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the EXTENSION

A Technical Supplement to Control Network

How BACnet® is Changing Building Automation Networking

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Briefly, What is BACnet?

BACnet is both an International (ISO) and ANSI standard for interoperability between cooperating building automation devices. Originally developed in 1987 under the auspices of the American Heating Refrigerating and Air-conditioning Engineers (ASHRAE), BACnet has been an ANSI standard since 1995 and ISO standard since 2001. BACnet was developed, and is under continuous maintenance, using an open consensus process that is welcome to all interested parties who may participate without fees. ASHRAE (an ANSI-certified standards-making 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.

BACnet is about interoperability between different building systems and devices. This can be simple information exchange to deeper integration, to complete and complex interoperation between competing component devices and systems. While definitely not "plug and play" interchangeability, BACnet does provide a 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 a decade of practice in millions of devices.

BACnet offers a flexible range of networking options including the use of Ethernet or IP-centric infrastructure, a very simple and low-cost twisted pair communication called MS/TP that is based on EIA-485, as well as dial-up telephone. 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. This approach includes 25 standard objects that cover many common and generally useful applications. In addition, there is a mechanism for implementors to create and use their own proprietary objects that can still be easily interoperable with other devices that choose to use them. This extensibility is free and guaranteed to be safe against unintended interference with other device's proprietary extensions.

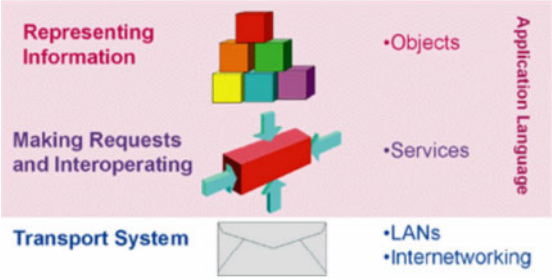
The object mechanism has proven to be robust and reliable as well as providing a high degree of backward and forward compatibility. In addition, BACnet has an extensive application services model that provides many types of useful services that implementors may elect to support in their devices. These services are grouped into logical areas for object access, alarm and event management, scheduling, trending, files, and device and network management.

In the increasingly important area of enterprise integration, BACnet has made a specific initiative 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.

Some applications in security and access control, and some types of physical venues, not to mention applications that use the public Internet, are concerned with issues of strong network security. BACnet has been engaged in a comprehensive initiative to define new strong network security extensions that will be incorporated into the standard to address 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 owners and specifiers to define their requirements for BACnet devices as well.

An independent third party testing and certification program for BACnet devices has been implemented by two separate organizations. The BACnet Testing Laboratory (BTL) is an independent not-for-profit company managed by BACnet International, a trade association of BACnet manufacturers. BTL performs device testing according to the companion test standard to BACnet 135.1. An identical testing methodology is used for testing in Europe by the BACnet Interest Group Europe (BIG-EU). Various third party companies also offer tools, services and consultation independent of device manufacturers.



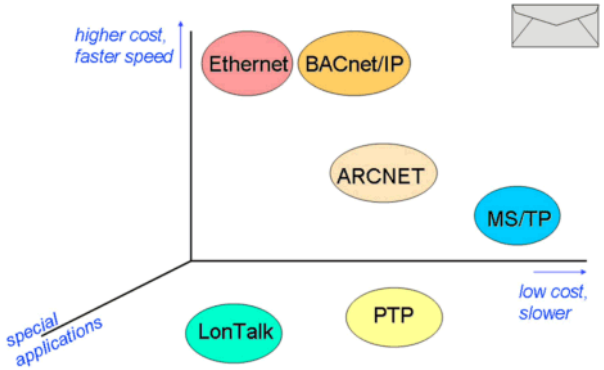
How Does BACnet Work?

BACnet works by dividing the problem of interoperability into three distinct areas, and by defining methods and standards for implementing each.

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 which may be of interest to other BACnet devices.

BACnet devices ask each other to perform services. For example, a device to which a temperature sensor is attached, may perform the service of reading the temperature and providing this information to another device which needs it.

The model of objects and services is realized by encoding messages into a stream of numeric codes which represent the desired functions or services to be performed. The "language" of this encoding is common to all BACnet devices. BACnet devices actually exchange information and do things by sending and receiving electronic messages containing this coded application language.



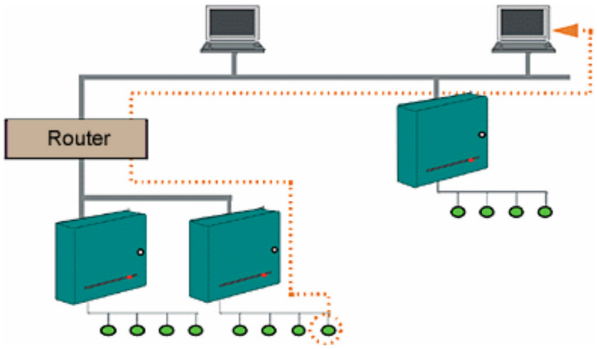
BACnet provides flexibility by allowing multiple types of transport systems to be used to convey these coded messages between devices. The transport system uses different types of electronic messaging standards and methods to convey coded messages. Even though different transport methods are used, the 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.

