A MEASUREMENT STUDY FOR UNDERSTANDING WIRELESS FORENSIC MONITORING

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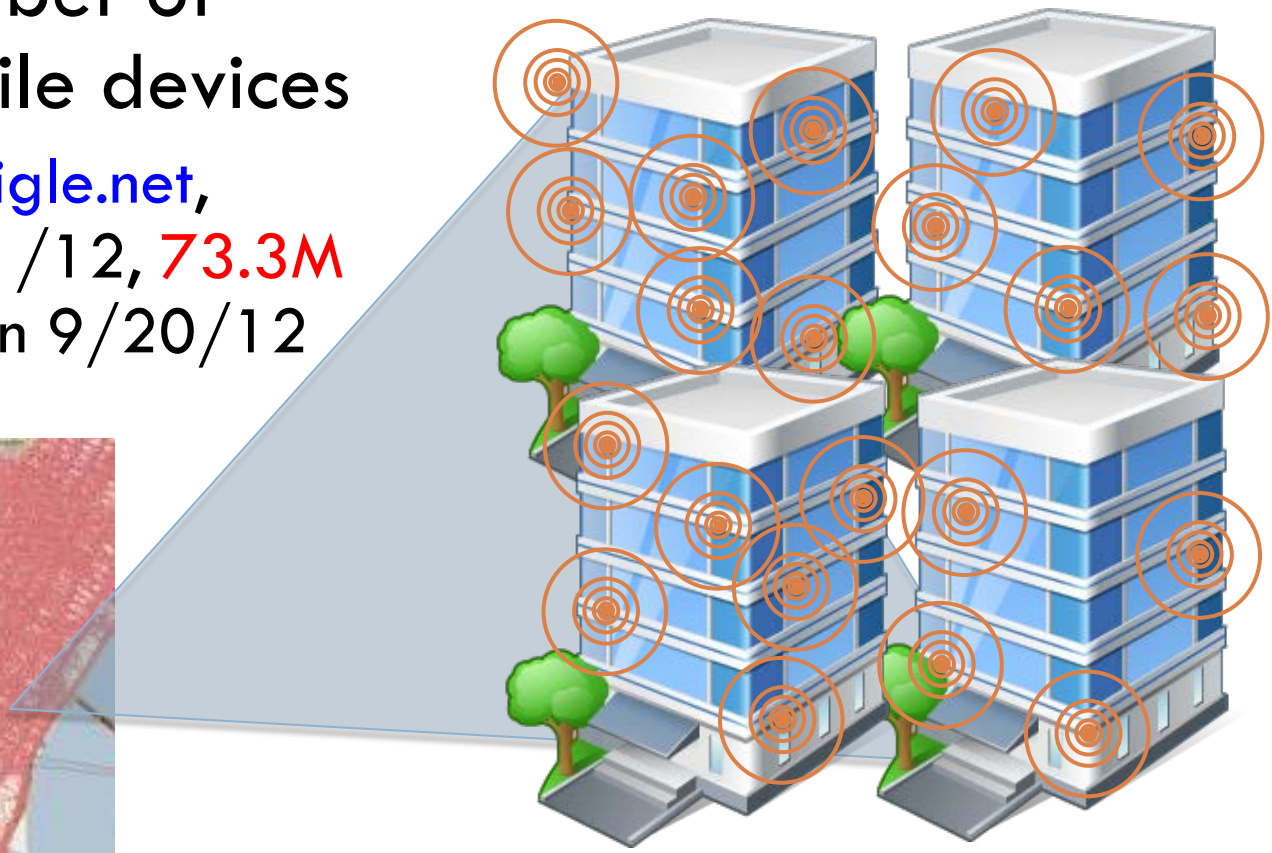
Outline

- Background
- Experiment setup
- Observations
- Future work

Background

- Increasing number of WiFi and mobile devices
  - According to wigle.net, 69.1M on 7/31/12, 73.3M wifi reported on 9/20/12



Background – Forensic Challenges

- Lack of traceability through WiFi nets
  - (Open) WiFi – hacker comes and goes
  - Usually no logs kept at APs
- Uncertainty of device identification
  - Mac spoofing, etc.
- Uncertainty of device location
  - Densely populated WiFi in Metropolitan neighborhood – difficulty in localizing device both horizontally and vertically

