TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

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Differential Wi-Fi – A Novel Approach for Wi-Fi Positioning Using Lateration

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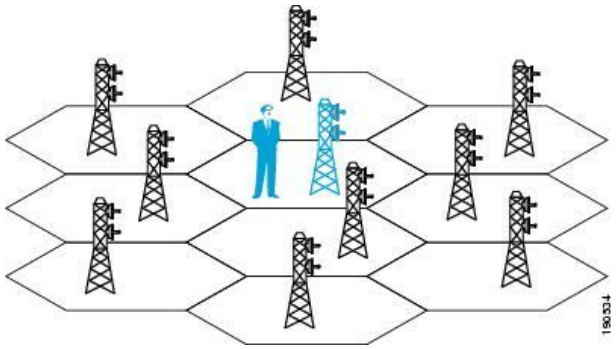
Positioning Methods

Cell-based positioning – Cell-of Orgin CoO

Simplest and most straight forward technique
Mobile positioning technique for finding the basic geographical coverage unit



Angulation

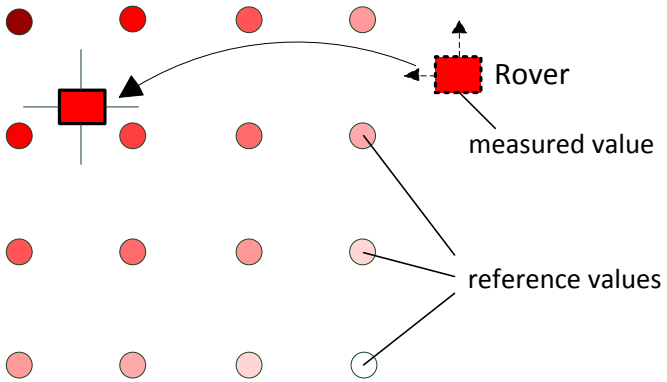
Angle of Arrival AoA measurements

Lateration

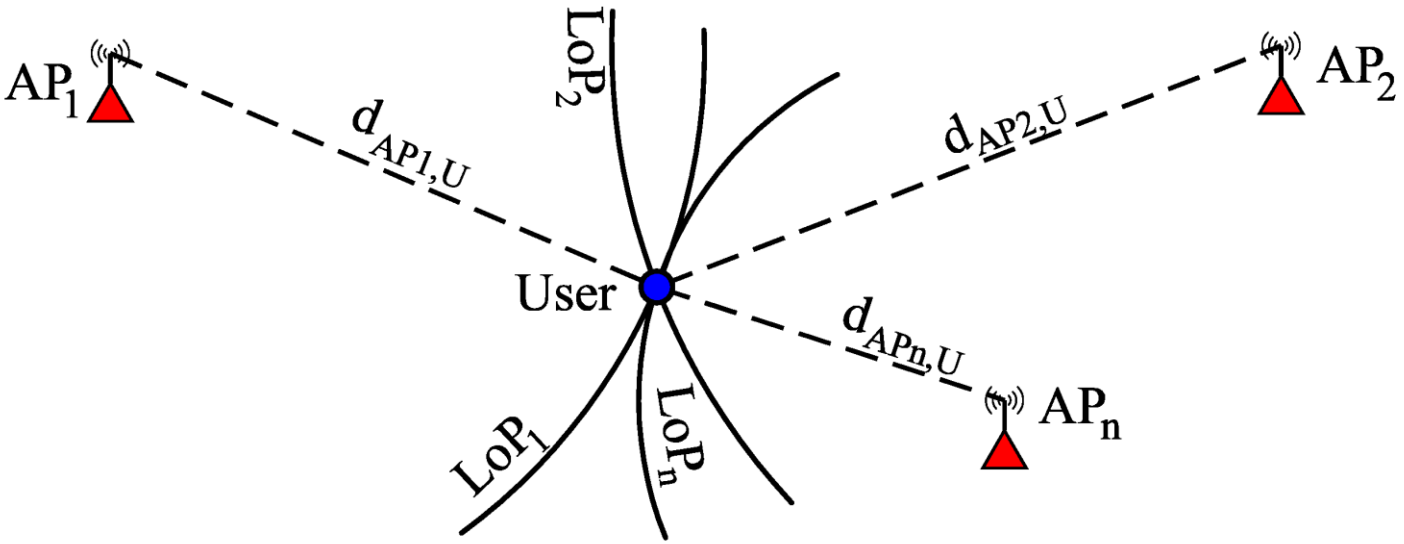
Time of Arrival ToA measurements
RSS-based techniques employ path loss models for range conversion

Location Fingerprinting

Training and positioning phase



Lateration

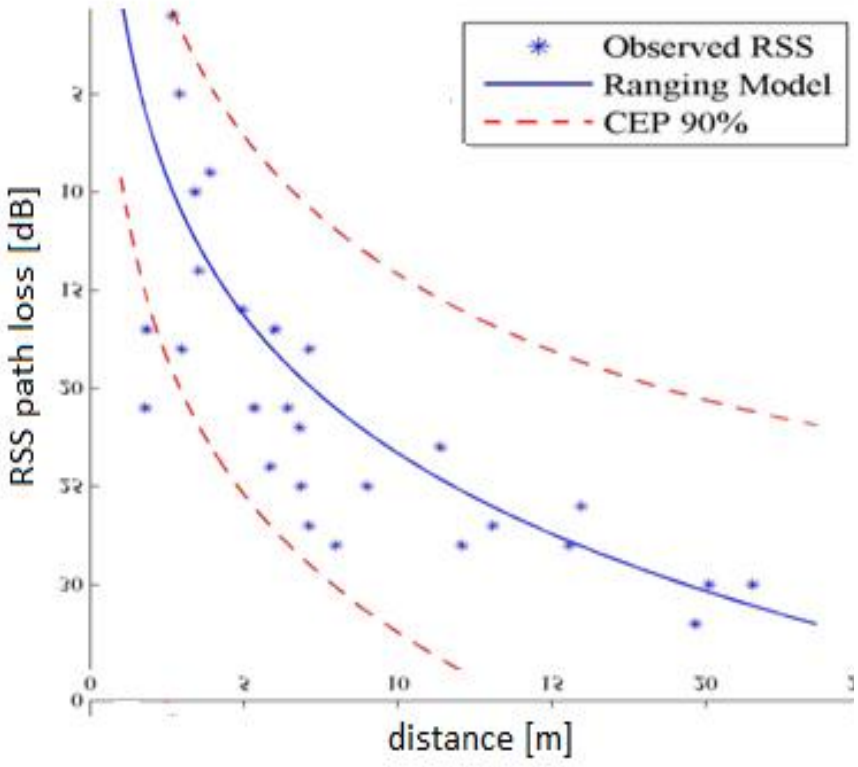


Intersection of at least 3 spherical surfaces given the centres and radii of those spheres

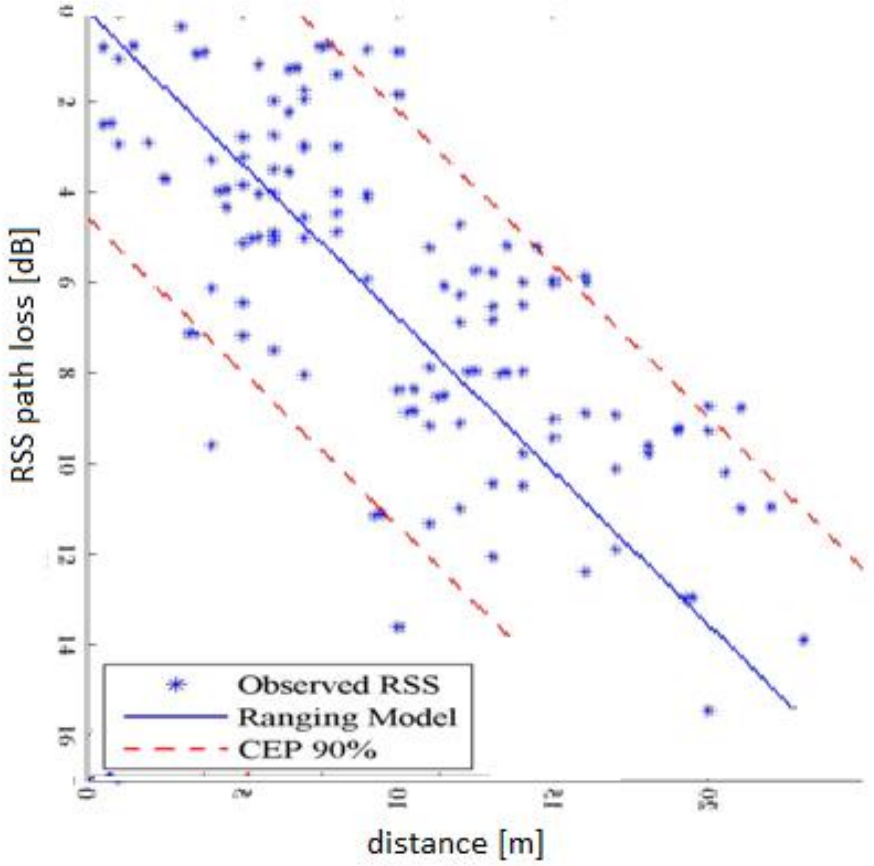
In RSS-based techniques, it is based on the nature of the RSS which varies with the changes of distance between transmitters and receivers

