CHANGING WHAT'S POSSIBLE

Panel #2: The Benefits and Challenges of Occupancy Sensing for HVAC

Panelists

- Paul Fini, *Cree*
- Prabir Barooah, *University of Florida*
- Maulin Patel, *Current, Powered by GE*
- Jim Klee, *Veris Industries*
- Mirrasoul Mousavi, *ABB Group*

The Role of Lighting in Energy-Saving HVAC Occupancy Sensing

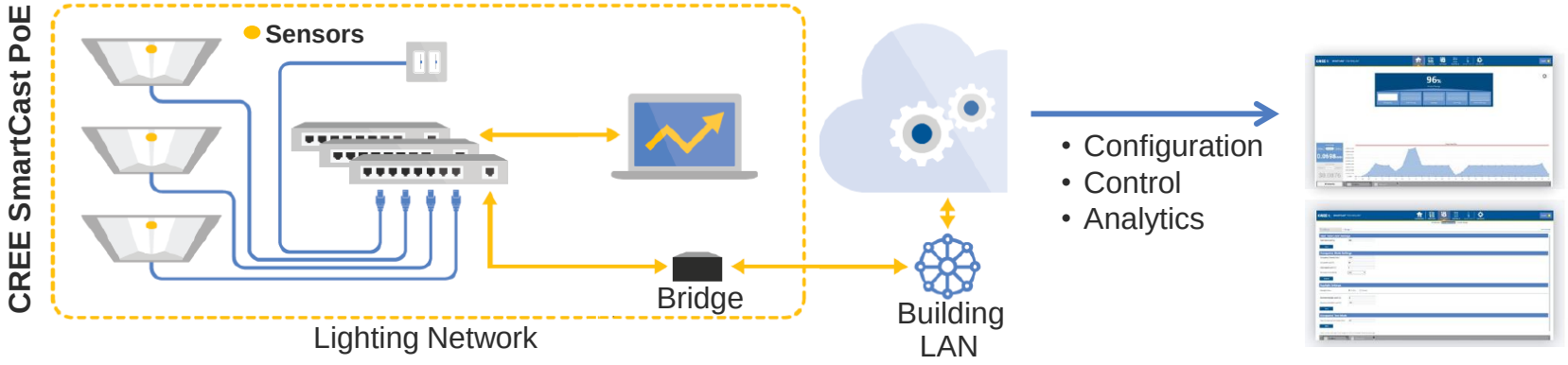
Paul Fini

7/13/16

Lighting as a Distributed Sensing Backbone

- HVAC and lighting share common occupancy sensing challenges:
  - **Accuracy**
  - **Agility**
  - **Type/Quality of Data**

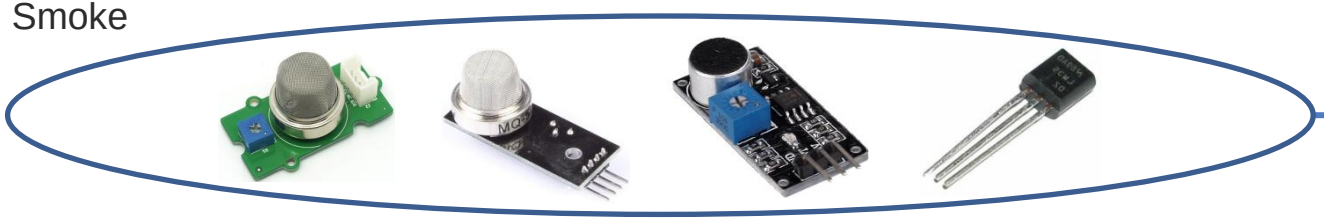
- **Lighting**: an omnipresent ecosystem for distributed and networked sensors
  - ✓ Comprehensive coverage
  - ✓ Electrical infrastructure
  - **Challenges**: cross-platform interoperability; easy commissioning

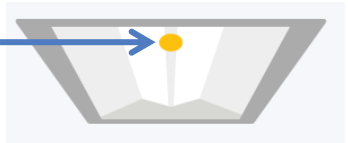


Scene Sensing for HVAC & Lighting

- **Scene Sensing**: move beyond “on/off”
  - Occupant detection
  - Occupant counting
  - Occupant traffic
  - Positional awareness
  - Spatially resolved illuminance

- **Modular Lighting-mounted Sensors**: augment scene sensing
  - Sound
  - Temperature
  - CO_2
  - Air quality
  - Smoke