Background – Goal of this work

- A *Measurement study* to
  - Explore Metropolitan WiFi nets characteristics
  - Explore representative Device Localization Approaches
    - K Nearest Neighbor (KNN): a fingerprinting based approach
    - Log-distance path loss model: a model based approach
    - A good survey: *Survey of Wireless Indoor Positions Techniques and Systems*, H. Liu, H. Darabi, P. Banerjee and J. Liu, IEEE Transactions on Systems, Man, and Cybernetics, Nov. 2007

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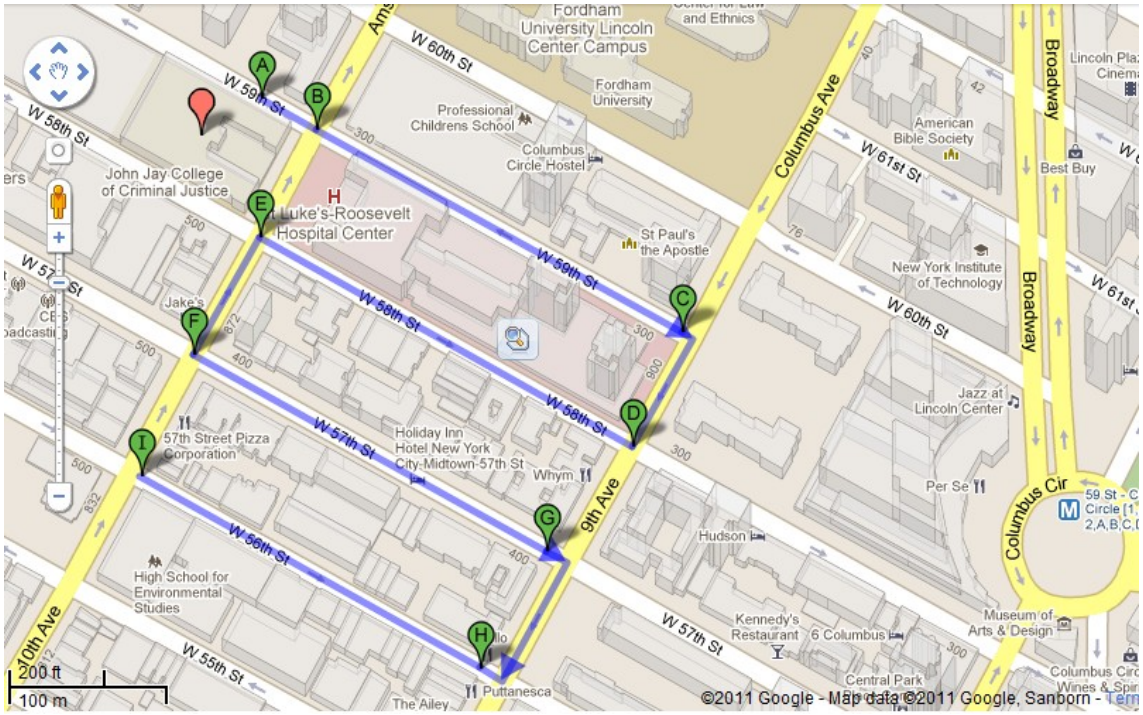
Equipment Setting

- Setting I
  - MacBook Pro laptop with Mac OS X10.7.4
  - integrated wireless card, BU353 GPS receiver
  - Kismet (Passive Scan)
- Setting II
  - MacBook Pro laptop, Backtrack in Virtual Machine running
  - Alfa wireless card, BU353 GPS receiver
  - Kistmet
- Setting III
  - HTC Stream Tablet, Android,
  - integrated wireless card, integrated GPS receiver
  - WiFum (Active Scan)

Testing Path and Duration



- Three-block urban neighborhood of midtown west Manhattan
- Three data sets per test run
- Four test runs on Dec 26, 2011 [14:06-14:35 (29 mins, A-H), 14:36-15:05 (29 mins, H-A), 15:07-15:35 (28 mins, A-H) and 15:36-15:58 (22 mins, H-A)]

