Standard Communications Protocol for Building Automation and Control Systems: BACnet™

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Buildings have become more sophisticated, utilizing micro-processor based controllers on a wide range of equipment. The need *to integrate standalone equipment* into a coherent automation and control system has become apparent. And building owners have identified a separate need *to share essential information between independent building systems* through a process called *interoperability*. While the industry has attempted many different solutions to meeting these requirements, a standard protocol adopted by all users and manufacturers holds the most promise for a successful future.

This paper examines the issues created by a proliferation of proprietary building automation system protocols, and focuses on how building owners, working under the auspices of ASHRAE, and with the cooperation of industry and government, developed a standard protocol called BACnet (Building Automation and Control Network). BACnet is an object based protocol that is supported over a wide range of physical communication media. A cross section of vendors have participated in the development of the standard and are committed to providing products which make use of it. A testing consortium sponsored by the United States National Institute of Standards and Technology has offered an avenue for proving out the standard.

The result of this process is a powerful standard that is being used today to provide an integration and interoperability solution on over 200 project sites. It provides a single development path for manufacturers and offers building owners future expansion capabilities with any vendor who supports the standard. BACnet was approved as ASHRAE Standard 135-95 in June of 1995. A complimentary ANSI (American National Standards Institute) standard followed, and BACnet will also be considered as an ISO (International Standards Organization) Standard.

INTRODUCTION

It is safe to say that there is a significant amount of confusion regarding the issue of communications and open, standard and proprietary protocols in our industry today. While we're all familiar with terms like setpoint, space temperature, Direct Digital Control (DDC) and the like, most of us are not literate in the language of baud rates, routers, networks and protocol stacks.

Like it or not, these words (and many more) are quickly becoming an important part of business for manufacturers. However, they should not have to be the business of building owners and facility managers.

While technology can give us the tools to create better building control systems, it can also create roadblocks which keep us from achieving our potential. Today, the proliferation of many vendor-proprietary communications protocols has at once created very intelligent building controllers and locked them out from working together; in a sense creating many brains, but no central nervous system for the building. But before we can propose a solution or examine its merit, it is helpful to review the circumstances which brought us to this point.

BACKGROUND

Advances in technology have changed the world over the past two decades, and the building controls industry is no exception. Pneumatic control was the standard offering for building HVAC systems in the 1970's, and we were never faced with questions of integration and interoperability since pneumatic controls were based on the same 20 PSI Main Air regardless of their manufacturer. In essence 0-20 PSI was the standard for pneumatic controllers. A damper actuator from one manufacturer and a valve controller from another could be used side by side on the same air handling unit since they both used the same main air to provide control of their outputs.

Even when the industry moved to electronic controls we did not suffer the problems we typically see today. Sensors and actuators still worked with physical quantities of resistance and voltage which could be easily measured, and did not

change from one manufacturer to another. Standard ranges like 0-10VDC and 4-20mA were generally accepted, and a sensor from one manufacturer could easily be used as an input to a controller from another manufacturer.

However, with the dawn of the micro-computer age in the early 1980's building control system manufacturers were able to incorporate a much higher degree of intelligence in their systems. With that intelligence came the need for a method of communications to share information with various elements of the system architecture. Seemingly random collections of 0's and 1's packaged in the right format allowed microprocessor controllers to send and receive building system information. Given no standard language for digital communication appropriate for the purpose, each manufacturer created their own proprietary protocol (language) optimized to most effectively support their products.

Projects which included early implementations of microprocessor based control systems did not experience difficulty attempting to share information from one independent system with another, since there was little information available in the first place.

