BACnet Celebrates 20 Years

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Celebrating BACnet's success is nothing new for true "BACneteers"—but 2015 is special. This year BACnet committee members, developers, implementers, installers, building owners, operators, and everyone else who has benefited from the protocol, will be celebrating the 20th anniversary of BACnet's adoption as ANSI/ASHRAE Standard 135. It has also been a bit more than 10 years since BACnet was embraced internationally as ISO Standard 16484-5 and then as a national standard in Europe, Asia, and other parts of the world.

The question is "How has BACnet done it?" How has BACnet managed to survive and thrive while many other protocols have come and gone? This article will look at some of BACnet's success factors and present brief descriptions of some of BACnet's features that have evolved over the last 20 years.

BACnet Success Factors

Here are the main reasons that BACnet is still around today:

- **BACnet was designed specifically for buildings.** While the original BACnet committee, SPC 135P, initially focused its attention on HVAC, we always had in mind that nothing should be done to preclude its use with other kinds of building systems. Today, BACnet supports lighting, life safety and security, physical access control, elevators, etc., and the committee is always looking for ways to extend BACnet into other areas such as, for example, emerging "smart grid" systems.
- **BACnet was designed to be extensible.** From the very beginning, those who were opposed to the development of a standard asserted that it would necessarily "stifle innovation." To prove the nay-sayers wrong, nothing was adopted by SPC 135P unless, and until, we could convince ourselves that innovation would not be affected. Although this was sometimes a great challenge, the passage of time has shown the validity of our choices. BACnet is not only readily extensible, almost always in a backwards compatible way, but has continuously evolved to meet today's communication requirements

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while embracing the new technologies that we knew would be coming along, even though we didn't know at the time what they would be.

- **BACnet has never depended on any particular hardware or network technology.** In fact, we studiously avoided any mention of networks or transport mechanisms until the basic communication structure, BACnet's objects and services model, had been agreed to. This, coupled with the use of the well-known ISO-layered communication model,[1] allowed us to use, in principle, any kind of network that we wanted. We picked ones that were in common use at the time (ARCNET, Ethernet, EIA-232, and EIA-485) and that were acceptable to the manufacturers because they were already familiar with them. While some protocols are stuck with old chipsets, BACnet has been able to embrace wireless communication, the Internet Protocol (IPv4), and even the latest IPv6 that will probably be a key component of the so-called "Internet of Things (IoT)." More on this later.
- **BACnet has no fixed communication architecture.** All the devices can be peers of each other in a "flat" arrangement or arranged in "hierarchies" depending on the needs of the systems being interconnected.
- **BACnet can be implemented in devices of any size, from very large to very small.** In the early days some disputed this (to promote their own small devices) but the vast preponderance of BACnet devices are "small." Of course, today's small devices are thousands of times more powerful than the devices of 20 years ago. We used to chuckle at the idea of a smoke detector on the Internet but that is exactly where the IoT seems to be going—and BACnet is going there, too!
- **BACnet is free.** BACnet is a worldwide standard and its use requires no fees, licenses, royalties or other payments to anyone.
- **BACnet is supported by dedicated professionals.** The most important success factor of all is that BACnet has attracted, pretty much since the beginning, a dedicated band of engineers and supporters from all over the world. While some have come and gone, there has, remarkably, always been a group of hardcore developers ready and able to carry on the work of keeping BACnet up-to-date and always improving. In fact, to celebrate BACnet's anniversaries, two of the most active support organizations, *BACnet International* and the *BACnet Interest Group-Europe*, have banded together to "take the show on the road." The "BACnet Global Roadshow 2015" will promote BACnet in the Americas, Europe, Africa, and Asia with events featuring live demos and educational presentations. More info is available at "www.bacnetroadshow.org."

TABLE 1 BACnet evolution by the numbers.

