Molé: a Scalable, User-Generated WiFi Positioning Engine

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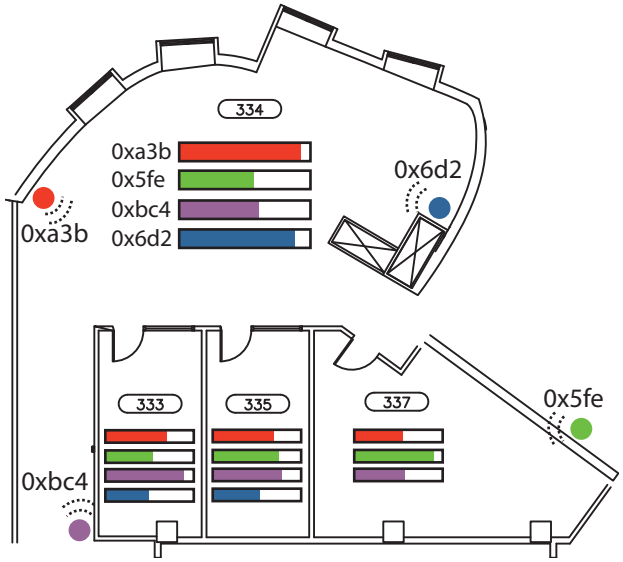
Mobile Organic Localization Engine (Molé)

Goal: human-scale indoor/outdoor applications



Organic, Crowd-sourced

- User-contributed signatures

On-device

- No server solver
- Works offline

Room-grain accuracy

- Not points on a map; not sub-meter accuracy
- No infrastructure requirements
- Good for many (not all) applications

Talk Outline

New Techniques

- Positioning algorithm (MAO)
- Scalable Design

Experimental Results

- Live algorithm comparison
- Using motion detection

Conclusion

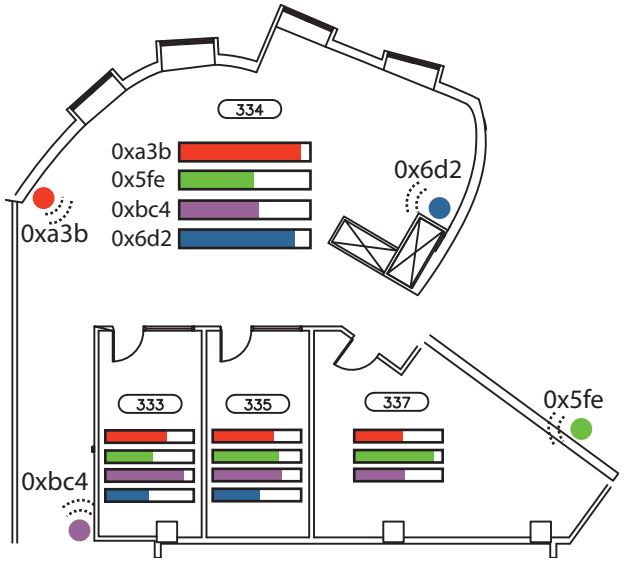
MAO Algorithm: Intuition

When a device is in a place,

- not only see the same signal strength distribution from the same APs,
- but will see the same response rate from those APs

