

LONWORKS IN BRIEF

This section contains three overview documents:

LONWORKS Technology Overview

LONMARK Interoperability Overview

LonPoint System Overview

These documents are intended to present a comprehensive introduction to the key terms and concepts necessary to understanding LonWorks technology, LonMark interoperability, and the LonPoint product family; as well as to provide a roadmap to detailed technical references.

The documents are intended to be read in order, and each builds on the previous one. In each document, key terms and concepts are highlighted in bold type, and references to in-depth technical publications are included. All of the referenced technical documents are available on the NI Channel CD and on the Authorized Network Integrator website, ni.echelon.com, and some are included in the Technical Reference Publications tab of this binder.

LONWORKS TECHNOLOGY OVERVIEW

This section presents an overview of the LONWORKS technology platform. Key terms and concepts are marked in bold type, and references to in-depth technical publications are included.

Introduction

Every automatic control system, whatever the industry or application, is comprised of the same basic components: **sensors**, such as thermocouples, switches, and keyboards; **actuators**, such as motors, relays, switches, displays, and valves; **application programs** executing the control logic, running on microprocessors; **communication networks** for getting data values and commands where they are needed; **human-machine interfaces (HMI)** for monitoring and supervisory control; and **network management tools** for installation, configuration, and maintenance. The difference in automatic control systems comes in the way in which product manufacturers and system integrators design and use these components. It is this unique and effective combination which makes all the difference in whether the final control system meets the requirements of the customer for functionality, cost, and maintainability.

Technology advancement is driving rapid changes in all types of system architectures, including control systems. In the last 20 years, centralized mainframe computers connected to dumb terminals were displaced by the distributed processing capabilities of mini-computers connected by local area networks, and those in turn were replaced by distributed peer-to-peer networks of powerful personal computers. The key to the huge success of each new wave of information systems products is the widespread acceptance of industry standards for microprocessors, communication protocols, operating systems, and other hardware and software building blocks. These standards allow many manufacturers to produce high volume hardware and software products that are **interoperable** they can be combined into information systems fitting any application without development of custom hardware, software, or tools. The **LONWORKS technology**, developed by Echelon and available as an open standard to all manufacturers, is the platform that is driving the same sweeping changes in control system architectures, displacing proprietary centralized systems with open, highly distributed, interoperable systems.

Figure 1 shows the centralized architecture that up until recently has been typical of most control systems in commercial and industrial applications. There are tens to thousands of sensors and actuators, also called **I/O points**, which are each wired to a sub-panel, which in turn connects to the controller panel via a proprietary master/slave communication bus. The controller panel contains a high-performance microprocessor running a custom application program that implements the control logic for all the I/O points connected to it. For large systems, this controller may communicate over another proprietary communication bus with other controllers. Sensors and actuators are either **legacy I/O devices**, meaning they have no communication capabilities (for example switch closure for discrete input devices or 4-20ma current for analog devices), or they may have proprietary communication interfaces to the master/slave bus. The system may have a proprietary HMI or may publish an interface to allow standard HMI tools to connect to the system. Every system must have a custom application program, which is developed using a proprietary programming language and non-standard software tools. Note the similarity of Figure 1 to a typical mainframe or minicomputer system of 10-20 years ago.

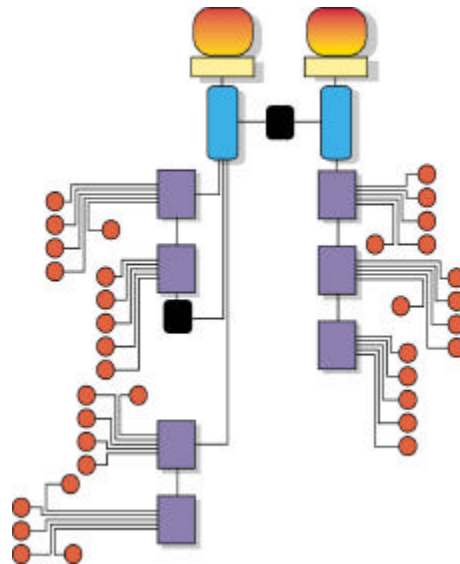


Figure 1. Centralized control architecture

Figure 2 shows the highly distributed, peer-to-peer architecture made possible by LONWORKS technology. There are no centralized controllers or home-run wiring panels. **LONWORKS devices**, (also called **nodes**), communicate with any other nodes in the system using a standard communications protocol on whatever physical medium is best (twisted pair, AC power line, radio frequency, fiberoptic cable, infrared). Each node has its own simple application program so that the control logic is distributed throughout the system; the node application is customized by setting configuration parameters rather than by custom programming. In principle, every sensor or actuator in the system can be a LONWORKS node; in practice, it is often more cost effective to group small clusters of I/O points, which are physically close and part of a single control loop, into a single node. HMI and network management tools are available from multiple vendors and can have access to all points in the system through the common communication protocol.

