Smart Buildings and The Smart Grid

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Smart Building → Grid-Aware Building

- Stove-piped functions (silos)
- Multiple front-ends
- Proprietary

- Partial integration across silos
- Multiple open protocols
- Comms link to Internet

- Multi-protocol, cross-silo framework for new applications
- Dynamic load modulation
- Fine-grained load control
Smart Building Concepts

• Integration of multiple building systems
  – HVAC, Lighting, Energy, Emergency/Life Safety
• Common platform for data mining and exchange
  – Using open communications standards
  – Common infrastructure and data delivery mechanisms
• Enterprise data access
  – IT standards and communication interface
• Able to act and react
  – Internal and external influences
• Monitor, Alarm, Schedule, and Manage
  – Central or remote access
  – Variety of User Interface Options
Building System Integration

- **FIRE**
  - Functionality checks
  - Detector service
  - Valve Pressure
  - Fire, Life, Safety

- **SECURITY**
  - Doors
  - PIR
  - Integration

- **ACCESS**
  - Doors
  - Buildings
  - Occupancy
  - Feed Forward

- **ENERGY**
  - Appliances
  - Electronics
  - Utility Monitoring (Elec/Water/Gas/Oil)
  - Load Shedding
  - Air/Water
  - Heat
  - Lighting
  - Solar Generation

- **HVAC**
  - Air-Handling Unit
  - Boilers
  - Pumps
  - Fans
  - Energy Control
  - Hot Water Heaters
  - Air Quality

- **LIGHTING**
  - Indoor/Outdoor: Schedules
  - Occupancy Sensing

- **Appliances**
  - Breakdown
  - Maintenance
  - Performance

- **Home Electronics**
  - Audio
  - Video
  - Computers

- **24/7 Monitoring**
  - Service/Maintenance
  - Demand Response
  - Conditioned Monitoring
  - Vehicle Charging

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Smart Buildings Elements

GUI - USER APPS
Alarms, Reports, Control, Monitoring, Load Shed, Demand Limiting, Financial Performance

Enterprise EMS

Campus BMS

Building BAS

Utility
Indoor Facility
Outdoor Facility
Energy
Demand Response
HVAC
Lights
Parking Irrigation
Street Lighting
Metering Sub Billing
System Integration and Access

• Sharing data from sensors
  – Occupancy sensor data used by HVAC, Lighting, and Security

• Monitor and effect energy consumption
  – Used by demand limiting control strategy
  – Real time adjustments via control system

• Who’s in control
  – Direct occupant control over environment
  – Facility staff control
  – Subsystem dependent - Lighting, HVAC, Security

• Alarm management
  – Single alarm, multiple recipients
  – Remote acknowledgement and response
  – Preventative maintenance based upon actual usage
Smart Grid Concepts

• Incorporates all aspects of the power grid
  – Energy generation, distribution, and consumption
• Ability to act and re-act to changing conditions
  – Weather variables, production costs, delivery price
• Supply and demand management
  – Communication from supply to demand
  – Control and monitoring of usage levels
  – Proactive and reactive management
• Electrical Grid Management
  – Demand Response
  – Load Shedding
  – Load Shaping
  – Response time in minutes (not days)
Demand-Side Communication Technology Needs

Figure Source: NIST Framework and Roadmap for Smart Grid Interoperability Standards, v1.0
Open Innovation within the Smart Grid

- Economics
- Carbon
- Efficient Operation

- Lowered Prices
- Wholesale and retail integration

- Automation
- Reliability
- Effectiveness
- Cost
- Choice
## The Common Elements: Access to Data and Communication

<table>
<thead>
<tr>
<th>Layer</th>
<th>Stakeholder</th>
<th>Data level</th>
<th>Data Types Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enterprise</strong></td>
<td>Owner/Master integrator/Facility Staff/Application Developer/Aggregator</td>
<td>5, 6 - Aggregate, Monitor, Report</td>
<td>Energy savings, pricing, reporting/monitoring, scheduling</td>
</tr>
<tr>
<td><strong>Campus/District</strong></td>
<td>Owner/Master integrator/Facility Staff/Application Developer/Aggregator</td>
<td>4, 5 - Schedule, Report, Monitor</td>
<td>Alarms, Monitoring, Scheduling, Energy Data,</td>
</tr>
<tr>
<td><strong>Premises/ System</strong></td>
<td>Owner/Integrator/Facility Staff/Application Developer</td>
<td>3, 4 - DR, Load shed, control, monitor, schedule</td>
<td>Energy mode, ADR Signals, Alarming, Scheduling</td>
</tr>
<tr>
<td><strong>Zone</strong></td>
<td>User/Occupant/ Manufacturer/Vendors/ Integrators</td>
<td>2, 3 - Status/Mode/Scene, schedule</td>
<td>Occupied mode, Load Shed mode, Lighting scene</td>
</tr>
<tr>
<td><strong>Room</strong></td>
<td>User/Occupant/ Manufacturer/Vendors/ Integrators</td>
<td>2 – Status Mode Scene</td>
<td>Occupied mode, Load Shed mode, Lighting scene</td>
</tr>
<tr>
<td><strong>Device</strong></td>
<td>Manufacturer/Vendors Integrators</td>
<td>1 - on/off/control, low level data</td>
<td>Temp, pressure, status, set points, mode, scene</td>
</tr>
</tbody>
</table>
Control Networking Platform
For Smart Buildings

