6.S062: Mobile and Sensor Computing

Class 1

http://db.csail.mit.edu/6S062.html

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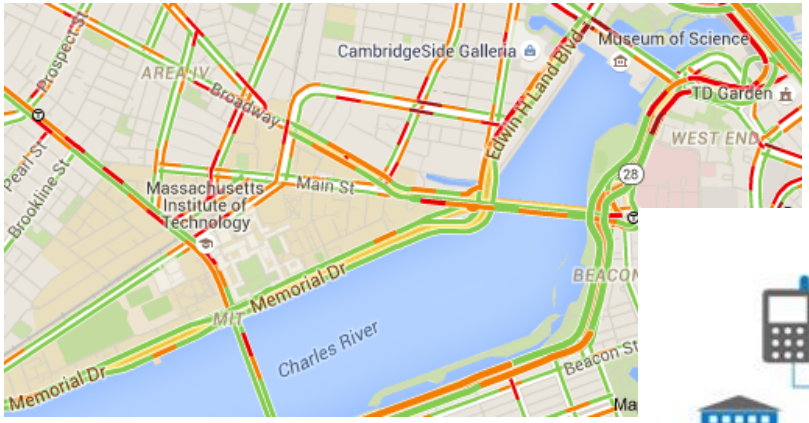
CambridgeSide Galleria
Museum of Science
TD Garden
WEST END
Massachusetts Institute of Technology
Main St
Memorial Dr
MIT
Charles River
Beacon St
Broadway
Pearl St
Brookline St
Prospect St
Edwin H Land Blvd
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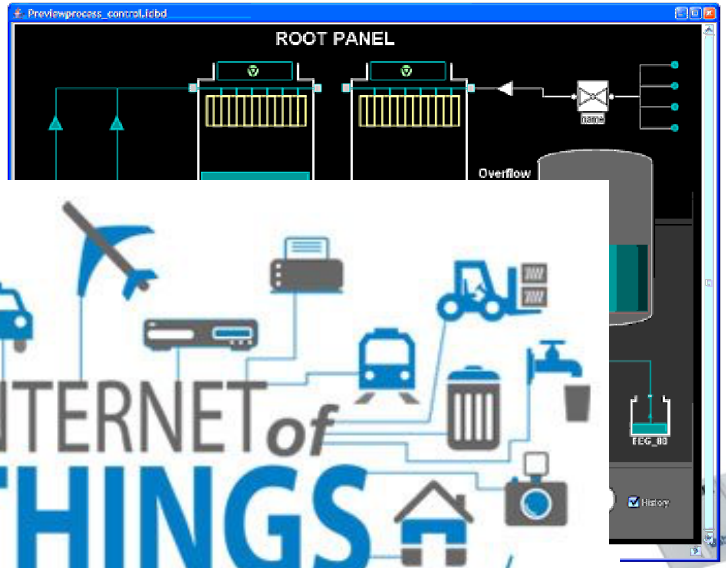

ROOT PANEL
Overflow
History


12:45

THE INTERNET of THINGS


CONNECTED


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


Introducing
E-Ink for MW
v2
from: MoonWalker
"Your last tweets from
your Twitter account!"
MOONWALKER

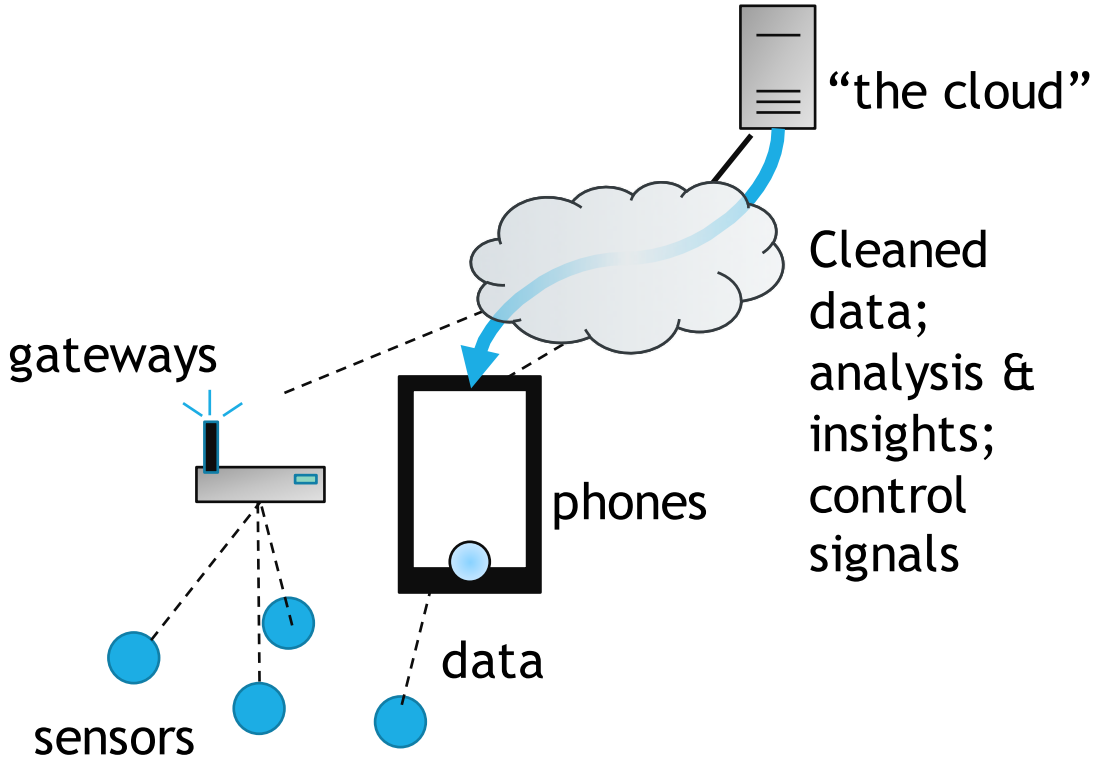
PROTOTYPICAL SENSOR SYSTEM ARCHITECTURE

Data path: sensors ➔ phones/basestations ➔ cloud

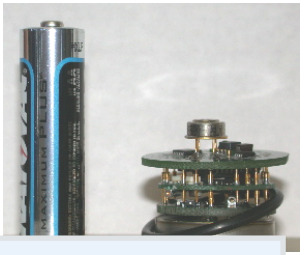
Sensors use low-power (BTLE, Zigbee) wireless

