



## **Opportunistic and Hybrid Localization**

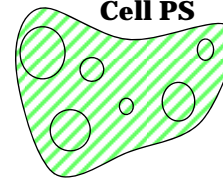
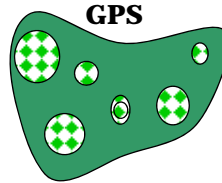
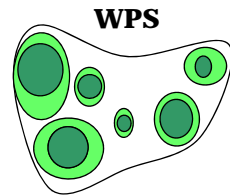
**Farshid Alizadeh  
6/17/2008**

### **Outline**

- Introduction
- WPS?
  - WPS unique features
  - Coverage and Performance
- WPS and opportunistic localization
  - GPS and Cellular
- WPS and hybrid localization
  - GPS & WPS



## Why Opportunistic and Hybrid?



<p><b>WPS</b></p> <ul style="list-style-type: none"> <li>- Urban indoor/outdoor (where people are)</li> <li>- SW solution</li> <li>- Accuracy: 20-40m (<b>Medium</b>)</li> <li>- TTFF &lt; 1 sec (<b>Good</b>)</li> <li>- Power: low (<b>Good</b>)</li> </ul>	<p><b>GPS</b></p> <ul style="list-style-type: none"> <li>- Outdoor/limited indoor</li> <li>- HW solution</li> <li>- Accuracy: &lt;10 m (<b>Good</b>)</li> <li>- TTFF : 1sec – 60sec (<b>Poor</b>)</li> <li>- Power: medium (<b>Medium</b>)</li> </ul>	<p><b>Cell PS</b></p> <ul style="list-style-type: none"> <li>- Universal coverage</li> <li>- SW solution</li> <li>- Accuracy: 150-700 m (<b>Low</b>)</li> <li>- Good TTFF &lt; 1sec (<b>Good</b>)</li> <li>- Power: low (<b>Good</b>)</li> </ul>
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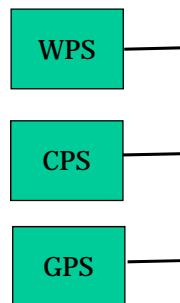
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## What is Opportunistic and Hybrid?

- Opportunistic:  
*“Integrating end results of different localization systems”*
- Hybrid:  
*“Integrating raw information and end results of different localization systems”*



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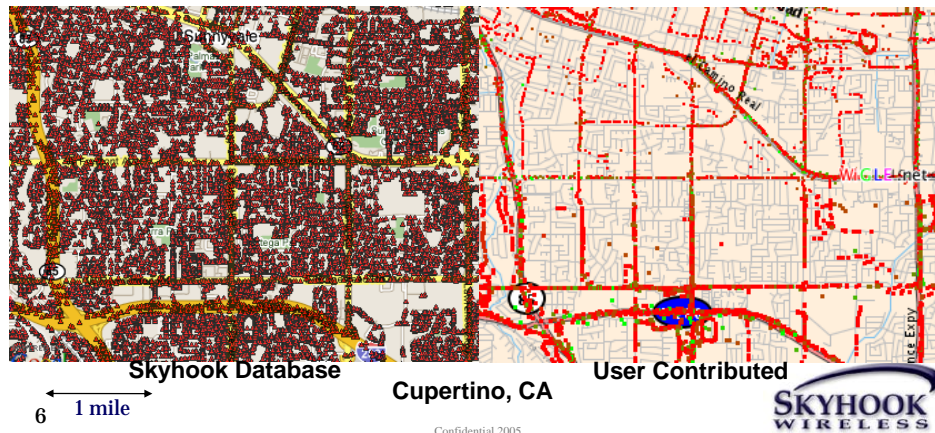
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## Finger Printing Database

- Comprehensive 360 readings per AP
- Quality assurance
- Standardized hardware
- Post-processing
  - GPS error correction, route matching

