Extending Place Lab to 3-D

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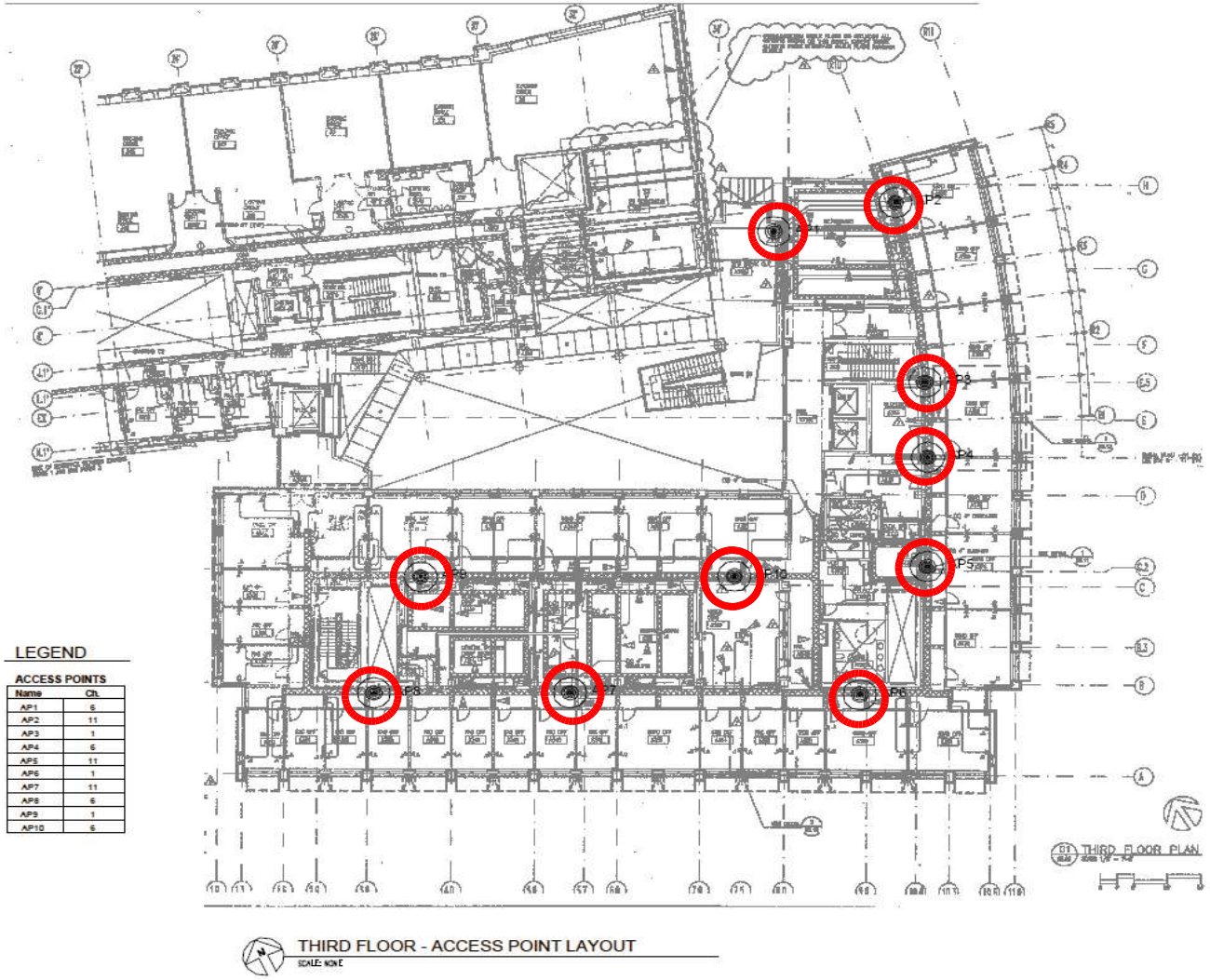
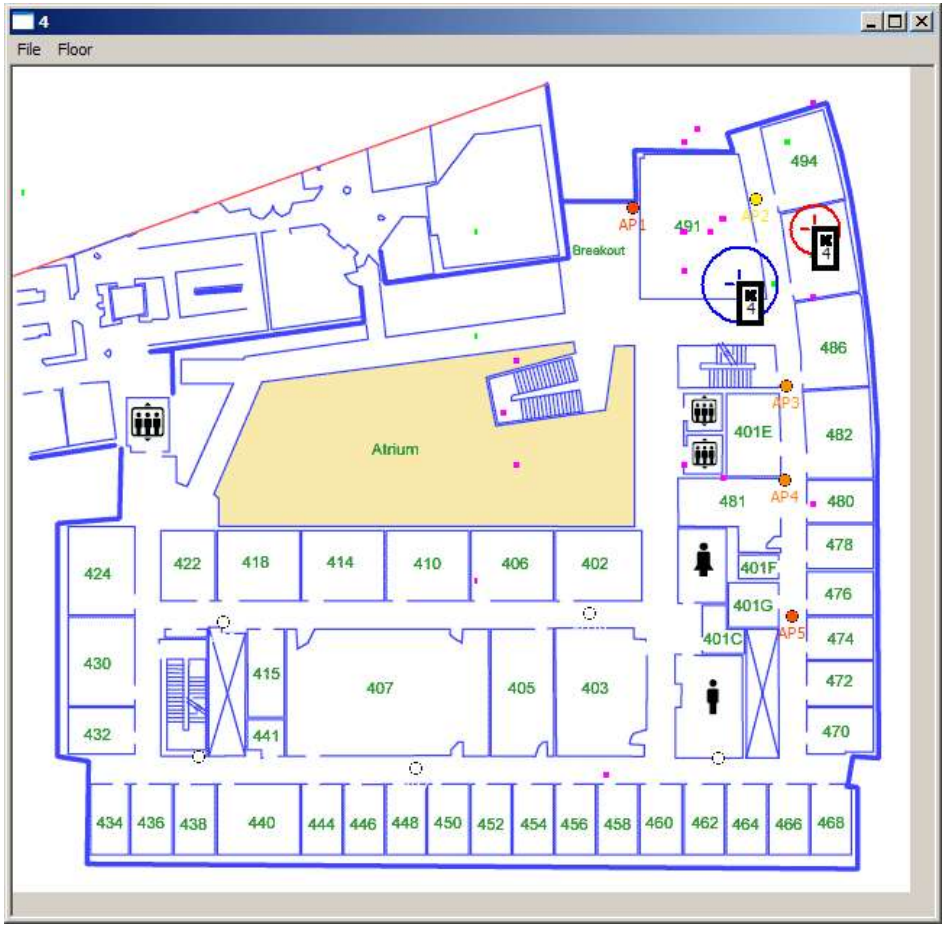
Basic concept

