

**End-to-End Solutions  
With  
LONWORKS® Control Technology**

*Any Point, Any Time, Any Where*

Revision 1.1

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## **Executive Summary**

Information convergence is happening at a faster pace than ever. The Internet has dramatically accelerated the rate at which different forms of information (data, voice, video, audio, control, etc.) are merging, thus allowing uninhibited mixing of information types for solving everyday problems. This convergence is allowing the end-user to more efficiently communicate and share information with the rest of the world.

The proliferation of distributed control networking has permitted control devices (appliances, thermostats, lights, switches, etc.) to reap the same benefits from networking that PCs have enjoyed in the past decade. These "leaf" or "edge" devices sense and control the environments around us - in buildings, factories, homes, planes, ships, trains, or anywhere else control is needed.

The seamless integration of data networks (Internet and Intranets) with control networks allows access to any control point from anywhere. The extension of the Internet into devices allows people to reach (monitor and control) devices using a familiar medium - the web browser.

LONWORKS control technology allows this integration to happen now. LONWORKS includes all the components necessary to implement fully open, interoperable, control systems that can be easily, and seamlessly, integrated with existing data networks.

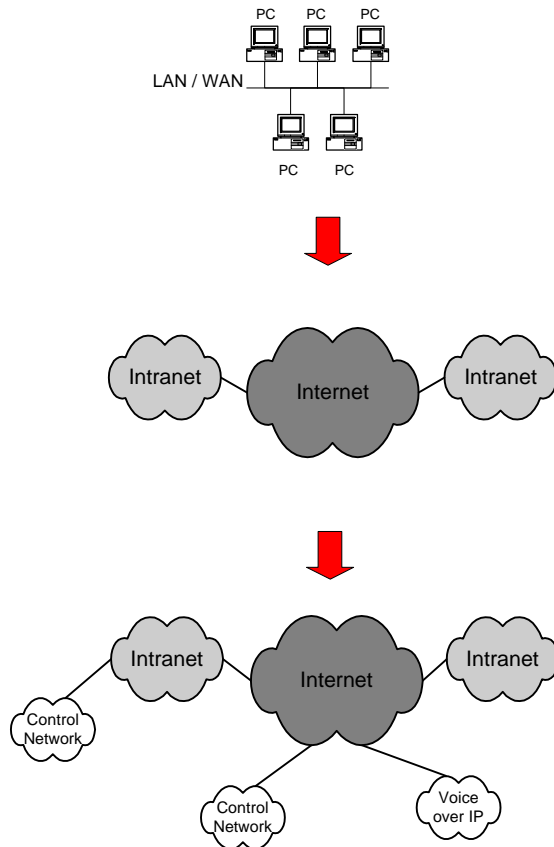
## **Information Convergence**

We're already in the third phase of the networking revolution. The networking revolution began about a decade ago when the computing world progressed through its mainframe and workstation phases.

The first phase of the networking revolution, the early WAN/LAN offerings of a decade ago, allowed businesses to be connected together. This was mainly a hardware-driven phase, with Ethernet, token ring, and other "low-level" networking products.

The second phase, the Internet/Intranet phase, allowed more seamless connectivity between people (via e-mail, web, video, audio, etc.). This phase was predominantly software-driven, with the proliferation of built-in TCP/IP stacks into operating systems, HTTP (Hypertext Transport Protocol), and the creation of the web browser.

The third phase, which is happening now, includes the integration of traditionally stand-alone islands of information into the big picture, including such things as voice-over-IP and control networks. Such a "network of networks" provides a universal, seamless networking fabric for people, devices and all the different information types they would need to interact with each other. The integration of control networks into the information pool allows people to reach devices and monitor and control them over existing data networks. Figure 1 illustrates these phases in the networking evolution.



**Figure 1. The three phases of the networking revolution.**

Each phase of the networking evolution discussed above provides a new level of integration for the user, thus relieving him/her from having to worry about the inherently different attributes of each type of information. For example, sending an audio attachment with an e-mail message a few years ago was a complicated task usually performed by the most technically savvy. Today, e-mail messages are often sent with audio and video attachments by non-technical users.

The integration of control information into the overall information pool represents the last remaining step in achieving true information interoperability - the ability for anyone, anywhere, to have access to any piece of data (assuming that access is allowed).

