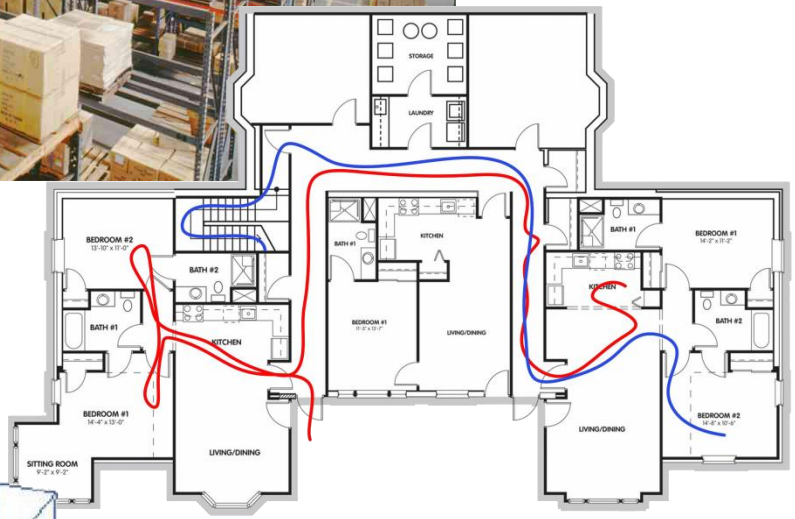
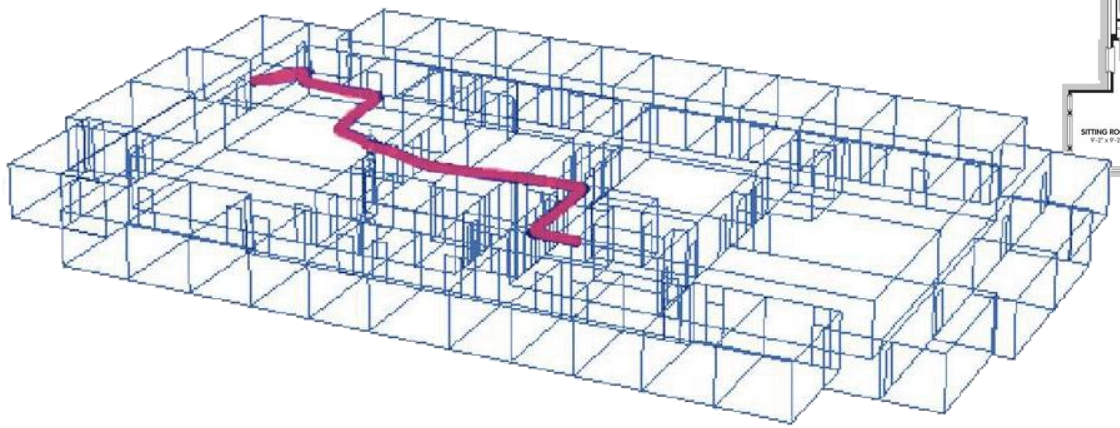
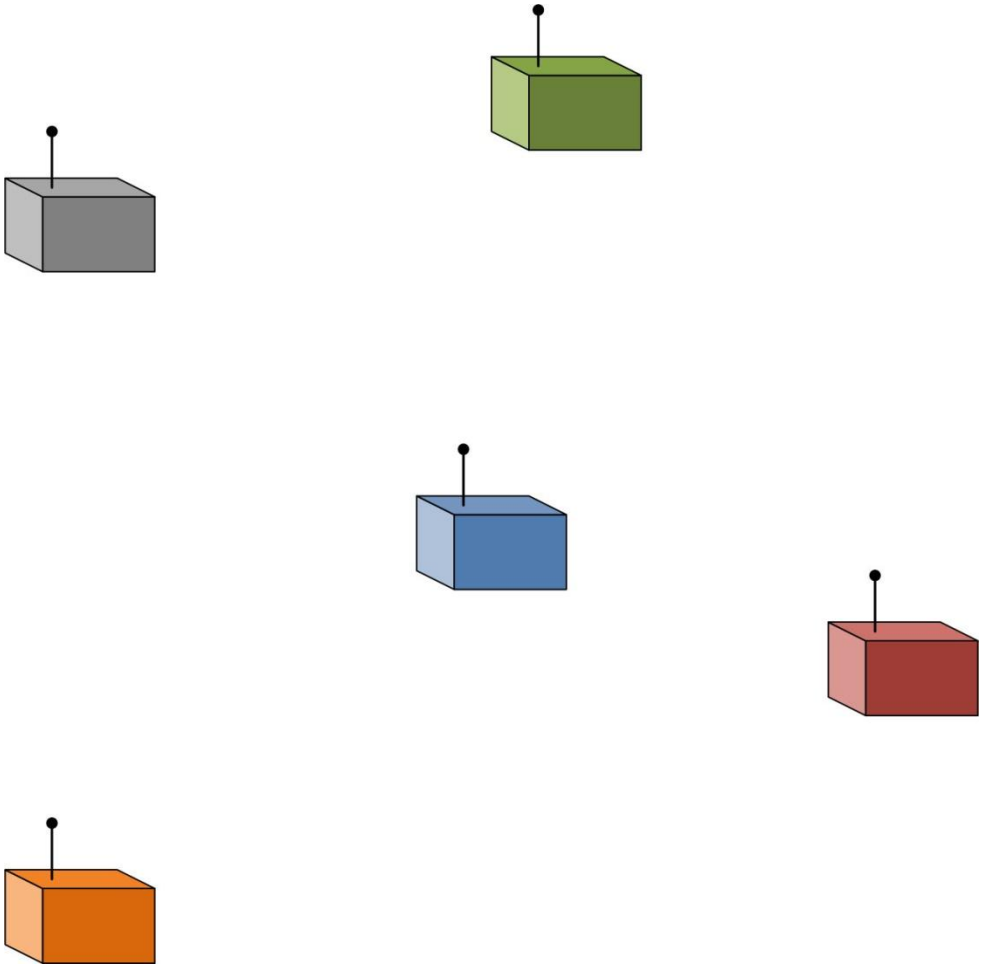
Location Awareness In Wireless Networks

