

Sensors and Controls Enabled Solutions



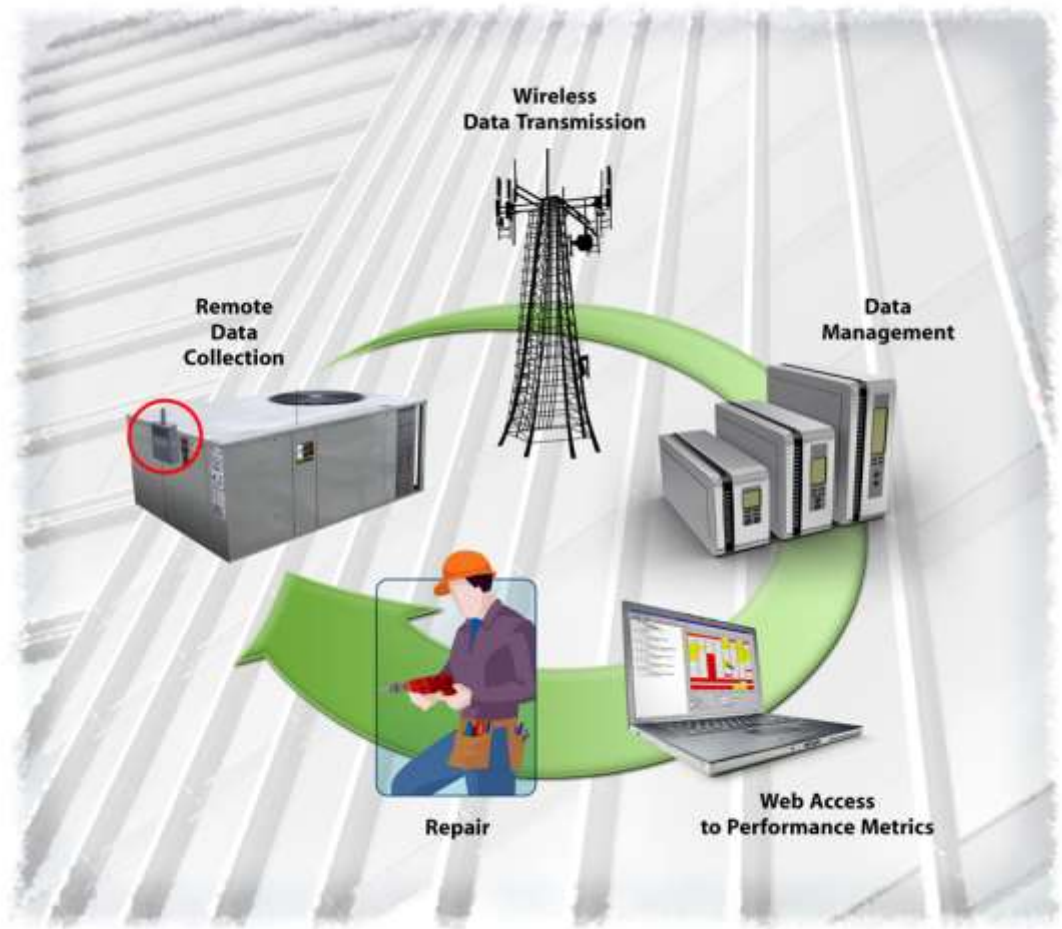
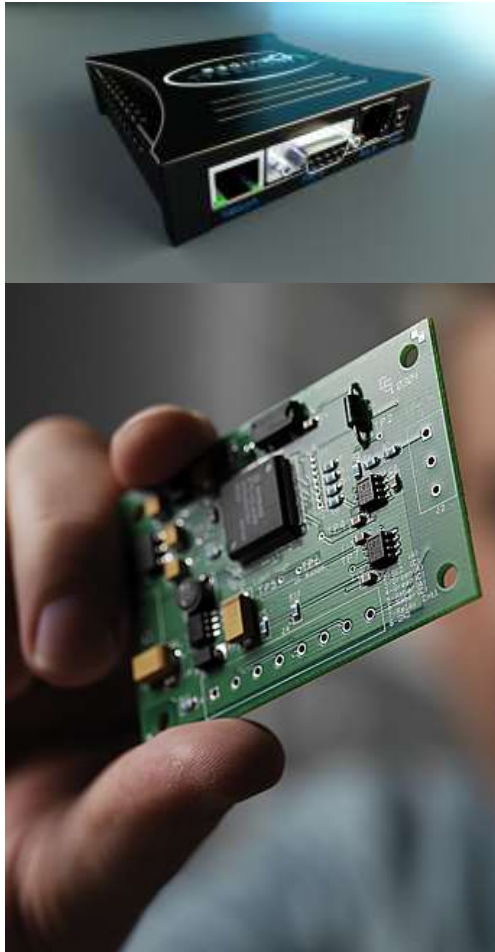
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George Hernandez
Pacific Northwest National
Laboratory

