Less is More: Efficient RFID-based 3D Localization

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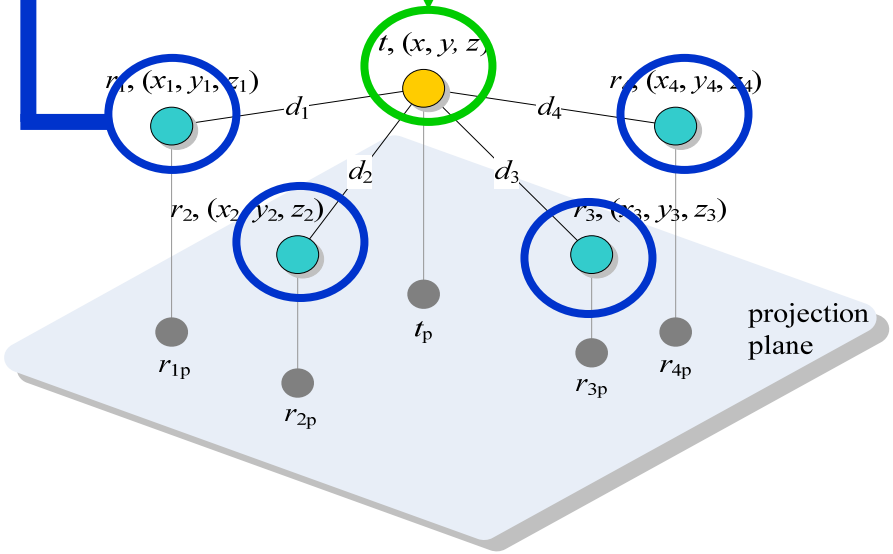
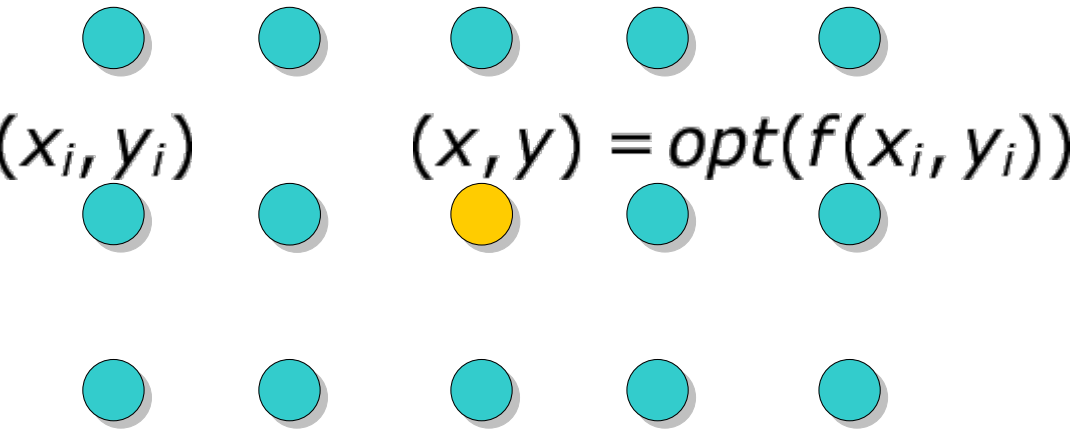
RFID 3D Localization

Leverage Reference Positions

Estimate Object Positions



Proposal:
Efficient Localization Scheme



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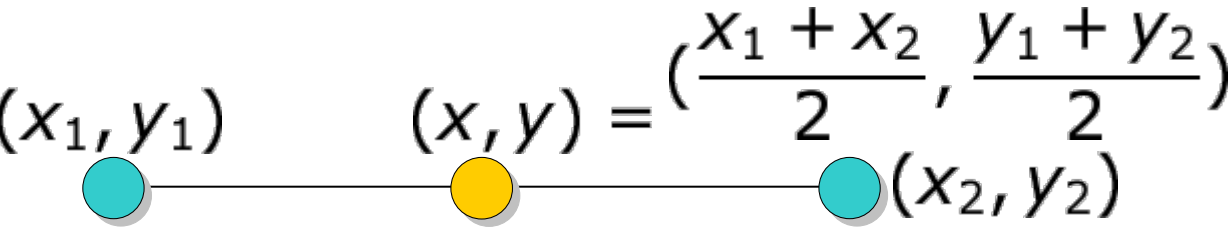


