Time of Flight and Geometrical Lateration Algorithms for Accurate Indoor Positioning

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1. Introduction

In recent years we have got used to ubiquitous presence of global positioning technologies and abundance of location-aware applications and services. Unfortunately, satellite based localization systems (such as GPS, GLONAS) cannot be used (or at least experience difficulties) in indoor and underground environments. Consequently, number of alternatives were investigated and proposed.

Recently a lot of attention is focused on WiFi (IEEE 802.11.x), Bluetooth 4.0 (IEEE 802.15.1) and low-power radio networks (IEEE 802.15.4) in quest to enable them accurate distance measurement and absolute localization within predefined area. As a result a number of radio technologies and techniques were (and still are) developed and tested – ultra wide band (UWB), chirp modulation, radio interferometric localization (RIL), just to name a few. Simultaneously, improvements in multilateration algorithms are developed to allow determination of 2D/3D position with highest accuracy, given inaccurate distance measurements.

2. Related work

Number of 802.15.4 transceivers manufactures enable their modules with proprietary ranging capabilities. ATMEL provides a Ranging Toolbox [1], that use proprietary approach that is likely to be a variant of RIL. NXP [2] is using dedicated time-of-flight engine to enable distance measurements in Jennic nodes. Nanotron [3] incorporates a TN 100 [4] modules that use chirp modulation and precise time measurements to increase accuracy of measurements. Recently DecaWave released low price and low power UWB transceiver that allows for distance measurements with accuracy below 20 cm [5].

Apart from radio technologies there are several ways how distance information and 2D/3D position can be found. The most used approach for distance measurements include time difference of arrival (TDoA) and time of flight (ToF) that can be calculated in several ways (e.g. Round Trip Time, Symmetrical Double-Sided Two-War Ranging). Position can be also calculated with different methods and algorithms – using linear or nonlinear least square methods, heuristics (e.g. Geo-N algorithm) or optimization methods (e.g. Kalman filters, Davidon-Flecher-Powell, Cayley-Menger).

3. Approach

Localization setup is based on pair-wise distance measurements. This trades off system capacity (number of mobile nodes that can be localized in a specified period of time and area) but requires no need for time synchronization, allows to measure the distance between any pair of nodes, even when infrastructure fails. The absolute localization is determined based on multilateration.

We use and evaluated DiZiC [4] and DecaWave [5] wireless nodes as well as different localization algorithms. Evaluation was conducted for different indoor environments: building areas (corridors and large rooms), sport halls, and underground mines.

4. Deployment requirements

Nodes are battery powered, deployed on tripods but can be easily attached to walls. Nodes are equipped with dipole antennas. Single node weights below 700g dimensions 10x10x5 cm. No special deployment is needed.

5. REFERENCES

[1] Atmel AVR2152: RTB Evaluation Application Software, User's Guide, 2013

[2] Jennic Wireless Microcontrolers, JN5148-001, Data Sheet, 2013

[3] Real Time Location Systems (RTLS), Nanotron Technologies GmbH, 2006

[4] TN 100: High performance CSS transceiver enabling location awareness, ST Micro, 2008

[5] DW1000, Wireless Transceiver using Ultra Wideband radio technology, Decawave, 2014