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Building Automation Technology Review

005-0162-01A

Printed in the United States of America.

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Introduction

The purpose of this document is to explain the overall architecture and implementation differences between BACnet and the LONWORKS platform. The benefits for product vendors who use the LONWORKS platform, and the open, standards-based communication protocol on which it is based, include faster time to market, lower product and life-cycle costs, and faster adoption of interoperable, multi-vendors Building Automation Systems (BAS).

BACnet Protocol

The BACnet protocol is a data communication protocol for building automation networks. A data communication protocol is a set of rules that control the exchange of data over a network. These rules have to be implemented consistently across all types of devices, and by all device manufacturers whose products are connected to a common network, for interoperability between devices to be achieved.

The BACnet protocol is based on a client-server model and its messages are called "service requests." A client machine sends a service request to a server machine, which performs the service and reports the results to the client. BACnet provides a tiered architecture with workstations at the top tier, controllers at the next tier, and so on. This tiered network requires gateways (effectively data converters) to translate between the protocol used at the workstation level and the many different protocols that can be used at lower tiers. Gateways are expensive devices and the overall cost to implement, manage, and maintain such a tiered system is higher than for a non-tiered, or flat, system architecture.

The BACnet protocol provides a pre-defined means of representing the functions of any device. Based on a four-layer collapsed protocol structure, this architecture corresponds to the physical, data link, network, and application layers of the OSI model as shown in a figure below. The BACnet protocol is designed so that there is only one logical path between networked devices. The BACnet network layer is customized for use in BACnet systems, meaning that standard infrastructure components like Ethernet routers cannot be used for routing between BACnet channels. Instead this layer was customized to support MS/TP Data link technology, which is neither as pervasive, nor as inexpensive, as standard infrastructure components like Ethernet routers.

All data via the BACnet protocol must be ASN.(1) encoded, a task that is difficult to host in the inexpensive 8-bit microcontrollers used in small devices such as VAV controllers, zone controllers, and rooftop units. With regard to system-to-system or enterprise communications the requirement to use ASN.(1) is problematic as this form of encoding has never been widely adopted. The industry norm is to use XML and not ASN.(1), further adding to the difficulty of using the BACnet protocol for applications in which standard IP infrastructure and enterprise applications must be incorporated in the overall system architecture. In fact, the application layer itself is more complicated using the BACnet protocol the OSI presentation layer is not present - only one transfer syntax is used, one defined by a fixed encoding scheme.

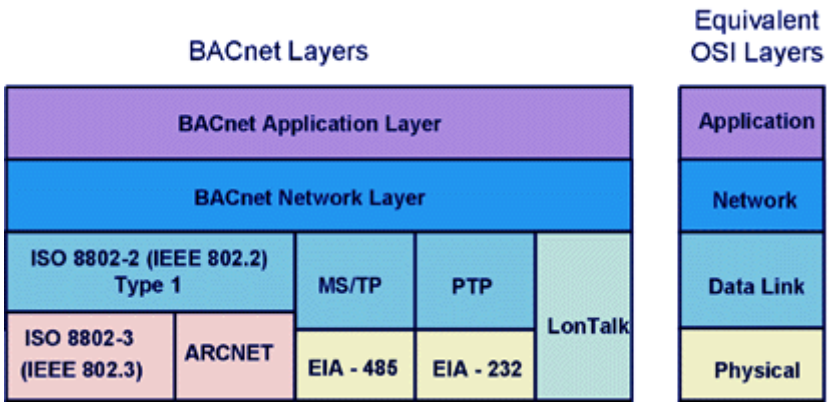
It is extremely difficult to construct an interoperable device network using the BACnet protocol because the design center for the protocol was an architecture that includes gateways. For example, the application interface is not defined in the BACnet protocol, enabling manufactures to each implement different, incompatible interfaces. With regard to object definition, the BACnet protocol defines mostly low-level objects (such as sensors and actuators) and only a very few high level objects (such as schedulers, alarm notifiers, and trend loggers). Sensor and actuator objects are particularly useful for implementing gateways, while schedulers and notifier objects are useful for implementing head-end controllers. What is

missing are standard profiles for HVAC devices, part of the glue that is necessary to build interoperable networks.