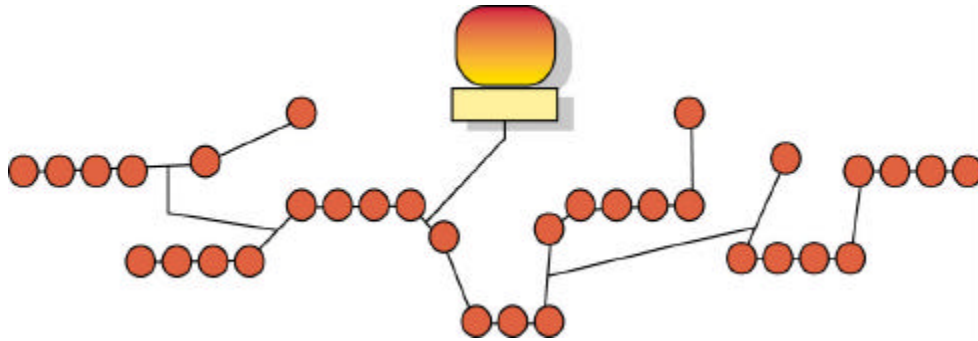


Fig. 2 LONWORKS distributed control architecture

The LONWORKS technology makes possible **information-based control systems**, rather than old-style **command-based control systems**. This means that in a LONWORKS system, each node application program makes its own control decisions, based on information it collects from other devices about what is going on in the system. In a command-based system, nodes issue control commands to other nodes, so a command-issuing node - typically a centralized controller - must be custom programmed to know a lot about the system function and topology. This makes it very difficult for multiple vendors to design standard control nodes that can easily be integrated. A major innovation of the LONWORKS technology is the concept of **network variables**, which makes it easy for manufacturers to design devices that systems integrators can readily incorporate into interoperable, information-based control systems.

The benefits to an end-user or system integrator of the LONWORKS enabled flat control architecture are:

- A wide variety of compatible, cost-effective LONWORKS devices available from multiple vendors,
- A variety of easy-to-use HMI and network-management tools from multiple vendors,
- Greatly reduced wiring costs,
- Short system design cycle - no custom hardware or programming,
- Greater system reliability - no single point of failure,
- Multi-vendor system maintenance options, and
- Ease of implementing new functions to meet end-user needs.

The sections that follow provide a technical overview of the key elements of the LONWORKS technology and the components that comprise a LONWORKS system; a description of the main features of the LonTalk communications protocol; and a discussion of the system configuration process.

The LonWorks Technology

The LONWORKS technology is comprised of these major elements:

- Neuron Chip control processors and transceivers - the hardware components used in LONWORKS devices;

- the LonTalk communication protocol - permanently embedded in each LONWORKS device; and
- LONWORKS Network Services (LNS) - the basis for easy-to-use, interoperable network management and HMI tools.

In addition, Echelon and other manufacturers provide a comprehensive set of design and development tools for LONWORKS devices and networks.

The physical core of every LONWORKS device is a **Neuron Chip** control processor – 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. The Neuron Chips are jointly designed by Echelon and its semiconductor partners Motorola and Toshiba, then manufactured in volume and marketed by the semiconductor partners. Over 5 million Neuron Chips had been shipped as of early 1998, with prices less than \$3 for some versions.

A **transceiver** is an electronic module that provides the physical interface between the communications port of the Neuron Chip and a physical medium, called a **channel**, which transports the digital communication packets to other devices. All devices connected to a specific channel must have compatible transceivers running at the same bit rate. Transceivers are available from Echelon and other manufacturers for a variety of media, including single twisted pair, power line, RF, infrared, fiber optics, and coax. Bit rates depend on the media and transceiver design; up to 1.25Mbps can be achieved on a single twisted pair. LONWORKS systems may have multiple channels of the same or different types of media; channels are connected by LONWORKS **routers**. The **LONMARK Interoperability Association** publishes design standards and certification services for a wide variety of transceivers, see reference [1]. LONMARK certified devices all use approved transceivers, guaranteeing interoperability over the physical medium.

The **LonTalk communications protocol** is a layered, packet-based, serial peer-to-peer communications protocol. Like the related Ethernet and Internet protocols, it is open and adheres to the layered architectural requirements of the International Standards Organization (ISO); but the LonTalk protocol is designed for the specific requirements of control systems, rather than data processing systems. Unlike many other communication protocols, LonTalk is designed to be media-independent, allowing LONWORKS systems to communicate over any physical transport media. The program implementation of the protocol, called **LonTalk firmware**, is contained in ROM in every Neuron Chip; the protocol provides for a number of modifiable configuration parameters to make tradeoffs in performance, security, and reliability for a particular application; a portion of non-volatile RAM in the Neuron Chip is reserved for these parameters.

LONWORKS Network Services (LNS) is a client-server architecture that provides the foundation for interoperable LONWORKS network tools. It enables component-based software design of a new generation of tools that can work together to install, maintain, monitor, and control LONWORKS networks. It also makes it easy to integrate control systems with other information systems. The architecture supports clients based on any platform; servers are currently based on Windows 95, Windows NT, and the Neuron Chip. See reference [2] for an overview.

Several companies supply tools for developing, testing, and programming LONWORKS devices. Echelon's offerings include the NodeBuilder and LonBuilder products. In addition, several 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.

LONWORKS System Components

A LONWORKS system consists of three types of components: LONWORKS devices, channels, and network tools.

Each LONWORKS device, or node, attached to the network contains at least a Neuron Chip and a transceiver in an appropriate mechanical package, usually with a suitable power supply. Depending on what the function of the device is, there may also be embedded sensors and actuators, input-output interfaces to external legacy sensors and actuators, or interfaces to host processors such as PCs. 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).