Today, micro-electronic controls have worked their way from sophisticated centralized controllers to simple unit controls and sensors. Now even a variable speed drive is nearly certain to include a microprocessor controller, mounted by the manufacturer and using a proprietary protocol. While there is an abundance of information available at the local keypad and display of this unit, it is essentially locked out from the rest of the system because it uses a proprietary communications protocol. One of the fundamental issues driving owners to seek refuge in standard protocols is integration. *Integration can be defined as the ability to group intelligent, standalone unit controllers into a cohesive building management system.*

A second driver is the issue of interoperability. Many owners have found themselves ''captive'' to one supplier, since it is not practical to expand a building or campus with another controls system which cannot communicate with the existing one. *Interoperability is defined as the ability to link multiple standalone building systems from a variety of manufacturers (such as those for HVAC, fire & life safety, lighting or access control) into a comprehensive unit.* Another example of interoperability might be the ability to tie dissimilar control systems in multiple buildings on a campus into a single campuswide system. This allows a single user workstation to provide day-to-day monitoring and control functions for all buildings and systems regardless of who supplied them.

In the same way that integration allows owners to easily incorporate equipment from a large pool of vendors, interoperability assures owners that they can competitively bid system controls with the understanding that a common protocol will provide a method for their system supplier(s) of choice to peacefully co-exist.

In a nutshell, integration allows users to pull large quantities of *dissimilar equipment* under the umbrella of a single building management system, while interoperability offers the same solution for *dissimilar building systems.*

CUSTOM INTERFACES, OPEN PROTOCOLS, GATEWAYS AND MORE

The commercial building control industry has made several attempts to address the issues of interoperability and integration. Custom interfaces linking unique control systems have offered a partial answer for many years. However, the need to license protocols and write confidentiality agreements creates a burden sometimes exceeding the value of the limited performance these custom protocol interfaces can offer. While these solutions did offer some degree of success, they did not represent a long term strategy. Enhancements to system controls at either end of the interface may render it useless, and problems at startup are not easily remediated when both controls vendors are convinced that their end of the interface is not at fault.

In an effort to remove some of the mystery surrounding custom interfaces, some suppliers have elected to publish their system or controller protocols, making them available to interested members of the public. Anyone is welcome to write a custom protocol translator to communicate with their equipment. Again, while this eliminates some of the licensing expense and confidentiality agreements, it does not change the relative effectiveness of interfaces completed between two proprietary protocols.

Today gateways and integrators are popular offerings. These devices package multiple custom interfaces as standard product offerings, and allow a variety of standalone equipment controllers to be linked to a larger building automation system. The development expense to create and maintain these protocol translators is staggering, and while they do provide a relatively stable platform for integrating equipment, they do not begin to address the needs of customers requiring interoperability between independent control systems.

Until recently, the efforts of the industry have been largely self serving, as manufacturers are more prone to protect their strategic market share than they are to implement changes which meet owners objectives but level the competitive playing field in the process. And while the technology exists to allow dissimilar building systems to communicate more freely (witness the marine electronics industry standard pro-

tocol, and to a lesser extent the industrial control market) few things have changed to allow practical exchanges of data which hold the potential for long term, cost effective solutions to both integration and interoperability.

ASHRAE SPC-135P

ASHRAE undertook a plan to overcome this problem in 1987 when it formed a committee to study the issue and propose a standard protocol which could be used by all manufacturers. Special Project Committee (SPC) 135P has been at work ever since defining a specification for BACnet (Building Automation and Control Networks). As ASHRAE is an accredited standards-writing body for the American National Standards Institute (ANSI), the process of creating an industry standard protocol was open to all interested parties, and representatives from all of the major controls companies were soon part of the working committee (see Table 1).

The goal of SPC-135P was to ''define data communications services and protocol for computer equipment used for monitoring and control of HVAC & R and other building systems.'' Over the course of several years SPC-135P created a specification for a protocol which could be used as an industry standard. In 1991 the committee published its initial draft of the specification and the mandatory public review generated over 500 comments. Appropriate changes were made, and in 1994 SPC-135P offered draft two and received roughly 200 comments. A third draft was made available in March of 1995 and was met with fewer than 10 comments.

Table 1. SPC-135P Representative Membership

American Auto-Matrix	Johnson Controls
Andover Controls	Landis & Gyr Powers
Barber-Colman Company	Siebe Environmental Systems
Energyline Corporation	Staefa
Honeywell	The Trane Company
Cornell University	National Institute of Standards & Technology (NIST)
Carrier	McQuay
Delta Controls	Various Owners and Engineers

The specification for BACnet was adopted as ASHRAE Standard 135-95 in June of this year.

