BACnet: Answers to Frequently Asked Questions

A primer on the revolutionary development in the building automation and controls industry—interoperability among different vendors' products

By H. MICHAEL NEWMAN,
Manager of Utilities Dept. Computer Section,
Cornell University,
Ithaca, N.Y.

This article answers some of the most frequently asked questions about ANSI/ASHRAE Standard135-1995, *BACnet ™—A Data Communication Protocol for Building Automation and Control Networks*.

What is BACnet?

As stated in the title of the above-referenced standard, BACnet is "a data communication protocol for building automation and control networks." A data communication protocol is a set of rules governing the exchange of data over a computer network. The rules take the form of a written specification (in BACnet's case, they are also on compact disk) that spells out what is required to conform to the protocol.

What kinds of things are covered by BACnet's rules?

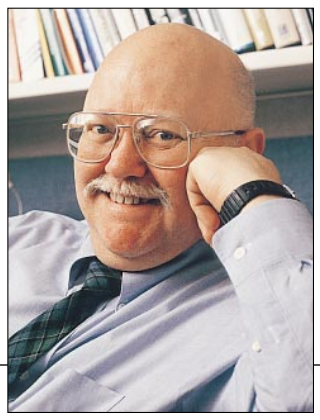
Everything from what kind of cable to use to how to form a particular request or command in a standard way is covered. What makes BACnet special is that the rules relate specifically to the needs of building automation and control equipment—*i.e.*, they cover things like how to ask for the value of a temperature, define a fan operating schedule, or send a pump status alarm.

But every manufacturer's system is different! How can BACnet possibly do all these things in a standard way?

The trick is that BACnet provides a standard way of representing the functions of *any* device as long as it *has* these functions. Examples are analog and binary inputs and outputs, schedules, control loops, and alarms. This standardized model of a device represents these common functions as collections of related information called objects, each of which has a set of properties that further describe it. Each analog input, for instance, is represented by a BACnet analog input object that has a set of standard properties like present value, sensor type, location, alarm limits, and so on. Some of these properties are required while others are optional. One of the object's most important properties is its identifier, a sort of numerical name that allows BACnet to access it unambiguously. Once devices have common "appearances" on the network in terms of their objects and properties, it's easy to envision messages that can manipulate this information in a standard way.

So what kinds of messages does BACnet define?

Because BACnet is based on a client-server model of the world, BACnet messages are called service requests. A client machine sends a service request to a server machine that then performs the service and reports the result to the client. BACnet currently defines 35 message types that are divided into 5 groups or classes. For example, one class contains messages for accessing and manipulating the properties of the objects described above. A common one is the "ReadProperty" service request. This message causes the server machine to locate the requested property of the requested object and send its value back to the client. Other classes of services deal with alarms and events, file uploading and downloading, managing the operation of remote devices, and virtual terminal functions.



H. Michael Newman was the chairman of ASHRAE Standard Project Committee (SPC) 135P, which developed BACnet. He is currently chairman of ASHRAE SSPC 135, which interprets and supports BACnet.

■ Is BACnet limited only to HVAC equipment? Can it be used with fire/life safety, lighting control, and other building automation systems?

Absolutely. In fact, if you think about it, BACnet already contains most of the capabilities required for non-HVAC communications. These include the ability to read and write binary, analog, and text data; schedule control actions; send event and alarm notifications; and so on. Nonetheless, the committee realized that these capabilities might not cover all situations and developed the standard with an eye toward accommodating future, unknown building automation and control applications. As a result, one of the real strengths of the BACnet model that emerged from this consideration is that it can be easily extended. If a vendor comes up with some new functionality for which communication is required, the vendor can add new properties to existing object types or create new object types that are accessed in exactly the same way as the 18 defined in the standard. This is not only expected; it is encouraged. Moreover, a vendor could even dream up new services that go beyond the standard ones. Of course, proprietary features may not be interoperable without vendor cooperation.

■ I keep hearing about interoperability, but I like the vendor I deal with now. Does BACnet require multi-vendor installations?

Definitely not. BACnet is just a protocol. It makes possible the interconnection of different vendors' equipment that uses BACnet but in no way requires it. Since many vendors will probably choose, sooner or later, to use BACnet as their "native" protocol, you could easily end up with a single-vendor BACnet system. Also, I agree with you. I would much prefer to deal with a single vendor or, at most, a couple of vendors. The issue is making sure their pencils stay sharp at bid time!

■ What about connecting BACnet systems together? What networking options are there for BACnet?