Enterprise Applications
PC, MAC, Android, iPhone

Any IP network

Building to enterprise Interface: protocol neutral

Smart Homes
Smart Campuses
Smart Buildings
Smart Branches
Standards-based Communication

Common Data Models

IP

Any IP network

IP-852
BACnet/IP
ISO/IEC14908

IP/852
Modbus
M-bus
LonWorks®
BACnet/IP
DALi®
EnOcean®
Zigbee®

SOAP/XML
Modbus
M-bus
LonWorks®
Other...

Enterprise Applications
PC, MAC, Android, iPhone

Smart Buildings

Smart Campuses

Smart Buildings

Smart Branches
Platform Example in Smart Building

Need: Open at every level – From System to Device

Enterprise Applications
- Energy Analytics
- Energy Asset Management
- Automatic Demand Response
- Peak Day Pricing
- Facility Management

Any IP network

Local IT Network Subsystem Interfaces

Device Level Network
- LonWorks
- BACnet
- Modbus, KNX
- DALI, M-bus
- EnOcean
Common App Model
Mix and match best-in-class subsystems – one App interface

- Integrate LonWorks, BACnet, DALI, Zigbee, Modbus systems across IP
- Define common App interface using LMI Profile model
- Enable App independence from control network
- Multiple device networks – LonWorks, Modbus, M-bus
- Co-develop by LonMark, ASHRAE, DALI, Zigbee, TC-247, ???
Enterprise Application Standard Interface

- Standard profile model
- Start simple – 10 profiles
- Reduce application interface complexity
- Host applications interface is protocol neutral
- Commonality, normalization
- Unbundle the app from the controls
Top Down - User Perspective

- User allowed to pick and choose Apps based on need, not bells and whistles
  - Solution is more open, less bundled
- Easier to specify multi-tier integrated solutions
  - App providers have common interface model to build to
  - Lower the cost for Apps
- Increases flexibility for integrators, installers
- Enable Demand Response type applications
  - OpenADR and LonMark Profile combined into one interface
- Better scalability and interaction across subsystems
EASI: Enterprise App Standard Interface

- CEN/LONMARK/BACnet/ASHRAE Joint Working Group
- Enable App developers to work with any sub-system
- Protocol neutral networks interface to host Apps
  - Application independent interface model – co-developed
  - Scalable solutions for any application
- Support new interface and driver products from multiple suppliers
  - Sub-system level drivers/interfaces – implementing in local data servers
  - Common data modeling – Web Services using SOAP/XML
  - Potential for network management tools for managing multiple protocols in one tool environment
Building and Grid Challenges

- Dealing with generation capacity shortages
- Managing lower capacity margins
- Reducing the number and intensity of peak consumption hours
- Balancing the wholesale and retail price of electricity
- Increasing energy savings through energy efficiency
- Managing building automation and response time and levels
OpenADR is an information exchange model to facilitate communication of price and reliability signals.

**Signaling** - continuous, 2-way, secure messaging for dynamic prices, emergency and reliability signals.

**Client-server architecture** - uses open interfaces for interoperability with publish and subscribe systems.

**Hardware retrofit or embedded software** - many clients fully implemented with existing XML software.
OpenADR Architecture

Commerical and Industrial

Residential, Small Commercial

Utility or ISO

Operators

Information System

Internet

API

Demand Response Automation Server

Alt Communication

Customer Group

Customer

Customer Group

API = Standardized Application Programming Interface
Ancillary Services and Renewable Integration

- Daily Peak Load Management
- Ramp Smoothing
- Shift Load to Night - Regulation Down
Evidence of AutoDR in Action
OpenADR Results

OpenADR Application Impacts
PG&E Demand Bid Test Day (all participants)

[Graph showing power usage with annotations]

AutoDR saves Capacity

AutoDR saves Energy
Continuous Energy Management

- Daily Energy Efficiency
- Time-Of-Use Energy
- Daily Peak Load Managed
- Day-Ahead (slow) DR
- Real-Time DR
- Spinning Reserve (fast) DR

Service Levels Optimized
Time of Use Optimized
Service Levels Temporarily Reduced

Increasing Levels of Granularity of Controls
Increasing Speed of Telemetry
Market Drivers

