verify the performance of STAR by comparing the results achieved by generic and measured channels. Results suggest that STAR achieves high capacities despite about 1 dB loss in SNR due to its operation in real-world conditions.

Prototype-based performance evaluation

Jalloul and Lin develop a novel architecture for a cellular base station modem engine (CBME), a single-chip multichannel transceiver that is capable of simultaneously processing and demodulating multiple users. Through key functional system partitioning, tightly coupled small DSP cores, and time-sliced reuse architecture, CBME achieves a high degree of algorithmic flexibility while maintaining efficiency. When channel estimation and both the frequency-locked and delay-locked loops are enabled with two diversity antennas, the simulations of the baseband performance of the chip correlate well with the laboratory bench testing.

Samardzija et al. evaluate the performance of a prototype of a MIMO HSDPA transceiver that implements a new multiuser detection scheme to discriminate the signals conveyed over interfering beams aimed at different terminals. The experimental testbed comprises a commercial multiantenna base station, multiantenna terminals, and custom MIMO ASICs. The measurement results confirm the power of multiuser detection, especially when the number of receive antennas does not exceed the number of transmit antennas at the base station.

This special issue gathers eleven significant research contributions both from academia and industry on system-integration-oriented transceiver design for beyond 3G wireless networks, a relatively large number given the challenging scope of the issue. We believe that they represent an excellent sampling of state-of-the-art research on the subject. We would like to thank all the authors for their timely contributions and we hope that their works will offer valuable references to researchers and practicing engineers in the field.

It is our hope, also, that this issue will promote further research on new transceiver design from the challenging perspective of system integration in real-world wireless systems.

Sofiène Affes
Jacob Benesty
David Gesbert
Laurence Mailaender
Mamoru Sawahashi

Sofiène Affes received the Diplôme d'Ingénieur degree in electrical engineering in 1992, and the Ph.D. degree with honors in signal and image processing in 1995, both from the École Nationale Supérieure des Télécommunications (ENST), Paris, France. He has been since then with INRS-ÉMT (former Telecommunications Center), University of Quebec, Montreal, Canada, first as a Research Associate from 1995 till 1997, then as an Assistant Professor till 2000. Currently he is an Associate Professor in the Personal Communications Group. His research interests are in wireless communications, statistical signal and array processing, adaptive space-time processing, MIMO, synchronization, and multiuser detection. From 1998 to 2002, he was leading the radio-design and signal processing activities of the Bell/Nortel/NSERC Industrial Research Chair in Personal Communications at INRS-ÉMT, Montreal, Canada. Currently he is actively involved in a major project in wireless of PROMPT-Québec (Partnerships for Research on Microelectronics, Photonics and Telecommunications). Professor Affes is the corecipient of the 2002 Prize for Research Excellence of INRS and currently holds a Canada Research Chair in High-Speed Wireless Communications. He is a Senior member of the IEEE and currently acts as a Member of the Editorial Board of the Wiley Journal on Wireless Communications & Mobile Computing. He currently sits on the Local Organizing Committee of IEEE VTC'2006-Fall, Montreal, Canada, as a General Cochair of the conference.



Jacob Benesty was born in 1963. He received an M.S. degree in microwaves from Pierre & Marie Curie University, France, in 1987, and a Ph.D. degree in control and signal processing from Orsay University, France, in April 1991. During his Ph.D. (from November 1989 to April 1991), he worked on adaptive filters and fast algorithms at the Centre National d'Études des Télécommunications (CNET), Paris, France. From January 1994 to July 1995, he worked at Telecom Paris University on multichannel adaptive filters and acoustic echo cancellation. From October 1995 to May 2003, he was with Bell Laboratories, Murray Hill, NJ, USA. In May 2003, he joined INRS-ÉMT, University of Quebec, Montreal, Quebec, Canada, as an Associate Professor. His research interests are in acoustic signal processing and multimedia communications. He was the cochair of the 1999 International Workshop on Acoustic Echo and Noise Control. He is a Member of the IEEE Signal Processing Society Technical Committee on Audio and Electroacoustics. He is a Member of the Editorial Board of the EURASIP Journal on Applied Signal Processing. He is the recipient of the IEEE Signal Processing Society 2001



Best Paper Award. He coauthored the book *Advances in Network and Acoustic Echo Cancellation* (Springer-Verlag, Berlin, 2001) and coedited/coauthored three more books.

David Gesbert is on the faculty of Mobile Communications Department, Eurécom Institute, France. He obtained the Ph.D. degree from École Nationale Supérieure des Télécommunications, France, in 1997. From 1997 to 1999, he was a Research Fellow at the Smart Antenna Research Group of the Information Systems Laboratory, Stanford University. In October 1998, he took part in the founding team of Iospan Wireless Inc, San Jose, Calif., a startup company that pioneered MIMO-OFDM (now Intel). Between 2001 and 2003 he was with the Department of Informatics, University of Oslo, as an Adjunct Professor. D. Gesbert has published about 80 papers and several patents all in the areas of signal processing, communications, and wireless networks. Dr. Gesbert is an Associate Editor for the IEEE Transactions on Wireless Communications and the EURASIP JWCN. He and his coauthors won the 2004 IEEE Best Tutorial Paper Award (Communications Society) for his 2003 JSAC paper on MIMO systems. He is a coauthor of the upcoming book *Space Time Wireless Communications: From Parameter Estimation to MIMO Systems*, Cambridge Press, 2005. Finally, D. Gesbert is a Coorganizer, with Prof. Dirk Stock, of the IEEE Workshop on Signal Processing Advances in Wireless Communications, 2006, Cannes, France.



Laurence Mailaender received the Ph.D. degree in electrical and computer engineering from the University of California, Santa Barbara, in 1996. From 1986 till 1991, he was a Senior Engineer at Stanford Telecommunications, Reston, Va, working on problems of CDMA detection and synchronization for satellite systems. In 1996, he joined Bell Laboratories, Lucent Technologies, in the Wireless Communications Research Department. There, during 2002, he was the Leader of Algorithm Development for Lucent's effort that produced the world's first working MIMO ASIC chips, and received the Bell Labs President's Gold Award. Currently Dr. Mailaender works on practical CDMA multiuser detection, as well as MIMO equalization and detection. He holds 7 US patents related to CDMA.



Mamoru Sawahashi received his B.S. and M.S. degrees from Tokyo University in 1983 and 1985, respectively, and received his Dr. Eng. degree from the Nara Institute of Technology in 1998. In 1985 he joined NTT Electrical Communications Laboratories, and in 1992 he transferred to NTT Mobile Communications Network, Inc. (now NTT DoCoMo, Inc.). Since joining NTT, he has been engaged in the research of modulation/demodulation techniques for mobile radio, and research and development of wireless access technologies for W-CDMA mobile radio and broadband wireless packet access technologies for beyond IMT-2000. He is currently serving an Editor of the IEEE Transactions on Wireless Communications. He is now the Director of the IP Radio Network Development Department in NTT DoCoMo, Inc.