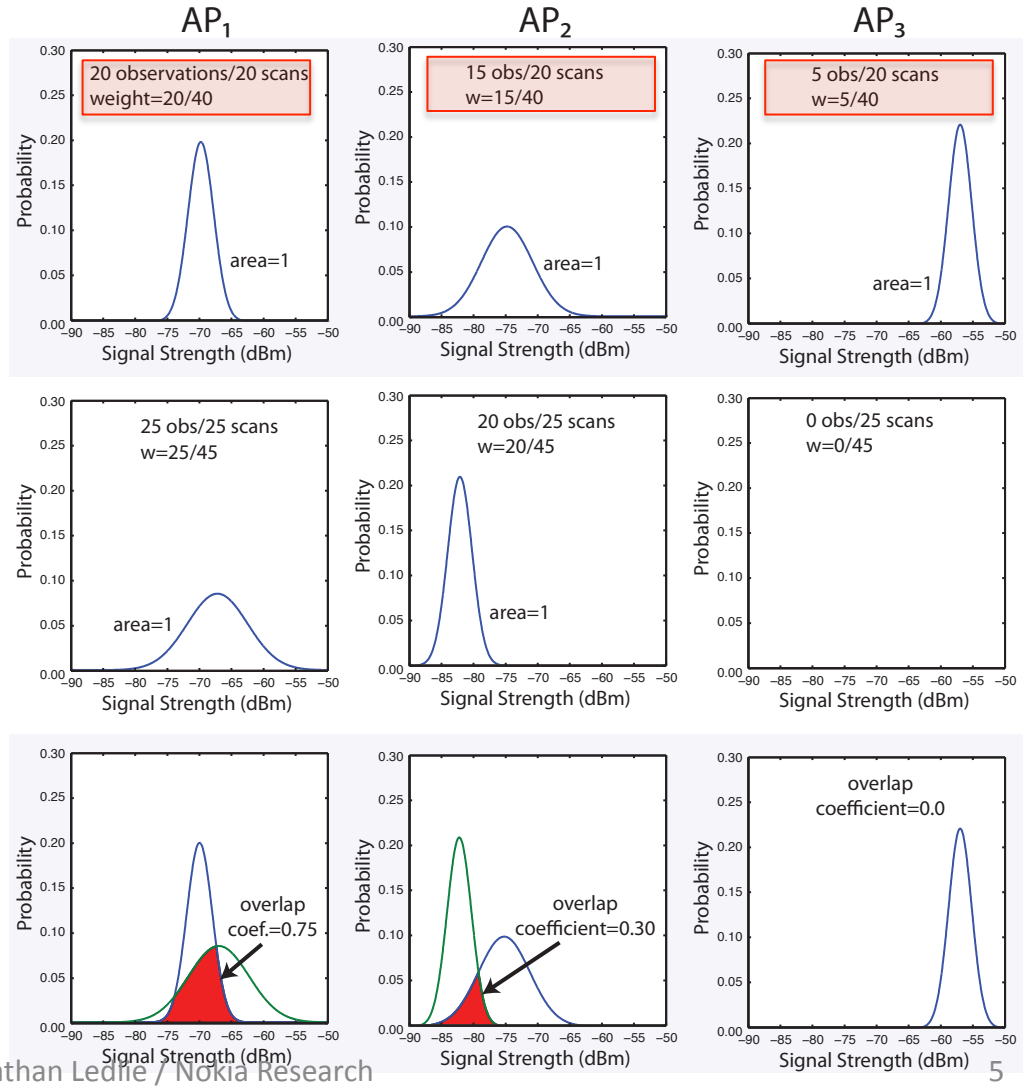
Weight = num. received / total received

$$w_i = r_i / \sum_{j=1}^{\tau} r_j$$



MAO Algorithm

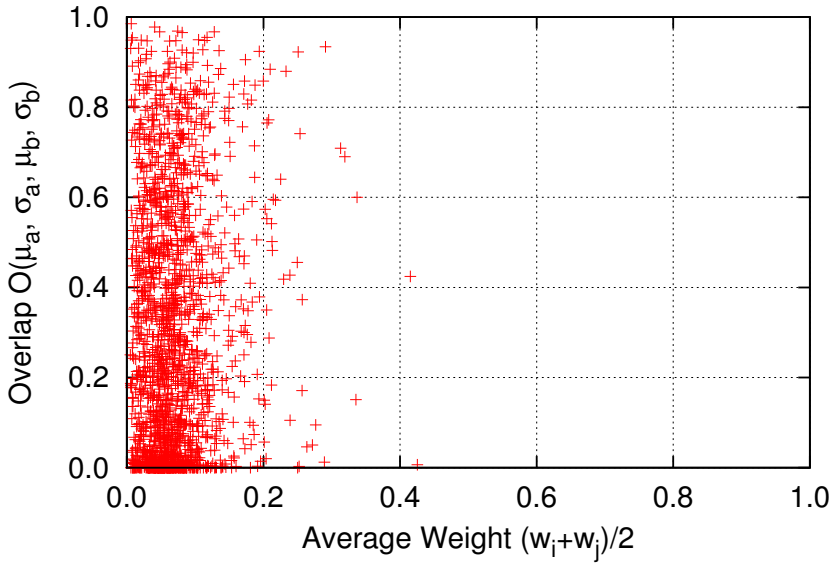
1. Distribution for each AP
   - Normalized
   - Gaussian; Kernelized Histogram
2. Compute maximum overlap when both APs present
3. Subtract penalty when either missing
4. Weigh overlap by response rate