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 - such as the Motorola 68000 series - to execute the application program, while using the Neuron Chip, with a special microprocessor interface 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 Neuron ID.

A channel is a specific physical communication medium to which a group of 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-20	Power line	5 Kbps	No limit	Determined by attenuation

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 - no constraints on stub length, device separation, branching, etc; just a maximum distance between any pair of nodes. For complete information on LONMARK approved channels and transceivers, see reference [1].

Network tools are software programs for network installation, configuration, monitoring, supervisory control, and maintenance. They may reside in a Neuron Chip or any other platform, such as hand-held computers or PCs.

Figure 3 shows the components of a LONWORKS system and illustrates the anatomy of several categories of LONWORKS devices with specific product examples. In the figure, Neuron Chips and transceivers are labeled 'N' and 'T' respectively.

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** 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. Shown in figure 3 are several examples of control devices:

- Echelon LonPoint AI-10 Module has two A/D converters allowing up to two analog input legacy devices (4-20 ma or 0-10 volt interface) to be connected to the network.
- Hubbell H-Moss Multiple Sensor Module is a wall-mounted unit that contains three embedded sensors monitoring temperature (T), occupancy (O), and humidity (H).
- Honeywell XL-10 VAV Controller contains an embedded damper actuator motor (M) and differential air-pressure sensor (P). It obtains room temperature and setpoint values over the network and implements PID single loop control to maintain room comfort.
- Echelon LonPoint SCH-10 Scheduler module has an embedded real-time clock (C) and highly configurable state machine logic for implementing scheduling and event-driven mode control for all or a portion of a LONWORKS system.

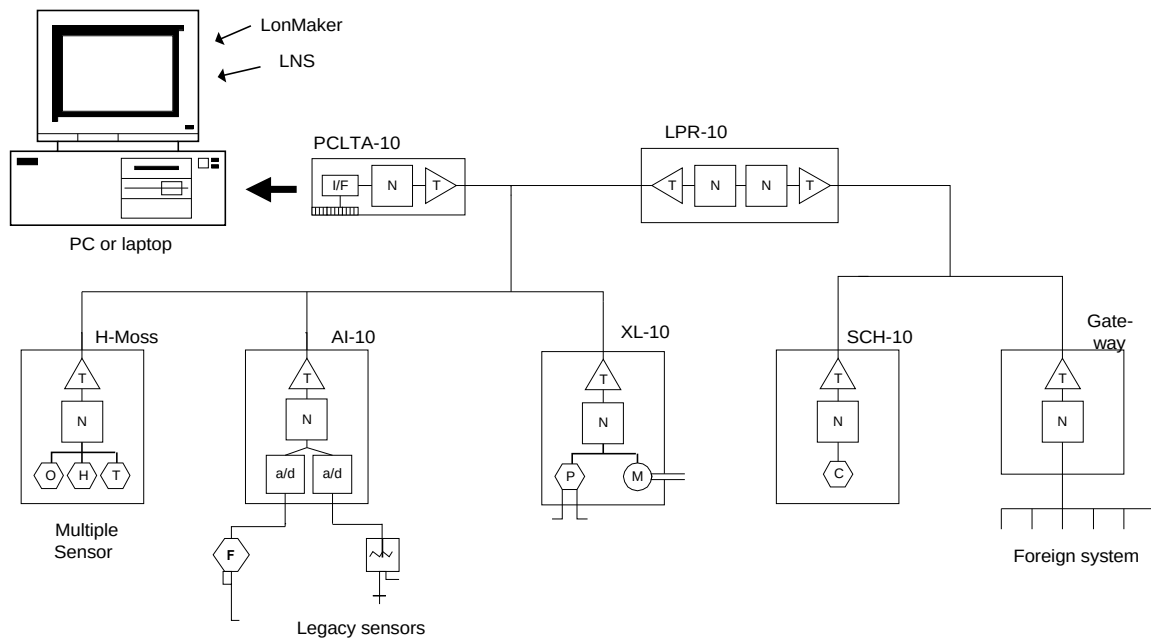


Figure 3. Anatomy of some LONWORKS devices

Router devices, such as the Echelon LPR-10, allow a single peer-to-peer network to span many types of transport media and support thousands of devices. A router 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.

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; translates between the two protocols as required; and converts the proprietary command-based messages of the foreign system to SNVTs used by the information-based LONWORKS applications.

The LonTalk Protocol Basic Features

The LonTalk communication protocol, contained in every LONWORKS device, is the heart of the technology platform. 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 other device names, addresses, or functions. It can optionally provide end-to-end acknowledgement of messages, encrypted authentication of messages, and priority delivery to guarantee bounded response times. Network management services allow for remote network management tools to interact with the device over the network, including reconfiguration of network addresses and parameters, downloading of application programs, reporting of network problems, and start/stop/reset of node application programs.

An overview of the features of the LonTalk protocol is provided below. A more comprehensive summary of the protocol is given in reference [3], and a very detailed bits-and-bytes level discussion is given in reference [4].

LonTalk is an open-standard, serial, packet protocol specifically designed for control networks. Devices on a channel take turns transmitting packets. Each packet is a variable number of bytes in length and contains the application-level 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. A network management packet is processed appropriately with no involvement required from the application program.

