SPEAKING THE SAME LANGUAGE

UNDERSTANDING PROTOCOLS AND THE NEED FOR INTEROPERABILITY

By: Russell V. Logalbo
Carrier Corporation
Syracuse, New York

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SPECIFYING FOR THE FUTURE

A major issue in building automation today is the lack of a standard, or "open," protocol. Such a protocol would allow DDC controls system components from different manufacturers to operate seamlessly in an integrated system, in a way transparent to the end user.

This "interoperability" would provide building owners and managers with more flexibility in procuring building control systems, whether they are purchasing new or upgrading existing systems. It would also enable system designers and end users to protect their investments, and provide customers with a vehicle for comparing HVAC system costs.

A standard protocol, of course, will not come without some potential pitfalls. First costs for complex integrated systems may increase. Operational problems might arise from interfacing components produced by multiple manufacturers. Current difficulties isolating and pinpointing the source of problems in mixed systems will continue.

Despite these pitfalls, and despite the fact that one, standard protocol is yet to be established, understanding your customers' need for interoperability is the key to designing proper systems today.

CONTENDERS FOR A STANDARD PROTOCOL

Several existing protocols - such as LonTalk and BACnet - are emerging as possible standards. The systems using these protocols, however, are technically complex, and should not be selected based on first cost. The choice should hinge on a skilled and experienced provider, since a proven track record is critically important to the successful completion of this type of project.

The first contender, LonTalk, is a seven-layer communications protocol that allows nodes to operate using an efficient, reliable communications structure. Developed by Echelon, the LON (local operating network) technology is based on a neuron chip microprocessor. The neuron chip contains hardware and firmware (instructions embedded in the chip) that operate all seven layers of the Open System Interconnection (OSI) Basic Reference Model (ISO 7498).

Carrier is an active member of the LonMark HVAC working group, and was the first HVAC manufacturer to sponsor the LonMark Interoperability Association, a fee-based organization of manufacturers using the LonTalk technology. The association's mission is to create implementers' agreements, called LonMark profiles, that provide the external constraints needed to assure interoperability at various levels.

HOW AN OPEN PROTOCOL WORKS

To explain the concept of an open protocol, we will focus specifically on BACnet, and Carrier's solution to meeting the needs of a BACnet customer.

The BACnet (building automation and control network) protocol was developed by ASHRAE and approved as a standard in 1995. It provides mechanisms through which computerized equipment of different functions can exchange information, regardless of the particular service they perform. That means BACnet may be used by head-end computers, general purpose direct digital controllers, and application-specific or unitary controllers.

The BACnet protocol provides a comprehensive set of messages for conveying encoded binary, analog and alphanumeric data to:

- Hardware binary input and output values
- Hardware analog input and output values
- Software binary and analog values
- Text strings
- Schedule information
- Alarm and event information
- Files and control logic

The protocol models each building automation and control computer as a collection of data structures called "objects," which contain properties representing various aspects of the device's hardware, software and operation. Objects provide a means of identifying and accessing information without requiring a detailed knowledge of the device's internal design or configuration.

BACnet is based on a four-layer, collapsed architecture that corresponds to the physical, data link, network, and application layers of the OSI.

The Physical Layer

The physical layer provides a means of connecting the devices and transmitting the electronic signals that convey the data. The physical layers of connectivity consist of a variety of industry or actual standards, including:

- Ethernet (ISO 8802-03)
- Arcnet
- Echelon
- RS485 (master-slave/token-pass)
- RS232 (point-to-point)

The Data Link Layer

The data link layer organizes the data into frames or packets, regulates access to the medium, provides addressing, and handles some error recovery and flow control.
**The Application Layer**

The protocol's application layer provides the communication services the applications need to perform their functions – in this case, monitoring and control of HVAC/R and other building systems. Typical application layer functions can be classified as:

- Virtual terminal
- File transfer
- Messaging
- Objects

BACnet defines a comprehensive set of object types and application services in addressing communication requirements among all levels of control in a distributed, hierarchical building automation system. Some examples of BACnet objects are:

- Analog input
- Analog output
- Analog value
- Binary input
- Binary output
- Binary value
- Loop
- Schedule

Along with each object is a set of services, or properties, that allows the operator of a BACnet system to edit, add and delete the objects and elements. These properties include "read and write," "create/delete object" and "remove/add elements."

**The Network Layer**

The BACnet network layer provides the means to relay messages from one BACnet to another, regardless of the data link technology in use on the network.

While the data link layer provides the capability to address messages to a single device or broadcast them to all devices on a local network, the network layer allows messages to be directed to a single remote device, broadcast on a remote network, or broadcast globally to all devices on all networks.

This makes a number of functions possible, including translating global addresses to local addresses, routing messages through one or more networks, accommodating differences in network types and maximum message sizes, sequencing, flow control, error control and multiplexing.

