Specifying Networked Controls with BACnet

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Introducing Appin and Grant Wichenko, P. Eng.

Appin Associates is a 30 year old consulting firm that specializes in:

- Mechanical Systems Design (HVAC, Boilers, Chillers) paying particular attention to the needs of Facility Operations (Fac Ops).
- Building Automation System (BAS) System design, specification and commissioning with emphasis on BACnet-based controls.
- Indoor Air Quality problems and mold remediation.

Grant Wichenko is a Professional Engineer. He is a member of ASHRAE SSPC-135 (BACnet), SGPC-13 (BAS Guideline Specification) and is active in ASHRAE 201P (SmartGrid).
Specifying Networked Controls with BACnet: Learning Objectives

1. Evolution of Controls: Describe the evolution of the controls business from pneumatics, to proprietary DDC system to interoperable Networked Controls using ASHRAE’s BACnet protocol.

2. Central Permit Facility, Libertyville, IL: List the equipment controlled in this building using the Networked Controls Design Model.

3. Division 25 Specification: Outline how CSI MasterFormat Division 25 Integrated Automation Division can be used to specify interoperable devices and systems.
Specifying Networked Controls with BACnet: Learning Objectives

• 4. Stakeholder Benefits: Describe the benefits of Networked Controls to the Owner, the Contractor, the Major Subcontractors, Equipment Suppliers and the Designers of Record.

• 5. Summary and Conclusions: List the reasons why the BACnet-based Networked Controls Design Model is a good solution to designing and specifying BASs successfully. The Design Model is ideally suited for the LEED and other Green projects. Applying the model will help make the facility “SmartGrid Ready”.

1. Evolution of Controls: Pneumatics, HVAC DDC and Aux Contact Alarms

- Controls were originally pneumatically or electrically actuated. This equipment is still used because it is rugged and still inexpensive.

- Electronic actuators when introduced more than 20 years ago, were expensive and unreliable.

- These devices are now the same cost or cheaper than their pneumatic or electronic cousins.
1. **Evolution**: Pneumatics, HVAC DDC and Aux Contact Alarms

- DDC systems used proprietary protocols for HVAC systems only.

- Many devices (chillers, generators) used to be standalone devices using proprietary protocols with limited alarming functionality.

- Normally, the DDC contractor wired to a common alarm contact on a local control panel. This alarm would represent many alarms and Maintenance personnel had to go to the local panel to see which of many alarm codes tripped the common alarm aux contact on DDC.
1. The Transition from “Stick-building” to Networked Controls using BACnet

- With the advent of BACnet, DDC systems are now interoperable or talk to each other. BACnet is now used by the electrical, fire, security, lighting and other industries.

- Devices such as chillers, boilers, generators, switchgear, lighting, fire, security and other equipment now come with networkable controls onboard.

- Many devices use Modbus. Now equipment suppliers are offering a choice of protocols including BACnet as well as gateways to convert from Modbus or proprietary protocols to BACnet.
1. The Transition from “Stick-building” to Networked Controls using BACnet

- The role of the Controls Contractor is now moving from “stick building” controls to networking devices using BACnet.

- “Stick building” means that the device like an AHU comes “brain-dead” and just like Gepetto who brought Pinocchio to life, the DDC system “brings life” to the AHU or boiler.

- Devices with Networked Controls come with BACnet on-board or use a protocol like Modbus that can be converted to BACnet so all devices on the BACnet Internetwork speak the same protocol.
2. Lake County Central Permit Facility (CPF), Libertyville, IL

- A green building with virtually all building systems integrated into a common BACnet Internetwork.
- The “Networked Controls” Design Model required vendors to supply their own BACnet interface to their devices. Traditional “Stick-building” was minimal. Systems were networked instead either as BACnet/IP or BACnet MS/TP.
2. Lake County Central Permit Facility (CPF), Libertyville, IL

Besides the BACnet Internetwork, other innovative features include a green roof and the storm water retention system.
2. CPF: Systems on the BACnet Internetwork

Automated Logic provided the Front End graphics for all systems. Johnson Controls provided the Chiller plant and Lab controls.
Specifying Networked Controls

Lift-Net provided a BACnet interface to the ThyssenKrupp elevator. There are plans to expand this interface. The elevator will be monitored remotely.