Key Scene Sensing Metrics & Challenges

- **Challenges in getting to <1% error rate:**
  - **Optimal λ range**
  - **Wide operating T range**
  - **Long working distances**
  - **Optics for wide FOV**
  - **Optimized frame rate**

- **On-board vs. Centralized Processing**
  - **SoC** compression & analysis
  - Field-upgradable
  - **Privacy**

- **Cost, Form Factor**
  - **Low Cost!**
  - Adequate **Processing power**
  - **Compact size**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TM

Panel Discussion Introductory Remarks

ARPA-E Occupancy Sensors Workshop

Prabir Barooah
Associate Professor
Mechanical and Aerospace Engineering
University of Florida

Research interests:
Theory:

1. Distributed control and optimization

Applications:

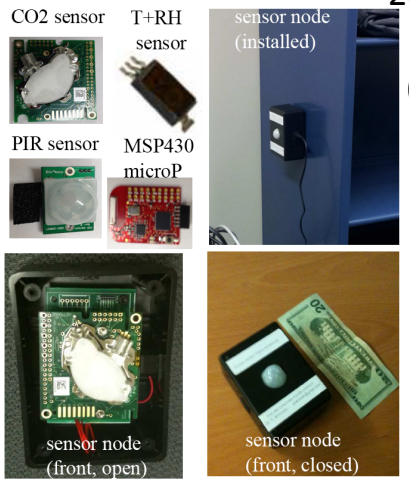
2. Building control to improve energy efficiency and comfort
3. Renewable energy integration through control of flexible HVAC demand

