Editorial

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The turbo codes appeared in the early 90s. While the idea of iterative/turbo processing was first applied to decoding, the idea quite rapidly "gained" other blocks of the communication chain, leading to the nowadays well-known "turbo principle."

When coded information is interleaved and gets transmitted over a channel with interference (intersymbol, interantenna, interuser, and combinations thereof), joint detection/decoding can be achieved, named turbo (joint) detection.

Yet another application of this principle is the exploitation of the residual information available at the output of a source coder. The exploitation of this redundancy, together with decoding, leads to joint source/channel decoding.

Finally, there have also been attempts to make the synchronization units benefit from the soft information delivered by the decoder. These approaches are called turbosynchronisation.

The first group of papers deals with turbo codes and ways to improve their performance.

In "Iterative decoding of concatenated codes: A tutorial," P. A. Regalia gives a tutorial on iterative decoding presented as a tractable method to approach ML decoding and viewed as an alternating projection algorithm.

D. M. Rankin et al. in "Parallel and serial concatenated single parity-check product codes" provide bounds and simulation results on the performance of parallel and serially concatenated single parity-check product codes as component codes. These codes provide a good tradeoff between complexity and performance.

In "On rate-compatible punctured turbo codes design," F. Babich et al. give a low-complexity method to optimize the puncturing pattern for rate-compatible punctured turbo codes. BER simulation results are provided for puncturing patterns designed with this method and compared to the corresponding transfer function bound results.

In "Convergence analysis of turbo decoding of serially concatenated block codes and product codes," authored by A. Krause et al., the stability of iterative decoding of serially concatenated codes where the extrinsic information on parity check bits are passed on from one decoder to the other is analyzed. The authors show that in some cases, the restraining factor on the extrinsic is vital to guarantee the stability of the iterative decoding process. Results of the stability analysis are confirmed by simulation results.

In "Design of three-dimensional multiple slice turbo codes," D. Gnaedig et al. extend an idea they suggested in an earlier publication of introducing parallelism in the turbo decoding. They apply this parallel implementation to a turbo code architecture with three component encoders. They show that this approach leads to lower the hardware complexity and higher the performance in terms of a lower error floor.

In "Improved Max-Log-MAP turbo decoding by maximization of mutual information transfer," H. Claussen et al. suggest to improve the performance of a turbo decoder by maximizing the transfer of mutual information between the component decoders. The improvement in performance is achieved by using optimized iteration-dependent correction weights to scale the a priori information at the input of each component decoder.

A different approach to reducing complexity of turbo decoding is taken by X.-M. Chen and P. A. Hoeher in "Trellis-based iterative adaptive blind sequence estimation for uncoded/coded systems with differential precoding," where the authors develop iterative, adaptive trellis-based blind sequence estimators based on joint maximum-likelihood (ML) data/channel estimation. The number of states in the trellis serves as a design parameter, providing a tradeoff between performance and complexity.

The application of turbo codes to space-time coding is investigated in "System performance of concatenated STBC and block turbo codes in dispersive fading channels" by Y. Du and K. T. Chan. The authors demonstrate that the concatenation of a block turbo code and a space-time turbo code confers on the combined code both high coding gain and diversity gain.

The second group of papers is related to the general topic of turbo detection.

The application of turbo coding to equalization is studied by H. Vanhaute and M. Moonen in "Turbo-per-tone equalization for ADSL systems." Here, the authors propose and demonstrate the benefits of a frequency-domain turbo equalizer.

D. J. van Wyk et al. in "Super-orthogonal space-time turbo transmit diversity for CDMA" investigate the concept of layered super-orthogonal turbo-transmit diversity (SOTTD) for downlink DS-CDMA systems using multiple transmit and single receive antennas. Theoretical and simulation results show that this scheme outperforms classical code-division transmit diversity using turbo codes.

In "Iterative PDF estimation-based multiuser diversity detection and channel estimation with unknown interference," N. Veselinovic et al. propose a kernel smoothing PDF estimation of unknown cochannel interference to improve multiuser MMSE detectors with multiple receive antennas. This estimation can be performed using training symbols and can also be improved using feedback from channel decoder. Simulation results are provided on frequency-selective channels.

The paper "An iterative multiuser detector for turbo-coded DS-CDMA systems," by E. O. Bejide and F. Takawira, proposes an iterative multiuser detector for turbo-coded synchronous and asynchronous DS-CDMA systems. The approach proposed here is to estimate the multiple-access interference but instead of performing (soft) interference cancellation, the estimated interference is used as added information in the MAP estimation of the bit of interest.

C. Hermosilla and L. Szczeciński in "Performance evaluation of linear turbo receivers using analytical extrinsic information transfer functions" investigate the performance analysis of turbo receivers with a linear front end. The method is based on EXIT charts obtained using only available channel state information and is hence called analytical. At each iteration, the BER can be obtained.

The third group of papers is devoted to the use of the turbo principle to perform source decoding.

The paper "Joint source-channel decoding of variable-length codes with soft information: A survey," written by C. Guillemot and P. Siohan, is an overview paper about the joint source-channel decoding of variable-length codes with soft information. Recent theoretical and practical advances in this area are reported.

Turbo joint source-channel decoding is considered in "Iterative source-channel decoding: Improved system design using EXIT charts" by M. Adrat and P. Vary. The EXIT chart representation is used to improve the error correcting/concealing capabilities of iterative source-channel decoding schemes. New design guidelines are proposed to select appropriate bit mappings and to design the channel coding component.

