Architecture and Notes on Smart * Hoboken

Gregg T. Vesonder, Ph.D.

Relevant Bio

- Systems and Software for 45+ years
- PhD in Cognitive Psychology - Computer modeling of learning and memory
- [Bell|AT&T] labs for 35+ years
- First commercial AI System ACE
- Dozens of projects
- Architecture Reviewer and served software engineering corporate stint at Bell Labs
- Mobile and Pervasive Systems Research Department and Cloud and Data Technology Department
- Adjunct Professor at University of Pennsylvania (since 2004)
- Industry Professor at Stevens and Director, Research, Systems and Software Engineering, was an adjunct at Stevens for 12 years
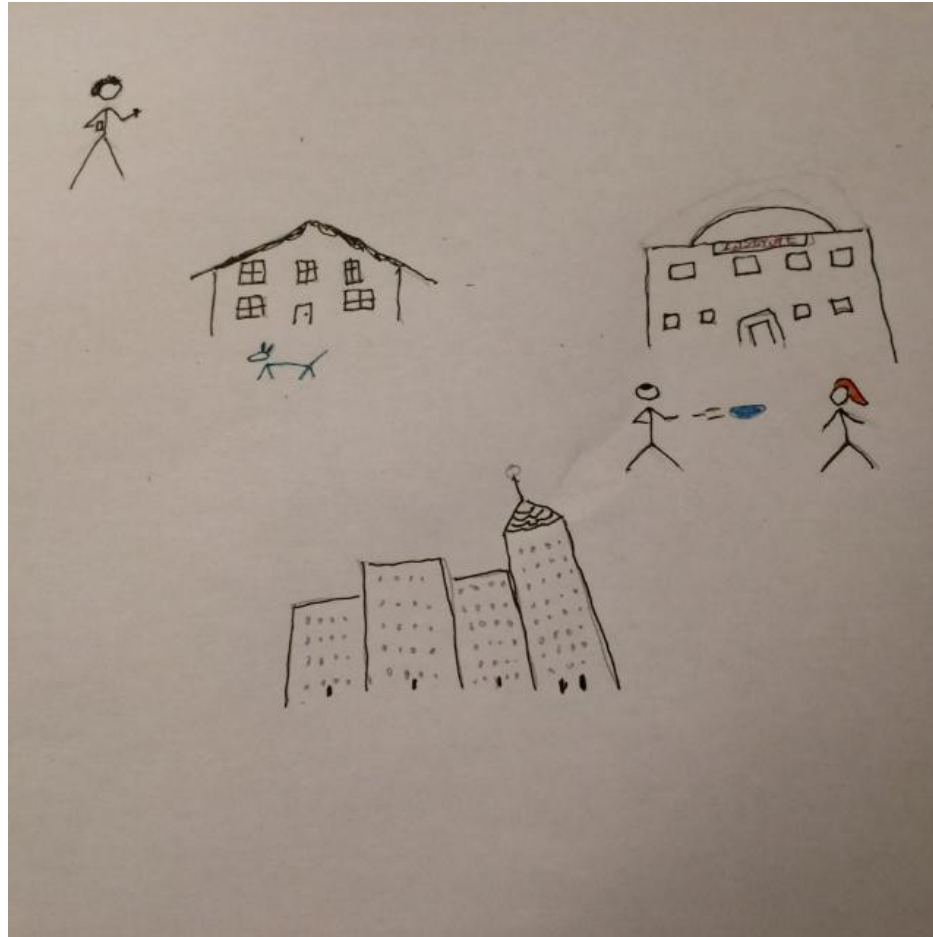
ROADMAP

