6.S062: Mobile and Sensor Computing

Class 1

http://6s062.github.io/6MOB

Lecturers

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The Lunchbox Reimagined

An intelligently designed, beautifully crafted lunchbox and smart lunch recipe app. Prepd Pack redefines the whole experience of taking lunch, from planning and preparing, to tracking the nutritional value of your lunches.

Everything You've Ever Wanted in a Personal Robot!

Expressions and gestures
Professor Einstein looks like the real Einstein and can smile, frown, and even stick his tongue out--to name a few of his 50+ gestures.

Fancy some brain-teasing fun?
Lend him your iPad™ and Android tablet, and he can play hours of interactive games with you to teach you science and math.

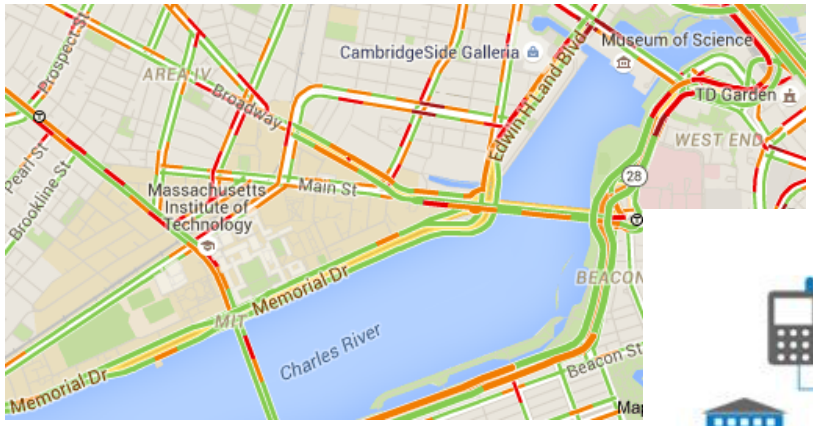
Stay organized
He will manage your calendar and to-do list. You just need to

Built-in Wi-Fi
Download new interactive apps from the cloud whenever you're ready for more learning and fun! Includes one-year of free cloud service.

Just want to talk?
He recognizes speech and loves to chatchat! He can talk about the weather, famous people, food, or math problems.

He can be recharged
Enjoy up to three hours of interaction with him every time


(MAX014 - MAX014 - 3100 Parkway Blvd - Kissimmee, Florida 2017-01-31 00:39:18
Did You Know?
YOU CAN USE OLD MOTOR OIL
TO FERTILIZE YOUR LAWN
Environmental Protection Agency


CambridgeSide Galleria
Museum of Science
TD Garden
WEST END
Massachusetts Institute of Technology
Main St
Memorial Dr
MIT
Charles River
Beacon St
Broadway
Pearl St
Brookline St
Edwin H Land Blvd
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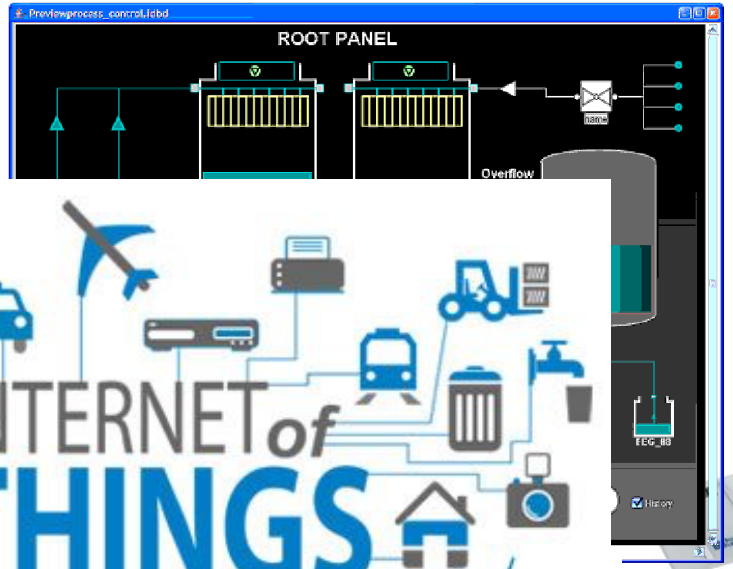

Previewprocess_control.idbd
ROOT PANEL
Overflow
name
EEG_B8
History


12:45


CONNECTED

THE INTERNET of THINGS


Glucometers
HPod
PT INR Monitors
Smart Body Scale
Oximeter
Wrist Blood pressure
Ear Thermometer
HBox
Arm Blood Pressure
HPod
WiFi

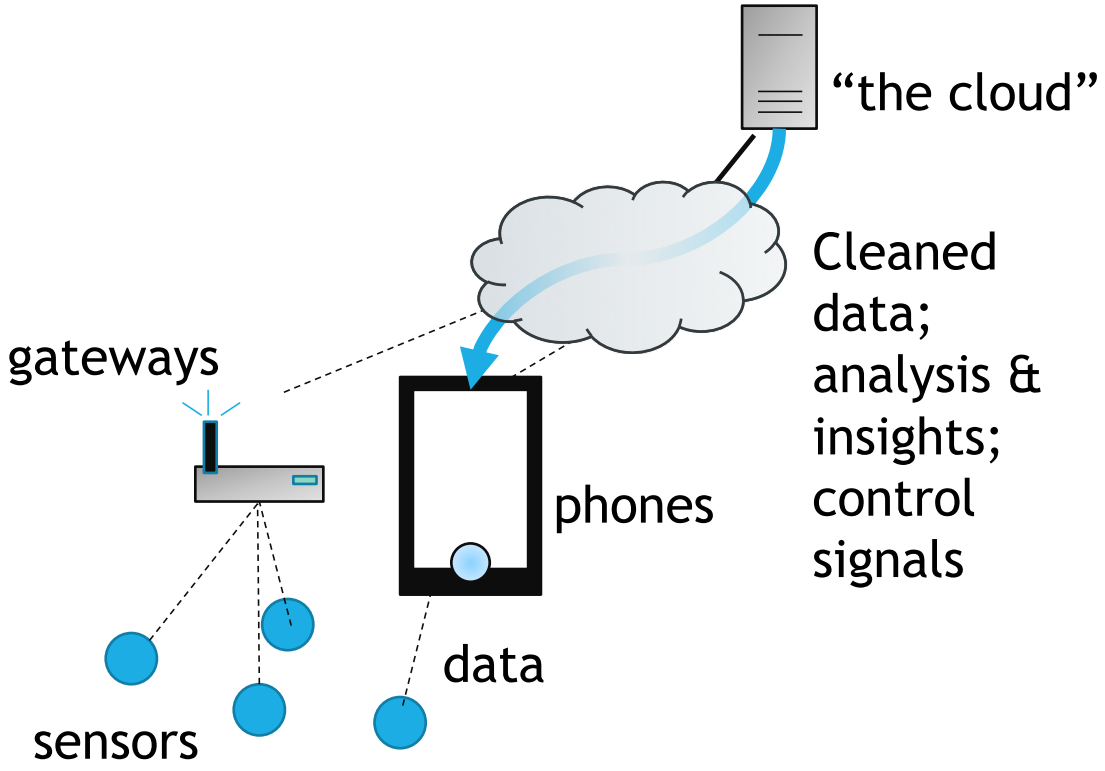
PROTOTYPICAL SENSOR SYSTEM ARCHITECTURE

Data path: sensors ➔ phones/basestations ➔ cloud

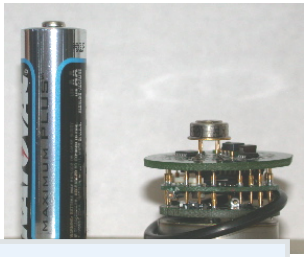
Sensors use low-power (BTLE, Zigbee) wireless

