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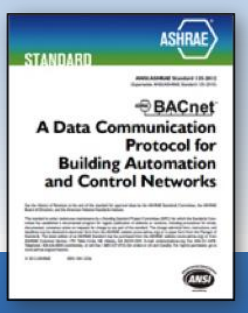
Introduction to BACnet

For Building Owners and Engineers

BACnet International

Purpose

The purpose of this document is to provide an overview of BACnet history, terminology and philosophy for building owners, managers and others involved with BACnet projects. The document provides an introduction to the topic of BACnet but it is not a comprehensive description of BACnet and it is not a product or system implementation guide.



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Introduction to BACnet

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Every effort has been made to assure that the content of this guide is accurate. However it is not a reference document. The definitive document is the BACnet standard.

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Briefly, What is BACnet?

BACnet®, short for "Building Automation Control Network", is a data communication protocol for building automation and control networks. BACnet is both an international (ISO) and ANSI standard for interoperability between cooperating building automation devices.

BACnet History

Originally developed in 1987 under the auspices of the American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE), BACnet has been an ANSI standard since 1995 and an ISO standard since 2003. BACnet is a registered trademark of ASHRAE.

BACnet was developed, and is under continuous maintenance, using an open consensus process where any and all interested parties are welcome and may participate without fees.

Figure 1: BACnet is a consensus standard developed with all stakeholders represented at the table.

ASHRAE (an ANSI-certified standards-body) oversees the standards activities and assures a balanced roster of voting members representing manufacturers, owners, consulting engineers, academia, government and general interest. This long history and open process has resulted in an extremely strong standard with wide support and adoption worldwide by a constantly growing number of manufacturers whose products serve the building automation and related markets.

Purpose of BACnet

BACnet is a standard data communication protocol that enables interoperability between different building systems and devices in building automation and control applications. The term "interoperability" has a variety of meanings from simple information exchange, to deeper integration, to complete and complex interoperation between component devices and systems. While BACnet does not enable "plug and play" device interchangeability, BACnet provides the means for many kinds of basic and complex interoperations to take place using standardized techniques that have proven to be flexible and robust in over 15 years of practice in tens of millions of devices. BACnet does not replace the need for DDC or control logic and does not attempt to standardize how devices are programmed.

BACnet offers a flexible range of networking options including the use of Ethernet or IP-centric infrastructure and a simple, low cost twisted pair communication called MS/TP that is based on EIA-485. A sophisticated routing capability allows scaling of BACnet internetworks into large and efficient systems, all within the same unified standard.

BACnet uses an object-oriented model for abstracting and representing information. BACnet includes 54 standard objects that cover many common and generally useful applications. In addition, there is a mechanism for implementers to create and use their own non-standard objects that can be easily interoperable with other devices that choose to use them. This extensibility is free and guaranteed to be safe against unintended interference from other devices' proprietary extensions. The object-based model has been proven to be both robust and reliable

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while providing a high degree of backward and forward compatibility.

Figure 2: BACnet provides a collection of objects manufacturers can combine to build devices tailored to specific applications.

BACnet also has an extensive application services model that provides many types of useful services that implementers may elect to support in their devices. These services are grouped into the following logical areas: object access, alarm and event management, scheduling, trending, files, device and network management.

In the increasingly important area of enterprise integration, BACnet has made a specific effort to define and standardize a suite of Web Services that provide enterprise applications with well-defined access to building automation information. In addition, initiatives have been undertaken to define XML schema for BACnet-oriented information.

Strong network security is of particular interest for applications in security and access control, some specific types of physical venues, and applications that use the public Internet. BACnet includes provisions for a very strong network security layer that address the needs of these kinds of applications.

BACnet currently employs a rigorous classification methodology for defining device capabilities. This allows vendors to publish the specific capabilities of their BACnet devices using standard terms and format, and for building owners and project specifiers to define their requirements for BACnet devices.

A global, independent third party testing and listing program for BACnet devices has been established. The BACnet Testing Laboratories (BTL) is managed under auspices of BACnet International. BTL awards the "BTL Mark" to devices that are shown to be tested according to ASHRAE Standard 135.1, the companion test standard to BACnet.

Figure 3: The BTL Mark on products assures users that they have been independently tested according to industry standard test requirements.

BTL requires the use of a single testing methodology regardless of the specific organization performing the tests. Various third party companies also offer test-related tools, services and consultation independent of device manufacturers.

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BACnet Overview

The BACnet data communication protocol defines standard methods that manufacturers can implement to make components and systems that can be interoperable with other BACnet components and systems.

Figure 4: The BACnet Standard was developed and is currently extended and maintained by the ASHRAE SSPC 135 committee

Building owners and system specifiers can also use BACnet as a tool for the specification of interoperable systems.

BACnet does not replace the need for specifying what a user wants or needs. It simply provides some standardized tools to help enable the creation and specification of systems that can interoperate.

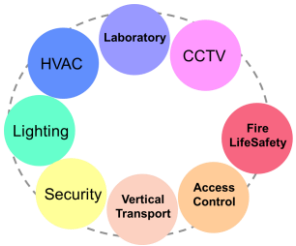

Figure 5: The BACnet Standard addresses integration across a broad range of building systems.

