Advanced Techniques of Localization: Application to 3G/4G Networks and Ray Tracing Tools

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We have GPS so Why Localization ?

- Expansion of demand on location-based services : localization persons (children, aged persons ...), emergency, armies, tracking, ... etc.
- Different levels of accuracy are required (100m for persons, <1m for emergency and army)
- Navigation based on GPS becomes inaccurate or impossible especially in urban canyons or even indoor environments, since the necessary amount of 4 directly visible satellites is not reached
- UWB : an emergent technology with high time precision = capability of ranging
- Co-existence of heterogeneous RANs : how to exploit this ?? !!
- Can position information improve the allocation of resources, the handover, the routing and MAC functionalities ?

Keywords

- WHERE FP7 Project
- Localization algorithms
- Hybrid Data Fusion
- Tracking
- Cooperative techniques
- Fingerprinting
- Channel Modelling
- Ray tracing and Localization tools

Wireless Hybrid Enhanced Mobile Radio Estimator

EU FP7 ICT-217033 : 14 partners, Prime: DLR

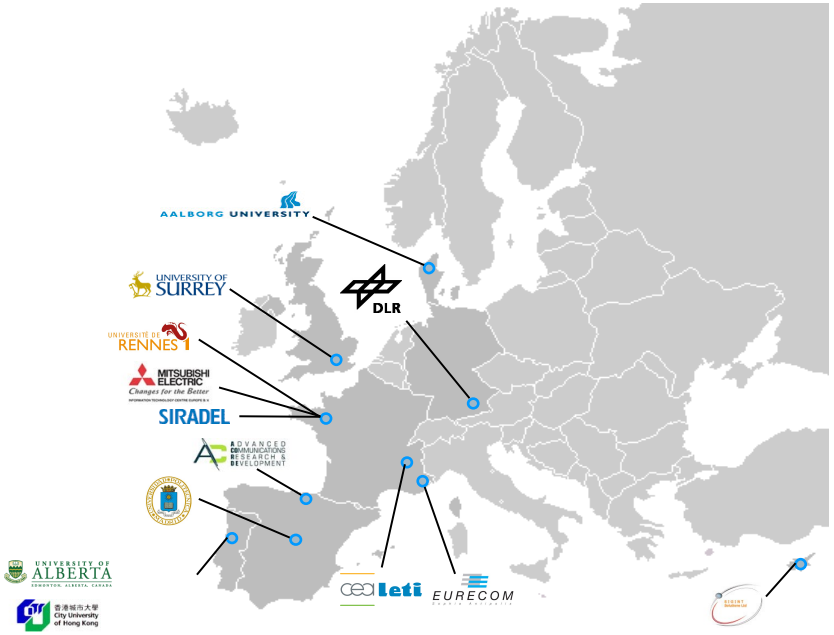
Duration: 30 Months (Jan 2008 – June 2010)

