Indoor positioning system based on low-cost commodity hardware

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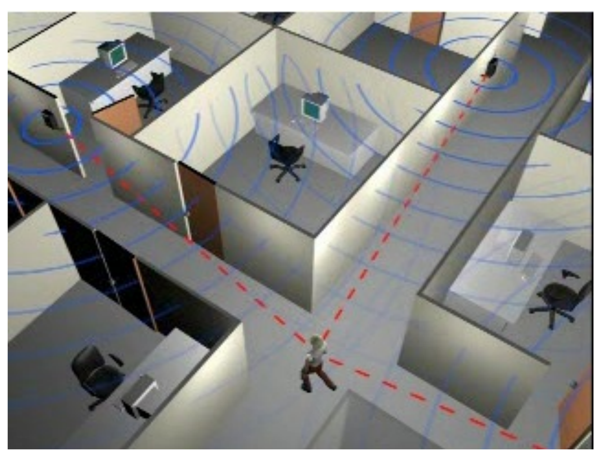
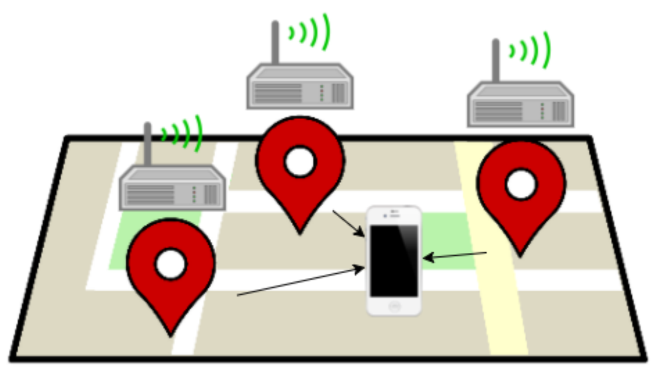
Motivation

Existing indoor positioning systems (IPS) on the market have the following issues:

- are expensive
- require specialised tracking hardware (i.e. WiFi tags)
- are available only to companies with large spaces (airports, hospitals, large retail companies)
- require user input.
- require extensive calibration (i.e. fingerprinting)
- require specialised knowledge to build and deploy

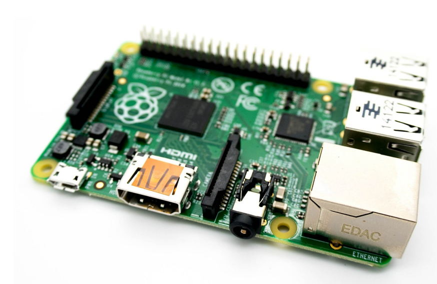
We identify that there is a need for a low-cost indoor positioning system that can be easily deployed and built.





Proposed solution

Low-cost WiFi-based IPS that uses Raspberry Pi devices for data collection, processing and visualisation.



The system has the following advantages:

- ubiquity, it collects the data without user input
- can track any WiFi-enabled device
- nodes can be battery powered
- the remaining CPU capacity can be used for other applications
- performs auto-calibration: each locator node acts as location anchor
- nodes have modular configuration, allowing for swapping and adding sensors

Design

Locator nodes:

- Raspberry Pi with two WiFi dongles
- transmits data to a server
- monitors WiFi enabled devices.

The server:

