STRATA Resource Inc

Investigating Open Systems

Comparing LonWorks® and BACnet®

Market Report

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1. Executive Summary

Before the advent of Open System technologies, building automation was the domain of proprietary DDC control solutions. Even though available solutions varied from manufacturer to manufacturer, they all shared an intrinsic quality. The solution manufacturer was the sole-source provider. They manufactured the controllers, developed the application software, were often the only installer, and unilaterally charted product development, deployment and product line diversity. When a facility owner selected a proprietary control solution they were not merely buying a product they were establishing a partnership. Far too often this partnership became one-sided in favor of the manufacturer and it was impractical, if not financially impossible, to change to another manufacturer after making the initial investment in their solution. This situation became known as the sole-source lock.

Open System technologies have changed how the building automation industry conducts business. The relationship between owner, system integrator, and manufacturer has been irrevocably changed. Owners now have the option to select products, applications, and installers for their open system solution. Manufacturers also have more options. No longer does a manufacturer have to be a sole source, they can incorporate third-party products, technology, and applications into their solution, which follow open system guidelines. By doing this manufacturers can expand their solution offering without the burden of R&D and focus on solution application, feature sets, services, and addressing the strategic business requirements of the customer.

Many owners are now taking advantage of Open System technologies to transform their facility from an overhead to an asset. This is accomplished by using open system solutions to create a total building control network that encompasses every building system. This enables an owner to achieve more effective equipment scheduling, tenant billing, data mining, and energy management. In addition owners have broken free of the sole-source lock, enabled competitive bidding and best-in-breed product selection.

Several studies, including the Turner & Townsend Group (a UK based engineering consultant group) cost comparison model and the CABA IIBC report on integrated automated building networks, have shown the benefit of open system solutions when compared to proprietary solutions. The Turner & Townsend study compared the installation costs between a proprietary installation and a LonWorks installation (using LonMark® certified devices). Their evaluation indicated a 4% savings per square meter when installing a LonWorks interoperable network over a proprietary installation. The CABA IIBC report indicated a $500K life cycle cost advantage when using a fully integrated system when compared to using a proprietary system for a typical 150K square foot building.

In order to achieve the vision of a total building control network an open system technology must be chosen. It must have a dynamic application, be able to utilize enterprise technologies, and have an established market presence. The challenge becomes selecting an open system technology. There are many technologies available that claim to be an "open system technology". Each has its merits, but only the LonWorks and the BACnet technologies have gained wide acceptance and application.

LonWorks and BACnet technologies can claim a global user base of manufacturers, installers, integrators, and end users. Each technology is capable of delivering a total building control network, however; they have very different network, software and hardware requirements. For all practical intents they are mutually exclusive solution approaches. Both platforms aspire to the same goals, but LonWorks and BACnet are not compatible technologies. Ultimately, one must be chosen over the other.

There are examples of networks that include both LonWorks and BACnet devices. Each installation requires a gateway device or translation application to facilitate communication between the two technologies. This introduces a single point of failure into the network and limits the benefits of using an Open System solution. When planning a new installation, the best course of action is to select either a LonWorks or BACnet based solution.

Before deciding between LonWorks and BACnet three areas need to be considered: the Open System goals; respective market presence; and solution approach. Both aspire to the Open System goals of

implementing an End-to-End solution that is Open, Interoperable and Multi-Vendor. Comparing market presence illustrates the influence each has on the market and comparing solution approach reveals the strengths and weaknesses of each approach. A comparative evaluation of LonWorks and BACnet with respect to the Open System goals provides the basis for making an informed decision.

Comparing market presence involves evaluating user community activity and the extent of the installed base. This evaluation shows a greater market acceptance for the LonWorks technology over BACnet. This implies a greater demand for LonWorks products and a more active community of manufacturers and system integrators.

Comparing solution approach shows the similarities and differences between the LonWorks and BACnet technologies. Evaluating their similarities shows that both can deliver complete End-to-End solutions with an array of control devices and operator interface options. Focusing on their differences shows significant divergence in several notable areas including device interoperability (and interchangeability), network management, product distribution and integration of new technology.

- The device communication guidelines maintained by LonMark® International for LonWorks device interoperability (and interchangeability) are focused on device type definitions (e.g., Required and optional network variables for a VAV device) to insure repeatability from device manufacturer to manufacturer. Whereas, the BACnet standard document does not explicitly define or provide guidelines for device type definitions.
- Neither the LonWorks or BACnet technologies have defined a database standard to store network characteristics, however, the wide spread use of the LNS® network operating system (available from Echelon®) and independent network tools and user interfaces has provided the LonWorks community with a common database structure and network management infrastructure. In the BACnet community, no third party database structure has gained wide spread acceptance; therefore, each solution provider supplies a custom network database structure.
- LonWorks and BACnet solutions are both available from several manufacturers, but only LonWorks component products are available from independent distributors.
- In general, the LonWorks community produces products based on new technologies (new to building automation) like IP and XML / Web Services earlier than the BACnet community. There are more LonWorks-based, non-solution specific IP and XML / Web Services devices available on the market than BACnet-based devices.

Selecting an Open System technology is a matter of choosing either a LonWorks or BACnet based solution. Both are capable of delivering an End-to-End solution, however, for product availability, product diversity, and vendor choice, LonWorks has a significant market lead.

2. Introduction

The demand for open systems in building automation has resulted in the development and promotion of numerous "open system technology" solutions. The landscape of options is crowded and confusing, with each option appearing to achieve the same goals of implementing an open, interoperable, multi-vendor solution. By evaluating the technologies that meet the open system goals and are being embraced by owners, system integrators and manufacturers as End-to-End solutions, the landscape clears to just two choices - LonWorks or BACnet.

The LonWorks and BACnet technologies have gained widespread application and are the clear choice as the leading open system technologies. They have distinguished themselves above the rest with a flexible architecture focused on meeting the growing requirements of building automation. Despite their achievements, LonWorks and BACnet have very little in common. They have very different origins, distinctive network architectures, diverse hardware and software requirements, and each has a core group of devout followers.

LonWorks and BACnet may aspire to the same goals, but they use vastly different methods and technology. The solutions are mutually exclusive and owners seeking an open solution must select either LonWorks or BACnet. Owners have turned to the numerous articles, discussions, debates and arguments circulating throughout the industry as the basis for their decision. Many of these sources include only anecdotal information, and do not include a comprehensive assessment of the technologies or benefits. Only an objective, side-by-side comparison presents a complete picture of each technology and provides the basis for an informed decision when choosing a solution. This is the best method for understanding their differences, achievements and potential.

This report presents an objective comparison of the LonWorks and BACnet technologies as the basis for making an informed decision when selecting an open system solution. Several aspects of the respective technologies, market acceptance, industry guidelines, product diversity, and user groups are discussed.

3. Why Open Systems

Before comparing the LonWorks and BACnet technologies an understanding of the benefits of the Open System approach is necessary.

Why select an Open System solution for building system control over a proprietary solution? Do Open System solutions provide better control, greater comfort or higher occupant satisfaction? Not necessarily, a proprietary solution can provide the same level of control, comfort and occupant satisfaction, as an open solution. This often leads people to the incorrect assumption that there are no compelling reasons or benefits for using an Open System solution. When in fact open solutions offer numerous benefits including competitive bidding, consistent installation, consistent maintenance, system integration and interoperability, data acquisition and product interchangeability.

The following table presents the core benefits that an Open System solution should deliver.

Open System Benefits	Discussion
Competitive Bids	With proprietary systems competitive bidding is only an option at the beginning of a project. With open system technologies, competitive bidding can be employed at the beginning of a project, for ongoing system maintenance, and future system expansion.
Consistent Installation	Each proprietary system has a unique installation topology, expansion requirements, and product sourcing. An open system will have a consistent installation topology regardless of the building system controlled or supply vendor. Open System solutions that following standard guidelines will create a uniform network throughout a facility.
Consistent Maintenance	Consistent installation results in consistent maintenance standards throughout a facility. Maintainers will only have to be trained on a single set of diagnostic, network management, and programming tools to assess any point in the control network. There will not be a requirement for specialized tool sets for each vendor or for each building system.
System Integration and Interoperability	Open system technologies have paved the way to total building integration. Each individual building system can be connected to form a single building control network, facilitate device interoperability, and be accessed through a single operator workstation. (For security reasons, certain sections of the network may be purposefully separated from the network - either logically or physically - but utilize the same technology.)
Data Acquisition	Using an open system solution to achieve total building integration will result in an unprecedented amount of control system data. This data can be used by an energy management program to effectively analyze energy usage, occupancy level, and external factors (such as energy price points) to reduce a facility's energy costs without compromising occupant comfort.
Product Interchangeability	Following open system guidelines and standards, manufacturers will produce devices with a documented network interface – known data types and network variables. Consistent device network interface structures will facilitate device interchangeability, between devices of similar function from different manufacturers. (Product interchangeability may not always be a seamless process, but with proprietary systems it was nonexistent.)

Table 3.1 – Open System Benefits and Discussion

An open system architecture can deliver benefits far beyond any proprietary system. These benefits are derived from creating a totally integrated control network throughout an entire facility. The more integrated your control systems the greater the saving for system installation and maintenance. Only with a fully integrated facility can you benefit from data analysis products like energy management systems.

The promise of open system technologies appears to be the ultimate solution for building automation control and management. However, open system solutions are not a "one-size-fits-all" solution. Many technologies and solutions are touted as open system solutions, but are unable to deliver. Creating further confusion, certain solutions are based on a bona fide open system technology, but implement it in a proprietary or closed fashion.