2. CPF: The ThyssenKrupp Elevator is on the BACnet Internetwork.

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
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<td>Normal</td>
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<tr>
<td>Safety Ckt Related Fault</td>
<td>Normal</td>
</tr>
<tr>
<td>Up Direction Pilot</td>
<td>Normal</td>
</tr>
</tbody>
</table>
2. **CPF**: Lift-Net provided a Webserver to the Elevator Management System.

- This screen gives a list of Elevator fault reports. The vendor has remote access to assist the Owner with maintenance and troubleshooting.

- This screen permits the Owner to record the results of the Firefighter’s Operation Test.
2. **CPF**: Eaton provided the BACnet Interface to the Fire Pump.
2. **CPF**: Johnson Controls the York Chiller Plant as a single BACnet Interface.

- **Operational Code**
  - Code: 3, Description: Stopped - Remote Shutdown

- **Warning Code**
  - Code: 1, Description: No Warnings Present

- **Safety Code**
  - Code: 1, Description: No Safety Faults Present

- **Cycling Code**
  - Code: 1, Description: No Cycling Faults Present
2. **CPF**: Automated Logic provided “Stick-Built AHU Controls and made MS/TP Network connections to the VFDs.”
2. CPF: Dri-Steem provided a BACnet IP connection to the Lab Humidifier.
2. **CPF:** The Owner can access the Dri-Steem embedded Webserver to permit alarm management and configuration of the device.
2. **CPF**: Lutron provided the BACnet Interface to the lighting system.

<table>
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<th>Location</th>
<th>cmd</th>
<th>status</th>
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<td>On</td>
</tr>
<tr>
<td>15b - CKT#2</td>
<td>On</td>
<td>Off</td>
</tr>
</tbody>
</table>

![Zoomed in view of BACnet Interface](image-url)
2. CPF: Eaton provided the BACnet Interface to the meter, trip unit and genset.
2. **CPF**: The Gamatronic UPS is on the BACnet Internetwork.
2. **CPF: GE provided the Fire Alarm Interface.**
2. **CPF**: Reasons why the Networked Controls Design Model Works.

- The Networked Controls Design Model specifies that the BACnet Interface comes with the equipment. This simplifies the installation as the supplier is responsible for the BACnet Interface, not the controls contractor. The work responsibilities are clear.

- Facility Operations staff and outside contractors have access to faults and statuses for all major equipment in this facility. When combined with a secure remote Internet access plan, Networked Controls saves transportation energy and maintenance labor costs.

- It is key to a [GREEN](https://www.greenbuilding.com) Facility Maintenance Plan.

• From a specifier’s perspective, controls was scattered throughout the original 16 Divisions. With the advent of MasterFormat 2004, Division 25 Integrated Automation is now the logical home for BASs.

• Division 25 is the vehicle to provide the controls and networking information for devices specified in other Divisions like:
  – 11 (Lab Controls),
  – 14 (Elevators),
  – 21 (Fire Protection), 22 (Plumbing),
  – 23 (HVAC), 26 (Electrical), 27 (Communications), 28 (Security),
  – And other Divisions.
3. **Div 25**: A Network Interface to a Boiler improves maintenance and enhances sustainability.

- Actual temperature/actual pressure
- Flame signal
- Actual fuel throughput
- O₂ value, Unit temperature, pressure
- Total start ups
- Operating hours counter
- Supply air temperature
- Flue gas temperature
- Combustion efficiency
- Operating hours total
- Fuel volume gas (read only)
- Fault history (last 20 faults).

*Remote monitoring and diagnosis is a GREEN sustainable plan as it saves Maintenance and travel costs!!!*
3. **Div 25**: Applying Networked Controls to Boiler BACnet Interfaces.

- A condensing boiler is normally specified in Section 23 52 00. We have specified the boiler BACnet interface in Section 25 20 23.52.

- Contractors will now have an easier time finding the BACnet interface as the boiler Section references the boiler controls Section. “Hunting and Pecking” during the frenzied bid period is limited.

- Designers only need to make a few references in the equipment Section to a corresponding location in the Division 25 Section where the BACnet interface is specified. This clarifies liability especially if the Division 25 Specification is prepared by other Designers.
3. **Div 25**: Applying Networked Controls to Boiler BACnet Interfaces.

- 23 52 00 provides information on the boilers (type, size etc.) There is a pointer to 25 20 23.52 for BACnet information.

- Putting this information in one Section is too much of a co-ordination job amongst the Design Team. Suppliers can go to this Section for controls information just as they would go to Division 01 for Shop Drawing submittal procedures.