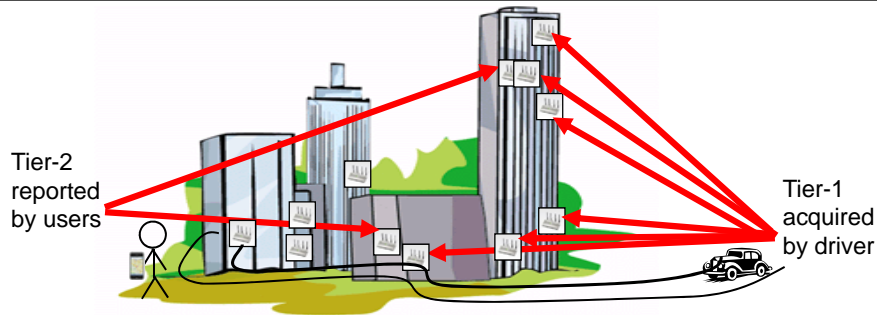


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## Universal, Self Healing Coverage



Total APs	US	Euro + Asia	Tier 2
50 million	26 m	16 m	8 m
		Downtown	Residential
		Avg # of detected APs	10-18
			5-9

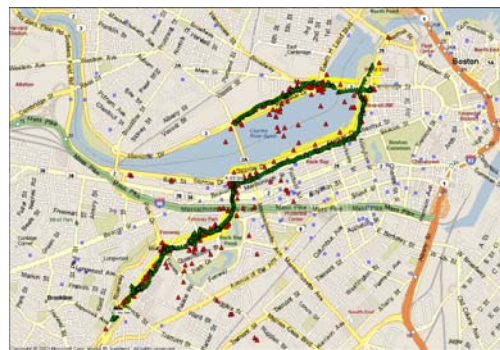
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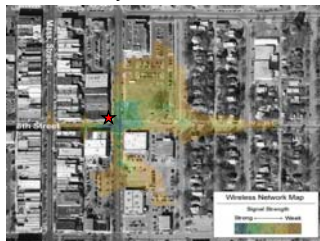


## Improve Algorithm Using QoE and CF

- QoE:  
*“Associating quality of estimate to RSS readings from different APs”*
- CF:  
*“Associating confidence factor to QoE”*



Centroid (Red) vs WPS (Green)



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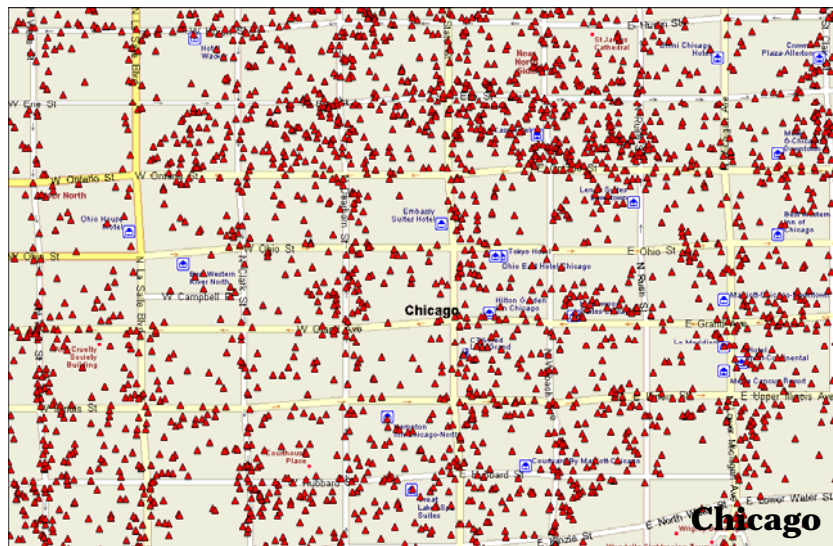
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## WPS Performance Results - Coverage