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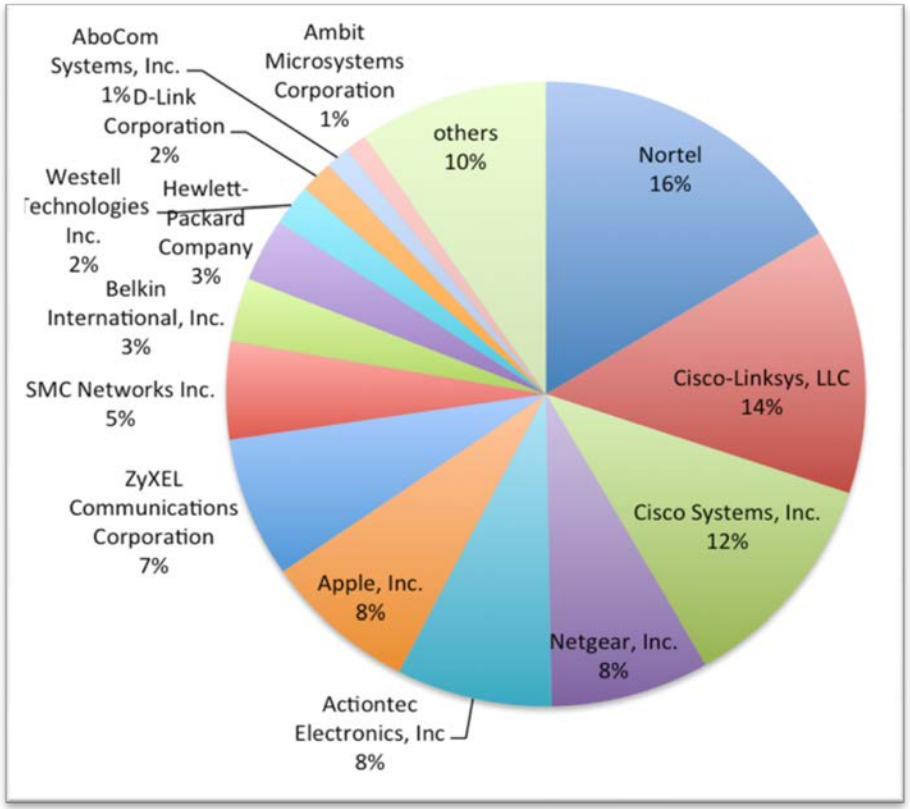
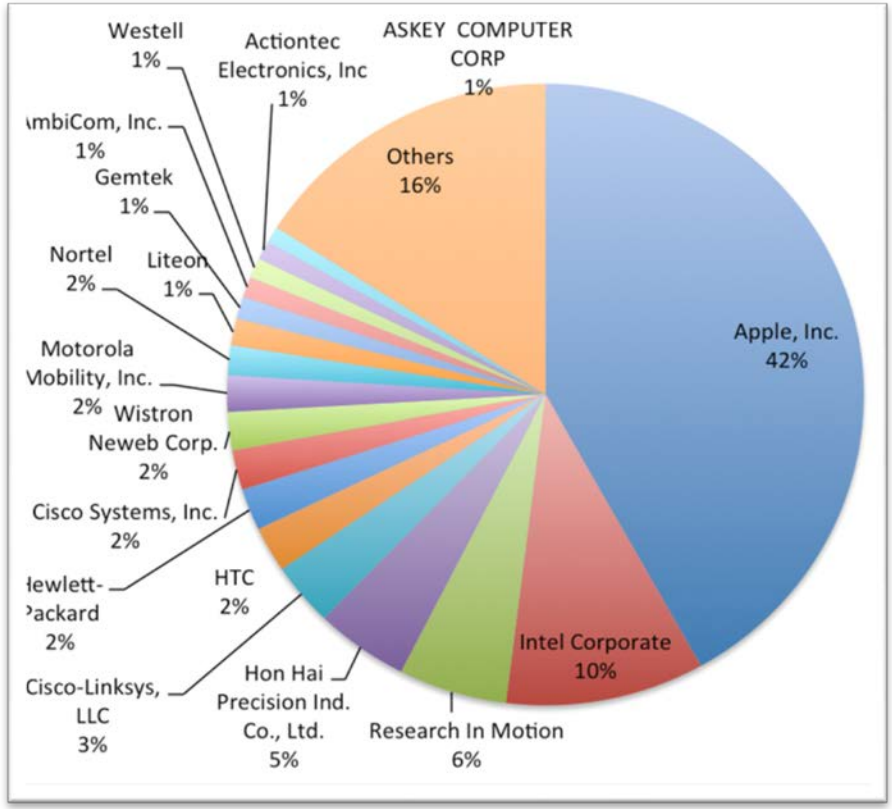
Number of AP

