Introduction to the LONWORKS® Platform

An Overview of Principles and Practices

Version 2.0

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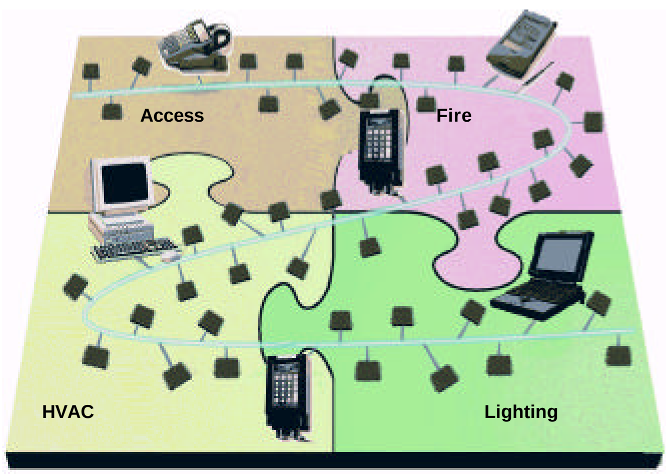
CHAPTER 1: INTRODUCTION

In the late 1980's, Echelon Corporation began the development of the LONWORKS platform in the belief that it would become a universal standard for control networks. A control network is any group of devices working in a peer-to-peer fashion to monitor sensors, control actuators, communicate reliably, manage network operation, and provide complete access to network data. A LONWORKS control network uses the LonTalk protocol to accomplish these tasks. LONWORKS technology has become a universal standard for control networks as literally thousands of companies develop products based upon it today.

In some ways, a LONWORKS control network resembles a data network referred to as a Local Area Network or LAN. Data networks consist of computers attached to various communications media, connected by routers, which communicate with one another using a common protocol. Control networks contain similar pieces optimized for the cost, performance, size, and response characteristics of control. Tailoring the network so that it is ideal for control functions makes it a Local Operating Network or LON®. LON characteristics allow networked systems to extend into a class of applications that data networking technology cannot reach. Manufacturers of control systems and devices are able to shorten their development and engineering time by designing LONWORKS components into their products. The result is cost effective development and consistency that allows devices from multiple manufacturers to be able to communicate.



LONWORKS control networks range in sophistication from small networks embedded in machines to large networks with thousands of nodes controlling fusion lasers, paper manufacturing machines, and building automation systems. Buildings, trains, airplanes, factories, and hundreds of other processes use LONWORKS control networks. In the building control industry, leveraging LONWORKS technology means using a common infrastructure for all the buildings systems. This allows the designer to eliminate excessive vertical integration, which is the often the reason for vertical isolation. This goal is visualized in the drawing above which illustrates an ideal open system implementation.

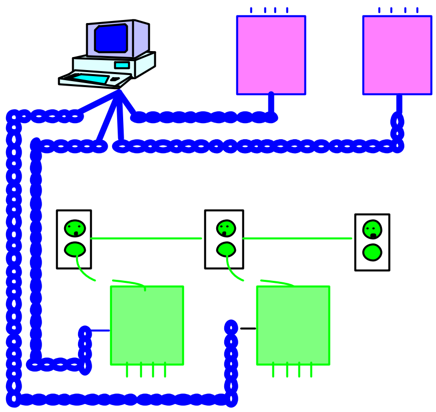
This introductory paper is provided to assist those interested in learning the basics of the LONWORKS platform. The document is meant only as an introduction to LONWORKS technology and not intended as a comprehensive reference. It begins with an overview of networks and protocols, highlights the technical aspects of the LonTalk protocol, and ends with a discussion on achieving product interoperability. The last chapter provides a list of more detailed related reading. It is important to note that many of the technical details discussed in this document are handled automatically by the protocol, the network operating system or network tools. The automatic handling of the lower level details of device communication is, in fact, one of the great strengths of LONWORKS technology.

CHAPTER 2: NETWORKS & PROTOCOLS

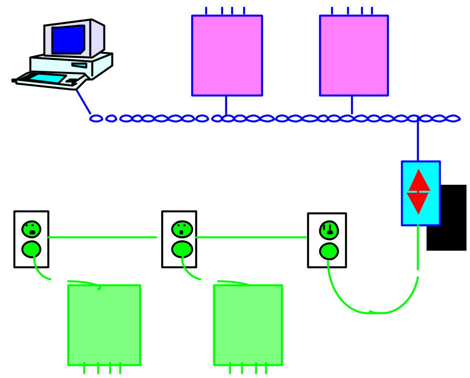
2.1 THE NETWORK

To understand good control network design, one must first understand the function of a network. Put simply, a network allows a number of intelligent devices to communicate directly with each other. No intervening supervisor is required to 'poll' devices for information and then re-transmit that information to other devices. No supervisory device is charged with responsibility for system wide algorithms.

This means that every device is capable of publishing information at its discretion. This information becomes digital serial data that travels directly over the network to other devices. The data transfer typically involves one sender of information and one or more receivers or listeners. The sender and receiver(s) must make some form of connection and then data is transferred as a string of on-off states.



Master/slave - communicate via supervisor



Network - communicate peer-to-peer

These on-off states begin and end as small, weak signals at the microprocessor level within each device. A component known as a **transceiver** is used to condition the microprocessor level on-off signals for long range delivery across the network signal pathway. The path between devices exhibits various physical characteristics and is called the **transmission medium**. The **transceiver,** then, is an electronic module that provides the physical interface between the communications port of a microprocessor and a physical medium, also called a **channel**, which transports the digital communication packets to other devices in the network. The choice of channel type and transceiver type affects transmission speed and distance as well as the network topology.

All devices connected to a specific channel must have compatible transceivers running at the same rate. It is possible to build a transceiver for any medium, though some are more difficult to implement and therefore more expensive. Transceivers are available for a variety of channel media, including single twisted pair, power line, RF, infrared, fiber optics, and coax. Data transfer rates on a network are dependent on the media and transceiver design. There are a number of characteristics that describe how any given signal type travels across the respective medium.

2.2 COMMUNICATION PROTOCOLS

A device on a network publishes information as appropriate to the application that it is running. The applications are not synchronized, and it is possible that multiple devices may all try to 'talk' at the same time. Meaningful transfer of serial data between devices on a network, therefore, requires organization in the form of a set of rules and procedures. These rules and procedures are called the **communication protocol** often abbreviated as the **protocol**. The protocol defines the format of the message being transmitted between devices and defines the actions expected when one device sends a message to another.

The protocol normally takes the form of embedded software or firmware code in each device on the network. A device that contains this protocol code together with some type of operational intelligence is referred to as a **node**. The embedded code that implements a communication protocol can be quite complex. To simplify understanding and implementation, complex ideas are often conceptually divided into multiple layers of functionality. In the software code used for network communication, these functional layers are collectively known as the **protocol stack**.

2.3 PROTOCOL MODELING

In an effort to standardize various worldwide communications developments, the International Standards Organization (ISO) developed a model for the generic network protocol stack called the Open System Interconnect (OSI) model. This model (the ISO/OSI model) is used to help developers and users alike segment the protocol into multiple standard feature and function layers. These layers cover aspects ranging from the type of wiring used, to the user interface in programs. The seven layers of the ISO/OSI model are shown below. This model is often used to compare the features and functionality of communication protocols. It is not a requirement that any given protocol implement every layer of this model or even that the layers be segmented as shown in the model. A truly complete and fully scalable protocol, however, provides all the services described in this model.

