University of Pittsburgh

Footfall – GPS Polling Scheduler for Power Saving on Wearable Devices

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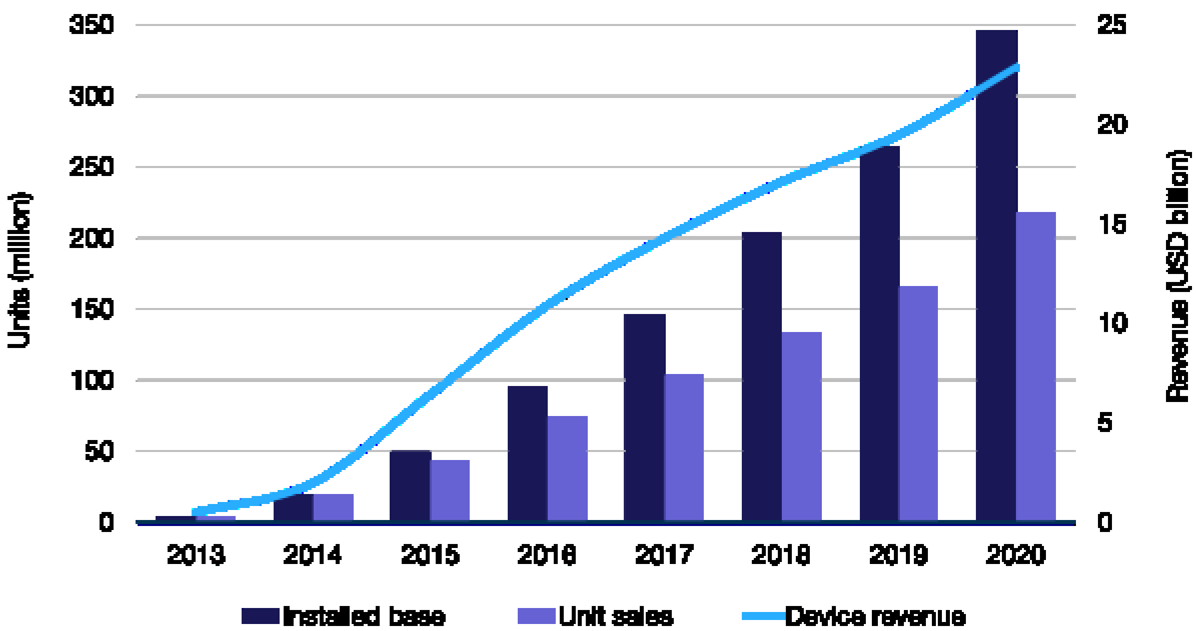
Talk Outline

- Background
- Current GPS Usage Model
- Footfall Design and Implementation
- Experiment and Evaluation
- Conclusions

Smart Wearables

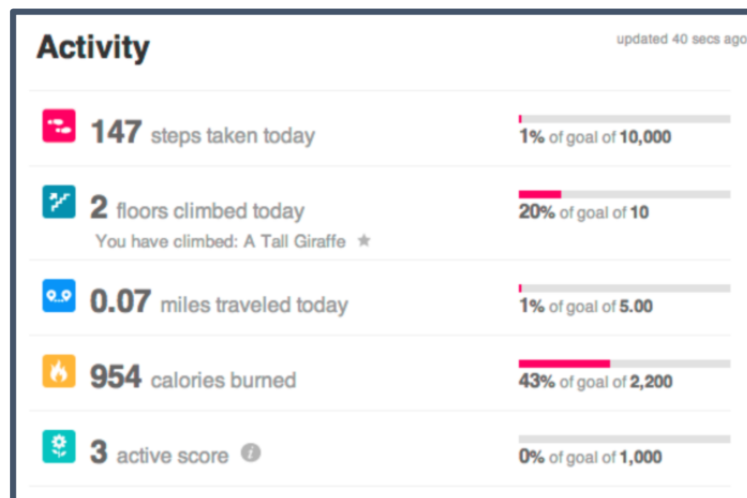
- Computing device that is worn on the body
  - Smartwatch, fitness tracker, eyewear, etc.
- Growing segment of electronics market
  - 350 million devices installed by 2020



*http://www.ccsinsight.com/press/company-news/2332-wearables-market-to-be-worth-25-billion-by-2019-reveals-ccs-insight

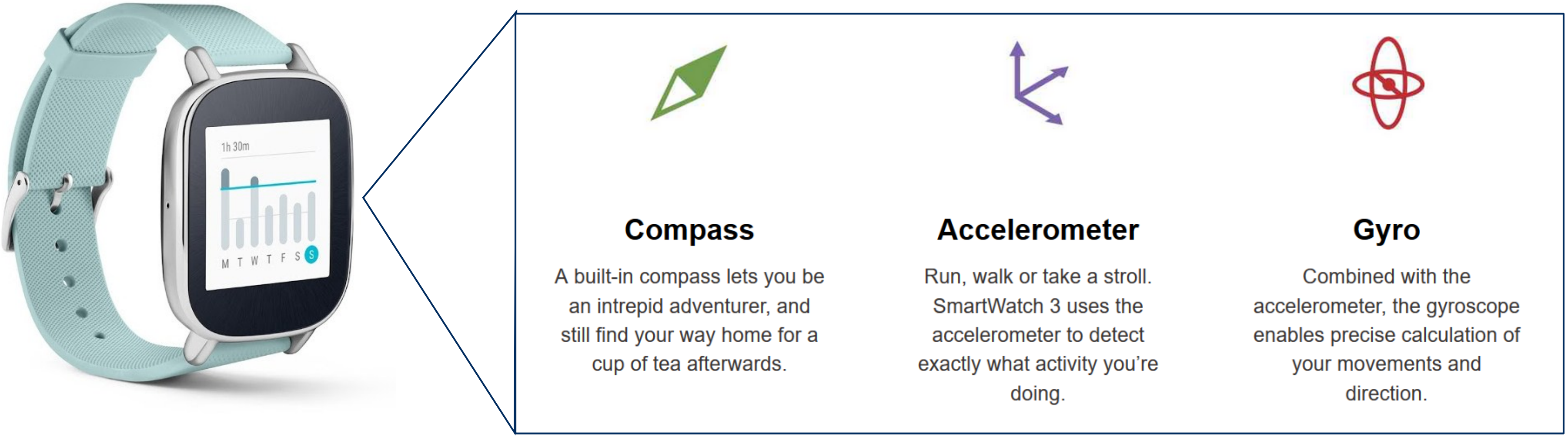
Wearable Use

- Most common use of smartwatches is fitness/activity tracking
- Fitness/activity trackers projected to make up more than 50% wearable sales in 2019



Tracking Fitness

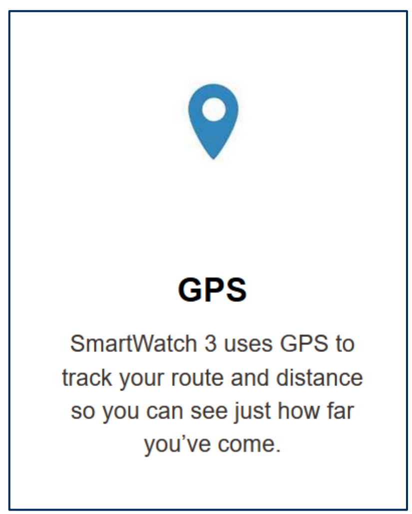
- Accomplished with embedded sensors
  - Accelerometer, gyroscope, heartrate sensors, etc.
- Logged and later transferred to another processing/visualizing unit

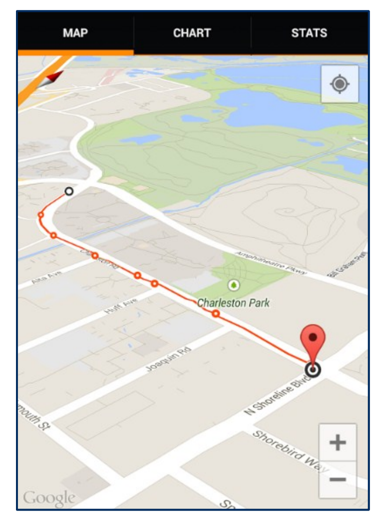


*http://www.sonymobile.com/global-en/products/smartwear/smartwatch-3-swr50/

Role of GPS in Wearable

- Wearables begin to include GPS in order to directly sample location information
- Goal: Track distance traveled in real time, reconstruct traveled route for later viewing
- Useful for both calorie tracking and training