Tool	Airport + Kismet	Alfa + Kismet	HTC + WiFum
Average # of AP/Position	15	11	24
Average # of AP/Trip	1823	1829	1520
Average percentage of Encrypted APs	0.706	0.6835	0.8205

Device Manufactory



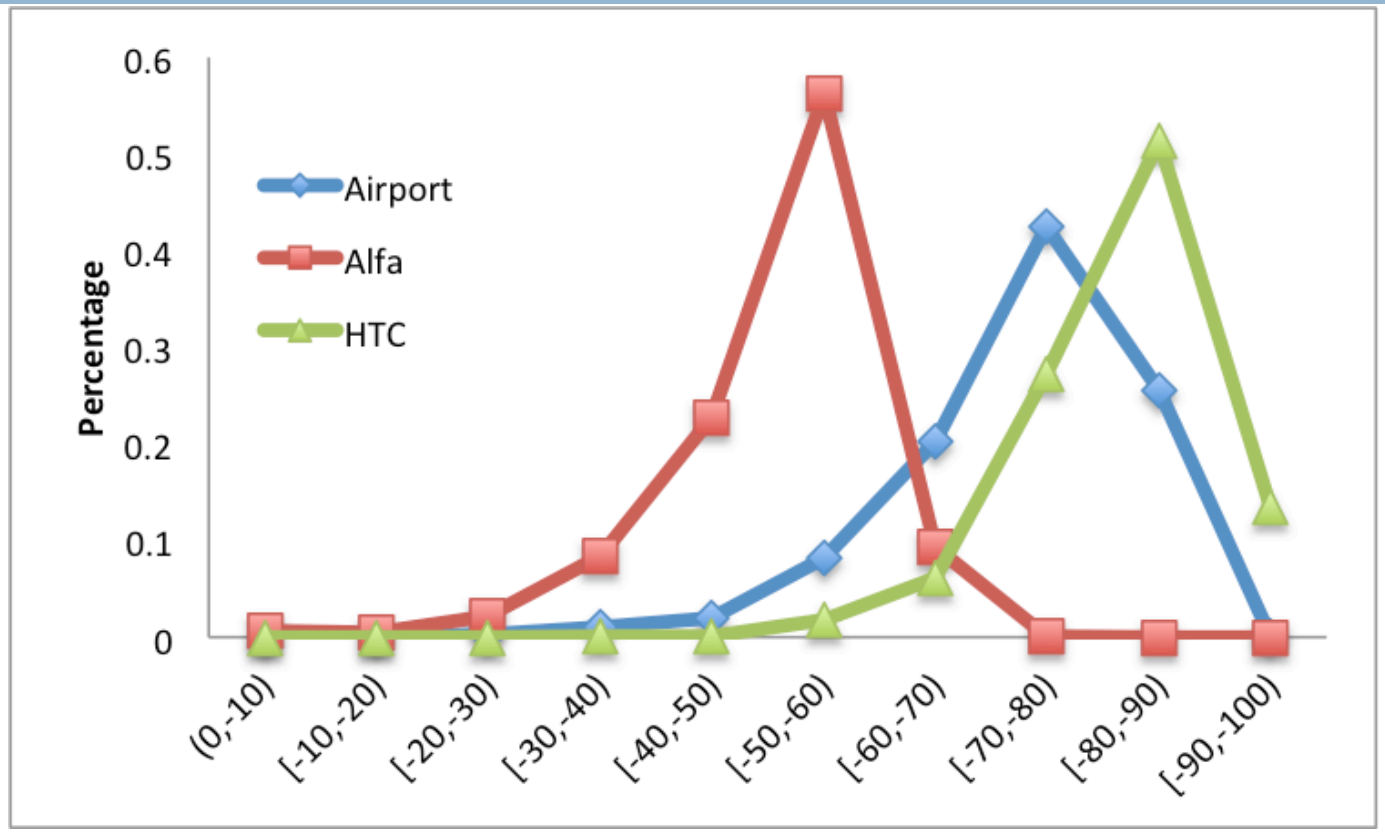