Probing Some instead of Collecting All

Benefits

Still can locate ✓

Much more efficient ✓

May be even more accurate ✓

Behind The Scenes

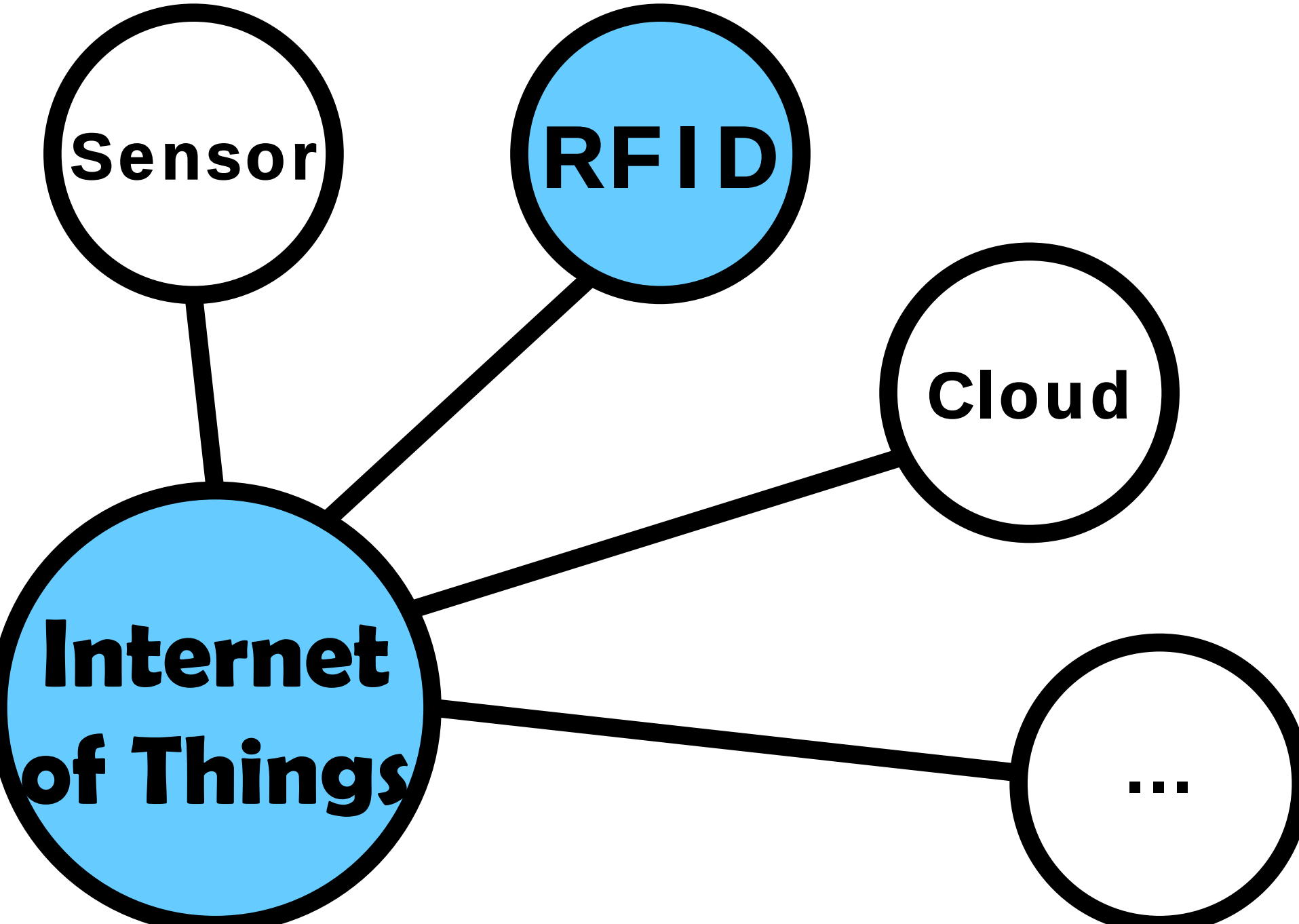
Why RFID?

Why RFID Localization?

Why Efficiency Matters?

RFID

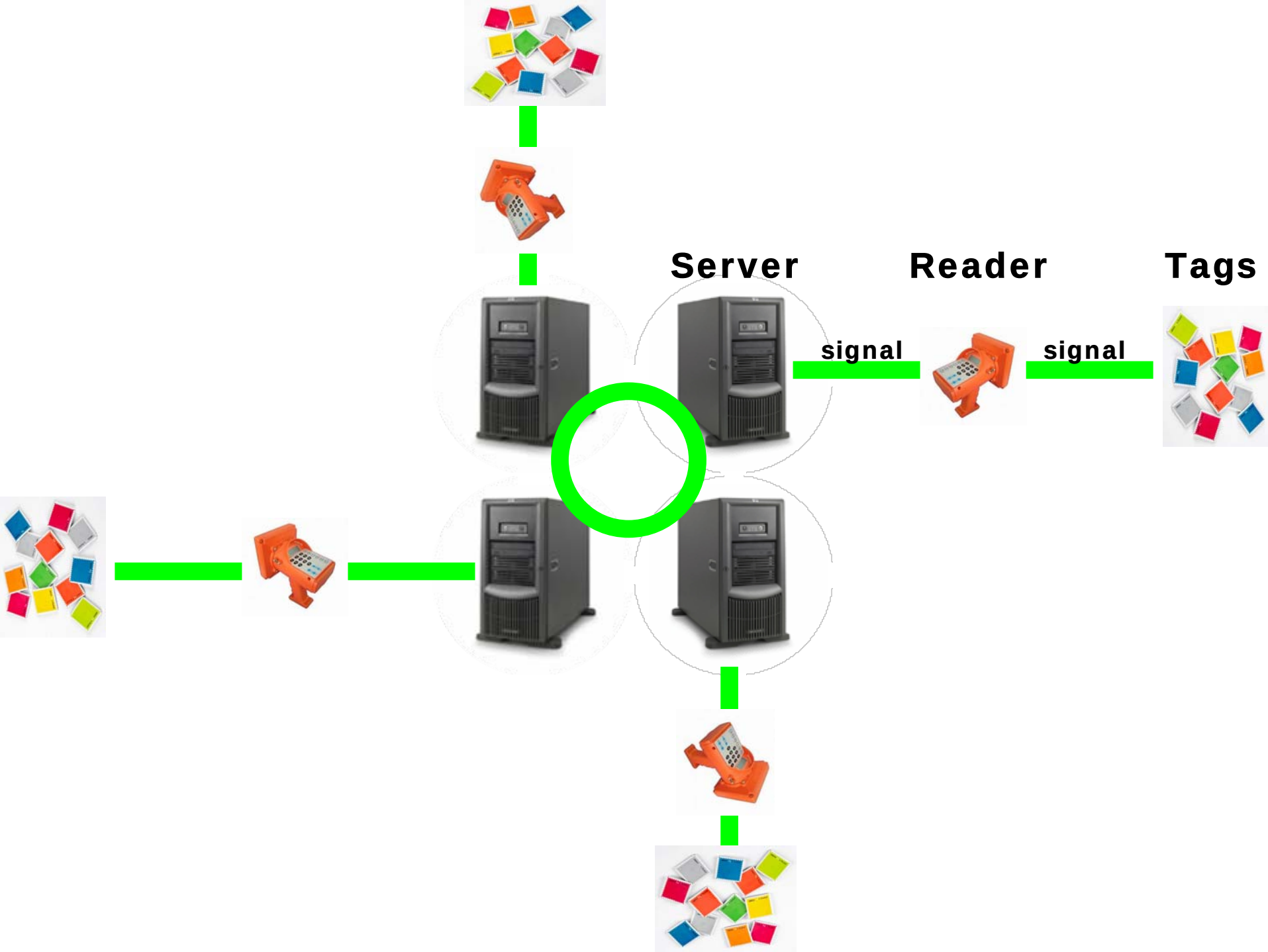
Radio Frequency IDentification


Sensor
RFID
Cloud
Internet of Things
...