Independence of Response Rate

For each AP i

$$\delta_i = \begin{cases} (w_a + w_b)/2 \times O(\mu_a,\sigma_a,\mu_b,\sigma_b) & \text{if } i \in A, i \in B \\ -w_a \times p & \text{if } i \in A, i \notin B \\ -w_b \times p & \text{if } i \notin A, i \in B \end{cases}$$



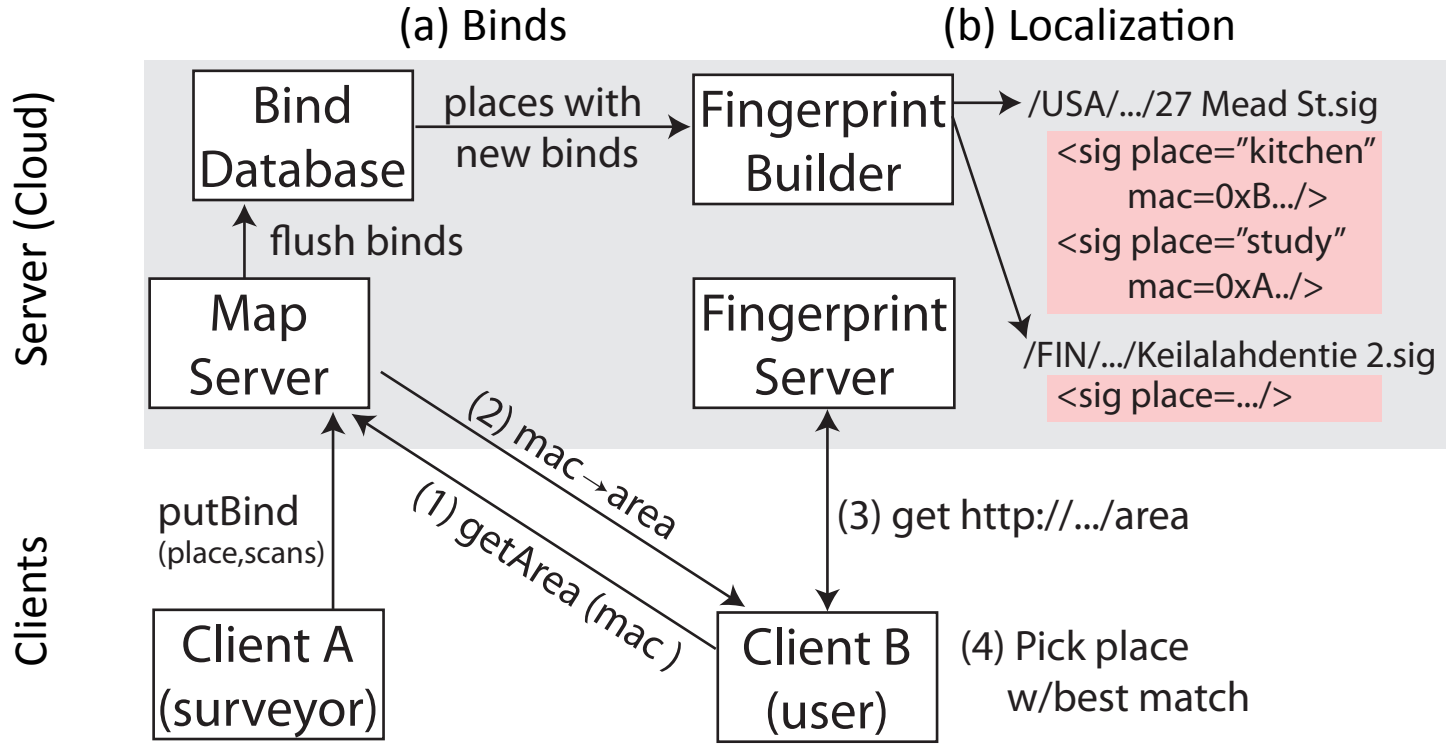