RSS decreases with the transmitted energy propagating into space

RSS Path Loss Patterns in Different Environments

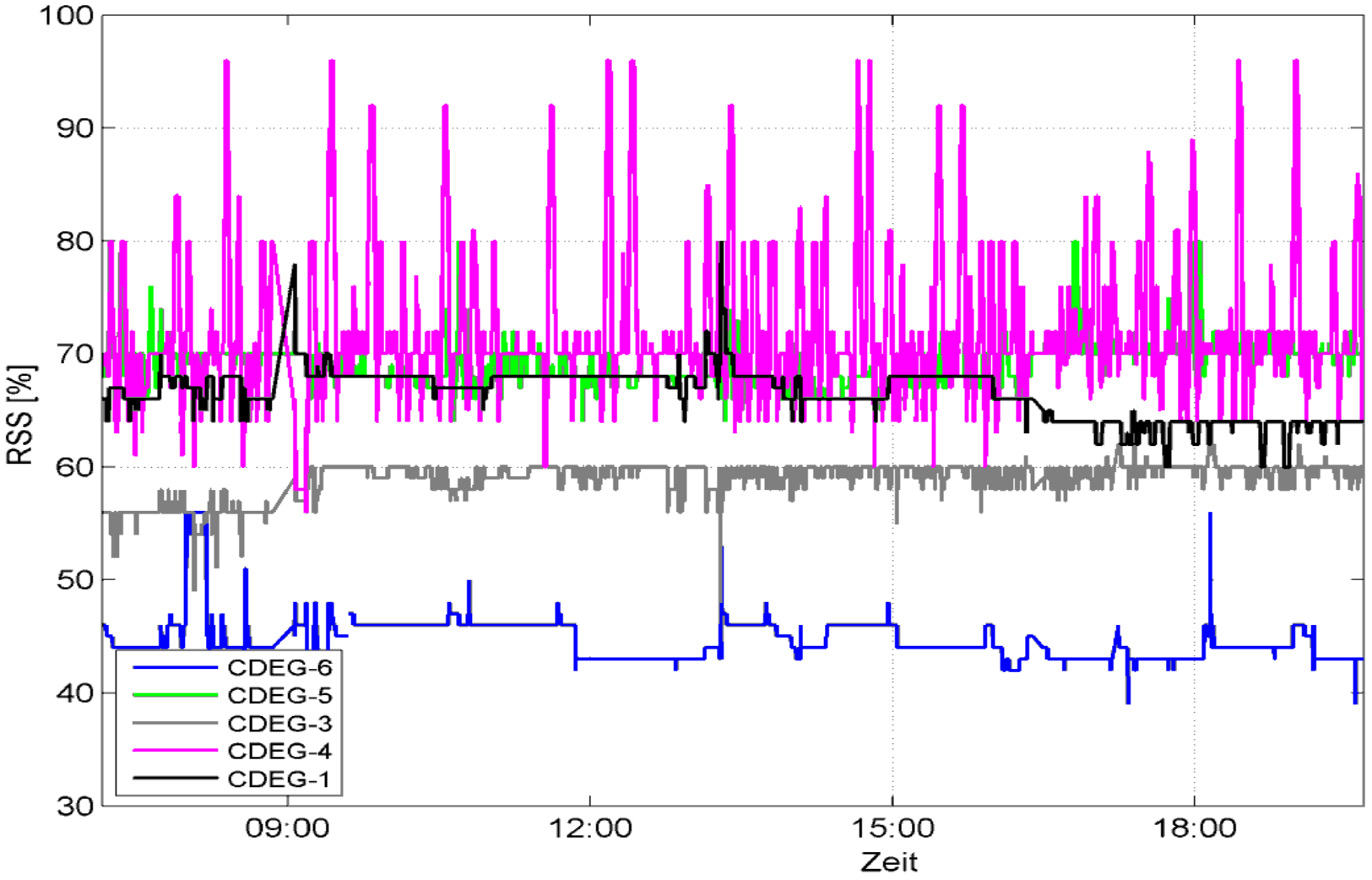


Log-distance pattern outdoors



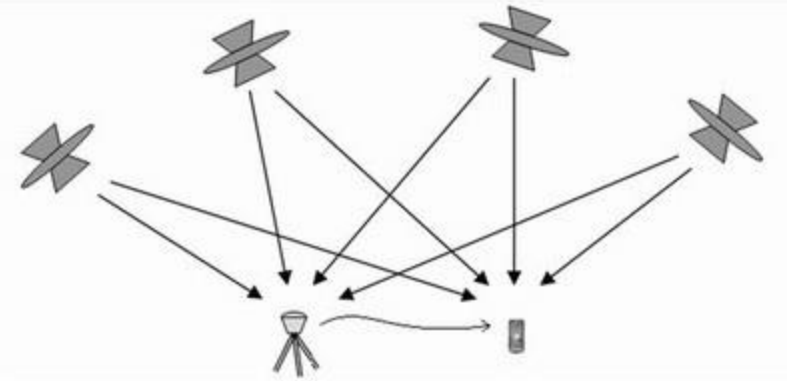
Linear pattern in a corridor indoors

Long-term RSS Observations



Differential Approaches

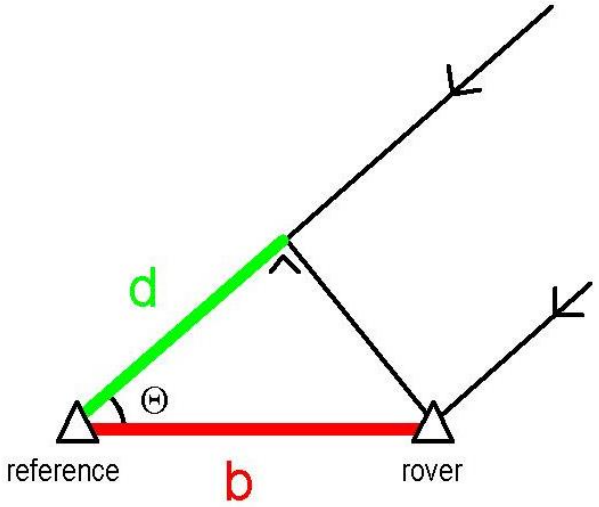
