Open, Interoperable Systems For Energy Control

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CONTROL SYSTEMS AND COMMUNICATION—THE EARLY DAYS

In the early days of energy control systems, before the advent of control networks, control systems consisted of masses of wires connected to relays, switches, potentiometers, and actuators. Cabling was installed in a point-to-point fashion between electrical panels, effectively wire-routing stations filled with terminal blocks, and the sensor inputs and actuator outputs. The functionality of these control systems was relatively rudimentary and inflexible, and adds, moves, and changes required extensive rerouting of wiring and connections.

The advent of solid state technology offered a means of using logic circuits to replace wire and relays. Electrical panels gave way to programmable logic controllers (PLC), which were programmed not with a screw driver but a data terminal. These PLC, first developed for the industrial process control industry, gradually migrated to the environmental control industry in the form of Direct Digital Control (DDC).

In fact, DDC rapidly evolved to the reference term that identified any piece of distributed direct digital control equipment. **Distributed,** meaning that the devices had an integral microprocessor; and **direct digital control** meaning that this intelligent device was mounted as close as possible to the point of control. Though DDC are used in some applications for environmental control, the predominant technology in the buildings industry is DDC. As increasingly powerful algorithms were developed, tighter control over processes could be achieved.

However, the issues associated with adds, moves, and changes remained and grew increasingly complex as systems grew in size. The software required to handle large systems was very complex, the DDC represented a single point of failure, and the DDC was still tethered to all of the sensors and actuators by cable bundles that were not easily modified (figure 1).

Moreover, the manufacturers of DDC developed them using proprietary internal architectures: if you wanted to expand a DDC you had to use expansion cards from the original manufacturer.

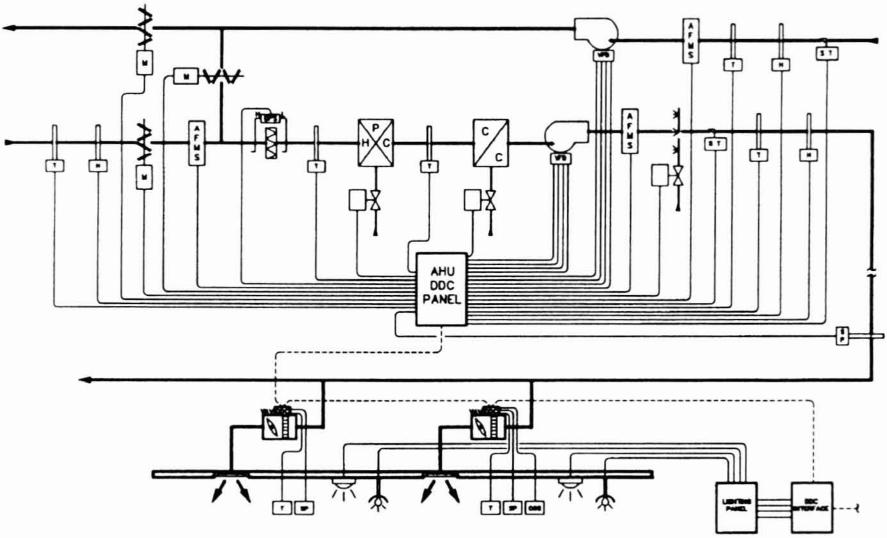

Figure 1
Closed, wiring-intensive architecture of centralized controllers

If you wanted to interconnect DDC from different manufacturers, the incompatibilities between manufacturers led engineers to focus on linking separate systems with relays, custom gateways, and RS-232 ports. The problem is that these interfaces didn't provide a detailed, seamless view into the different systems. They allowed only limited status and control information to be passed between the different systems. Fault status information couldn't be shared, information from different sensors wasn't accessible for combinatorial logic programs, and systems couldn't adapt their responses in real-time based on receiving the overall system status.

INTEROPERABILITY AND OPEN SYSTEMS

Creating a seamlessly integrated control system requires interoperability among the components of that system, as well as other related systems that must exchange information (figure 2). Interoperability is the process by which products from different manufacturers, including those in different industries, exchange information without the use of gateways, protocol converters, or other ancillary devices. Achieving interoperability requires a standardized means of communicating between the different devices; it depends on a system level approach that includes a common communication protocol, communication transceivers, object models, programming and troubleshooting tools, and so on.

