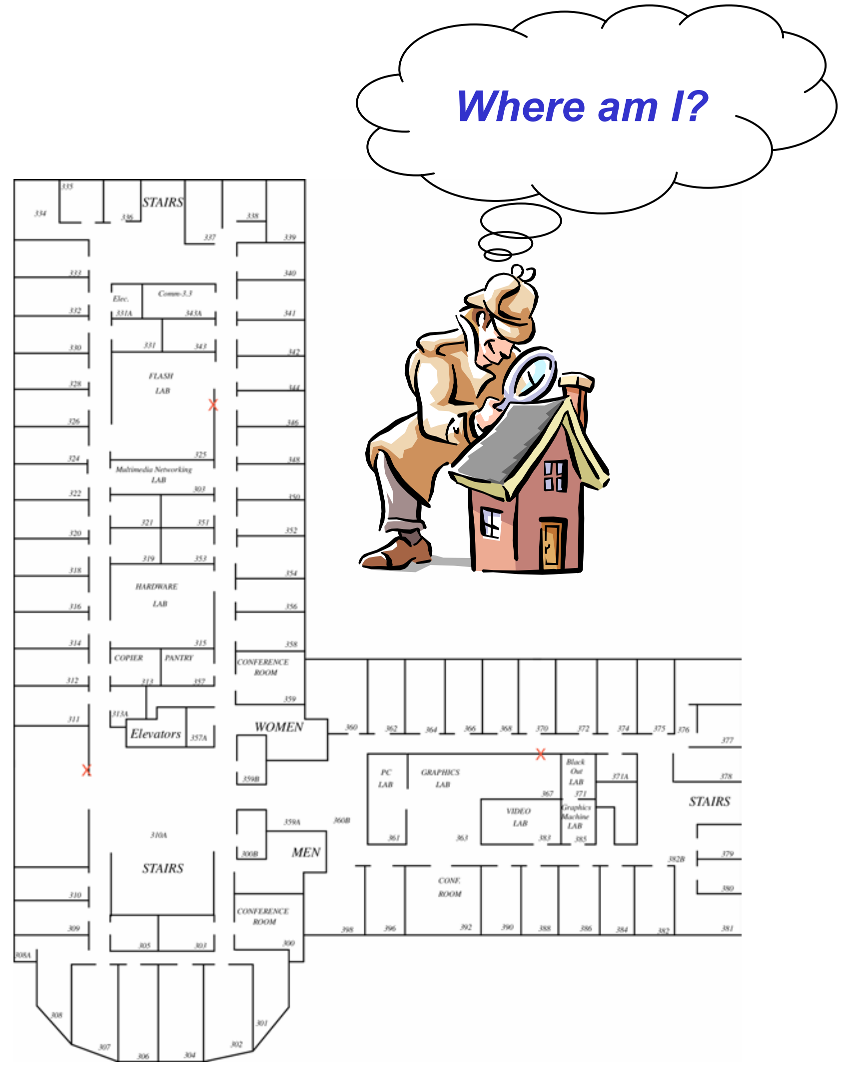
Mobile User Localization Using IEEE 802.11b WAPs

An Nguyen, Niloy J. Mitra and Jaewon Shin

Movitation

- Location service for Mobile Computing Environment
- Installing extra infrastructure (beacons etc)
  - Fine resolution: << meters
  - High cost
- Using existing infrastructure (IEEE 802.11a/b/g WAP's)
  - Crude resolution: ~ meters
  - No cost



Previous Works

- MSR RADAR
  - Pioneered the idea of using WAP’s for the mobile user localization
  - No tracking
- Rice University
  - Used HMM algorithm for tracking

Our Approach: Bayesian Filtering

- Bayesian Filtering: General probabilistic framework for combining the prior knowledge (how things are moving in general) with the new information (what you observe)

$$p(x^{(t+1)} \mid \overline{z^{(t+1)}}) = C \cdot p(z^{(t+1)} \mid x^{(t+1)}) \cdot \int p(x^{(t+1)} \mid x^{(t)}) \cdot p(x^{(t)} \mid \overline{z^{(t)}}) d\mathbf{x}^{(t)}$$

$x^{(t)} \in \{s_1, \cdots, s_N\}$, N: # the data collection locations.