DEFINITION OF BACNET PROTOCOL

In deference to existing standards, SPC-135P chose to define the BACnet protocol using the existing OSI (Open Systems Interconnection) model established by the ISO (International Standards Organization). The OSI model consists of seven layers which define the various functions of any protocol (see Table 2). Several layers of the OSI model go well beyond the expected uses of BACnet, and in its final form BACnet employs only four layers. However, limited functions of other layers have been appended to the four layers used by BACnet.

BACnet protocol defines new application and network layers specific to the objectives of commercial building automation systems, and makes use of existing standards for data link and physical layers whenever possible. The presentation, session and transport layers have been eliminated in the collapsed BACnet architecture.

A brief overview of the characteristics of the remaining layers of the BACnet protocol may help to aid in understanding its scope and intended use in commercial building environments.

Application Layer

The application layer includes functions and services specific to BACnet. BACnet identifies several building blocks called Objects which represent physical quantities, or standard elements of control systems such as files, or schedules (see

Table 2. Open System Interconnection Model

Basic Reference Model	BACnet Model
Application Layer	Application Layer
Presentation Layer	—
Session Layer	—
Transport Layer	—
Network Layer	Network Layer
Data Link Layer	Data Link Layer
Physical Layer	Physical Layer

Table 3-1). In addition, the application layer includes many standard Services which can be invoked to manage or control Objects identified in the system (see Table 3-2). Simply put, the application layer of the BACnet standard defines an alphabet, words and the grammatical rules of a new building control language.

A BACnet Device is a collection of Objects which might describe a building or unit controller. Each Object is a collection of Properties that describe the details of the object and/or its setup parameters.

For example, a *BACnet device* might represent an air handling unit (AHU) controller. This controller would include a number of *BACnet objects* to describe the operating conditions of the AHU: analog input objects for discharge air temperature, damper and valve position, binary input objects for filter and fan status, analog output objects to control valves and actuators, and binary output objects to start the fan or control a 2 position valve. Each BACnet object has an associated list of standard *BACnet properties* which specifically describe its characteristics (see Table 3-3).

BACnet application services represent the tools to communicate information between objects, and to link objects into useable systems. In a typical building example the chiller may use the *BACnet service* ''read property'' to poll the position of the chilled water valve on a number of AHUs. The BACnet chiller device can then use this information to reset the ''present value'' property of an analog output object representing leaving water temperature setpoint for the chiller.

Network Layer

BACnet supports several types of networks and physical media as outlined in the description of the data link and physical layers below. The network layer describes how information is passed between devices connected to a variety of networks comprising a BACnet ''inter-network''. For example, an inter-network might include both an Ethernet

Table 3-1. *Standard BACnet Application Objects*

Analog Input	Binary Input	Schedule
Analog Output	Binary Output	Program
Analog Value	Binary Value	Notification Class
Calendar	Command	Device
Event Enrollment	File	Group
Loop	Multi-state Output	Multi-state Input

Table 3-2. *Standard BACnet Application Services*

AcknowledgeAlarm	ConfirmedEventNotification	GetAlarmSummary
GetEnrollmentSummary	SubscribeCOV	UnconfirmedCOVNotification
AtomicReadFile	AtomicWriteFile	AddListElement
RemoveListElement	CreateObject	DeleteObject
ReadProperty	ReadPropertyConditional	ReadPropertyMultiple
WriteProperty	WritePropertyMultiple	DeviceCommunicationControl
ConfirmedPrivateTransfer	UnconfirmedPrivateTransfer	ReinitializeDevice
ConfirmedTextMessage	UnconfirmedTextMessage	TimeSynchronization
Who-Has	I-Have	Who-Is
I-Am	VT-Open	VT-Close
VT-Data	Authenticate	RequestKey

Table 3-3. *Properties of an Analog Input Object*

Object__Identifier	Object__Name	Object__Type
Present__Value	Device__Type	Status__Flags
Description	Reliability	Out__Of__Service
Update__Interval	Units	Min__Pres__Value
Max__Pres__Value	Resolution	COV__Increment
Time__Delay	Class	High__Limit
Low__Limit	Deadband	Limit__Enable
Event__Enable	Acked__States	Notify__Type
Event__State		

and ARCNET LAN connected by a router. Among other things, the network layer of BACnet filters communication so that only messages directed at nodes on the remote LAN are propagated.