Commercial scan DB of 1400 spaces

Overlap vs. average weight: : $\sigma^2 = 0.11$

System Design

Scale to many users via device-side computation

- Batching; Hierarchical namespace; Limited polling



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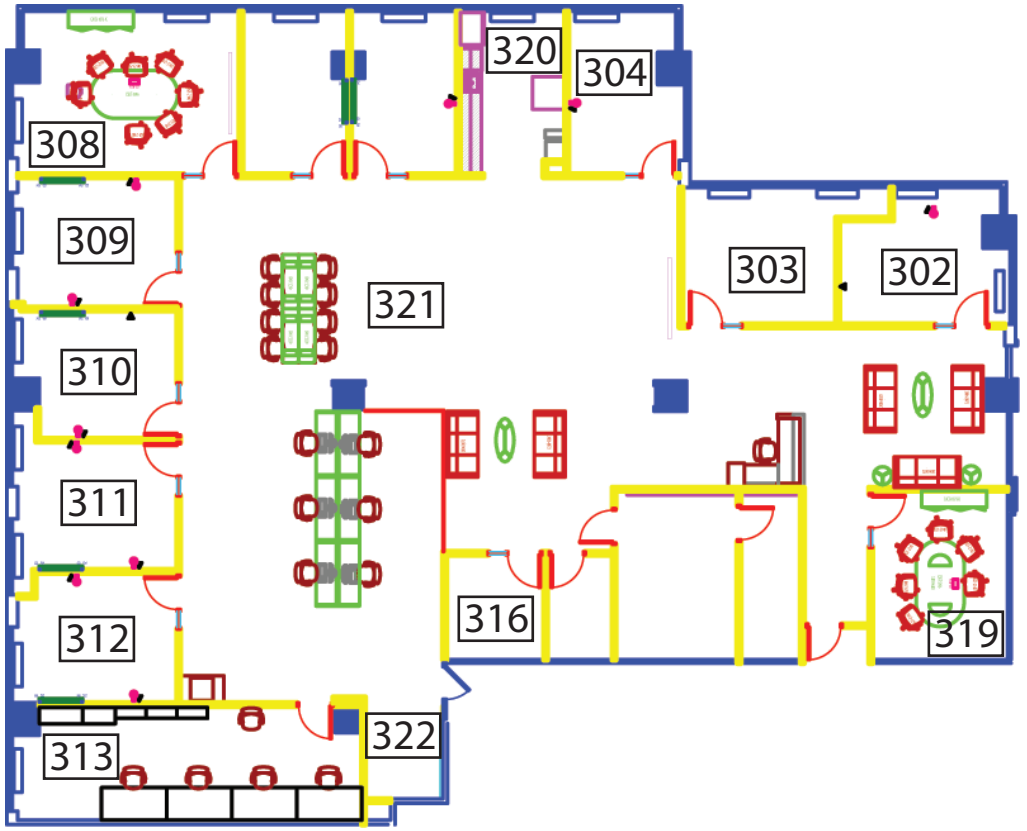
Evaluation: Algorithms

Live Experiment:

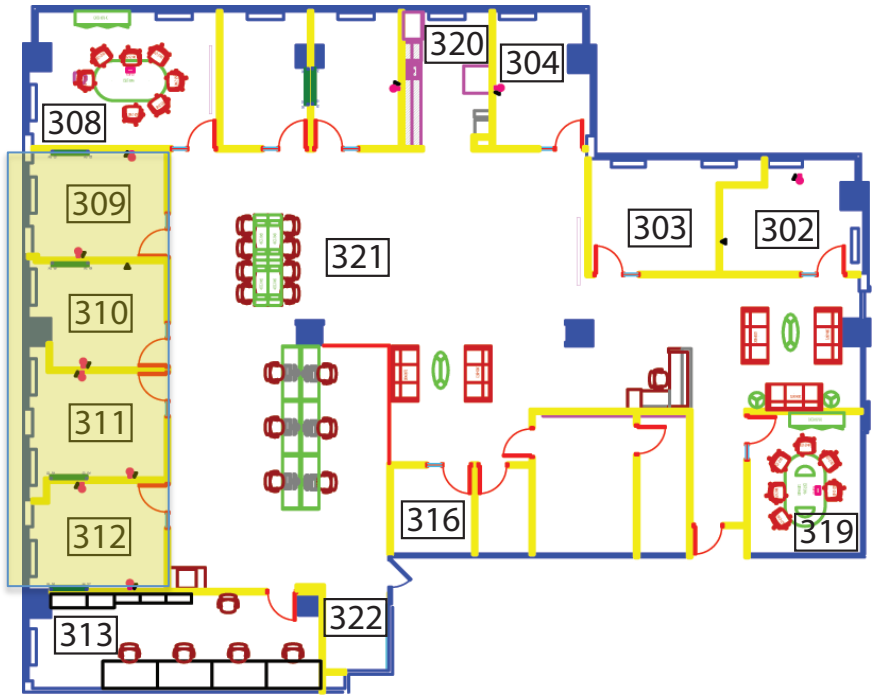
- Placed spot-check phones in each room
- Each ran six algorithms in parallel
- Add bind for each room
- Compute hit rate



Evaluation: Algorithms

Room	Mao/ Gauss	MAO/ Hist./ No Wt.	MAO/ Hist./ No Pen.	MAO/ Hist./ Penalty	Bayes/ Gauss	Bayes/ Histo-gram
302	92.87	100.00	100.00	100.00	100.00	100.00
303	90.59	100.00	100.00	100.00	74.64	88.52
304	92.09	98.73	100.00	100.00	91.46	79.75
308	99.84	99.84	100.00	100.00	90.49	100.00
309	32.86	42.70	59.37	58.89	31.75	43.33
310	1.59	10.95	41.75	81.59	24.76	11.43
311	90.59	41.15	87.08	94.90	87.56	95.37
312	42.88	93.67	90.03	70.89	70.09	72.47
313	100.00	100.00	100.00	100.00	99.16	100.00
316	100.00	100.00	100.00	100.00	98.73	100.00
319	99.84	100.00	100.00	100.00	98.57	97.14
320	100.00	98.74	100.00	100.00	99.37	100.00
321	99.22	100.00	100.00	100.00	100.00	100.00
322	88.38	100.00	100.00	99.53	92.15	97.33
All	80.46	84.49	91.17	93.16	82.52	84.43