- This process is repeated for all Divisions including 11, 13, 21, 22, 23, 26, 27, 28, 33, 41, etc. where Networked controls are specified.

"I could not find the %$***@@@ Section" is no excuse!!!!
3. **Div 25: The Boiler Plant is a Built-Up BACnet Device.**

The boiler plant consists of a plant controller BACnet device, single on-board BACnet devices for the VSDs and stick built sensors and other devices supplied and installed by Division 25.

This is an example of a Built-up BACnet Device.
3. **Div 25**: Specifying the link between Sections 23 50 00 and 25 20 23.52.

**PART 1 - GENERAL**

<table>
<thead>
<tr>
<th>HEATING BOILERS</th>
<th>Section 23 52 00</th>
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</thead>
<tbody>
<tr>
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<td>Page 1</td>
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**2010-12-03**

**1.1 SUMMARY**

.1 Related Sections:

.1 Section 01 33 00 - Submittal Procedures.
.2 Section 01 47 15 - Sustainable Requirements: Construction.
.3 Section 23 21 13.01 - Hydronic Systems: Copper.
.4 Section 23 21 13.02 - Hydronic Systems: Steel.
.5 Section 23 21 14 - Hydronic Specialties.
.6 Section 23 51 00 - Breeching, Chimneys and Stacks.
.7 Section 25 20 23.52 Integrated Automation - BACnet Interface Device (Gateways/Native BACnet Devices) - Heating Boilers (All Types).
.8 Section 25 35 13 Integrated Automation - Actuators & Operators.
.9 Section 25 35 16 Integrated Automation - Sensors & Transmitters.
.10 Section 25 35 19 Integrated Automation - Control Valves.
3. **Div 25**: Specifying the link between Sections 23 50 00 and 25 20 23.52.

.6 Controller to be fully BACnet compatible, and capable of interfacing with building DDC system as detailed in control sequences on drawings.

.7 Boiler management system to modulate supply water temperature based upon outdoor air temperature as measured by building DDC, as detailed in control sequence.

2.9 **BACNET INTERFACE DEVICES**

.1 Provide BACnet Interface Devices for each Heating Boiler so that the units are presented as a series of AV and BV BACnet objects. See 25 20 23.52 for the list of objects that must be supported. This list is the minimum acceptable.

.2 All actuators, sensors, and control valves supplied shall conform to 25 35 13, 25 35 16, and 25 35 19.
3. **Div 25**: Spec Section 25 20 23.52 specifies the boiler BACnet Interface.

These are the Boiler BACnet object lists (fault codes, supply water setpoint, etc.)
3. **Div 25:** The Five BACnet Interface Device Types

- Single On-board BACnet Device (a generator).
- Built-up BACnet Device (gas-fired AHUs with VSDs and humidifier).
- Plant Controller BACnet Device (computer room air conditioners)
- Networked BACnet Device (a booster pump c/w a VSD).
- Stick-built BACnet Device (an AHU fan with no onboard controls).

- Each Device Type has a set of Trade Responsibilities that defines:
  - Who supplies what including line power if required.
  - Who wires what and terminates what.
  - Who provides the networking (cable, IP address allocations, testing, etc.).

*“I did not allow for this in MY scope” is no excuse!!!!*
3. **Div 25:** The Specification protects the Equipment Supplier.

- Each of these systems, particularly the fire, fuel oil and other systems may have their own proprietary interfaces and security requirements.

- The BACnet interface gives read-only access to the system for maintenance or monitoring.

- Changes to setpoints or re-programming is done in the proprietary interface purchased for the device.
4. **Stakeholder Benefits:**

**The Owner.**

- The construction contract is between the GC and the Owner only. There is no contractual relationship with the Subtrades.

- The Owner has a process to enforce BAS compliance to the Contract Documents from the equipment suppliers, the major sub contractors and finally to the General Contractor.

- The Commissioning process is simplified as the trade responsibilities require the supplier to start and commission the device first. The Networked Controls interface is done as a separate step.
4. **Stakeholder Benefits:**

The General Contractor.

- The GCs do not care about BACnet. They want a process that allows them to enforce compliance down to the equipment supplier level.

- The Networked Controls Trade Definitions avoid disputes and delays in construction. The complaints now relate to suppliers who will not submit the BACnet interfaces with their equipment Submittals now find the Submittals being rejected. This will diminish over time.

