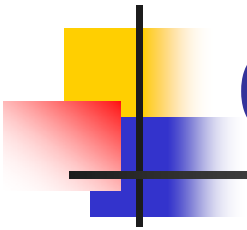
# RFID-Based 3-D Positioning Schemes

Chong Wang, Hongyi Wu, and Nian-Feng Tzeng
Center for Advanced Computer Studies
University of Louisiana at Lafayette

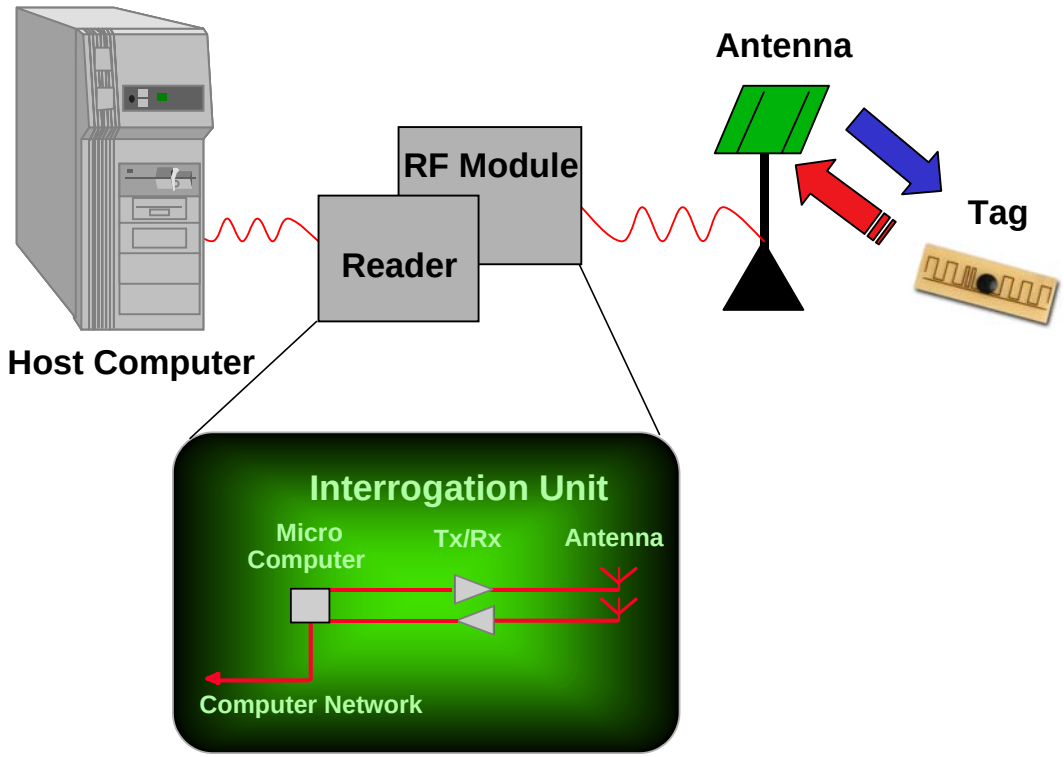


# Outline

- Introduction
- Active Scheme
- Passive Scheme
- Simulation
- Experimental Results
- Conclusion

# RFID

- Automatic identification technology
- Transponder, interigator, antenna

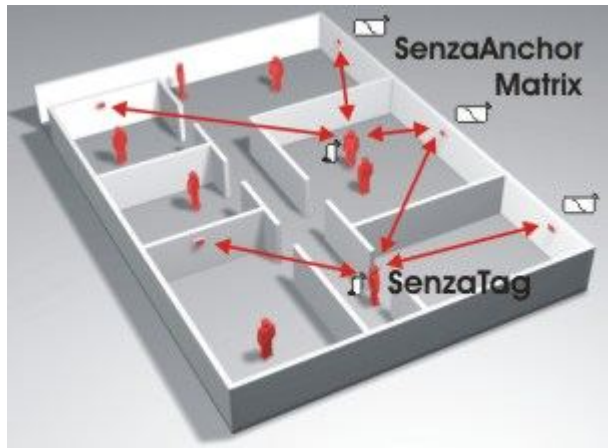


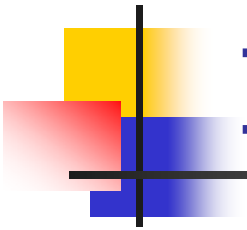
# Characteristics

- No line-of-sight required
- Multiple simultaneous reads
- Long read range(active tag)
- Long life span
- Very low cost
- No (so) orientation sensitive

# RFID Localization

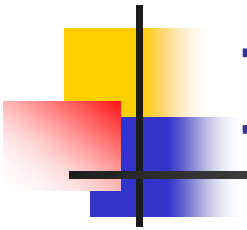
- An important application of RFID
  - ➔ Localization (warehouse, shipping container, ……)