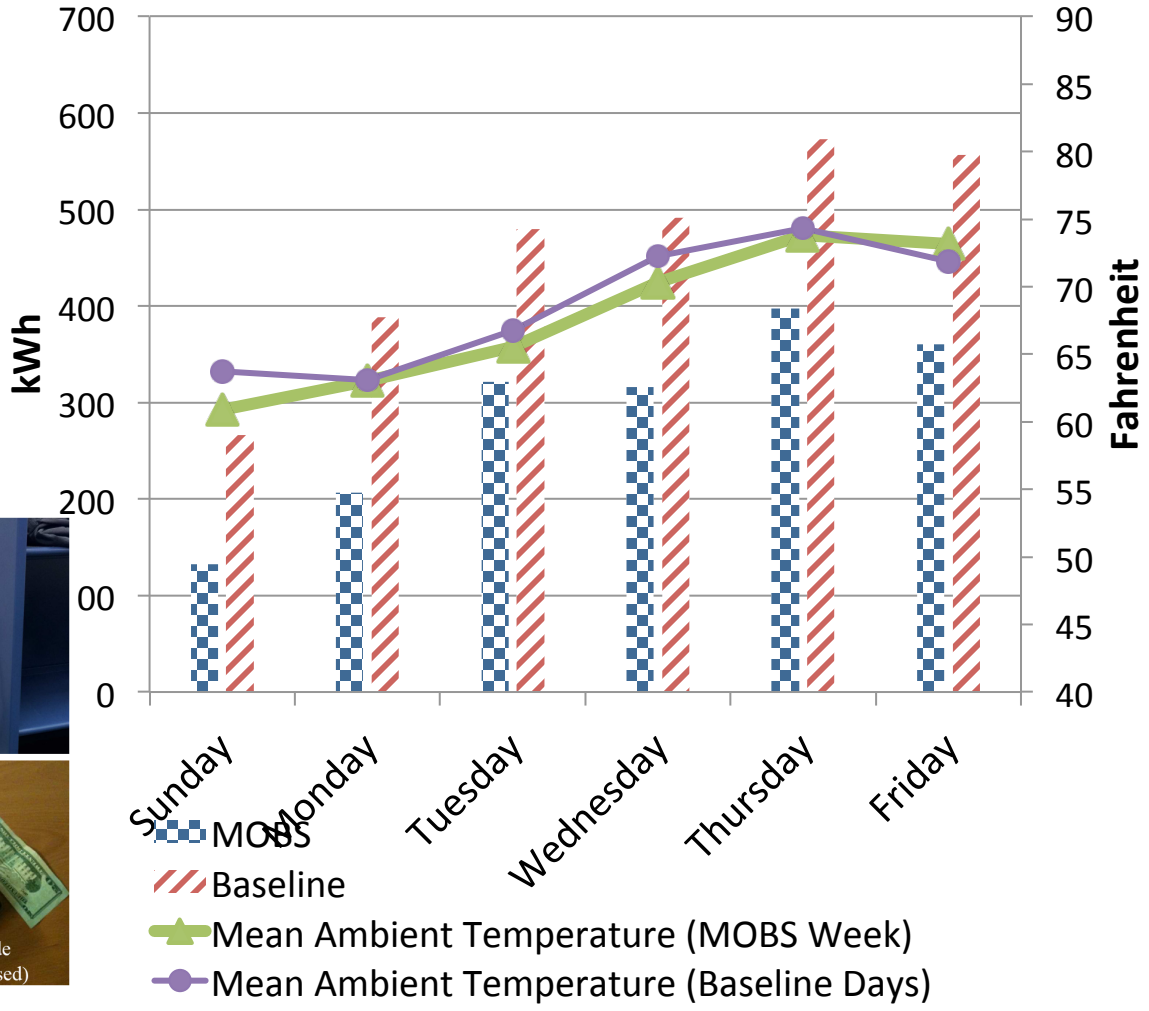
Occupancy-based HVAC control

Measured **O**ccupancy-**B**ased **S**etback control at Pugh Hall, UF campus, LEED silver 2008

1. UF wireless sensor module

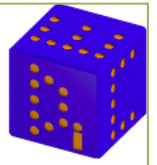
MSP 430 microP motion detector [T + RH + CO2] sensors





* Supported by NSF

Occupancy-based HVAC control



Outcomes and lessons learned:

- Demonstrated 40% HVAC energy savings in a LEED silver campus building with binary occupancy sensing and zone-level airflow flow/reheat control (small offices)
- Rule-based control with presence detection sufficient for zone-level control, predictive optimization suffers from diminishing return on complexity (Goyal et al., Applied Energy, 2013)
- Whole-building level control requires predictive optimization, >50% savings possible
- Occupancy count estimation a bottleneck in large spaces and for whole building optimization.

Comments

- *What's the end application?*
  - Requirements for that application
- *Control = sensing, actuation, algorithm*
  - More focus on algorithms and sensing. Not enough on actuation?
  - More focus on zone-level control. Higher savings with co-optimization of whole building/district operation?
- *Market needs*: no one cares about energy efficiency. Need value-added services:
  - Personalized comfort
  - Grid support (flexible demand)
- *Indoor climate constraints*:
  - Lack of information on the effect of transient conditions on comfort and productivity
  - Sensor error transients
- *Cost:*
  - Device cost is easy, system cost, not.

Transforming the Future of Energy

Maulin Patel (Ph.D.)
General Manager, Intelligent Enterprises

current
powered by GE

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PORTLAND, OREGON USA

Hotel/Motel Occupancy Controls

SDGE
A Sempra Energy utility

The Gas Company
A Sempra Energy utility

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

PG&E
Pacific Gas and Electric Company

Measure Title: Guest Room Occupancy Controls for HVAC & Lighting systems (CA)

Measure Purpose: Hotel & motel guest room occupancy schedules are highly variable, and rooms are frequently conditioned while vacant. Installation of occupancy controls have been shown to reduce unnecessary energy consumption in unoccupied guest rooms.

Measure Description: Hotel & motel guest rooms would require installation of occupancy controls for HVAC equipment, and all lighting fixtures, included plug-in lighting. Examples of occupancy controls include captive card key controls and sensor-based controls. Guest room occupancy controls will return HVAC equipment to a setback position, and turn off lighting when a room is vacant.

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Hotel/Motel Occupancy Controls

