

## intelligent building design ... Investing in Interoperability

*From the editor...*

*With another deadline looming, I couldn't afford to wait until Monday to retrieve an important file from the office. I held my badge near the card reader in the vestibule. The building authorized my entry, unlocking the security door to let me pass. Once-dark lights automatically illuminated, anticipating my path. By the time I reached my office, conditioned air was gently spilling from the diffusers overhead and my favorite Yanni CD was playing softly in the background...*

*This may not be the stuff of good fiction, but neither is it science fiction. With the advent of open, standard protocols like BACnet® and LonTalk®, interoperable control systems and intelligent buildings are becoming a reality. Although this technology is still new, it is developing rapidly and the number of interoperable products from manufacturers of HVAC equipment and controls keeps growing.*

*It's not too soon for building owners and facility managers to factor interoperability into their plans for system upgrades, renovation, and new construction. This EN discusses the challenges that interoperability imposes on system designers, and offers suggestions to help you design and specify an interoperable system.*

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1. BACnet and LonTalk can be used to allow interoperability between:

- a) HVAC controllers only
- b) non-HVAC controllers only
- c) many different controller types
- d) BACwhat? LonWho?

For commercial building control systems—and for the people who own and manage them—interoperability represents one of the most promising developments since direct digital controls (DDC) were introduced in the early 1980s.

By the time that open, standard protocols like BACnet and LonTalk were introduced nearly a decade later, building owners and facility managers found themselves locked in their own Towers of Babel. The specialized DDC controllers that controlled individual

pieces of equipment so well were largely incompatible with each other. System upgrades, whether to accommodate facility expansion or simply to keep pace with technology, meant changing the entire building automation system (BAS), or more likely, adding dedicated interfaces for each new system. Owners watched their purchasing power and bidding options dwindle.

Today, interoperability is a requirement within the building controls industry. It means that:

- Independently designed DDC products work together using the same communication standard.
- A single user interface monitors and controls independently designed DDC products.

### Building a Controls Infrastructure

Infrastructure describes the basic facilities, services, and installations needed for something to function. If that “something” is a building, then its infrastructure includes plumbing, power, and telecommunications. Automated control systems are part of that infrastructure, too—particularly in large applications with multiple buildings and/or systems provided by different manufacturers.

Careful infrastructure planning, design, and installation are required to protect and enhance the value of the facility; ongoing maintenance and management are equally important. Owners and facility managers must consider:

- first cost
- operating costs (energy, maintenance, manpower)
- performance (consistency, reliability, predictability)
- extensibility (flexibility, better use of resources)

Factoring interoperability into an HVAC system design lets the owner take advantage of the information-sharing capabilities available today. It also helps the building automation infrastructure (not to mention the occupants of the facility), keep pace with and benefit from changes in technology. ■

Interoperability makes competitive bidding possible at the equipment and system levels; owners can now choose the best products, application knowledge, and service from a variety of suppliers. In effect, interoperability helps them reduce the cost of acquiring and maintaining their BAS infrastructures.

*“Many existing facilities share a common malady...*

Of course, interoperability *does* pose new challenges for consulting engineers who are more familiar with HVAC systems than with digital control networks. They must develop a basic understanding of interoperable controls and learn to work within the practical limits of today’s technology.

## What Interoperability Isn’t

2. Which protocol(s) enable “plug-and-play” interchangeability?
- a) BACnet
  - b) LonTalk
  - c) Both a and b
  - d) None of the above

Too often, “interoperability,” as represented by the BACnet and LonTalk protocols, is confused with “interchangeability” or “plug-and-play.” Neither of these open, standard protocols includes criteria to govern the programming, setup, and sequence of operation of compatible devices... nor are those functions recognized as interoperable by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the LonMark Interoperability Association.

Devices that are BACnet- or LonTalk-compatible can interoperate with each other; however, setting up and commissioning them is likely to be unique and vendor-specific. To illustrate, consider the programmable, unit-level controller for an air handler. Both BACnet and LonTalk provide a means for other devices to monitor and override individual input and output points, but neither protocol provides a common programming format for the logic statements that reside in the controller.

Consequently, connecting a BACnet device to a BACnet network—or a LonTalk device to a LonTalk network—does not guarantee that the device will

*... a fragmented controls network that limits extensibility...*

inherently function properly with the building automation system. Flexibility in the implementation of these protocols means that some setup is necessary to make them perform as intended.