Before deciding on an open system technology or solution it must meet the Open System goals of delivering an *End-to-End solution that is Open, Interoperable and Multi-Vendor*.

4. Open System Goals

Both the LonWorks and BACnet technologies aspire to the Open System goals of enabling *the implementation of an End-to-End solution that is Open, Interoperable and Multi-Vendor.* This section defines the goals and evaluates how a LonWorks or BACnet solution can deliver the goals.

4.1. Defining the Goals

The open systems goals originate from owner frustrations with the rising costs of maintaining a sole-sourced proprietary system. They want to break the sole-source lock and bring operating costs under control without sacrificing quality. They expect open technology manufacturers to provide a full-featured, complete solution and not just parts and pieces. To meet these requirements, open systems must meet the functional needs of the building, be easier to expand than a proprietary solution, be capable of combining disparate building systems, allow best-in-breed product selection and enable competitive bids.

The following table presents a definition for each Open Systems goal.

Goals	Definition
Open	The technology is available for any manufacturer to develop and deliver devices or software as individual products or as part of a complete solution
Interoperable	Devices use peer-to-peer communication to share information within a single system (e.g. HVAC) and across multiple systems (e.g. HVAC and Security) without the use of a gateway or translation software
Multi-Vendor	A solution can be constructed using devices and software produced from different manufacturers, without the need for gateways or manufacturer specific software or network tools
End-to-End Solution	A holistic approach that applies the technology to every system level from field devices to the operator interface and ancillary products (e.g. diagnostic tools)

Table 4.1 - Open System Goals and Definitions

4.2. Achieving the Goals

A technology must meet all of the open system goals to be considered an open system. Achieving some, but not all of these goals does not result in an open system. There are several technologies that meet one or more, but not all of these goals. Consider the following points when evaluating an open system solution:

- There are companies that claim their proprietary technology to be *Open*. These companies make their protocol and hardware architecture available to third party manufacturers, and may even offer certification for any third party product developed. Their technology is available for any manufacturer to develop products, but it is not an Open System because a single company controls the underlying protocol.

- Select proprietary solutions have a level of *Interoperability* between either HVAC and Security systems or HVAC and Lighting systems. This is limited interoperability, exclusively with products from a single manufacturer. Their devices may use peer-to-peer communication across multiple systems, but it is not an Open System because it is exclusive to a single vendor. This precludes an alternate vendor from making network modifications because they do not have access to the original vendor's proprietary tools.

- Several technologies are available that can create a limited *Multi-Vendor* environment, such as Modbus. Manufacturers have applied Modbus to a variety of products, and it is possible to use Modbus products from multiple manufacturers in a single system. Using Modbus products from multiple manufacturers does not make an Open System, because it cannot deliver an End-to-End solution.

- Nearly every proprietary solution is an *End-to-End* solution offering a holistic approach. Each product in a proprietary solution is manufacturer specific and therefore not an Open System.

An Open System must be an End-to-End solution with a multi-vendor product mix that uses peer-to-peer communication across all building systems.

4.3.   Delivering the Goals

LonWorks and BACnet technologies both aspire to the same Open System goals, but the task of delivering the goals is left to the manufacturers and integrators. Each technology provides a level of design and implementation flexibility and options not seen in traditional proprietary control systems. The result is a market of solutions and products that carry either the LonWorks or BACnet name where some achieve the Open System goals and others do not. For owners to benefit from the Open System goals they need to first recognize how LonWorks and BACnet can meet the goals and second, require products and solutions to deliver the goals.

The following points discuss how the LonWorks and BACnet technologies achieve the Open System goals and how to recognize implementations that deliver the goals.

Open -   Both technologies are readily available to manufacturers for the development of products and solutions. This is facilitated through standards organizations, which cultivate industry expertise to maintain and update standards. LonWorks and BACnet solution components, guidelines and core standards are available from and maintained by independent organizations.

- The BACnet Standard is maintained and available through the ASHRAE® Standing Standard Project Committee 135 (SSPC-135). The SSPC-135 maintains all aspects of BACnet, including the protocols, data types, and device profiles.
- The core component of the LonWorks technology, the LonTalk® protocol, is maintained and available through the CEA as the ANSI/CEA[1] 709 family of protocols. LonTalk can be implemented on any processor, however, the Neuron® processor (with LonTalk embedded) is the processor of choice for most LonWorks product development. Two different semiconductor manufacturers produce the Neuron processor.
- LonWorks guidelines for data types and device profiles are created and maintained by the LonMark International organization. All LonMark guidelines are available on their website. These guidelines are frequently applied to LonWorks products and solutions.

Interoperable -   LonWorks and BACnet provide access to interoperability differently.

- The LonWorks technology provides field level interoperability to all devices, which creates a flat network of peer devices. This is critical for implementing multi-vendor solutions and for eliminating the need for gateways and translation devices. The only way to inhibit LonWorks interoperability is to use proprietary data types. Adhering to LonMark guidelines (functional profiles, and SNVT and SCPT data types) will safeguard interoperability.
- The BACnet standard specifies several interoperability areas - data sharing, alarm and event management, scheduling, trending, and device and network management. Each area represents a specific set of BACnet elements that manufacturers must choose to implement uniformly to provide interoperable products (there is no required subset of elements for BACnet compliance).

Multi-Vendor -   Manufacturers can use either LonWorks or BACnet to develop a multi-vendor solution. Part of the original intent for the creation of each technology was to enable and promote the development of multi-vendor solutions. The only hurdle is getting manufacturers to develop products that use standard data types and not proprietary data types. There are many vendors that offer LonWorks and/or BACnet product and solution options, but not all of them faithfully use standard data types. The LonWorks standard data types (SNVT, SCPT) are available from LonMark and the BACnet standard data types (standard objects) are published in the BACnet Standard document. Using proprietary data types limits the effectiveness of each technology and inhibits the creation of a multi-vendor solution.

End-to-End Solution -   There are numerous examples of LonWorks and BACnet installations worldwide. Not all of them delivered what the owner was expecting and not all of them deliver an End-to-End solution. Several vendors offer a gateway solution that appears to be an End-to-End LonWorks or BACnet solution. An End-to-End solution does not require a translation device between the HMI and the field devices or between field devices controlling different building systems.

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[1] The LonWorks protocol, commonly referred to as LonTalk, is ANSI/CEA 709.1, Control Network Protocol Specification. It is maintained by the CEA through their standard processes and is available through their affiliate, Global Engineering Documents. LonTalk is an Echelon trademark and for the purposes of this document, references to LonTalk denote ANSI/CEA 709.1.

Recognizing which open system solutions deliver the Open System goals is the key to achieving the benefits of open systems. Both the LonWorks and BACnet technologies were designed to meet the open system goals; however, some manufacturers have used the inherent flexibility in these open technologies to close their solution and effectively deliver a proprietary solution. A LonWorks or BACnet solution that delivers the Open System goals adheres to standard data format guidelines, is interoperable between different vendors and does not use a gateway architecture.

5. Comparing LonWorks and BACnet

Comparing LonWorks and BACnet is not always an "apples to apples" comparison. There are significant differences in technology and solution approach. When exploring these differences there is a tendency to get lost in a technical discussion of bits and bytes, which is more relevant for the computer and software industries than it is for the building automation industry. A comparison relevant to building automation should focus on market presence and solution approach. A market presence comparison is an indication of user and manufacturer acceptance through the number of user organizations and product availability. A solution approach comparison illustrates the tangible differences and implementation issues to consider when evaluating a solution. The following sections compare the LonWorks and BACnet market presence and solution approaches.

5.1. Market Presence Comparison

Market presence is an important factor when faced with choosing between competing technologies. Numerous technologies have been developed, marketed and praised only to disappear from the marketplace after a few years of service. The difference between the technologies that thrive and the ones that fade is not always technology based. Very often, success or failure is a function of market acceptance, product availability and product diversity.

In general, the market presence of Open Systems has profoundly affected how business is conducted. From owners to manufacturers to system integrators, it is changing how projects are specified, products are manufactured and solutions implemented. Consider the following points when evaluating the market presence of Open Systems:

- Owners are using open systems to seize the opportunity and advantage of choice. They are choosing manufacturers, choosing products and choosing system integrators, with no sole-sourced strings attached.

- Manufacturers are producing products and solutions to meet open system specifications. Open system technology puts less demand on the manufacturer's resources. For proprietary solutions, a manufacturer has to invest in ongoing R&D for solution maintenance and improvement. For an open solution, a third party is maintaining and updating the core technology enabling the manufacturer to focus on application, feature sets and addressing the strategic business requirements of the customer.

- System integrators no longer have to represent multiple manufacturer product lines to meet all project specifications. Representing multiple product lines often requires a dedicated internal resource for each product line. Using an open system technology enables system integrators to use products from multiple vendors without the need for specific training on each product line, which lessens the demand on internal resources. Open systems technology enables a system integrator to focus on a single solution approach for all building automation applications.

Open Systems have changed the way business is conducted. It is not a question of whether Open Systems have the market presence to survive, but a question of selecting which open system technology to use.

Evaluating the LonWorks and BACnet market presence with a focus on accessibility to products and user-base clearly demonstrates the influence each technology has on the market. The number of manufacturers developing products is an indication of the availability and diversity of products. The size of a technology's user-base is directly related to the longevity of the technology. User groups are a focal point for the promotion and adoption of a technology platform; they promote best practices in local regions, and are an indication of overall market acceptance.

The following table lists several LonWorks and BACnet statistics that relate to market presence on a worldwide basis.

