Poster: Integration of WiFi ToF Positioning System in the Open, Flexible and Adaptive WiSHFUL Architecture

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ABSTRACT

We integrate a prototype WiFi Time-of-Flight (ToF) ranging and positioning system in the WiSHFUL software platforms and hardware radios for experimental prototyping. Users can have access to ToF measurements as well as computed positions through unified programming interfaces that make possible to investigate innovative positioning and networking solutions.

1 INTRODUCTION

Research on indoor localization techniques has gained an immense interest lately, with many contributions such as [3–5, 8] that have concretely shown that achieving accurate positioning capabilities in indoor areas is possible. However, as of today, there is lack of access to ranging and positioning systems for experimentation. The availability of such system would allow to design novel positioning algorithms and introduce innovate networking protocols that exploit location data.

We take advantage of the flexibility of WiSHFUL architecture [1] and the unified programming interfaces (UPIs) to act on the design of WiFi radio subsystems and integrate a prototype ranging and positioning system in a modular and platform agnostic architecture. The WiSHFUL software architecture allows focusing on novel network programs, without the hassle of setting up a dedicated testbed, a key feature that can be hardly find anywhere else. The integrated system provides raw Time-of-Flight (ToF) measurements and position data in near real-time for a number of WiFi nodes as clients.

2 WIFI TOF POSITIONING SYSTEM

Our WiFi ToF positioning system can estimate in near real-time the location based on ToF measurements, and without requiring any input from inertial sensors [6]. In order to compare the performance of our system with others from academia and industry, our system has also participating to the Microsoft Indoor Localization Competition 2016 [2]. The system was ranked 5th out of ten teams in the final. 5 APs were deployed over a challenging and uncontrollable space of more than 500 m^2, with a final average position accuracy of 3.17 m. More APs allow to achieve better accuracy.

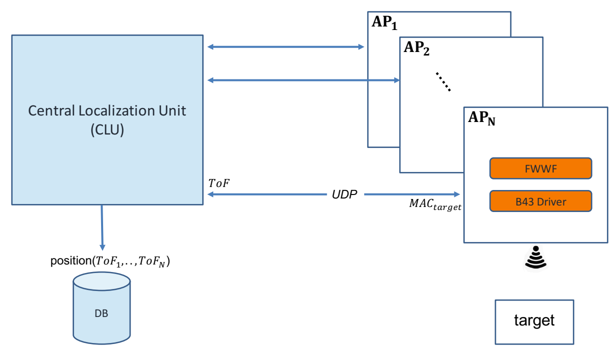

Figure 1: Current architecture of WiFi ToF positioning system [6].

Figure 1 gives a high level overview of the current architecture for ranging and positioning. The system is orchestrated by the Central Location Unit (CLU), that controls the rest of the nodes (APs and target devices), computes the ranges and positions, and makes data available to be exploited by other applications through a database. The CLU issues measurement rounds to the APs. Measurements are scheduled using a time division approach, where only one AP at each time can measure the ToF to the target devices.

Measurements are performed by each AP using a modified FWWF firmware. These measurements may be related to different targets, as the system allows the continuous tracking of multiple targets. The CLU receives raw ToF measurements from the APs. After this set of measurements is received, the CLU estimates the distance from each AP to each intended target. For that, different approaches have been developed to adapt the algorithms to different scenarios.

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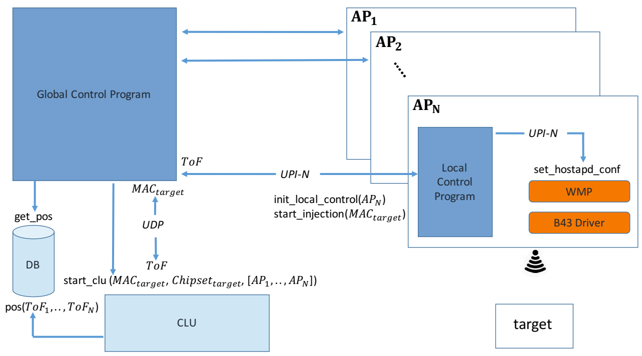

Figure 2: Envisioned architecture of WiFi ToF positioning system integrated in the WiSHFUL framework.

As not all WiFi chipsets behave the same, the database includes information about chipset offset that has been calibrated beforehand. Only one calibration step is needed, and the process does not need to be repeated. Methods to automatically estimate the chipset have been investigated and will be integrated in a next version of the system.

Using the estimated distances, a multi-lateration algorithm is used to make a position estimation. This algorithm makes use the Weighted Non-Linear Least Square (NLLS) techniques to compute the position from this initial value. The NLSS algorithm is implemented using the Newton-Gauss method with line-search for the step-size, a well-known method for this problem. Our implementation takes into account that as a result of quantization errors in the range estimation, divergence problems may occur in the algorithm. As such, we perform pre-filtering of the data to remove the side effects of quantization. As for the initial position for the computation, we use the one given by a linear least square (LLS) algorithm, having the advantage of being computationally efficient.

3 INTEGRATION OF POSITIONING SYSTEM IN WISHFUL

A high level illustration of the envisioned architecture wherein we integrate the WiFi ToF ranging and positioning system in WiSHFUL is shown in Fig. 2. This new architecture allows us to take advantage of the versatility of WiSHFUL's design for experimentation. In WiSHFUL, the Local Control Program (LCP) manages and controls the single device, while the Global Control Program (GCP) manages and controls with a group of devices. In our integrated system, the LCP controls the deployment-specific Local Monitoring & Configuration Engine. The latter injects traffic to target nodes and gathers raw ToF measurements. In order to achieve the highest flexibility in the proposed architecture, the firmware used in the Local Monitoring & Configuration Engine is based on the Wireless MAC Processor (WMP) [7] rather than the modified FWWF firmware as done so far.

The LCP sends the ToF measurements to the GCP in batches. The GCP forwards the measurements received by N APs to the CLU, that is responsible of computing first the distance to the device and then its position. Experiments from users can be performed remotely accessing the w.iLab.2 testbed (covering an area of 66x20.5 m),[1] with all the APs running the WMP firmware on Alix boards. Nodes can be either static or dynamic (using Turtlebot II Robotic Platforms in the w.iLab.2 testbed), thus making possible to study various compelling scenarios.

Users have access to raw ToF measurements as well as computed positions using unified programming interfaces (UPIs) to investigate various applications such as novel positioning algorithms and designing location-aware link and networking protocols. The vision is that the capability to exploit positioning information for serving an increasing number of users with a given amount of resources in power, time and frequency, can help to better manage networks.

[1] http://doc.ilabt.imec.be/ilabt-documentation/

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