

OPEN SYSTEMS IN BUILDING MANAGEMET: LONWORKS vs. BACNET

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Abstract: The LonWorks and BACnet technologies gained widespread application and are the best choice as the leading open system technologies. They have distinguished 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 different origins, different network architectures, different hardware and software requirements, and each has a core group of users. 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 differences and implementation issues to consider when evaluating a solution.

Key words: LonWorks, BACNet, building management, open systems, comparison

I. INTRODUCTION

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 [1].

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 without the expenses of R&D and focus on solution application, feature sets, services, and addressing the strategic business requirements of the customer [1].

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 [2].

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 [2].

Before deciding between LonWorks and BACnet three areas need to be considered: the Open System goals, the solution approach and the market presence.

II. OPEN SYSTEMS BENEFITS

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 strong reasons or benefits for using an Open System solution. In fact open solutions offer numerous benefits including competitive bidding, consistent installation, consistent maintenance, system integration and interoperability, data acquisition and product interchangeability.

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 [2].

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 [2].

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 [2].

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)[2].

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 [2].

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)[2].

III. OPEN SYSTEMS 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.

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 [2].

- 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 [3].

- The core component of the LonWorks technology, the LonTalk® protocol, is maintained and available through the CEA as the ANSI/CEA1 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 [1].

- 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 [4].

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 [1].

- 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) [5].

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 problem 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 [2].

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 [2].

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 gateway architecture.

IV. SOLUTION APPROACH COMPARISON

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.

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 [1].

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 [4].

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 [5].

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 [5].

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 nor 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 [2].

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 [1].

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) [5].

Design guidelines and certifications - 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 [4].

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 [3].

Protocols - 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. 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 [5].

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 [1].

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 [1].

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 [6].

Standards - 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 [3].

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 [1].

V. 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.

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 [2].

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 [2].

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 [2].

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 [1].

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.

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 [5].

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.

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.

VI. CONCLUSIONS

When investigating open system technologies and solutions two things become immediately visible: (i) the benefits of a properly installed and managed open system solution can turn a facility into an asset and (ii) the LonWorks and BACnet technologies are the only two practical options available.

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 network management.

Comparing market presence involves evaluating user community activity and the extent of the installed base.

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