Phones and gatewaysuse WiFi, cellular, or wired Internet links

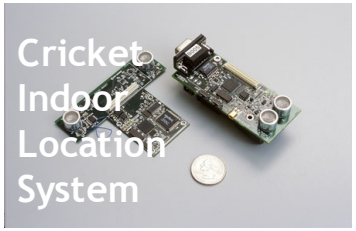
Processing happens on sensors, basestations, phones, and cloud

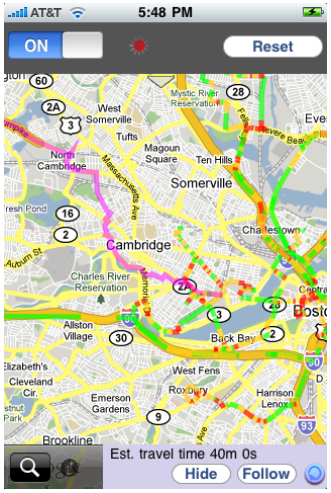


OUR IOT EXPERIENCE



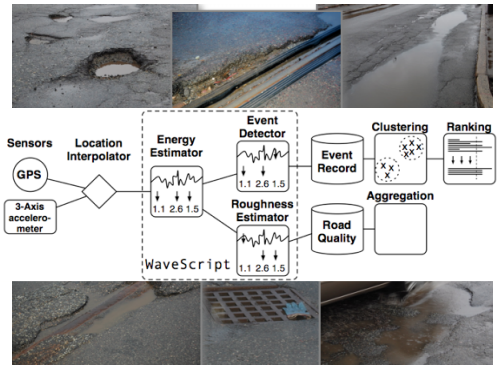
TinyDB: The Sensornet is the Database



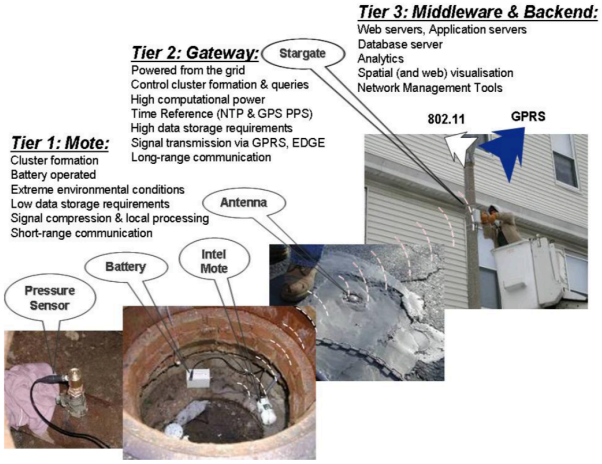


iCarTel crowdsourced traffic aware routing app

Lutron Light Control app for controlling lutron lighting systems from iPhone



Pothole Patrol



Pipenet

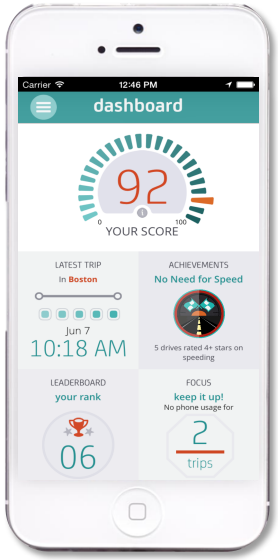
DriveWell safe driving app and BTLE accident-detection device

CASE STUDY: DRIVEWELL + TAG

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

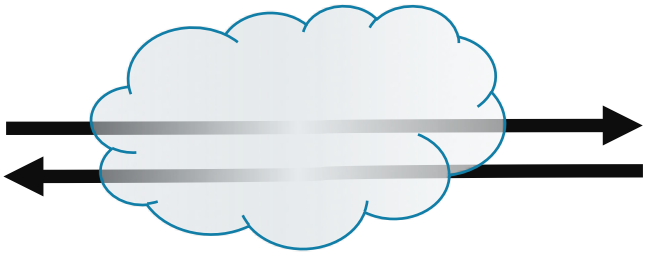
Requirement 1:
3+ years battery life

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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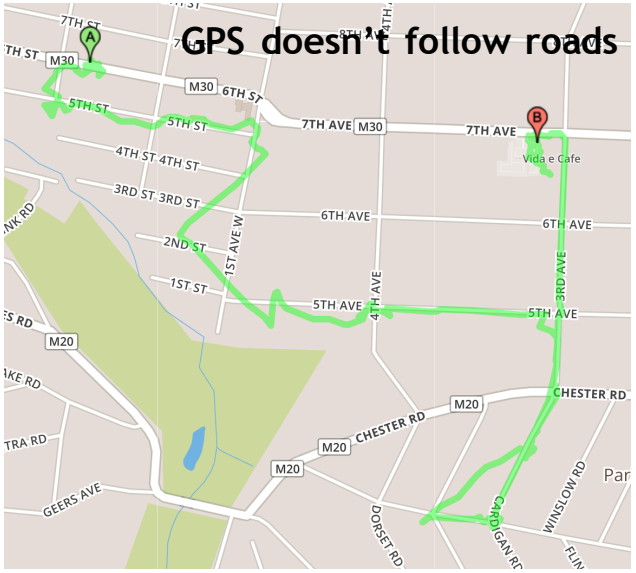
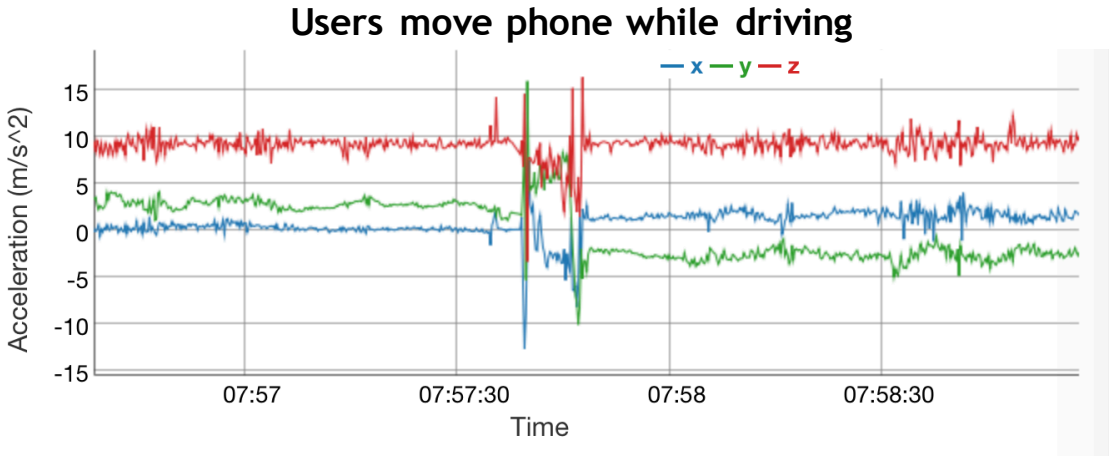
DRIVEWELL DATA CHALLENGES