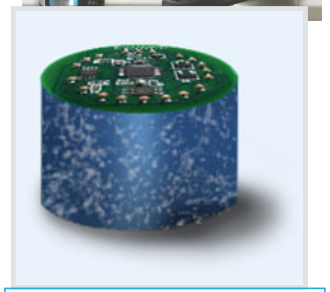
Phones and gatewaysuse WiFi, cellular, or wired Internet links

Processing happens on sensors, basestations, phones, and cloud

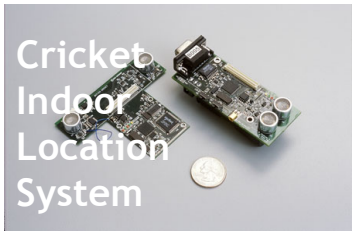


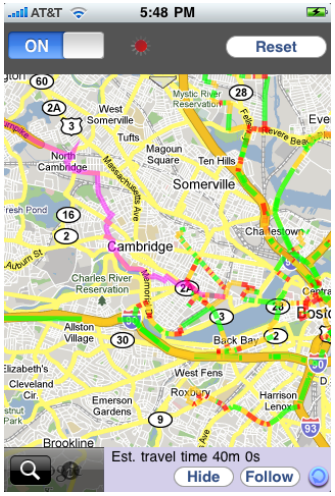
OUR IOT EXPERIENCE





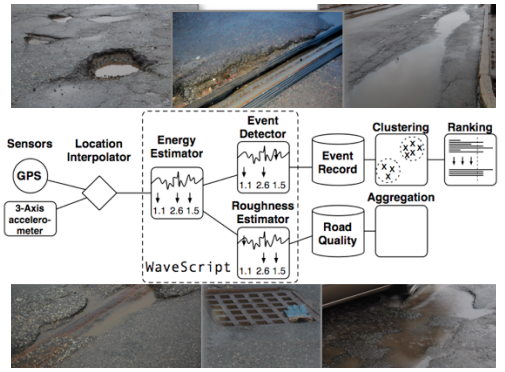
TinyDB: The Sensornet is the Database





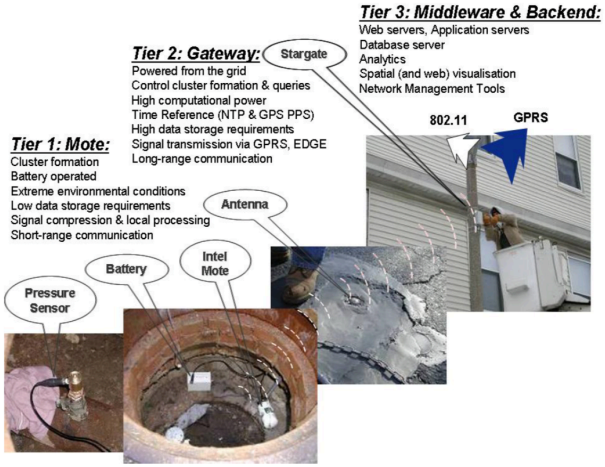
iCarTel crowdsourced traffic aware routing app

Lutron Light Control app for controlling lutron lighting systems from iPhone



Pothole Patrol

DriveWell safe driving app and BTLE accident-detection device



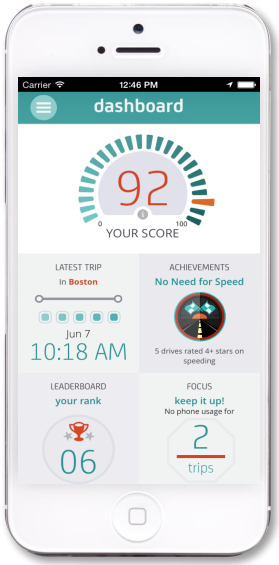
Pipenet

CASE STUDY: DRIVEWELL + TAG

Key capabilities: “safety score”, end-to-end collision alerting facility

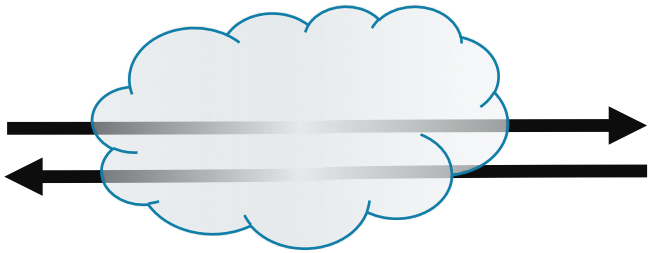
Requirement 1:
3+ years battery life

Acceleration Data
Impacts
Trip starts (triggered)
(Over BLE)