BACnet includes but is not limited to HVAC applications. It is intended to apply to all types of automated building systems. There are interoperable products available in each of these categories: fire, security, lighting, HVAC, elevators, etc.

BACnet addresses the goal of interoperability by defining a generalized model of how automation devices work, a method for describing the information that they contain, and a method for describing protocols that one device can use to ask another device to perform some desired action.

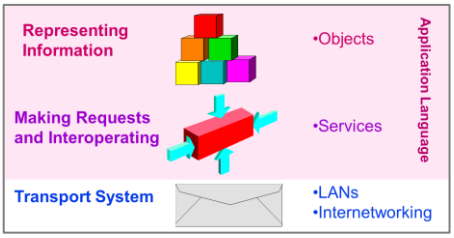

Figure 6: BACnet addresses interoperability at all levels of device communication architecture.

Devices

A BACnet device is often comprised of a microprocessor-based controller and software combination that is designed to understand and use the BACnet protocol. A BACnet device is typically a controller, gateway, or user interface. Every BACnet device contains a device *object* that defines certain device information, including the device object identifier or instance number. A BACnet device object instance number must be field-configurable to be unique across the entire BACnet network where the device in installed. For brevity this number is often called the *device instance*. In addition to the device instance, each BACnet device contains a collection of information about the device and any input and output points that it monitors and controls. The collection of information frequently includes control programs and logic as well as data values.

Device Interoperability

BACnet divides the task of device interoperability into three distinct areas: Objects (information), Services

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(action requests), and Transport systems (internetworking, electronic messages). BACnet defines methods and requirements for implementation of each of these areas.

Objects

All information within an interoperable BACnet device is modeled in terms of one or more information *objects*. Each object represents some important component of the device, or some collection of information that may be of interest to other BACnet devices. Objects may represent single pieces of information, or a collection of multiple pieces of information such as a logical grouping. Objects represent either physical or virtual information, such as analog and binary inputs and outputs, control algorithms, specific applications, and calculations.

The BACnet standard defines 54 different standard object types. The implementation of a given device may make use of arbitrary combinations of these standard object types to represent information and control logic that are relevant to the device's specific application. Standard object types are useful because their meaning and application are well defined and their components consistently implemented from one device to another. The BACnet standard also allows for the creation of non-standard or proprietary objects for which interoperability with other vendors may not be as consistent.

Each object is identified with an object identifier. An object identifier is a 32-bit binary number containing a code for the object type and the object instance number. In addition, every object, no matter its purpose or function, has a collection of *properties* that define the object. Each *property* includes at least a name and a value.

Properties

A BACnet *property* conveys information about a BACnet object. Objects have a collection of properties, based on the function and purpose of the object. Each property contains two pieces of information: a property identifier and the property's value. Property Identifiers are numbers that uniquely identify a given property in the context of the Object type. Properties may be defined as read-only or read/write. A property's purpose is to allow other BACnet devices to read information about the object containing the property, and potentially write (change) a different value to the property. Depending on the type of object that the property belongs to, particular object properties may be optional or required for implementation per the BACnet standard. For each

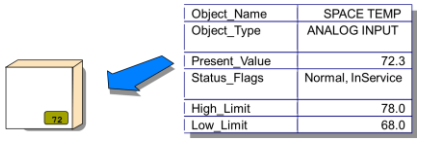

Figure 7: BACnet Objects include properties that define their capabilities, operation and related data

standard BACnet object type, the BACnet standard defines which properties are required and which are optional. Objects may also contain properties that are non-standard or proprietary.

Services

BACnet *services* are formal requests that one BACnet device sends to another BACnet device to ask it to do something.

Services are grouped into five categories of functionality – object access (read, write, create, delete); device management (discover, time synchronization, initialize, backup and restore database); alarm and event (alarms and changes of state); file transfer (trend data, program transfer); and virtual terminal (human machine interface via prompts and menus). The service defines each request,

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and any parameters that need to be conveyed in the request and its reply.

The model of objects and services is realized by encoding messages into a stream of numeric codes that represent the desired functions or services to be performed. The "language" of this encoding is common to all BACnet devices. BACnet devices exchange information and do things by sending and receiving electronic messages containing this coded language. BACnet provides flexibility by allowing multiple types of *transport systems* to be used to convey these coded messages between devices.

Transport Systems

The *transport system* uses different types of electronic messaging standards and methods to convey coded messages. Even though different transport methods are used, the coded message content remains the same. This philosophy allows the designer or specifier to choose the most cost-effective transport method for a given application.

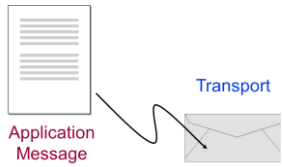

Figure 8: BACnet provides multiple message transport options to meet the needs of different applications

Network Types

The 2012 BACnet standard defines seven network types, which serve as the transport for BACnet messages. The seven supported network types are:

- BACnet/IP
- BACnet MS/TP (Master-Slave/Token Passing)
- BACnet ISO 8802-3 (Ethernet)
- BACnet over ARCNET
- BACnet Point-to-Point (EIA-232 and Telephone)
- BACnet over LonTalk Foreign Frames
- BACnet over ZigBee

The network types encompass the physical and datalink layers of the protocol. This combination of physical and datalink layers is often called the MAC (Medium Access Control) layer.