Project Budget: 5.7 Mio. €, EU Funding: 4 Mio. €

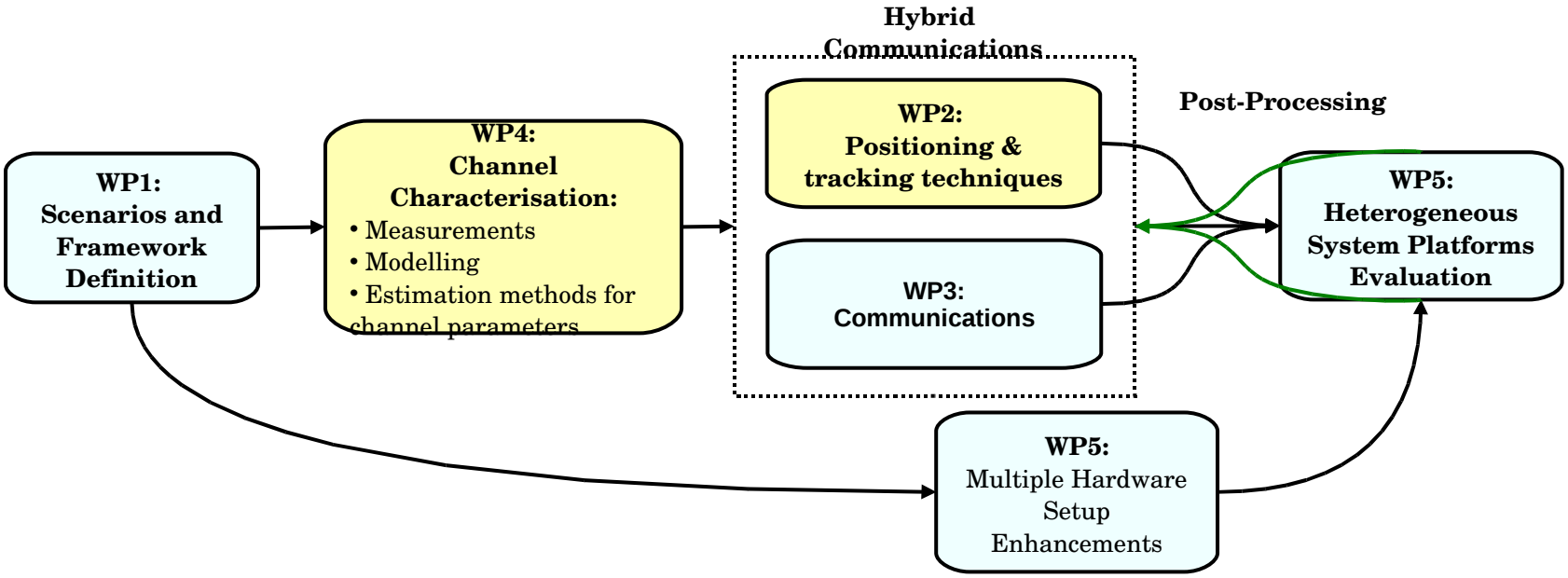
www.ict-where.eu

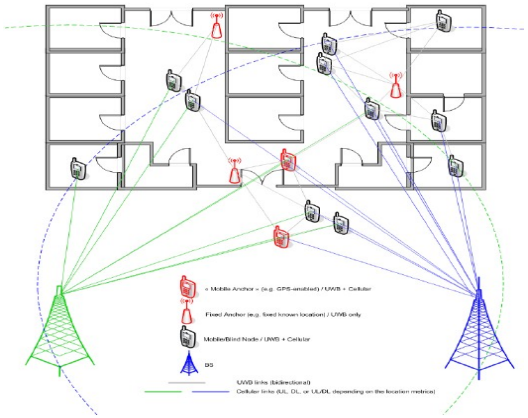
- Integration of communications and positioning
- Positioning with mobile radio communications and short range communications systems
- Improvement of radio communications systems by using position information
- Demonstration/Trials

The project WHERE aims to improve the efficiency of mobile communications systems by providing innovations for the integration of communication and positioning.

