Abteilung [Firma]	Speicherdatum / Uhrzeit	Autor
MK	26.06.2014 10:29	AB
[Zähler 10]	Seite 1 von 8	

Gedruckt: 26.06.2014 13:55:00

[Thema]

easyPoint

[Titel]

IPSN competition results

[Kategorie]

fieldtest

[Manager]

Version 1.5

Überblick / Zusammenfassung:

[Kommentare]

April 2014 the IPSN arranged a Microsoft indoor competition. The detailed results from the easyPoint system, developed by Lambda:4 Entwicklungen GmbH are presented here.

The easyPoint system is the winning solution with an average deviation of 0,72m!

Versionshistorie

Version	Datum	Verfasser	Gemachte Ergänzungen
1.5	26.06.2014	AB	Endgülitge Formattierung

Detailed results for the easyPoint system, technology by Lambda:4 Entwicklungen

1 Microsoft Indoor Localization Competition 2014 2
2 The easyPoint Technology 3
3 Upcoming standards, Integration in 2.4 GHz protocols 3
4 Deployment in the competition 4
5 Detailed results of the contest 4
6 Results by Simulation more / less easyPoint anchor nodes 8

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

1 Microsoft Indoor Localization Competition 2014

In Berlin on April 2014 14th the Microsoft Localization Competition took place at the IPSN conference hotel.
In an area of about 300m² - two conference rooms 9 by 10 meters and the hallway – the organization team defined 20 positions and measured the truth positions by laser. For all competitors it was allowed to use up to ten anchor nodes.
The 20 positions were unknown by the competitors while installation and calibration.

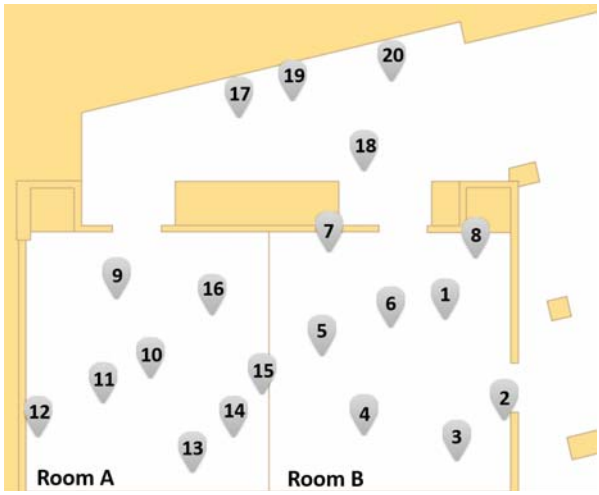

Figure 1:Floorplan of the competition area with 20 positions


Figure 2: Room B, after the setup day the furniture was completely rearranged


Figure 3: Impressions from the setup day, the installed equipment from the competitors and how many people were present. During both days people were invited to enter the test area and to walk around in the area.

Lambda:4 participates with its technology easyPoint (www.lambda4.com/easyPoint/) which is in a prototype stadium. The easyPoint system uses low cost anchor nodes, a tag and a mobile tablet. Lamdba:4 deployed only six (10 were allowed) anchor nodes without any calibration. Just the raw measured distances to each anchor node have been used for the position calculation.

easyPoint is the winning solution!
The easyPoint system achieved an average deviation of only 0,72 m in the contest and was the leading solution for indoor localization in this competition!

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

2 The easyPoint Technology

The distances between the tag and each anchor node are measured. The calculated distances are broadcasted by Bluetooth to the mobile tablet. The tablet calculates the position in relation to the anchor nodes, the position is visible on the display.
The distance is calculated by measuring the phase of the incoming clean carrier signal. With an antenna array and a frequency hopping the phase differences of the signals will lead to a distance.

Figure 4: Hardware prototypes anchor node "easyPoint", tag "Rex" and mobile device with indoor localization app

3 Upcoming standards, Integration in 2.4 GHz protocols

Many protocols are using the 2.4 GHz ISM band (e.g. Bluetooth, WiFi, ZigBee). In this competition we saw a huge noise level in the 2.4 G band, but because of using a narrow bandwidth signal by our technology this had no relevant impact on our system. The coexistence with other 2.4 GHz using standards is no issue.
But the right way to go is the integration of the distance calculation by phase measurement in the main 2.4 GHz using standards. Bluetooth has already started the integration of mayor components of this technology in the coming Bluetooth LE standards in the Dircection Finding Working Group.

