

# Positioning in Ad-Hoc Networks

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## Directions and Results

Jan Beutel

Computer Engineering and Networks Lab  
Swiss Federal Institute of Technology Zurich

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**ETH**

Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich



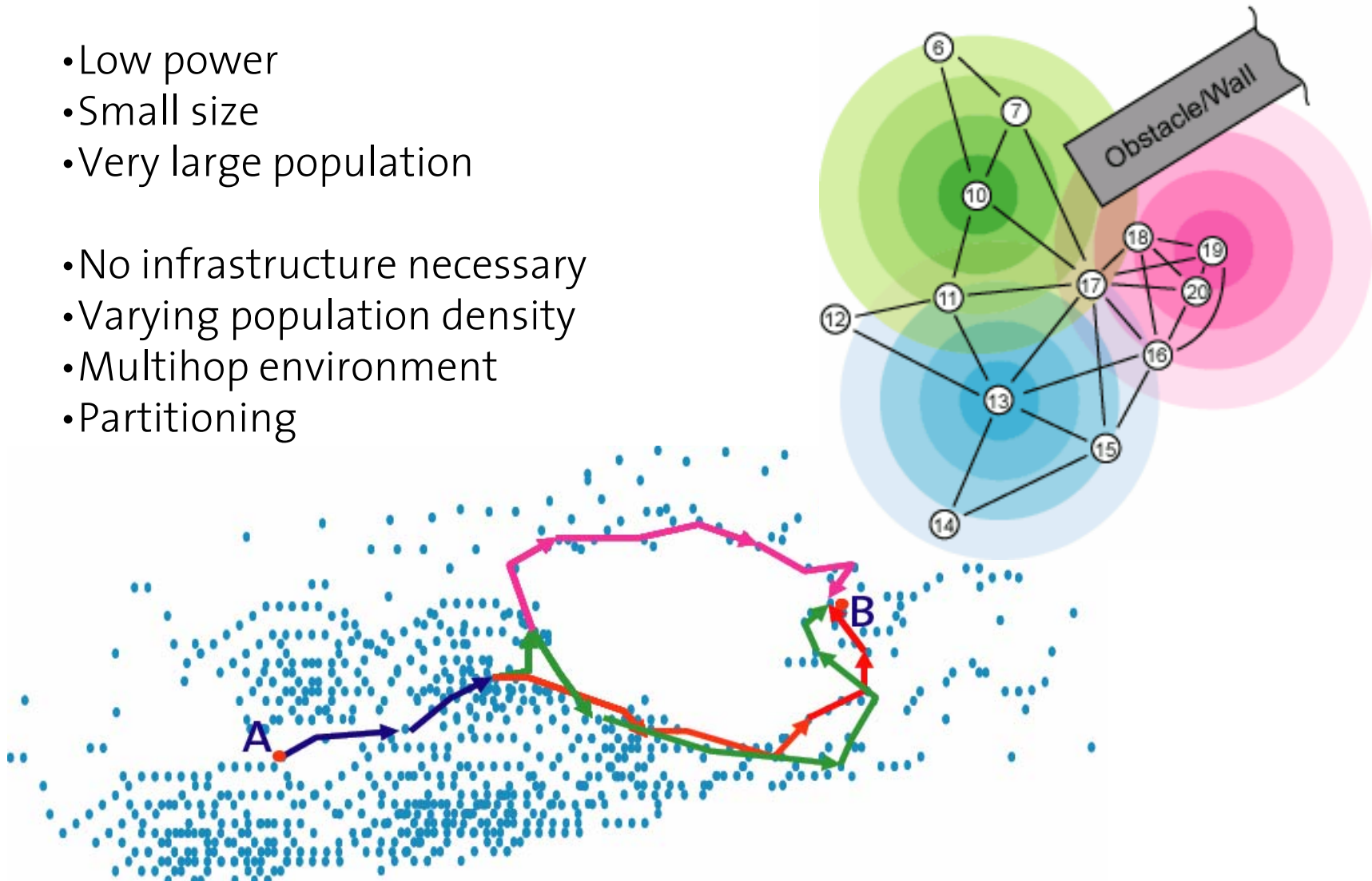
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# Ad-Hoc Network Scenarios

- Low power
- Small size
- Very large population
- No infrastructure necessary
- Varying population density
- Multihop environment
- Partitioning