Reference stations at known locations



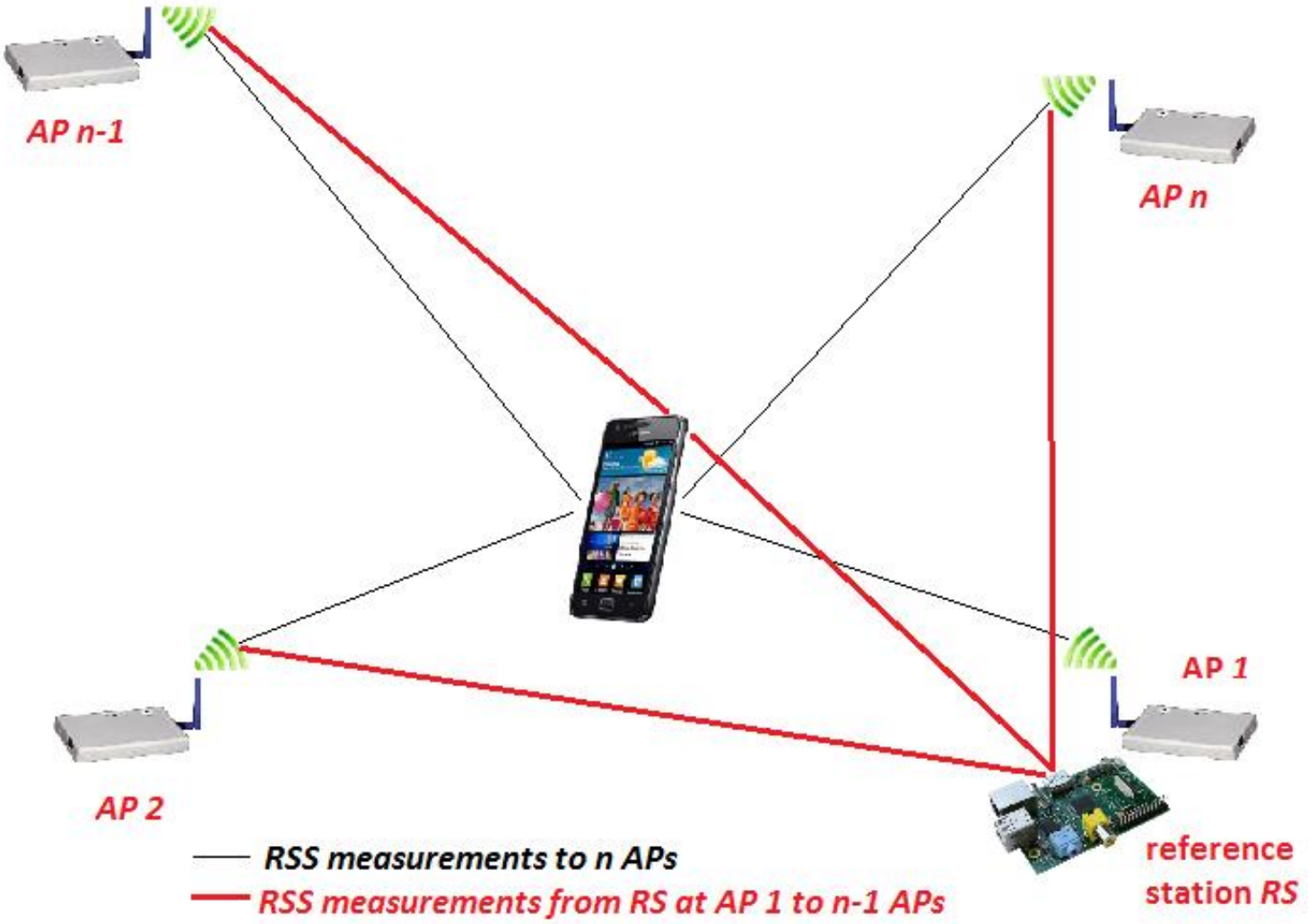
Corrections for the user regarding:

- Signal propagation
- Spatial and temporal variations

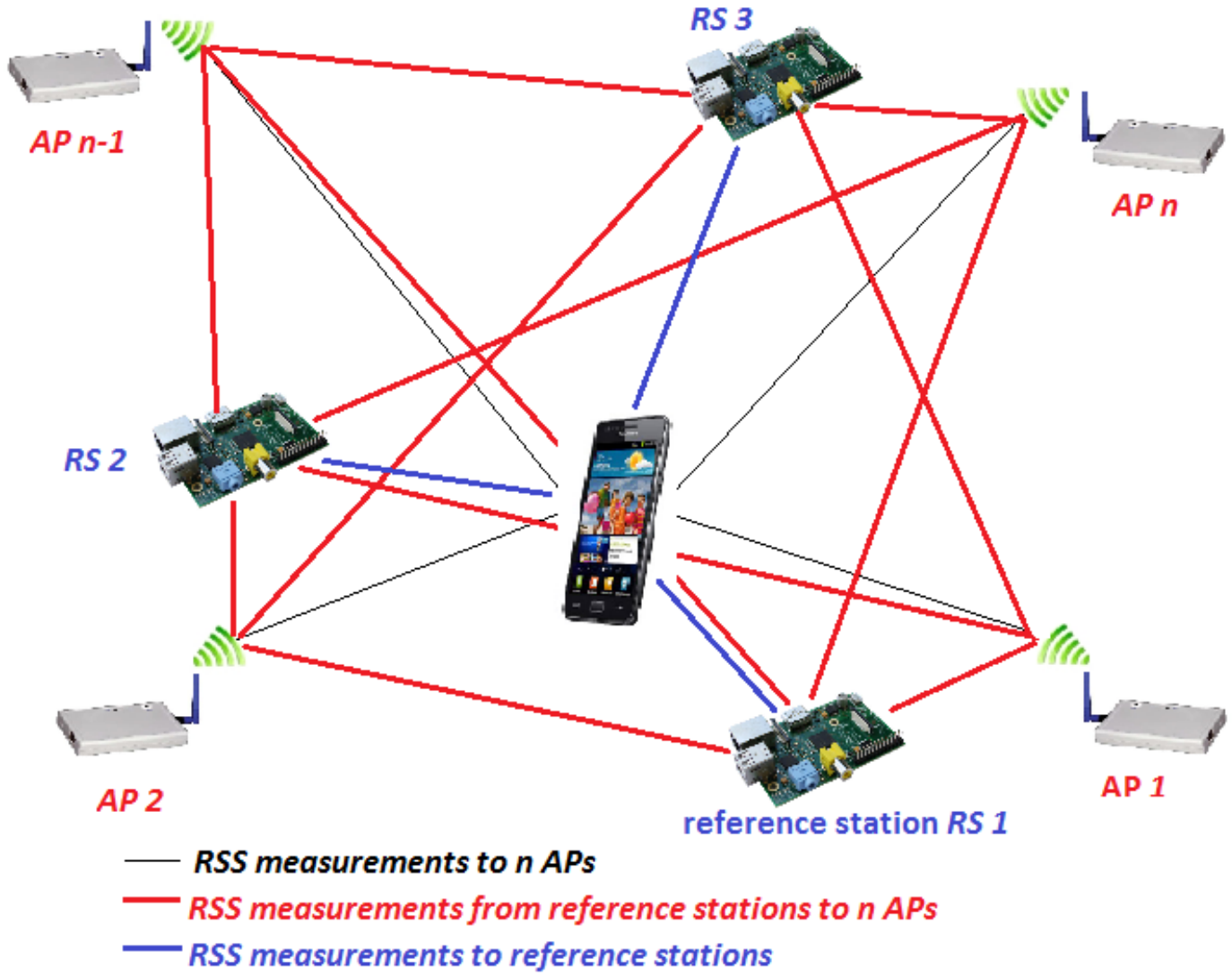
2 approaches and positioning methods



Differential Wi-Fi (1st Approach)



Differential Wi-Fi (2nd Approach)

