NEW TOOLS FOR SPECIFYING BACnet

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ANSI/ASHRAE Standard 135-1995, *BACnet - A Data Communication Protocol for Building Automation and Control Networks"* ushered in a new era for building automation and control systems by making it possible to integrate building control products made by different manufacturers. Today, hundreds of thousands of BACnet products are installed around the world *(Figure 1)*.[1] BACnet products are used to control HVAC, lighting, and fire detection systems, and for integrated equipment control. Despite the success of BACnet projects, owners and consulting engineers continue to struggle with properly specifying these integrated systems.

To address this need, Addendum *d* to the standard was developed to provide new tools for specifiers. This addendum and several others have been incorporated into the *2001* version of the standard.

Addendum *d* replaces BACnet Clause *22*. Conformance and Specification. The addendum introduces a new concept called BACnet Interoperability Building Blocks (BIBBs). As the name suggests, each BIBB defines a small portion of BACnet t'unctionali ty needed to perform a particular task.

BIBBS are combined to build the BACnet functional requirements for a device in a specification. Before explaining BIBBs and their use in more detail, it is helpful to discuss why this change was made.

The Past: Specifying BACnet

Developing a good BACnet specification is not difficult if you have expertise in computer communication protocols and understand the features of BACnet. The problem is that few people in the building industry have that kind of expertise.

Historically, owners and consulting engineers did not need to understand communication protocol issues. Most jobs relied on a single vendor to handle the communication details. Other than establishing some minimum performance requirements, there was no need to delve into the details of the communications.

Having the tlexibility of open, interoperable building automation systems involves a tradeoff. The building owner, or his representative. must assume the responsibility of ensuring that communication and integration details are handled properly. This is especially true for large systems involving multiple buildings that change over time. These details cannot be left to whatever Lendor gets a particular part of the job. A new set of issues must be considered for developing a project specification anti then managing the project.

The BACnet standard offers many features and options. Why is it so complex'? After all. the best way to achieve interoperability is to eliminate choices and make everything the same. However. various components of an integrated building automation system have unique application needs. A chiller controller is not the same as a VAV box controller or a smoke detector. Variations exist in the amount of infomiation to be exchanged and the cost and speed constraints on the underlying network technology.

BACnet is the only consensus-developed communication standard in the building industry. The goal of BACnet's developers was to provide a comprehensive solution to meet the needs of all com-

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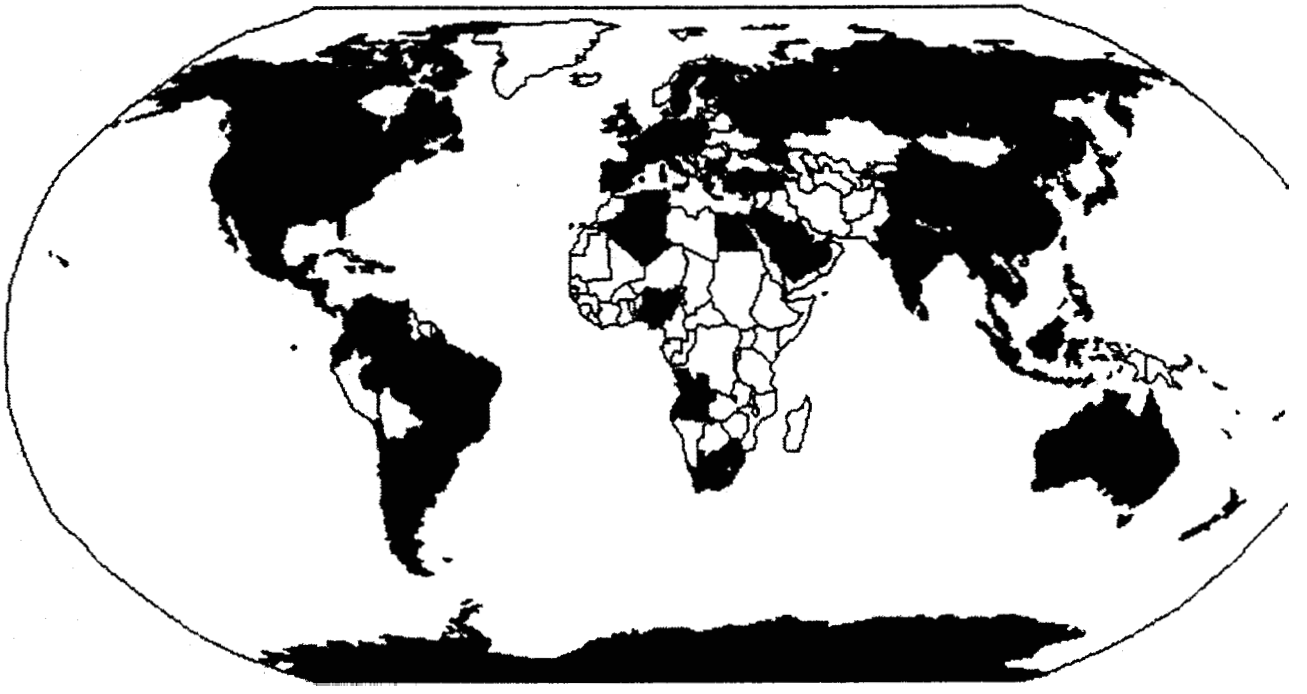

