

# Your Noise is My Signal


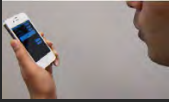
**Shwetak N. Patel**  
University of Washington

<http://ubicomplab.cs.washington.edu/>

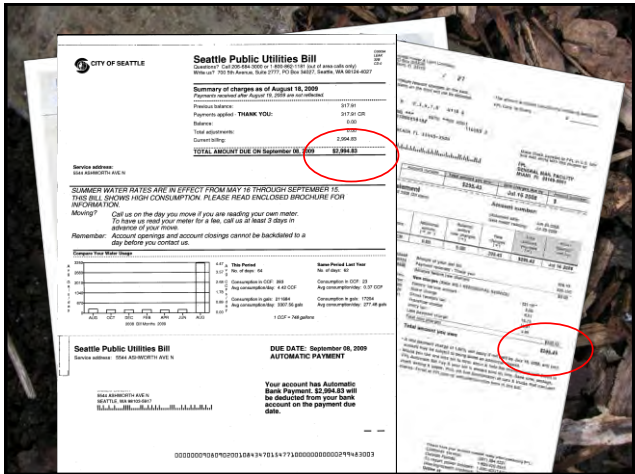
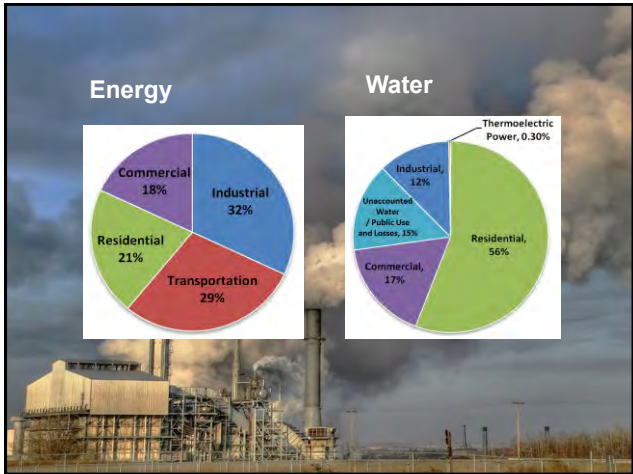


## Two Applications

- Electricity and water sensing in the home
  - Breaking down energy and water use
- Mobile health
  - Microphones for sensing lung function

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## 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

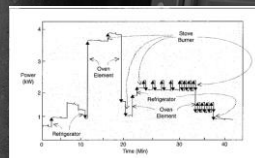
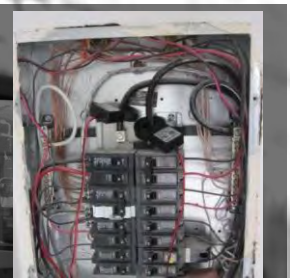
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## Existing Solutions

- 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



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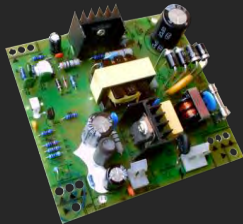
## Our Approach: Your noise is my signal

- 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)

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## Switch Mode Power Supplies (SMPS)

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

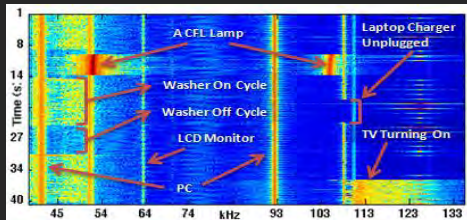


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## For example...

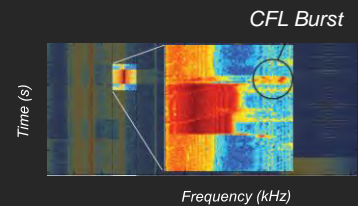
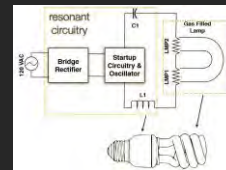


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## Modeling

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

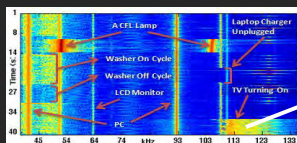


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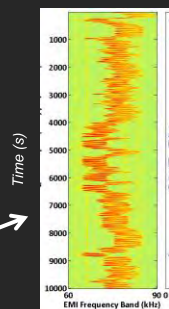
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## Modeling

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



TV



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## “Stick-On” Power Meter

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




CHI 2010

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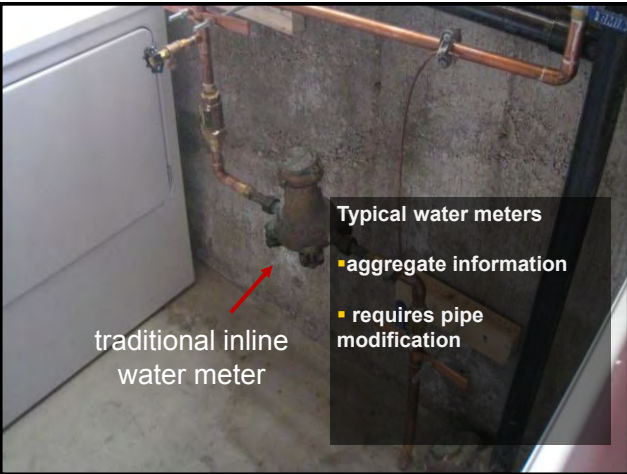
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## Water Sensing