Trip data:
Acceleration
Gyroscope
Position

Requirement 2:
< 5% battery drain / hour *when driving*



Requirement 3: 10 second end-to-end notification of accidents

Requirement 5:
Accurately measure mileage and detect various harsh events

Amazon AWS Cloud

Requirement 4:
Real time trip feedback in a few minutes

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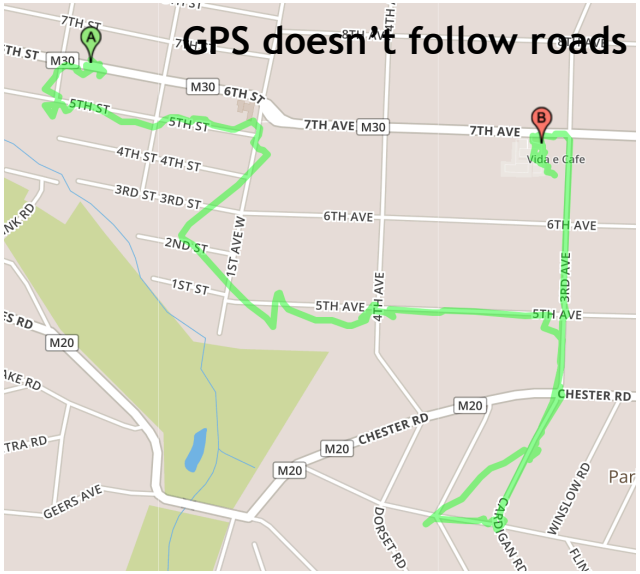
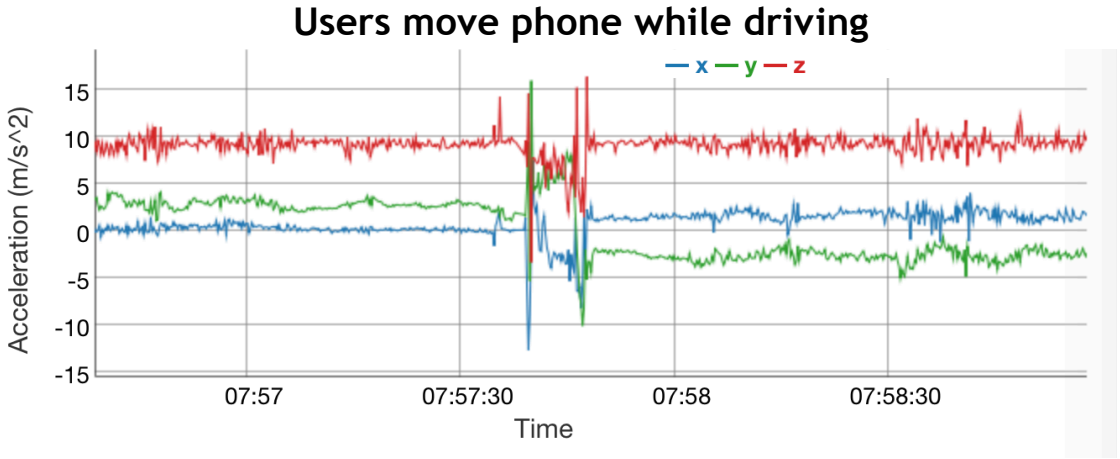
DRIVEWELL DATA CHALLENGES





Certain classes of devices experience failures

Discover CBCharacteristic for CBService misses a few characteristics

442 Views 15 Replies Latest reply: Sep 29, 2015 2:05 AM by masakazu

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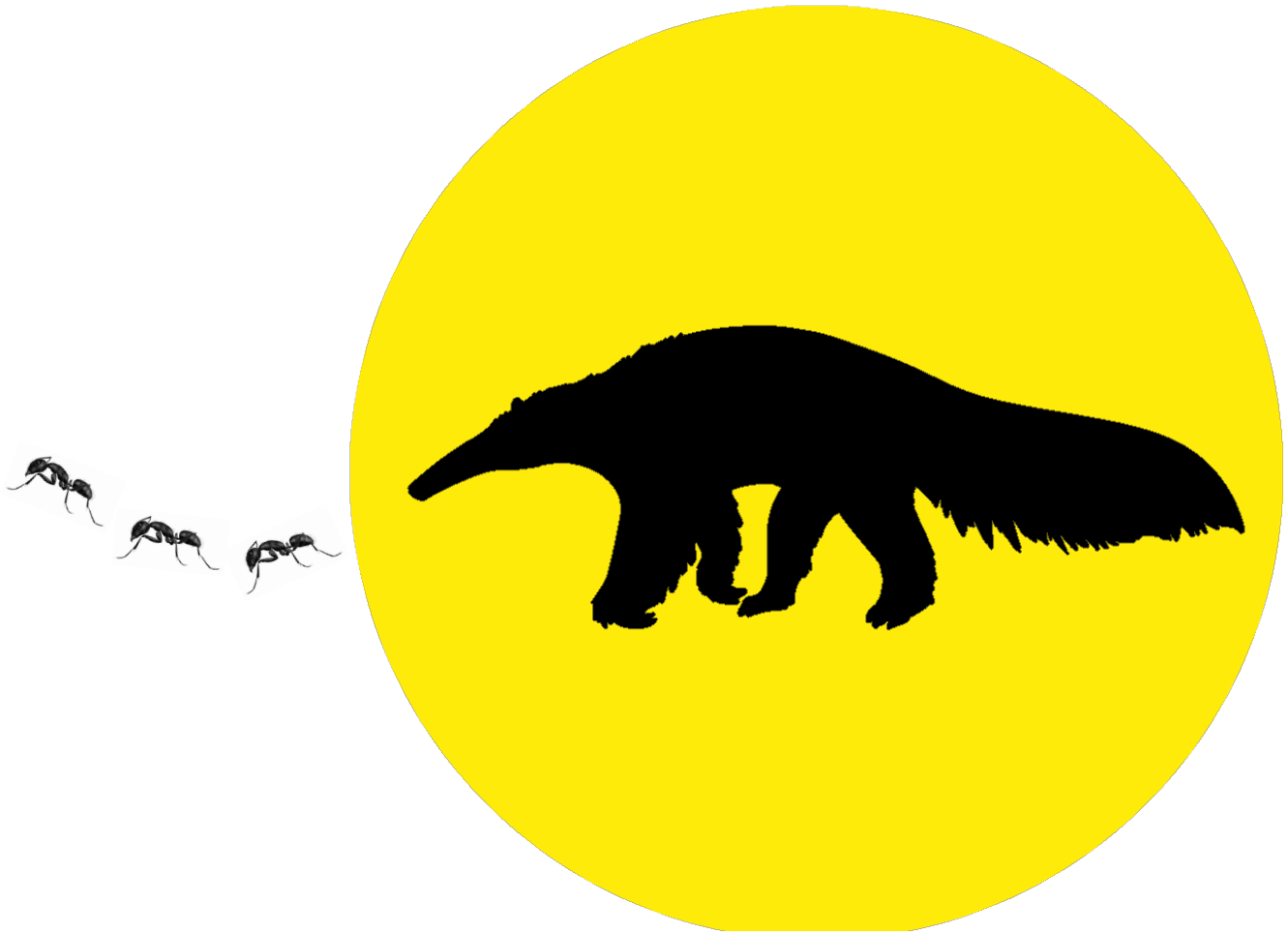
AN ANTERNET OF THINGS



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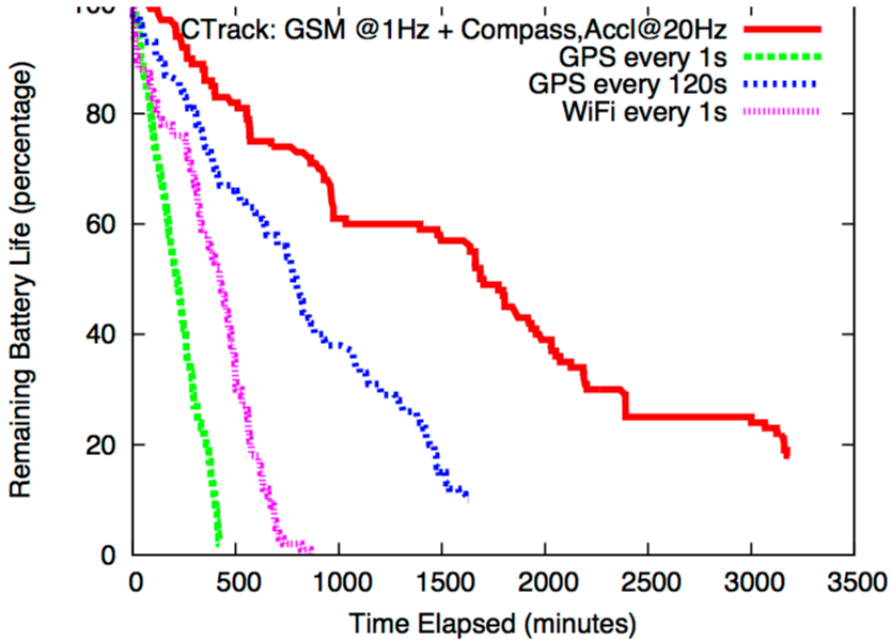
VTRACK/CTRACK