Conformance & Interoperability

All devices conforming to the BACnet protocol are required to have a Protocol Implementation Conformance Statement (PICS) that identifies all of the implemented portions of protocol. In order to conform to the BACnet protocol, all devices must pass a conformance test that verifies the correct implementation of the object types and services indicated in the PICS. If manufacturers create different implementations, something that is commonly done, then incompatibilities emerge and what in theory should have been a multi-vendor, interoperable network in reality becomes a proprietary network comprised of sole-sourced devices. The protocol may still be called BACnet, but other BACnet-enabled devices cannot interoperate. Single vendor networks are more expensive both to purchase and with respect to replacement parts and life-cycle costs.

The collapsed protocol structure of the BACnet protocol is shown in the figure below.



Layer 1 – Physical: Ethernet, ARCnet, MS/TP, PTP & the LonTalk® protocol
Layer 2 – Data Link (media access & framing):
Layer 3 – Network (destination addressing)
Layer 4 – Missing – combined with Application Layer
Layer 5 – Missing – combined with Application Layer
Layer 6 – Missing – combined with Application Layer
Layer 7 – Application Layer:

- Transport, Session, Data Interpretation (preambles – headers)
- Security & authentication services
- Objects

A BACnet/IP network functions in concept identically to the other non-IP network types with respect to directed messages and broadcast messages, including local, remote, and global broadcasts. All stations on the local network receive a local broadcast, while all stations on a single remote network receive a remote broadcast. All stations on all networks comprising the BACnet inter-network receive a global broadcast.

Layer	**Octets**
Layer 2 Header	3
Layer 2 Address Information	22
Data	46 to 1500
Layer 2 CRC	4

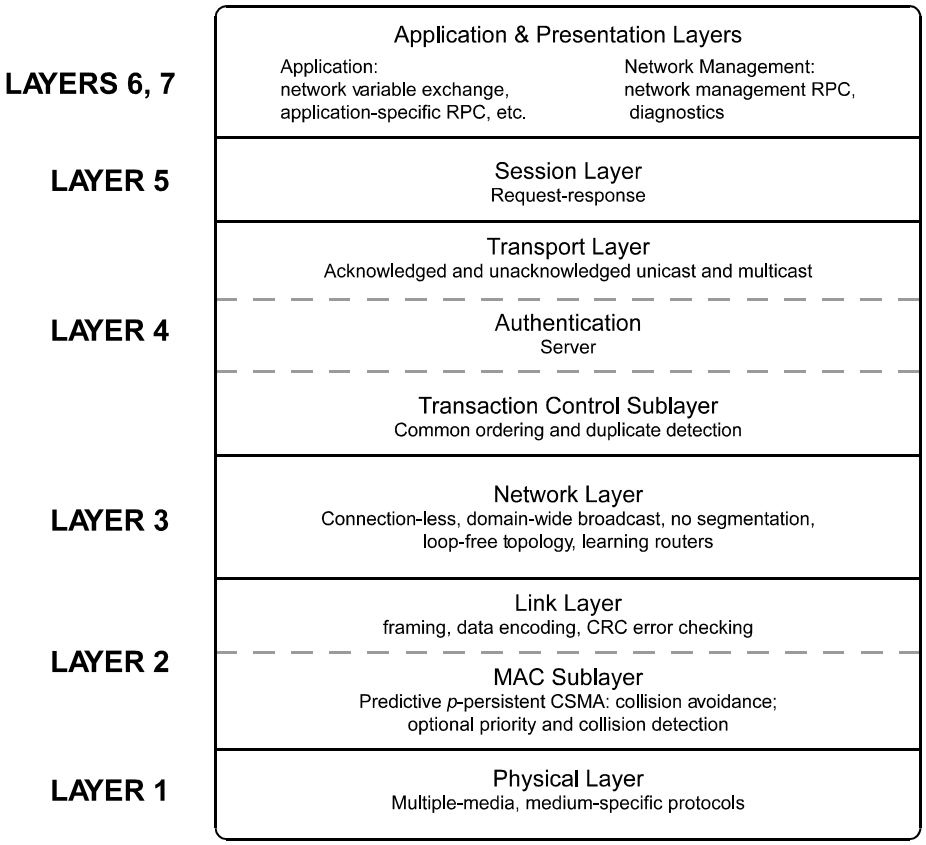
Most manufacturers utilizing the BACnet protocol have created uniquely proprietary extensions of the protocol. The extension layer, built as an above the protocol, is required to accomplish anything beyond basic communications. The real problem is that no two vendors implement the same custom extensions, so it becomes a totally proprietary solution.

