SENSING TECHNOLOGIES FOR DATA COLLECTION AND MONITORING

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DIL '14 – STATE OF THE SCIENCE

Data is empowering

[UFL BuildGreen]

Regions of Strong Coupling Between Soil Moisture and Precipitation

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Previous estimates of land-atmosphere interaction (the impact of soil moisture on precipitation) have been limited by a lack of observational data and by the model dependence of computational estimates. To counter the second limitation, a dozen climate-modeling groups have recently performed the same highly controlled numerical experiment as part of a coordinated comparison project. This allows a multimodel estimation of the regions on Earth where precipitation is affected by soil moisture anomalies during Northern Hemisphere summer. Potential benefits of this estimation may include improved seasonal rainfall forecasts.

Atmospheric chaos severely limits the predictability of precipitation on seasonal time scales. Weather forecasts, which rely heavily on atmospheric initialization, rarely demonstrate skill beyond about a week. Hope for accurate seasonal forecasts lies with simulating the atmospheric response to slowly varying states of the ocean and land surface—components of the Earth system that can be predicted weeks to months in advance. A systematic response of the atmosphere to these boundary components would contribute skill to seasonal prediction.
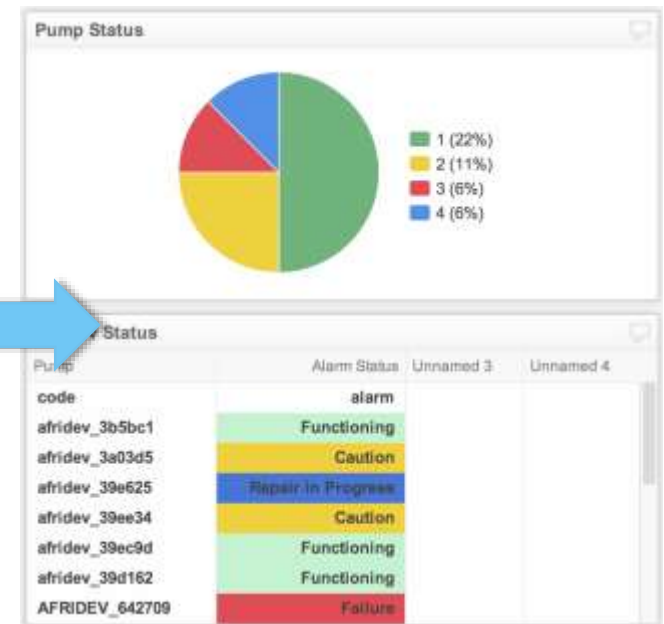
[GLACE Team Rainfall Estimation]

Where does data come from?

Sensors

Used to get data from the physical world to the digital world

Automated, continuous data collectors

[SweetSense]

The most important question in planning your deployment, part 1

How often do I need to get data from my sensors?

[Global Seismographic Network]

[Bennet: Crane Charades]

[Seismic Surveys]

