Master Thesis Presentation

Design and Implementation of an Adaptive Indoor Positioning System based on Received and Interpolated Signal Strengths

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Problem Statement

- **Good Accuracy – Lacking Scalability & Maintainability**

  Current indoor positioning techniques already offer good accuracy performances. The main problem is that most of them *do not consider*:

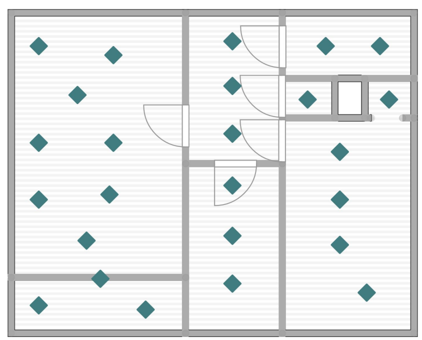
  - setup
  - maintenance
  - scalability.

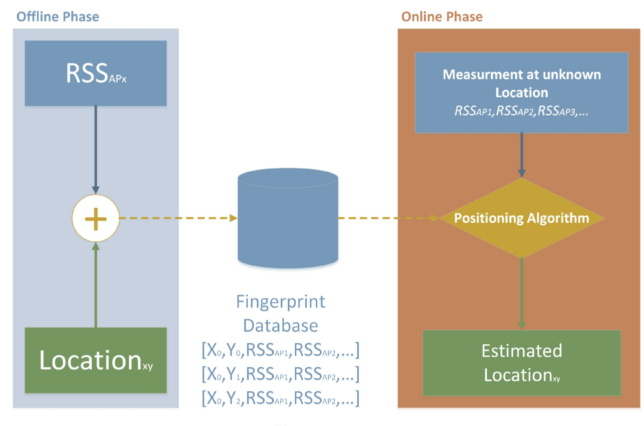
- **No Site Adaptation**

  most systems are optimized for a specific site, not for generic usage

Techniques of Indoor Positioning

- **Scene Analysis / Fingerprinting**
  - Method: IEEE 802.11+ Received Signal Strength Indication (RSSI)
  - Offline phase: create reference database
  - Online phase: compare with live measurements





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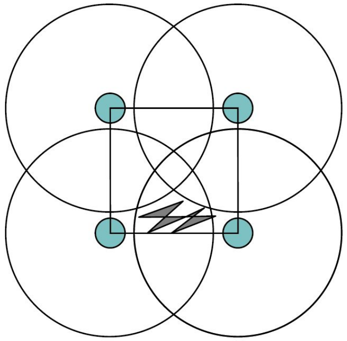
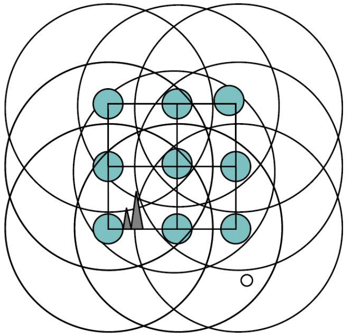
- W.M. Yeung and J.K. Ng. An Enhanced Wireless LAN Positioning Algorithm based on the Fingerprint Approach. In TENCON 2006. 2006 IEEE Region 10 Conference, pages 1–4, Nov 2006.

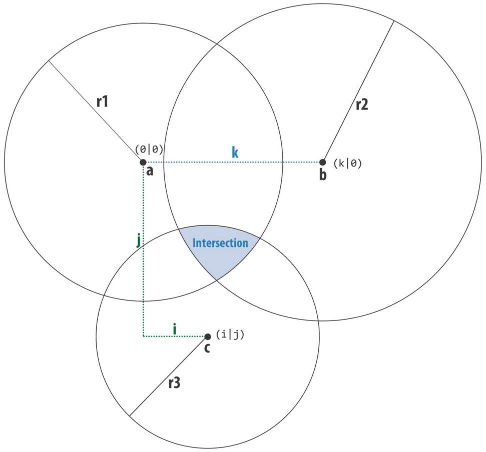
State of the Art: Techniques of Indoor Positioning

- **Proximity**
  - Method: Bluetooth, RFID,…
  - Algorithms: RSS + KNN, TOA,…
  - Properties strongly depended on setup and method





- **Geometric Methods**
  - Trilateration, Triangulation
  - low accuracy



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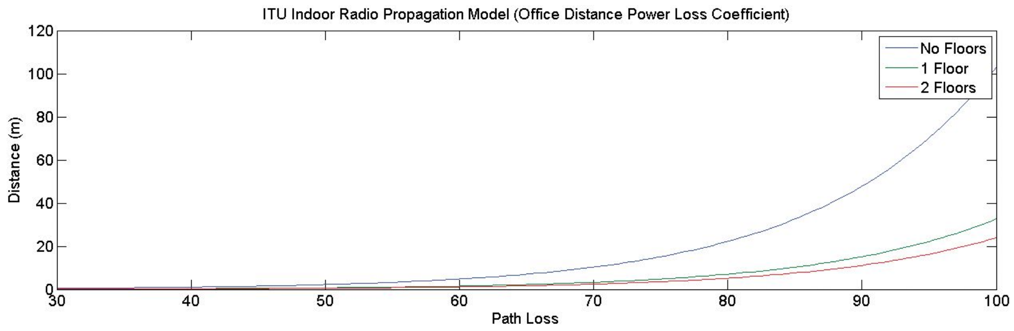
State of the Art

Related Work

- Early IEEE 802.1/RSS scene analysis style indoor system in literature from Microsoft Research (2000)
- Mixed views regarding performance of RSS
- Various models for models for indoor attenuation described



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- Ambili Thottam Parameswaran, Mohammad Iftekhar Husain, Shambhu Upadhyaya, et al. Is Rssi a Reliable Parameter in Sensor Localization Algorithms: An Experimental Study. Field Failure Data Analysis Workshop, F2DA09, 2009.