Tradeoff between accuracy and cost



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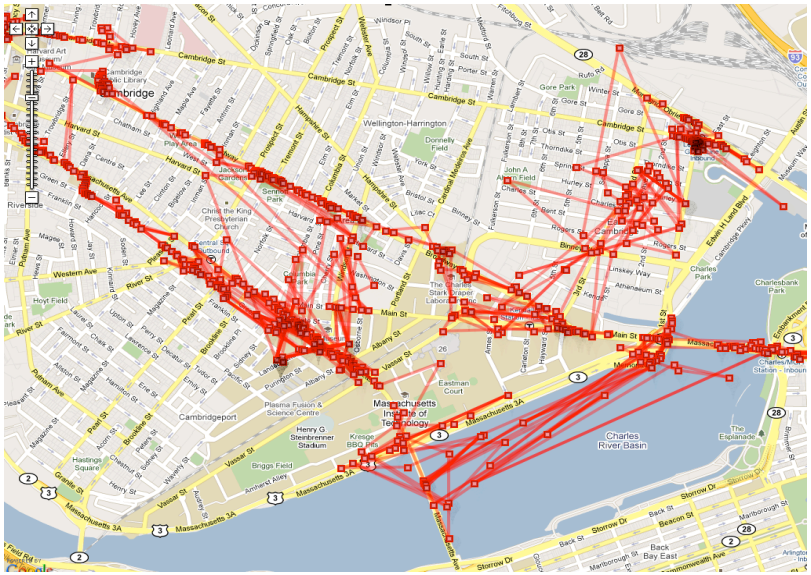

From this…

To this…

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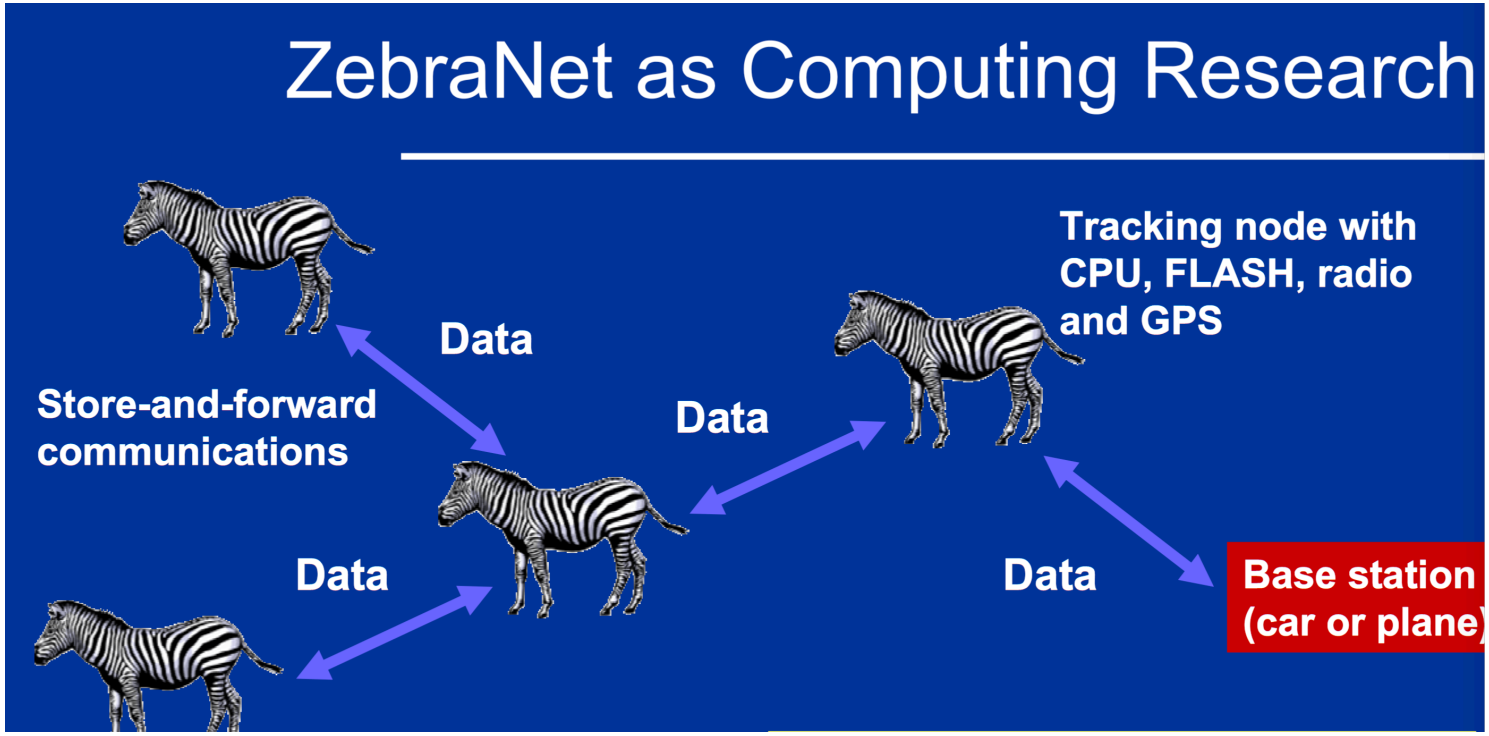
EXAMPLE: ZEBRANET



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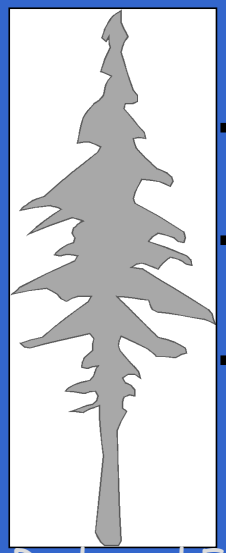
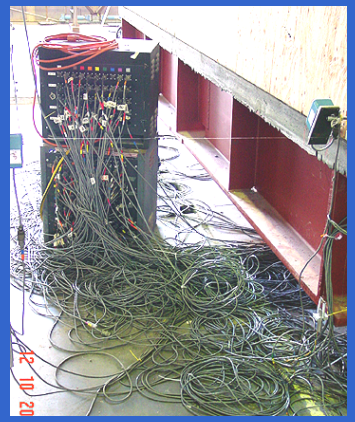
My PhD – Sensor Networks & TinyDB

Habitat Monitoring: Storm petrels on Great Duck Island, microclimates on James Reserve.



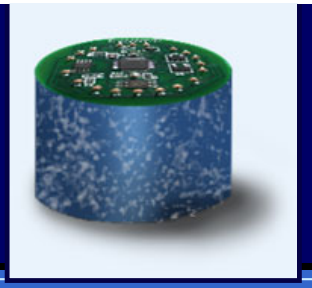
Redwood Forest Monitoring

Earthquake monitoring in shake-test sites.