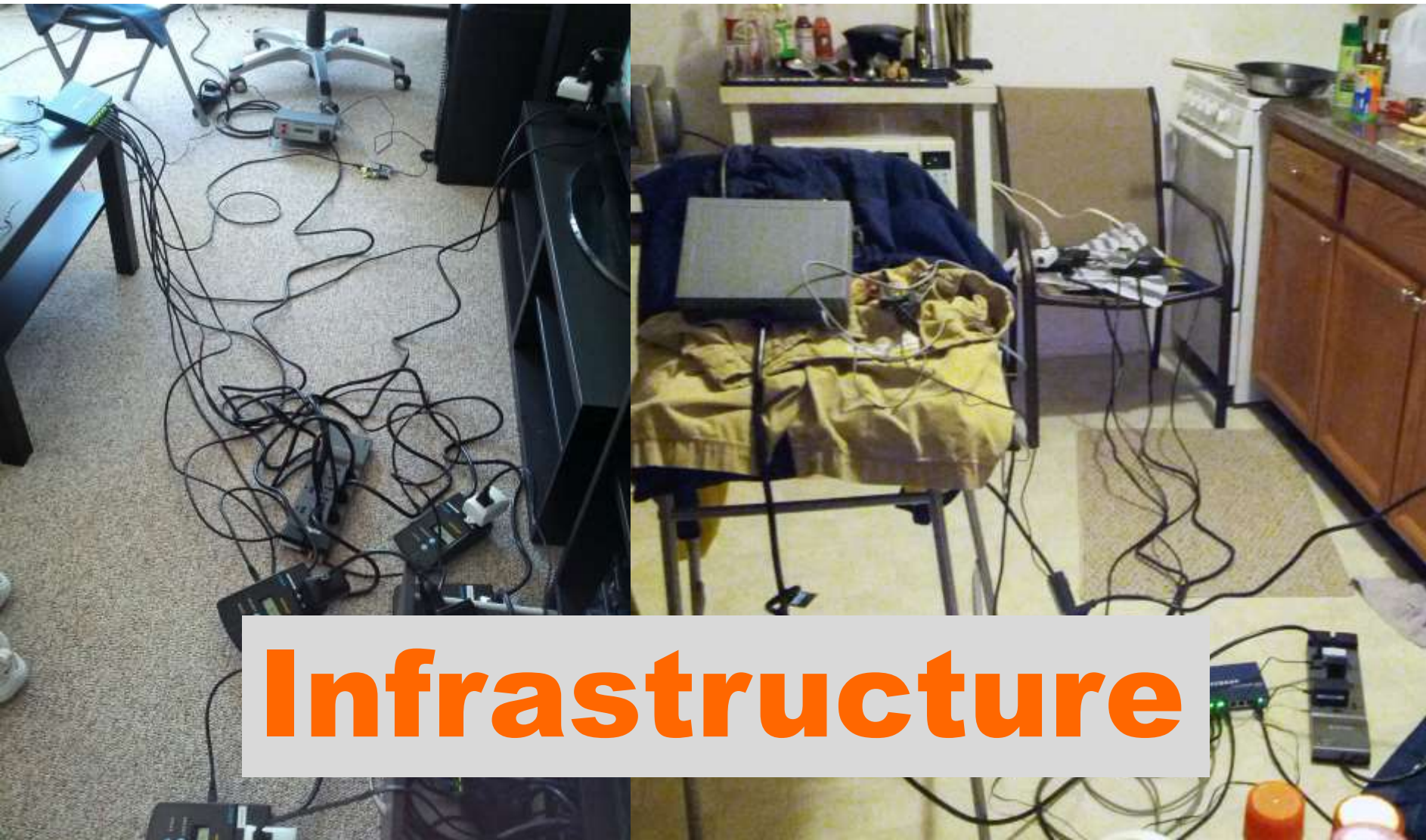*Real-time*   *Periodic*   *Single Dump*

How am I going to get data off of my sensors?

All forms of communication are not created equal

Instrumenting a home with WattsUp.net

Infrastructure

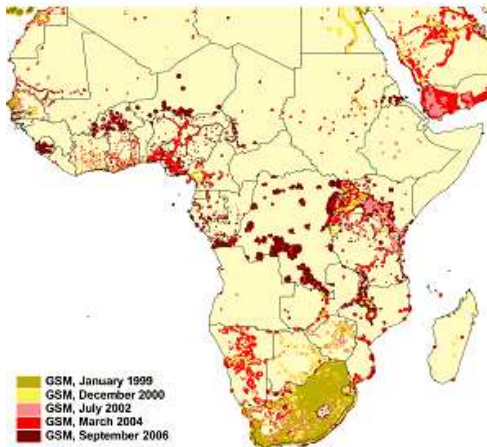# Going wireless does not eliminate infrastructure costs, it only shifts it

