Back to the Basics About BACnet

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As the ASHRAE SPC 135P Committee moves toward completion of BACnet, a standard protocol for the commercial building industry, questions remain regarding what BACnet will actually provide. Will the new BACnet standard be able to meet the inter-communications needs of commercial buildings of today and tomorrow?

In this commentary, Steven T. Bushby, Secretary of the ASHRAE SPC 135P Committee, reviews the original goals and intentions of the ASHRAE Committee and discusses the status of the proposed BACnet Standard.

BACnet Summary

Today's direct digital control (DDC) systems employ proprietary communication protocols which prevent systems supplied by different manufacturers from communicating with each other. This has resulted in "captive customers" who, upon buying a control system, are unable to upgrade or expand it without going back to the same manufacturer.

This lack of communication capability between control systems made by different manufacturers also prevents the building owner from obtaining the most capable building service by not allowing the owner to choose, regardless of the system manufacturer, the best Energy Management and Control System (EMCS), the best digital controllers, the best security system, the best fire detection system, or the best telecommunications system.

The solution to these problems is an industry standard communication protocol.

BACnet is a communication protocol for Building Automation and Control Networks which has been developed under the auspices of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). ASHRAE is an accredited standards-writing body under the rules of the American National Standards Institute (ANSI), the national standards body in the United States.

BACnet has been published as a draft ASHRAE/ANSI standard and has completed its first public review. Several changes have been made to the draft standard as a result of the public review. A revised version of the standard is expected to be released in late summer or early fall of 1993 for additional public review. This second review will give the public a chance to comment on changes which were made to the draft standard as a result of the first public review. It is expected that BACnet will be published as an ASHRAE/ANSI standard in 1994.

The three largest control system manufacturers in the United States, Honeywell, Johnson Controls, and Landis & Gyr Powers have all publicly announced their intention to support BACnet in their products. Many smaller manufacturers have also announced similar plans. There is a very strong movement in the user community in the United States and Canada to require the use of BACnet in their specifications.

Participants in BACnet Development

The rules for development of American national standards require that all meetings be open to any interested parties and that membership on standards committees reflect a broad range of interests affected by the standard. The ASHRAE committee developing BACnet is known as Standards Project Committee (SPC) 135P. The voting membership of SPC 135P represents the interests of vendors, users, and general interest groups in approximately equal numbers. The manufacturers that have been directly involved in the development of BACnet are:

American Auto-Matrix	Johnson Controls
Andover Controls	Landis & Gyr Powers
Barber-Colman Company	Siebe Environmental Systems
Energyline Corporation	Staefa
Honeywell	The Trane Company

The United States government and the Canadian government have also been active participants in the standardization process.

BACnet Architecture

Most building control systems today are based on a hierarchical model. Application-specific or unitary controllers are the lowest level in the hierarchy. These controllers interface with and are supervised by one or more levels of "field panels." At the top is one or more operator workstation. BACnet is designed to address all of these levels. In fact, BACnet is designed to accommodate a hierarchical architecture of this type but does not require it.

There are many variations on this hierarchical scheme in existing systems and every expectation that new variations will develop in the future as control technology changes. It is the express intent in BACnet to allow and encourage innovative new approaches to control system architecture.

From the standpoint of the OSI [Open Systems Interconnection model for computer communication protocol standards development]

Reference Model, BACnet is a collapsed architecture implementing layers 1, 2, 3, and 7.

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The Application and Network layers provide a uniform interface to one of several options at the Data Link and Physical layers. The lower layer options provide a range in both price and performance, permitting system designers to optimize the architecture to match the needs of the customer. It is possible in a BACnet system to use different Data Link and Physical layer options in different parts of the control system.

In the language of BACnet, each different piece would form a "network." The purpose of the Network layer is to provide a way to connect these networks, forming an "internetwork." If there is no need for multiple networks in a control system, the Network layer collapses to two octets, almost eliminating the associated overhead.

In control systems where a BACnet internetwork is used, the network layer overhead is not present in all messages. It is only needed for messages which must be routed from one network to another. For local messages the network layer again collapses to two octets.

The routers which connect different BACnet networks also provide filtering. Only messages which are addressed to nodes on a remote network pass through the filter. This improves the efficiency on all of the networks in the system.

The lower layer options in BACnet are discussed in more detail in the following sections.

BACnet Application Layer

The BACnet application layer is based on an object-oriented approach. Standardized objects provide an abstract, network-visible view of the proprietary data structures and control algorithms. BACnet objects represent the controller's functionality.

BACnet defines a small number of application services which enable the properties of the objects to be manipulated in a very general way. Most of the routine communication between controllers can be carried out with only two application services: ReadProperty and WriteProperty.

This approach has several very important implications. Since much of the complexity of the controller is represented by the objects, the number of application services needed in the protocol can be substantially reduced. For example, downloading a program, changing a loop setpoint, modifying a schedule, initiating an equipment start-up sequence, and much more can be accomplished with one application service: WriteProperty.

Low cost devices with limited processing resources can possess a great deal of application functionality while only implementing a small subset of BACnet application services. New object types or new properties of existing object types can easily be defined to extend the protocol to accommodate new developments in technology. New application services can also be defined but will not, in general, be needed because the existing services are general in nature.

This flexibility permits easy extensions which may be needed to integrate non-HVAC building services and also permits vendor proprietary extensions without loss of interoperability. In the case of a proprietary extension, existing functionality is not lost and use of the extension only requires knowledge of the existence and purpose of the new objects.