LONWORKS Platform

The LONWORKS platform is a distributed control system that enabled peer-to peer and/or master-slave communication among intelligent devices. LONWORKS technology uses a flat architecture that supports the address requirements of the entire system but allows logical segmentation. Segmentation is achieved through network level routers that are transparent to the applications in the nodes, and which provide direct access by installation, diagnostic, or monitoring tools connected anywhere in the network.

The open, standards-based LonTalk® protocol (also knows an ANSI/CEA 709.1 and IEEE 1473-L) provides a set of communication services by which a device can send and receive messages from other devices over the network. Optionally, it provides end-to-end acknowledgements of messages, authentication of messages, and priority delivery to provide bounded transaction times.

The LonTalk protocol (OSI – 7-layer protocol for control networks) provides following features:



Layer 1 – Physical

Since control networking applications require support for multiple-media (both to accommodate different installation scenarios and to simplify system expansion), the LONWORKS platform supports a wide range of different physical media including powered and unpowered free topology twisted, power line, radio frequency, infrared, fiber optic, and coaxial cable.

Layer 2 – Link (media access & framing)

A media access scheme is critical for a control network, and system performance depends upon the sophistication of the access scheme. Predictive p-persistent CSMA, collision avoidance, optional priority, and collision detection access schemes are used in the LonTalk protocol. Options may be adjusted by channel, by node, or by variable on a given node to optimize performance without penalizing the rest of the control system. Application level determinism is enhanced with a dedicated application.

Layer 3 – Network (destination addressing)

This layer ensures the correct delivery of messages or packets from one source to one or more destination devices. Key features are connection-less, domain-wide broadcasts, a lack of segmentation, loop-free topology, and the availability of learning routers.

Layer 4 – Transport (end-to-end reliability)

The transport layer ensures complete data transfer and includes services such as acknowledge and unacknowledge unicast and multicast messages, an authentication server, and a transaction control sub-layer (common ordering and duplicate detection). The efficient implementation allows LonTalk packets to be very short, which preserves network bandwidth and speed messaging.

Layer 5 – Session (remote actions)

The session layer sets up, coordinates, and terminates conversations, exchanges, and dialogs between applications. This layer also handles session and connection coordination.

Layer 6 – Presentation (data interpretation)

This layer, also called the syntax layer, is usually part of an operating system, and defined where incoming and outgoing data are converted from one presentation format to another. The LonTalk protocol provides tremendous flexibility by transferring syntax as network variables, messages, or foreign frames.

Layer 7 – Application (sensor/actuator application compatibility)

Communication partners, quality of service, and data syntax are identified at this level, as are user authentication and privacy. This layer is not the application layer itself, although some applications may perform application layer functions. The LonTalk protocol provides some of these features at lower layers to make it easier and substantially less complex to develop applications and create interoperable products.

A typical LonTalk packet size is shown in the following figure.

Layer	Octets
Layer 2 Header	1
Layer 3 Address Information	4
Layer 4 Service Type	1
Layer 5 Header	2
Layer 6 Header	2
Data	2 to 218
Layer 2 CRC	2

A LONWORKS/IP network, in concept, functions similar to a BACnet/IP with one very significant exception: in a LONWORKS /IP solution, the communication packets are tunneled within UDP/IP packets using the open EIA-852 standard. This architecture makes it possible span long distances at very high speeds using standard IP infrastructure including Ethernet routers. Accordingly, networks can span the gamut from very basic two node systems all the way global Web-based systems encompassing potentially millions of sites.