## Levels of Interoperability

3. *True or False:* BACnet and LonTalk cannot exist within the same building automation system.

A **unit-level controller** provides stand-alone control of a device such as an air handler or a cooling tower. Networks of unit-level controllers are coordinated by an intermediate, system-level controller. A **system-level controller** resides on the main LAN (local area network) of a building control system, along with system controllers that coordinate other building control

functions such as HVAC, lighting, or fire-and-life safety.

Interoperability at the unit (equipment controller) and system (building controller) levels is important to the overall flexibility of the BAS infrastructure, as well as for competitive procurement.

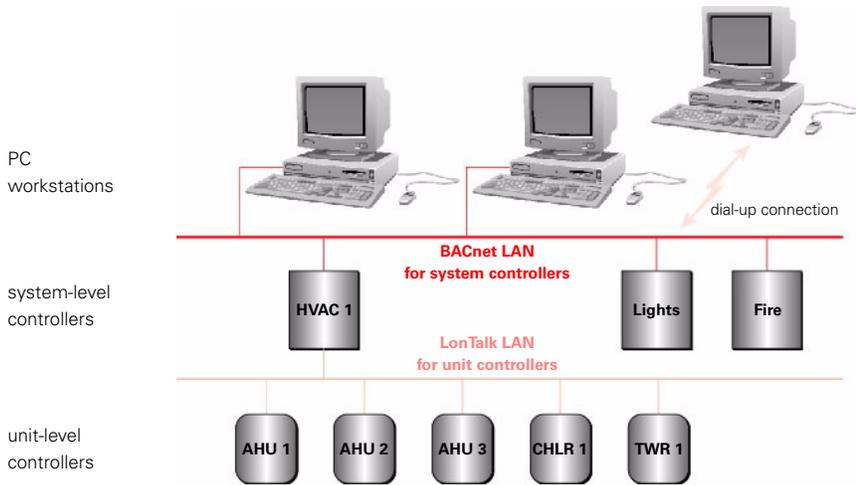
**Tiered or flat?** Figure 1 illustrates the conventional approach to BAS architecture; the hierarchy delineates subsystems by function and scope. Distributed, unit-level controllers are attached to a central, system-level controller. This design reduces the number of interface points and isolates each subsystem for commissioning and diagnostics without compromising interoperability.

An alternative approach favored by some designers uses an open, standard protocol to flatten the BAS architecture by connecting the unit-level controllers directly to the main LAN. This approach reduces hardware first cost by eliminating the system-level

*... and results from an ad hoc approach to building automation.”*

controllers, but requires scattering the system coordination logic generally found in system controllers (scheduling, trending, and optimization routines) throughout the controls network. This can make the building control system more difficult to install and commission, and usually requires the services of a system integrator (SI). Troubleshooting the system and assigning responsibility for maintenance or service can be equally difficult...and potentially expensive.

**Figure 1. Tiered BAS Architecture with BACnet and LonTalk Protocols**



**BACnet plus LonTalk.** Some vendors insist that BACnet is the only feasible standard for commercial building control; others make a similar claim for LonTalk. Both protocols are important tools for delivering interoperability. Designing the BAS architecture to take advantage of their respective strengths offers the best opportunity to provide single-point monitoring and control while minimizing components and labor.

**BACnet at the system level.**

BACnet’s strength is its ability to exchange data over common (and in many cases, existing) high-speed, local and wide-area networks such as ARCNET, Ethernet, and Ethernet/IP (the Internet). BACnet also has well-defined standards for typical, system-level BAS applications such as scheduling, trending, and alarm management.

It works well for communications between system-level controllers, letting subsystems such as HVAC and

lighting exchange information through a single user interface. BACnet also works well for providing centralized control over multiple, stand-alone buildings.

**LonTalk at the unit level.**

The LonTalk protocol is particularly well-suited for unit-level, peer-to-peer communication from equipment controllers. Prepackaged in a microprocessor chip, LonTalk provides a cost-effective, easy-to-implement means of connecting stand-alone devices (boiler controls or a factory-mounted, variable-frequency drive, for example) within the scope of an HVAC subsystem.

LonTalk’s popular, twisted-pair wiring option (FTT-10a/Free Topology) is twice as fast as the BACnet twisted-pair option and similar proprietary offerings. Also, the LonMark Interoperability Association has created standard definitions of typical control devices. These “functional profiles” greatly enhance the capacity for interoperability among LonTalk unit controllers.