Traditional monitoring apparatus.

TinyDB: The Network is the Database



- Users specify the data they want
  - Simple, SQL-like queries
  - Using predicates, not specific addresses
- Challenge is to provide:
  - Expressive & easy-to-use interface
  - Power efficient execution framework
    - » Efficiently fetches data from network
    - » While capturing as much data as possible

The Power of Declarative Thinking!

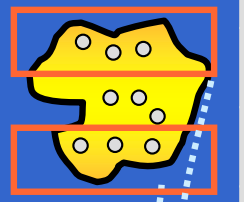
Many research groups became excited about related set of ideas in early 2000's

Aggregation Queries

2
```
SELECT AVG(sound)
FROM sensors
EPOCH DURATION 10s
```

"Count the number occupied nests in each loud region of the island."

3
```
SELECT region,
CNT(occupied)
AVG(sound)
FROM sensors
GROUP BY region
HAVING AVG(sound) > 200
EPOCH DURATION 10s
```



Epoch	region	CNT(…)	AVG(…)
0	North	3	360
0	South	3	520
1	North	3	370
1	South	3	520

Regions w/ AVG(sound) > 200

ILLUSTRATION: IN-NETWORK DATA PROCESSING IN TINYDB

Multihop data collection

- Divide sample period into short time *intervals*
- Assign each node to an interval according to its depth in the tree

Key idea: combine data as it is transmitted in the network

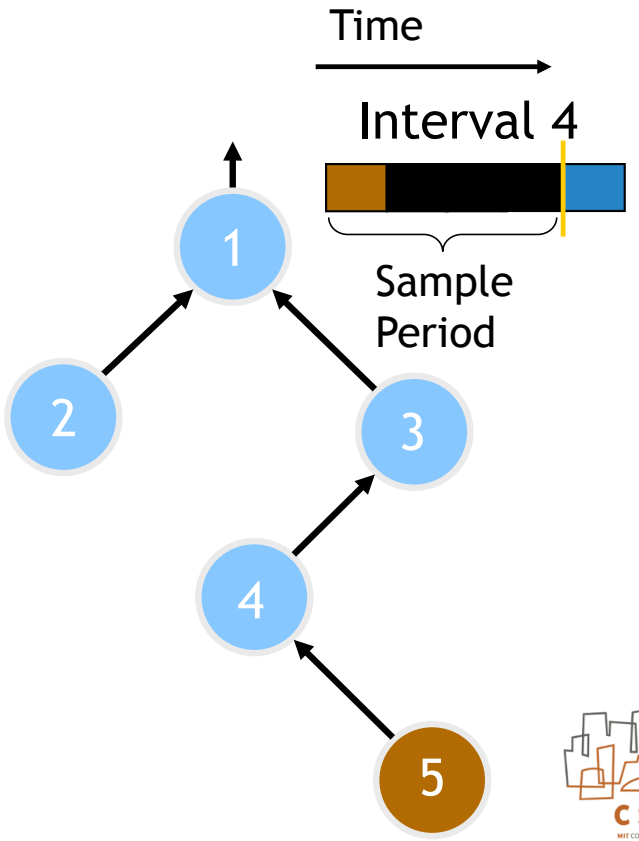


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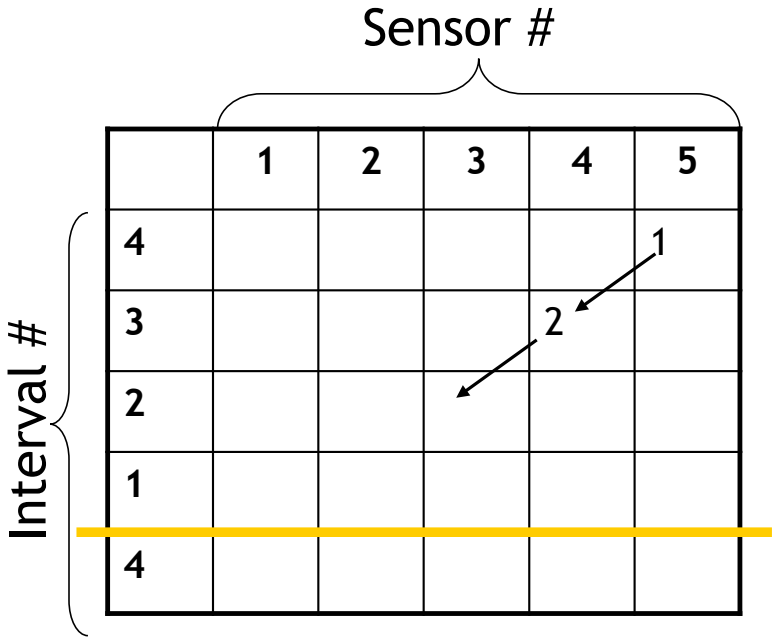
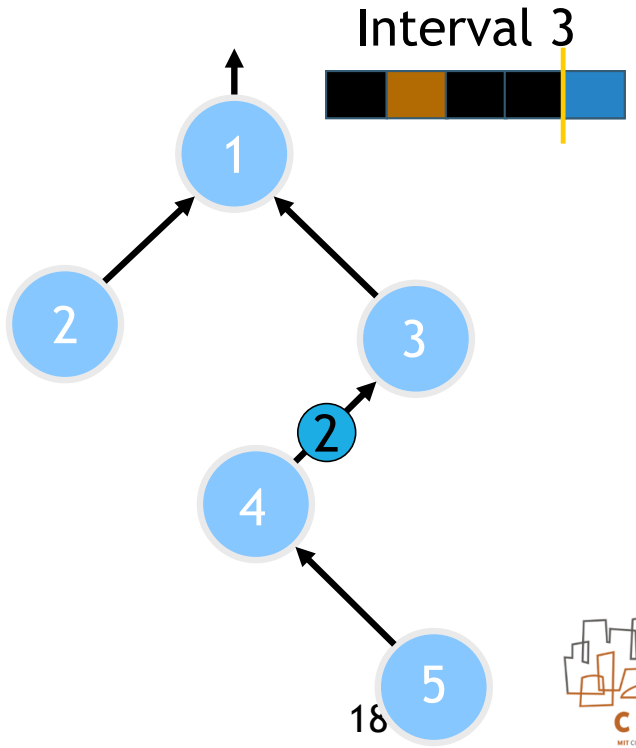
ILLUSTRATION: IN-NETWORK DATA PROCESSING