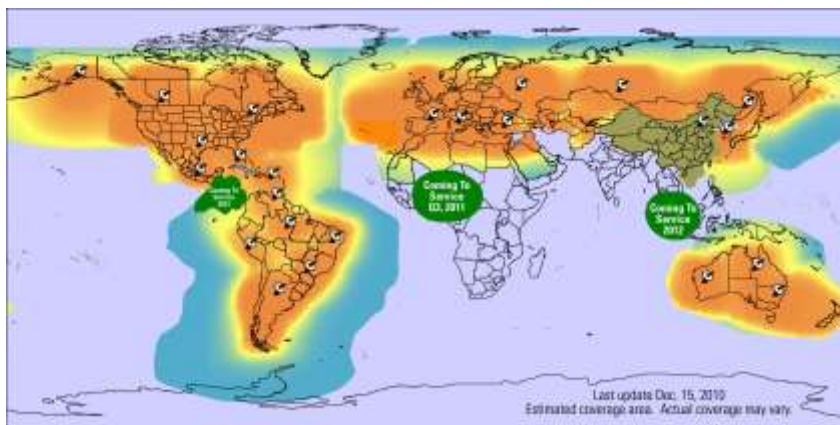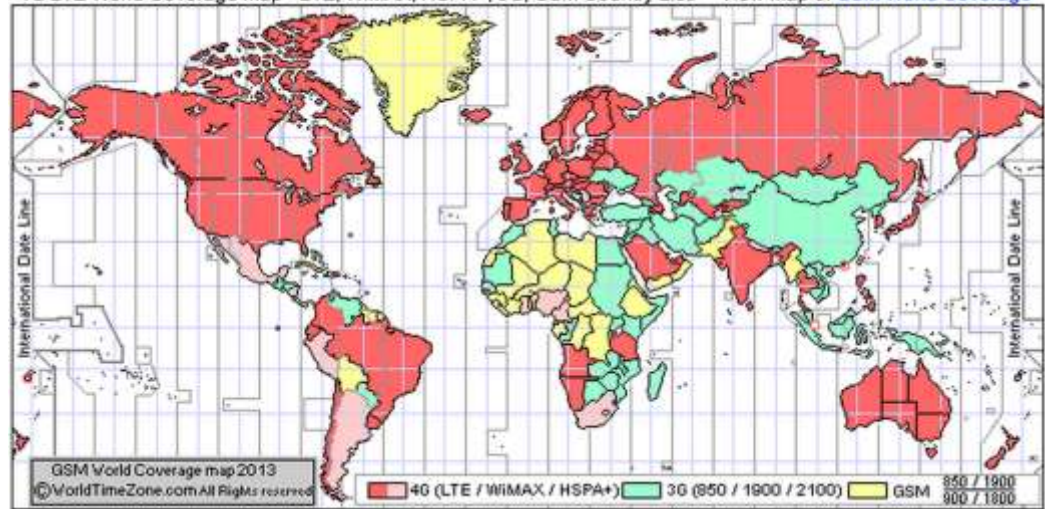Wi-Fi Router

Hidden Infrastructure

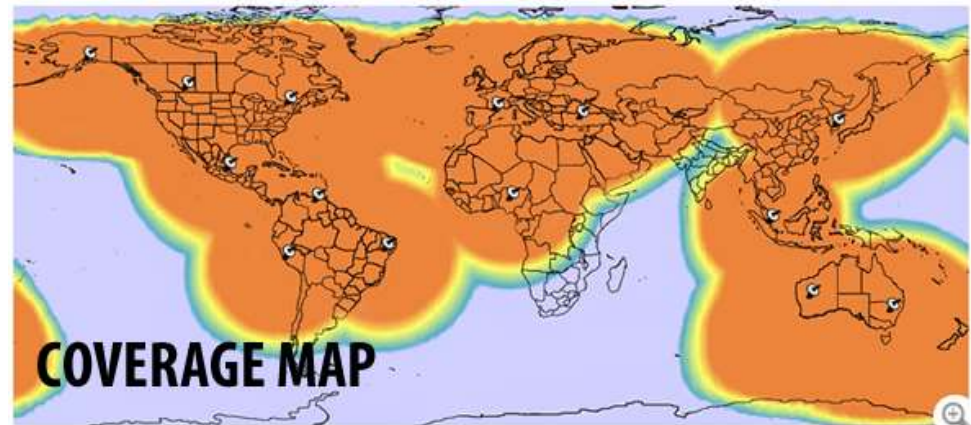# There is no truly ubiquitous communications infrastracture