Areas of Further Research

- **Accuracy is the only Focus**
  Most systems see accuracy as only important property; scalability, maintainability and complexity often left out

- **Use of Trilateration with RSS**
  How can this method be used in combination with received signal strength

- **Better Adaption of indoor propagation models**
  Usually propagation models include certain parameters for different situations, but these are based on empirical data and may still be too specific

Method

1. **Analysis**
   Analysis and evaluation of "*State of the Art*" and selection of fitting techniques

2. **Concept and Design**
   Assessment of findings and how to apply to available technology

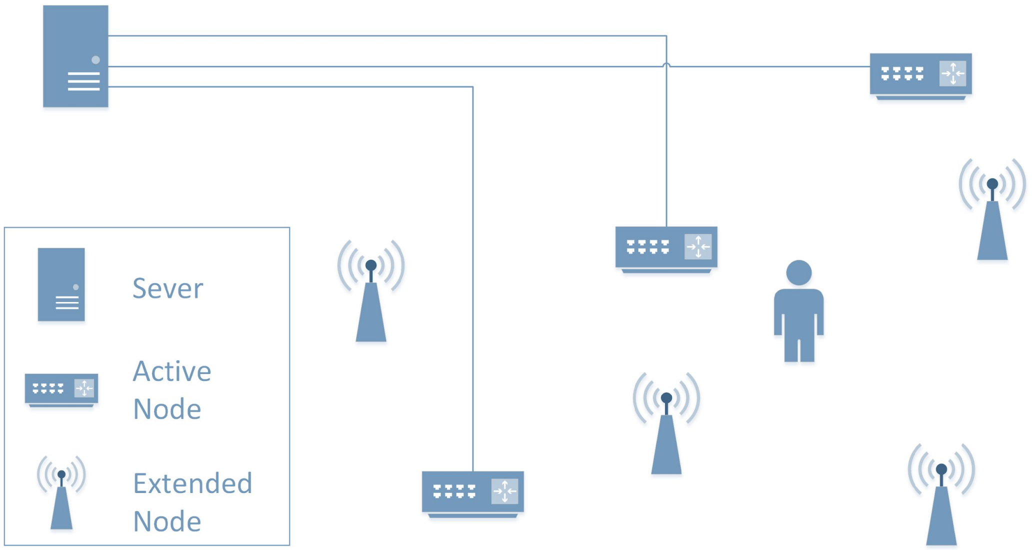
3. **Implementation**
   Entails implementation of web services in embedded systems and application servers as well as a rich user interface

1. **Experiment**
   Compare proposed system in different settings with "*State of the Art*" commercial solution

Method

Design & Implementation

- Methods:
  - IEEE 802.11 + RSS + KNN
  - Propagation Models
  - Trilateration
- Active Nodes
  - Measure environment
  - Regular access points
- Extended Nodes
  - Pre-deployed APs
- Central Management



