# *With BACnet, the Object Concept has established itself in the world of Building Management*

Originating from the USA and designed specifically for Building Management systems (BMS), the BACnet protocol is currently enjoying growing success in Europe. It uses an object oriented concept and hence the supervision of a BACnet system is much easier to implement if the top-end BMS is itself object oriented.

In buildings and facilities management, equipment related to heating, ventilation and air-conditioning (HVAC) is monitored and controlled, either locally or remotely. There is a constant demand to improve the performance of installations and to reduce installation and maintenance cost. To answer this need, ASHRAE, the standards organisation for BACnet sought a primary reduction in installation costs by reducing the cost of cabling.

HVAC professionals had, in the past, raised the same questions as their control engineer counterparts and around the same time (in the 1980's). Like them, they had considered solutions to similar technical problems, but the parallel stops there. While control engineers were somewhat disorganised in their planning with no centralised standards bodies, HVAC professionals have been able to rely on a respected and strong organisation which is both structured and experienced, ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) created in 1894, and which counts many thousands of members (now said to be 51,000). So BACnet (Building Automation and Control network) was able to establish itself in the market quickly.

## Established fully in 2003, with an ISO endorsement

Work having effectively started in 1987. ASHRAE created a work group (SSPC 135) to think about the development of a standard communications network. The objective was to avoid the multiplicity of proprietary solutions, which was definitely not attractive to the user community. The development work could not be considered to be late in starting because at this time too, the control engineers had not really started their work on field bus.

ASHRAE managed to avoid the confrontation between HVAC equipment providers such as that which occurred in the automation world, where each party was trying to impose its point of view and thus complicate and elaborate the next release of the IEC61158 standard.

Discussions at ASHRAE had been only a little less arduous: the BACnet standard (whose first version was referenced as AHSRAE 135-1995) was released in 1995, which was after eight and a half years of work. Whilst achieving this first step, the workgroup considered whether to use LonTalk from Echelon, which was well used at this time and targeting at building applications. But the structures of the data and the services of LonTalk were so far from the BACnet objectives that LonTalk was finally dismissed.

Adopted by ANSI (in the USA) at first, it then became an international standard in 2003, under the ISO 16484-5 reference. BACnet is also a European standard (EN 16484-5), which increases its acceptability in the market.

BACnet is not fixed. The standard has evolved at a sensible pace. Its first revision was in 2001 (that was 6 years after the first version) and then there was another one in 2008 (referenced as 135-2008 by ASHRAE). In the latest version, features added relate for example to access control systems management, alarm recording and Web services configuration for energy management in buildings.

Although it has been created by the HVAC community, BACnet now relates to any equipment that can be managed by a building management system: access control systems, fire security, lighting systems and even service lifts, for example.

With its global standardisation and its capacity to respond to the needs of the building management users, BACnet enjoys a growing success in the world. There are around 400 providers of BACnet equipment. English speaking countries are the most advanced, with the USA leading the way, which is not surprising with BACnet emanating from the USA. Many countries are now looking to adopt BACnet: Japan, Germany (BACnet was standardised by DIN) and Switzerland recently took big steps towards adoption.

France is also active, with the creation of the BACnet France association in April 2007.

Despite its influence, BACnet is not the only player in the market. There are other field buses for building applications, such as Lon and KNX ("Konnex" created from Batibus, EHS and FIBus). All these buses are more complementary to BACnet than real rivals to it. For example, KNX is aimed at small field equipment, for automation applications; the supervision for houses and small buildings for example. In a single building, several of these standards can be present but there are no difficulties in centralising everything on a BACnet based BMS: In fact, protocol converters exist which enable KNX and LonWorks to interface to BACnet.

## BACnet Basis

The BACnet standard is extremely detailed (around 600 pages), which facilitates its successful deployment, avoiding the usual compatibility issues where suppliers fail to meet a standard due to error or misunderstanding.

**BACnet allows an extensive choice of the physical network level** and leaves a wide choice for low levels (physical and network). It currently offers five network options but it is likely to be more in the future (CAN and ZigBee are under consideration). The objective is that the equipment providers can choose the best support for their needs in terms of data rates, distances and costs. Standards supported include Ethernet 10/100 Mbps (bits per seconds), and Arcnet at 2.5 Mbit, which can both use twisted pair, coaxial cables or optical fibres. For applications with lower data rate requirements, BACnet has defined an MS/TP protocol (master-slave/token-passing), which allows twisted pair and LonTalk to be supported at up to 1Mbit. On the top of all these local networks, BACnet proposes a PTP (Point to Point) protocol that can provide point to point connections using a telephone link or an RS-232 link.

Despite all of these options, it is obvious that nowadays Ethernet dominates the market. Protocols such as Arcnet or MS/TP have had their glory days (at least in the USA) and they have obviously lost their speed advantage.

To provide a complete building management solution using the BACnet standard when several networks are present in the building, the different networks must be interconnected with one another, using either a router (if it is a BACnet network) or a gateway (if the network is not cited in the BACnet standard). Routers only repackage BACnet messages before forwarding them without changing their structure. However gateways have the overhead of conversion of the messages before forwarding them.

**The object concept.**
This is a fundamental concept of BACnet. Today, it may sound standard, but at the end of the 80's, when the major BACnet design decisions had been made, it wasn't an obvious choice. At this time, another object concepts were better know in the network arena: MMS (Manufacturing Messages Specification), the famous MAP network designed for automation applications in the car industry (and mainly used by General motors). But MAP was too expensive and didn't survive the arrival of field bus and the growing power of Ethernet; and MMS didn't survive the disappearance of MAP.

A BACnet object is simply defined as a group of data associated to a specific function and which is possible to identify and to access in a standard manner across the entire network. The concept of an object can relate to the information provided by the physical inputs and outputs, but also to the non-physical concepts such as the software program, calculations, names, the manufacturer, the owner, etc.