Figure 1 GSM cell phone expansion in Sub-Saharan Africa, 1999 – 2006

GSM, January 1999
GSM, December 2000
GSM, July 2002
GSM, March 2004
GSM, September 2006

4G LTE World Coverage Map - LTE, WiMAX, HSPA+, 3G, GSM Country List.   View Map of GSM World Coverage

GSM World Coverage map 2013
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4G (LTE / WiMAX / HSPA+)   3G (850 / 1900 / 2100)   GSM   850 / 1900   900 / 1800

Last update Dec. 15, 2010
Estimated coverage area. Actual coverage may vary.

[satphonestore.com coverage, 2010]

COVERAGE MAP

[satphonestore.com coverage, 2011]

The next question:
How am I going to power my sensor?

Informed by the previous questions

Batch Offloading is easy:

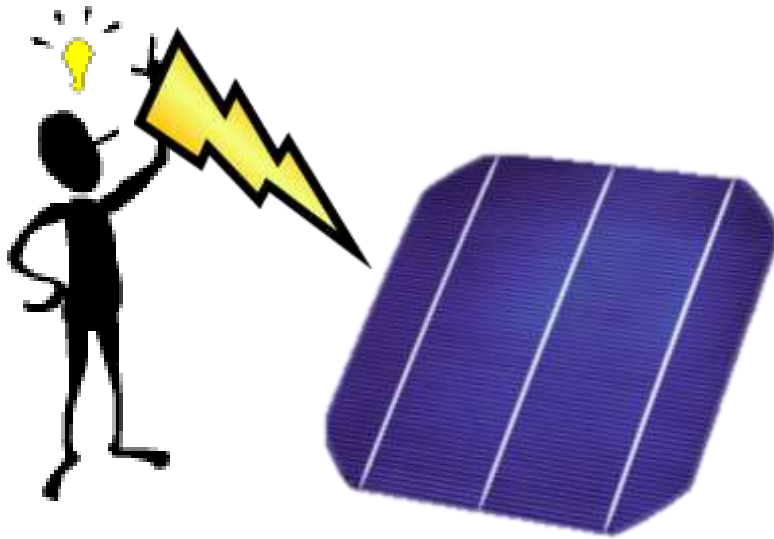　Battery size proportional to data size

Wired networks:

　Relative cost of adding power wires is low (usually)

Wireless…

Idea: Do we need a battery?

[UMass Rivernet]

[CSIRO Fleck1]

Up until now, we have discussed "Traditional Sensing"

To sense temperature, use a temperature sensor

Systems goals do not necessarily map directly to sensing goals

"I need a sensor that measures water flow"

+ Mechanically challenging

"It needs to be wireless and last for several months"

"I want to measure if people wash their hands after they use the toilet"

You actually want a temperature sensor

Paul Martin, Zainul Charbiwala, Mani B. Srivastava
DoubleDip: leveraging thermoelectric harvesting for low power monitoring of sporadic water use
In Sensys'10

The Monjolo Principle
Combining non-traditional sensing and energy harvesting

Harvest side-channels of energy – wakeup frequency is the sensor
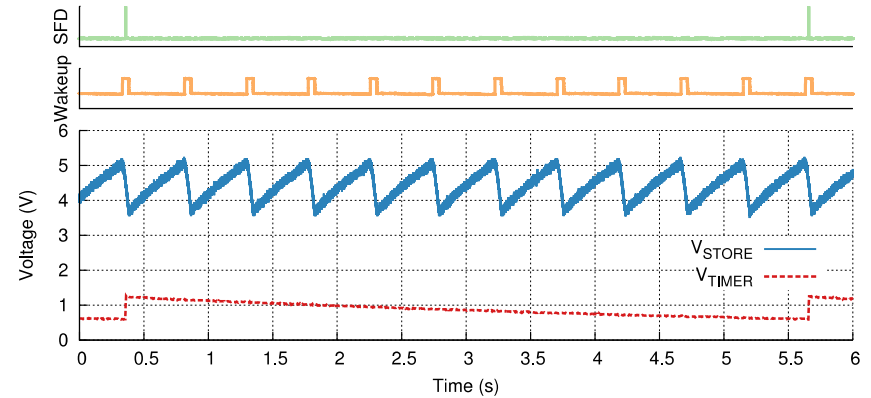
[Monjolo, Sensys '13]