$z^{(t)} \in [\text{min\_SNR}, \text{max\_SNR}]^M$, M: # WAP's

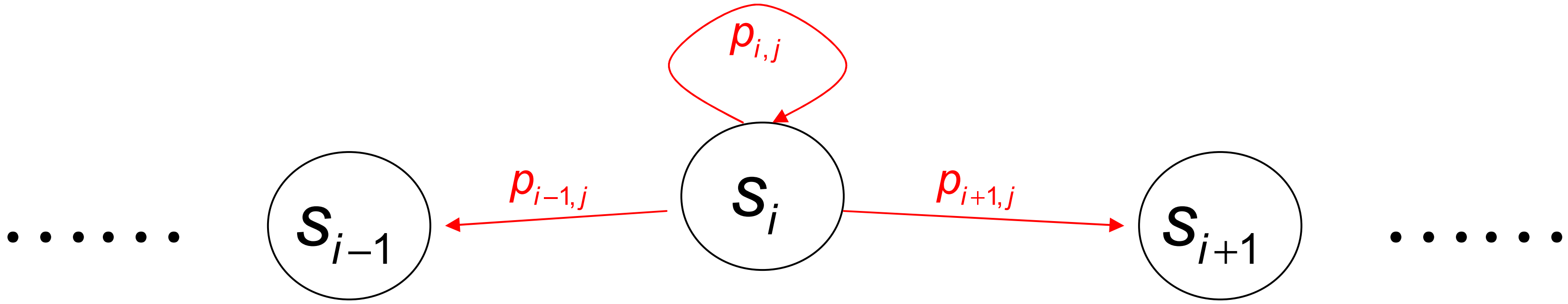
$\overline{z^{(t)}} = \{z^{(0)}, \cdots, z^{(t)}\}$

$p(x^{(t+1)} \mid x^{(t)})$: Dynamic model (prior knowledge)

$p(z^{(t+1)} \mid x^{(t+1)})$: Observation model (new information)

