

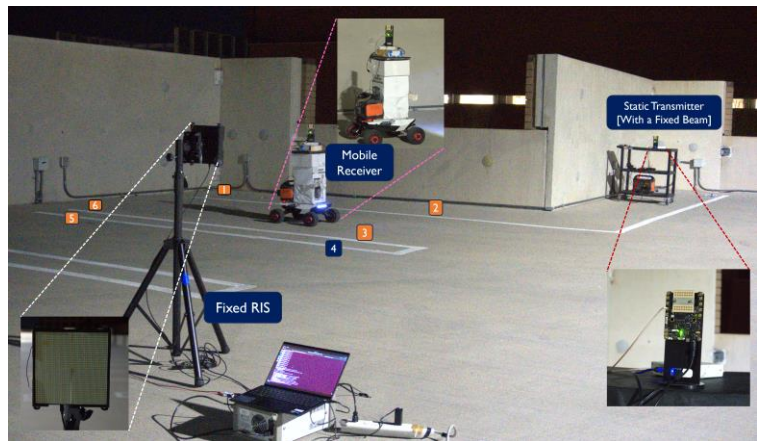
Reconfigurable Intelligent Surfaces with User Mobility: A Real-World Evaluation

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Reconfigurable intelligent surfaces (RISs) are expected to play a key role in future communication systems in 5G, 6G, and beyond. This is thanks to their ability to control the signal propagation and achieve desirable communication performance. In millimeter wave (mmWave) and sub-terahertz networks, a key potential role of RISs is to assist the base stations by reflecting its signals towards the users and improving the downlink receive power. This is particularly important in scenarios where the line-of-sight (LOS) link between the base station and user is blocked. To achieve sufficient received signal power, however, these RISs typically need to be very large and shape narrow beams. Adjusting these narrow beams to find the best beamforming/reflection direction is very challenging as it requires large beam training/search overhead. This becomes even more difficult when the users are mobile as this limits the available time for beam training. Overcoming these challenges is then essential to realize the RIS gains in practical wireless communication systems.

In this paper, we conduct a large-scale real-world evaluation of RISs under user mobility and realistic communication scenarios. The main objective is to (i) investigate the reliability of the mmWave RIS communication links under user mobility and (ii) provide insights and observations that could guide the development of adaptive RIS configuration algorithms. Towards this objective, we adopted the setup in the figure where a mmWave (28GHz) transmitter and receiver are



communication through the mmWave RIS. The transmitter (emulating a base station) is stationary with a fixed beam adjusted towards the RIS. The receiver phased array is carried by a robot (mobile user). The RIS consists of four metasurface tiles, each hosting 256 (16×16) independently tunable radiating elements. Every radiating element is integrated with mmWave PIN diode that allows single-bit phase modulation [0° , 180°] of the incident waves. The total 1,024 elements are controlled by an embedded microcontroller processing unit (MPU) which stores all the codewords and facilitates the necessary communication and coordination with the base station for rapid electronic beam scanning. Due to the scalability of the design, the size of the RIS can easily be increased by laterally cascading additional metasurface tiles.

Results: To evaluate the feasibility of using RISs to support mobile use cases, we used the setup in the figure above to collect the receive power at the mobile receiver in two scenarios: (i) For a grid of locations with the RIS and receive phased array performing joint exhaustive search at every location and (ii) for trajectories where the RIS and receive phased array leverage beam tracking to estimate the future beams while the robot is mobile. The first scenario provides a reasonable upper bound (as the receiver stays at the same location for the full exhaustive beam search). Analyzing the achievable power of the second scenario compared to the first one is expected to draw important insights into the performance and feasibility of RISs in mobile communication use cases.