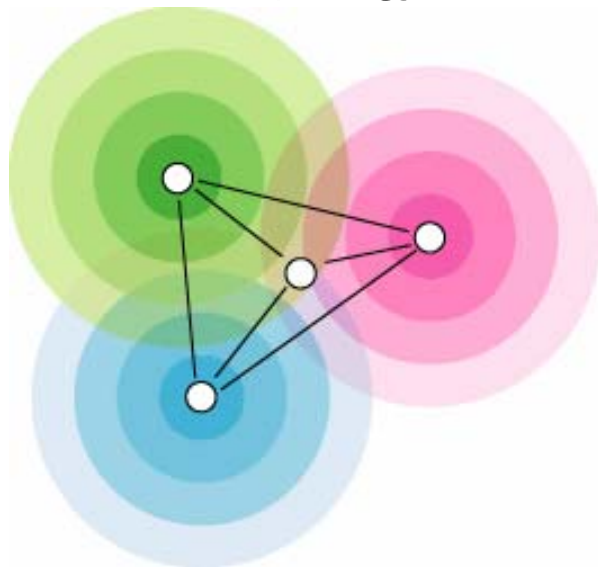


# Positioning: The Problem

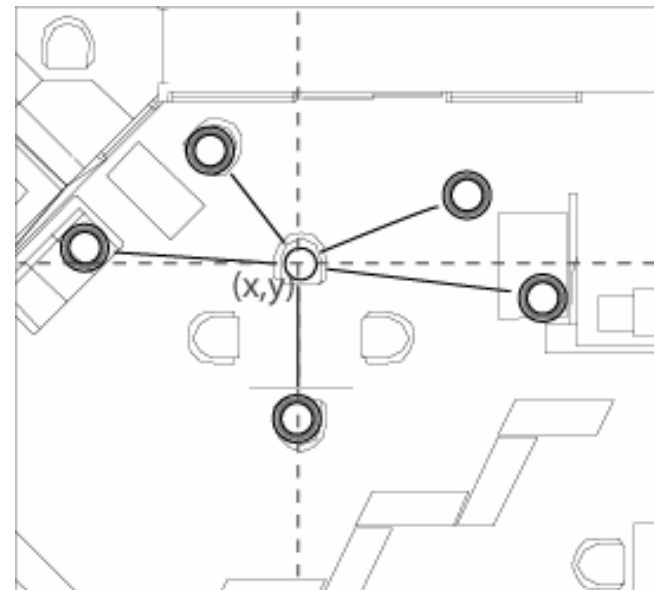
Finding the **position** of **networking nodes**