The third phase of the networking evolution promises to put people in touch with their surrounding environments more than ever (or at least put the necessary resources at their disposal). The benefits of seamless interoperability between people and devices through a global networking infrastructure are numerous and include:

- Increased accessibility/comfort (seamless integration of multiple networks)
- Higher system functionality/flexibility (more products from more vendors)
- Lower maintenance cost
- Increased reliability

The three main parties involved in the control system's life cycle, namely the OEM (Original Equipment Manufacturer), the system integrator, and the end-user, all benefit from a top-down fully interoperable control networking solution.

The benefits listed above can only be achieved by a true end-to-end control networking solution. Take the World Wide Web for example. Its benefits, effortless and timely information exchange and e-commerce among others, were not available for quite some time despite the fact that most of the individual technologies involved had been around for quite a while. Only after a complete end-to-end solution was offered (the HTTP protocol, the HTML language, and the web browsers, in addition to the existing Internet) did the web catapult into a revolutionary tool for connecting people.

The same analogy can be used for a control networking solution. A winning choice *must* offer a seamless, easy-to-use, *truly* open, and *truly* interoperable solution - a complete solution.

## **Why Control Networks are Important**

So why is there a need for control networks? Why not keep designing control systems using the same centralized architecture that has been used for the past 25 years? There are numerous answers to these questions<sup>1</sup>, but they are all based on one fundamental concept - user requirements and expectations have changed dramatically in the past decade. The old control systems of yesterday are simply not flexible enough, cost-effective enough, nor reliable enough to withstand the demands of the marketplace.

Let's look at an intelligent building as an example. An automated lighting system within a building uses control networks to tie together all the lights, dimmers and switches to an underlying network, and control information is shared between these devices. The installer no longer needs to worry about individually wiring switches to lights, and the end user (you and me) don't have to be concerned when our lighting requirements change from day-to-day (e.g. as new lights are added, or offices and furniture are rearranged). Additional cost savings are also gained by the fact that lights automatically shut themselves off based on occupancy and/or preset schedules. This can be accomplished with control networks. But there is more to the advantages of control networking.

Now imagine that other control subsystems exist in the same building. The security subsystem, the HVAC (heating, ventilation, and air conditioning) subsystem, the access control subsystem, the fire and life safety subsystem, the elevator subsystem, not only work independently as autonomous systems, but harmoniously together to create new levels of comfort, convenience, and safety. What's more, the building superintendent has complete access to all subsystems in the building from the comfort of his web browser in his office on the other side of town. All this can only be achieved with an open and interoperable control networking platform that offers an end-to-end solution.

The same analogy can be applied to other control applications in factories, homes, or any other environment where control is needed - practically everywhere. An important thing to remember is that a complete end-to-end control networking solution creates many applications and solutions previously unimaginable - just as PCs, LANs and the Internet ushered in a new economy and business solutions nobody could have imagined a decade ago.

It is tempting to want to extend the capabilities of the Internet and the Web to perform the functionality described above. The "IP-everywhere" concept, where every control device contains the TCP/IP stack, is not technically and economically practical. TCP/IP protocol was designed for data networking (large files, slow response time), not control networking (small but frequent packets). Also, TCP/IP was not designed to run in devices where size and cost are a premium.

Another recent concept is the extension of the existing RTOSs (Real Time Operating System) into the internet/web world. Although RTOSs provide a real solution for a complex embedded device, providing a TCP/IP stack and a web server only extend *that* device's reach. There is still a need for small and low cost devices to be connected together in low-cost, interoperable fashion. The control world requires a new solution all together.

## What Makes a Control Networking Platform

There are many things that are required of a complete control networking platform. A true end-to-end solution for control networking should offer more than a mere protocol. Such a platform must address a minimum set of criteria to be viable. These criteria, along with the benefits they offer are listed below.

- *Interoperability* (both at device level and system level) - lower integration, installation and maintenance costs. Higher system functionality and flexibility.
- *Network operating system* - a robust, universal platform for installation, configuration, monitoring and control of networks. Software tools interoperability.
- *Seamless integration with IP networks* (Internet and intranets) - True end-to-end connectivity between people and devices, using the existing LAN infrastructures.
- *Easy-to-use application programming environment* - Programming environment tailored to the needs of control devices and systems as well as the developers. Rapid time-to-market for devices. Rapid device proliferation. More choice in less time.
- *Infrastructure tools and support* (routers, repeaters, PC interface cards, etc.) - System scalability and flexibility.
- *Low cost device hardware requirements* - Lower device and system cost. Faster adoption. More market penetrations. Higher volumes. Even lower prices.