- Want to determine location inside a building
- Sample applications:
  - Position-aware reminders
  - Location-aware buddy list
  - Guidance for the cognitively impaired
  - Smart conference rooms

Idea


LEGEND
ACCESS POINTS
Name Ch.
AP1 6
AP2 11
AP3 1
AP4 6
AP5 11
AP6 1
AP7 11
AP8 6
AP9 1
AP10 6
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
THIRD FLOOR PLAN
THIRD FLOOR - ACCESS POINT LAYOUT
SCALE: NONE

Collecting data



•Beacon readings and ground truth were collected using a GUI showing map of each floor

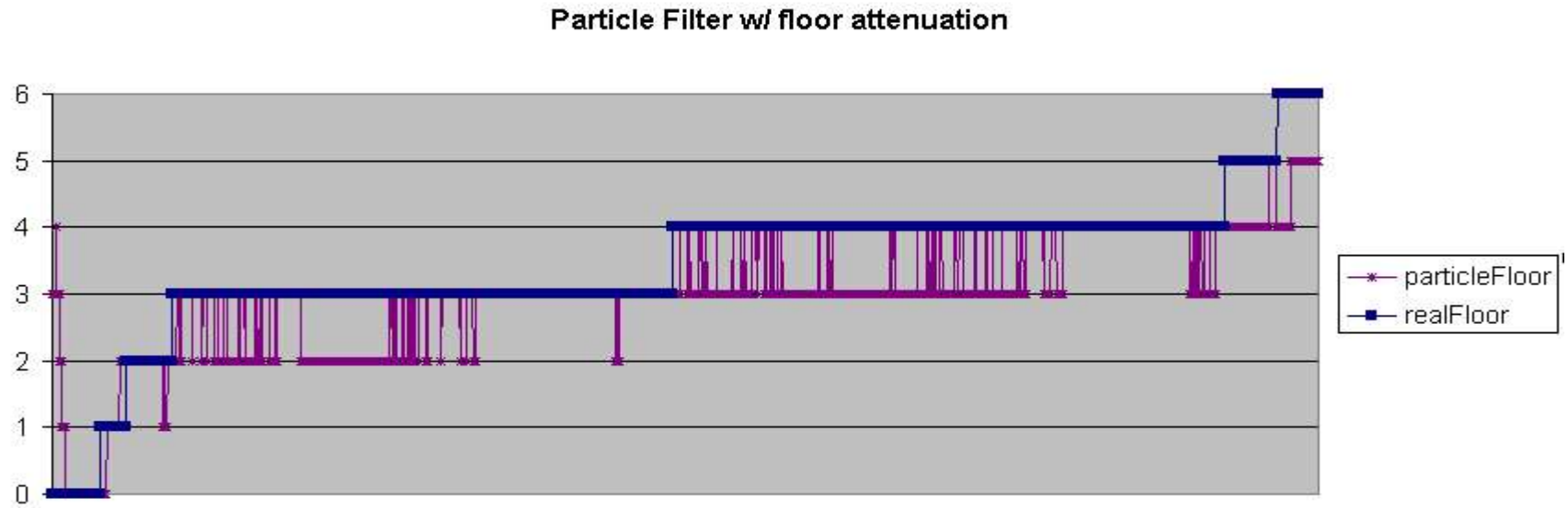
Intel's Place Lab

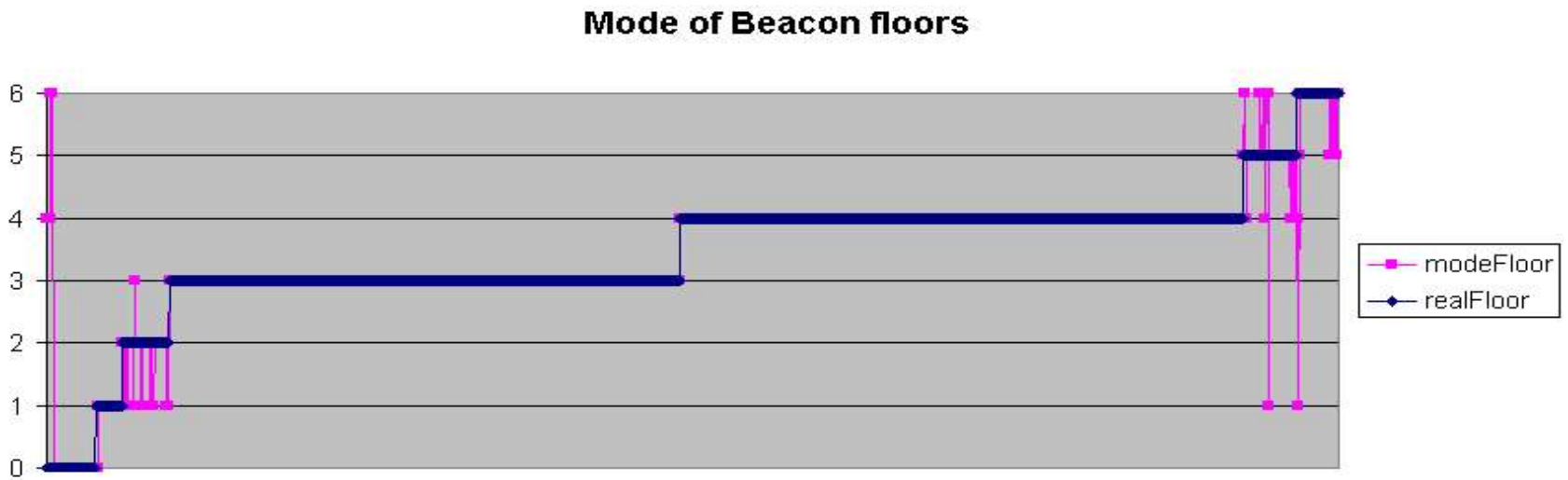
- Java codebase
- Provides basic localization functionality
  - Reading signals
    - WiFi
    - GPS
  - Particle filters
  - GUI classes
- Designed to be extended

Research issues

- How to interpret beacon readings
  - Compute centroid of APs heard
  - Use particle filter
- Place Lab extensions:
  - Beacon database includes extra information (e.g., floor)
  - Sensor model updated to include signal attenuation due to floors
  - Motion model updated to change floor variable

Evaluation– floor estimation





Evaluation – location estimation

	Mean 2d error	Median 2d error	Std. dev.
Particle filter	31.4m	32.3	11.9
Centroid of APs on floor	12.6	11.2	9.0

- Particle filter uses original sensor model (based on *signal strength*), with a floor attenuation factor of 0.8
- Centroid first computes the mode of the stronger half of APs heard to determine floor, then takes the centroid of those APs
- Note: highly calibrated fingerprinting systems can get 5-10m accuracy