	OSI Layer	Purpose	Services
7	***Application***	Application Program	Standard objects & types, config props, file xfer, network services
6	***Presentation***	Data Interpretation	Network variables, application messages, foreign frames
5	***Session***	Remote Actions	Dialog, remote procedure calls, connection recovery
4	***Transport***	End-to-End Reliability	End-to-End acks, service type, pkt sequencing, duplicate detect
3	***Network***	Destination Addressing	Unicast & multicast, destination addressing, packet routing
2	***Data Link***	Media Access & Framing	Framing, data encoding, CRC, media access, collision detect
1	***Physical***	Electrical Interconnect	Media specific details, xceiver type, physical connect

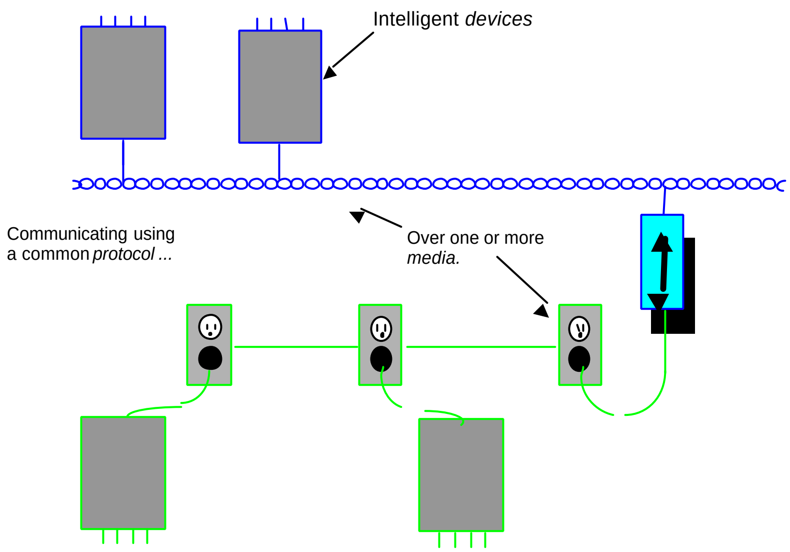
ISO/OSI 7 LAYER MODEL

2.4 CONTROL NETWORKS

Networks have been around for a number of years. They were originally designed for connecting large computing systems to each other. The communication protocols employed were ideal for passing large amounts of data between computers designed for batch processing. Through time, these protocols evolved to increase in scale and incorporate greater functionality and flexibility. Most, however, continued to be designed for data communication between computers or individuals.

Eventually, the cost of microprocessors reached the point that they could be incorporated into inexpensive controllers and control devices. It was at this point that design engineers began to realize the communication protocols they were using were not really 'tuned' for optimal performance in control systems. Control networks have a number of unique requirements that make them different from data networks. These include:

- Frequent, reliable, secure communications between devices
- Short messages formats for the information being passed
- Peer-to-peer functionality for every device
- Price points that enabled small, low-cost nodes



It was the need to address these control specific network requirements, together with the belief that a market standard for communications would allow interoperability that would empower the market to increase in size and efficiency, that brought about the introduction of the LonTalk protocol.

CHAPTER 3: THE LONTALK PROTOCOL

3.1 THE PROTOCOL DEFINITION

The LonTalk communication protocol is the heart of LONWORKS technology. The protocol provides a set of communication services that allow the application program in a device to send and receive messages from other devices over the network without needing to know the topology of the network or the names, addresses, or functions of other devices. The LonTalk protocol can optionally provide end-to-end acknowledgement of messages, authentication of messages, and priority delivery to provide bounded transaction times. Support for network management services allows for remote network management tools to interact with the device over the network, including reconfiguration of network addresses and parameters, downloading application programs, reporting network problems, and start/stop/reset of node application programs.

The **LonTalk protocol** is a layered, packet-based, peer-to-peer communications protocol. Like the related Ethernet and Internet protocols, it is a published standard and adheres to the layered architectural requirements of the International Standards Organization (ISO). The LonTalk protocol, however, is designed for the specific requirements of control systems, rather than data processing systems. Each packet is a variable number of bytes in length and contains the application-level (layer 7) information together with addressing and other network information. Every device on a channel looks at every packet transmitted on the channel to determine if it is an addressee. If so, it processes the packet to see if it contains data for the node's application program or whether it is a network management packet. The data in an application packet is provided to the application program and, if appropriate, an acknowledgement message is sent to the sending device.

To handle message collisions on the network, the LonTalk protocol uses a Carrier Sense Multiple Access (CSMA) algorithm similar to that used by Ethernet. The LonTalk protocol builds upon the CSMA algorithm to provide a media access protocol which allows for priority messaging and dynamically adjusts the number of packet time slots, based on predicted network traffic. By dynamically allocating network bandwidth the algorithm, known as a predictive p-persistent CSMA protocol, permits the network to continue operating in the presence of very high levels of network traffic without slowing the network during periods of light traffic.

3.2 LONTALK PROTOCOL ADDRESSING

To simplify network configuration and management, it is possible to assign logical addresses to nodes. A logical address allows the user to associate a name with a physical device or node. Logical addresses in a control network using LonTalk are defined at the time of network configuration. All logical addresses have two parts. The first part is the **domain ID** that designates the domain. A **domain** is simply a collection of nodes, often the whole system, which may interoperate. The second part of the logical address specifies either a single node in the domain by its unique 15-bit **node address,** or a predefined **group** of nodes with its unique 8-bit **group address.** Every LonTalk packet transmitted over the network contains the logical node address of the transmitting node (the **source** address) and the address of receiving nodes (**destination address)** that can either be the physical Neuron ID address, the logical node address, a group address, or a broadcast address.

Multiple domains are used if the number of nodes exceeds the allowed domain limit or if there exists a desire to separate the nodes so that they do not interoperate. It is possible for two or more independent LONWORKS systems to share the same physical network, as long as each system has a unique domain ID. Devices in each system respond only to those packets corresponding to their domain ID and do not know about or care about packets addressed with other domain IDs. Devices also respond to packets addressed with their own physical ID, which is usually known only to the corresponding network management tools. Of course, when a physical network is shared, overall network response times will be affected due to the increased number of packets, so coordinated overall network design is required.

A **group** is a logical collection of nodes within a domain. However unlike subnets, a group is a collection of nodes that are grouped together without regard for their physical channel location. The Neuron Chip allows a node to be configured as a member of up to 15 groups. There is a limit of 256 groups per domain. Maximum group size is 64 nodes when acknowledged messaging is used, unlimited size for un-acknowledged messaging. Groups are an efficient way to optimize network bandwidth for one-to-many network variable and message tag connections

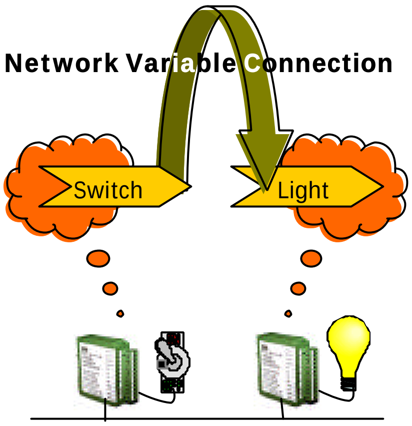
In summary, each domain in a system using the LonTalk protocol **can have up to 32,385 devices**. There can be **up to 256 groups in a domain** and each group can have any number of nodes assigned to it, except that when end-to-end acknowledgement is required, groups are limited to 64 nodes. **Each node can be a member of up to 15 groups.** This information is listed in tabular form below.

• **Nodes in a subnet**	**127**
• **Subnets in a domain**	**255**
• **Nodes in a domain**	**32,385**
• **Domains in a network**	**2^{48}**
• **Maximum nodes in system**	**32K x 2^{48}**
• **Members in a group**	
◆ **Unacknowledged or Repeated**	**No Limit**
◆ **Acknowledged or Request Response**	**63**
• **Groups in a domain**	**255**
• **Channels in a network**	**No Limit**
• **Bytes in a network variable**	**31**
• **Bytes in an explicit message**	**228**
• **Bytes in a data file**	**2^{32}**

3.3 LONTALK NETWORK VARIABLES

The LonTalk protocol implements the innovative concept of **network variables(NVs, pronounced en´·vê).** NVs greatly simplify the task of designing LONWORKS application programs for interoperability with multiple vendors' products; and of facilitating the design of information-based, rather than command-based, control systems. A network variable is any data item (temperature, a switch value, or an actuator position setting) that a particular device application program expects to get from other devices on the network (an **input NV**) or expects to make available to other devices on the network (an **output NV**).

The application program in a device doesn't need to know anything about where input NVs come from or where output NVs go. When the application program has a changed value for an output NV it simply writes the new value to a particular memory location. Via a process that takes place during network design and installation called **binding**, the LonTalk firmware is configured to know the logical address of the other devices or group of devices in the network expecting that NV, and it assembles and sends the appropriate packets to these devices. Similarly, when the LonTalk firmware receives an updated value for an input NV required by its application program, it puts the data in a particular memory location. The application program knows it will always find the latest data value at that location. The binding process thus creates logical **connections** between an output NV in one device and an input NV in another device or group of devices. Connections may be thought of as "virtual wires". If one node contains a physical switch, with a corresponding output NV called "switch on/off", and another node drives a light bulb with a corresponding input NV called “lamp on/off”, creating a logical connection by binding these two NVs has the same functional effect as connecting a physical wire from the switch to the light bulb.