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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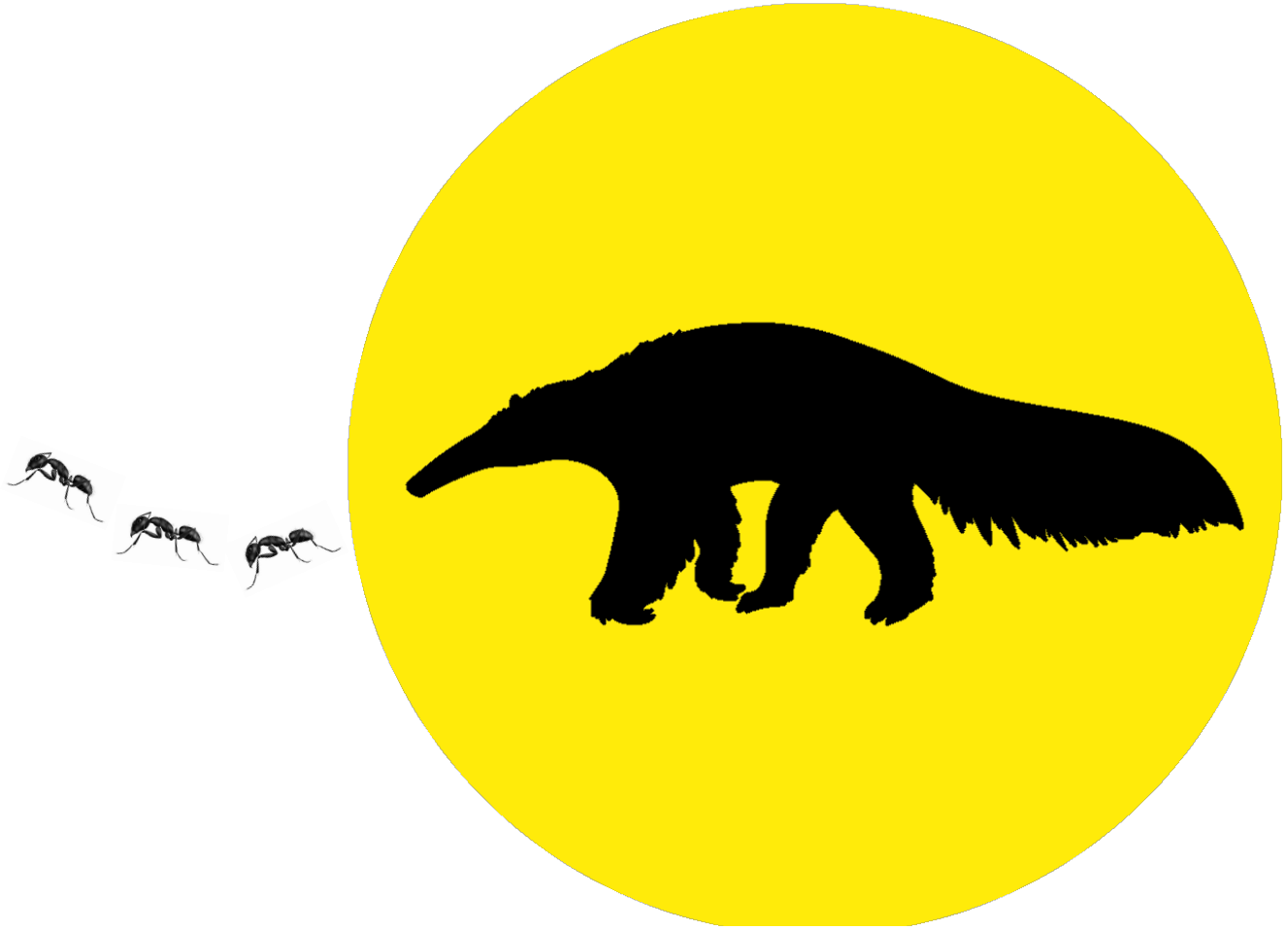
AN ANTERNET OF THINGS



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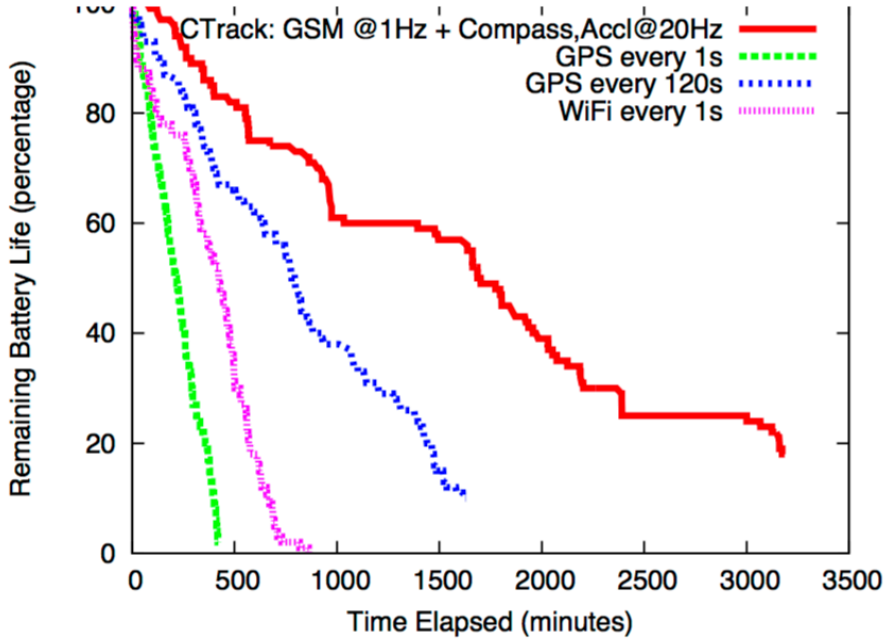
VTRACK/CTRACK