Topic	LonWorks	BACnet

Statistics	• April 2002 - Over 18 million LonWorks devices installed
	• Neuron processors - Over 54 million shipped
	• Developers worldwide - Thousands
	• LNS® plug-ins listed - Over 280
	• LonWorks product database - 1322 products listed from 172 manufacturers[*]
	• Engenuity Systems - 1196 products for sale on website[*]
	• LNO product database - Over 820 products listed[*]
		• BACnet Vendor ID[*] - Over 180
		• BMA® Product Database – Over 135 products listed from 16 manufacturers[*]
		• 2000 BMA Survey Results[*]
		   ○ Installations 19,054
		   ○ Countries 82
		   ○ Gateways 2,410
		   ○ Devices by Network Type
		      ▪ Ethernet - 11,970
		      ▪ ARCnet - 95,567
		      ▪ MS/TP - 248,500
		      ▪ PTP - 1,549
		   ○ Workstations 15,807
		   ○ Large Controllers 53,391
		   ○ Unitary Controllers 299,600

Certification	• LonMark International Members - Over 300 worldwide
	• LonMark Certified Devices – Nearly 700
	• Companies with Certified Products - Over 70
	• LonMark Task Groups - 12
	• LonMark Functional Profiles - Over 70
		• BMA Members
		   ○ Corporate - 26
		   ○ Individual - 11
		   ○ Affiliate - 4
		• BTL® Listed Devices[*] - 133
		• Companies with Certification - 13
		• BACnet Working Groups – 9

Certification Centers	• LonMark International - LonMark Certification Tool (LCT) - web-based certification tool for device certification	• North America - BTL (BACnet Testing Laboratories), USA • Europe - German Certification Center Pending

International & Regional Organizations	• LonMark International (Worldwide)
	• LonMark Americas (North America)
	• LonMark Japan
	• LonMark Switzerland
	• LonMark Denmark
	• LonMark Germany
	• LonMark Italy
	• LonMark France
	• LonUsers (International User Groups) (~ 670 companies represented)
	   ○ LonUsers Austria
	   ○ Belgum LonUsers Group (BeLON)
	   ○ LonUsers Espana
	   ○ LonUsers Finland
	   ○ LonUsers Netherlands
	   ○ LonUsers Sweden
	   ○ Polish LonUsers Group
		• BMA (BACnet Manufacturers Association)
		• SSPC-135 (The BACnet Committee)
		• BIG-NA (BACnet Interest Group - North America)
		• BIG-EU (BACnet Interest Group - Europe)
		• BIG-AA (BACnet Interest Group - AustralAsia)
		• BIG-ME (BACnet Interest Group – Middle East)
		• BIG-RU (BACnet Interest Group - Russia)
		• BIG-SW (BACnet Interest Group - Sweden)

International Events	• LonWorld conference and exhibition held annually in Asia, Europe or North America • Annual LonUsers conferences held in China, Korea, and Japan • LonMark Seminars held as AHR Expo • LonMark Open Systems Tour – Multi-city Professional Education Seminars	• Annual conferences held in North America and Europe • BMA/BTL sponsored BACnet Interoperability Workshop ("Plugfest") held twice a year • BIG-EU sponsored BACnet Interoperability Workshop ("Plugfest") held once a year

Table 5.1 - LonWorks and BACnet Market Presence Comparison

[*] For more information see section 8, *Appendix – Products, Industry Organizations, Certifications*

5.2.   Market Review

The information available indicates that, when compared to BACnet, LonWorks has greater market presence with a larger installed base and a larger community applying the technology.

Obtaining a precise count of installed LonWorks and BACnet devices is nearly impossible, due to the nature of open system technologies. Numerous companies worldwide are actively installing and manufacturing LonWorks and BACnet products. To gain a perspective on the installed base of each technology, several indicators must be evaluated.

- For installed LonWorks devices, the number of Neuron processors delivered is the best guideline. Even though LonTalk can be ported to any processor, the Neuron processor is still the primary choice for many manufacturers. Evaluating the number of Neuron processors delivered results in an installed base of tens of millions of devices worldwide.
- The number of LonWorks developers and manufacturers underscore the number of Neuron processors delivered. Worldwide there are thousands of developers producing hardware and software products and hundreds of manufacturers listing products in the various LonWorks product databases
- For installed BACnet devices, manufacturer survey responses are the only guideline, because BACnet is not based on a specific processor or technology component. BACnet product development and installation can easily escape notice. As a result the total number of BACnet devices installed is anyone's guess, and the 2000 survey results are viewed as a minimum number of installed devices.
- The number of BACnet Vendor IDs and the number of companies in the BMA product database are leading indicators of BACnet product development. The Vendor IDs represents the total number of companies that could be developing BACnet products. The companies listed in the BMA product database represent the leading edge of the BACnet community.

What is easier to determine is the size and activity of each user community. The activities of installers, manufacturers and distributors can be seen through evaluation of user groups, product databases, and product certifications.

- The activity of the LonWorks community is apparent from the 1000s of products represented in various databases, the number of users groups worldwide, and the 100s of LonMark certified devices. These are all indicators of an active and expansive community of manufacturers and installers.
- The activity of the BACnet community is most apparent from the 2000 BMA market survey, the number of worldwide user groups, and quantity of BTL certified products. These are all indicators of a tightly knit community of manufacturers and installers.

The market data presented is from publicly available sources and clearly indicates the market lead the LonWorks community has over the BACnet community. Both communities are showing growth in the critical areas of membership and product certification. This demonstrates a high interest level from manufacturers and installers in both technologies. The number of available LonWorks products, user groups and certified products suggests a larger community and technology acceptance over BACnet. The BACnet community is active, but smaller by comparison with lower industry membership, less product certification activity, and fewer user groups.

5.3. Solution Approach Comparison

A direct comparison of solution options most often reveals the deciding factor or factors for selecting a particular solution. The key to effectively comparing any two solutions is to evaluate similar aspects of each in a side-by-side comparison. This illustrates strengths and weaknesses and ultimately provides the basis for selecting the solution most appropriate for your application. The challenge is identifying shared elements that influence the installation, life cycle, expandability and serviceability of the installed system.

Creating a comparative table of LonWorks and BACnet elements is a challenge. Both technologies approach building automation very differently, and in several cases elements of one do not exist in the other. Ultimately, the topics selected represent implementation and product issues along with milestones achieved by each technology since their inception.

The following table is a comparative overview of LonWorks and BACnet elements. The table serves as a summary of topics and their significance to each technology. Supporting arguments and additional detail for each topic are supplied in the sections following the table.

Topic	LonWorks	BACnet
History	1988 – Protocol developed by what later became Echelon Corporation (1990) 1994 – LonMark Organization formed 1995 – 1st LonMark Certified Device 1997 – LNS 1.0 released 1998 – 100th LonMark Certified Device 1999 – 200th LonMark Certified Device 1999 – i.LON® 1000 release - IP integration 1999 – LonTalk becomes ANSI/EIA standard 709 2001 – i.LON 100 release – XML / Web Services 2001 – 300th LonMark Certified Device 2002 – LonTalk Update release by ANSI/EIA 2002 – 400th LonMark Certified Device 2003 – LonMark International formed (non-profit) 2004 – LonMark Americas formed 2004 – 500th LonMark Certified Device 2005 – 600th LonMark Certified Device	1987 – ASHRAE® SPC-135 committee formed 1995 – BACnet1995 released (ASHRAE-135) 1995 – BACnet1995 becomes ANSI standard 1998 – BIG - NA and BIG - EU established 1999 – BMA established 2000 – BTL established 2000 – BIG - AA established 2001 – BACnet2001 released 2001 – BACnet2001 becomes ANSI standard 2002 – 1st BTL Listed Device 2002 – XML Work Group established 2003 – BACnet becomes ISO Standard 16484-5 2003 – BIG - ME established 2003 – BACnet *Methods of Testing and Conformance* published (ASHRAE-135.1) 2004 – BACnet2004 released 2004 – BACnet2004 becomes ANSI standard 2005 – BIG - RU established 2005 – 100th BTL Listed Devices
Network Architecture	• A "bottom up" solution focused on device interoperability • Open standard that employs a common protocol • Flat network topology • Peer-to-Peer device communication	• A "top down" solution focused on HMI integration • Open standard that can employ multiple protocols • Tiered network topology
Network Management	• No common database for network characteristics specified in standard • Several solution specific and independent network database platforms available • LNS is the predominate choice of network database platform • LNS Network Management tools available from many sources (approximately 30) • Single tool to access any vendor's devices and all media types • View and configure network devices • View network variables and establish peer-to-peer communications • Single tool enables graphical presentation of network and common database to store network characteristics	• No common database for network characteristics specified in standard • Several solution specific database platforms available • Few independent network management tools (approximately 5) • No single network management tool can view all supported protocols • A typical installation uses network tools supplied by the solution vendor • Network management functions limited by protocol selection

Topic	LonWorks	BACnet
Operator Interface Software	• LNS developed as a vehicle for HMI communication • OpenLDV™ with core LNS components available with Echelon NICs to allow any non-LNS based HMI to interface with LonWorks networks • Many native LNS HMI applications • Many vendor specific communication drivers • LNS DDE available from Echelon • LNS OPC available from several 3rd party developers/suppliers • LNS database back-up and restore features	• Originally BACnet was intended for use at the operator level • Several native BACnet HMI applications available • Several vendor specific BACnet communication drivers available • BACnet OPC and DDE available from 3rd party developers/suppliers • Most HMI network communications use BACnet over IP, ARCNET or Ethernet. • HMI communication with MS/TP protocol, typically requires additional hardware

