

Triangulation Positioning by Means of Wi-Fi Signals in Indoor Conditions

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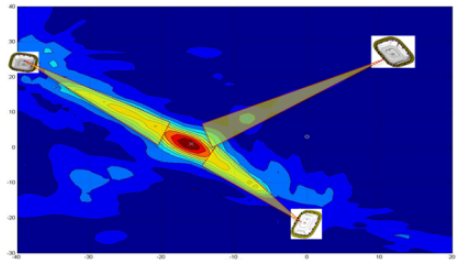
Moscow Power Engineering Institute

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WiFi Angular Measurements

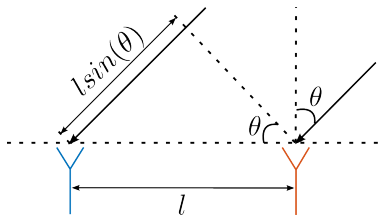
WiFi is widespread, so it is the promising technology for positioning purposes

Commercially successful Cisco Hyperlocation products use the triangulation approach

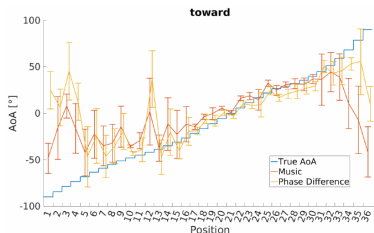


Is the antenna model correct?

Simple geometric model:



Accuracy degradation for large AoA:



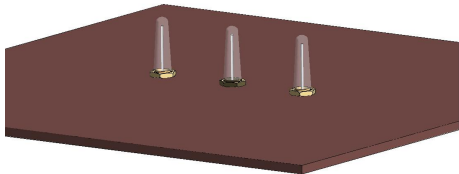
Triangulation is based on angle-of-arrival (AoA) estimations

Signal phases for separated antennas depend on the angle (as a trigonometric function for the simple geometric model)

How much does the mutual coupling of antennas influence on AoA estimations and disturb the simple model?

Requirements:

- be similar to ones in other researches
- be similar to usual MIMO AP antennas
- be easy representable in simulation programs
- be made for mockup

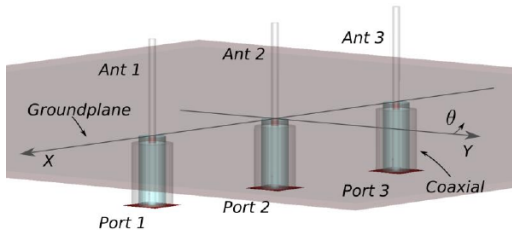


Chosen antenna system:

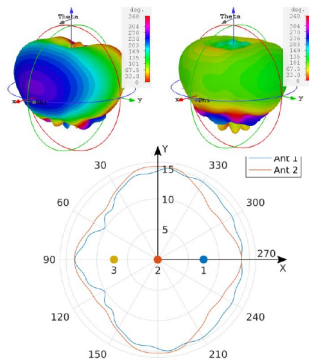
- Three pins
- The pin's length is $\frac{\lambda}{2}$
- The distance between closest is $\frac{\lambda}{2}$

Computational electromagnetic model

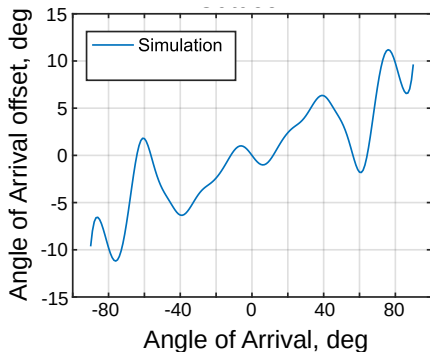
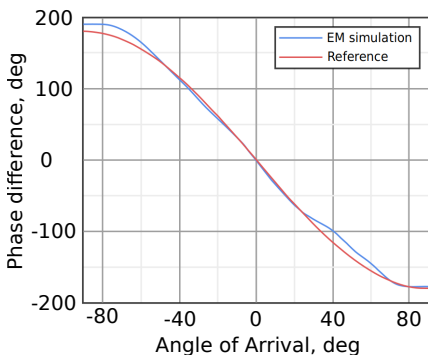
Ground plane is PEC 15x15 cm
Pins are cores of cables
Cable braids are connected to the ground plane
Frequency is about 5GHz



RPs are disturbed:



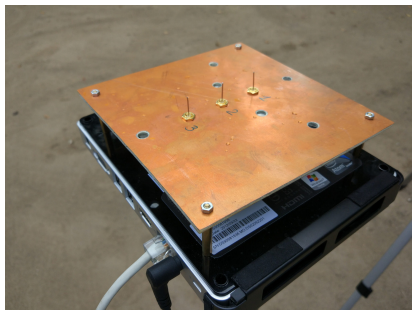
The simulation predicts significant biases for phase differences (up to 15-20 degrees)...



...and corresponding biases in the AoA estimations based on the geometric model (up to 5-10 degrees)

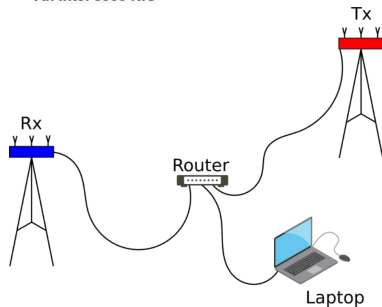
Both the TX and the RX are based on COTS Intel 5300 WiFi 802.11n cards.