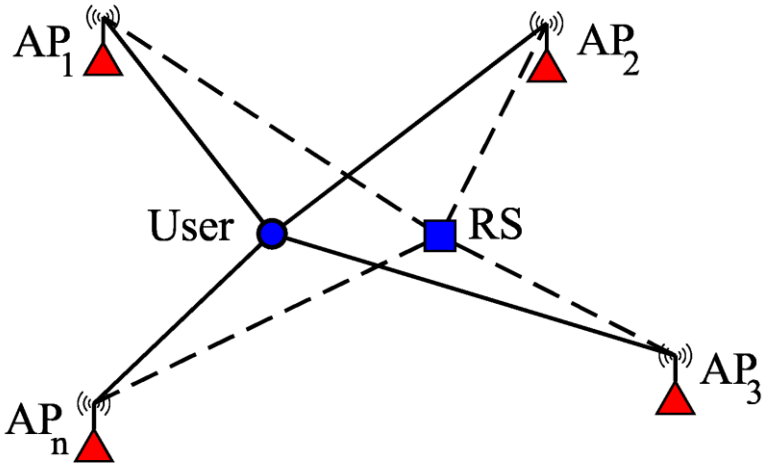


DWi-Fi Lateration Methods

1. DGPS principle

RSS corrections

$$RSS_{corr} = RSS_{calc} - RSS_{obs}$$

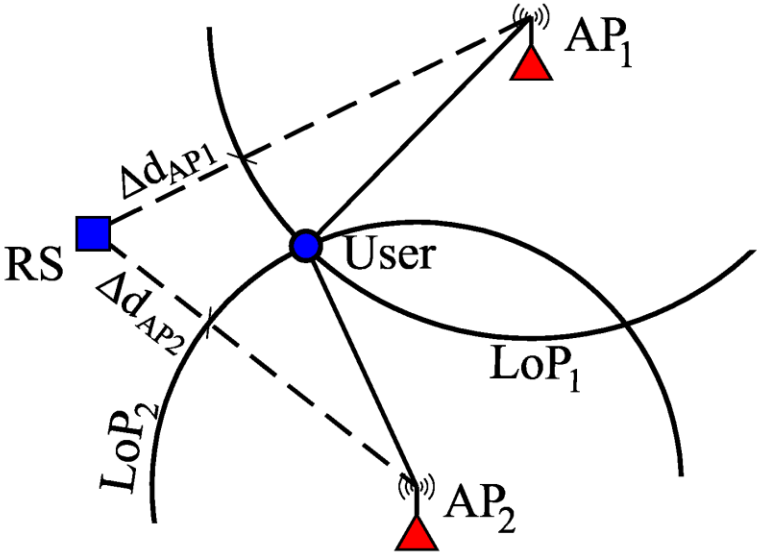


2. VLBI principle

RSS differences

$$\Delta RSS = RSS_{User} - RSS_{RS}$$

$$d_{U,AP_i} = d_{RS,AP_i} - \Delta d_{AP_i}$$



System Components

Wi-Fi Access Points: distinguished by their MAC addresses

Reference Stations: Raspberry Pi's

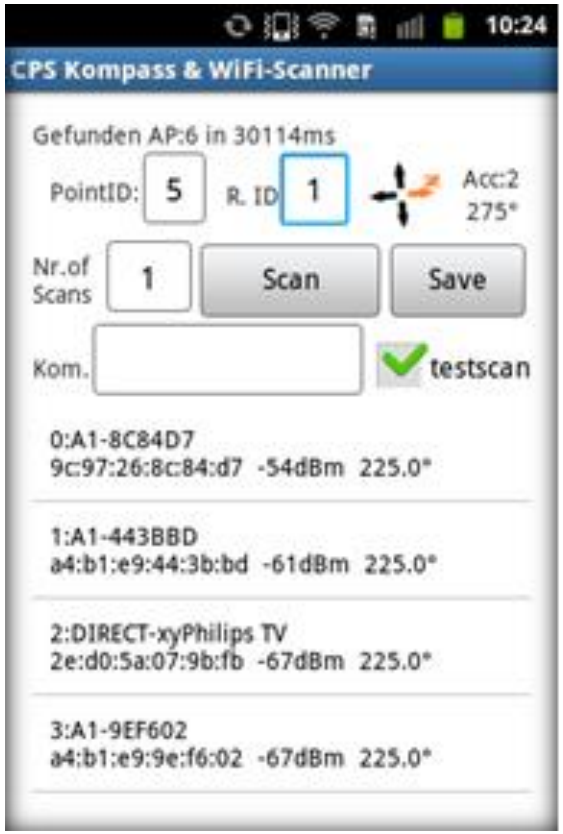
Low-cost credit-card sized computer

© www. raspberrypi.org

USB Wi-Fi adapter