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

Logical addresses are defined at the time of network configuration. A **domain** is a collection of nodes, usually the whole system, which interoperate. All logical addresses have two parts: the first part is the **domain ID**, designating the domain; the second part 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 a **destination address** that can either be the physical Neuron ID address, the logical node address, a group address, or a broadcast address.

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 Neuron 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 LONWORKS system comprised of a single domain can have up to 32,385 devices. There can be up to 256 groups in a system 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.

The LonTalk protocol implements the innovative concept of network variables (**NVs**), which greatly simplifies 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, such as a temperature, a switch value (on/off), an actuator position setting, which 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 doesn't need to know anything about where input NVs come from or where output NVs go or what they cause to happen. 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 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*. For example, 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 connection by binding these two NVs has the same functional effect as connecting a physical wire from the switch to the light bulb.

In order for applications to correctly interoperate using NVs, data within a system must be interpreted in the same way, e.g. all temperature values must be in either Centigrade or Fahrenheit. To facilitate this, over a hundred common system variables, called Standard Network Variable Types (SNVTs), have been defined and published. See reference [5] for a current list and details of all SNVTs.

The Network Design and Configuration Process

A system integrator performs four major steps to implement a control system for a specific customer: system design, network configuration, application configuration, and installation. Each of these steps is made highly efficient by powerful tools such as LonMaker for Windows.

System design primarily consists of two steps: first, selection of LONWORKS devices that incorporate the necessary I/O points - or can interface to legacy I/O points - and that have application programs suitable for implementing the necessary control functions such as PID loops, scheduling, etc; second, determination of the appropriate types and numbers of channels and then selection of routers to connect them.

Network configuration consists of:

- Assigning domain ID and logical addresses to all devices and groups of devices
- Binding the network variables to create logical connections between devices
- Configuring the various LonTalk protocol parameters in each node for the desired features and performance, including channel bit rate, acknowledgement, authentication, priority service, etc.

Network configuration may be quite complex, but the complexity is hidden by the powerful tools that are part of the LONWORKS technology platform. For example, using Echelon's LonMaker for Windows, the physical design of a network is as simple as dragging and dropping device icons onto a drawing and selecting the channel to which they attach. Functional network design is as simple as dragging the devices' application function blocks onto the drawing and connecting inputs and outputs to determine which function blocks use what network variables.

Network configuration can be either an ad hoc process or a pre-engineered process: in the **ad hoc** method, the nodes are already connected to the network and powered-up, and the configuration data is downloaded over the network as it is defined. In the **pre-engineered** method, the information is collected into a database by the network configuration tool and is downloaded to the nodes at installation time. In either method, the configuration tool automatically maintains a database that accurately reflects the configuration of each node in the system.

Application configuration is the process by which the application program in each node is tailored to the desired functionality by selecting the appropriate configuration parameters. Each device manufacturer defines how this is accomplished. Most manufacturers provide for downloading the parameters over the network, but a few still require the attachment of a special tool, such as a handheld programmer, directly to the device. LONWORKS Network Services (LNS) provides a platform for manufacturers to create easy-to-use graphical configuration interfaces, called **plug-ins**, that are then automatically compatible with any other LNS-based network tool. For example, the applications in the Echelon LonPoint Modules all have LNS-based plug-ins for configuration. After defining and performing network configuration of one of these devices using LonMaker for Windows, the user can simply right-click on the device icon, select Configure from a pop-up menu, and the application plug-in is immediately launched from within LonMaker.

Installation of a LONWORKS system consists of: installing the physical communication media for the channels; attaching the LONWORKS devices, including routers, to the channels; attaching legacy I/O points to the devices; and using a network installation tool such as LonMaker to download the network configuration data and application configuration data to each device (**commissioning a device**). For devices whose application programs are not contained in ROM, the network tool downloads the application program into non-volatile RAM memory in the device. Devices are usually either commissioned and tested one at a time or commissioned in off-line mode, then brought on-line and tested one at a time.

Reference Documents

The documents listed below are available from the Echelon website, www.echelon.com, or the Authorized Network Integrator website, ni.echelon.com. They may also be ordered from Echelon.

1. LONMARK Layer 1-6 Interoperability Guidelines (078-0014-01)
2. LONWORKS Network Services (LNS) Architecture Strategic Overview
3. LonTalk Protocol (Echelon Engineering Bulletin 005-0017-01, 27 pages)
4. LonTalk Protocol Specification (Echelon Manual 078-0125, 114 pages).
5. The SNVT Master List and Programmer s Guide (005-0027-01)

LONMARK INTEROPERABILITY OVERVIEW

This Section presents an overview of the LONMARK Interoperability Association and summarizes its standards for interoperability of LONWORKS devices. It is assumed that the reader is familiar with the basics of the LONWORKS technology (see reference [1] for an overview). Key terms and concepts are marked in bold type, and references to in-depth technical publications are included.

Introduction

The 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, the LONWORKS technology is widely used in proprietary systems such as vehicle control systems, conveyor systems, and telephone central office monitoring systems.