Our Approach: Dynamic Model

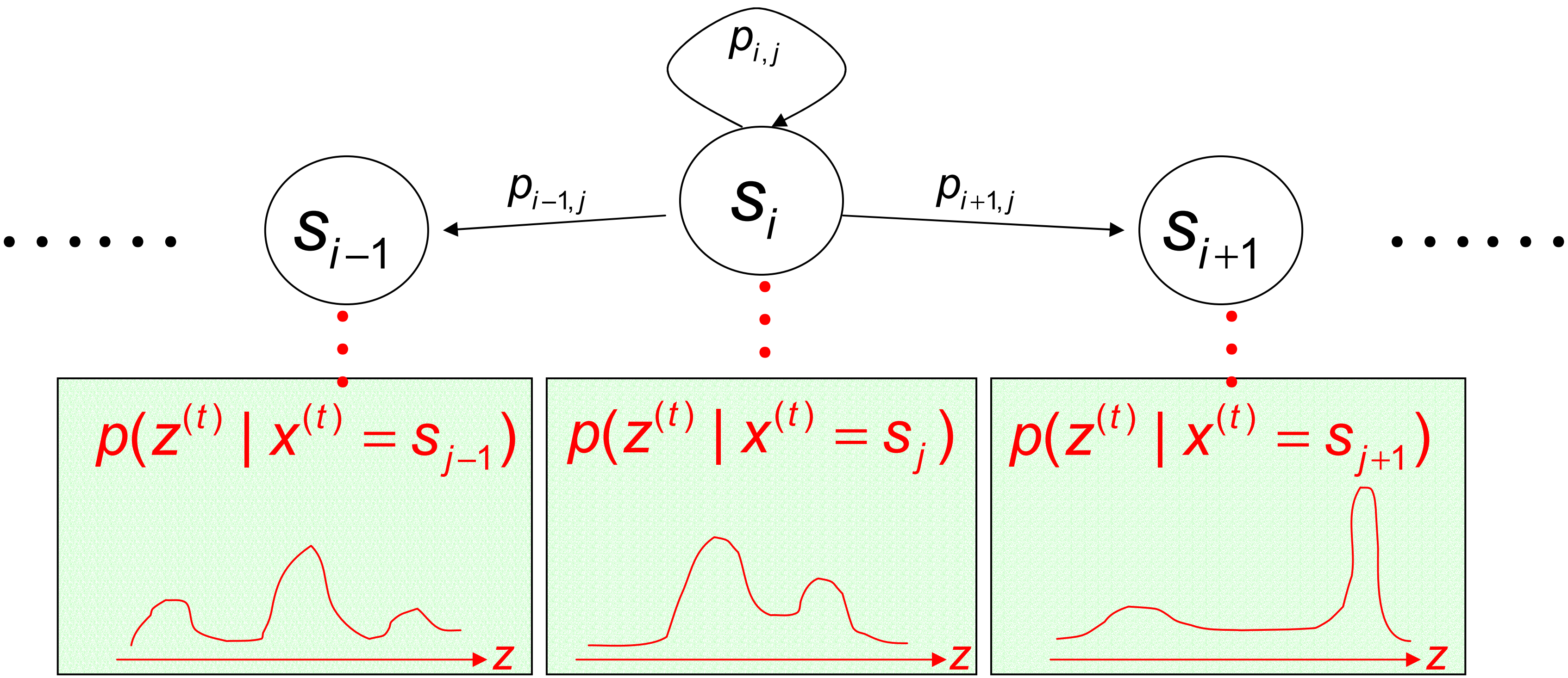
$$p(x^{(t+1)} \mid x^{(t)})$$



Q) How to model p_{ij} ? Easy

Our Approach: Observation Model I

$$p(z^{(t)} \mid x^{(t)})$$

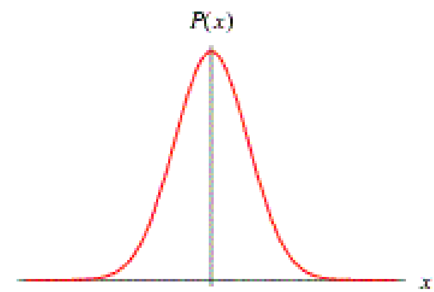


Q) How to model $p(z^{(t)} \mid x^{(t)} = s_i)$? Hard!

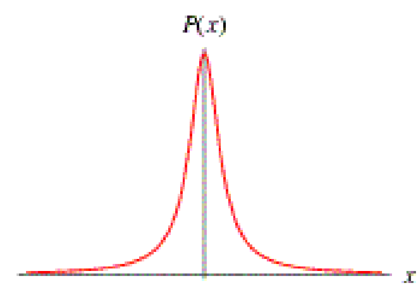
Our Approach: Observation Model II

Q) How to model $p(z^{(t)} \mid x^{(t)} = s_i)$?

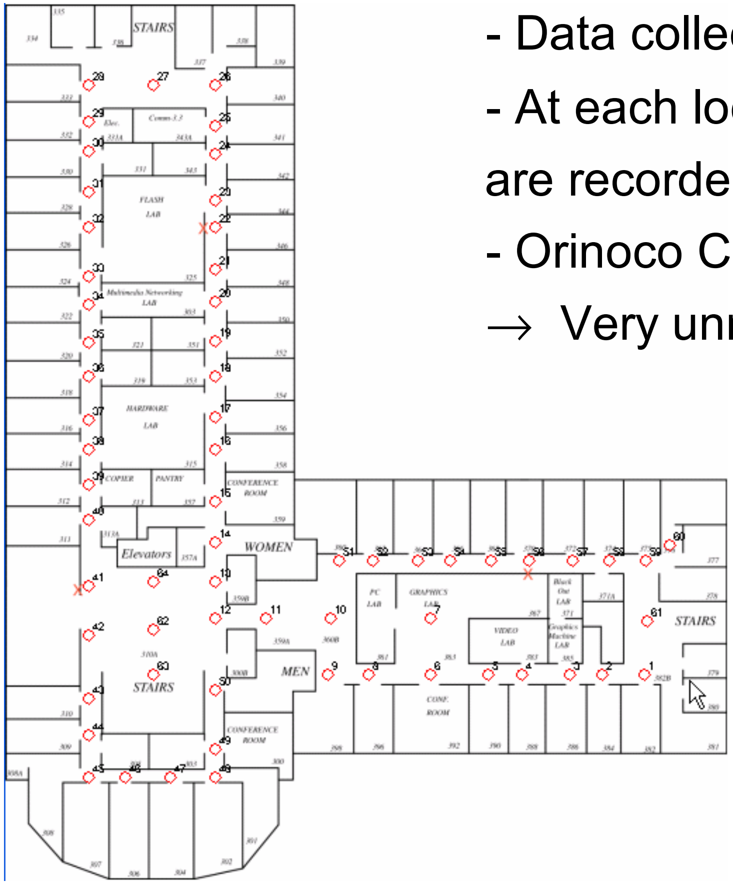
- Non-parametric model: not enough data and ...
- Parametric model:
  - Gaussian ($\exp(-cx^2)$)



  - Cauchy ($\frac{\alpha}{\alpha^2 + x^2}$)