RFID Tag

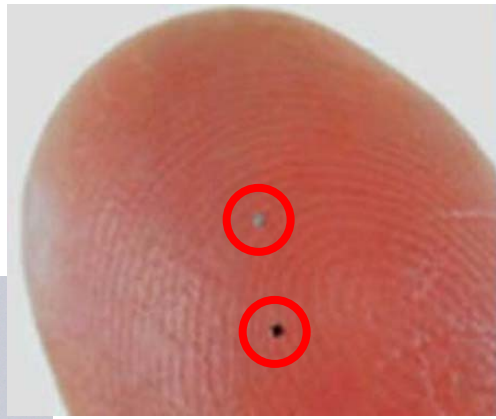
Communicate

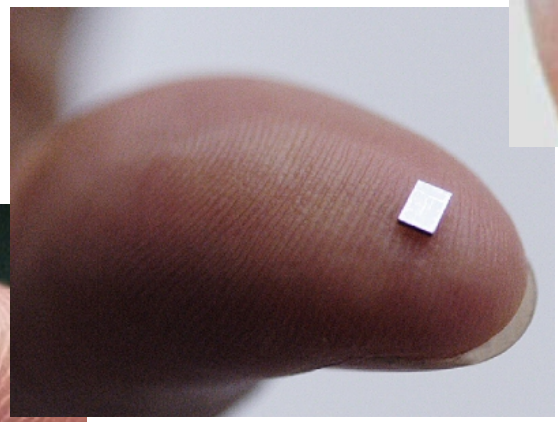
Compute

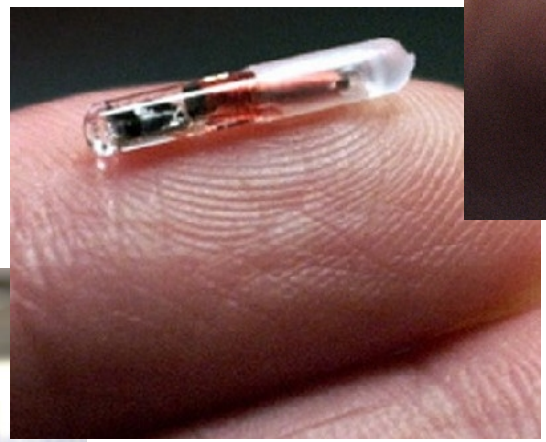

Server
Reader
Tags
signal
signal

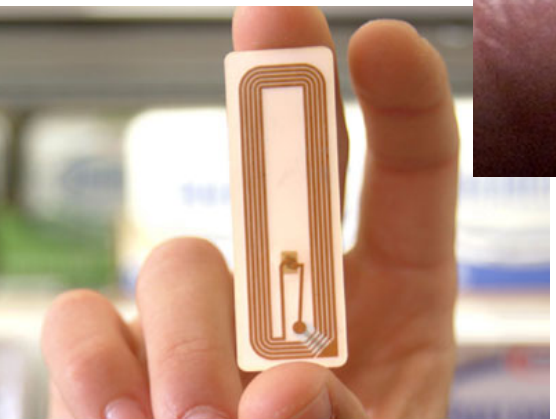
RFID Powder

0.4×0.4 mm!









Location Is Important

Location Is Important

TAGS -> TAGS -> TAGS

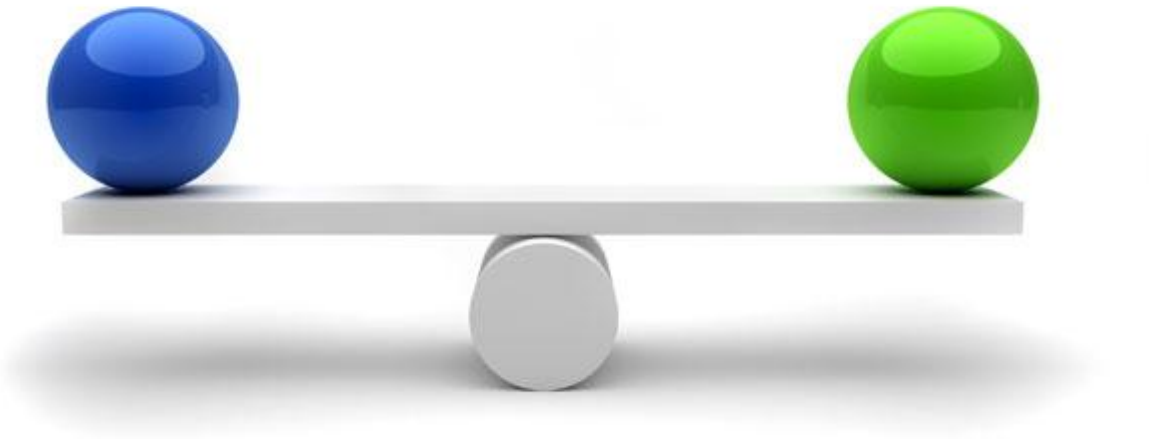
1.35 Billion

2013 (Expected)