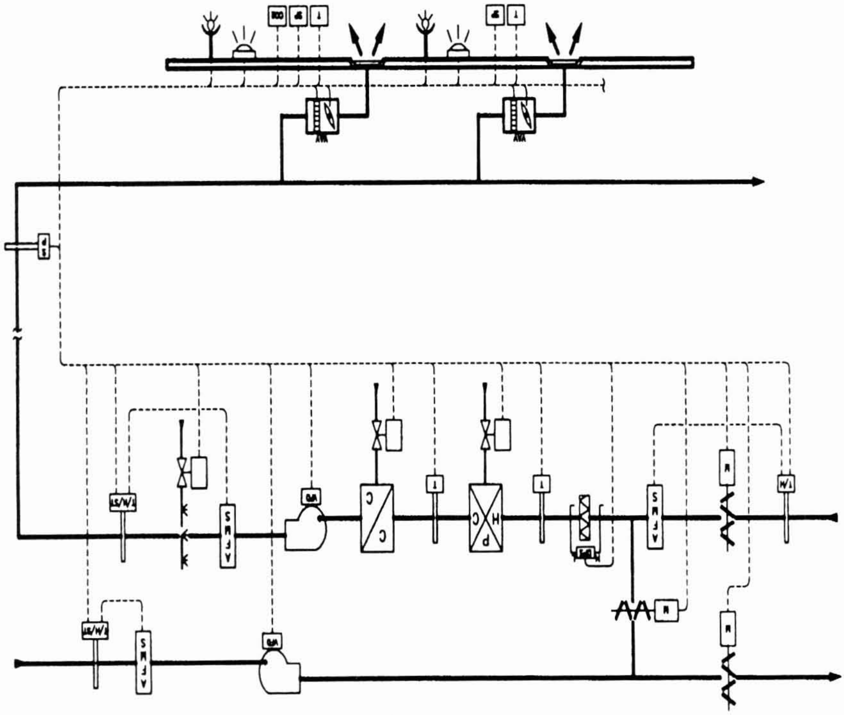

Figure 2
Open, interoperable control network with minimal wiring

The benefits made possible by interoperability are many. Since one sensor or control device can be shared among many different systems, fewer sensors/controls are needed and the overall cost of the monitoring system drops appreciably. For example, in a building automation system one interoperable motion sensor can share its status with the zone heating system for occupancy sensing, the access control system for request-to-exit purposes, the security system for intrusion detection, and the fire alarm system for occupancy sensing. The motion sensor still performs the same task—detecting motion—but it can share the information with the many subsystems that can make use of its status.

The ability to share more information between systems makes possible many long sought-after applications, including integrated energy control systems. For example, in response to access control reader data and daylight illumination sensors, the HVAC and lighting systems can automatically adjust the comfort and illumination levels in pertinent work areas based on individual preferences and energy costs. Lighting can be adjusted on a cubicle-by-cubicle basis for computer operators and occupants near windows—either automatically or through commands entered from a user's PC via the corporate LAN. Heating can be similarly tailored.

Or, based on signals from smoke detectors, the HVAC system can create positive or negative air pressure of select areas to cause a fire to move away from occupied areas while the lighting system leads the way to the closest exit. The possibilities are limited only by the creativity of the designers.

For a facility owner, interoperable products offer the advantage that devices can be selected from among different manufacturers; the owner is no longer tied to any one manufacturer's proprietary technology. Aside from the cost savings achieved by open competition, the facility owner is safe in the knowledge that replacement products will be available if any one manufacturer goes out of business or discontinues products. Service contracts can be openly bid since no proprietary devices will be used, thereby avoiding single source service contracts.

Interoperability also benefits equipment manufacturers because their products will be assessed based on their quality and functionality—not on their ability to meet a closed, proprietary specification. Interoperability levels the playing field and increases competition, insuring that the best devices for the job will win.

LonWorks® TECHNOLOGY

While interoperable control systems might have been a pipe dream only a few years ago, they can be built today using a technology called LonWorks. Developed by Echelon Corporation, Palo Alto, California, LonWorks technology allows all forms of energy-related devices and other building and industrial control devices to communicate with one another through a common communication protocol that is shared among all devices. Communication transceivers and transport mechanisms are standardized, as are object models and programming/troubleshooting tools to enable the rapid design and implementation of interoperable, LonWorks-based devices. Network management software, protocol analyzers, IP routers, PC and PCMCIA interfaces, and development tools are all available off-the-shelf to speed development and reduce time to market. In short, LonWorks offers a system level approach to interoperability, and comprises a complete set of tools and products.