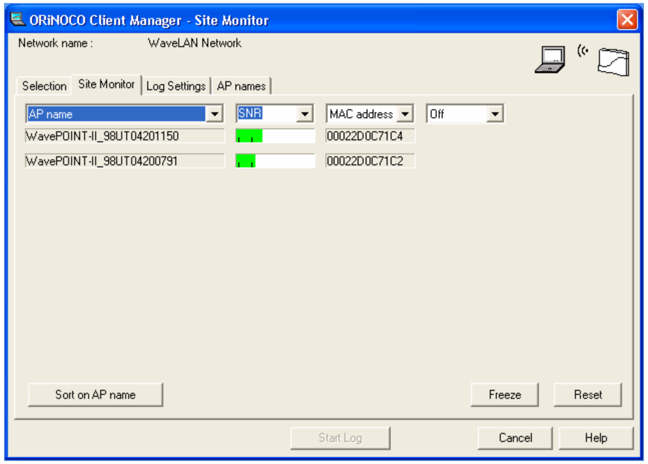


Data Collection I

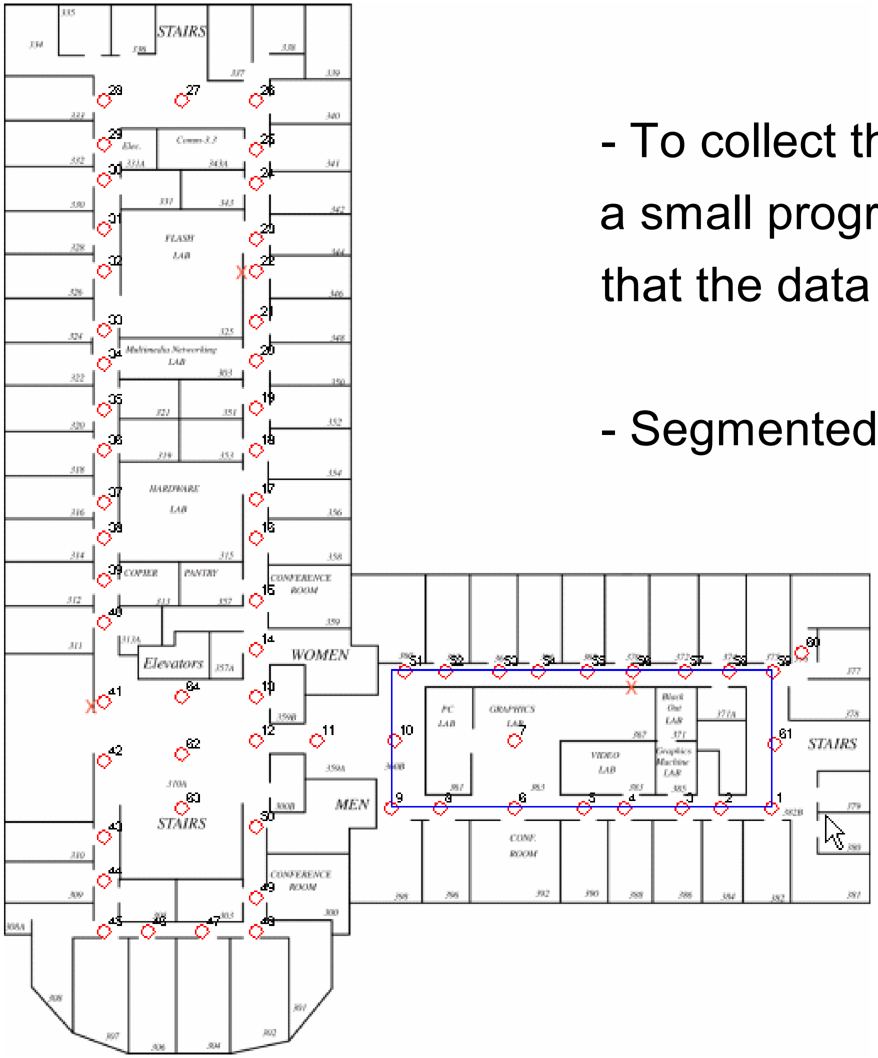


- Data collected at 64 locations. ($\therefore\ x^{(t)} \in \{s_1, \cdots, s_{64}\}$)
- At each location, the signal strengths from 3 WAP's are recorded for about 30 seconds.
- Orinoco Client Manager was used to collect the data.

