A Distributed Indoor Localization Framework

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***Abstract*—We outline in the sequel a modular indoor positioning framework. The solution consists of a ranging component, an algorithm component and a coordinator connecting the latter to the hardware. The front and back ends may be distributed among one or more systems. For the purpose of this competition our energy efficient 802.15.4 hardware is used: five fixed anchors and one or more mobile tags. Euclidean distances are estimated from phase offset measurements between the anchors and the mobile tag. Current positions are computed using the Super MDS algorithm on the measured distances. Finally, results are visualized on a mobile application in real time.**

***Index Terms*—ZigBee, 802.15.4, Super MDS, Localization**

I. Introduction

With the recent development of wireless sensor networks (WSN) indoor positioning has become accessible and a considerable effort has been put into developing accurate solutions. Specific requirements, environmental constraints and precision are a few of the issues that have been extensively addressed.

The proposed framework has a modular scalable architecture as it was designed to evaluate several ranging technologies and positioning algorithms. As such, in order to obtain enhanced accuracy while using low power devices, hardware based on the AT86RF215 transceivers from Atmel was integrated for this demo. Namely ZigBee (IEEE 802.15.4) devices were used to perform phase measurements. The hardware is complemented by the Super MDS (SMDS) algorithm [1], used to compute the relative 3D positions. The choice of SMDS algorithm is motivated in Section III.

II. Architecture

The framework architecture is illustrated in Figure 1.

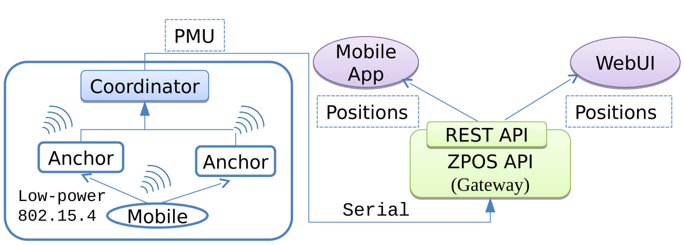

Fig. 1: Overall Architecture

It consists of two main components: phase measurement and ZPOS API that performs both ranging and positioning. The coordinator collects phase measurements of each anchor-node and passes them as PMU packets, via a serial communication, to the ZPOS API.

ZPOS API consists of two modules: ranging and positioning. While the first computes distances out of phase measurements, the latter computes current position of the mobile tag using the SMDS Algorithm.

Finally, positions calculated by ZPOS API are forwarded to the front-end user applications via RESTful interface.

The reason of using a modularized approach is to allow the separation of components. Such an architecture allows connecting different technologies in order to perform positioning. Furthermore, algorithms, often constrained by the need of high computational resources, may run distributively in the cloud. The choice of using 802.15.4 hardware is to demonstrate how low power devices can achieve positioning almost as accurate as the popular UWB devices.

III. SMDS Localization Algorithm

As opposed to the conventional metric MDS algorithm, which utilizes only the euclidean distances between the devices, the SMDS algorithm takes into account both the distance and angle information, allowing localization under an absolute coordinate system by the knowledge of the coordinates of one single node. The difference in these two algorithm comes predominantly from using entities that are vectors between two tags, instead of the coordinates of the source nodes.

Whereas the MDS uses the Gram Kernel matrix with the dissimilarities being the distances between the tags, the SMDS uses the Edge Gram Kernel with the dissimilarities being the inner product between two vectors. A weakness in the conventional MDS algorithm, which is overcome by the SMDS algorithm, is that each element in the kernel matrix computed is dependent on all the estimated distances and therefore results in an algorithm prone to error propagation.

References

[1] G. Freitas de Abreu and G. Destino, “Super mds: Source location from distance and angle information,” in *Wireless Communications and Networking Conference, 2007.WCNC 2007. IEEE*, March 2007.