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Editorial

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Reconfigurable Intelligent Surface (RIS), also known as intelligent reflecting surface or large intelligent surface, is an emerging new physical-layer technology in the field of wireless communications. The basic idea of RIS is to deploy a reconfigurable passive array in the environment to manipulate the propagation of electron-magnetic waves. RIS promises a new design paradigm for wireless communications, where the wireless propagation environment can be dynamically controlled, which is substantially different from the conventional design that focuses only on the transmitter and receiver. For RIS-aided wireless communications, some of the current methodologies in conventional communication systems need to be revised, and some novel solutions are required to realize the potential benefits of the RIS. Although the number of publications about RIS has recently sharply increased, there are still many challenging issues to be extensively investigated, such as the RIS channel modeling, fundamental performance limits, the system design, joint optimization of the RIS and the transceivers, channel state information acquisition, and interdisciplinary applications. The goal of this Special Issue on "Reconfigurable Intelligent Surface Aided Wireless Communications" of *Intelligent and Converged Networks* (ICN) is to attract high-quality papers of original research on RIS-aided wireless communications. The response from the community to the call has been overwhelming. Many of the submissions are from the most well known research groups in the field. After a strict review process, we decided to accept 8 papers, which were selected based on the technical relevance and merits.

This issue contains 8 papers, covering a wide selection of topics as follows.

Motivated by the recent increasing interests in the field of RISs and the consequent pioneering concept of the RIS-enabled smart wireless environments, the first paper, entitled "*Reconfigurable intelligent surfaces for wireless communications: Overview of hardware designs, channel models, and estimation techniques*", is an RIS tutorial, which overviews the latest advances in RIS hardware architectures as well as the most recent developments in the modeling of RIS unit elements and RIS-empowered wireless signal propagation. The authors also present a thorough overview of the channel estimation approaches for RIS-empowered communications systems, which constitute a prerequisite step for the optimized incorporation of RISs in future wireless networks. Finally, this paper discusses the relevance of the RIS technology in the latest wireless standards, and highlights the current and future standardization activities for the RIS technology and the consequent RIS-empowered wireless networking approaches.

The second paper, entitled "*Reconfigurable intelligent surface-aided wireless communications: An overview*", is also a tutorial. Specifically, different from the conventional active phased antenna array, there is no dedicated radio-frequency chain installed at the RIS to perform complex signal processing operations. Taking advantage of its working principle, RIS can be deployed in an indoor/outdoor environment to dynamically manipulate the propagation environment. This paper first reviews the latest advances in RIS, including the application scenarios,

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system model, channel model, and the information theoretic analysis. Then, the authors discuss the promising physical realization and the key signal processing techniques such as precoding and channel estimation. Finally, the prototyping of RIS systems is presented in this paper, and some interesting future research problems for the RIS-aided communications are given.

In the third paper, entitled "*Maximizing dirty-paper coding rate of RIS-assisted multi-user MIMO broadcast channels*", a downlink multi-user scenario is investigated, where RIS is used to maximize the dirty-paper-coding (DPC) sum rate of the RIS-assisted broadcast channel. Different from prior works, which maximize the rate achievable by linear precoders, this paper assumes a capacity-achieving DPC scheme is employed at the transmitter and optimizes the transmit covariances and RIS reflection coefficients to directly maximize the sum capacity of the broadcast channel. This paper proposes an optimization algorithm that iteratively alternates between optimizing the transmit covariances using convex optimization and the RIS reflection coefficients using Riemannian manifold optimization. Simulation results show that the proposed technique can be used to effectively improve the sum capacity in a variety of scenarios compared to benchmark schemes.

The forth paper, entitled "*Performance analysis of reconfigurable intelligent surface assisted systems under channel aging*", investigates the performance of an RIS-assisted multi-user multiple-input single-output (MISO) wireless communication system considering the impact of channel aging caused by the users' relative movement. In particular, the authors first propose a model incorporating the joint effects of channel aging and channel estimation error to investigate the performance of the RIS-assisted system. Then, the novel closed-form expressions for characterizing the sum spectral efficiency with zero-forcing precoding are derived. From these analysis, this paper unveils that increasing the number of reflecting elements on the RIS generally yields a better system performance, but with a diminishing return when the number of elements is sufficiently large. Finally, simulation results are presented in this paper to validate the accuracy of the analytical results.

The fifth paper, entitled "*User cooperation for RIS-aided secure MIMO systems*", proposes to use RIS to enhance the physical layer security in the Rician fading channel where the angular direction of the eavesdropper is aligned with a legitimate user. In this scenario, this paper considers a two-phase communication system under the active attacks and passive eavesdropping. Under the active attacks, this paper investigates an outage constrained beamforming design problem under the statistical cascaded channel error model, which is solved by using the Bernstein-type inequality. As for the passive eavesdropping, an average secrecy rate maximization problem is formulated, which is addressed by a low-complexity algorithm. Finally, numerical results in this paper show that the negative effect of the eavesdropper's channel error is larger than that of the legitimate user.

Benefiting from the growth of the bandwidth, Terahertz (THz) massive MIMO can support the new application with explosive requirements for future 6G wireless systems. In the sixth paper titled "*Reconfigurable intelligent surface based hybrid precoding for THz communications*", an RIS-based hybrid precoding architecture for THz communication is developed. To address the challenging problem of phase shift optimization, the sum-rate maximization problem is reformulated as a parallel deep neural network based classification problem, which can be solved by the proposed low-complexity deep learning based multiple discrete classification (DL-MDC) hybrid precoding scheme. Finally, this paper provides numerous simulation results to show that the proposed DL-MDC scheme works well both in the theoretical Saleh-Valenzuela channel model and practical 3GPP channel model.

The seventh paper, entitled "*Aerial intelligent reflecting surface for secure wireless networks: Secrecy capacity and optimal trajectory strategy*", studies the potential of the aerial intelligent reflecting surface (AIRS) in secure communication, where an RIS-carried by an unmanned aerial vehicle is utilized to help the communication between the ground nodes. Specifically, this paper formulates the joint design of the AIRS's deployment and the phase shift to maximize the secrecy rate. To solve the non-convex objective, the authors develop an alternating

optimization approach, where the phase shift optimization is solved by the Riemannian manifold optimization method. To reduce the complexity, this paper employs an element-wise block coordinate descent based method. Simulation results verify the effect of AIRS in improving the communication security, as well as the importance of designing the deployment and phase shift properly.

In the eighth paper, entitled "*Reconfigurable intelligent surface assisted grant-free massive access*", the authors propose to leverage the burgeoning RIS for grant-free massive access working at millimeter-wave frequency to further boost the access reliability. By attaching independently controllable phase shifts, reconfiguring, and refracting the propagation of incident electromagnetic waves, the deployed RISs could provide additional diversity gain and enhance the access channel conditions. On this basis, to address the challenging active device detection (ADD) and channel estimation (CE) problem, this paper develops a joint-ADDCE (JADDCE) method by resorting to the existing approximate message passing algorithm with expectation maximization to extract the structured common sparsity in traffic behaviors and cascaded channel matrices. Finally, simulations are carried out to demonstrate the superiority of the proposed scheme.

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