PERVASIVE SYSTEMS
RESEARCH GROUP

RSS-based Self-Adaptive Localization in Dynamic Environments

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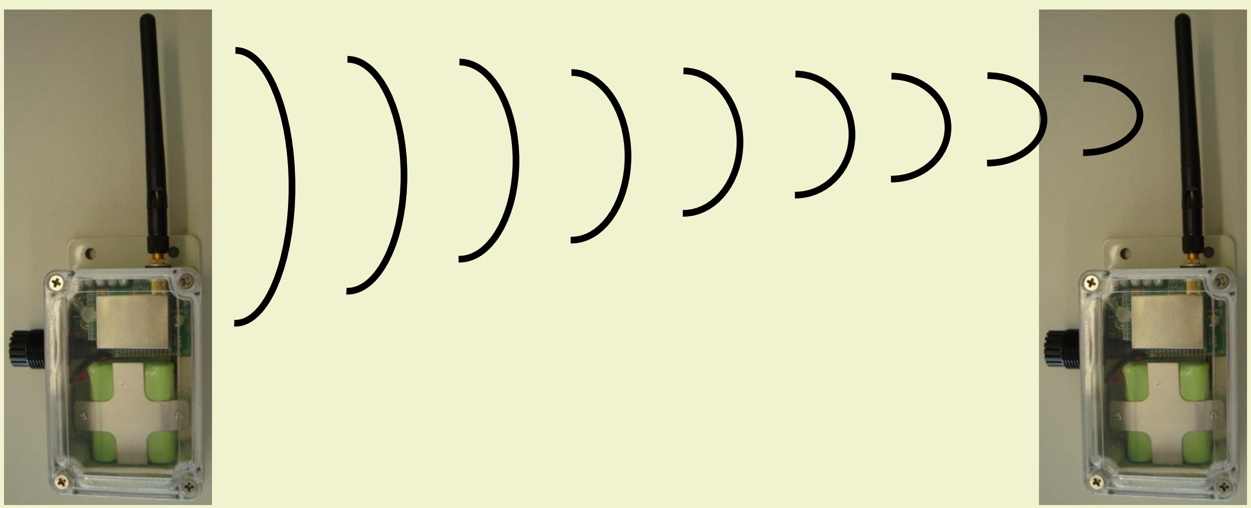
Motivation

Signal Strength Measurements

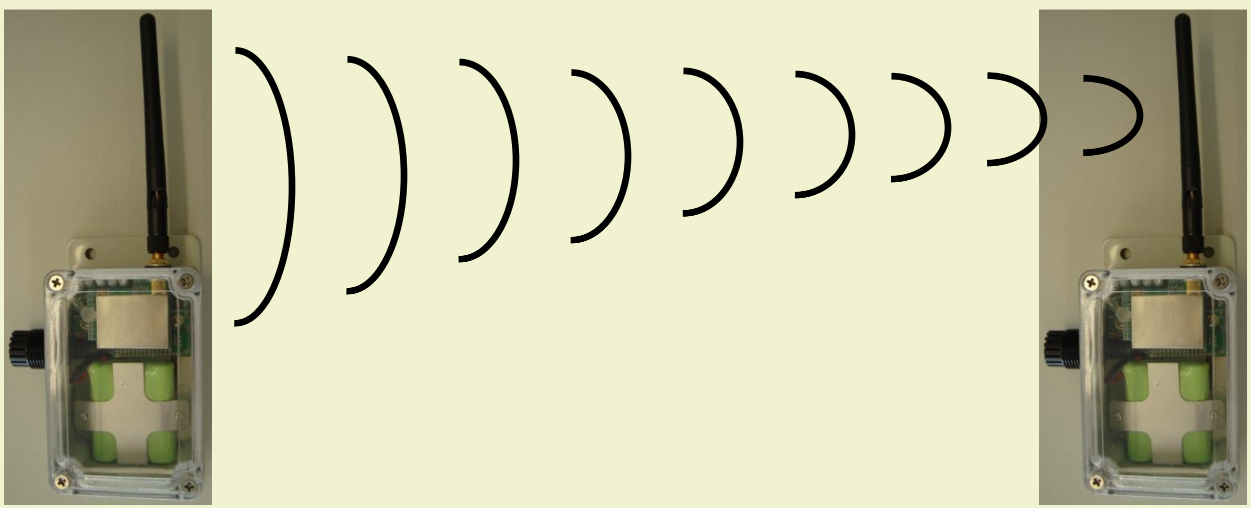
- ***Availability***
- ***Complexity***
- ***Energy consumption***



Motivation

<u>HOWEVER</u>

- ***Highly dynamic***
- ***Highly depending on environment***
- ***Very unreliable***



Motivation

SOLUTION

- ***Calibrate propagation model (2.4 GHz)***
  - ***Height transmitter/Receiver (6→30 cm, +17% decay)***
  - ***Materials (height grass, +32% decay)***
  - ***Antenna orientation (factor 32 difference)***

Motivation

<u>SOLUTION</u>

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  - ***Height transmitter/Receiver (6→30 cm, +17% decay)***
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Calibration determines scalability, applicability and performance of localization algorithm.