- Virtual wire
- Created and changed with Network Tool
- Can be changed without reprogramming device
- Makes adds, moves, and changes easy

3.4 LONTALK MESSAGE TYPES

The LonTalk protocol offers three basic types of message service and also supports authenticated messages. An optimized network will often use all of these services. The first type of message service provides for end-to-end acknowledgement and is called **acknowledged** messaging. When using acknowledged messaging, a message is sent to a node or group of nodes and individual acknowledgements are expected from each receiver. If acknowledgements are not received, the sender times out and retries the transaction. The number of re-tries and the time-out are both selectable. The second message type is **unacknowledged repeated**. Using this message type causes a message to be sent to a node or group of nodes multiple times. This service is typically used when broadcasting information to a large group of nodes since an acknowledged message would cause all the receiving nodes to try to transmit a response at the same time. The third type of message is simply an **unacknowledged** message in which the message is sent once to a node or group of nodes and no response is expected. **Authentication** service for messages allows the receivers of a message to determine if the sender is authorized to send that message. Thus, authentication prevents unauthorized access to nodes and is implemented by distributing 48 bit keys to the nodes at installation time.

3.5 LONTALK CHANNEL TYPES

The LonTalk protocol is designed to be media-independent, allowing LONWORKS systems to communicate over any physical transport media. This empowers the network designer to make full use of the variety of channels available for control networks. The protocol provides for a number of modifiable configuration parameters to make tradeoffs in performance, security, and reliability for a particular application.

A channel is a specific physical communication medium (such as twisted pair or power line) to which LONWORKS devices are attached by transceivers specific to that channel. Each type of channel has different characteristics in terms of maximum number of attached devices, communication bit rate, and physical distance limits. The table below summarizes the characteristics of several widely used channel types.

Channel Type	Medium	Data Rate	Max devices	Max distance
TP/XF-1250	Twisted pair, bus	1.25 Mbps	64	125m (bus length)
TP/XF-78	Twisted pair, bus	78 Kbps	64	1330m (bus length)
TP/FT-10	Twisted pair, flexible topology	78 Kbps	64 (up to 128 if link- powered)	500m (node to node)
PL-2x	Power line	5 Kbps	~500	Environment Dependent

Of particular importance is the flexible-topology twisted pair channel, TP/FT-10, which allows devices to be connected by single-twisted-pair wire segments in any configuration. There are no constraints on stub length, device separation, or branching.

3.6 LONTALK FEATURES AND BENEFITS

In summary, the variety of services available for the LonTalk protocol provides enhanced reliability, security, and optimization of network resources. The features and benefits of these services include:

- ♦ Supports a broad range of communication media, including twisted-pair wiring and power lines.
- ♦ Supports reliable communication, including defense against unauthorized system use.
- ♦ Offers predictable response times independent of network size.
- ♦ Supports networks constructed with a mix of media types and communication speeds.
- ♦ Provides interfaces that are transparent to the nodes.
- ♦ Supports tens of thousands of nodes — but is equally effective in networks with only a few nodes.
- ♦ Permits arbitrary connectivity among nodes
- ♦ Allows peer-to-peer communication thus enabling its use in distributed control systems.
- ♦ Provides an effective mechanism for product interoperability, such that products from one manufacturer can share information about standard physical quantities with those of another manufacturer.
- ♦ Implements solutions to network management issues within the protocol.

3.7 THE LONTALK STANDARD

Up until a few years ago, the LonTalk protocol was only available embedded in the Neuron chip. This guaranteed consistent application by all manufacturers. Now that a large number of compliant devices have been installed, Echelon Corporation has published the LonTalk protocol and made it an open standard under the EIA 709.1 Control Networking Standard. The protocol is therefore freely available to anyone. The easy way to get a copy of the protocol is to access the Internet site **http://global.ihs.com/** and request a copy of EIA 709.1.

The most cost-effective manner in which to implement the LonTalk communications protocol continues to be by purchasing a Neuron chip. The EIA standard, however, allows any company willing to undertake the investment to implement the protocol in the microprocessor of their choice. This might be economically desirable for devices with applications that require more powerful processors than the Neuron chip.

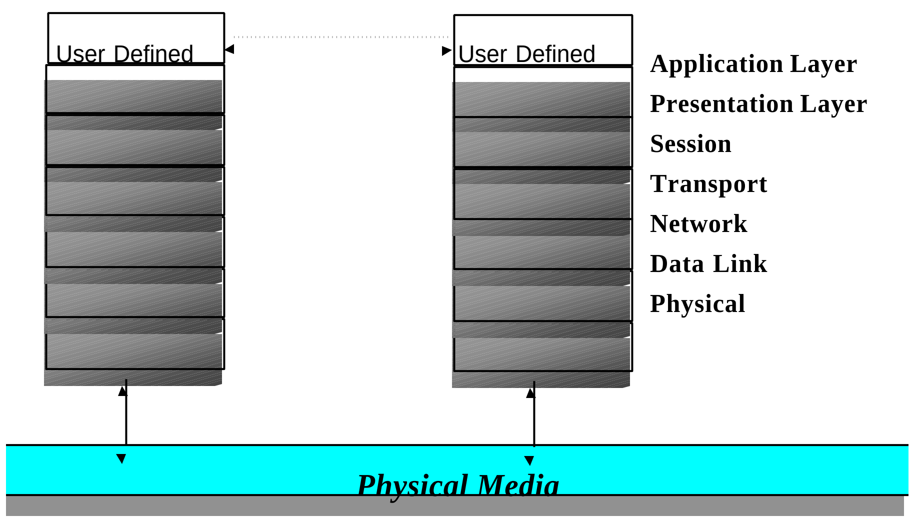
CHAPTER 4: LONWORKS TECHNOLOGY

4.1 BUILDING A PLATFORM

Echelon Corporation invented the LONWORKS technology and is the primary caretaker of the LONWORKS platform. Though a large number of control manufacturers currently use LONWORKS, relatively few have made a priority of implementing open systems based upon a standard protocol and standard network management. In fact, many companies continue to leverage the efficiencies of the LONWORKS technology while developing systems that continue to be closed and proprietary.

Echelon began the development of the LONWORKS platform in 1988. The initial vision continues to drive the company forward. Create a standard, cost effective method to allow inexpensive control devices to communicate with each other effortlessly. Then use the standard communication capabilities to allow devices from multiple vendors to easily interoperate on the same network. Echelon understood that simply developing a protocol specification was not sufficient to achieve the goal of multi-vendor systems. It was necessary to build a cost-effective, standard method through which the protocol could be used and supply all the necessary development tools and networking products.

The overriding goal of the LONWORKS technology is to make it easy and cost effective to build open control systems. Echelon developed the LONWORKS platform believing there were three fundamental issues that had to be addressed to create interoperable products in the control market. First, a protocol optimized for control networks, but relatively generic in its ability to work with different types of controls had to be developed. Second, the cost to incorporate and deploy this protocol in devices had to be competitive. Third, the protocol had to be introduced in such a way that implementation would not vary by vendor as this would destroy interoperability.



LonWorks provides everything but the application

In order to effectively address all of these issues, Echelon Corporation set out to create a complete platform for designing, creating, and installing intelligent control devices. The first step was achieved through the creation of the LonTalk protocol, which was described in a previous section. Addressing the cost and deployment issues meant finding an economical way to provide implementations of the protocol to customers along with development tools.

4.2 THE NEURON CHIP

In order to achieve economical and standardized deployment, Echelon designed the **Neuron Chip**. The Neuron name was chosen to point out the similarities between proper network control implementation and the human brain. There is no central point of control in the brain. Millions of neurons are networked together, each providing information to others through numerous paths. Each neuron is typically dedicated to a particular function, but loss of any one does not necessarily affect the overall performance of the network.

