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E-mail: jzus@zju.edu.cn

Editorial:

Special issue on 5G wireless communication systems and technologies

Ping ZHANG
(*Beijing University of Posts and Telecommunications, Beijing 100876, China*)
E-mail: pzhang@bupt.edu.cn

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Recently, the explosive growth of data traffic due to ubiquitous smart devices has accelerated the current 4G systems towards further technological evolution. Indeed, we are now moving into the 5G era as we reach for 2020 and beyond. Compared with 4G mobile communications, 5G needs to meet extremely high performance requirements in more diverse scenarios. These requirements are challenging and may even be conflicting, and need the design of new network architectures, new radio access techniques, and new transmission waveforms.

In recent years, both academia and industry have shown a lot of interest in the key techniques of 5G systems, such as network framework, massive multiple-input multiple-output (MIMO), full-duplex, physical layer security, device-to-device (D2D), and energy harvesting. However, there are still many technical challenges to overcome before the deployment of 5G networks. Hence, the objective of this special issue is to showcase contributions from both academia and industry to motivate discussions on advanced and innovative techniques for 5G.

The papers in this special issue can be categorized into two groups. The first group consists of one review paper, and the second group eight research papers.

In the first group, Ali *et al.* (2017) discussed the state-of-the-art research on different beamforming techniques for massive MIMO systems in 5G, and clarified the importance of beamforming techniques in massive MIMO systems for eliminating and resolving the many technical hitches that massive MIMO system implementation faces. Classifications of optimal beamforming techniques adopted in wireless communication systems were reviewed in detail to determine which techniques are more suitable for deployment in massive MIMO systems to improve the system throughput and reduce intra- and inter-cell interferences.

In the second group, Li *et al.* (2017) presented an indoor measurement campaign for massive MIMO radio channels using a high-performance frequency domain channel sounder with different virtual large-scale arrays. The measurement system uses different array topologies including a 64-element linear array, a 64-element planar array, and a 128-element planar array.

Zhang *et al.* (2017) investigated the full-rate space-time block code (FSTBC) transmission scheme for the amplify-and-forward relay D2D system. To improve the transmission efficiency and achieve better communication quality, two low-complexity detection methods were designed to circumvent the prohibitive complexity problem of traditional maximum likelihood detection for FSTBC transmission, namely, detection methods with the maximum likelihood combining algorithm and the joint conditional maximum likelihood detector.

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Yuan *et al.* (2017) focused on secure relay beamforming design with a correlated channel model in the relaying network. Depending on correlation

information, they derived the conditional distribution of the eavesdropping channel. Specifically, two beamforming designs at the relay were studied for the approximate ergodic secrecy rate.

Wang *et al.* (2017) studied the optimal precoding for a full-duplex system. In the presence of residual self-interference (SI) after imperfect SI cancellation, the downlink transmission rate maximization problem subject to a targeted uplink rate was formulated as a non-convex optimization problem to characterize the achievable rate region for the considered system. Considering the case in which the SI channel was strongly correlated, the above problem was transformed into a convex problem by exploiting the rank-one property of the SI channel.

Feng *et al.* (2017) developed a joint user association and resource partition framework for downlink-uplink decoupling (DUDe) for a tiered heterogeneous cellular network. Different from the traditional association rules such as maximal received power and range extension, a coalition-game-based scheme was proposed for the optimal user association with DUDe.

Zhang and Lyu (2017) provided an interference coordination framework for a two-tier heterogeneous network (HetNet) that consists of a massive-MIMO enabled macro-cell base station (MBS) and a number of full-duplex small-cell base stations (SBSs). To suppress the interference and maximize the throughput, the full-duplex mode of each SBS at the wireless backhaul link should be carefully selected. To address this problem, they proposed two centralized algorithms, a genetic algorithm and a greedy algorithm.

Kuang *et al.* (2017) proposed a novel method of joint two-dimensional direction-of-arrival (DOA) and channel estimation with data detection for uniform rectangular array in the massive MIMO system. They first estimated the channel impulse responses by using training sequences. After that, the DOAs of waves were estimated based on a unitary ESPRIT algorithm using previous channel impulse responses estimation instead of accurate channel impulse responses, and then the enhanced channel impulse responses estimation can be obtained.

Niu *et al.* (2017) investigated a joint robust cooperative beamforming and artificial noise scheme for secure communication in amplify-and-forward relay networks by treating the energy receiver as a potential eavesdropper. To solve the formulated non-convex worst-case secrecy rate maximization problem, they proposed a two-level optimization approach which involves one-dimensional search and semi-definite relaxation.

We thank all the authors for their contributions to the special issue. We appreciate the dedication of the reviewers for their time and careful reviews. It is our hope that these papers capture some of the latest major scientific developments in the field, and that they can serve as a springboard for further improvements and developments. The great support from the editorial office is also highly appreciated.

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