BACnet is designed so that there is only one logical path between devices, eliminating the need for optimal path routing algorithms. Devices that interconnect two disparate BACnet local area networks (LANs), such as ISO 8802-03 (Ethernet) and Arcnet, and provide the relay function are called "routers."

**BACnet CONFORMANCE CLASSES**

There are six conformance classes to BACnet, forming a hierarchy of device capabilities based on the implementation of certain BACnet objects and services. The requirements for each class include the requirements of all other classes with a lower number.

For example, a Conformance Class 1 device only needs to have a single object and the ability to interpret and carry out a request to read and return the values of that object's properties. This is defined by BACnet as a "read" property. A Class 2 device must do the same, but also needs to carry out a "write" property conformance. A Class 3 conformance includes all the requirements of Classes 1 and 2, as well as "I am," "I have," "read property multiple," write property multiple, and "who has" and "who is" properties.

There is no relation between conformance class and a good or best purchase. When a system is designed with just Class 2 devices, they may be all that are required for that particular application.

**BACnet FUNCTIONAL GROUPS**

Some BACnet object types and application services are classified in functional groups. Each group defines a combination of application services and standard object types required to support the communication needs of that particular building automation function.

BACnet functional groups represent capabilities that can be added to devices of any conformance class, and are intended to guide designers and specifiers of multi-vendor building automation systems. There are 13 functional groups, including:

- Clock functional group
- Hand-held functional group
- Personal computer workstation functional group
- Event initiation functional group
- Event response functional group
- Time master functional group

**BACnet PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT**

A protocol implementation conformance (PIC) statement is a written document created by a manufacturer to identify the particular BACnet-specified options implemented in a device. The statement is a public document available for use by any interested party, and at a minimum, should convey:

- Basic information identifying the vendor and describing the BACnet device
- The device's conformance class
Specify the BACnet Standard

Since BACnet’s release, its adoption as a standard for the HVAC industry has been gradual – but is gaining momentum in the specifying community. Consequently, now is the time to anticipate open systems and understand how Carrier uses BACnet to provide interoperability.

When specifying the BAClink device, or responding to a specification for BACnet compliance, you must first determine the customer’s requirements and the level of BACnet connectivity required.

Carrier’s BACnet Offering

Carrier has developed and released for sale a Conformance Class 3 Gateway – called BAClink – to interface a CCN (Carrier Comfort Network) with a BACnet LAN. BAClink provides read/write access, and also sends alarm messages from a CCN to a BACnet LAN using Ethernet (ISO 8802-03) as the physical layer of connectivity.

See Figure 1 for typical Ethernet/BACnet network using Carrier BAClink hardware.

By responding to requests for data, and receiving and processing commands and data from a BACnet device, BAClink allows access to CCN status, setpoint, and time schedule data. It will also pass alarm, alert and return-to-normal messages from selected CCN controllers to the BACnet network. Standard application services supported by BAClink include:

- Read and write properties to supported objects
- Device management services
- Alarm messaging via confirmed message service
- Device re-initialization
- Time synchronization

BAClink also supports these BACnet object types:

- Analog in, binary out, analog value

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See Appendix A for an example of Carrier’s PIC statement for the BAClink Class 3 device.

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**Figure 1 - BACnet Network Overview**
- Binary in, binary out, binary value
- Device object, schedule object
- Multi-state input, multi-state output
- Calendar object
- Notification class object

BAClink contains factory-configured templates of up to 100 points for each type of supported equipment, such as a 30GX/HX Screw Chiller or a 19XR Centrifugal Chiller. You can select up to 24 of these points for BACnet access in each piece of equipment. These points become BACnet objects, of which BAClink supports a total of 360. Up to four user-configurable templates are also provided to support Carrier's general-purpose, field-installed Comfort Controller.

The BAClink module supports up to 15 CCN devices on any primary or secondary bus; if a design calls for more than 360 objects or 15 controllers, additional BAClinks can be added to the CCN network. See Figure 1 for a typical Ethernet/BACnet network using Carrier BAClink.

Included in the BAClink package is a standard CIO (communications input/output) module, a compact, industrial-grade PC loaded with BAClink software, and a six-foot serial cable for PC-to-CIO module communications. The PC is wall-mounted and contains an Ethernet communication card for interface to the customer's Ethernet LAN.

When specifying BAClink for a project, be sure to specify the following customer-supplied hardware:
- One RJ-45 Ethernet cable long enough to connect the building's Ethernet network to the BAClink wall-mounted PC (maximum length from the network hub to the PC is 328 feet)
- A supply of 110 or 220 VAC power for the BAClink's PC
- One enclosure (optional) large enough to house the BAClink CIO module; the flush-mounted enclosure should be 11.25" H x 1.875" W x 6.30" D
- Two 18/20 VAC power supplies (part number CEAS221045-01) to power up the BAClink CIO module

See Figures 2 and 3 for typical installation of BAClink hardware.