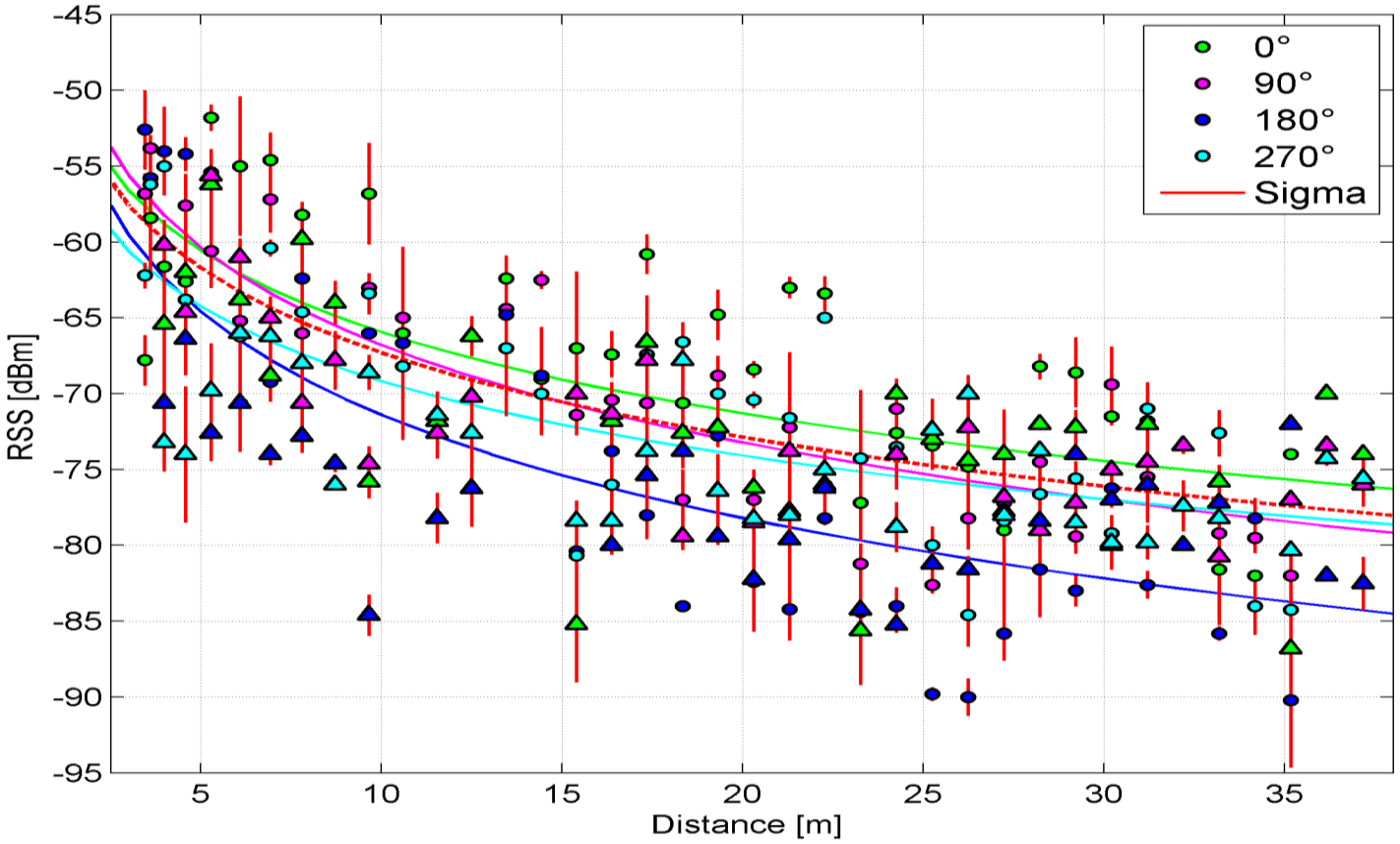
Python Script

App user interface



Relationship Distance - RSS for SM 1

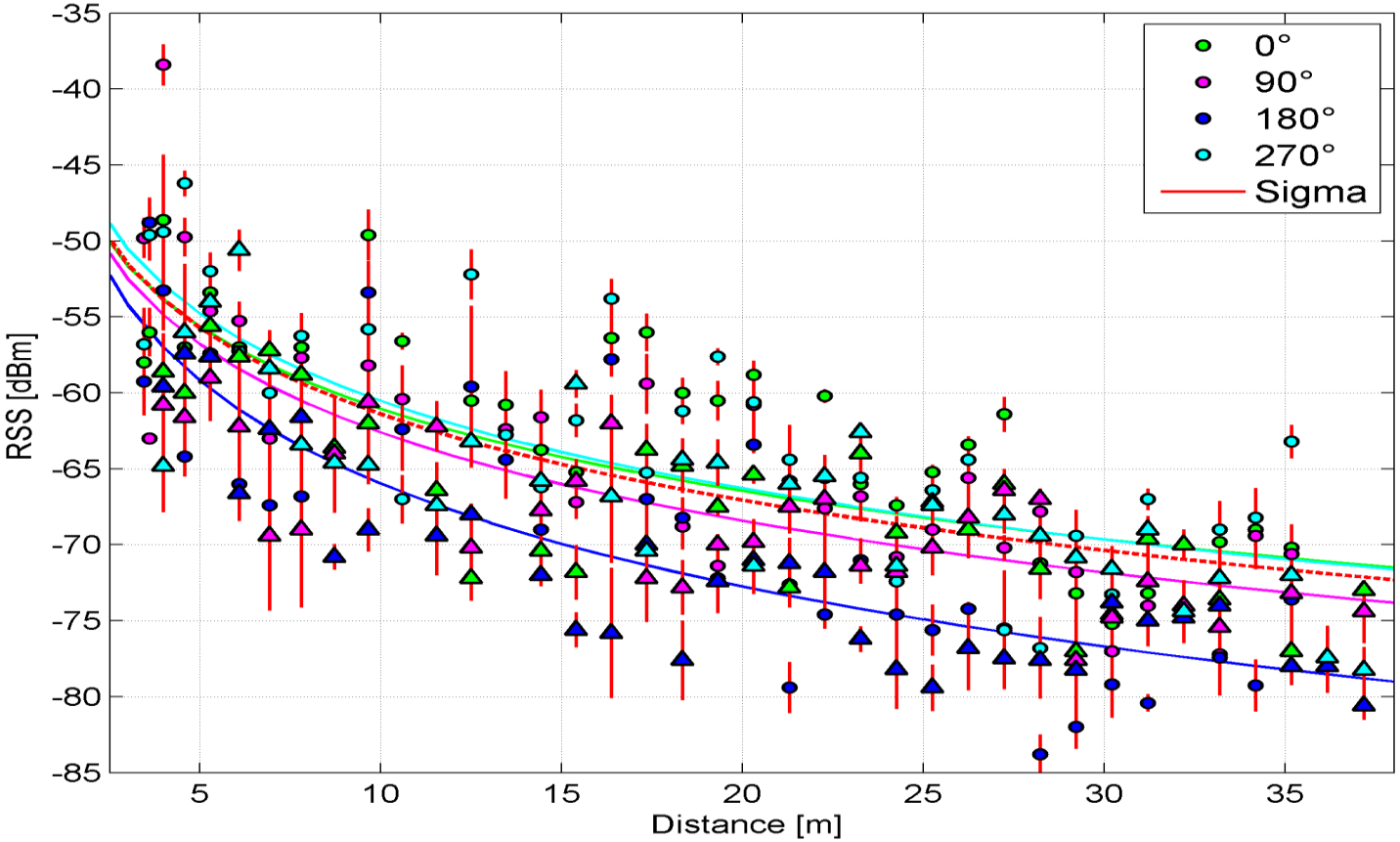
$$RSS = a * \log(distance) + b$$



a = -8.03755 dBm
b = -48.79595 dBm

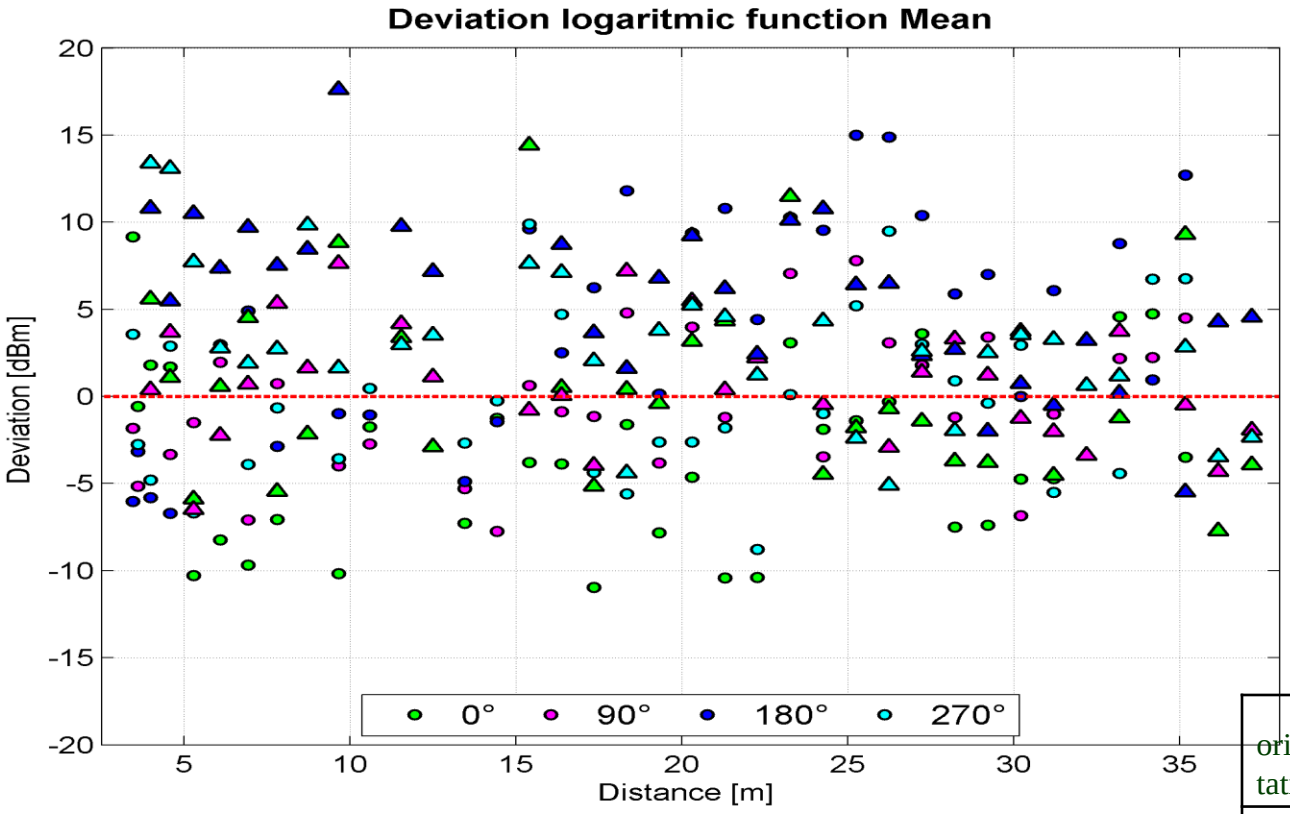
Relationship Distance - RSS for SM 2

$$RSS = a * \log(distance) + b$$



a = -8.17212 dBm
b = -42.58458 dBm

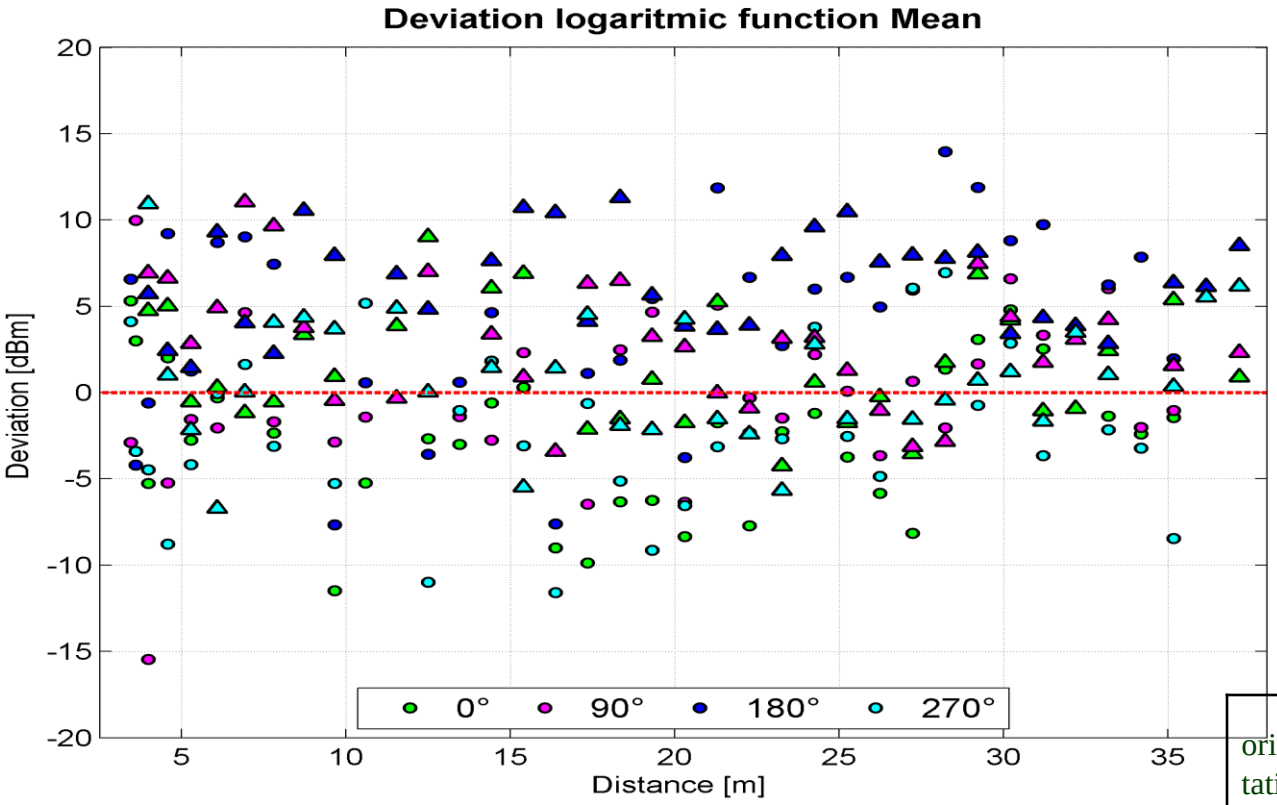
Deviations from log-FCN for SM 1



orien-tation	direction	
	1	2
0°	5.305	4.122
90°	3.452	2.776
180°	6.487	6.264
270°	3.814	4.250

mean deviations [dBm]

