Your Noise is My Signal

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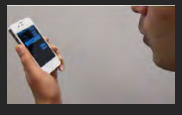
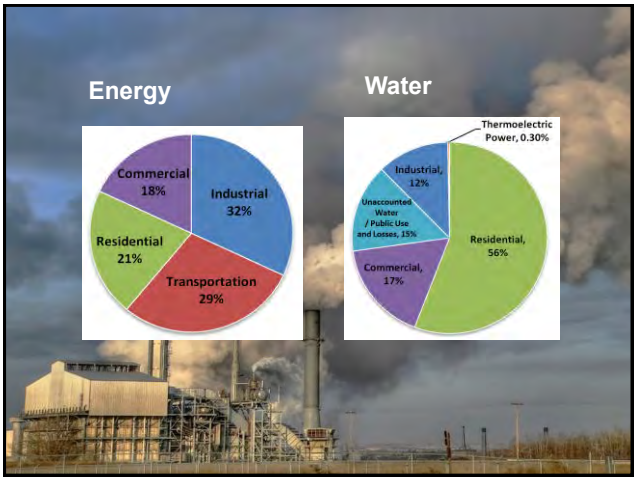
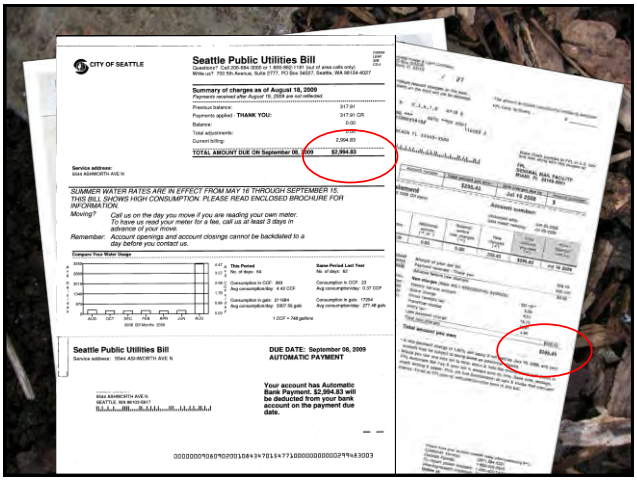
Two Applications

- Electricity and water sensing in the home
  - Breaking down energy and water use

- Mobile health
  - Microphones for sensing lung function





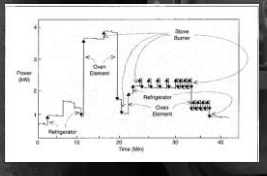


Role of Computer Science

- The “energy problem” isn’t just technical
  - Political, social, etc
- CS still plays a major role
  - Garner better understanding of energy and water use
  - Sensing, analytics, visualization, prediction
- Data sparse → data rich science

Existing Solutions

- User current and power from breaker panel
- Requires an electrician



ElectriSense

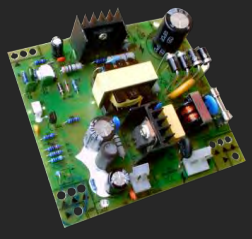
- Single sensor on the power line can detect the use of most electrical devices

Our Approach: Your noise is my signal

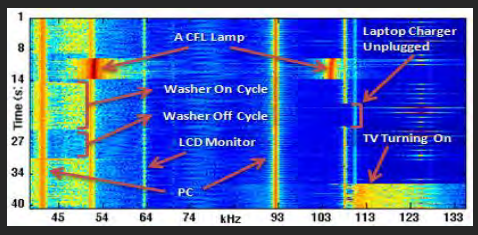
- Instead of just current, sample the voltage at a high rate
  - Only have to look at one location
- Electrical devices produce noise (transient and continuous)

Switch Mode Power Supplies (SMPS)

- Small, efficient
- Very popular
- Produce continuous EMI noise

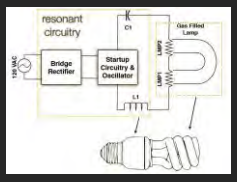


For example…

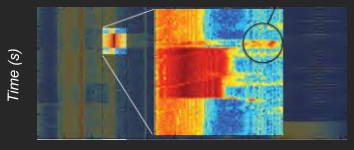


Modeling

- Use a circuit model
- The load characteristics dictates EMI noise



CFL Burst



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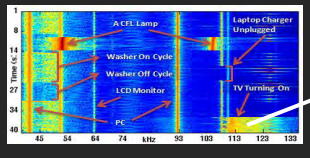
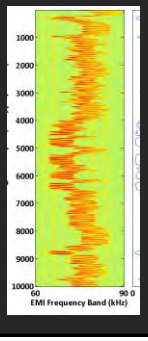


TV



"Stick-On" Power Meter

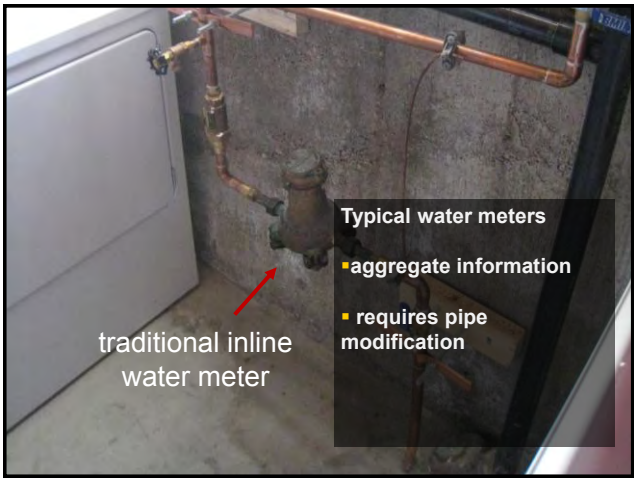
- Detects the magnetic field behind the metal
- Within 4% of "true power"
- Provides additional features for classification

