

# Applications and effects of IoT on human behavior

---

CSE 291 – Internet of Things  
Christine S Chan  
3/2/2016

System Energy Efficiency Lab

[seelab.ucsd.edu](http://seelab.ucsd.edu)

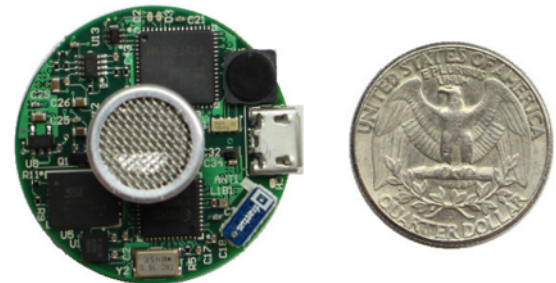


# Our Relationship with the Digitized World



# Opportunistic IoT

- Main opportunity and application: *data sharing* based on human *mobility* and *gregarious nature*
- Three types of sensing awareness
  - User awareness
  - Ambient awareness
  - Social awareness
- Ad hoc, opportunistic networking of devices (e.g., mobile phones and smart vehicles) using short-range radio techniques (e.g., Bluetooth and Wi-Fi).
- Examples: Apple Pay, Web Whatsapp, Fitbit syncing, Opo @ UMich



# Our Relationship with the Digitized World

---

- How can we leverage the current (and developing) Internet of Things to study and improve human behavior?

# Exploiting Competition and Technology

---

- Do you know how much \$ you pay for electricity per month?
- Do you know how many kWh you consume?
- Can be reported by utility company
- SDG&E: “Manage, Act, Save” program
- OPOWER (startup) supplies algorithms that operate with data provided by local utilities
- Smart metering allows more sophisticated household profiling
  - Proactive, detailed bill alerts
- Normative messaging
  - Compare to real neighbors
    - “77% of San Marcos uses fans!”
  - Compare to hypothetical neighbors
    - Houses similar to yours in size, age, and location.
  - Smileys are good; absence of smileys is ok; frownies get you customer complaints

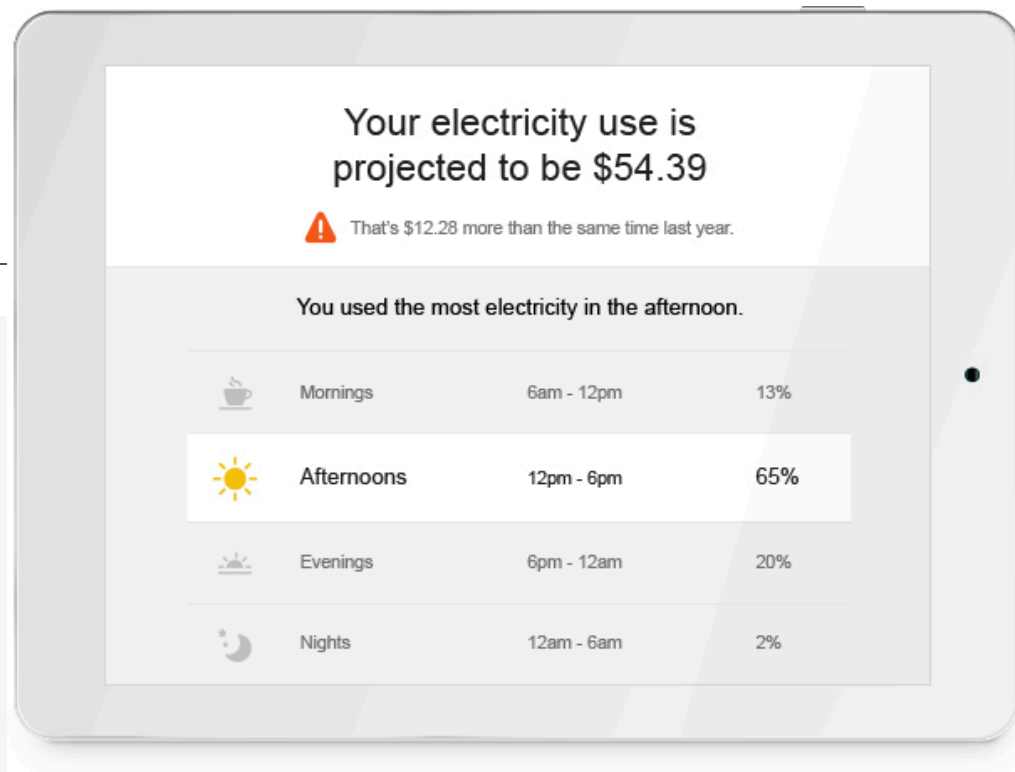
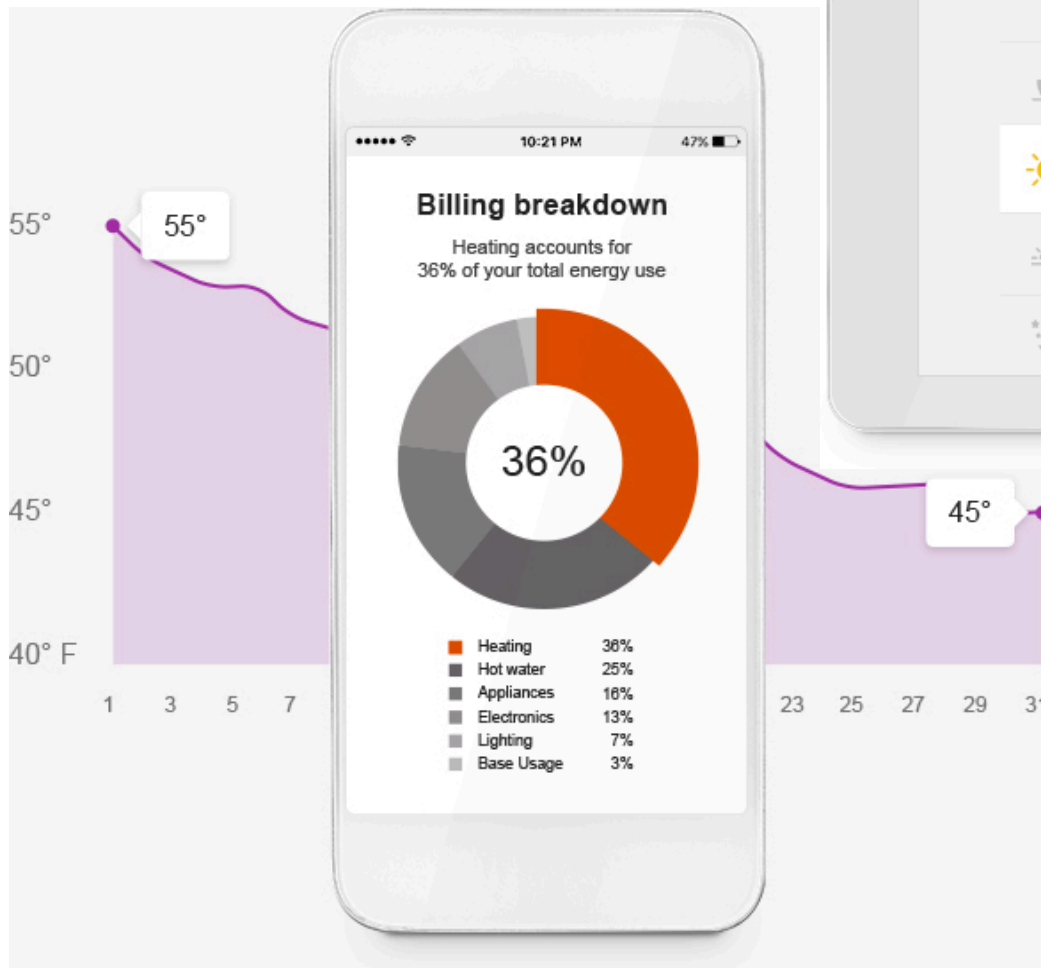
<http://www.csmonitor.com/Technology/2009/0930/energy-use-falls-when-neighbors-compete>