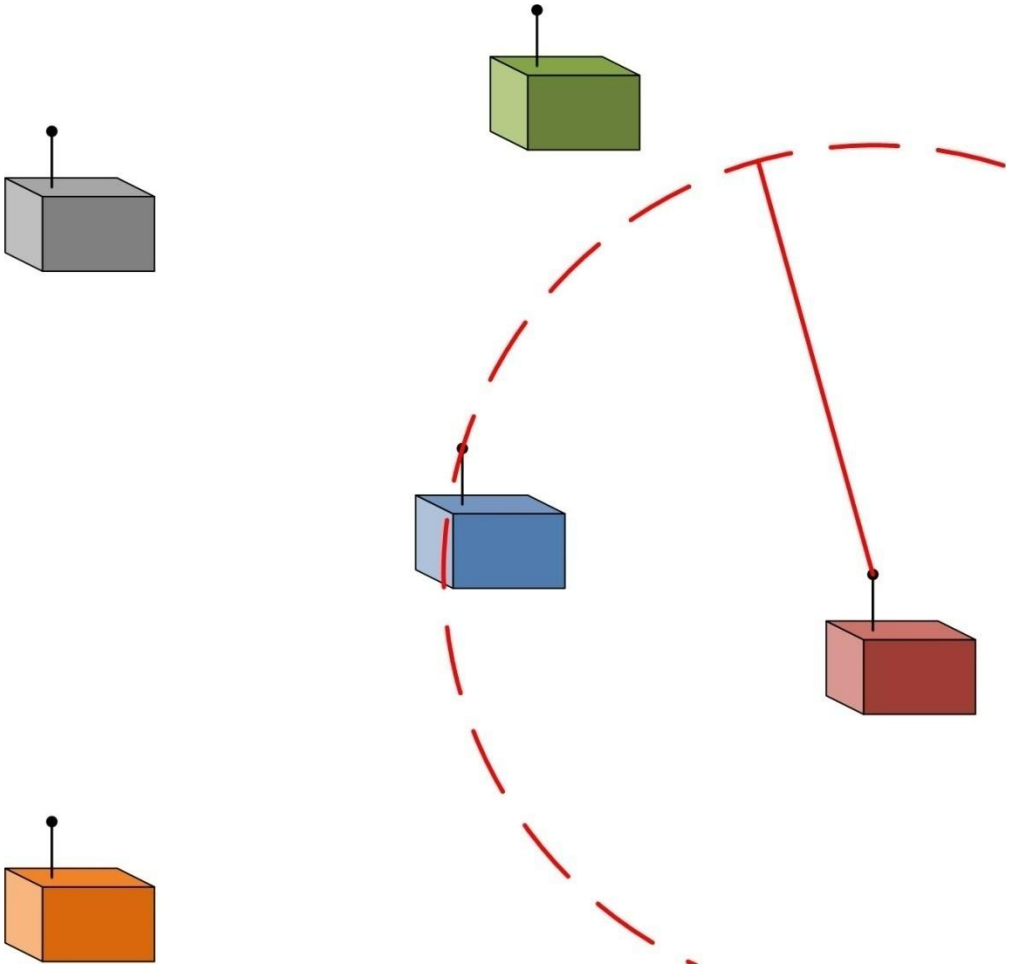




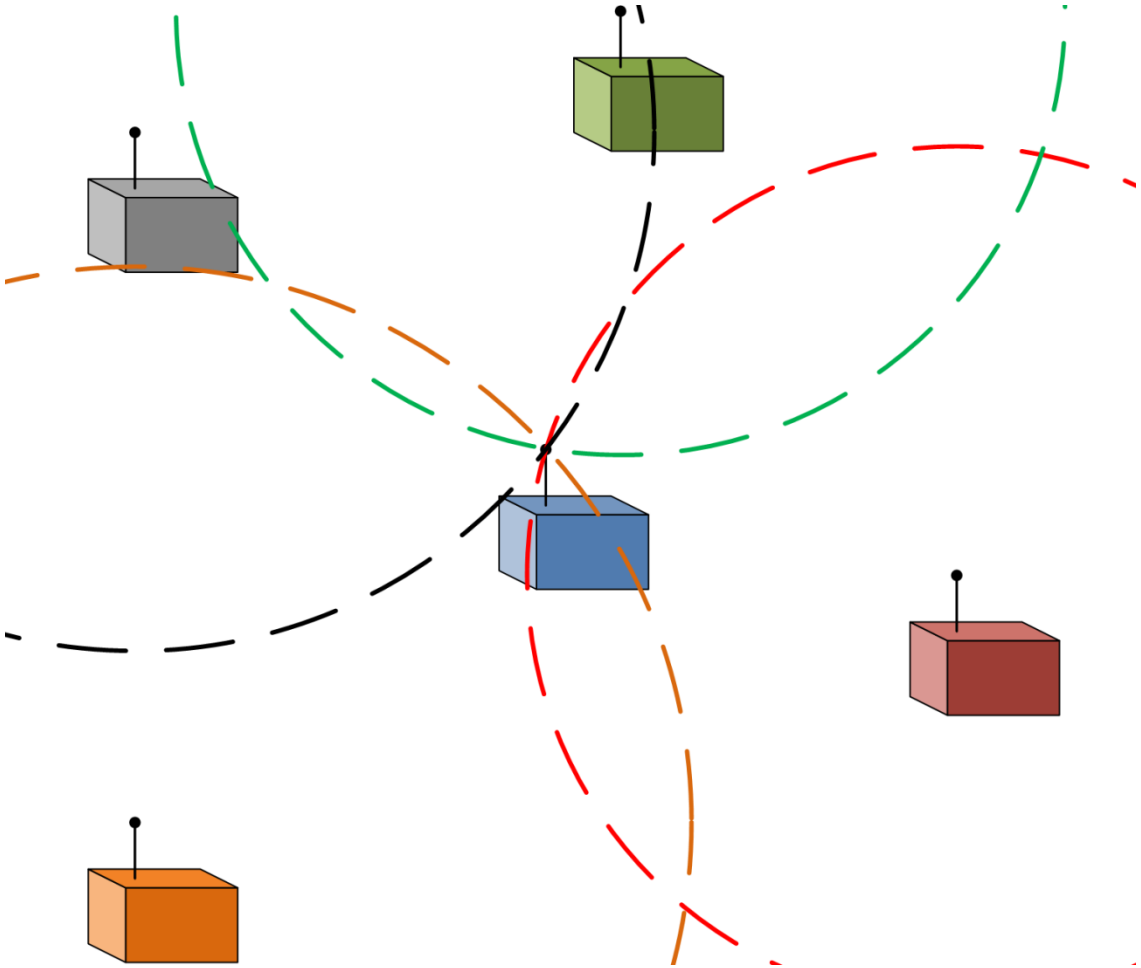
The Localization Problem



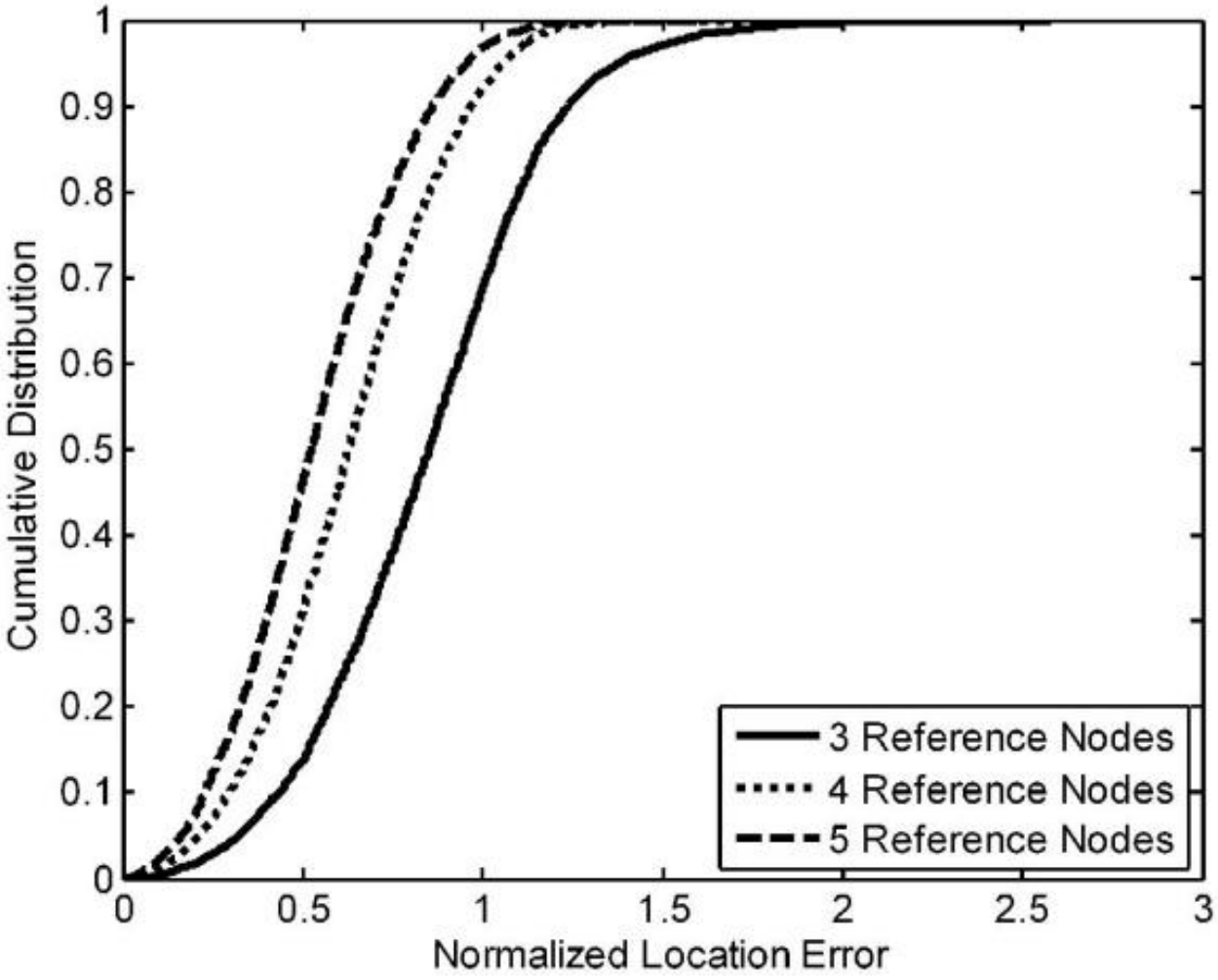
The Localization Problem



The Localization Problem



Location Accuracy vs. Ranging Accuracy



Ranging Constraints

IEEE 802.15.4 compatible RF time of flight ranging

- 2 MHz RF bandwidth
- Half duplex radios
- 16 channels in 2.4 GHz ISM band
- No time synchronized infrastructure