## The LONWORKS System

The LONWORKS platform offers a complete end-to-end solution for the control systems of today and tomorrow. In addition to the LONWORKS offerings from Echelon<sup>3</sup>, several key partnerships between Echelon and leading networking and communication companies promises to extend the power of LONWORKS even further by making the basic technology accessible to a greater number of people and to a greater number of applications and markets.

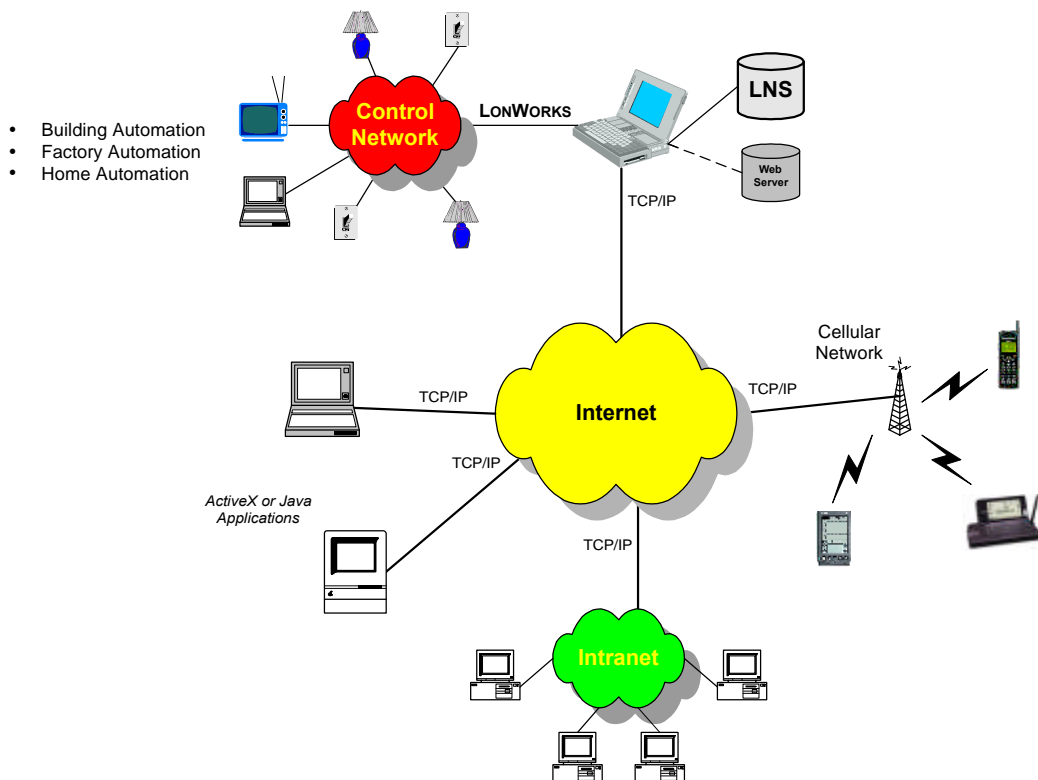
LONWORKS technology provides several different, yet complementary, components, tools and architectures.

## LNS - LONWORKS Network Services

LNS provides the first network operating system for control networking on the market. Its client-server architecture allows software client tools (e.g. human-machine interfaces, supervisory controls, operator stations, etc.) to be attached to the network, along with control devices, allowing a truly scalable control networking solution for small (several dozen devices) to very large (thousands of devices) control systems.

The rich functionality built-into LNS ensures support for the wide ranging set of requirements of control systems encountered in different industries and applications. The object-oriented approach used by LNS allows all network devices and attributes to be treated as objects with properties and methods. This is a powerful and intuitive approach that allows rapid system and application development, even for complex systems.

In addition, LNS provides seamless connectivity to the control network via TCP/IP. Since this functionality is built into LNS, there is no need for external gateways. This feature of the LNS essentially allows access to all the network objects over a TCP/IP connection to the LNS server. Figure 2 illustrates how LNS fits into the big picture by allowing a seamless connection between control networks and the Internet and Intranets.