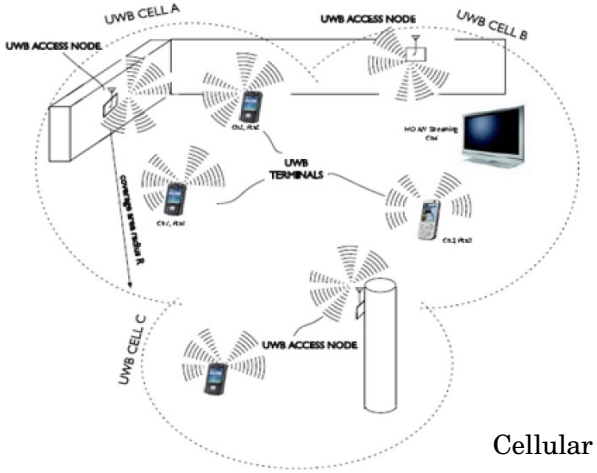


Work packages & Scenarios





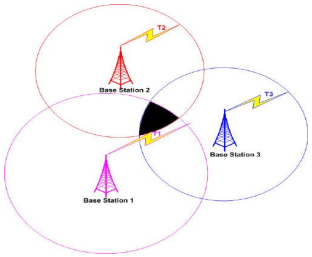
Cellular + UWB



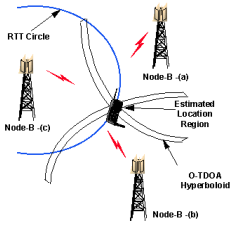
Cellular UWB (UCELLS)

- We assume that the terminal is able to obtain continuously an estimation of its position with the associated position accuracy (PA)
- The network seeks to globally minimize actions to achieve positioning.
- What (type, amount) of data is available in current context ?
  - With which precision ?
  - What PA can be achieved with this data ?
- Does an additional measurement may improve the current PA ?
- Need to list all possible set of homogeneous and heterogeneous combination of observable data leading to a finite set of solutions (1 or more)
- We focus on DF algorithms in both :
  - UWB networks
  - 3G/4G networks