Because there are vast opportunities in many industries for truly interoperable systems, the LONMARK Interoperability Association was formed in 1994 by Echelon and a group of LONWORKS users dedicated to building truly interoperable systems products. **Interoperability** means that multiple devices (also called nodes), from the same or different manufacturers, can be integrated into a single control network without requiring custom node or network tool development. The LONMARK Association is dedicated to developing standards for interoperability, certifying products to those standards, and promoting the benefits of interoperable systems. Only LONWORKS devices that have been certified by the LONMARK Association – called **LONMARK devices** – can carry the distinctive 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.

In its standard-setting activities, the LONMARK Association focuses in two areas:

- specification of standard transceivers and the associated physical channels, and
- definition of standards for structuring and documenting node application programs.

Transceiver and Physical Channel Standards

The LONMARK standards 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.

The channel types which are used most often by system integrators are the TP/XF-1250 (twisted pair bus at 1.25 Mbps), the TP/FT-10 (twisted pair free topology at 78 kbps), and the PL-20 (power line at 5 Kbps). The characteristics and limitations of these channels are summarized below.

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, free topology	78 Kbps	64 (up to 128 if link-powered)	500m (node to node)
PL-20	Power line	5 Kbps	--	--

Application Program Standards

The LONMARK standards for interoperable device application programs are contained in *LONMARK Application Layer Interoperability Guidelines*, reference [3]. 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.

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 (SNVTs), 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.

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. Complete documentation on all LONMARK objects can be found on the LONMARK Association website.

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', reference [4]. 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.

LONMARK guidelines specify exact documentation rules so that proprietary configuration tools are not required when using LONMARK devices. All LONMARK devices must be **self-documenting**, thus assuring that any network management tool, such as Echelon's LonMaker for Windows, 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 maintains a database of the external reference files for all LONMARK devices.

Reference Documents

The documents listed below are available from the LONMARK website, www.lonmark.org, or the Authorized Network Integrator website, www.ni.echelon.com. They may also be ordered from Echelon or the LONMARK Association.

1. LONWORKS Technology Overview
2. LONMARK Layer 1-6 Interoperability Guidelines (078-0014-01)
3. LONMARK Application Layer Interoperability Guidelines (078-0120-01)
4. The SCPT Master List (005-0028-01)
5. The SNVT Master List and Programmer's Guide (005-0027-01)

LONPOINT SYSTEM OVERVIEW

This section presents an overview of the Echelon LonPoint System and related products. It is assumed that the reader is familiar with the basics of the LONWORKS technology and LONMARK interoperability standards (see references [1] and [2] for overviews). Key terms and concepts are marked in bold type, and references to in-depth technical publications are included.

Introduction

The Echelon LonPoint System is a family of products designed to enable system integrators to realize the benefits of the LONWORKS technology in highly distributed, peer-to-peer control networks for building and industrial applications. The family consists of:

- **LonPoint control devices and routers** LONMARK-certified devices with application programs providing many distributed control functions such as scheduling, signal conditioning, and PID loop algorithms, as well as standard I/O interfaces that permit easy incorporation of non-LONWORKS sensors and actuators into any system, and the
- **LonMaker for Windows Integration Tool** a powerful network tool based on the Visio graphical user interface used to design, commission, and maintain distributed control networks comprised of both LONMARK and other LONWORKS devices.

Figure 1 shows the components of a distributed control system using the LonPoint System and other LONMARK devices in a distributed, peer-to-peer control network.

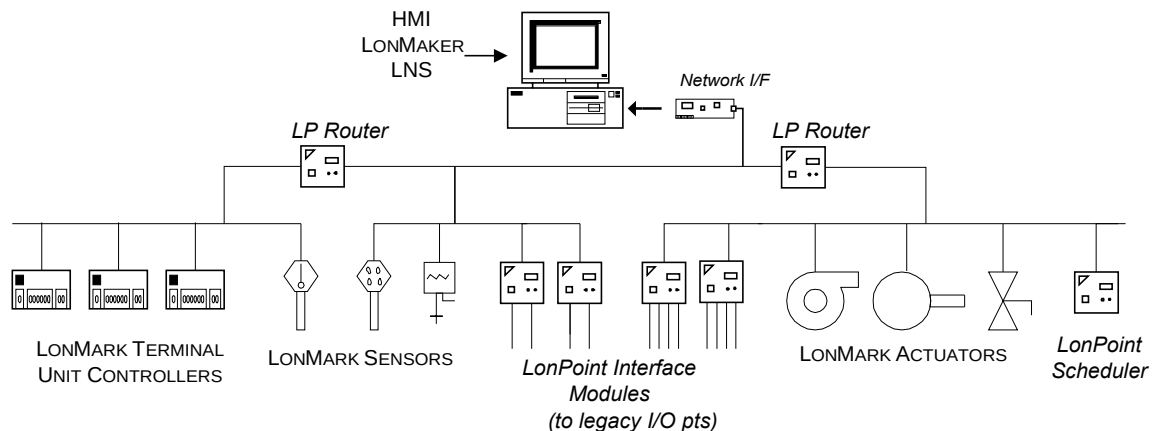


Figure 1. System components

In addition to the LonPoint devices and LONMAKER Integration Tool, systems will usually include LONMARK sensors and actuators, LONMARK terminal unit controllers (packaged controllers - such as VAV and rooftop units - which incorporate several sensors and actuators with single-loop control algorithms into a single node), human-machine interface (HMI) software tools, and network interface devices that connect PCs or laptops to the network.