STANDARD	1995	2012
Number of Pages	501	1039
Number of Data Link Types	5	7
Number of Object Types	18	54
Number of Services	33	38
Number of Working Groups	3	13

BACnet's Evolution

One way to measure BACnet's growth and maturation is just to look at the numbers. See *Table 1*. As you can see, the number of pages in the standard has more than doubled. This reflects the addition of 2 new data links, 36 new object types, and several new services. See *Table 2*. The number of new services is actually more than just the difference between the 2012 and 1995 numbers because some of the original services have been retired and replaced by new ones. It is also noteworthy that the number of committee working groups has grown significantly indicating the new areas of interest that are now being considered. See *Table 3*.

A second, and arguably more meaningful, way to assess BACnet's evolution is to look at how it has been refined and expanded. Below are brief descriptions of some of the more significant developments.

Life Safety and Security. One of the first areas chosen for expansion was life safety alarm and control. This led to the Life Safety Point and Life Safety Zone objects and the LifeSafetyOperation service. Together these additions allow for monitoring and managing fire alarm, life safety, and security systems in a supervisory way without infringing on the various Underwriters Laboratories and National Fire Protection Association standards and codes.

Physical Access Control. To allow BACnet to be deployed in physical access control systems (PACS), the Life Safety and Security - Working Group (LSS-WG) developed 7 new object types. Again, see *Table 2*. The

Twenty Years of BACnet

1987 – 1990

January 1987 ASHRAE Standards Committee (StdC) approves formation of SPC 135P, "Energy Monitoring Control Systems (EMCS) Message Protocol."

June 1987: First SPC meeting held at Opryland Hotel, Nashville. | StdC approves name change from "EMCS Message Protocol" to "BACnet."

1995 – 1996

September 1995: First 17 "Vendor IDs" issued. In May 2015 there were 827.

December 1995: BACnet approved for publication as an ANSI/ASHRAE standard.

February 1996: First "BACnet Booth" at Atlanta ASHRAE Winter Meeting, with theme "BACnet—Your Connection to the Future."

June 1996: SSPC 135 created to maintain BACnet under "Continuous Maintenance."

1998 – 1999

May 1998: First "BACnet Interest Group," BIG-Europe, holds its kick-off meeting in Frankfurt.

January 1999: First BACnet addendum, BACnet/IP, published. | BIG-North America launched.

December 1999: BACnet approved as a Korean national standard, KS X 6909.

model is described in a "white paper" available at www.bacnet.org/bibliography. The beauty of it is that BACnet PACS uses existing object access, change-of-value (COV), and alarm and event services so that no new services were required.

Lighting. Lighting is a specialty unto itself involving far more than simple on-off control. For example, there are issues of ramping the lighting intensity up and down at various rates; sequencing the order of specific lights or groups of lights; controlling the lights in steps as opposed to specific target luminosities; blinking the lights prior to shutting them off entirely, etc. These considerations have been taken into account in the new Channel and Lighting Output object types. In addition, there is a new unconfirmed WriteGroup service to relay lighting commands to potentially large groups of devices with a single write.

Metering. The need for BACnet to be able to represent "meters" has been around since at least 2000. Based on requests from Europe and Japan, two new object types were introduced: the Accumulator and Pulse Converter. The Accumulator object essentially represents an electric utility meter and is aimed at accurately capturing total consumption over time. The Pulse Converter, in contrast, is focused on current rate of consumption.

Control. Two object types are related to control and have as their main function the generation of outputs to some properties of some other objects. In the Command object, these outputs are explicitly stated in the object's properties. In the case of the Load Control object, the mechanism by which loads are controlled (shed) is implicit and not network visible. This object is expected to play a key role in "utility integration" or "smart grid" work.

Logging. BACnet-1995 had no logging capability of any kind. To address this obvious deficiency, the Event Log, Trend Log, and Trend Log Multiple object types were added to facilitate the collecting, or "logging," of timestamped data. The Trend objects collect values by one of three means: polling, COV or triggered. The Event Log object logs event notifications that it receives. The reading of data from the log buffers is done using the ReadRange service, not the ReadProperty services. ReadRange was created just for this purpose.

