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VOLUME 2

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Integrating Fire Systems With Other Building Automation and Control Systems

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ABSTRACT

There are many economic and operational reasons to integrate fire systems with other building automation systems. Integration of this kind requires communication standards and careful design practices. BACnet™ is an internationally recognized communication protocol standard specifically designed for integrating building automation and control systems. Thousands of BACnet systems can be found around the world and its popularity is growing. Newly proposed additions to BACnet make it very well suited for integrating fire systems with other building automation systems.

Even with communication standards there are other design issues that need to be addressed in order to assure the integrity of fire systems when they are integrated with other building systems. Best design practices, testing procedures and building codes need to be modernized to accommodate integrated building systems.

INTRODUCTION

The technology of building automation and control systems has advanced rapidly over the past fifteen years. Today's technology provides building owners and designers with a rich assortment of options and flexibility. State-of-the-art building automation and control systems are characterized by powerful personal computer workstations and intelligent distributed controllers that process complex algorithms quickly and efficiently. These advances have taken place across a variety of building services including heating, ventilating, and air conditioning (HVAC) control systems, lighting control systems, access control systems, and fire detection systems.

In spite of these advances, building owners have been frustrated by the inability to bid projects competitively and to integrate innovative products made by different manufacturers in ways that best suit the unique needs of their facility. The main obstacle has been incompatible proprietary communication protocols. The adoption of BACnet [1] as the standard communication protocol for integrating building control products has changed the industry and opened the door to new innovation in building control technology and true integration of previously isolated building systems.

In the United States, the National Electrical Manufacturer's Association (NEMA) Signaling, Protection, and Communication Section (3SB) has endorsed the use of BACnet as the preferred way to integrate fire systems with other building control systems. The National Fire Protection

Association (NFPA) is in the process of revising Standard 72 [2] to address design issues related to integrating fire systems with other building systems. First generation BACnet fire system products are already available in the marketplace in the United States and in Europe. These are clear indications of interest in integrating fire systems with other building systems and in using the BACnet protocol as a means to accomplish that goal.

A BACnet OVERVIEW

BACnet is a standard communication protocol developed by the American Society of Heating Refrigerating, and Air-Conditioning Engineers (ASHRAE). It has been adopted as a pre-standard by the European Community [3, 4] and has been proposed as an ISO standard. Today there are over 60 companies with registered BACnet vendor identifiers. These companies are located in North America, Europe, Asia, and Australia. Commercial BACnet product offerings range from gateways that connect proprietary systems, to complete product lines that use BACnet as the primary or sole means of communication. There are thousands of installed systems ranging in complexity from a single gateway to very large office buildings with top-to-bottom native BACnet systems, to campus or city wide systems linking multiple buildings. BACnet products include HVAC controls, lighting controls, and fire detection systems.

Fundamentally, BACnet, like any communication protocol, is a set of rules that provide a way to exchange information. BACnet was designed and optimized specifically to meet the needs of building automation and control applications and to convey the data needed by these applications including, but not limited to: hardware binary input and output values; hardware analog input and output values; software binary and analog values; schedule information; alarm and event information; files; and control logic. BACnet does not define the internal configuration, data structures, or control logic of the controllers.

BACnet is designed to be scalable from very small low-cost devices to very large complex systems that may involve thousands of devices and multiple buildings located anywhere in the world. It achieves this by combining an object oriented representation of the information to be exchanged, flexible choices for local area network (LAN) technology, an ability to interconnect local area networks, and an ability to use internet protocols (IP) protocols to link buildings over wide area networks. The structure of the BACnet protocol and its relationship to the Open Systems Interconnection (OSI) – Basic Reference Model [5] is shown in figure 1.

BACnet represents the information and functions of any device by defining collections of related information called "objects", each of which has a set of properties that further characterize it. For example, an analog input is represented by a BACnet Analog Input object that has a set of properties that include its present value, sensor type, location, alarm limits, and others. Some properties are required and others are optional. A device is represented by an appropriate collection of network visible objects. Once the information and functionality of a device has a common appearance on the network in terms of standard objects and properties, it is then possible to define messages that can be used to access and manipulate this information in a standard way. This combination of standard objects and standard messages to access and manipulate their properties make up the BACnet application layer.