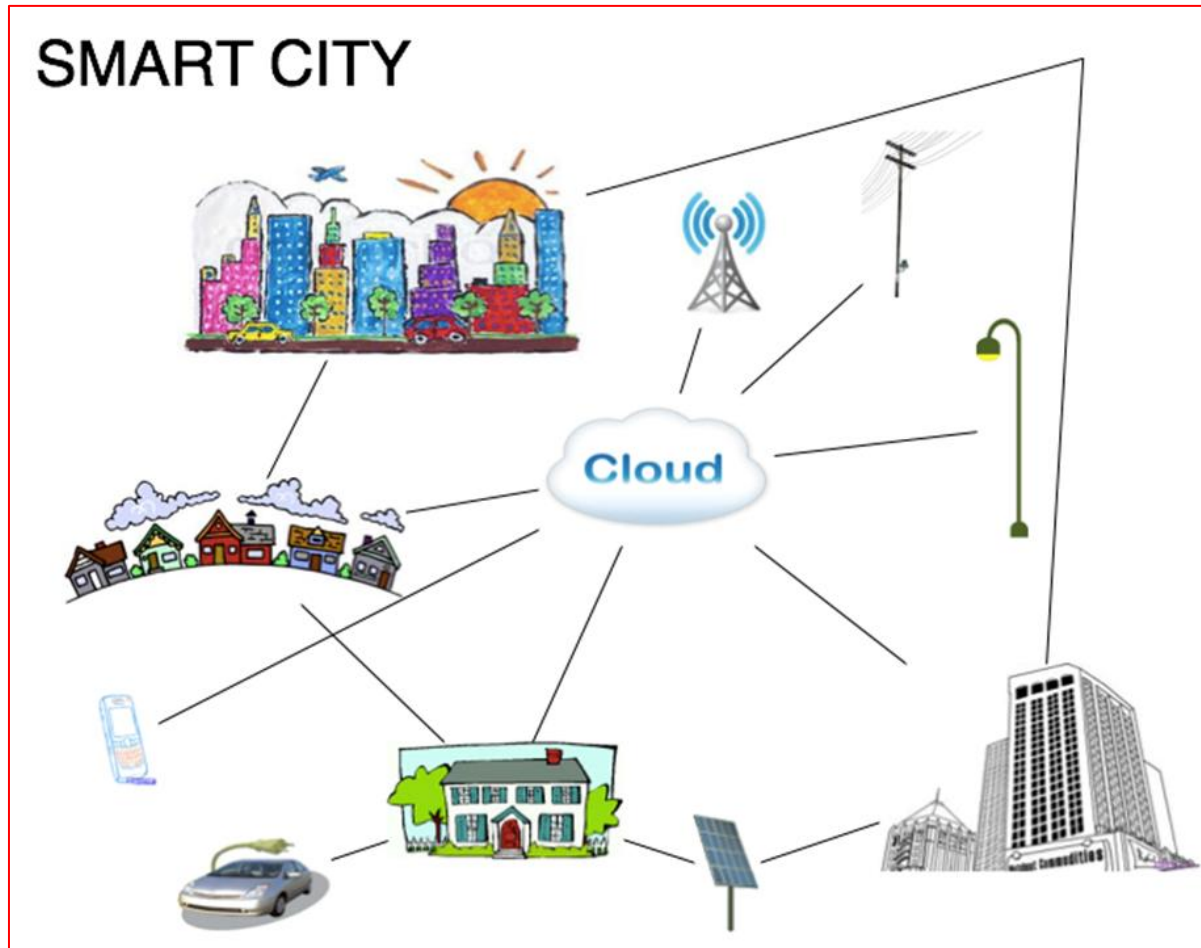- "Architecture" of Smart Cities

- Sensored

- Fukishima

Smart *
Architecture

Smart *

Smart City (very notional architecture) Architecture

Radio!

Cloud!

RADIO

- ZigBee
- Z-Wave
- Wi-Fi
- LTE, 3G, 2G

Cloud

Ubiquitous and sharded

   -resiliency

Reliable

Near Unlimited Storage Capacity

Scaling on Demand

Analytics

Secure (VMs, Containers)

Cost effective, e.g, erasure coding

My Experience

- indoor sensors using t-mote skys
- MAPS Department at AT&T Labs – Research
  - cloud research too
- smart Hoboken prototype
  - Digital|virtual Hoboken too
- beacon project

T-mote sky projects

- Placed all around our building ~40 motes

- ZigBee radios

- Temperature, humidity and light sensors

- Later added power, "bump in the line" sensors for our servers

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
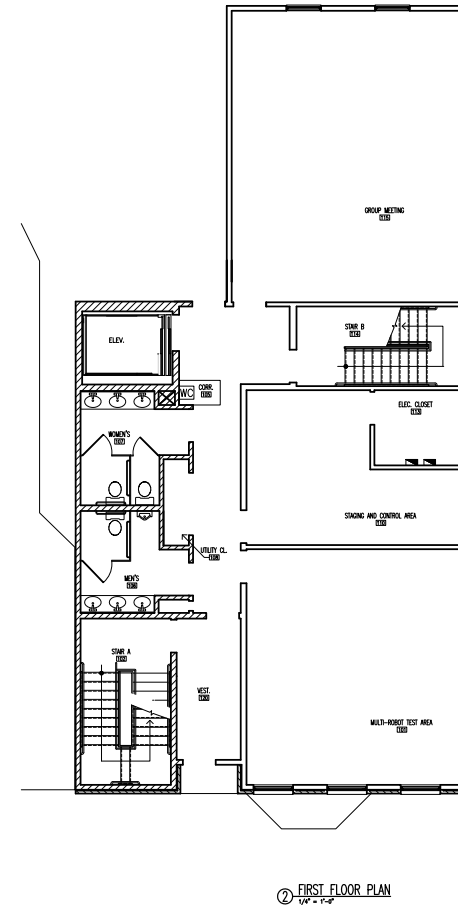- Storage
- *Maintenance*
- Analysis
  - Big Data

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- Storage
- Analysis
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Recurrent Issues

- Power
- Location
- Communication
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- Security
- *Maintenance*
- Analysis
  - Big Data

FIRST FLOOR PLAN

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- *Maintenance*
- Analysis
  - Big Data

100 meters

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- *Maintenance*
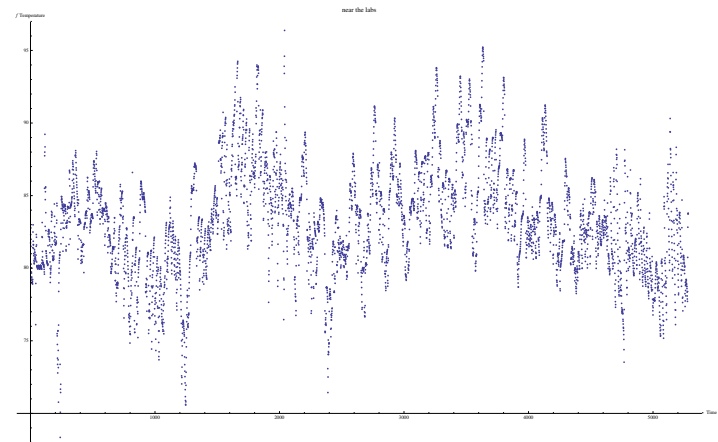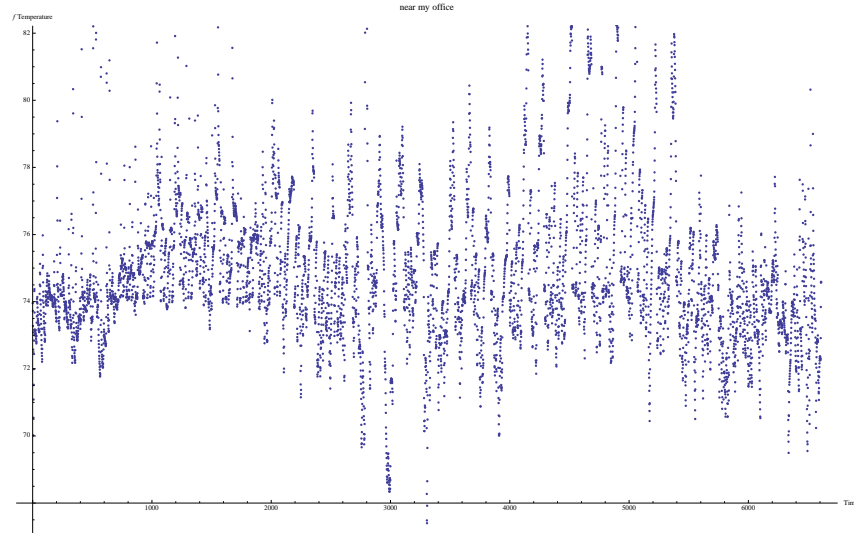- Analysis
  – Big Data

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- **Security**
- *Maintenance*
- Analysis
    - Big Data

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- *Maintenance*
- Analysis
  - Big Data
  - Missing Data
  - (Power)