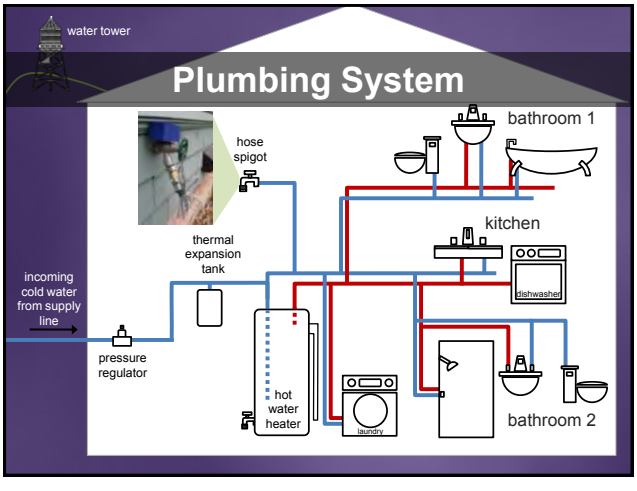
CHI 2010

Water Sensing

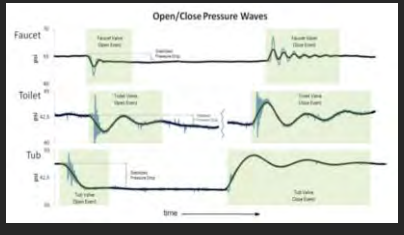
- Single-point sensor of water usage
- Identifies water usage activity down to a fixture level (e.g., toilet)
- Provides estimates of flow at each fixture

hydrosense





Fixture-level Event Detection



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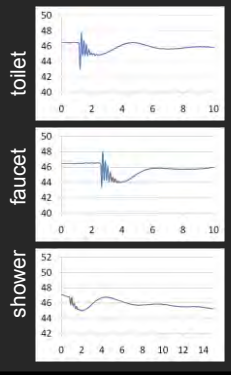
Modeling of Water Valves



Signature dependents on:

- fixture type
- valve type
- valve location in home

Example User Interfaces

Water User Interfaces

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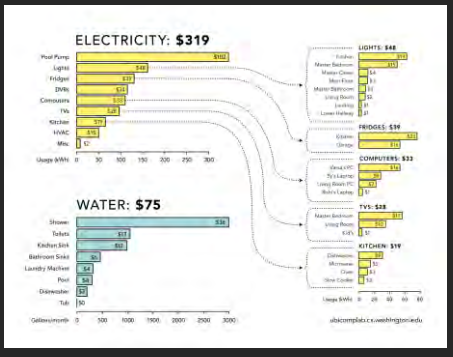
New Electricity Bills

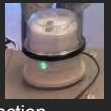
Courtesy of Belkin, Inc.

Surprising Insights

Energy Reports



Interesting Outcomes

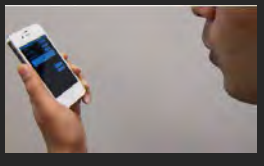


- Integration into meter (for utility installs)
  - Hot swappable
  - Embedded systems challenges, feature extraction, compression

- Circuit models useful for UL and FCC

Mobile Health Sensing

- Using existing sensors on mobile phones for health sensing
  - Heart rate, blood pressure, lung function
  - Use “signals” on the body



Mobile Health Sensing

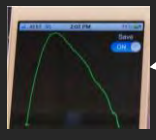
- Spirometry
  - Measuring lung function
- Need for self-management tools for chronic diseases
- Spirometry is a mainstay of monitoring respiratory conditions

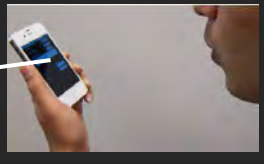
Clinical Spirometer

Home Spirometer

Mobile Health Sensing

- SpiroSmart: Mobile phone spirometer application
  - No additional hardware needed
  - Ability to provide remote coaching





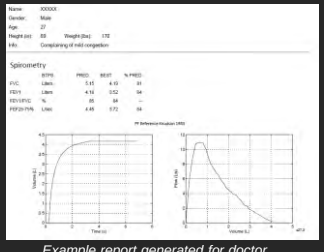
How it Works

- Traditional spirometers use a flow sensor (e.g., turbine) – we only have the microphone
- Lip reverberations and vocal tract resonances to infer flow
  - The "noise" in speech recognition

Clinical Spirometer *Home Spirometer*

Current Progress

- Evaluated in 52 patients
  - Accuracy within 5% when compared to a clinical spirometer
    - Clinically acceptable variance (within FDA accuracy)
- Output similar measures to clinical spirometers



Example report generated for doctor

Summary

- Signals of interest in unusual places
  - Single point sensing of electricity and water
  - Spirometry using microphone
- Need to bring together deep knowledge from many disciplines
- Other projects: Using body as an antenna



with Microsoft Research

Questions?

- Thanks!