Alarm and Event Notification. A tremendous amount of effort has gone into the improvement of BACnet's alarm and event processing. The difference, as a reminder, is that "alarms" are events intended for human consideration whereas "events" are intended more for machine-to-machine communication. The improvement has focused on two main areas. The first was to improve the consistency and legibility of the alarm algorithms and to specifically relate the defined and standardized algorithm *parameters* to specific object *properties* and, also, to clarify how "faults" are handled. A fault is a condition where there is a detected problem with the reliability of an object's properties. The second was to make it easier for relatively low-capability devices to participate in alarm and event notification. To accomplish this, in addition to the original Event Enrollment and Notification Class, the committee added a Notification Forwarder object type. This new object allows notifications to be sent to

2000

February Formation of the BACnet Manufacturers Association (BMA) is announced at Dallas Winter Meeting.

March BIG-AustralAsia formed and has booth at exhibition in Melbourne, Australia.

June "BACnet Testing Laboratories" (BTL) begins product testing at Cimetrics in Boston.

July BACnet translated into Japanese.

August ISO/TC 205 approves BACnet as a Committee Draft in Tromsø, Norway, first step to becoming ISO standard.

October First Interoperability Workshop or "Plugfest" held at NIST. Plugfests have been held in North America every year since.

November Chinese translation of BACnet released.

TABLE 2 BACnet Object Types. Those in gold were defined in BACnet – 1995. All of the others have been added since.

BASIC DEVICE OBJECT TYPES	PROCESS RELATED OBJECT TYPES	CONTROL RELATED OBJECT TYPES	METER RELATED OBJECT TYPES	COLLECTION RELATED OBJECT TYPES	SCHEDULE RELATED OBJECT TYPES	NOTIFICATION RELATED OBJECT TYPES	LOGGING OBJECT TYPES	LIFE SAFETY AND SECURITY OBJECT TYPES	PHYSICAL ACCESS CONTROL OBJECT TYPES	SIMPLE VALUE OBJECT TYPES	LIGHTING CONTROL OBJECT TYPES
Device	Averaging	Command	Accumulator	Group	Calendar	Event Enrollment	Event Log	Life Safety Point	Access Zone	Character String Value	Channel
Analog Input	Loop	Load Control	Pulse Converter	Global Group	Schedule	Notification Class	Trend Log	Life Safety Zone	Access Point	DateTime Value	Lighting Output
Analog Output	Program			Structured View		Notification Forwarder	Trend Log Multiple	Network Security	Access Door	Large Analog Value	
Analog Value						Alert Enrollment			Access User	BitString Value	
Binary Input									Access Rights	OctetString Value	
Binary Output									Access Credential	Time Value	
Binary Value									Credential Data Input	Integer Value	
Multi-State Input										Positive Integer Value	
Multi-State Output										Date Value	
Multi-State Value										DateTime Pattern Value	
File										Time Pattern Value	

one place and then distributed to other destinations. This provides flexibility, since the destinations can be maintained in a single location in a presumably more powerful device, and benefits less-capable devices that may not have the ability to store a potentially large set of destinations.

Another refinement has been the addition of an Alert Enrollment object type. The Alert Enrollment is similar to Event Enrollment except that "alerts" are free-form, stateless annunciations of whatever the originator wishes to convey, independent of any particular algorithm or property. This satisfies the long-desired wish to be able to "just send a notice about something" that doesn't fall into any particular category.

Data Representation. Back in 1995, the only kind of simple data that BACnet could directly represent were binary and analog values where the latter had to be real floating point numbers. Over the years there had grown the desire to able to represent a much greater set of data types. Enter the "simple value objects." Again, see *Table 2*. Not surprisingly, once the committee got ahold of the project, the simple objects became much more complex with some people wanting commandability, intrinsic event reporting, etc., just like most other full-fledged objects. The compromise was to equip the objects with all of the properties needed for this more complicated functionality but to make the properties optional. So now you can have simplicity or complexity, your choice.