The sections that follow provide descriptions of the LonPoint control devices, LonPoint routers, LonMaker tool, and Echelon network interface devices.

LonPoint Control Devices

LonPoint control devices are LONMARK-certified devices that provide all the control functions that usually reside in centralized controllers in old-fashioned, hierarchical control architectures, and in addition allow **legacy I/O devices** (non LONWORKS sensor and actuators) to be attached physically and functionally into LONWORKS systems. LonPoint control devices contain TP/FT-10 transceivers for attaching to free-topology twisted-pair physical media. The application program in each device consists of a set of **function blocks (FBs)**, which are LONMARK objects (see reference [2] for more information) that perform basic control functions. These function blocks, together with the LONMARK objects contained in the other LONMARK devices attached to the system, form a pool of objects that are configured and connected, using the LonMaker tool, to implement the desired system functionality.

The four LonPoint devices that provide attachment for legacy I/O are:

- **AI-10 Analog Input Interface Module** provides two 16-bit analog inputs to attach to sensor devices with 0-24ma, 0-10v, and 100-15kohm interfaces. The application program has an analog sensor FB corresponding to each input, as well as several other FBs, as shown in Table 1.
- **AO-10 Analog Output Interface Module** provides two 12-bit analog outputs to attach to actuator devices requiring 0-20ma or 0-10v interfaces. The application program has an analog actuator FB corresponding to each output, as well as several other FBs, as shown in Table 1, including two PID loop controller objects.
- **DI-10 Digital Input Interface Module** provides four digital inputs to attach to sensor devices with dry contacts or 0-32vdc interfaces. The application program has a digital sensor FB corresponding to each input, as well as several other FBs, as shown in Table 1.
- **DO-10 Digital Output Interface Module** provides four digital outputs to attach to actuator devices requiring dry contacts or 0-32vdc interfaces. The application program has a digital actuator FB corresponding to each output, as well as several other FBs, as shown in Table 1.

The **SCH-10 Scheduler Module** provides a real-time clock, calendar, and system scheduler for coordinating system functions. An integral battery-backed real-time clock chip/calendar chip provides input to the Real Time Clock functional block. Two other powerful function blocks provide time-based or input-based control functions for a system or a subsystem. Time-based control is specified via the Event Scheduler function block. System schedules may be defined based on the time of day, day of the year, of specific month and day. The Mode Generator functional block allows the design of sophisticated control algorithms that use both time-based events and the current or historical values of selected analog and digital points in the network. For example, in an HVAC system, the scheduler module can define a set of operating modes for the system - such as morning warm-up, normal operation, night purge, emergency override - based on both time of day and the status of variables in the system. Multiple scheduler modules can be chained together for redundancy or for more complex scheduling applications.

Functional Block	DI-10	DO-10	AI-10	AO-10	SCH-10
Digital Sensor	4				
Digital Actuator		4			
Analog Sensor			2		
Analog Actuator				2	
Analog Function Block	4	2	4	2	
Digital Encoder	2	2	2	2	
PID Controller				2	
Translator	6	4	4	2	
Real time Clock					1
Event Generator					1
Mode Generator					1

Table 1. Allocation of function blocks

There are multiple copies of several types of highly flexible function blocks built into each of the LonPoint interface modules, as shown in Table 1:

- **Analog Function Block** performs mathematical, logical, or enthalpy calculations using up to two analog network variables and one discrete network variable. The calculated output network variable may be analog or digital (true/false).
- **Digital Encoder Function Block** performs any Boolean logic function on up to four digital network variables to create a digital (true/false) output network variable as well as a mode output variable.
- **PID Controller Function Block** implements a standard proportional-differential-integral (PID) dynamic control loop using two analog input network variables (setpoint and process variables) and generating an analog output variable (control variable).
- **Type Translator Function Block** - converts data, with scaling and mapping, from one SNVT (Standard Network Variable Type) to another. Useful for connections to other LonWorks devices that use different SNVT types.

Every type of function block in the LonPoint devices is highly flexible and can be configured for adaptation to many applications. Each type of function block (except those in the scheduler module) has an LNS-compatible plug-in, which is an easy-to-use, graphical configuration program launched directly from LonMaker. Figure 2 shows the user interface for the Digital Sensor plug-in. Configuration options such as debounce time, inversion, pulse width, delay, and override values are easily set. (LonMaker allows configured FBs to be saved as a special object that can be used over and over, eliminating the need to separately configure each instance). The scheduler module has a separate LNS-compatible, graphical application program that also contains a simulator, allowing the system designer to test the scheduling algorithms in accelerated time to verify correct operation.