SELECT COUNT(*) FROM sensors





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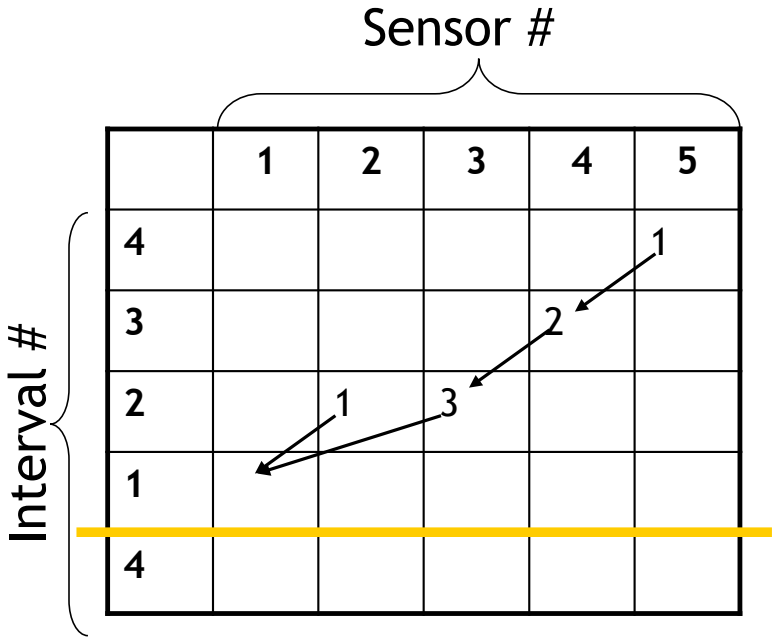

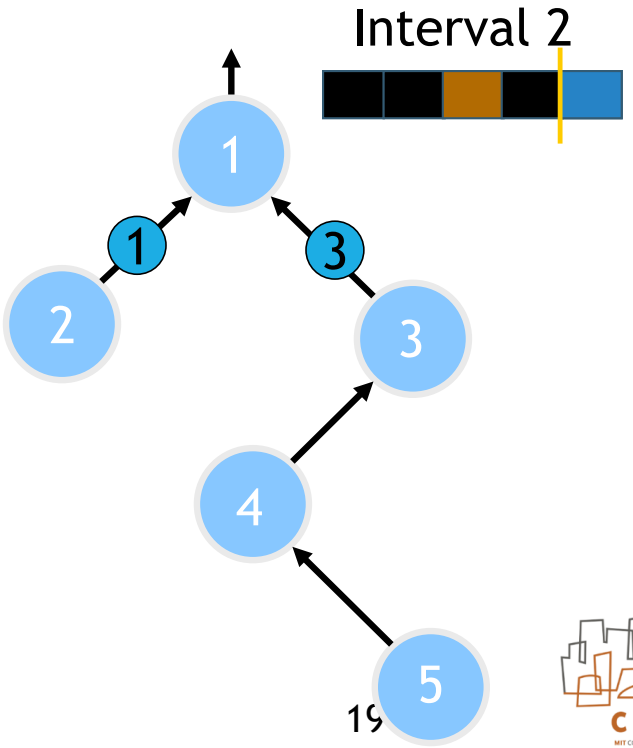

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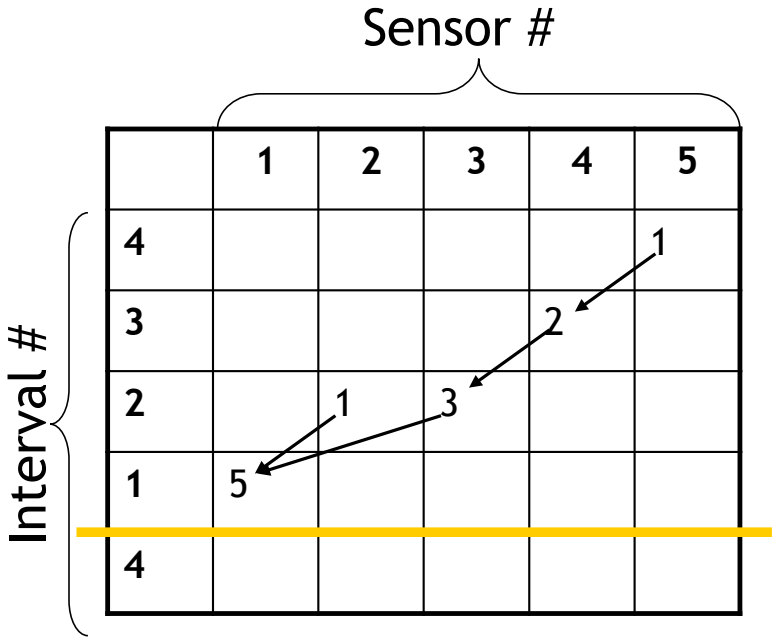
ILLUSTRATION: IN-NETWORK DATA PROCESSING

SELECT COUNT(*) FROM sensors



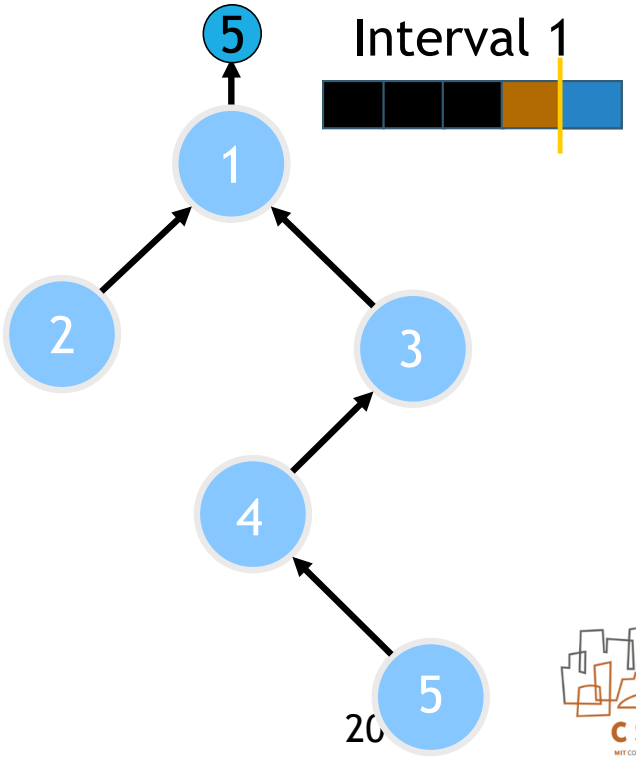


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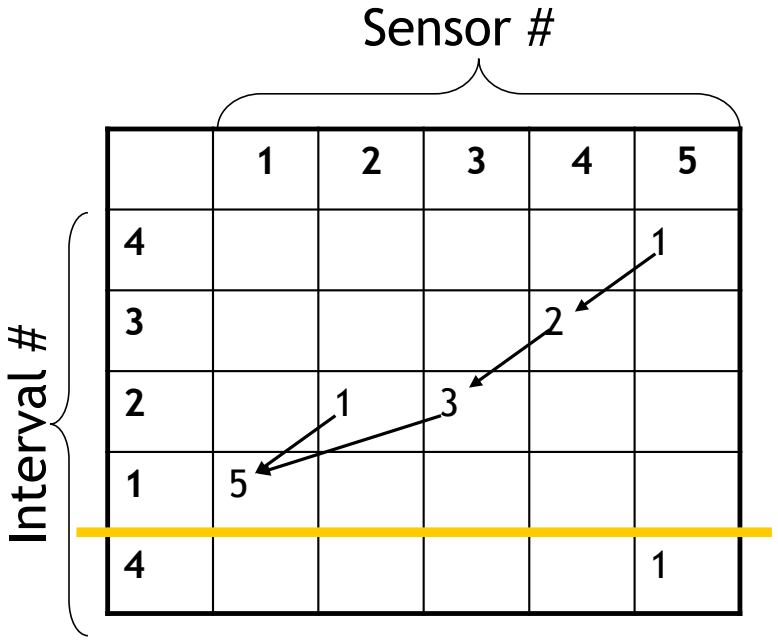
ILLUSTRATION: IN-NETWORK DATA PROCESSING