Smart Hoboken

- 19 libellium sensor installations
  - 6 additional meshlium servers
  - Arduino like
  - ZigBee
- Several streets in Hoboken particularly
  - Washington and Sinatra
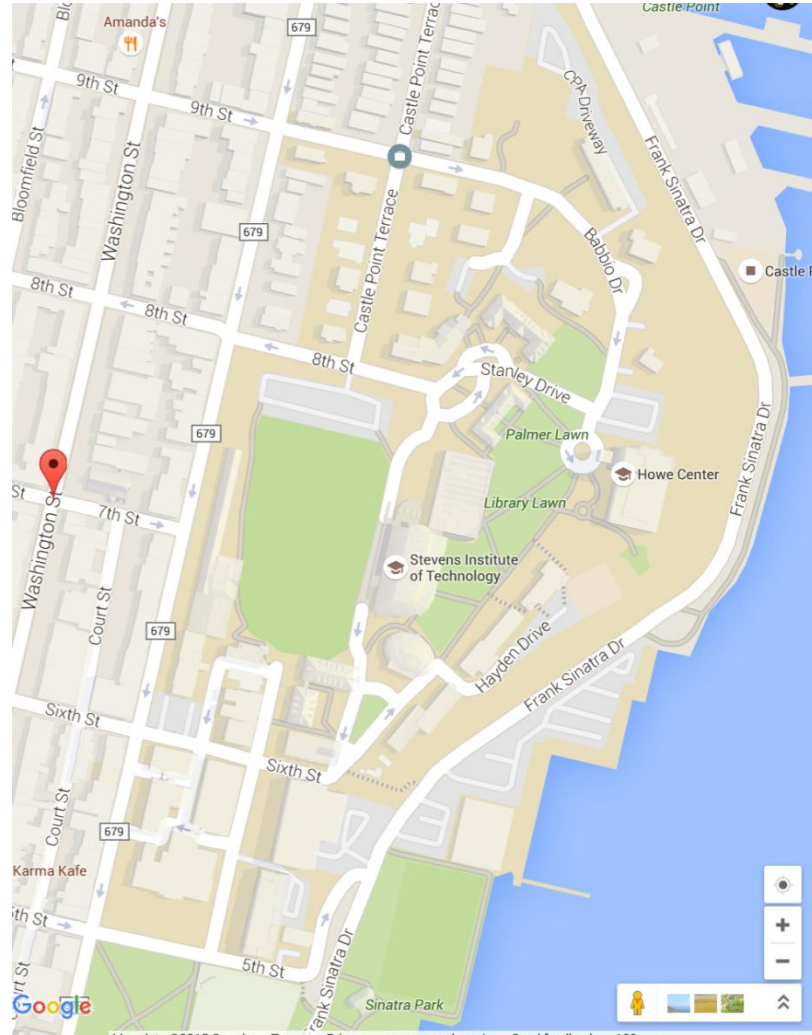
Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
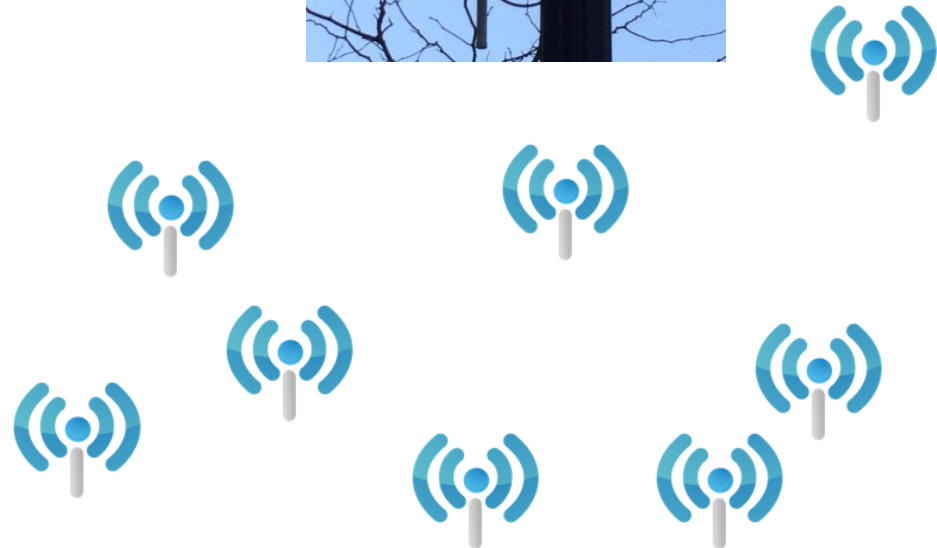- Analysis
  - Big Data

Solar panels, batteries, and trees

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- *Maintenance*
- Analysis
  – Big Data

Recurrent Issues

- Power too!
- Location too!
- Communication
- Calibration
- Security
- *Maintenance*
- Analysis
  - Big Data

Recurrent Issues

- Power
- Location
- Communication
- **Calibration**
- Security
- *Maintenance*
- Analysis
  - Big Data

Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- Maintenance
- Analysis
  - Big Data

Recurrent Issues

- Power
- Location
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Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- Analysis
  - Big Data

12227	2015-07-23 14:18:45	0	1N	382549587	253	60	BAT	100
12226	2015-07-23 14:13:39	0	1N	382549587	253	59	MCP	65
12225	2015-07-23 14:13:39	0	1N	382549587	253	59	BAT	100
12224	2015-07-23 14:08:33	0	1N	382549587	253	58	MCP	64
12223	2015-07-23 14:08:33	0	1N	382549587	253	58	BAT	100
12222	2015-07-23 14:03:27	0	1N	382549587	253	57	MCP	63
12221	2015-07-23 14:03:27	0	1N	382549587	253	57	BAT	100
12220	2015-07-23 13:58:21	0	1N	382549587	253	56	MCP	71
12219	2015-07-23 13:58:21	0	1N	382549587	253	56	BAT	100
12218	2015-07-23 13:53:15	0	1N	382549587	253	55	MCP	61
12217	2015-07-23 13:53:15	0	1N	382549587	253	55	BAT	100
12216	2015-07-23 13:48:09	0	1N	382549587	253	54	MCP	64
12215	2015-07-23 13:48:09	0	1N	382549587	253	54	BAT	100