The heart of a LonWorks hardware device is the Neuron® Chip, an integrated circuit that combines a sophisticated communications protocol, three microprocessors, a multitasking operating system, and a flexible input/output scheme. Manufactured under license by both Motorola and Toshiba, the chip is sold and supported worldwide.

Any devices that use a Neuron Chip can send signals to, or receive signals from, each other without a central network computer or server. Ensuring the interoperability of these network communications is the responsibility of an independent organization called the LonMark® Interoperability Association. Funded through member dues, the LonMark Association defines the interoperability guidelines for LonWorks devices, including communication transceivers and object models. Products that bear the LonMark logo are certified to adhere to the LonMark interoperability guidelines and can be used with confidence in integrated control systems.

The existence of interoperability guidelines helps ensure that control devices can share information. However, this capability would be for naught if there was not also an interoperable means of defining, installing, and reconfiguring a control network. After all, even a well designed control system needs to be changed from time to time. Overcoming the limitations of closed, centrally controlled, DDC-based systems dictates the need for an open, interoperable, multi-vendor installation and maintenance tool architecture. This would permit multiple technicians to simultaneously configure and maintain different portions of a control network using tools from different manufacturers.

The LonWorks Network Services operating system, LNS, is "middleware" software that provides a standard platform for supporting interoperable applications on LonWorks networks. Offering a powerful client-server architecture, LNS permits multiple installers to simultaneously configure a control system. Manufacturers can provide a unique look and feel to their products by creating customized human machine interfaces. By offering a common platform with a customized "front end," LNS makes it possible for multiple vendors to supply interoperable tools.

In order to speed the configuration of devices from different manufacturers, LNS defines a "plug-in" standard. This standard allows sensor, actuator, and device manufacturers to provide customized applications for their products. When those products need to be configured, the LNS-based tool will automatically present a configuration screen that the manufacturer has tailored to the device being configured. Regardless of the LNS-based tool being used, the configuration screen for that product will remain consistent. This capability simplifies the task of training installers, allows device manufacturers to give the programming interface a unique look and feel, and permits tool vendors to offer products that are both unique looking and interoperable.

Figure 3 shows a typical LNS-based tool that implements a Visio® user interface. Visio provides users with a familiar, CAD-like environment in which to design a control system, and Visio's smart shape drawing environment offers an intuitive, simple means for creating devices. The tool includes a number of smart shapes for LonWorks networks, and users can create new shapes for unique device configurations or complete subsystems. Stencils can be constructed with predefined devices, function blocks, and connections between them. Master shapes corresponding to complete subsystems can be created and saved. Additional subsystems can then be created by simply dragging the shape to a new page of the drawing, a time-saving feature when designing complex systems.

To ensure interoperability, it is important that both control devices and configuration tools adhere to the LonMark interoperability guidelines. LonMark features such as standard functional profiles, configuration properties, resource files, and network variable aliases make it possible to achieve interoperability between tools, devices, and tools and devices.

An LNS DDE Server allows LNS-based networks to share information with DDE-compatible human-machine interfaces (HMIs). One commonly used operator interface package is Wonderware's InTouch®.

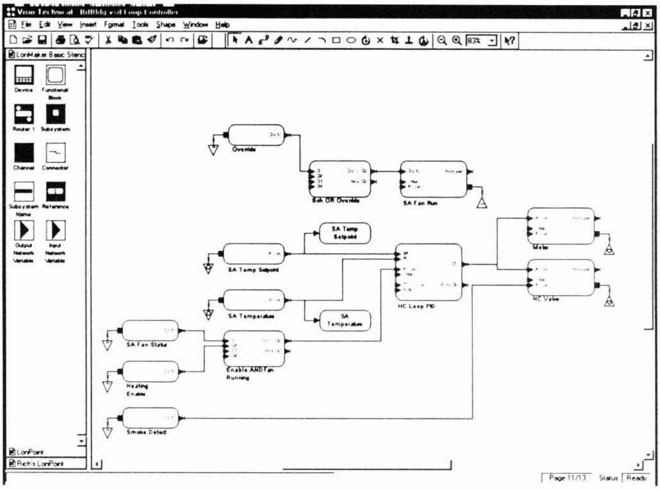

Figure 3
Typical LNS-Based Tool—Network Configuration Screen

OPEN, INTEROPERABLE SYSTEMS—AN EXISTENCE PROOF

While LonWorks technology holds the potential to create open and interoperable control systems, the key is in the execution of the design. LonWorks was designed to be deployed using an open, interoperable, distributed architecture, however, it can also be configured in a manner that is closed and proprietary—similar to traditional DDC and other closed, hierarchical control systems. Proper execution is needed to create open LonWorks control systems, and to realizing the economies and benefits of which this technology is capable.