- 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

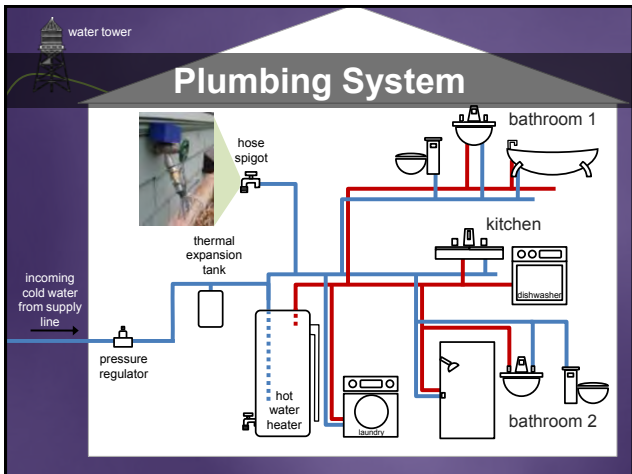
hydrosense




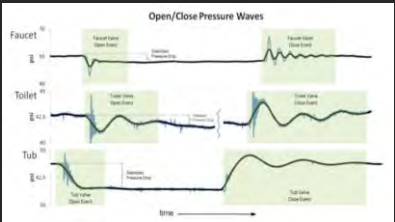
traditional inline water meter

Typical water meters

- aggregate information
- requires pipe modification



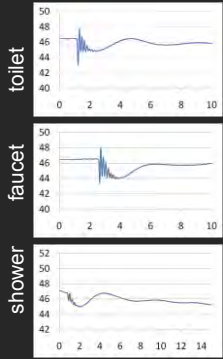
## Fixture-level Event Detection

The graph displays pressure waves for three fixtures: a faucet, a toilet, and a tub. The y-axis represents pressure in PSI (ranging from 40.0 to 60.0), and the x-axis represents time. The graph shows distinct pressure spikes and dips corresponding to fixture events. For the faucet, there are 'Faucet Open (Slow Event)', 'Faucet Open (Fast Event)', and 'Faucet Close (Slow Event)'. For the toilet, there are 'Toilet Flush (Slow Event)' and 'Toilet Flush (Fast Event)'. For the tub, there are 'Tub Open (Slow Event)' and 'Tub Open (Fast Event)'.

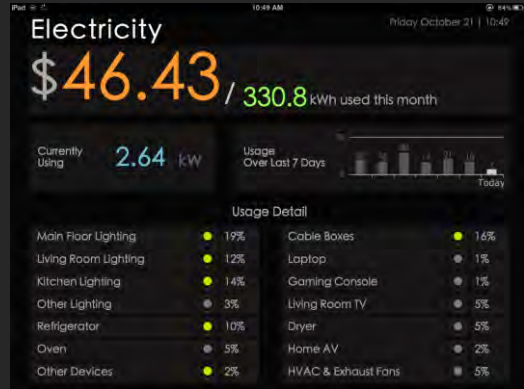
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## Modeling of Water Valves



- Signature depends on:
- fixture type
  - valve type
  - valve location in home

## Example User Interfaces



## Water User Interfaces



## New Electricity Bills

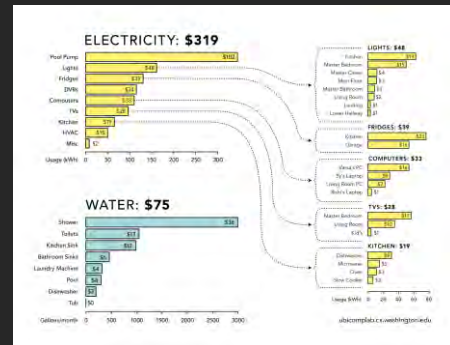


Courtesy of Belkin, Inc.

## Surprising Insights



## Energy Reports

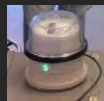


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## Interesting Outcomes

- Integration into meter (for utility installs)
  - Hot swappable
  - Embedded systems challenges, feature extraction, compression
- Circuit models useful for UL and FCC



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## Mobile Health Sensing

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



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## 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



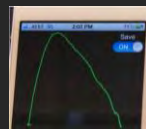
Home Spirometer

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## Mobile Health Sensing

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



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## 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

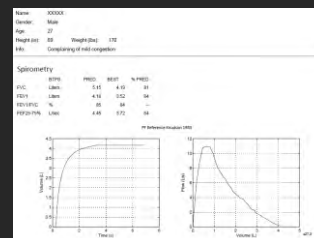


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## Current Progress

- 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



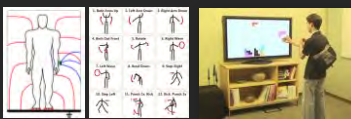
Example report generated for doctor

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## 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**

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## Questions?

- Thanks!

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