Invited Talk

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Beijing Jiao Tong University, China, 23 November 2019

PPT slides will be available at
www.saifurrahman.org
What is a Smart City

There is no single consensus definition of a smart city, but there is some agreement that a smart city is one in which information and communication technology (ICT) facilitates improved insight into and control over the various systems that affect the lives of residents.


Building Blocks of a Smart City
Cities across the world are deploying technology to gather data trying to become cleaner, reduce traffic, and improve urban life. Starting with energy management, to disaster preparedness, to public safety, to parking spot assistance, to paying bills online, to facilitate emergency vehicle movement, and much more.

Elements of a Smart City

- A neighborhood in a smart city:
  - A smart traffic crossing sensitive to traffic volume
  - Synchronized traffic lights for smooth flow
  - Emergency vehicle priority access
Connected Transportation

- Connected vehicles and travelers will be able to share data with all sorts of equipment, and be able to procure mobility as a service, whenever wherever.
Stockholm City Traffic Management

The system allows buses that are more than a minute behind schedule to automatically receive priority at traffic lights.

Internet of Things (IoT)

IoT-enabled smart buildings offer in-building device mobility, occupant comfort, and indoor activities automation.
IoT Applications in Healthcare, Agriculture, Transport, Energy

How do you make a large number of IoT devices work together?

Need a software platform
WiseBldg

An open-architecture software platform that can monitor and control any IoT device with a known API

WiseBldg: Building Energy Management Platform

Overview

WiseBldg (pronounced “Wise Building”) is BEM Controls’ powerful, low-cost, open-architecture software platform that can monitor and optimally control major electrical loads (e.g., HVAC, lighting and plug loads), as well as solar PV systems, energy storage units and other IoT sensors in commercial buildings. It is built on the DoE-sponsored BEMOSS platform developed at Virginia Tech.
WiseBldg: Range of Applications

- **Open, Modular Platform that grows with customer needs**: Start small, add new buildings, open devices at any time
  - *Energy* – HVAC, Lighting, Plug-loads
  - *DERs* – Solar, Battery Storage
  - *Other IOT* – Environmental sensors, Security cameras
- **Easy to operate and maintain**: End-user installs their own *hardware* and controls the system based on insights from WiseBldg and their own daily needs
- **Realtime control**: Take action based on existing situations
- **Analytics**: Smarter and more accurate control informed by load forecasting
- **Future-ready**: AI-driven, *blockchain* capable

WiseBldg supports multiple IoT devices through industry standard protocols and communications technologies.
Multiple-protocol Interoperability

**Communication Technologies**
- Ethernet (IEEE 802.3)
- Serial Interface (RS-485)
- ZigBee (IEEE 802.15.4)
- WiFi (IEEE 802.11)

**Data Exchange Protocols**
- BACnet (IP and MS/TP)
- Modbus (RTU and TCP)
- Web (e.g., XML, JSON, RSS/Atom)
- ZigBee API
- Smart Energy (SE)
- OpenADR (Open Automated Demand Response)

Experience from building controls

**Measured energy savings across deployments**
- **20%**  HVAC Energy Savings
- **25%**  Lighting Energy Savings

**Improved operations and maintenance:** WiseBldg analytical platform enables operators to detect faults when devices operate outside standard thresholds enabling building operators to investigate prior to device failure.

**Occupant satisfaction:** spaces controlled by WiseBldg have been more comfortable due to more consistent temperature profiles and healthier air quality through consistent monitoring of environmental factors (CO2 levels, PM 2.5).
Energy Savings from Sensor Deployment & Control

25,000 sqm building in Alexandria, VA

5 Wireless thermostats

Raising the set point from 6am-6pm demonstrates 10.5% energy savings in HVAC load per degree temperature increase.

Pre-cooling to cut Peak-time Demand

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<tbody>
<tr>
<td></td>
<td>Base case</td>
<td>DR case</td>
<td>Base case</td>
<td>DR case</td>
</tr>
<tr>
<td>$P_{max}$</td>
<td>3.37 kW</td>
<td>3.63 kW</td>
<td>3.29 kW</td>
<td>3.36 kW</td>
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Classroom under Real-time Monitoring

- Power meter
- Environmental sensor (CO2, noise, temperature)
- BEMOSS core
- Plug load controller
- Thermostat
- Motion sensor
- Weather Sensor Integration

Indoor Environmental Monitoring

- Bemoss Core: Weather Sensor21
  - Indoor Environment Status
    - Temperature: 71.4°F, Humidity: 22.0%
    - Pressure: 30.65 Pa, CO2: 484.0 ppm, Noise: 47.0 db

- Outdoor Environment Status
  - Temperature: 74.3°F, Humidity: 49.0%
  - Minimum Recorded Temperature: 74.3°F, Maximum Recorded Temperature: 74.3°F
Based on occupant requirements, light intensity level was reduced during October – December 2016. Results indicate the average kWh savings of about 34%.

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Measured Energy Consumption (kWh)</th>
<th>Total Calculated Energy Consumption without Dimming (kWh)</th>
<th>Energy Savings by Dimming (%)</th>
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<tbody>
<tr>
<td>October 2016</td>
<td>264.37</td>
<td>399.90</td>
<td>33.89%</td>
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<tr>
<td>November 2016</td>
<td>278.13</td>
<td>423.78</td>
<td>34.37%</td>
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<tr>
<td>December 2016</td>
<td>280.76</td>
<td>426.40</td>
<td>34.16%</td>
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<tr>
<td>Total (October-December)</td>
<td>823.26</td>
<td>1250.08</td>
<td>34.14%</td>
</tr>
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Note: Scheduled dimming level from 6:30am to 9:00pm. Open office area A: 50%; Open office area B: 45%; Chief office’s desk area: 60%; Chief office’s meeting area: 50%; Conference room A: 50%; Conference room B: 45%. Lights are off after 9:00pm.
Electricity Savings in Street Lighting

People/cars are clearly visible under the white LED light.

High Pressure Sodium vs LED

Existing HPS Lamps (Dec 2010)

New LED Lamps (June 2012)
ICT-based Lighting Intensity control (80%)

Infrared Sensors Monitor Traffic

ICT-based control to dim lights to 50%
HPS vs LED
Monthly Electricity Consumption

• Average electricity savings of 75% was experienced after the installation.
• Avoided CO2 emission was 6,127 kg/year.

Solar PV System Monitoring and Control
Solar PV and Smart Inverter Integration

WisBldg User Interface

Smart inverter control
Managing Battery Storage from WiseBldg Platform

Battery Cells

Battery Storage Monitoring & Control

Tumalo Energy Initiative: Battery Storage
An Energy Internet Platform for Energy Efficiency on a Smart City Block

Utility/DR Aggregator

Internet

HVAC
Lighting loads
Plug loads
Power meters
Water meters
PV & storage
Security camera

Customers/Operators
Buildings

www.bemcontrols.com

Transactive Energy is Driving Interest in Blockchain-related Technologies

Many use cases

Transactive Energy
- Supply and Demand Matching
- P2P trading
- Energy Settlement
- Micropayments for Energy

Other
- EV Charging
- Smart Meter Data
- Asset Management/Lifecycle
- Grid Cybersecurity
- Certifications

Power system facing new challenges
- Cybersecurity threats to the grid
- Rethinking the role of the intermediary in energy markets (DRAs, electricity retailers)
- Need for trust as energy ecosystem develops: utilities (DSOs), prosumers, end-users

Disruption in the Energy Markets
- Massive deployment of intermittent generation
- Rise of the Prosumer
- Wider acceptance of Smart Home/Building technology
Thank You

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