## Relative vs. Absolute Positioning Mode

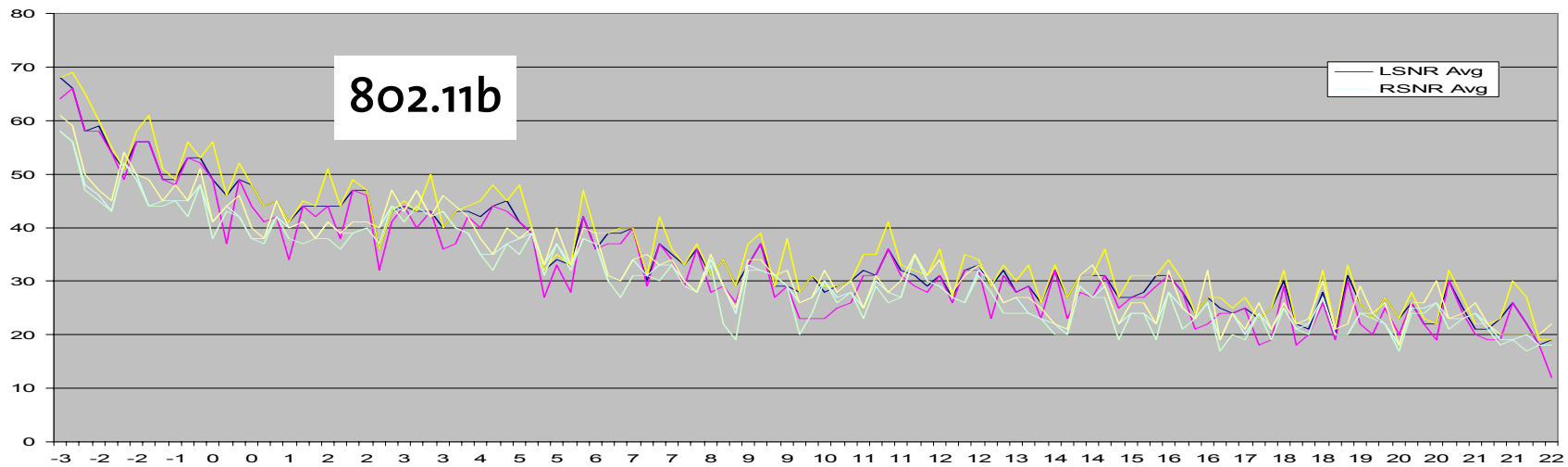
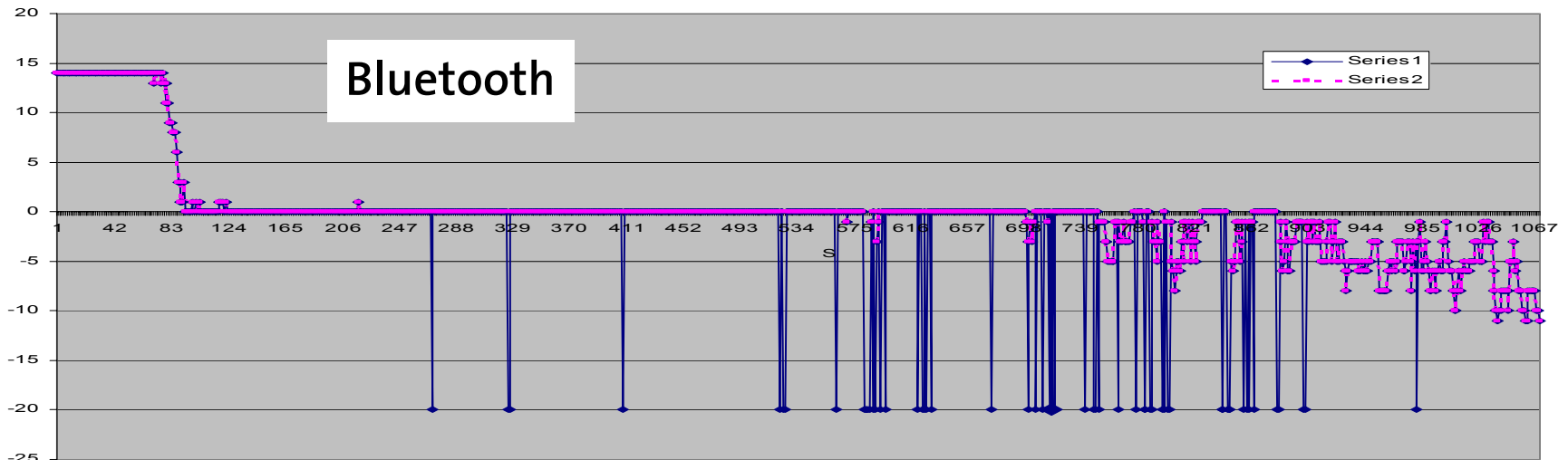
Other Networking Nodes,  
Distance and Geometric  
Topology