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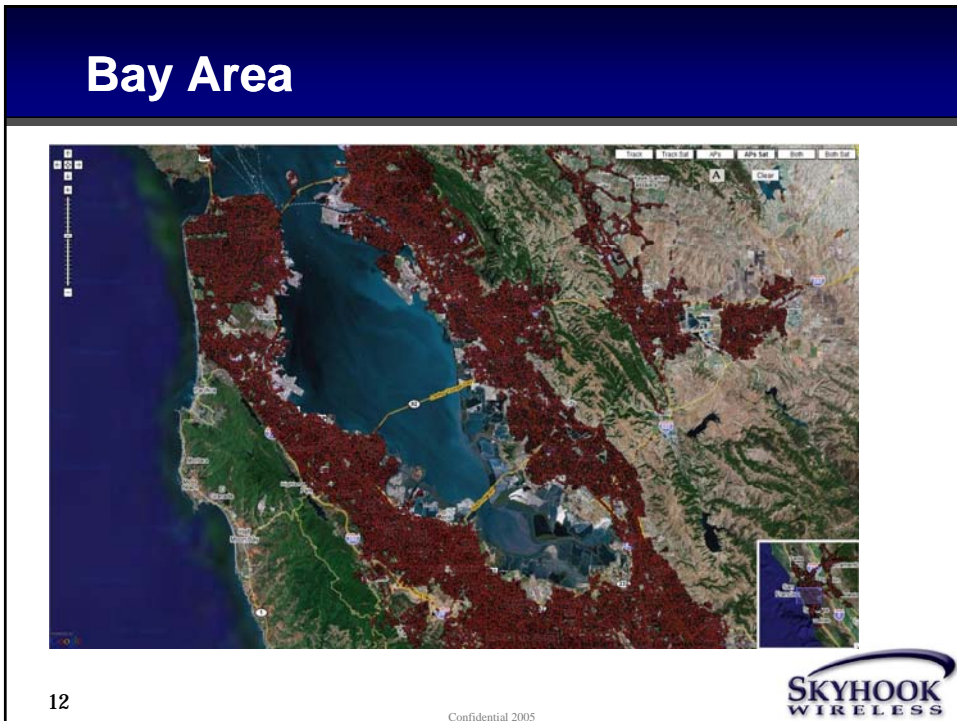




## Manhattan



## Bay Area



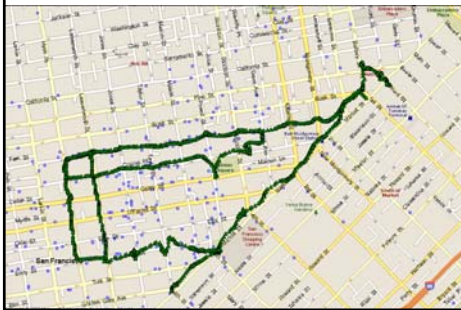


## WPS Coverage and Performance

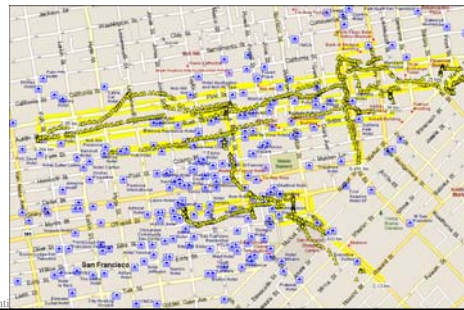
100 random points in Manhattan and San Francisco; 60 outdoor, 40 indoor

Sensor	Mode	CEP50	CEP95	TTFF	Yield
HTC- Tilt	WPS	28m	83.3m	420ms	Indoor: 98.0% Outdoor: 98.3%
HTC- Tilt	GPS	34m	115.8	>5 min	Indoor: 0% Outdoor: 33.9%

