DDC Open Systems—An Overview

John J. McGowan, CEM, CDSM, CLEP
Vertical Market Manager, Performance Contracting
Johnson Controls, Inc.

The DDC market is global and is filled with multi-national customers and service providers. This article gives a broad perspective on issues at hand.

As you will see in this and the articles that follow, there are common needs for communication and control on the part of building owners worldwide. As these individuals seek to address these needs, the first thing they encounter is a baffling array of new concepts and technologies in the area of DDC communication and networking. As with every paper that I have published on this topic in the last 15 years, my goal is to address this issue by clarifying both the present, and key milestones in the past that have led us to this point in time. This foundation will provide a useful framework within which to view What's Ahead.

System owners began to voice concerns in the early 1980's regarding some complexities in the long term management and expansion of DDC systems. In many respects the DDC industry was in its infancy at that time, and the rapid pace of product development combined with the breadth of products in the market presented issues for owners. The ultimate impact of these issues was a significant awareness of the role that communication played in the long term success of DDC systems, and with that the importance of Protocols and networking. These terms along with countless communication related product and technology buzzwords have become critical to system selection in the past three years.

Why three years? Because BACnet®, an American Society of Heating, Refrigeration and air Conditioning Engineers (ASHRAE) standard, was published in 1995. Prior to that time, for more than a decade the issue has been a source of varying levels of interest, but with the publishing of that standard, industry took notice. The standard, simply by virtue of its existence, should be able to solve a host of problems. As is often the case, some even believed it would solve problems it was never intended to address. To make matters even more complex, rather than

having the numerous communication protocols in the industry resolve into one ideal option, the industry is facing several "ideal" options. A term that has evolved recently to refer to systems using one of the many proprietary protocols available in the market until now is a "legacy" system. So, if you have been confused about BACnet®, open systems, LonWorks®, etc. or are wondering where does the industry go from here?, read on.

THE ISSUE

Evolution of communication issues within the controls industry is the subject of a complete paper, and several of the authors in this edition cover various aspects of that topic. Though a detailed focus on control evolution is not appropriate here, a brief discussion of some key industry concerns is important to highlight the urgency of this issue. During the mid to late 1980s end users had concerns regarding communication with control systems. Trends in the industry were towards: system integration, distributed Direct Digital Control, user friendly interface, Personal Computer front ends, flexible systems with ease of use as a goal of the system. The communication discussion involved each of these trends. These trends became more complicated, end users noted, when more than one manufacturer's control equipment was installed in the same building. This meant that there was more than one front end system, data could not be shared between systems, and control could not be integrated among systems. Because of these complications, many end users did not find their systems easy to use, and the issue of an open protocol developed.

It was also believed that an open or standard protocol, employed in the design of all new control systems, would allow end users to mix and match various manufacturers' components in the same system. This expectation, though possible to achieve with a standard communication protocol, is much more a function of the control sequences executed by controllers. As a result the mere existence of a standard is not likely to address this desire. Unfortunately, even today there is still great confusion over this issue.

To expand, it is key that two of the control trends above were central themes in the call for open protocols. At the core of the open protocol issue are end user requests for:

- Remote communication from a front end to more than one system, and
- Standardized networking for communication between distributed controllers.

It is important to read those two bullets again, because there is a great deal of uncertainty in the industry about the distinctions that must be drawn between these two issues.

CONNECTIVITY AND INTEROPERABILITY

This author coined the term "Link" about 15 years ago to refer to the first communication issue. This term referred to the need for a standard interface between personal computer (PC) front ends and control systems. PCs were being used extensively for communication with control systems of multiple manufacturers, and software interface protocol end was proprietary. Use of a common protocol or communication "Link" between a PC and multiple systems was posed as one solution to this issue. The author later referred to this as a "connectivity" solution, but the complexity of the issue demanded more consideration.