One metric based techniques



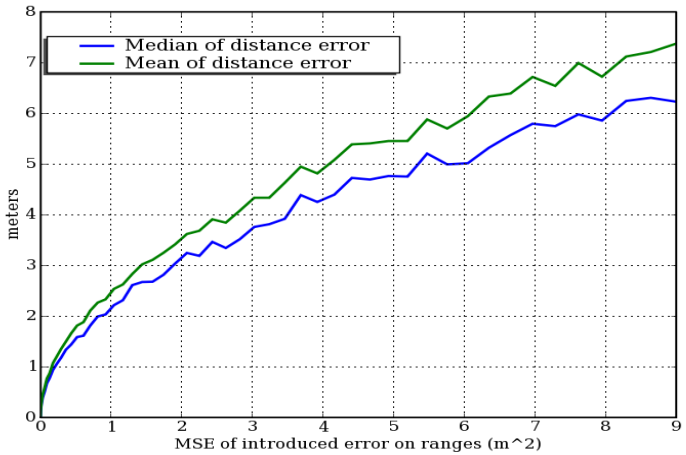
Ranging: ToA, RSS



TDoA

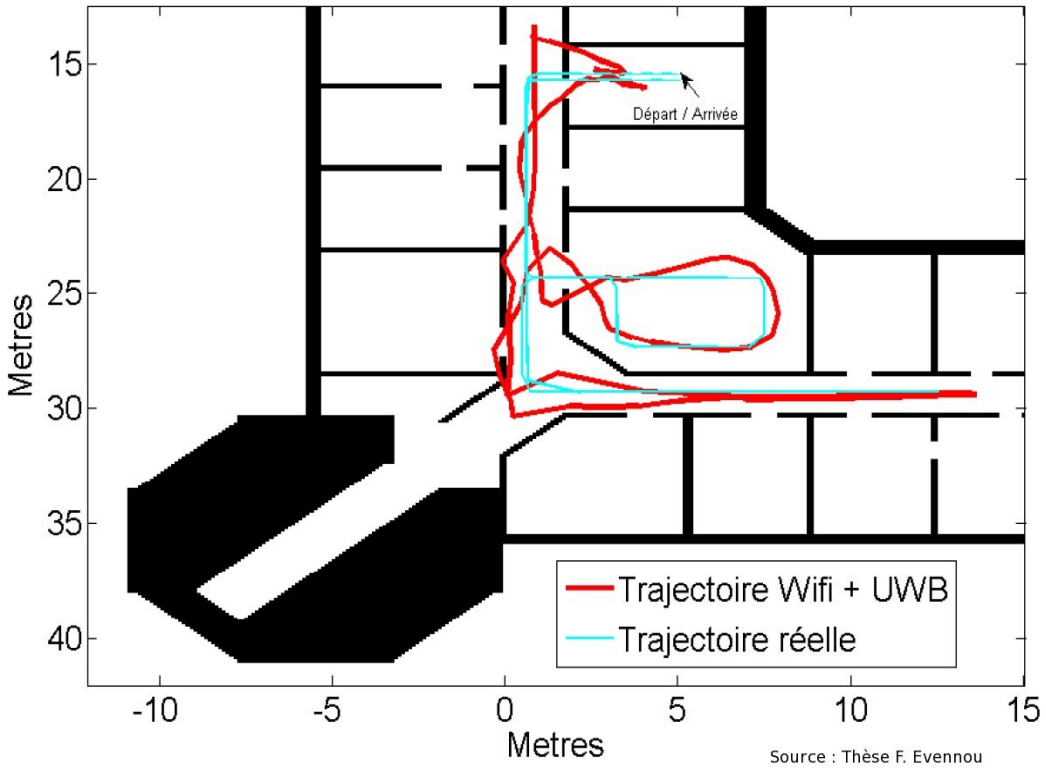
AoA

Hybrid Data Fusion consists in combining different simple metrics (ToA, TDoA, RSS, AoA) to obtain position. Thus, it achieves more accuracy in position location.



Evolution of PA as a function of MSE of range

- Many applications need to follow the movement of a user or a mobile.
- Many techniques will be studied respecting a motion model:
  - Kalman Filter, Extended K F
  - Particle Filter
  - Fingerprinting.