**Figure 2. LNS as the catalyst for bringing together the Internet, Intranets and control networks.**

LNS's multi-tiered architecture (LONWORKS at the device level and TCP/IP at the system level) allows both data and control networks to leverage each other and offer added value to their respective users. For example, an employee in an office building can monitor the environmental status of his/her office (heating, lighting, etc.) through a web browser.

Conversely, a control system could dispatch an alarm condition to the building manager by sending a priority e-mail message.

It is important to note that the flat architecture offered by LONWORKS does mean that everything is at one level, or on one physical network. Flatness, in the LONWORKS case, implies that devices and tools are at the same *logical* level, thus guaranteeing true seamless interoperability between them. The combination of LNS, and LONWORKS routers allow multiple channel types (media) and multiple subsystems to be connected together to allow peer-to-peer interoperability between them. This can only be achieved with a "flat" architecture and without the use of application gateways and bridges (which, by definition, strip away any underlying interoperability hooks within an architecture or protocol).

An extension to this flat architecture concept is brought on by an effort underway between Echelon, Cisco and Toshiba, described below.

### The LonPoint® System

An example of how an end-use system based on LONWORKS can provide true end-to-end connectivity is the LonPoint System (<http://ni.echelon.com>). The LonPoint System is a set of hardware and software components for network integrators to design and commission open, multi-vendor, control systems in record time, at a lower cost than ever possible before.

The hardware portion of the system is a set of fully configurable control modules that provide analog and digital input and output blocks for connecting standard sensors and actuators to (e.g. temperature sensors, relays, lights, etc.) the network.

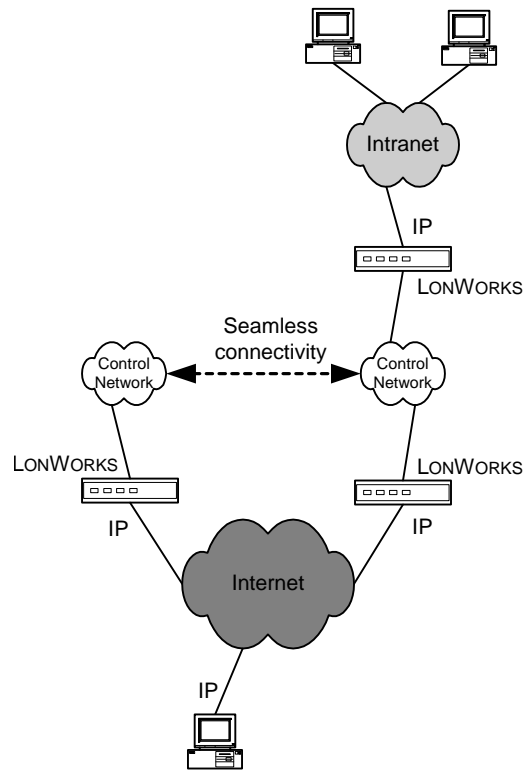
The LonMaker® for Windows® software tool, based on the LNS architecture, allows rapid design and deployment of control networks based on the LonPoint modules and third-party LONWORKS-based products. The hardware and software are closely tied together using LNS Plug-Ins for devices that allow intuitive and rapid device installation and configuration.

LonMaker for Windows, being an LNS application, allows access to the control network via TCP/IP. In fact the LonMaker for Windows application itself could run remotely over TCP/IP (over the Internet or an Intranet), allowing remote installation, maintenance, monitoring, and control of a control system.

### Cisco-Echelon Partnership

The Cisco-Echelon initiative to bring data networks and control networks together provides another path for providing a total end-to-end control networking solution based on LONWORKS technology and IP.

The first product to come out of this partnership will be a LONWORKS-to-IP router to seamlessly route packets between control networks and IP-based data networks. Figure 3 illustrates how such a router fits into the big picture.