Method: Phase 1 & 2

Measurment, Evaluation & Generation

Phase 1: Node Setup & Placement

Phase 2: RSS Measurement

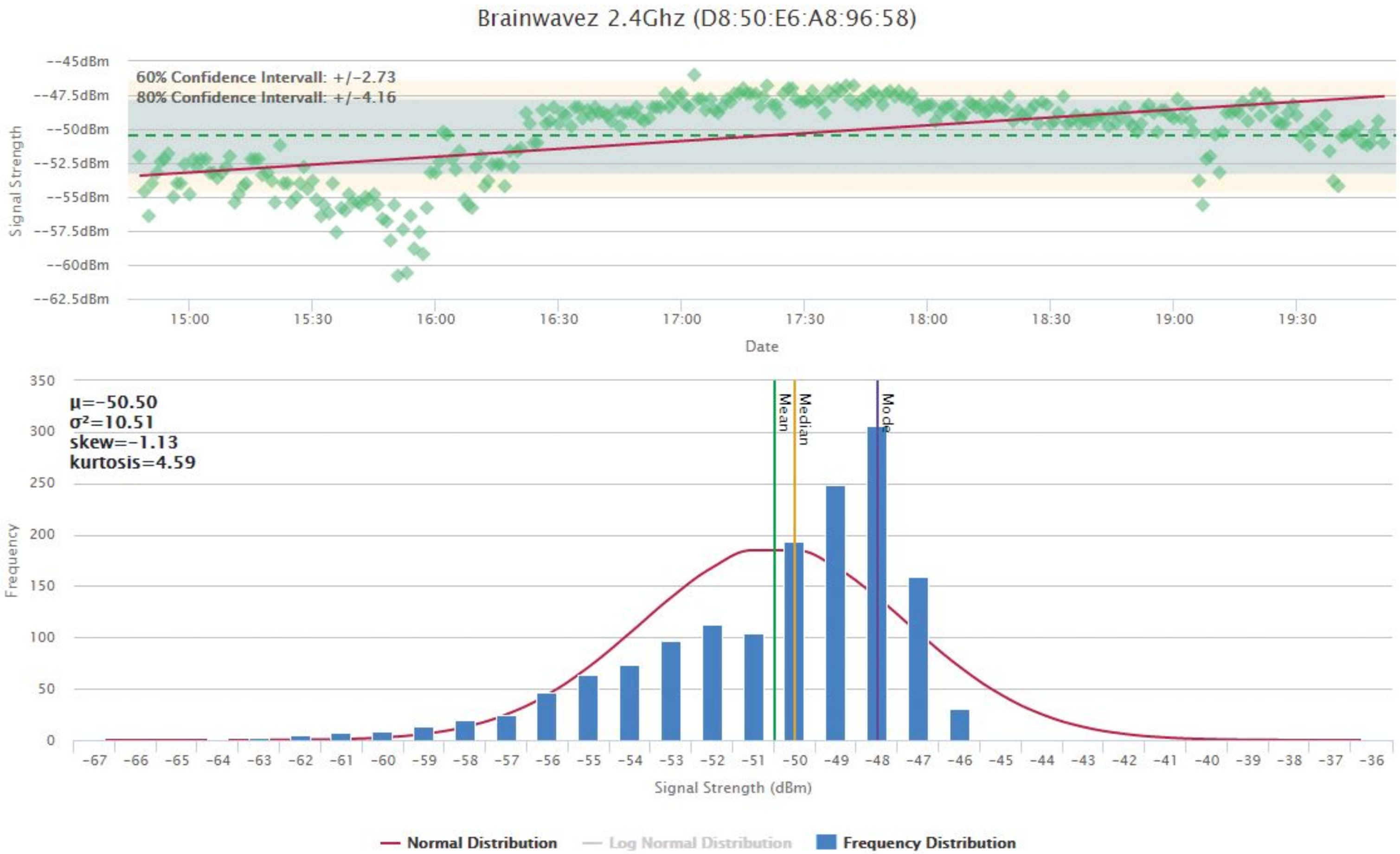
Phase 3: Site Evaluation

Phase 4: Map Generation

Positioning

Phase 5: Live Positioning

Method: Phase 1 & 2



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Method: Phase 1 & 2

Extended Nodes | Distance Matrix | Signal Strength Map

WLAN_2_4Ghz

Multi. Values | Show Only Managed

Mean: -65.05dBm x 0.95 = -61.80dBm / Median: -66dBm / Dist: 6.20m (Mult: 5.81m)

Mean

SSID	TP-Link (3) Client xxx.1 - TPLink	Linksys (1) (x0.95) Node xxx.xxx.1.1 - Linksys	TP-Link (1) (x0.95) Node xxx.xxx.2.1 - TPLink	TP-Link (2) (x0.966) Node xxx.xxx.3.1 - TPLink
3WebCube71DE	-79.89dBm	-82.65dBm	-81.48dBm	-83.57dBm
A1-9EE2C2	-86.60dBm			
A1-f35570	-81.39dBm	-84.97dBm	-81.73dBm	-79.92dBm
Amtmann	-88.50dBm	-73.78dBm	-71.72dBm	-86.28dBm
Brainwavez 2.4Ghz	-61.34dBm	-45.56dBm	-46.52dBm	-54.26dBm
CMA_Homebase	-84.64dBm			-82.67dBm
Carlos3	-84.16dBm		-81.93dBm	
Client xxx.1 - TPLink		-61.80dBm	-79.31dBm	-49.04dBm
HP-Print-8E-LaserJet Pro MFP	-76.76dBm		-55.67dBm	-76.84dBm
MATRIX-HOME	-88.22dBm			
MagicBus	-85.14dBm			
NETGEAR_EXT	-77.78dBm			-84.53dBm
Node xxx.xxx.1.1 - Linksys	-61.80dBm		-50.79dBm	-51.56dBm
Node xxx.xxx.2.1 - TPLink	-79.34dBm	-49.31dBm		-61.09dBm

Method: Phase 3 & 4

Measurment, Evaluation & Generation

- Phase 1: Node Setup & Placement
- Phase 2: RSS Measurement
- Phase 3: Site Evaluation
- Phase 4: Map Generation