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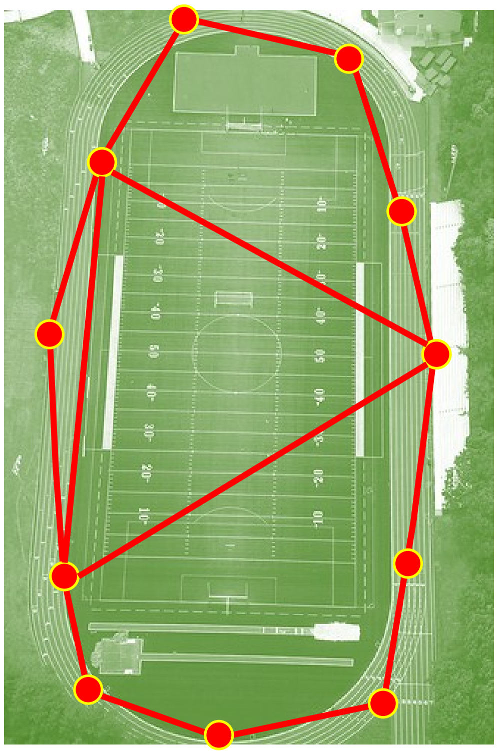
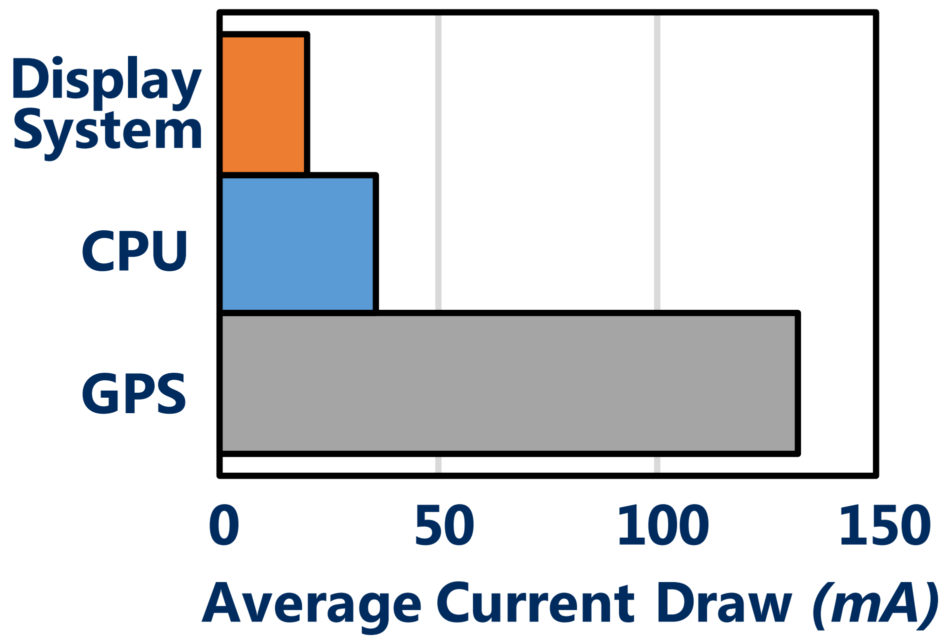
Weaknesses of GPS

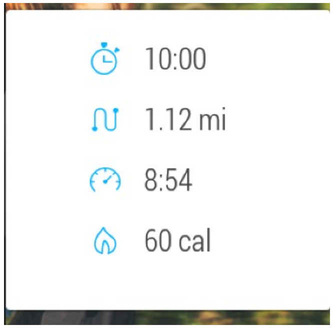
- Accurate distance measurement is difficult
- High power consumption when enabled

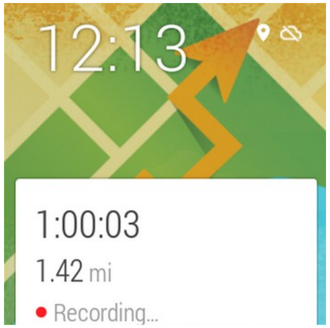




Existing Applications

- Existing fitness apps request high sample rate when recording route
- Forces GPS unit into high power mode
- 30 minutes of GPS = 20% of battery capacity



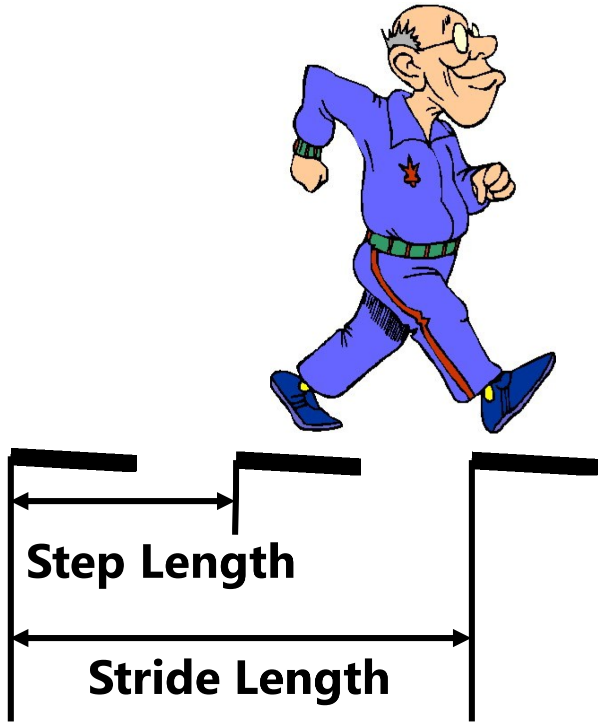


Research Question

- Can we provide target features at lower power by…
  - Using existing sensors instead of GPS to accurately estimate distance traveled?
  - Reconstructing the traveled route in a more intelligent manner?

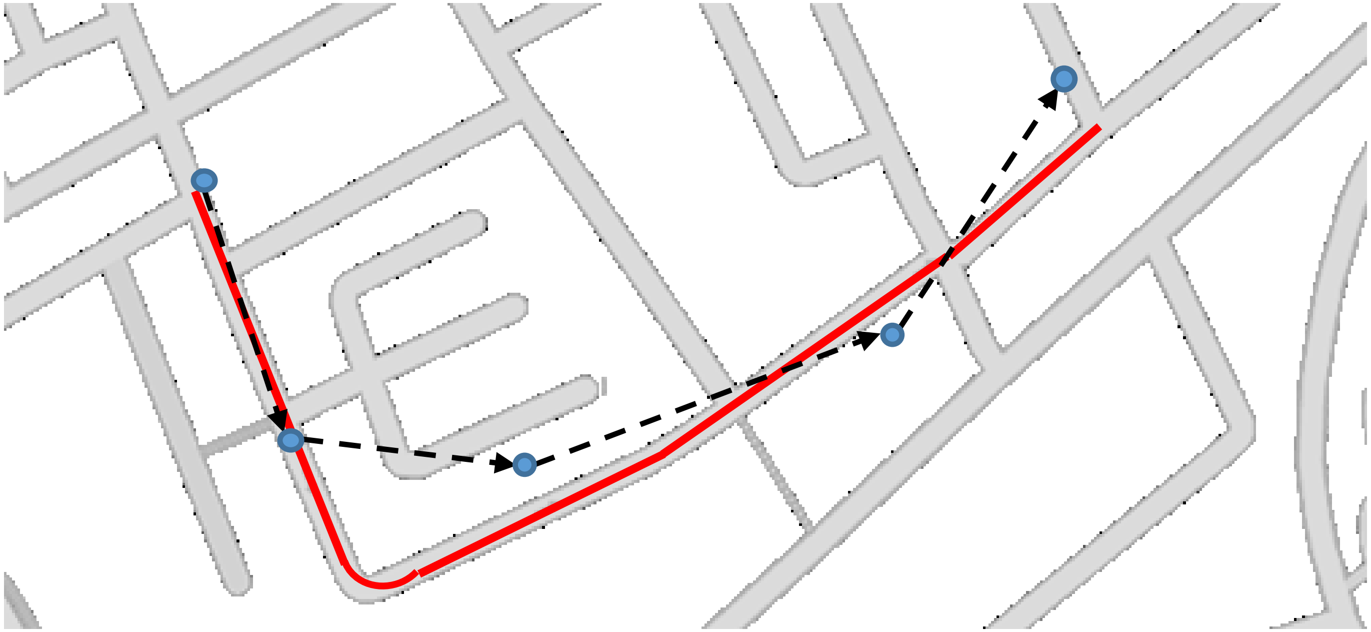
Feature #1: Distance Traveled

- Smartwatch already records step count
  - Very mature technology
- Combine with stride length to get distance