A BACnet message itself is independent of the MAC layer used to transport the message.

Therefore, in BACnet, messages to command or monitor information are the same, no matter which MAC layer used for transport.

A BACnet router is used to join multiple network types. A BACnet router is a device that links dissimilar

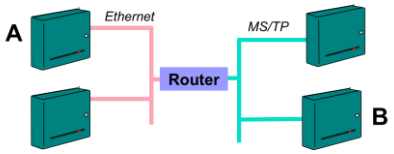

Figure 9: BACnet allows for routers to connect various network types. Routers can be standalone devices or can be built into automation controllers.

network types (e.g., BACnet/IP to MS/TP, BACnet 8802-3 to ARCNET) and passes BACnet messages among the network types without changing or disturbing the message content.

Network Type Caveats

BACnet/IP

This MAC type is commonly used with existing Ethernet infrastructure, VLAN and WAN networks. Devices plug directly into Ethernet switches or hubs. This is a fast and high performance type of LAN, but also the most expensive. BACnet/IP uses UDP/IP for compatibility with existing IP infrastructure. When BACnet/IP is used with multiple IP subnets, then special additional device functionality called BACnet Broadcast Management Devices (BBMDs) are required to manage inter-subnet BACnet broadcast messages.

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BACnet MS/TP

This LAN type uses EIA-485 twisted pair for signaling up to 4000 feet. It is the most popular type of BACnet LAN for unitary and application-specific controllers, and is also the lowest cost.

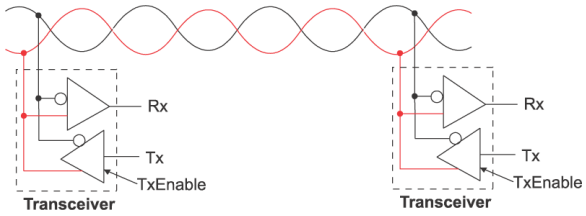

Figure 10: Standard twisted pair wiring is one of the options supported by BACnet

BACnet ISO 8802-3 (Ethernet)

BACnet can be used directly with Ethernet 8802-3 networks. This MAC type is comparable to BACnet/IP in terms of cost and speed, but limited to a single physical infrastructure that does not make use of IP routers.

BACnet over ARCNET

This MAC type has two forms: 2.5Mbs coax, and 156Kbs over EIA-485. The ARC156K form has a modest increase in performance compared to MS/TP for a slight cost difference. A limited number of vendors support BACnet using ARCNET.

BACnet Point-to-Point

This MAC type is only used over dial-up telephone networks. The direct EIA-232 connection style is generally no longer used in favor of direct Ethernet connection.

BACnet over LonTalk Foreign Frames

BACnet allows the transport component of LonTalk to be used to carry BACnet messages. However, the two protocols are not interoperable.

BACnet over ZigBee

This MAC is a wireless mesh network generally used with very low-cost devices. It is typically used as a gateway to ZigBee devices and not as a native BACnet transport.

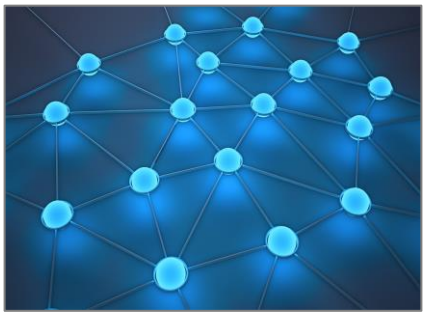

Figure 11: ZigBee is one of the wireless networks supported by BACnet

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Interoperability Areas

Using the concepts of devices, objects, properties, and services, BACnet provides functional capabilities referred to as "Interoperability Areas." There are five Interoperability Areas: Data Sharing, Trending, Scheduling, Alarm & Event Management, and Device & Network Management. These Interoperability Areas are defined by BACnet Interoperability Building Blocks (BIBBs), which are discussed in the ***Specifying Interoperability with BACnet*** section later in this document.

Data Sharing

Data Sharing is the exchange of information between BACnet devices. It may be uni-directional or bi-directional. Interoperability in this area permits the collection of data for archival storage, graphics, and reports, the sharing of common sensor or calculated values between devices, the carrying out of interlocked control strategies, and the modification of setpoints or other operational parameters of BACnet objects.

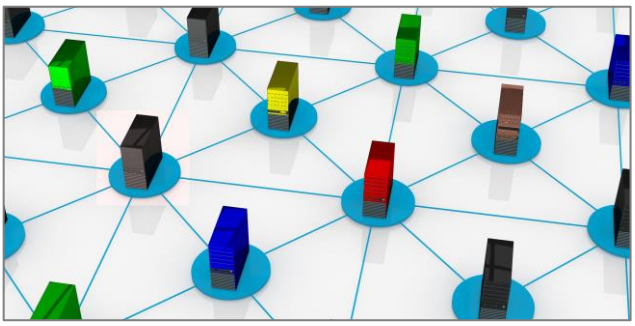

Figure 12: BACnet enables data sharing among different types of devices from a broad set of suppliers

In Data Sharing, a client device requests data from a server device, and may also send control commands to the server. Typical Data Sharing requests that a client will make to a server are ReadProperty and WriteProperty.