Addressing Recurrent Issues

- Power
- Location
- Communication
- Calibration
- Security
- Analysis
  - Big Data
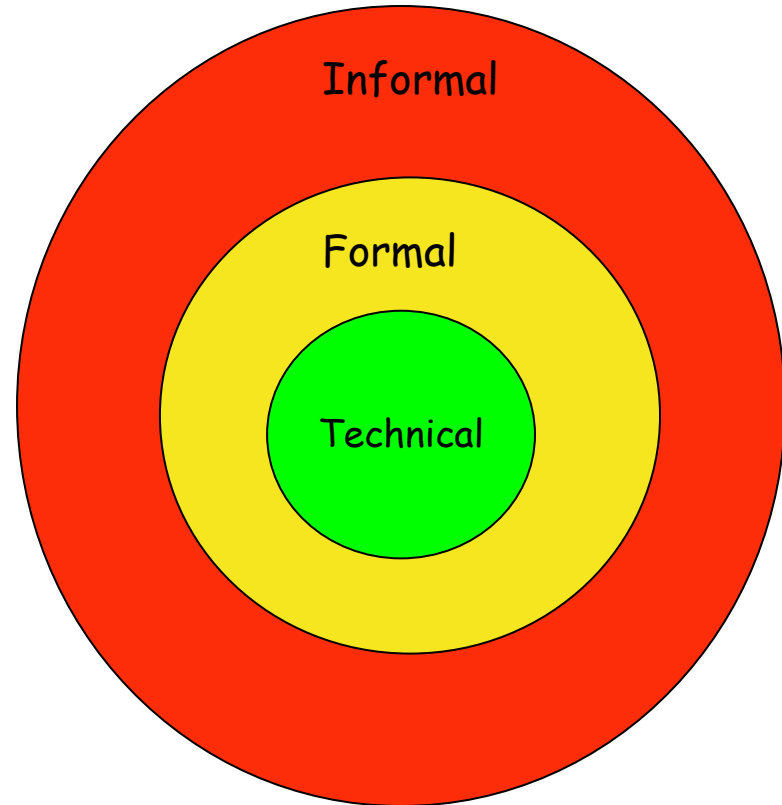
Fukishima

Japan's Tsunami

STEVENS INSTITUTE *of* TECHNOLOGY

Fukushima

PHOTO: ISSEI KATO/AFP/GETTY IMAGES

3 of 6 nuclear reactors melted down

money.cnn.com

Radiation Spread

- Government reported on the spread of radiation
- A 20 kilometer exclusion zone was established
- Citizens were skeptical about the government reports
- Radioactive water was leaking into the ocean

wikipedia

Personal Radiation Detectors

- Citizens needed another way to assess the threat
- Personal radiation detectors emerged built on microprocessor technology
- iPhone Safecast app
- Data placed in repository
- APIs to access data
- Soon citizens were posting their own data

amazon.com

Medcom.com

SafeCast Map
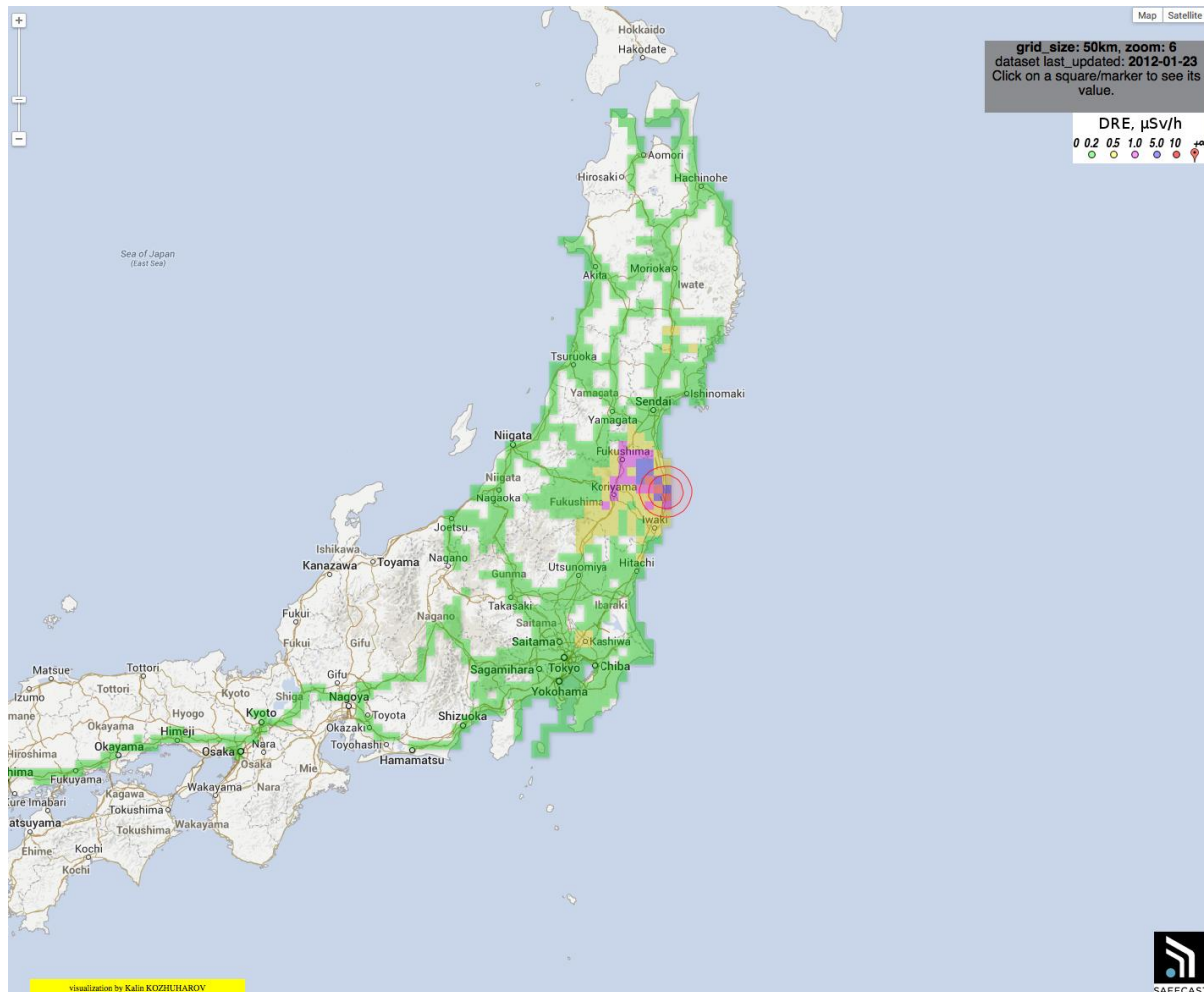
Other Maps

- Large number of readings invaluable
- Compared against government produced data
- Compared against their data – calibration is an issue
- Real-time data
- Multiple visualizations