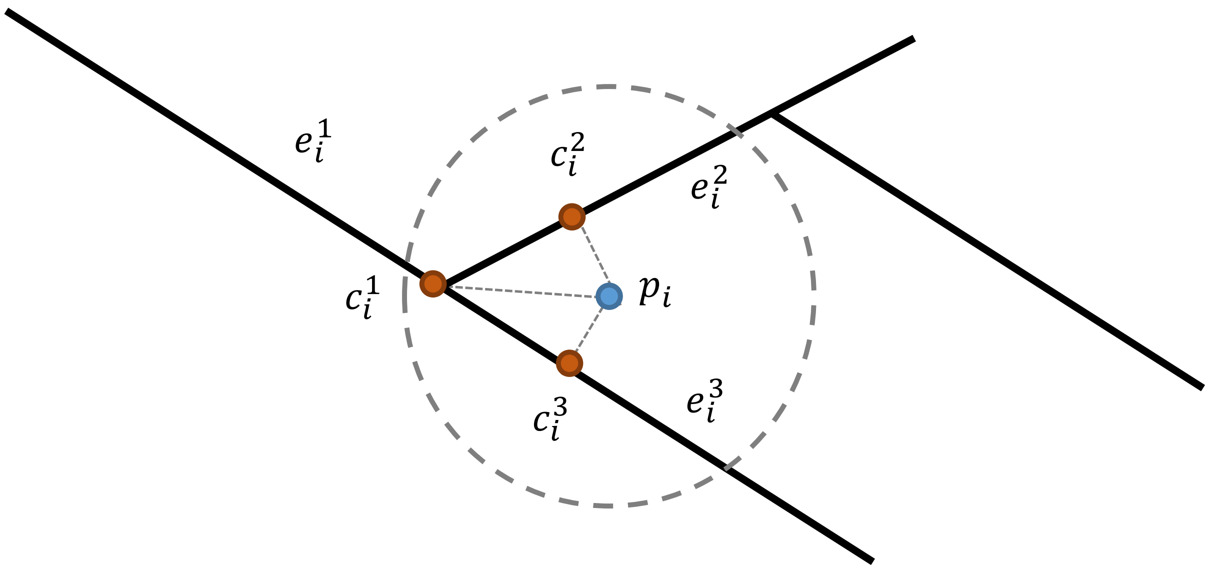
Feature #2: Route Traveled

- Can utilize map-matching algorithms (MMA's)
- Modern MMA's can function with very sparse data

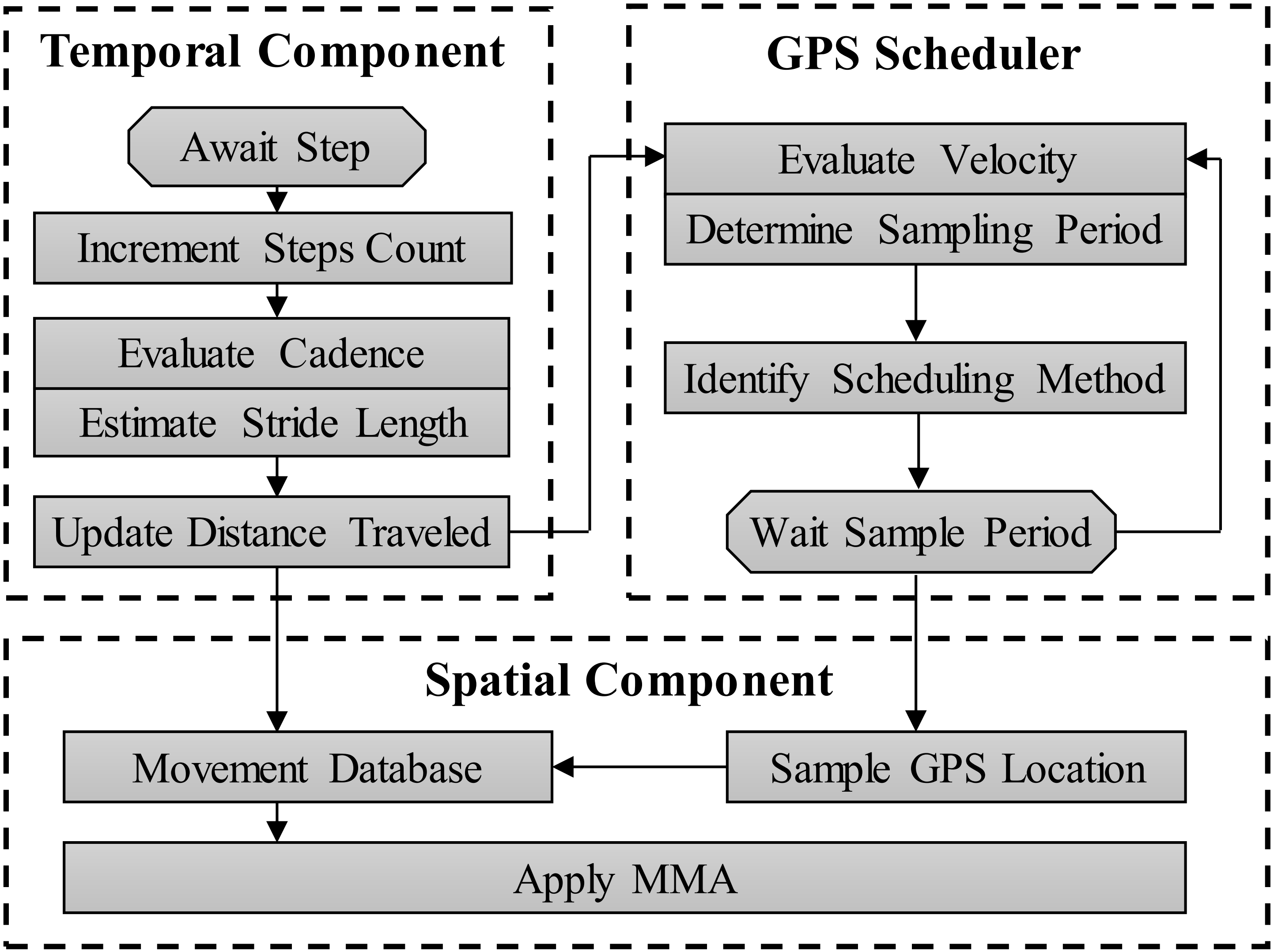


How It Works

- Road network is edges and nodes
- Location sample compared to candidate points on underlying network
- True location is considered candidate point that most closely matches observed