Reference Positions,  
Map Database



# RSSI Samples Over Distance - Free Space

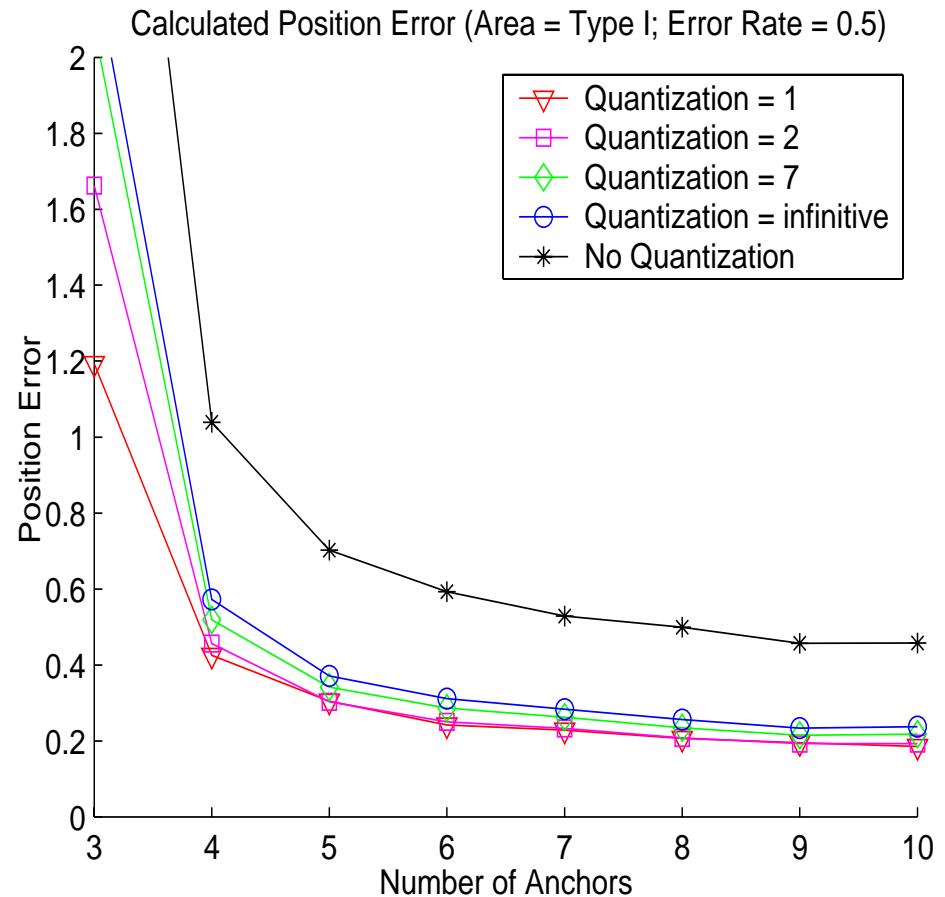


# Redundant Triangulation

## Every node executes

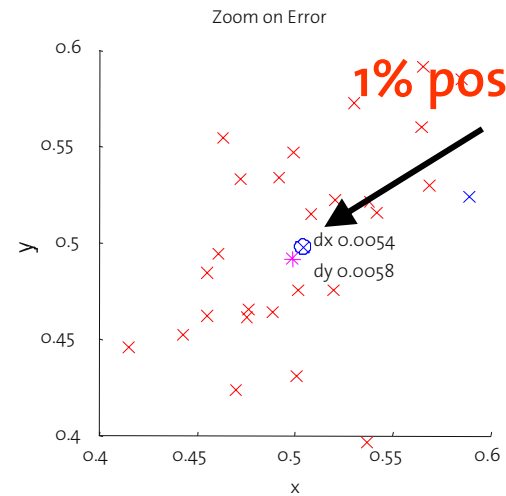
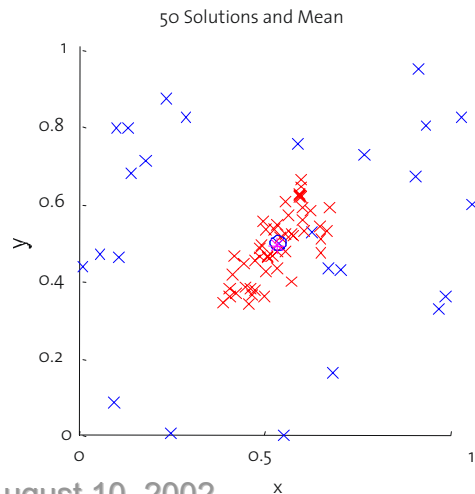
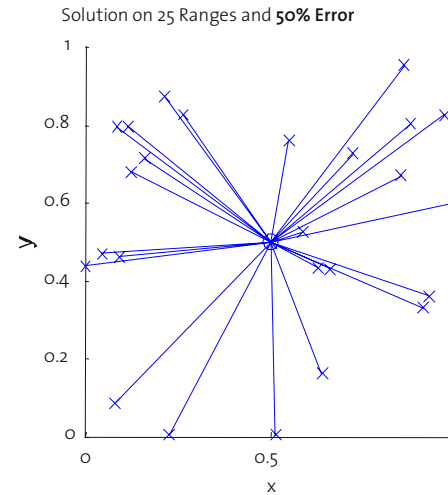
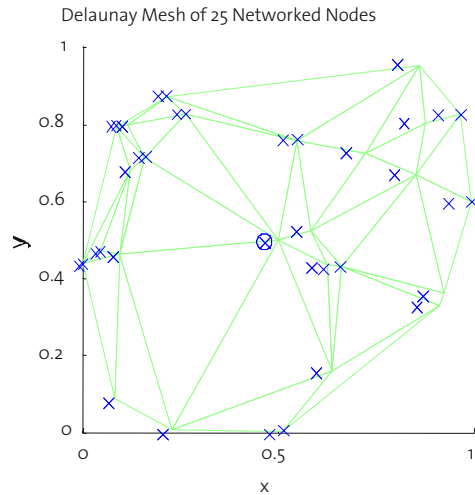
- Identification of neighbors
- Establishing range estimates
- Maintaining a set of a minimum of 3 linear equations to the neighbors
- Solve for MMSE