<http://www.psmag.com/nature-and-technology/whos-saving-electricity-in-your-neighborhood-39932>

[http://www.slate.com/articles/technology/the\\_efficient\\_planet/2013/03/opower\\_using\\_smiley\\_faces\\_and\\_peer\\_pressure\\_to\\_save\\_the\\_planet.html](http://www.slate.com/articles/technology/the_efficient_planet/2013/03/opower_using_smiley_faces_and_peer_pressure_to_save_the_planet.html)

[http://articles.chicagotribune.com/2014-03-03/features/ct-energy-comparisons-brotman-talk-0303-20140303\\_1\\_energy-hog-energy-efficiency-comed](http://articles.chicagotribune.com/2014-03-03/features/ct-energy-comparisons-brotman-talk-0303-20140303_1_energy-hog-energy-efficiency-comed)

<https://www.ase.org/resources/step-local-energy-program-helps-maryland-save>



Similar Homes

Friend Rank

About Me

How I did in **October** ▼

**i** Room for improvement

⚡ Used 12% more than September

👍 Used less than yearly average

Efficient homes ?

**\$35.12**  
300 kwh

All homes ?

**\$37.12**  
312 kwh



**My home**

**\$43.00**  
340 kwh

**An easy way to save:**



Turn off lights when not needed

👤 1,021 people do this

Show more tips ➔



**Join a group, compete together!**

Find people with similar interests to drive efficiency at home.

Search groups ➔

You are being compared to to **214,827** homes with these characteristics:

↕ **0-500 sq ft**

❄ **Central A/C**

💧 **No fireplace**

📍 **NE Climate**

[Edit my home information](#)

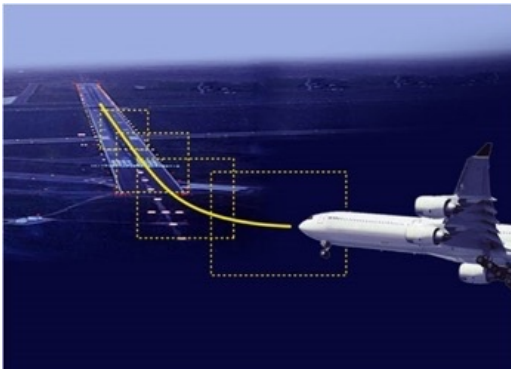
# Exploiting Competition and Technology

---

- Sacramento, CA case study
  - Trial over only 5% of the service area (35,000 homes)
  - 20 most efficient homes consume **587 kilowatt-hours (kWh)** per month, others consume **2-3x as much**
  - 2% energy savings == power 1000 homes for a year
  - Program costs \$10 per customer per year
  
- Other regional results
  - Better PR: 19% fewer calls, shorter call times
  - OPOWER (nationwide): 3% energy savings
  - ComEd (Midwest): 2% energy savings
  - Maryland: 15% energy savings per home (\$375 per year)

# Transportation Applications

- **Vehicle control:** Airplanes, automobiles, autonomous vehicles
  - All kinds of sensors to provide accurate, **redundant** view of the world
  - Very tight timing constraints and requirements
- How many processors/ASICs in modern consumer autos?
  - Engine control, break system, airbag deployment system, windshield wiper, door locks, entertainment system, **OnStar emergency support**
  - CAN (controller area network) is a low-level protocol
- What would you do with access to these systems?