Footfall Design

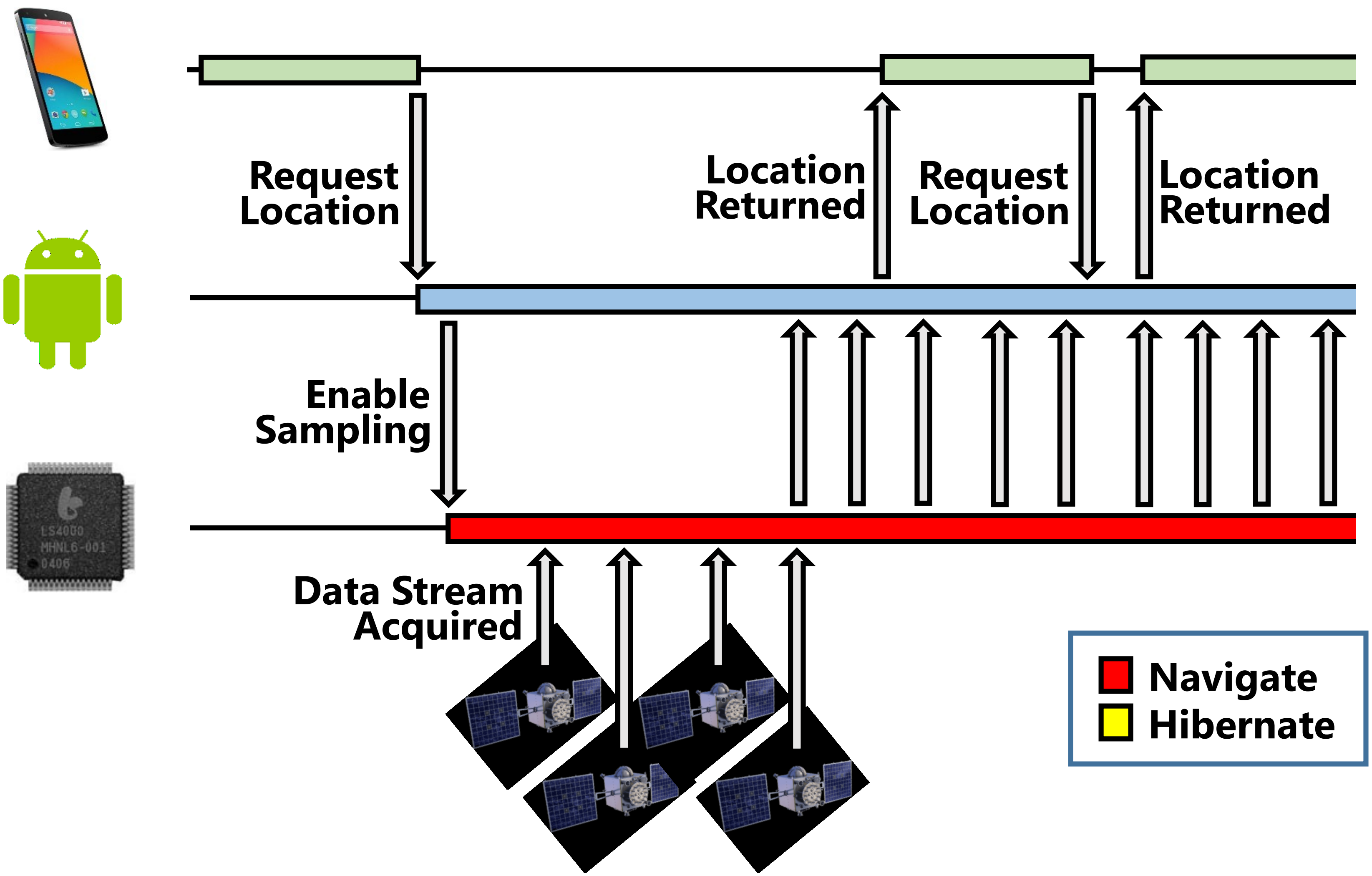


Android GPS Management

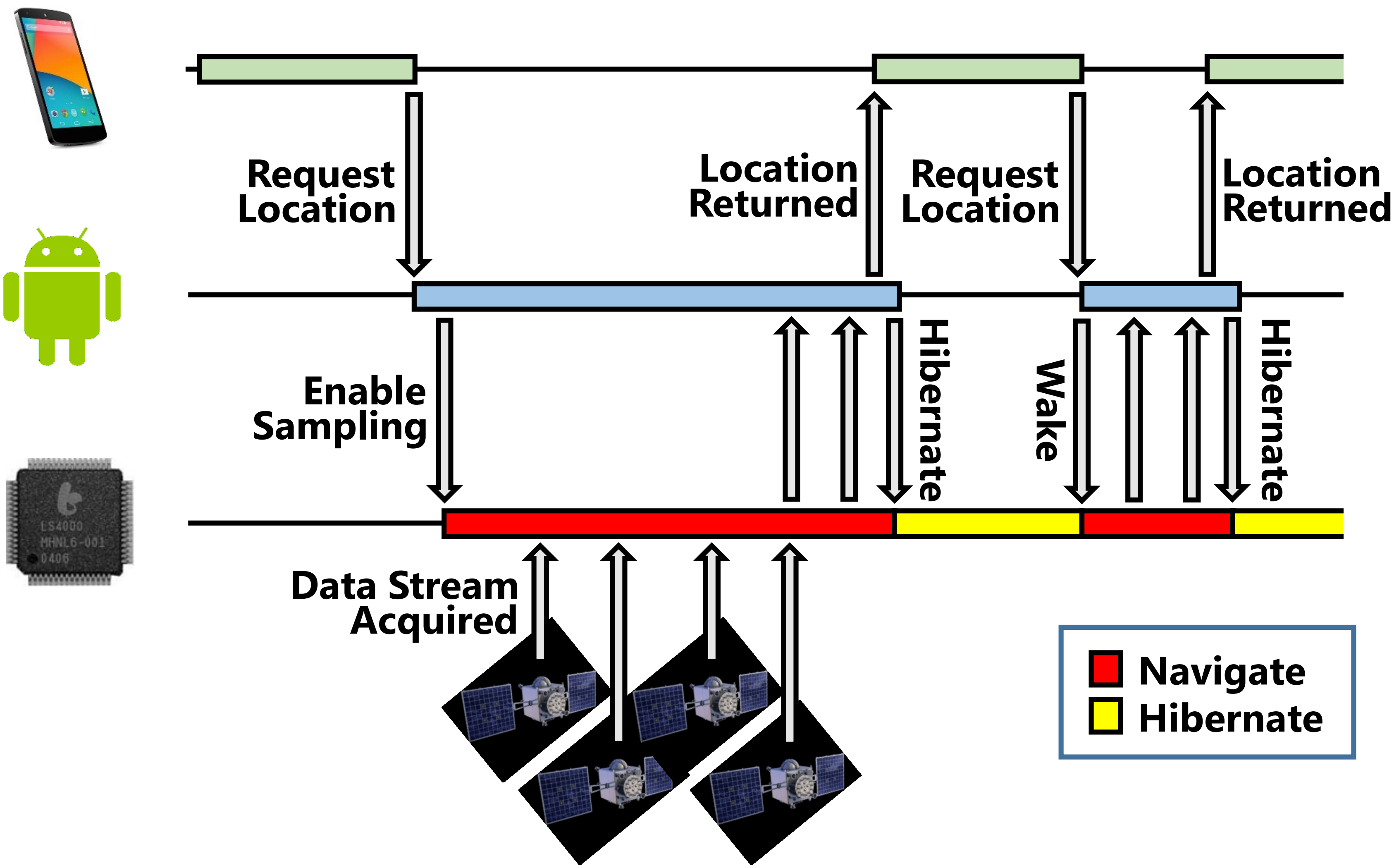
- GPS power mode is managed by system
- Hardware supports 3 power modes: navigate, hibernate, and off

Power Mode	Description
Navigate	Powered on, actively sampling
Hibernate	Powered on, not actively sampling
Off	Completely powered off