# Indoor Localization

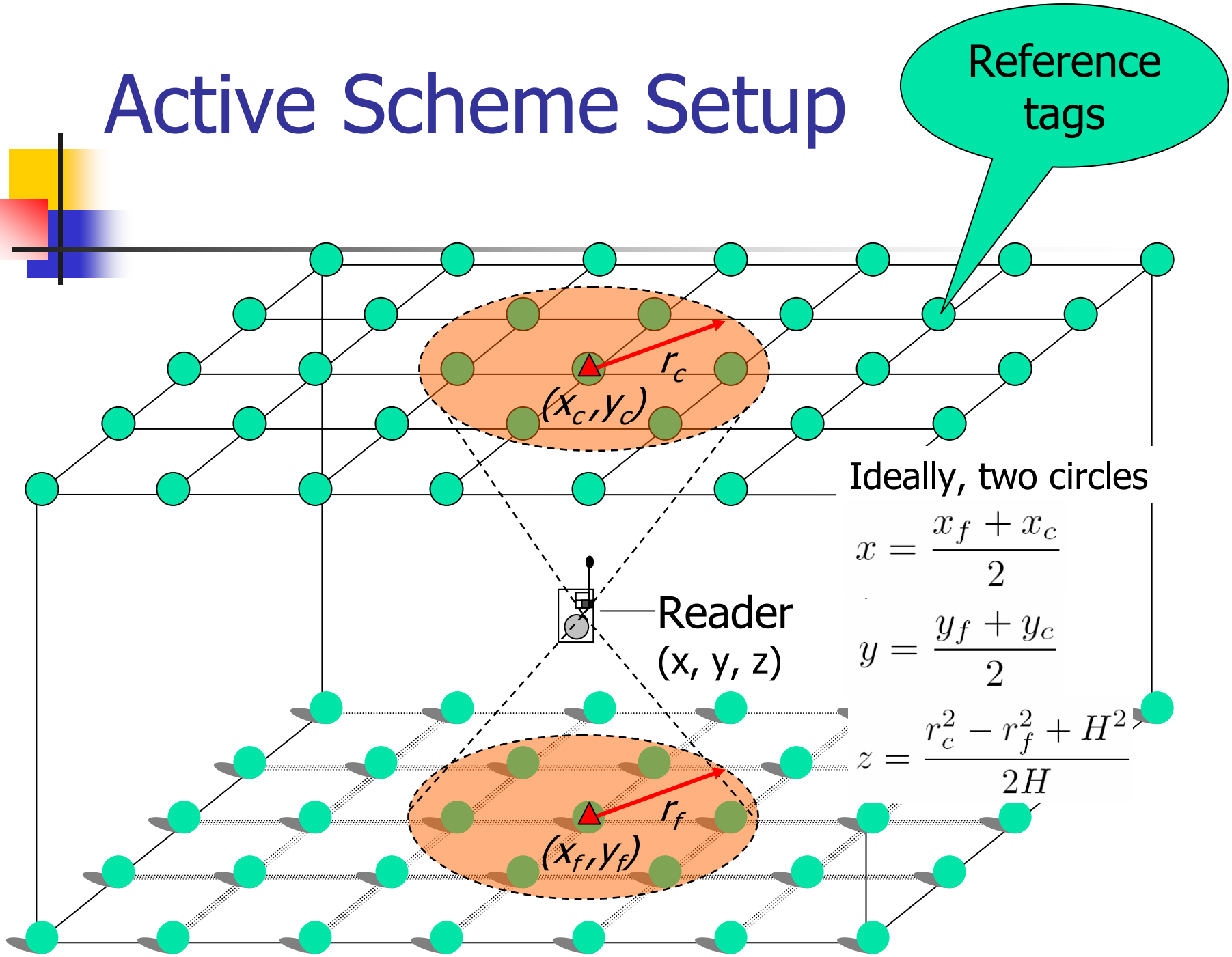
- Infrared
  - Active Badge
  - IR emitter communicate with a network of sensors in the building
  - Line-of-sight required, transmission range is short
- IEEE 802.11
  - RADAR
  - Combine empirical measurement and signal strength modeling to determine location
  - NIC needed, not practical for small device



# Indoor Localization

- Ultrasonic
  - Cricket Location Support System & Active Bat Location System
  - Use time-of-arrival to measure distances
  - High accuracy, expensive
- RFID
  - LANDARC
  - Use RFID tags as reference tags
  - Coarse accuracy, 2-D