Motivation

SOLUTION

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  - ***Height transmitter/Receiver (6→30 cm, +17% decay)***
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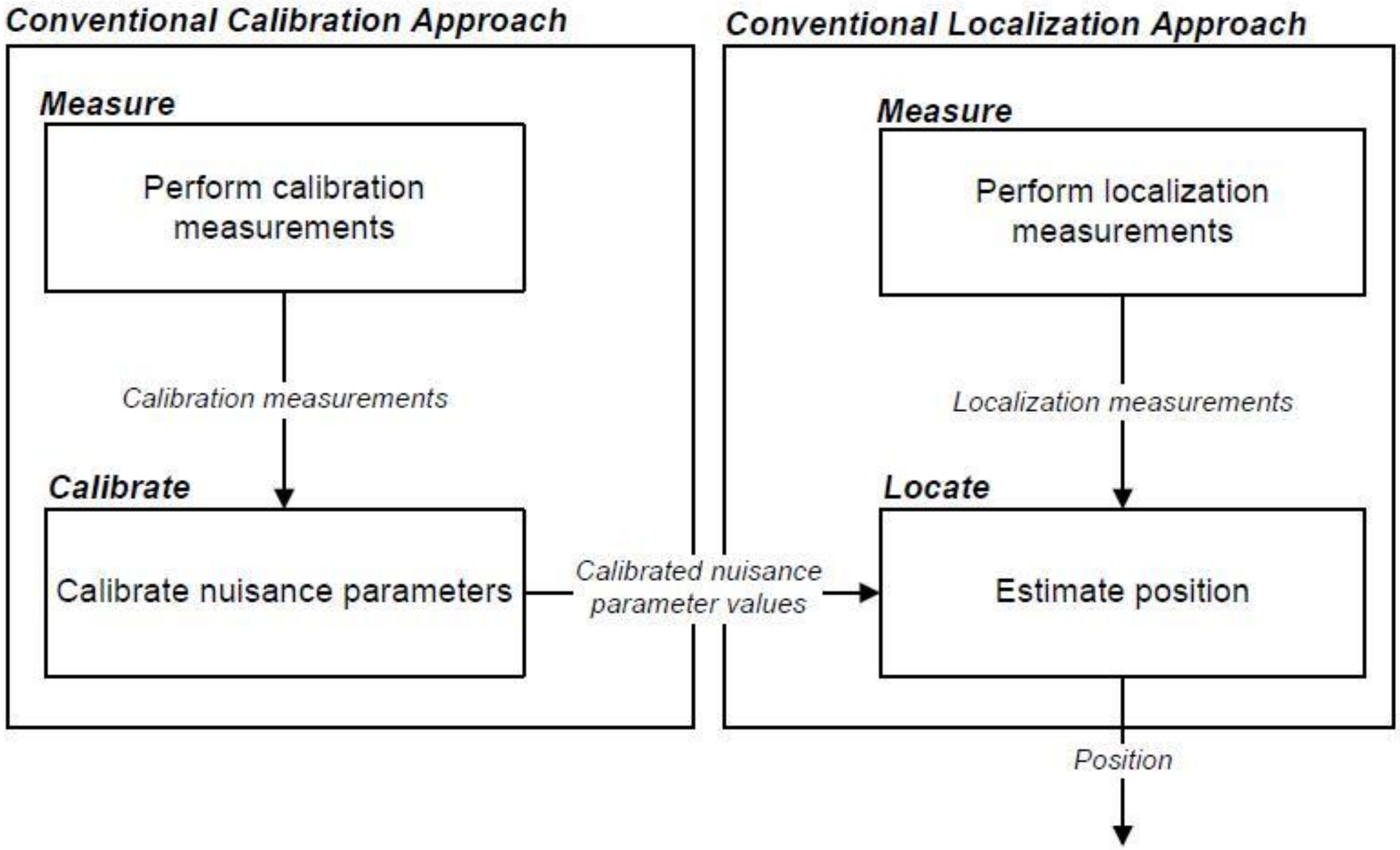
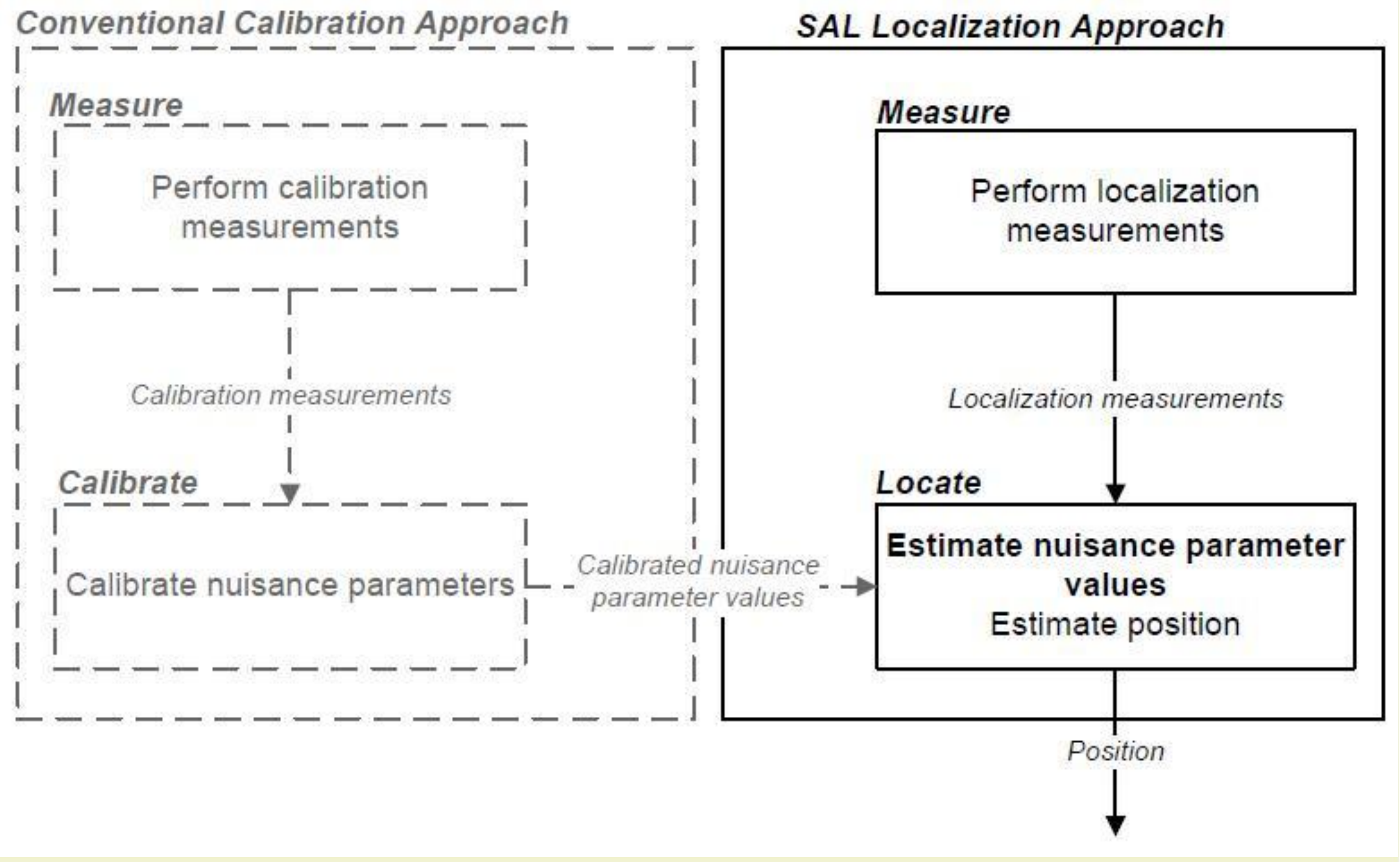
- ***Mobile radio***
  - ***Optimal calibration = orientation/place dependent***
  - ***Calibrate propagation model each time the radio locates itself***

Motivation


Conventional Calibration Approach
Measure
Perform calibration measurements
Calibration measurements
Calibrate
Calibrate nuisance parameters
Calibrated nuisance parameter values
Conventional Localization Approach
Measure
Perform localization measurements
Localization measurements
Locate
Estimate position
Position

Motivation


Conventional Calibration Approach
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SAL Localization Approach
Measure
Perform localization measurements
Localization measurements
Locate
Estimate nuisance parameter values
Estimate position
Position