Design Guidelines	• LonMark International sets LonWorks guidelines (physical layer; application layer via functional profiles), which define mandatory and optional data elements, and product certification requirements
	• 73 - LonMark Functional Profiles (LFP)
	• 30 - LFPs in development
	• Define standard data types (SNVT and SCPT)
	    ○ Over 170 published SNVT
	    ○ Over 290 published SCPT
	• LonMark International certifies product compliance
		• BACnet standard defines architecture and sets broad product development guidelines
		• Identifies data types, PICS format, BIBBs and device profiles
		• 150 - published data types
		• 23 - published standard objects
		• 67 - published BIBBs
		• 6 - published device profiles
		• BACnet committee (SSPC-135) maintains the BACnet standard, but does not certify product compliance

Certification	• Device certification is performed by LonMark web-based certification tools • Devices certified against LFP • LFP defines specific mandatory and optional data elements (direction and type) for implementation • Published LFPs available at LonMark website • List of certified devices and accompanying documentation available at LonMark website	• The BACnet Testing Laboratories (BTL) tests and lists BACnet products using manufacturer independent tools • The BTL does not set BACnet development guidelines; nor do they establish mandatory/optional data elements for devices • The BTL tests against BACnet device profiles specified in BACnet standard • List of certified devices and accompanying documentation available at BTL website • BTL performs testing for 5 of the 6 device profiles
Device Architecture	• Generic controller - Neuron Chip processor, Neuron C programming language, I/O Channels, Transceiver • Hosted controller - Neuron Chip plus 3rd party processor • Non-Neuron - 3rd party processor with ported implementation of LonTalk • Majority of LonWorks controllers use the Neuron Chip processor	• Processor independent • Programming language independent • Final controller specification at manufacturer's discretion • No device protocol usage guideline • Majority of field devices use MS/TP protocol
Devices	• All devices use LonTalk, most devices use the Neuron; some are non-Neuron devices • Infrastructure - Routers, web servers, gateways, NIC • Non-HVAC - Access, Energy Management, Fire & Smoke Control, Motor Control, Lighting, etc • Data Collectors - schedulers and trend loggers	• All devices are protocol specific • Routers - used to translated between protocols or extend existing LAN • Supervisory Devices - typically use multiple protocols • Gateways - most commonly developed BACnet device • Non-HVAC - Access, Lighting, Motor Control

Topic	LonWorks	BACnet
Diagnostic Tools	• Network Diagnostic tools available from several vendors • Single tool can access and evaluate a multi-vendor network • Single tool can access all media types	• Very few diagnostic tools available • Must be maintained to include new BACnet objects and data types
Protocols	• Single protocol - ANSI/CEA-709.1 (LonTalk) • EIA/CEA-852 to tunnel LonTalk over IP • LonTalk embedded into every Neuron Chip • LonTalk can be ported to almost any processor or microcontroller • All LonWorks devices use LonTalk • Supports various media including unshielded twisted pair, fiber optics, radio frequency, infrared, and power line carrier.	• Multiple protocols supported • BACnet/IP, Ethernet, ARCNET, MS/TP, PTP, LonTalk • All industry standard protocols • Each with specific implementation and media requirements • A device could support 1 or more protocols
IP and XML / Web Services	• Many vendors have developed Web Services devices to exchange data between the field and enterprise levels • Echelon's i.LON Web Services device series is used by many vendors in-lieu-of in-house development • EIA-852 - LON/IP products available from several manufacturers • LNS API accessible over IP directly • Porting existing LFP profiles to XML (coordinating effort with the oBIX "XML / Web Services Guideline" development under the auspices of OASIS)	• Many vendors have developed Web Services devices to exchange data between the field and enterprise levels • XML Work Group established to create BACnet/WS interface. Interface intended to be protocol neutral. • Final version of the BACnet/WS document is not yet available.
Distribution	• Direct from manufacturer as part of a complete solution • Many companies produce solution independent LonWorks devices (HVAC, lighting, sensors, motor control, power metering, security, life safety, diagnostic tools, etc.) • Independent distributors representing devices from multiple vendors	• Direct from manufacturer as part of a complete solution • Very few companies produce solution independent BACnet devices (lighting, diagnostic tools, motor control, gateways) • No independent product distribution
Related Standards Qualifications	• EN14908 European Standard • IFSF – International Forecourts Standards Federation (EU petrol station controls) • IEEE 1473L– In train controls • AAR – Electro-pneumatic braking controls; USA • SEMI – Semiconductor Equipment Manufacturer's Industry • Finnish Homes – Automation standard	• ANSI/ASHRAE Standard 135 • ISO Standard 16484-5 • CEN-TC247 – EU government buildings • Korean National Standard

Table 5.2 - LonWorks and BACnet Solution Approach Comparison

5.4. Solution Review

The above comparative table presents a spectrum of information on topics relevant to LonWorks and BACnet users. There are several differences noted in the table to consider when selecting a solution. Ultimately selecting between LonWorks and BACnet will depend on the functionality of the building and owner expectations. Several topics of comparison should be carefully considered before selecting a technology including, product availability, product certification, and network architecture. Each topic presented in this table is discussed in the following section.

6. Comparison Discussion

Table 5.2 is a concise presentation of topics and information relating to LonWorks and BACnet. In this section, each topic from the table is discussed in further detail. This provides a better understanding of the differences and similarities between LonWorks and BACnet.

6.1.   Network Architecture

The BACnet and LonWorks network architectures differ greatly. The intrinsic difference is that LonWorks is an open protocol technology and BACnet is an open standard. This may sound like a difference of semantics, but in fact this is the fundamental difference that sets the two technologies apart. All of the network architecture differences between LonWorks and BACnet stem from this.

LonWorks is an open protocol technology, which means that the network architecture is based on a single protocol - LonTalk. LonTalk is what every LonWorks device has in common, regardless of manufacturer, device type, processor, or communication media. Using a single protocol enables a peer-to-peer network topology where all network devices are peers and any device can communicate with the operator workstation without requiring a gateway, supervisory controller, or other intermediary device.

LonTalk facilitates interoperability by creating a single set of network rules that apply to all devices and software. Manufacturers, system integrators and owners have recognized the benefits of device level interoperability and often characterize LonWorks as having a "bottom up" network architecture. LonTalk commonality provides manufacturers with a standard set of design requirements (which shortens product time to market) and enables system integrators to use products from multiple manufacturers without requiring specialized training or manufacturer specific software. It empowers owners to open their facility to competitive bids and multi-vendor installations, without compromising the integrity or maintainability of the network.

BACnet is an open standard, which means it defines a comprehensive set of rules for network architecture and product development that is not technology dependent. BACnet is processor independent, programming language independent and it supports 6 different protocols (each with specific implementation and media requirements). This empowers manufacturers with unparalleled flexibility in product development and solution architecture, which has resulted in a lack of commonality between devices and software applications. There are no design guidelines to set expectations.

BACnet is a "top down" network architecture that focuses on operator interface integration. As a result, in practice many BACnet based solutions focus on gateway integration at the operator interface. The network architecture consists of a BACnet compliant operator workstation connected to an array of gateways translating system data from various third party solutions. Other solutions, called native BACnet systems, apply BACnet elements at each solution level. Native BACnet systems employ multiple BACnet protocols, which creates a tiered architecture using either supervisory controllers or other intermediary devices to translate between protocols. These solutions are dependent on manufacturer specific software to install and maintain.

The differences in network architecture affect the owner's options to open a facility to competitive bidding and the interchangeability of products in the network. With respect to BACnet, the combination of multiple protocols in a single solution, combined with the vendor specific nature of the supervisory controllers, can make it difficult to replace the system integrator or achieve product interchangeability. With respect to LonWorks, the combination of LonMark guidelines and using a single protocol throughout the network, regardless of the media or manufacturer, facilitates a flat architecture, and provides the option to replace the system integrator and achieve product interchangeability.

6.2. Network Management and Operator Interface Applications

LonWorks and BACnet share several similarities in their approach to operator interface applications and have significant differences in network management administration. Every control solution, regardless of the underlying technology, requires some form of operator interface and network management tool. Proprietary solutions typically bundle network management functions with the operator interface application. This makes network management functions transparent to the user and configuration is done automatically, creating a proprietary lock on the system.

Neither the ANSI/CEA 709 or BACnet standard documentation specifies a common database platform for storing network characteristics. Several solution specific database platforms exist for both LonWorks and BACnet implementations. These proprietary database implementations inhibit the owner's ability to competitively bid operator interface applications or replace the system integrator without incurring significant cost to reconfigure the network. Many companies within the LonWorks community have addressed this issue by using the LNS operating system as a common platform (developed by Echelon), while the BACnet community has not yet adopted a common platform.

The LNS operating system was developed by Echelon and is widely used by the global LonWorks community. LNS provides a common platform for interface development and network management, which has accelerated the use of LonWorks at the operator interface level. There are many LNS network management tools and operator interface applications available. The network management tools can view and configure network devices from any manufacturer across any LonWorks media type. Most network management tools also provide a graphical representation of the network and network diagnostic functions, which makes management intuitive and reduces configuration time. These tools are available from many developers and are independent applications that are not bundled with the operator interface application.

BACnet network management functions are typically bundled with the operator interface application. There are a few independent network management applications available. Those available typically represent the network in a hierarchical tree view and not graphically. BACnet network management tools focus on the higher-level protocols and require hardware to communication with the field level protocols (like MS/TP).

There are several examples of LonWorks and BACnet operator interface applications, each using one of several communication methods to connect to the network – custom communication driver interface, OPC or DDE. BACnet installations typically have a dedicated BACnet operator interface application with a custom network database. The typical LonWorks solution uses an LNS-based operator interface application with a LNS network database. Regardless of the LNS connection method, using LNS standardizes network commands from installation to installation. This ensures that owners receive essential maintenance features, like database backup and restore.