A BACnet object is characterised by a "type" which indicates what "kind" of object it is and by an "identifier" which represents the unique name of the object within the equipment. For instance, the object that sets allowed limits of temperature variation may be called SPACE TEMP. Its type would be Analog Input and among its properties, there will be the current value of the temperature monitored by the sensor, the high and low limits that will trigger alarm or event notifications, the current running state of the sensor (normal or out of service, etc.). It may also carry asset information such as the date it was fitted, the manufacturer, the location, the owner, the client, its sensor type, etc., etc.

BACnet specifies a certain number of types as standard objects (37, so far). From these objects, a large number are "user" functions of the equipment (analog input, binary output, etc.). Certain objects specified by BACnet represent features related to the BACnet protocol, such as history object (TrendLog) and data and alarm notification objects.

BACnet allows the equipment manufacturers to define their own objects and to add "proprietary" properties to standard objects, with, of course, the possibility to access the object properties (whether they are standard or proprietary).

BACnet does not imply in the object implementation whether they are standard (defined by BACnet) or proprietary (defined by the manufacturer). This is decided by the developers and hence the same object won't necessarily have the same level of performance for each brand of equipment. With BACnet however, the information exchange mechanisms will be identical.

BACnet equipment is described from standard objects. Each piece of equipment contains a certain number of objects and the more complex it is, the more objects it will have: analog inputs, binary outputs, control loops, schedules, etc. Each piece of equipment is linked using BACnet and acts as a client and/or a server on the BACnet network.

**A client-server model.**
BACnet is based upon a standard client-server model and messages between equipment are known as service requests. When a client sends a service request, the server will execute the service and return the result to the client.

BACnet lists 35 types of messages. These "Application Services" can be ranked into 5

categories:
- alarms and events
- file access
- object access
- remote control of equipment
- virtual terminals

When communications between a supervised system and a BMS is used, these BACnet "Application Services" can go much further than when using a classical approach (e.g., OPC), where the services available do not support functionality beyond the "read and write of data".

## From a classic BMS connection ...

For BMS software that isn't based upon a native object concept, data exchanged between the BMS and external systems is represented in the BMS as "variables".

In the case of communications based upon "variables", the data types exchanged are only elementary and in the form of "simple" data types supported by the BMS: Boolean, integer, real, string. The association between the data type inside the supervised system and the data type of the BMS is usually implicit (e.g. a bit in a controller is directly associated to a Boolean) or they refer to elementary logic (e.g. the parsing of a word as a group of Boolean values, for example). This type of elementary exchange is usually made today using the OPC standard.

Even if the organization of these variables allows a logical object to be simulated, the configuration of the communication between a BMS that is not intrinsically (native) "object" based, requires the establishment of many "point to point" links, as BACnet objects can have several dozen properties, and a unique name must be defined for each of these variables!

## ... To native BACnet integration

When the BMS is designed with a native object base (as is the case of Panorama E²), it is possible to establish a direct "object to object" link. To access a BACnet network object in a BMS application, it is necessary to create a "representation" of this object inside the application. This representation of the BACnet object allows access to the network objects (object properties, for example) in the same way as if this object was local to the application. The BMS then manages updates of its local object properties each time the BACnet object properties change. Likewise the BMS also manages the update of BACnet object properties (via the WriteProperty service).

This approach is simpler than the classic approach as there is only one link per BACnet object rather than many dozen. To establish a direct link between the BMS objects and external controller objects, it is necessary that the BMS knows the "structure" of these external objects. For example Panorama E² has a tool, known as a class descriptor which can, by configuration, define the equivalent BACnet object structure inside the BMS to what exists externally on the BACnet network. When ASHRAE adds new objects, only new class descriptors for these objects need to be defined in the BMS software.
This principle easily allows BMS model objects to be adapted to the specifics of each manufacturer who have the possibility to define specific properties to standard objects and also to create their own objects.

Furthermore, this also allows object models to be developed for BACnet objects of a particular manufacturer's controllers, defining specific properties and objects, such that when that manufacturer's hardware is connected to the BMS, objects will match the hardware both functionally and visually. For example, if an xyz controller is attached, its manufacturer's own style graphical representation as well as all its properties can be linked using one simple object to object connection.

## Classic functions, the BACnet way

**BACnet History Function**
The BACnet protocol has mechanisms that enable equipment from the network to send values from a history function to BMS objects. Services that support these functions are the "Trend Log" and "Trend Log Multiple" objects that store history values and allow access through the "Log_Buffer" property to them. Thus, data can be logged locally at a controller and uploaded to the BMS when and if needed.

**BACnet Alarm Management**
The BACnet protocol incorporates services to support alarms and events. The services (ConfirmedEventNotification or UnconfirmedEventNotification) are used by server objects to send alarms and events to client objects. The AcknowledgeAlarm service allows a notified alarm to be acknowledged.

The processing of alarms and events associated to a controller's BACnet object can be easily made inside the BMS by defining an alarm object as a child of the local object that represents the controller's object that will generate the notifications.

Parameters sent during a notification are thus automatically forwarded to the child alarm object through its "Category" property ("Event Type", "To State" parameters,...) and the "Label" property ("Message Text" parameter).

All BMS functions (display, history, acknowledge summary, etc.) are used as a normal for this alarm object.

**BACnet Network Performance**
The BACnet services remove the great burden imposed on a network by the traditional BMS being required to scan continuously to look for data changes. The BACnet COV (Change of Value) service means that urgent data is sent to the BMS only when it occurs, thus speeding response times and reducing network loading. Likewise, the WriteProperty service allows important information is sent quickly from the BMS to its intended recipient.

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