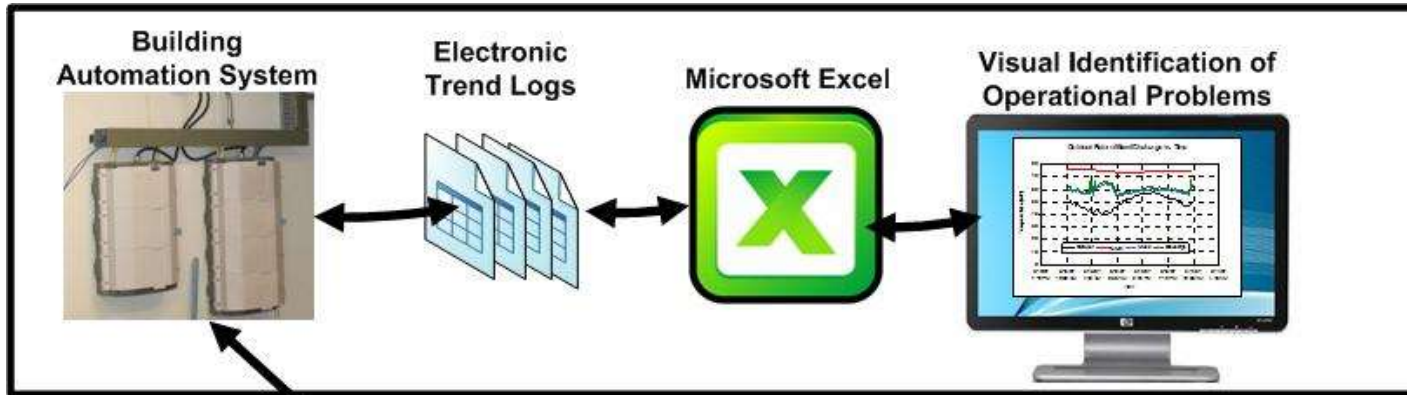
Advanced Controls and Diagnostic Packages for Packaged Air Conditioners

