Improving Performance with Building Automation Systems

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Meet Your Panelists

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Working to Deliver the Energy You Need, Whenever You Need it; that’s our Promise to You
Contents

• Background
• Controllers
  ▪ Control Strategy
  ▪ Hardware
  ▪ Software
• Communication Protocols
• Dashboards
• Best Practices
• Case Studies

Source: FEMP

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Background

Building Automation System

- Fire Control System
- Building Security System
- Energy Management System
- Elevator/Escalator System

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Core BAS Functionality

- **Controls** the building environment
- **Operates** systems
  - Based on occupancy schedules and demand
- **Monitors** system performance
  - Implements corrective actions
- **Provides** alerts and alarms

Source: FEMP
Core BAS Operations

- **Sequence of Operations**: Narrative step-by-step descriptions of how the building system components will react when specific conditions are reached.

- **Control Strategy**: Defines what will be controlled, how, and when.

- **Collection Points**: Points consist of the hardware, both analog and digital, required to implement the control strategy and includes the sensors, actuators, etc.

Source: FEMP
• **What Is Controlled?**
  - Chillers
  - Boilers
  - Air handling units (AHUs)
  - Roof-top units (RTUs)
  - Fan Coil units (FCUs)
  - Variable air volume boxes (VAVs)
  - Heat pump units (HPUs)
  - Lighting systems
  - Indoor environmental quality (IEQ)
  - Renewable energy
  - Water use
  - Demand response

• **Future Control Possibilities**
  - Photovoltaics
  - Motorized shades
  - Uninterruptible power supplies (UPS)
  - Backup generators
Background

BAS Historical Timeline

- 1950’s Pneumatic systems
- 1960’s VAV and sensors
- 1970’s Computerized analog Energy Mgmt System
- 1980’s Microprocessor Inputs/Outputs and early Direct Digital Contol (DDC) modules
- 1990’s Open protocols (BACnet and LON)
- 2000’s Wireless and smart buildings
Pneumatic Systems

Pros
- Lower cost
- Steady-state reliability

Cons
- Tuning of pressures
- Re-balancing controllers
- Air leaks
- Availability of parts
- Control board programming

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Service Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once A Week</td>
<td>Drain compressor, tank, filter, bowl, and any air lines that have drain cocks. Check compressor crankcase oil level. Check compressor safety-relief valve.</td>
</tr>
<tr>
<td>Once A Month</td>
<td>Inspect discharge air filter. Check pressure-reducing valve setting.</td>
</tr>
<tr>
<td>Once Every 3 Months</td>
<td>Change crankcase oil. Oil the compressor motors. Check compressor pressure switches.</td>
</tr>
<tr>
<td>Once Every 6 Months</td>
<td>Check for moisture, oil and dirt in air lines. Clean the intake air filter, felt and screen types. Check the compressor belt. Check the pressure relief valves. Check calibration, operation, nozzles, and restrictors of transmitters temperature controllers, pressure controllers, thermostats and humidists. Check piping of pressure transmitters and controllers. Clean elements and humidists. Lubricate dampers, check damper actuators and close-off.</td>
</tr>
<tr>
<td>Once A Year</td>
<td>Replace cartridge-type intake air filters. Check calibration of receiver controllers. Check throttling ranges of humidists, thermostats, temperature and pressure controllers. Lubricate packing, adjust packing or repack valves. Check valves for tight close-off. Check E-P and P-E relay operation. Check diverting, averaging, high/low, volume booster relay operation. Check diverting switch operation. Check gradual switch operation.</td>
</tr>
</tbody>
</table>
Background

- Direct Digital Control (DDC)
  - Intelligent network of electronic equipment
    - Microprocessor-based controllers
    - Sensor input converted to digital form
      - Digital is on/off
      - Analog is a number
    - Control logic performed by software

Source: NIST
• **What Are BAS Benefits?**
  - Use less energy (5% to 15%)
    - Outside air optimization
    - Vacancy sensors
  - Decrease cost of operation
    - Decreased maintenance costs (short cycling)
  - Achieve security/safety
  - Improve indoor environmental quality
    - Offer a comfortable work environment
    - Fewer occupant complaints

*Source: FEMP*
Background

- **BAS Components**
  - **Collector**
    - temperature, occupancy, and CO2 sensors
  - **Controller**
    - gathers temperature, pressure, flow rate from collectors
    - makes decisions based on rules and settings
  - **Output device**
    - transducers, actuators, relays
  - **Communications protocol**
    - facilitates communications between sensors and controllers
  - **Dashboard**
    - human/machine interface

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Communication Protocols

Source: KMC Controls
What Is Control?