# Active Scheme Setup



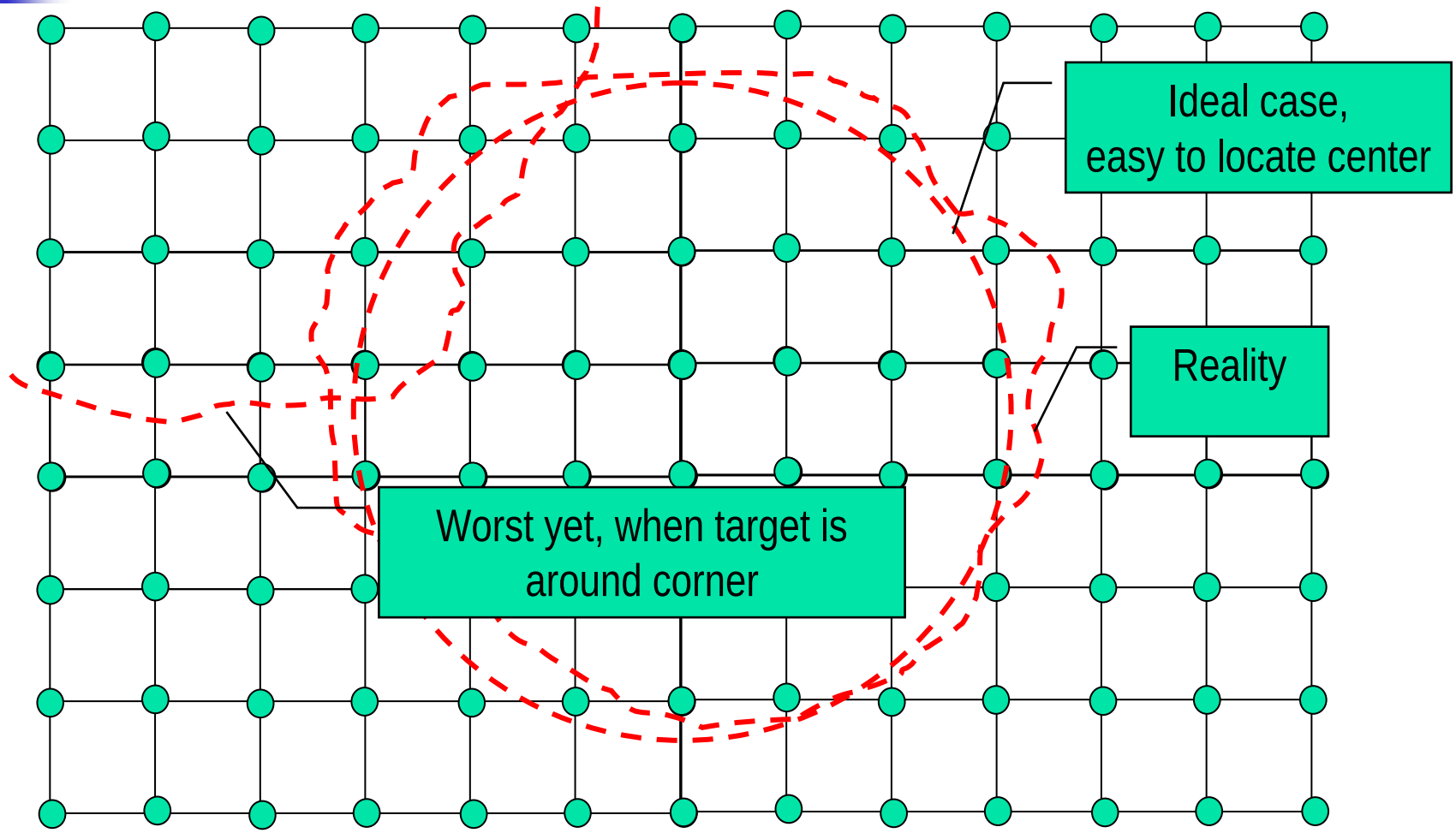

Ideally, two circles

$$x = \frac{x_f + x_c}{2}$$

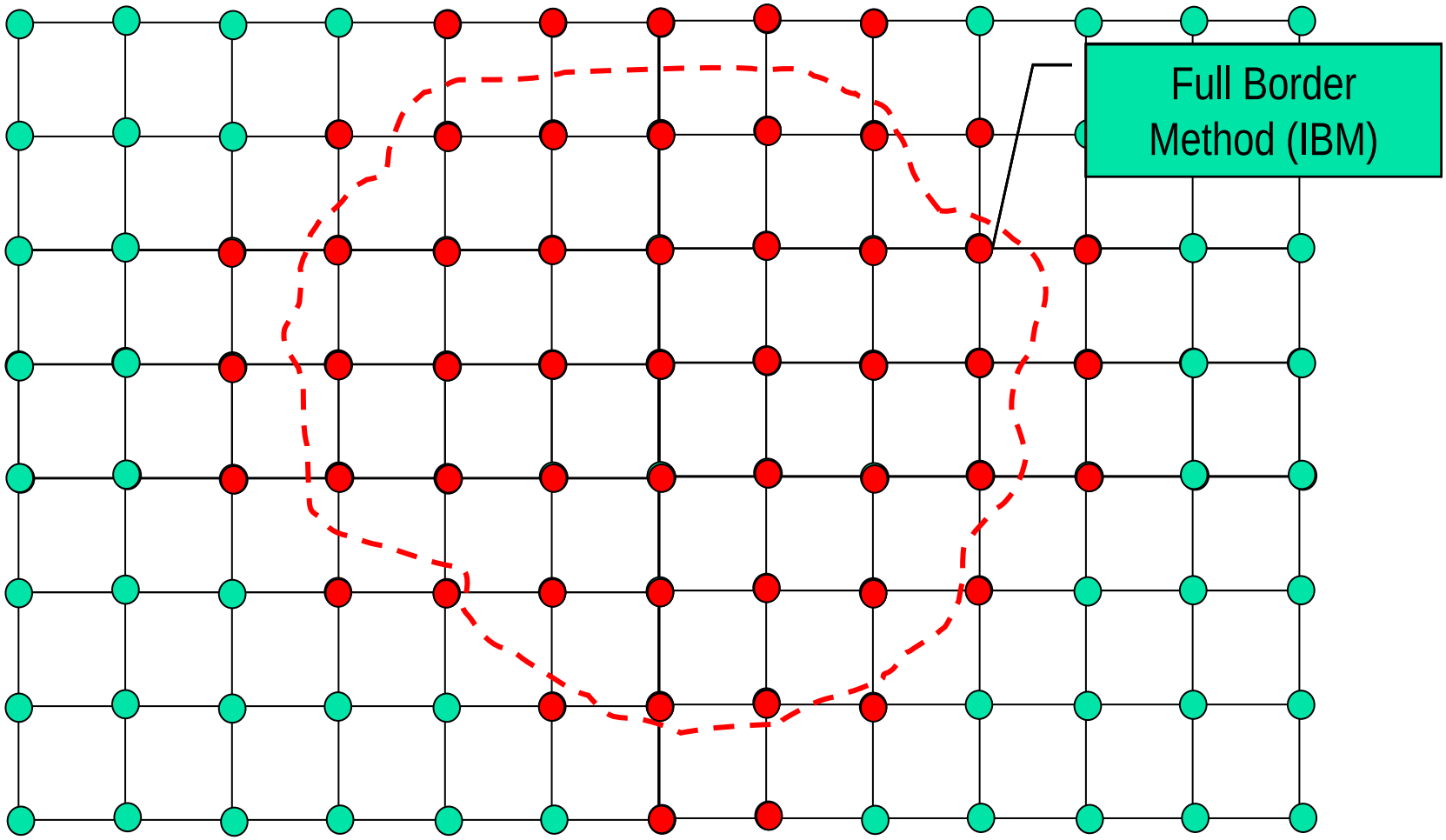
$$y = \frac{y_f + y_c}{2}$$

$$z = \frac{r_c^2 - r_f^2 + H^2}{2H}$$

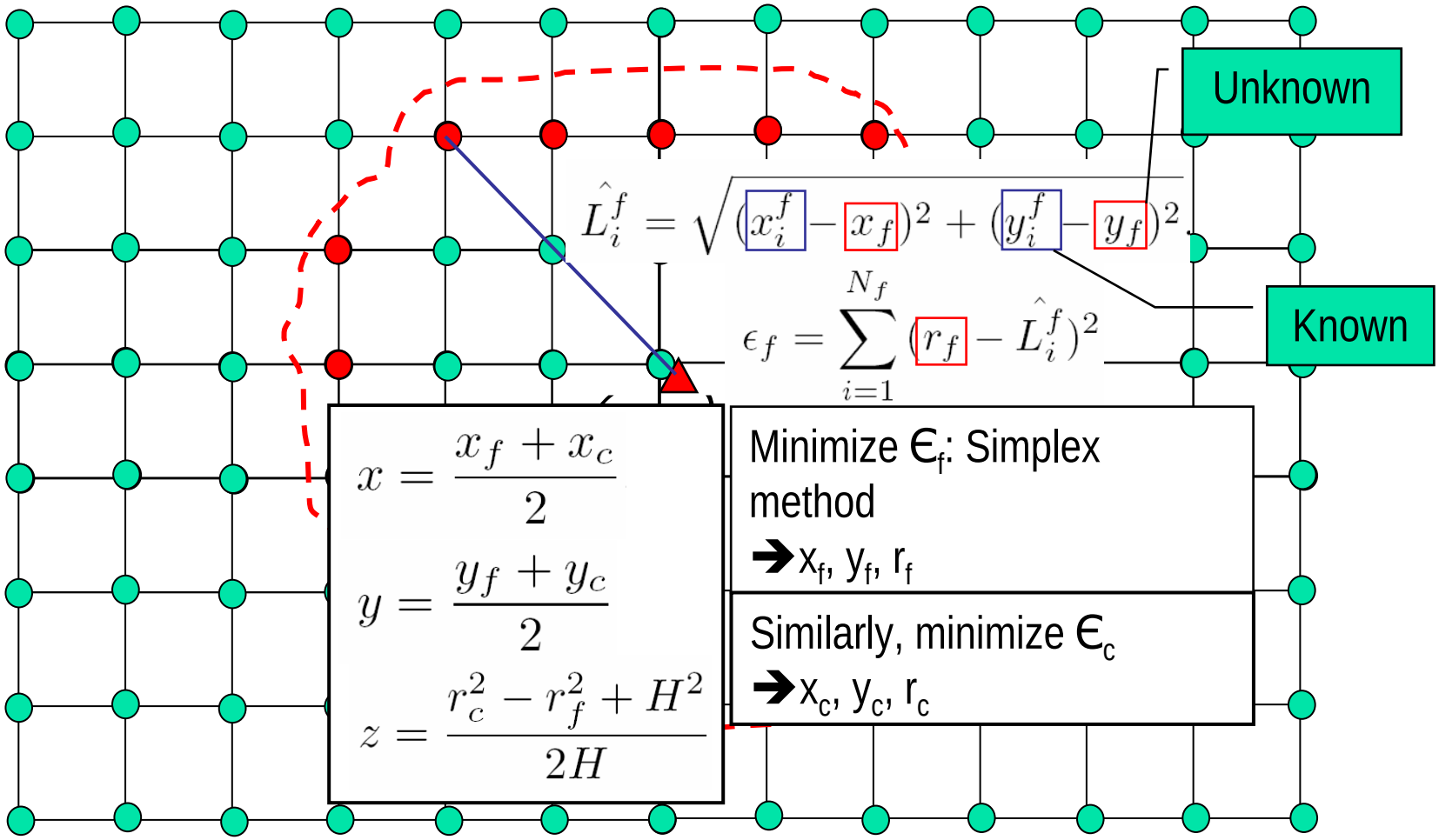