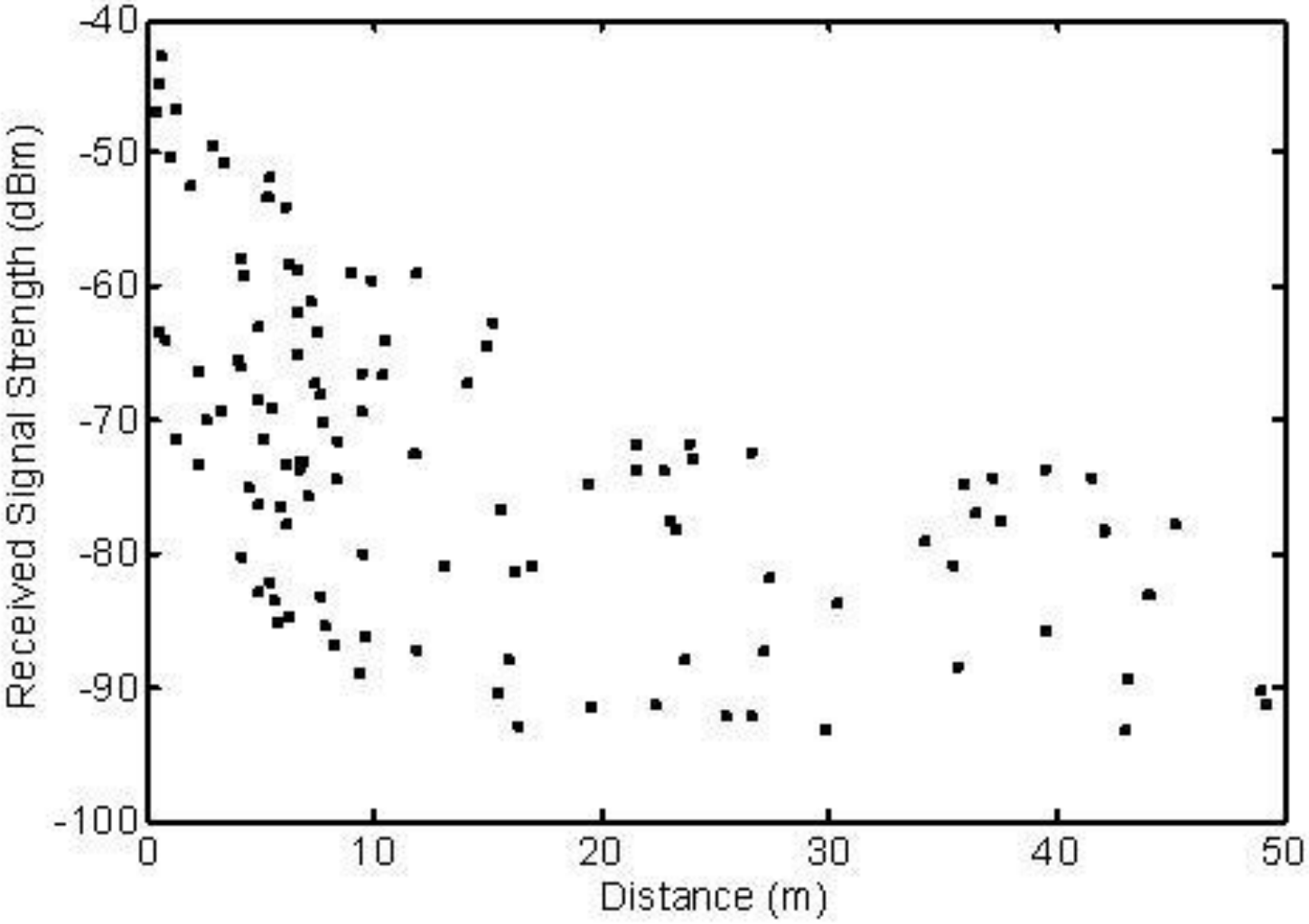
Why Ranging is Challenging

- Time synchronization
- Noise
- Sampling
- Half duplex radios
- Environmental clutter

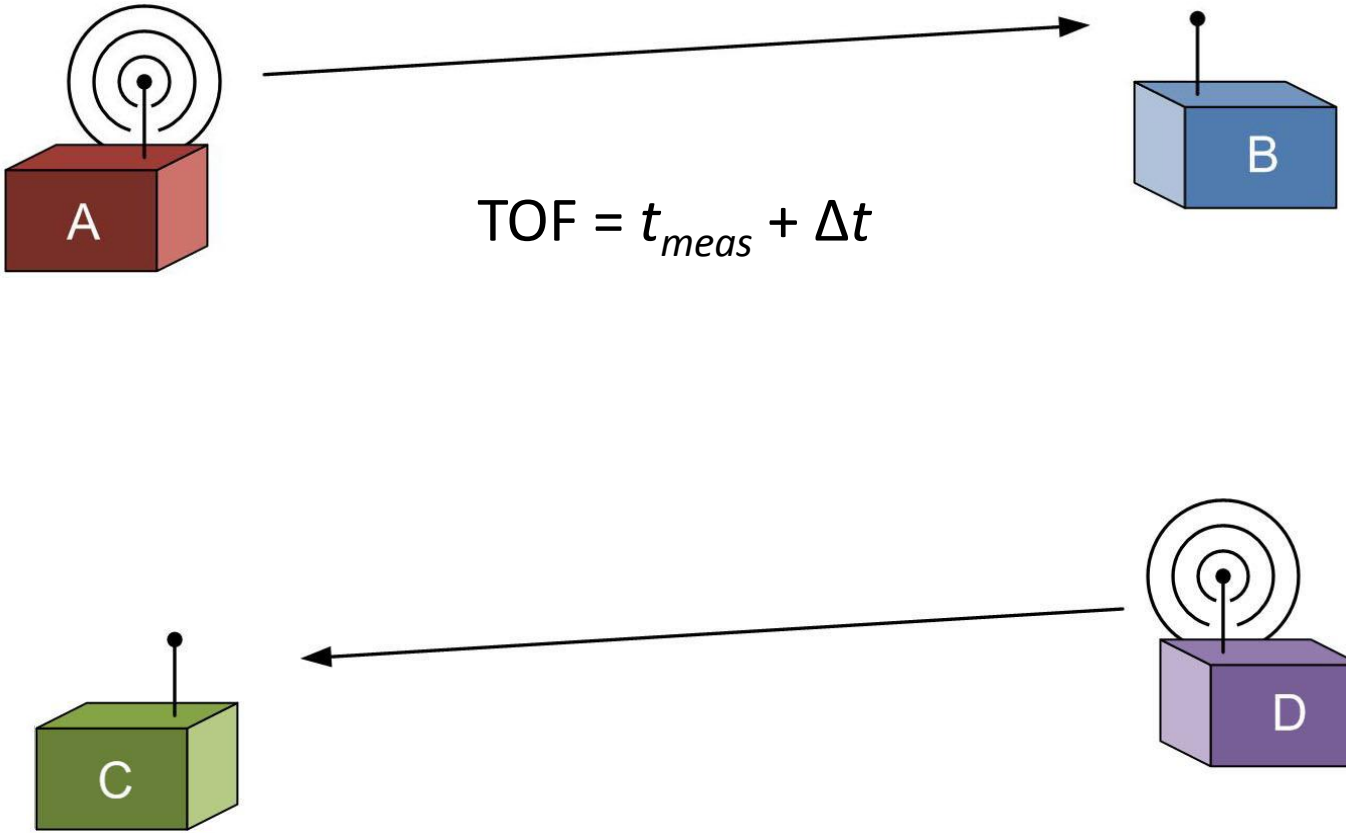
And why do those things matter?