Periodic Samples, <10 Seconds



Periodic Samples, ≥10 Seconds

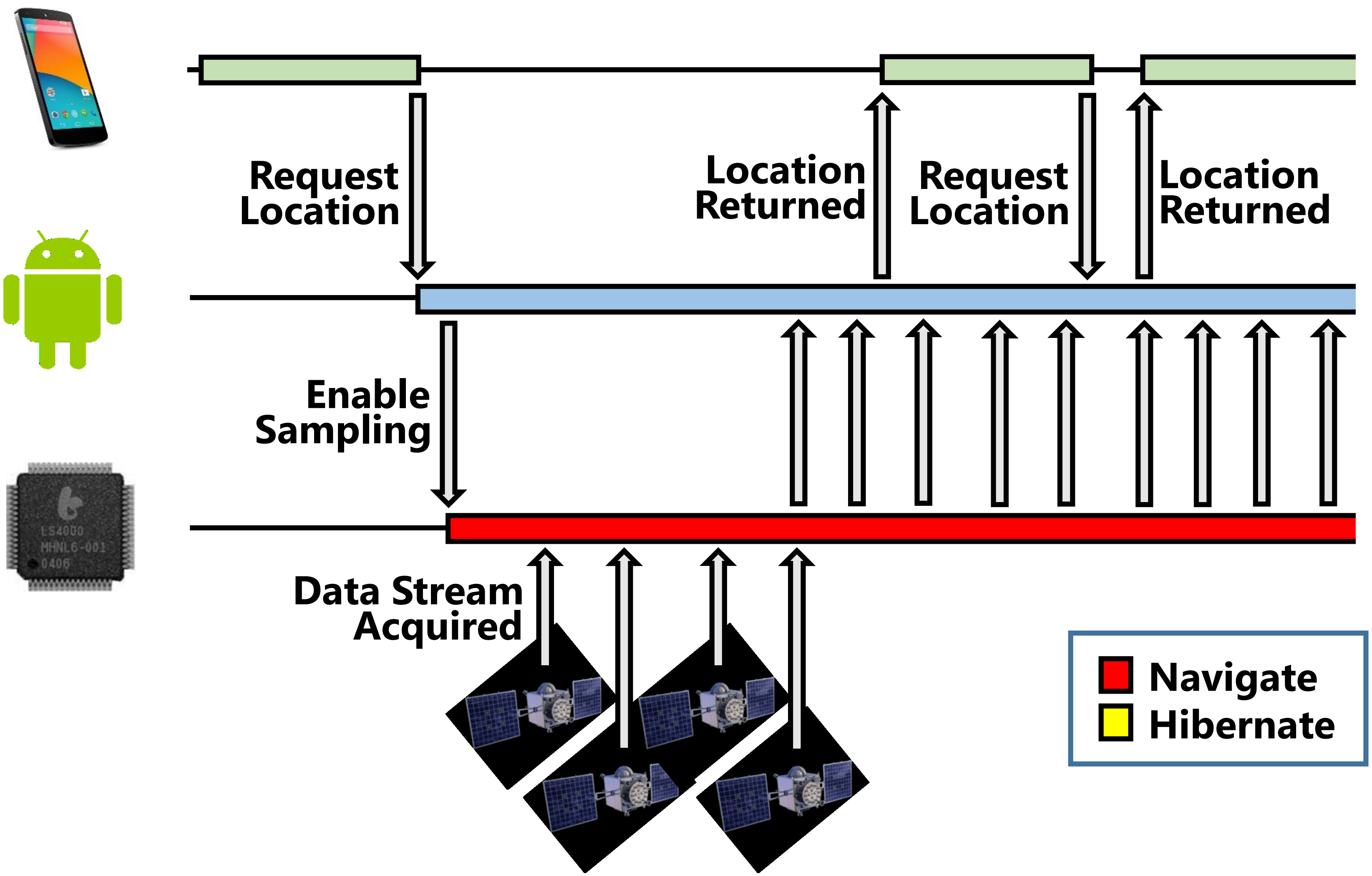


GPS Scheduler

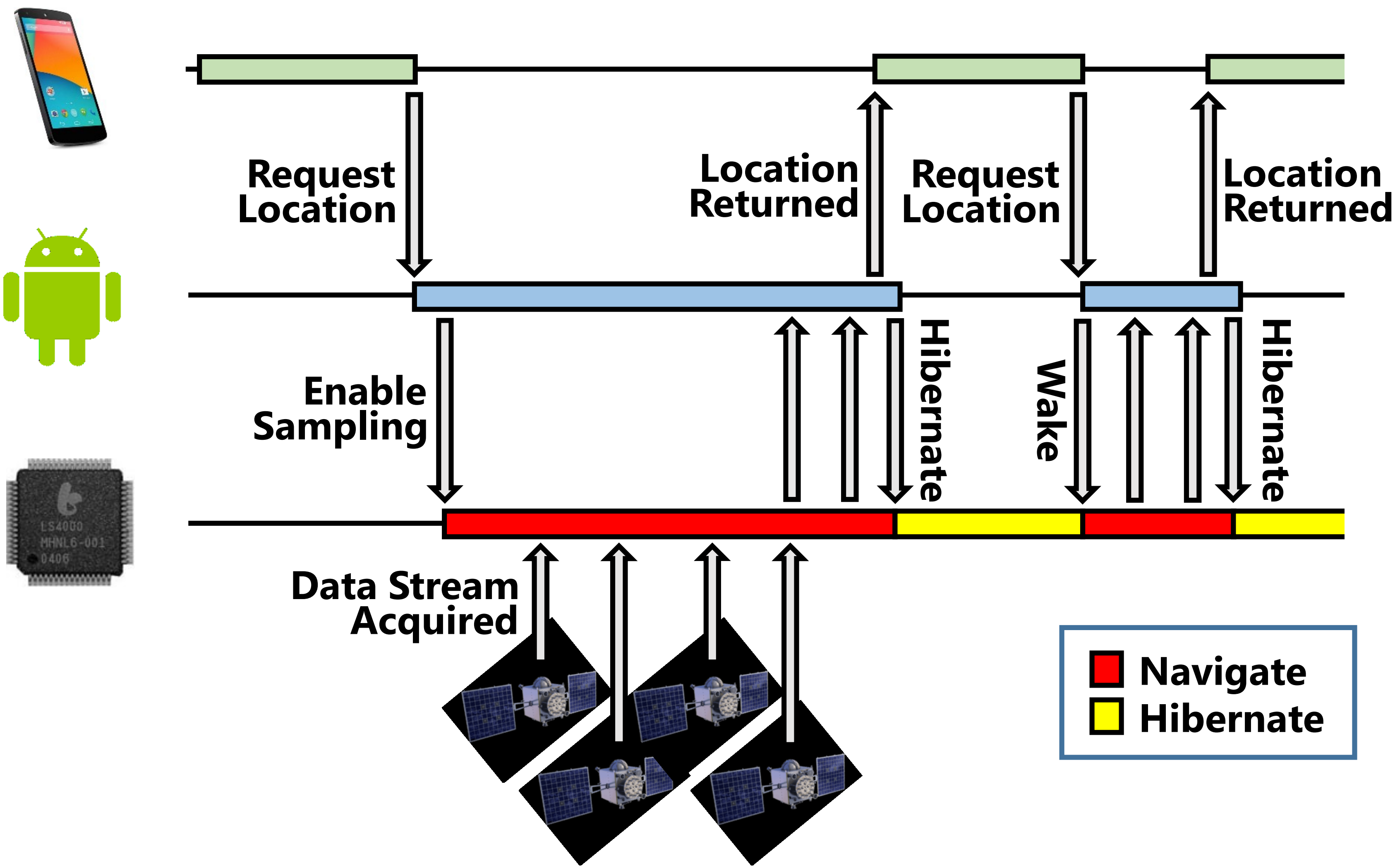
- Existing scheduler is optimized for higher sampling rate
- Can update the scheduler to more efficiently utilize the time between samples

Sample Period	Power Model
T<2	$G_{NAV} * t$
2≤T≤13	$\frac{t}{T} * \{[G_{NAV} * TTAA] + [G_{HIB} * (T - TTAA)]\}$
T>13	$\frac{t}{T} * [G_{NAV} * (TTFF + TTAA)]$