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

4 Deployment in the competition

Lambda:4 deployed only 6 (six!) anchor nodes in the competition area – two in each room and two in the hallway. The anchor nodes were simply placed on the wall with a small hook and connected to a power supply or battery.
The anchor node positions have been measured by a laser range finder leading to 0,1 meter-level accuracy.
These anchor node positions have been programmed into the app on the tablet.
On the tablet the X- / Y-positions of the tag are displayed by the app.
Only the single distances are used to get the position! There is no fingerprinting, combination with other sensors (e.g. inertial) or filtering of the results.

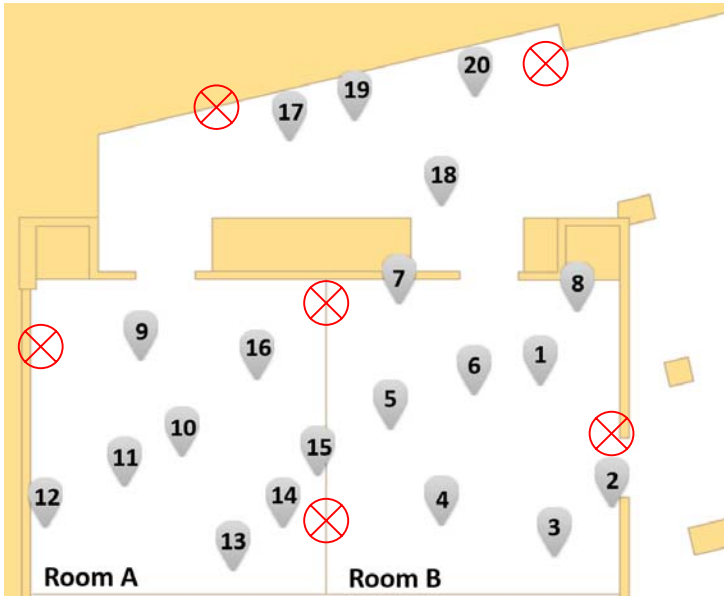

Figure 5: Rough positions of 6 deployed easyPoint anchor nodes in the competition area

5 Detailed results of the contest

Parallel to the competition itself we additionally logged the time while the system was at each of the 20 positions. With this time log, the positions ground truth and our data we analyzed the competition results with our engineering software.

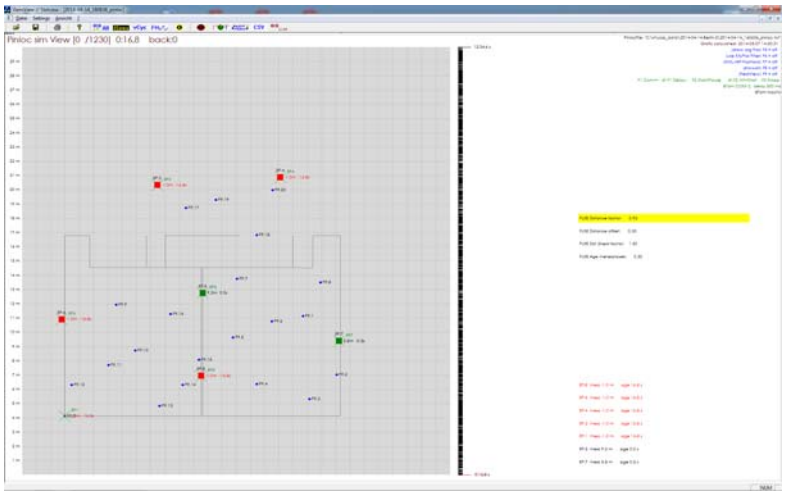
Figure 6: Engineering software screenshot of the six anchor node positions EP3-EP8, contest positions P9.01-P9.20 and rough floor plan

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

In a time period of about 12 minutes we got 760 calculated positions with an average error of 0.79 meters.