Up until now, I have just been talking about the BACnet object-oriented model and the various services or message types. You still need to pick an appropriate network technology to connect everything together. The BACnet committee spent a lot of time on this part of the standard. We ended up with five different options, each of which fills a particular niche in terms of the price/performance tradeoff. The first is Ethernet, the fastest at 10 million bits per sec (Mbps), with 100 Mbps also recently available. Ethernet is also likely to be the most expensive in terms of cost per device. Next comes ARCNET at 2.5 Mbps. Both Ethernet and ARCNET can use a variety of physical media—coaxial cable, twisted pairs, and even fiber optic cable. For devices with lower requirements in terms of speed, BACnet defines the master-slave/token-passing (MS/TP) network, designed to run at speeds of 1 Mbps or less over twisted pair wiring. Echelon Corp.'s LonTalk® network can also be used on the various media listed above. All of these networks are examples of local area networks or LANs. BACnet also defines a dial-up or point-to-point protocol called PTP for use over phone lines or hardwired EIA-232 connections. A key point is that BACnet messages can, in principle, be transported by any network technology, if and when it becomes cost effective to do so.

■ You mentioned that BACnet can use LonTalk. Does that mean that any equipment that uses LonTalk can automatically talk to BACnet systems?

Unfortunately not. LonTalk is Echelon's specification for a recently developed LAN technology that many people thought would be a useful addition to the BACnet standard. BACnet uses LonTalk to convey BACnet messages in an identical manner to the way BACnet messages are transported by Ethernet, ARCNET, and MS/TP. Confusion stems from the fact that Echelon has its own generic control language that is also transported by LonTalk. For LonTalk devices to be interoperable, even using Echelon's language, there has to be agreement among implementers as to what the generic messages mean in a particular context. To obtain such agreements, Echelon has set up the LonMark Program, which has working groups, made up of people from each industry, that are trying to reach implementers' agreements on how to use Echelon's proprietary control language in a common way for their applications. The point is that the BACnet language and the Echelon language are fundamentally different, and devices using one of the languages can never interoperate directly with devices using the other, even though they might possibly share a common LonTalk LAN.

■ I like the idea of BACnet, but what about all my existing DDC systems? Can BACnet help tie them together, too?

Maybe, maybe not. For a BACnet device, say an operator workstation, to talk to non-BACnet devices like your existing DDC system from XYZ Controls, you need an intervening gateway. A gateway is like a United Nations translator that can speak two languages. On one side, it speaks BACnet and on the other side, the XYZ protocol of your existing (legacy) system. Naturally, the most likely source for such a gateway would be the XYZ company, and they may or may not choose to develop one.

■ What if some of my DDC systems are on Ethernet and some are on, say, MS/TP. Is there any way to connect them together?

Yes. Besides allowing the use of different LANs, the BACnet standard also specifies how to build

routers. Routers are simply devices that connect multiple networks together. The networks may be of the same or different types.

Now I'm confused. What's the difference between a router and a gateway?

I don't blame you for being confused because a lot of people use the terms almost interchangeably. In BACnet, a router is a device that passes a message from one network to another without changing the form or content of the message. If the networks are of different types, the addresses and error checking—in short, the "packaging"—of the message may get changed, much as you would repackage an ordinary U.S. Postal Service letter if you were going to send it further using FedEx or UPS. A gateway, on the other hand, opens the letter, translates it into a second language if possible, puts it back into some type of envelope, and then sends it on. Obviously, it can take more time and energy to do a translation than to simply forward a message, so gateways are more complicated machines than routers.

Do BACnet routers really exist?

Sure. In fact, the National Institute of Standards and Technology (NIST) BACnet Interoperability Testing Consortium sponsored a demonstration booth at the International Air-Conditioning, Heating, Refrigerating Exposition in Atlanta in February 1996. Controllers were running on all the BACnet network types except PTP, and all were interoperating. An Ethernet-ARCNET router, an Ethernet-MS/TP router, and an Ethernet-LonTalk router interconnected them. Each workstation was programmed to display identical graphics and was able to carry out identical control actions, even though three different operating systems and four different LANs were involved. Fig. 1 is a schematic of this setup.

What is the NIST BACnet Interoperability Testing Consortium?

