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Editorial

Multiuser MIMO Transmission with Limited Feedback, Cooperation, and Coordination

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Wireless communication systems are already exploiting powerful multiple antenna technologies based on the principles of multiple input multiple output (MIMO) communication. By now, the principles of single user MIMO communication links are well understood. The next generation of systems, though, will use more advanced MIMO communication strategies that support multiuser MIMO. In this way, the spatial degrees of freedom can be better exploited by properly scheduling multiple users. However, multiple user communication with MIMO is more challenging than single user MIMO because channel state information at the transmitter is crucial to enhance the system capacity and also due to the additional degrees of freedom entailed by suppressing, cancelling, or avoiding interference. For example, limited feedback algorithms that are used to quantize channel state information at the receiver and send this information back to the transmitter(s) or relay(s) become more complex, since they need much higher resolution to achieve similar performance as their single-user counterparts. Consequently, advances in limited feedback communication are still required to make multiuser MIMO viable in next-generation systems.

Although using multiuser MIMO within individual cells has considerable potential, even larger performance gains can be achieved by using multiuser MIMO across cooperative base stations. In the ideal case with perfect cooperation across all cells, the set of all base station antennas can be thought of as a single, distributed antenna array. Significant gains can also be achieved by some level of local coordination, for example, neighboring base stations might jointly choose beamforming directions in order to achieve interference alignment. In this general setting, there are fundamental challenges associated with transceiver design, limited channel information, and cooperative mechanisms.

For this special issue we received 23 submissions of which we accepted nine. All papers were peer reviewed by multiple reviewers. We summarize the papers accepted for the special issue as follows.

The article entitled "Space-frequency block code with matched rotation for MIMO-OFDM system with limited feedback" by M. Zhang et al. presents a novel matched rotation precoding (MRP) scheme to design a rate one space-frequency block code (SFBC) and a multirate SFBC for MIMO-OFDM systems with limited feedback. The proposed rate one MRP and multirate MRP can always achieve full transmit diversity and optimal system performance for arbitrary number of antennas, subcarrier intervals, and subcarrier groupings, with limited channel knowledge required by the transmit antennas. Simulations show that the proposed SFBC with MRP can overcome the diversity loss for specific propagation scenarios, always improve the system performance, and thus demonstrate flexibility and feasibility making it suitable for a practical MIMO-OFDM system with dynamic parameters.

The article entitled "On the asymptotic optimality of opportunistic norm-based user selection with hard SINR constraint" by X. Zhang et al. studies the optimality of the opportunistic norm-based user selection system in conjunction with hard SINR requirements under max-min fair beamforming transmit power minimization. It is shown that not only as the number of transmitting antennas goes to infinity but also when a limited number of transmit antennas and/or median range of users are available, only insignificant performance degradation is observed with respect to the optimum in simulations with an ideal channel model or based on measurement data.

The article entitled "Mode switching for multi-antenna broadcast channel based on delay and channel quantization" by J. Zhang et al. considers the degradation of the performance of multiple-input multiple-output (MIMO) communications by imperfect channel state information and shows that its effect on single-user (SU) and multiuser (MU) MIMO transmissions is quite different. In particular, MU-MIMO suffers from residual interuser interference due to imperfect channel state information while SU-MIMO only suffers from a power loss. This paper compares the throughput loss of both SU and MU-MIMO in the broadcast channel due to delay and channel quantization. Accurate closed-form approximations are derived for achievable rates for both SU and MU-MIMO. Based on derived achievable rates, a mode switching algorithm is proposed, which switches between SU and MU-MIMO modes to improve the spectral efficiency based on average signal-to-noise ratio (SNR), normalized Doppler frequency, and the channel quantization codebook size. The operating regions for SU and MU modes with different delays and codebook sizes are determined, and they can be used to select the preferred mode.

Limited feedback enables the practical use of channel state information in multiuser multiple-input multiple-output (MIMO) wireless communication systems. Unfortunately, when codebooks are used to quantize the channel state, achieving the high resolution required with multiuser MIMO communication is challenging due to the large number of codebook entries required. The article entitled "Progressive refinement of beamforming vectors for high resolution limited feedback" by R. W. Heath et al. proposes to use a progressively scaled local codebook to enable high resolution quantization and reconstruction for multiuser MIMO with zero-forcing precoding. New local Grassmannian codebook designs are provided along with several new algorithms for implementing the progressive quantization with low complexity.

The article entitled "Limited feedback multiuser MIMO techniques for time-correlated channels" by E. Zacarias et al. studies limited feedback for single-user and multiuser MIMO transmission. In the first half of the paper, the role of limited feedback for single-user MIMO systems in the presence of strong interfering signals is investigated. In this setting the optimal transmit strategy depends on the channel as well as the spatial structure of the interference, and methods for feeding back such information are proposed and analyzed. In the second half of the paper, a partial feedback mechanism for multiuser MIMO systems with time correlated channels is proposed. The proposed method tracks each entry of the channel matrix using single-bit quantization, and further limits the feedback rate by feeding back information for only a few of the channel entries during each feedback slot.

The article entitled "Effects of mutual coupling and noise correlation on downlink coordinated beamforming with limited feedback" by Y. Dong et al. considers the impact of receiver correlation, antenna coupling, matching, and noise on the performance of coordinated beamforming systems. A novel coordinated beamforming technique for two receivers is presented, suitable for MIMO broadcast channels with signal and noise correlation at the receiver end. Numerical results suggest that, even in the presence of strong coupling, most of the benefits of coordinated beamforming can be preserved by using appropriate matching networks and linear beamforming. Such benefits can be achieved even with limited feedback.

Ubaidulla and Chockalingam contribute the article entitled "Robust THP transceiver designs for multiuser MIMO downlink with imperfect CSIT" which discusses Tomlinsson-Harashima precoding based on two different models for the uncertainty in channel state information at the transmitter (CSIT). The first model assumes that the CSIT error is Gaussian-distributed; whereas the second model bounds the norm which results in an uncertainty set. The authors propose iterative algorithms involving semi-denite programs (SDPs). Finally they show that the proposed robust designs outperform nonrobust designs as well as robust linear transceiver designs reported in the recent literature.

The article entitled "Downlink multicell processing with limited backhaul capacity," by O. Simeone et al. discusses performance limits in linear cellular system using the Wyner model with base station coordination. The authors derive achievable rates for different transmission configurations that require varying degrees of side information and thus have different backhaul capacity requirements. They show that side information in the form of codebook information is required for achieving high data rates, while multicell processing with no codebook side information provides adequate performance for low data rate targets.

The article entitled "A WiMAX-based implemenation of network MIMO for indoor wireless systems" by S. Venkatesan et al. establishes the performance that can be achieved in indoor networks using network MIMO, or base station coordination. They quantify the gains in spectral efficiency under realistic indoor propagation conditions through comprehensive simulations within the framework of IEEE 802.16e Mobile WiMAX standard. A major outcome of the paper is to show that with sufficient backhaul connections between the base stations, multifold increases in spectral efficiency are achieved using network MIMO. This confirms that multicell coordination is one viable solution to improving capacity in cellular sytems.

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