- Speed of light
  - 30 cm/ns
  - 1 ft/ns

RSS Based Range Estimation

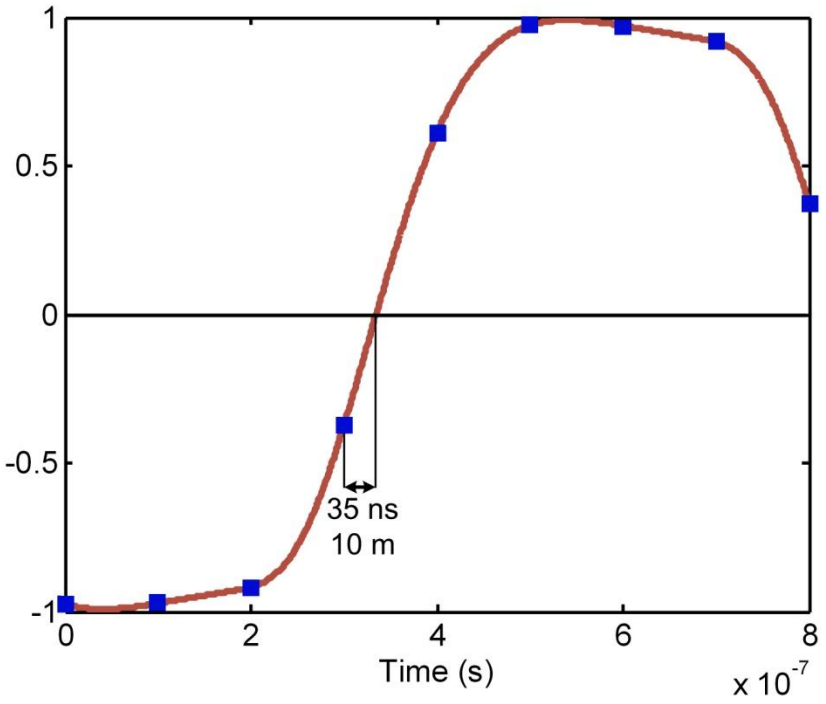


Time Synchronization

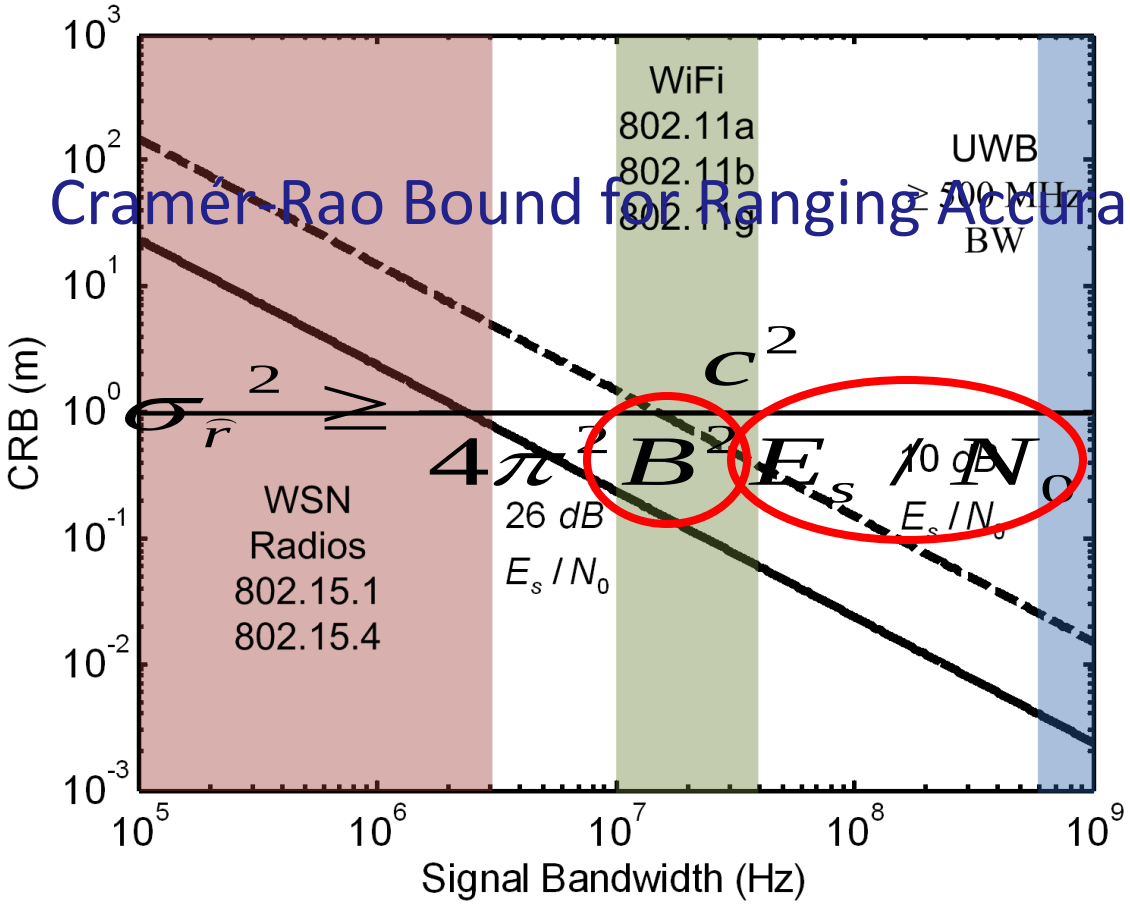


Range Binning

- Signal sampled by receiver
- Resolution of $1/f_s$
- What about Nyquist sampling?