GOAL

Plug-And-Play wireless localization system

- ***Deploy and you are done***
- ***Multi-hop network***
- ***Automatic calibration***

Contents

- *Hardware*
- *Propagation model*
- *Antenna orientation*
- *Self-Adaptive Localization*
- *Results*
- *Localization server*

Hardware

- ***Chipcon 2.4 GHz modules***
  - *4kb memory*
  - *8051 Processor*
  - *IEEE 802.15.4 Radio*
  - *External Antenna*

- ***Costs***
  - *+/- 5 euro*

Propagation Model

- **Log-normal Shadowing model**
  - **Scalair model**

$$P_d = P_{d_0} - 10 \cdot n \cdot \log_{10}(\frac{d}{d_0})$$

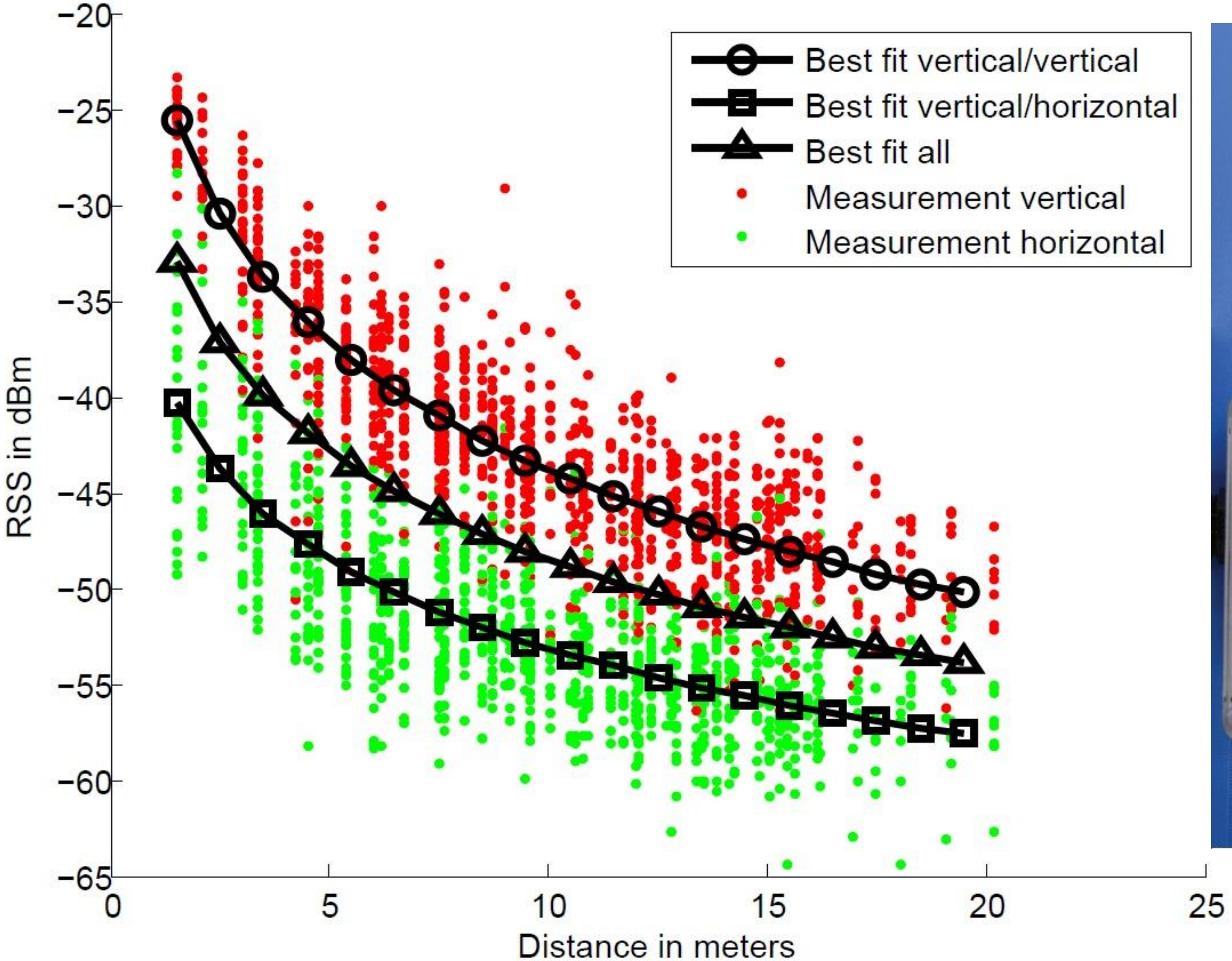
- **Unknowns are** P_{d_0} **and** n

Antenna Orientation

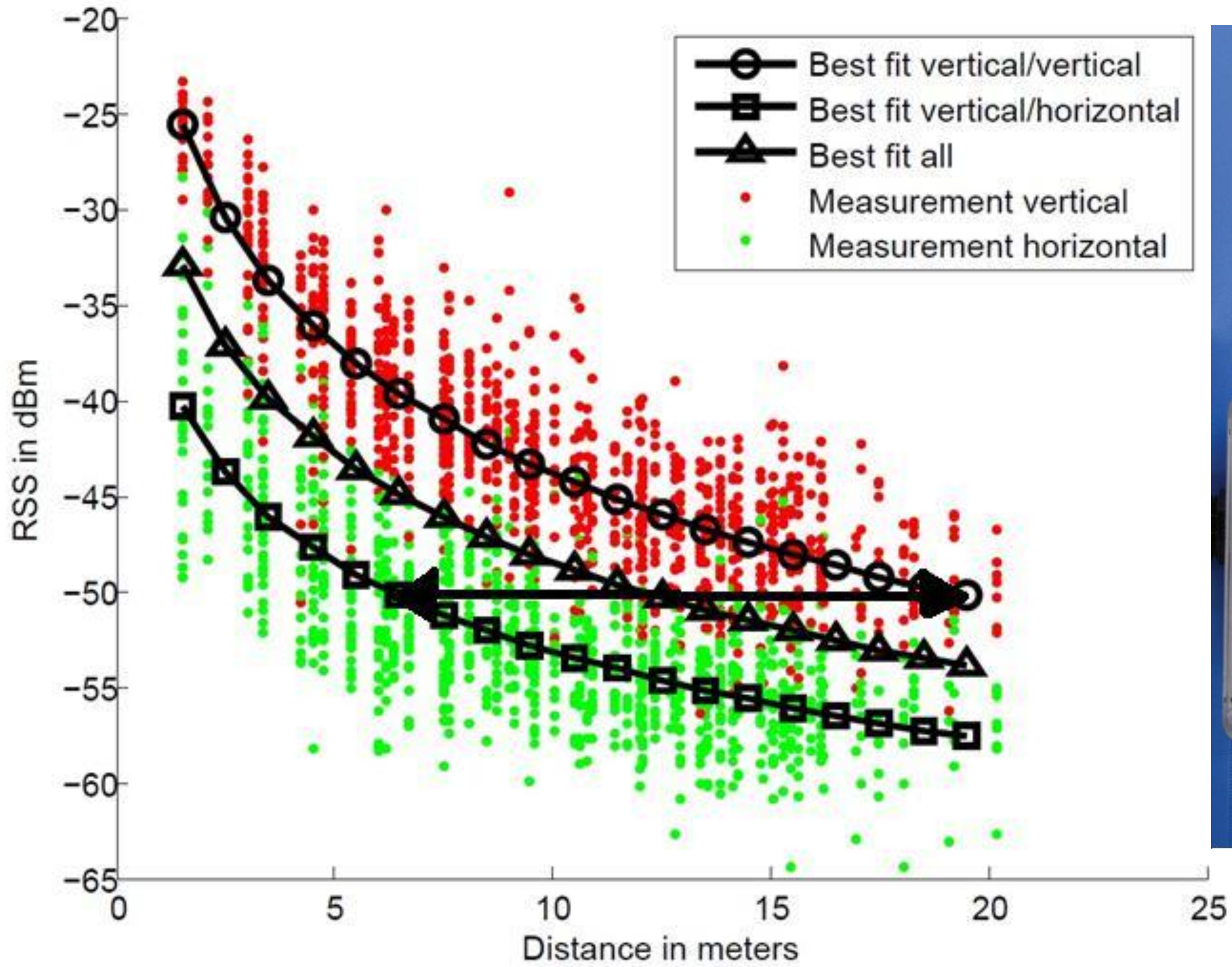
- **What happens?**

- **Can we model this using a scalair model?**

Antenna Orientation



Antenna Orientation

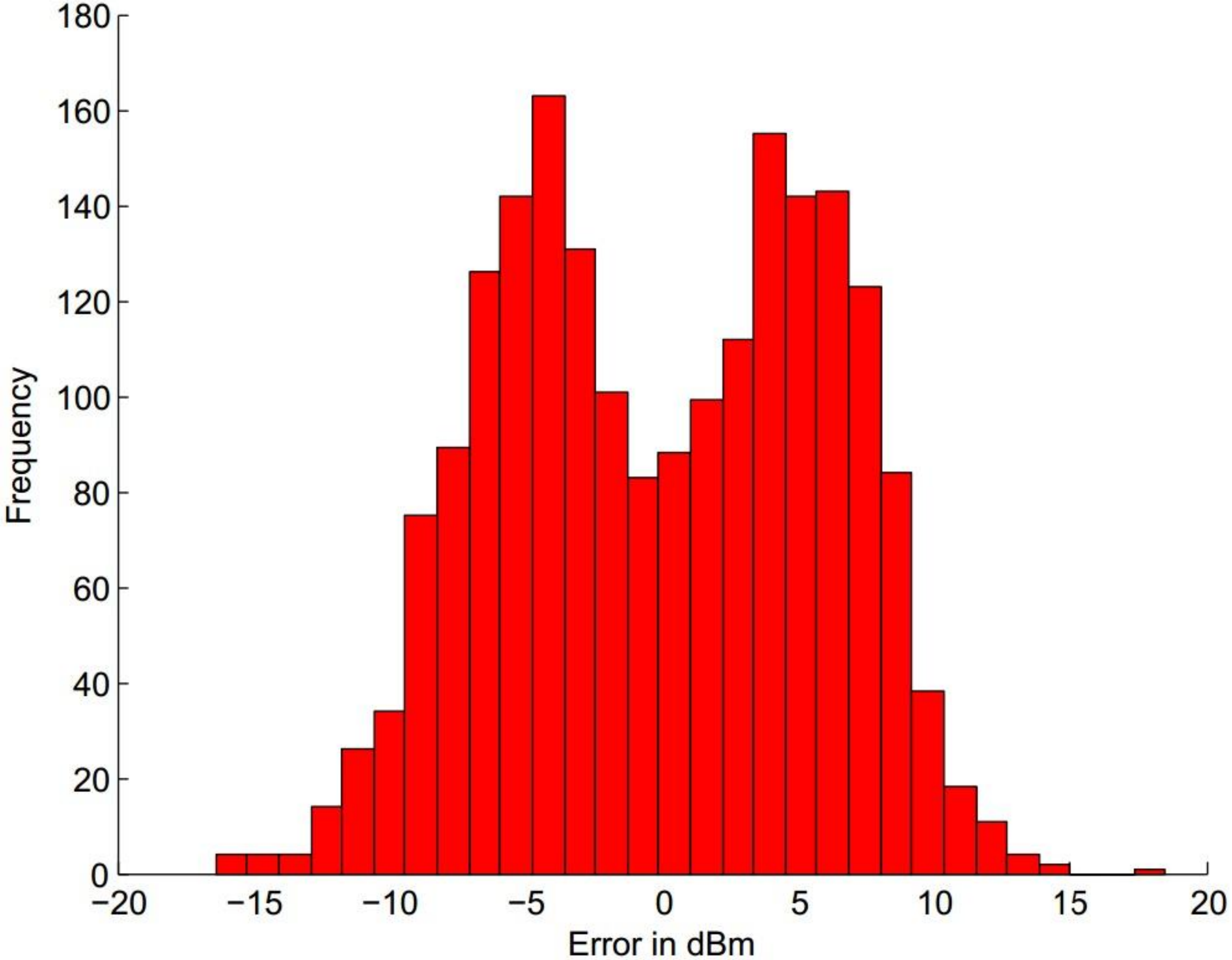


Antenna Orientation