1- Choose reference points

2- Measurements or simulations in these points

3- Fingerprints databases

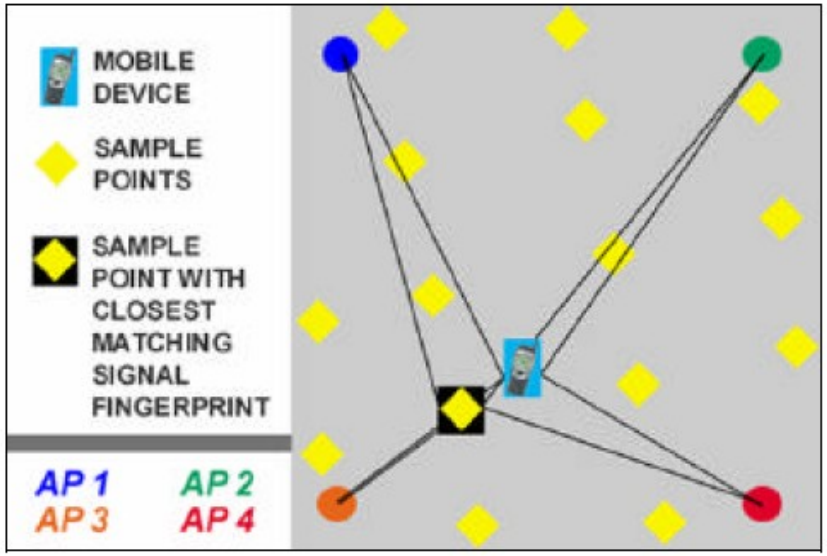
Off-line Phase

1- Measurement at assumed point

2- Matching measurement to databases

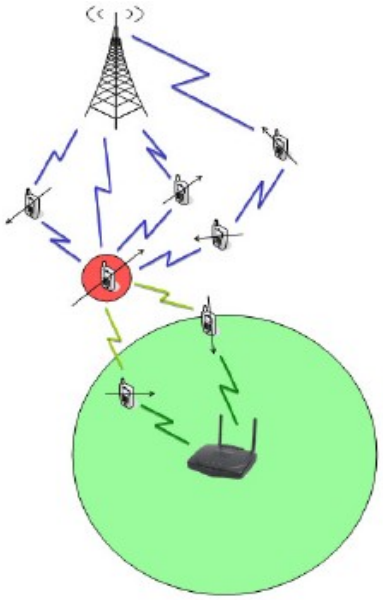
3- Positioning

On-line Phase

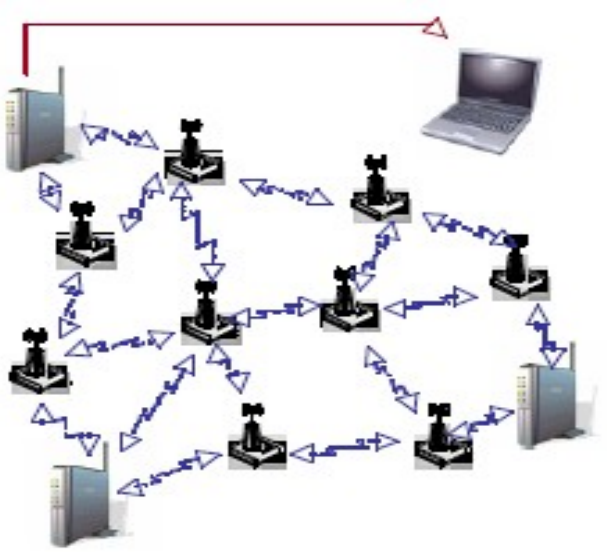


Cooperate to get position and using position information to cooperate

- Surrounding mobiles know and provide their position information (e.g. by broadcasting or by answering a 'ping')
- A less equipped mobile can receive this information via short range communication such as ZigBee or UWB
- Exchange positioning information through peer-2-peer communications links



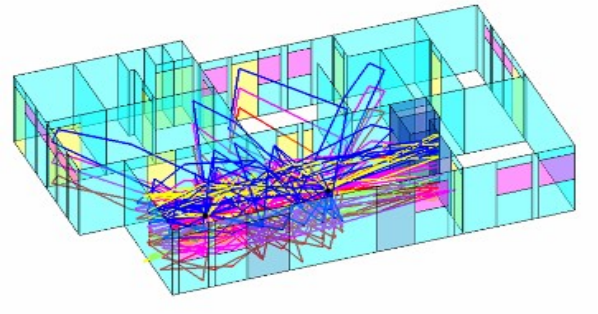
Relaying

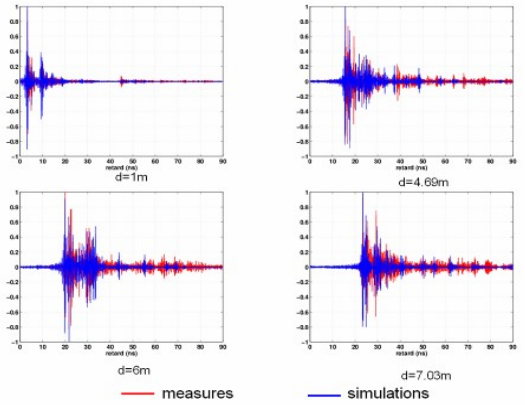


Cooperation

WP4 : Channel Modelling & Ray tracing tool

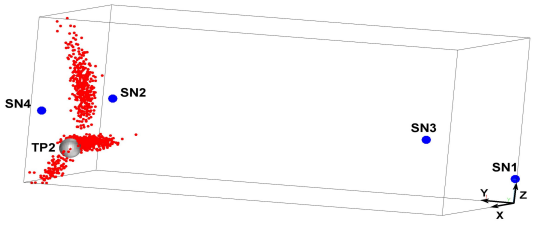
- To develop an heterogeneous ray tracing tool in Python language able to
  - Simulate and characterize 3G & 4G networks
  - Support MIMO channels and heterogeneous RANs
  - Yield Fingerprints databases
- To develop a localization module to be integrated on RT tool able to
  - Test different location algorithms (simple, hybrid)
  - Test tracking, fingerprinting, and cooperative algorithms
  - Show performances of these algorithms
- To perform some measurements in order to evaluate RT & Localization tool