Tradeoff between accuracy and cost



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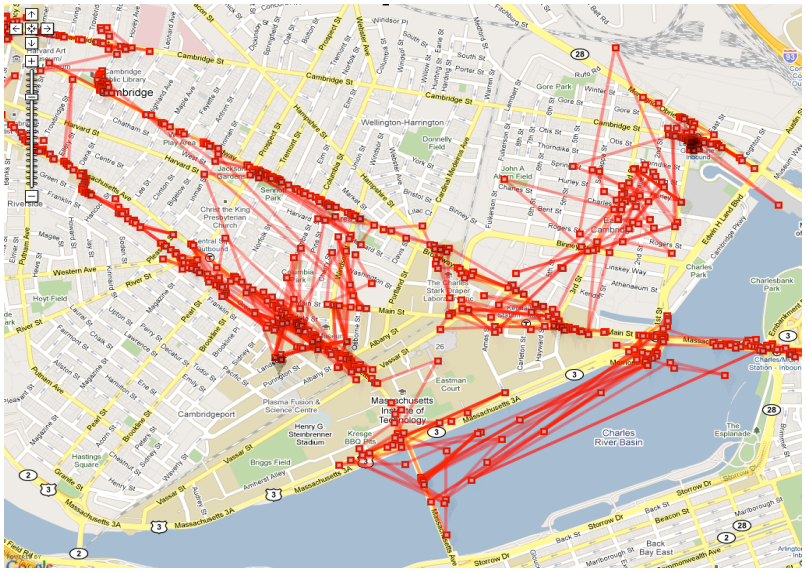

From this…

To this…

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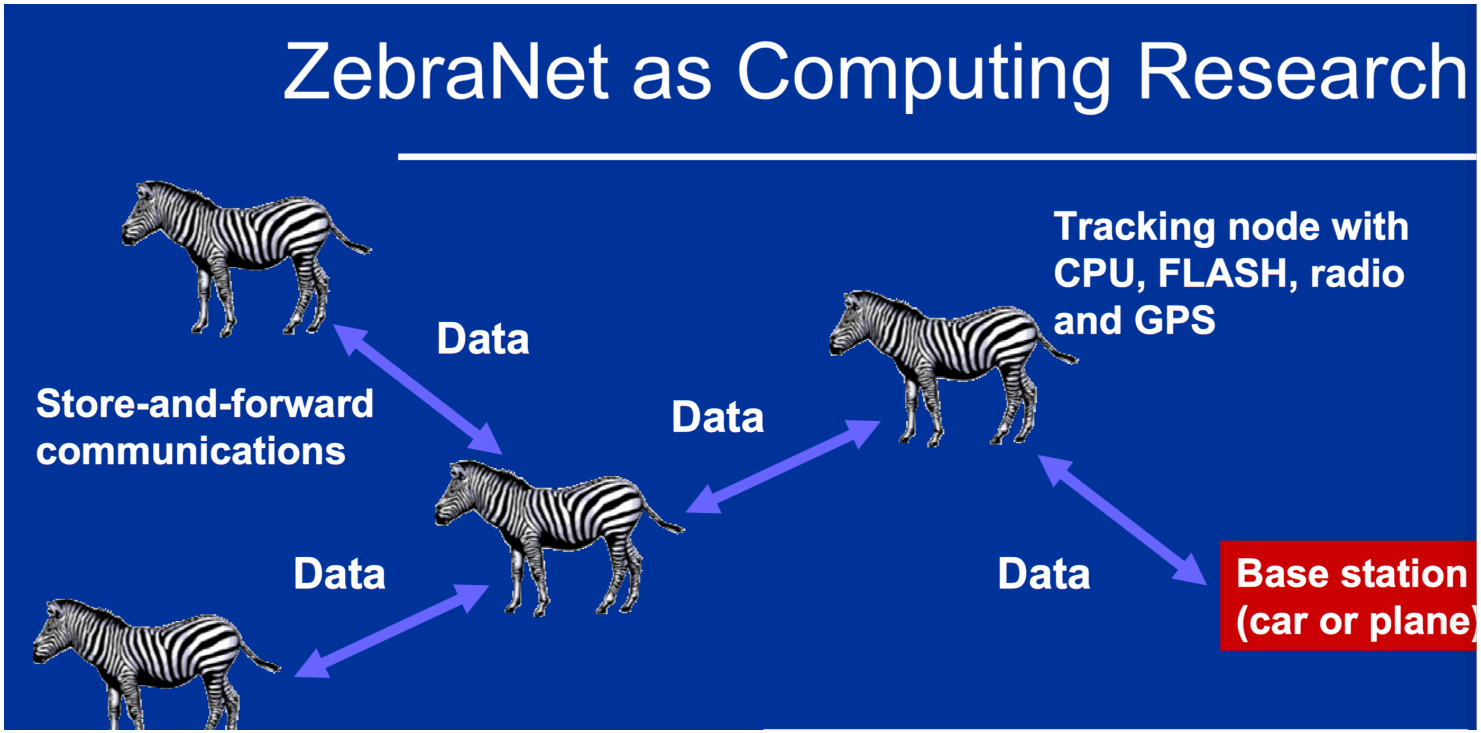
EXAMPLE: ZEBRANET



