TDoA-based Localization Using Enhanced Multilateration

Fernando Perez-Cruz, Chih-Kuang Lin, Howard Huang
Nokia Bell Labs
Email: {fernando.perez-cruz, chih-kuang.lin, howard.huang}@nokia.com

***Abstract*—For the IPSN 2016 Microsoft indoor localization competition, we propose a system based on uplink TDoA using commerically available hardware from Nanotron and a proprietary multilateration algorithm.**

I. Introduction

Localization based on time-difference-of-arrival (TDoA) is a well-known technique that serves as the basis of globally deployed positioning systems such as GPS (Global Positioning System) and 3GPP LTE OTDOA (observed time difference of arrival) [1]. In the downlink version of TDoA, of which GPS and LTE OTDOA are examples, mutually synchronized transmitters send radio-frequency reference signals whose times of arrival are measured at the device to be tracked. These measurements and knowledge of the transmitting devices are used as inputs to a multilateration algorithm for estimating the location of the device.

In GPS, the transmitters are satellites that are synchronized using atomic clocks, and there is typically a line-of-sight channel between multiple satellites and the tracked device. In LTE OTDOA, the transmitters are terrestrial cellular base stations, and each base could achieve synchronization using a GPS receiver. Unlike in GPS, the channel between a typical base station and the device is not line of sight, and channel impairments due to non-line-of-sight multipath propagation can introduce a positive timing bias which significantly degrades the time of arrival measurement compared to a line-of-sight channel. The quality of the resulting location estimate is also significantly degraded.

In uplink TDoA systems, a device is attached to the object to be tracked transmits a signal which is received by multiple mutually synchronized receivers. Similar to the downlink case, the object location is estimated using a multilateration algorithm whose inputs are the locations of the receivers and their time-of-arrival measurements. The performance of uplink TDoA systems are limited by the same non-line-of-sight channel impairments as the downlink case.

II. System Description

Our proposal is an uplink TDoA system operating in the 2.4GHz unlicensed band, as shown in Figure 1. An RF tag transmits a proprietary reference signal, and five anchor receivers placed near the edges of the competition space measure the ToA. These ToA measurements are inputs to a multilateration algorithm running on a laptop, and the location of the tag can be displayed on the laptop.

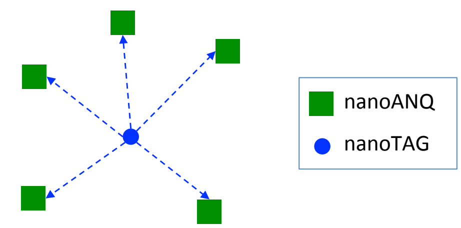

Fig. 1. Block diagram of the uplink TDoA proposal.

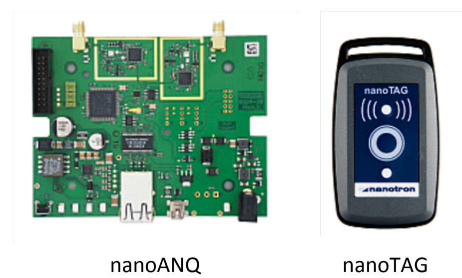

Fig. 2. Hardware components provided by Nanotron.

The tag and anchor hardware are commercially available from the German startup company Nanotron [2]. The tag and anchors are known respectively as a nanoTAG and nanoANQ, and they are shown in Figure 2. The anchors are synchronized using a Nanotron-proprietary algorithm. Nokia Bell Labs provides an enhanced multilateration algorithm which accounts for the non-line-of-sight channel impairments. While the system is capable of 3D localization, given the competition limitation of 5 anchors and unknown space size, it is unlikely that the achieved error in the vertical dimension would match the error in the 2D plane.

Acknowledgment

The authors gratefully acknowledge Thomas Foerste and his colleagues at Nanotron for providing the hardware and associated software for enabling our multilateration algorithm.

References

[1] 3GPP TSG RAN WG1, PRS design for LTE Rel-9 positioning, R1-092590, June 2009.
[2] www.nanotron.com