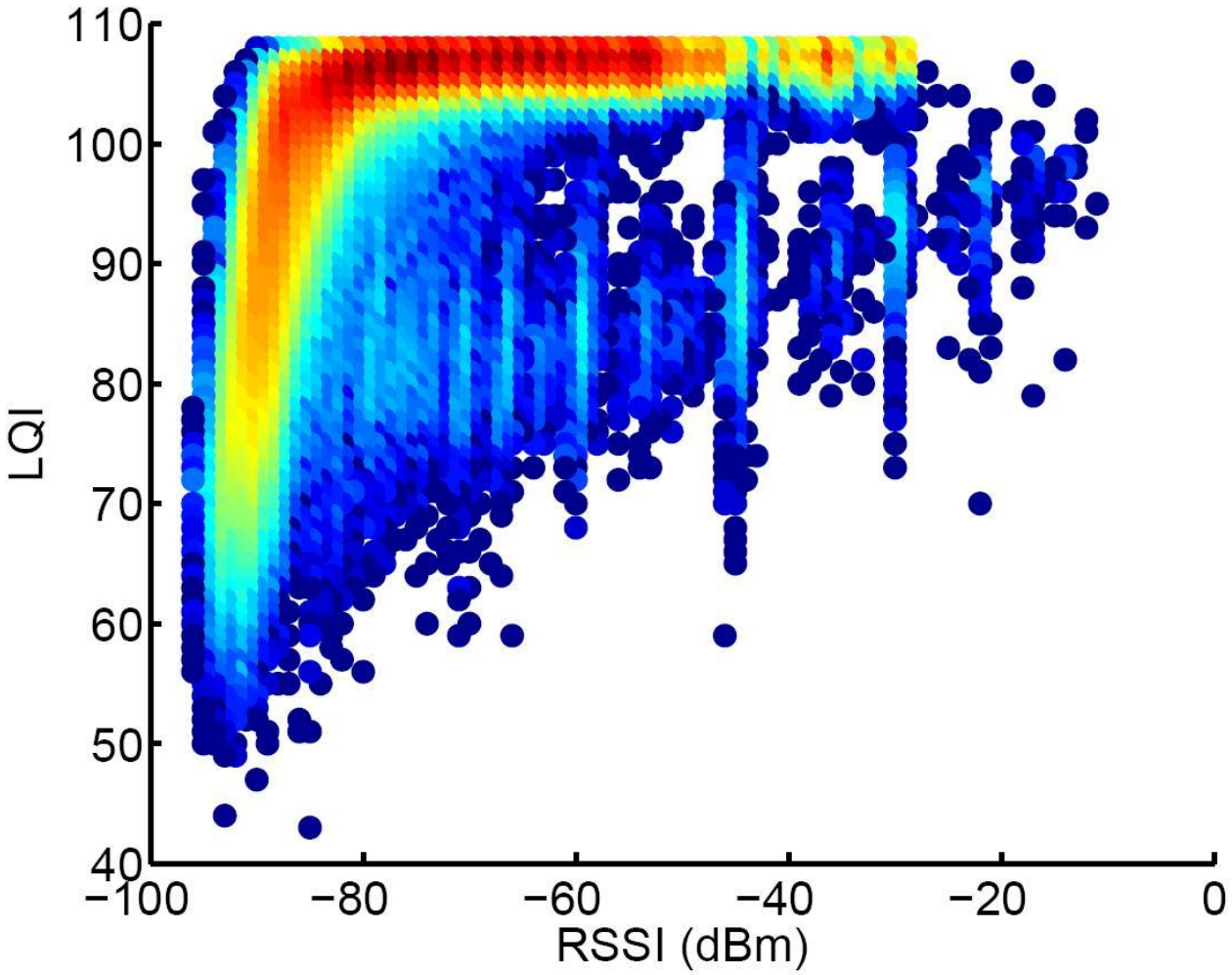


Noise



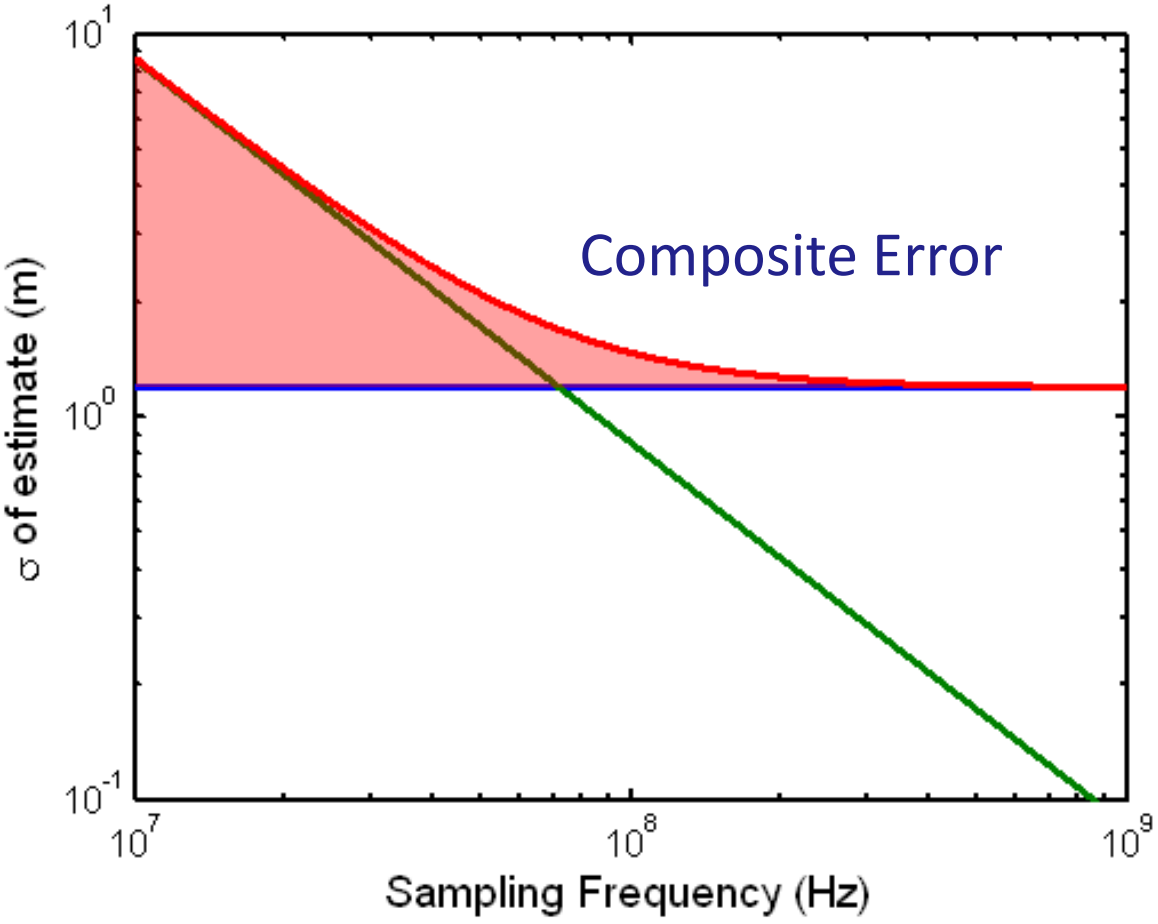
$$\sigma_{\hat{r}}^2 \geq \frac{c^2}{2\pi^2 B^2 E_s / N_0}$$

Wireless Sensor Network Conditions



S. Lanzisera, A. Mehta, K. Pister, "Reducing Average Power in Wireless Sensor Networks Through Data Rate Adaptation," IEEE International Conference on Communications (ICC), June 2009.

Range Binning & Noise

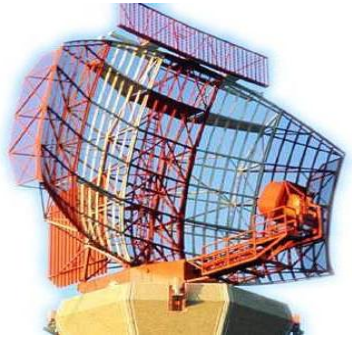


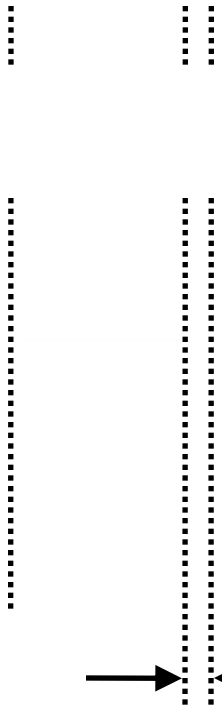
Full Duplex Two Way Ranging

- Developed during WWII
  - Identify friend or foe
- Widely used in civil aviation starting in 1950's

Cessna ARC-RT-359A Transponder (Wikipedia)