Both LonWorks and BACnet are successfully applied at the operator interface level, but only LonWorks is achieving success with network management tools. The widespread use of the LNS platform provides a common development environment for LonWorks interface development. This common approach has resulted in interchangeable LNS-based network management tools and leverages enterprise technologies (OPC, DDE). BACnet does not deliver the benefits of network management and there is no widely accepted network database platform analogous to LNS. This can result in more required vendor specific software for a BACnet installation than for a LonWorks installation.

6.3.   Design Guidelines and Certification

Design guidelines and product certification are areas of divergence between LonWorks and BACnet.

LonMark establishes guidelines for the LonWorks community, including standard data types (SNVT, SCPT) and LonMark Functional Profiles (LFP). LonMark certifies products against those guidelines. If a manufacturer wants to produce a LonMark Certified device, they must follow the requirements specified in the LFP. The LFP specifies the mandatory and optional network variables and configuration properties for each device type. This provides repeatability by setting design expectations for manufacturers to meet. It also establishes a level of interchangeability between devices of like functionality from different manufacturers.

The BTL tests and lists products for the BACnet community, but does not set design guidelines. They verify that the manufacturer has implemented BACnet correctly, but they do not set device functionality expectations for the manufacturers to meet. The BTL tests against a broad classification of requirements called BACnet Device Profiles, described in the BACnet standard. There are 6 profiles that describe a range of functionality and effectively establish 6 categories that represent all BACnet control devices.

The difference in certification practices is best illustrated by an example of a vendor seeking certification for a VAV controller.

- For LonMark certification the vendor must adhere to the VAV LFP. The LFP guarantees repeatability (for the mandatory network variables and configuration properties) from vendor to vendor by defining the data to be exchanged and the actions to be taken upon receipt of the data by the VAV controller.
- For BTL testing the vendor must adhere to one of the BACnet Device Profiles. BACnet Devices Profiles do not specify functional characteristics specific to the device type. As a result, there is no VAV BACnet profile. The vendor is left with tremendous development latitude with respect to BTL listing. This makes repeatability from vendor to vendor unlikely.

In practice, this means that an integrator using a single network management tool is able to configure and commission LonMark certified devices into a building automation network with a significant level of confidence. In contrast, BACnet device interoperability is likely to require an installation tool specific to each device manufacturer. This fundamental difference can limit a system integrator's ability to create a multi-vendor, interoperable BACnet installation.

6.4.   Devices and Diagnostic Tools

There are a variety of aspects to evaluate when comparing LonWorks and BACnet devices and diagnostic tools. Focusing on owner, system integrator and manufacturer issues presents three different comparisons. Each comparison has its merits and several key points are discussed in this section.

For device manufacturers the BACnet standard offers more design flexibility than the LonWorks technology. Manufacturers can implement BACnet on processors they are using for their proprietary solution in a programming language they are familiar with, because BACnet is processor and programming language independent. They can choose any one or more of the 6 supported protocols to implement in a device, because there are no usage restrictions or guidelines to set expectations. Using the LonWorks technology, manufacturers must use the LonTalk protocol, but can choose to use the Neuron processor (with embedded LonTalk) or port LonTalk to a processor of their choice. Using the Neuron processor can reduce the time to market for LonWorks devices as compared to BACnet devices. Overall, device manufacturers have more design freedom using BACnet.

System Integrators and owners are looking for a diverse array of products to address the comprehensive needs of a facility. The LonWorks technology offers greater product diversity and selection through an abundance of component manufacturers offering LonWorks product versions or options. This is evident when comparing the LonWorks product database (hosted by Echelon) and the BMA product database. Comparing these databases reveals a large disparity between the number of available LonWorks and

BACnet products. Neither database represents all available products, but they represent the best available source of product information.

Diagnostic tools are used to address network issues and often to independently prove interoperability and network integrity. Because LonWorks uses the LonTalk protocol at all network levels and in every device, a single diagnostic tool can assess all network devices regardless of manufacturer or media type. Most LonWorks diagnostic tools are small hardware devices that an integrator can easily have onsite and plug into the network. Software diagnostic tools (protocol analyzers) are available for LonWorks networks from multiple competitive vendors. By contrast, there are very few BACnet diagnostic tools available. They are all PC-based software applications that can only assess the upper level protocols and they require routine updates to include new BACnet objects and data types.

The vision of an Open System solution at the field level is a networked array of control devices from different manufacturers and disparate building systems. Achieving this is a function of obtaining the right products and using repeatable installation practices. The commonality of LonTalk simplifies LonWorks development and installation to one set of network rules and it speeds the delivery of devices and diagnostic tools to market. The flexibility that manufacturers gain from BACnet does not translate into more diverse products for owners or system integrators.

6.5. Protocols

Protocol usage varies significantly between LonWorks and BACnet.

- LonWorks is a single protocol technology, which uses the LonTalk protocol at all network levels and in every device. LonTalk supports various media types; each operates at a different speed based on the physical properties of the media. Network routers are used to change media and synchronize packet transmission between media speeds. LonWorks installations use LonTalk to create a flat topology where the media type is transparent to the network architecture.

- BACnet supports 6 protocols (referred to as data link layers), each with its own implementation and media requirements. Several of the protocols support multiple communication speeds. Many native BACnet installations use multiple protocols, creating a tiered architecture with supervisory devices translating between protocols.

The following table lists the 6 BACnet protocols.

BACnet Protocol	Reference	Speed
BACnet/IP	Internet Protocols	
Ethernet	ISO 8802-3	10 Mbps
ARCNET	ATA/ANSI 878.1	19kbps – 10Mbps; 2.5Mbps
MS/TP (Master-Slave/Token Passing)	EIA-485 (RS-485)	9.6kbps, 19.2kbps, 38.4kbps, 76.8kbps
PTP (Point-To-Point)	EIA-232 (RS-232)	9.6kbps – 56kbps
LonTalk	Version 3.0 (ANSI/CEA 709.1-B-2002)	32kbps – 5Mbps

Table 6.1 - BACnet Protocols

BACnet supports multiple protocols in an effort to address economic and network performance issues. The goal was to establish a low cost LAN option for field devices and a high performance LAN option for larger devices and operator interface connections. Each of the selected protocols is an industry standard protocol, except for MS/TP. The BACnet committee (SSPC-135) developed MS/TP as a low cost LAN for BACnet field devices. During the initial development of BACnet all available low cost LAN technologies were perceived as proprietary, which made them unacceptable for inclusion in the BACnet standard and fueled the development of MS/TP. MS/TP is now the field level protocol of choice.

LonTalk is included as a BACnet protocol option, but it is rarely used. It was included as an alternative low cost LAN option to MS/TP. Many of the manufacturers on the BACnet committee have an investment in LonTalk devices and wanted this option included in BACnet. Regrettably, including LonTalk in BACnet does not provide a link between the two technologies. The BACnet and LonWorks data structures are incompatible. A device using BACnet objects over LonTalk cannot communicate with a device using LonWorks objects over LonTalk.

The following table lists the media types supported by the LonTalk protocol.

LonWorks Protocol	Media Type
LonTalk	Shielded or Unshielded twisted pair - free topology
	Shielded or Unshielded twisted pair - bus topology
	Fiber optics
	Radio frequency
	Infrared
	Power line carrier

Table 6.2 - LonTalk Media Types

The media supported by LonTalk can address a multitude of control network configurations. The twisted pair free topology option is the popular choice for field level building controls. It offers the most flexible network configuration and simplifies installation. The LonWorks twisted pair transceiver types can accommodate either shielded or unshielded cabling, and are polarity insensitive. These two factors simplify installation and can reduce costs. Fiber optics and radio frequency are frequently used between routers to easily extend a network across long distances and wide areas. The infrared and power line carrier communication media are being applied for lighting control, alarming and remote control applications. The power line, free-topology and fiber optic signaling technology for LonWorks networks are ANSI/CEA standards 709.2, 709.3 and 709.4, respectively.

LonWorks and BACnet both support the Internet Protocols (IP). BACnet over IP is defined within the BACnet Standard and LonWorks over IP is defined in the EIA/CEA-852 standard. The EIA/CEA-852 standard, *Tunneling Component Protocols Over Internet Protocol Channels*, provides the basis to tunnel ANSI/CEA-709.1 (LonTalk) over IP. Supporting IP communications is becoming increasingly important as buildings adapt to unified structured cabling systems based on IP.

LonTalk represents a simplified approach to network configuration and application over the BACnet protocols. The BACnet protocols attempt to balance manufacturing cost, existing design architectures, and installation familiarity; whereas the LonTalk protocol focuses on overcoming installation obstacles and creating a cohesive network that adheres to a single set of network rules.

6.6.   IP and XML / Web Services

There is a growing demand for enterprise connectivity and the use of enterprise applications in building automation solutions. Enterprise technologies are opening new opportunities for system integrators and the diversity of enterprise applications is improving the owner's ability to administer and maintain an installation. As a result, for long-term success, automation solutions must leverage IP and XML / Web Services to meet owner expectations.

Many LonWorks and BACnet vendors have a Web Services option as part of their solution. This allows the owner to browse the control network using a standard Internet browser application, eliminating the need to install operator workstation applications on every view station. It also enables routine data mining using a standard enterprise spreadsheet application for event logging and data trending. Each web services solution incorporates proprietary elements (such as data format, tag naming conventions, and others), because there is no standard within the buildings community to address these issues. The buildings

community is using the IT standards that govern IP and XML usage, but the language of Web Services is vendor specific.