# Effective Reference Tag Set



# Effective Reference Tag Set

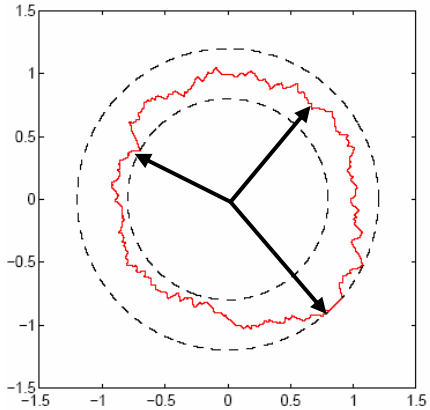


# Coordinate Calculation

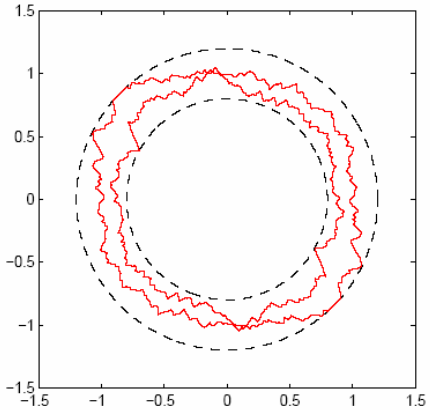


# Compensate Degree of Irregularity

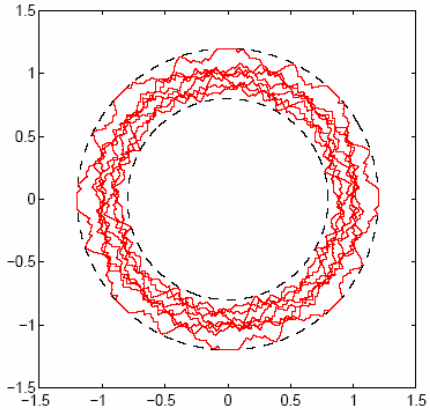
- Problem