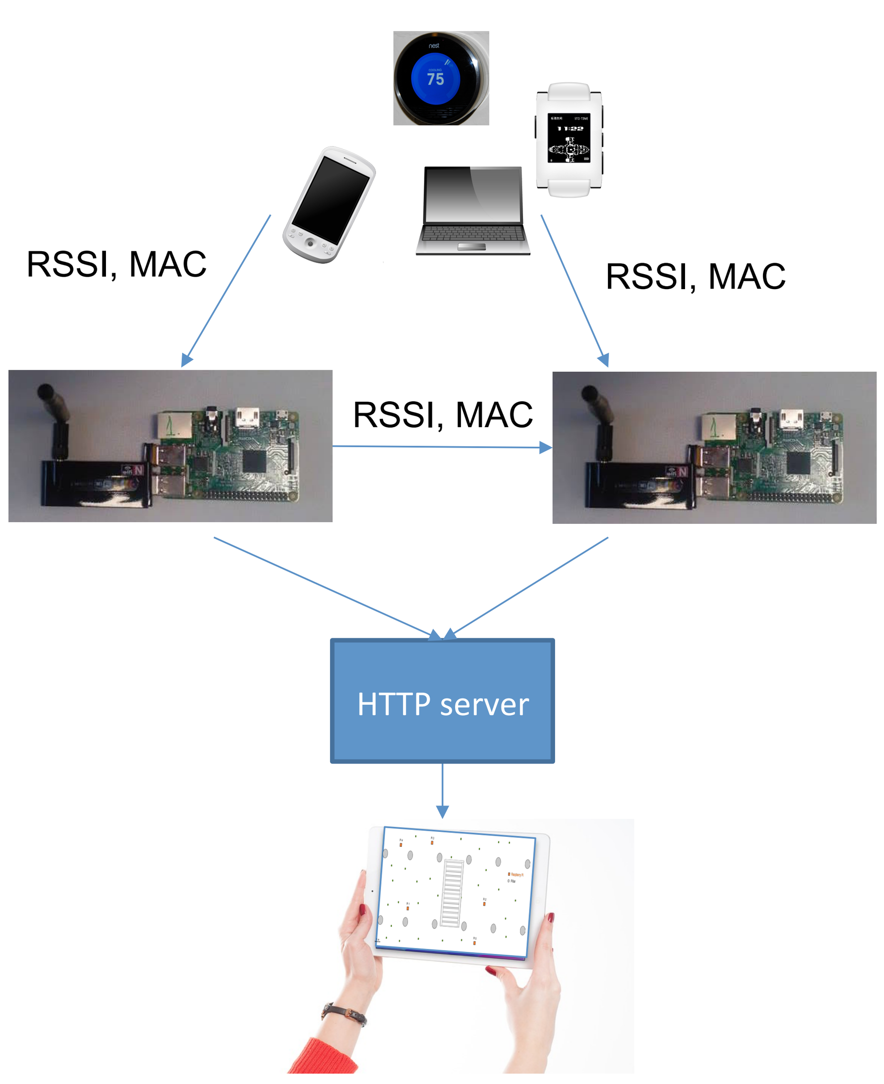
- Raspberry Pi
- Access Point
- No Internet connection
- Located on one of the locator in nodes in previous designs.

The algorithm:

- trilateration
- k-nearest neighbours algorithm
- self-calibration: the locator nodes are position anchors for the purpose of signal strength normalisation.

Cost:

- locator node: £52
- server: £35



Methods

To prove the feasibility and performance of the system, we conducted a preliminary experiment in an office area of 30x13m^2. The office, shown in Figure 1, contains computers, tall metal drawers, thick pillars, four Access Points, printers, microwaves, Bluetooth enabled devices and other furniture and equipment typical in an office environment.

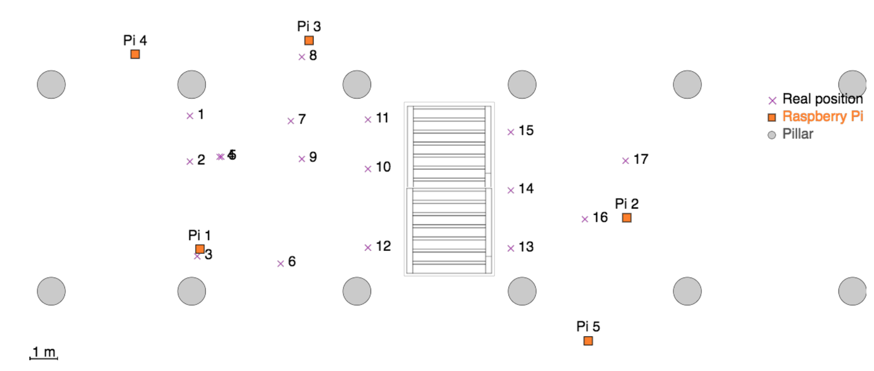


Fig. 2 Top-view of the test section

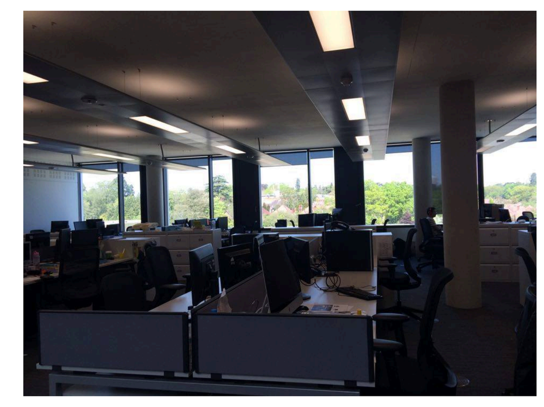


Fig. 1 Section of the test environment

The locator nodes were divided across the office and placed on desks. Figure 2 shows a top-view of the test section, the positions of the locator nodes and test points.