U.S. DEPARTMENT OF
ENERGY

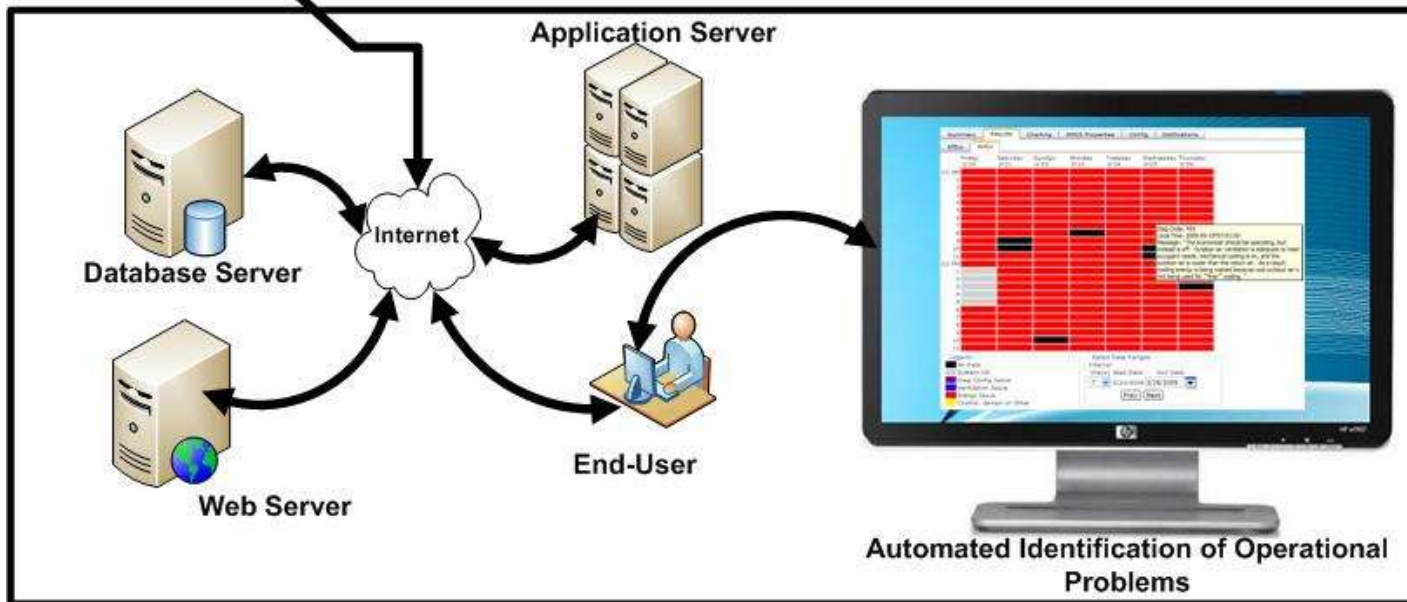
Energy Efficiency &
Renewable Energy



Building Diagnostics Market Deployment: Re-tuning Automation



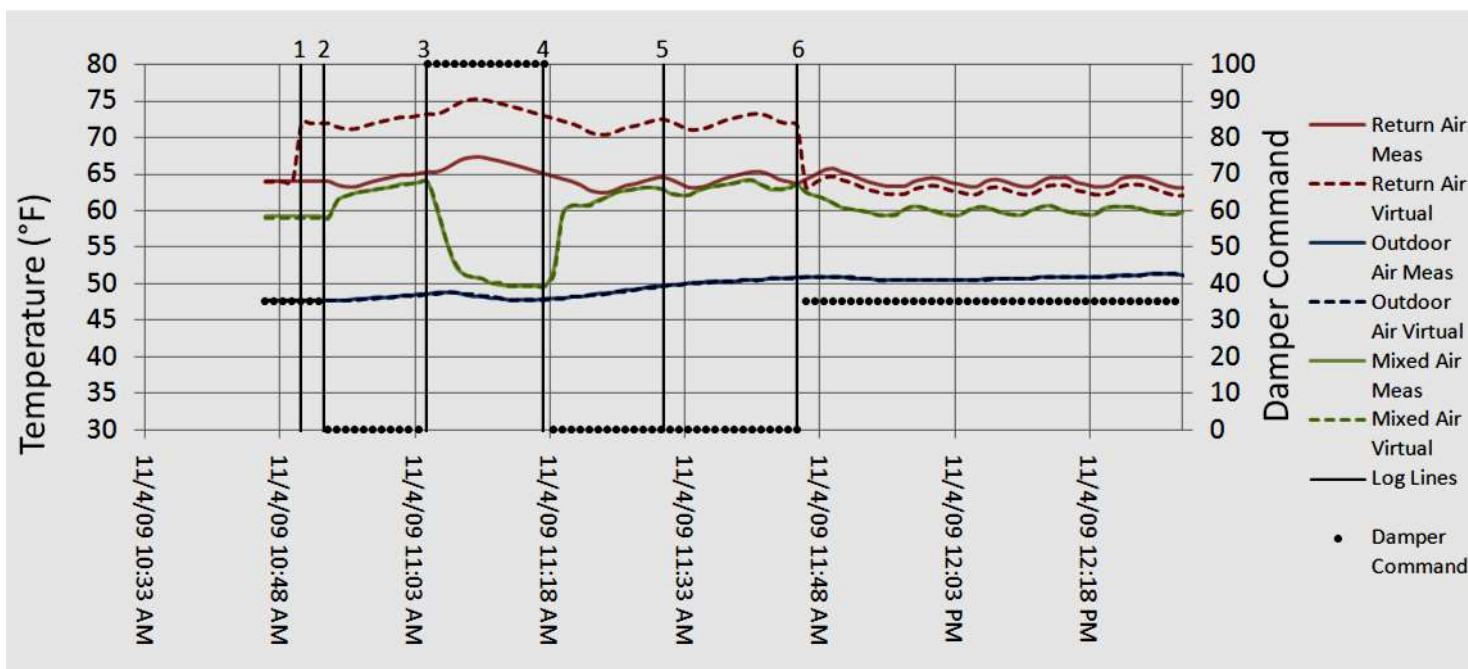
Current
Semi-Automated
Approach



Proposed
Fully-Automated
Approach

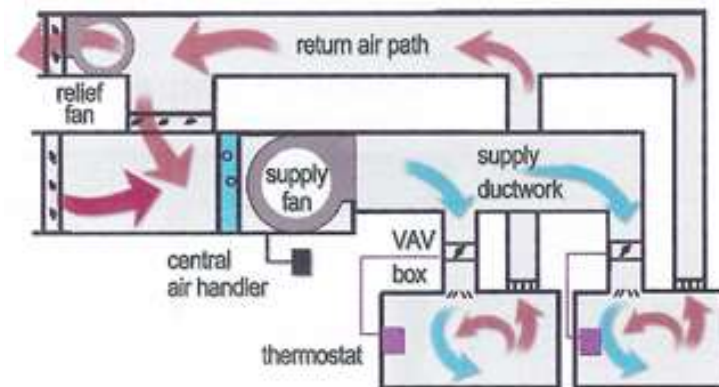
Self-Correcting and Self-Configuring HVAC Controls

Control systems that automatically and in real time correct and optimally compensate for faults occurring in HVAC systems and their components. Ultimately these capabilities