Spot-check phones running six algorithms in parallel; live with same scans



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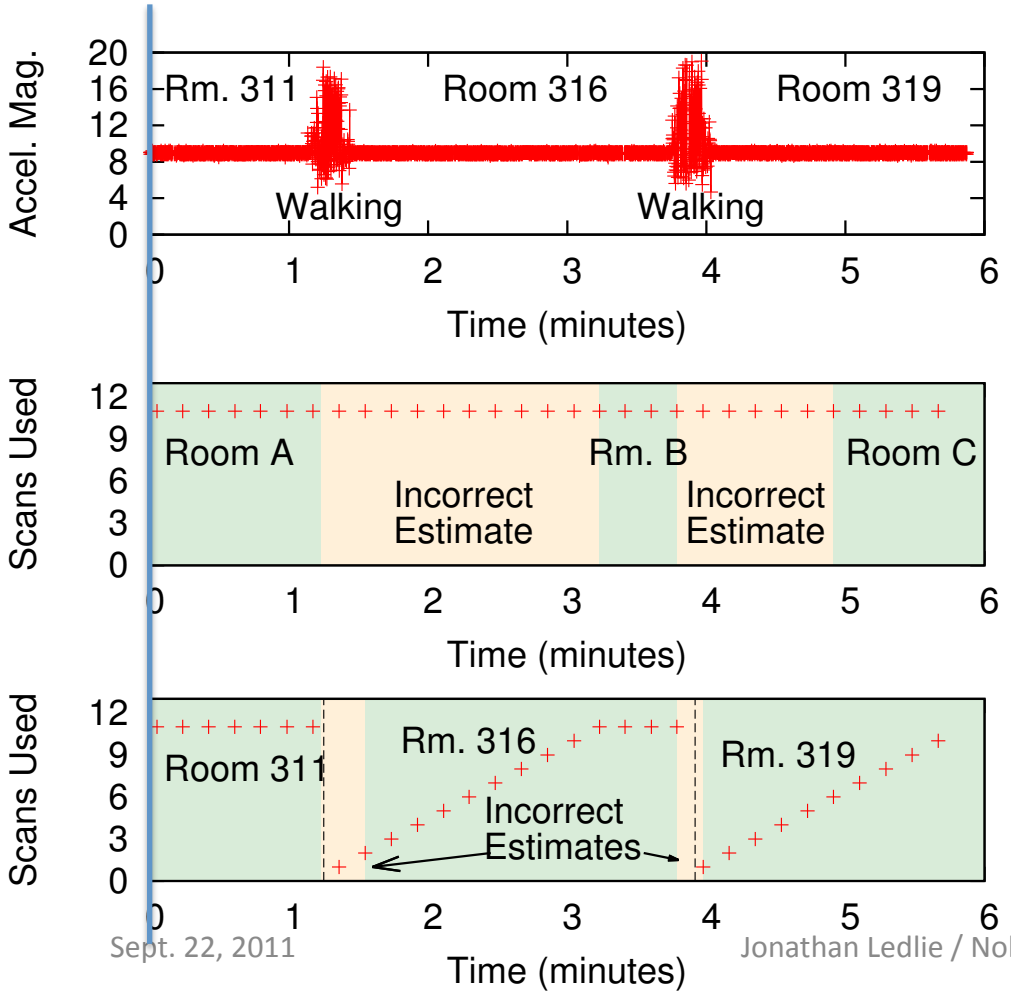
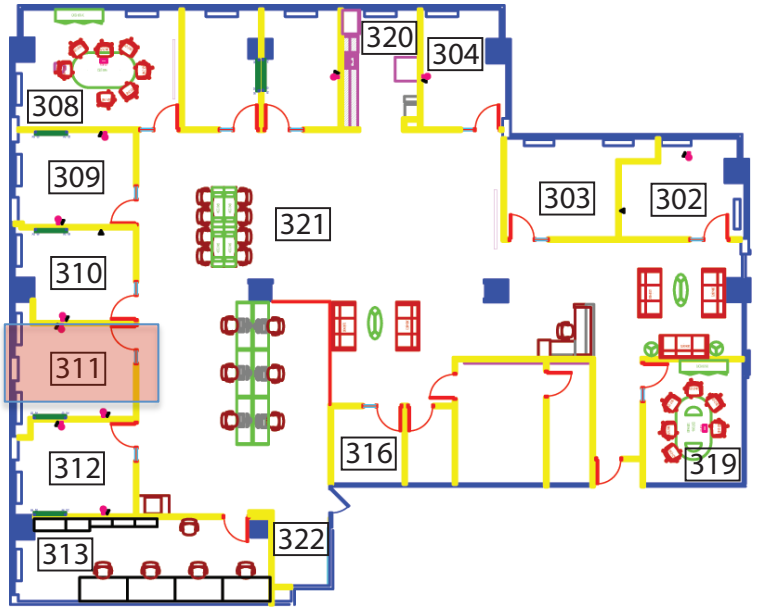
Evaluation: Motion Detection

Eliminate stale WiFi scans using motion detection

- Ran two versions of Molé in parallel on same device





Also reduces bind pollution

Conclusion

Molé: Mobile Organic Localization Engine

- New algorithm: uses more information
- New methods: movement detection
- Batched, scalable design

Thanks!