The measurements have been done using a Fluke laser distance meter and the tracked device was a Kazam Thunder smart phone.

Results and discussion

We conducted tests at 17 different locations within the office area discussed in the Methods section using up to five locator nodes.

Five locator nodes:

- an accuracy of up to 0.65m with a mean of 3.09m
- nodes are not evenly spread, leaving part of the test area uncovered.
- the distance between nodes amplifies the effects of interference and Line-of-sight (LOS) obstructions.

Three locator nodes:

- the first nine test points, using three locator nodes only: one, three and four
- the effect of nodes positioning
- an accuracy up to 0.84m has been obtained with an average of 2.59m.

Comparing both results, it is noticed that better accuracies were obtained at the same test points, which proves the importance of *the locator nodes density* on the performance of the system.

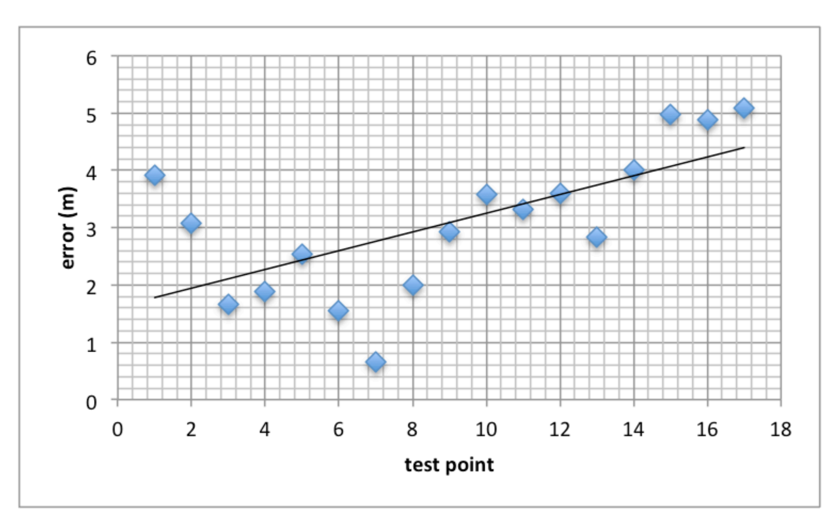


Fig. 1 Results obtained with five locator nodes

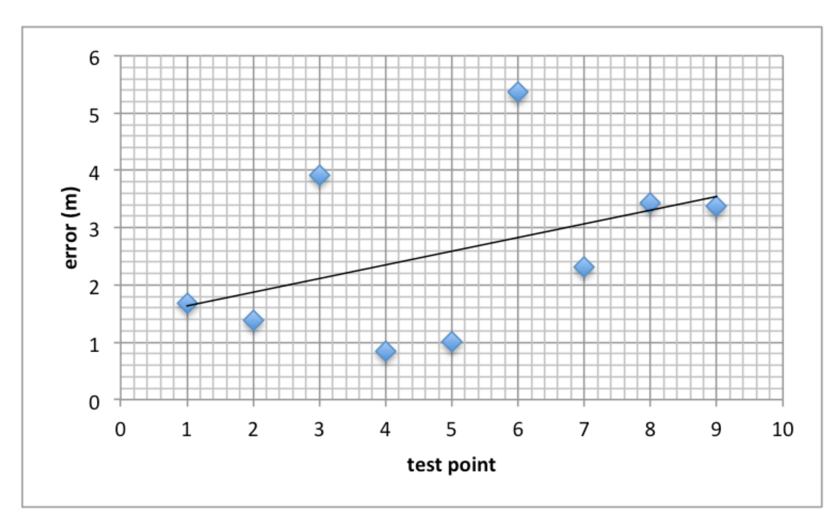


Fig. 2 Results obtained with three locator nodes

Conclusions

We have demonstrated a low-cost, ubiquitous indoor positioning system. Preliminary tests show that accuracies comparable with the one obtained by commercial systems can be obtained.

We have also explored the effect of node positioning and density on the performance of the system.

Future work

Further work will focus on developing the system so that it can be deployed within an University campus to be used for building resource management and location-aware applications.

References

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