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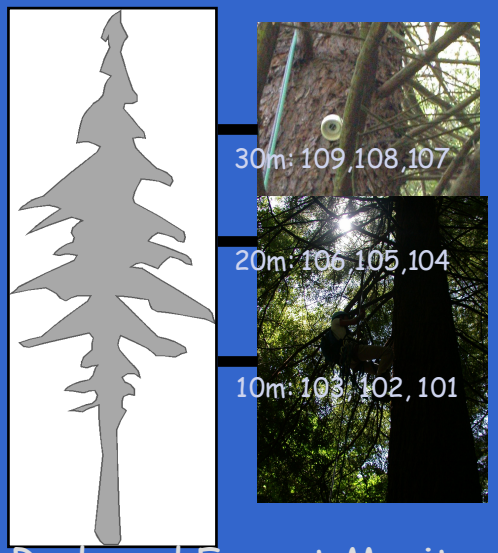
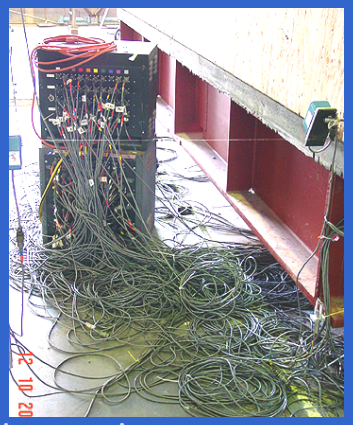
My PhD – Sensor Networks & TinyDB

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



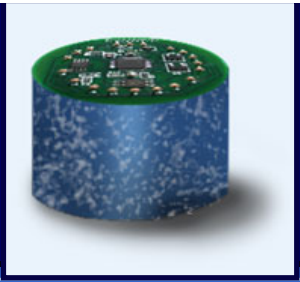
Redwood Forest Monitoring

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!

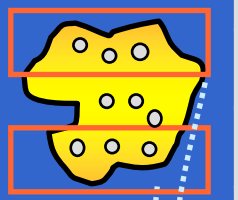
Many research groups became excited about related set of ideas in early 2000's

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

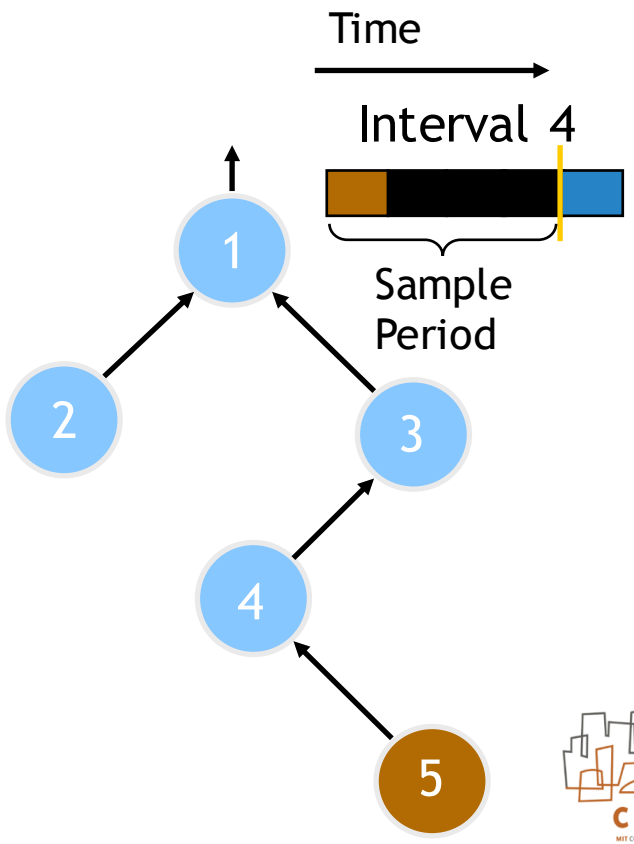


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ILLUSTRATION: IN-NETWORK DATA PROCESSING

