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Beyond Diagonal RIS-assisted Multiple Antenna Communications

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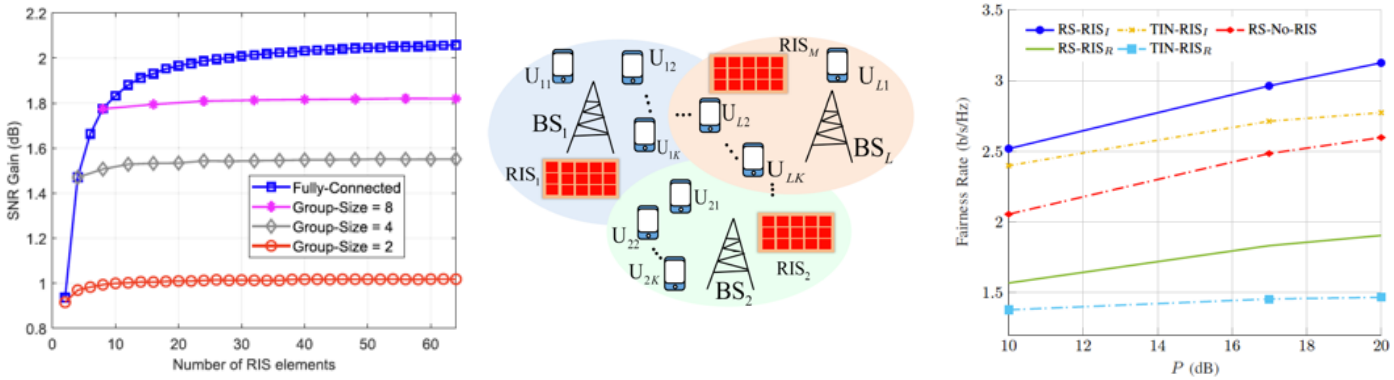
What are the gains of beyond diagonal RIS in single user MIMO links? How can we optimize the BD-RIS matrix efficiently? How can BD-RIS be combined with rate splitting in ultra-reliable low-latency energy efficient communications?



In the left figure, the signal-to-noise ratio gain of beyond-diagonal RIS compared to diagonal RIS for a single user multiple antenna link is illustrated over the number of RIS elements. The fully connected RIS architecture allows to re-distribute the received signal energy between all RIS elements while the group-connected architecture allows energy distribution among the group. We then apply the BD-RIS to multi-cell downlink transmission as shown in the system model in the middle figure. Together with rate splitting BD-RIS shown significant gains in terms of fairness rate.

KEY FINDINGS

Beyond diagonal RIS architecture has higher hardware and circuit complexity but allows more degrees of freedom in optimization of the reflection properties of the surface. In the first work [1], we study the gain of BD-RIS compared to standard diagonal RIS architecture for single-user multiple antenna links. To perform a fair comparison, we develop an efficient optimization algorithm for the RIS matrix based on Takagi's factorization. In the second paper [2], BD-RIS are placed in a multi-cell downlink transmission scenario with rate splitting within ultra-reliable low-latency communications. The second order achievable rates are optimized with respect to beamforming, power control, and BD-RIS matrix. we show that RSMA and RIS can be mutually beneficial tools when the system is overloaded, i.e., when the number of users per cell is higher than the number of base station antennas. Additionally, we show that the benefits of RSMA increase when the packets are shorter and/or the reliability constraint is more stringent. Furthermore, we show that the RSMA benefits increase with the number of users per cell and decrease with the number of BS antennas. Finally, we show that RIS can highly improve the system performance, and BD-RIS outperforms regular RIS.

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M. Soleymani, I. Santamaria, E. Jorswieck and B. Clerckx, "Optimization of Rate-Splitting Multiple Access in Beyond Diagonal RIS-assisted URLLC Systems," in IEEE Transactions on Wireless Communications