## Dissemination of data over the network

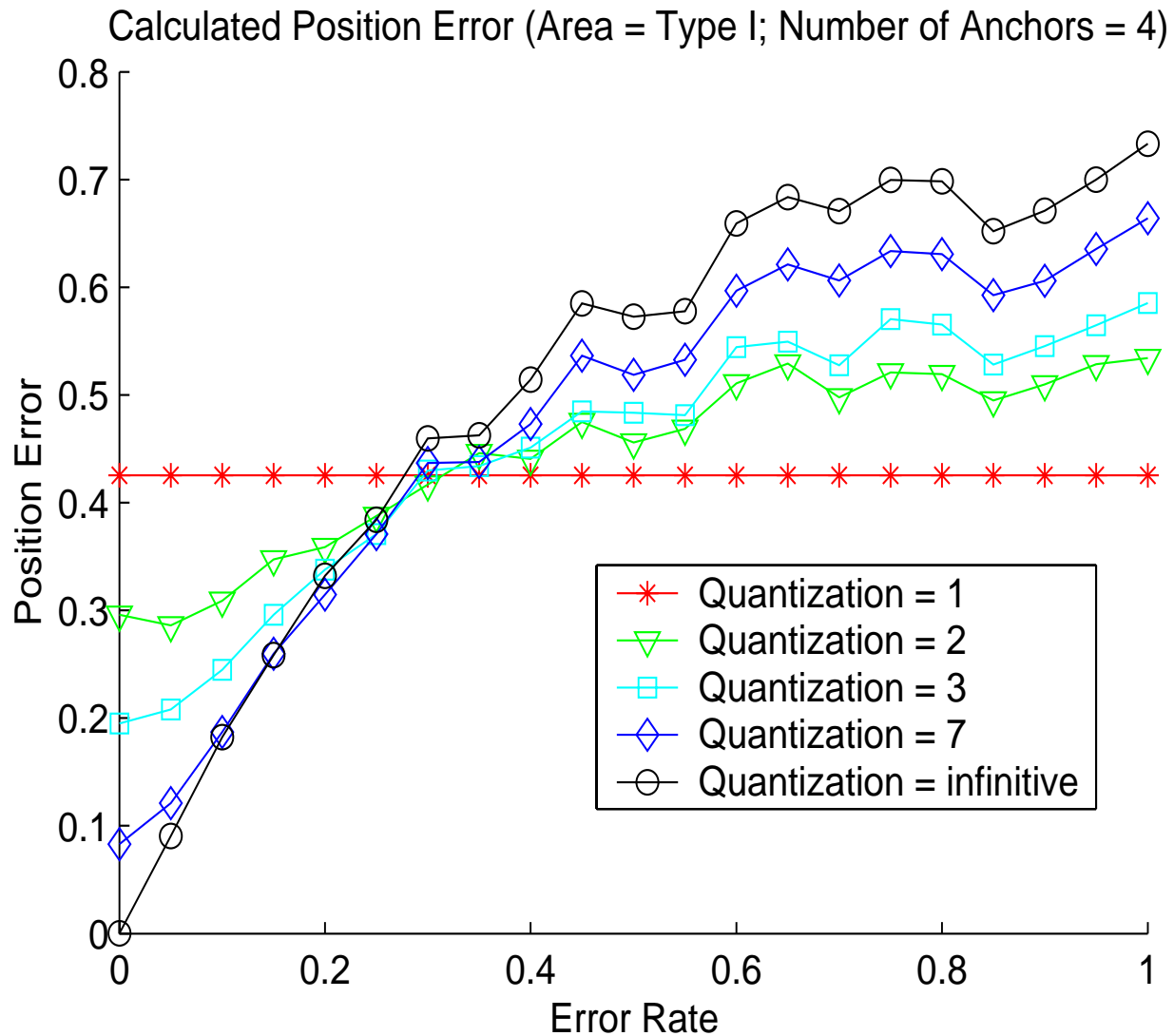


# Redundant Triangulation and Filtering

Average over 25 individual triangulations with 50% range error

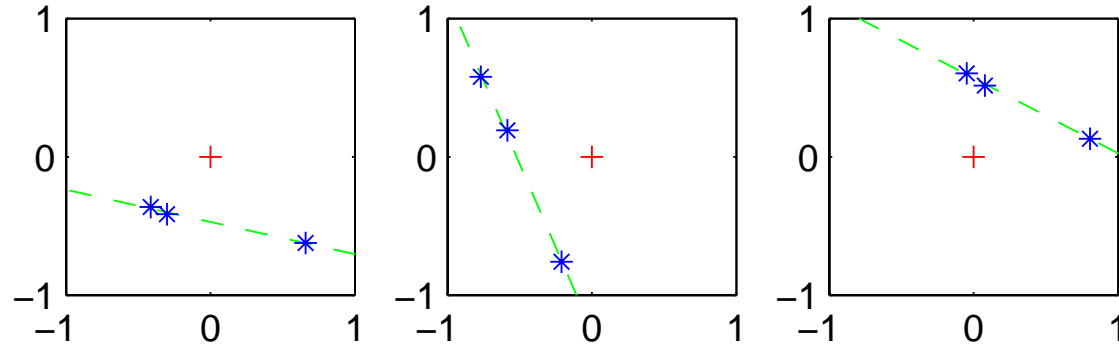


# Influence of Range Quantization

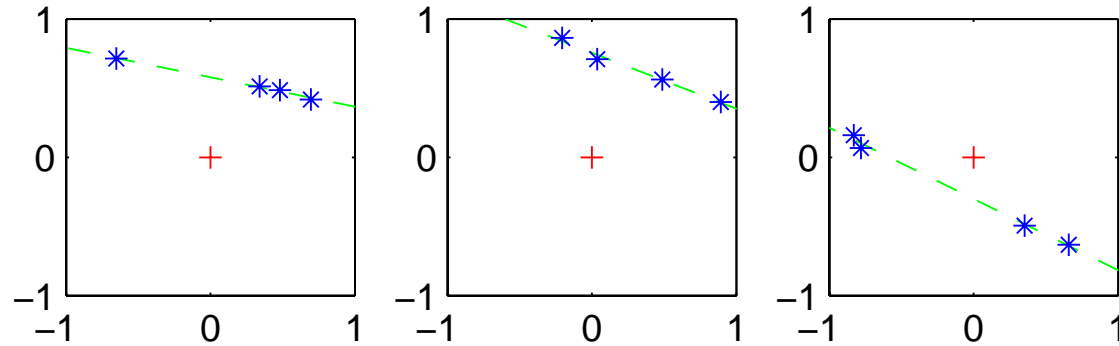