In total, BACnet defines 18 standard object types and 30 application services. The application services are divided into five classes: Alarm and Event Services, File Access Services, Object Access Services, Remote Device Management Services, and Virtual Terminal Services.

Lower Layer Options in BACnet

The strategy used in developing BACnet was to decide what information needed to be transferred and how to represent that information as the first step. Once that was established, the problem of how to get the bits from place to place was addressed. The objectives at this stage were to:

1) Utilize existing, widely available technology in preference to inventing something new.
2) Adopt international standards to meet our needs if possible.
3) Provide a way to achieve some backward compatibility to existing products.
4) Provide a range of performance options with respect to speed and throughput.
5) Provide at least one low cost option to accommodate low cost application-specific controllers.
6) Provide at least one deterministic media access control option.
7) Provide dial-up telephone access.

The outcome of the process was a selection of several choices which could be combined, if required, into one system. The options are:

1) ISO 8802-2 & ISO 8802-3 (Ethernet)
2) ATA/ANSI 878.1 (ARCNET)
3) MS/TP [RS-485]
4) Point-to-Point (Dial-up telephone [RS-232])

Ethernet

The Ethernet option is well known and requires no explanation. It is worth noting that the ISO 8802-2 LLC Class 1, Unacknowledged Connectionless Mode service, interface is used for all of the BACnet options. ARCNET and MS/TP are mapped into this interface.

ARCNET

ARCNET is a widely used standard in the process control industry which is beginning to appear in the building control industry as well. It is a low cost token-passing protocol with a nominal bandwidth of 2.5 Mbit/sec.

ARCNET was chosen over international standard token passing protocols on the basis of cost. It was considered essential to have a high performance token passing option in BACnet for applications which might require deterministic media access. The ARCNET trade association claims that there are more installed ARCNET nodes in the world than any other protocol.

MS/TP

To achieve the goals of a very low cost option with at least some backward compatibility, it was considered essential to base one choice on EIA Standard 485 (formerly known as RS-485). This is by far the most widely used physical layer protocol in the U.S. today. There was, however, no existing data link protocol standard to use with EIA-485. We were also unable to obtain access to any proprietary protocols that were suitable, so we invented our own. The result was the Master-Slave/Token-Passing protocol or MS/TP.

MS/TP permits up to 255 nodes on a single network. A configurable number of nodes in this address space are designated as "masters" and they form a logical token ring. This is the token-passing part of MS/TP. If Slave nodes exist, they have no access to the communication medium except to respond to requests sent to them by one of the master nodes, forming the master-slave part of the protocol. Thus MS/TP can be entirely a peer-to-peer network, entirely a master-slave network, or a combination of the two.

The MS/TP protocol was designed with very specific hardware constraints in mind.

1) A UART [Serial communications component] capable of transmitting and receiving eight data bits with one stop bit and no parity.
2) An EIA-485 transceiver whose driver may be disabled.
3) A timer with a resolution of ten bit times.

These are *very* simple hardware requirements intended to be as inexpensive as possible. It would be impossible to implement a protocol like Profibus [a European standard] with this hardware, for example. The idea is to extend BACnet functionality as far as possible into the realm of low cost devices, perhaps even to smart sensors and actuators.

MS/TP was not designed to be used at higher levels in a control system hierarchy. MS/TP is most useful for connecting low cost devices together. The MS/TP LAN would then be connected to one of the higher performance LANs and the rest of the BACnet internetwork through a more sophisticated controller which serves as a router for the MS/TP messages.

These LAN options in BACnet provide several choices for transmission media: shielded twisted pair, coax, and fiber optics. Both bus and star physical topologies are possible.

Conformance to BACnet

In order to account for the fact that control devices may not need to implement all of the capabilities of BACnet in order to perform their function, six classes of conformance are defined. The intent of the conformance classes is to accommodate the functionality of devices that are commonly used today without creating arbitrary barriers that will restrict future innovation. The classes define communication capabilities, not control functionality.

Some features of BACnet are not included in any conformance classes. These capabilities are divided into "functional groups." An example of a functional group is the Event Initiation Functional Group. Some devices may not have the capability to detect the occurrence of events and initiate reports of their occurrence. Others simply never have a need to, such as an operator interface, perhaps.

The idea of a functional group is to group together communication capability which is needed to perform a clearly defined building control function, without placing artificial restrictions on which devices in the system need to have that capability. Building owners can specify the functionality they want in a device without being experts in computer communications. At the same time, manufacturers are not forced to provide unnecessary functionality in a device just to meet the requirements of an arbitrary conformance class.

NIST's Role in Developing BACnet

NIST [National Institute of Standards and Technology] staff have provided leadership and technical support for this industry-wide effort to develop a standard communication protocol which is capable of meeting the present and future needs of the building industry. NIST staff has contributed directly to the standard by writing large portions of the standard, building laboratory prototype implementations of the protocol, developing a framework for testing conformance to the standard, and making NIST facilities available to manufacturers who wish to test their own prototypes.

Conclusions

BACnet addresses the needs at all levels in a hierarchical control model. It is designed to be easily extended to accommodate future innovation in the control industry. It provides a way to connect control devices with a wide range in price and capability.

BACnet uses popular, widely available networking technology. This permits BACnet systems to be easily integrated with data processing and office automation LANs if desired. BACnet can easily be extended to accommodate non-HVAC building services such as lighting control, fire detection, and security access control, making it a useful vehicle for developing "intelligent buildings."

BACnet has strong support among many control system manufacturers and the building controls market in North America, even though it is now only a draft standard.