Figure 1: The shaded areas depict 82 countries and territories where RACnet systems are installed.

ponents in a distributed building automation system. That includes devices for HVAC, lighting, and access control, as well as fire detection and other building system functions. One size does not fit all. Options were needed that provided flexibility for the system. This flexibility is one of BACnet's main strengths and the primary reason it will stand the test of time. It also makes specifying systems more difficult.

The *1995* BACnet Standard

The 1995 standard contained tools intended to make it easier for people without expertise in computer communications to select BACnet features for a project. It didn't make sense to combine all of the features of BACnet into a single product. The feature set needed to be divided into useable parts that could be selected to meet the requirements of various components of a BACnet system. Only those BACnet features needed for a particular application would be implemented. The guiding principles used include:

- Link communication capabilities to application needs that are well understood;
- More is not always better. Provide the needed capabilities and no more: and
- Provide a path for innovation. Don't lock in today's approach to distributing control functionality.

The result was a set of hierarchical conformance classes and an orthogonal grouping concept based on particular applications such as detecting and announcing alarms or serving as a time master. These collections of communication capabilities were called functional groups. The idea was to select an appropriate conformance class and then add func-

tional groups until the desired functionality was represented. It didn't work.

The simultaneous use of two fundamentally different approaches to dividing BACnet features was confusing. This approach did not allow specifiers to describe requirements in easy to understand language. Numerical conformance classes were used to avoid locking capabilities into specific control devices. thereby stifling innovation. In practice. people specified the highest class thinking it must be the best. instead ofspecifying only what was needed. The inherent asymmetry ofthe communication process was not well represented. And finally. the granularity of the choices turned out to be too coarse.

The Present: Using BIBBs

The original goals were on target but the end result did not work as well as hoped. ASHRAE Standing Standards Project Committee 135, the committee charged with maintaining the standard turned to a work in progress for inspiration.

A group of experts in specifying building automation systems was developing a guideline on that subject (now published as ASHRAE Guideline 13-2000, *Specifying Direct Digital Control Systems*). This guideline recommends specifying DDC systems by describing the requirements in five interoperability areas: data sharing. alarm and event management. scheduling, trending. and device and network management. These five iiiteroperability areas represent the capabilities needed by building operators to perform the day-to-day activities of running a building.

It seemed to make sense to define components of BACnet functionality within these broad categories to make it easier to specify RACnet. It was decided to use small building blocks so that. for each functional area, a specifier can select from a range of capabilities that best meet the intended application of the device. The idea for BACnet Interoperability Building Blocks (BIBBs) was born.

BIBBs come in pairs. designated **A** and B. that reflect the clientiserver nature of control system communication. The A BIBB represents the client or device that is trying to obtain information or command an action. The B BIBB represents the server or device that provides the data or carries out the conimanded action. If two devices support the complementary BACnet capabilities (the A and B side ofthe same BIBB), then they are interoperable from the standpoint of that function. *Table 1* lists a portion of the BIBBs defined in Addendum *d* and the shorthand notation used to reference them.

The basic idea *is* that for each kind of device included in a specification (e.g.. workstation, building controller. application specific controller, etc.). the functional areas they need to support are selected. Then. BIBBs that apply to that functional area are chosen to match the level of desired sophistication. An example might help make this clear.