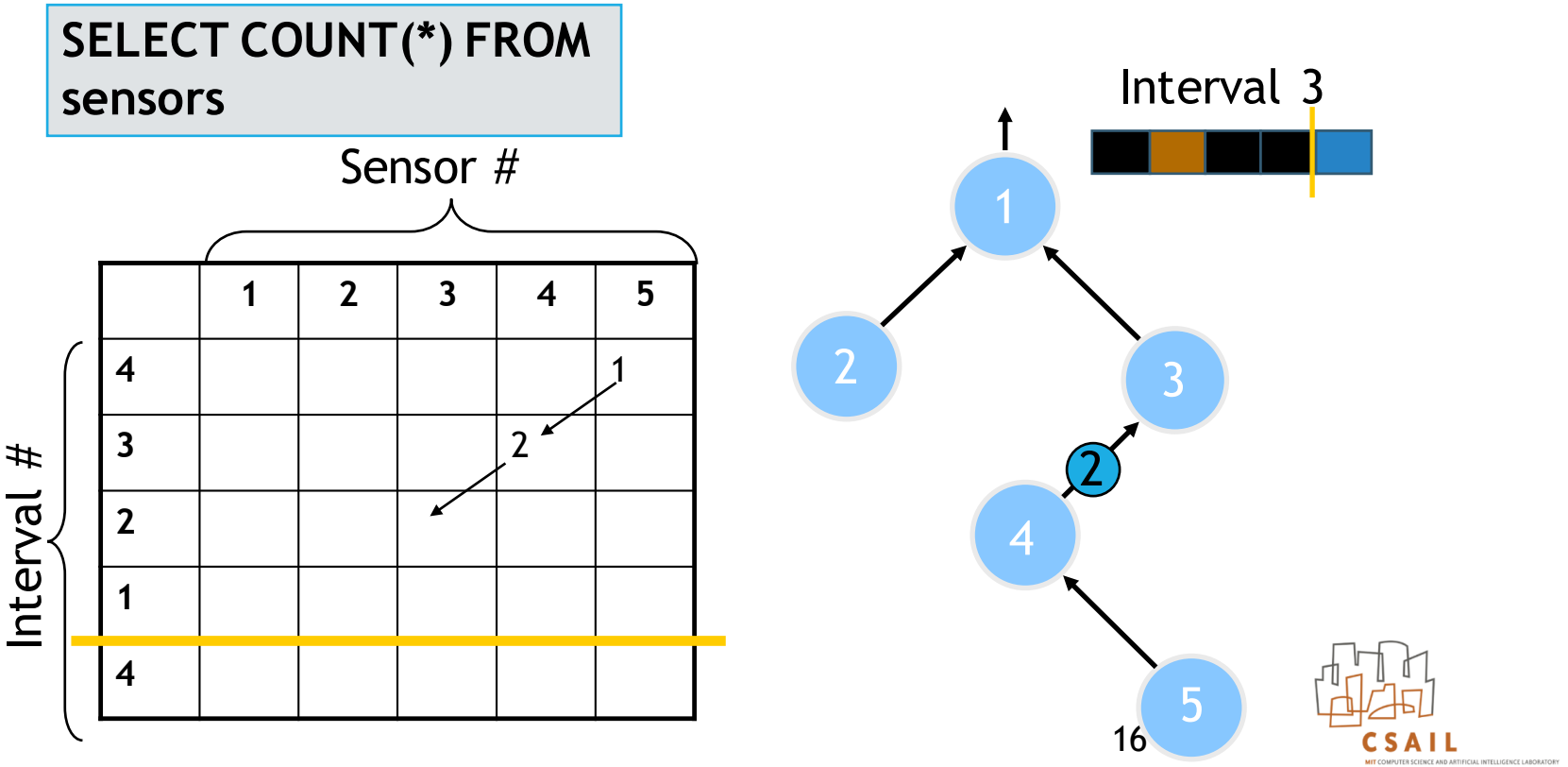
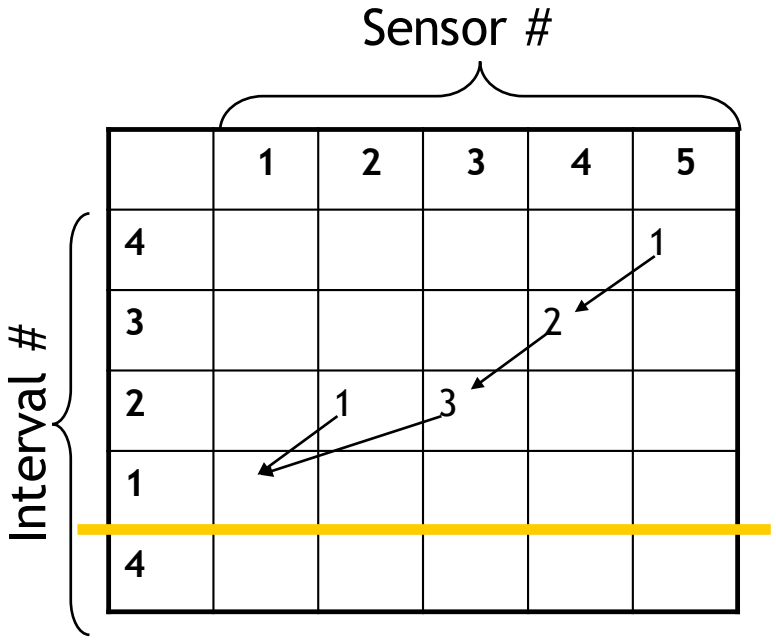
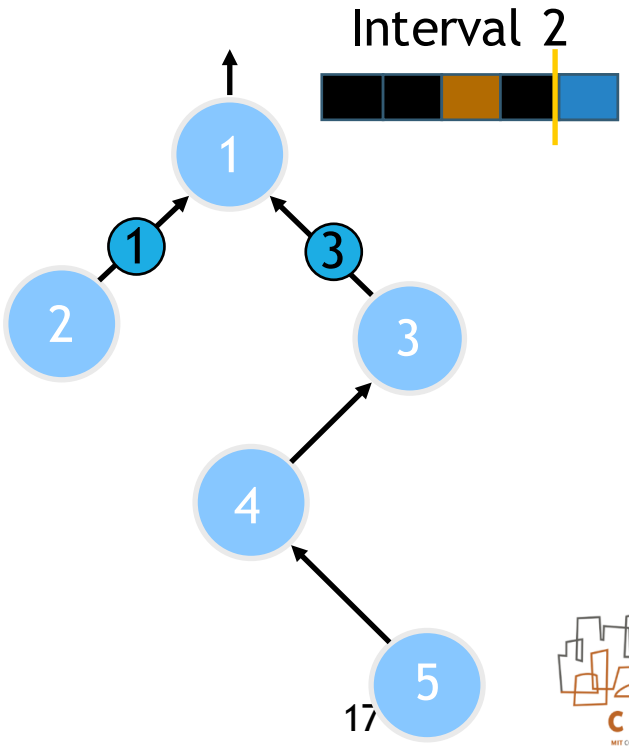