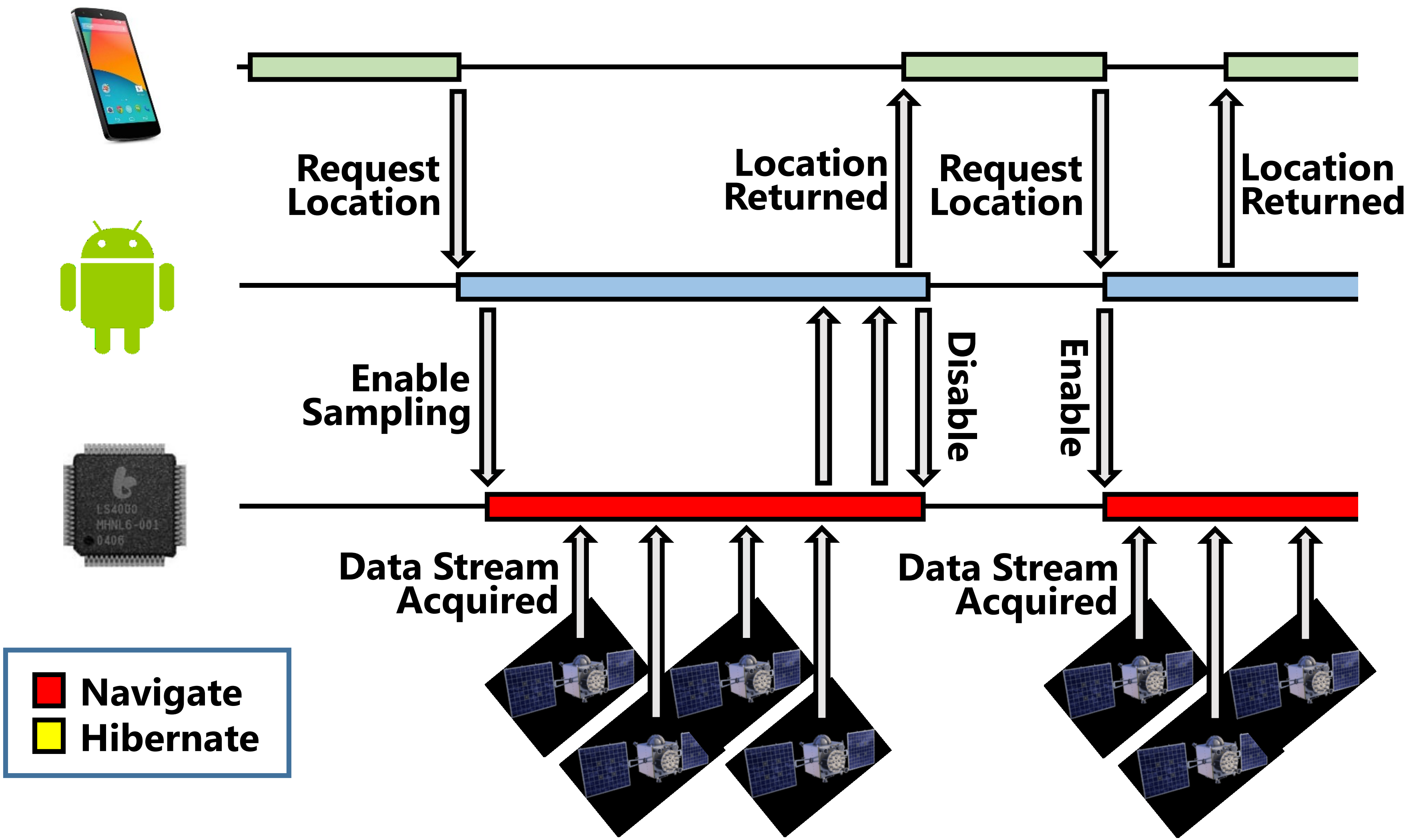
Periodic Samples, <2 Seconds



Periodic Samples, 2≤T≤13 Seconds

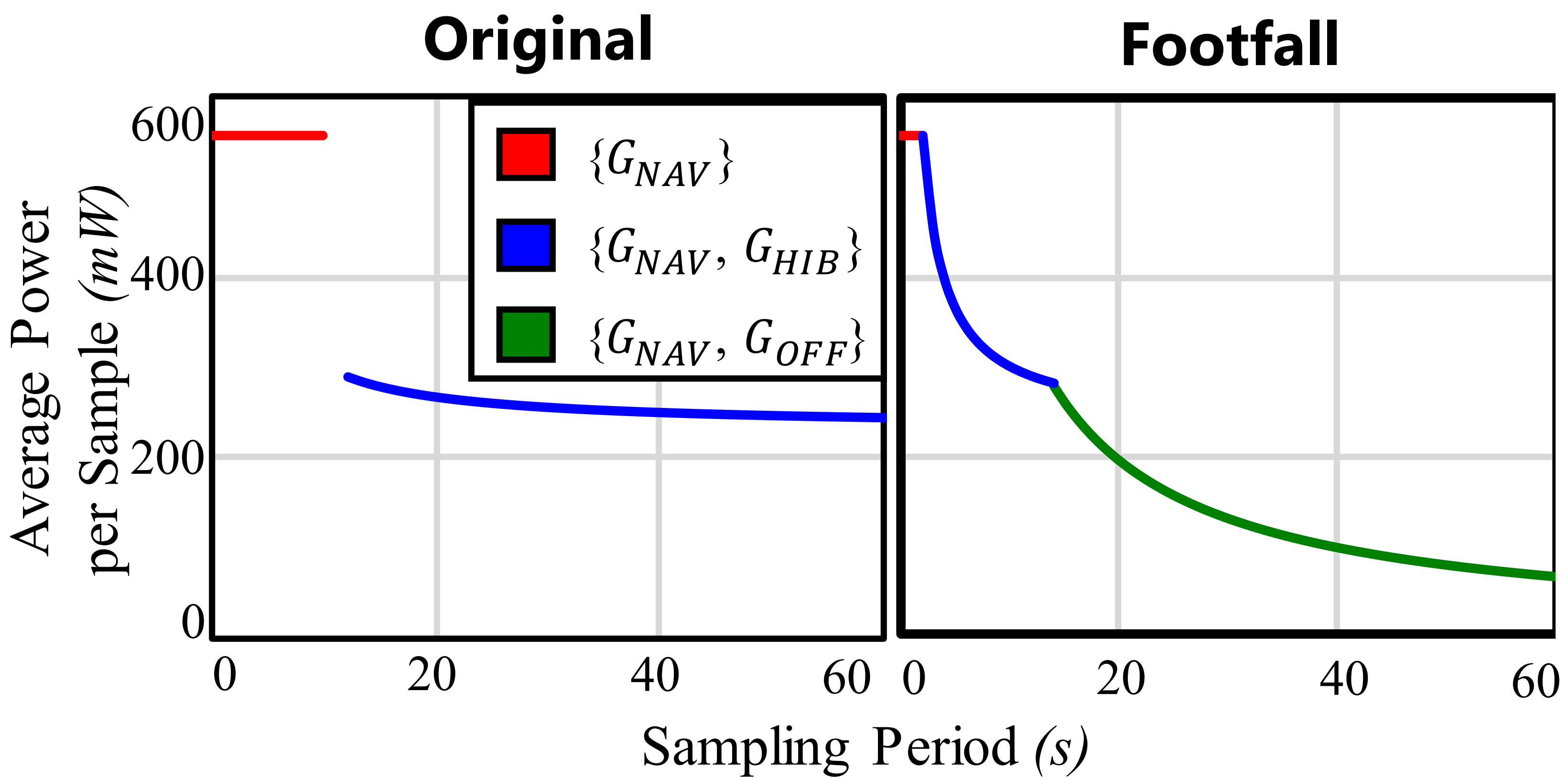


Periodic Samples, >13 Seconds

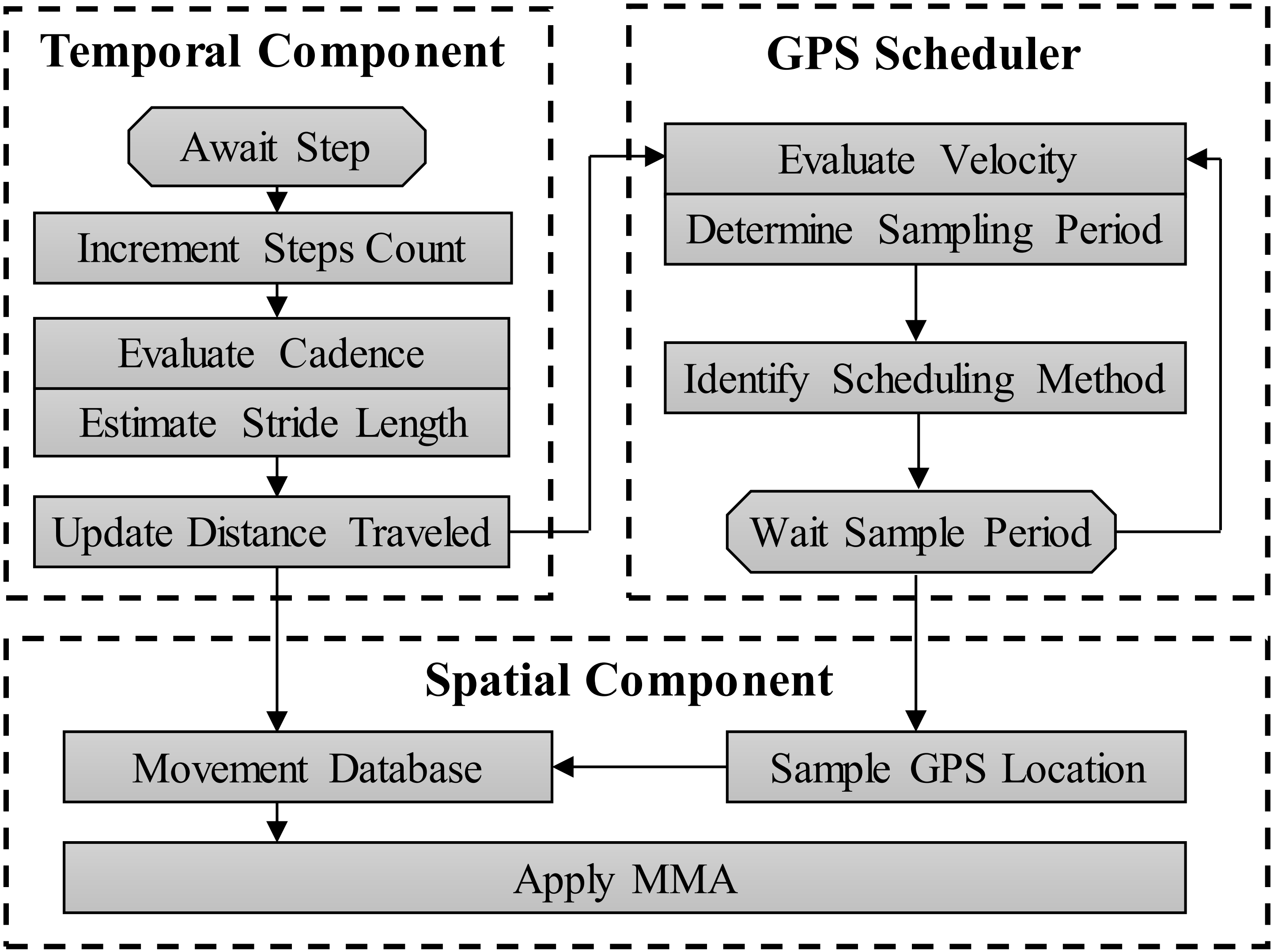


What Does This Allow?

- **Intelligently scheduling GPS power allows significant reduction in power per sample**