SELECT COUNT(*) FROM sensors



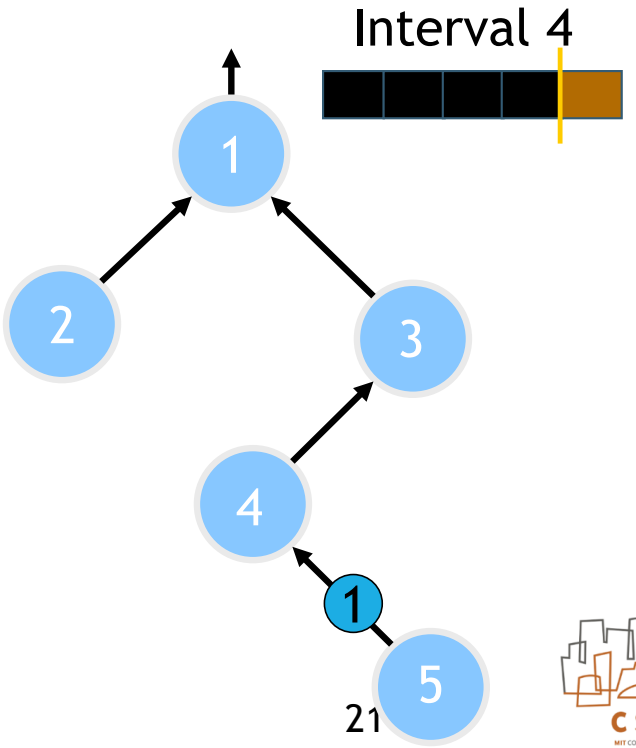


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ILLUSTRATION: IN-NETWORK DATA PROCESSING

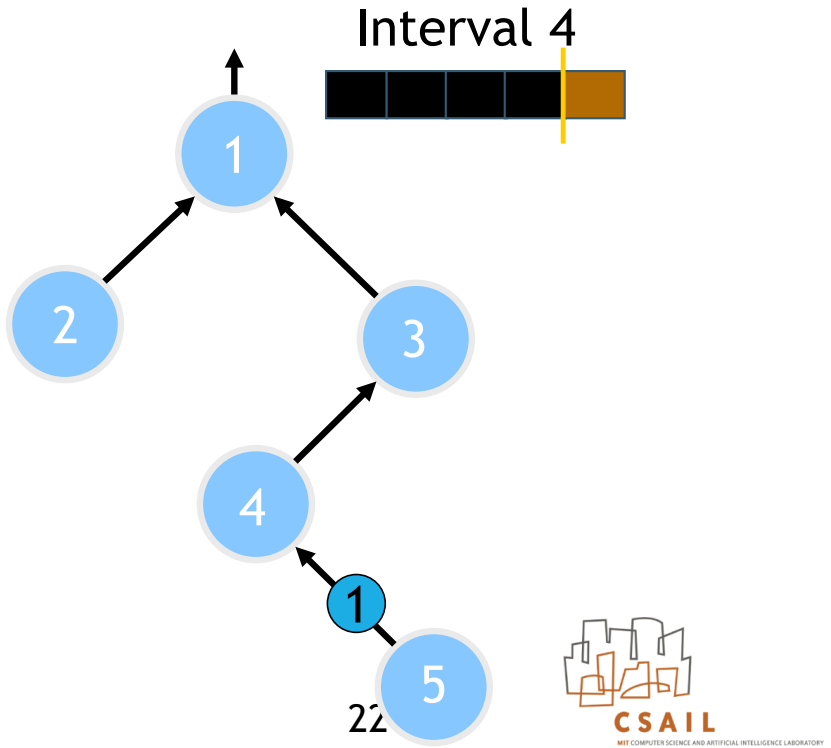
Nodes can sleep most of the time
Each node transmits only one COUNT

SELECT COUNT(*) FROM sensors

Sensor #

Interval #

	1	2	3	4	5
4	zzz	zzz	zzz		1
3	zzz	zzz		2	zzz
2		1	3	zzz	zzz
1	5	zzz	zzz	zzz	zzz
4	zzz	zzz	zzz		1



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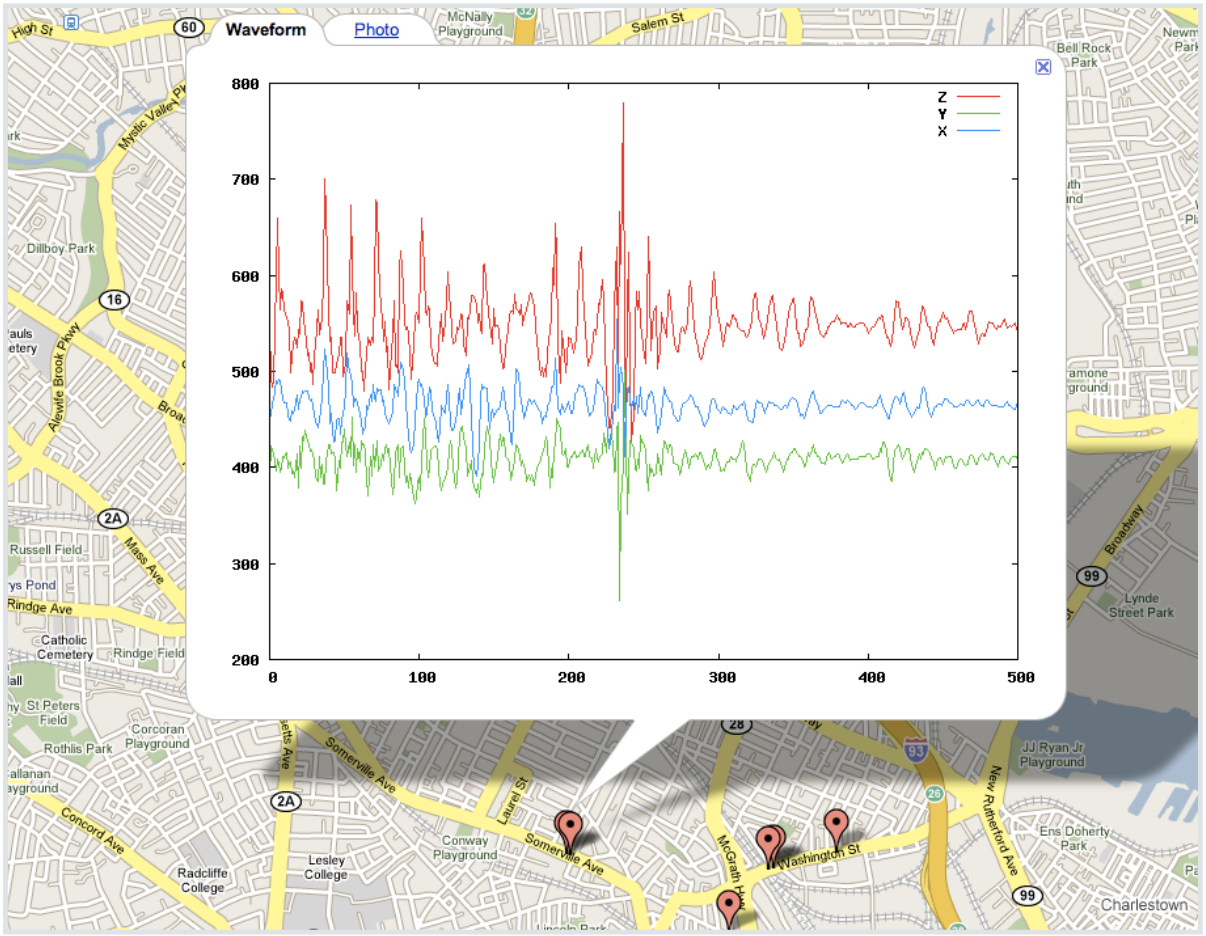
POTHOLE PATROL