spectrum.ieee.org

STEVENS INSTITUTE *of* TECHNOLOGY
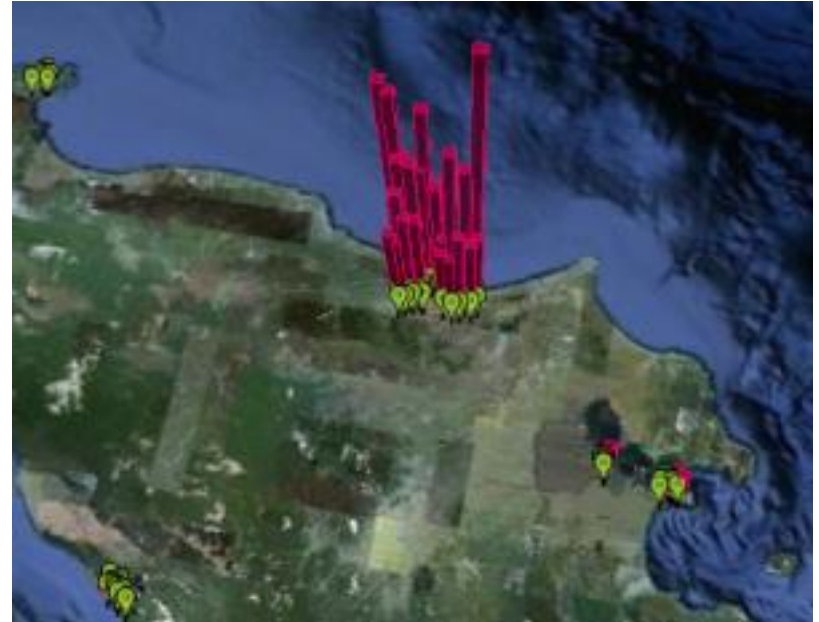
How it works

- People or machines generate data
  - PAN
- Data is transferred to a collecting point
- Data is ordered in some way
  - Database
- Code is written to access the data -> APIs
- Developers use APIs to access data

Yo

Yo is an almost absurd exercise in minimalism; the app allows you to send and receive "Yo" with your contacts—and that's it. There's no content, no options, no customization... just "Yo."
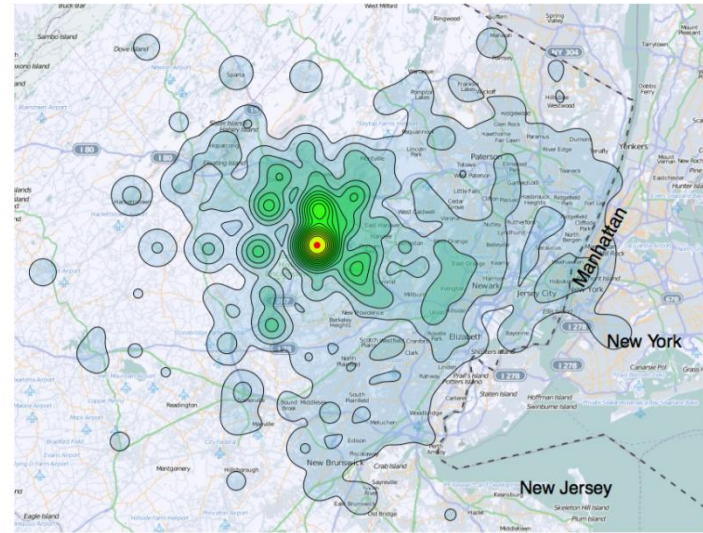
WHAT GOOD IS THIS APP?

http://www.dailydot.com/technology/yo-app-israel-missile-strike/

Thanks!

BACKUP

Smart Phones as sensor devices

A Tale of One City

Becker, R.A., et.al. AT&T
Labs-Research

- 15 million voice CDRs

- 26 million SMS CDRS

- Was it reflective of behaviour, the laborshed?

(a) Call Detail Records
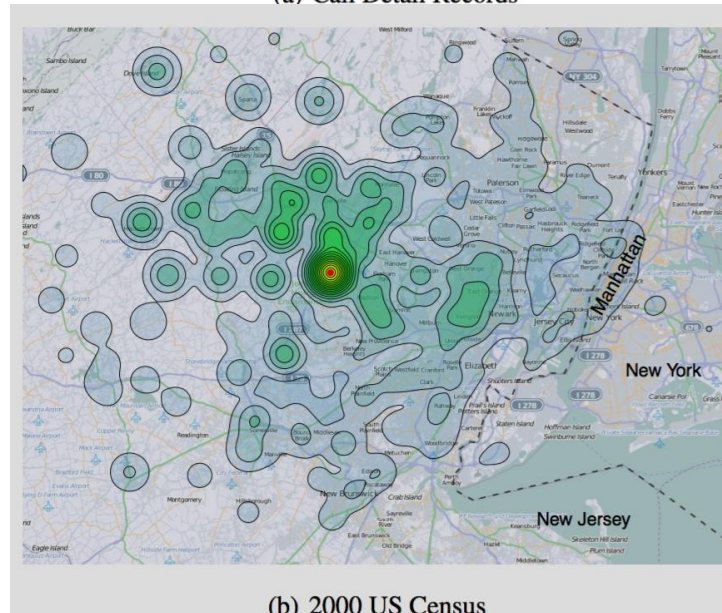
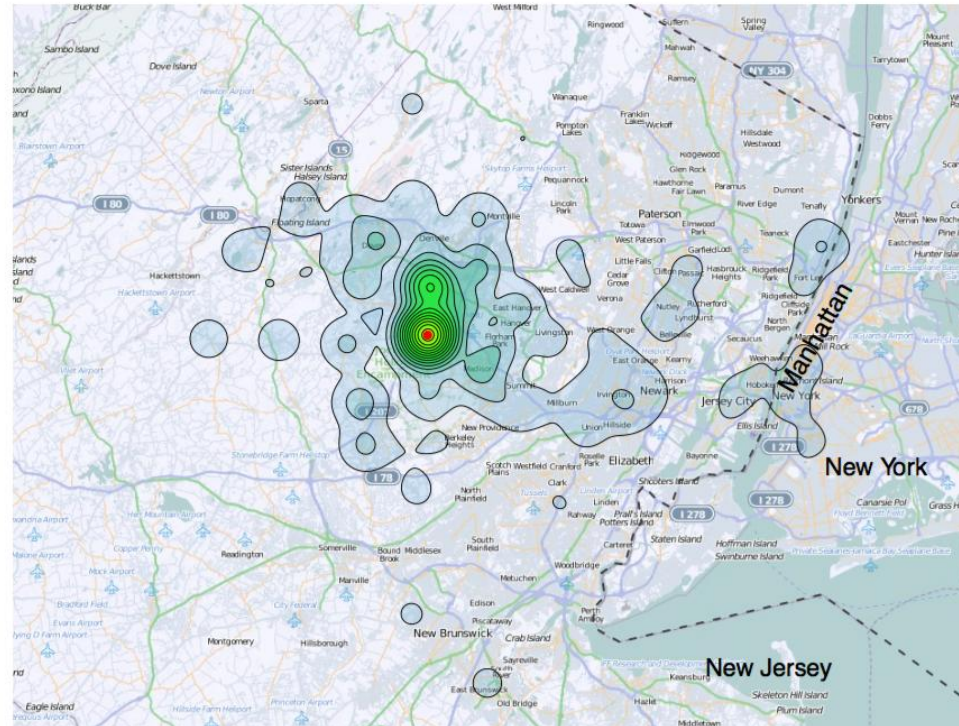
(b) 2000 US Census

