Center for Embedded Networked Sensing

RAPS: Rate-Adaptive Positioning Systems for Energy Efficient Localization on Smartphones

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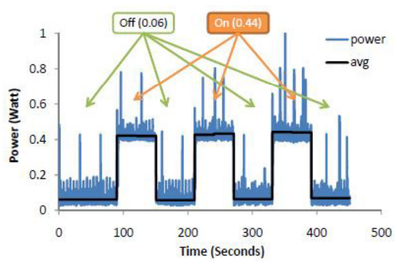
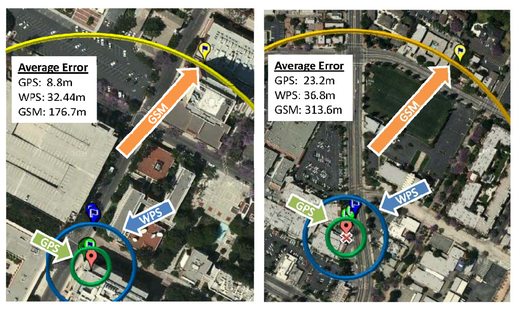
Introduction: "Trade-off position accuracy for energy"

Problem

- Many emerging smartphone applications require position information to provide location-based or context aware services.
- GPS is preferred over GSM/WiFi based methods, but ***GPS is extremely power hungry***.
- Fixed interval periodic duty cycling will not solve the problem; it may have significant error without significant energy benefits.



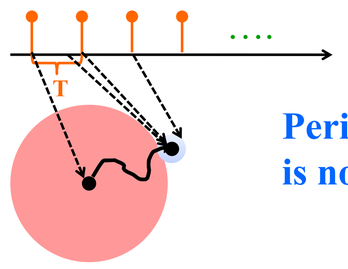


Goal

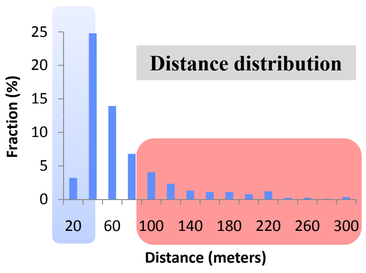
- Reduce the amount of energy spent by the positioning system while still providing sufficiently accurate position information.
- ***Trade-off position accuracy for reduced energy***.

Main Idea

- An energy-efficient positioning system that ***adaptively duty-cycle GPS*** only as often as necessary to achieve required accuracy based on user mobility and environment.

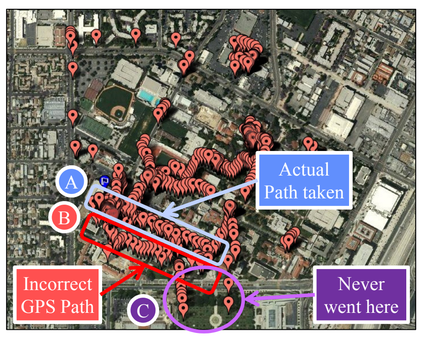


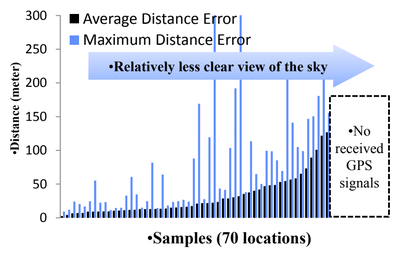
Periodic duty-cycling is not good enough



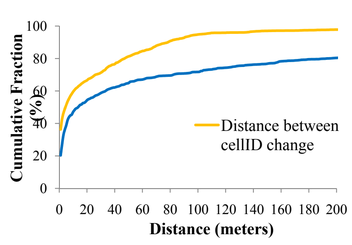
Observations and Challenges: "GPS is less accurate in urban areas"

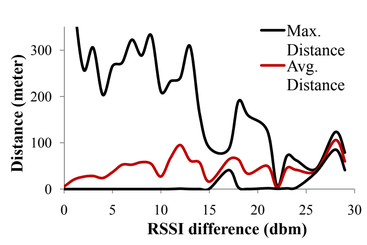
GPS is less accurate in urban areas

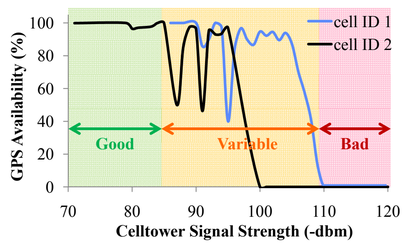




Cell-tower and RSS data cannot reliably measure user movement, but can detect GPS unavailability.