- Commissioning and closeout is far simpler as the majority of the BAS work is done up front. The big issue is getting the Equipment Supplier’s startup technician, the TAB Subcontractor, BAS Subcontractor, the Owner’s staff show up at the same time.
4. **Stakeholder Benefits:** The Major Subcontractor (M/E/P).

- Lighting, Fire Alarm and other Controls Trades can bid on one system or multiple systems depending on their capabilities.

- Requiring all devices provided in the Work to speak BACnet to the network regardless of what they speak in the background, eliminates the need for “science project” gateways and a separate system integrator.

- Like the GCs, most major subs do not have extensive controls knowledge. The Networked Controls Design Model gives clear-cut rules on who does what. There are very few debates about responsibilities.
4. **Stakeholder Benefits:**

The Equipment Supplier.

- The equipment sections clearly state that there is a BACnet interface to be supplied. There are points to the corresponding 25 20 nn.nn section where the BACnet interface information is required.

- Suppliers only have one place to look for information on BACnet requirements.

- Suppliers require education so they understand the Networked Controls Design Model. We often resolve issues with the factory personnel who have the detailed controls knowledge.
4. **Stakeholder Benefits:**

The Designers of Record.

- The Designer adds language into the equipment specification and the Related Sections Section about the BACnet interface to point suppliers to the relevant Division 25 sections containing BACnet information.

- Shop Drawing Submittals are not approved and equipment cannot be ordered until the BACnet interface device is also approved. This is a small extra step to make the process work.

- Designers can focus on the design as specifying the networking and the BACnet Network interfaces are by others. Designers still write the sequences and pick the points. They only give up the BACnet and networking requirements and most are happy to do so.
5. **Summary and Conclusions:** Specifying Networked Controls

- The transition from a “stick building” to a Networked Controls design model has come of age as most devices now come with some onboard networking “smarts”. This was not possible 10 years ago.

- Networked Controls can apply to a range of devices including boilers, elevators, switchgear, meters, fire alarm, lighting and security and other devices specified in the Work.

- Networked controls allows the Owner to obtain information about the health of equipment that could not be obtained by instrumenting the device (e.g., internal temperatures or faults in VSDs or chillers).
5. **Summary and Conclusions:** Specifying Networked Controls

- BACnet allows all these building systems to talk to each other. BACnet has expanded to lighting, fire, security, electrical devices, elevators, etc.

- Designers must pick equipment with BACnet interface devices. Many HVAC suppliers can provide native BACnet devices or Modbus to BACnet gateways for their devices.

- The CSI MasterFormat Division 25 simplifies interoperability for the Owner and if properly written, can provide clear lines of responsibility for the Contractor, the Owner and the Designer.
5. Summary and Conclusions: Specifying Networked Controls

- Equipment Suppliers now have some wiring and equipment responsibilities. This is because some equipment suppliers may sell integral BACnet interfaces whereas others provide remote mounted gateways.

- They are now responsible for this additional wiring to make the “equals” process work. Most sub the work to others and this has not created problems.

- Many suppliers are now designing their own BACnet Interfaces. This will simplify the implementation of Networked Controls.
5. Summary and Conclusions: Specifying Networked Controls

- Naming conventions are absolutely critical as these conventions start at the design stage and must be carried through to the facility operations stage. There can only be one Device #1!!.

- Shop Drawing Submittals are not approved and equipment cannot be ordered until the BACnet interface device is also approved.

- Contractors who are not used to this front ending these Submittal requirements will complain about this. The complaining stops when they find out at the end of the job that the closeout and commissioning process is smoother and faster.
5. Summary and Conclusions: Specifying Networked Controls

• When combined with a secure remote Internet access plan, Networked Controls saves transportation energy and maintenance labor costs. It is consistent with a GREEN Facility Maintenance Plan. Such remote access will reduce the Contractor’s costs to service warranty claims.

• As we move to an IP v6 environment, more devices in a room will be addressable (e.g., electrical plugs, smoke heads, doors, individual light ballasts, VAV controllers, etc).

• Such fine room level control permits demand responses to real-time pricing changes without causing problems for occupants (e.g., dimming lights when the room is unoccupied).
5. **Summary and Conclusions:**

Specifying Networked Controls

- Such designs are consistent with SmartGrid and LEED credits for IAQ and M&V. Ongoing commissioning and integration to preventive maintenance systems are now part of the design.

- The Networked Controls Design Model makes this possible.

THANK YOU FOR YOUR TIME.