The cards mounted into Lenovo Q180 PCs, controlled by Kubuntu 14.04.

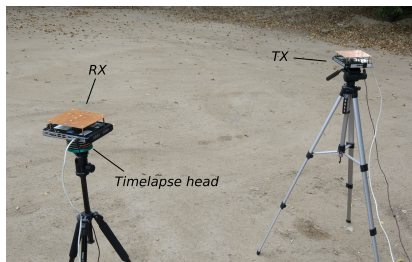


An Intel 5300 NIC

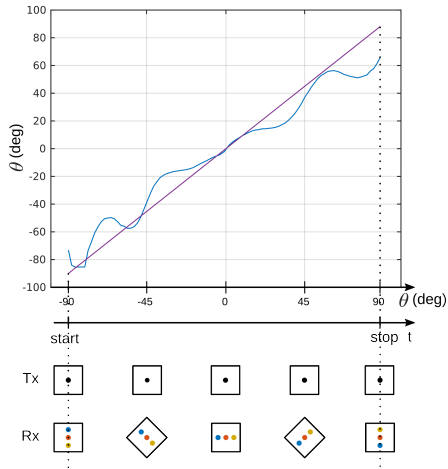
+ CSITool

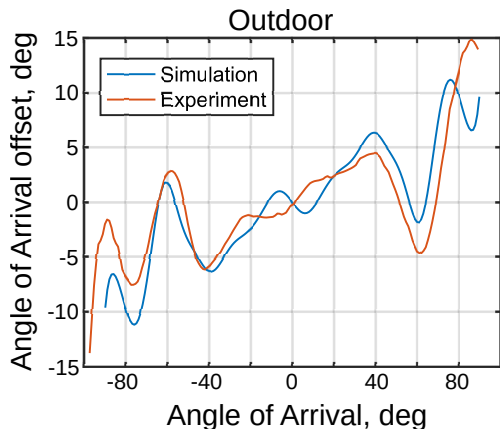


We need true angle values. Even and slow rotation allows to compute the angle from packets time stamps.



Revo EPH-6
180 deg per 15 min
Transactions every 3 sec





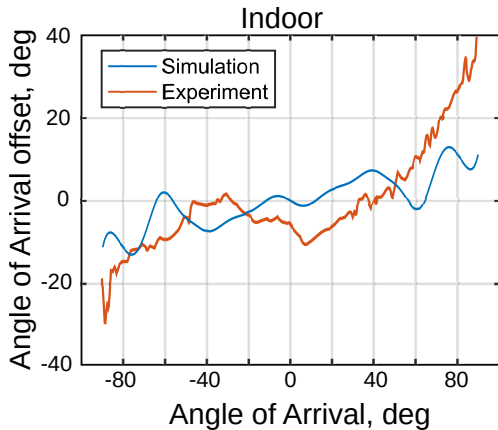
The experimental results are close to the simulation results!

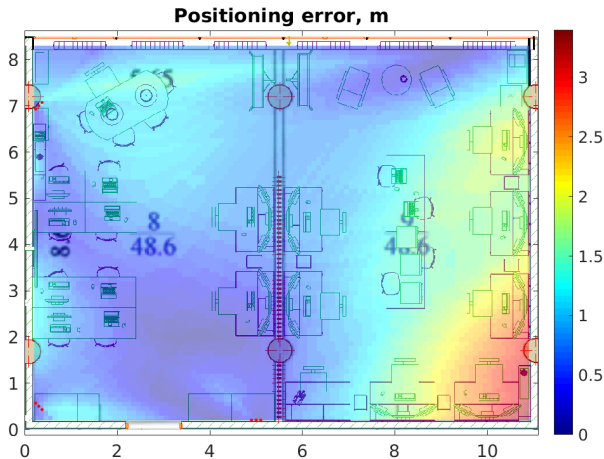
Difference < 5 deg

Experimental results: indoor

The overlap into the indoor conditions much worse

Errors ~ 10 deg





- Experimental error profile for simulation
- 3 AP in the left part of laboratory room
- About 1 m positioning accuracy

- Mutual coupling is significant for WiFi AoA estimation
- It can cause up to 10 degrees of additional errors
- We should use actual measured RP to mitigate the errors
- WiFi AoA can be used for indoor positioning, errors are ~ 1 m

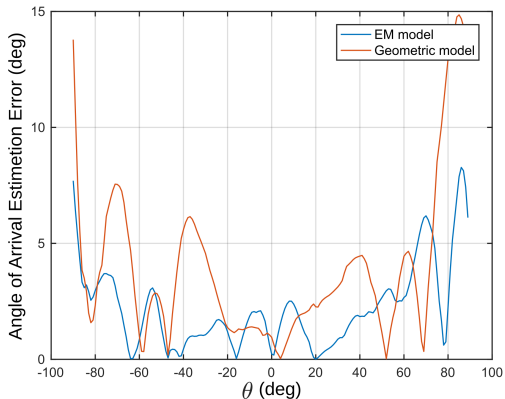
Thank you for your attention!

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Extra slides: Mutual coupling consideration profit



Utilization of the EM results instead of the simple geometric model allows to decrease AoA estimation errors (about two times in our case)