# Example Transportation Scenarios

---

1. *Honk a stranger's horn, turn on his windshield wipers, drive his car remotely through his OnStar system*
2. A network of sensors in a vehicle can interact with its surroundings to provide information
  - Local roads, weather and traffic conditions to the car driver
  - Adaptive drive systems to respond accordingly
3. Automatic speed/braking control via fuel management systems
  - Condition and event detection sensors can activate systems to maintain driver and passenger comfort and safety through the use of airbags and seatbelt pre-tensioning
4. Sensors for fatigue and mood monitoring based on driving conditions, driver behavior and facial indicators
  - Ensuring safe driving by *warning the driver* or *directly controlling* the vehicle

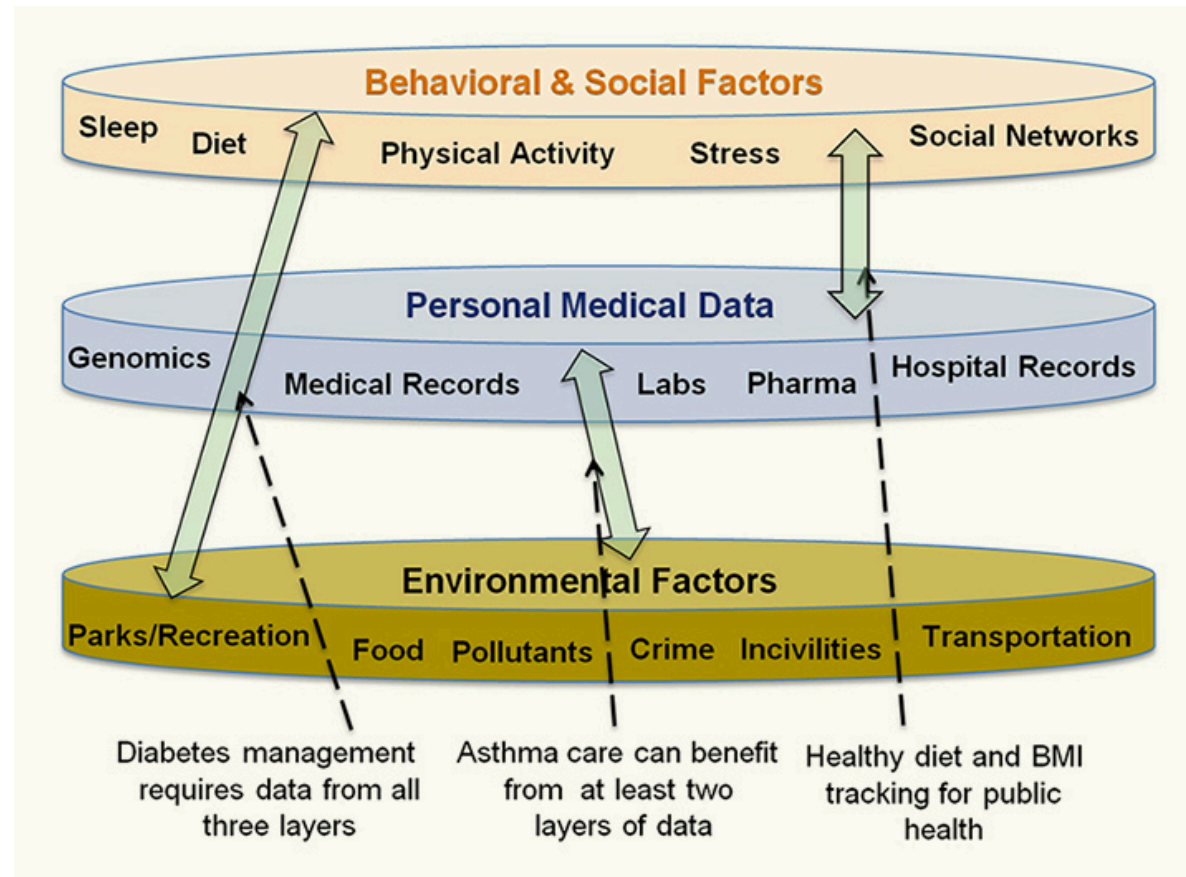
# How is Health Sensed/Quantified?

- What kind of health and fitness-related data is out there?
    - Fitness trackers (Nike+, Fitbit)
    - Calorie tracker (Calorie King)
    - Sleep tracker (Zeo)

Social and individual behavior
  
  - Bio implants (pacemaker, Cochlear implants, glucose monitor)
  - Hospital records
  - Genomic information
  - Family medical history
  - Prescription drug use
- Formal medical data
- 
- Local air quality index
- Relative humidity
- Public food safety
- Public water safety
- Environmental factors
- 
- How accessible are these data streams to (1) you, (2) your doctor, and (3) medical researchers?