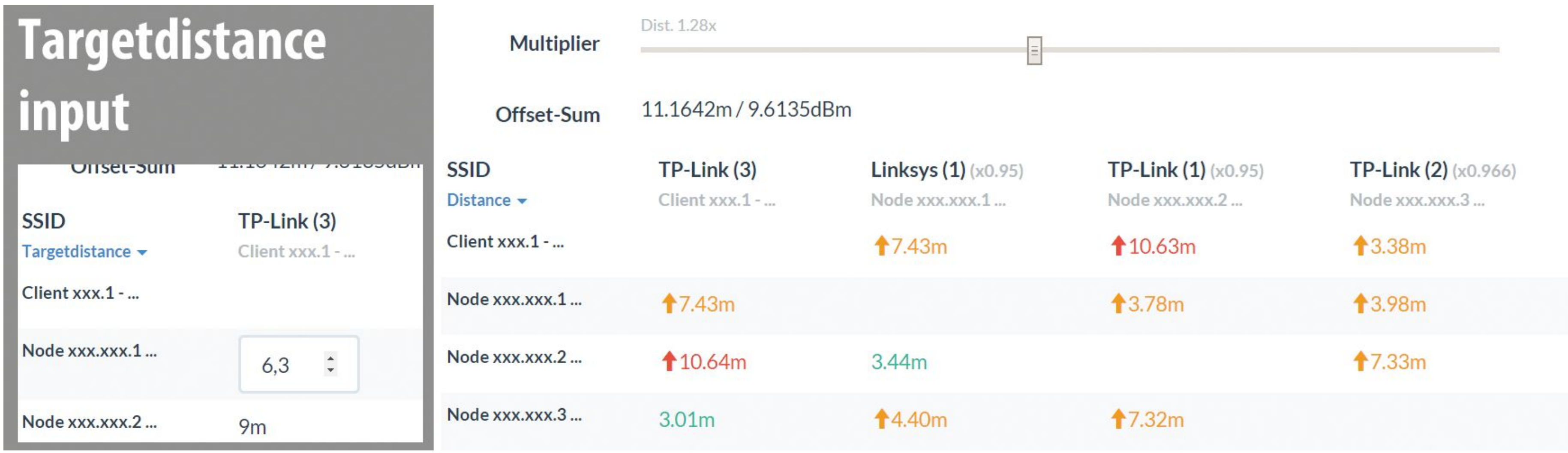
Positioning

- Phase 5: Live Positioning

Method: Phase 3

Site Evaluation

Input of actual physical distances for later automatic Adaptation



Method: Phase 3

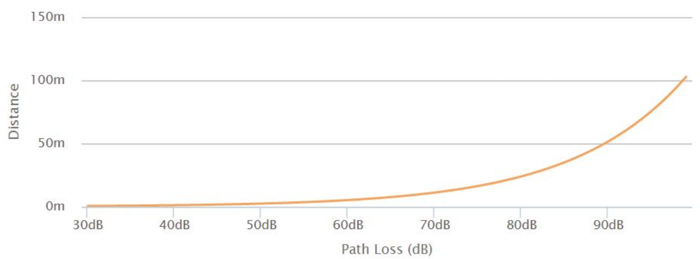
Adapting the Propagation Model

Intial Model

Environmental Model: INDOOR_OBSTRUCTED_OFFICE

Bound	90	dB
Factor	1	x
Offset	0	m

Graph

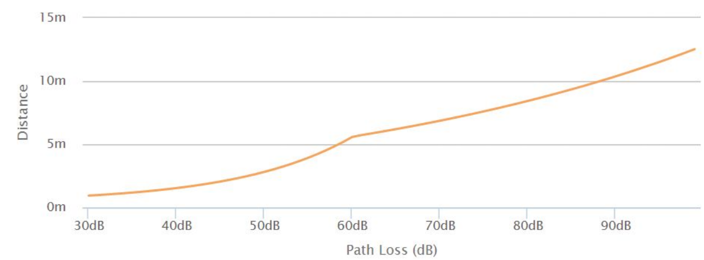