Monjolo in action

http://inductor.eecs.umich.edu/pathouse.html
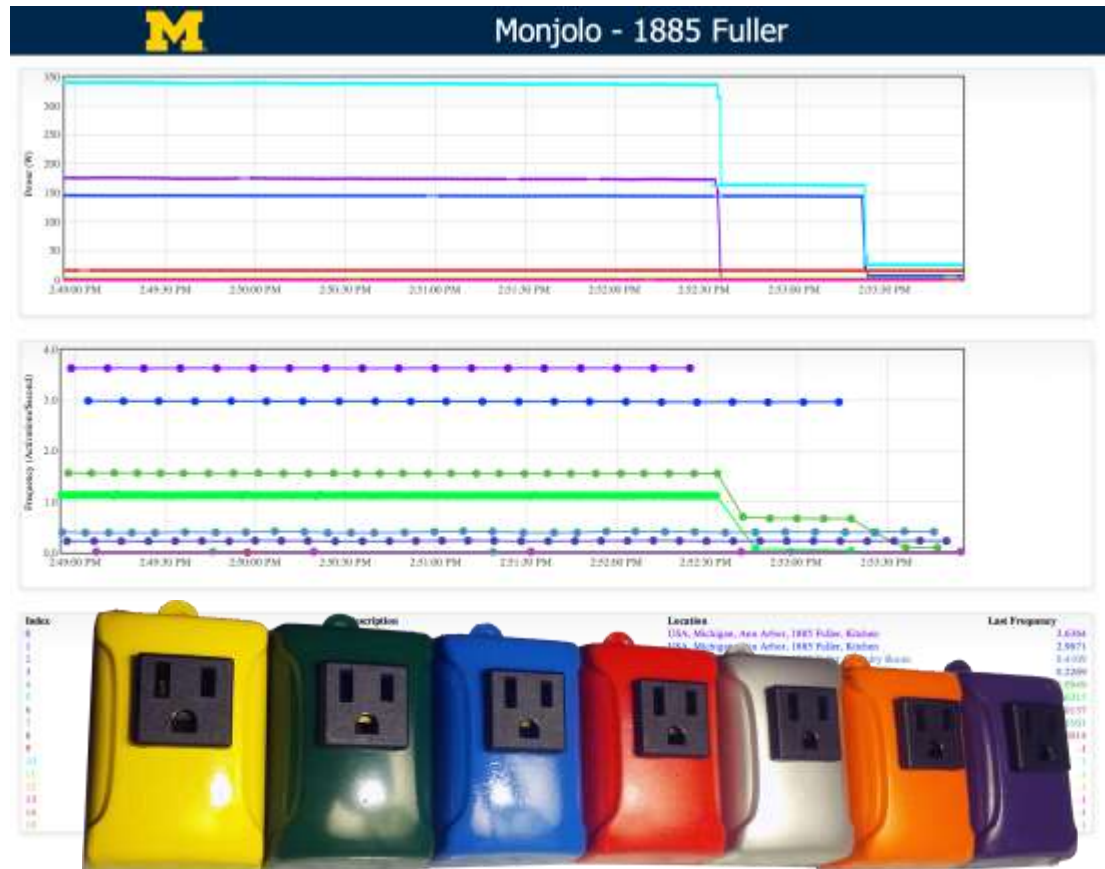
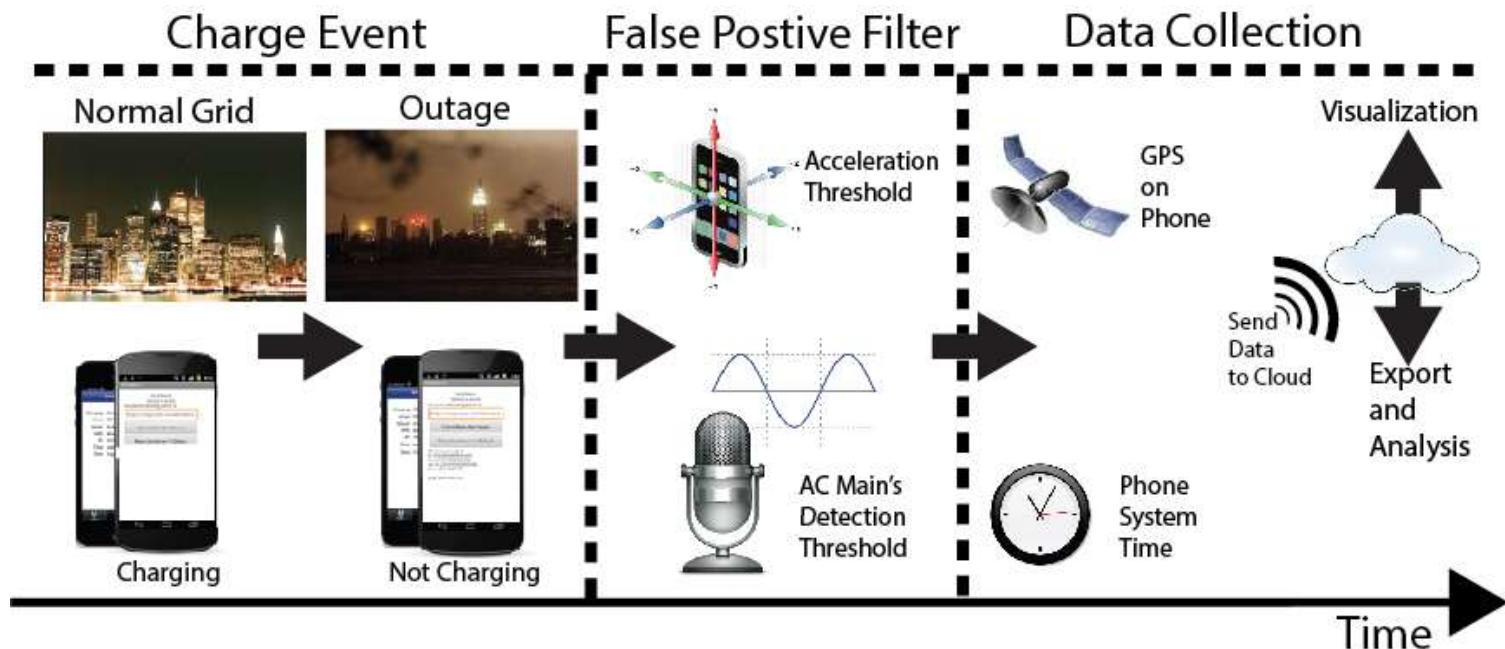# I have neglected the most deployed sensor in the world...