The second critical issue that was raised by users, and noted above, was the desire to be able to easily upgrade systems, and to do so with multiple manufacturers' devices. In fact, there was a segment of the industry that wanted fully interchangeable controllers, from any manufacturer, to be able to function in the same DDC system. Today we would refer to this as full scale "interoperability." In fact there is a growing consensus in the industry that there are levels of interoperability from simple interface at the low level, to complete interchangeability at the high level.

It is clear that interoperability is an essential element of any DDC system. Consider the growth of Distributed DDC, which was made possible by technology developments in the controls, electronics and data processing fields. Distributed direct digital control (DDC) systems are cost effective on individual pieces of equipment, and have become common on devices as small as VAV boxes. Key to the use of these controllers with a complete system, however, is the ability to provide a means for network communication between these controllers, other control products and a front end, typically a PC.

WHAT IS A PROTOCOL?

Knowing drivers for development of a communication standard is helpful, but is anyone still unclear on the definition of a protocol? In the simplest of terms, a protocol is a set of rules which allows one computer to understand what another one is saying. The key elements of a protocol define:

- format of the data,
- information necessary for data conversion between machines and
- timing to define the data transmission speed and sequence.

Written computer instructions which make up the elements of a protocol are generally called source code.

A protocol exists wherever two systems must communicate, and historically it was common practice for the protocol source code to be proprietary. Interestingly, this is not unique to the controls industry. The issue may be found in every aspect of the computer industry, and within any industry that integrates computers into products. The search for a solution in other industries led to development of independent research organizations and to significant corporate investment. Regardless of the industry, questions always seems to revolve around the issues of proprietary, standard and open protocols.

OPEN AND STANDARD PROTOCOLS

As the issue is explored it quickly becomes evident that the protocol is simply a piece of software that either aids or impedes an owner's ability to meet his needs for the system. It is important to state that up front, because no protocol is a solution in itself. Rather, intelligent application of the protocol in the design and development of systems that are intended to meet an owner's need, is the solution.

To craft solutions in other industries, research groups came into being that were focused on providing solutions through standard communication between mainframe computers. The Corporation For Open Systems was one such. Another solution, Manufacturing Automation Protocol (MAP) was an early result of a major expenditure made by

General Motors Corporation to ensure that all production control systems used standard communication. In each of the above cases communication guidelines were provided by the International Standards Organization (ISO) which provide a model for developing communication standards.

So, what is the difference between open or standard protocols? Quite simply, **Open Protocols** differ from other protocols only because the source code is not proprietary, it is published and available, but is often controlled by a company. A **Standard Protocol** on the other hand, while also being published and available, is controlled by a standards organization. BACnet® is a standard protocol, published by ASHRAE. The source code is published and the intent is that this protocol would be designed into more than one manufacturer's system, and allow for a *standard* in controller communication. Through ASHRAE, the industry focused this effort on meeting the critical needs of the buildings industry. Other open protocols have also been offered to the industry as solutions.

To return to an earlier theme, whether a protocol is open or standard does not address an owner's needs. It is critical to carefully evaluate the needs for a particular project, and to then select one or more systems and protocols that can meet those needs. A final issue regarding standard protocols, is that some method of compliance to the standard must be provided, and the status of this issue for BACnet® from ASHRAE and LonWorks® from Echelon, will be discussed in the articles that follow. In closing, note that "open system" is yet another term used in the industry and discussed below.

SYSTEM INTEGRATION OR INTEROPERABILITY

System integration is a term that the author has long used to refer to the requirement for coordinating control, and other activities such as access, fire, etc., that occurs among all the components in a building. In the past the topic interoperability often assumed that there may be more than one level of sophistication or architecture required. More complex systems have traditionally required higher level architectures to accommodate their needs where such complexity would overburden simple systems.

DDC systems to date have evolved around architectures that take

a hierarchical or peer-to-peer approach. Solving the interoperability needs under that scenario takes one approach; however, a new level of complexity is being proposed by others in the industry and that is to further distribute system intelligence. This approach would involve multiple individual components, such as schedulers, smart sensors and PID loop controllers, that reside on a flat architecture.

