Notions of Parallel Computing as a Means of Enabling Short Design Cycles in RF-Based Inference Systems

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With the modern ubiquitousness of smartphones, the wireless landscape has changed considerably. A noteworthy aspect of the Wi-Fi technology present on most smartphones is the fact that data packets can be captured and analyzed in a passive manner. This feature enables a host of RF-related applications, beyond digital communications; this includes cognitive adaptation, detection, localization, inference of social graphs, and device-user association. The wardriving movement illustrates well how Wi-Fi signals can be tied to physical locations. In this work, we are interested in the problem of assessing room occupancy based on Wi-Fi activity. More specifically, we wish to estimate the number of active devices contained within a designated area based on the likelihood of monitored packets coming from within or outside of that area. This statistical tasks relies on knowledge of antenna radiation patterns, signal propagation, packet metadata, and received signal strength indications.

The primary design task described above is numerically demanding. Its computational complexity grows exponentially with the number of active devices within range of the sensors. This renders the corresponding design problem of selecting locations and antenna profiles for the monitoring system difficult, as simulations must be repeated several times. Our proposed framework is to apply notions of parallel computing to the computation associated with this estimation task. Parallel computing in this context is a powerful paradigm that enables the fine tuning of antennas for passive monitoring. We emphasize that the RF component of this problem is new, distinct from communication systems or standard radars, because the objective function differs from other application scenarios. In this sense, implementing estimation algorithms with parallel or distributed computing can allow for much more efficient computation and hence better design processes with fast feedback. Preliminary results indicate that using parallel and distributed computing in the computation phase of this inference task yields significant improvements in terms of completion times. In a broader sense, this research explores the interplay between parallel algorithms, antenna and propagation in the context of statistical information processing.

Overall, newer problems involving evaluation of RF-based inference systems can be challenging to compute. Modern advances in parallel and distributed computing can be leveraged to reduce the temporal cost of evaluation algorithms. The implementation of parallel and distributed algorithms in the computation associated with the design cycle of RF-based inference systems will allow researchers to explore the design space of such systems more efficiently.