The BACnet committee (SSPC-135) is addressing this issue through their XML Working Group. The group is examining how best to incorporate XML / Web Services into the BACnet Standard. Incorporating XML will enable BACnet manufacturers to take advantage of enterprise technology and reduce the time to market for XML-based BACnet products. The intent of their efforts is to develop a Web Services standard for the buildings community that is not BACnet specific. It could be adopted by any building control technology or platform. As of May 2005 their draft specification is out for public review, and a standard document is expected sometime in 2006.

The LonWorks community has already included IP and XML / Web Services in LonWorks products and solutions. The i.LON product series from Echelon provides the infrastructure for Web Services solutions. Several companies now produce web servers (similar to the i.LON) and EIA-852 devices. EIA-852 enables LonTalk tunneling over the industry standard Internet Protocol (IP) for router and gateway products. LonMark is addressing the market shift to leverage enterprise technology by porting existing LonMark Functional Profiles (LFP) to XML format.

Most of the LonWorks community is focused on the development of the oBIX (Open Building Information Exchange) standard to define XML / Web Services for the buildings community. The oBIX committee is part of the OASIS (Organization for the Advancement of Structured Information Standards) standards development organization. The first published oBIX standard is expected in 2006.

Enterprise technologies will continue to play a strong role in building automation. The success of a building automation solution will be based on how well it leverages the benefits and opportunities of enterprise technologies. The LonWorks community is already adapting to this market demand and is delivering solutions that leverage this technology and capitalize on new opportunities.

6.7.   Distribution

No single manufacturer produces all products necessary for a comprehensive building automation solution that addresses all building systems. Manufacturers typically specialize in a single specific building system, which aligns with their core competencies. As a result, mutually exclusive proprietary solutions from multiple vendors are required to automation and control a single facility. This type of installation traditionally requires one or more gateway interfaces to connect each system into a multi-vendor network. This has been the industry standard for decades. These gateway network architectures produced several daunting issues, which do not exist in a multi-vendor Open System solution environment.

Open System solutions enable integrators and owners to select best-in-breed products to create a multi-vendor solution based on a central technology that does not require gateway interfaces. Creating a multi-vendor installation is only possible if you have access to vendor products apart from their respective solution. To achieve this it is critical that owners and integrators have access to products from an array of manufacturers through independent distribution.

Nearly all LonWorks component manufacturers and many solution providers offer their product lines (or select products) through an independent sales channel. The largest US-based independent distributor of LonWorks products is Engenuity Systems. They represent over 1000 products from over 50 different vendors worldwide, including software, infrastructure and control devices for all aspects of LonWorks building automation. This is possible because LonMark has defined functional characteristics for specific device types (such as VAV and FCU controllers), enabling integrators to routinely craft solutions from devices of pre-defined characteristics.

This level of independent product distribution is not seen in the BACnet community. An overwhelming majority of BACnet products are solution-specific and available only as part of a total solution from a single vendor. There are a few infrastructure products, motor control, and lighting controllers available as individual component products. This makes best-in-breed product selection almost impossible. Having

VAV controllers from vendor 'A' and FCU controllers from vendor 'B' in a single project is unlikely because these products are typically not available for purchase apart from their respective solutions. Furthermore, the BACnet standard does not define functional characters of specific controller types (such as VAV and FCU controllers), making it difficult to integrate a multi-vendor installation.

Independent distribution enables one-stop-shopping and it is a testament to interoperability and technology maturity. When a system integrator or owner purchases a product from an independent distributor they expect that product to come off the shelf and be easily integrated into their installation, with minimal or no support from the distributor. The LonWorks Technology has fostered greater product availability, where third party off-the-shelf products can interoperate with any vendor solution.

6.8. Related Standards Qualifications

Standards organizations play an important role in building automation. They are a primary resource for architects, engineers and owners to obtain information and guidelines on the latest automation requirements and procedures. When a technology is maintained or listed by a standards organization it becomes available to a wide audience of industry authorities and becomes a typical component of building specifications.

BACnet was created and is maintained by the ASHRAE organization (American Society of Heating Refrigeration and Air-Conditioning Engineers). ASHRAE has been developing building standards for more than a century and is regarded as the preeminent resource of standards for buildings. All ASHRAE standards strive to be product neutral and to present a practical engineering guideline for system design in buildings. ASHRAE has also succeeded in establishing a rapport with many international and domestic standards organizations. ASHRAE's activities and reputation has positioned the BACnet committee (SSPC-135) to introduce BACnet to many standards organizations. Several standards organizations have adopted or endorsed the use of BACnet with their membership. The most significant recognition of BACnet has been its adoption as ISO Standard 16484-5.

As an ISO Standard, BACnet is accessible to a larger community of users. ISO standards have little impact in North American building specification, but they influence specifications in Europe. European projects that previously did not have BACnet in the specification will now list it as an acceptable option. This will ultimately increase the number of European BACnet users and vendors.

Echelon created and independently maintained the LonWorks technology for many years. Over time the LonWorks technology and solution approach was adopted by several standards organizations (including IFSF – International Forecourts Standards Federation (EU petrol station controls); IEEE 1473 – In train controls; AAR – Electro-pneumatic braking controls; USA; SEMI – Semiconductor Equipment Manufacturer's Industry; Finnish Homes – Automation standard) and it also is part of a standard for building automation called EN14908. The most significant recognition of LonWorks is the adoption of LonTalk as ANSI/CEA Standard 709. This provides continual maintenance for LonTalk and ensures that it meets the future needs of control networks. It also enables LonTalk to be implemented on any processor; it is no longer confined to the Neuron processor. The Neuron processor implementation of LonTalk remains the popular choice among control device manufacturers; however, some infrastructure devices are now using ANSI/CEA-709.1 on a non-Neuron processor. ANSI/CEA-709.1 has greatly improved the power, throughput and availability of LonWorks infrastructure devices.

LonWorks and BACnet have both achieved acceptance and secured continual maintenance within the standards community. In the area of specification development, BACnet has a clear advantage over LonWorks because it is an ASHRAE standard. ASHRAE standards are the most often used guidelines for specification development for buildings. This increases the exposure of BACnet to the specifying community. The LonWorks technology and LNS are not well represented in ASHRAE standards, primarily due to their product focus. As a result there is an increasing number of individual BACnet building specifications "on the street", which has lead to the perception that BACnet is better suited for building controls, when in fact both LonWorks and BACnet are equally capable technologies.

The LonWorks technology appears to have broader appeal when addressing total-building specifications and large multi-building specifications. This is primarily due to the diversity of LonWorks products, which covers the complete range of building automation systems. Where as, BACnet products typically focus on traditional (HVAC) building control systems. Recently a number of North American LonWorks based specifications have become available that each encompasses several hundred buildings. These include the US Army Corps of Engineers, New York City Public Schools, City of Chicago government buildings, Chicago School District, and State of Louisiana Government Buildings.

LonWorks and BACnet each have their strengths and exposure within the standards community. Specifiers can apply each technology to a variety of building applications. Their appeal varies depending on project scope and application. Because both are firmly entrenched in the standards community, LonWorks and BACnet will propagate through the industry for years to come as the primary choices for Open System solutions.

7. Conclusions

When investigating open system technologies and solutions two things become immediately visible:

- The benefits of a properly installed and managed open system solution can turn a facility into an asset
- The LonWorks and BACnet technologies are the only two practical options available

There are several other open technology choices in the market, however, LonWorks and BACnet are the only technologies, that can deliver the open systems goals of *implementing an End-to-End solution that is Open, Interoperable and Multi-Vendor.* The LonWorks and BACnet technologies are mutually exclusive and one must be chosen over the other. A comparative evaluation of market presence and solution approach with respect to the Open System goals provides the basis for making an informed decision.

Comparing market presence involves evaluating user community activity and the extent of the installed base. From this report the following points regarding market presence can be concluded:

- When evaluating the user community it is apparent that the LonWorks community is larger, is producing more products and has more certified devices than the BACnet community.
- From the available information regarding installed base, there is a significantly larger LonWorks installed base consisting of millions of devices installed worldwide.
- Comparing market presence shows greater market acceptance for the LonWorks technology over BACnet. This is visible in the areas of product availability (through independent distribution), product diversity, and product certification activity. This implies a greater demand for LonWorks products and an active community of manufacturers and system integrators.

Comparing solution approach shows the similarities and differences between LonWorks and BACnet. Evaluating their similarities shows that both can deliver a complete End-to-End solution with an array of control devices and operator interface options. Focusing on their differences shows significant divergence in several notable areas including device interoperability (and interchangeability), network management, product distribution and integration of new technology.

The device level interoperability differences affect network architecture and the ability to create multi-vendor solutions. From this report the following points regarding interoperability (and interchangeability) can be concluded:

- The LonWorks technology enables peer-to-peer data exchange at the field level and with the supervisory/management level, creating a flat network architecture with the potential for multi-vendor interoperable networks.
- To proliferate interoperability (and interchangeability), LonMark International has established physical and application layer guidelines and functional profiles (each is available on the LonMark website). The functional profiles facilitate device-to-device communications by defining a set of functional characteristics for specific device types. This enables owners to choose, substitute, and integrate products from multiple vendors, thereby providing competition and competitive bidding.
- The BACnet standard, while also defining how devices can exchange information, does not define device profiles analogous to LonMark profiles. Instead, manufactures are free to choose which BACnet functions to implement within devices. This results in devices from competing manufacturers that may not communicate device-to-device or be freely substituted with one another. Device-level BACnet data is typically exchanged through supervisory devices creating a tiered network architecture. Future network expansion is often dependent on manufacturer specific applications to interface with supervisory devices.