Data-Sharing BIBBs	
DS-RP-A, DS-RP-B	Data Sharing - ReadProperty
DS-RPM-A, DS-RPM-B	Data Sharing - ReadPropertyMultiple
DS-WP-A. DS-WP-B	Data Sharing - WriteProperty
DS-WPM-A. DS-WPM-B	Data Sharing - WritePropertyMultiple
Alarm and Event Management BIBBs	
AE-N-A, AE-N-I-B	Alarm & Event - Notification - Internal (events internal to the device)
AE-N-A. AE-N-E-B	Alarm & Event - Notification - External (events external to the device)
AE-ACK-A. AE-ACK-B	Alarm & Event - Acknowledgments
AE-INFO-A. AE-INFO-B	Alarm & Event - Information (collect or provide summary information about past events)
Scheduling BIBBs	
SCHED-A. SCHED-I-B	Scheduling actions internal to the device
SCHED-A. SCHED-E-B	Scheduling actions external to the device
Device and Network Management BIBBs	
DM-DDB-A. DM-DDB-B	Device Management - Dynamic Device Binding (find other BACnet devices)
DM-DOB-A. DM-DOB-B	Device Management - Dynamic Object Binding (find other BACnet objects)
DM-DCC-A, DM-DCC-B	Device Management - Device Communication Control (temporarily silence a device)
DM-TS-A, DM-TS-B	Device Management - TimeSynchronization (local time)
DM-UTC-A, DM-UTC-B	Device Management - UTCTimeSynchronization
DM-RD-A, DM-RD-B	Device Management - Reinitialize Device (remotely reset a device)

able 1: Sample BACnet 'nteroperability Building Blocks.

Application Area	BIBBs Required	Functionality That Can Be Specified
Data Sharing	DS-RP-B DS-WP-B	• Ability to provide the values of any of its BACnet objects upon request • Ability to allow modification of some or all of its BACnet objects by another device
Alarm and Event Management	none	No requirements
Scheduling	none	No requirements
Trending	none	No requirements
Device & Network Management	none	No requirements

Table 2: BACnet application-specific controller requirements.

How to Use a BIBB

The data-sharing BIBBs contain. among others. Readproperty, ReadPropertyMultiple, WriteProperty, and WritePropertyMultiple. The Readproperty service provides a way to read a single property of a single object. The WriteProperty service provides a way to write to a single property of a single object. ReadPropertyMultiple and WritePropertyMultiple are more complicated in that they can read or write to multiple properties, possibly from multiple objects. in a single message. Reading or writing multiple values at one time can iniprove communication efficiency. However, this requires more memory and processor resources. and is thus more expensive.

To select a BIBB the specifier must decide which level of capability is most appropriate. Consider a very simple application-specific controller.

- Does it have data that needs *to* be shared with some other device in the system'?The answer is almost certainly yes. This means that it must support the B-side of one of the ReadProperty BIBBs (some other device can read the properties of its objects).
- Does it have the resources to answer requests for more than one data value at a time'? Let's assume the answer is no. That means DS-RP-B is the appropriate choice.
- Does it need to provide a way for another device to change the value of one or more of its properties (e.g., a setpoint)'? If yes, then it should also support DS-WP-B.
- Does it need to get data from or change values in another device'? It probably doesn't. which means that it does not need any of the **A** side BIBBs.

The end result is a specification that these controllers must support DS-RP-B and DS-WP-B. This type of reasoning for each of the application area can be used to select building blocks that define the communication capabilities for any BACnet device.

Standard Device Profiles

It still requires expertise to select all of the appropriate BIBBs. To make this process easier, Addendum *d* defines a standardized version of several typical control system components: a BACnet Operator Workstation: a BACnet Building Controller; a BACnet Advanced Application Controller: a BACnet Application Specific Controller: a BACnet Smart Actuator; and a BACnet Smart Sensor. The set of BIBBs for each of these devices is already selected and listed in a table. In order for a vendor to claim to meet the communication requirements for one of these standard BACnet devices, all of the listed BIBBs must be supported.

Some vendors may object to the categorization of their equipment. While every vendor will claim that their product is unique. specifiers need to be able to have these broad categories when selecting equipment. This is a common approach used with mechanical equipment such as air handlers. Specifiers select the generic category for the application and then describe the feature set in detail. The BACnet committee used this same approach for DDC component selection.