Deviations from log-FCN for SM 2

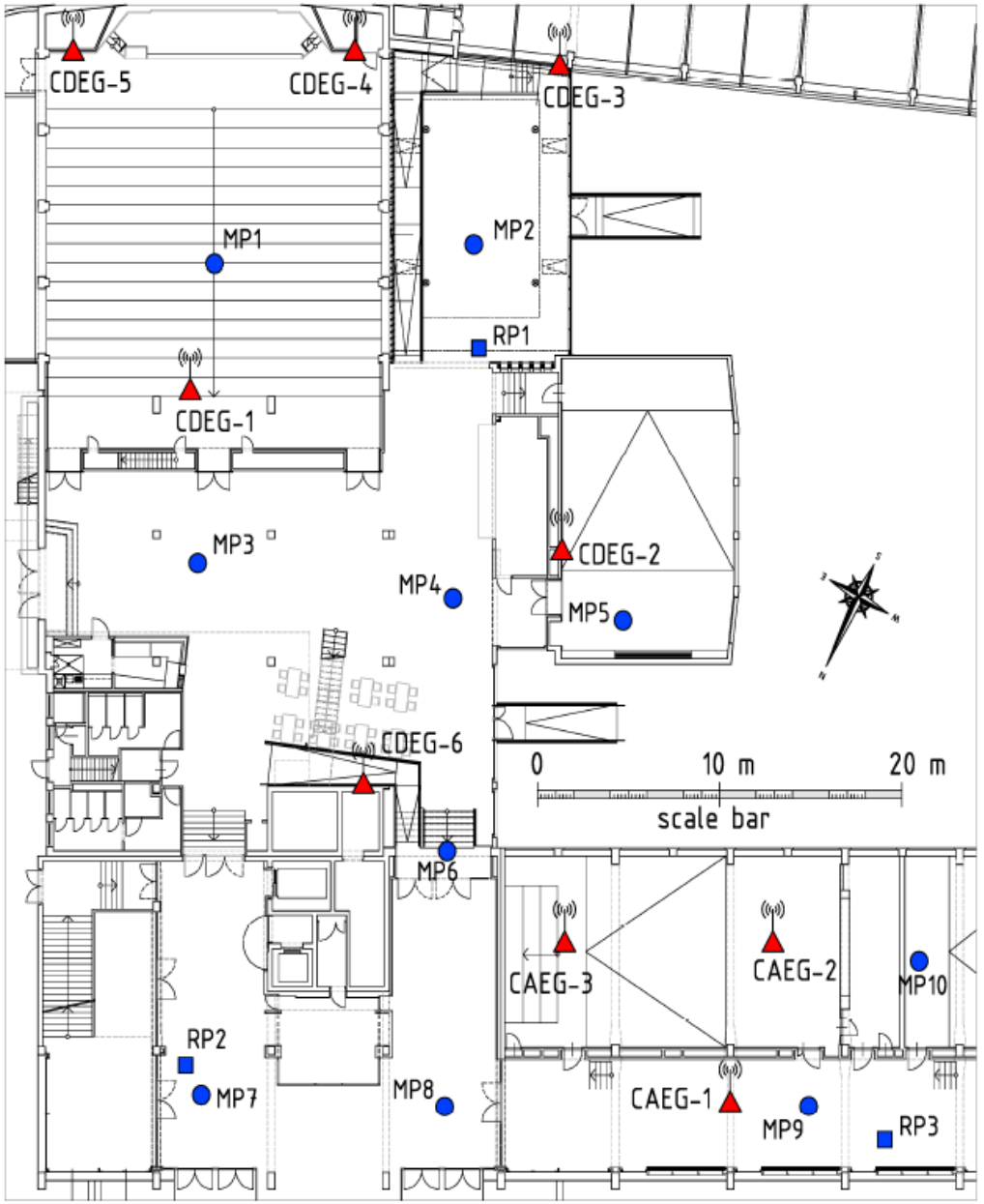


orien-tation	direction	
	1	2
0°	3.992	3.066
90°	3.554	3.833
180°	5.942	6.406
270°	4.348	2.971

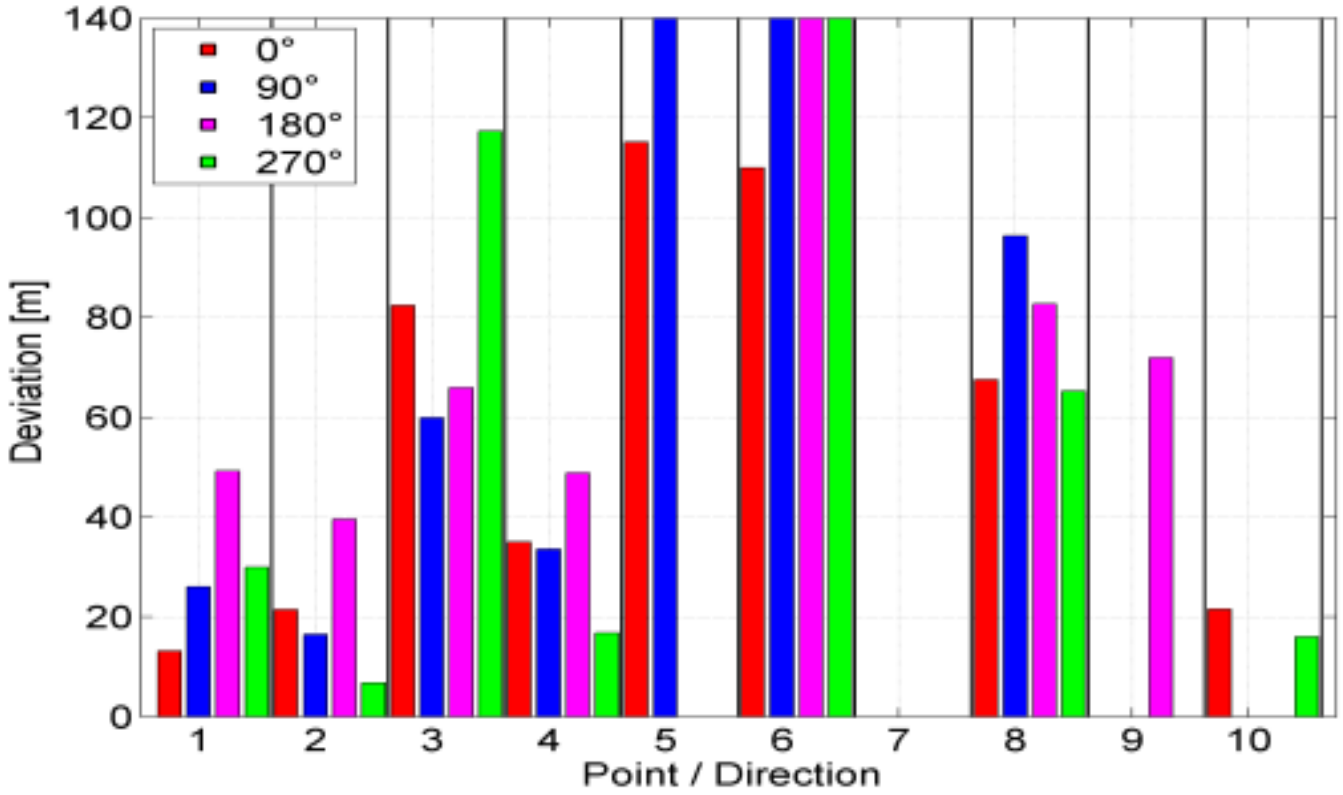
mean deviations [dBm]