Error

Distribution

Plot



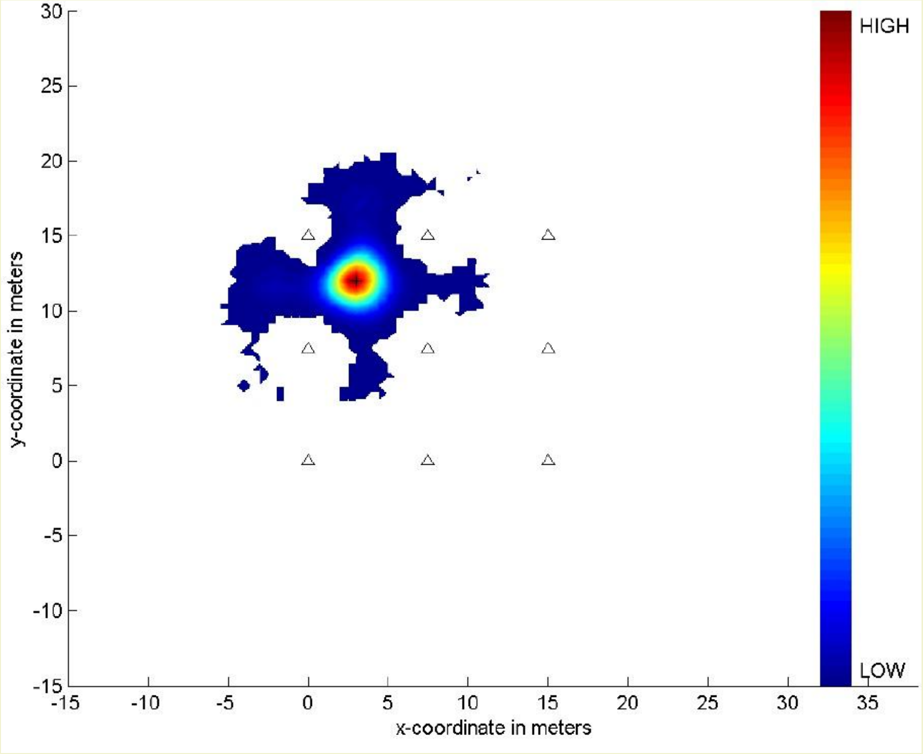
Self-Adaptive Localization

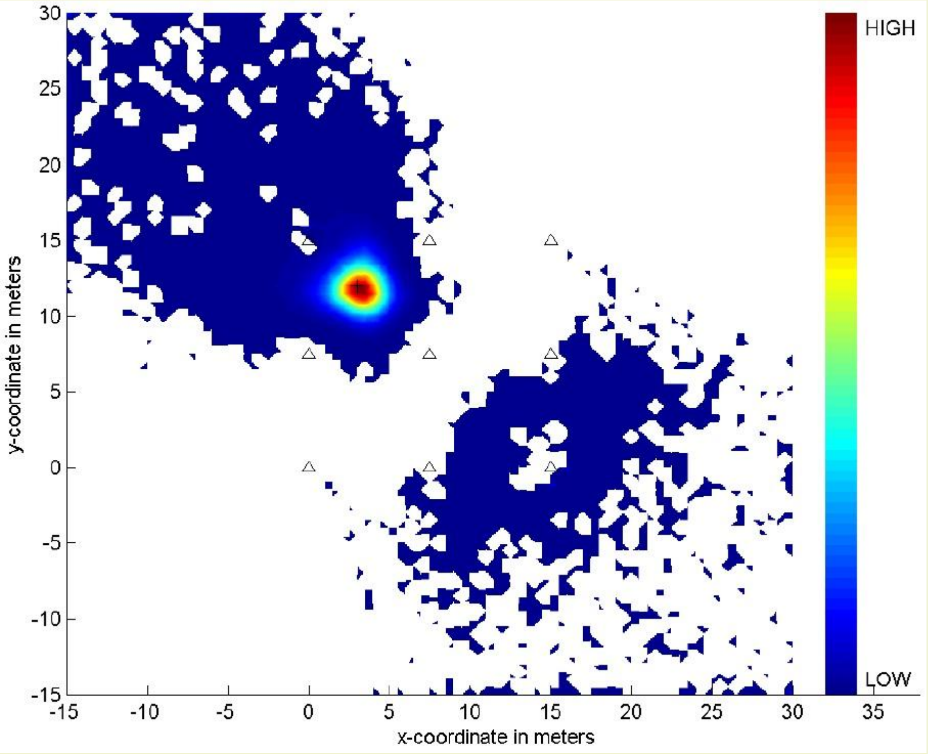
- **Propagation model parameters are P_{d_0} and n**
  - **3 Self-Adaptive Localization algorithms**

TYPE	Unknowns	Calibrated P_{d0}	Calibrated n
LN-CON	{x,y}	Yes	Yes
RR-SAL	{x,y, P_{d0}}	No	Yes
PLE-SAL	{x,y,n}	Yes	No
LN-SAL	{x,y, P_{d0},n}	No	No

Self-Adaptive Localization

What happens if we do this?