The next screenshot shows the measurements for all competition positions. The blue circles are the calculated positions and the red lines show the deviation to the ground truth of the position. The bar on the bottom indicates the deviation in meters to the ground truth. Mostly the deviation is below 1 meter, but in one case up to 4 meters (see position 17).

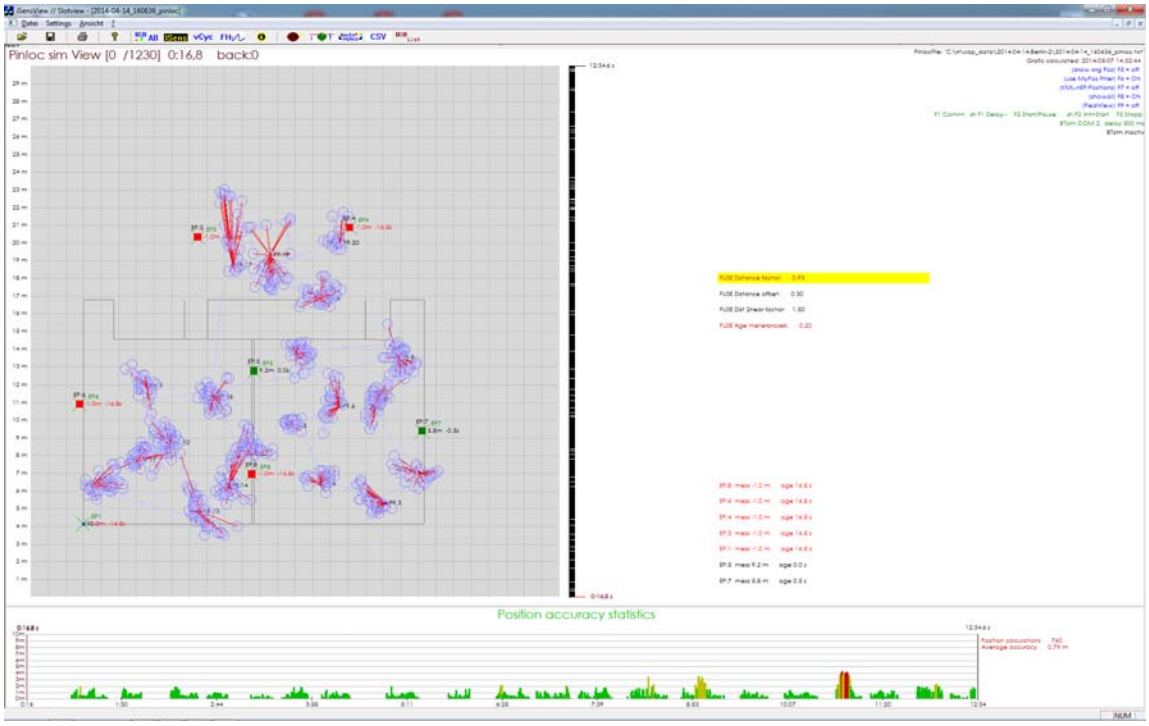

Figure 7: Calculated positions und deviations to the ground truth

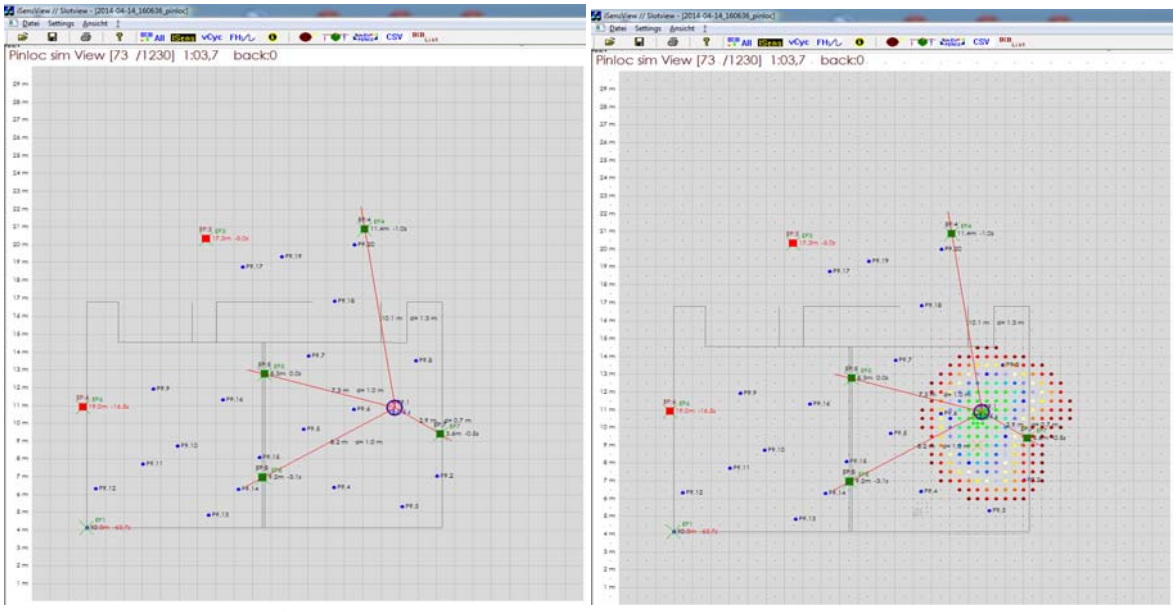

Figure 8: Calculation for position 1

In Figure 8 you see the trilateration for position 1. The red lines are showing the single distances measured to each anchor node and the blue circle is the calculated