THE FUTURE OF INTEROPERABILITY

The advent of interoperable building systems is a promising development in the HVAC industry. Carrier, an active participant in the creation of the original BACnet standard, has been and will continue to be a leader in the industry's pursuit of reliable interoperability.

We are currently a member of the ASHRAE BACnet committee – charged with maintaining the standard and initiating improvements and addendums – and of the BACnet Interoperability Testing Consortium, sponsored by the National Institute of Standards (NIST). We also play an active role in the industry's ongoing effort to refine and improve the BACnet and LonMark standards, and will encourage HVAC/R product development that conforms to them.

Interoperability has generated great expectations in the marketplace. As HVAC and other industries focus on the issues and opportunities, we will certainly see dramatic developments in the coming years. Carrier will continue to lead the way in the research and design of products to meet the interoperability needs of our customers and their buildings.

For valuable assistance and information on interoperability and open protocols, please refer to the list of sources.
BACnet PROTOCOL IMPLEMENTATION
CONFORMANCE STATEMENT

Vendor Name: Carrier Corporation
Product Name: BAClink
Product Model Number: CEAS130355

PRODUCT DESCRIPTION:
This product will provide bidirectional communication between the Carrier Comfort Network System and a BACnet system operating at Class 4 or higher, residing on an Ethernet media.

BACnet CONFORMANCE CLASS SUPPORTED

<table>
<thead>
<tr>
<th>Class 1</th>
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BACnet FUNCTIONAL GROUPS SUPPORTED

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<th>Clock</th>
<th>Files</th>
<th>HHWS</th>
<th>Reinitialize</th>
<th>PCWS</th>
<th>Virtual Operator Interface</th>
<th>Event Initiation</th>
<th>Virtual Terminal</th>
<th>Event Response</th>
<th>Device Communications</th>
<th>COV Event Initiation</th>
<th>COV Event Response</th>
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BACnet STANDARD APPLICATION SERVICES SUPPORTED

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<tr>
<th>Application Services</th>
<th>Initiate Requests</th>
<th>Executes Requests</th>
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<tr>
<td>Confirmed COV Notification</td>
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</tr>
<tr>
<td>Confirmed Event Notification</td>
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<td>☑️</td>
</tr>
<tr>
<td>Get Alarm Summary</td>
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<td>☐</td>
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<tr>
<td>Get Enrollment Summary</td>
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<td>☐</td>
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<tr>
<td>Subscribe COV</td>
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<td>Unconfirmed Event Notification</td>
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<tr>
<td>Atomic Write File</td>
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<tr>
<td>Remove List Element</td>
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<tr>
<td>Application Services</td>
<td>Initiate Requests</td>
<td>Executes Requests</td>
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<td>Reinitialize Device</td>
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<td>Confirmed Text Message</td>
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<td>Unconfirmed Text Message</td>
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<td>Time Synchronization</td>
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<tr>
<td>Who Has</td>
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<tr>
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<tr>
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**STANDARD OBJECT TYPES SUPPORTED**

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<th>Dynamically Writable Properties</th>
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Carrier Corporation – Subject To Change Without Notice  
Page A2
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<thead>
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<th>Object Type</th>
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**DATA LINK LAYER OPTION**

- [ ] ISO 8802-3, 10BASE5
- [X] ISO 8802-3, 10BASE2
- [X] ISO 8802-3, 10BASET
- [ ] ISO 8802-3, Fiber
- [ ] ARCNET, coax star
- [ ] ARCNET, coax bus
- [ ] ARCNET, twisted pair star
- [ ] ARCNET, twisted pair bus
- [ ] ARCNET, fiber star
- [ ] MS/TP master, baud rate(s): ____________________________
- [ ] MS/TP slave, baud rate(s): ____________________________
- [ ] Point to Point, EIA 232 baud rate(s): ______________________
- [ ] Point to Point, modem baud rate(s): ______________________
- [ ] LonTalk, medium: _________________________________
- [ ] Other: _____________________________________________
CHARACTER SETS SUPPORTED

Indicating support for multiple character sets does not imply they can all be supported simultaneously.

☒ ANSI X3.4*
☐ IBM/Microsoft DBCS
☐ JIS C 6226
☐ ISO 10646 (UCS4)
☐ ISO 10646 (UCS2)
☐ ISO 8859-1

Special Functionality

Segmented Requests Supported ☐ Yes ☒ No Window Size: ________________
Segmented Responses Supported ☐ Yes ☒ No Window Size: ________________
Router ☒ Yes ☐ No

Describe the supported routing capabilities: Proprietary RS485 to Ethernet

Property Range Restrictions:

* ANSI X3.4 is US ASCII or simply ASCII.