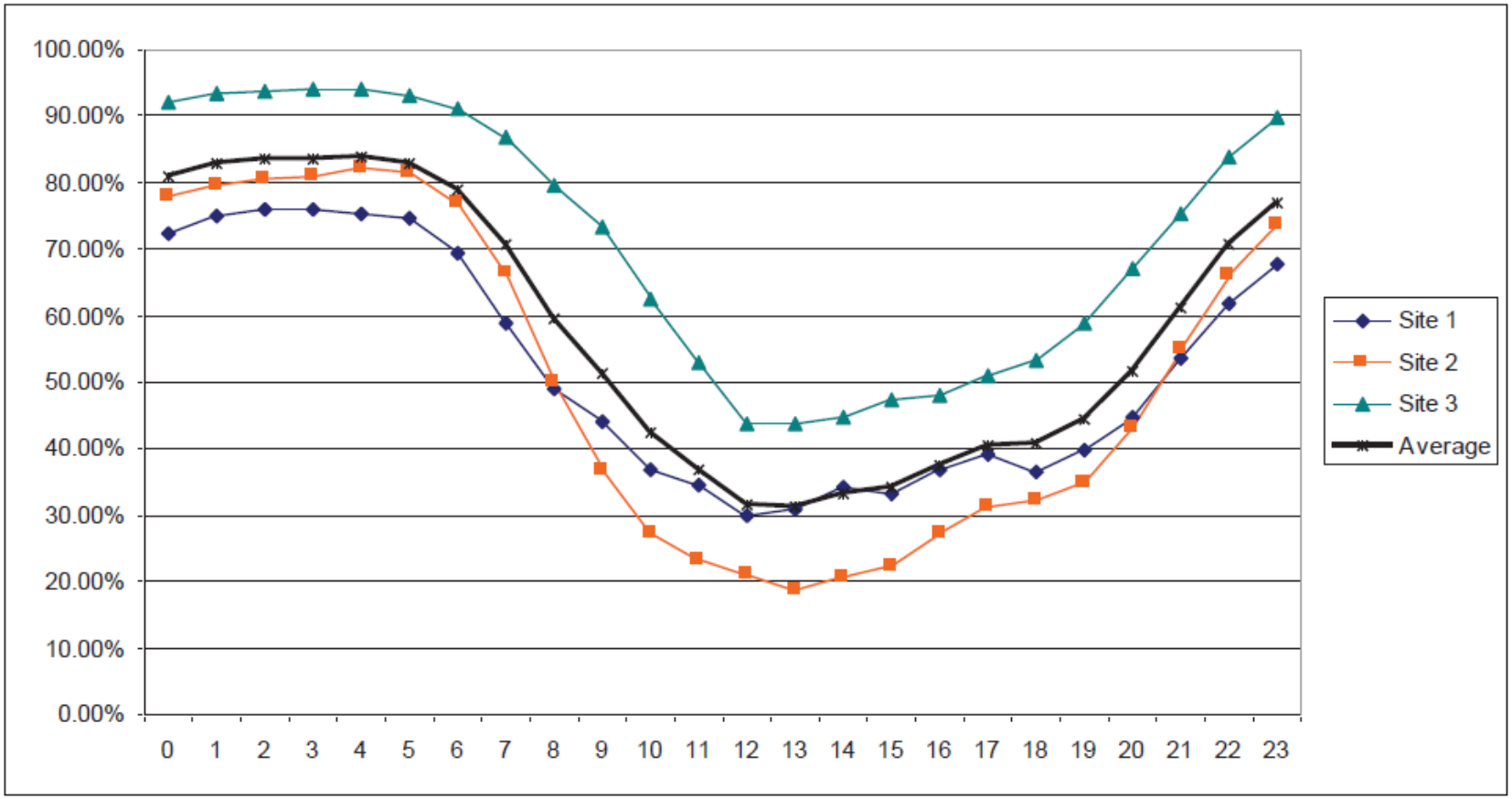

Figure 3: Occupancy Patterns of Hotel Guest Rooms from CLTC Field Study

Hotel/Motel Occupancy Controls

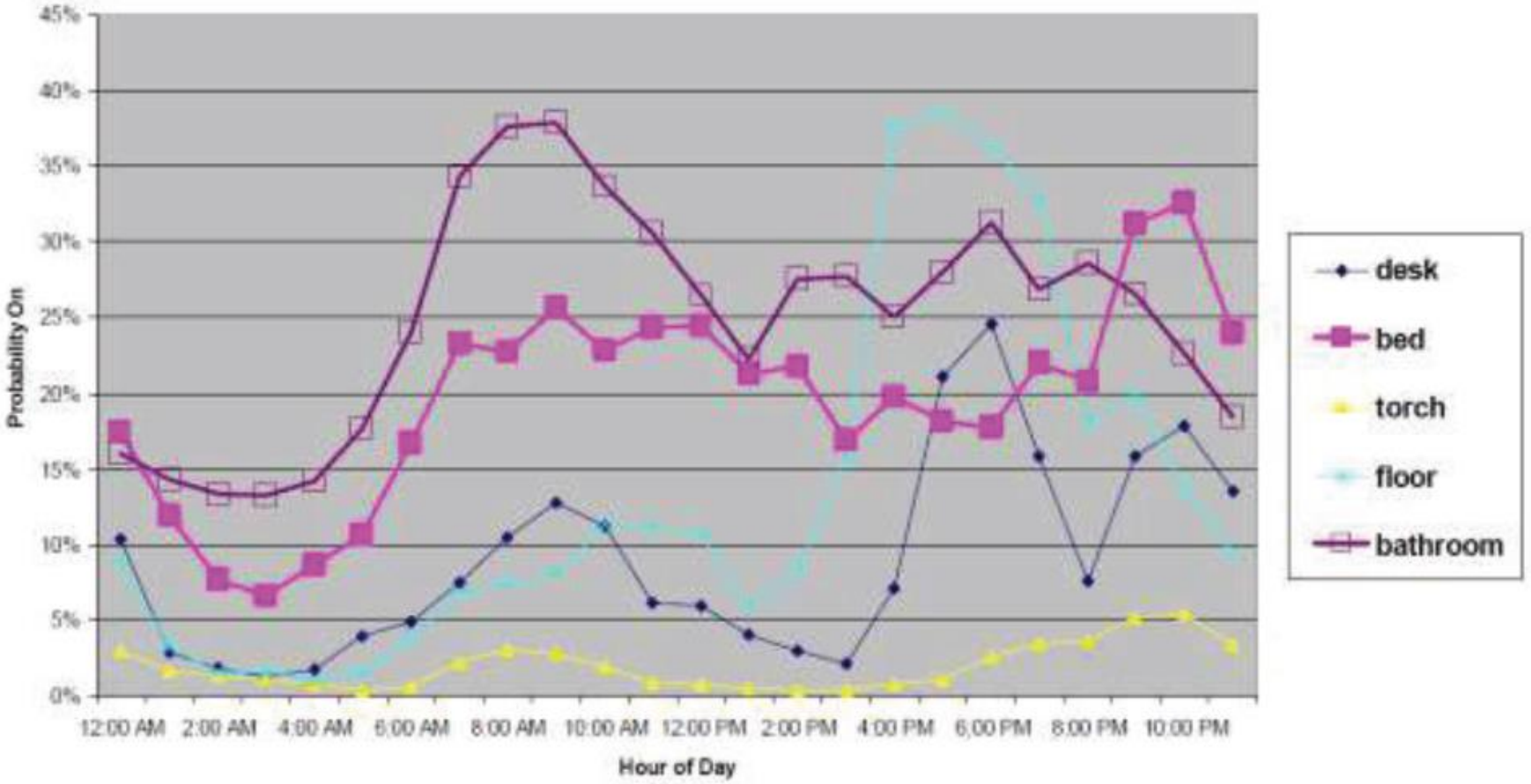

Figure 5: Use Patterns for Guest Room Lighting Types

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Hotel/Motel Occupancy Controls

Anticipated Results:

- 12%-25% annual guest room HVAC energy reduction with a 5-degree setback when a room is vacant
- 2.19 GWh = $64,154,425 total energy savings in 1st year of implementation in California
- Reducing the runtime of the HVAC and Lighting equipment will extend the life of the equipment and reducing the maintenance and replacement costs.
- Some occupancy control systems can be centrally wired to allow hotel staff to identify rooms that are unoccupied and deliver more efficient cleaning and maintenance services

Measure Cost Effectiveness :

- Cost of equipment and installation vary by technology, system sophistication, and number of guest rooms.
- Prices from $100 up to $500 per guest room
- $246 per guest room for occupancy controls was used for this study with a $75 installation/wiring cost for a total of $321 total installed cost per guest room

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Hotel/Motel Occupancy Controls

Analysis and Results:

- Research and analysis of the hotel/motel occupancy controls for guest room HVAC & Lighting showed cost-effective application in both new construction and retrofit projects.
- This report proposes mandatory requirements for occupancy controls for guest rooms in new construction only.
- It is recommended that this measure be considered for retrofit requirement in a future code update

New Construction Opportunity:

- In California alone approximately 80 hotel building are built each year
- At the start of 2014, there where 2,925 active hotel project under construction in the US
- Those 2,925 active projects accounts for a total of 357,769 rooms
- This is an increase of 16.4 percent over January 2013

http://www.cnbc.com/id/101428199#.