Network management functions are used in every control solution to design, configure, commission, and install devices. From this report the following points regarding network management functions can be concluded:

- In proprietary solutions these functions are tied to a proprietary network database and are either distributed among several software applications or bundled with the operator interface application. Often network management functions appear invisible or operate automatically in the background during system/device configuration.
- Neither the LonWorks or BACnet technologies have defined a database standard to store network characteristics.
- Much of the LonWorks community has standardized on the LNS® network operating system (available from Echelon®) for network database creation and management. The wide spread use of LNS provides a common network database and client-server environment for LonWorks installations. Many vendors have developed LNS-based products that can interact with devices and interface with operator interface applications from multiple vendors. This flexibility strengthens vendor independence by enabling network service from a wide array of network management tool providers.
- In the BACnet community there is no third-party product analogous to LNS available. Each BACnet solution vendor supplies a custom network operating system and network database structure (which may require vendor specific tools to implement). BACnet solutions also rely on a network management tool that is specific to the vendor supplying the solution.

Product distribution and the integration of new technology are two vital areas for commercial success and market influence. From this report the following points regarding product distribution and integration of new technology can be concluded:

- Independent product distribution provides system integrators and owners the opportunity to select the best-in-breed products without being tied to a manufacturer specific solution.
- LonWorks and BACnet solutions are both available from several manufacturers, but only LonWorks component products are available from independent distributors.
- There is no independent distribution of BACnet component products.
- Incorporating new technology (new to building automation) like IP and XML / Web Services into products helps to maintain a competitive edge and provides more value to the customer.
- The LonWorks community has embraced new technologies like IP and XML / Web Services. Products are readily available, from independent distributors and solution providers, opening new opportunities for property owners and system integrators.
- The BACnet community has been slower to adopt new technologies, resulting in longer time-to-market for new products.

Selecting an Open System technology is a matter of choosing either a LonWorks or BACnet solution. Both are capable of delivering an End-to-End solution, however, for product availability, product diversity, vendor choice and the latest technology, LonWorks has a significant market lead.

8. Appendix – Products, Industry Organizations, Certifications

The information presented here is from publicly available industry sources. It is included to support statistics and discussions put forth in this report. Each table is maintained by its respective authority and is subject to change without notice.

8.1. LonWorks Product Database

This is a global database of LonWorks based products hosted by Echelon Corporation. It includes products from various manufacturers and is devoted to the promotion of the LonWorks technology, Open Systems and interoperability in the controls network industry. The database is intended to be the most comprehensive collection of LonWorks devices and services available worldwide. It does not represent all available products and services, but it is the best available source of information. (www.echelon.com)

The database includes approximately 1322 products from 172 manufacturers worldwide. (December 2005)

Categories	#	Categories	#
Access Control	74	Actuators	125
Asset Management	5	Doors & Windows	103
Fire/Life Safety	42	Hospital Equipment	56
Human-Machine Interfaces	99	HVAC	286
Integration Components	167	Lighting Control	343
LonWorks Training	13	Mechanical	49
Monitoring & Security	132	Motor Control	45
Network Infrastructure	462	Network Management	59
OEM Components	68	Plumbing & Irrigation	12
Power & Energy Management	68	Refrigeration	44
Sensors	170	Software	84
Vertical & Horizontal Transportation	4	Wiring Devices	58

Table 8.1 - LonWorks Product Database Categories

8.2. BMA Product Database

This database is hosted by the BMA and lists BACnet products available from BMA member companies. It includes products from various manufacturers and is devoted to the promotion of the BACnet technology. Products listed are not sold through the BMA. The database is provided as a resource for locating available BACnet products and manufacturers. It does not represent all available products and services, but it is the best available source of information. (www.bacnetassociation.org)

The database includes approximately 138 products from 16 manufacturers worldwide.

Device Profiles	#
BACnet Operator Workstation (B-OWS)	10
BACnet Building Controller (B-BC)	35
BACnet Advanced Application Controller (B-AAC)	55
BACnet Application Specific Controller (B-ASC)	39
BACnet Smart Actuator (B-SA)	9
BACnet Smart Sensor (B-SS)	0

Table 8.2 - BMA Product Database Categories

8.3.   Engenuity Systems Product Representation

Engenuity Systems is an independent distributor of LonWorks products and materials. They are the largest US distributor of LonWorks products, representing a global range of products from manufacturers and software developers. Their website includes product information, Internet demos and online commerce. They have approximately 1196 products from over 50 manufacturers worldwide listed for sale on their website. (www.engenuity.com)

Product Category	#	Product Category	#
Access & Security	93	Accessories	75
Analog I/O	51	Analysis Software	10
Application Specific Controllers	47	Books About LonWorks	3
Combinations Of Products		Control Modules	27
Data Logging	9	Development/Debug Products	32
Digital I/O	77	Displays And Keypads	31
Energy Management Products	26	Fire & Life Safety	17
Gateways	182	GUI/HMI Software	8
Handheld Devices	4	IP Connectivity	41
Lighting Control	73	Mixed Analog & Digital I/O	41
Multi-Function Sensors	24	Network Interfaces	103
Network Managers	34	Occupancy Sensors	21
OPC/DDE Servers	15	Pressure Sensors	29
Programming Software	7	Protocol Analyzers	14
Repeaters	22	Routers	84
Schedulers	9	Services	31
Temperature Sensors	50	Terminators	17
Thermostats	13	Training Classes	20
Transceivers	15	User Interfaces	7
Wire	9	Written Documentation	16

Table 8.3 - Engenuity Systems Product Categories

8.4.   LNO Database

The LNO (LON Nutzer Organisation e.V.) is an organization of companies, institutions and distributors of LonWorks technology in the German speaking countries. It is one of the largest, oldest and most active LonUsers organizations. The LNO Product Database is a collection of products, providers and information on LonWorks products available from companies in German speaking countries. Products listed are not sold through the LNO. The database is provided as a resource for locating available LonWorks products and manufacturers. (www.lno-db.de)

Categories	#
Products	826
Providers	128
Applications	557
Services	78
Reference Stories	37

Table 8.4 - LNO LonWorks Database Categories

8.5.   BACnet Vendor ID

A BACnet Vendor ID is the first step in developing and producing BACnet products and solutions. Any company planning to, or exploring the possibility of developing BACnet products must have a Vendor ID prior to beginning development. BACnet Vendor IDs are issued to any requesting company, however, not all companies issued a Vendor ID produce BACnet products. As of December 2005, 188 Vendor IDs have been issued and are distributed internationally as shown in the following table. (www.bacnet.org)

Country	#	Country	#	Country	#	Country	#
USA	93	United Kingdom	4	Netherlands	2	Finland	1
Japan	29	Korea	4	France	1	Ireland	1
Germany	14	China	3	Austria	1	Malaysia	1
Canada	13	Poland	3	Sweden	1		
Australia	6	South Africa	2	Taiwan	1		
Switzerland	5	Italy	2	Belgium	1		

Table 8.5 – International Distribution of BACnet Vendor IDs

8.6.   BACnet Manufacturers Association (BMA) Survey

Survey responses are the only way to track BACnet use because the BACnet Standard is not based on a specific technology. In 2000 the BMA conducted a survey of its then 15 corporate members to determine how many BACnet products were in use. Only 6 companies responded to the survey and the results of their responses are presented in the table below and in Table 5.1. (www.bacnetassociation.org)

2000 BMA Survey Results	#
Installations	19,054
Countries	82
Gateways	2,410
Devices by Network Type	
• Ethernet	11,970
• ARCNET	95,567
• MS/TP	248,500
• PTP	1,549
Workstations	15,807
Large Controllers	53,391
Unitary Controllers	299,600

Table 8.6 – 2000 BMA Survey Results

8.7.   International Organizations – LonWorks Community

The LonWorks community supports numerous international LonUser and LonMark organizations. The LonUser organizations are independent, regional organizations of LonWorks developers and users that promote LonWorks technology, organize marketing activities, provide a central place for information, and initiate cooperation between LonWorks developers and users. These groups work to provide up-to-date information on the LonWorks technology and promote best practices. The LonMark organizations are affiliate non-profit companies to the parent LonMark International organization (also non-profit). The LonMark International membership sets guidelines for the LonWorks community (LFP, SNVT, SCPT, etc.) and certifies products. All of the LonUser organizations are transitioning to become LonMark affiliate companies.

LonMark Organizations	Website
LonMark International	www.LonMark.org
LonMark Americas	www.LonMarkAmericas.org
LonMark Switzerland	www.LonMark.ch
LonMark Denmark	www.LonMark.dk
LonMark Japan	www.LonMark-JP.com
LonMark Germany	www.LonMark.de
LonMark Italy	www.LonMark.it
LonMark France	www.LonMark.fr

Table 8.7 – LonMark Organizations and Websites

LonUser Organizations	Website
European LonUsers Web Portal	www.lonusers.info
LonUsers Espana	www.lonusers-es.com
LON Nutzer Organization (Germany)	www.lno.de
Polish LonUsers Group	www.plug.org.pl
LonUsers Austria	www.lno.at
LonUsers Finland	www.tpu.fi/lonusers
LonUsers Sweden	www.lonusersweden.org
Belgium LonUsers Group (BeLON)	www.belon.be
LonUsers Netherlands	www.lonteam.nl

Table 8.8 - LonUser Organizations and Websites

8.8.   International Organizations - BACnet Community

The BACnet community consists of several international users groups and the ASHRAE committee defining the BACnet standard. User Groups are organizations of manufacturers, facilities personnel, system integrators, and consultants that promote the use of open systems using the BACnet technology. These groups work to provide up-to-date information on the BACnet standard and promote best practices.