(a) Access Points



(b) Mobile Devices

3807 Access Points and 6615 Mobile Devices from Kismet traces

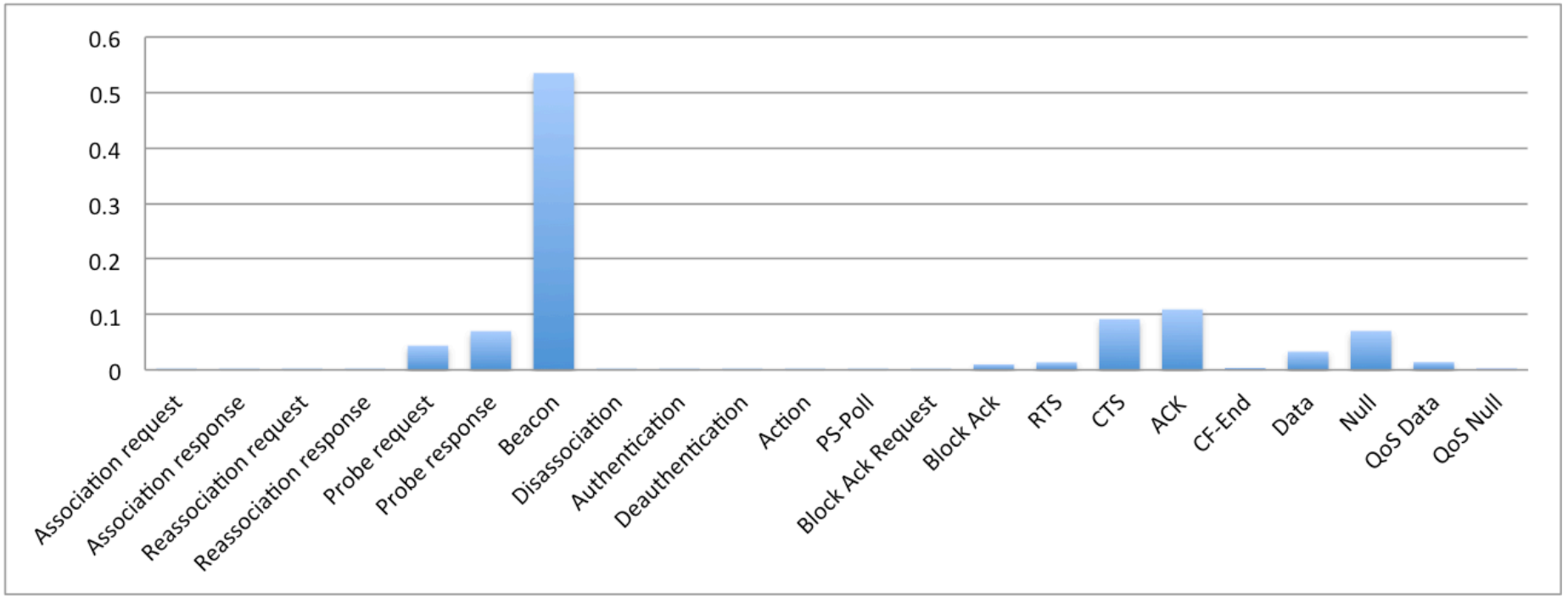
RSS Sensitivity



- Average Received Signal Strength (RSS):