Data Link Layer

The data link and physical layers of the BACnet protocol stack define the actual packaging and delivery of BACnet protocol messages. Just as you can pack oranges in a box and deliver them from the grove to a grocery store via a plane, train or tractor trailer, it is possible to send BACnet messages via a variety of carriers. It was the intention of the BACnet committee to make use of existing standards where they were available; at the same time they wanted to insure that they identified options which met users needs for high performance as well as low cost solutions.

ARCNET and Ethernet were chosen as high performance LAN implementations for the data link of BACnet. ARC-NET (ANSI Standard 878.1) is a token passing, deterministic method of data communications running at 2.5 megabytes per second (Mbps). ARCNET passes a token from node to node, and any given node may only communicate when it has the token. ARCNET is widely used in industrial control systems, and was chosen as a cost effective LAN topology.

Ethernet (ISO Standard 8802-3) is a collision detection mode of LAN communications and runs at 10 Mbps. Since there is no token associated with this LAN, nodes are free to send messages whenever there is no other activity on the link. Messages sent by two nodes at the same time will collide; the message will be lost and the nodes will wait for a speci-

fied period of time before attempting to re-send. Using ARC-NET and Ethernet to send BACnet messages is roughly analogous to shipping oranges via airfreight, where the oranges are BACnet messages, the orange crate represents the ARCNET or Ethernet data link, and the airplane is equivalent to the physical layer.

Nearly all commercial building automation systems make use of EIA-485 (formerly RS-485) as a physical link, typically for multi-drop or daisy-chained unit controller communications. While manufacturers have created their own flavors of EIA-485, there are no standards defined for it at the data link layer. Since it is a very popular and cost effective method of communication, the BACnet committee defined its own rules for using this physical link. Master/Slave Token Passing (MS/TP) allows for both master and slave nodes on a link. Only masters may get the token and initiate communications on the link, slave nodes may only respond to a request for data. It is optimized for very cost effective, but lower performance applications typical of unit controller communications. MS/TP typically operates at 9600 baud. Using MS/TP for BACnet is similar to sending a box of oranges via railroad car.

Echelon Corporation has defined a protocol of their own design for use in commercial building control systems. Lon-Talk™ is a protocol which is closely associated with communication hardware (Neuron chips) also marketed under the Echelon name. While the BACnet committee elected not to endorse Echelon's definition of a standard protocol, they did allow for BACnet messages to be sent via Echelon's application of the data link layer. This is analogous to filling

an empty grapefruit box with oranges and shipping them by rail.

Point to Point (PTP or Dial Up) is a communications mode optimized for hardwired connections between two devices or dial up communications. It is a non-LAN based topology consisting of a single node on either end. Communication rates are similar to MS/TP, and relatively speaking PTP is a much simpler topology to implement than the LAN options described above. PTP is another communications mode defined by the BACnet committee as a standard to be used with the EIA-232 physical link. In relation to the options described above, PTP is roughly equivalent to shipping the same box of oranges via tractor trailer.

Physical Layer

This layer of the OSI model consists of the actual physical interconnection between nodes, and the method of signaling upon it. For example, coaxial cable, twisted pair, and optical fiber are three different media associated with both ARCNET and Ethernet. However the signaling methods (voltages and timing) used by each are different. Therefore the definition of the physical layer for ARCNET and Ethernet via coax are different. EIA-485, EIA-232 and specifics for passing information to an Echelon LonTalk data link layer are each also described by a unique physical layer profile. Table 4 describes several options within the basic BACnet OSI model.