Partyshed

Figure 3: Morristown partyshed map showing the home locations of people who used their cellphones during weekend late nights in downtown Morristown. Comparing to the earlier laborshed maps, partiers' homes are concentrated in areas closer to Morristown than workers' homes.
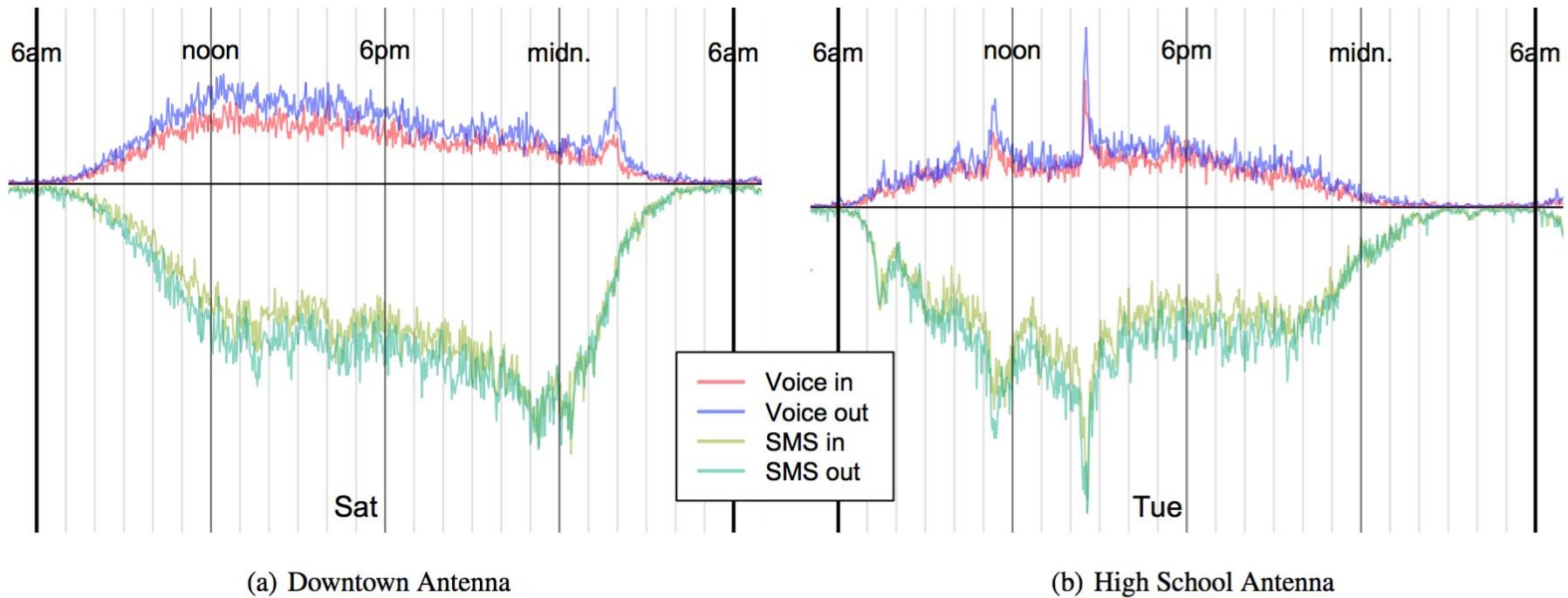
SMS + Telephone calls

(a) Downtown Antenna   (b) High School Antenna

Figure 4: *Lip plots* of voice call and SMS volumes show unusual spikes highlighting local patterns or events in Morristown. Call volume (plotted upwards; inbound: red; outbound: blue) and SMS volume (plotted downwards; inbound: light green; outbound: dark green) on two antennas are shown. The antenna in (a) points towards the commercial and restaurant district and the antenna in (b) points towards the high school. A voice peak occurs Saturday at 2AM when the bars close. Both voice and SMS peaks occur Tuesday when the school lets out.

Anonymization

The data was collected and anonymized by a party not involved in the data analysis. In place of the phone number of the person involved in a transaction, each CDR contains an anonymous identifier consisting of the 5-digit billing zip code and a unique integer. Each CDR also contains the starting time of the voice or SMS event, the duration of the event, and the locations and azimuths of the antennas of cell tower antennas associated with the event.