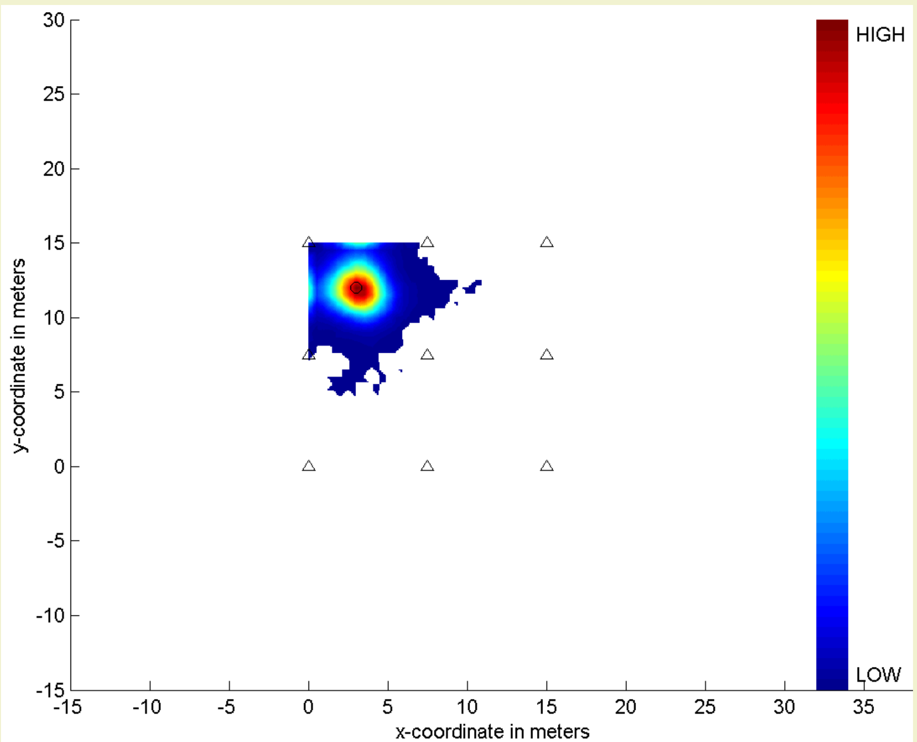


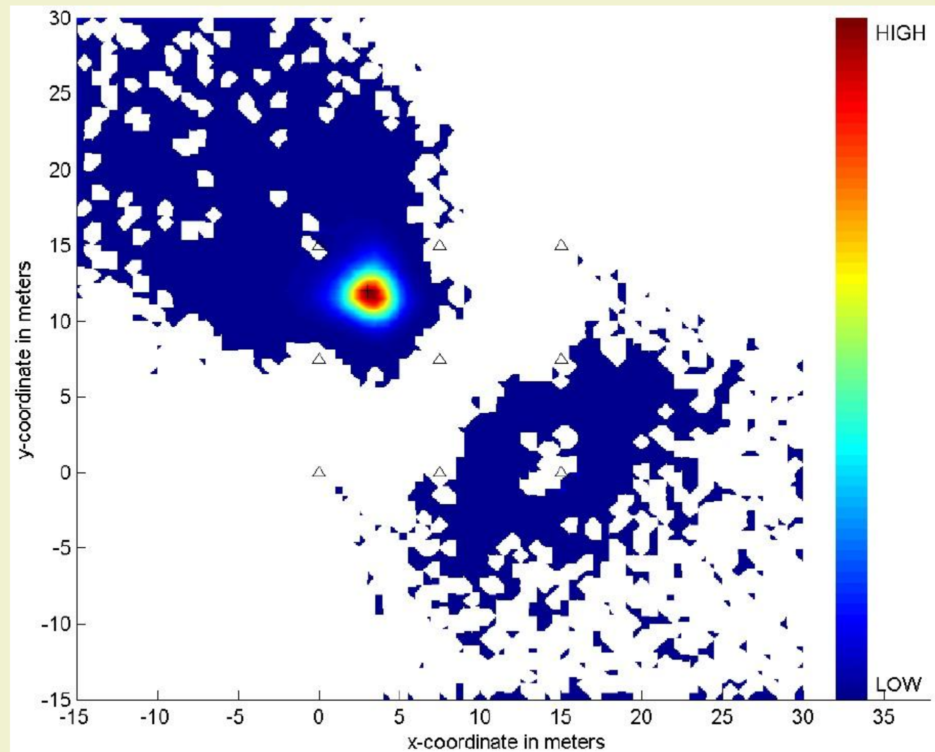
P_{d_0} and n are known

P_{d_0} and n are unknown

Self-Adaptive Localization

Put constraints on estimator





So Self-Adaptive Localization is not possible under all circumstances

Results

- Environment

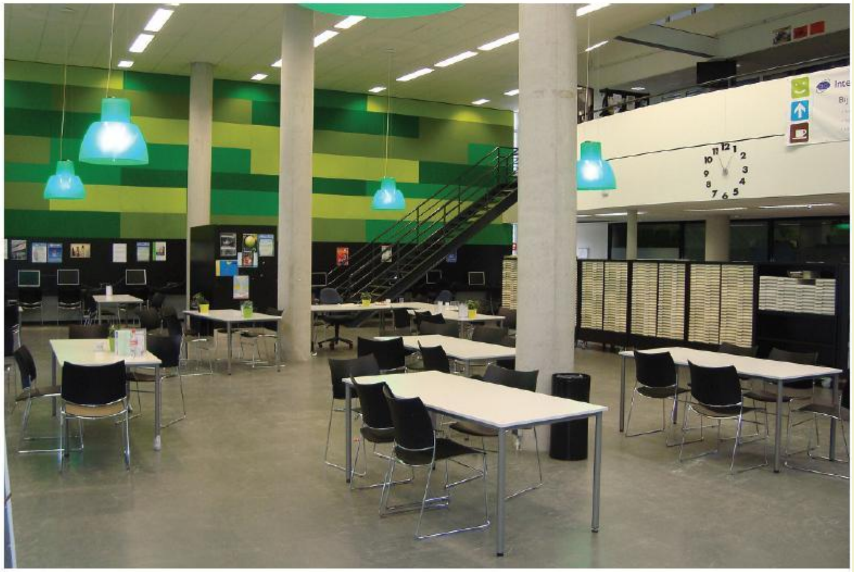
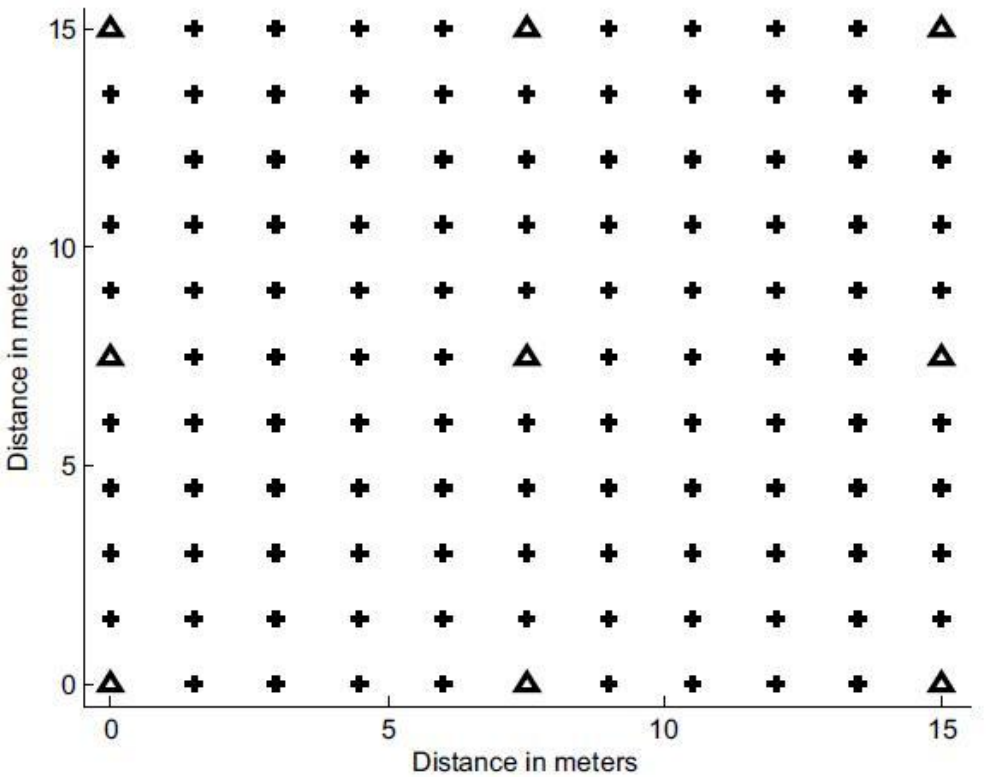
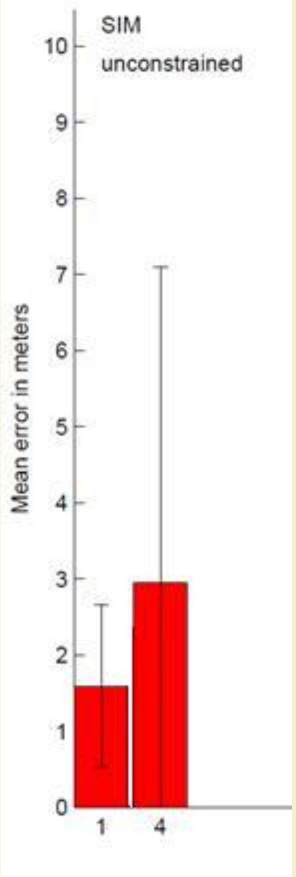