A variety of cabling connections are possible for the specific physical and data link layers supported by BACnet. As mentioned above, coax, twisted pair and optical fiber are all possible for ARCNET and Ethernet. EIA-485 uses twisted shielded pair, and multi-conductor cable is appropriate for EIA-232. LonTalk supports transceivers for several other connections, including powerline carrier, radio frequency and infrared.

MOVING FORWARD WITH THE BACNET STANDARD

Given that SPC-135P has defined a standard protocol with sufficient flexibility to be used in many applications and with several options for physical and data link connections, we should now turn our attention to how BACnet might be used, and how it can alleviate the problems of integration and interoperability identified by building owners.

The BACnet specification defines standard objects and services which can be used to share building control information between devices located at any level of a building automation system architecture (Figure 1). MS/TP is appropriate for linking unit controllers to building controllers while ARCNET and Ethernet are best used at the building controller to user workstation level of the architecture. Point to Point is a valid method of monitoring remote field panels from a

Figure 1. BACnet identifies data link and physical layer options appropriate for all levels of a building automation system architecture.
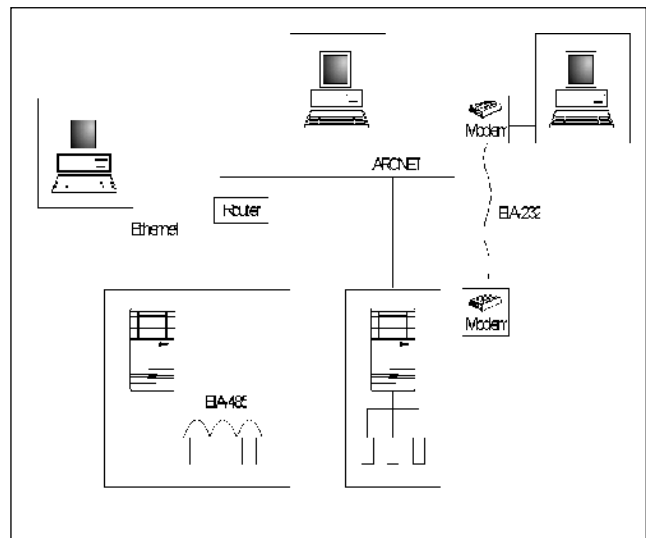

Table 4. Example BACnet Protocol Stacks

APPLICATION	BACnet Applications Layer				
NETWORK	BACnet Network Layer				
DATA LINK	ARCNET	Ethernet	LonTalk	MS/TP	PTP
PHYSICAL				EIA-485	EIA-232

central PC. Routers direct communications from one network to another within the greater BACnet inter-network.

While the BACnet specification outlines communication at all levels of the system architecture, it is probably better applied at certain points than others. Some in the industry have looked for BACnet to provide a ''plug and play'' solution for connecting a random selection of equipment, controllers and workstations into a cohesive building management system. Plug and play is a very popular concept, however even BACnet may not be able to fully address the high expectations that customers have come to associate with their visions of interoperability.

It's true that the BACnet specification allows for a VAV box from one vendor to communicate with an air handling unit controller from another. And a building controller and user workstation from still other suppliers might complete the system. However, in practice it is unlikely that this would provide the best solution for any building owner. Consider the issues of commissioning, and the lack of any one supplier who is responsible for the performance of the entire system. (However, it is possible that this niche may be filled by a new breed of contractor focused on integration services.) BACnet does not exist to propagate exotic recipes for building control systems; rather it offers a convenient means to exchange data between complimentary building systems where none was possible before.

BACnet can serve the integration needs of customers by providing a standard method of interface to such ancillary devices as fume hoods, variable speed drives and computer room units. These devices are largely standalone controllers with many status and few control points. BACnet provides the means to pull them under the umbrella of a larger building automation system where a custom interface or gateway was the only previous solution. Offering BACnet as a standard communications protocol on standalone unit controllers like these removes the burden of creating and maintaining custom integrator interfaces and allows manufacturers to concentrate their limited resources on creating control applications which better manage indoor air quality, energy, and comfort.

