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Editorial
Multiuser Cooperative Diversity for Wireless Networks

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Multihop relaying technology is a promising solution for future cellular and ad hoc wireless communications systems in order to achieve broader coverage and to mitigate wireless channels impairment without the need to use high power at the transmitter. Recently, a new concept that is being actively studied in multihop-augmented networks is multiuser cooperative diversity, where several terminals form a kind of coalition to assist each other with the transmission of their messages. In general, cooperative relaying systems have a source node multicasting a message to a number of cooperative relays, which in turn resend a processed version to the intended destination node. The destination node combines the signal received from the relays, possibly also taking into account the source's original signal. Cooperative diversity exploits two fundamentals features of wireless medium: its broadcast nature and its ability to achieve diversity through independent channels. There are three advantages from this.

(1) Diversity. This occurs because different paths are likely to fade independently. The impact of this is expected to be seen in the physical layer, in the design of a receiver that can exploit this diversity.
(2) Beamforming gain. The use of directed beams should improve the capacity on the individual wireless links. The gains may be particularly significant if space-time coding schemes are used.
(3) Interference mitigation. A protocol that takes advantage of the wireless channel and the antennas and receivers available could achieve a substantial gain in system throughput by optimizing the processing done in the cooperative relays and in the scheduling of retransmissions by the relays so as to minimize mutual interference and facilitate information transmission by cooperation.

In response to the demand for novel ideas and results, this special issue presents a sample of current activities and up-to-date efforts in design, implementation, and performance analysis of cooperative diversity systems. A brief summary of each paper is listed as follows.

In the first paper by Z. Yang and A. Høst-Madsen, the cooperation efficiency of the multiple-relay channel when carrier-level synchronization is not available is investigated, assuming that all nodes use a decode-forward scheme. It is shown that by using decode-forward relay signaling, the transmission is interference-free, even when all communications share one common physical medium. Furthermore, for any channel realization, there always exist a sequential path and a corresponding simple power-allocation policy, which are optimal. To illustrate the efficiency of cooperation and provide prototypes for practical implementation of relay-channel signaling, the authors propose two heuristic algorithms. Finally, the numerical results show that in the low-rate regime, the gain from cooperation is limited, while the gain is considerable in the high-rate regime.

In the second paper, by D. Wang and U. Tureli, the authors try to face the inefficiencies caused due to the existing medium-access control (MAC) schemes, when multiple-input multiple-output (MIMO) transmit/receive schemes and orthogonal frequency-division multiplexing (OFDM) are used in broadband multihop ad hoc networks. A new transceiver architecture with MIMO-OFDM and MAC scheme is proposed, named multiple-antennas receiver-initiated busy-tone medium access (MARI-BTMA), which is based on receiver-initiated busy-tone medium access (RI-BTMA) and uses multiple out-of-band busy tones to avoid the collision of nodes on the same channel. With the proposed MAC scheme, multiple users can transmit simultaneously in the same neighborhood. Although the proposed MARI-BTMA shows good performance at high traffic load, to improve the performance at low traffic loads, 1-persistent MARI-BTMA is proposed so that users can choose different MAC schemes according to the statistical traffic load in the system. In the same paper, both theoretical and numerical analyses of the throughput and delay are presented, while analytical and simulation results show the improved performance of MARI-BTMA compared with RI-BTMA and carrier sensing medium access/collision avoidance (CSMA/CA).

In the third paper, by Y. Yuan et al., a cluster-based cooperative MIMO scheme is proposed to reduce the adverse impacts caused by radio irregularity and fading in multihop wireless sensor networks. This is an extension of the LEACH protocol, enabling the multihop transmissions among clusters by incorporating a cooperative MIMO scheme into hop-by-hop transmissions. The proposed scheme can gain effective performance improvement through the adaptive selection of cooperative nodes and the coordination between multihop routing and cooperative MIMO transmissions. Moreover, the optimal parameters which minimize the overall energy consumption, such as the number of clusters and the number of cooperative nodes, are derived. Simulation results exhibit that the proposed scheme can effectively save energy and prolong the network lifetime.

In the fourth paper, by T. Abe et al., the MIMO relay scheme is proposed where each of the multiple-relay nodes performs QR decompositions of the backward and forward channel matrices in conjunction with phase control (QR-P-QR). A group nulling approach is used to decompose a multiple source-destination (SD) MIMO relay channel into parallel independent SD MIMO relay channels, and then apply the QR-P-QR scheme to each of the decomposed MIMO relay links. Numerical examples show that the proposed relay scheme offers higher capacity than other existing relay schemes.

In the last paper by T. A. Tsiftsis et al., the end-to-end performance of dual-hop cooperative selective diversity links, equipped with nonregenerative relays and operating over nonidentical Nakagami-m fading channels, is studied. Closed-form expressions are presented for the cumulative distribution function and the probability density function of the end-to-end signal-to-noise ratio (SNR), while analytical formulae are derived for the moments and the moment-generating function. The proposed mathematical analysis is complemented by numerical examples, including the effects on the overall performance of the SNRs unbalancing as well as the fading severity.

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George K. Karagiannidis was born in Pithagorion, Samos Island, Greece. He received his university degree in 1987 and his Ph.D. degree in 1999, both in electrical engineering, from the University of Patras, Patras, Greece. From 2000 to 2004, he was a Researcher at the Institute for Space Applications and Remote Sensing, National Observatory of Athens, Greece. In June 2004, he joined the faculty of Aristotle University of Thessaloniki, Greece, where he is currently an Assistant Professor at the Electrical and Computer Engineering Department. His major research interests include wireless communications theory, digital communications over fading channels, cooperative diversity systems, satellite communications, and free-space optical communications. He has published and presented more than 70 technical papers in scientific journals and international conferences, he is a coauthor in two chapters in books and also coauthor in a Greek edition book on mobile communications. He acts as a reviewer for several international journals and he served as a Technical Program Committee Member for ICC '04 and ICC '05. He is Member of the editorial boards of IEEE Communications Letters and EURASIP Journal on Wireless Communications and Networking.

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