To the developer and the integrator, the beauty of the Neuron Chip lies in its completeness. The built-in communication protocol and processors remove the need for any development or programming in these areas. To refer back to the ISO/OSI model of a communication protocol, the Neuron Chip provides the first 6 layers. Only application layer programming and configuration needs to be provided. This standardizes implementation and makes development and configuration relatively easy.

Most LONWORKS devices take advantage of the functions of the Neuron Chip and use it as the control processor. The Neuron Chip is a semiconductor device specifically designed for providing intelligence and networking capabilities to low cost control devices. The Neuron Chip includes both communication and application processing capabilities with User code and I/O devices provided by the device developer. Echelon Corporation designed the original Neuron, but Neuron derivatives are now normally designed and manufactured by Echelon’s manufacturing partners. Cypress Semiconductor, Motorola, and Toshiba are all current producers of these chips. Multiple suppliers create a competitive environment for the Neuron chips and help drive prices down.

The Neuron is basically a system-on-a-chip with multiple microprocessors, read-write and read-only memory (RAM and ROM), communication and I/O interface ports. The read-only memory contains an operating system, the LonTalk communication protocol, and an I/O function library. The chip has non-volatile RAM for configuration data and for the application program, both of which are downloaded over the communication network. At the time of manufacture, each Neuron Chip is given a permanent unique-in-all-the-world 48-bit code, called the Neuron ID. A large family of Neuron Chips is available with differing speeds, memory type and capacity, and interfaces. Over 7 million Neuron Chips had been shipped as of early 1999, with prices less than $3 for some versions.

A complete implementation of the LonTalk protocol, called LonTalk firmware, is contained in ROM in every Neuron Chip. This allows the Neuron to assure use of a common protocol implemented in exactly the same way on every device. Most LONWORKS devices include a Neuron chip, which has an identical, embedded implementation of the LonTalk protocol. This approach eliminates the “99 percent compatibility” problem and assures that connecting LONWORKS devices together on the same network requires little or no additional hardware. The Neuron chip is actually three, 8-bit inline processors in one. Two are optimized for executing the protocol; the third is for the node’s application. The chip is, therefore, both a network communications processor and an application processor. This ensures that no matter who manufactured the control device/network, the underlying protocol that allows such devices to communicate is the same.

Every Neuron Chip, or any other processor implementing a licensed copy of the published LonTalk protocol, has a 48-bit ID guaranteed to be unique. Thus every LONWORKS device has a unique physical address that can be used by the LonTalk protocol. However, the ID is generally used only at initial installation and for diagnostic purposes. To simplify normal network operation, logical addressing methods are used.

4.3 NEURON CHIP APPLICATION PROGRAMS

Applications for LONWORKS networks are written in "Neuron C." Once written, the Neuron C code is 'compiled' into the 0s and 1s understood by the Neuron and loaded into memory either on or attached to the chip. Neuron C is really ANSI C, with three very important extensions:

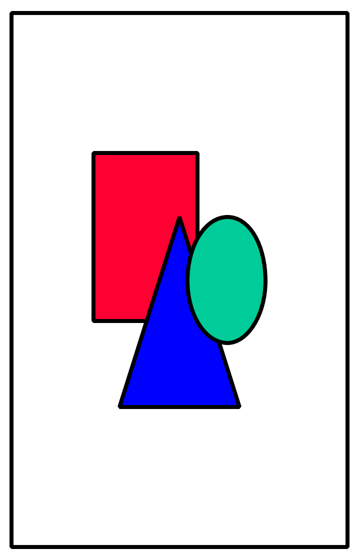
- A new statement type, the "when" statement, to introduce "events", and define task execution order;
- 37 additional data types, 35 I/O objects and 2 timer objects, to simplify and standardize device controller usage, and;
- Integral message-passing mechanisms for both explicit (physical, logical, and destination-name addressing) and implicit (network variable) message formats.

The fact that it is basically ANSI C makes Neuron C easy to learn and provides a large base of existing programmers. Neuron C has a slightly different programming paradigm, however, in that it uses a programming model based on events. In other words, applications are typically triggered by events occurring elsewhere on the network or at the particular node. Therefore, the network itself is event driven. This means that LONWORKS networks have much lower traffic than other types of networks, like the typical office LAN. It also means that a device does not have to wait to be polled to report a condition.

In some complex applications, the processor speed or maximum memory of the Neuron Chip family may be insufficient to accomplish the desired function of a LONWORKS node. To accommodate these applications, some versions of the Neuron Chip have a high-speed parallel interface allowing any microprocessor to execute the application program, while using the Neuron Chip, with a special microprocessor interface application(called a **MIP** application), as its network communications processor. Alternatively, the open LonTalk protocol can be ported to run directly on any processor; in such cases, a LONWORKS device does not require a Neuron Chip, but all such devices are assigned a unique 48-bit ID.

4.4 TRANSCEIVERS

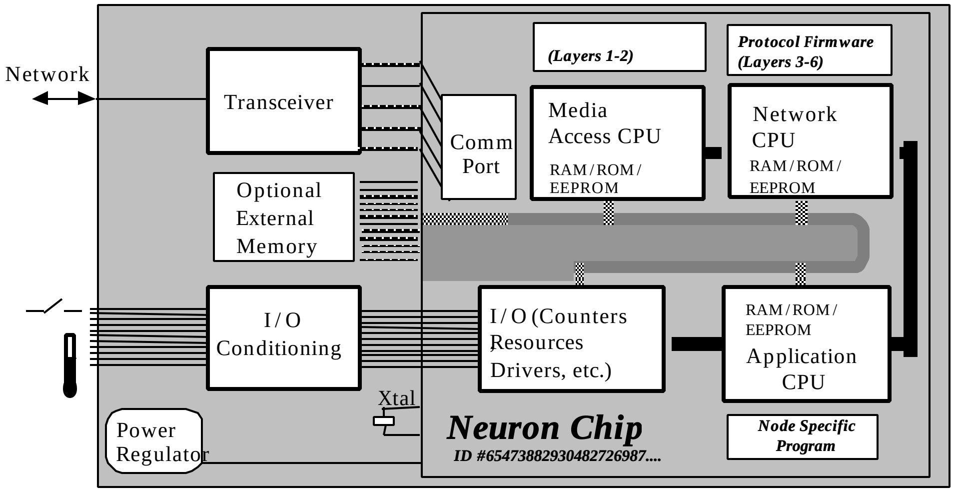
Transceivers provide a physical communication interface between a Neuron Chip and a LONWORKS network. These devices simplify the development of interoperable LONWORKS nodes and are available for a variety of communications media and topologies. It is important to know which transceiver is in any given product to allow the products to interoperate directly. Products with different transceiver types can still interoperate, but this requires the use of a router. Echelon offers twisted pair and power line transceivers designed for a wide variety of applications while other manufacturers provide transceivers for radio frequency, fiber, and a variety of other media.



4.5 LONWORKS DEVICES

Each LONWORKS device, or node, attached to the network normally contains a Neuron Chip and a transceiver in an appropriate mechanical package. Depending on the function of the device, there may also be embedded sensors and actuators, input-output interfaces to external legacy sensors and actuators, interfaces to host processors such as PC's, or an interface to another Neuron and transceiver in a router.

The application program that is executed by the Neuron Chip implements the “personality” of the device; it may be permanently resident in ROM (read-only memory) or may be downloaded over the network into non-volatile read-write memory (RAM).



COMPONENTS OF A LONWORKS DEVICE

The job of most of the devices in a LONWORKS network is to sense and control the state of the components that comprise the physical system being controlled. These are called **LONWORKS control devices or nodes** and they may have any combination of embedded sensors and actuators or input-output interfaces to external legacy sensors and actuators. The application program in the device may not only send and receive values over the network but may also perform data processing (e.g. linearization, scaling) of the sensed variables and control logic such as PID loop control, data logging, and scheduling.

4.6 ROUTERS

Transparent support for multiple media is a unique capability of LONWORKS technology, allowing developers to choose those media and communication methods best suited for their needs. Multiple media support is made possible by routers. Routers can also be used to control network traffic and partition sections of the network from traffic in another section, increasing the total throughput and capacity of the network. Network tools automatically configure routers based on network topology, making the installation of routers easy for installers and transparent to the nodes.