In "LDGM codes for channel coding and joint source-channel coding of correlated sources," W. Zhong and J. Garcia-Frias propose to use low-density generator matrices (LDGM) codes. These codes offer a complexity advantage thanks to the sparseness of the encoding matrix. They are considered for the purpose of coding over a variety of channels, and for joint source-channel coding of correlated sources.

The paper "Iterative list decoding of concatenated source-channel codes" by A. Hedayat and A. Nosratinia focuses on the use of residual redundancy of variable-length codes for joint source-channel decoding. Improvement is obtained by using iterative list decoding, made possible thanks to a nonbinary outer CRC code.

Z. Tu et al. describe an efficient method to build syndrome former and inverse syndrome former for parallel and serially concatenated convolutional codes in "An efficient SF-ISF approach for the Slepian-Wolf source coding problem." This opens the way to the use of powerful turbo codes designed for forward-error correction for solving the Slepian-Wolf source coding problem. Simulation results show compression rates very close to the theoretical limit.

The final group of papers is related to the topic of soft information-driven parameter estimation.

As many coded systems operate at very low signal-to-noise ratios, synchronization is a difficult task. The theoretical aspects of the synchronization problem are studied in "Carrier and clock recovery in (turbo-) coded systems: Cramér-Rao bound and synchronizer performance" by N. Noels et al., where the Cramér-Rao bound (CRB) for joint carrier phase, carrier frequency, and timing estimation is derived from a noisy linearly modulated signal with encoded data symbols. On the practical side, H. Wymeersch and M. Moeneclaey in "Iterative code-aided ML phase estimation and phase ambiguity resolution" propose several iterative ML algorithms for joint carrier phase estimation and ambiguity resolution.

We wish all the readers a very exciting "special issue" that we believe is highly representative of the different trends currently observed in this research area.

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Luc Vandendorpe was born in Mouscron, Belgium, in 1962. He received the Electrical Engineering degree (summa cum laude) and the Ph.D. degree from the Université catholique de Louvain (UCL), Louvain-la-Neuve, Belgium, in 1985 and 1991, respectively. Since 1985, L. Vandendorpe is with the Communications and Remote Sensing Laboratory of UCL. In 1992, he was a Research Fellow at the Delft Technical University. From 1992 to 1997, L. Vandendorpe was a Senior Research Associate of the Belgian NSF at UCL. Presently, he is a Professor. He is mainly interested in digital communication systems: equalization, joint detection/synchronization for CDMA, OFDM (multicarrier), MIMO and turbo-based communications systems, and joint source/channel (de)coding. In 1990, he was corecipient of the Biennal Alcatel-Bell Award. In 2000, he was corecipient of the Biennal Siemen. L. Vandendorpe is or has been a TPC Member for IEEE VTC Fall 1999, IEEE Globecom 2003 Communications Theory Symposium, the 2003 Turbo Symposium, IEEE VTC Fall 2003, and IEEE SPAWC 2005. He is Cotechnical Chair (with P. Duhamel) for IEEE ICASSP 2006. He is an Associate Editor of the IEEE Transactions on Wireless Communications, Associate Editor of the IEEE Transactions on Signal Processing, and a Member of the Signal Processing Committee for Communications.

His current research interests are modulation, channel coding (turbo codes), joint source-channel coding, space-division multiplexing, and space-time coding. He received the Blondel Medal from SEE, France, in 2001. He is a Senior Member of IEEE and the IEEE ComSoc France Chapter Chair since 2001. He has been involved in several TPC conferences (Globecom, ICC, ISTC, ECWT, etc.) and was on the executive organization committee of ICC 2004 in Paris.

Alex M. Haimovich is a Professor of electrical and computer engineering at the New Jersey Institute of Technology (NJIT). He recently served as the Director of the New Jersey Center for Wireless Telecommunications, a state-funded consortium consisting of NJIT, Princeton University, Rutgers University, and Stevens Institute of Technology. He has been at NJIT since 1992. Prior to that, he served as the Chief Scientist of JJM Systems from 1990 until 1992. From 1983 till 1990, he worked in a variety of capacities, up to Senior Staff Consultant, for AEL Industries. He received the Ph.D. degree in systems from the University of Pennsylvania in 1989, the M.S. degree in electrical engineering from Drexel University in 1983, and the B.S. degree in electrical engineering from the Technion, Israel, in 1977. His research interests include MIMO systems, array processing for wireless, turbo-coding, space-time coding, and ultra-wideband systems, and radar. He recently served as a Chair of the Communication Theory Symposium at Globecom 2003. He is currently an Associate Editor for the IEEE Communications Letters.

Ramesh Pyndiah was qualified as an Electronics Engineer from "ENST Bretagne" in 1985. In 1994, he received his Ph.D. degree in electronics engineering from "l'Université de Bretagne Occidentale" and in 1999, his HDR (Habilitation à Diriger des Recherches) from "Universit de Rennes I." From 1985 to 1990, he was a Senior Research Engineer at the Philips Research Laboratory (LEP) in France where he was involved in the design of monolithic microwave integrated circuits (MMIC) for digital radio links. In October 1991, he joined the Signal & Communications Department of "ENST Bretagne," where he developed the concept of block turbo codes. Since 1998, he is the Head of the Signal & Communications Department. He has published more than fifty papers and holds more than ten patents.