should be integrated with building control systems to ensure that new and existing commercial buildings continuously operate near peak efficiency.



- Automation System Perspective

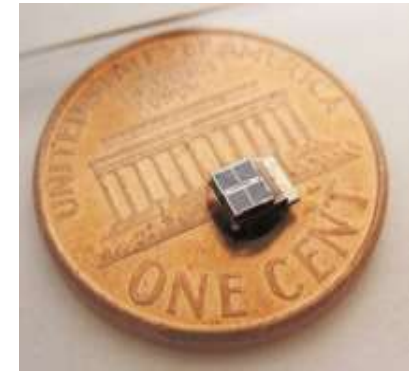
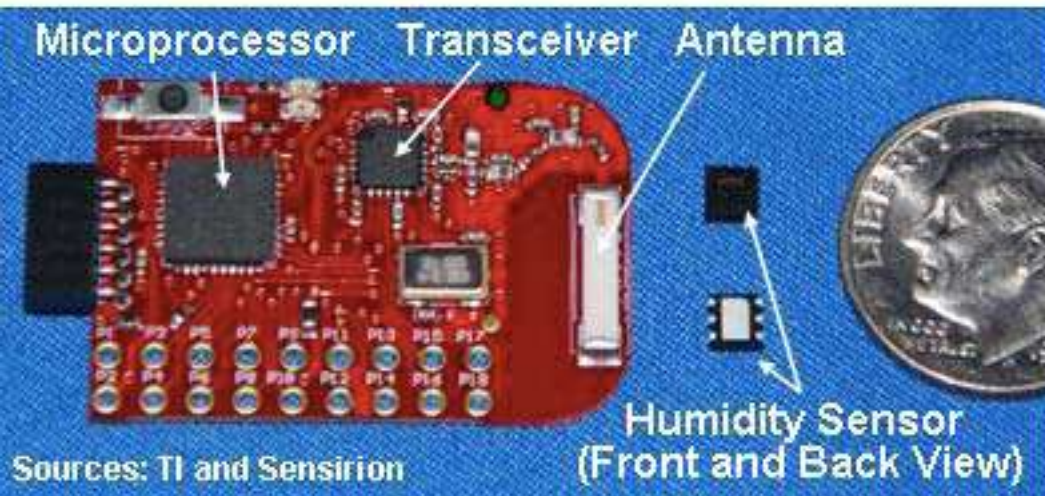
- Exploit Multivariate Interactions Between Control Loops
- Exploit Physical Interaction of Resources -Air-Water-Electricity-
- Adapt Set-Points Dynamically -Time of Day, Unoccupied Zones-
- Monitor Equipment Efficiencies and Energy Sinks
- Deploy New Sensor Technologies