position. All distances are statistical 7% too long. On the right picture the colored dots show the feasibility of the

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

position. The calculation function is looking for the highest feasibility, all green dots are feasible.

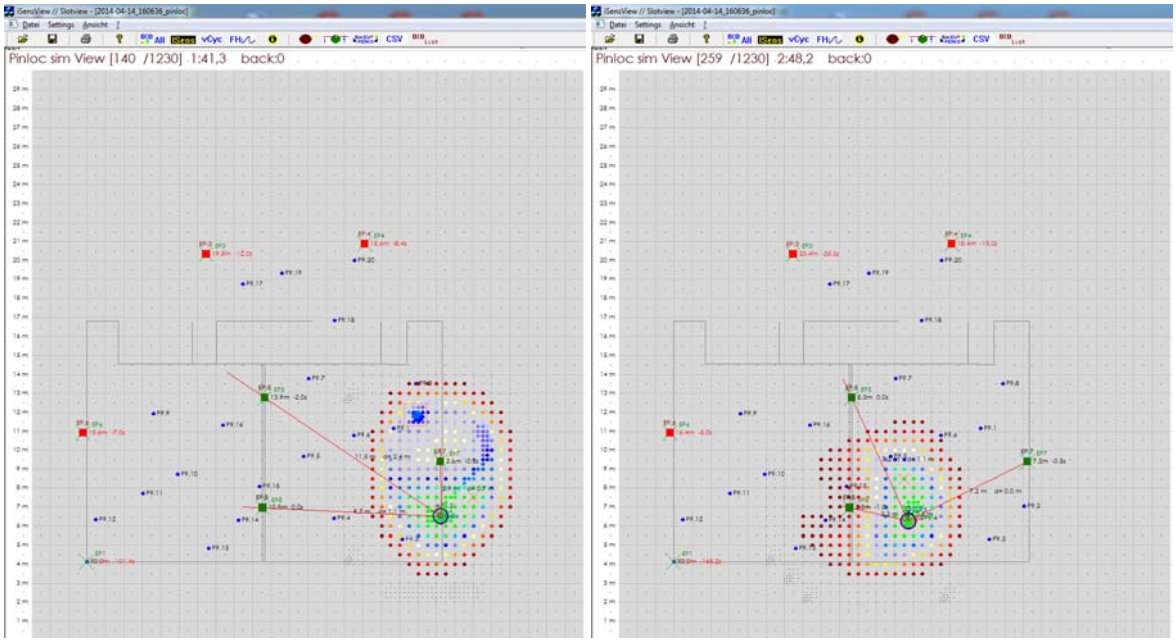

Figure 9: Two more examples for high accuracy left position 2, right position 4

In the next Figure 10 the calculation for position 14 is shown, the deviation for this position is about 3 meter. The deviation is shown by the thick red line between the blue circle und the blue dot with caption “P9.14”.
The reason for this error is the too short calculated distance to the anchor node EP5.