Field Tests

9 Access Points APs
3 Reference stations RPs
10 Test points MPs

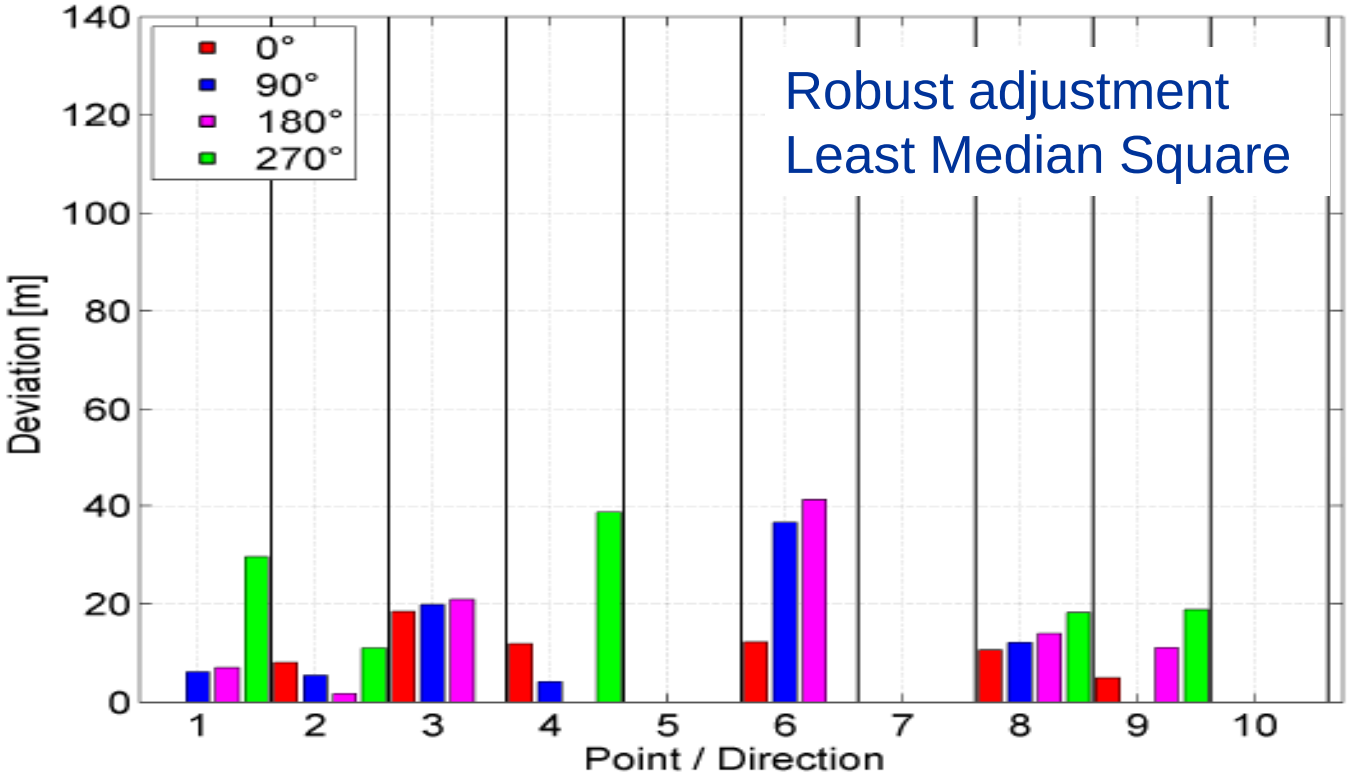


Deviations from True Position (1)



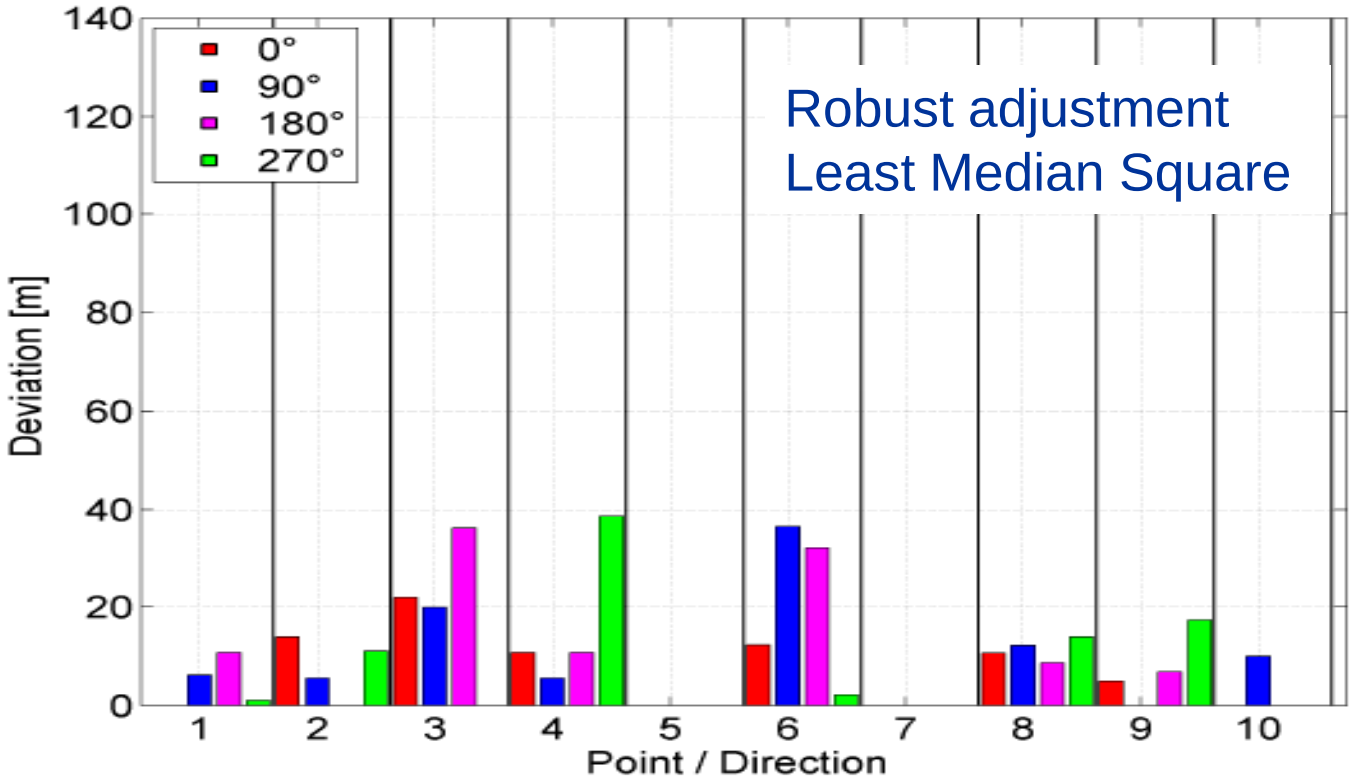
Without differential corrections
using reference station measurements

Deviations from True Position (2)



With differential corrections
using reference station measurements

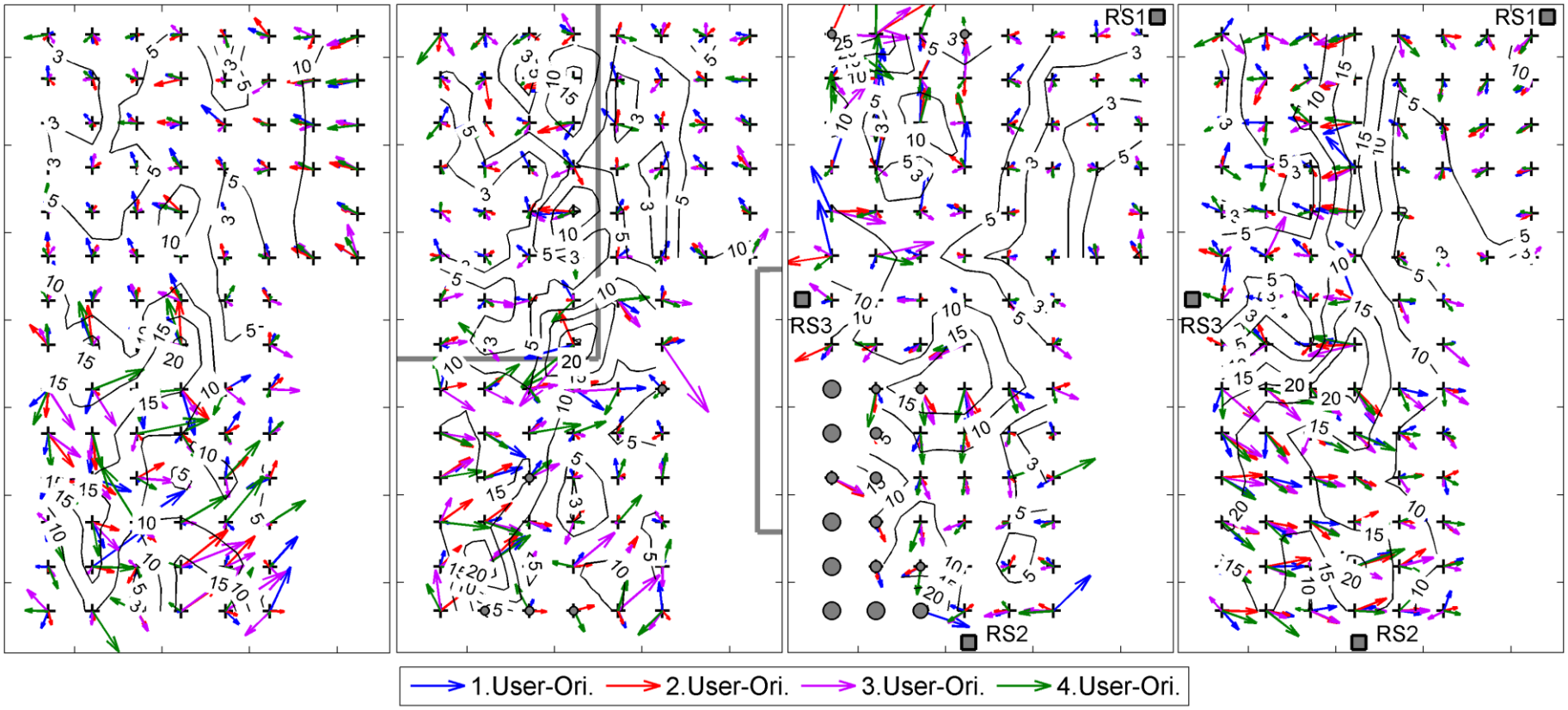
Deviations from True Position (3)