# Very Large Errors and Topology

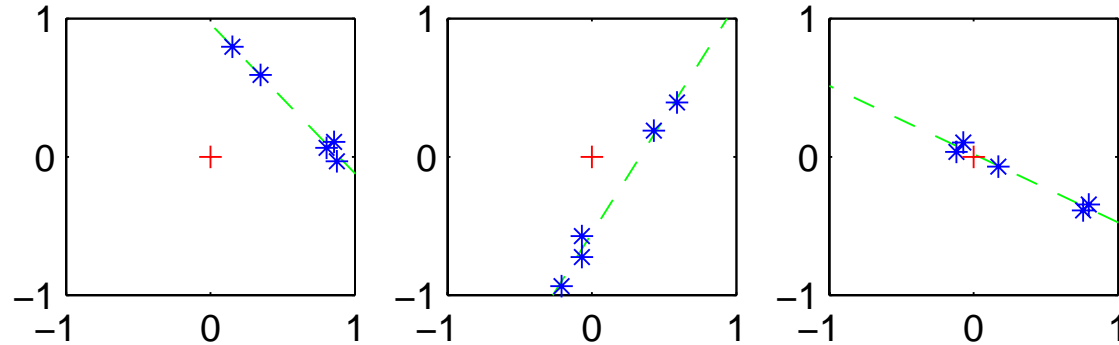
3 anchors ~ 94%



4 anchors ~ 6%

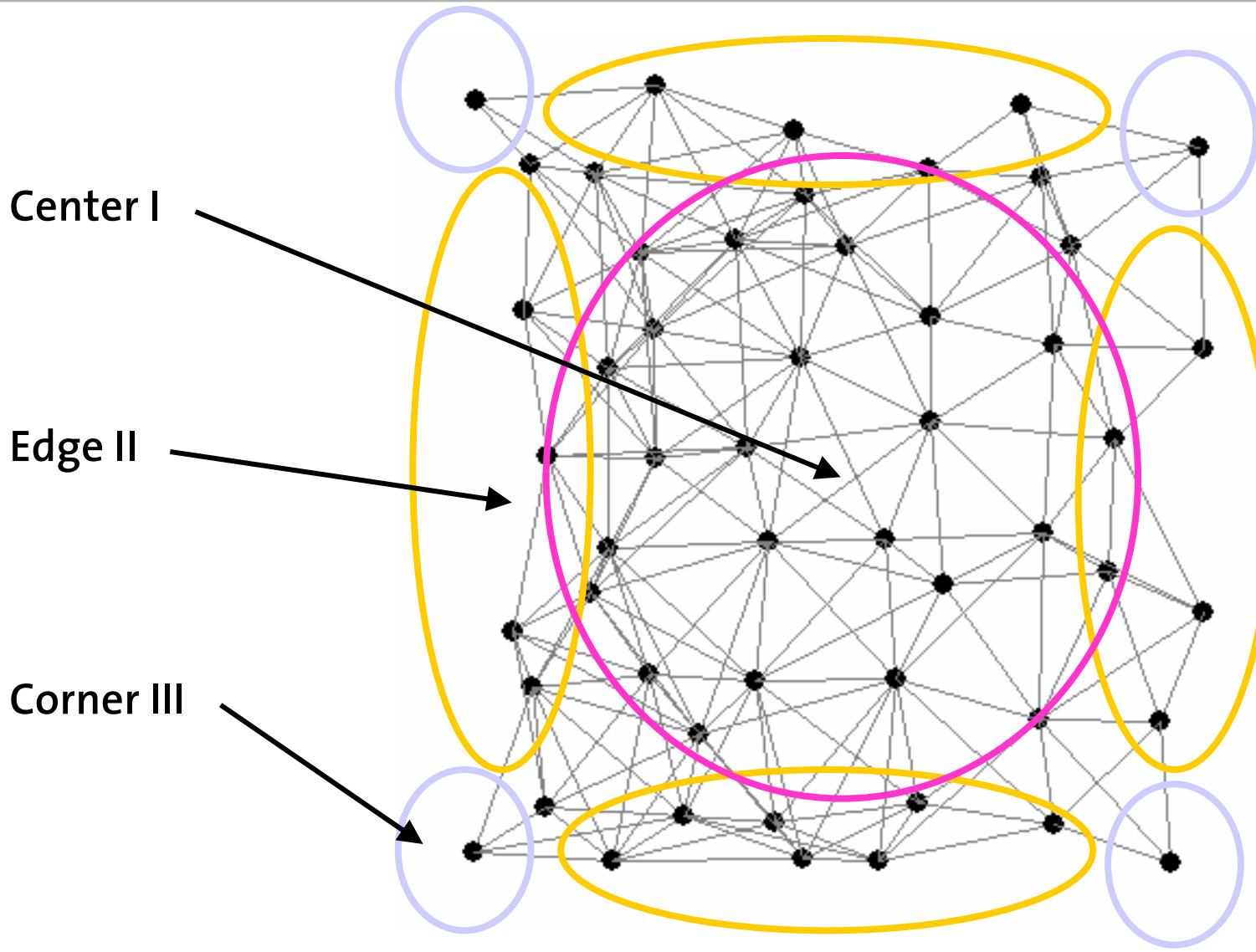


5 anchors >1%

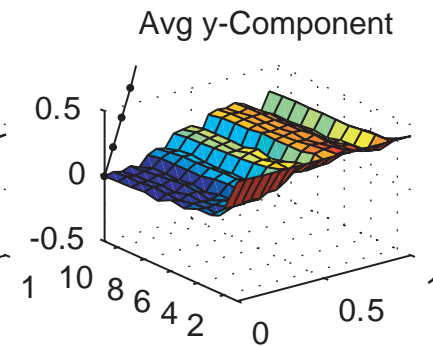
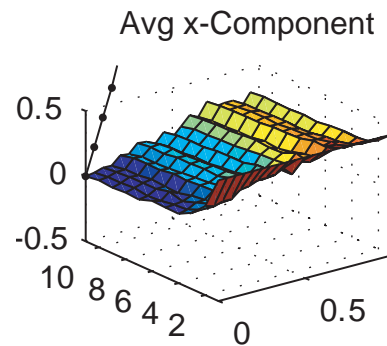