IDTechEx.com

Efficiency

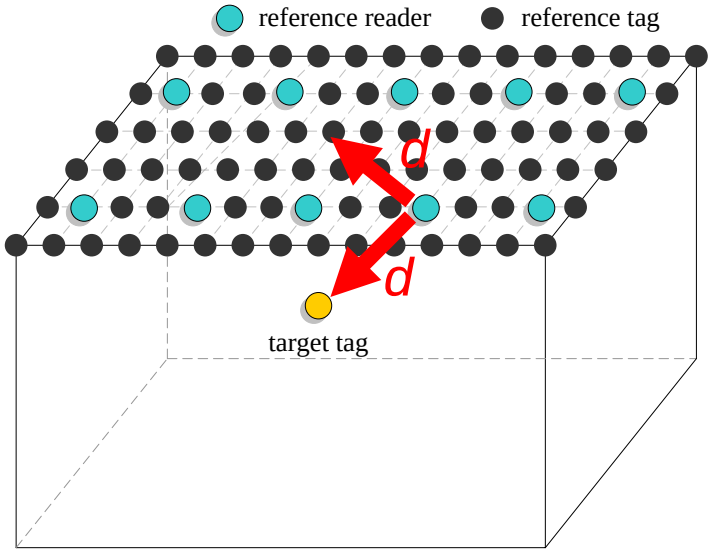
Accuracy



Efficient Protocols for Large RFID Systems

RFID 3D Localization Schemes Focus SOLELY On Accuracy

Existing Work: Passive Scheme



locate *target tag*

deploy *reference readers*

reference tags

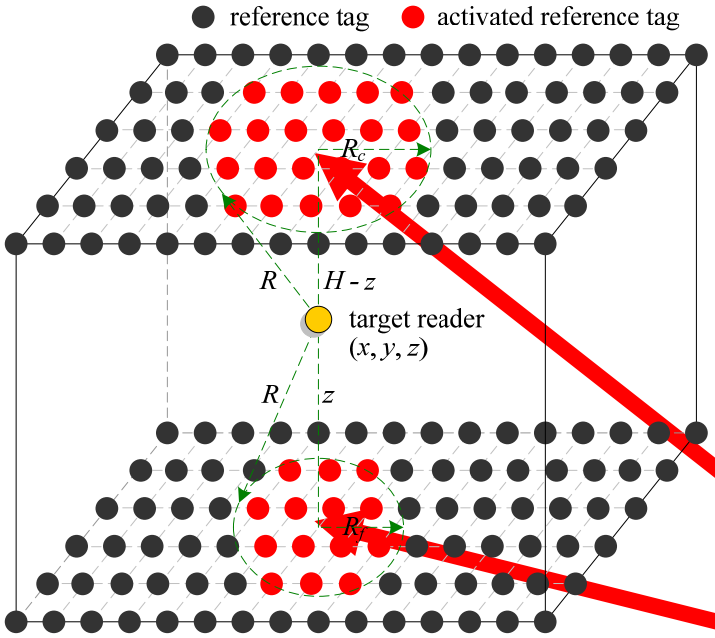
(with known locations)

dist(ref-reader, tar-tag)

= dist(ref-reader, ref-tag)

distances to ⩾3 ref-readers locate a tar-tag

Existing Work: Active Scheme



locate *target reader*

deploy *reference tags*

(with known locations)

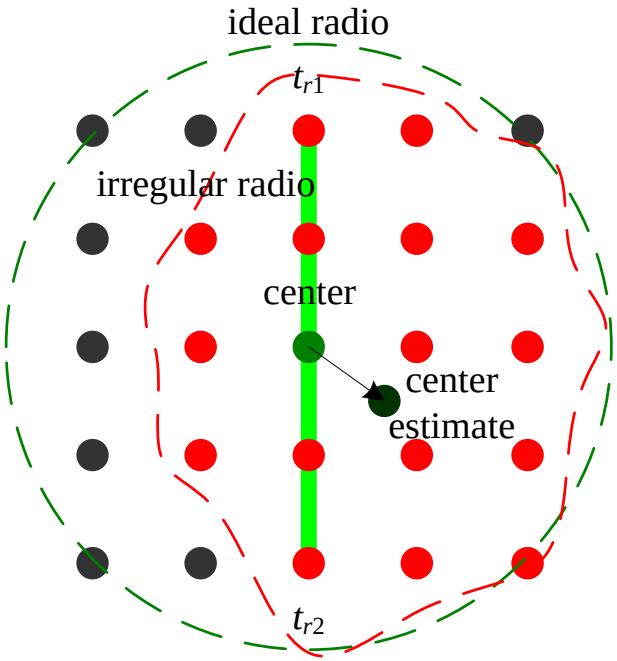
location estimation:

$$(x_c, y_c) = \min \sum (R_c - \sqrt{(x_c - x_i)^2 + (y_c - y_i)})^2$$

$$(x_f, y_f) = \min \sum (R_f - \sqrt{(x_f - x_i)^2 + (y_f - y_i)})^2$$

$$(x, y) = (\frac{x_c + x_f}{2}, \frac{y_c + y_f}{2});\ z^2 + R_f^2 = (H - z)^2 + R_c^2 = R^2$$

Existing Work: Limitations



Inefficiency

read all activated tags

Contaminated Optimization

optimized location may not be accurate

Less references may yield more accurate location estimate

Why Not Collect Less?

