WINS: Tracking of Mobile Devices with WiFi Time-Of-Flight

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1. EXTENDED ABSTRACT

Introduction. The research community is striving to find a pinpoint solution for indoor localization of mobile devices. Previous efforts for personal devices have mainly focused on radio-frequency signal strength and mobile inertial sensors [1–3]. Solutions based on Time-of-Flight (ToF) have received relatively little attention, mainly due to the inherent difficulties to obtain accurate signal propagation time measurements on commercial off-the-shelf (COTS) hardware.

In this demo, we extend our previous concept of an echo ranging technique for WiFi [4] that leverages the existing 802.11 protocol timing specification to build WINS, a full-fledged ToF-based indoor localization system. WINS relies on a customized firmware operating in the core of the 802.11 MAC state machine of a low-cost WiFi chipset (cost per unit of less than six dollars) that we integrate in COTS Access Points (APs) for accurate ToF measuring.

WINS (WiFi Navigation System.) In the WINS system, multiple APs operating as ToF ranging stations estimate their distances to mobile targets. These APs are equipped with Broadcom WiFi chipsets that run our customized version of the 802.11 openFWWF firmware [5]. Using only MAC-layer features of the 802.11 standard, we measure the ToF from received acknowledgments after the transmission of data frames and pass the results to the open-source b43 driver. Measurements are analyzed in the driver, and sent to a central positioning unit (inside the network infrastructure) for noise cancellation and positioning computation similar to the mechanisms in GPS.

Contest Setup. The APs and the mobile devices to be tracked run exclusively on *commodity hardware*. For the contest, we will deploy ten of our own 802.11 APs which are net5501 embedded machines from Soekris. We can demonstrate the tracking of arbitrary 802.11 devices such as smartphones, tablets, or laptops. The only requirement is that the WiFi hardware on the mobile target schedules ACKs with sufficient precision as it is the case for most chipsets currently on the market. No special software is required on the mobile devices to be tracked. Experiments are conducted using the 802.11b/g standard in the 2.4 GHz ISM band. Targets can move freely along the exhibition space and remain tracked as long as at least four APs are able to perform ToF measurements to the targets. A server machine in the same local network computes the mobile targets' positions, displayed in real time on a monitor screen through a simple Web application. The installation of the system at the exhibition requires only simple tests to place the fixed APs on the conference map.

Conclusions. In this competition, we aim to be the first to implement a functional prototype to showcase that WiFi ToF echo techniques can be used to track mobile targets using COTS hardware for the mobile devices and APs. WINS runs purely on the infrastructure side, it uses a low-cost WiFi chipset attached to off-the-shelf 802.11 APs and advanced statistical analysis and filtering of data. We address research questions such as the systematic error of the mobile target and how to alleviate the effect of multi-path. *No fingerprinting* and *no calibration* are needed. WINS is able to operate in crowded environments with interference as long as 802.11b/g ACKs from the mobile devices can be received by at least four APs. We expect 95-percentile accuracy of less than 5 meters at the exhibition.

2. REFERENCES

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