- Occupants Perspective

- Increase/Decrease Thermostat Set-Points (1°F ~ \$10,000/yr)
- Put Desktop Computer in Stand-By Mode (Lower Heat Generation)
- Check Air Pattern in Office and Move Away from Air Inlets/Outlets
- Monitor Temperature Gradients in Office Space
- Ask for Occupancy Sensor – Not Only for Lighting
- Wear a Jacket/Short Sleeves – Metabolic Rates

Inexpensive Sensor Motes for Building Environment



Solid State Battery

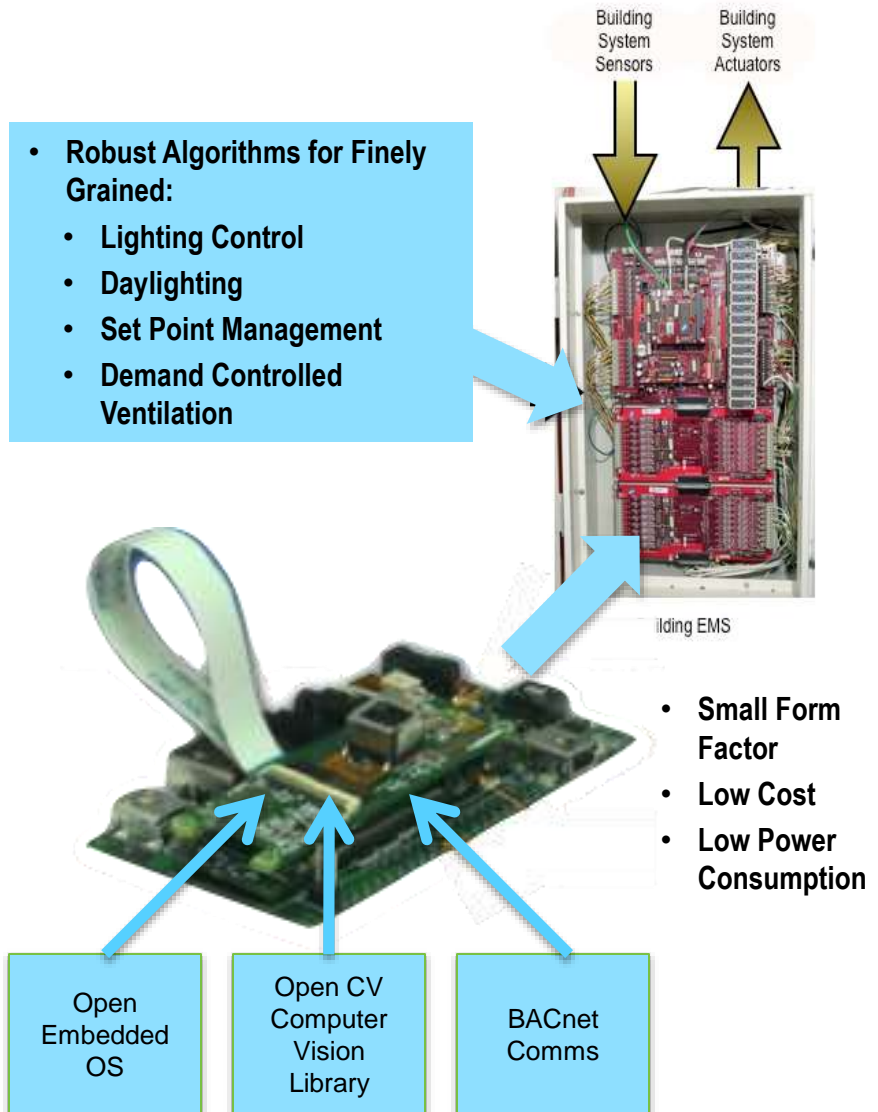
Ultra-low power microprocessors
And radios mean sensors can be powered by harvesting energy from the environment, in this case ambient light.



Need Addressed: Motion sensors are a poor surrogate for occupancy measurement. Performance deficiencies impact occupant comfort, resulting in related controls being disabled or severely undertuned.

Project Goal: Cost-effective, embedded image processing techniques will be developed to better match occupancy with control signals for retrofit or new construction. A broader value proposition including integration with building security systems is also possible.