Adapted Model

Environmental Model: INDOOR_OBSTRUCTED_OFFICE

Bound	60,1044	dB
Factor	0,2834	x
Offset	0,4156	m

Graph



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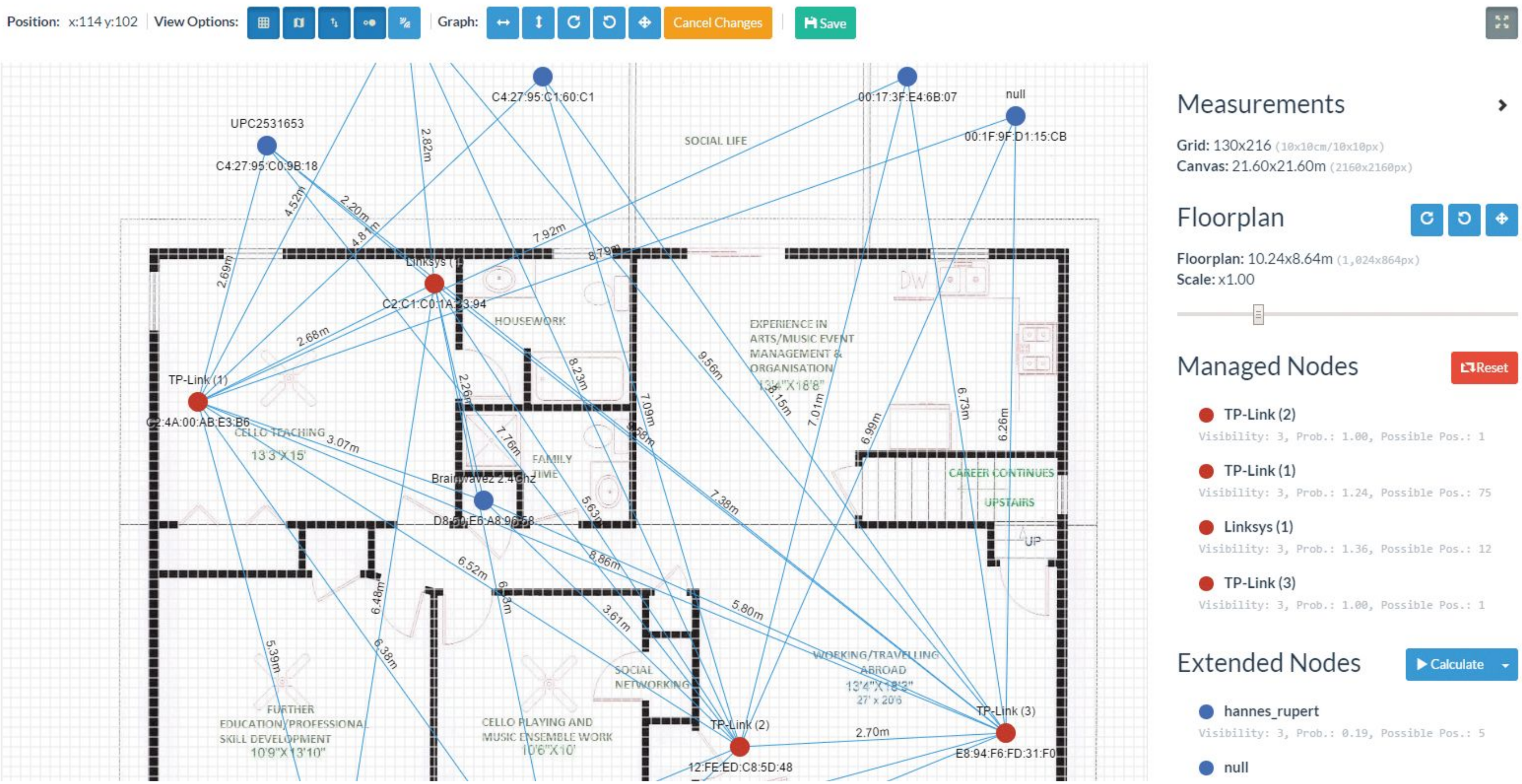
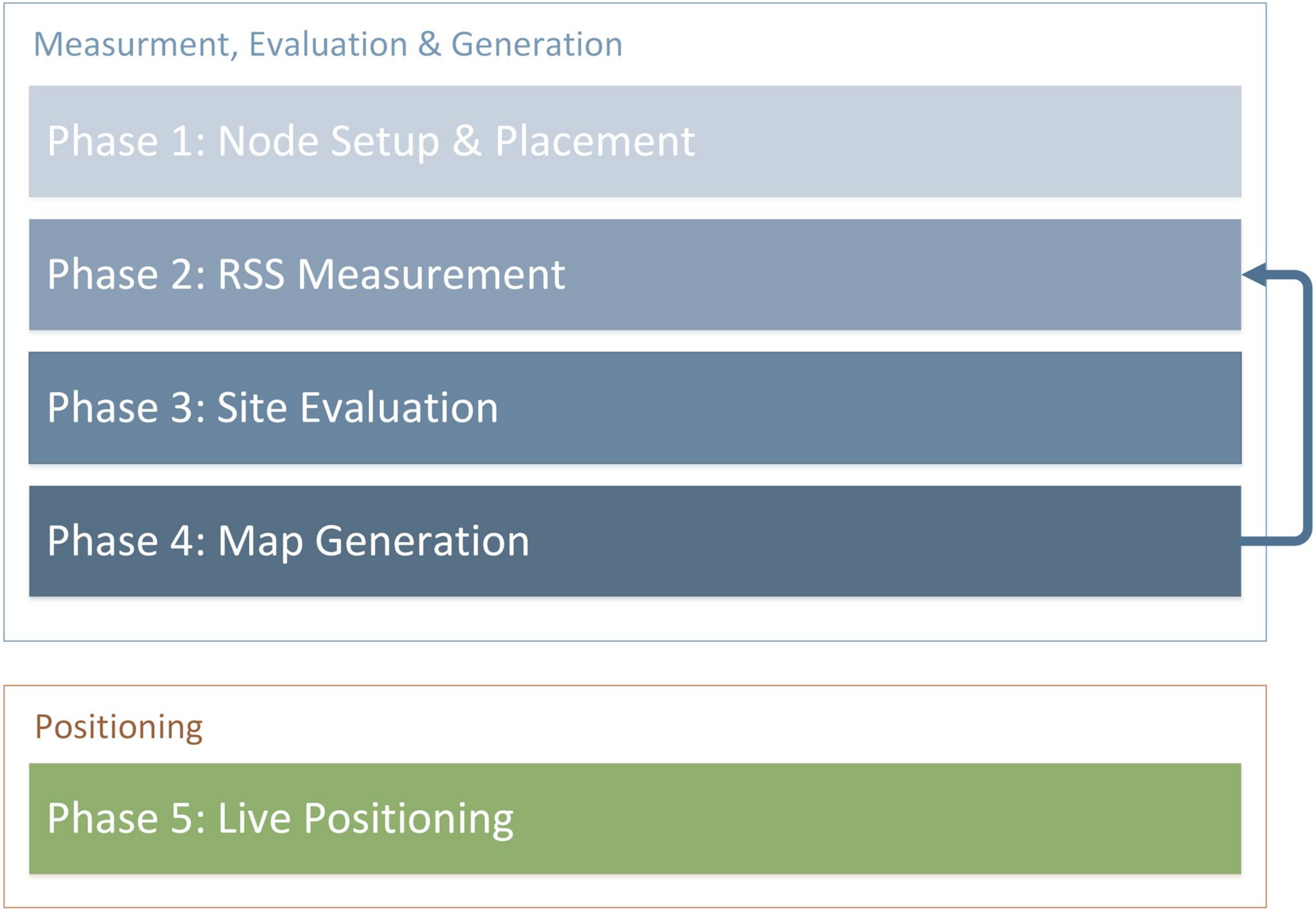
- J.M.P. Keenan and A.J. Motley. Personal Communication Radio Coverage in Buildings at 900 MHz and 1700 MHz. Electronics Letters, 24(12):763–764, Jun 1988.