# Whole-Health Research

- “Data E-platform Leveraged for Patient Empowerment and Population Health Improvement” (DELPH I)
- Integrate access and analysis of all health-related distributed across diverse stakeholder platforms
- Draw inferences from diverse data:
  - Structured
  - Streaming
  - Noisy
  - Analytical models



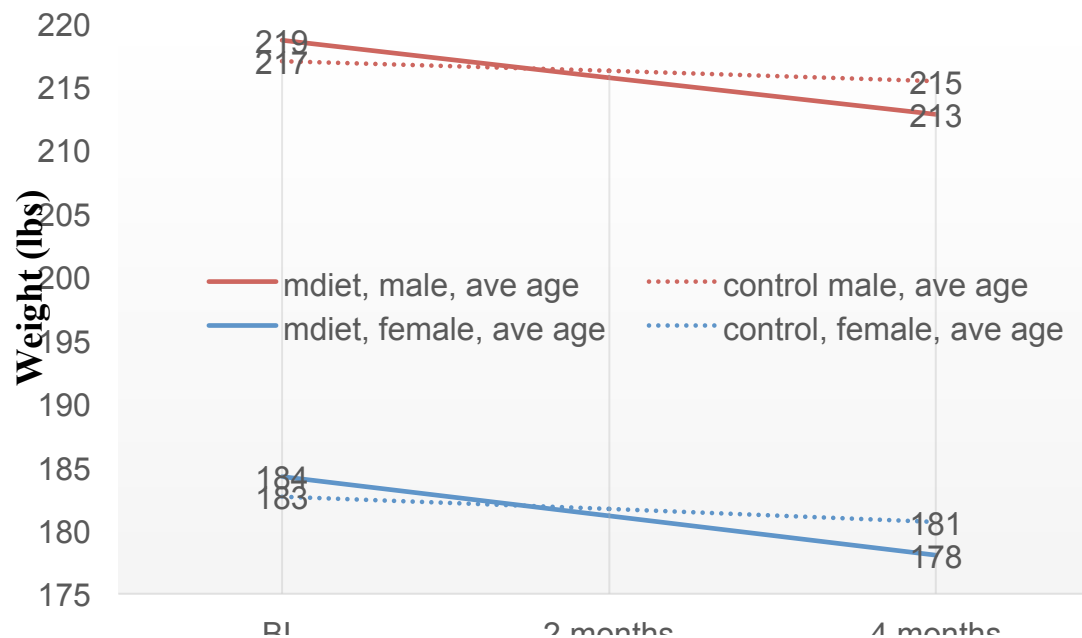
# Dieting Assistance for Patients

- mobile Dietary Intervention Through Electronic Technology (mDIET)
- An SMS/MMS intervention tool for:
  - Overweight and moderately obese men and women
  - Ages ranged 25-55
  - Range of ethnic background (majority Caucasian and Hispanic/Latino)
  - 4 month period
- Focused on nutrition and physical activity

|                               | mDIET                                                            | Control   |
|-------------------------------|------------------------------------------------------------------|-----------|
| Text & Picture Messages       | ✓ Daily messages and questions, optional number and timing       | ✗         |
| Brief Counseling Calls        | ✓ Monthly                                                        | ✗         |
| Self-monitoring               | ✓ Weekly weight report via text, daily food and exercise journal | ✗         |
| Printed Educational Materials | ✓ Weekly                                                         | ✓ Monthly |