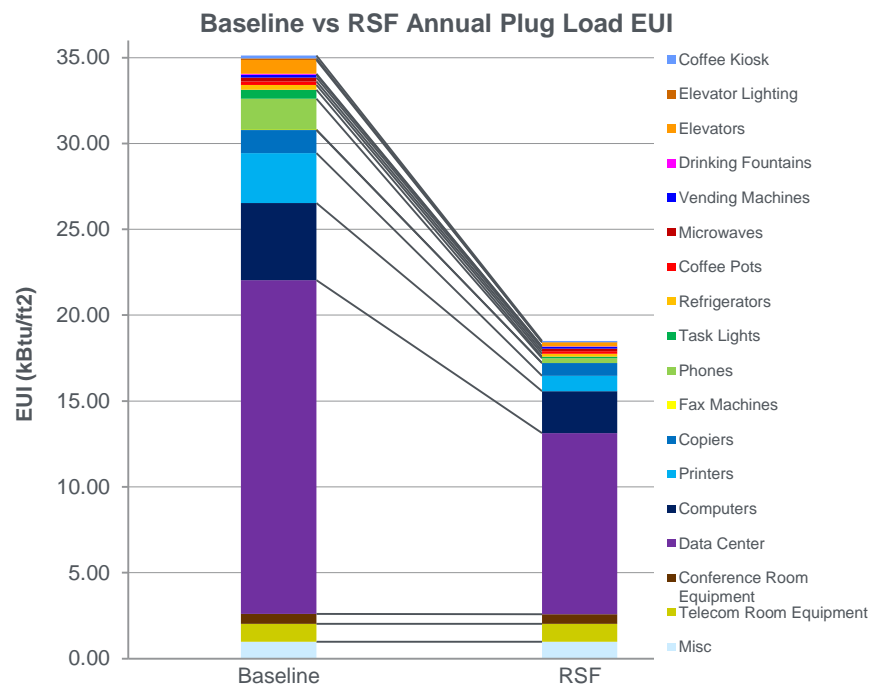
Commercialization: The project is built upon production-like hardware used in the cell phone industry, open source software libraries, and the BACnet interoperability standard to improve the likelihood of market adoption. Commercialization partners are actively being sought.



MELs Management Selection Process and Lessons Learned

Need Addressed: MELs (Miscellaneous Electric Load) energy use is an increasingly significant portion of commercial building energy consumption. There is a growing market for control devices that reduce MELs energy consumption, but it is unclear which devices are the best fit for a given project's energy goals. End users need direction to determine the control strategy that will provide the energy savings needed in their individual projects.

Project Goal: The rigorous selection process that was used to identify MELs control strategies for NREL's RSF will be documented along with results and lessons learned from the effort. From the RSF work, a technology guide will be developed that will aid designers and building operators in the selection of MELs control strategies in new construction and retrofit projects.



- Many MELs Operate 24/7
 - Significant Wasted Energy
- Turn Off Equipment
 - Occupant Participation
 - Control Devices
- Annual RSF plug loads modeled at 18.5 kBtu/ft² versus the baseline load of 35.1 kBtu/ft²

- Expensive (typically >\$100)
 - Elements inexpensive; electronics and packaging drive up cost
- Inaccurate
 - +/- 1C isn't good enough for space diagnostics
- Unreliable
 - Devices don't typically fail; worse, they drift
- System specific
 - Every automation system uses different sensors type
- Hard wired – Enough said!
- Installed in the wrong place
 - Rarely are sensors installed in correct location, usually wherever was easiest for installer
- Require mapping
 - Physical connection, logical location, custom range, name

- **Wireless**
 - Mesh?; Frequency?; Power?; Security?; Locations?
- **Low Cost**
 - Cost must include sensor and deployment
- **Reliability**
 - Eliminate calibration through redundancy or self diagnostics
- **Use Case Specific Packages**
 - BAS/EIS enhancement; Retro-commissioning; Diagnostics
- **Sensor Types**
 - Temperature, Rh, CO2, Flow (air and liquid), Pressure, Power

- There are lot's of issues to resolve. The question at hand for buildings and energy efficiency is where is the most bang for the buck.
- Third party service providers need a more cost effective way to collect data so they can ply their wares.
- Imagine a world where a practitioner with no sensors domain expertise could simply walk around a building, stick sensors everywhere, and they would self identify, self map, be accurate and not fail!!!

Utopia? – *Maybe* Possible? - ***Absolutely***