Antenna Design for Graph Inference: Striking a Balance between Quality and Quantity

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This research initiative seeks to develop a framework for better understanding the role of antenna design in inference-based tasks about interactions among device owners. In the envisioned setting, a collection of monitoring radios gather information about the geographical locations of devices over time using packet sniffing. The monitoring stations are passive, listening to ongoing Wi-Fi communications in promiscuous mode. These radios only record and disseminate meta data, thereby preserving the anonymity of the owners. More specifically, the monitoring system stores time-stamped, media access control (MAC) addresses as unique identifiers. The collected information, which is stored in a centralized database, is then analyzed to assess basic graphical properties, such as friendship or other forms of social connectivity.

The underlying assumption in this work is that, under normal conditions in a public place, spatiotemporal interaction is a strong indicator of social connectivity. In other words, devices that often found themselves in close proximity are likely to be owned by people who know one another. The objective of this effort is to examine the impact of the antenna when conducting this network inference, and study the tradeoffs associated with the size of the antenna, its physically-achievable radiation patterns, and the quality of the information it can provide in this scenario. In particular, an antenna with a broad pattern will likely be able to listen to a much larger number of devices, but the spatial resolution of these devices will be poor. On the other hand, an antenna with a narrow directed beam is less likely to capture pertinent activity, yet it offers much better spatial resolution. This natural tradeoff between the amount of data collected and the quality of the gathered information is explored through numerical simulations and testbed implementation. This leads to guidelines on the design of effective antennas for the purpose of inference. These findings extend to adaptive implementations with pattern-dynamic antennas. This preliminary study offers supporting evidence to the claim that the careful design of antenna patterns can improve the performance of monitoring systems significantly, leading to better estimates of pairwise interactions. Overall performance is subject to device density and the a priori probability of interactions among pairs of randomly selected owners.

To carry our analysis, we postulate that active devices are confined to lie in a two-dimensional square. The motion of each device is modeled as an independent random walk, reflected at the boundaries. However, the walk pauses for a random amount of time when two related devices find themselves in close proximity. The testbed implementation is based on Android™ smartphones and radio monitoring devices with custom antennas.