more efficient

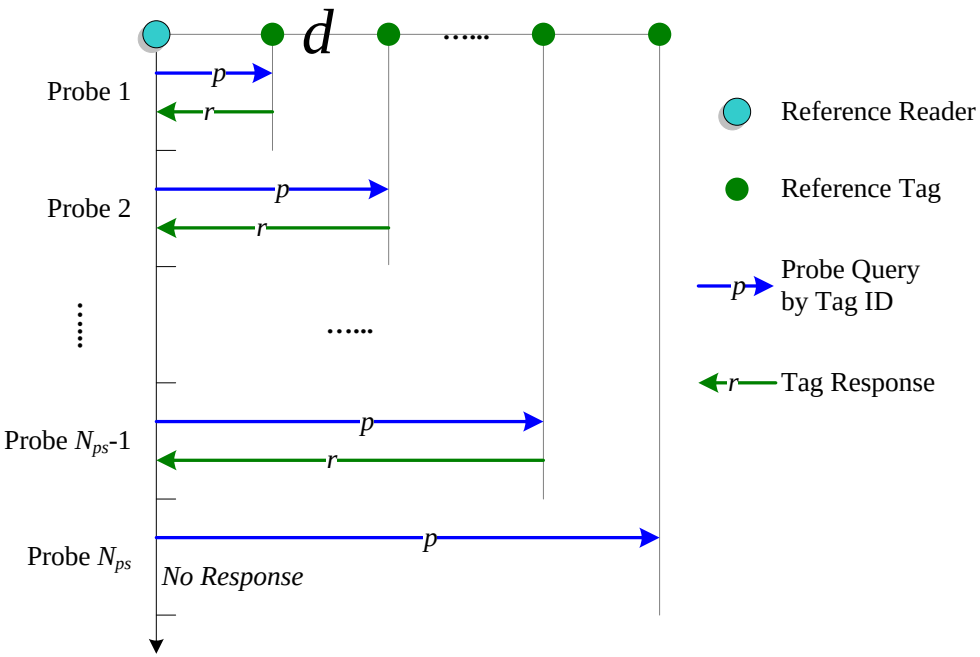
not necessarily less accurate

Probe Some instead of Collect All

efficient passive scheme

efficient active scheme

Proposal:
Efficient Passive Scheme



distance estimation

find *l*: min power level for ref-reader to read tar-tag ✔

estimate d_{eps}: distance from ref-reader to tar-tag

probe co-row/column ref-tags at power level *l* with increasing distance;

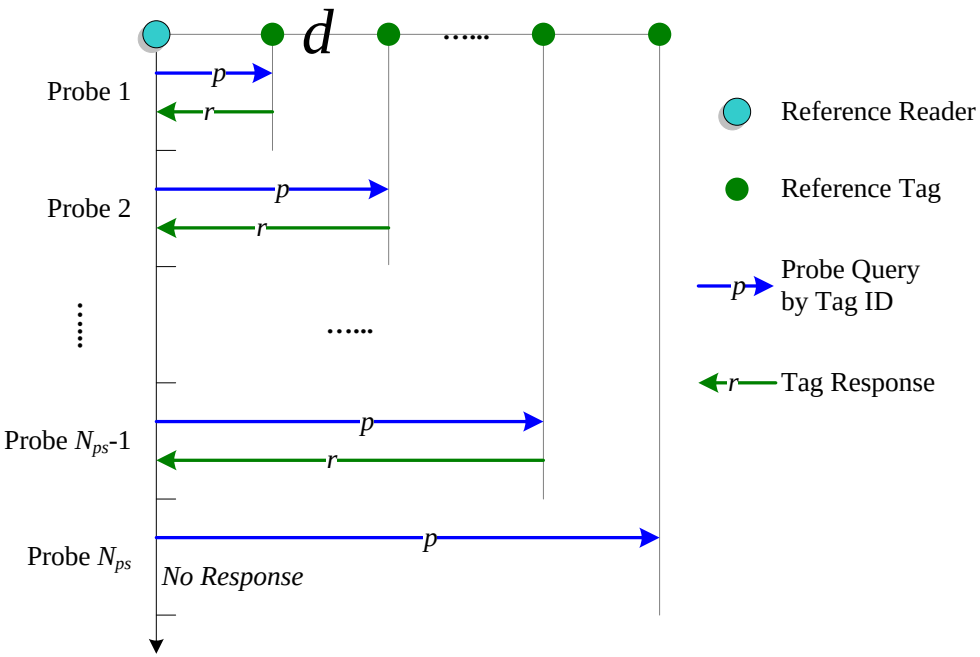
till Probe N_{ps} w/o response;

$$d_{eps} = \frac{(N_{ps} - 1)d + N_{ps}d}{2}$$

location estimation

distance estimates to ⩾3 ref-readers + ref-reader locations

Proposal:
Efficient Passive Scheme



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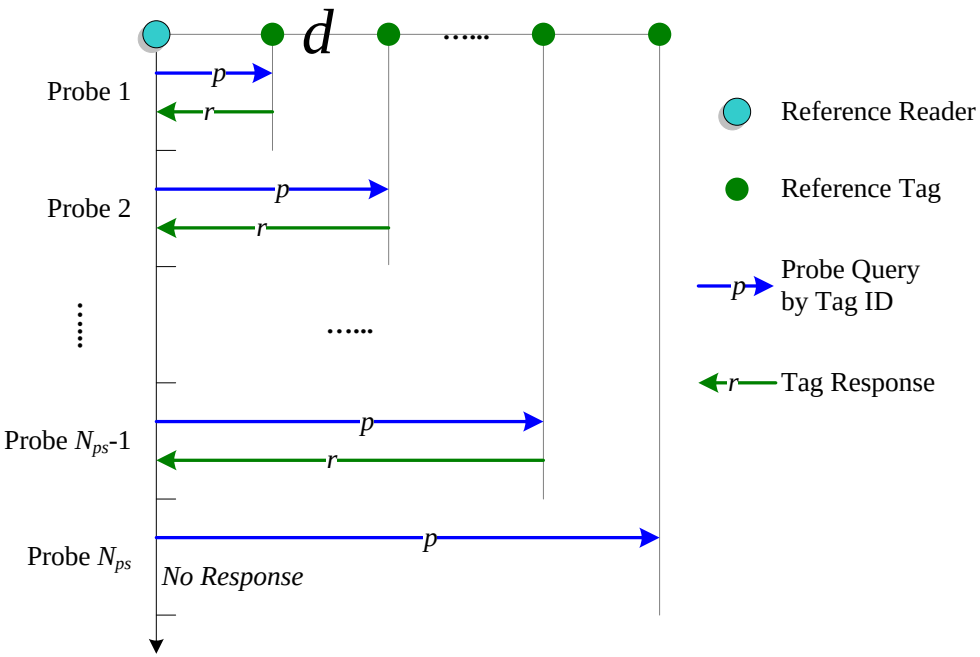