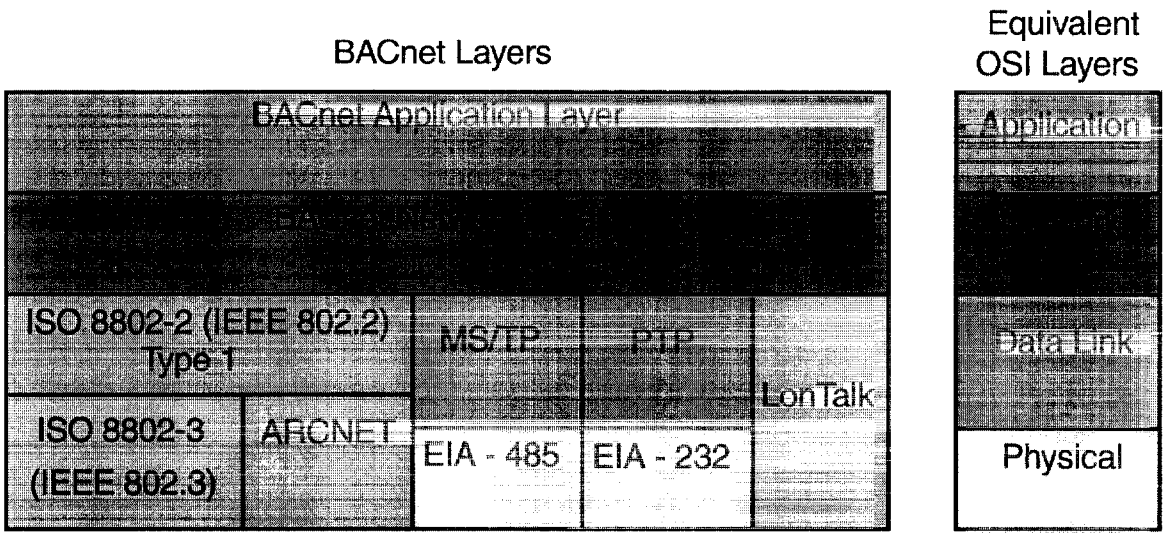

Figure 1. BACnet Protocol Architecture

Once the information to be exchanged and message structures are defined, it is necessary to provide a way to transfer the information from one place to another. BACnet provides a choice of five LAN technologies to meet this need. Several choices are provided because different building control applications have different cost and performance constraints that must be met. A single network technology cannot meet the needs of all applications. A LAN is defined by a combination of the Data Link and Physical layers of the OSI model. The LAN options available in BACnet are shown in figure 1.

The first option is ISO 8802-3, better known as "Ethernet". It is the fastest option and is typically used to connect workstations and high-end field devices. The second option is ARCNET which comes in modestly high speeds or in slower, lower cost versions. BACnet defines the MS/TP (master-slave/token-passing) network designed to run over twisted pair wiring. Echelon's proprietary LonTalk[1] network can also be used. The Ethernet, ARCNET and LonTalk options all support a variety of physical media. BACnet also defines a dial-up or "point-to-point" protocol called PTP for use over phone lines or hardwired EIA-232 connections.

A key point is that BACnet messages are the same no matter which LAN is used. This makes it possible to easily combine LAN technologies into a single system. The purpose of the network layer is to provide a way to make such interconnections. It is common in large systems to combine high speed (and high cost) networks with lower speed (and lower cost) networks in a single system. Such a system is shown in figure 2. Figure 2 also illustrates that BACnet has wide area networking capability that is implemented using IP.

[1] Certain trade names and company products are mentioned in the text in order to specify adequately the equipment used. In no case does such an identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products are necessarily the best for the purpose.

