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.

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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.

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