- Process sensor data
- Apply logic
- Create an output

Controller

Collector/Sensor

Heating Coil

Heating Water Supply

Airflow

Heating Water Return

Controlled Output Device
Getting to the “Smart” in Smart Buildings

Control Systems and Devices
- Existing, system-level (e.g., thermostats)
- BMS/BAS, Sensors, Sub-meters
- BMS/BAS, Sensors, Sub-meters, Wireless Sensors

Data
- Historic, system level
- High Frequency, current
- Peer Buildings, External Data Services (weather, etc.), Building Occupancy

Building Software
- None
- Conditional Rules
- Prescriptive, Predictive, Optimization, Simulation

Source: IDC Energy Insights

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Intelligent Continuous Control Software

- Adaptive, self-learning

Source: BuildingIQ
Control Hardware

- ControlTrends BAS 2012 **Controller of the Year** Candidates
  - EasyIO Infocon Sedona 30P-SF
  - Vykon JEC-234 JACE
  - Lynkspring JENSYS
  - Johnson Controls FX-PCG
  - Honeywell Spyder
  - CAN2GO UN2

Source: Johnson Controls
Control Software

- ControlTrends BAS 2012 **Control System of the Year Candidates**
  - Tridium VYKON Niagara
  - EasyIO Infocon
  - Loytec LINX (Austria)
  - Johnson Controls FX
  - Honeywell WEBS

*Source: Tridium*

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Control Software

- ControlTrends 2012 Energy Management Application of the Year Candidates
  - Johnson Controls Panoptix
  - ActiveLogix Periscope
  - CSI³ Prophet
  - Building Logix Energy Logix
  - eSight Energy

Source: CSI³ Prophet

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Communication Protocols

- **Defacto Industry Accepted**
  - Ethernet (fast)
  - Modbus
  - Internet Protocol (convenient)

- **Agency/Association Approved**
  - LONworks
  - BACnet
    - Ethernet
    - ARCNET
    - BACnet/IP
    - MS/TP (Master-Slave/Token-Passing)
    - PTP (Point-to-Point)
    - Lon Talk

Source: NIST
• **Building Automation & Control Network (BACnet)**

- **Devices**
- **Objects**
  - Input/Output (I/O)
  - Calculations
- **Properties**
  - Minimum limit
  - Maximum limit
  - Present value
- **Services**
  - Read
  - Write
  - Who-is

Source: Contemporary Controls

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Taking Advantage of Internet Protocol (IP)

Source: Contemporary Controls
Communication Protocols

• Java Application Control Engine (JACE) Input Device

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## Communication Protocols

### Wireless Communications

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Battery Life</th>
<th>Throughput</th>
<th>Range</th>
<th>Increasing Range</th>
<th>Max Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>WiFi (802.11)</td>
<td>1-2 days</td>
<td>54,000 kb/s</td>
<td>100 meters</td>
<td>Add access points</td>
<td>2,007</td>
</tr>
<tr>
<td>Zigbee (802.15.4)</td>
<td>3-5 years</td>
<td>250 kb/s</td>
<td>1000 meters</td>
<td>Gateway mesh</td>
<td>65,000</td>
</tr>
<tr>
<td>Bluetooth (802.15.1)</td>
<td>1 day</td>
<td>720 kb/s</td>
<td>10 meters</td>
<td>Add access points</td>
<td>8</td>
</tr>
<tr>
<td>UWB (802.15.3a)</td>
<td>20 days</td>
<td>110,000 kb/s</td>
<td>10 meters</td>
<td>Add access points</td>
<td>8</td>
</tr>
<tr>
<td>EnOcean (ISO 14543)</td>
<td>&gt;5 years</td>
<td>120 kb/s</td>
<td>30 meters</td>
<td>Gateway mesh</td>
<td>&gt;65,000</td>
</tr>
</tbody>
</table>

### Video

[YouTube Video](http://www.youtube.com/watch?v=buV11ZPJ7MQ#t=133)
Communication Protocols

- **Wireless Topologies**
  - Point-to-point
  - Point-to-multi-point
  - Mesh network
  - Star-mesh network

Source: Dave Craven, KC Rep Source / Everex

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Dashboard Software

• Optimize the BAS User Interface
  ▪ Trending
  ▪ Scheduling
  ▪ Downloading memory to field devices
  ▪ Real-time “live” graphic programs
  ▪ Parameter changes of properties
  ▪ Alarm and event information
  ▪ Secure access
  ▪ Execution of global demands

Source: FEMP

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Optimize the BAS User Interface*

- Consult the users
  - How do they use the system?