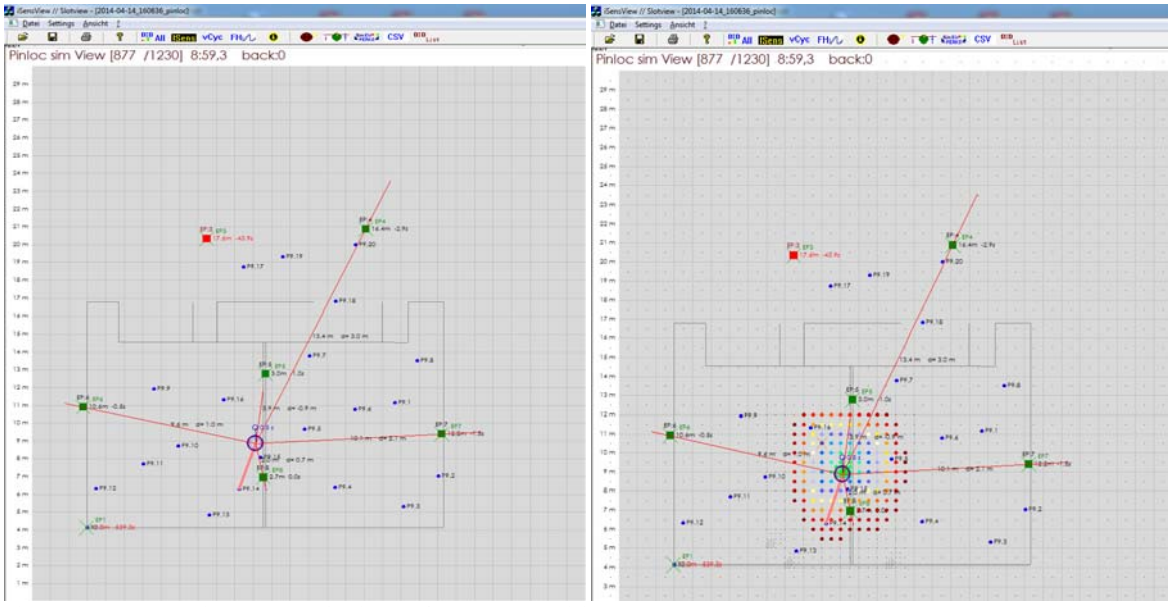

Figure 10: Showing a deviation of 3m at position 14

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

On position 17 – see figure 11 below – we have an error of about 4 meter. The reason for this deviation is the too long measured distance for anchor node EP8.
But in the figure 11 on the right we see two high feasibilities. The calculated position and the ground truth of position 17 got a very similar feasibility – second maximum of the algorithm.