Fig. 3. Measurement environment



Results

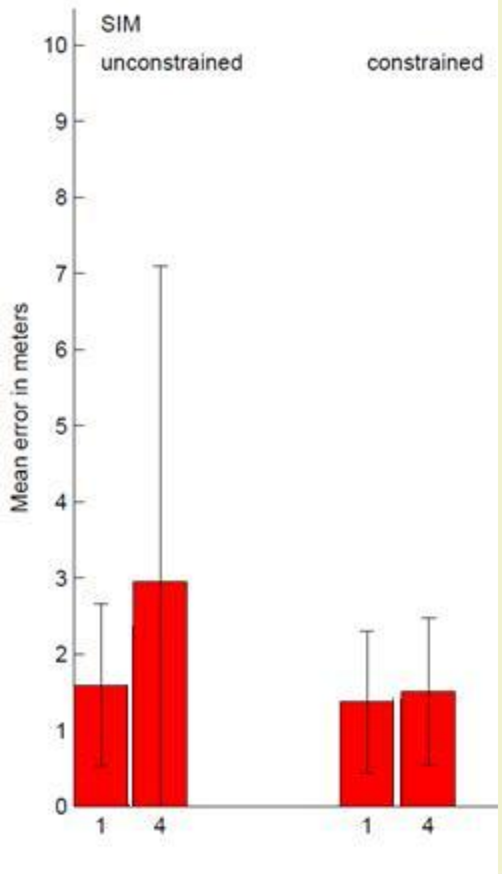
- Vertical antenna orientations
  - Unconstrained CON vs SAL



  - 1: Calibrated
  - 4: Unknown: $\{P_{d_0}, n\}$

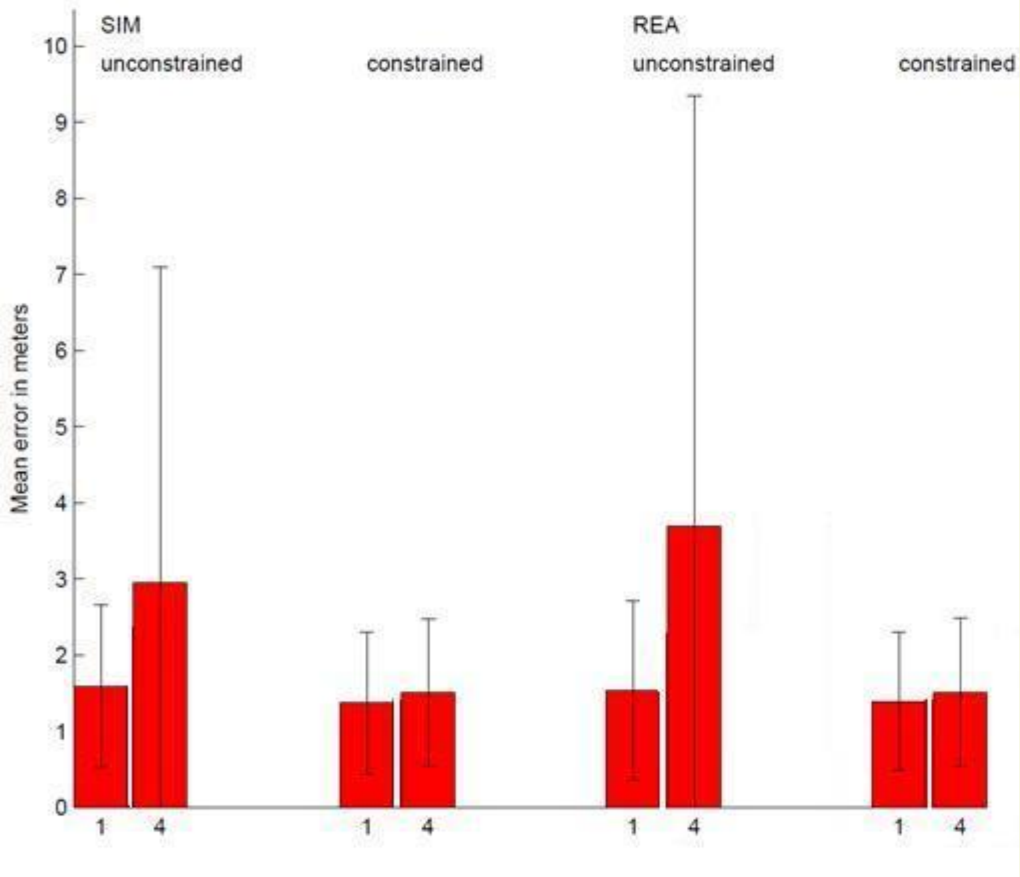
Results

- Vertical antenna orientations
  - Unconstrained CON vs SAL
  - Constrained CON vs SAL
  - 40% less error
  - 67% less std
  - 1: Calibrated
  - 4: Unknown: $\{P_{d_0}, n\}$



Results

- Vertical antenna orientations
  - Unconstrained CON vs SAL
  - Constrained CON vs SAL
  - 40% less error
  - 67% less std
  - Measurements vs Simulations
  - 1: Calibrated
  - 4: Unknown: $\{P_{d_0}, n\}$