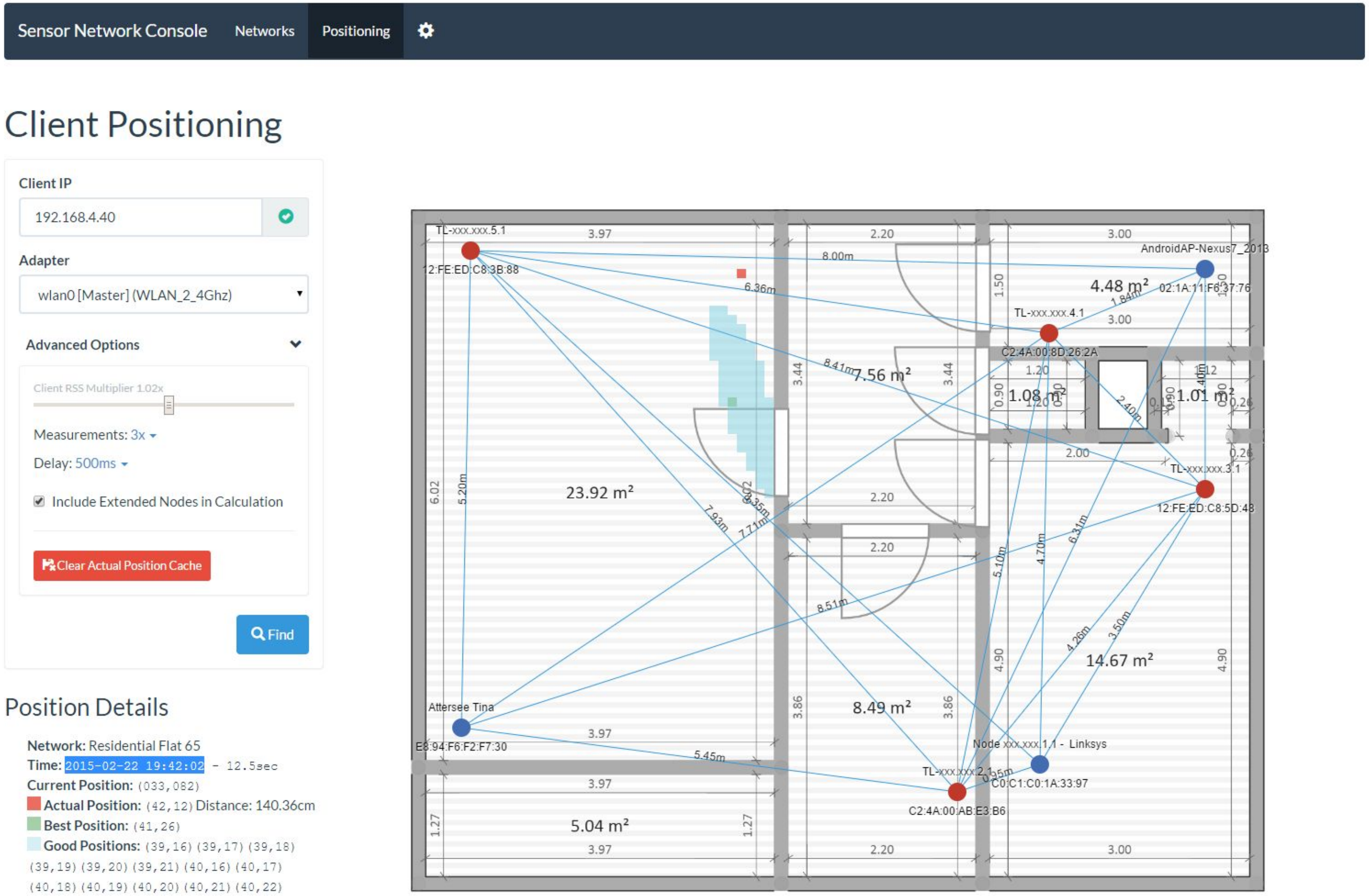
Signal Strength Map Generation



Method: Phase 5 - Positioning



Method: Phase 5 - Positioning



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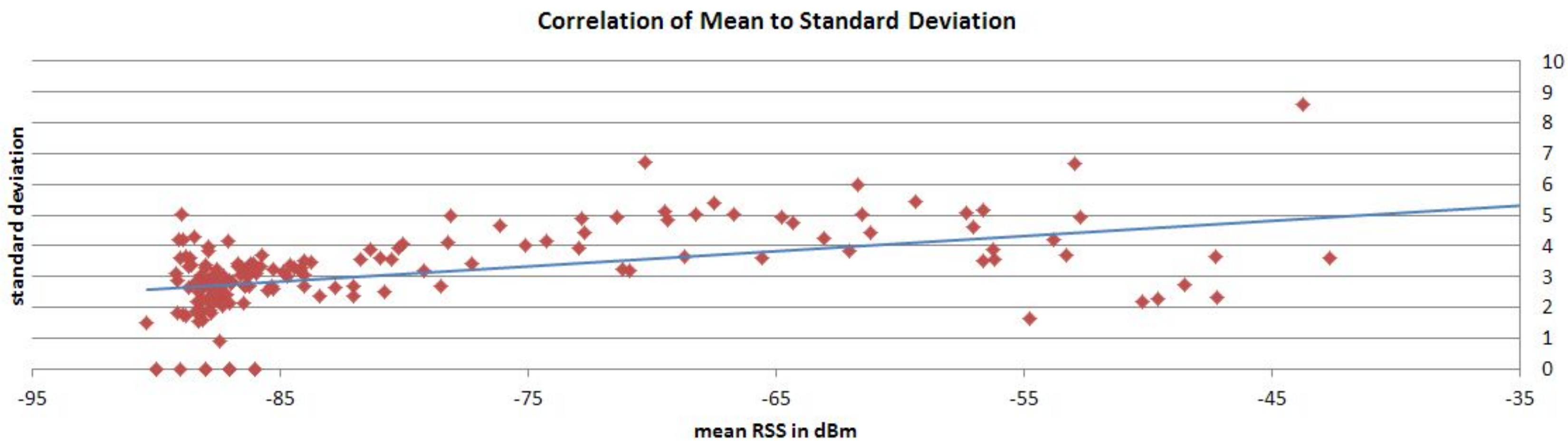
Results