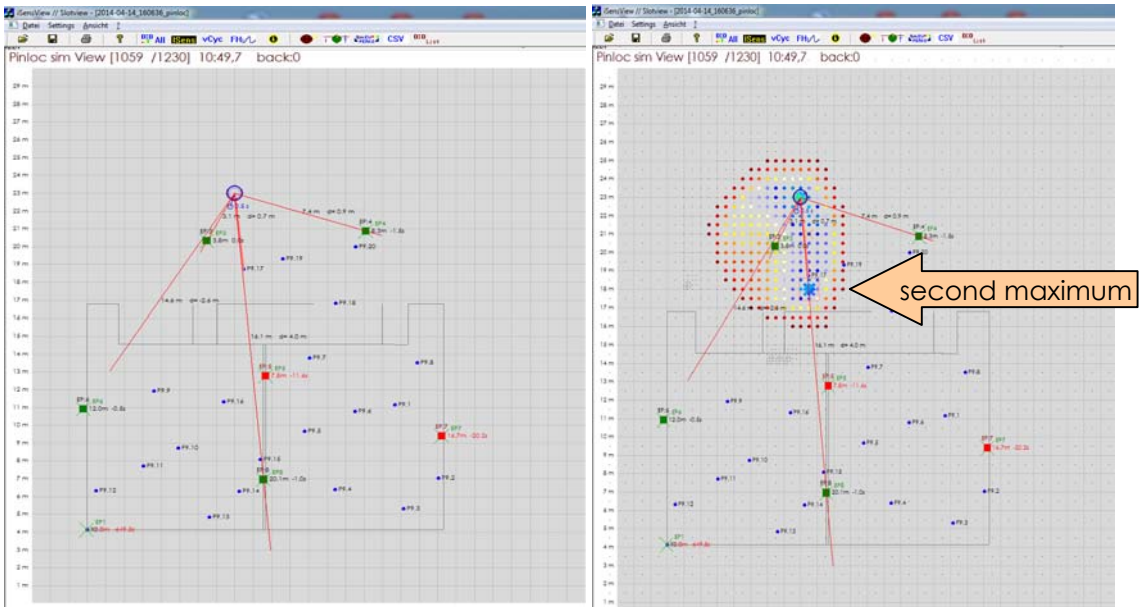

Figure 11: Showing position 17 with a deviation of about 4m, but a second maximum of the algorithm is very close to the ground truth of position 17.

If we look on all deviations of the single anchor distance measurements, we can see in figure 12 that most of them are between 0 m and +2 m.

In the next figure each anchor node has its color and the bars show the deviation for each measurement. The typical average measurement offset of 7% is already compensated. Some deviations are bigger and also negative, at these points the algorithm is still improvable.

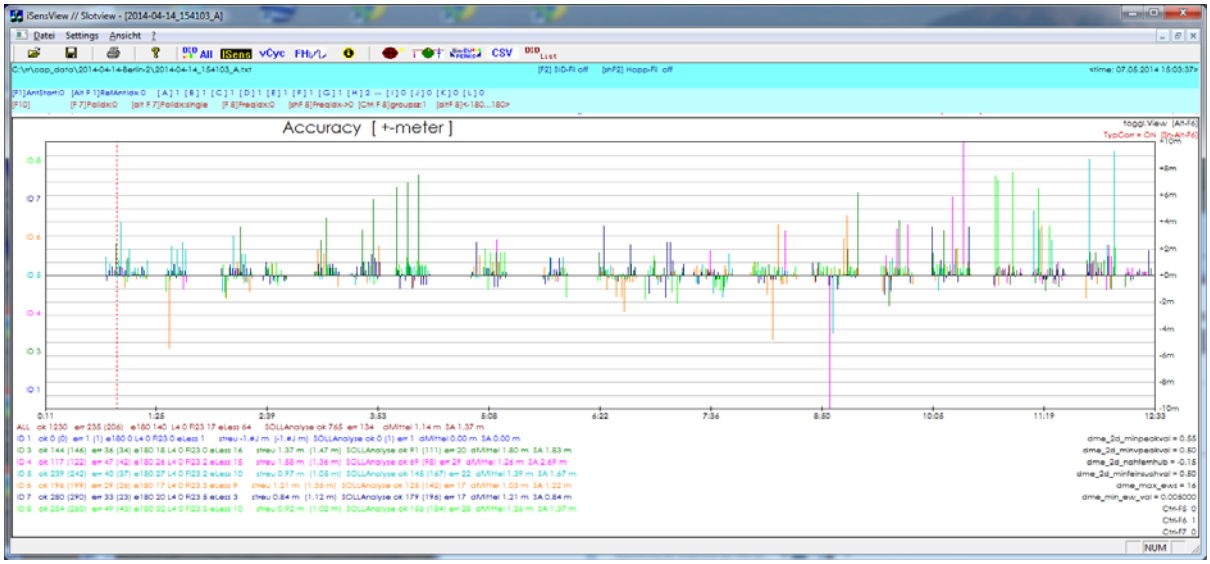

Figure 12: Deviations for single distance measurements to different anchor nodes.

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.