  - Diff. antenna gains and path loss in different directions
  - Imperfect circle
- Solution
  - Low cost antenna array with multiple radiation elements
  - Superpose responses



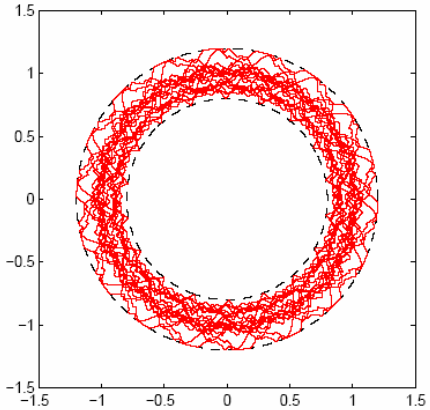
(a) k=1.



(b) k=2.

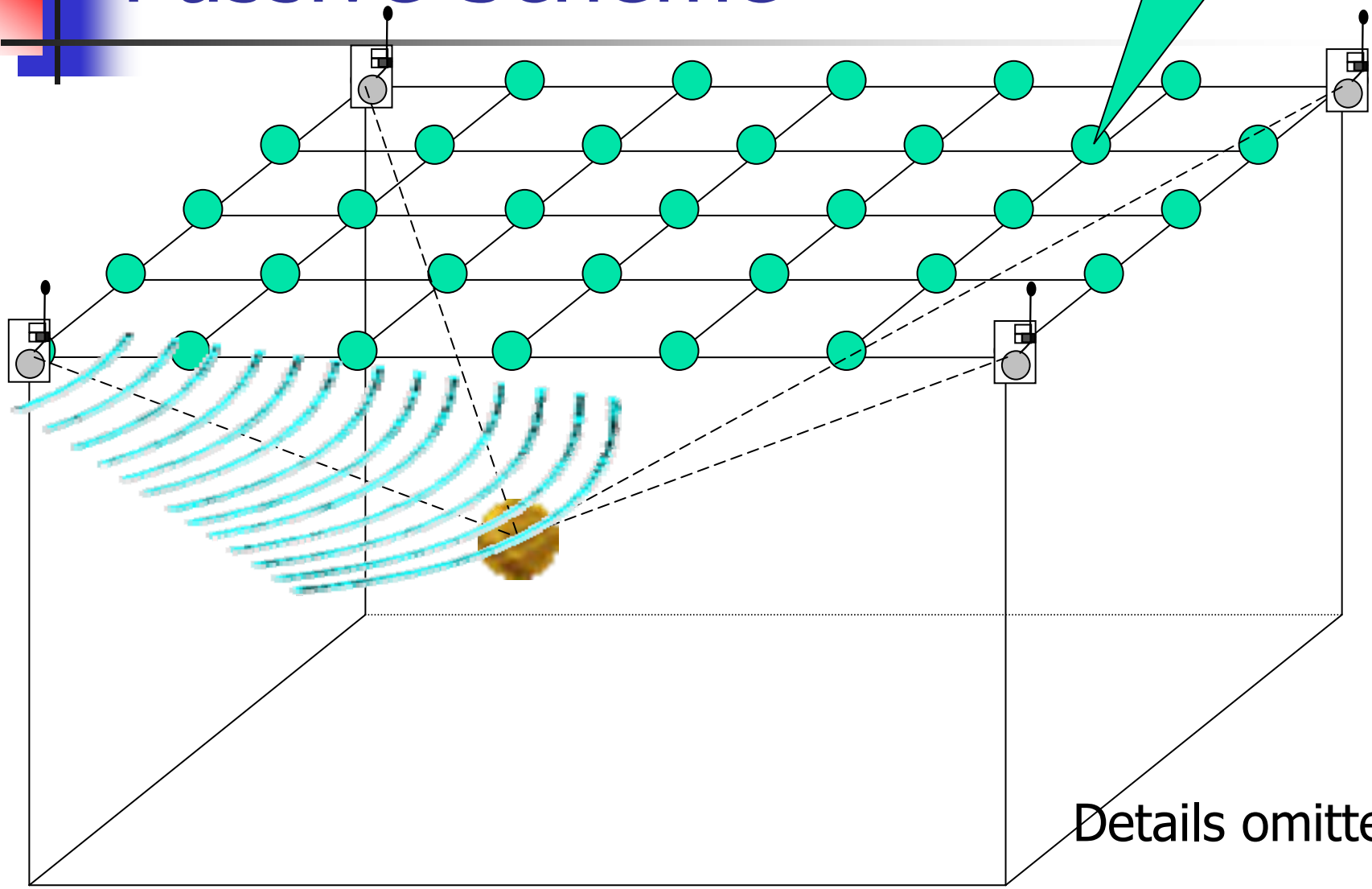


(d) k=8.