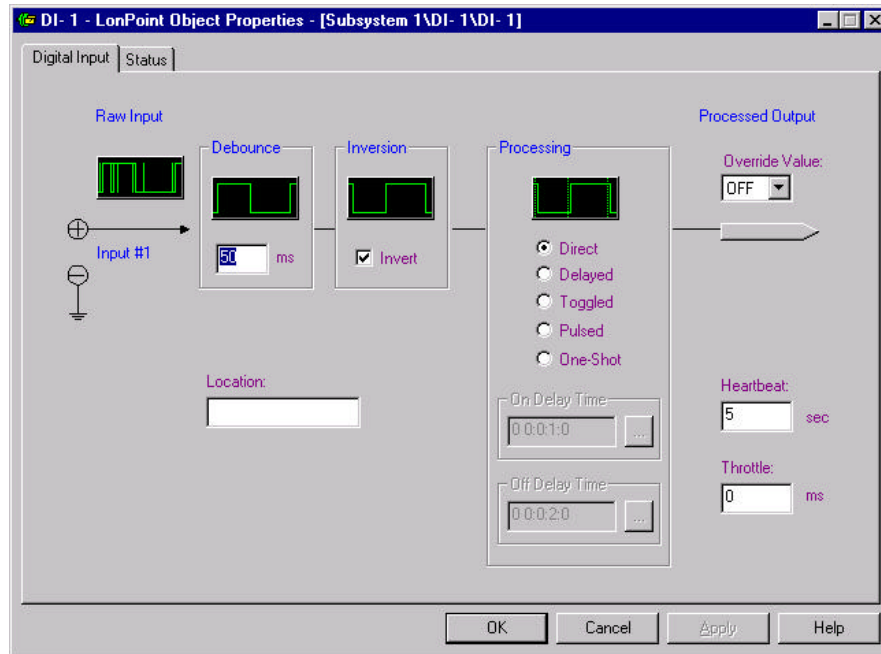


Figure 2. Digital Sensor Configuration Interface

The physical packaging of the LonPoint control devices incorporates a number of innovations for easy, low-cost installation and maintainability. A unique, two-piece design allows pre-wiring and cable testing by an electrician prior to installation of the electronics; technician time can be reserved for tasks such as node configuration. The modules mount to a **Base Plate** (Type 1), (see Figure 3) which is in turn mounted to a 4x4 electrical box or Echelon's EuroBox, for wall or DIN rail mounting. Power and network wiring are looped through the base plate, providing the ability to replace modules by hot-plugging without disrupting network operation. Modules operate on any supply voltage from 16 to 30 volts, AC or DC. Color-coded screw terminals and polarity-insensitive power and network connections minimize the chance of miswiring, and the free-topology transceiver design allows wiring to be run via the most convenient route. A front panel jack accesses the twisted-pair network without any disassembly, saving time when the network must be accessed for configuration or maintenance.

A front panel bar-code label with the model, revision, and two removable stickers, containing the unique 48-bit Neuron ID, is provided. When placed on the building or system design plans, these Neuron ID stickers can save installation time, especially for inaccessible nodes.



LonPoint Routers

The LonPoint router devices, called **LPR Modules**, can interface two different twisted-pair channels, for example a TP/FT-10 free-topology channel, running at 78kbps bit rate, to a TP/FX-1250 backbone channel running at 1.25Mbps bit rate. There are six models, which differ only by channel pair types, as shown below:

Name	Model	Channel Types
LPR-10	42100	TP/FT-10 to TP/ FT-10
LPR-11	42101	TP/FT-10 to TP/XF-78
LPR-12	42102	TP/FT-10 to TP/XF-1250
LPR-13	42103	TP/XF-78 to TP/XF-78
LPR-14	42104	TP/XF-78 to TP/XF-1250
LPR-15	42105	TP/XF-1250 to TP/XF-1250

Like the LonPoint control modules, LPR modules are configured with a graphical LNS plug-in launched from LonMaker and have the same physical packaging, with two exceptions: a different base plate (Type 2 Base Plate) is used, which accommodates two channel connections; and the front plate has two front panel jacks so either channel can be accessed.

LonMaker for Windows Integration Tool

The LonMaker for Windows Integration Tool is a software package for designing, installing, and maintaining multi-vendor, open, interoperable LONWORKS control networks. Based on the LONWORKS Network Services (LNS) network operating system, the LonMaker tool combines a powerful client-server architecture with a Visio user interface. The result is a tool that is

sophisticated enough to design, commission, and maintain a distributed control network, yet economical enough to remain on site as a maintenance tool.

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

The LonMaker tool provides comprehensive support for LonPoint and other LONMARK-certified devices, as well as other LONWORKS devices. The tool takes full advantage of LONMARK features such as standard functional profiles and configuration. LonPoint function blocks and LONMARK functional profiles are exposed as graphical function blocks within a LonMaker drawing, making it easy to visualize and document the logic of a control system.

LonMaker provides the user with a familiar, CAD-like environment in which to design a control system. Visio's smart shape drawing feature provides an intuitive, simple means for creating devices. The physical design of a network basically consists of dragging shapes for the desired devices onto a drawing and specifying to which channel they are to be attached. The logical design consists of dragging function blocks or other LONMARK objects - comprising the device application programs - onto the drawing and then connecting output SNVTs from each object to the appropriate input SNVTs of other objects. Figure 4 shows the LonMaker user interface.