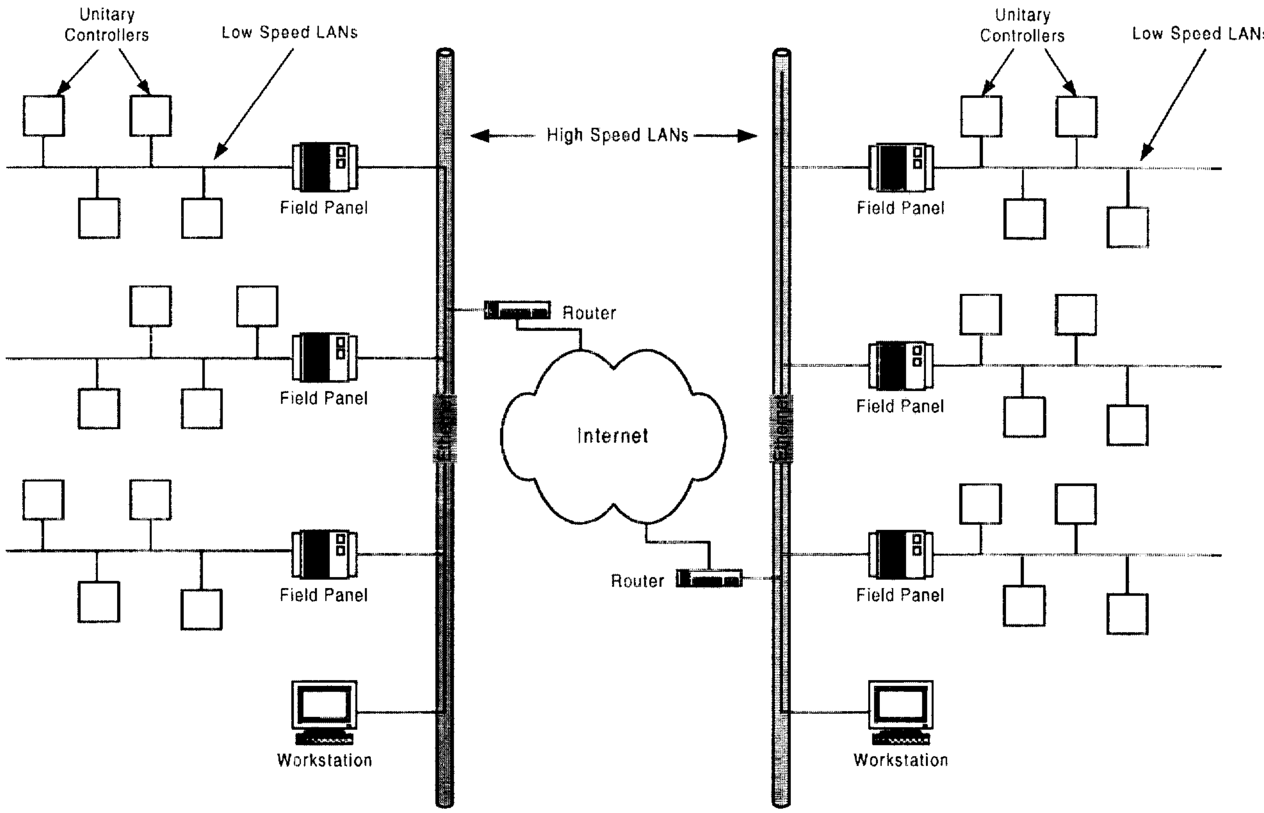

Figure 2. A Hierarchical Building Control System Structure

In principle, BACnet messages can be transported by any network technology. This means that technologies that have not even been invented yet can be used in the future to convey BACnet messages and they can be integrated into today's systems in the same way that multiple existing network technologies can be combined today. This lack of dependence on today's technology is a very important feature of BACnet.

The object-oriented structure also provides a way to add new application functionality to BACnet by defining new objects and/or new application services. This is being done to add functionality needed for fire systems. Two new BACnet objects, Life Safety Device, and Life Safety Zone have been developed. The Life Safety Device object represents the features of an individual detection or enunciation device. The Life Safety Zone object represents the status of a collection or "zone" of life safety devices. When these objects detect an alarm, the alarm status latches until a reset command is executed. A new application service has also been developed that provides a way to reset latched alarms and to silence enunciating devices. All of these additions were developed with assistance from the fire industry and have been approved by the BACnet committee. They are currently undergoing a public review process and are expected to be approved as part of the BACnet standard [6].

More detailed information about BACnet concepts and structure may be found elsewhere [7]. There is also tutorial information and an extensive bibliography available on a web page maintained by the BACnet committee (www.BACnet.org).

WHY INTEGRATE FIRE SYSTEMS WITH OTHER BUILDING SYSTEMS?

There are many reasons for integrating fire systems with other building automation and control systems. Examples include smoke control, single seat access to building information, easier maintenance, sharing sensor data, obtaining information about the location of people during an emergency, and providing infrastructure for new technology to improve performance and safety.

Fire detection systems have been integrated with door locks and with HVAC fan and damper controls for smoke management for several years but these systems have relied on relays controlled by the fire system to override the normal controls. This kind of integration has primarily involved constant volume HVAC systems and required only on/off control of fans and dampers to be moved to fully open or fully closed positions.

Many modern HVAC systems are far more complex. Variable air volume systems are used to reduce energy consumption. These systems require sophisticated control algorithms to operate either a continuously variable speed fan or inlet guide vanes to control the static pressure in the supply air duct. Variable air volume boxes control the airflow from the supply duct into individual rooms by modulating dampers. The control algorithms for these systems are complicated and require interlocks and safeties to prevent over stressing ductwork in the event that dampers do not open when fans are turned on. Smoke management is much more complicated with these systems and outside of the capability of most fire systems. What is needed is a way for the fire system to command the HVAC control system to enter a smoke control mode and let the HVAC controllers manage the equipment.

New sensors are being developed that can recognize various contaminants in the air that can represent a fire signature or a hazardous contaminant that poses a life safety threat. In an integrated system these sensors could be used by the HVAC control system to control ventilation rates with no adverse impact on their life safety functions. Multiple uses for the same information will make it more cost effective to implement new sensor technology.

In some buildings access control systems monitor the location of building occupants. Providing access to this information to the life safety systems could be very helpful in an emergency. Emergency response personnel would know where to look for occupants who need to be evacuated. They could also reduce the risk to themselves by avoiding dangerous areas where no people are present.