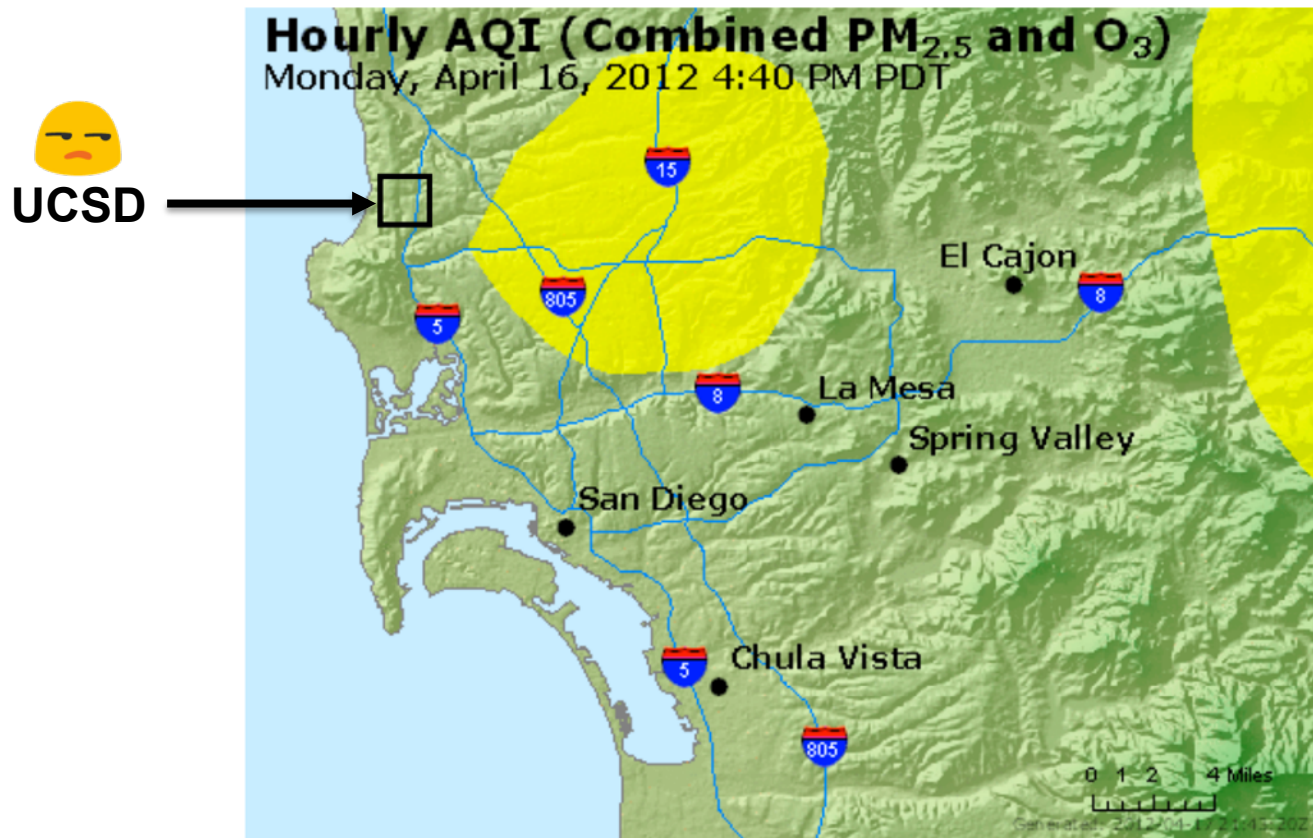
# Dieting Assistance for Patients

- At baseline, no significant differences for weight between mDIET and Control group
- Control group lost about 2lbs and mDIET group lost about 6.25lbs over 4 months of study
- 95.6% of participants would recommend mDIET to friends/family
  - "Felt commitment every day – could not let myself forget my goals"
  - "They served as an excellent reminder to watch what I ate"
  - "I found that texting your weight every week was extremely helpful"
- Next: feasibility study for culturally-specific messaging



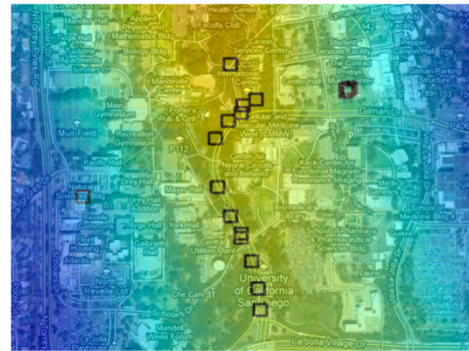
# Urban Air Quality Sensing

- For an asthma patient at UCSD, how helpful is this map?



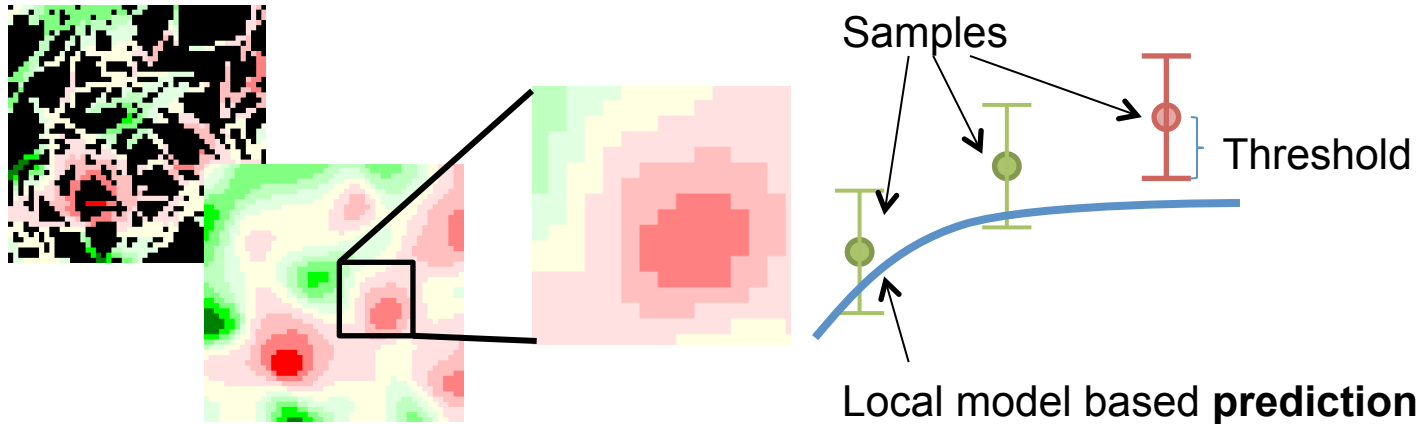
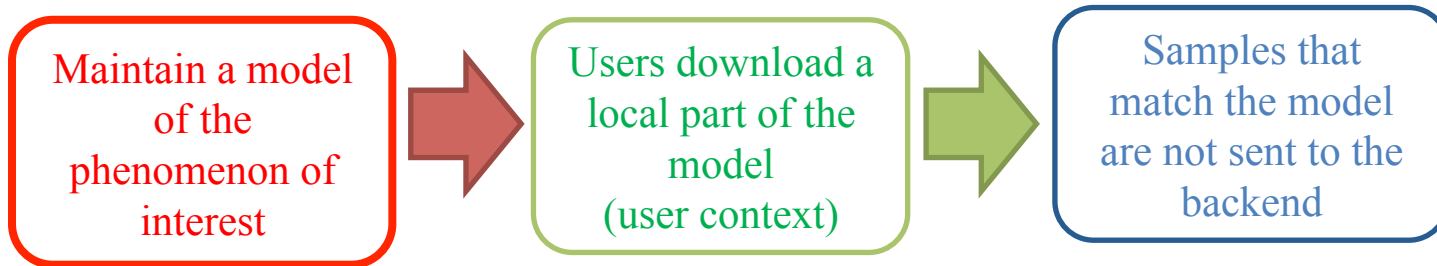
# Urban Air Quality Sensing

- CitiSense: wireless personal pollutant exposure monitoring – much better!
- Sensors identified “urban valleys” of trapped pollution, enabling commuters to choose alternate routes



What are some potential costs of this “upgraded” monitoring scheme?