A WriteProperty request allows a client device to write to (possibly changing) a property of an object in the server device. If two or more clients write to the same property of the same object in the same device, then the most recent write takes effect.

In situations where there is a need to synchronize the actions of multiple clients potentially writing to the same property, implementers may elect to use a command prioritization mechanism. In this case, the write property request will be accompanied by a command priority from 1 to 16 where 1 is most important and 16 is least important. If the command priority is absent from a write request, it defaults to 16 (least important). If a command priority is provided to an object that does not support prioritization, then the priority is ignored.

A *commandable object* usually has one property, often the Present_Value property, which benefits from this special behavior.

Additionally, a commandable object has two special properties: Priority_Array and Relinquish_Default. When a new value is written to a commandable Present_Value at priority X, that new value is recorded in the Xth slot in the Priority_Array. After the value is recorded, the Priority_Array is examined from slot 1 to 16 (in decreasing order of importance). The value contained in first non-empty slot is then used to set the commandable Present_Value property. Values associated with less important (lower priority) writes are still saved in the Priority_Array. When a client no longer requires control of the commandable object, it *relinquishes control* at the priority level it had previously written by writing a special *null* or empty value to that priority. After control is relinquished, the Priority_Array is again examined for the lowest (most important) non-empty slot. If all 16 slots of the Priority_Array are empty, then the special property Relinquish_Default's value is used to set the commandable Present_Value property.

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BACnet Priority

As a rule, a given BACnet "site" may use its own unique interpretation of the meaning for each priority level as long as those meanings are consistent throughout that location. However, BACnet recommends the following standard priority-level meanings that should be used unless there is a compelling reason not to:

1. Manual Life-Safety
2. Automatic Life-Safety
3. Available
4. Available
5. Critical Equipment Control
6. Minimum On/Off
7. Available
8. Manual Operator
9. Available
10. Available
11. Available
12. Available
13. Available
14. Available
15. Available
16. Available (Default)

Change Of Value (COV)

In the simplest cases, data sharing uses reading and writing of object property values to exchange information between devices. However, when a large number of values are exchanged frequently, a side effect is that a lot of traffic must occur on the network to carry the back and forth exchanges. In many cases values don't actually change very often so this continuous updating wastes available network time exchanging values that haven't changed since the last time they were sent. One way to mitigate this traffic is to use a Change Of Value (COV) scheme. With COV, the client *subscribes* to the server device that contains the value of interest and indicates a minimum amount of change that is required for notification. After the subscription is accepted, the server device itself watches the object property. If the value changes by more than the trigger amount since the last reported value, then the server issues a COV Notification message that reports the change. In this way, only changing values get reported, thus saving a lot of network traffic. But COV is not a substitute for reading values. When the client tries to make a subscription, the server may not be able to accept it. Servers typically have a limited number of subscriptions available and they may all be in use. The client must fall back to using a ReadProperty in that case. Once subscribed, if the client has not seen a change notification for "a while" it may be because the value hasn't changed, or because the notification has not been able to reach the client due to traffic, router congestion and other causes. So clients must periodically re-subscribe in order to keep values from becoming stale, and to keep using the subscription resource.

Trending

Trending allows BACnet devices to enable trend collection and request trend data from other BACnet devices. Although it is possible to use ReadProperty or COV methods to sample data periodically from a central location, these techniques do not scale very well. As the number of sampled data points gets larger, more and more data must be brought back to the central location within the sample interval. In BACnet, rather than having the central location gather the accumulated trend data, the burden of sampling is distributed into multiple devices.

Trend Log objects manage the sampling of data at some interval, and the storing the data samples themselves. The Trend Log uses COV (when possible) to attempt to sample data from a monitored object property, falling back to ReadProperty when necessary. A supervisory client or workstation may

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periodically check the Trend Log and read its data in bulk. Alternatively the Trend Log can send a special EventNotification after some number of samples or when the Trend Log starts to near its capacity. This signals the supervisory device to come and collect the trend data.

Some Trend Log implementations can only trend (sample) data from object properties of objects in the same device as the Trend Log object (so-called *internal trending*). Other implementations in client devices may also be able to communicate outside of the device to sample data from objects in other devices (*external trending*).

Scheduling

Scheduling allows BACnet devices to establish and edit schedules that reside in BACnet devices so that control can be coordinated based on dates and times. BACnet Calendar objects are used to indicate whether each day is active or inactive according to that calendar. Device programs may look at the Calendar and decide to do something based on that status. Individual dates may be specified, as well as ranges of dates. The date list may also include WeekNDays which are (day-of-week, week-of-month, month) ordered lists. Individual parts of dates, date ranges and WeekNDays may include special values for ANY. For example (Tuesday,2,ANY) means the second Tuesday every month. These allow for powerful repeating schedules to be created that do not have to be revised every month or year.