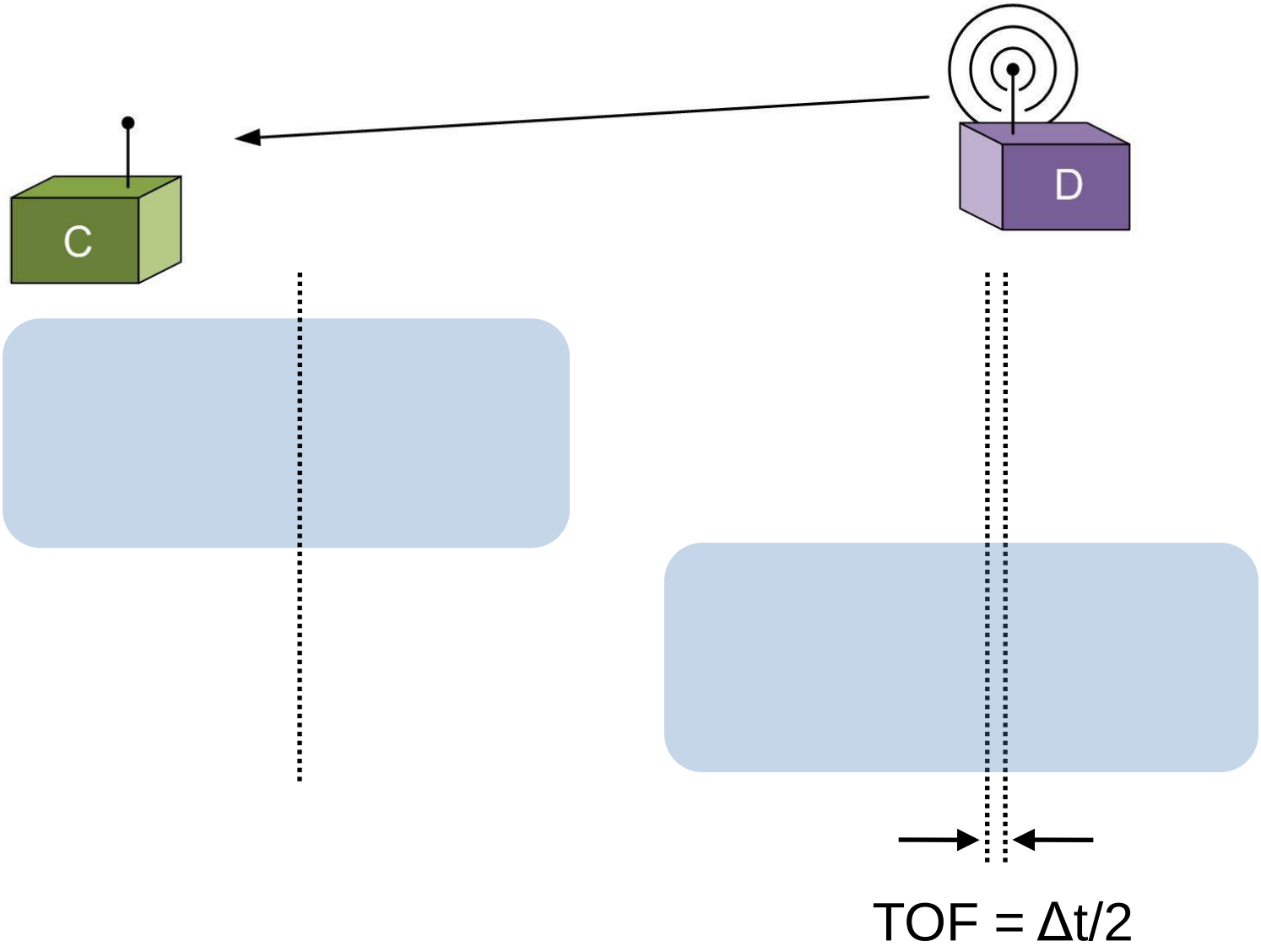
Full Duplex Two Way Ranging



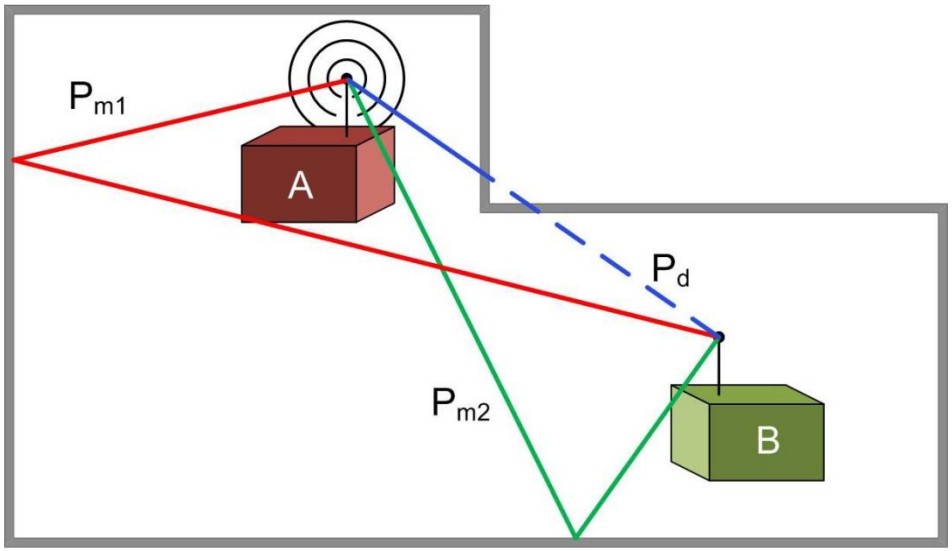


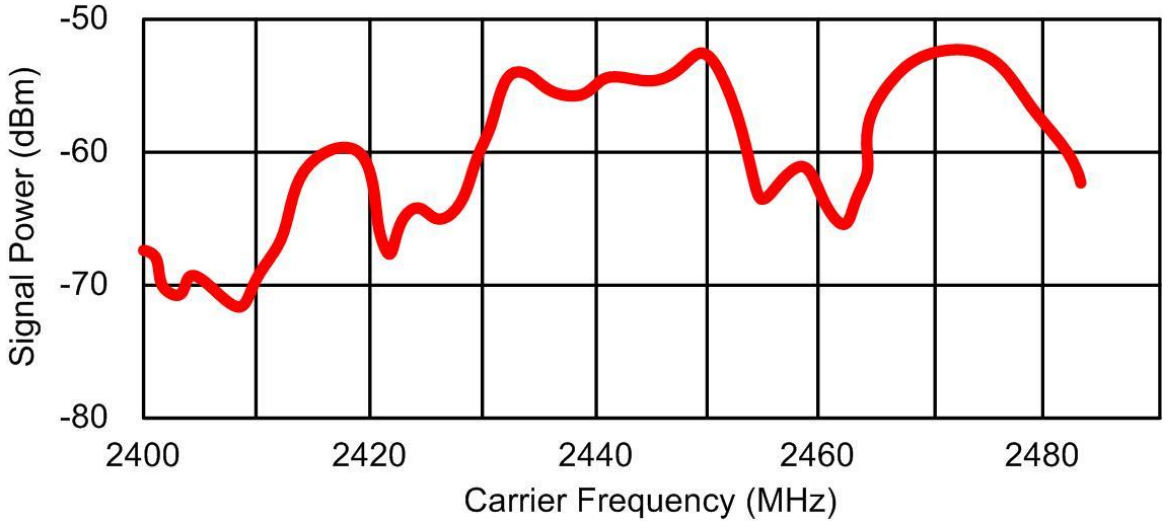
TOF = Δt/2

Code Modulus Synchronization



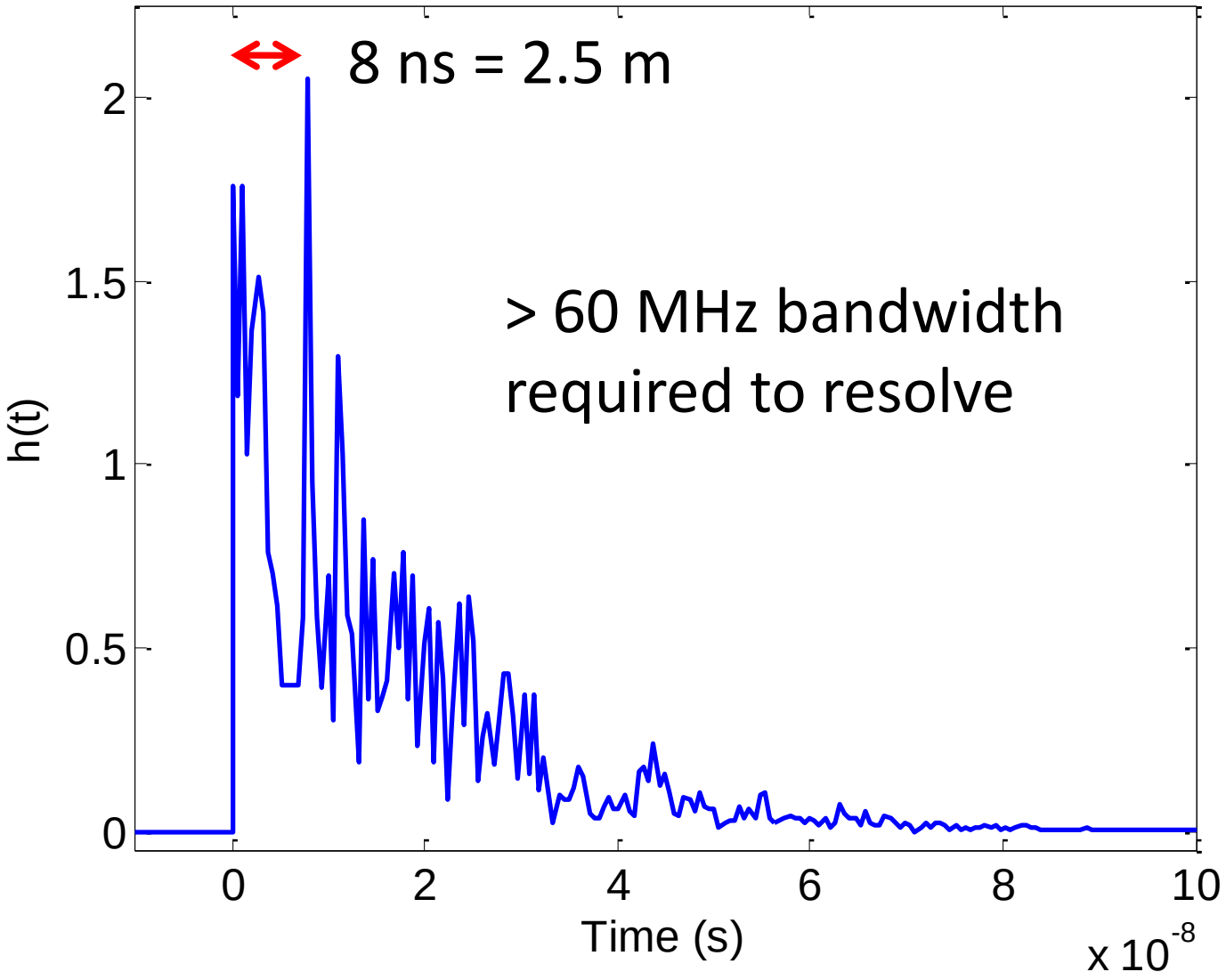
Multipath Propagation



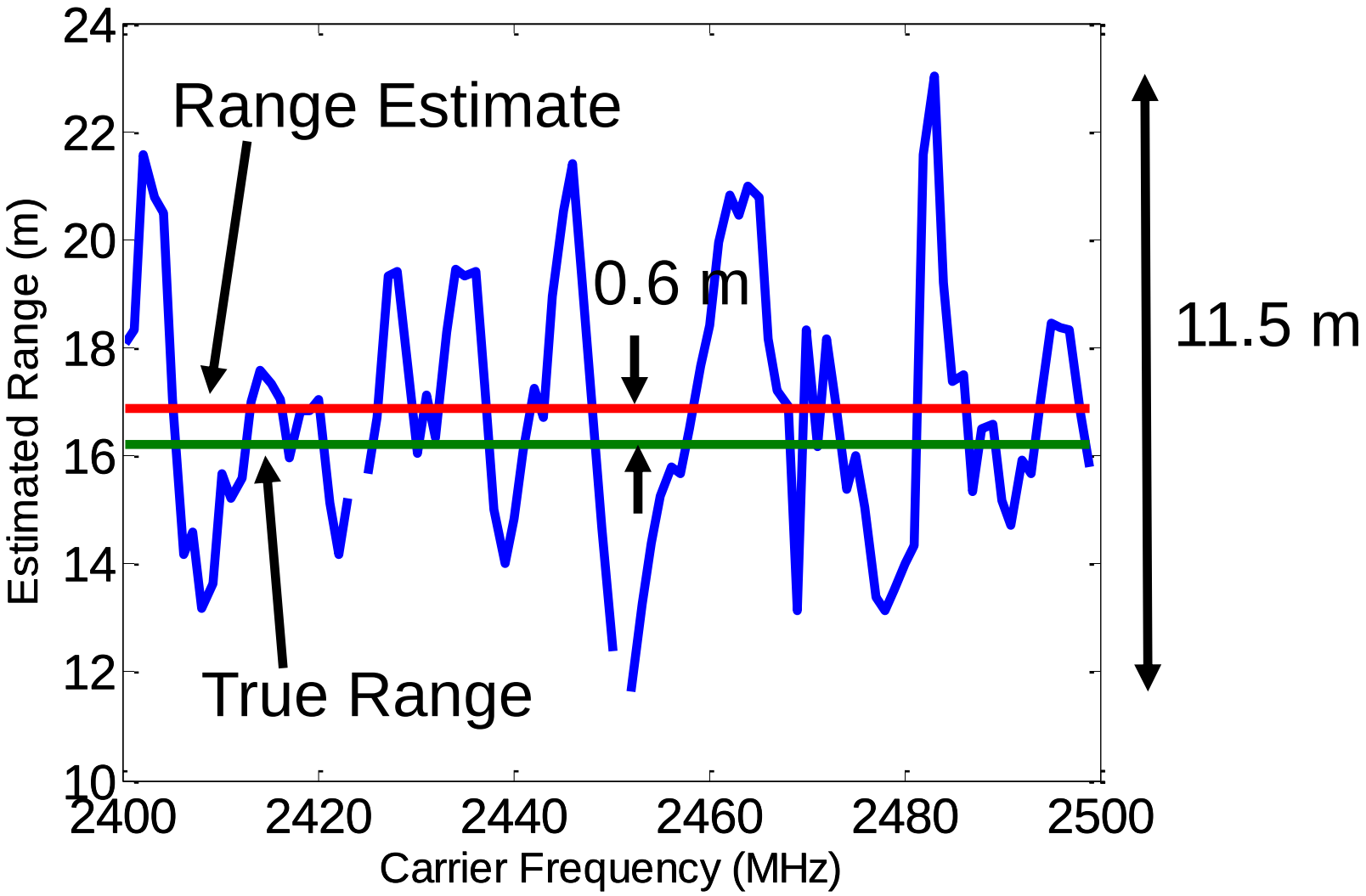


Werb, J., Newman, M. Berry, V. & Lamb, S. (2005). Improved Quality of Service in IEEE 802.15.4 Mesh Networks. *Proceedings of International Workshop on Wireless and Industrial Automation*.