An unique feature of BACnet is its scalable internetworking facility. When two or more LAN transports are needed, this element of BACnet permits arbitrary scaling of BACnet networks by joining the different segments together. A router is a BACnet device which couples two or more network segments together and passes messages back and forth, only when necessary. The router may bridge together two of the same type of LAN segments, such as Ethernet to Ethernet, but more typically routers also serve the function of coupling different LAN types together, for example Ethernet to MS/TP.

Object Oriented Access to Information

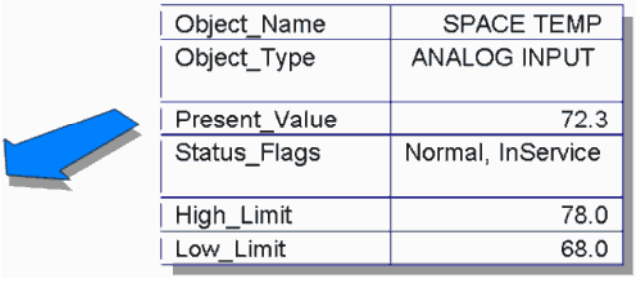
All information in a BACnet system is represented in terms of objects. An object is an abstract concept that allows us to talk about and organize information relating to physical inputs and outputs, as well as non-physical concepts like software, or calculations.



Objects may represent single physical "points", or logical groupings or collections of points which perform a specific function. For example, an object might represent a physical input device like a temperature sensor or thermostat, or an output device like a fan or pump or valve position. Objects can also represent non-physical concepts like program logic, schedules and historical data.

All objects in BACnet provide a set of properties that are used to get information from the object, or give information and commands to an object. You can think of an object's properties as a table with two columns. On the left is the name or identifier for the property, and on the right is the property's value. Some properties are read-only meaning that you can look at the property value, but not change it. Some properties can be changed (written).

For example a temperature sensor, might be represented as a BACnet Analog Input object. The example shows a few of the properties that might be available with this object, although in practice there would be many more properties than those shown in Figure 4.



Object_Name	SPACE TEMP
Object_Type	ANALOG INPUT
Present_Value	72.3
Status_Flags	Normal, InService
High_Limit	78.0
Low_Limit	68.0

The object has a name property ("SPACE TEMP") and an object type (ANALOG INPUT). The Present_Value property tells what the temperature sensor is reading at this moment (72.3 degrees). Other properties show other information about the sensor object, such as whether it appears to be functioning normally, or High and Low Limits for alarming purposes.

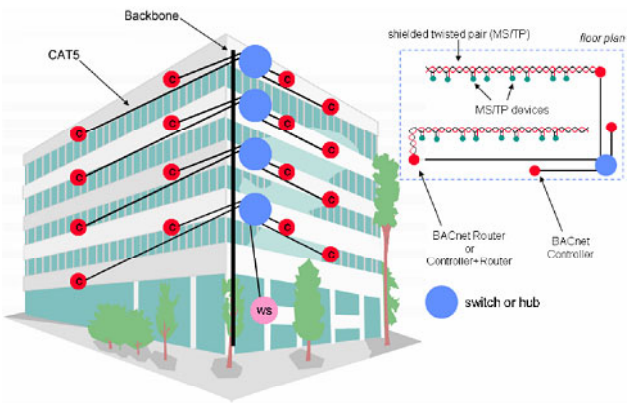
BACnet defines a growing set of "standardized object types" that cover a wide range of generic functionality. The standard defines both required and optional properties and their behaviors for each object type. New application areas are under development including an extensive set of new objects with specific applications in access control and security, as well as lighting.

Vendors can also implement their own non-standard properties for some objects with whatever behavior the vendor chooses. It is also possible, and encouraged, for vendors to implement their own additional object types. These non-standard object types may include whatever properties the vendor chooses. Whether an object type is non-standard or not, and whether a property is proprietary or not, the object property is read or written in the same manner. All you need to know is the existence of a property and what its purpose is, and you can use it just like any of the standard properties. This key fact allows vendors to extend BACnet and add functionality into BACnet arbitrarily into the future, without ever changing the standard itself.

As new technology and techniques are invented, new object types can be used to represent the key parameters or information from and control of those objects. Innovation can proceed without interference from BACnet! This feature may be the single most important aspect of BACnet because it allows new functionality to be incorporated into a vendor's product without requiring a change to the standard, or anyone's "permission," and without breaking existing implementations.

Typical Building Wiring

BACnet networks tend to use a combination of Ethernet-based infrastructure and lower cost MS/TP and/or ARCNET® 156K twisted pair networks.