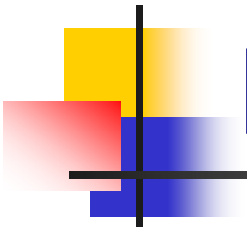


(e) k=16.

# Passive Scheme

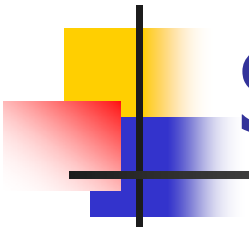



Details omitted…



# Performance Evaluation

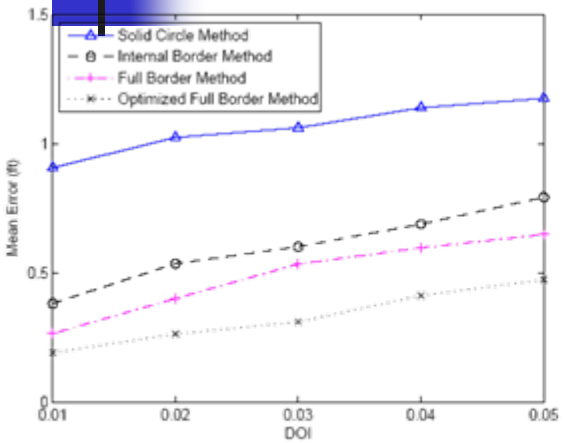
- Analysis: analyze average error in coordinates of the target
  - skipped, see paper
- Simulations
- Experiments



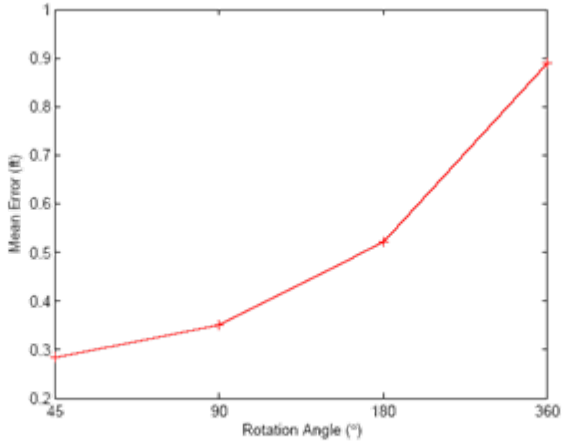
# Simulation Setup

- Space: 40’x8’x8’
- Simulation parameters
  - Degree of Irregularity (DOI)
  - Reference tags: Δ’ apart, Δ=1 by default
  - Location of target
  - Number of readers (for Passive Scheme)
  - Number of power levels (for Passive Scheme)

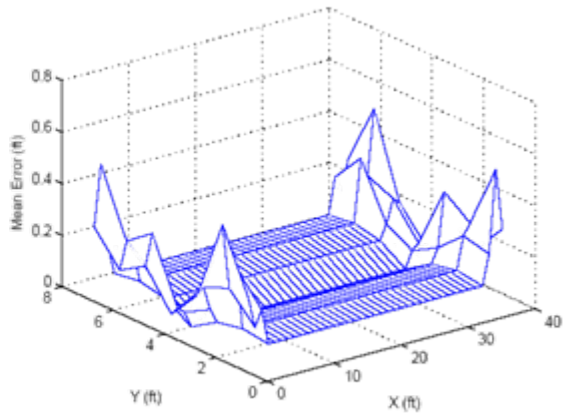
# Active Scheme



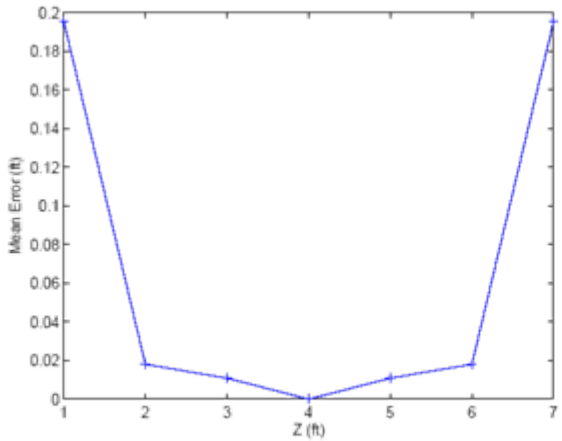

(a) Impact of DOI.



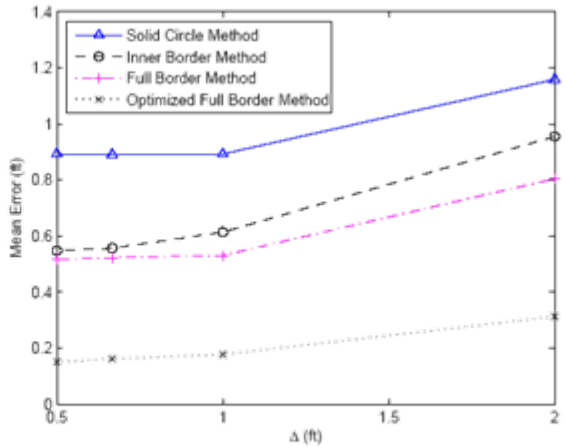

(b) Impact of radiation elements ($k$).