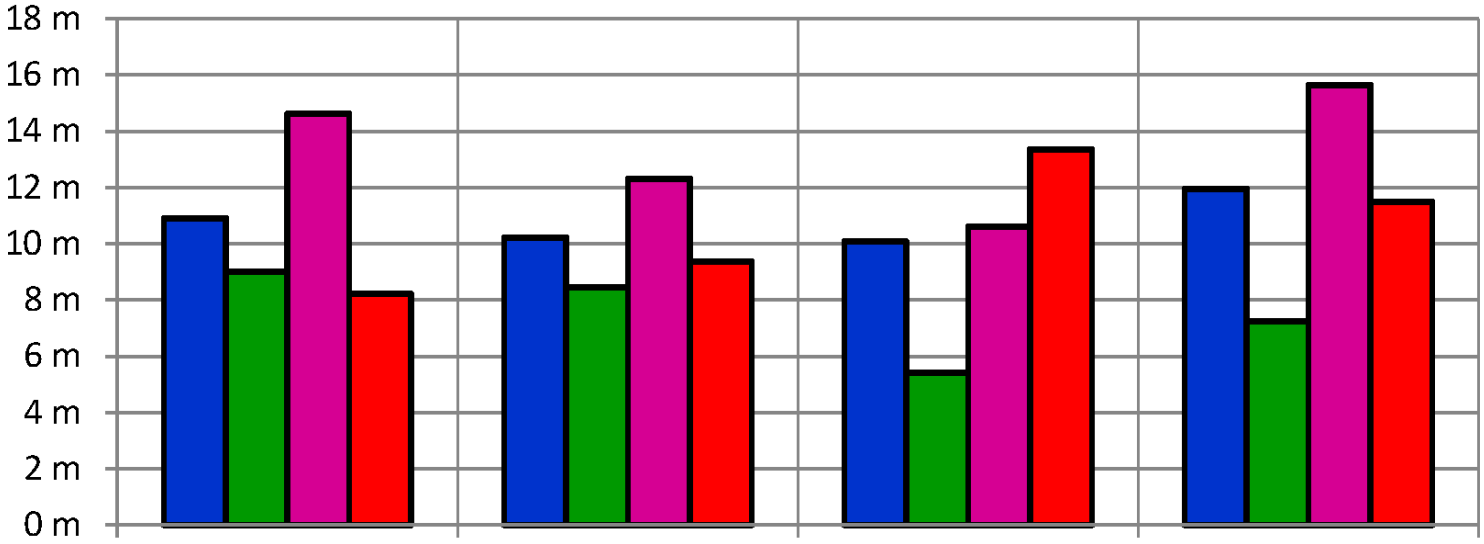
With differential corrections using reference station measurements and consideration of user orientation

Areal Deviations from True Position (1)

one-slope model multi-wall model diff. model 1 diff. model 2



Areal Deviations from True Position (2)



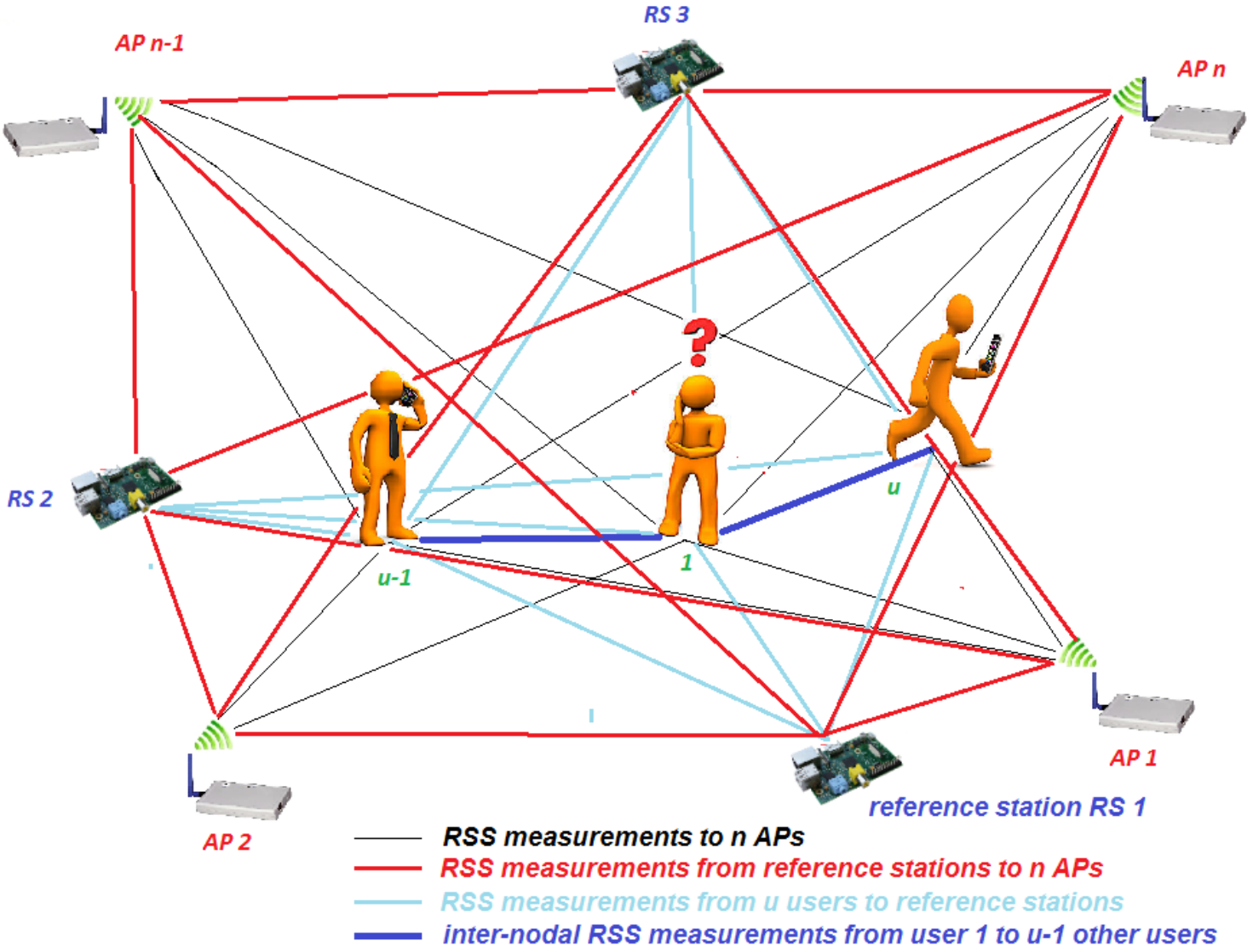
one-slope model multi-wall model diff. model 1 diff. model 2

Best results are achieved in area with computers

Multi-wall shows slight improvement

Differential model 1 achieves good results in central area of test site but lower accuracies in margin areas

Cooperative Positioning Solution



Summary and Outlook

Spatial and temporal variations are considered

2 new differential DWi-Fi approaches are developed

Improvement can be achieved in the network of reference stations

Shorter distance to reference stations yields better results

Application of dynamical radio maps is investigated

Additional use of personal hotspot functionality

Fusion with inertial sensors