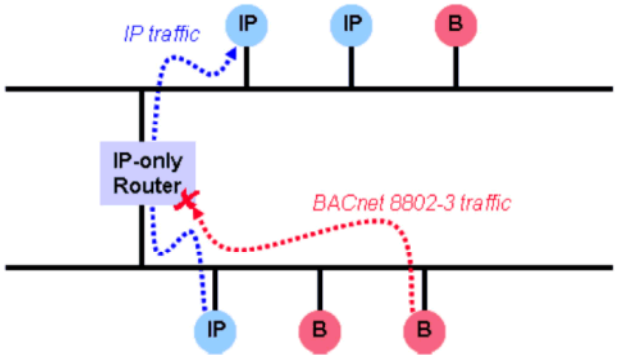


Vertical backbones in the corners or building core distribute a LAN infrastructure which may be shared with non-BACnet devices. In the past these backbones used thickwire (10BASE5) or thinwire (10BASE2) Ethernet and hubs on each floor. Today, the LAN segments are typically distributed from switches rather than hubs and use CAT5 or CAT6 exclusively. The switch-based architecture is considerably more robust since the network is essentially reduced to all point-to-point connections with little concern for end-to-end distance.

From the corner/core location, terminal wiring reaches out to BACnet/IP or BACnet 8802-3 controllers and BACnet routers. Increasingly popular are BACnet controllers that include router functionality, obviating the need for stand-alone routers.

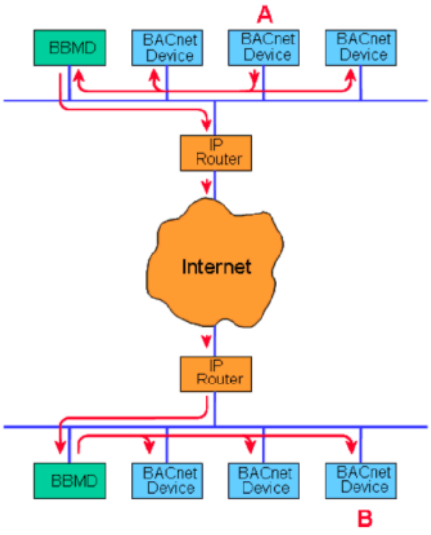
Ethernet Infrastructure Pitfalls

With LANs that consist of a single logical segment, (even bridged Ethernets can be thought of as one big logical segment), or IP infrastructures using a single IP subnet, life is easy with BACnet. However, IP-centric infrastructures can pose several challenges if there are IP routers in place.



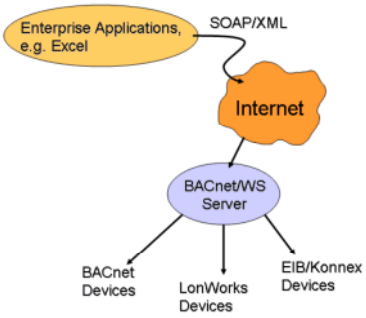
Some types of IP routers have a so-called bridging feature. When this type of router receives a non-IP Ethernet packet type, if bridging is enabled, the packet simply passes through the router transparently. Regrettably, some very popular IP routers don't do bridging. This causes problems when BACnet 8802-3 devices (labeled "B") try to send messages, including broadcasts. One of the motivations for using BACnet/IP devices is that their unicast transmissions are not blocked by "IP-only" routers.

However, BACnet/IP introduces a different problem when there are multiple IP subnets that each have BACnet/IP devices. BACnet makes extensive use of broadcast messages. Since broadcasts are blocked by IP routers as a matter of course, this means that BACnet/IP devices on different subnets need special management. The BACnet Broadcast Management Device (BBMD) handles distribution of broadcasts across multiple subnets.



BBMDs take broadcast messages and embed them in unicast UDP/IP messages with a BACnet Virtual Link Layer (BVLL) which can pass through all intervening IP routers and send them to peer BBMDs for further distribution. BBMDs use a "Broadcast Distribution Table" to identify peer BBMDs and special BVLL messages to indicate that the enclosed message is to be broadcast to all BACnet devices on the remote IP subnet.

BACnet Web Services



Many enterprise applications are making increasing use of Web Services as a means of communicating information from servers on public and private internets. Using the well known HTTP and TCP/IP protocols that are used by websites, a Web Service encapsulates requests and replies in special XML documents that are based on the so-called SOAP schema. The problem with this approach is that the web services themselves are not standardized, so interoperability is by no means assured or even possible without a lot of custom programming or human intervention. The BACnet/WS standard uses SOAP, XML and existing Web Services frameworks to convey building automation information. It provides a streamlined method for enterprise applications to read and write point information, discover a hierarchy of points and devices, access alarm information and historical trend data.

The scheme is not tied to BACnet and is equally applicable to LonWorks, EIB/Konnex and other existing automation networking protocols and information.

The ubiquity of Ethernet-based products and infrastructure devices, as well as falling costs and increasing prevalence of IP-centric infrastructure is well suited to BACnet. This robust standard is ideal for realizing all the benefits of these technologies.

Mr. Fisher attended Carnegie-Mellon University where he studied Computer Science and Artificial Intelligence. He was a charter voting member of ASHRAE's SPC 135P and has been very active in the development of the BACnet® Standard since its inception. Fisher is President of PolarSoft Inc., a Pittsburgh-based software company that specializes in BACnet software development and consulting. Fisher has over 35 years experience in real-time software, human-interface design and distributed direct digital control systems. Fisher holds several patents for laboratory control systems and fiber-optic communications.