**The Language of Interoperability**

Rita Tatum, a contributing editor to the February 1999 issue of *Product Trends* noted that “(the) interoperability lexicon can look like alphabet soup fit only for deciphering by those who might have access to a Rosetta Stone.”

The following mini glossary doesn’t claim to be a Rosetta Stone, but it does define many of the controls-related terms used in this newsletter.

**BACnet.** Building Automation Control Network; an open, standard communication protocol developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) specifically for the building controls industry. BACnet defines how information is packaged for consistent transmission between building automation products from different vendors.

**conformance.** Similarity in form; a component design that corresponds with a particular set of rules. A component’s conformity to the requirements of a standard protocol does not mean that it is interoperable, interchangeable, or able to be integrated with other conforming components.

**gateway.** A device that translates one set of communication rules to another. It connects networks that use different protocols, allowing them to pass data to each other. A gateway is sometimes called an “integrator” or “bridge.”

**integration.** Combines several functional systems into one (for example: security, metering, lighting, HVAC, and fire-alarm systems). Signals from these systems travel over the same digital network, and they can be controlled from the same workstation using uniform commands and graphics.

**interchangeability.** The capability of multiple vendors’ products to functionally replace each other on the same communication network without custom hardware and/or software.

*continued on page 4*

*The Language of Interoperability,  
continued from page 3*

**interoperability.** Digital communication between independently manufactured products designed to the same open-communication standard.

**LonTalk.** An interoperable protocol developed by the Echelon Corporation and named as a standard, EIA-709.1, by the Electronics Industries Alliance.

**protocol.** A set of rules or standards governing the exchange of data over a digital communications system.

A protocol is **proprietary** if it is used, produced, or marketed under the exclusive legal right of an individual or organization. An **open** protocol is available to public domain and is shared among vendors. Open protocols permit strategic updates of individual equipment rather than requiring replacement of the entire system. A protocol is considered **standard** if it is formalized by a governing body. Both BACnet and LonTalk are open, standard protocols.

**system integrator.** A consultant who helps design and implement systems with interoperable controls. Mixed-vendor and specialized systems often require this expertise. ■

## What About Legacy Systems?

4. *True or False:* Gateways provide limited information, add cost to projects, and should always be avoided.

A **gateway** translates data from one set of communication rules to another, acting as an interface

between devices that use different protocols. Also known as “integrators” or “bridges,” gateways can protect an owner’s past investment in control systems.

The addition of gateways sometimes offers a more practical solution to interoperability than the wholesale replacement of non-interoperable controllers. In new construction or significant renovation projects, however, consider controllers that connect to the BACnet/LonTalk infrastructure without the need for gateways.

## Specifying Interoperable Systems

5. *True or False:* Specifying interoperability is as easy as saying “shall be BACnet or LonTalk compatible.”

Although open, standard protocols make it easier to deliver interoperability, design details must be explicitly acknowledged and communicated. An effective specification:

- defines required functions and performance,
- addresses methods and equipment that will achieve the required performance.

There are two approaches to specifying interoperable systems—performance-based and prescriptive. **Performance-based specifications** stipulate the required functions and

performance without dictating the methods and equipment for achieving that performance. A **prescriptive specification** is more detailed in its stipulation of methods and equipment. A performance-based specification with appropriate prescriptive language usually yields the most cost-effective solution.

Regardless of which approach you adopt, be sure to clearly and completely state the following information in the specification.

**Stipulate the protocol and wiring media.** Explicitly state which elements of the system must support a particular protocol, as well as how the elements will be connected. For example, “HVAC and Lighting systems shall communicate using BACnet protocol over ARCNET or Ethernet LAN”; or “Terminal unit controllers shall reside on the LonTalk FTT-10a network.”

BACnet and LonTalk are defined over a number of different wiring media. Base your selection on the cost and performance characteristics of each medium, the ease of future additions, and the degree of compatibility with other media. (Twisted-pair wiring at 78 Kbaud, for example, is not directly compatible with Ethernet over the Internet at 10 Mbaud.)

**Identify data shared between systems.** Be sure to state which LonTalk functional profile, BACnet device profile, or standard BACnet objects each controller must support. For example, “Terminal unit controllers shall support the LonMark Space Comfort Controller functional profile”; or “The status of all smoke detectors, pull stations, and other alarm devices shall be described as BACnet standard binary input (BI) objects.”

