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Editorial

Cooperative Communications in Wireless Networks

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Next-generation wireless networks will go beyond the point-to-point or point-to-multipoint paradigms of classical cellular networks. They will be based on complex interactions, where the involved nodes cooperate with one another in order to improve the performance of their own communication and that of the global network. Cooperative communications based on relaying nodes have emerged as a promising approach to increase spectral and power efficiency, network coverage, and to reduce outage probability. Similarly to multiantenna transceivers, relays provide diversity by creating multiple replicas of the signal of interest. By properly coordinating different spatially distributed nodes in a wireless system, one can effectively synthesize a virtual antenna array that emulates the operation of a multiantenna transceiver.

The demand for new-generation wireless networks has spurred a vibrant flurry of research on cooperative communications during the last few years. Nevertheless, many aspects of cooperative communications are open problems. Furthermore, most of the cooperative systems proposed so far are based on ideal assumptions, such as unfeasible synchronization constraints between the relay nodes or the availability of perfect channel state information at the resource allocation unit. There is a need for research on practical ways of realizing cooperative schemes based on realistic assumptions. The objective of this special issue is to contribute to this twofold objective: to advance in the understanding of cooperative transmission and to explore practical limitations of realistic cooperative systems.

The first four articles of this special issue focus on the first objective, mainly. They analyze and, eventually, optimize the performance of cooperative protocols. Cooperative diversity is expected to provide significant improvement in terms of outage probability in systems affected by slow fading and shadowing. Nevertheless, the analysis of relay-assisted systems affected by lognormal fading has not received much attention. In the first article of this special issue, D. Skraparlis, V. Sakarellos, A. Panagopoulos, and J. Kanellopoulos analyze the effects of correlated lognormal fading in regenerative relay-assisted networks assuming maximum ratio combining (MRC) or selection combining (SC) at the destination. An exact analytical expression of the outage probability has been provided for both orthogonal relay schemes based on time or frequency division multiple-access protocols and nonorthogonal schemes supported by full-duplex relays and directive antennas at the sources. The analysis points out the significant impact that the fading correlation has on the system performance. Additionally, the quality of the source-relay link is shown to be a critical factor in the performance of all the considered systems. More specifically, the variance of the lognormal fading link source-relay has to be smaller than the variance of the source-destination link.

The second article is coauthored by L. Vanderdorpe, J. Louveaux, O. Oguz, and A. Zaidi, and considers a decode-and-forward relay setup with OFDM modulation at the source and the relay. The article considers a relaying protocol according to which the relay adaptively forwards detected data from the source. For each relayed carrier, the destination implements maximum ratio combining between the signal received from the source and the signal received from the relay. The authors investigate power allocation schemes for this protocol, both under an individual and a sum-power constraint assuming perfect channel state information.

In the third article, **Ö.**Oruz and U. Aygölü delve into the appropriate coding schemes for a two-user cooperative communications channel. They propose the use of coordinate interleaved trellis codes over QPSK and 8PSK modulations exploiting both cooperative and modulation diversities over Rayleigh channels. Using upper bounds on the pair-wise error probability, the authors derive coding design criteria related to the cooperation feasibility, diversity order, and coding advantage. New cooperative trellis codes are obtained by exhaustive computer search. Using numerical evaluation, these codes are shown to outperform some reference space-time codes used in cooperation with coordinate interleaving.

The issue continues with a contribution by R. Vaze and R. W. Heath Jr. on the diversity-multiplexing tradeoffs for multiple-antenna, multiple-relay channels. The authors begin by considering a multihop relay channel and investigate an end-to-end antenna selection strategy. The proposal is to look at the selection of a subset of antennas per relay, and find the path that maximizes the mutual information among all possible paths. A compression protocol for the two-hop relay channel, including the direct link, is considered. In both cases, the goal is to design protocols to touch all points of the optimal diversity multiplexing tradeoff region.

Cooperative communications are reasonably well understood from the theoretical perspective. However, practical realizations of cooperative communication systems are still quite limited. For this reason, the last three articles in this special issue are devoted to implementation aspects related to cooperative communication systems.

In the first one, P. Zetterberg, C. Mavrokefalidis, A. Lalos, and E. Matigakis provide an experimental evaluation of different cooperative communication protocols from the physical-layer point of view. The presented results were obtained from a real-time testbed consisting of four nodes and implementing, among others, amplify-and-forward, decode-and-forward, as well as distributed space-time coding techniques. The authors elaborate the practical computational requirements and constraints of the cooperative techniques under evaluation, and they provide an accurate assessment of the performance loss associated with the implementation of each technique. The presented results will be very useful in order to select appropriate cooperative techniques for practical realizations of cooperative communications in future wireless communication networks.

In the second article, devoted to implementation aspects of cooperative communications, P. Murphy, A. Sabharwal, and B. Aazhang present the results of over-the-air experiments for an amplify-and-forward cooperative system based on orthogonal frequency division multiplexing. The system uses a distributed implementation of an Alamouti code and discusses several interesting implementation issues. Experimental results show gains in the order of 5 dB to maintain comparable error rates. Quite remarkably, the authors show that a significant number of components used in conventional noncooperative channels need not be altered to allow implementation of cooperative OFDM.

Finally, the last article in this special issue takes an experimental approach to develop an understanding of cooperative communications at the MAC layer. In this article, T. Karakis, Z. Tao, S. R. Singh, P. Liu, and S. S. Panwar present two different implementations in order to demonstrate the practical viability of realizing cooperative communications in a real environment. Their article describes the technical challenges encountered in the implementation of these approaches, as well as the rationale behind the corresponding solutions that were proposed. It is shown, via experimental measurements, that cooperative communications are very promising techniques in order to boost the performance of practical wireless network.

Given the vast amount of research in cooperative wireless communications, this special issue can be no more than a sample of recent progress. Nevertheless, we hope you will enjoy reading it as much as we did organizing it.

We would like to take this opportunity to thank the authors for their efforts in the preparation of their manuscripts. We are also very grateful to the reviewers who refereed the manuscripts in a timely manner and provided valuable feedback to the authors. We would also like to acknowledge the fact that the work by part of the team of guest editors has been supported by the FP7 Network of Excellence NEWCOM++ (216715).

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