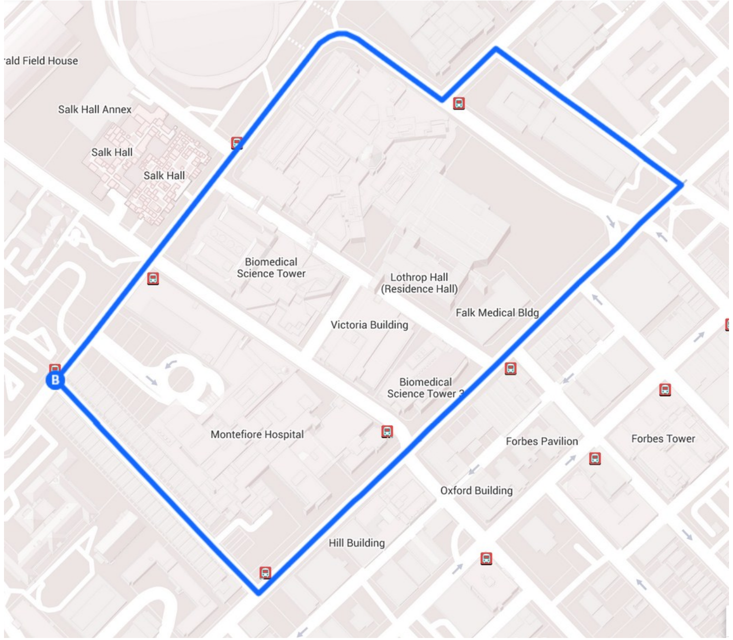


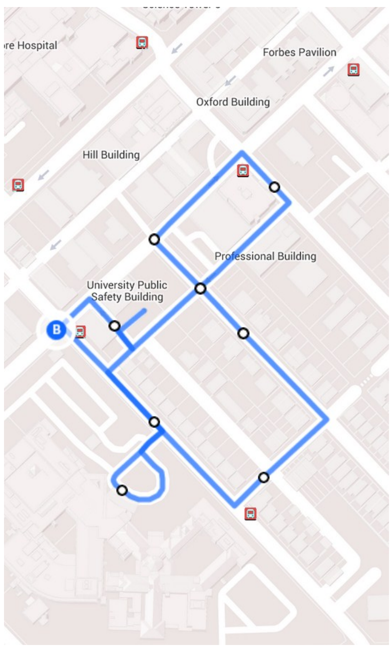
Footfall Design

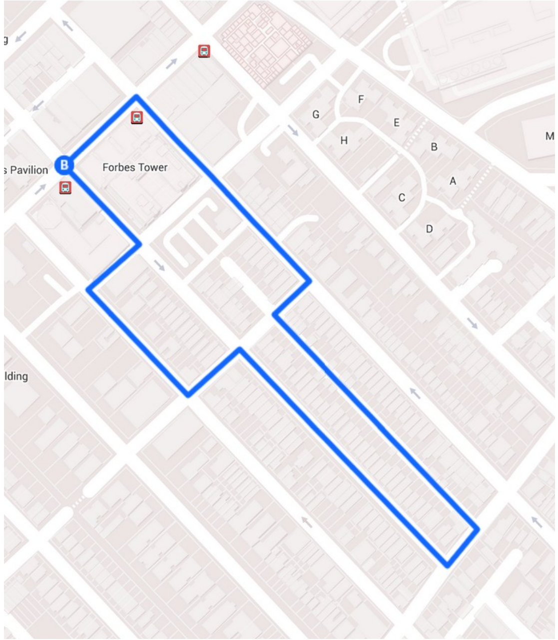


Experimental Evaluation

- Captured information from routes traveled on local roads by 5 users
- Varied in length, elevation, and underlying road network complexity