ILLUSTRATION: IN-NETWORK DATA PROCESSING

SELECT COUNT(*) FROM sensors





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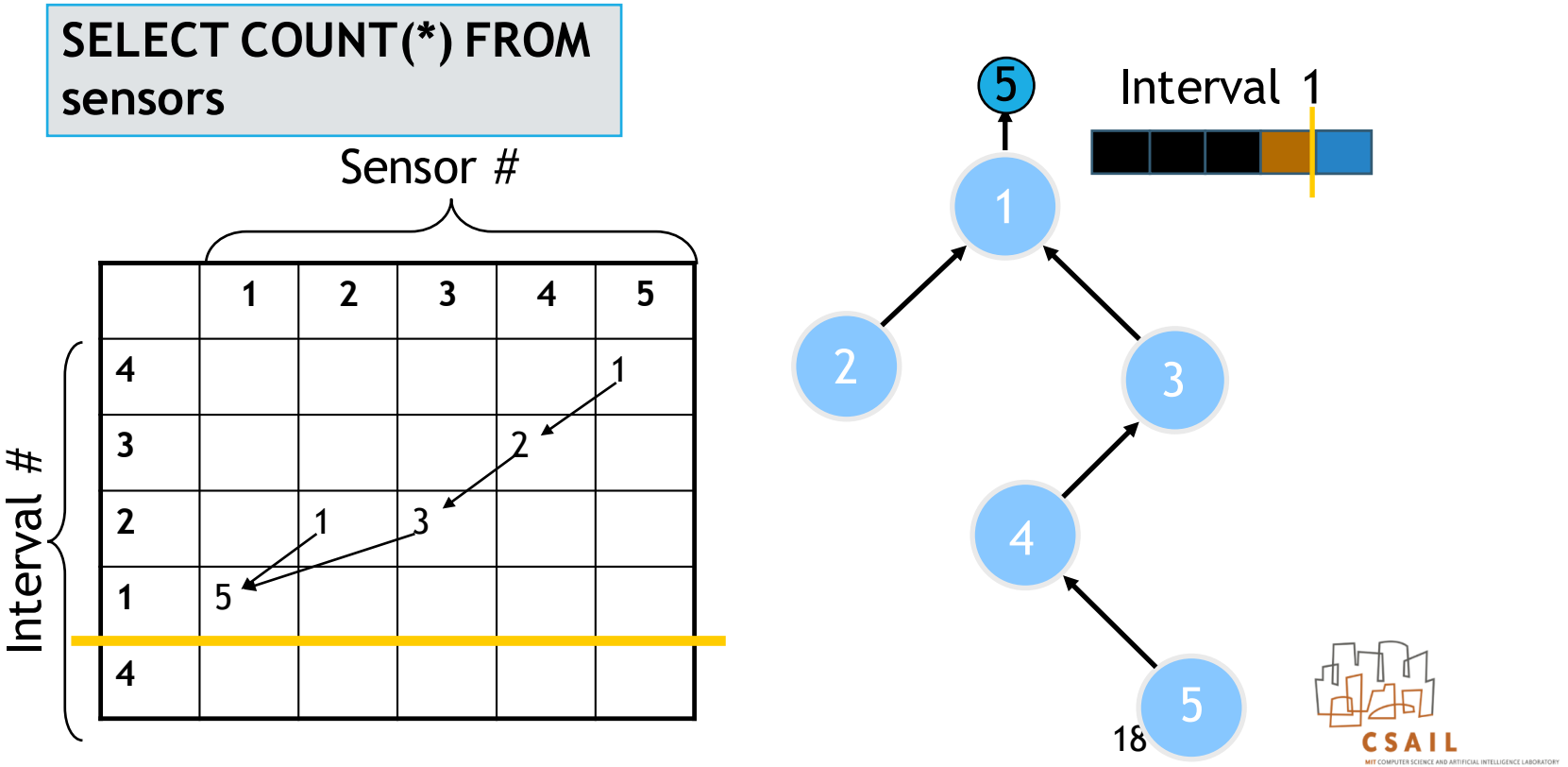
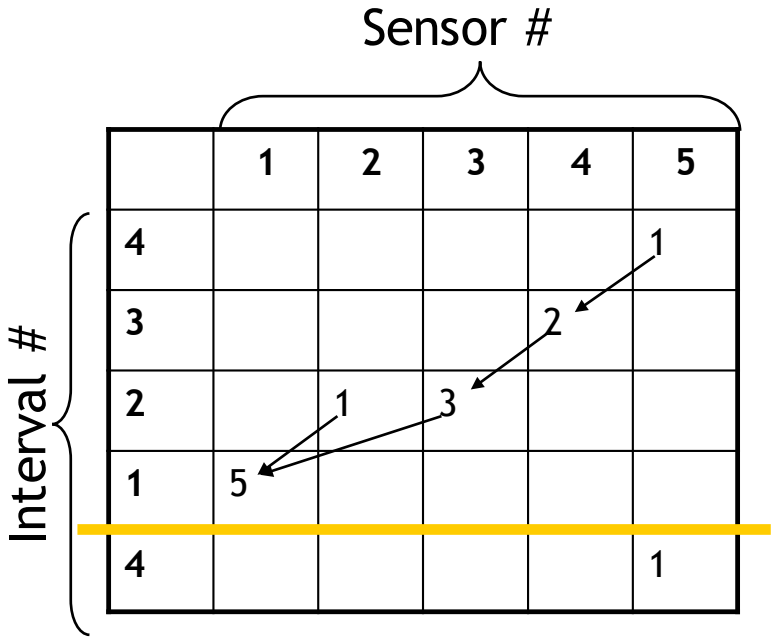


ILLUSTRATION: IN-NETWORK DATA PROCESSING

SELECT COUNT(*) FROM sensors



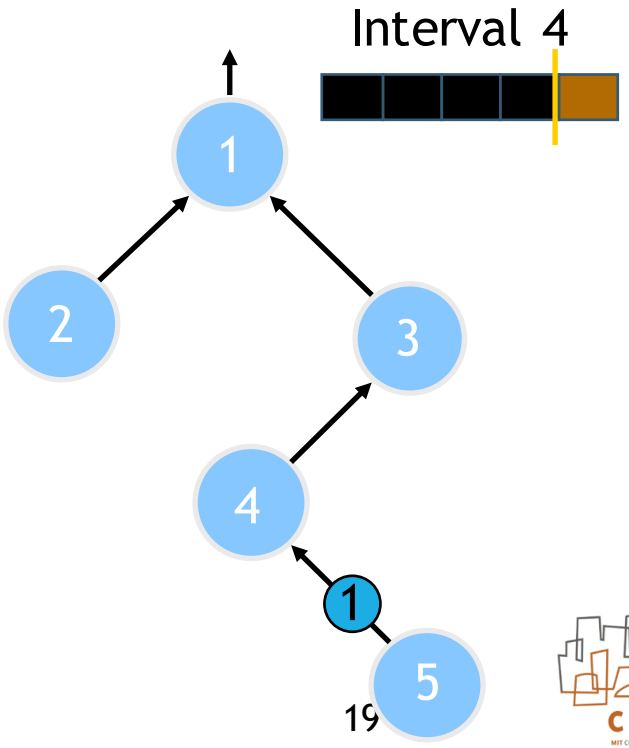
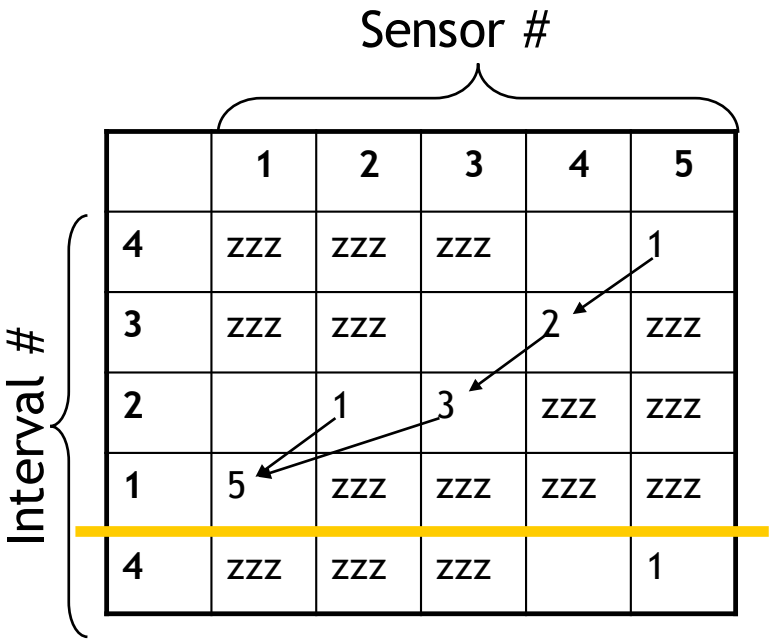
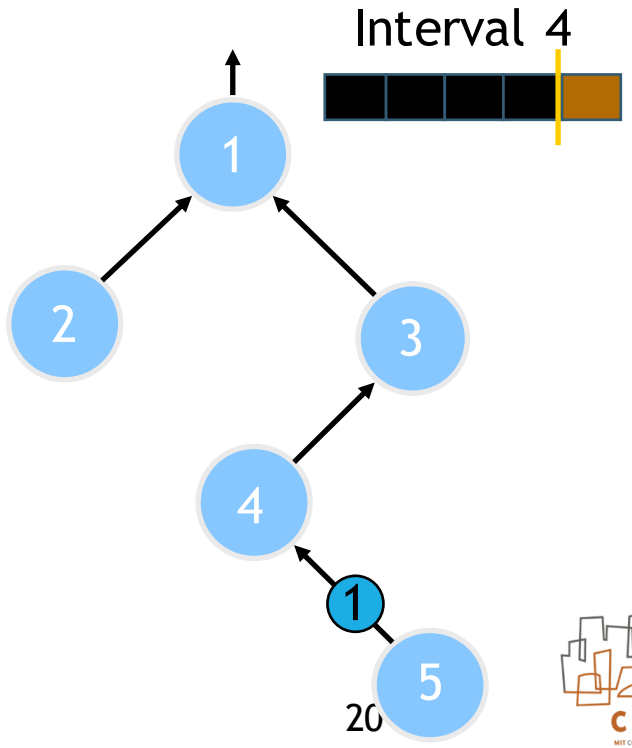