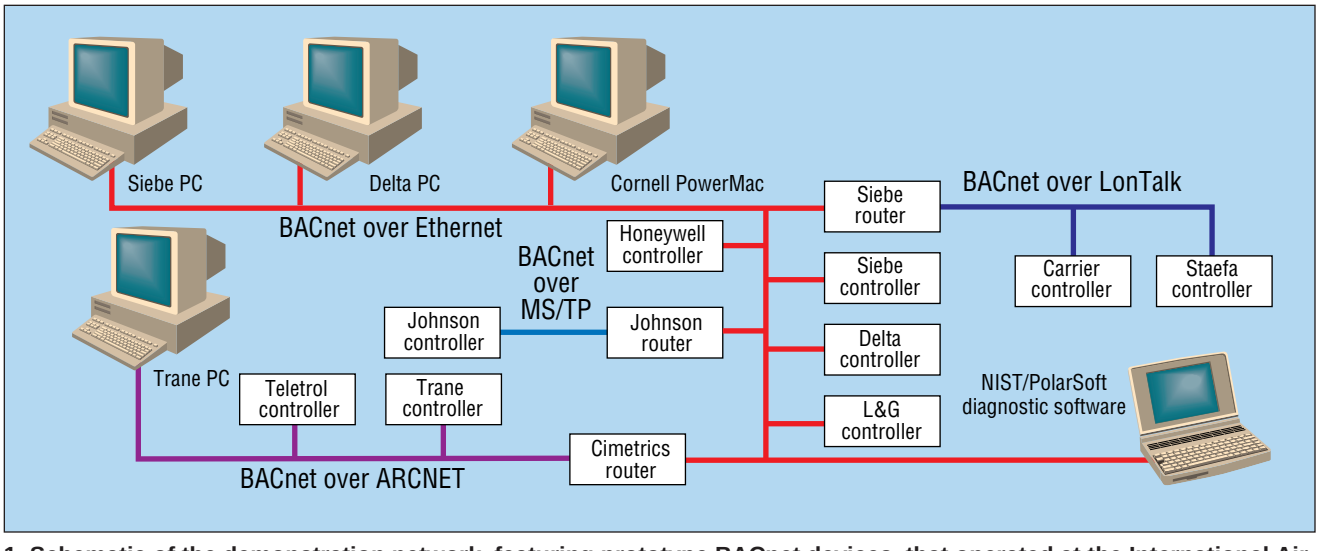
When BACnet was under public review, several commenters suggested that BACnet devices should actually be built and tested before releasing the standard. The committee agreed but needed to find a way to do the testing such that potential implementers could feel comfortable with the idea of bringing their prototypes together with those of their competitors for a noncompetitive, nonjudgmental evaluation. Also, we wanted to find a neutral venue for the testing—*i.e.*, not one of the vendors' manufacturing sites. Happily, NIST offered the use of its lab in Maryland. Moreover, NIST has a mechanism known as a "Cooperative Research and Development Agreement," which allowed us to set up the testing and still protect everyone's proprietary interests. There are currently 20 consortium members, 17 of whom are manufacturers.

What about BACnet certification? Will NIST be certifying BACnet conformance?

BACnet certification is, for the moment, still an unresolved issue although everyone agrees that it is needed. NIST will definitely *not* be doing any sort of certification nor will ASHRAE as a society. Two things are needed: 1) a standard method of testing conformance and 2) a decision on who will be responsible for issuing the BACnet "stamp of approval." Developing such a test will be one of the top priorities of the ASHRAE Standing Standard Project Committee (SSPC 135) that was formed to interpret and extend BACnet.

Speaking of conformance, what can you tell me about writing specifications for BACnet systems?

The first thing is that your specification must



1 Schematic of the demonstration network, featuring prototype BACnet devices, that operated at the International Air-Conditioning, Heating, Refrigerating Exposition in Atlanta, February 1996.

clearly state what kinds of network functions you need. For example, if you want your field panel to be able to start and stop equipment based on date and time, that does not necessarily require any network functionality. But if you want to be able to manipulate the controller's schedule from a remote workstation, both the workstation and the field panel have to support the appropriate BACnet capabilities in terms of objects and services. Ideally, you should become familiar with BACnet's conformance classes and functional groups. These will help you translate your network needs into BACnet terminology. But even if you are not completely familiar with these things, you can still be successful. Just carefully list the things you want to be able to do across the network—time-based things, alarm and event requirements, points that you want to share between devices—and state that they must be accomplished using BACnet.

What are conformance classes?