The Smartphone!

GridWatch: Crowdsourcing power grid health monitoring

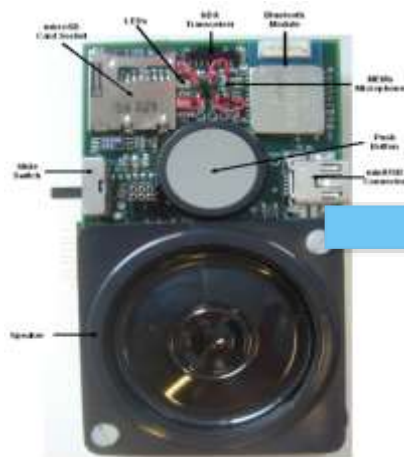**Insight:** **You pick up your phone to unplug it**

+ Power loss without motion is likely a power outage

[GridWatch HotMobile '14]

Smartphones have a diverse array of powerful sensors

Accelerometer, Gyroscope, Magnetometer, GPS, camera, …

And communication (cellular, WiFi, Bluetooth, NFC) is built in

Pentland '06   Pentland '07   Pentland '09

Augmenting smartphones to add "missing" sensors

Geiger Counter

EKG Monitor

Thermometer

CC Terminal

CO Sensor

Soil Moisture

[slide courtesy Prabal Dutta]

Takeaways

If you can think something to measure, it can be measured

Though measuring it directly may not always be the best approach

Constraints on data-collection define the rest of your system

Or at the least are a very good place to start

Smartphones are useful, but not a panacea

And can be costly (though re- and multi-purposeable)

Ask not what you can do for DIL, but what DIL can do for you

Problems, challenges, we need them!