Schedule objects are based on the idea of *time values* which are pairs (time,value) that specify a value to use at a particular time. One way of thinking of BACnet schedules is a variable value that changes at different times during each day. In its simplest form the Schedule object has a Weekly_Schedule which is an array of seven slots that correspond to the days of a normal week: Monday, Tuesday, Wednesday, etc. Each slot contains a list of time values to be used on that day. The Schedule also has an Effective_Period that specifies when it should be used.

Although the Weekly_Schedule may suffice for most days, if there are special days or a period where a different schedule is needed, that is accommodated by an Exception_Schedule. BACnet calls these *special events* which are themselves an ordered list of (activedays, time values, priority). The activedays may reference a Calendar so that the special event is only

Figure 13: BACnet provides robust scheduling mechanisms to support a broad set of building system requirements

valid on days when the Calendar is active. Alternatively the special event may be active for a particular Date, Date Range or WeekNDay. The time values represent times on those days when the special event takes precedence over any Weekly_Schedule that may be in effect on that day and time. If more than one special event is scheduled for the same day and time, the EventPriority specifies their relative importance to each other.

Although device programs may monitor a Schedule object value to determine what to do from moment to moment, it is more common for the Schedule to *write to* other object properties when the schedule value changes. The Schedule includes a list of *references* or *bindings* to other object properties that are written by the Schedule object. Some devices are only servers and do not have the ability to write to objects except those that reside in the same device as the schedule. These

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are called *internal schedule* devices. Devices that are also clients may have the ability to write to object properties in *other* BACnet devices. These kinds of devices often can also provide *external scheduling*.

Alarm & Event Management

Alarm & Event Management defines the exchange of data based on pre-defined alarm limits or event triggers. The event or alarm may require human intervention and acknowledgement. Alarms and events may also be logged and summaries generated. In BACnet, alarms and events are essentially the same. An object that detects an alarm uses an associated Notification Class object to determine if, when and where the alarm should be reported. An EventNotification message can be sent to one or more *alarm recipients*.

Intrinsic Reporting means that a particular object has alarm detection built in to the logic of the object itself. *Algorithmic Reporting* means that an Event Enrollment object is used to do the detection by constant monitoring of some other object and applying one of several standard algorithms (procedural rules) and parameters to detect the alarm. BACnet devices may use one or both mechanisms for alarm detection.

For alarm detection, BACnet objects maintain an *event state*, which is NORMAL, OFFNORMAL or FAULT. There are several kinds of OFFNORMAL and FAULT conditions that can occur. The Notification Class object is a dispatcher that evaluates the alarm transition from one state to another. It can decide whether to ignore the alarm, or to initiate a notification. It can choose among recipient devices for notification based on the new state, time of day, days of week and several other criteria. Notifications can be transmitted once, or repeatedly until a *confirmation* is received from the recipient. They can also specify whether a *human acknowledgement* is required for a given notification. The notifications may be prioritized and classified as well.

Device & Network Management

Device & Network Management allows BACnet devices to discover other BACnet devices, discover objects within devices, establish and re-establish communications, synchronize time, and re-initialize a device's program.

Binding is the process of establishing connections between devices. One device needs to know the BACnet network segment and MAC address where another device is located. BACnet requires a unique one-to-one relationship between a given device instance and a (network number, MAC address) pair. A *device binding* is the relationship between a device instance and the (network,MAC) pair. Although device bindings can be created statically (by a human configuration), when there are many devices, this can be a big maintenance challenge if network numbers or MAC addresses ever change. Typically devices only remember the device instance and perform *dynamic device binding*. Dynamic device binding requires the use of BACnet Who-Is and I-Am services so that a client can transmit a "Who-Is device X" request and then only device instance X will reply with "I-Am device X". The reply contains the device's current network number, MAC address and additional information (like Vendor ID). This allows devices to discover each other dynamically.

There is also a *dynamic object binding* which allows devices to remember objects by name and issue "Who-Has object name" in order to locate the object (and its instance) and the object identifier of that named object.

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Specifying Interoperability with BACnet

BACnet devices can vary greatly in their implementation of BACnet features and functionality. There is no such thing as "one size fits all" for building automation, so BACnet had to be flexible in allowing the many different kinds of features that are found in a wide range of devices, yet still assure that devices could interoperate with each other at a feature level.

The standard defines a format for disclosing BACnet information such that vendors, customers and consulting engineers can use that information to understand the functionality implemented in a given device. The Protocol Implementation and Conformance Statement (PICS) is a standardized BACnet datasheet for disclosing BACnet features implemented in a given device. A key element of the PICS is the use of BACnet Interoperability Building Blocks (BIBBs). BIBBs define sets and groupings of functionality that can be easily compared from device to device, to determine which BACnet features should be interoperable between devices.

Figure 14: BACnet Interoperability Building Blocks (BIBBs) simplify specification development and product selection.

A robust treatment of the many considerations required for writing specifications that include building automation interoperability is beyond the scope of this guide.