Channel Impulse Response



Dealing With Multipath



Multipath Mitigation

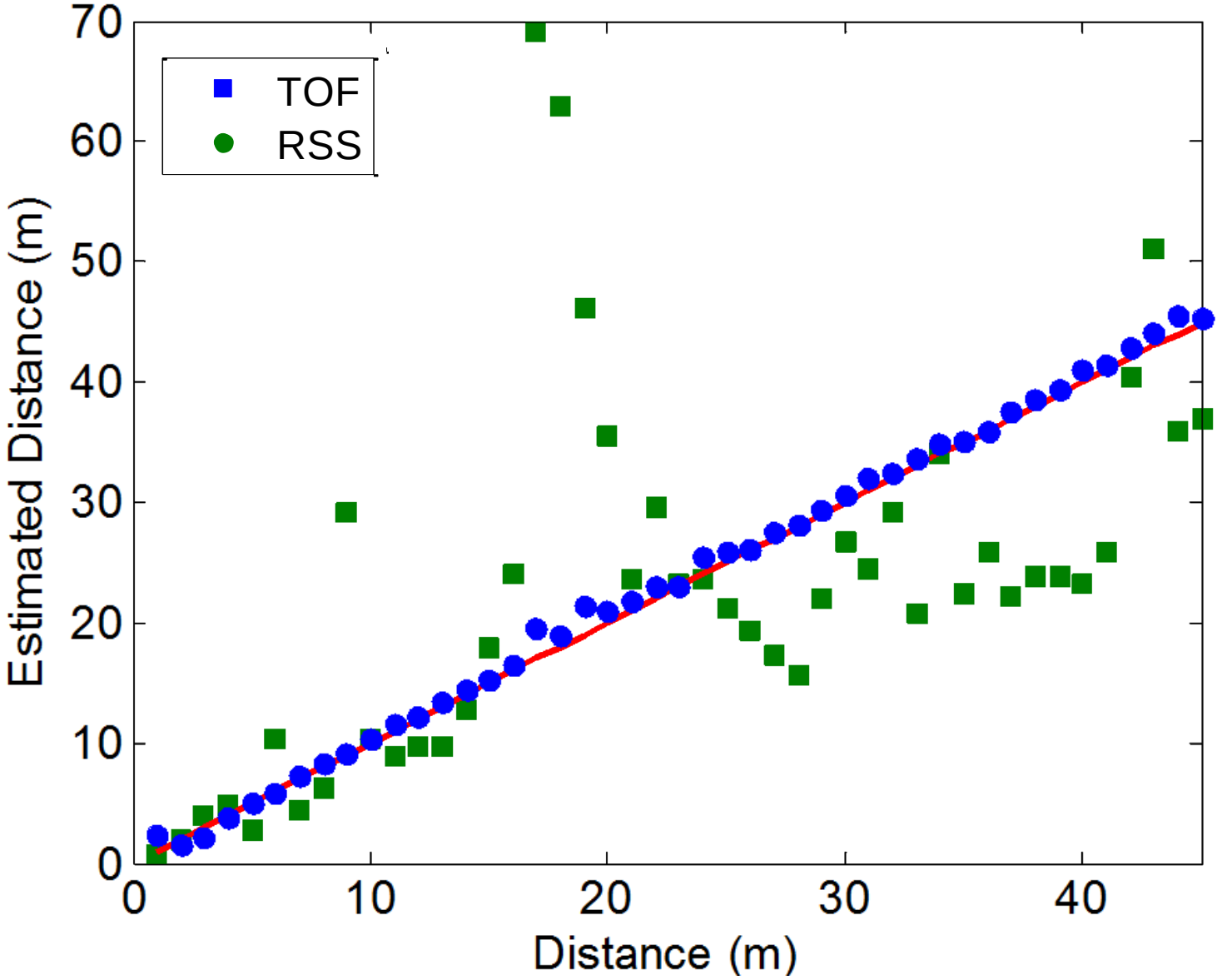
Proposed method deals well with multipath signals with amplitude less than direct path

- This is true in all line of sight channels
- It is also true in some obstructed channels

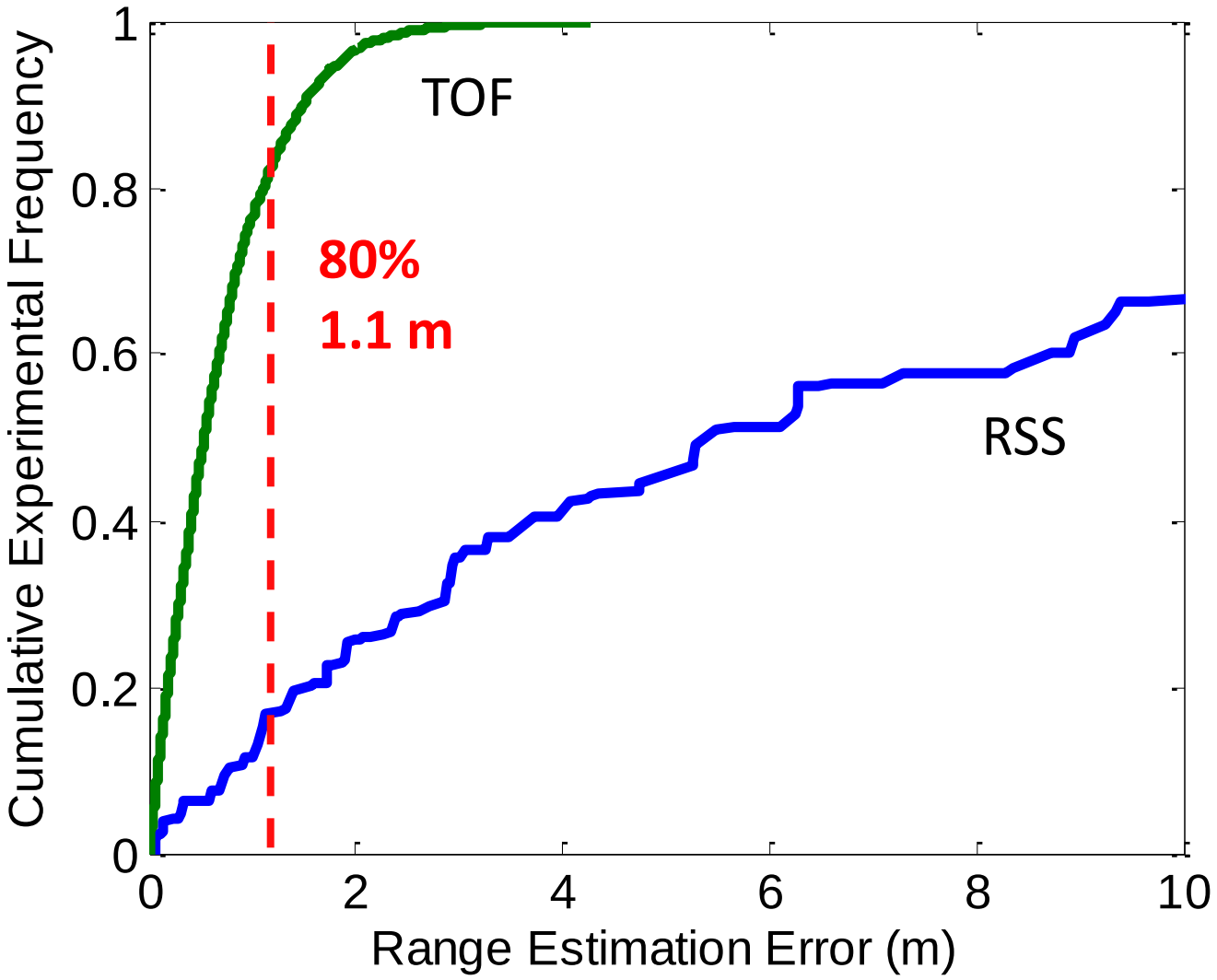
What happens when MP is too strong?