# Smart phones as sensor devices(Cisco)

Measure	Description	Application
Number of devices	The number of Wi-Fi devices (smartphones, tablets, or laptops) identified within an area during a time window	Determine the number of customers or potential customers by date and time
Dwell/waiting time	An estimation of the duration during which a device is present in a particular space	Determine the amount of queuing or the average time spent in a shop or facility
Crowding factor	A normalized value determined by the number of devices seen within an area during any time window	Helps determine potential bottlenecks or where extra resources are needed
Dominant direction	The most typical directions of travel through an area	Knowing the flow of pedestrians across a hallway at various times promotes better safety precautions
Speed	The straight-line distance between two points divided by the duration between them	Being able to differentiate between pedestrians, cyclists, and cars, for example, is important in a city context
Churn	The relative number of devices that appear and disappear during a time window	How well restaurants process clients at different times of the day is crucial to their profitability
Retention	The opposite of churn, measuring the relative numbers of devices remaining in the area over time	Measures how well certain venues attract and keep an audience
Frequency	The number of times a device is detected within a specific time window	Measures the loyalty of the visitor, or how many need to be informed of the layout if they are first-time visitors

http://www.cisco.com/c/en/us/products/collateral/wireless/mobility-services-engine/white_paper_c11-728970.html
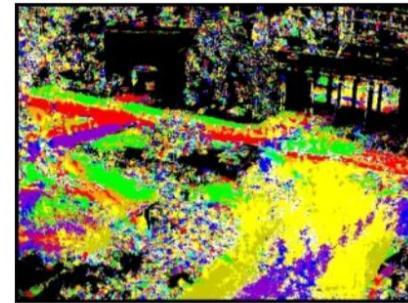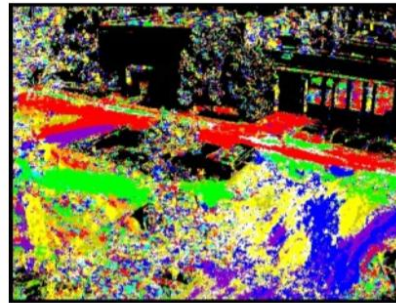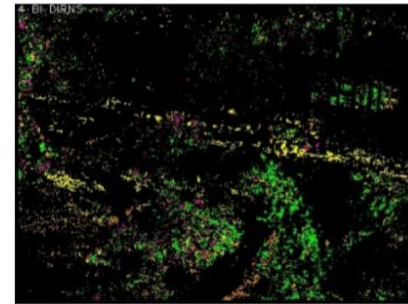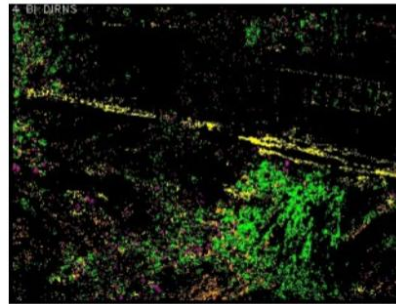
O'Gorman – Bell Labs

UCLA campus
-2 intervals representing
27min (l) & 12 min (r)
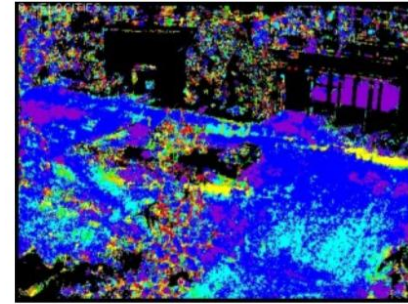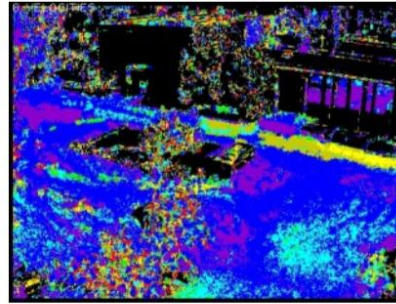Note class change and
Food trucks
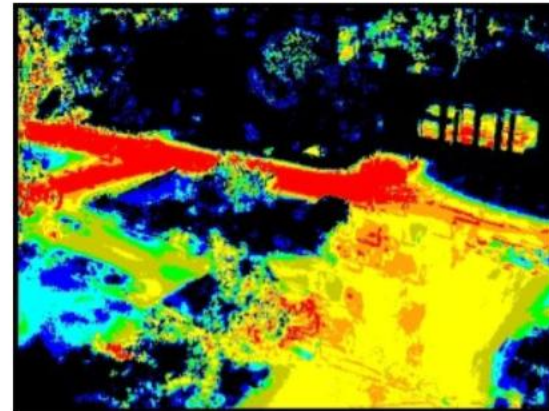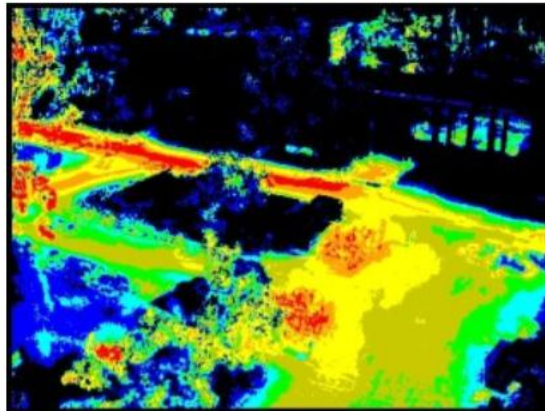
Continuation of analysis:
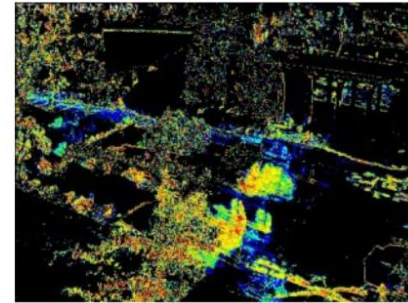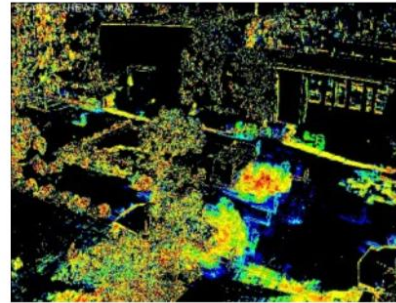-direction red (r), green(l)

Bidirection – yellow overlap
 opposing directions (sidewalk),
 green vertical motion (grass)

Velocity –blue & cyan slow
Red (high) leaves

            dwell

Power

- Technical
  - Whenever possible, line power
  - Solar/wind + battery backup
  - Power and radio related
    - Protocols
- Formal
  - Just enough data – analytics
    - Privacy
  - Active upgrade policy
- Informal
  - Embed (lights, phones, beacons)
- Maintenance – plan and test (lab setup)