Given the increasing array of options, it remains as critical as ever for owners to define requirements prior to making any system purchasing decisions. **Interface Interoperability** may be viewed as a communication issue meaning that different systems may be connected and share data. **Control or Interchangeable Interoperability** is more focused on the idea of controller integration, which mixes more than one manufacturer's controller within a system. The key of course is that the controllers must operate as though they were designed to be a system, again a result that is not ensured simply based upon standard communication. At the system level, multiple complete systems are integrated. In most cases the system level integration does not integrate controller level functions. Rather it uses a single front end for programming, monitoring and other PC functions with all the systems. This type of integration is very similar to a **gateway** which is discussed below, under "implementations for the future."

"**Open Systems**" or integration introduces a number of confusing variables into the discussion of standard protocols. Some of the most critical concerns include: warranty, service, maintenance liability and control integration. Warranty is a question that arises with these systems because each manufacturer would be hard pressed to identify legitimate warranty claims. Legitimate claims would be those involving traditional problems that could not be blamed on other controller interference, design error, field installation problems, etc. Service and maintenance liability are similar to the warranty issue, however the key here is who does the owner call for service. Further the challenge is to ensure that unnecessary site visits and finger pointing do not result in extended downtime.

Control interoperabilty is the last and perhaps the most critical problem. In order for these controllers to work as a system, the designer and installer must plan for control interaction. This means that the control loop in one device could overrule the internal design algorithm in a second device. This is extremely dangerous, particularly where the second device does not have sufficient data to provide effective control.

These problems present significant obstacles to system interoperability. Options for developing such systems cannot be addressed until the specific requirements for the system and the environment where it will be installed are resolved.

STANDARDS IMPLEMENTATION OPTIONS

The above introduction to industry trends and to protocols is limited, but it provides a framework for discussing where the industry is headed. There have been any number of short and long term solutions posed to address industry concern over the number of proprietary packages in use for networking and communication. For the most part these proposed solutions fit into the three categories below, and each will be discussed.

1. Alliances; a hardware or software gateway package to translate between protocols,
2. Industry network standardization on an existing protocol such as LonWorks®, or
3. DDC network standardization on a new protocol such as BACnet®

Alliances and Gateways

Alliances between manufacturers who share protocols and offer owners a hardware or software conversion package has been an effective shortcut to solving these issues. Protocol conversion requires cooperation, and the development of a device to act as a translator between PC front ends or controllers and control systems. These conversion packages are often called **gateways.** With this option there is no change to the existing protocol. A package is developed which can interpret that protocol, convert it to a protocol which the front end system understands, and pass it through to the front end. This package may be hardware, software or a combination.

The desirability of this option is that existing systems could be easily modified to allow communication, and that any front end could conceivably function as a standard. As noted, a gateway would be used for universal front end technology, but gateways are not limited. Gateways can be integrated into stand-alone hardware or distributed controllers to

allow system wide communication. This option does not to assume that all existing protocols are acceptable for the long term, but it has been an effective technique for merging existing and new protocols within the same system.

It is highly likely that gateways will remain common with DDC systems, particularly as it becomes more common to integrate disparate system; i.e., utility meter databases, with controls. Ultimately, systems that use gateways to integrate existing and new DDC equipment and perhaps add interface to a variety of other computer-based facility equipment can fit the definition of an open system.

Existing Protocols

The challenge facing this industry has appeared to be choosing either a new or existing protocol as a standard for control network and interface communications. The primary distinction is whether there will be one protocol, such as BACnet® or if standardization will occur on two or more protocols. The most likely contender for a second protocol standard at this point is LonTalk®, part of the LonWorks® offering.