It is unlikely that manufacturers will ever be able to completely cast off their proprietary protocols in favor of a 100% BACnet architecture. The synergy of a complete automation system from a single supplier offers many functions and services which go well beyond what can be identified in the BACnet specification, which by its nature is a representation of the ''least common denominator'' of all things possible in the industry. For example, while BACnet facilitates the free flow of information for monitoring and basic control of a multi-vendor system, it might not represent the optimum means to setup and configure necessary operating parameters

specific to a particular manufacturer's unit or equipment controller which is part of the multi-vendor system.

BACnet offers its greatest benefits when it is used to share high level information between independent building control systems. When a system or subsystem can be identified and optimized for primary control, then BACnet can serve as a common link allowing independent primary control systems to share information for supervisory control and monitoring applications in other systems of the building or campus (Figure 2).

Owners should be encouraged to look for system solutions to HVAC, lighting, fire & life safety, access control, elevator control, etc. and then use BACnet to coordinate them into a comprehensive facility-wide system. In a similar manner, BACnet allows large projects to expand and campuses to add new buildings with an independent controls system of choice. While the primary control might be supplied by a different vendor on each project, BACnet can coordinate the independent pieces into a high level system capable of sharing pertinent data between system elements, and report back to a single user workstation for day-to-day operations such as monitoring, supervisory control and data management.

Consider a building which reads a tenants security badge when they arrive at the front lobby after normal working hours. The user's badge information can be shared with the elevator control system which brings a car to the lobby and allows the tenant access only to their floor of the building. When they arrive at their office, lights and HVAC are turned

Figure 2. *BACnet protocol links multiple standalone building systems into a cohesive facility-wide system for day-to-day operation including supervisory control, monitoring, and data management.*
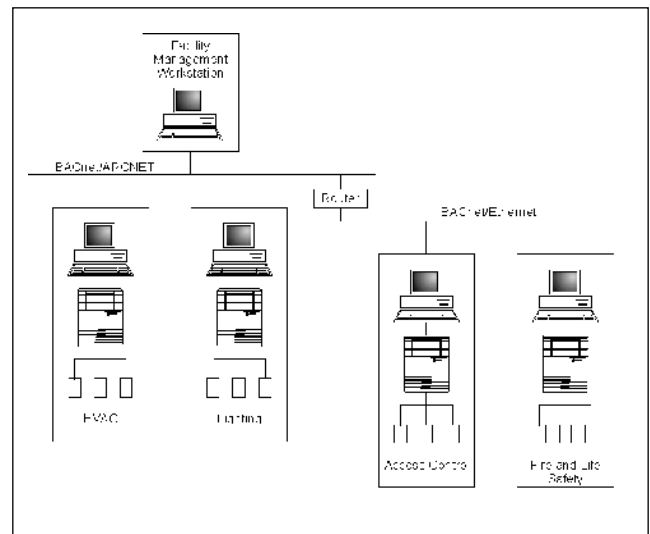
on and the building management system has logged their after-hour usage to generate a monthly bill. All of this is possible by making independent system data available to other building systems in the form of BACnet objects.

Similarly, owners of large, expanding projects and multiple buildings benefit. A project might have been originally installed using building control systems from vendor A. When the next building or expansion is let, vendor B has a more attractive price, better product or stronger relationship with the owner. BACnet allows the owner to add an independent system from vendor B while still maintaining a means to provide interoperability between the two.

WHAT'S NEXT?

BACnet was adopted as ASHRAE Standard 135-95 in June of 1995. It is already being used by several manufacturers in standard product, and there are more than 200 projects in the United States which have successfully used BACnet to link control systems and/or equipment from multiple vendors. All major controls suppliers and many key HVAC equipment manufacturers are developing support for the BACnet specification in their products. Several additional BACnet projects are currently under way in Asia, Australia, Canada and Brazil.