(c) Location dependency ($z = 4$).

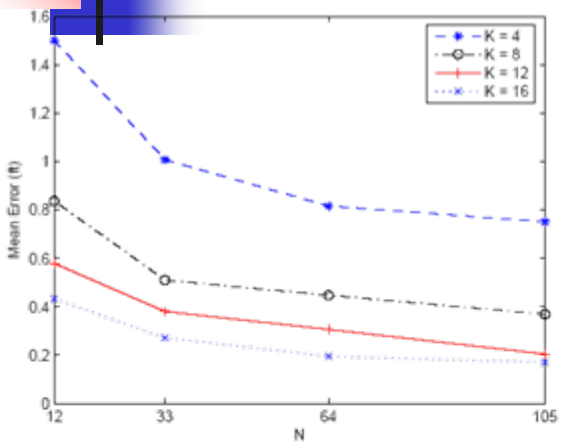



(d) Location dependency ($x = 20$, $y = 4$).

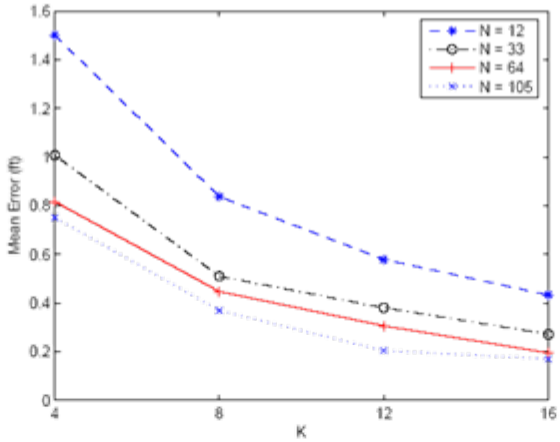



(e) Impact of reference tag density ($\Delta$)

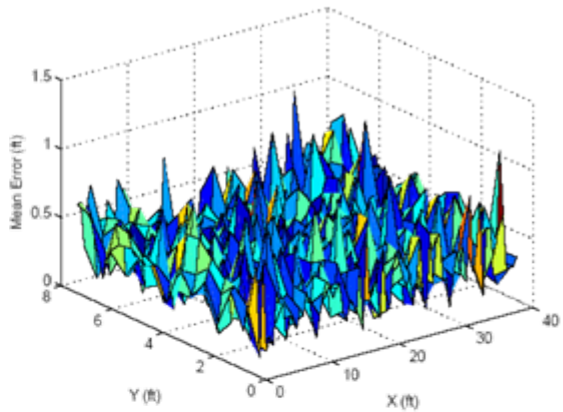
# Passive Scheme



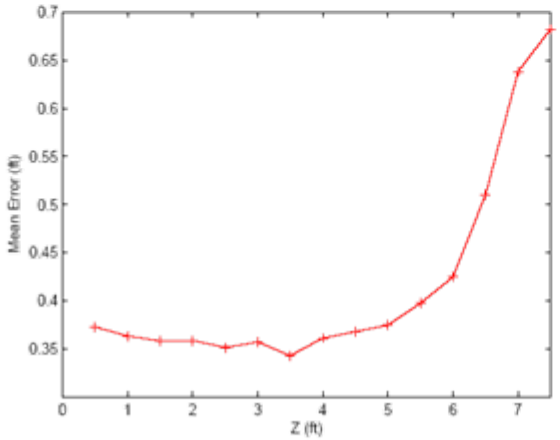

(a) Impact of the number of readers ($N$).



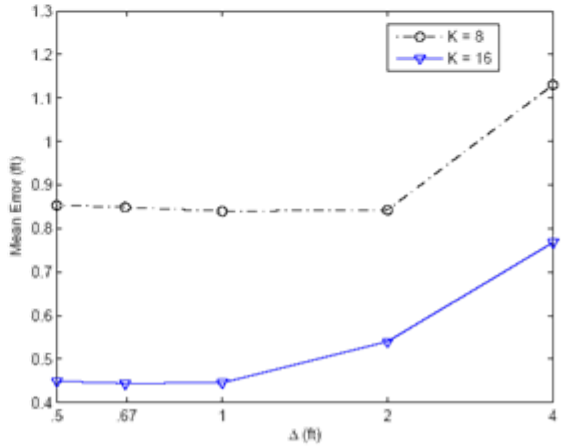

(b) Impact of the number of power levels ($K$).




(c) Location dependency ($z = 4$).