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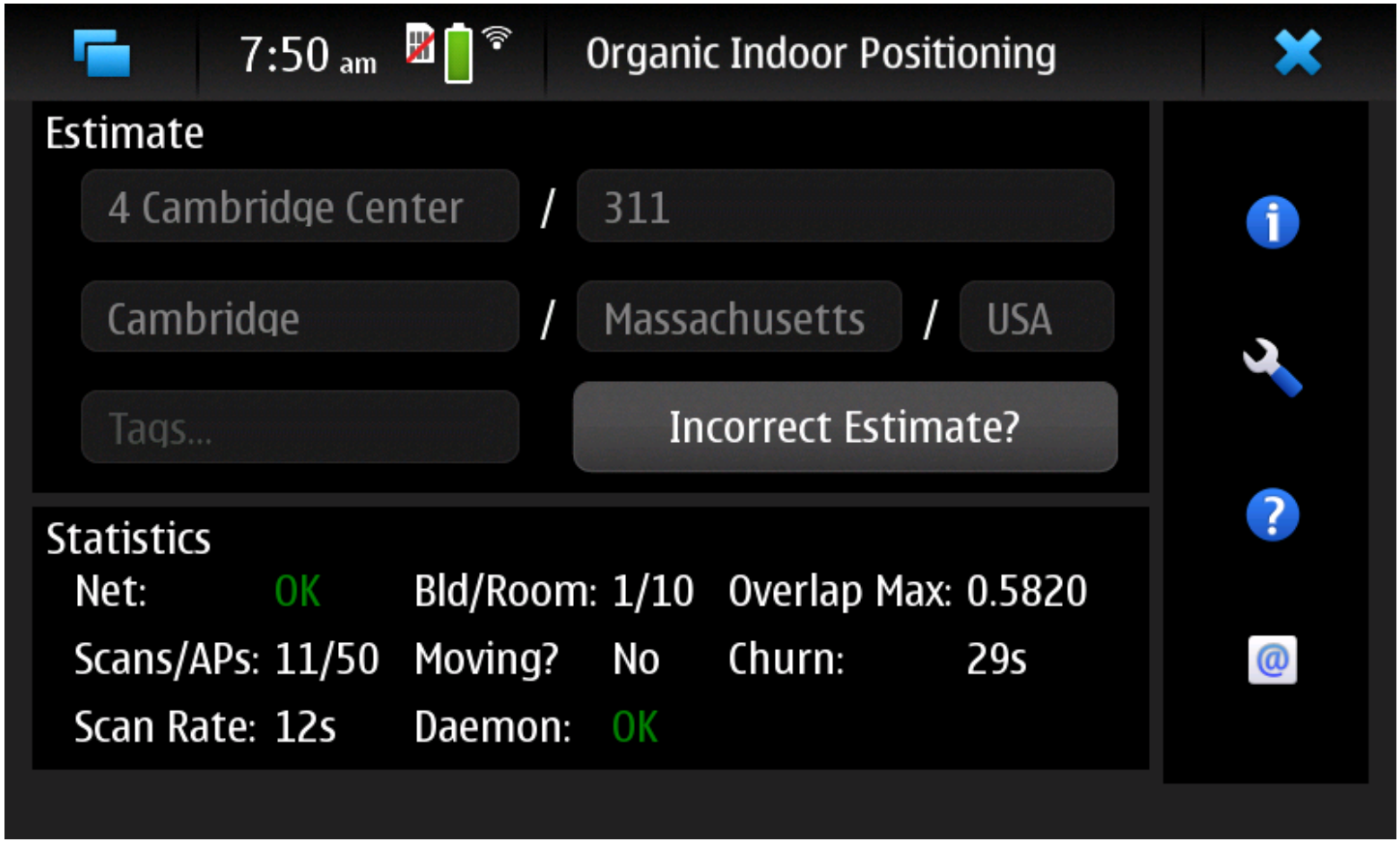
Open source