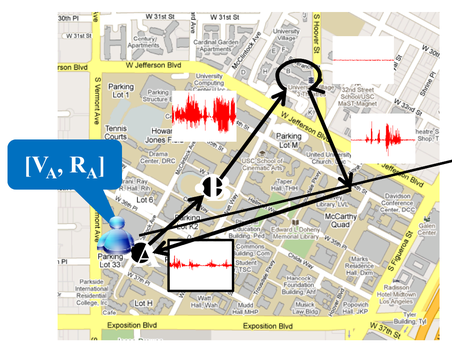


Design and Evaluation: "Use cheaper sensors to rate-adaptively duty cycle GPS"

RAPS Components

- Determine when and when not to turn on GPS efficiently using the cheaper sensors available on a smartphone

- **Movement Detection**
  - Use ***duty-cycled accelerometer*** with onset detection algorithm to efficiently measure the activity ratio of the user.
- **Velocity Estimation**
  - Use ***space-time history*** of the past user movements along with their associated activity ratio to estimate current user velocity.
- **Unavailability Detection**
  - Use ***celltower-RSS blacklisting*** to detect GPS unavailability (e.g. indoors) and avoid turning on GPS in these places.
- **Position Synchronization**
  - Utilize ***Bluetooth-based position synchronization*** to communicate and reduce position uncertainty among neighboring devices.



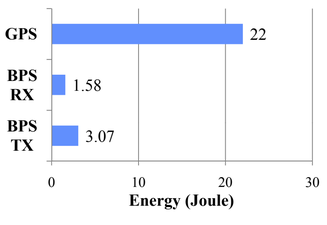
$$V_A = \frac{\text{distance}_{A\to B}}{\text{time interval}_{A\to B}}$$

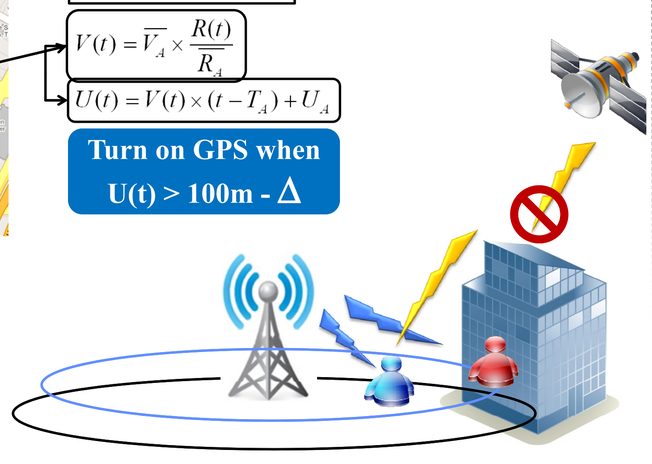
$$R_A = \text{activity ratio}_{A\to B}$$

$$V(t) = \overline{V_A} \times \frac{R(t)}{\overline{R_A}}$$

$$U(t) = V(t) \times (t - T_A) + U_A$$

Turn on GPS when U(t) > 100m - Δ

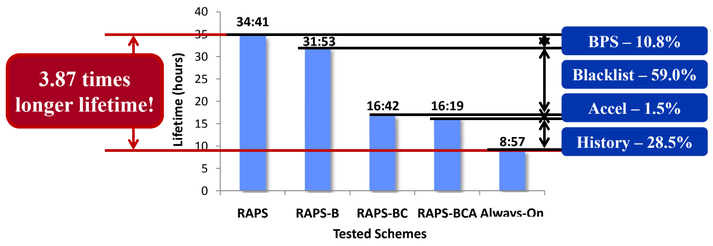




Do not turn on GPS when not available!