WPS



GPS



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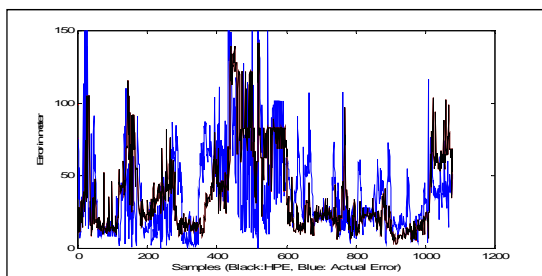
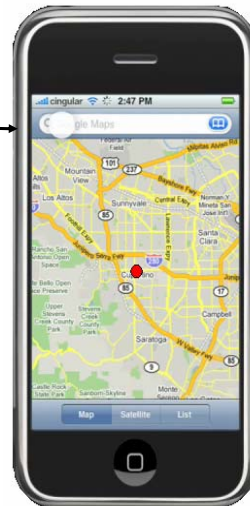
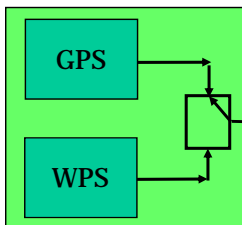
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## Complementary Opportunities GPS

### Two methods to switch

- Availability
- Using HPE



Accuracy of HPE algorithm in WPS

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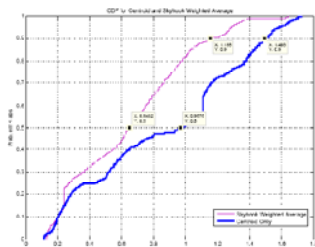
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## Complementary Opportunities Power Based Cell Positioning

- Cell pos accuracy is decisively less than WPS
- Switching based on availability of WPS

	Urban	Suburb
Weighted Avg	230m	650m
Nearest Neighbor	70m	316m



CDF prepared by Ferit Akgul

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WPS

Cell







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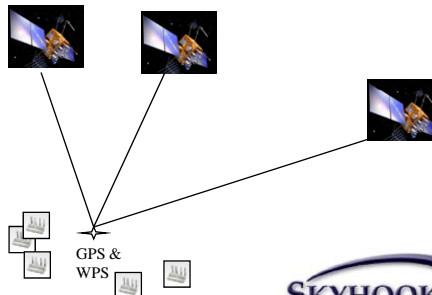
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## Hybrid Positioning

	Universal coverage	Reduced TTFF	Effective power mgt	Best accuracy
Opportunistic	✓	✓	✗	✗
Hybrid	✓	✓	✓	✓

- Integrating GPS and WPS raw measurements
  - GPS with no fix & partial measurements can improve accuracy
- Power consumption is minimized at the system level



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## Hybrid – GPS + WPS Accuracy

	<b>GPS</b>	<b>WPS</b>	<b>Hybrid</b>
<b>50% Error</b>	<b>N/A</b>	<b>68.0 m</b>	<b>44.5 m</b>
<b>95% Error</b>	<b>N/A</b>	<b>116.7 m</b>	<b>96.9 m</b>

- Test setup:
  - No GPS fix
  - GPS acquired 2+ satellites
  - Challenging for WPS
  - SiRF start III
  - Broadcom 1350 WLAN Mini card

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## Hybrid – GPS + WPS Power Consumption

	<b>Tracking</b>	<b>One-Shot</b>	<b>Total</b>
<b>GPS</b>	<b>130-200mW</b>	<b>8.775 – 13.5 W</b>	<b>8.19-12.6 W</b>
<b>WPS</b>	<b>130-200mW</b>	<b>0.26-0.4 W</b>	<b>0.195 – 0.3 W</b>
<b>Hybrid</b>	<b>130-200mW</b>	<b>0.94-1.45 W</b>	<b>0.535 – 0.825 W</b>

- Assumptions
  - Average warm start: 10 sec
  - GPS acquisition time out: 4 min
  - 25% of indoor no GPS signal
  - 50% tracking – 50% one-shot

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## Summary and Conclusion

- High-lighted WPS' features
- Potential of opportunistic localization to provide universal coverage and reduce TTFF
- Potential of hybrid localization to not only provide universal coverage and reduce TTFF, but also reduce power consumption and increase accuracy

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## Acknowledgement

- Prof. Kaveh Pahlavan helping with presentation
- Dr. Pratap Misra helping with hybrid localization results
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