External Alfa card > Cards of Mac computer & HTC tablet

Packet Type

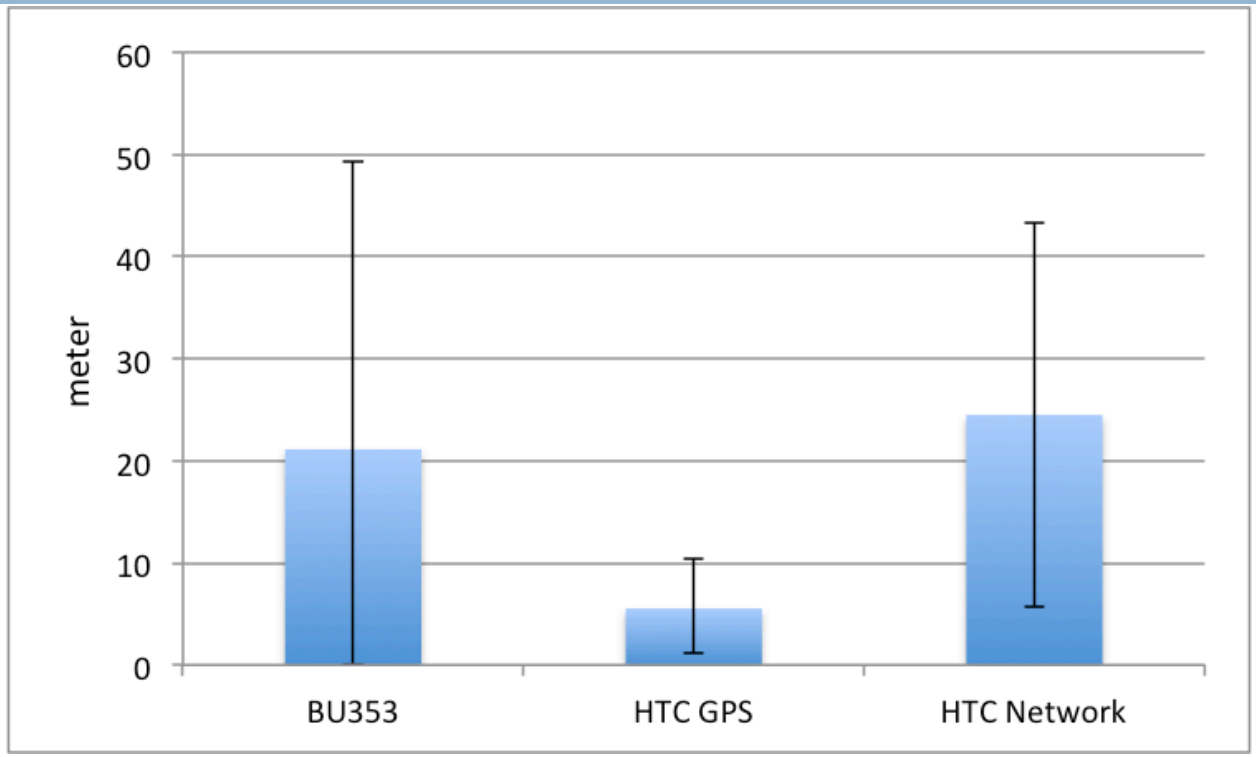


- 362,305 packets from Kismet traces
- 50% beacons from APs, 20% CTS & ACK, 11% Probe req/rep
- only approx 3% data

Location Variance

- Choose 10 locations along the path
- At each location gather trace continuously for 2 mins
- Record GPS coordinates from three different experiment settings
- Center Point = (avg latitude, avg longitude)
- Error Distance = |empirical location – center point|

Average Error Distance



- External GPS (BU353) provides worse consistency in location estimation
- Integrated GPS of HTC tablet provides relatively stable location info
- The HTC *Network* approach – combine cell tower & wireless APs – does not provide a significantly better position consistency as we thought