Application Area	BIBBs Required	Functionality That Can Be Specified
Data Sharing	DS-RP-B DS-RPM-B DS-WP-B DS-WPM-B	• Ability to provide the values of any of its BACnet objects upon request • Ability to allow modification of some or all of its BACnet objects by another device
Alarm and Event Management	AE-N-I-B AE-ACK-B AE-INFO-B	• Generation of limited alarm and event notifications and the ability to direct them to recipients • Tracking acknowledgments of alarms from human operators • Adjustment of alarm parameters
Scheduling	SCHED-I-B	• Ability to schedule actions in the local device based on date and time
Trending	none	No requirements
Device & Network Management	DM-DDB-B DM-DOB-B DM-DCC-B DM-RD-B	• Ability to respond to queries about its status • Ability to respond to requests for information about any of its objects • Ability to respond to communication control • Ability to synchronize its internal clock upon request • Ability to perform reinitialization upon request

Table 3: BACnet advanced application controller requirements.

The standard provides guidance about what type of functionality can be specified for each of the standard device types. knowing that the underlying communication details are supported. This allows the specifying engineer to focus on the application requirements instead of the communication requirements.

A BACnet Application Specific Controller (B-ASC) is defined as a device with limited resources and limited or no programmability that is intended for use in a specific application. *Table* 2 shows the communication requirements for a B-ASC' and the kind of application functionality that can be specified. A specification that uses this profile should state that the controllers provided should meet the requirements of

a B-ASC. The specifier then adds specific functional requirements that fall within the range of those indicated for the device. In this case the specification should indicate which values are shared and how they are used. It also should indicate which values are modifiable and by whom.

A somewhat more complicated device is a BACnet Advanced Application Controller (B-AAC). A B-AAC is a device that may be intended for a specific application but it supports some degree of programmability and has a richer set of features than B-ASC. *Table* 3 shows the communication requirements for a B-AAC and the kind of application functionality that can be specified. For this device, it is possible to specify more complicated application functions such as generating alarms. defining schedules. and synchronizing clocks. The overall idea of this approach is to keep the work focused on what the specifier knows—the requirements of the building control application.

The standard devices are intended to be a guide. If they meet the needs of a project. use them to make life easier. If the project has special needs for one or more devices, then go back to the complete set of BIBBs and select the most appropriate ones. Specification to this level of detail requires a more complete understanding of the communication details. To do it well requires more work and expertise than specifying the standard device types.

Other Specification Issues

All of the discussion in this article applies to application functionality of the BACnet devices Other specification issues must be carefully considered to make the project successful over time. These include which network technologies to use. a naming convention for BACnet objects. and a numbering convention for BACnet networks. These issues are discussed in detail in NISTIR 6392.[2] This document was prepared for the General Services Administration to help it develop high-quality BACnet specifications. NISTIR 6392 includes a checklist that can be used to determine whether a BACnet specification is complete. NISTIR 6392 predates the final version of Addendum *d*. It was based on a draft version of the BIBBs that differ in some details from the version adopted as part of the standard.

What Happened to Gateways?

The list of standard BACnet devices does not include a gateway. This may seem strange since many projects need a gateway to connect to previously installed non-BACnet systems. Inclusion of a gateway profile was a topic of considerable debate. Eventually, it was decided that a gateway could be made to have the same functionality as any of the standard devices. The needs and cost constraints of a particular project should dictate how much functionality is required in a gateway. For this reason no standard gateway was included. Although this is a reasonable argument. very little guidance is provided for the individual who needs to specify gateway requirements. NISTIR 6392 includes BIBB requirements for a gateway and recommendations for the other functional requirements that should be specified.

Summary

The RACnet standard makes it possible to integrate a variety of building automation and control products. Building owners and consulting specifying engineers have had difficulty understanding how to write quality BACnet specifications. It has been difficult because. for the most part. specifiers have no background in computer communications, and the tools provided in the 1995 standard to bridge this gap have not worked well in practice. Newly approved Addendum *d* to the BACnet standard improces the situation by defining a set of interoperability building blocks that can be used to clearly define the communication requirements of a BACnet system.

The addendum also includes several standardized building control devices for which BIBBs have already been selected. Guidance is provided regarding the type of application functionality that can be specified for each of these devices. The intent is to provide a reliable communication framework from which the specifying engineer can build using what he knows best. the functional requirements of the application.

References

1. BMA 2000 Annual Report, p. 9, BACnet Manufacturers Association, 55 Temple Place, Boston, MA 02111-1300.

2. 1999. NISTIR 6392, *GSA Guide to Specifying Interoperable Building Automation and Control Systems Using ANSI/ASHRAE Standard 135-1995, BACnet*. National Institute of Standards and Technology. Available online at www.BACnet.org.