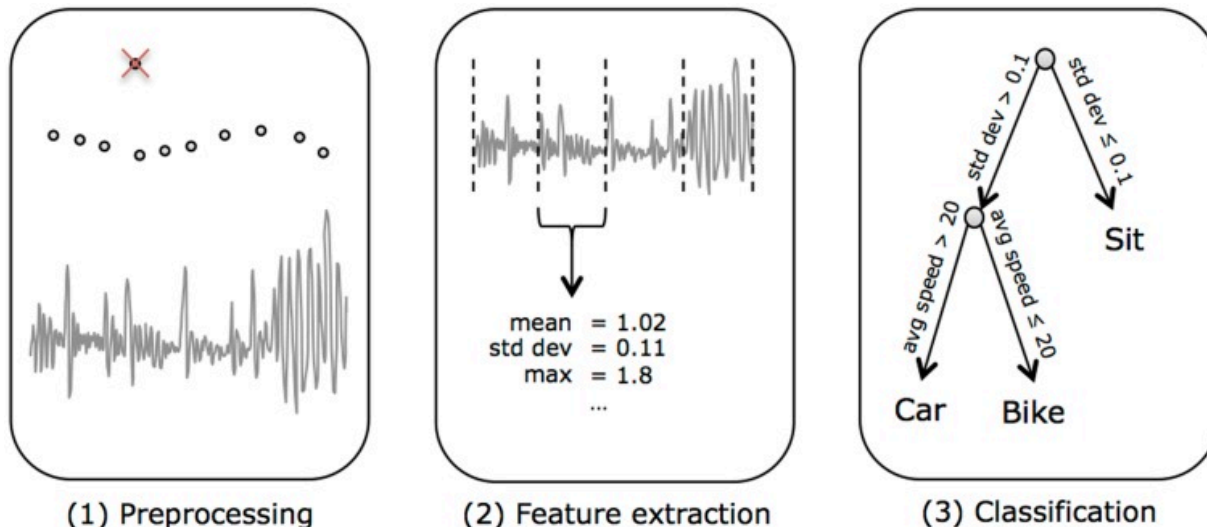
# Model-Driven Urban Air Quality Sensing



- Study of 30 users in San Diego downtown
- Up to 80% power reduction when using context compared to basic compression

# Changing Health Research Workflows

- How is location and active activity traditionally collected and verified?
  - Travel and time use diaries [patient]
  - Self-report surveys [patient]
  - Video-capture and coding [researcher]
- These methods are biased, unreliable, and/or hugely labor-expensive
- Personal Activity and Location Measurement System (PALMS)
  - Use sensors and machine learning techniques to develop new protocols
  - segmenting trips and identifying transportation mode from GPS data



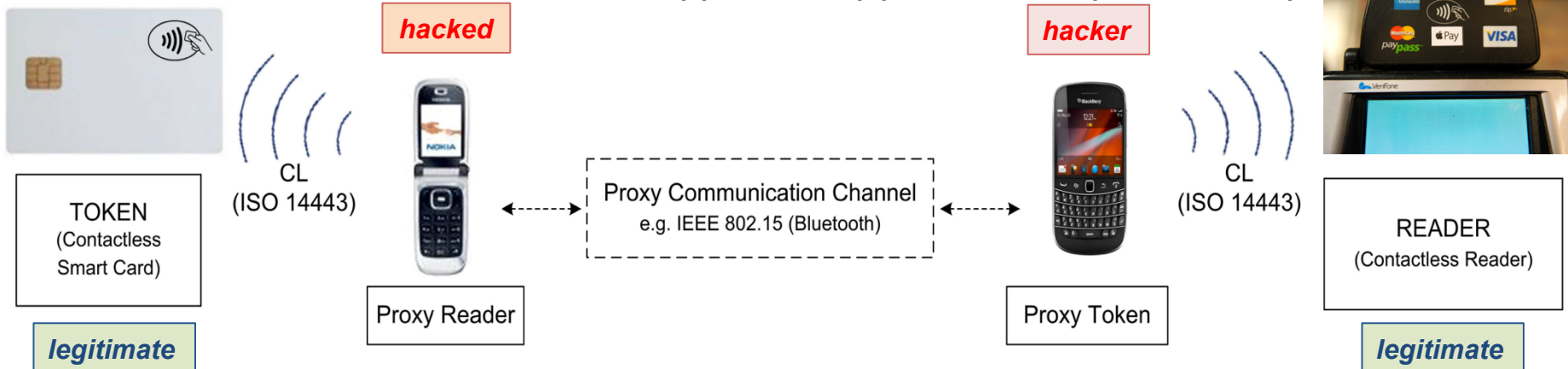
# Security and Privacy

---

- Between the technology and the user, how many players can affect the speed vs. security of adoption?
  - Developers
  - Vendors
  - Marketers
  - Installers
  - Hackers
  - Regulators
- “Technology” is human... in that the providers will be as lazy, greedy, and negligent as they can get away with

# NFC Device Relay Attack

- There ~300 device models with NFC capability on the market today. Juniper expects 500m users globally by 2019
- Grand Master Chess attack: bypasses application-layer security