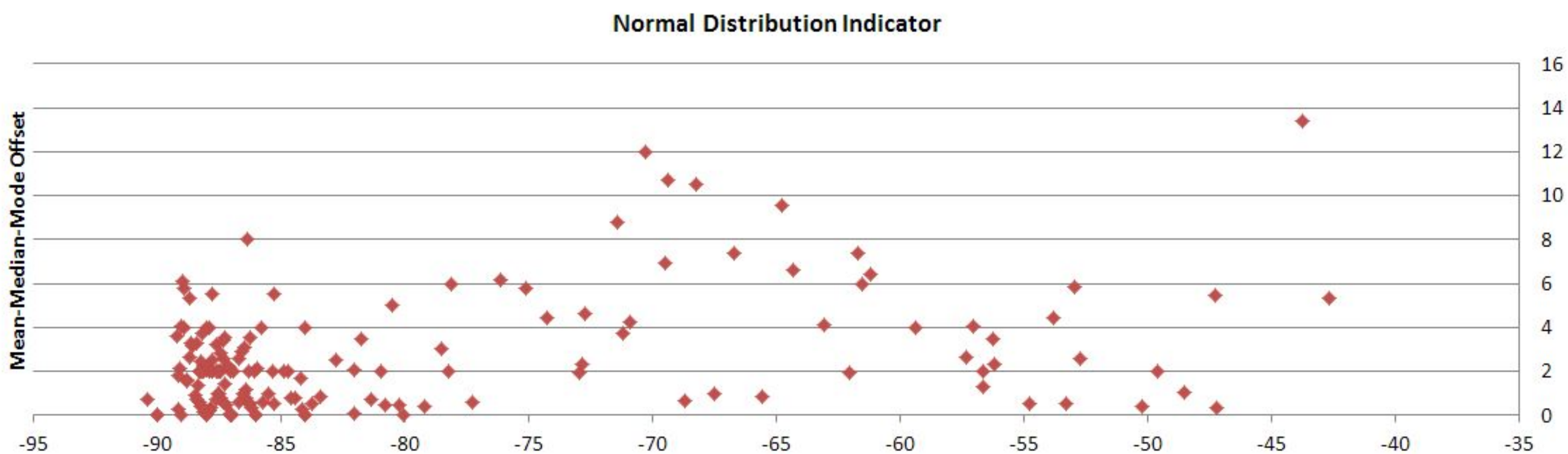
Summary of Results

- Adapts well to the specific environment
- Good *scalability* and low *maintenance* with easy setup
- Accuracy between 2 to 4 meter on average
- Initial positioning with trilateration works well
- Quality degrades with non-correlating RSS