Impact of Protocol Differences on Products and Services for BAS

Category	BACnet	LONWORKS Systems
Cost	**Higher Cost System:** ▪ Client/server and tiered architecture requires more gateways with custom software ▪ Network layer customized to support MS/TP – Non-Standard Ethernet routers required ▪ Requires more expensive components due to ASN.1 encoding and large packet size protocol ▪ Customized installation and diagnostic tools for each data link type	**Lower Cost System:** ▪ Simplified and flexible approach to network configurations, installations and applications ▪ Less expensive twisted pair free topology provides field level building controls ▪ Lower cost components are used for designing devices ▪ Single protocol throughout allows the use of one common installation and diagnostic tool; provides the ability to access all network devices regardless of the manufacturer and media
Complexity	**Needless complexity:** ▪ Collapsed architecture increases complexity in application layer ▪ Application interface not defined that leads to different implementations ▪ Longer time to market for development of new devices ▪ Limits customers choices because of the limited number of products available and lack of interoperability ▪ Support for 6 different protocols with specific implementation and the need for different media made the	**Well defined structure:** ▪ Provides ability to multiple media type at PHY layer and well defined API for a simpler and faster development of products ▪ Sophisticated & flexible media access scheme enhances performance of a control network ▪ By defining a single set of network rules – SNVT, SCPT, Functional Blocks and profiles - promotes faster development of products as well as interoperable products from multiple vendors

Category	BACnet	LONWORKS Systems
Complexity (con't)	**Needless complexity:** overall system design and installation complex	**Well defined structure:** ▪ Availability of ICs in which the protocol and physical layer transceivers are embedded shortens development time and reduces costs
Interoperability	**No device level interoperability** ▪ Unique, proprietary extensions makes implementations proprietary and non-interoperable ▪ Lack of development guidelines enabled device manufacturers to implement their own data elements, limiting the number of interoperable products available from multiple vendors ▪ Limited number of certified products reduces competition and raises product prices ▪ Generally no product substitution from other vendors	**Device level interoperability** ▪ Enables multi-vendor and multi-market solutions ▪ LONMARK® organization defines guidelines and tests against those guidelines – results in interoperability for multiple products, from multiple manufacturers ▪ Guidelines are developed through industry consensus process ▪ Large number of certified products available from multiple vendors ensuring competitive prices and products can be substituted for one another
Diagnostic and Development Tools Availability	**Limited diagnostic tools available** ▪ PC-based software tools can access only the upper protocol layers ▪ Requires routine updates to include new objects and data types - customer remains locked in to proprietary tools ▪ Different development tools are required for each of the 6 supported protocols	**Tools available from multiple sources** ▪ Addresses network issues easily and quickly ▪ Allows verification of interoperability and network integrity ▪ Time tested development tools available from Echelon and multiple other vendors

Conclusions

The architecture and implementation of BACnet and the LONWORKS platform differ substantially. The BACnet protocol was intended to enable workstations from different BAS suppliers to work with a wide range of devices by means of gateways that converted data from device protocols to the BACnet protocol. The BACnet protocol leaves many implementation decisions to the discretion of the product manufacturers, whose implementations vary and for whom interoperability has not been of primary importance.

The LONWORKS platform was designed with a flat architecture which does not need gateways between devices, and which supports the use of installation and diagnostics tools that can be shared among all devices. The implementation of the LonTalk protocol is standardized which, together with the availability of industry defined objects makes possible multi-vendor interoperable systems. The open, standards-based LONWORKS platform enables manufacturers to bring products to market faster, it enables integrators to use common installation and diagnostic tools, and it provides specifiers and facility owners with lower installation and life cycles costs that one should expect from interoperable, multi-vendors BAS.