- Allows DR resource ready for dispatch.
- Improves DR reliability, predictability, value, etc.
- Simplifies and reduces cost of DR
- Creates interoperability among customer systems
- Increases customer participation, reduce labor of manual price response
- Allows customer to choose level of response and how to enable a DR and energy strategy
- Allows ability to embed automation in customer’s control system
## Commercial Building DR Actions

<table>
<thead>
<tr>
<th>End Use</th>
<th>Type of Response</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scaling Down</td>
<td>Scaling Down</td>
</tr>
<tr>
<td>HVAC</td>
<td>Global temperature adjustment,</td>
<td>Seconds</td>
</tr>
<tr>
<td></td>
<td>Decreasing duct static pressure, etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turning off compressor(s), chiller(s), etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 2-5 minutes</td>
</tr>
<tr>
<td>Lighting</td>
<td>Dimming down lights</td>
<td>Seconds</td>
</tr>
<tr>
<td></td>
<td>Turning off lights</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than one minute</td>
</tr>
<tr>
<td>Plug Loads</td>
<td>N/A</td>
<td>Seconds</td>
</tr>
<tr>
<td></td>
<td>Turning off equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Miscellaneous Electric Loads</td>
<td>Turning off power</td>
<td>Seconds</td>
</tr>
</tbody>
</table>
## DR Rules Application Engine Example

### New LonMark Profile

<table>
<thead>
<tr>
<th>Demand Response Rules App</th>
<th>DR Server Message</th>
<th>DR Client</th>
<th>LonMark Profile</th>
<th>LonMark Profile</th>
<th>Notification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event</td>
<td>Utility ADR signal</td>
<td>Building Response</td>
<td>HVAC Response</td>
<td>Lighting Response</td>
<td></td>
</tr>
<tr>
<td>Stage 0</td>
<td>DR Level 1</td>
<td>Nothing</td>
<td>HVAC_Mode 1</td>
<td>SCENE_1</td>
<td>Nothing</td>
</tr>
<tr>
<td>Stage 1</td>
<td>DR Level 2</td>
<td>Minimal</td>
<td>HVAC_Mode 2</td>
<td>SCENE_2</td>
<td>Notify facility manager - email</td>
</tr>
<tr>
<td>Stage 1</td>
<td>DR Level 3</td>
<td>Minimal</td>
<td>HVAC_Mode 2</td>
<td>SCENE_2</td>
<td>Notify facility manager, supervisor</td>
</tr>
<tr>
<td>Stage 2</td>
<td>DR Level 4</td>
<td>First Level</td>
<td>HVAC_Mode 3</td>
<td>SCENE_3</td>
<td></td>
</tr>
<tr>
<td>Stage 2</td>
<td>DR Level 5</td>
<td>First Level</td>
<td>HVAC_Mode 3</td>
<td>SCENE_3</td>
<td></td>
</tr>
<tr>
<td>Stage 2</td>
<td>DR Level 6</td>
<td>Second Level</td>
<td>HVAC_Mode 4</td>
<td>SCENE_4</td>
<td>Notify facility manager, CFO</td>
</tr>
<tr>
<td>Stage 3</td>
<td>DR Level 7</td>
<td>Second Level</td>
<td>HVAC_Mode 4</td>
<td>SCENE_4</td>
<td></td>
</tr>
<tr>
<td>Stage 3</td>
<td>DR Level 8</td>
<td>Maximum</td>
<td>HVAC_Mode 5</td>
<td>SCENE_5</td>
<td>Notify CEO - all - confirm action</td>
</tr>
<tr>
<td>Stage 3</td>
<td>DR Level 9</td>
<td>Maximum</td>
<td>HVAC_Mode 5</td>
<td>SCENE_5</td>
<td></td>
</tr>
<tr>
<td>Critical Alert</td>
<td>DR Level 10</td>
<td>Shut Down (go home)</td>
<td>HVAC_Mode Off</td>
<td>SCENE_OFF</td>
<td>Notify all - confirm action</td>
</tr>
</tbody>
</table>
LonMark and OpenADR Update

• LonMark and OpenADR Liaison Agreement
  – Enable seamless interoperability
• LonMark Smart Grid Profiles
  – Energy Metering, Solar, Geothermal
  – Building DR Management
• OpenADR Alliance certifying products for compliance with standard
  – Standard published by OASIS
  – Pursuing international standardization through IEC PC118
Summary

- Facilities are and will continue to be multi-platform, multi-protocol, multi system
- Communication and data standards is critical
- New applications, new platforms, common data
- Communication at the building to the grid is mandatory
  - NIST taking leadership role
  - LonMark, BACnet, Zigbee, OpenADR and others working together
- Find ways to make integration simpler
- Encourage participation – Join committee, enable voice
Questions?

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