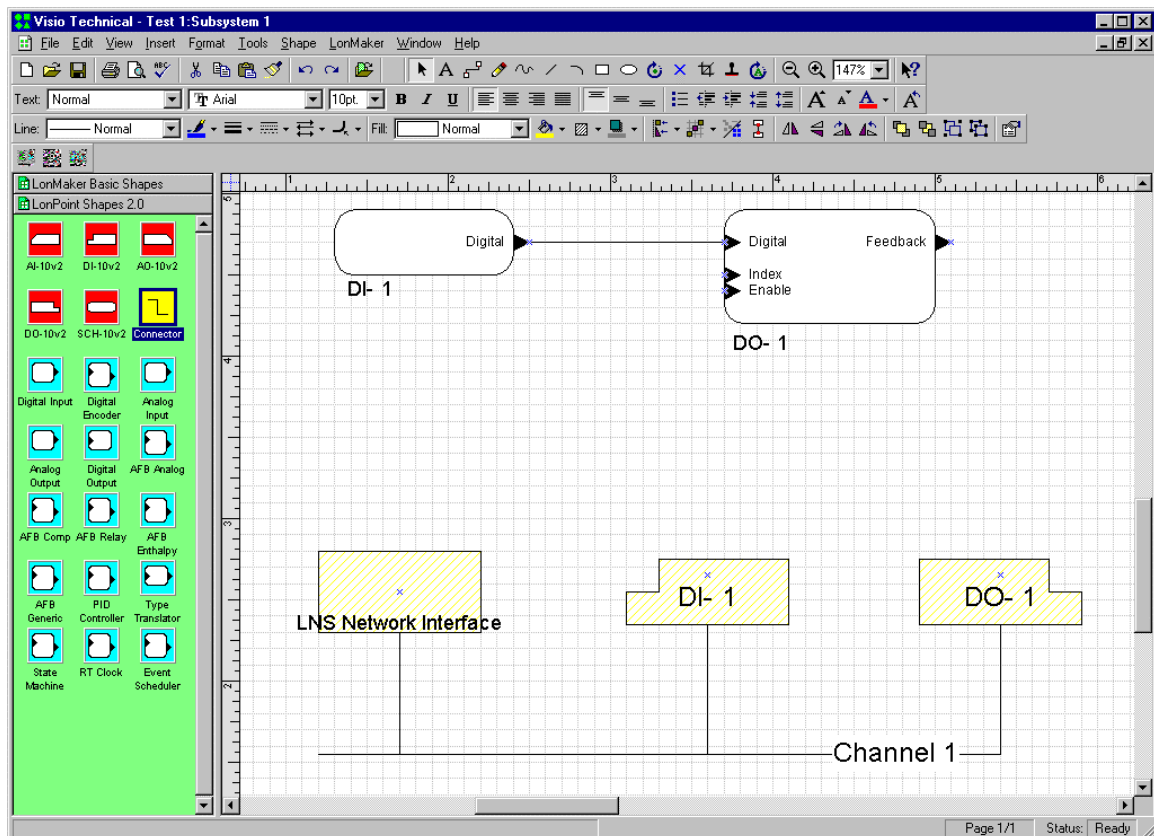


Figure 4. LonMaker User Interface

The LonMaker tool includes a number of basic smart shapes for LONWORKS networks and LonPoint devices, as well as the capability for customizing shapes. Custom shapes may be as simple as a single device or function block, or as complex as a complete subsystem with predefined devices, function blocks, and connections between them. Additional subsystems can be created by simply dragging the custom subsystem shape to a new page of the drawing, a timesaving feature when designing complex systems.

For pre-engineered systems, network design is usually done off-site, without the LonMaker tool attached to the network. However, network design may also take place on-site, with the tool connected to a commissioned network. This feature is especially desirable for smaller networks or where adds, moves, and changes are a regular occurrence.

Network installation time is minimized by the ability of the installer to commission multiple devices at the same time. Devices can be identified by service pin, bar-code scanning the Neuron IDs, or manually entering the IDs. Testing is simplified by an integrated application for browsing network variables and configuration properties. A management window is provided to test, enable/disable, or override individual function blocks within a device or to test, wink, or set online and offline states for devices.

For monitoring and supervisory control (HMI) applications, the LonMaker tool is compatible with a variety of third-party products including operator interface packages such as Wonderware's InTouch and National Instruments' LabView and BridgeView. In addition, the LonMaker tool can both import and export AutoCAD files and generate as-built documentation. An integrated report generator can also be used to provide a detailed report of the network configuration.

Echelon Network Interface Devices

Echelon provides a family of network interface devices to enable host computers such as PCs and laptops to physically and functionally connect to the network:

- PCLTA-10 PC LonTalk Adapter Packaged on a half-length ISA Bus card, plugs into any ISA (Industry Standard Architecture) slot in a PC or laptop computer. Available with three transceiver options: TP/FX-1250, TP/FX-78, and TP/FT-10;
- PCC-10 PC Card Packaged on a Type II PC card (formerly PCMCIA), plugs into any PC Card slot in a PC or laptop. Has TP/FT-10 transceiver built-in; optional cable pods adapt to TP/XF-1250 or TP/FX-78 channels;
- SLTA-10 Serial LonTalk Adapter Packaged in a stand-alone enclosure. Has standard EIA-232 serial interface. Can attach to the serial com port of any PC, laptop, or other host computer. Alternatively, can allow remote dial-in and dial-out from the network to a remote host using standard Hayes-compatible modems at each end.

References

The documents listed below are available from Authorized Network Integrator website, www.ni.echelon.com, or the Echelon website, www.echelon.com. They may also be purchased from Echelon.

1. LONWORKS Technology Overview
2. LONMARK Interoperability 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)
6. The SNVT Master List and Programmer's Guide (005-0027-01)
7. LonMaker for Windows User's Guide (078-0168-01)
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)