Retrofit Opportunity:

- In retrofit applications, the efficiency of the HVAC and lighting systems is typically lower, leaving more room for improvement in energy efficiency vs. new construction.
- Even with no regulatory requirement in California, the payback will be quicker than new construction

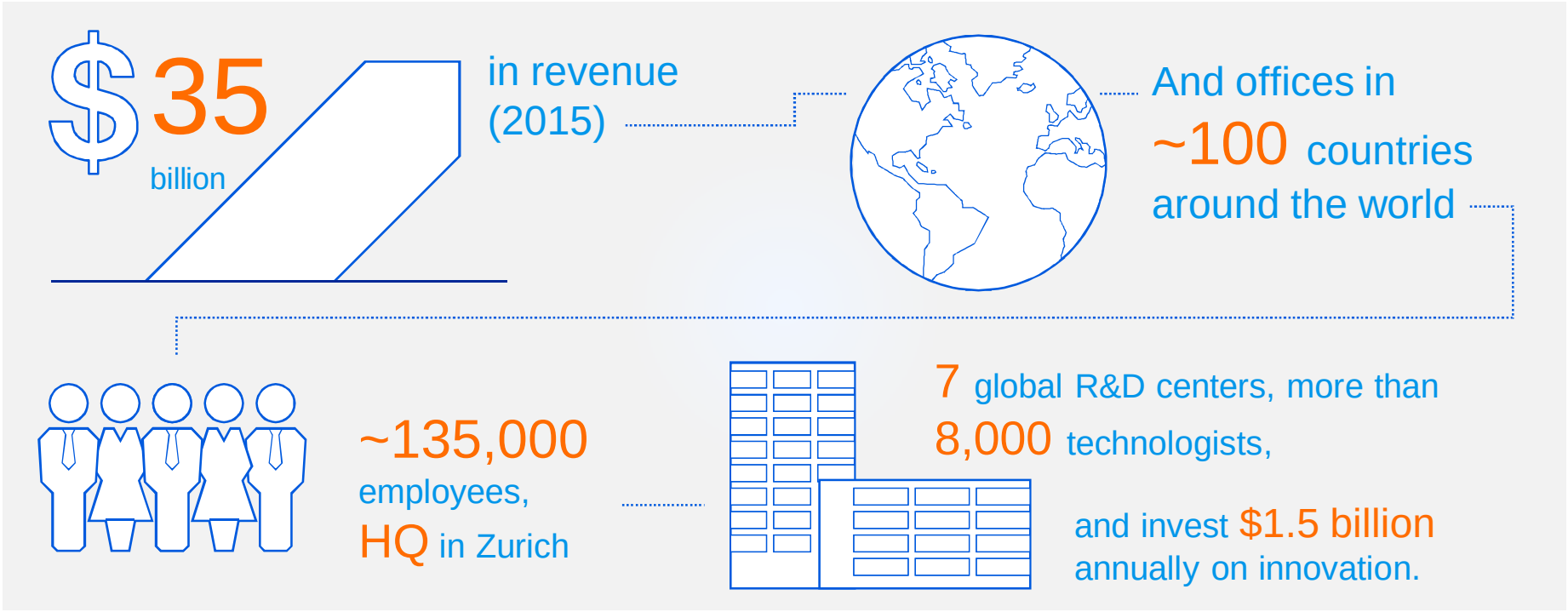
Mirrasoul J. Mousavi, ARPA-e Workshop, Portland, OR, July 13, 2016

Advanced Occupancy Sensors for Better Buildings Workshop

Roundtable Introductory Remarks

ABB: a global leader in power and automation technologies

Serving industrial, utility, and transportation infrastructure market segments



US headquarters co-located in Raleigh, NC with US Corporate Research as part of 7 global corporate R&D centers

Electrification Products (EP) Division supplies building products, systems, and solutions including Busch-Jaeger occupancy sensors and Thomas & Betts products, *delivering more than 1.5 million products a day*

Occupancy Sensing Technologies
Benefits and Challenges: Traditional Approaches

Observation:

- Occupancy Sensor vs. Motion Sensor: Indoor vs. outdoor lighting control [NEMA WD 7-2011]