Research is now underway at the National Institute of Standards and Technology (NIST) to develop a new generation of smart fire panels that can make use of sensor data from an integrated system to calculate heat release rates in a fire. Using this information, a fire model in the panel can predict how the fire will grow and spread. These predictions can be used by emergency response personnel to plan a strategy for fighting the fire. It could even be transmitted by the building systems to fire stations or fire trucks so that planning can begin before emergency personnel reach the site. This could significantly improve response time, saving lives and reducing property loss.

For all of these reasons and probably others, integrating fire systems with other building systems makes a lot of sense. The technology is already being driven in that direction by market forces.

INTEGRATION ISSUES THAT NEED TO BE ADDRESSED

There are several important integration issues that need to be addressed if these potential benefits are to be realized. The primary concerns are ensuring the integrity of fire systems in emergencies and isolating them from interference caused by failures of other building systems, meeting building code and Underwriters Laboratory (UL) listing requirements, and regulating and tracking human responses to alarms and trouble conditions.

Maintaining the integrity of the fire system and protecting it from failures in other building systems is primarily a matter of system design practice. Today this is being handled by using a gateway to isolate the fire system from outside interference. All of the components of the fire system reside on one side of the gateway and communicate using proprietary protocols in the same way that they did before BACnet. The BACnet gateway provides a way for other building systems to get information from the fire system but protects the fire system from interference from outside. This provides the necessary protection but it also limits the integration possibilities.

An alternative approach is to develop best design practices for constructing networks of integrated systems. By appropriate selection of network technology and appropriate use of routers and bridges to filter traffic, interference problems and concerns about guaranteed access to network bandwidth in an emergency can be effectively eliminated. Business network systems commonly use these techniques today and there is no reason why they cannot be applied to building automation systems.

Having fire systems tested by UL and listed for their intended purpose is an expensive and time-consuming practice. It is unrealistic to expect manufacturers of other building automation devices to absorb this expense when their products are not directly involved in detecting or responding to a fire just because they can communicate with listed fire devices. The testing and listing procedures need to be updated to recognize this reality. By combining good design practices with tests that ensure the integrity of the fire system under conditions that can occur assuming that the design practices are followed, safety concerns can be satisfied without sacrificing the benefits of integration. In some locations building codes may need to be modified so that they are based on performance criteria instead of prescriptive requirements.

In fire systems it is very important to ensure that only authorized personnel can silence alarms, reset alarms, and perform other operations that significantly affect the performance or status of the fire system. Traditionally this has been done by having dedicated fire system workstations that provide the operator with capabilities that are assigned when the operator logs in. In an integrated system there may be many workstations that have the ability to send messages that are important in this regard. Fire panels need to be protected from accidental or intentional disruption from other devices or workstations in the building. BACnet provides mechanisms for authenticating messages but they are not widely implemented. This is another design issue that needs to be addressed.

INTERNATIONAL STANDARDS ACTIVITIES

It was previously mentioned that BACnet has been adopted as a standard in the United States and as a pre-standard in the European Community. The International Organization for Standardization (ISO) Technical Committee 205 is deliberating the adoption of BACnet as a world standard. This is being done as part of the activities of Working Group 3, Building Control System Design. The participants in this activity include representatives from the United States, Europe, Japan, and Australia. BACnet is now at the working draft stage and is expected to advance to the committee draft stage soon. The ISO activities are being coordinated with the ongoing maintenance of BACnet in the United States. The intention is to incorporate into the U.S. standard any additional features needed to obtain international acceptance of the protocol. It is also expected that any additions that come from the continuous maintenance process in the U.S. will be incorporated into the ISO standard. An effort is being made to coordinate BACnet testing and certification programs in Europe and the U.S. There is a strong international consensus that it is in everyone's interest to be able to freely market BACnet products anywhere in the world. A common standard and reciprocal certification recognition are critical if this is to happen.

SUMMARY

There are a variety of important reasons for integrating fire systems with other building automation systems. These include smoke control, single seat access to building information, easier maintenance, sharing sensor data, obtaining information about the location of people during an emergency, and providing infrastructure for new technology to improve performance and safety. A standard communication protocol is a critical infrastructure component to make this integration possible. BACnet is such a protocol and it is gaining popularity around the world.

Even with communication standards there are other issues that need attention. Systems must be designed and maintained in ways that will assure the integrity of the fire system even when other components of the building automation system fail. It is also necessary to design the system so that bandwidth is available to the fire system when an emergency arises. Best practice design guidelines can meet these needs. UL testing and listing procedures need to be updated to address open integrated systems. In some cases building codes may need to be revised to performance-based approaches.

Market forces are already pulling the industry in the direction of integrated systems. As new technology is developed that adds capabilities because of the integration, the pressure to integrate systems will grow. The end result will be buildings that are easier to operate and are safer for the occupants.

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