Introduction to the Issue on Soft Detection for Wireless Transmission

In recent years, soft-input soft-output detectors that operate based on the turbo principle have found tremendous applications in the transceiver design for wireless transmissions. These schemes can significantly improve the quality of wireless transmission by performing joint iterative data and channel detection through the exchange of soft information. For many applications of interest, however, the exponential complexity of the optimal maximum a posteriori probability (MAP) detector becomes prohibitive. This motivates the design of suboptimal soft detectors whose complexity scales gracefully with system dimension. Various signal processing algorithms have been developed for such detectors including those based on tree-search, trellis structure, and linear filtering. The design of soft detectors addresses new challenges that arise as we gear towards the next generation communication systems, targeted for higher data rates/spectral efficiencies and improved data integrity for mobile scenarios. The goal of this special issue is to explore recent advances in the design of soft detectors for wireless transmission, with a focus on novel signal processing algorithms and methods. We received a large number of manuscripts, out of which 16 papers were accepted for publication in this special issue.

The first set of papers focuses on soft detection for multiple-input multiple-output (MIMO) channels. MIMO technology is envisioned to be a core technology to achieving higher data rates. The first five papers bring recent research contributions to soft MIMO detection. The paper “Optimally Efficient Max-log APP Demodulation in MIMO Systems” by Prasad et al. develops stack tree-search based demodulators that provide soft outputs in the form of exact max-log log-likelihood ratios. The paper “Approximate MAP Detection with Ordering and Successive Processing for Iterative Detection and Decoding in MIMO Systems” by Choi develops successive detectors with different ordering methods to achieve superior detection performance over existing detectors with reduced complexity. The paper “Efficient Soft-Output Demodulation of MIMO QPSK via Semidefinite Relaxation” by Nekuii et al. proposes two computationally efficient soft MIMO demodulators based on an adaptation of the semidefinite relaxation method for hard demodulation to list-based soft demodulation. The paper “Block-Orthogonal Space-Time Code Structure and Its Impact on QRDM Decoding Complexity Reduction” by Ren et al. introduces the block-orthogonality property for space-time codes, which can be exploited by QR-decomposition-based decoders to achieve significant decoding complexity reduction without performance loss. The paper “Allocation of Computational Resources for Soft MIMO Detection” by Cirkic et al. develops methods that adaptively allocate computational resources to the detection problems of each channel realization under a total per-codeword complexity constraint.

The second set of papers explores message-passing algorithms for soft detection. The paper “A Message-Passing Receiver for BICM-OFDM over Unknown Clustered-Sparse Channels” by Schniter presents a factor-graph approach to joint channel-estimation and decoding that merges recent advances in approximate message passing algorithms with those in structured-sparse signal reconstruction and SISO decoding. The paper “SISO Detection over Linear Channels with Linear Complexity in the Number of Interferers” by Colavolpe et al. considers detection over linear channels impaired by additive white Gaussian noise and derives novel detection algorithms by applying the sum-product algorithm to a suitably designed factor graph. The paper “Iterative Tomographic Solution of Integer Least Squares Problems with Applications to MIMO Detection” by Goldberger et al. develops iterative techniques based on a tomographic least squares decoder and two-dimensional belief propagation to provide good suboptimal solutions to the general integer least squares problem. The paper “Low-Complexity Detection in Large-Dimension MIMO-ISI Channels Using Graphical Models” by Som et al. shows that belief propagation on graphical models, including Markov random fields and factor graphs, can be efficiently used to achieve near-optimal detection in large-dimension MIMO-ISI channels at quadratic and linear complexities. The paper “SigSag: Iterative Detection through Soft Message-Passing” by Saber et al. introduces novel decoding algorithms based on belief propagation that are compatible with the 802.11 framework and allow the decoding of interfering users.

The third set of papers addresses soft detection over frequency-selective channels. The paper “Progressive Inter-carrier Interference Equalization for OFDM Transmission over Time-Varying Underwater Acoustic Channels” by Huang et al. develops a progressive receiver that updates the system model over iterations to account for channels with large Doppler spreads. The paper “Markov Chain Monte Carlo Detection for Frequency-Selective Channels Using List Channel Estimates” by Wan et al. develops a statistical approach based on Markov chain Monte Carlo techniques for joint data detection and channel estimation over time-varying frequency-selective channels with long delay spread. The paper “Groupwise Frequency Domain Multiuser MMSE Turbo Equalization for Single Carrier Block Transmission over Spatially-Correlated Channels” by Grossmann et al. studies group-wise soft interference cancelling minimum mean-squared error filtering combined with maximum a posteriori signal detection for multiple access single carrier block transmission.

The fourth group of papers addresses other aspects and applications of soft detection. The paper “Joint Decoding of LDPC Codes and Finite-State Channels via Linear-Programming by Kim et al. presents a linear programming LP formulation of joint detection and decoding, and develops an efficient iterative solver for the proposed joint LP decoder. The paper “Itera-
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