Title
Toward Resource Efficient Homes: From Measurements to Sustainable Choices

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Toward Efficient Homes: from measurements to sustainable choices

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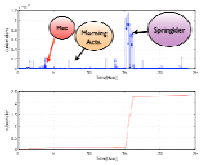
Motivation: Better Understanding and More Efficient Consumption

Demands for Resource Efficient Homes

- Buildings account for at least 30% of world greenhouse gas emissions (Royal Institution of Chartered Surveyors);
- In the past 30 years, water consumption in the US has tripled while population has doubled;
- 85% of American electricity comes from non-renewable resources (US EPA);

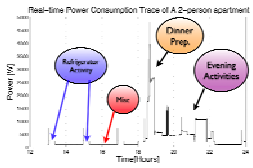
Need for Fine Grained Information

- Prior social studies suggest obvious advantages of self-monitoring concern active consumer involvement and participation;
- Empirical studies have shown real-time consumption information helps reduce resource consumption by 15%, participants want to have real-time fine-grained information;



Real-time water consumption in a single family home

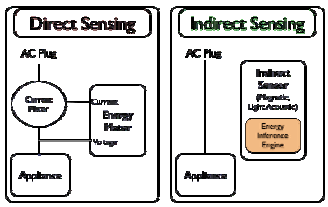
Real-time power consumption in a single family apartment

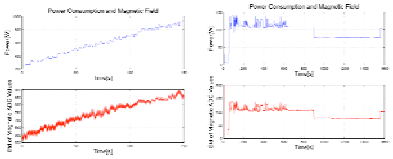


Design Concept: Less-invasive Resource Consumption Inference Mechanism

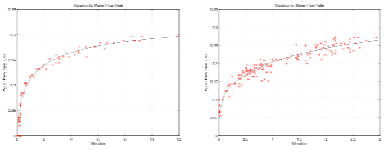
Direct/Indirect Sensing

- Direct resource monitoring devices need to be installed in-line, making it difficult to retrofit appliances;
- Indirect monitoring concept senses signals from appliances when they are consuming resources;
- Indirect sensor offers various benefits, e. g. easy/seamless installation, cheap sensor cost, better coverage, etc.;





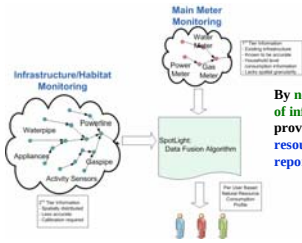
1-dimentional magnetometer is able to capture power consumption related signals



1-dimentional acceleration sensor captures water flow related signals

Sensor Calibration Challenge

-Indirect sensor needs to be calibrated *in-situ* due to installation, manufacturing, ambient condition variability;



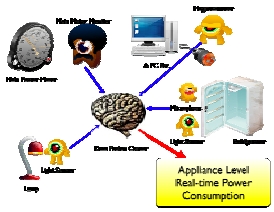
By networking two types of information, we hope to provide personalized resource consumption report with less cost!

Autonomous Calibration/Machine Learning Mechanism Exploiting Information Architecture

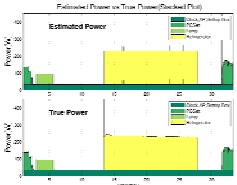
Prototype Fine Grained Power and Water Monitoring Systems

Appliance-level Power Monitoring

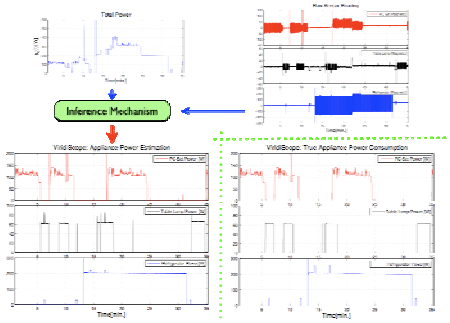
- The system consists of a main meter monitor, magnetometers, acoustic sensors and light sensors;
- An information fusion center combines data from distributed sensors and profiles power consumption;
- The fusion center uses a model-based machine learning algorithm that calibrates indirect sensors and estimates appliance level real-time power consumption;



Power monitoring system design concept



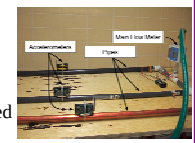
The model based machine learning algorithm can estimate ghost-power consumption

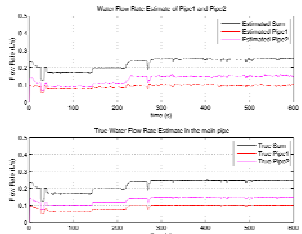


Autonomous inference engine takes signals from heterogeneous sensors to infer appliance level power consumption, we can see the the estimated power consumption (left bottom) is very close to the true power consumption (right bottom)

Pipe-level Water Monitoring

- Consists of a main meter monitor and vibration sensors;
- Autonomous and adaptive calibration algorithm has been developed;
- A test-bed has been assembled and tested (less than 10% error);





Pipe-level water monitoring is possible using cheap vibration sensors on pipes not in the pipes

Future Work

- Accounting for other resources (gas, heating oil)
- Augmenting monitoring dimension from resource consuming end-point level to each person's activity level
- Data representation and effective user interfaces