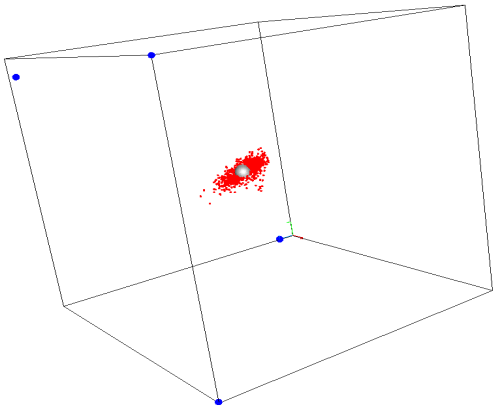


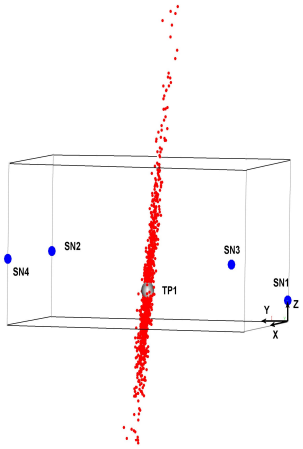


Once RT tool take off, we will be able to

- Study the effect of NLOS propagation and multipath on the performances of studied algorithms.
  - Position Accuracy
  - CRB
- Using
  - More realistic description of channel and simulated environment
  - More realistic scenarios
  - Cross check between simulations and measurements



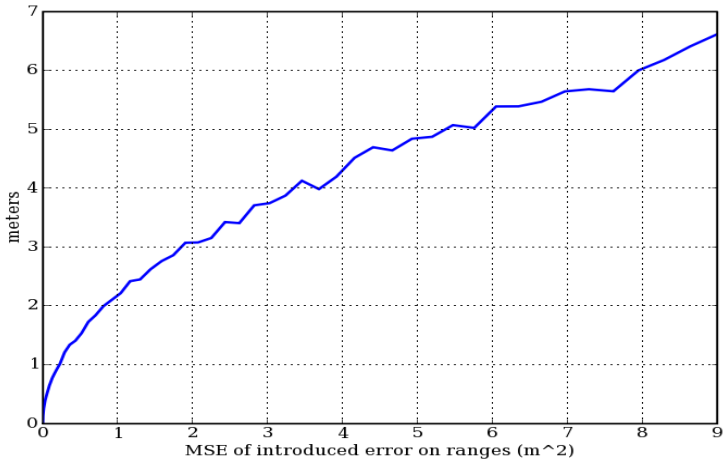




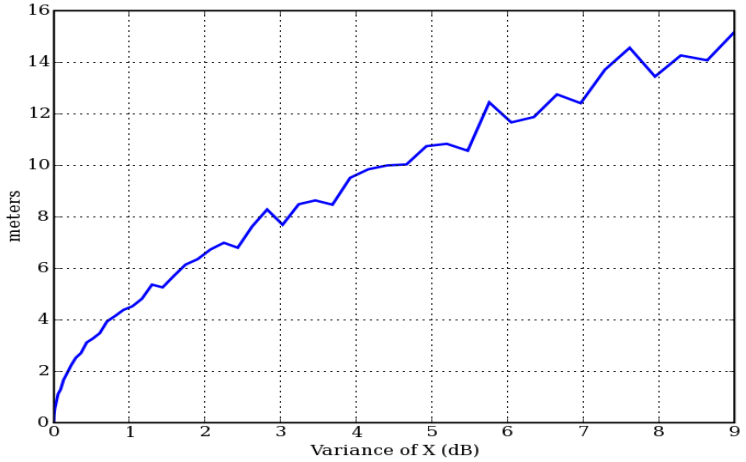
Let's discuss: Localization & WSN

- 53 from 263 papers (20.1 %) in my bibliography store deal with localization in WSN !!
- How can we use WSN to improve localization ?
- What kind of information can be given by WSN and with which precision?
- How can positioning information affect WSN functionalities and power efficiency ?
- What about these couples of keywords :
  - WSN & Data Fusion
  - WSN & Cooperative techniques
  - WSN & Tracking ?

