Poster: Precise Indoor Localization using PHY Information

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ABSTRACT

This poster shows the viability of precise indoor localization using physical layer information in WiFi systems. We find that channel frequency responses across multiple OFDM subcarriers can be suitably aggregated into a location signature. While these signatures vary over time and environmental mobility, we notice that their core structure preserves certain properties that are amenable to localization. We demonstrate these ideas through a functional system, implemented on off-the-shelf Intel 5300 cards (that are designed to export per-subcarrier information to the driver). We evaluate the system in a busy engineering building, a cafeteria, and the university museum, and demonstrate localization accuracies in the granularity of $1m$ x $1m$ boxes, called *spots*. Results show that our system, *PinLoc*, is able to localize users to a spot with 90% mean accuracy, while incurring less than 6% false positives. We believe this is an important step forward, compared to the best indoor localization schemes of today.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Wireless communication*

General Terms

Algorithms, Design, Experimentation, Measurement

1 Background and Hypotheses

Precise indoor localization has been a long standing problem. In addition to such high accuracy demands, applications demanding precise localization are inherently intolerant to small errors. If a localization scheme incorrectly places a user in the adjacent aisle in the grocery store the purpose of localization is entirely defeated. We refer to this problem as *spot localization*, where a device in a specific $1m$ x $1m$ box needs to be identified.

To solve this problem, we find that channel frequency responses across multiple OFDM subcarriers can be suitably aggregated into a location signature. While these signatures vary over time and environmental mobility, we notice that their core structure preserves certain properties that are amenable to localization. Fig. 1 shows the CFRs recorded on a laptop at a fixed location over a period of $100s$. We observe two emerging clusters denoted by two vectors U_1 and U_2 - CFRs belonging to the same cluster are not identical but appear as noisy realizations of the cluster mean. We find that at different locations, completely different clusters emerge – motivating using these clusters as location signatures. We also find that if a few spots experience large number of clusters, they are predominantly dominated by the frequency clusters. Thus we are not very likely to see most of them during the localization phase.

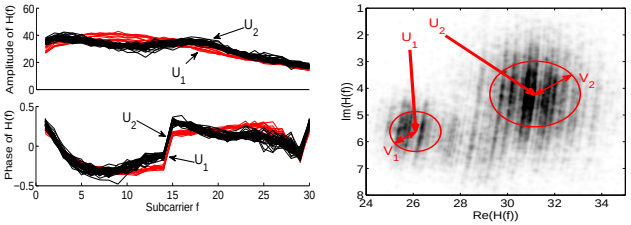

Figure 1: (a) The amplitudes and phases of the channel responses of 50 (out of 20000) packets sent over a link (we see two unique clusters, U_1 and U_2) (b) PDF of the complex value of the 20000 channel responses for a single subcarrier

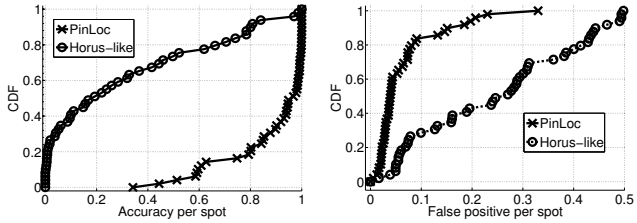

Figure 2: Pinloc performance: (a) Accuracy, (b) False positive

2 Results and Future Work

We evaluate PinLoc across 50 different spots using war driven training data and several test samples. We wardrive using a Roomba robot to find and store clusters specific to a particular spot. The test samples were taken on a different day. Figure 2 reports results from our engineering building experiments. PinLoc achieves nearly 90% mean accuracy across 50 spots (Figure 2(a)), consistently outperforming Horus [1]. The false positives (FP) are also maintained to less than 6%, compared to more than 25% in Horus (Figure 2(b)). RSSI based algorithm is significantly worse than PinLoc, since it is represented with a single real number; not exploiting the rich information provided by CFR.

The results presented above motivates us to investigate further to make PinLoc a practical system. Towards future work, we would like to evaluate PinLoc at real settings such as museum, grocery shop. We will also investigate implications of height and orientation on PinLoc's performance.

3 References

[1] M. Youssef and A. Agrawala. The horus WLAN location determination system. In *MobiSys*, 2005.

MobiSys'11, June 28–July 1, 2011, Bethesda, Maryland, USA.
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