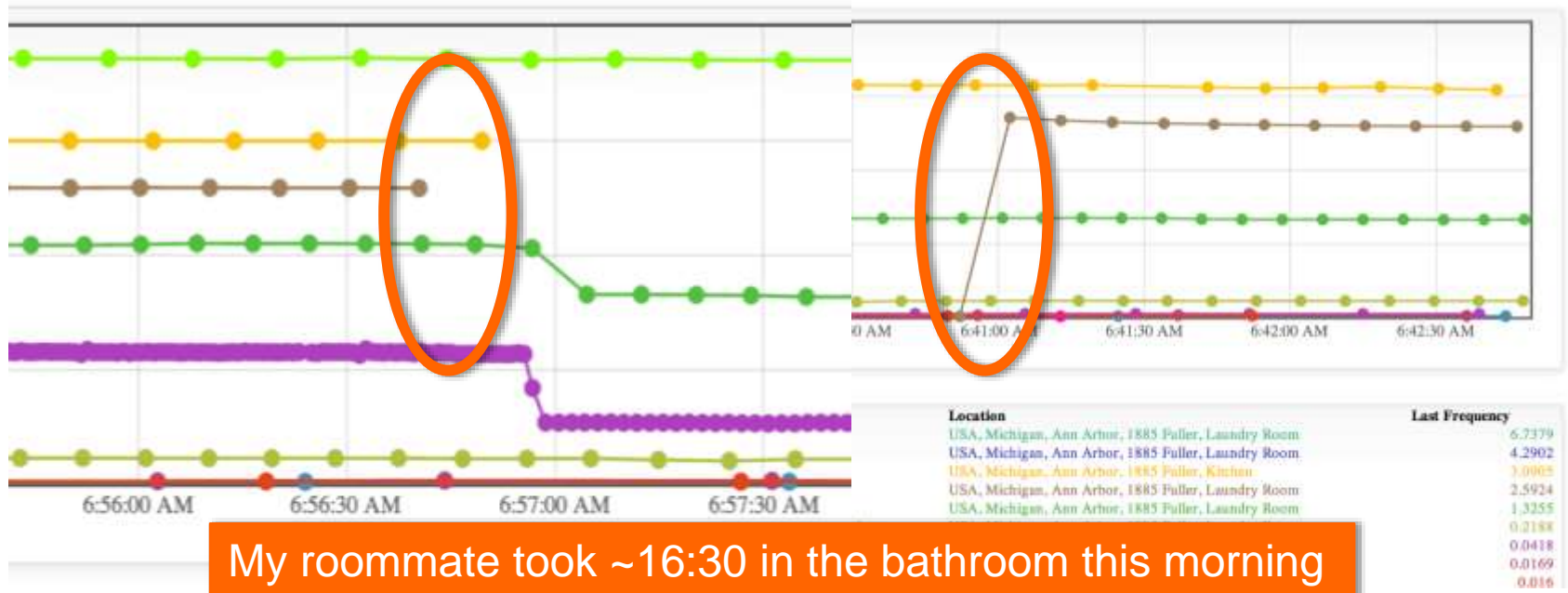**What is interesting to collect?**

What constraints aren't we seeing?

Especially those that are developing world related

Cultural help: We like data too much for our own good

We can see devices turn on / off

Lose sight of the fact that humans are turning them on and off

My roommate took ~16:30 in the bathroom this morning

Privacy implications

What should a system like this look like?

I have lots of cool hardware with me today – come find me!

lab11.eecs.umich.edu

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