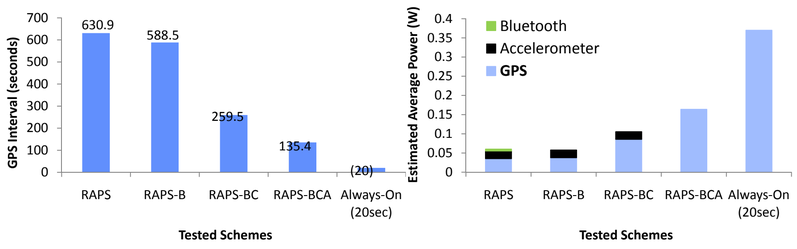
Evaluation Results – *3.87times longer lifetime!!*

Lifetime of the phones



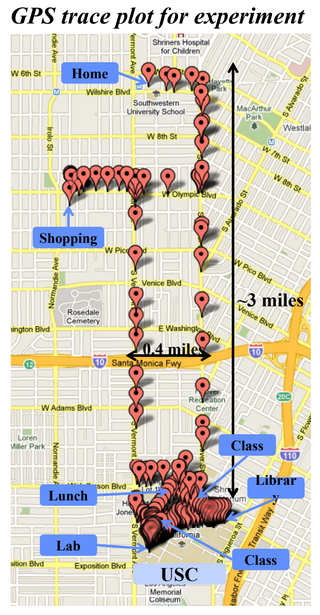
Six different schemes used for evaluation

	History	Accel.	Cell-RSS Blacklist	BPS
RAPS (2)	○	○	○	○
RAPS-B	○	○	○	×
RAPS-BC	○	○	×	×
RAPS-BCA	○	×	×	×
Always-On	Always on GPS			

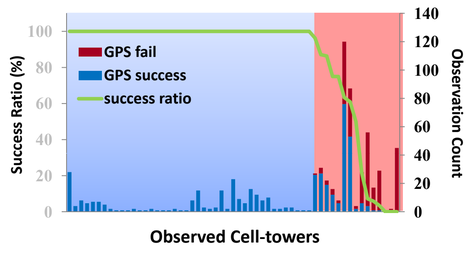


RAPS reduced energy consumption by 48% over fixed duty-cycles with comparable accuracy also.

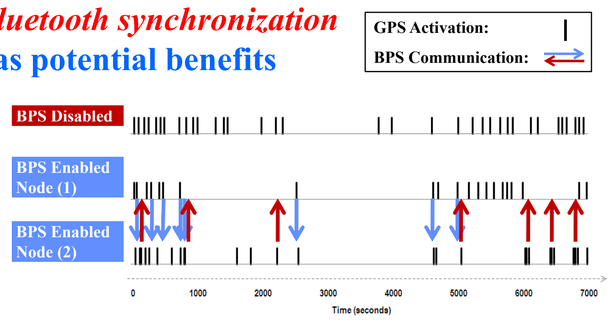
GPS trace plot for experiment



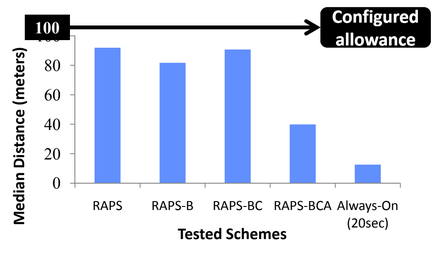
Celltower-RSS blacklisting **contributed 59% of the total lifetime increase**



Bluetooth synchronization **has potential benefits**



Median distance between two GPS updates



Jeongyeup Paek, Joongheon Kim, Ramesh Govindan, **Energy-Efficient Rate-Adaptive GPS-based Positioning for Smartphones**, *ACM MobiSys*'10.

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