Protocol Implementation and Conformance Statement (PICS)

The PICS is a tool for consulting engineers, vendors and customers to determine what functionality devices support and what functionality is interoperable with other devices. The PICS format may vary between vendors, but it defines basic information in BACnet terms that is common among vendors. The PICS discloses the following areas of information about a BACnet device:

- Product name, version, and description
- Device profile (BACnet standard Annex L) to which the device conforms
  - *B-OD, B-OWS, B-AWS (BACnet Operator Workstations)*
  - *B-BC (BACnet Building Controller)*
  - *B-AAC (BACnet Advanced Application Controller)*
  - *B-ASC (BACnet Application Specific Controller)*
  - *B-SS (BACnet Smart Sensor)*
  - *B-SA (BACnet Smart Actuator)*
- BIBBs supported by the device
  - *Data Sharing*
  - *Trending*
  - *Scheduling*
  - *Alarm and Event*
  - *Network Management*
  - *Device Management*
- Segmentation support and window size
- Standard object types supported, plus an indication of objects that can be created and deleted by a third-party BACnet system/device. For each object type supported, the PICS also lists those optional

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properties that are implemented, and any range restrictions on property values.

- MAC layers support
  - *BACnet/IP (Annex J)*
  - *BACnet Ethernet (10,100,1000Mbs and media types)*
  - *BACnet ARCNET (2.5Mbs, 156Kbs)*
  - *BACnet MS/TP (EIA-485 Master-Slave/Token Passing datarates)*
  - *BACnet Point-To-Point (EIA-232,modem)*
  - *BACnet LonTalk over Foreign Frames*
  - *BACnet over ZigBee*
- Device address static binding support
- Networking options support
  - *Router*
  - *BACnet Tunneling (Annex H)*
  - *BACnet/IP BBMD (BACnet Broadcast Management Device)*
- Character sets support
  - *UTF-8*
  - *ISO 10646 (UCS-4)*
  - *IBM/Microsoft DBCS*
  - *ISO 10646 (UCS-2)*
  - *JIS X 0208*
  - *ISO 8859-1*

BACnet Interoperability Building Blocks (BIBBs)

BIBBs provide a logical method for disclosure of BACnet device support for all of the BACnet interoperability areas. Interoperability functions are grouped into categories or areas:

1. Data Sharing
   a. *Read/write property*
   b. *Read/write multiple properties*
   c. *COV (Change of Value)*
   d. *Unsubscribed COV*
2. Trending
   a. *Viewing and modifying trends – internal*
   b. *Viewing and modifying trends – external*
   c. *Automated trend retrieval*
3. Scheduling
   a. *Scheduling – internal*
   b. *Scheduling - external*
4. Alarm and Event Management
   a. *Alarm and event notification – internal*
   b. *Alarm and event notification – external*
   c. *Alarm acknowledgement*
   d. *Life safety alarm*
5. Device Management
   a. *Device binding - discovery and connection*
   b. *Object binding - discovery and connection*
   c. *Device communication control*
   d. *Private transfer of message*
   e. *Text message*
   f. *Time synchronization*
   g. *UTC time synchronization*
   h. *Reinitialize device and restart notification*
   i. *Backup and restore device database*
   j. *List manipulation*
   k. *Object creation and deletion*
   l. *Virtual terminal*
6. Network Management
   a. *Device connection establishment*
   b. *Router configuration*

Each BIBB is defined with an A or B in terms of prescribed functional support:

– A: User of data as a client - initiate function

– B: Provider of data as a server - execute function

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Achieving interoperability between two or more BACnet devices requires support for the A type functionality in the device acting as the user of data, and support for the B type of functionality in the provider of the data. All devices that claim to implement a given BIBB must support the function required (BIBB) and the "Initiate" or "Execute" side of the functionality, depending on the role of the device. For example, if one device supports DS-RP-A and a second device supports DS-RP-B then it is expected that those two devices can interoperate the DS-RP feature together.

BACnet Listing

In 2000, the BACnet community created a not-for-profit organization to address interoperability testing and listing services for manufacturers of BACnet devices. This organization is called the BACnet Testing Laboratories, or BTL, and it operates under the auspices of BACnet International.

Figure 15: BACnet Interoperability Workshops help to ensure multi-vendor projects go smoothly

Two key tasks of this organization are:

- Sponsoring an annual BACnet Interoperability Workshop ("PlugFest") where suppliers can test BACnet implementations in a broad, multi-vendor interoperability environment.
- BTL awards the "BTL Mark" to devices which are shown to be tested according to ASHRAE Standard 135.1, the companion test standard to BACnet. To maximize global testing consistency, BTL requires the use of a single testing methodology regardless of the specific organization performing the tests.

Figure 16: The BTL Mark on products assures users that they have been independently tested according to industry standard test requirements.

Vendors may or may not submit their products for independent testing according to the globally recognized BTL methodology. Customers can identify products that have been tested through the BTL process by referring to the BTL listing maintained at http://www.bacnetinternational.net/btl/ or by the presence of the BTL Mark on the product itself. BACnet International recommends that Customers require the use of BTL Listed products whenever possible.

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BACnet Terminology

ANSI
Acronym for *American National Standards Institute*

ASHRAE
Acronym for *American Society of Heating, Refrigerating, and Air Conditioning Engineers*

Analog
A variable number used to measure a continuously varying entity, such as pressure or temperature.

BACnet
Acronym for "Building Automation Control Network". Also ANSI/ASHRAE Standard 135-2012. BACnet is an ASHRAE and ANSI standard protocol, which is a protocol designed for the building automation industry. This is also an international standard known as ISO 16484-5. The testing of BACnet is based on a companion standard ANSI/ASHRAE 135.1-2011.