Twenty Years of BACnet

2001 – 2002

June 2001 First consolidated revision "BACnet-2001" published. Additional consolidated revisions published in 2004, 2008, 2010, and 2012.

August 2001 BACnet delegation visits China.

October 2002 ASHRAE Journal publishes first "BACnet Today" supplement. The supplement was published through 2013.

2003

January BACnet adopted verbatim as ISO 16484-5, to be maintained by ISO/TC 205, Building Environment Design. ASHRAE chosen as Secretariat.

July BACnet companion ANSI/ASHRAE Standard 135.1, Method of Test for Conformance to BACnet, published. Consolidated updates published in 2007, 2009, 2011, and 2013.

November First European Plugfest held in Stuttgart, Germany. European Plugfests have been held every year since.

2004 – 2005

May 2004 BACnet delegation visits Dubai and

Moscow. BIG-Middle East forms.

September 2004 First BACnet Europe Journal published by MarDirect. Today there are also journals for China; France; Italy; Latin America, Portugal and Spain; and the Middle East.

February 2005 BIG-Russia and BIG-Sweden are announced.

December 2005 ANSI/ASHRAE 135.1 published for first time as ISO 16484-6.

Access to Collections of Data. The Group object type, one of the originals in BACnet-1995, provides access to collections of property values in the *same device*. The Global Group object type extends this idea to property values derived from objects *anywhere* in the BACnet internetwork and adds the ability to generate event notifications and to monitor a set of status flags along with other properties. The Structured View object type provides access not to a set of values but to a collection of objects related

2006 – 2009

January 2006 BACnet International launched from consolidation of BIG-NA and the BMA.

March 2006 New BTL testing lab opens in India.

April 2007 BACnet France Association forms, in Paris.

July 2007 BACnet Interest Group–Finland (BIG-FI) is announced.

September 2009 BIG-Poland forms.

October 2009 BIG-China forms and BACnet Forum 2009 Beijing is held.

2010 – 2012

July 2010 BACnet International Journal debuts.

October 2012 "BACnet-2012," the very latest and greatest, published.

2015

March 2015 Internet Engineering Task Force selects BACnet MS/TP as the standard data link protocol for IPv6 over twisted pair, making possible BACnet's participation in the "Internet of Things."

by some characteristic of importance to the implementer and is intended to allow the creation of meaningful hierarchies of objects. Each Structured View object has a Node_Type property that is intended to suggest the purpose of the object rather than a precise definition. Node types include UNKNOWN, SYSTEM, NETWORK, DEVICE, ORGANIZATIONAL, AREA, EQUIPMENT, POINT, COLLECTION, PROPERTY, FUNCTIONAL, OTHER. BACnet-2012 suggests interpretations of these but there is also a character string Node_Subtype property so just about anything is possible.

New Network Types. One of BACnet's strengths is that it can potentially run over any network. Since 1995, BACnet/IP was added to provide full Internet Protocol support. And recently the first description of using BACnet over a wireless network was provided with a ZigBee specification.

BACnet Web Services. To support "enterprise integration", i.e., applications at an enterprise level that need access to facility data such as energy use, occupancy, temperature setpoints, room conditions, and so on, the committee developed BACnet Web Services (BACnet/WS). The key concept is that the BACnet/WS data model and access services are *generic* and can be used to model and access data from any

TABLE 3 BACnet Working Groups. The OS-WG is the only direct descendant of the three working groups that were formed in 1987, at our first committee meeting, combining the original "Object Types and Properties" and "Application Services" WGs.