- Large errors result
- Localization algorithm must help mitigate

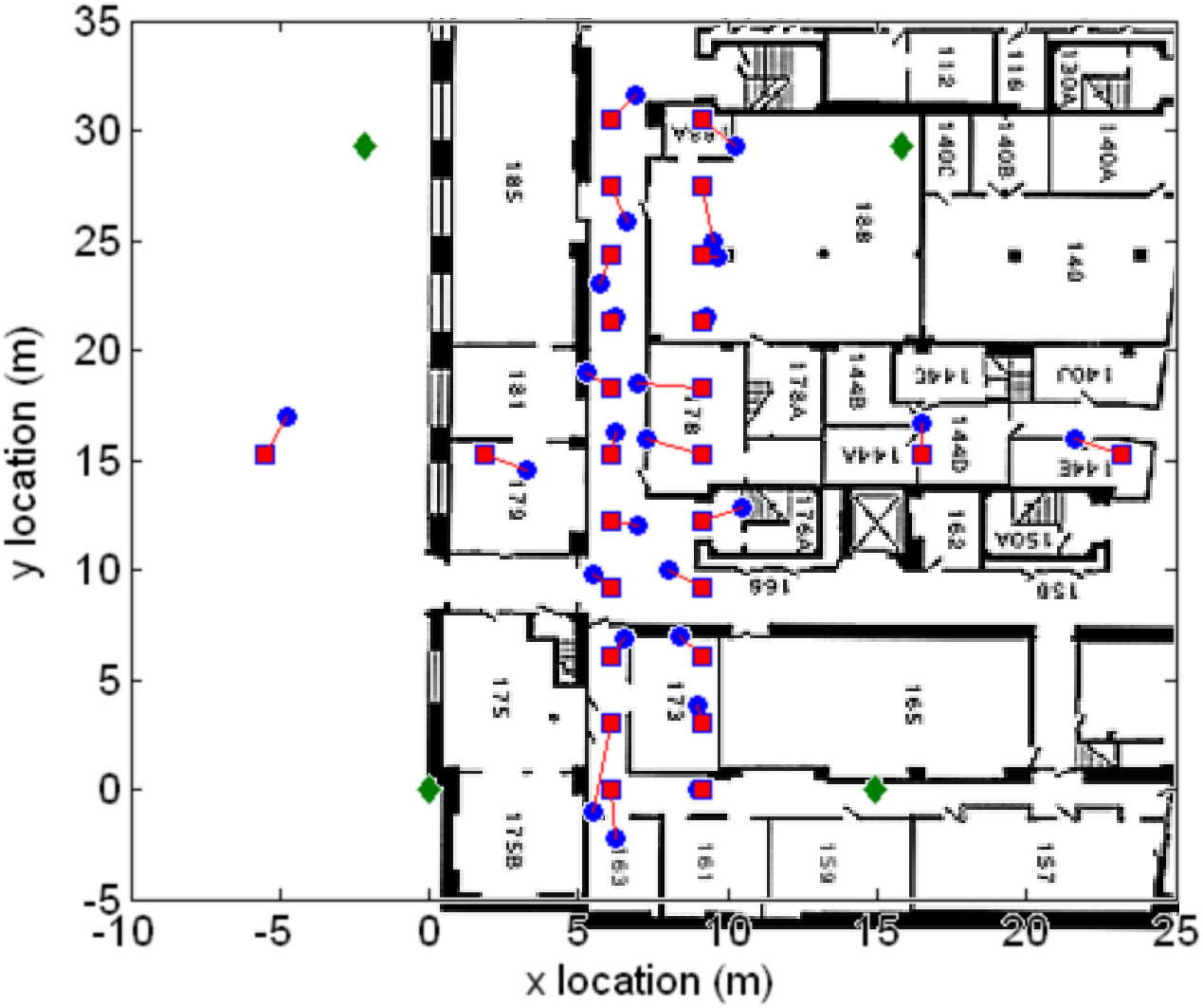
Comparison to RSS



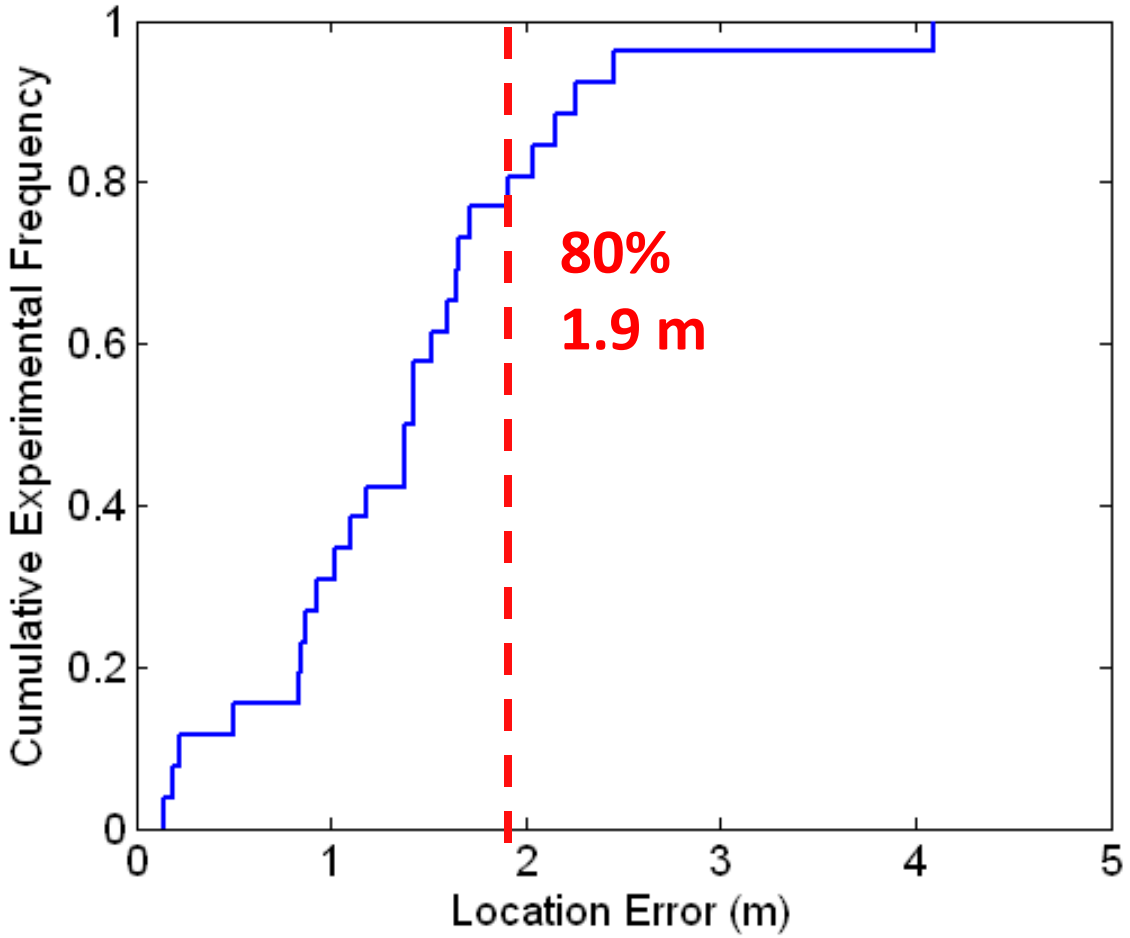
Outdoor Ranging Accuracy



Outdoor Location Tracking



Ranging Accuracy: Indoors



The Upshot

- Fixed node placement is important
- The more fixed nodes the better
- If fixed nodes are above most clutter, results are pretty good.