Location

- Technical
  - Accurate location reporting
  - Heartbeat – I'm here
- Formal
  - Accurate data bases
  - Consistency audit
- Informal
  - Crowd sourcing

Communication

- Technical
  - Simplify BLE
  - Stanardize – IPv6
  - Minimal radios
- Formal
  - Analysis for just enough
  - Different modes
- Informal
  - Crowd sourced, e.g., data mule

http://rohitagarwal24.blogspot.in/2013/12/a-software-engineer-perspective-on-iot.html
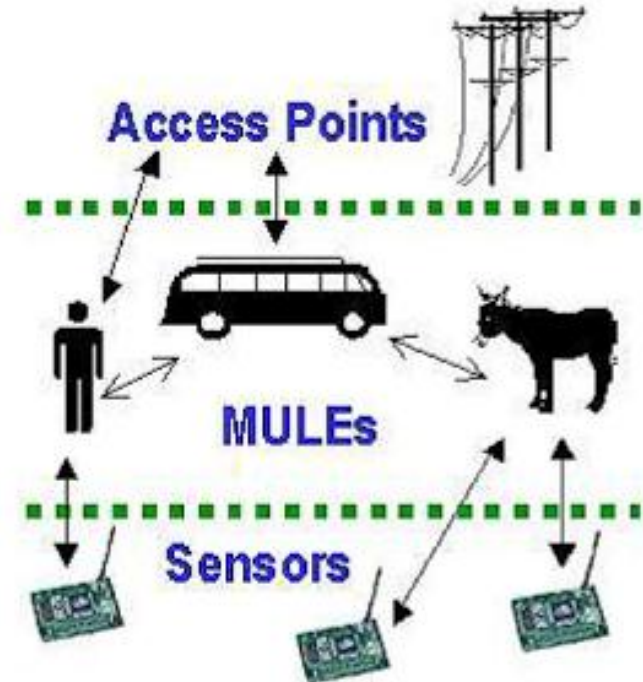
Calibration

- Technical
  - Redundant sensors
- Formal
  - Plan: periodic tests, syncs
- Informal
  - Crowd sourced – smart phone sensors
  - Social media – hot, noisy, air quality
    - Very least indicate if sensors are sane

Security

- Technical
  - Embed (beacons)
  - Open
    - Secure communication and software update mechanism (agents)
- Formal
  - Tested infrastructure
  - Educate Public
- Informal
 - Involve

Agent Smith, The Matrix

Analysis and Big Data

- Technical
  - Blackboard model
  - Other sources
- Formal
  - Focused analysis
  - Collect only what you use (privacy)
- Informal
  - Communicate the value
  - Crowd source analysis (programmable web)
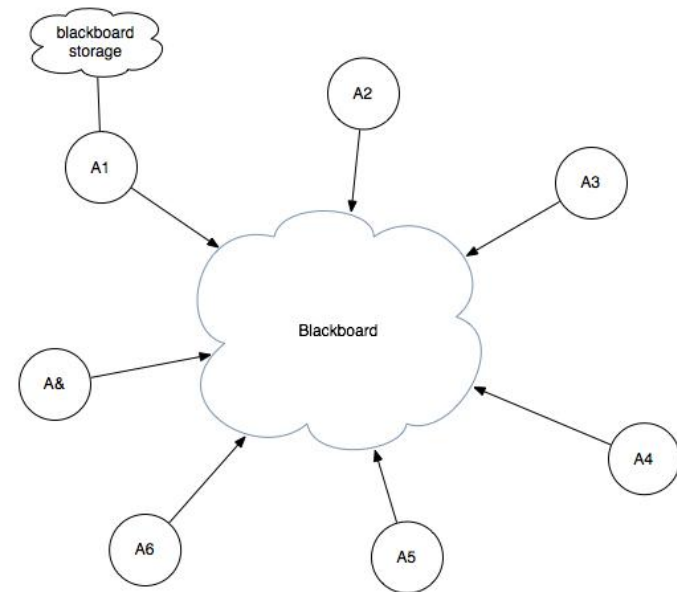
Cross Cutting – IoT Ecosystem

- Location is important!
- Emulate, Simulate, Lab test
- Beacons
- Environment Eggs
- Smart Homes
- AI – beyond ML to blackboard architecture and agents
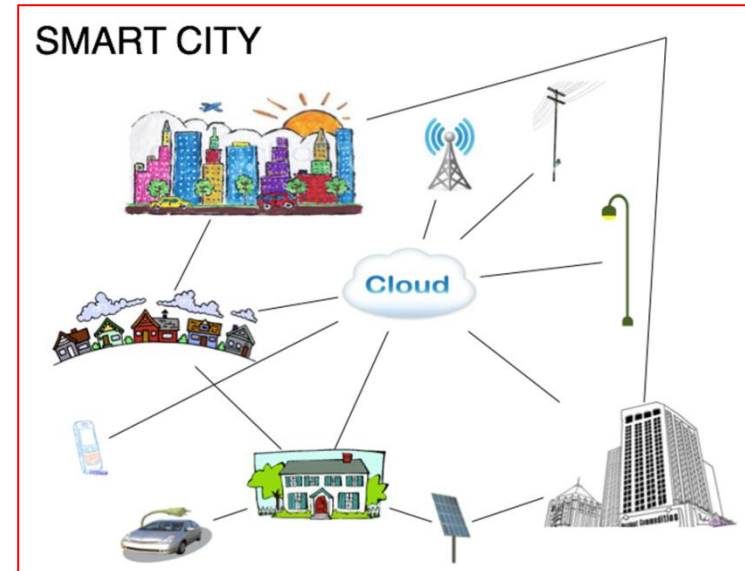
Water Sensors (Libelium)

- Potable water monitoring
  Monitor the quality of tap water in cities.

- Chemical leakage detection in rivers
  Detect leakages and wastes of factories in rivers.

- Swimming pool remote measurement
  Control remotely the swimming pool conditions.

- Pollution levels in the sea
  Control realtime leakages and wastes in the sea.

- Water Leakages
  Detection of liquid presence outside tanks and pressure variations along pipes.

- River Floods
  Monitoring of water level variations in rivers, dams and reservoirs.