Router devices allow a single peer-to-peer network to span many types of transport media and support thousands of devices. A router typically has two interconnected neurons, each with a transceiver appropriate to the two channels to which the router is connected. Routers are completely transparent to the logical operation of the network, but they do not necessarily transmit all packets; intelligent routers know enough about the system configuration to block packets that have no addressees on the far side. Using another type of router called a tunneling router, LONWORKS systems can span great distances over wide-area networks such as the Internet.

4.7 DEVELOPMENT TOOLS

Development tools typically include an environment for developing and debugging applications at multiple nodes, a network manager to install and configure these nodes, and a protocol analyzer to examine network traffic to ensure adequate network capacity and to debug errors. Echelon's LonBuilder® tool can be assembled in various configurations, with a range of optional tools. Development Tools make it easy and inexpensive for manufacturers to design and test individual nodes for LONWORKS based control networks.

Several companies supply tools for developing, testing, and programming LONWORKS devices. In addition, multiple companies offer software tools for network design and system management, such as Echelon's LonMaker™ for Windows, and HMI tools, such as Wonderware's InTouch.

4.8 NETWORK ADAPTERS

Network interface devices do not connect to control sensors and actuators, but rather have physical interfaces to external host computers such as PCs or hand-held maintenance tools. The device application program provides communication protocols and an API (application program interface) to allow the host-based programs such as network tools to access the LONWORKS network. The Echelon PCLTA-10 LonTalk Adapter is a network interface device packaged on a standard PC ISA adapter card. It plugs into the ISA bus internal to the PC, enabling access to the network for network tools such as LNS and LonMaker for Windows.

Gateway devices allow proprietary legacy control systems to be interfaced to LONWORKS systems. A gateway device has a physical interface appropriate to the foreign system device or communication bus. Its application program interfaces to the proprietary communication protocol for the foreign system. The gateway translates between the two protocols as required to allow messages to pass between the two systems. It is possible in some cases for a gateway to convert the proprietary command-based messages of the foreign system to the SNVTs used by the information-based LONWORKS network. A gateway, however, should not be confused as a device in the network. It is a foreign object and a link to a dissimilar system. Even if selected messages can be passed between the two systems, the link is far from seamless, provides a bottleneck, and introduces separate operating systems and network tools into the integration effort.

4.9 NETWORK OPERATING SYSTEMS

A network Operating System (NOS) provides a common, network-wide set of services supporting monitoring, control, installation, and configuration. The NOS also provides programming extensions for easy use of network management and maintenance tools. A LONWORKS NOS must additionally provide data access services for HMI and SCADA applications as well as remote access via LONWORKS or IP networks.

A properly designed NOS allows for synchronization services between multiple tools used by a single or multiple users. In order for a NOS to support complete interoperability, it must support LONMARK services for accessing LONMARK objects and configuration properties, as well as those for creating LONMARK dynamic network variables. Finally, the NOS must support standard plug-ins by multiple manufacturers for easy device configuration.

The LNS Network Operating System provides a standard platform for supporting interoperable applicaionts on LONWORKS networks. LNS permits multiple applications and users to manage and interact simultaneously with a network. This feature alllows multiple installers equipped with a software tool to commission devices on the network at the same time.

LONWORKS Network Services (LNS) is a client-server architecture that provides the foundation for a new generation of interoperable LONWORKS network tools, which are products used in designing, configuring, installing, and maintaining LONWORKS systems. While the architecture supports clients based on any platform, servers are based on Windows 95 and Windows NT.

The LONWORKS Network Services (LNS) network operating system is "middleware", software that provides the standard platform for control network services. LNS offers a powerful client-server architecture that serves all of the control data to client devices using LONWORKS control networks or client PC's using TCP/IP data networks. Simple high level programming interfaces ensure anyone can build any application using all the information available in all of the devices.

LNS uses a multi-client/multi-server architecture that forms a platform for installing, upgrading and interacting with control networks. With client/server architecture, management tasks can be networked from multiple points at the same time, allowing multiple users to install devices, diagnose problems and make repairs simultaneously. LNS is scalable, changeable and upgradeable. LNS provides a generic software model for configuring, commissioning, maintaining, controlling and monitoring control systems and an implementation for delivering these features to LONWORKS networks.

The LNS Plug-in standard encourages sensor, actuator, and device manufacturers to provide more value to users through software components linked to their unique products. Rather than trying to develop custom programming for each project in the field, network integrators use plug-ins that configure the re-useable software objects in devices which have been designed for a specific function. These device plug-ins often contain built-in troubleshooting tools, user dialogues to aid or confirm configuration choice, as well as custom GUI to monitor or graph data held in the device. In effect, manufacturers can write smart software once to simplify the use of their products in hundreds of LONWORKS networks.

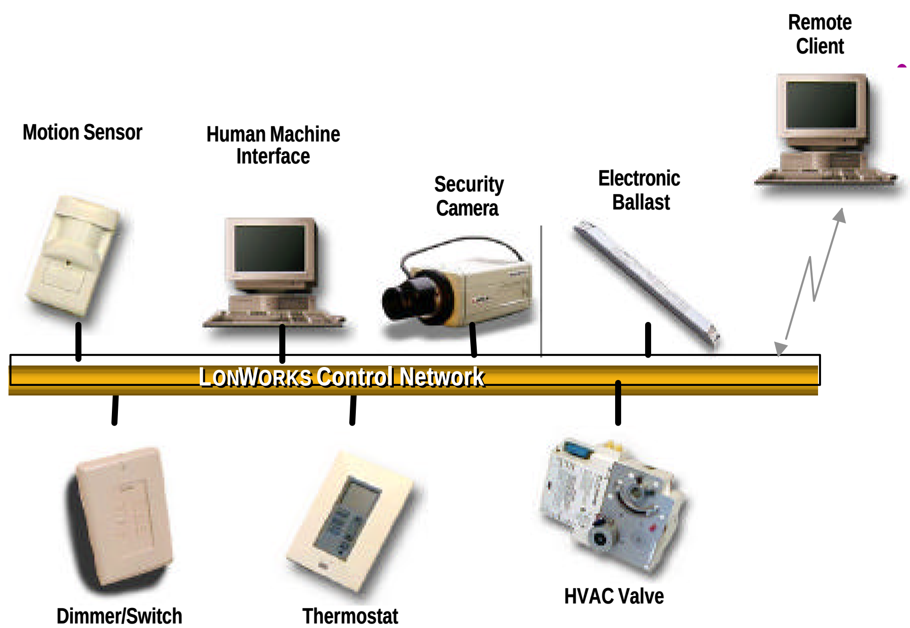
Using LNS a manufacturer's device plug-in software runs without modification in any PC. There is no need for a dedicated LONWORKS card in each PC. LNS Plug-ins simplify the management of the network by masking the underlying communication mechanisms between the software component and the device. Thus, many existing devices can become fully interoperable by simply writing a plug-in. A standard interface is set for manufacturers to customize the "front end," while LNS makes it possible for multi-vendor software components to work together.

Network tools are software programs built on top of the Network Operating System for network installation, configuration, monitoring, supervisory control, and maintenance. Echelon's offering automatically launches the plug-in registered for a selected device to present the manufacturer's software, if no plug-in has been supplied a generic text/table browser is provided as a default. This provides a single expandable tool covering the entire life cycle of the network to simplify the tasks of installers.

CHAPTER 5: INTEROPERABILITY

LONWORKS technology, developed by Echelon, enables the development of truly interoperable devices and systems. However, since the technology is communication-media-independent and does not prescribe how device application programs are to be structured, simply using the LONWORKS technology does not guarantee that LONWORKS devices from different manufacturers can interoperate in the same system. Indeed, LONWORKS technology is widely used in proprietary systems such as vehicle control systems, conveyor systems, and telephone central office monitoring systems.

There is an important difference between a collection of interoperable devices and an open system. It is impossible to have an open system without interoperable devices, but quite possible to have a collection of interoperable devices in a closed system. In other words, interoperable devices are necessary, but not sufficient to achieve open systems. Proper network design is the additional requirement to implement a truly open system. Interoperable devices are the most basic component in the development of open systems. Thus, the LONMARK Association was formed to promote and support those manufacturers that produce interoperable devices.