$\rightarrow$ Very unreliable



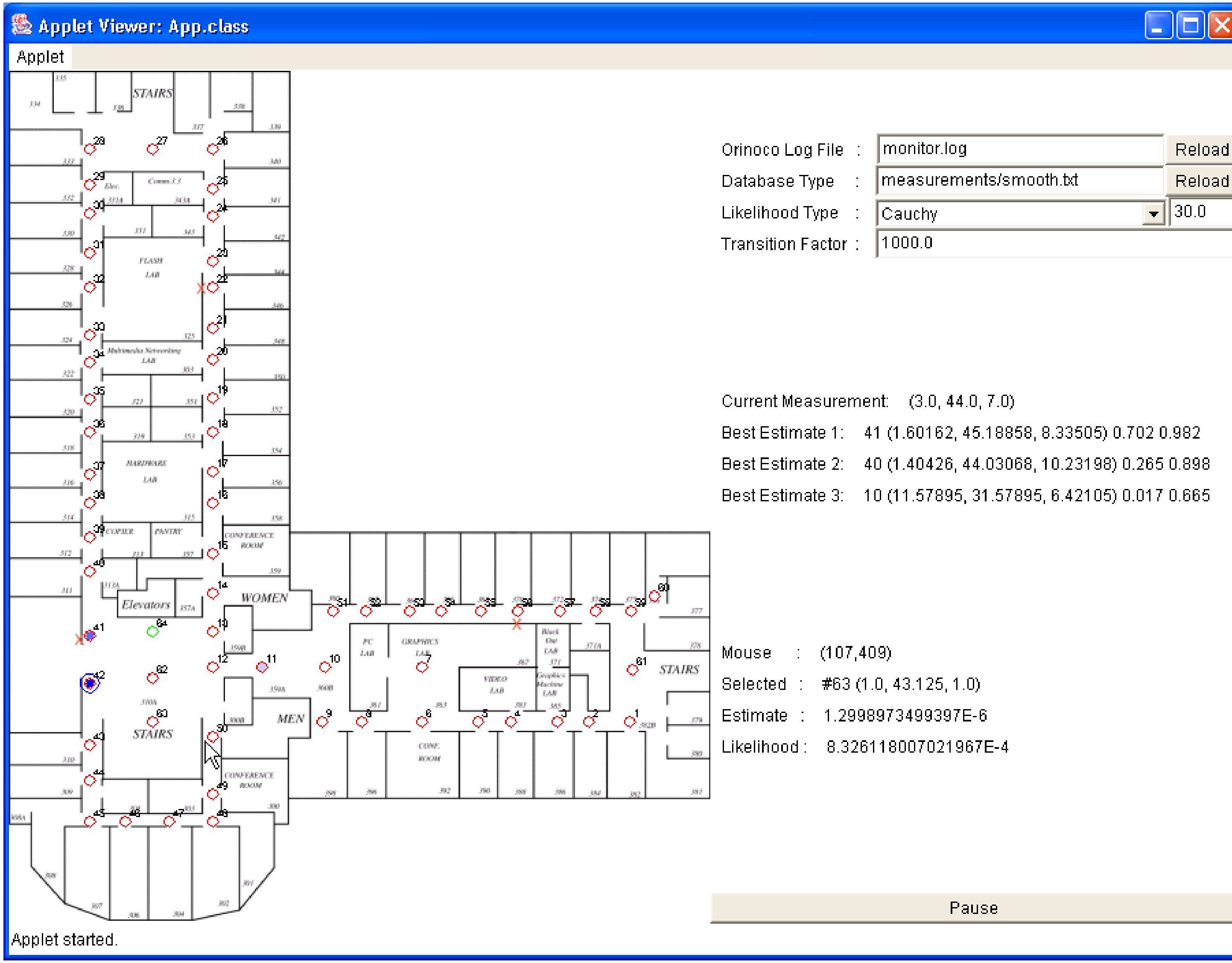
Data Collection II



- To collect the ground-truth data, we wrote a small program that shows the moving agent that the data collector should follow

- Segmented the whole path in the small paths

Testbed


Applet Viewer: App.class
Applet
STAIRS
Elevators
WOMEN
MEN
STAIRS
STAIRS
Orinoco Log File : monitor.log
Reload
Database Type : measurements/smooth.txt
Reload
Likelihood Type : Cauchy
30.0
Transition Factor : 1000.0
Current Measurement: (3.0, 44.0, 7.0)
Best Estimate 1: 41 (1.60162, 45.18858, 8.33505) 0.702 0.982
Best Estimate 2: 40 (1.40426, 44.03068, 10.23198) 0.265 0.898
Best Estimate 3: 10 (11.57895, 31.57895, 6.42105) 0.017 0.665
Mouse : (107,409)
Selected : #63 (1.0, 43.125, 1.0)
Estimate : 1.2998973499397E-6
Likelihood : 8.326118007021967E-4
Pause
Applet started.

Result

- Real data playback
- Real demo

Conclusion and Future Works

- Impulsive nature of RF signal characteristics seems to be better described by Cauchy distribution.
- When the system has “meaningful” reading, the tracking performance seems reasonable.
- Future works
  - No quantitative analysis done
  - Passive listening → Active probing?
  - Tracking in continuous state space
  - Extend this to IPAQ

  and many others