Uninterrupted and Continuous Connectivity in Wireless Networks Using RISs

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Clusters
Lichtenberg II Cluster Darmstadt

Software
MATLAB

Institute
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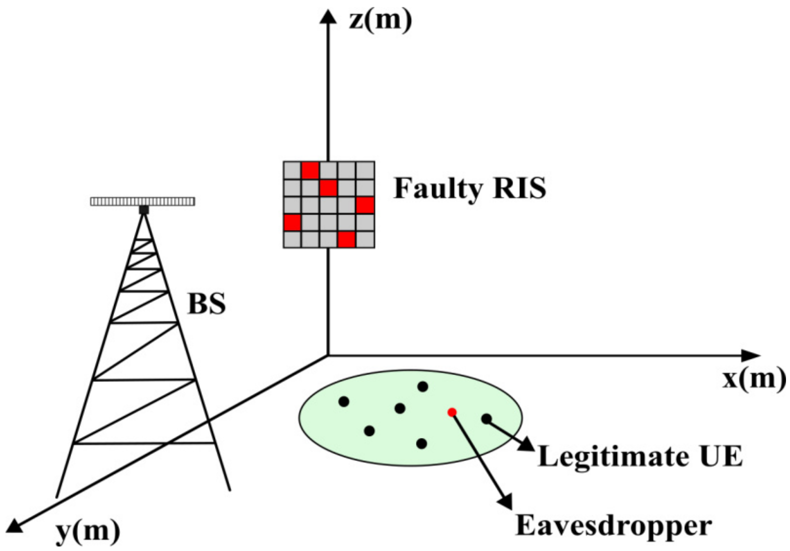

Figure 1: Simulation setup

Introduction

Reconfigurable Intelligent Surfaces (RISs) are being explored to enhance wireless links when the line of sight (LoS) between a transmitter and a receiver is blocked by obstacles. By applying controllable phase shifters, an RIS can redirect incident energy toward the intended user equipment and thereby improve the experienced quality of service. In practice, however, RIS undergoes hardware issues. In other words, reflecting elements may fail and thus cannot steer the signals to the intended user equipment. This can produce unwanted leakage in the network and lower the secrecy rate of the legitimate users.

Methods

To mitigate leakage and enhance confidentiality, the project studies two optimization problems: (i) sum secrecy-rate maximization and (ii) max-min signal-to-leakage-and-noise ratio (SLNR). Both are highly nonconvex (NP-hard) joint designs over transmit precoders and RIS phase shift configurations. We employ an Alternating Optimization (AO) framework, where we fix one variable and optimize the other one, repeating until convergence. Subproblems are cast as generalized Rayleigh-quotient updates or convex approximations solved numerically in MATLAB (CVX and custom routines). Because performance must be evaluated over realistic random network layouts, we run large Monte Carlo iterations (approximately 1000 realizations of user/obstacle/eavesdropper positions) and average the metrics. The nested AO iterations inside each realization make the computational load too heavy for a personal laptop, motivating the use of high-performance computing (HPC) resources. Each trial builds and factorizes channel and covariance matrices that scale with base-station, user, and RIS element counts. Keeping AO variables for about 1000 trials stresses memory and runtime locally, so simulations run in parallel on the cluster.

Results

Initial large-scale runs on the cluster revealed that the proposed algorithms were not delivering the expected behavior: AO objective values occasionally stagnated or decreased, and increasing the number of RIS elements did not consistently raise the max-min SLNR or the sum secrecy rate. Moreover, it was expected to face a decrease in the sum secrecy rate with the increase of faulty elements. However, the results did not depict this. These anomalies suggested that the mathematical problem statements or their numerical implementations still contained errors.

Discussion

Using the diagnostic output from the HPC runs, we revisited the derivations and wireless channel modeling assumptions. This led us to identify the issue to correct several mathematical steps and revise parts of the proposed approach. The simulations need to be run again using the newly defined problem. The goal is to recover monotonic improvement across AO iterations and to observe non-decreasing performance trends as the number of effective RIS elements/faulty elements grows.

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