The United States National Institute of Standards and Technology (NIST) has sponsored a BACnet lab for members of a Testing Consortium with favorable results. Manufacturers have used the lab to test their products with other BACnet compatible devices for over a year. NIST and ASHRAE cooperated to sponsor a booth at the 1996 ASHRAE Exhibition including a working demonstration of products from eleven manufacturers who are using BACnet to address customer requirements for integration and interoperability.

ASHRAE is instituting a standing committee to maintain and further develop standard 135-1995. This committee began its work at the summer ASHRAE meetings in San Antonio in June. The focus of this committee will be to specify a standard method of testing BACnet products for compliance to the standard. The committe will also address how to create specifications which allow for competitive bidding yet ensure workable, truly interoperable installations.

As the industry learns to apply BACnet, it is important to understand that simply specifying equipment or controls be ''BACnet compatible'' is not sufficient to ensure an interoperable solution. The BACnet specification includes roughly 500 pages outlining a variety of objects and services which may or may not be applicable to all products depending on their intended use. In addition, there are many valid options for connecting BACnet devices, and it is possible for unique

elements of a system to support exclusive data link or physical layers making the devices incompatible without a BACnet router.

BACnet requires every BACnet device to include a Protocol Implementation Conformance Statement (PICS). Among other things, the device PICS describes who manufactures the product, what it is, which BACnet services and objects it supports, and which physical connections are available. Reviewing the PICS for BACnet objects included in a design will confirm whether the objects, services and physical connections supported will allow them to communicate.

BACnet also identifies six conformance classes and 13 functional groups which represent support for specific groupings of BACnet services and functions. These are intended to provide a convenient method to describe common system characteristics that are supported. For example, the Event Initiation and Event Response functional groups describe a BACnet device' ability to generate and/or log and acknowledge alarms.

SUMMARY

The issues of integration, interoperability and standard protocols are very dynamic. It's tempting to let the constant barrage of information lead one to believe that even a standard protocol document won't provide a solution to many of the issues that we face today. But, however clouded the concept may seem at the moment, BACnet is still the strongest hope for providing a common communications protocol for the commercial building market.

It is not surprising that there are some difficulties to be resolved when the undertaking is so great; changing the direction of an industry this size is a formidable task. On the other hand, these growing pains are necessary to give us the tools we need to concentrate on creating systems which offer better solutions to our customers.

Through ASHRAE, the industry has defined a standard protocol which *can* help manufacturers address the issues which are important to building owners and engineers. Manufacturers are beginning to make the necessary changes to support BACnet, but end users must continue to voice what it is they want from this open standard. Most manufacturers will welcome input now, as they are beginning to formulate how they will use BACnet to provide integration and interoperability.

While many vendors have made strides to use BACnet as a solution for integration, only a few have begun to answer customers needs for interoperability as well. Patience and persistence on the part of building owners and managers will pay off in the long run in systems which facilitate

competitive bidding and offer easy integration of equipment and controls into a single, comprehensive facility automation system.

REFERENCES

ASHRAE, 1993. ''BACnet—Data Communication Protocol for Building Automation and Control Networks''. Advanced working draft 2. Atlanta, Georgia: ASHRAE SPC-135P—029.

ASHRAE, 1993. ''BACnet—Data Communication Protocol for Building Automation and Control Networks''. Advanced working draft 3. Atlanta, Georgia: ASHRAE SPC-135P—031.

Elyashiv, T., November 1994. ''Beneath the Surface: BACnet Data Link and Physical Layer Options''. *ASHRAE Journal*. Vol. 36, No. 11, pp.32-36.

Bushby, S., August 1993. ''Back to the Basics About BACnet''. The Trane Company, PL-ES-BAS-000-S-28.

Shinn, K., April 1994. ''A Specifier's Guide to BACnet''. *ASHRAE Journal*. Vol. 36, No. 4, pp. 54–58.

Bushby, S. and Newman, M., January, 1994. ''BACnet: A Technical Update''. *ASHRAE Journal*. Vol. 36, No. 1, pp.S72-S86.

Summa, J., September 1995. ''The Ultimate Intelligent Building''. *Engineer's Digest*. pp. 53–55.