Overcoming the limits of traditional, closed, hierarchical systems is best accomplished with a flat, fully distributed control architecture. Such an architecture allows the owner to take advantage of the labor and equipment savings associated with networked cabling. It also minimizes the probability of a single point of failure, a shortcoming of centrally controlled systems. To be truly useful, this architecture needs to include provisions for connecting both intelligent sensors and actuators (ones with on-board networking) and legacy sensors and actuators in a common network. Multiple network management tools should be supported (reducing costs by allowing several technicians to work simultaneously) and these tools should be available from different manufacturers. Satisfying these many and diverse requirements dictates a systems approach to the architecture, hardware, and software; it cannot be accomplished with a piecemeal collection of devices and components.

An example of such a systems approach to control networks is Echelon's LonPoint System. The LonPoint System is a family of products designed to integrate new and legacy sensors and actuators, as well as LONMARK® devices, into cost-effective, interoperable, control systems. In contrast to traditional control networks based on DDC or other proprietary controllers, the LonPoint System offers a flat system architecture in which every control point performs some control processing. Distributing the processing throughout the network lowers the overall installation and life cycle costs, increases reliability by minimizing single points of failure, and provides the flexibility to adapt the system to a wide variety of applications.

The LonPoint System includes the LonMaker for Windows tool and a family of LonPoint interface, scheduler, and router modules. In this system, digital and analog Interface Modules, Scheduler, and Router modules provide I/O and application processing, timekeeping and scheduling, and routing, respectively. The interface modules seamlessly integrate sensors and actuators into peer-to-peer, interoperable networks. The Scheduler Module provides time, date, and system status to other modules on the network, and includes a programmable state machine. The Router Modules can be used to create high speed backbones to optimize network traffic, extend the size of the network, as well as to create bridges to other channels containing third party devices.

Resident within each module is a configurable application program. The program includes a variety of function blocks (i.e., PID, analog function, discrete sensor, type translators) that are configured by the LonMaker for Windows tool. Linking together the software function blocks of the LonPoint modules with the resources of third party LONMARK devices creates a distributed control system that offers greater functionality, higher reliability, and lower cost than a DDC-based system. The LonPoint System may be operated as a self-contained control system, integrated with other LONMARK or LONWORKS devices, or combined with remote systems and a remote supervisory station to form a wide area control system.

This type of system can lower overall equipment, installation, and life-cycle costs, and offers more flexibility than DDC with regard to adds, moves, and changes. At an installation at the Edward J. Minskoff

Equities building in New York, the use of such a System resulted in a 25% reduction in the total job cost, and a 30% reduction in commissioning labor compared with a DDC-style system (*Engineered Systems* magazine, 1998). Typical of LonWorks control networks, there was less wire to install, more flexibility with regard to system layout, and the ability to reconfigure the network either locally or remotely by telephone connection.

SUMMARY

The world of energy control systems has come a long way technologically since the advent of solid state controls. The availability of LonWorks control network technology, and of products like the LonPoint System that use this technology, opens the door to a new generation of energy control systems. Besides offering capabilities not previously available from control systems, open, interoperable systems offer higher reliability, greater vendor choices, and lower life-cycle costs than closed, controlled-based systems. The benefits to be reaped from these systems, both in terms of energy savings and lower system costs, are limited only by one's imagination and vision.

ABOUT THE AUTHOR

Michael R. Tennefoss is the director of product marketing at Echelon. Mr. Tennefoss joined Echelon from Stellar Systems, a manufacturer of intrusion detection sensors and alarm monitoring systems, where he served as director of monitor & display products. Before joining Stellar Systems, he was the director of marketing at ETP and vice president of marketing at Vindicator Corporation. Echelon's LonWorks technology was introduced in 1990 and is today being built into next generation products by over 3500 companies in a variety of industries—from factory automation to energy control systems to consumer electronics. Echelon Corporation provides a full range of hardware and software products to support the development of control networks. Echelon is headquartered in Palo Alto, California, and has subsidiaries throughout Europe and in Japan and China.

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