**Figure 3. How end-to-end connectivity is enhanced by the LONWORKS-IP Router**

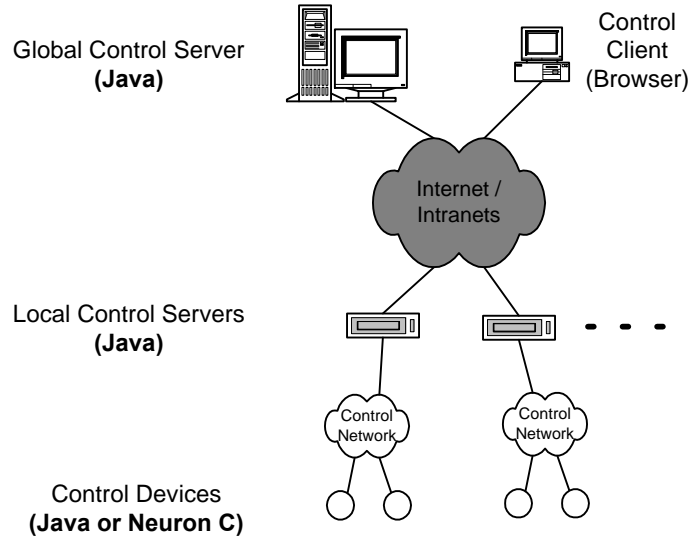
Routing information in a truly seamless fashion is not a trivial task. Care must be taken that all relevant parameters (data, addressing, units, interoperability information, etc.) for each protocol are conveyed and represented fairly and adequately on the other protocol. This is most certainly not a feat for one company to try to accomplish, as it requires a team effort from experts on several different camps.

Cisco, Echelon and several other leading companies are working together to define the exact "tunneling" specification for passing LONWORKS packets over IP. This effort is part of the Router task group of the LONMARK® Interoperability Organization, which is responsible for promoting interoperability among LONWORKS-based devices and systems.

#### Toshiba-Echelon Partnership

Toshiba and Echelon have formed an initiative geared toward enabling enterprise-wide integration of control and data networks. These "I/O to CEO" solutions will allow businesses to lower costs and significantly increase productivity by sharing information from a variety of devices and networks.

Toshiba is now realizing this concept in its Enhanced Network Computing (ENC) architecture. The ENC integrates LONWORKS distributed control network with information management systems based on Java™ architecture to create a truly seamless integrated information and control architecture. This is accomplished by integrating LONWORKS intelligent distributed control systems with an architecture-independent, object-oriented, Java platform and language. This is shown in Figure 4.



**Figure 4. The Toshiba ENC architecture.**

The basic ENC configuration has three layers. The Global Control Server with the Control Client (Browser), the Local Control Server and the Control node (LONWORKS device with I/O). The Global Control Server is connected to the TCP/IP network, the Local Control Server is connected to both the TCP/IP network and the LONWORKS network, and the Control Devices are connected to the LONWORKS network.

The Local Control Server shown in figure 4 is the most important component of this architecture as it provides seamless connectivity between IP and LONWORKS networks (basically a LONWORKS-IP router).

The three-layer architecture described above essentially allows a top-down Java approach to networking. All applications, from the control device level up to the enterprises supervisory stations, can now be implemented using the common Java language. This allows even more seamless integration of the various levels, in addition to faster implementation and debugging time.

The current programming language for LONWORKS control nodes (using Neuron Chips) is Neuron C (programming language based on ANSI C, with extensions to support run-time features provided in the Neuron Chip firmware). JDevice is a Java programming model with complete Neuron C functionality that can be used with both Neuron Chips and the new Pentagon chip, an enhanced 32-bit RISC core with Java that supports LONWORKS and Ethernet networks.

Using Java as the platform for this architecture allows the use of off-the-shelf and custom Java Beans (prepackaged application and user interface Java software components) for developing complete Java applications for monitoring and control (e.g. trending, data logging, operator interface stations, etc.).

## Conclusion

We are at a critical technological juncture where all the important components exist to form a complete end-to-end solution for distributed control networking.

Control networks are here. They are helping to create new levels of convenience, comfort, safety, and reliability. LONWORKS, and in particular LNS, are the cornerstones of this revolution in distributed control networks.

The extension of the Internet into the controls world is a natural and intuitive next step. Consumers should not have to be concerned about the kind of networks being used to meet their needs (the same way that making a telephone call should not burden the caller with dealing with the idiosyncrasies of the local, long distance, cellular, and up-link satellite networks). Information (data, control, voice, audio, video) must and will flow freely as the networking concept permeates more industries and allows more and more systems to merge.

Only a fully integrated solution can provide truly interoperable and end-to-end functionality required for seamless networking. LONWORKS control networks provide the core control system platform with built-in support for extending it beyond the controls world and into the data/computing world.

The fusion of data and control networking is inevitable, and it is happening today with LONWORKS.

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