5.1 THE LONMARK ASSOCIATION

Because there are vast opportunities in many industries for interoperable products, the LONMARK Interoperability Association was formed in 1994 by Echelon and a group of LONWORKS users dedicated to building interoperable products. **Interoperability** means that multiple devices from the same or different manufacturers, can be integrated into a single control network without requiring custom nodes or custom programming. The **LONMARK Association** is dedicated to developing standards for interoperability, certifying products to those standards, and promoting the benefits of interoperable systems.

The LONMARK brand provides device level assurance of interoperability. Only LONWORKS devices that have been certified by the LONMARK Association – called **LONMARK devices -** can carry the LONMARK logo. Membership in the LONMARK Association is open to all interested companies; different dues structures exist for manufacturers, system integrators and end-users. Complete information about members, current activities, and published standards may be obtained from the Association's website (www.LONMARK.org).

The Association is governed by an Industrial Council drawn from members representing all of the interested communities. Membership in the Association is open to any company, organization, or individual committed to the development, manufacture, and use of LONMARK-certified products based on the LonTalk protocol. The Association develops technical product specifications and guidelines, which ensure that products designed accordingly will interoperate. It also develops and publishes functional profiles which describe in detail the application layer interface, including the network variables, configuration properties, and default and power-up behaviors required for specific, commonly used control functions. Thus, the Association focuses on two areas:

1. **Transceivers and the associated physical channel guidelines**
2. **Guidelines for structuring and documenting node application programs.**

5.2 TRANSCEIVER AND PHYSICAL CHANNEL GUIDELINES

The LONMARK guidelines for transceivers and physical channels are contained in the document *LONMARK Layers 1-6 Interoperability Guidelines*, reference [2]. Table 2.1 of that document shows all the standard physical channels for which corresponding transceivers are certified. It also provides guidelines for use of the LonTalk protocol – buffer sizes/ counts/types, address table entries, etc

The channel types which are used most often in buildings are the TP/XF-1250 (twisted pair bus at 1.25 Mbps), the TP/FT-10 (twisted pair flexible topology at 78 kbps). Occasionally, the PL-20 power line type is used to leverage existing power wiring as a transmission medium.

5.3 APPLICATION PROGRAM GUIDELINES

The LONMARK guidelines for interoperable device application programs are contained in *LONMARK Application Layer Interoperability Guidelines*. These guidelines are based on "object-oriented programming", which is the current standard for computer programming throughout the information systems community. Under this methodology, application programs are comprised of modular segments of code called **objects**. Each object performs a well-documented function and communicates with other objects according to rigid input-output interface specifications. Once a complete set of objects has been created, the task of designing an application becomes one of selecting the appropriate objects and "connecting" them.

In order for applications from multiple manufacturers to easily interoperate using NVs, the data within the NV must be interpreted in the same way. As an example, all temperature values must be in either Centigrade or Fahrenheit. This is facilitated by the LONMARK Association, which has defined and published over a hundred common system variables. These are referred to as **Standard Network Variable Types (SNVTs -** pronounced "snivets"). Check the references for a current list and details of all SNVTs.

LONMARK objects form the basis of interoperability at the application layer by specifying standard formats for how information is input to and output from a node and shared with other nodes on the network. LONMARK objects are defined as a set of one or more input and/or output Standard Network Variable Types with semantic definitions relating the behavior of the object to the network variable values and to a set of configuration properties. To provide for future expansion and to enable manufacturer differentiation, the LONMARK object definitions are comprised of mandatory network variables, optional network variables, and configuration specifications.

5.4 OBJECTS AND FUNCTIONAL PROFILES

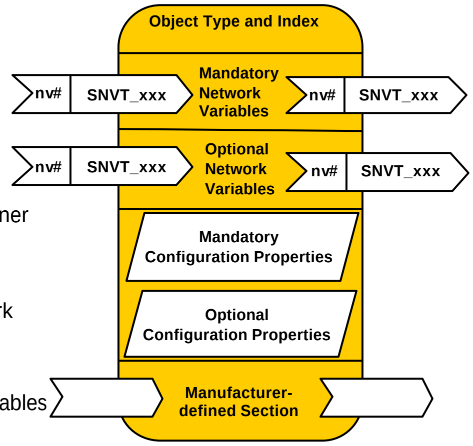
The LONMARK guidelines define two types of objects: generic **LONMARK objects** and **LONMARK functional profiles**. Generic objects are used in many applications across a broad spectrum of industries. An example is the Open Loop Sensor Object, which makes available on the network the value from any form of sensor integrated with or connected to the LONMARK device. Functional profiles are designed for specific application areas, such as HVAC or lighting systems. An example is the VAV Controller functional profile, which takes room temperature value from the network and implements a PID control algorithm to drive a damper actuator to regulate room temperature. The LONMARK Association forms task groups of interested members to design, approve, and publish functional profiles in numerous functional areas, such as HVAC, security, lighting, and semiconductor manufacturing systems.

The initial set of LONMARK objects, published in the LONMARK Interoperability Guidelines January 1995 provided a basic set of generic objects (sensor, actuator, and controller) from which a broad set of applications could be implemented. Input and output data types were intentionally left open to interpretation according to the particular application. LONMARK members have since moved forward and defined the data types and associated configuration properties to arrive at new, application-specific objects described by Functional Profiles.

LONMARK Functional profiles describe in detail the application layer interface, including the network variables, configuration properties, and default and power-up behaviors required on LONMARK devices for specific, commonly used control functions. Profiles standardize functions not products. Profiles therefore give industry groups universal shorthand in which to describe common units of functional behavior. This shorthand eases the specification process and enhances interoperability without compromising a specifier's ability to call for unique capabilities, or a manufacturer's ability to differentiate a product from the competition. A product can be based on one or more Functional profile in addition to any combination of the basic LONMARK objects.

Each LONMARK object exchanges information with other LONMARK objects only by SNVTs. However, most objects also require customization for a specific system application. The LONMARK guidelines specify data structures called Standard Configuration Parameter Types (**SCPT**, pronounced skip-it) and User-defined Configuration Parameter Types (**UCPT**, pronounced you-keep-it), which provide standards for documentation and for the network message formats used to download the data to the device by network tools. SCPTs are defined for a wide range of parameters used in many kinds of functional profiles, such as hysteresis bands, default values, min-max limits, gain settings, and delay times. SCPTs are to be used wherever applicable and are documented in “The SCPT Master List”. In situations where there is not an appropriate SCPT available, manufacturers may define UCPTs for configuring their objects, but these must be documented in resource files according to a standard format.
An application program in a LONMARK device thus consists of one or several LONMARK objects, each configured and used independently of the others, which can be connected to any other objects on the network to implement the desired system-level functionality. Each LONMARK device also contains a node object, which allows its own status and the status of the other objects in the node to be monitored by network management tools. A template for LONMARK object features is shown below.

- Type of object
- Index on device
- Mandatory Network Variables
  - Minimum implementation
  - Use SNVTs
- Optional Network Variables
  - Implemented in standardized manner
  - Use SNVTs
- Configuration Properties
  - Applies to device, object or network variable
- Manufacturer-defined section
  - Manufacturer-defined network variables and types
  - Proprietary, non-interoperable interface



All LONMARK devices must be self-documenting, thus assuring that any network management tool based on LONWORKS Network Services can obtain from any LONMARK device (over the network) all the information needed to connect the device into the system and to configure and manage that device. Each LONMARK device also must have an external reference file (a specially formatted text PC file with a .XIF extension), so that network tools can design and configure a network database prior to physical connection of the devices and can then commission the devices after they are installed. On its website, the LONMARK Association will maintain a database of the external reference files for all LONMARK devices.

5.5 LONMARK RESOURCE FILES

The LONMARK Application Layer Guidelines also specify certain requirements for user defined configuration properties and network variables on a LONMARK device. User defined configuration properties which must be set at installation time for node operation must be defined with resource files and user documentation. This information must be supplied at the time the node is certified.

Any and all configuration information required to make a device fully functional must be implemented and exposed via LONMARK configuration properties. All user defined network variable types must have definitions contained in a resource file that is supplied along with the other materials required for node certification. These files define the user types and enumeration values (*.TYP), formatting information for rendering the user types (*FMT), and string resource files for at least one language (*.<language extension>).

There are three types of device resource files that support the use of configuration properties and network variables on a device.