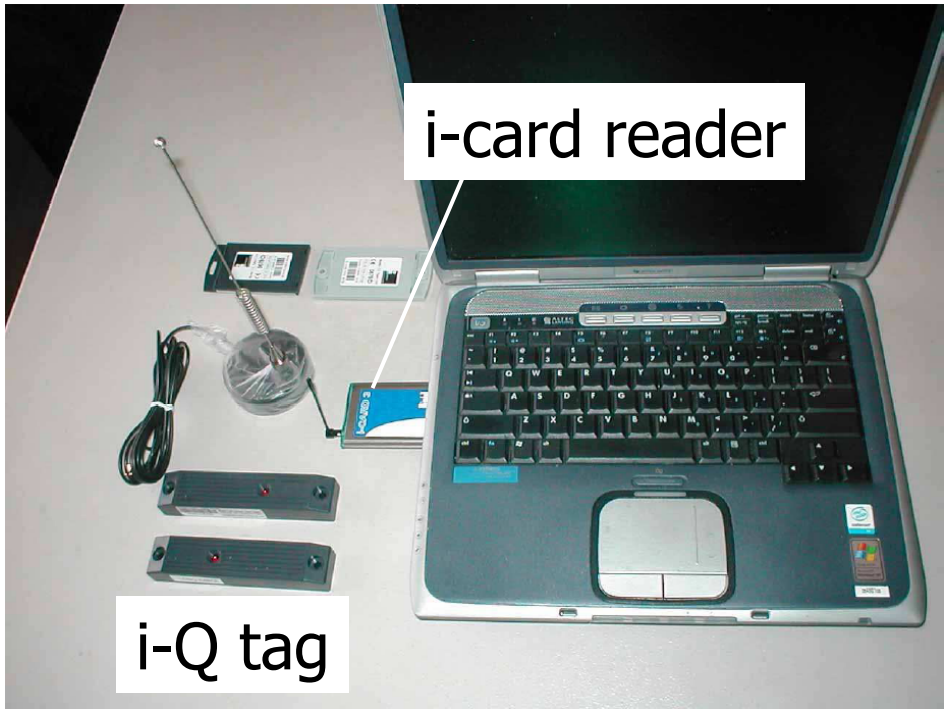

(d) Location dependency ($x = 20$, $y = 4$).



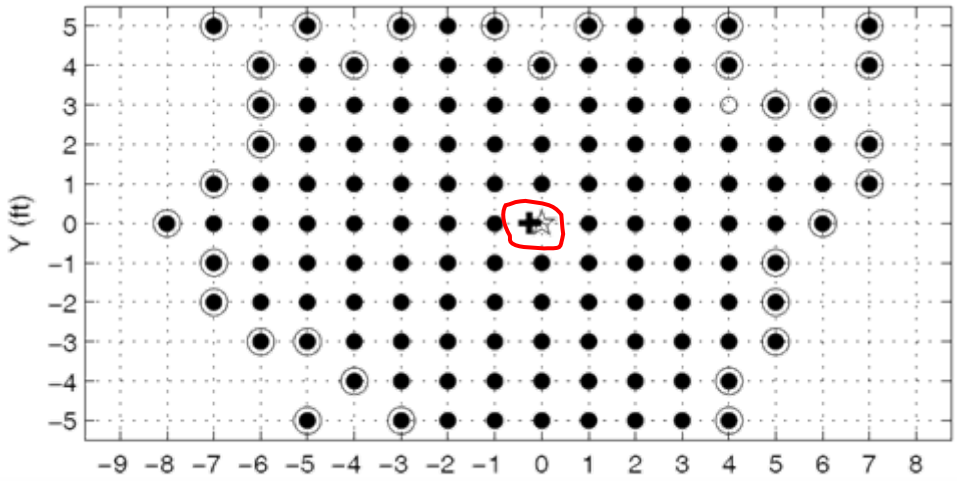

(e) Impact of reference tag density ($\Delta$).

# Experiment Setup

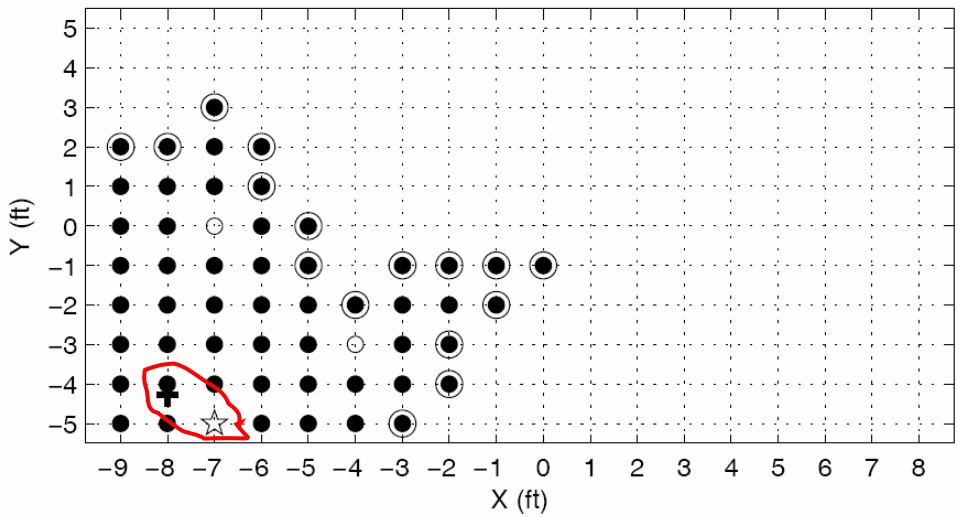
- Space: 18.5’x11’x7’ apartment room
- IDENTEC RFID kits



# Experimental Result




Target at center

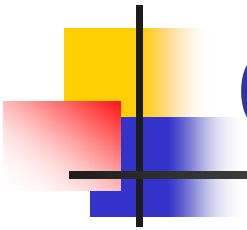



Target at corner

# Summary

- Proposed two 3-D positioning schemes
- Both schemes are based on nonlinear optimization methods

| | Active Scheme | Passive Scheme |
|---|---|---|
| Target | Reader | Tag |
| Reference Nodes | Tags | Tags and Readers |
| Reference Note Deployment | Ceiling and Floor | Ceiling (or Floor) |
| Range Free | Yes | Yes |
| Power Level | One | Multiple |
| Multiple Tracking | No | Yes |
| Positioning Time | Short | Long |
| Hardware Cost | Low | High |
| Error (ft) | $0.2 - 0.5$ | 0.3-3.0 |



# Questions?

- Thank you!