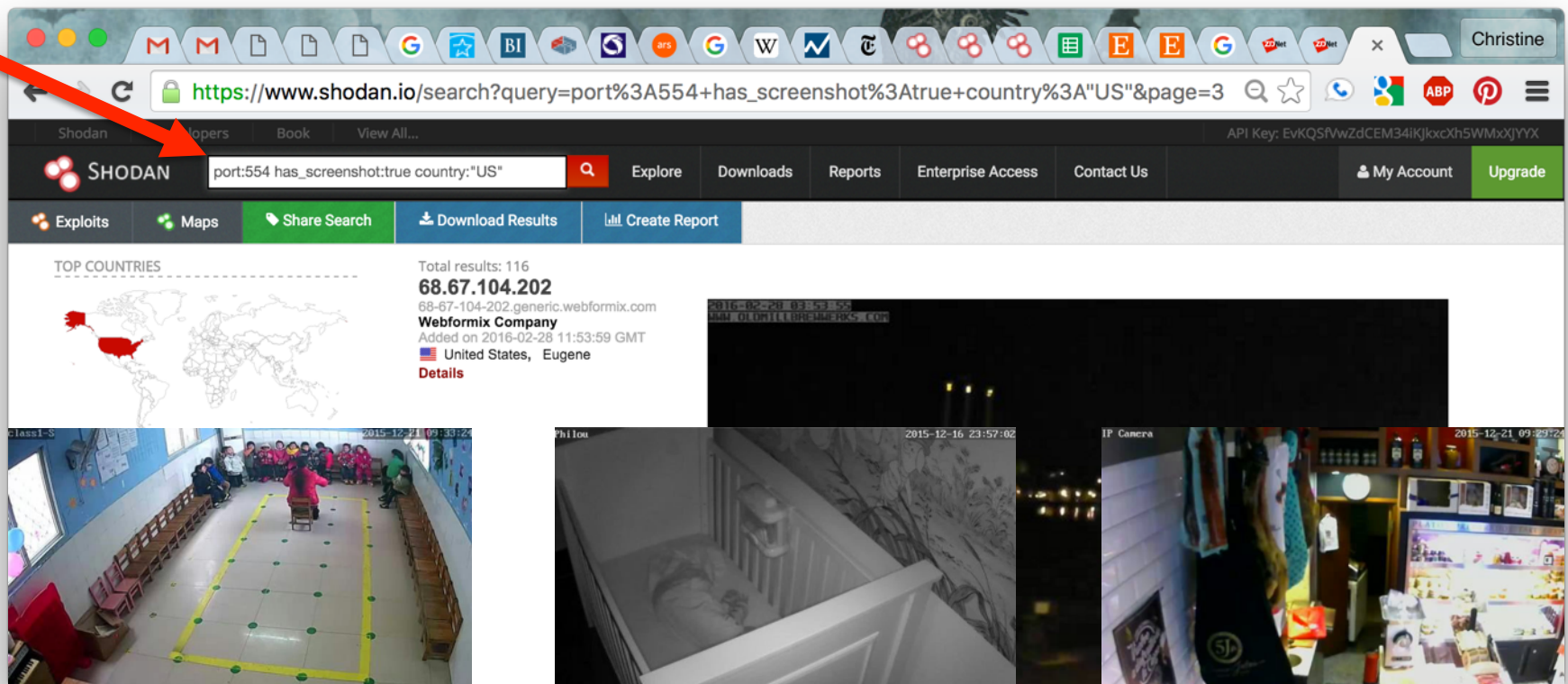
- How can users/developers protect against this attack?
  - Only install trusted apps
  - Disable NFC by default / RFID-blocking cases
  - Two-factor authentication
  - Timing constraints (e.g. in Android) – *in research*

<http://www.idigitaltimes.com/new-android-nfc-attack-could-steal-money-credit-cards-anytime-your-phone-near-445497>

Vila, José, and Ricardo J. Rodriguez. "Practical Experiences on NFC Relay Attacks with Android: Virtual Pickpocketing Revisited\*." <https://eprint.iacr.org/2011/618.pdf>

