SpotFi: Decimeter Level Localization Using WiFi – Public Review

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There is no doubt that the ability to localize wireless devices has had a significant impact on their possible use cases. In less than a decade, since the advent of smartphones, localization has become an indispensable service. Smartphones use a combination of methods for localization; e.g., iPhones use a combination of information from cellular, WiFi, and Global Positioning Systems (GPS) networks. The combination of information is crucial for accuracy and speed of localization in diverse operating environments.

There is another trend in the making, which involves embedding wireless access in increasingly more devices as part of the larger Internet-of-Things movement. Most of these devices, due to weight, size and cost constraints, have only one wireless access method, often either WiFi or Bluetooth. WiFi-based localization has been studied for 15+ years, and definitely not a new topic. The intense research activity has given rise to many ideas, which have delivered increasingly improved localization performance. However, the best known localization methods often cannot easily be deployed on top of current WiFi Access Points (APs).

The key contribution of SpotFi is achieving accurate WiFi-based localization without requiring any change to current WiFi Access Points (APs). The localization leverages channel state and RSSI information exposed by commodity APs and hence can be deployed using current APs. Perhaps even more importantly, it does not require the mobile devices to have any additional sensors and only relies on their WiFi. With such hard constraints, SpotFi's biggest contribution is achieving an accuracy of around 30-50 cm in office environments. The accuracy is on par with best reported results, which often require either more antennas per AP, or additional capabilities like motorized antennas or mobile devices with additional sensors.

SpotFi cleverly leverages well-known methods to achieve the above-mentioned accuracy numbers. First, it jointly estimates angle of arrivals(AoA) and time of flight (ToF), using small phase differences across all antennas and sub-carriers. The explicit modeling of AoA and ToF across all sub-carriers creates a virtual sensor array that has sufficient dimensions to estimate all the paths in high-scattering environments. The estimation itself is performed using well-known MUSIC algorithm. The estimation step is followed by two additional steps, that include selecting the direct path from noisy estimates, and then combining noisy direct path estimates from multiple APs for triangulation to estimate the location. The authors perform extensive experimental analysis, that includes analysis of each step of SpotFi.

While extensive, the experimental system was tested only at 5 GHz due to firmware limitations of Intel 5300 WiFi cards. In addition, the comparison with best known method, ArrayTrack, is limited to three-antenna implementation of ArrayTrack; the original ArrayTrack system used 6-8 antennas.

SpotFi is an excellent contribution for significantly improving the capabilities of WiFi-based localization, for single-domain networked deployments of APs. However, such localization advances cannot still be brought to homes yet, where the dominant use case includes one AP covering the whole home. In addition, many of the IoT devices may opt to use Bluetooth, due to its higher power efficiency compared to WiFi; examples include wearables like Fitbit. Bluetooth-only devices continue to be left out of the mainstream localization research.