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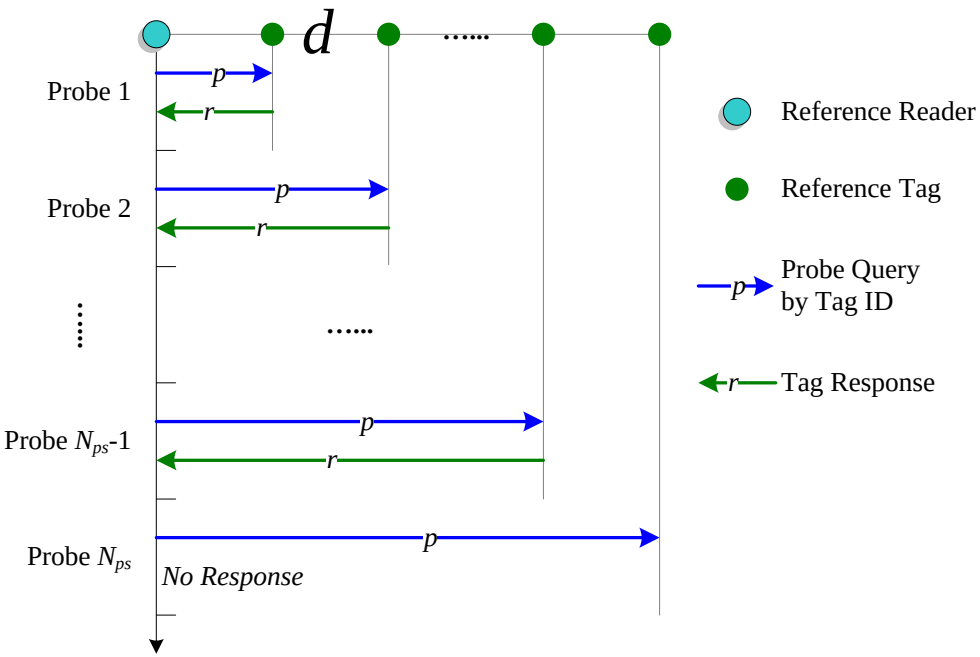
Efficient Passive Scheme



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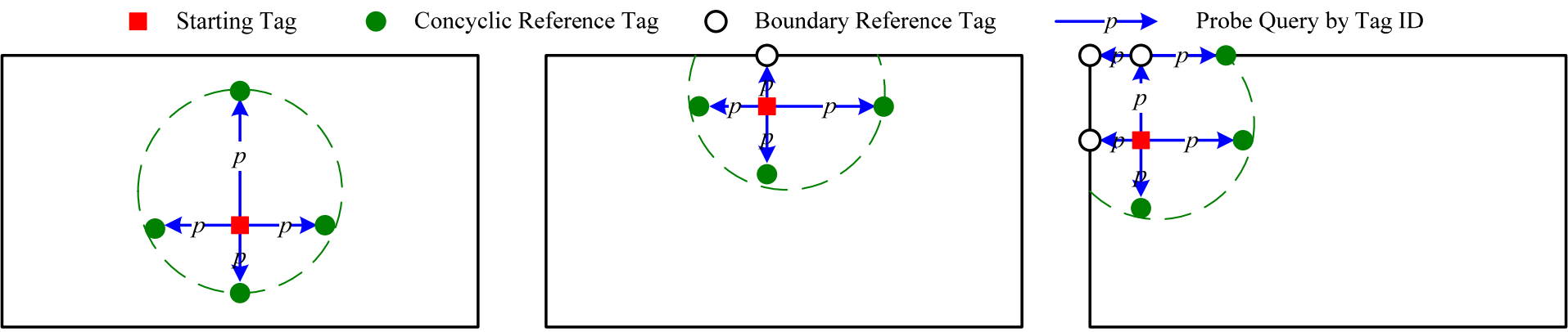
location estimation