Results: Discussion RSS

Received Signal Strength as Indicator for Distance

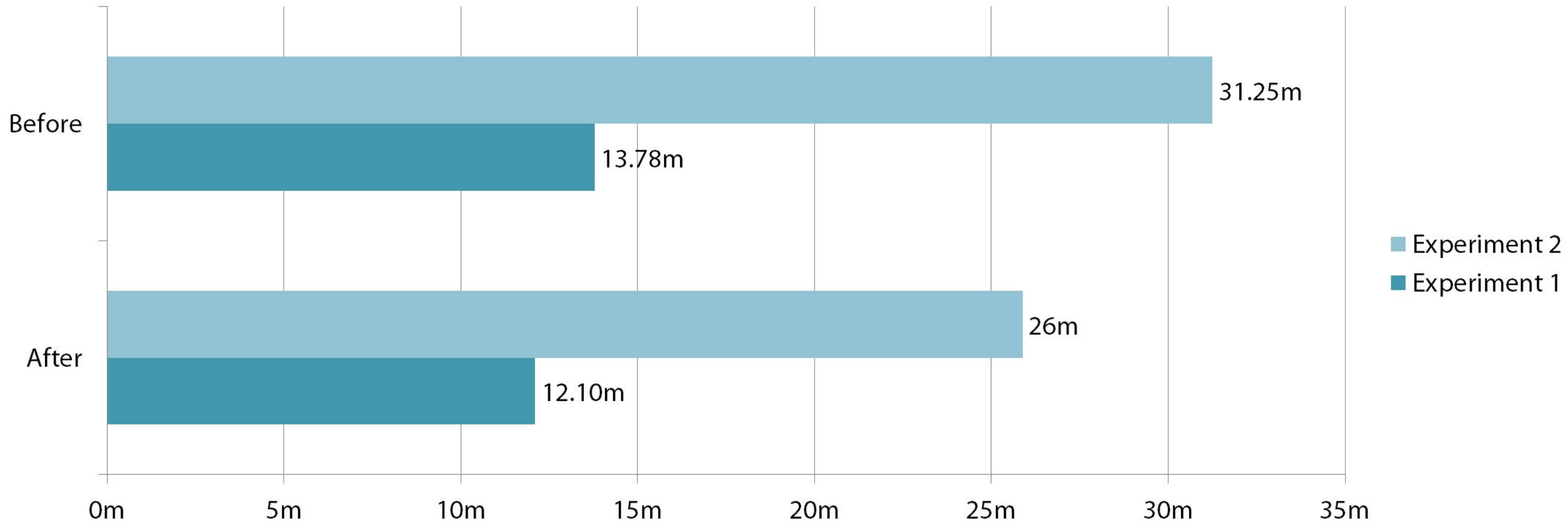




Results: Adaption

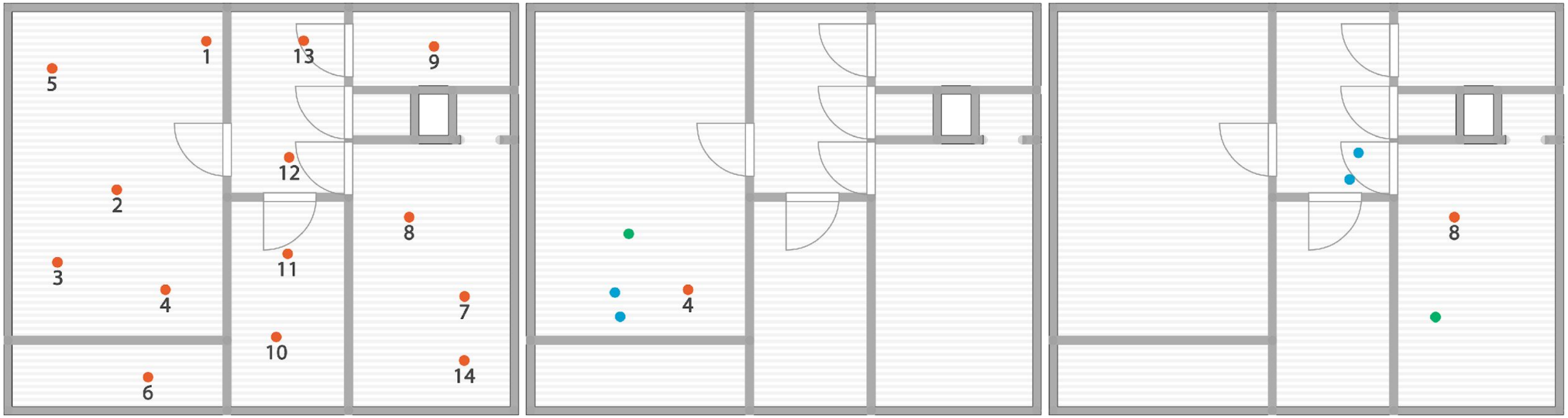
Site Adaptation Performance

Reduction of distance error between 13% to 18%

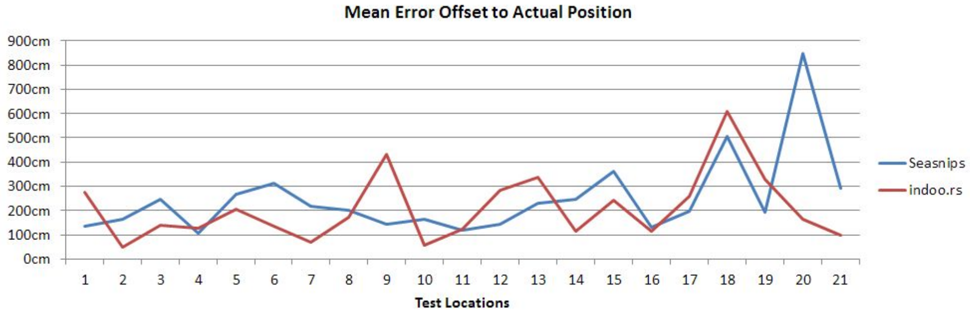


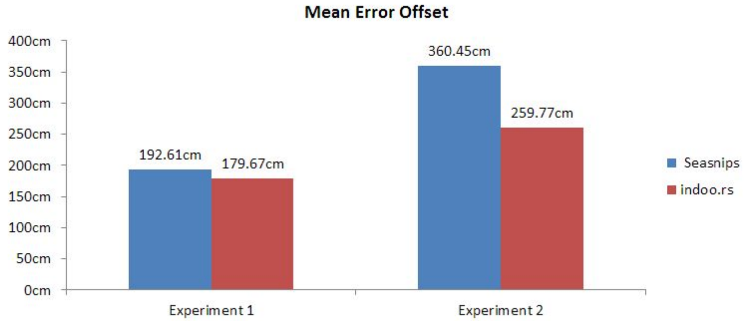
Results: Accuracy

Setup



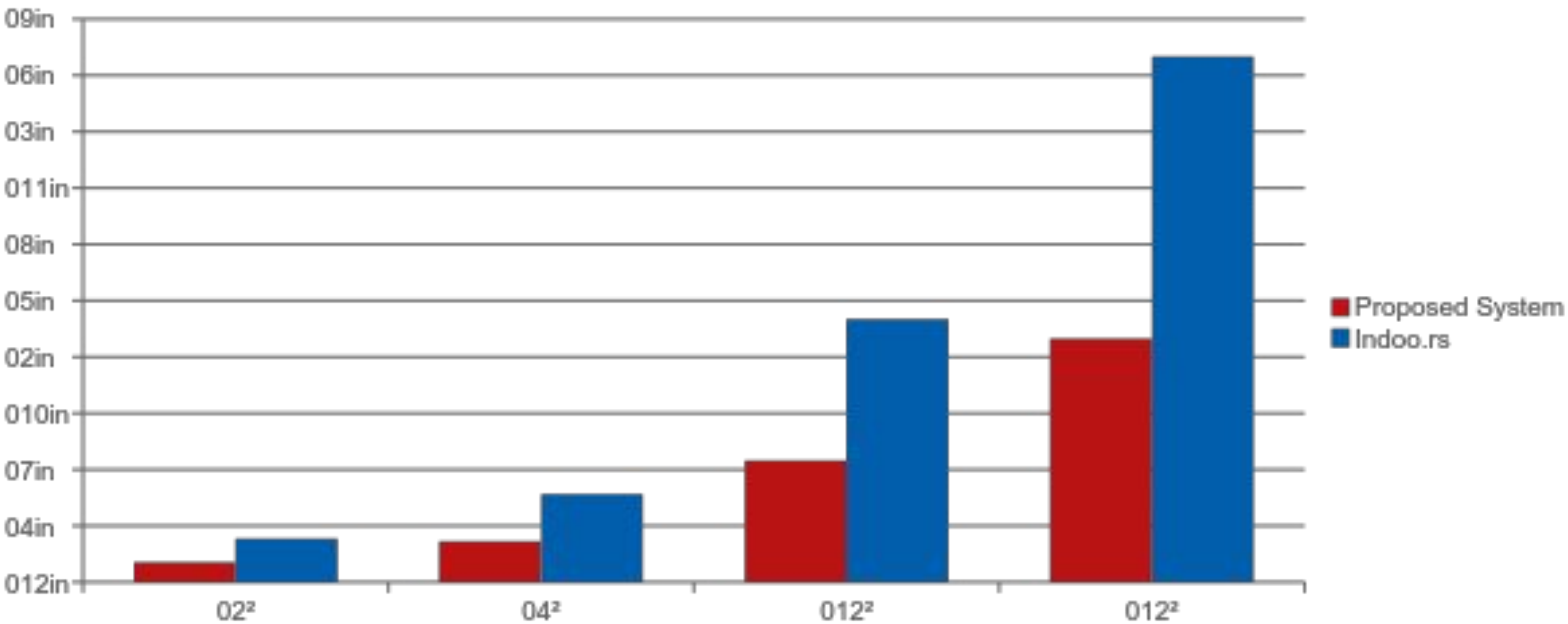
Accuracy





Maintainability

Initial setup time of indoor positioning system



Discussion & Future Work

Discussion

- RSS not ideal indicator, but suffices
- non-correlating RSS presents problem

Future Work

- Counter the impact of human body interference
- Implement algorithms optimized for moving targets
- Evaluate different positioning algorithms like “Smallest M-vertex Polygon” or “Clustering Nearest Neighbor”

References

- Asim Smailagic, Jason Small, and Daniel P Siewiorek. Determining User Location for Context Aware Computing through the use of a Wireless LAN Infrastructure. Institute for Complex Engineered Systems Carnegie Mellon University, Pittsburgh, PA, 15213, 2000.

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