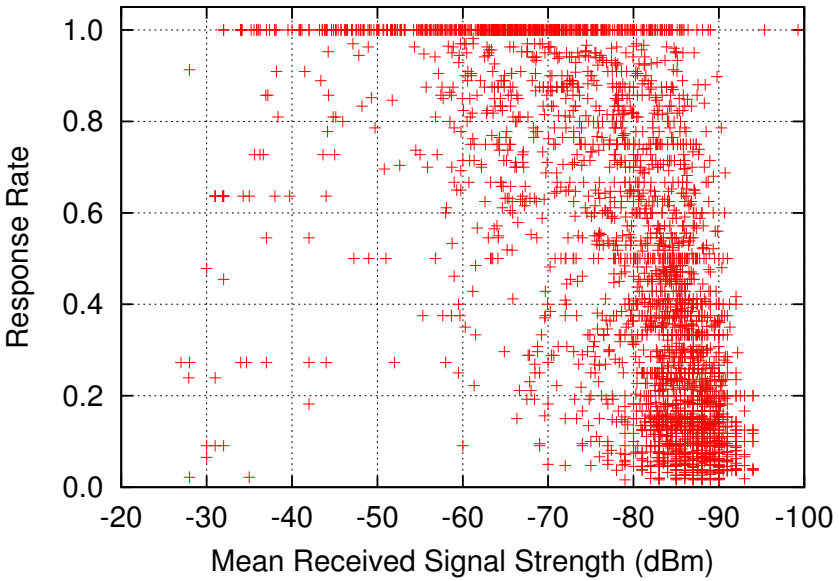
- Maemo, Ubuntu client packages available
- http://projects.developer.nokia.com/mole

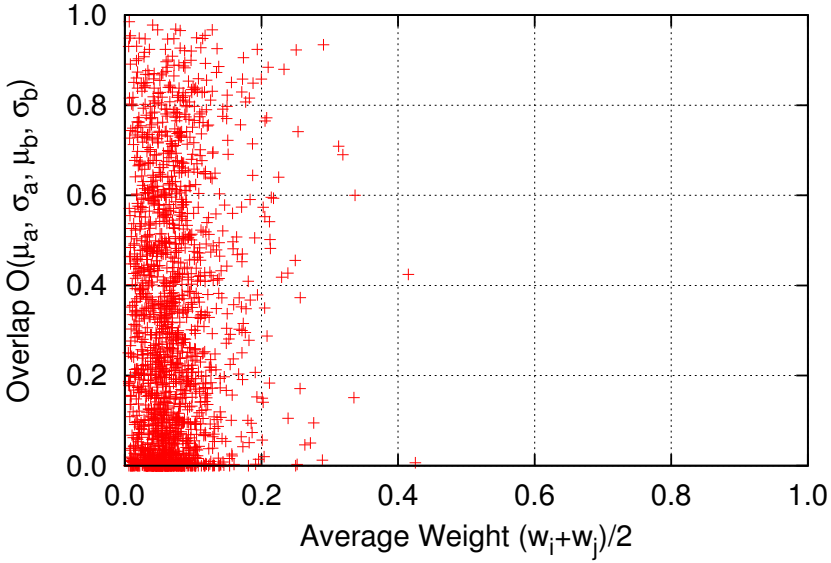
Extra Slides Follow

User Interface (Alpha)



Independence of Response Rate





81 binds from Molé (houses, offices)
Mean RSSI vs. response rate: $\sigma^2 = 0.62$

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Overlap vs. average weight: : $\sigma^2 = 0.11$