Organization	Website
BMA (BACnet Manufacturers Association)	www.bacnetassociation.org
SSPC-135 (The BACnet Committee)	www.bacnet.org
BIG-NA (BACnet Interest Group - North America)	www.big-na.org
BIG-EU (BACnet Interest Group - Europe)	www.big-eu.org
BIG-AA (BACnet Interest Group - AustraliAsia)	www.big-aa.org
BIG-ME (BACnet Interest Group – Middle East)	www.big-me.org
BIG-RU (BACnet Interest Group - Russia)	www.big-ru.org
BIG-SW (BACnet Interest Group - Sweden)	

Table 8.9 - BACnet Organizations and Websites

8.9.   Certifications - BTL Product Listings

The BACnet Testing Laboratory (BTL) tests BACnet products against BACnet Device Profiles. Products that successfully complete the testing are listed on the BTL website along with supporting documentation and are allowed to carry the BTL mark. The BTL operates independent of the BACnet Committee (SSPC-135) and ASHRAE®, but is closely monitored by the BMA.

As of December 2005 there are 133 BTL listed devices from 13 companies.

Device Profile	#
BACnet Operator Workstation (B-OWS)	0
BACnet Building Controller (B-BC)	32
BACnet Advanced Application Controller (B-AAC)	54
BACnet Application Specific Controller (B-ASC)	38
BACnet Smart Actuator (B-SA)	7
BACnet Smart Sensor (B-SS)	0

Table 8.10 – BTL Product Listings

8.10.   Certifications – LonMark Product Listings

LonMark International tests and certifies products against LonMark Functional Profiles (LFP). Products that successfully complete the testing are listed on the LonMark website along with supporting documentation and are allowed to carry the LonMark logo.

As of December 2005, over 600 devices have been LonMark certified from over 70 companies.

Category	LonMark Functional Profile	#
Access/Intrusion/Monitoring	Entry/Exit	3
	Identifier Sensor	2
	Modem Controller	2
Energy Management	3-Phase Energy Meter	6
	Circuit Breaker	1
	Utility Data Logger Register	4
Fire & Smoke Devices	Fire Smoke Damper Actuator	5
Gateways	Gateways	3
	HVAC Gateways	1
	Industrial Gateways	1
Generic Actuator	Generic Actuators	7
Generic Controller	Generic Controllers	5
Generic Human-Machine Interfaces (HMIs)	LCD/LED Panel HMI	1
	Panel Interface	1
	RF Remote Control	1

Category	LonMark Functional Profile	#
HVAC	Air Handling	1
	Boiler Controller	2
	Chilled Ceiling Controller	2
	Chiller	12
	Damper Actuator	13
	Discharge Air Controller	8
	Fan Coil Unit Controller	13
	Heat Pump with Temperature Control	6
	Plant Controller	14
	Pump Controller	1
	Roof Top Unit Controller	12
	SCC - Air-Handling Unit	3
	SCC - Chilled Ceiling	1
	SCC - Fan Coil	14
	SCC - Generic	13
	SCC - Heat Pump	4
	SCC - Rooftop Unit	2
	SCC - Template for Controller-based nodes	28
	SCC - Unit Ventilator	9
	SCC - Variable Air Volume	21
	Space Comfort Control Command Module	6
	Thermostat	2
	Unit Ventilator Controller	2
	VAV Controller	19
I/O	4 Analog input	1
	4 Digital input, 4 digital output	1
	4-Channel digital input	1
	4-Channel digital output	2
	8-Channel digital input	4
	8-Channel Digital Output	1
	Analog Input	1
	Digital I/O	4
	Digital Input	2
	Digital Input Node	1
	Digital output	3
	Generic Analog Input	5
	Generic Analog Output	3
	I/O	1
	Multi-Channel I/O	5
	Multi-I/O module	33
	Multi-Output Module	2
Industrial	Generator Set	2
Lighting	4-Switch relay	1
	Dimmer 1-10V	2
	Lamp Actuator	10
	Lighting Controller	8
	Lighting Panel Controller	1
	Multi-switch/multi-sensor	3
	Occupancy controller	1
	Partition Wall Controller	1
	Real-Time Keeper	2
	Scene Controller	1
	Scene Panel	5
	Switch	15
	Switch / Sensor	1
	Thyristor Dimmer	1
	Transistor Dimmer	1
Motor Controls	AC Drive (v3.0 Products Only)	2
	Variable-Speed Motor Drive	11
Network Infrastructure	Foreign System Connection Sensor	2

Category	LonMark Functional Profile	#
Sensors	Conductivity Sensor	1
	Gas Concentration Sensor	3
	Light Sensor	1
	Multi-Function Sensor	4
	Occupancy Sensor	3
	PH Sensor	1
	Pressure Sensor	2
	Sensors	22
	Temperature Sensor	3
Wiring Devices	AC Load Relay	2

Table 8.11 – LonMark Product Listings

8.11.   Definitions – LonMark Functional Profiles (LFP)

LonMark Functional Profiles (LFP) defines a set of required and optional data elements for each device type. The profiles are established by the LonMark membership and are available for download in PDF format from the LonMark International website (www.LonMark.org).

As of December 2005, there are over 70 profiles available.

LFP Category	Profile Name	Profile #
Access/Intrusion/Monitoring	Identifier Sensor	5035_10
	Entry/Exit Device	5051_10
	Modem Controller	5091_10
	Telephone Directory	5092_10
Fire & Smoke Device	Fire Smoke Damper Actuator	11001_10
	Smoke (Intelligent) Fire Initiator	11002_01
	Smoke (Conventional) Fire Initiator	11003_01
	Thermal Fire Initiator	11004_01
	Pull Station Fire Initiator	11005_01
	Audible Fire Indicator	11006_01
	Visible Fire Indicator	11007_01
	Universal Fire Initiator	11010_01
	Universal Fire Indicator	11011_01
HVAC	Fan Coil Controller	8020_11
	Roof Top Unit Controller	8030_11
	Chiller	8040_10
	Heat Pump with Temperature Control	8051_10
	Thermostat	8060_10
	Chilled Ceiling Controller	8070_10
	Unit Ventilator Controller	8080_10
	Space Comfort Control Command Module	8090_10
	VAV Controller	8010_11
	Damper Actuator	8110_11
	Pump Controller	8120_10
	Valve Positioner	8131_10
	Boiler Controller	8301_10
	Space Comfort Controller Functional Profile	8500_20
	Discharge Air Controller	8610_10
Industrial	Generator Set	13110_11
	Automatic Transfer Switch	13120_11

LFP Category	Profile Name	Profile #
Input/Output	Open-Loop Sensor	0001_11
	Closed-Loop Sensor	0002_11
	Open-Loop Actuator	0003_11
	Closed-Loop Actuator	0004_11
	Analog input	0520_10
	Analog output	0521_10
Lighting	Lamp Actuator	3040_10
	Occupancy Controller	3071_10
	Switch	3200_10
	Scene Panel	3250_10
	Constant Light Controller	3050_10
	Scene Controller	3251_10
	Partition Wall Controller	3252_10
	Real Time Keeper	3300_10
	Real Time Based Scheduler	3301_10
	Lighting Panel Controller	3401_10
Management	Node Object	0000_20
	Calendar	0006_10
	Scheduler	0007_10
	Utility Data Logger Register	2110_10
	Utility Meter	2201_10
Motor Control	Variable Speed Motor Drive	6010_11
	Sunblind Actuator	6110_10
	Sunblind Controller	6111_10
Refrigeration: Display Case Controller	Refrigerated: Defrost Object	10010_10
	Evaporator Control Object	10011_10
	Thermostat Object	10012_10
Sensor	Light Sensor	1010_11
	Pressure Sensor	1030_10
	Temperature Sensor	1040_10
	Frost Sensor	1042_10
	Relative Humidity Sensor	1050_10
	Rain Sensor	1051_10
	Occupancy Sensor	1060_10
	CO2 Sensor	1070_10
	Air Velocity Sensor	1083_10
Vertical/Conveyor Transportation	Elevator/Lift Position Indicator and Message Display	14011_10
	Elevator/Lift Hall Lantern	14012_10
	Elevator/Lift Arrival Gong	14013_10
	Elevator/Lift Car-Direction Lantern	14014_10
	Elevator/Lift Fire-Systems Port	14041_10
	Elevator/Lift Voice Announcer	14061_10
White goods / Appliance	Clothes Washer - Domestic	15011_10

Table 8.12 – LonMark Functional Profiles

8.12. Definitions – BACnet Device Profiles

Annex L of the BACnet standard specifies six "standardized" types of BACnet devices. Any device that implements all the required BACnet capabilities for a particular device type and interoperability area may claim to be a device of that particular type. This section indicates which BIBBs (BACnet Interoperability Building Blocks) must be supported by each device type, and for each interoperability area. Devices may also provide additional capabilities and shall indicate these capabilities in their PICS (Protocol Implementation Conformance Statement) document.

Refer to the BACnet standard Annex L for complete details on the requirements for BACnet Device Profiles.

BACnet Device Profiles	Abbreviation
BACnet Operator Workstation	B-OWS
BACnet Building Controller	B-BC
BACnet Advanced Application Controller	B-AAC
BACnet Application Specific Controller	B-ASC
BACnet Smart Actuator	B-SA
BACnet Smart Sensor	B-SS

Table 8.13 – BACnet Device Profiles

BACnet Interoperability Areas
Data Sharing
Alarm and Event Management
Scheduling
Trending
Device and Network Management

Table 8.14 – BACnet Interoperability Areas

STRATA R e s o u r c e Inc