ILLUSTRATION: IN-NETWORK DATA PROCESSING

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

SELECT COUNT(*) FROM sensors





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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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POTHOLE PATROL

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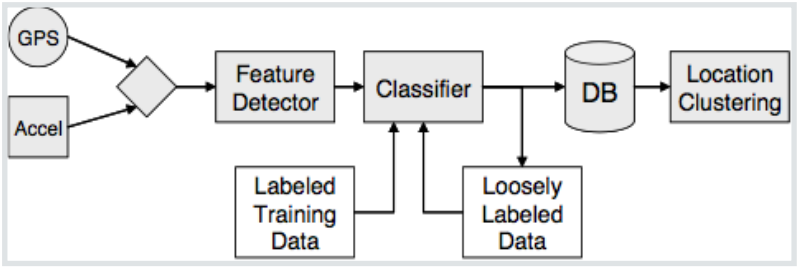
CLASSIFICATION-BASED APPROACH

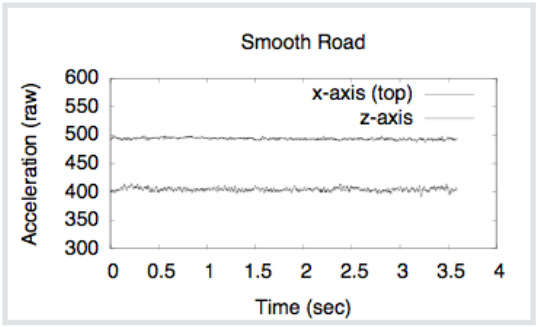
Classifier differentiates between several types of anomalies

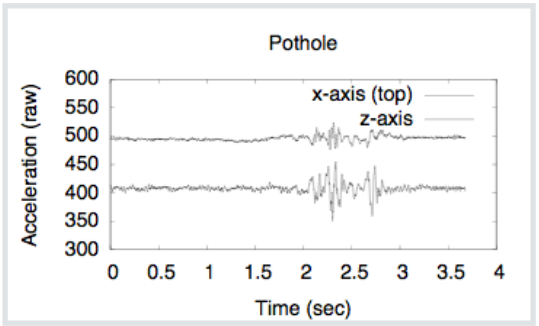
Window data, compute features per window

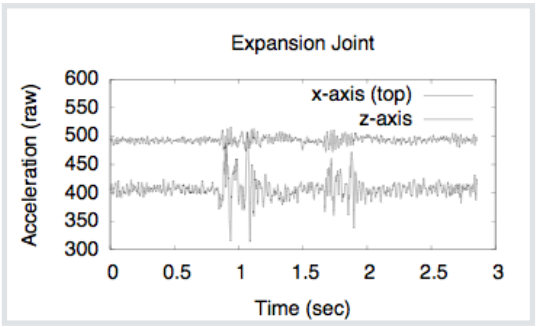
Variety of features:

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









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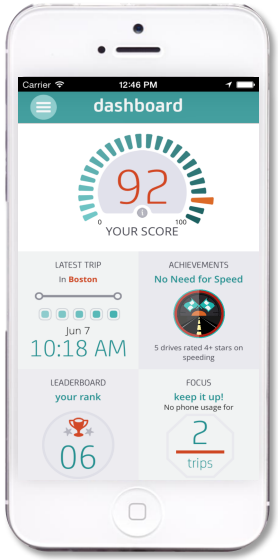
CASE STUDY: DRIVEWELL + TAG

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

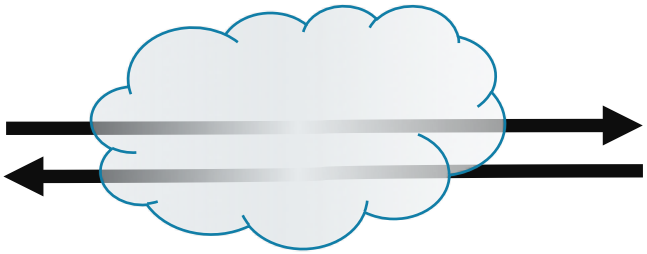
Requirement 1:
3+ years battery life

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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