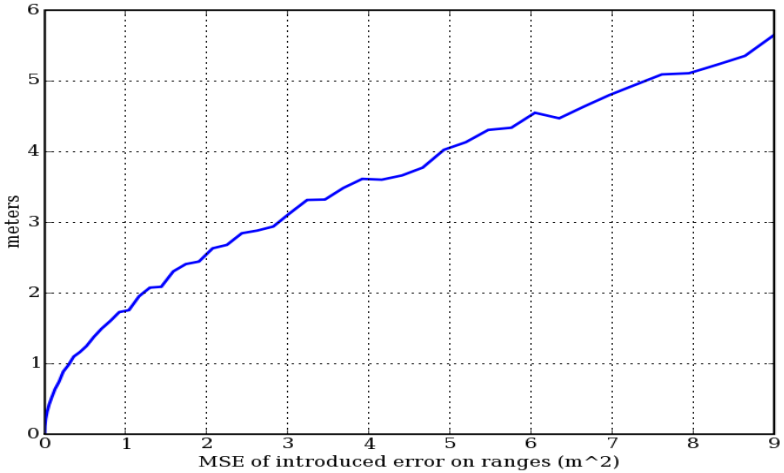
One-metric based algorithms



4 TOA



4 RSS



4 TDOA

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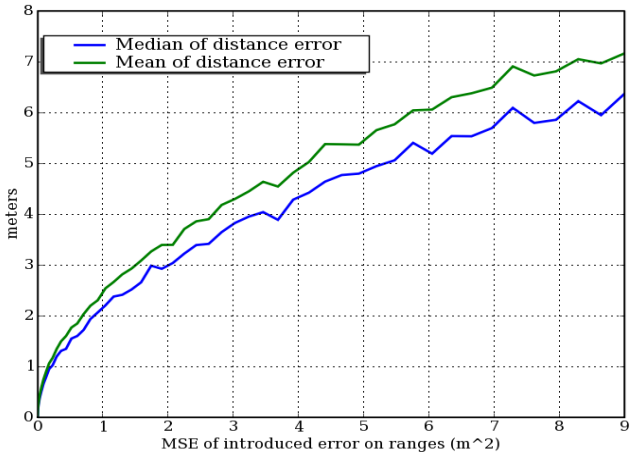
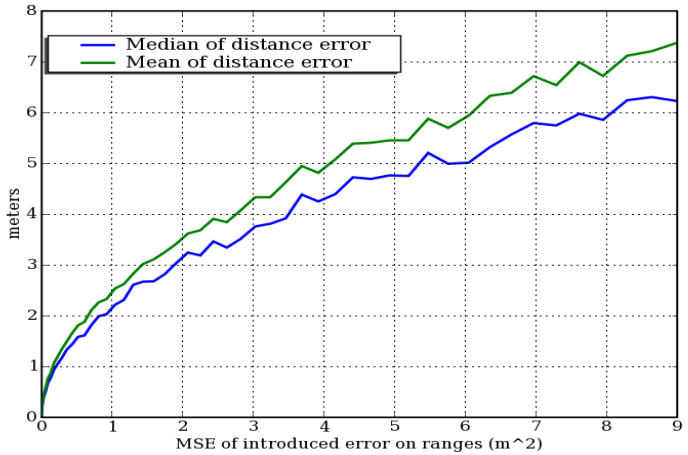
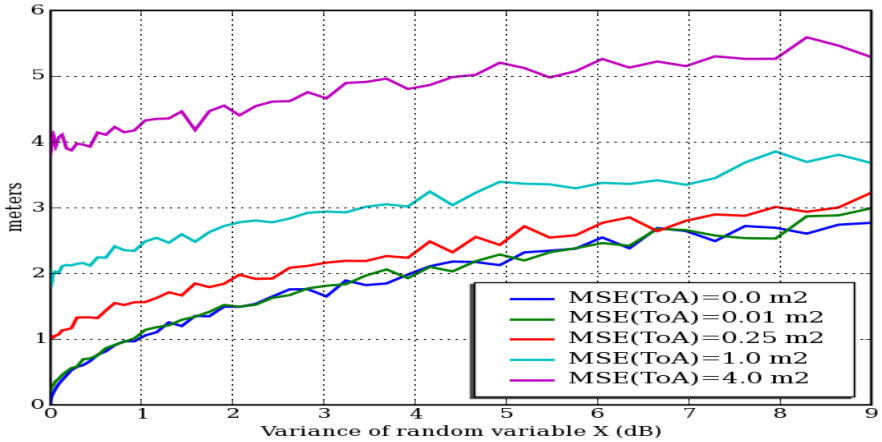