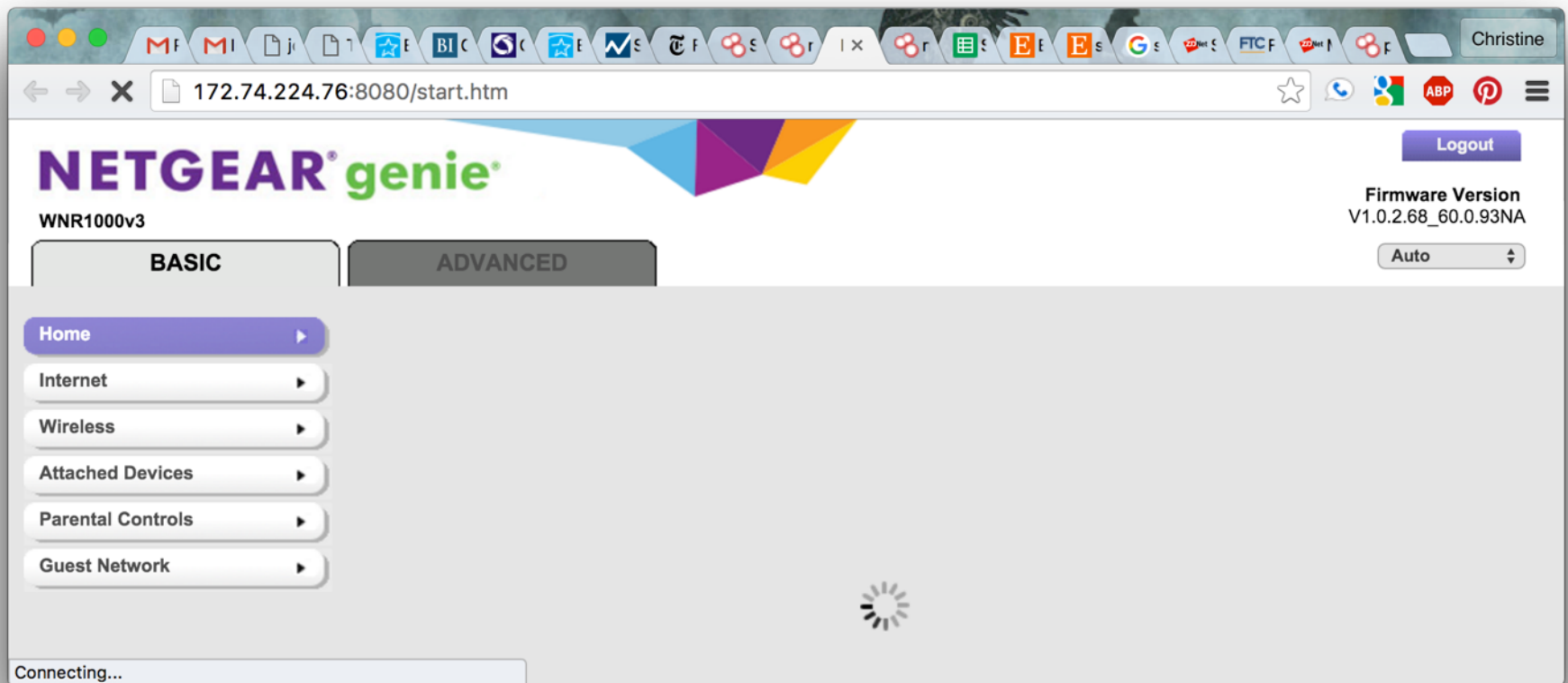
# Surfing the Insecure IoT

- How many of your web-connected devices are left on when not in use?
- Shodan – a search engine for the (unsecured) IoT
  - Web servers, FTP servers, SSH, and Real Time Streaming Protocol (RTSP port 554)
  - Devices that should not be externally accessible but are using default/no credentials

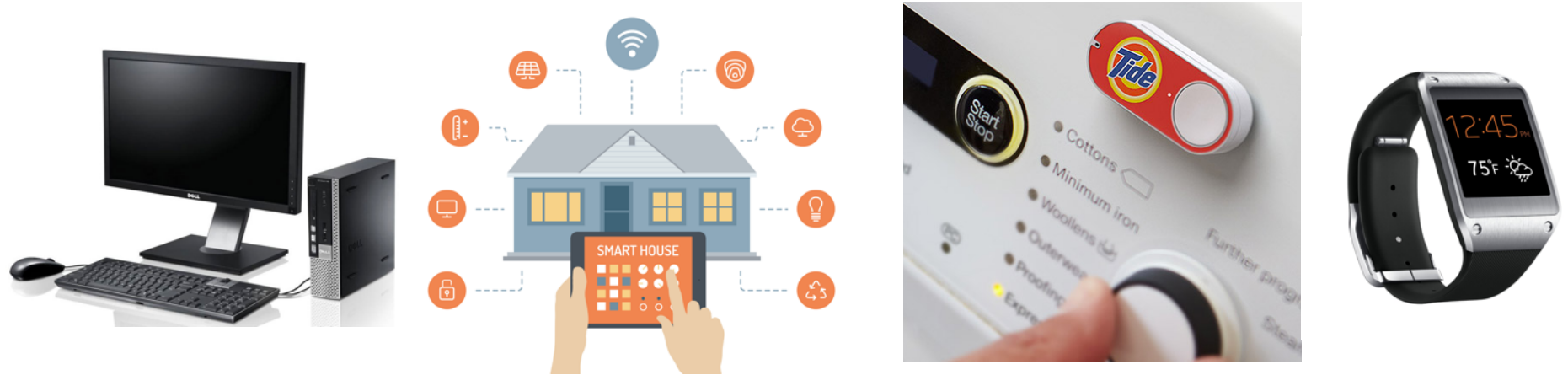


# Surfing the Insecure IoT

- Tracks device banners (info advertised to the web), not content
- Includes routers, switches, webcams, traffic lights, SCADA systems, and even home security systems.
- Password: pleasechangemenow



# Catching Up to the Insecure IoT



- How has your understanding of Internet usage changed in the last 10 years?
  - Barrier to entry is extremely low by design
  - Many more types of access channels
  - Level and volume of real, detailed personal information
  - Data can be stored and retrieved indefinitely

# Catching Up to the Insecure IoT

---

- Consumer education
  - Things do NOT work securely out of the box
  - Opt out vs. opt in
- Federal Trade Commission (FTC) regulation
  - Triggered by TRENDnet falsely claiming to provide secure video transmission, including storing and transmitting user login credentials in clear, readable text over the Internet
  - Issued security best practices in January 2015 for IoT marketers
    - Data minimization – only store what is essential, and perform regular deletes
    - Hiring practices and oversight for third-party providers
    - Consumer choice of how their information will be used
  - *"Any Internet of Things-specific legislation would be premature at this point."*

# Summary

---

- New ways to exploit human dynamics for good
  - Efficient, non-intrusive data sharing
  - Leverage the wide-spread adoption of devices to solve old problems
  
- New ways to exploit human dynamics for bad
  - Billions of uneducated users releasing data freely
  - Magnified security and privacy issues