BACnet Broadcast Management Device (BBMD)
Some BACnet operations such as dynamic device binding rely on broadcast messages that are received by every BACnet device on a local segment, and in some cases across segments or globally within the whole BACnet internetwork. Because of how IP handles routing, broadcasts cannot cross IP subnets. In situations when there are multiple IP subnets with BACnet/IP devices, a special device functionality is required to deliver broadcasts to all members of a multi-subnet community. BBMDs fill this role. The functionality of BBMDs is often built in to larger controllers or routers, but not always.

BACnet Interest Group (BIG)
Associations formed by BACnet users for the benefit of BACnet users. BIGs enable individuals to exchange information and share experiences about the implementation and application of BACnet. Many BACnet Interest Groups have formed around the world to support BACnet users. There is BACnet International, BIG-EU Europe , BIG-CA China/Asia, BIG-FI Finland, BIG-ME Middle East, BIG-PL Poland, BIG-RU Russia, BIG-SE Sweden and BIG-AA AustralAsia.

BACnet International
BACnet International is the international organization that encourages the successful use of BACnet in building automation and control systems through interoperability testing, educational programs and promotional activities. BACnet International complements the work of other BACnet-related groups whose charters limit their commercial activities.

BACnet International community membership includes a who's who list of top tier companies involved in the design, manufacturing, installation, commissioning and maintenance of control and other equipment that use BACnet for communication.
(More Information on BACnet International)

BACnet International was formed from the merger of the BACnet Manufacturers Association (BMA) and BIG-NA North America.

BACnet Interoperability Building Blocks (BIBBs)
Collections of one or more BACnet services that function to define the interoperational capabilities of BACnet device. Certain BIBBs may also be predicated on the support of certain, otherwise optional, BACnet objects or properties. BIBBs may also constrain allowable values of specific properties or service parameters.

BACnet Testing Laboratories™ (BTL)
BACnet Testing Laboratories was established by BACnet International to support conformance testing and interoperability testing activities and consists of BTL Manager and the BTL-WG (BTL Working Group).
(More BTL Information)

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BACnet/IP or B/IP
BACnet/IP or B/IP refers to the BACnet MAC layer that uses UDP/IP messaging to transport BACnet messages across IP infrastructures.

Binary
In BACnet, binary generally refers to discrete two-state values. See also *Digital*.

Bridge
A device that connects two datalinks together. A bridge can connect a wired Ethernet and fiber-optic Ethernet, for example. Unlike routers, bridges are protocol-independent. They forward messages without analyzing their content.

Client
In networked systems, an application or device acting as a requestor or consumer of data. A client makes requests to a server device for data resident in the server or for the server to perform actions on its behalf.

Datalink
The datalink layer as defined in the OSI (Open Systems Interconnection) model. The datalink organizes a package of data into a structure and manages the delivery of that data to a specific destination. In BACnet ANSI/ASHRAE Standard 135-2012, there are seven distinct datalink network types:

- BACnet/IP
- BACnet ARCNET
- BACnet Ethernet 8802-3
- MS/TP (master-slave/token passing)
- BACnet over LonTalk Foreign Frames
- BACnet PTP (point-to-point)
- BACnet over ZigBee

Device Instance
The instance portion of the Object_Identifier of a given device's Device object. Unlike all other object types, each device may contain only one Device object. The instance number of this Device object must be field-configurable so that it may be assigned a unique instance number among all of the Device objects of all of the devices on a given BACnet internetwork.

Digital
Discretely valued entities represented by two states, such as an on/off switch. See also *Binary*.

Ethernet
A high-speed MAC layer also known as ISO8802-3.

Extensible Markup Language (XML)
XML is a worldwide standard for defining documents and data structure that has many applications. In the context of BACnet, XML is used with BACnet/WS web services to facilitate the exchange of data and requests with enterprise application programs.

Half-router
In BACnet, a device that can participate as one partner in a point-to-point (PTP) connection. Two half-routers form an active PTP connection and act as a single router.

HTML
HyperText Markup Language is a worldwide standard for defining and identifying format and grouping information ("markup") within text documents. Characteristic styling such as bold, italic, font, color and so forth are indicated by the tagging of words or sections of documents. Most commonly used in web pages.

HTTP
The HyperText Transport Protocol is carried over TCP and is used to facilitate exchange of information typically encoded using text, HTML or XML. Most commonly used in web pages and web services.

ID (Identifier)
BACnet defines three important IDs used to identify BACnet devices, objects, and properties. An Object ID

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identifies an object's type and instance number. A Vendor ID defines the vendor who manufactured a device. A Property ID identifies a property by a code.

IP
Acronym for Internet Protocol. IP handles the breaking up of data messages into packets (also called datagrams), the routing of the packets from their origin to the destination network and node, and the reassembling of the packets into the data message at the destination. IP operates at the internetwork layer of the TCP/IP model, which is equivalent to the network layer of the ISO/OSI reference model.