- Type File: This file uses the .TYP extension and contains network variable type, configuration property type, and enumeration definitions.
- Format File: This file uses the .FMT extension and contains format information for the network variable and configuration property types defined in the type file.
- Language File(s): Every set of device resource files must contain one or more language files. These files contain language dependent strings. Their extensions depend on the language to which they apply. For example, an American English language file would have a .ENU extension, while a British English language file would have a .ENG extension

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User defined network variable types (UNVTs) and configuration property types (UCPTs), enumerations, and language dependent strings are supported on LONMARK devices by creating associated device resource files including a .TYP file, a .FMT file, and one or more language resource files. These Device Resource Files are then used by installation and configuration tools to correctly interpret and make use of network variables and configuration properties on a device. For example, in a multi-vendor LONWORKS network that contains devices from several different manufacturers, each manufacturer would provide their own set of device resource files with the type, format, and language information specific to their devices.

In some cases, there is a network variable or configuration property type that the manufacturer wants to use which is not defined in the SNVT and SCPT lists. In this case, the manufacturer may create user resource files, which allow them to define their own net-work variable and configuration property types (UNVTs and UCPTs).

5.6 LONMARK PROGRAM IDS

A LONMARK **program ID** is a unique identifier that is included in every LONMARK device. The standard program ID contains information on the manufacturer of the device, the functionality of the device, the tranceiver used as well as the intended usage and can be used by network tools to functionally identify devices on a LONWORKS network. The fields within the standard program ID are as follows:

- Format. A 4-bit value defining the structure of the program ID. Program ID formats 8 and 10 - 15 are reserved for interoperable LONMARK nodes. ID format 8 is used for Standard Program IDs. Format 9 can be used during development to test decoding of standard IDs by a network management tool. For the format shown above, format number 8 or 9 should be used.
- Manufacturer ID. A 20-bit unique ID identifying each manufacturer of interoperable LONMARK nodes. This ID is assigned to a manufacturer upon request when it becomes a member of the LONMARK interoperability Association.
- Device Class. A 16-bit ID identifying the device class. This ID is drawn from a registry of pre-defined class definitions. The device class indicates the primary function of the device. If an appropriate class designation is not available one will be assigned upon request.
- Device Subclass. A 16-bit ID identifying a subclass within the device class. This ID is drawn from a registry of pre-defined subclass definitions. The device subclass indicates the transceiver type used on the device and also its intended usage, i.e. residential, industrial, commercial building etc. If an appropriate subclass designation is not available one will be assigned upon request.
- Model Number. An 8-bit ID identifying the specific product model. Model numbers are assigned by the product manufacturer and must be unique within the device class and subclass for the manufacturer. The model number within the program ID does not necessarily have to conform with the manufacturer's model number.

CHAPTER 6: GLOSSARY

The terms listed here represent some of the more common terms or phrases used when discussing LONWORKS technology and interoperability.

Certification - A written statement or symbol proving that a product or device meets a certain standard. The certification brand for LONWORKS products is the LONMARK symbol.

Echelon Corporation – the company, headquartered in Palo Alto, California, that invented and supports the LONWORKS platform.

Functional profile - LONMARK shorthand that enables equipment specifiers to select the functionality they need for a system. The profile is developed through a review and approval process, including a cross-functional review to ensure the profile will interoperate within an individual subsystem and also provide interoperability with other subsystems in the building.

Gateway - A host computer that connects networks that communicate in different languages. Gateways are more complex than routers because they handle the conceptual elements involved in allowing one application protocol to work with another. Gateways are not required when all the devices in the system use the same protocol.

IP - Acronym for Internet protocol, IP is part of TCP/IP (Transmission Control Protocol/Internet Protocol), the basic programming foundation that carries computer messages around the globe on the Internet.

Interoperability - The ability of systems from different manufacturers and of different types to share information with each other without losing any of their independent function capabilities.

LAN - The acronym for local area network. A LAN is a communications network that links a number of different workstations in the same area. The local area may be defined as the same building or campus of buildings. Using the LAN, individual workstations or computers can send messages and files to each other and to shared devices, such as printers, disk storage and other computer systems. LAN performance is measured in the amount of data that can be transmitted and received, usually expressed as megabits transmitted per second, so its critical factor is speed.

LON - A Local Operating Network. The difference between a LON and a LANis that a LAN is designed to move data that can be long and complicated. A LON is designed to move very short event driven control messages that contain commands and status information to trigger actions. LON performance is measured by the number of transmitted commands and responses.

LONMARK-® A brand that indicates a product can be used in a multi-vendor interoperable system.

LonTalk- ® The open control networking protocol developed by Echelon Corporation.

LONWORKS.® Echelon's family of hardware and software products that allow customers to develop, build, install and maintain control networks. In total, Echelon offers more than 75 different products under the LONWORKS umbrella.

Neuron Chip- A microprocessor that is at the heart of LONWORKS products. Originally designed by Echelon, the Neuron Chip is sold in a competitive market by Cypress Semiconductor, Motorola and Toshiba.

Node - In a LONWORKS system, a node is a control location and is composed of a Neuron chip, a power supply and a communications transceiver.

Peer-to-peer communications- The ability of nodes to communicate directly with each other, so a central control system is not required. This form of communications is called "peer to peer."

Protocols - Rules that order how information is transmitted and presented. An "open protocol" is one in which the manufacturer has made the language "translation" available to anyone who wishes to use it.

Router - A device that routes information from one network or subnetwork to another. The router receives the message from the first network and sends it to the second network exactly as received. In normal operations, routers do not store any messages they pass to the other network.

SCPT – An acronym for Standard Configuration Parameter Type SCPTs are used to configure the application programs in devices.

SNVT - An acronym for Standard Network Variable Type. LONWORKS controllers use SNVTs to define data objects. Each SNVT is identified by a code number that the receiving controller can use to determine how to interpret the information presented.

Transceiver - A device that is both a transmitter and a receiver. The device can transmit and receive signals on a communication medium.

CHAPTER 7: FREQUENTLY ASKED QUESTIONS

What does the LonTalk communications protocol provide?

Protocols today are generally designed to follow the ISO standard "Open Systems Interconnection Reference Model," which encompasses a full set of protocol features, and classifies them according to seven functional categories (referred to as "layers"). Thus the "seven layer OSI model".
The LonTalk protocol implements all seven layers of the OSI model, and does so using a mixture of hardware and firmware on a silicon chip, thus precluding any possibility of accidental (or intentional!) modification. Features include media access, transaction acknowledgement, and peer-to-peer communication, and more advanced services such as sender authentication, priority transmissions, duplicate message detection, collision avoidance, automatic retries, mixed data rates, client-server support, foreign frame transmission, data type standardization and identification, unicast/multicast/broadcast addressing, mixed media support, and error detection & recovery. For an overview of the LonTalk design, and the benefits of fully functional protocols, refer to "LonTalk Protocol Rationale", available from Echelon Corporation.

How fast can the LonTalk protocol be run?

At one time the speed was limited to 10MHz. However, a new 20MHz implementation has been completed opening the way for the highest performance Neuron based LONWORKS networks ever.

Further, as the developers find more uses for the protocol, processing horsepower can become an issue. This issue is addressed by opening up the LonTalk protocol specification to allow any company to port it to the processor of their choice. This means that applications requiring 16 or 32 bit processing power, can now host the protocol in native mode.

Is the LonTalk protocol Reliable? What provisions for reliability are incorporated?

The LonTalk protocol offers two principal reliability techniques. Reliable delivery is assured by true end-to-end acknowledgements, made possible by a full OSI based protocol and the fact that it is encapsulated in silicon (most protocols can only guarantee that a packet was successfully transmitted, not that it was actually received by the application). Data integrity is guaranteed by the fact that *all* packet transmissions incorporate a full 16-bit error polynomial.

Additionally, transceivers for difficult media (i.e., low bandwidth, with high noise and attenuation) incorporate forward error correction, able to detect and correct single bit errors without retransmission.

Is network performance predictable?

An integral part of the protocol used in LONWORKS networks is its unique media access technique, termed “predictive p-persistent CSMA, with optional priority & collision detection.” It provides linear response to offered traffic load, predictable response time for heavily loaded networks, and consistent performance independent of network size.

What is a Neuron Chip and why use it?

The Neuron is actually 3 8-bit inline processors in one. Two are optimized for executing the protocol, leaving the third for the node's application. It is therefore both a network communications processor and an application processor. Up until a few years ago, all devices on a LONWORKS network required a Neuron Chip.