3 TDOA/ 1 TOA



3 TDOA/ 1 RSS



3 TOA/ 1 RSS

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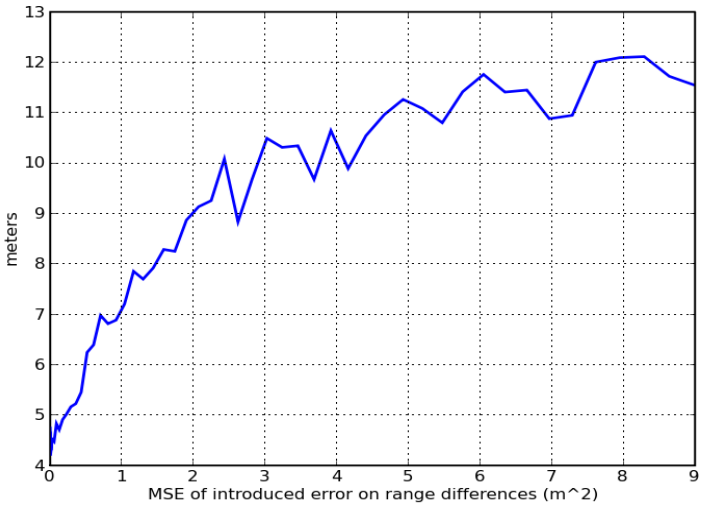

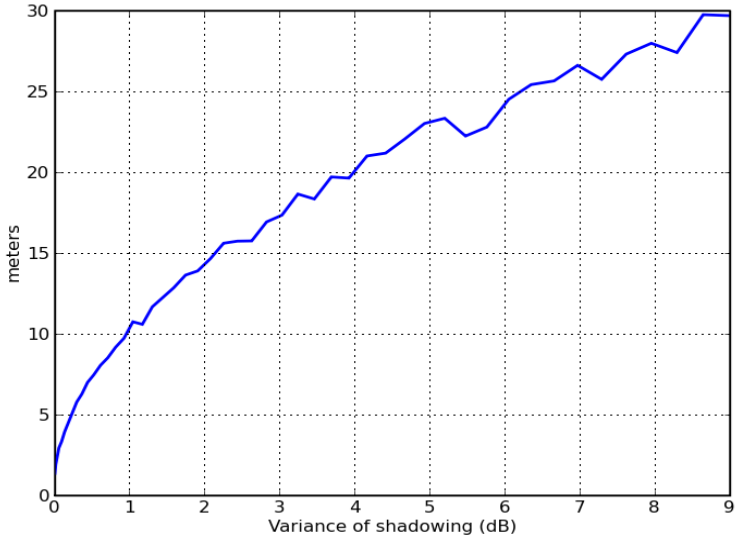

3 Cellular TDOA/ 2 UWB TOA

3 Cellular RSS/ 1 UWB TOA