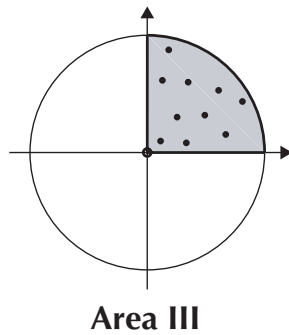
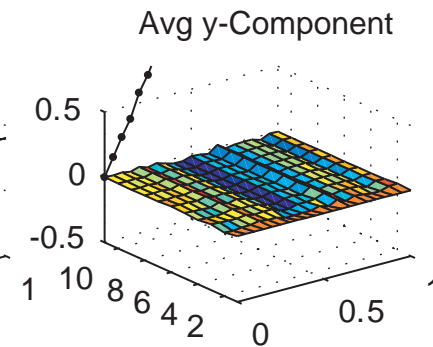
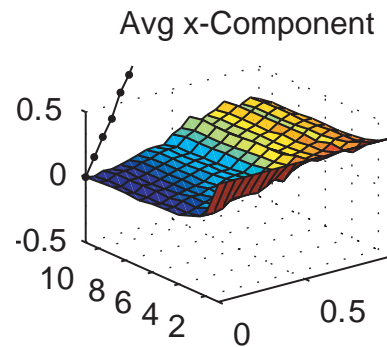
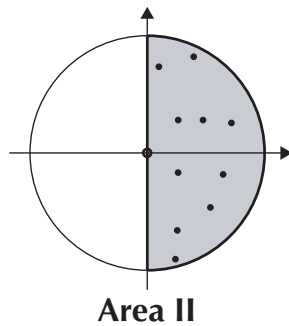
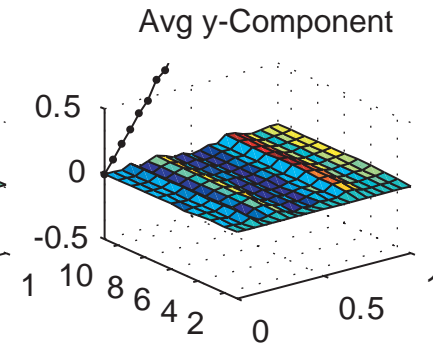
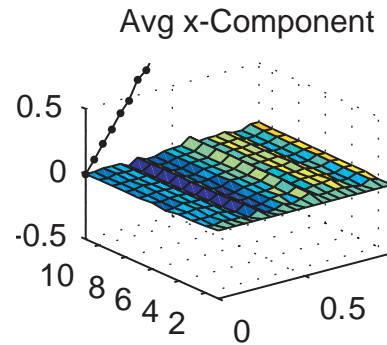
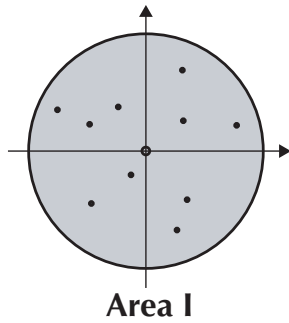




