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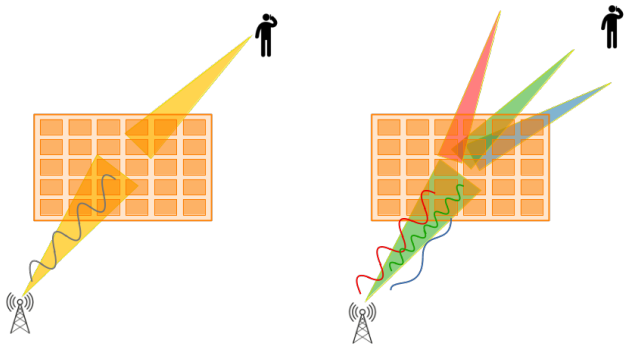
Bachelor's Thesis

How Reconfigurable Intelligent Surfaces Behave in Wideband Communication Systems

Abstract

While reconfigurable intelligent surfaces (RIS/IRS) are promising for improving coverage under shadowing conditions at high carrier frequencies (mid-band, mmWave, and sub-THz), their performance in wideband systems is fundamentally limited by their frequency-dependent behavior. RIS act similarly to planar antenna arrays: ideal implementations with unlimited phase shifts can achieve beam steering, but practical RIS with limited phase-shifter ranges introduce strong frequency selectivity, leading to beam squint, reduced beam shifting range, and performance degradation as bandwidth increases. As system bandwidth and array size grow, the achievable beam steering range shrinks relative to the RIS beamwidth, which constrains their effectiveness for very wideband IMT-2030 targets.



Content

The aim of this thesis is to evaluate the behavior of RIS using different modeling and simulation frameworks, including MATLAB and Sionna. In particular, the thesis will investigate how RIS beam steering performance is affected in wideband transmission scenarios. The central objective is to demonstrate that, as the signal bandwidth increases, the effective beam steering flexibility of RIS diminishes due to inherent frequency-dependent effects. To support and contextualize the simulation results, analytical derivations based on array and system-theoretical principles will be provided as a reference for comparison.

Requirements

Basic wireless communication and electromagnetics principles, interest in novel 6G-related communication networks, Python, Matlab.

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