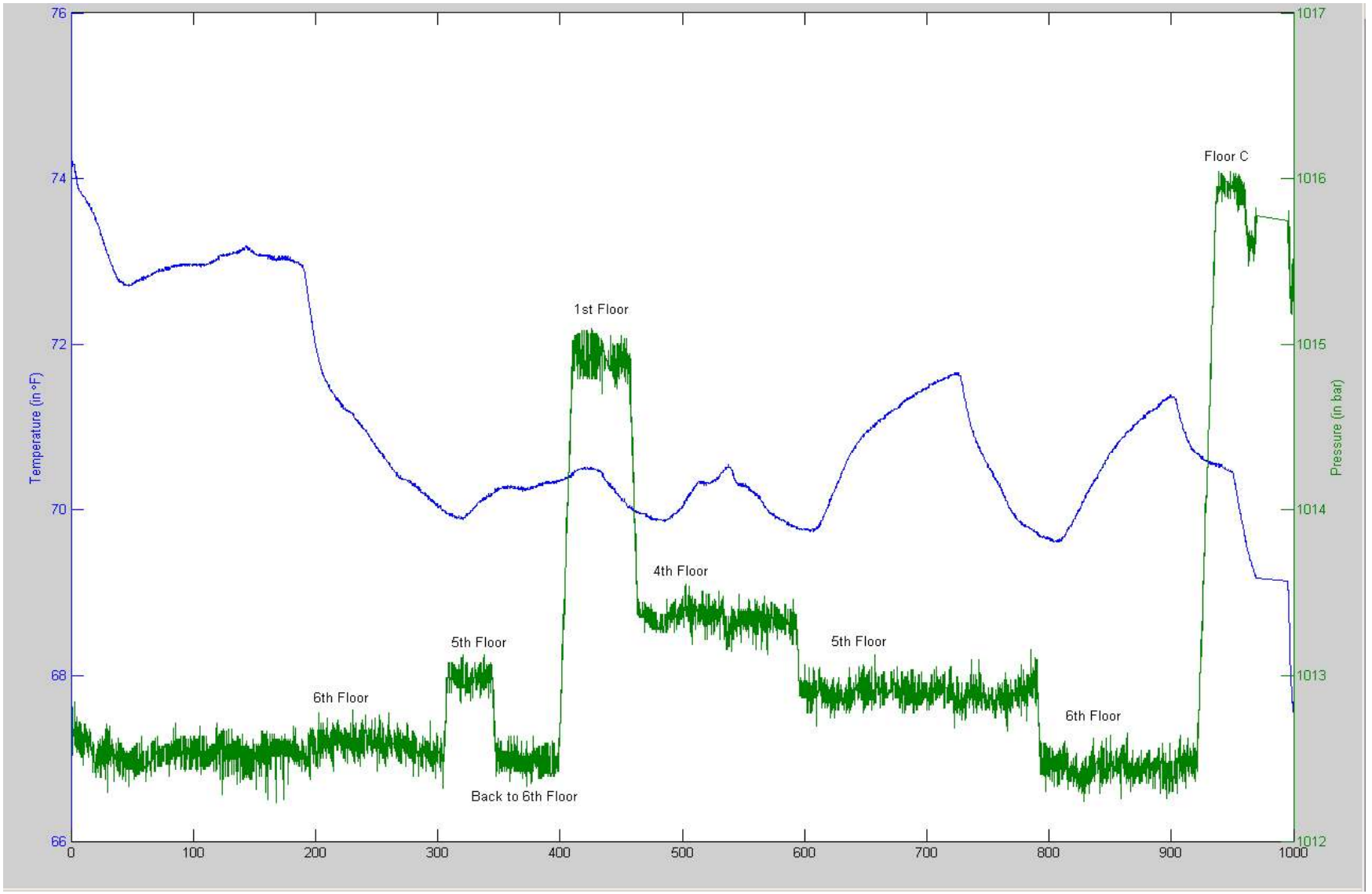
Improving accuracy

- Sensor model
  - *Classify APs based on their physical properties (model-based)*
  - Empirically learn AP properties (histogram- or fingerprint-based)
- Binning based on response rate at different distances from APs
  - Bin size of 10m produces mean 2d error of 17.2m, median error of 14.5m
  - Doesn't take into account effects across different floors: only gets right floor 15% of the time, within 1 floor 87% of the time
- Binning based on distance and floor
  - Bin size of 10m produces mean 2d error of 16.4m, median error of 16.0m
  - Gets right floor 56% of the time, within 1 floor 99% of the time

Map Based Particle Filter

- Take into account knowledge of environment
  - Walls
  - Open spaces
  - Stairwells/elevators
- Intuitively, a signal passing through several walls should be weaker
- Mobile computers shouldn't change floors unless in an elevator or stairwell
- For each particle in particle filter, use this information to decide what its likelihood is

Barometric pressure



Tradeoffs

- Can get better accuracy with
  - More extensive fingerprinting
  - Additional sensors (accel, barometric, ultrasound)
- But this comes at a price (time and money)
  - Data collection and management
  - Equipment calibration
- This limits scalability

Thanks!

Questions?