BACnet specifies a six-level hierarchy of device capabilities based on the implementation of certain BACnet objects and services. A Conformance Class 1 device, for example, only needs to have a single object and be able to understand and carry out a request to read and send back the values of that object's properties (ReadProperty). A Conformance Class 2 device, besides having Conformance Class 1 capabilities, needs to be able to carry out a request to change the value of an object's properties (WriteProperty). Higher numbered conformance classes tack on additional capability. This hierarchy could correspond to the capabilities that might be associated with a smart sensor at the Class 1 end and a full-featured, general-purpose direct digital controller at the Class 6 end. Please note that there is no correlation between conformance class and "good or bad." A system made up of Class 2 or 3 devices may be all that a particular application requires.

You also mentioned functional groups. What are they?

Early on, it became apparent that something more than conformance classes was needed to specify BACnet capabilities. For example, suppose you have a simple Class 2 device like a smart actuator, but you want it to be able to control the device connected to it based on a time schedule. As mentioned earlier, the ability to do time-related things over the network, such as setting a device's clock and altering schedules, requires a certain collection of BACnet objects and services. Each such collection, for a specific function, is called a functional group. There are currently 13 functional groups in the standard, covering such things as what objects and services would be required to act as a BACnet handheld workstation, a PC workstation, a device capable of initiating or responding to alarms and events, a device capable of supporting virtual terminal logins, and so on.

The BACnet demonstration exhibit at the 1996 International Air-Conditioning, Heating, Refrigerating Exposition in Atlanta.

What is a PICS?

PICS stands for protocol implementation conformance statement. It is basically a BACnet spec sheet listing a device's BACnet capabilities. Every BACnet device is required to have one. It contains a general product description, the conformance class of the device, the functional groups supported, a list of all the services supported as a client and/or server, which LAN options are available, and a few other items relating to character sets and special functionality. A PICS is the place to look to see what a device's capabilities are. Additionally, a specifier could draft a PICS as a way of conveying what BACnet capabilities are desired for a particular job.

What is happening next within ASHRAE?

The SSPC will be working on a number of refinements or extensions to the standard. As I mentioned earlier, the top priority is to finalize a conformance testing addendum. We will also be looking at ways to enhance the use of BACnet with the Internet protocols (IP). This refinement, BACnet/IP, will hopefully be available for public review later this year. We are also planning to revisit the whole subject of conformance classes and functional groups to see if it can be streamlined. Another working group is looking at fine-tuning the operation of the MS/TP LAN. Finally, a working group is looking at specifying the definitions of several new "macro objects" whose properties would be the parameters required for the monitoring and control of a large-scale device like a heat pump, chiller, or packaged rooftop air conditioner.

What else is going on?

Besides the SSPC activities, there are some BACnet demonstration projects underway. One that has been in the news quite a bit is the General Services Administration's rehab of the Phillip Burton Federal Building at 450 Golden Gate Ave. in San Francisco.* The neat thing about this project is its scale and complexity. It will involve more than 1000 controllers, four (possibly five) different vendors, several applications including lighting control, and an interface to the local electric utility. It is scheduled to be completed by the end of this year.

See related story in You'll Want To Know on page 8 of this issue.

There is also some activity on the international standards front. BACnet has been selected by the European Community (EC) standards committee CEN TC247 as a European "pre-standard," meaning that it will undergo an evaluation process over the next couple of years to see whether it should become a full-fledged EC standard. The International Organization for Standardization (ISO) committee TC205 is also considering whether BACnet should be designated an ISO standard. All of this is quite remarkable, considering that BACnet was published only 14 months ago (January 1996).

Are there any BACnet products actually installed and in use today?

Definitely. Of course, it is hard to get a precise tally, but if NIST consortium members are to be believed, *there are more than 1000 BACnet sites up and running at this moment*. Of these, roughly one-third are multi-vendor installations. Most of the sites are in the United States, but members also claim to have installations in Canada, Mexico, Brazil, Germany, Switzerland, the U.K., Hong Kong, Singapore, Australia, and Taiwan. It wouldn't surprise me if there were more installations that I haven't heard about.

When will more products be available?

This, of course, is a key question. There is a bit of chicken and egg here: the vendors will probably accelerate their product development if they see a growing user demand, and users will probably increase their demand if they see more BACnet products in the marketplace. If you are a user, the best thing to do would be to express your interest in BACnet products directly to your friendly local vendor.

How can I learn more about BACnet?

Continue to read *HPAC* and other publications; get a copy of the standard, either in hard-copy form or on CD, or both; and attend seminars or short courses offered by ASHRAE and other organizations. Don't overlook vendor literature. A number of vendors now have tutorial information on BACnet in general and their BACnet products in particular. There is also a book called *Direct Digital Control of Building Systems*, immodestly enough by me, that has a lot of information on both data communication fundamentals and their application to BACnet. HPAC

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