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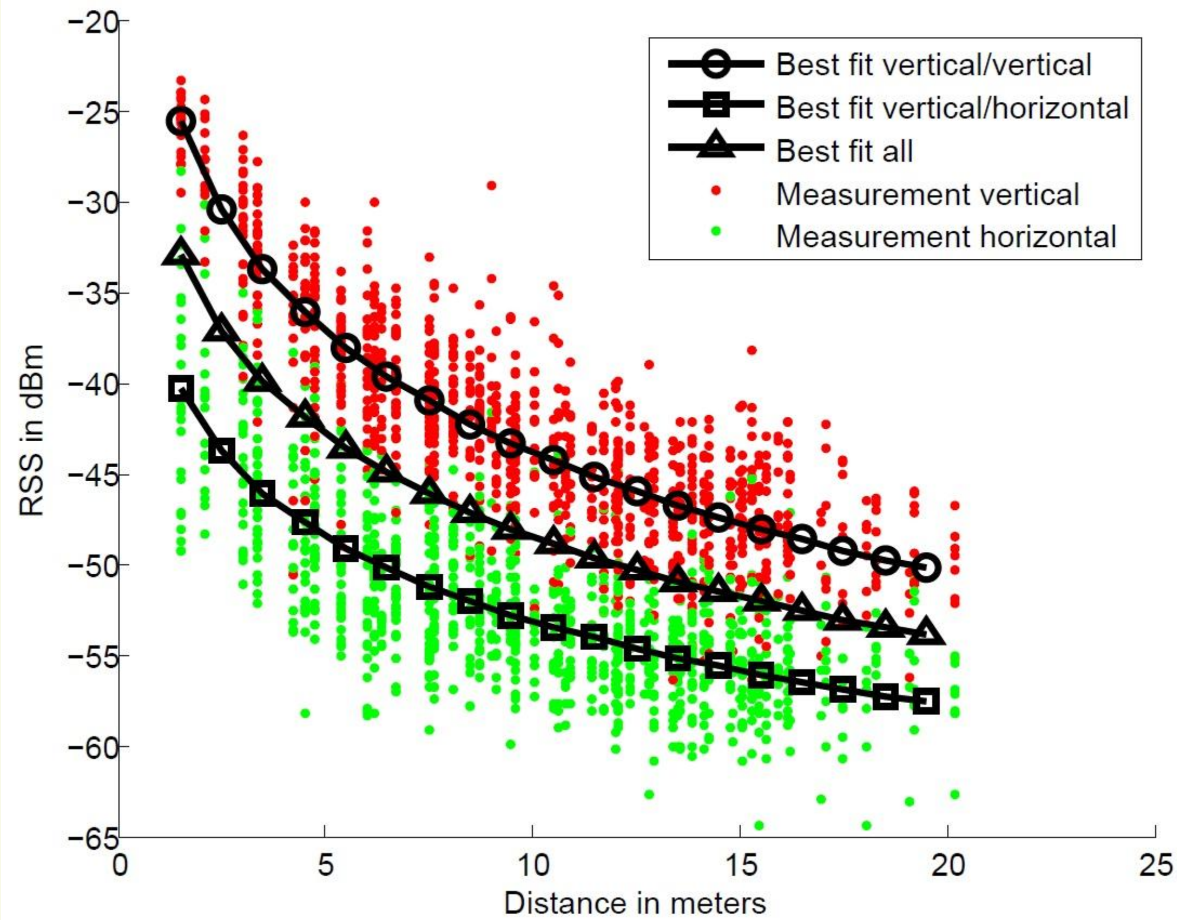
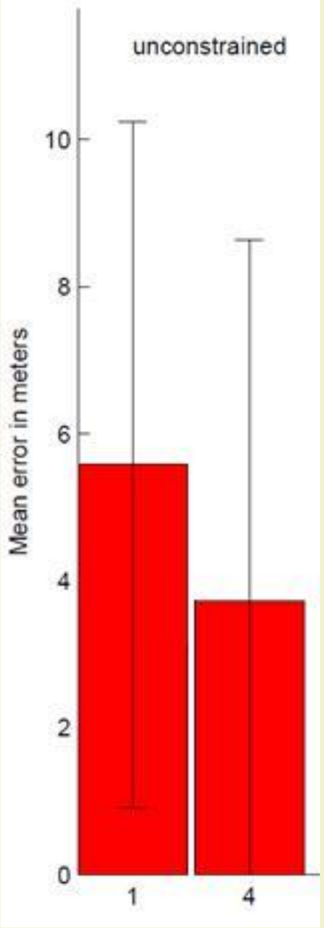
Results

- Unknown antenna orientation



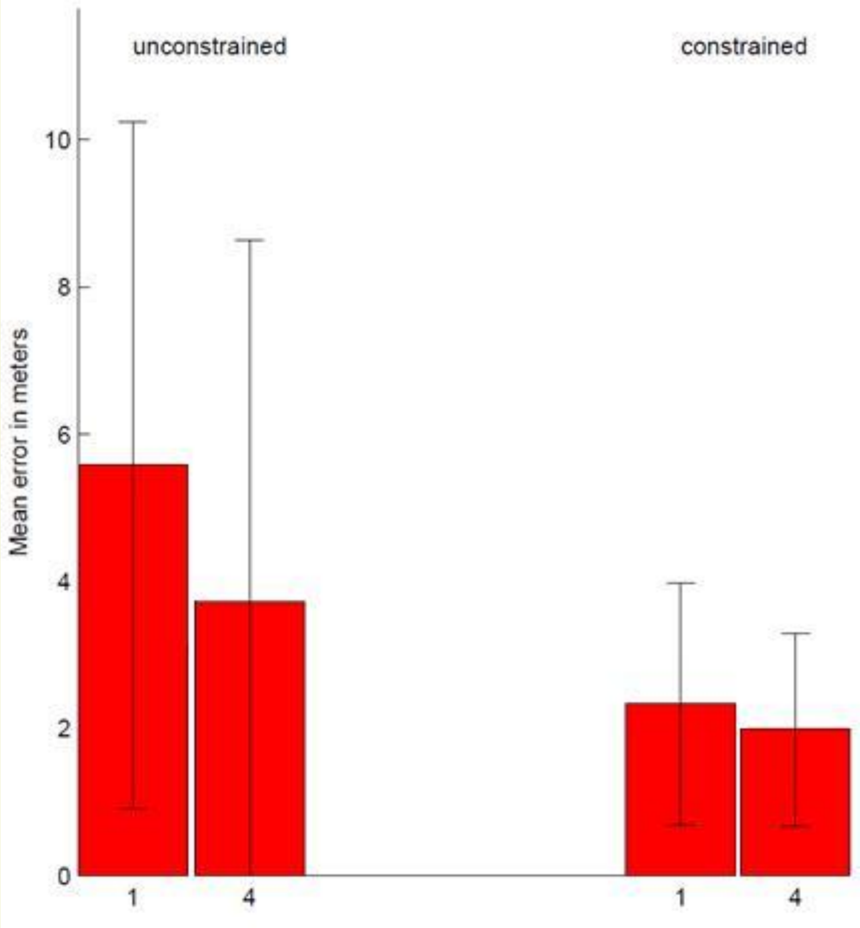
Results

- Unknown antenna orientation
  - Unconstrained: SAL > CON
  - 1: Calibrated
  - 4: Unknown: $\{P_{d_0}, n\}$



Results

- Unknown antenna orientation
  - Unconstrained: SAL > CON
  - CONSTRAINED:
    - 64% less error
    - 73% less std
  - 1: Calibrated
  - 4: Unknown: $\{P_{d_0}, n\}$



Localisation Server

- ***Localization specific data is sent to server.***
- ***Can localize 10.000-100.000 nodes/seconds***
  - ***Per processor***

Conclusion

Automatic calibration saves effort and money.

- ***Plug-and-Play localization network.***
  - ***Covering building of four floors.***
  - ***Including real-time PIR sensor data.***
  - ***~1 meter error indoor.***

- ***Error reduced by ~50%***
- ***Reliability increased by ~100%***