The LonWorks® offering has generated enthusiasm in the industry, and in fact has been used as the basis for a number of control related product developments. Recent development of the LonMark Interoperability Association, an independent association supported by manufacturers and others, is more evidence of the viability of this option. The key here is that LonWorks® is not a communication standard because it is control by Echelon, Inc., an independent company. Yet clearly the LonWorks® offering is open, and has already been implemented and offers much to the industry. Availability of multiple protocols is a workable solution if owners commit to careful design and development of specifications.

A New Standard

Developing a state of the protocol for controller networking with a direct component to enable standard remote communication is the option that ASHRAE worked on from 1987 until 1995. The result—BACnet®—is a package that was designed to meet current, as well as future system needs. This option, when combined with gateways, would offer a comprehensive solution. Development of a new protocol, though viable, presents complications as well, because availability of the standard is only the first step. After the standard is available time must

be allowed for products to be developed that apply the standard.

This general coverage does not address many of the basic issues being considered by controls manufacturers and the ASHRAE Standards Committee. The articles that follow will shed more light on many of these issues.

WHERE THE INDUSTRY IS HEADED

Based upon the drivers and issues that have been outlined in this article, options for users include two protocol standards for networking and communication. Though some would say that LonWorks® is not a standard, but an open communication protocol controlled by a company, for our purposes it appears to be a *defacto* standard. Each of the standards, or any option considered, must be evaluated by the user to ensure that it meets requirements for any particular project. Timing and cost must also be considered because application of a standard may require an investment in time and dollars. As appropriate, users will likely continue to need gateways to utilize and integrate existing technology. These options make it possible to integrate control systems with one front end, thus simplifying use and interface with these systems.

The establishment of a standard protocol is exciting, challenging and necessary, but will never outweigh a clear and explicit statement of requirements. It is now more important than ever for managers to become conversant with the language of protocols, and to track the progress of this effort. This is because options for new and existing systems will be affected by whatever action is taken. It is also important because information is critical to the effective management of systems, and access to data is dramatically affected by this issue. Also, system communication remains the best means of maintaining their controls and ensuring their overall performance. And the topic of protocols cannot be separated from any discussion of system communication.

The best first step that each individual, and the industry, can take is to understand your present and future requirements for a DDC system, and how a standard can impact those needs. With this information it will be possible to make intelligent and effective decisions about the communication products that make sense for our industry.

ABOUT THE AUTHOR

John J. "Jack" McGowan, CEM.—During his 20 year career in energy, business and government, McGowan has been:

- Business development with Johnson Controls, Inc. working on energy and water efficiency projects for educational institutions, state and municipal customers.
- Director, New Mexico Energy Conservation & Management Division (EMNR Department)
- Honeywell Market and Product Development Manager
- Principal with a Direct Digital Control installation & contracting firm and
- Corporate Energy Manager with a Fortune 500 retail firm.

McGowan published five books and numerous articles on business and technical topics, including:

- *Distributed DDC, A Guide to Building Automation*, Fairmont Press / Prentice Hall, 1995
- *Networking For Building Automation & Control Systems*, Fairmont Press / Prentice Hall, 1991.
- He is the author of over 25 articles and technical papers, and is a regular speaker at national and international conferences, and association meetings.

McGowan has taught seminars on open systems and related topics for the Association of Energy Engineers in the United States and the Centre for Management Technology in Southeast Asia. He also teaches technical and business courses at the University of Phoenix and the University of New Mexico.

Mr. McGowan was named "International Energy Professional of The Year" in 1997 by the Association of Energy Engineers (AEE). He also received a "Professional Development Award For the Western United States" in 1991 from AEE. He has been listed in Who's Who in the World (1999), Who's Who in Science and Engineering, in the Second (1994-1995) and Third (1996-1997) Edition, Marquis / Reed Publishing.

McGowan is a Certified Energy Manager (CEM), Certified Cogeneration Professional (CGP), Certified Lighting Efficiency Professional (CLEP), and Certified Demand Side Manager (CDSM).

Johnson Controls, Inc., Controls Group, 3840 Commons Ave. N.E., Albuquerque, NM 87109; 505-345-6221; fax 6779