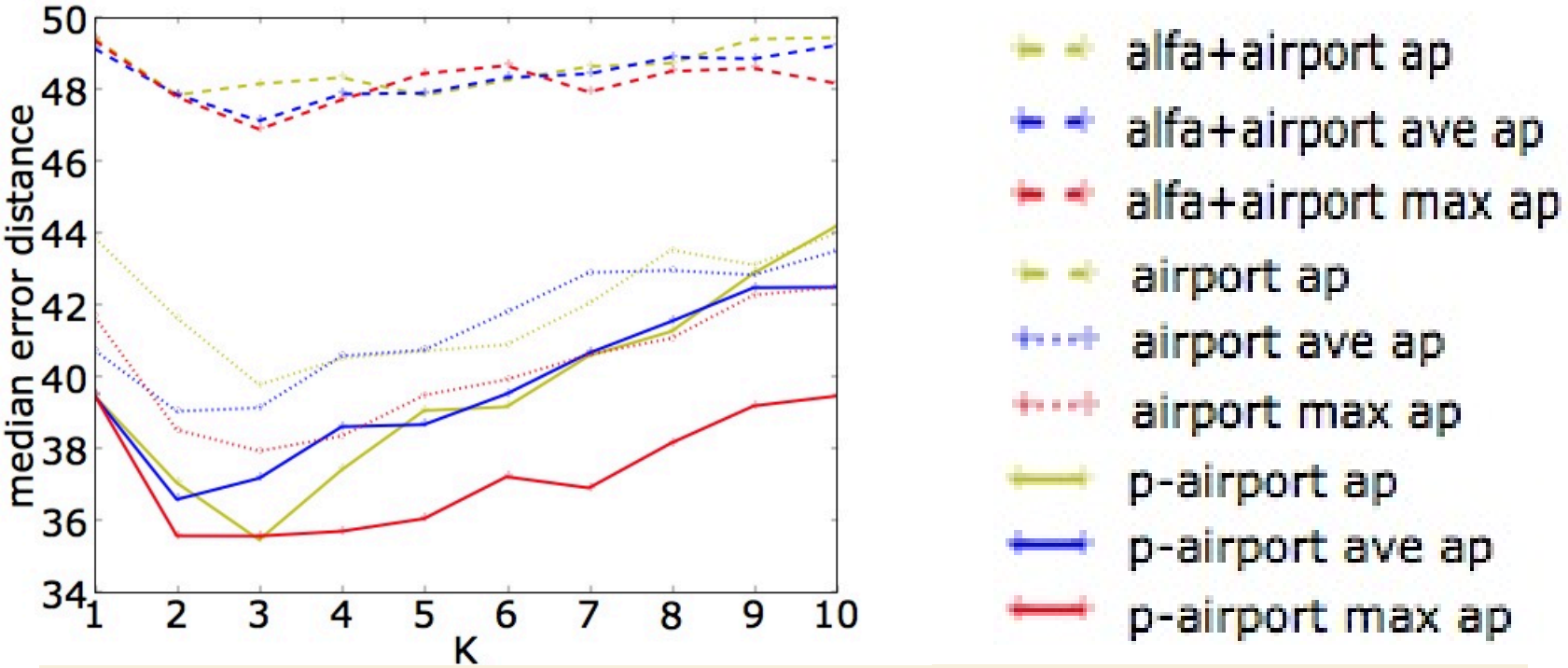
K Nearest Neighbor (KNN) Approach

- Hypothesis
  - *The set of APs and their associated signal strengths observed at a position represents a fingerprint that is unique to that position*
- Method:
  - Build an RF fingerprint database
  - Compare the observed RSS vectors to fingerprints in the database
    - Find K closest neighbors, estimate the new location via their positions
    - use Euclidean distance as the distance metric between unknown and known locations

Evaluating KNN Approach

- Add 12 (kismet) datasets gathered in one week of April/11
  - Same setting with Setting I
- Data sets:
  - p-airport: the 12 traces from past (April/11)
  - airport: all 16 traces gathered through setting I
    - 12 traces from April/11, 4 traces from December/11
  - alfa+airport: 16 traces from above + 4 Dec. traced gathered through setting II
- AP selection mechanisms
  - ap: use all Aps
  - avg ap: select APs that show larger than Avg RSS at more than one location
  - max ap: only select APs that show Maximum RSS at more than one location

KNN



- Mostly, error distance smallest when K=3
- Alfa USB wireless card provides significantly worse results than the integrated wireless card
- "Time" plays a role in localization accuracy => change of network parameter?

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Future Work

- More Measurement!!
  - Establish “ground truth”
  - Static trace gathering: monitoring points close to static APs
  - More thorough investigation on localization algorithms
    - Compare and contrast the performance of existing ones, propose new one (?)
    - Combine traces from both static AP and moving monitoring points
    - Vertical localization

Thanks !

Q&A