ISO/OSI Reference Model
Short for International Organization for Standardization /Open Systems

Interconnection Reference Model
The model is the foundation of most network standards. It breaks down network communications into seven conceptual levels, each concerned with a specific aspect of network communications. The seven layers are Application, Presentation, Session, Transport, Network, Data Link and Physical.

Instance
In BACnet, a number that uniquely identifies an object within a device or a device on a BACnet internetwork. See also *Device Instance*.

Internetwork
A set of two or more networks interconnected by routers.

LAN
Acronym for Local Area Network. A single network providing the physical infrastructure for device communication based on a common MAC layer datalink.

Native BACnet
A device that uses BACnet as its principal if not only means of communication.

Medium Access Control (MAC)
The part of a network that handles access to the physical network (medium) for a particular datalink. In BACnet, each device has a unique MAC Address/Network Number combination that identifies it on the BACnet internetwork.

MS/TP
Acronym for Master-Slave/Token Passing. It is a type of MAC layer implemented using the EIA-485 signaling standard. This LAN type is suitable for unitary controller and terminal control communications. To initiate communications on the network, a node must receive a "token" (actually a small message), that is passed from one node to another around the network. Master devices are allowed to have and manage the token, whereas slave devices are allowed only to respond to requests from master devices.

National Institute of Standards &Technology (NIST)
An agency of the U.S. Department of Commerce. The NIST charter is to strengthen the U.S. economy and improve the quality of life by working with industry to develop and apply technology, measurements, and standards. NIST has played an integral role in the development of BACnet.

Object
A collection of information in a BACnet system, described by its properties. An object might represent information about a physical input or output, or it may represent a logical grouping of points that perform some function, such as a setpoint. Every object has an identifier (such as AI-1) that allows the BACnet system to identify it. An object is a collection of data points that contain additional information other than present value. An object is monitored and controlled through its properties.

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Peer-to-Peer (P2P)
A type of network in which messages are passed between each node, and each node is an equal peer on the network that may act as a client or server or both.

PlugFest
Every year BACnet International sponsors an event called PlugFest. BIG-EU sponsors a similar event in Europe. Interested manufacturers and developers of BACnet products get together in host locations (locations vary from year to year), to have a multi-day interoperability test. Groups of vendors with common interests connect their equipment together and do performance and interoperability tests with each other; first testing in small focus groups, and then in a larger network. The results of these tests are confidential to encourage a collegial and interactive event where the whole point is to discover issues and failures without concern or embarrassment.

Point-to-Point
A type of network in which disconnection is the normal status, but when messages are to be passed between nodes, and the nodes are on different networks, then network routers make a temporary connection. Used primarily for dial-up telephone connections.

Properties
An individual data element of an object. Every object may contain an arbitrary number of properties that define aspects of the object's operation or knowledge. Properties may act as indicators of information known to the object or as "setpoints" or receivers of information from outside of the object. BACnet specifies over 350 standardized properties for objects. Three properties (Object_Identifier, Object_Name, and Object_Type) must be present in every object. BACnet also requires that certain objects support specific additional properties. The type of object and the type of device in which that object resides determine which properties are present. Some properties can accept writes, and others can only be read.

Protocol Implementation Conformance Statement (PICS)
A document that details the particular BACnet objects, services and capabilities supported by a type of BACnet device. Every BACnet-conforming device has an associated PICS published by the manufacturer.

Router
A device that connects two or more, usually different, MAC layers together. Routers are similar to bridges, but provide additional functions, such as message routing and forwarding based on various criteria.

Schema
Refers to the standardized definition of specific XML tags that make them suitable for a particular application. BACnet/WS defines an explicit schema for information sharing and interoperability.

Server
In electronic networked systems, an application or device acting as a provider of data, responding to a request from a client.

Services
How one BACnet device gets information from another device, or commands a device to perform certain actions (through its objects and properties, of course), or lets other devices know that something has happened. The only service required by all devices is the ReadProperty service. There are 41 standard services in the 135-2012 standard.

TCP/IP
Acronym for Transport Control Protocol/Internet Protocol. TCP/IP is one of several protocol standards used by the public Internet and IP-centric infrastructures in general. IP deals only with packet transmission and routing and is analogous to BACnet's Network Layer. TCP provides a connection-oriented delivery mechanism that can multiplex between multiple destination and source "ports" maintained by a target destination IP address. TCP/IP is a stream-

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oriented protocol that enables two hosts to establish a connection and exchange streams of data. Although TCP/IP is used extensively in Internet communications, it is not used by BACnet except in BACnet/WS which can exchange messages using HTTP over TCP/IP.

UDP/IP

Acronym for User Datagram Protocol/Internet Protocol. UDP/IP is one of several protocol standards used by the public Internet and IP-centric infrastructures in general. IP deals only with packet transmission and routing and is analogous to BACnet's Network Layer. UDP provides a connectionless delivery mechanism that can multiplex between multiple destination and source "ports" maintained by a target destination IP address. This should not be confused with TCP/IP.

BACnet/IP uses the combination of IP address and UDP port as a pseudo-MAC address in combination with a BACnet Virtual Link Layer (BVLL). This combination acts like a MAC layer in its own right for conveying BACnet datagrams over UDP/IP.

XML

See *Extensible Markup Language*.

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