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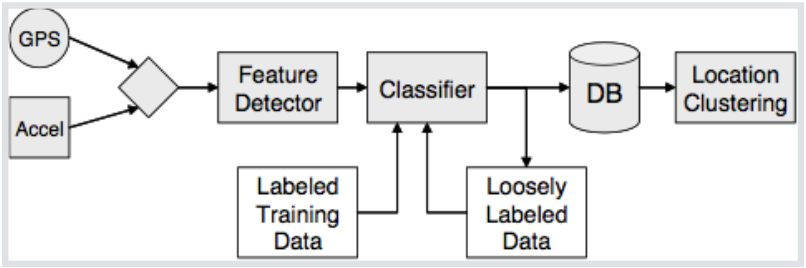
CLASSIFICATION-BASED APPROACH

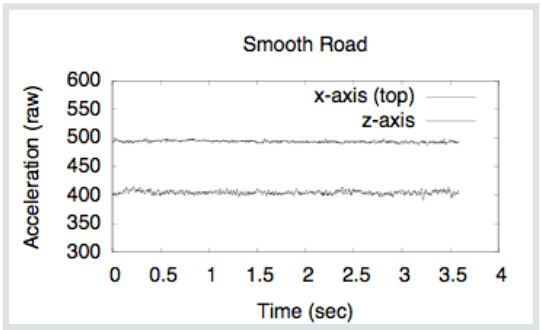
Classifier differentiates between several types of anomalies

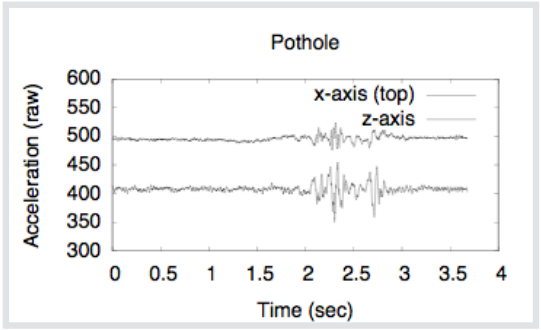
Window data, compute features per window

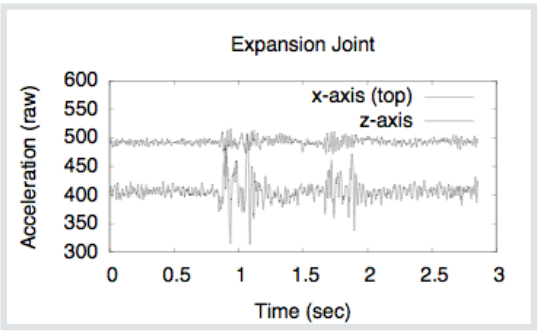
Variety of features:

- Range of X,Y,Z accel
- Energy in certain frequency bands
- Car speed
- …









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POWER USED BY SOME COMMON COMPONENTS

Component	Approximate Power Consumption
LTE Radio (transmit @ 1 Mb/s)	1700 mW
3G Radio (transmit @ 1 Mb/s)	1700 mW
WiFi (transmit @ 1Mb / s)	400 mW
ARM+RAM uProc (100% cpu)	2000 mW
ARM+RAM uProc (idle)	70 mW
Smartphone Screen (full brightness)	850 mW
GPS (once lock is acquired)	100-150 mW
Accelerometer (@10 Hz)	75 uW
Image sensor (@1080p/30Hz)	270 mW (Sony IMX206CQC)

Collecting the data is cheap; displays & radios & processing are expensive

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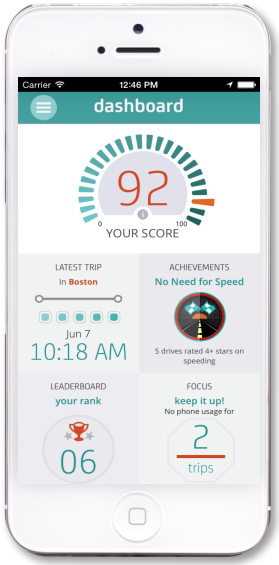
CASE STUDY: DRIVEWELL + TAG

Key capabilities: “safety score”, end-to-end collision alerting facility

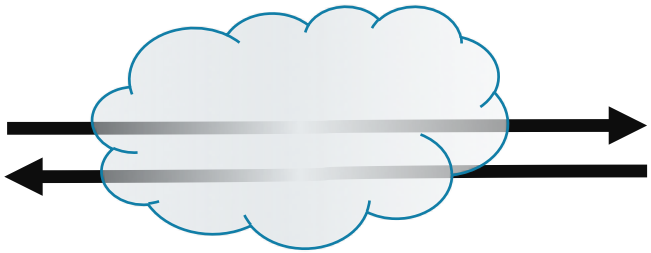
Requirement 1:
3+ years battery life

Acceleration Data
Impacts
Trip starts (triggered)
(Over BLE)



Trip data:
Acceleration
Gyroscope
Position

Requirement 2:
< 5% battery drain / hour *when driving*



Requirement 3:10 second end-to-end notification of accidents

Requirement 5:
Accurately measure mileage and detect various harsh events

Amazon AWS Cloud

Requirement 4:
Real time trip feedback in a few minutes

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TOPICS

- Positioning technologies, including GPS, WiFi and cellular localization
- Wireless networking, including BLE, WiFi, Zigbee, as well as multi-hop and store-and-forward ("muling")
- Resource constraints, including power, bandwidth, and storage
- Inertial sensing, including accelerometers, gyroscopes, IMUs, dead-reckoning
- Other types of sensors, e.g., microphones and cameras
- Application studies
- Embedded hardware and software architecture
- Embedded system security
- iOS APIs for accessing various sensing and wireless networking technologies

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