WORKING GROUP	PURPOSE
AP-WG: Applications	To develop applications-oriented "profiles" to represent building system devices such as chillers and VAV controllers.
DM-WG: Data Modeling	To develop the BACnet framework(s) for complex data models both on the wire and in other machine readable formats. This is the home of the new BACnet/WS extensions.
EL-WG: Elevator	To develop BACnet extensions to allow the monitoring of elevator/escalator systems.
IP-WG: Internet Protocol	To extend BACnet/IP capabilities to deal with developments such as NAT firewalls and IPv6.
IT-WG: Information Technology	To examine future communication requirements of building automation systems and how they might affect BACnet. An important theme is IT-BAS convergence.
LA-WG: Lighting Applications	To research, draft, and propose additions to BACnet to support the requirements of lighting control applications.
LSS-WG: Life Safety and Security	To research, draft, and propose additions to BACnet to support the requirements of life safety and security applications such as fire alarm and control systems.
MS/TP-WG: Master-Slave/Token-Passing	To work on enhancements and issues relating to BACnet MS/TP LANs and PTP communications.
NS-WG: Network Security	To develop ways to manage the primary workstation in life safety emergencies and to develop a general mechanism for authorizing and transferring control authority along with auditing mechanisms.
OS-WG: Objects and Services	To develop protocol modifications to support new objects and new services.
SG-WG: Smart Grid	To develop protocol enhancements to enable a building to act as a full participant in the grid - receiving price and event signals from grid operations as well as requests for resource status, and responding to grid signals with control actions to appropriately manage energy.
TI-WG: Testing and Interoperability	To extend and maintain Standard 135.1 - the BACnet Testing Standard, to extend and maintain the BACnet Interoperability Building Block definitions and Device Profiles, and to identify and resolve existing interoperability issues in the BACnet standard itself.
WN-WG: Wireless Networking	To investigate the use of BACnet with wireless communication technologies such as ZigBee, the 802 series of wireless Ethernet, and others.

source, whether the data is local to the web services server or the server is acting as a gateway to other standard or proprietary protocols. The interface is also bidirectional so that data can be written from the enterprise application to the underlying control system, regardless of its intrinsic communication protocol. BACnet/WS was designed for simple data exchange and history retrieval for simple clients and is currently being significantly extended to allow for more complex data types and subscription services.

Network Security. Compared to the security provisions of BACnet-1995, the current security architecture is sweepingly comprehensive and can protect BACnet messages to whatever degree is needed. It is designed to apply to all BACnet network types, device types, message types, and so on. Perhaps because of its inherent complexity and the growing availability of other technologies, this BACnet security capability has yet to find significant deployment.

Specifying BACnet. This is a topic unto itself. BACnet-2012 contains descriptions of eight standardized "Device Profiles" that are defined in terms of support for specific "BACnet Interoperability Building Blocks" for the five "Interoperability Areas," Data Sharing, Alarm and Event Management, Scheduling, Trending, and Device and Network Management. These can be used to put together a specification that is precise and can be used to compare "apples to apples" when the bids arrive.

BACnet Going Forward

While BACnet's evolution has been impressive, it is continuing to be developed at an incredible pace. Here is some of the current work:

- Elevator/escalator support.
- Extended BACnet/WS capabilities, featuring REST, JSON and OAuth2 technologies.
- IPv6 support for all BACnet network types.
- Extended MS/TP frames. This has just been approved and the Internet Engineering Task Force has been given a Frame Type assignment to carry encapsulated IPv6 data. This will allow MS/TP to potentially be a key part of "Internet of Things" communication.
- Network Port Object Type to allow viewing or modifying the characteristics of whatever network ports a BACnet device may have.
- New object types such as Timer and Binary Lighting Output.
- Automatic configuration of MS/TP addresses.

I know I have short-changed some of the current work and, probably, even some of the additions of the last 20 years but space is limited. I haven't even mentioned the testing standard, 135.1. If you want to get up to speed, please read the standard(s), visit www.bacnet.org or, better yet, attend some committee meetings. All are welcome!

References

1. ISO 7498 (1984), *Information processing systems—Open Systems Interconnection—Basic Reference Model*.

For Further Reading

ANSI/ASHRAE Standard 135-2012, *BACnet—A Data Communication Protocol for Building Automation and Control Networks.*
ANSI/ASHRAE Standard 135.1-2013, *Method of Test for Conformance to BACnet.*
Newman, H.M. 2013. *BACnet: The Global Standard for Building Automation and Control Networks.* New York: Momentum Press. ■