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First-principle modeling and Statistical Characterization of Wireless Channels in Complex Electromagnetic Environments

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1 Overview

Ever increasing demands for the network capacity in wireless communications have pushed the data rate towards and beyond multi-Gigabits per second (Gbps). Millimeter wave (mmWave) communication emerges as a promising and powerful option for achieving these rates. Applications include the next generation 5G mobile system, vehicular communications, wireless video and virtual reality network, and Internet of Things (IoT). Due to the lightly licensed spectrum, the significant attention received by various organizations, and the high rewarding, mmWave has been identified as The Battle of the Bands. Nevertheless, the development of mmWave wireless communication systems also faces significant technical obstacles. A key challenge is to understand the physics and characteristics of mmWave wireless channels in complex environments, which are critical for the analysis, design, and application of future mmWave systems.

In the the first part of this talk, we present high-resolution, high-performance computational algorithms for extreme-scale channel modeling in real-world environments. The system-level large scene analysis is enabled by the novel, ultra-parallel algorithms on the emerging exascale high-performance computing (HPC) platforms. The results lead to much greater channel model resolution than existing deterministic channel modeling technologies. All relevant propagation mechanisms are accounted for in first-principles. Such a modeling framework will be critical to gaining fundamental physics of wireless propagation channels in real-world scenarios.

The second part of the talk is devoted to a quantitative statistical analysis of mmWave wireless channel in complex fluctuating scattering environments. The work is based on a separation between universal statistical behavior of scattering matrix and deterministic coupling channel characteristics. Small components (Rx/Tx antennas, base stations, etc.) in the computational domain are modeled using first-principles and large portions (complex operation environments) are modeled statistically. The new framework is expected to serve as a powerful verification tool in the design stage of future mmWave devices and systems, while maintaining a high level of confidence on the in-situ performance.