*Note: LonTalk “functional profiles” list the mandatory, optional, and vendor-specific variable types appropriate for a given application. “Device profiles” are a new tool for specifying BACnet interoperability; they outline the basic requirements for standard types of interoperable controllers—for example, Operator Workstation, Application-Specific Controller, and Smart Actuator.*

Include a list of interoperable points for each controller and/or system. This may be simply a matter of adding an extra column to the point lists to identify the BACnet and/or LonTalk points; see Table 1 for an example. Bear in mind that the number of points may impact the cost of the project.

**Describe what each controller is expected to do** with the interoperable data available via the network. For example, “Display status of all points on graphics and trend status; add to standard life safety report; report changes in event log and other internal records.”

Both BACnet and LonTalk provide the means to deliver the following interoperable functions:

- Data sharing—controlling the status and monitoring the value of connected points
- Scheduling—viewing and editing appointed system events
- Alarm and event management—annunciation and acknowledgment of device alarms
- Trending—collection of data on system performance and energy usage
- Device and network management—for example, checking for loss of

communication and coordinating time clocks in controllers

**Confirm the interoperability of each product.** Suppliers should demonstrate how their products support interoperability. Request a BACnet “protocol implementation conformance statement” (PICS) and a list of supported LonMark functional profiles, including optional network variables. For example:

The terminal-unit-controller supplier shall provide a list confirming their support of all mandatory data included in the specified functional profile, and identifying which optional network variables and configuration properties that they support. Any vendor-defined network variables or configuration properties shall be described via an XIF file supplied with the product.

Remember: BACnet and LonTalk protocols do *not* provide interoperable programming or sequences of operation; nor do they yield interchangeable controllers.

**Table 1. Example Points List (Partial ) for a Chiller Plant**

Point Name	Analog		Binary		Alarm	BACnet Point(s)
	Input	Output	Input	Output		
System supply-water temperature	temperature	set point			low limit	AI, AO
System return-water temperature	temperature					AI
Evaporator refrig temperature	temperature				low limit	AI
Evaporator refrig pressure	pressure				high limit	AI
Condenser refrig temperature	temperature				low limit	AI
Condenser refrig pressure	pressure				high limit	AI
Demand limit	% RLA	set point			high limit	AI, AO
Unit status			on/off	on/off		BI, BO
Tower sump level			status		proof	BI
Tower sump heater			status	enable/disable		BI, BO

## Where to Learn More

Advances in technology and specification techniques suggest that BACnet and LonTalk will remain standard protocols for years to come. Applying them in combination establishes a BAS infrastructure that delivers interoperability in an efficient and economic manner. Our challenge is to educate ourselves and mentor our clients so that, together, we can make decisions that best serve their digital communication needs.

The following Web sites provide additional information about interoperability; invest the time to

explore these resources. After all, your most valuable design tool is knowledge.

- [www.bacnet.org](http://www.bacnet.org), the official Web site of the ASHRAE BACnet committee, SSPC 135
- [www.lonmark.org](http://www.lonmark.org), Web site of the LonMark Interoperability Association
- [www.trane.com](http://www.trane.com), corporate Web site for The Trane Company

Trane *Connections*, a multimedia presentation on compact disc, contains a wealth of information to help building managers and design professionals understand the sometimes complex issue of interoperability. Visit [www.trane.com/connections/](http://www.trane.com/connections/) to request a free copy. ■

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*To comment on this article, send a note to The Trane Company, Engineers Newsletter Editor, 3600 Pammel Creek Road, La Crosse WI 54601, or e-mail us from [www.trane.com](http://www.trane.com). You can also find back issues of recent Engineers Newsletters on the Trane Web site.*

## Quiz Answers

1. **c)** BACnet and LonTalk can be used to allow interoperability between many different controller types.
2. **d)** No protocol currently enables “plug-and-play” interchangeability.
3. **False.** Applying LonTalk and BACnet at different levels in the same BAS architecture capitalizes on the strength of each protocol, and creates an infrastructure that can be easily extended.
4. **False.** While open, interoperable controls provide the best solution for new applications, gateways may provide a viable alternative for adding interoperability to legacy control networks.
5. **False.** Adequately specifying interoperability requires more detail, including the communication protocol, network media type, interoperable points, performance-based descriptions of functionality, and prescriptive language to define communication parameters. ■



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