ATOLS

A WSN-based, RSS-driven, Real-time Location Tracking System for Independent Living Facilities

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Indoor Location Tracking

Radio-based:
- TOA / TOF, TDOA / TDOF, AOA
- Phase Difference
- RSS

Non-radio-based:
- Ultrasound, infrared, pressure sensors, active floor

considered passé these days
Problem definition

Estimate the location of people (and possibly other objects) wearing RF Tags.

- Coordinates in 3D
- Named places (within a building)

A practical project: a system was already deployed, and we wanted to extend it with the new functionality …

… in some preferably minimalistic way
Militza (Brugges)

an Independent Living facility
Annonciaden (Antwerp)
What is a “location”?
The WSN: Tags & Pegs

Tags implement some end functionality, e.g., sensing; a Tag can be mobile.

Pegs act as semi-infrastructure (e.g., static, devoid of sensors/actuators, used solely for communication).

Pegs can be used as reference, e.g., for location tracking (if they do not move).

Power considerations: Pegs can be powered from external sources, while Tags are battery powered.

The hierarchy is natural in many applications.
Devices

CC430F6137 (MSP430 + CC1100)

4 KB RAM
32KB flash

BMA250 (accelerometer)

7cm
Devices
Devices: MSP430/CC1100

- Small footprint, 4KB of RAM, 32KB for program (this is not a Java-friendly platform)
- Radio is ISM, highly configurable, (can be) integrated with the microcontroller, not BT
- Adjustable transmit power level, RSS measurable by the receiver
Software

**PicOS**: Olsonet’s OS for tiny devices

**TARP/VNETI**: Olsonet’s ad-hoc mesh networking scheme (no ZigBee)

**VUEE**: Olsonet’s virtual development and testing platform for complete applications (praxes)
RSS is a crude attribute

- high power
- longer distance
- fewer Pegs
- cruder estimates

- low power
- shorter distance
- more Pegs
- finer resolution
Profiling / surveying

Attempts at correlating RSS with distance via blanket functions don’t work too well

**Profile Sample:** a vector of readings collected from a known location

**Tracking Sample:** a vector of readings collected from a tracked device

We can afford (relatively) many Pegs (say, tricky areas can be better covered, if that helps)
A floor in Annonciaden

tricky locations can be split internally
Location bursts

Tags emit “bursts” of 32 short packets transmitted at increasing power levels [in groups of 4]:

- Pegs receive what they can and forward the corresponding RSS vectors to the master.
# loc 1'0'2, att 5 "23-Jul-2016 19:59:03"

<table>
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<th>Peg</th>
<th>power level</th>
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<tr>
<td>3</td>
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<td>61</td>
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<tr>
<td>4</td>
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<td>69</td>
</tr>
<tr>
<td>12</td>
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</table>

P0  | P7  |
---|-----|
0  | 60  |
0  | 73  |
0  | 80  |
A tracking sample ...

... looks similar, except that the location isn’t known

Vectors arrive individually, the estimator can use any set of three or more vectors to attempt an estimation

Given a set of tracking vectors: 

\[ \{ (P_i, RSS_i^0, ..., RSS_i^7) \} \]

... and a set of profile samples, guess at the most likely location
The algorithm (a rough idea)

- Iterations by power levels, from low to high

- Maintain the set of ranked candidate locations; each iteration can trim the set and update the ranks of whatever locations remain in the set

- If after trimming the set becomes empty, the last nonempty set (with its ranks) is returned (the highest ranked location is the simple result)
Like RFID/ranging combo

Low power levels have priority; this way, closeness to a Peg always translates in a good estimate

Allows for sparse coverage in areas where some tolerance can be afforded; no need to be close to a Peg for a decent estimate
Some options

History option? In the underlying application, the tracking events tend to be sparse; can be adapted to periodic (non-triggered) tracking.

Area geometry info can be provided (a measure of effort to cross locations) and is relevant jointly with the history option.

Integrated into the event (sensor data) passing network; some events can act as (potentially strong) location hints.
Accuracy?

Difficult to quantify in a global and meaningful way

An error may be more tolerable if the locations are easy to reach from one another

90% (absolute) success rate in some accidental and rather poorly devised setup
Range, density?

100m ballpark range in open air [minimal antennas]; 10-50m in a building, depending on wall type, etc.

Recommended (?) (at least) one Peg for every formal location

Different types of walls (obstacles) affect the range, sometimes drastically

Easy to throw in extra Pegs if there are problems (the network is a true (I mean TRUE) mesh (ad-hoc)
Energy budget

Location burst: 32 x 80 @ 38400 + overhead → 0.2s @ ca. 20 mA

Idle Tag current drain: 3uA

10s → 5+ months (1000 mAh battery)
20s → 9+ months
1m → 2+ years
1h → practically forever

Variable interval, e.g., triggered by accelerometer

can be reduced to 16 or so
That’s it

THANK YOU