- Design a template
  - Goal is four clicks to get to any system
  - Standardized naming convention
    - 107FCEX2 AHU-101 Northwest 4th Floor AHU
    - Zone (Zn-T), Room (Rm-T), or Space (SP-T) temperature

- Implement and measure
  - Pick several existing customers and run through the process
  - Refine the process taking notes of what is working and not working
  - Adjust as new technology comes out

*Source: Phil Zito, blog.buildingautomationmonthly.com

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Optimize the BAS User Interface

- Design a template
  - Process driven, interconnected, easy to understand graphics layout

Source: Phil Zito, blog.buildingautomationmonthly.com
Dashboard Software

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Dashboard Software

• Optimize the BAS User Interface
  ▪ Design a template
    • Process driven, interconnected, easy to understand graphics layout

Source: Phil Zito, blog.buildingautomationmonthly.com
Graphics Front-End

Source: Johnson Controls
BAS Best Practices

• Use a multiple controller stand-alone system architecture
  ▪ The failure of a single controller should not impact more than one mechanical system on a BAS network
• Settle on products from one BAS manufacturer (one language)
• Non-volatile flash memory is preferred over UPS for memory (power outages)
• Updating software versions should be easy
• Can you view the dynamic process (software) as it happens in order to diagnose problems?

Source: DAVID REARDON, Robert E. Lamb Inc
BAS Best Practices

- Can you edit the controller software without a controller reload or reboot?
- Can I upload the software residing in the controller to configure, edit, save, and download to the controllers?
- Is the controller software flexible enough to add functionality such as logical expressions?
- From the operator workstation
  - Can I configure, edit, save, and download to the controllers?
  - Can I view all software and points from any and all controllers on the BAS network?

Source: DAVID REARDON, Robert E. Lamb Inc
BAS Best Practices

• BAS Vulnerability to Hacking*
  ■ Separate monitoring and control functionality
  ■ Use encryption for network traffic
  ■ Push, not pull, information to the user
  ■ Avoid a single point of failure
  ■ Close “back doors” to the BAS server
  ■ Manage user names and passwords from one location
  ■ Limit some users rights to “read only”

*Source: Phil Zito, blog.buildingautomationmonthly.com
St. Joseph Elementary School (Canada)

- 18,000-square-foot elementary school
  - Two floors and basement
- Wireless HVAC and lighting controls
  - 61% savings on electrical labor costs
- 31 valve actuators, 57 relays, 20 thermostats, and 59 switches
- 9 CAN2GO® controllers
  - 119 inputs and 117 outputs
- 15% savings on energy bills

Source: SCL Elements Inc.
Charles Wayne Properties (Daytona Beach, FL)

- 121,000 square foot, 10-story office building
- 34 LONMARK Certified **programmable** controllers
  - 30 with Hand/Off/Auto (HOA) switches
- 50 LONMARK Certified **configurable** controllers
  - ECC-VAV and EC-Stats **DEFINE?**
- Monthly energy consumption reduced by 50% during winter
- Projected savings of 25-30% during summer
- Lonwatcher network management tool

Source: Distech Controls Inc.
Office Building (New York City)

- 2.5 million square feet
- Integrated the legacy BMS with BuildingIQ server/algorithms
- Input existing building data, weather, tariffs, and DR signals
- Implementation took three weeks
- Saved $500k of HVAC energy in first year
- No detrimental impact of tenant comfort
- Achieved LEED Gold-EB certification

Source: BuildingIQ
Conclusions

- DDC control hardware is becoming a commodity
- Software is the heart of today’s BAS systems
  - Programming costs will overtake hardware costs
  - Self-commissioning and auto-tuning capabilities
- Wireless is expanding rapidly (powerline next?)
- Knowledge of how to control HVAC trumps vendor systems
- BAS supports commissioning and LEED verification
- Machine-to-machine (M2M) networking driving Internet addressability among connected components

Source: Gaylen Atkinson, Atkinson Electronics
Additional Resources

- The Controls Freak
  (www.thecontrolsfreak.com)

- Building Automation Monthly
  (http://blog.buildingautomationmonthly.com/)

- ControlTrends by Eric Stromquist
  (http://controltrends.org)
QUESTIONS?

Resources For You

- Sign up for our FREE Solution Center eNewsletter
  - Ask an Expert
  - Tools, calculators and energy-saving tips
  - All available at....
- Call us at 800-805-0490