distance estimates to ⩾3 ref-readers + ref-reader locations ✓

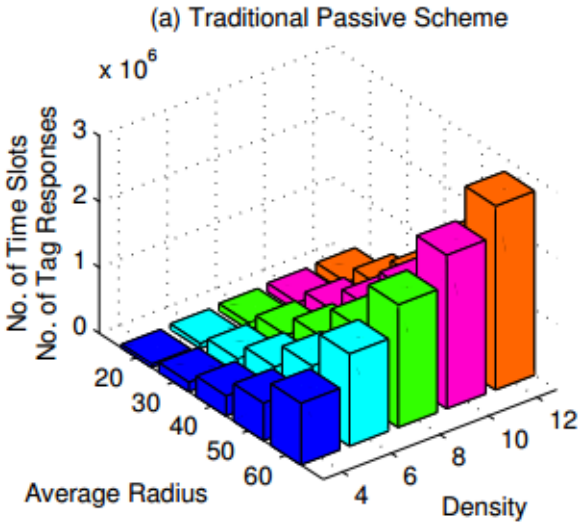
Proposal:
Efficient Active Scheme

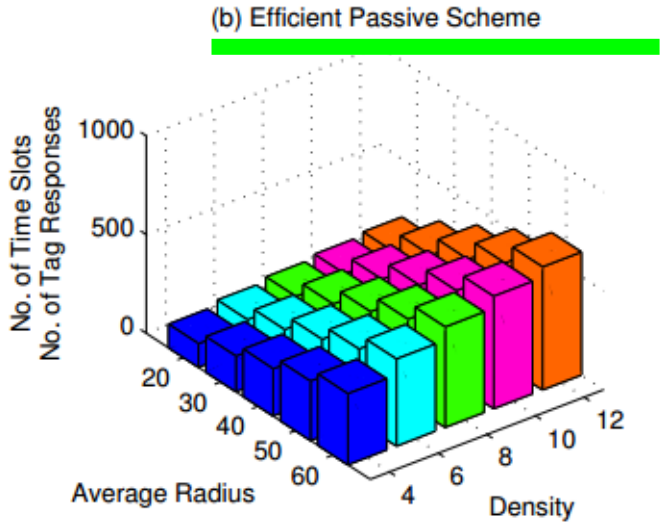


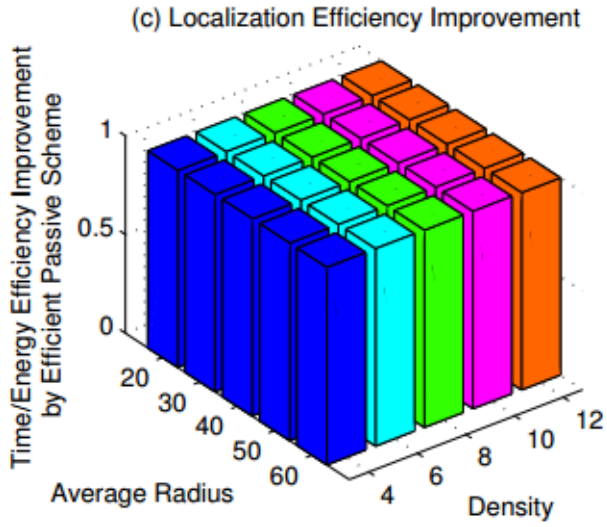
three nodes confine the center of their circumscribed circle