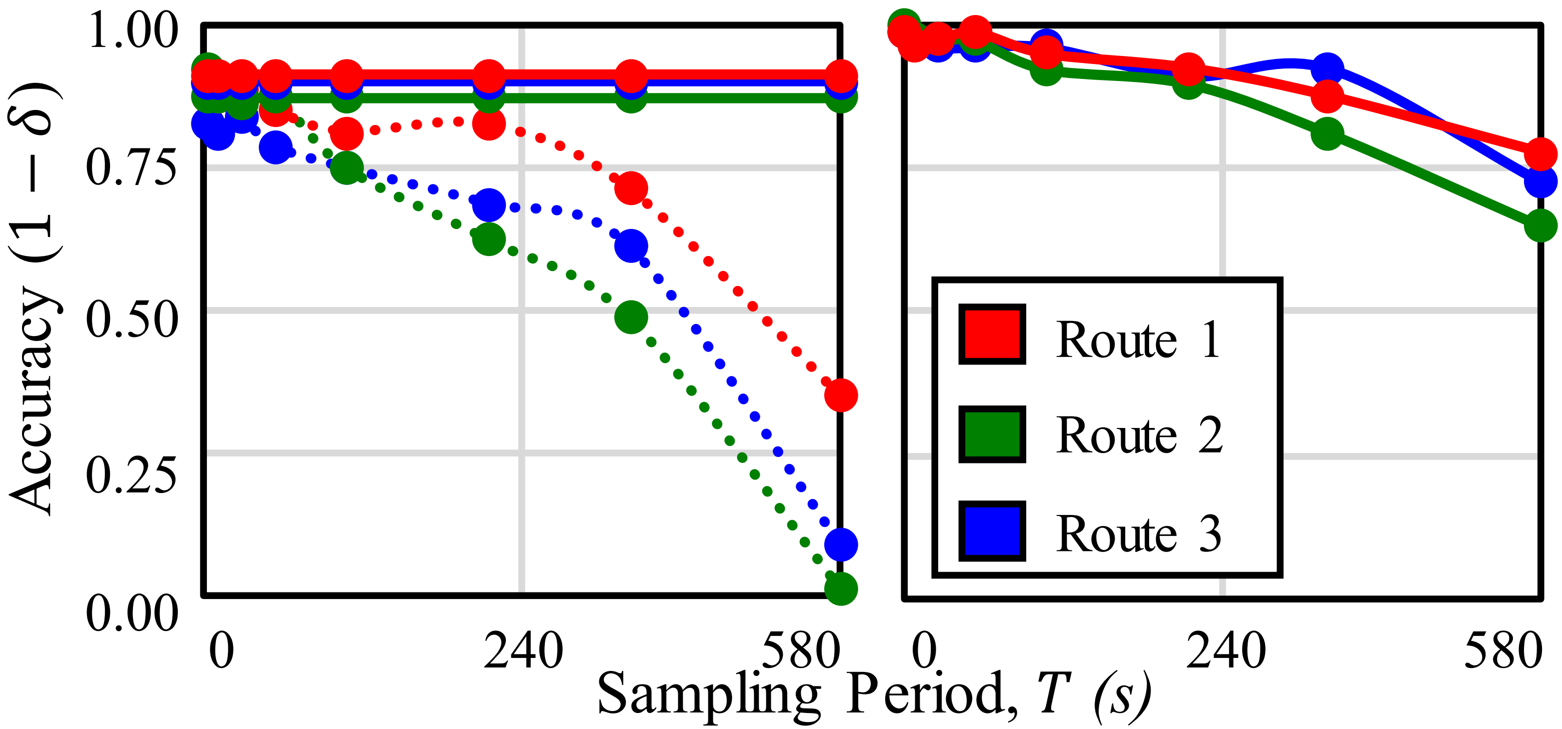




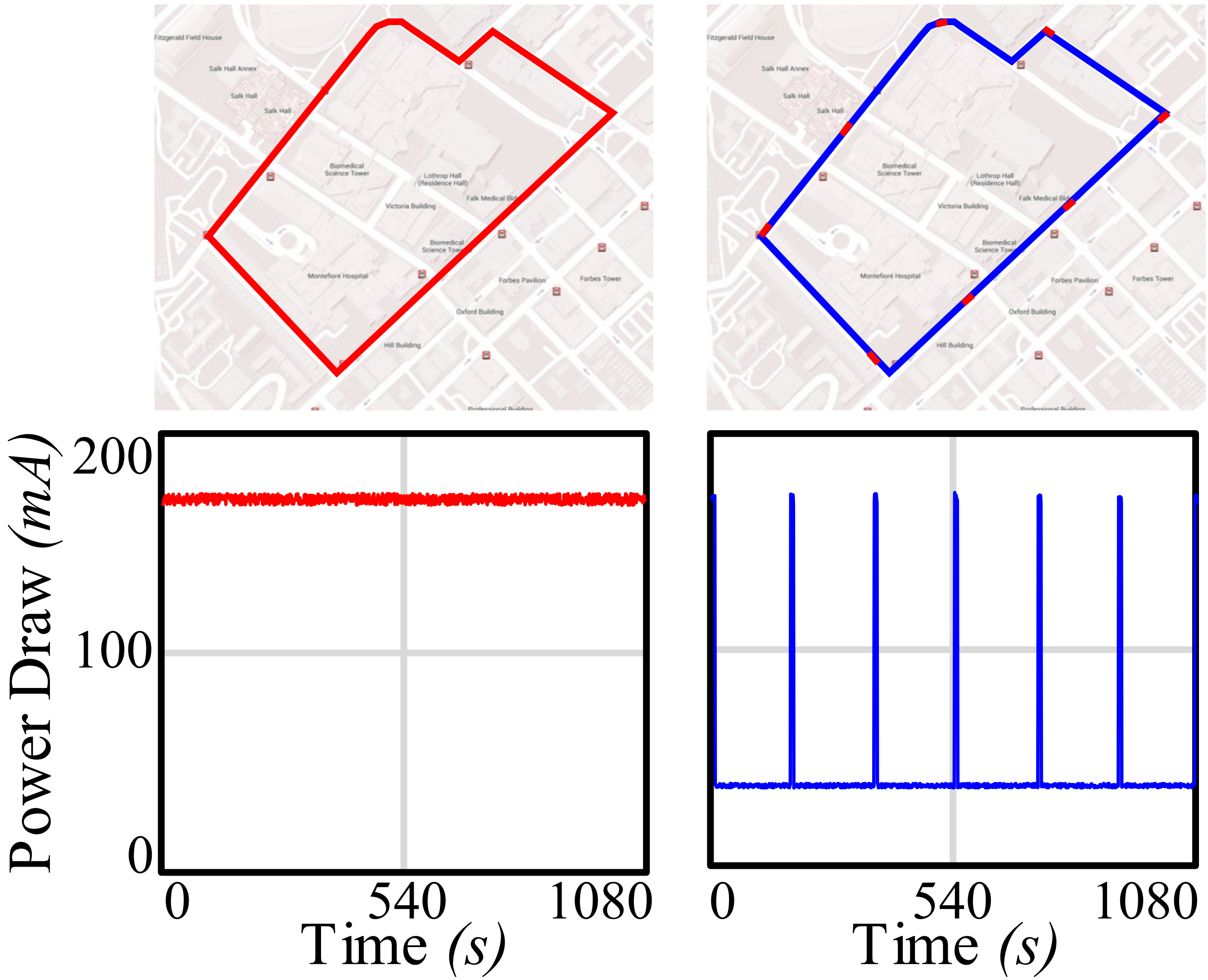


Accuracy vs Existing

- Distance traveled estimation remained high
- Route reconstruction proved robust to low sample rates

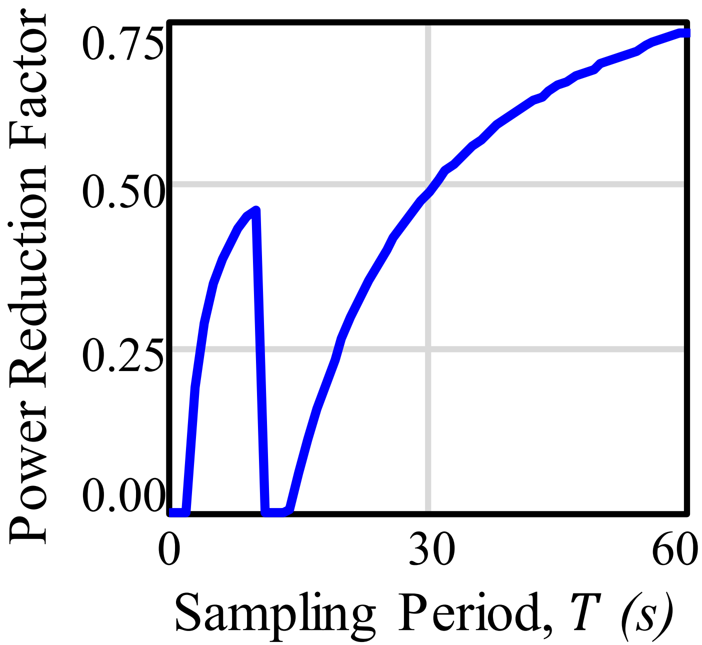


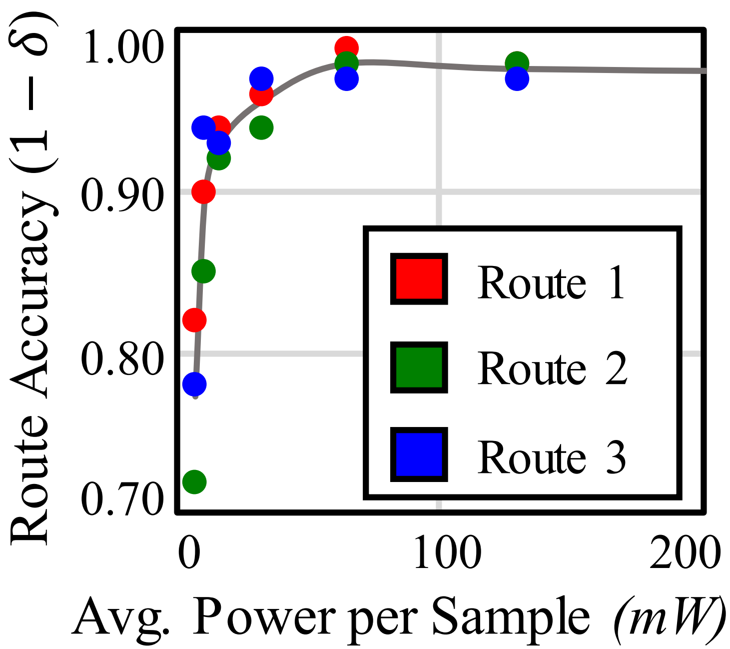
Power Picture



Reductions in Power

- Updated scheduler reduces power consumption by up to ~75%
- Obvious relationship demonstrated between power utilization and route accuracy





Conclusions

- **Existing wearable fitness application inefficiently utilize GPS capabilities**
- **GPS power overhead can be greatly reduced while still providing target features**
- **A updated GPS scheduler can provide significant power savings at low sample rate**

Thank You!