1st wave (circa 1992): Binary occupancy detection (Yes/No) for lighting control

- Passive Infrared (PIR), Ultrasonic, Sound, Microwave technology, Photosensors, etc.…
- Autonomous, wired, and often proprietary installation
- Simple single-purpose architecture and use cases
- Recent trends added wireless options (WiFi/Zwave/etc…) and energy harvesting (single technology)

Benefits

- Saved energy by NOT using it when not needed (best efficiency is energy not served)
- Immediate benefits could be realized when sensors worked reliably and consistently for both major and minor motion!
- Enabled rule-based automation schemes

Occupancy Sensing Technologies
Benefits and Challenges: Emerging Trends

The 2nd wave: Powered by IoT technologies

- Enables data-driven approaches removing the burden of human rule-making
- From occupancy sensing to occupancy estimation
- Detect number of people and their activity levels
- Support for distributed as well as central i.e. cloud-based architectures
- Challenges
  - Privacy and security
  - Cost-effectiveness and ROI tools esp. for multi-measurand sensors
  - Interoperability
  - Ease of use, configuration, and retrofittability (DIY for residential)
  - Self-recognition, troubleshooting, and recovery
- Ideal best solution for stand-alone distributed occupancy sensing
  - no wires, no batteries, no programming, no maintenance!

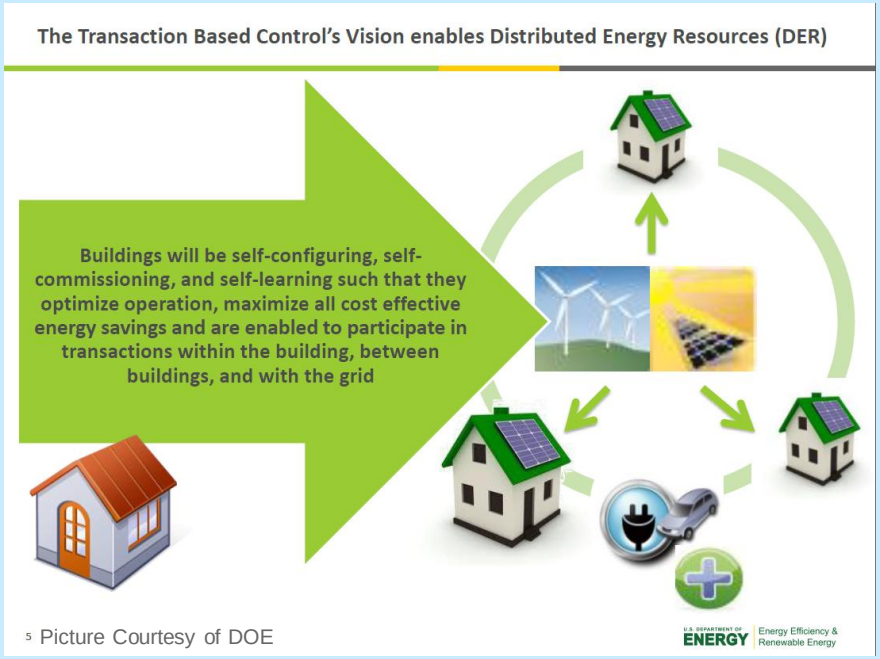
Why now:

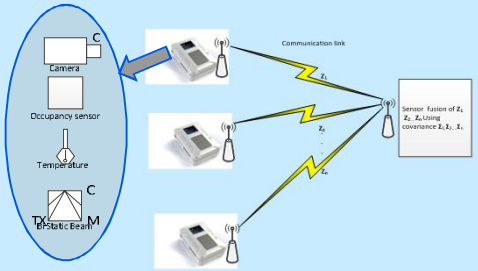
- Confluence of a number of underlying hardware and software technology advancements
- Low-cost computing architectures
- Ubiquitous communications and interconnectivity (system of systems)
- Machine/deep learning and **edge analytics**

Occupancy Sensing Technologies

Towards supporting new use cases for Intelligent Buildings

- Buildings are no longer passive energy hogs (up to 45% total final energy use on a global scale)
- Smart buildings are active participants in energy use and production
- New use cases not afforded by traditional approaches for building automation
- Smart occupancy sensors enable condition-based building energy management
- 1st stage: gain insight into co-optimizing building energy use and occupant comfort
- Opportunities
  - Indirect/proxy methods e.g. RSS
  - IoT sensors and wearables
  - Accuracy correction/compensation through sensor fusion





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