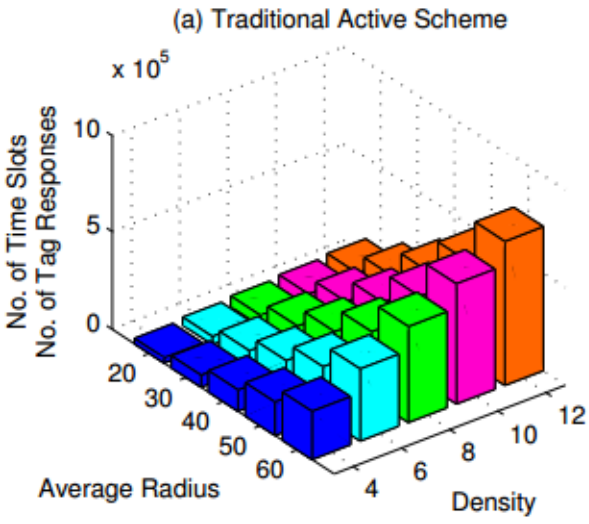
probe ⩾3 concyclic reference tags

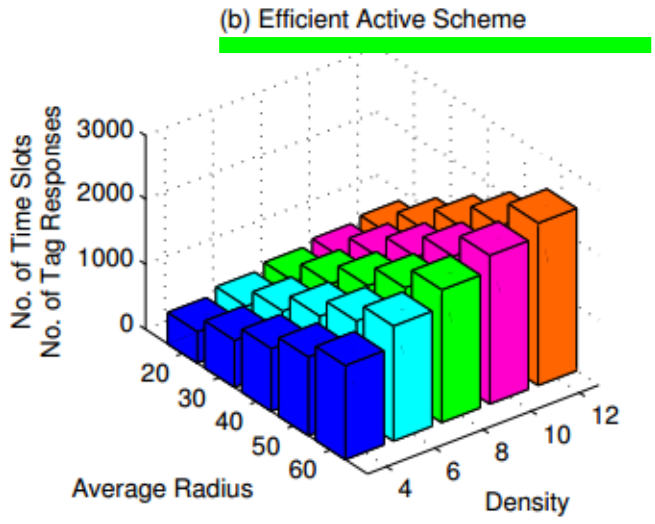
Simulation Results

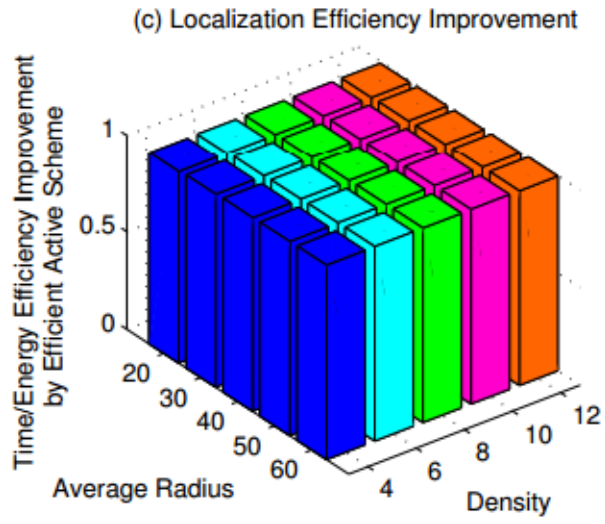




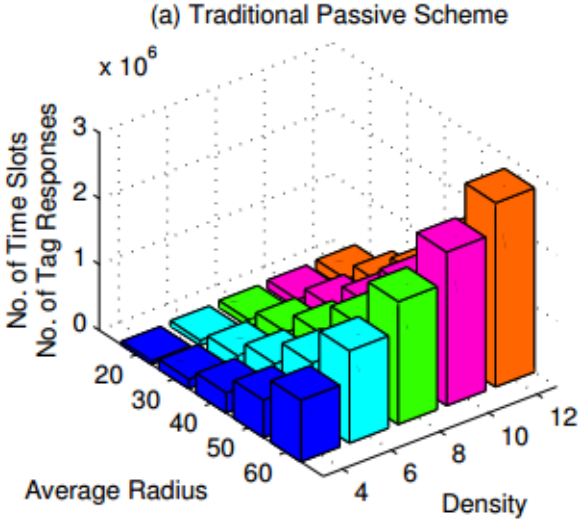


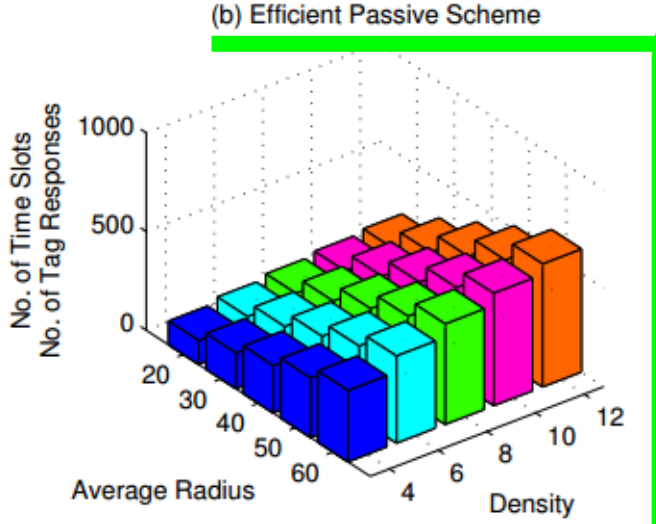


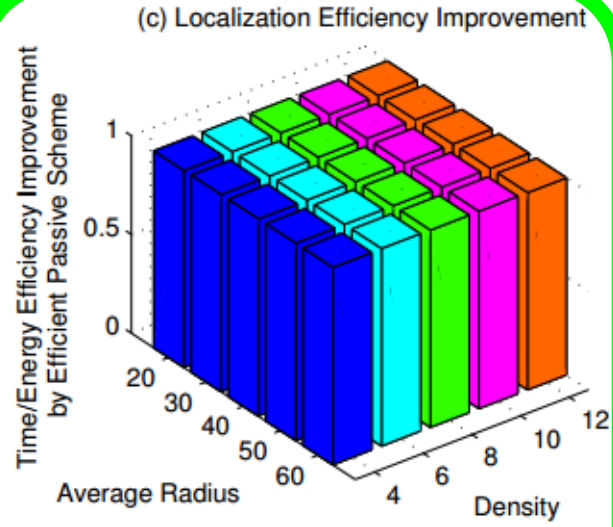


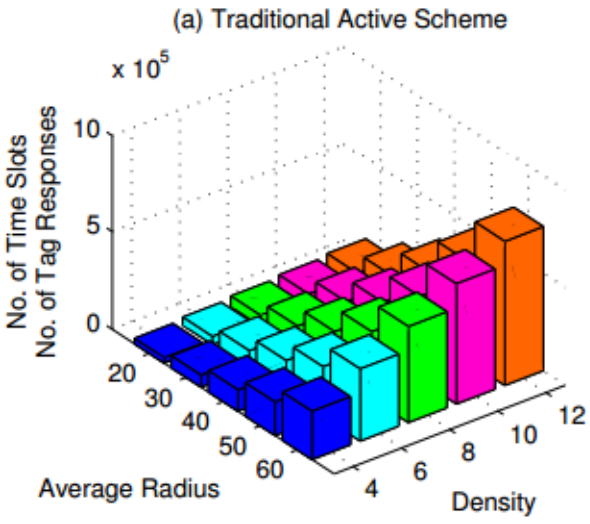


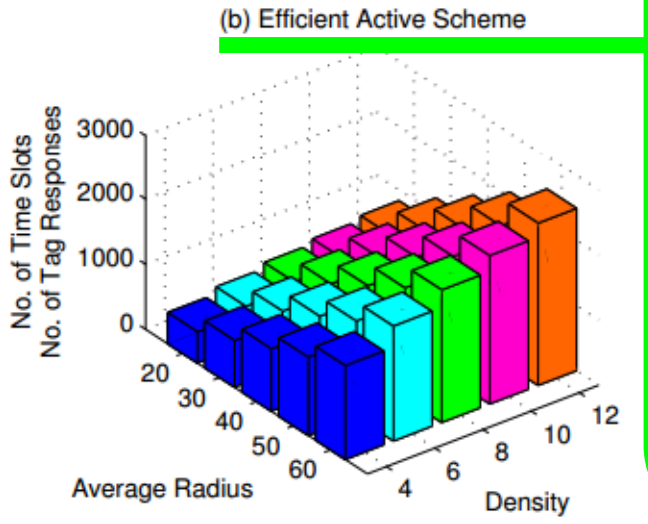
95% Efficiency Increase

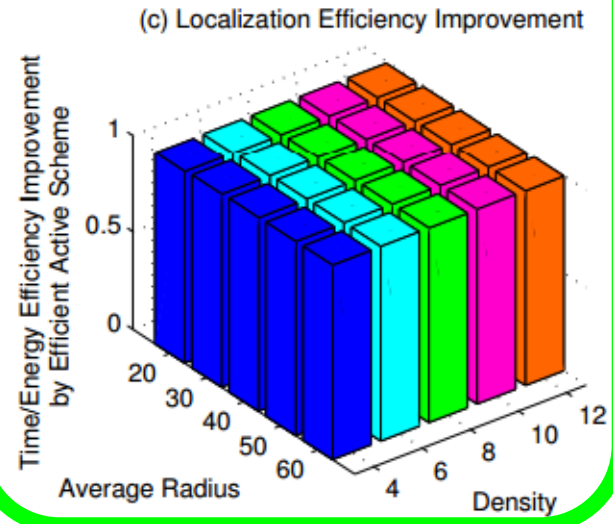












Conclusion

RFID 3D Localization Made Efficient
but not necessarily less accurate

Future work: empirical evaluation
accuracy evaluation
localization application
(e.g., misplacement pinpointing, activity sensing)

References

1. RFID-Based 3-D Positioning Schemes

   Chong Wang, Hongyi Wu, and Nian-Feng Tzeng

   INFOCOM 2007

2. Fault-Tolerant RFID Reader Localization Based on Passive RFID Tags

   Weiping Zhu, Jiannong Cao, Yi Xu, Lei Yang, and Junjun Kong

   INFOCOM 2012

Thank You

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