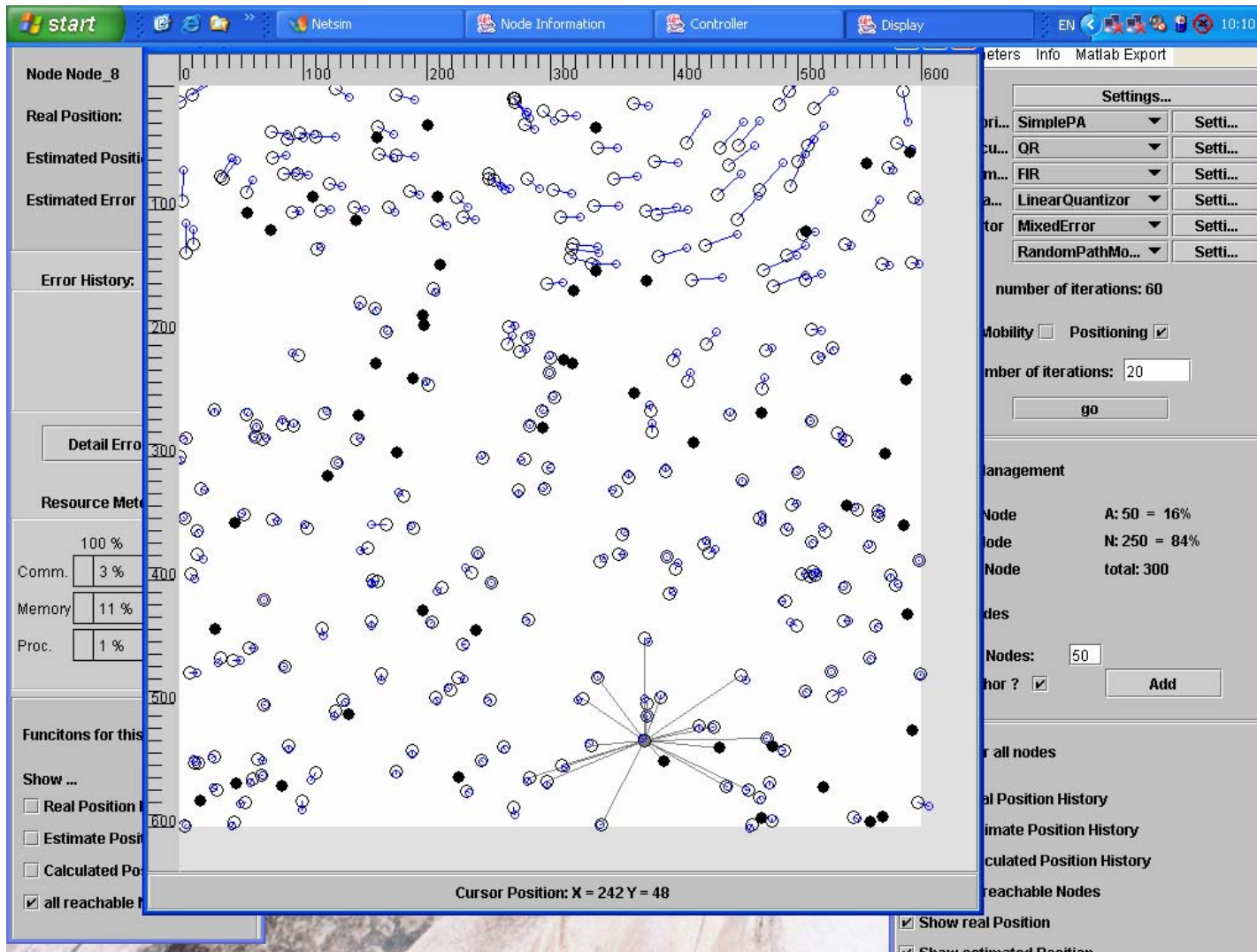
# Influence of Border Regions



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# Ad-hoc Network Simulation Environment



# The TERRAIN Algorithm



- Triangulation via Extended Range and Redundant Association of Intermediate Nodes
- Algorithm creates local maps
- Every node waits to be included in  $\geq 3$  maps
- Extended ranges calculated from respective maps
- Triangulation node based on extended ranges
- Network-wide iterations