Having two processors dedicated to network tasks and one dedicated to application tasks ensures that the complexity of the application does not negatively impact network responsiveness and vice versa. Additionally, packaging both functions onto one chip save design and production costs.

•Use of the Neuron Chip guarantees a controlled hardware execution environment for the protocol. To ensure sufficient processing power, the protocol is implemented with a mixture of hardware and firmware.

•The Neuron Chip also allows the inclusion of additional functionality to facilitate control node design. The Neuron chip incorporates watchdog timers, on-board diagnostics, 35 device controller types, a distributed real-time operating system, run-time libraries, three types of memory, and even a 48-bit software-accessible serial number (which, guaranteed by the chip's manufacturers to be unique, provides an always-available installation address for any Neuron chip-based node).

•Designed for a broad range of industries and applications, and manufactured in volume by multiple semiconductor manufacturers, the Neuron chip offers a lower-cost instantiation of the LonTalk protocol than could be achieved in custom implementations.

The net result is that the Neuron Chip is the best and most economical LONWORKS processor for anyone not requiring extreme processing power.

Can LONWORKS guarantee an end to end communication between devices across subsystems?

End to end acknowledgement is vital for an application either to know that a message got to its destination or that it did not get there within the real time requirements of the system. Each LONWORKS network variable can be configured to one of 3 types of message service.

Acknowledged service assures that the sending node (Ack) will get a confirmation (Ack'd) that the receiving node registered a message. If the confirmation is not received back within a specified time period the node will retry to send the message. If after a number of retries the confirmation has still not been received a transaction timeout error message will be logged to the sending node. This service type allows for the greatest network stability at the most efficient bandwidth utilization.

Is a LONWORKS network deterministic?

In normal operation LonTalk CSMA protocol based networks are non-deterministic because nodes are not provided equal access to the network at specified minimum time delays. . However by using priority mode it can be deterministic, in the sense of an upper bound on transmission time, for some nodes and some network variables. The CSMA protocol is a listen- before-transmit scheme in which a node with a message to transmit first listens to the network. If no message traffic is detected, then the node will transmit. Nodes send messages on the basis of their ability to resolve packet collisions and sometimes on the basis of priority messaging. The benefits of the CSMA protocol over deterministic token passing protocols become apparent during high traffic and network overload conditions. Echelon's LonTalk media access protocol uses a predictive p-persistent CSMA protocol, which dynamically adjusts the number of packet time slots, based on predicted network traffic. By dynamically allocating network bandwidth, the predictive p-persistent CSMA protocol permits the network to continue operating in the presence of very high levels of network traffic without slowing the network during periods of light traffic. The benefits of this technology are its high efficiency, low overhead, low cost hardware, elimination of the need for network wide synchronization, and lack of loss prone tokens.

What provides the deterministic guarantee and behavior of the network?

By definition there is no deterministic guarantee of network behavior. However, the LonTalk predictive p-persistent CSMA protocol embedded within Neuron Chips have proven robustness and reliability in over 6 million field applications since 1992. The predictive p-persistent CSMA protocol also overcomes the issue of unsuccessful media access by employing transceiver designs that limit the number of stations on a single network segment. In addition, each node is limited to a single outgoing transaction at a time; transmitters stop and wait for an acknowledgment prior to accessing the communications medium again. These two implementation details overcome a key limitation of other CSMA protocols by making it impossible for a working station to be denied access to the communications medium indefinitely.

What are the LONWORKS network size and messaging limitations?

A LonTalk network domain is a logical collection of nodes on one or more channels and is limited to a total of 32,385 nodes. Although the LonTalk protocol does not support communications between domains, application programs may be implemented to forward message packets between two domains. A LonTalk subnet is a logical collection of up to 127 nodes installed on a single segment within a domain (a segment is either a single channel or multiple channels connected by physical repeaters) .Up to 255 subnets can be defined within a single domain.

Network domains are used to logically transmission media that must be shared by potentially multiple control network applications. Power line and RF media are the most notable examples.

A group is a logical collection of nodes within a domain. However unlike subnets, a group is a collection of nodes that are grouped together without regard for their physical channel location. The Neuron Chip allows a node to be configured as a member of up to 15 groups. There is a limit of 256 groups per domain. Maximum group size is 64 nodes when acknowledged messaging is used, unlimited size for un-acknowledged messaging. Groups are an efficient way to optimize network bandwidth for one-to-many network variable and message tag connections.

Network data transmission speed and maximum number of nodes per channel is a function of channel type; the speed is1.25 mb/sec for theTP/XF-1250 channel and 78kb/sec for the TP/FT-10 or TP/XF-channels. Each can support up to 64 devices.

See “LonTalk Protocol” (Engineering Bulletin 005-0017-01C) and “LONMARK Layers 1-6 Interoperability Guidelines” (078-0014-01E) for more details.

What is interoperability and what are its benefits?

Interoperable is the ability to integrate products from multiple vendors into flexible, functional systems without the need to develop custom hardware, software, or tools.

Four Benefits of Interoperability

- Interoperable products allow project engineers to specify best of breed systems rather than be forced into using one vendor's entire line of products.
- Interoperable products increase the overall market for your products by allowing you to compete for what would otherwise be closed bids.
- Interoperability decreases product costs among your business' division by allowing your engineering teams to build to a standard specification.
- Interoperable systems allow building and plant managers to monitor facility wide using standard tools, regardless of which company made a particular subsystem.

How is product interoperability assured?

For many users of control networks, this is the single most important question. Interoperable products can expand your business, increase your profit margins, save your customers money, and offer you increased vendor choices when specifying systems. In short, it's good for everyone from developers, to integrators to end-users. Integration without frustration - the ability to integrate products from multiple sources without the need for custom development - can be the driving force that leads to the search for a control network technology.

LONWORKS networks approach interoperability in three ways.

First, up until 1996, Echelon made the protocol available on the Neuron Chip only. Since most every LONWORKS node available today has a Neuron in it, they share a baseline level of interoperability. it encapsulates as much as possible into standard silicon, to reduce the potential for diverging interpretations. This serves two purposes. One, it provides to every LONWORKS application utilizing Neurons a fundamental commonality at the silicon level. Two, it provides over 7 million (and counting) devices installed world-wide, and each can be thought of a an interoperability reference for any ported processor (non-Neuron processors running the LonTalk protocol). Echelon ensures, via license, that any port of the protocol must interoperate with the Neuron chip.

Second, it incorporates standard types & objects (so products can agree on the meaning of shared data), and an intrinsic control model (because extrinsic control limits interoperability) into the programming model.

Third, the LONMARK Interoperability Association, has been established to help create the guidelines for interoperability and to certify products that conform to the interoperability guidelines.

The association establishes technical guidelines and promotes the LONMARK brand worldwide.

What guidelines are followed to achieve LONMARK certification?

All LONMARK-certified devices go through the same certification process. You can get the details from the LONMARK website ***www.LONMARK.org***. If you have questions about specific devices, or find that specific devices do not comply with the guidelines, notify the LONMARK Association via the contact link on the web site.

Where can I get information regarding LONMARK product compliance guidelines?

The LONMARK website, wwwLONMARK.org, has all applicable documents available for downloading. In general, an integrator will have little need for the information concerning the Layer 1-6 information. It is the Layer 7, application layer information that is most relevant to the network integrator.

CHAPTER 8: REFERENCES

The documents listed below are available from at www.echelon.com or www.LONMARK.org.

1. LonTalk Protocol (Echelon Engineering Bulletin 005-0017-01, 27 pages)
2. LONWORKS Network Services (LNS) Architecture Strategic Overview
3. LONMARK Layer 1-6 Interoperability Guidelines (078-0014-01)
4. LONMARK Application Layer Interoperability Guidelines (078-0120-01)
5. The SCPT Master List (005-0028-01)
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8. LonPoint® Application and Plug-in Guide (078-0168-01)
9. LonPoint System Data Sheets
10. PCLTA-10 PC LonTalk Adapter User's Guide (078-0159-01)
11. PCC-10 PC Card User's Guide (078-0155-01)
12. SLTA-10 Adapter User's Guide (078-0160-01)
13. LonManager® Protocol Analyzer User's Guide (078-0121-01)