6 Results by Simulation more / less easyPoint anchor nodes

Based on these results we made two simulations with less and with more anchor nodes.

To achieve the result with only four anchor nodes, we calculated the positions by using only the distance measurements of the anchor nodes ID 4, 5, 7 and 8.
With four anchor nodes we achieve an accuracy of 1,15 m overall for 764 positions.

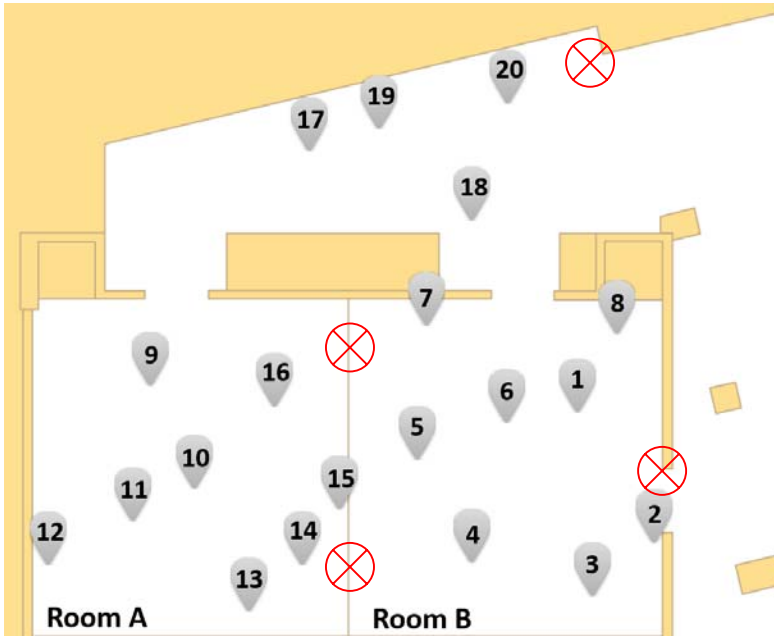

Figure 13: Rough positions of 4 deployed easyPoint anchor nodes in the simulation

We also estimated what accuracy would be possible if we use 10 anchor nodes. The average accuracy would be improved to less than 0,45 m.

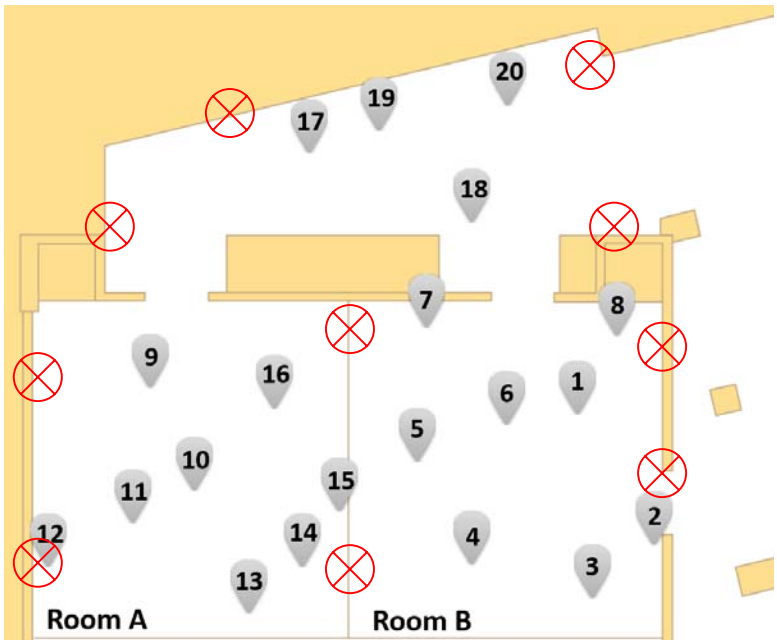

Figure 14: Rough positions of 10 deployed easyPoint anchor nodes for accuracy estimation

© Lambda:4 Entwicklungen GmbH ● Bugdahnstraße 5 ● 22767 Hamburg
Die unberechtigte Weitergabe oder Vervielfältigung dieses Dokuments ist untersagt.