PRACTICAL CONSIDERATIONS FOR PROTOCOL STANDARDS

A realistic look at how open/standard protocols will meet designers' and operators' needs for improved interoperability among HVAC equipment and control systems of different manufacture

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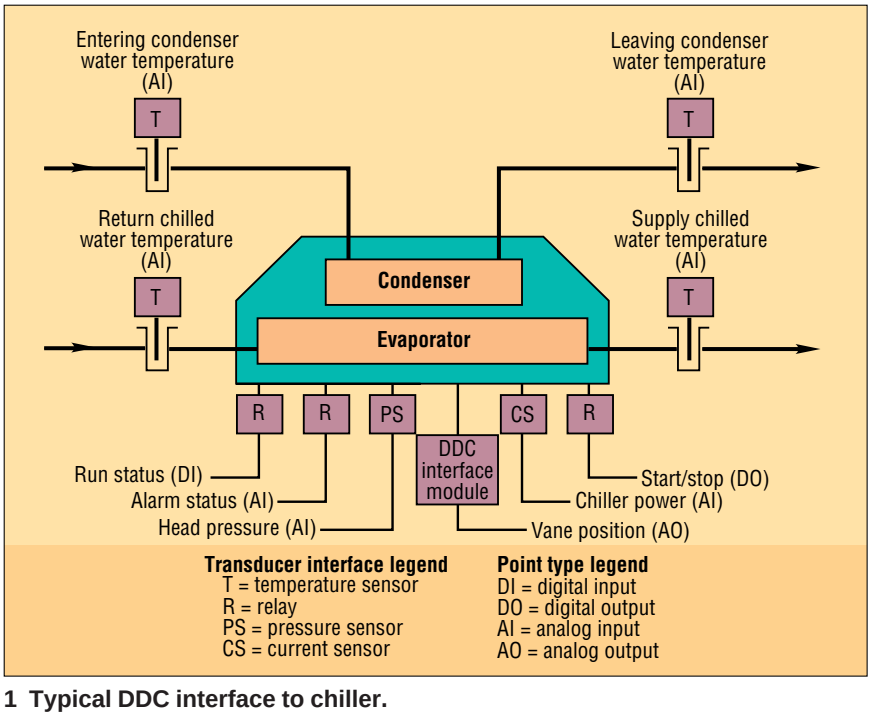
Oscar Wilde, a cynical observer of modern mankind's follies, once observed "When the gods wish to punish us, they answer our prayers." I fear this insightful commentary is soon to be visited upon the building construction industry. For some years, I have heard my colleagues carp about the lack of progress toward a standard protocol for DDC systems. Well, soon such standards will exist, and for many it may well become more of a punishment than a blessing!

Those with hands-on DDC systems experience must shudder at the thought of having multiple DDC systems on a single network. While a standard in communication may lead to a uniform mechanism of displaying data and issuing commands to individual system points, operators will still have to cope with the differences among the various systems in changing programs, displaying trends, and point database operations, not to mention dealing with the idiosyncrasies of each different system. Furthermore, knowledgeable operators must surely wonder to whom they will turn if the network performance does not meet expectations. What if controllers are not receiving necessary information from others of different manufacture, or what if it takes too long for operator displays to be updated?

On the other hand, designers and operators are beginning to understand the need for improved communication capabilities among components of different manufacturers. Virtually every piece of mechanical and electrical equipment used in buildings today comes factory assembled with some type of microprocessor control module. Requiring each manufacturer to be compatible with a particular control system to integrate the control of all components is becoming increasingly expensive and slowing the pace of technological advancement that is so important to our industry today.

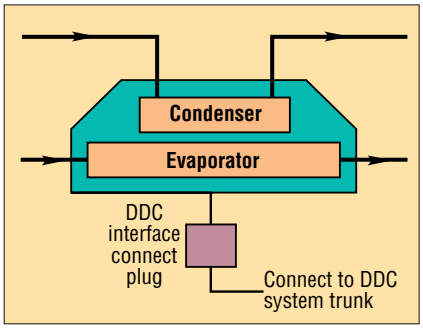
Importance of controls

Some in the industry question if all this emphasis on controls is really necessary. The answer should be obvious. For years, studies



1 Typical DDC interface to chiller.

have shown large numbers of office workers are dissatisfied with the workplace comfort and air quality. The underlying problems only rarely involve a lack of capacity of HVAC components to provide necessary heating, cooling, or ventilation. Rather it is almost entirely the lack of proper control—particularly zone control—that breeds this dissatisfaction.



2 DDC interface to trunk compatible chiller.

A major roadblock to HVAC designers' understanding of the need for improved controls stems from our industry's historic assumption that uniform temperature and ventilation conditions within each building will adequately satisfy all occupants, and that under normal occupied conditions, the internal loads throughout a building are reasonably uniform. Acceptance of this assumption has reduced the requirement for effective controls in the minds of many designers. However, the notions that uniform load conditions actually exist in buildings today and that uniform comfort conditions are acceptable to building occupants need to be reconsidered. Studies have found that the perception of ideal comfort and air quality may vary substantially among individuals. More recent studies are also showing a strong link between worker productivity and ability to control space conditions. Complicating the picture are the increasingly large variations of heating and cooling loads within areas of buildings today.

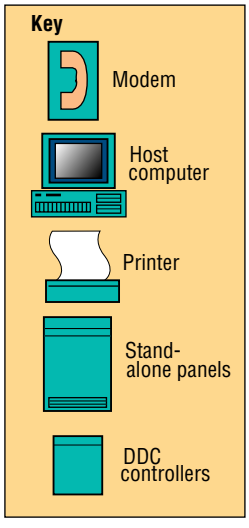
Architects and interior designers have traditionally worked to design buildings and spaces that are visually attractive and inviting. HVAC designers are now beginning to realize they must design mechanical/electrical systems that are environmentally attractive and inviting. As building owners and managers are learning to exploit their tenants desires for improved comfort and air quality, our industry is having to learn how to design HVAC systems that provide improved individualized terminal control. The major difference between such systems and the systems of today is the high level of integrated controls required to provide such conditions economically.

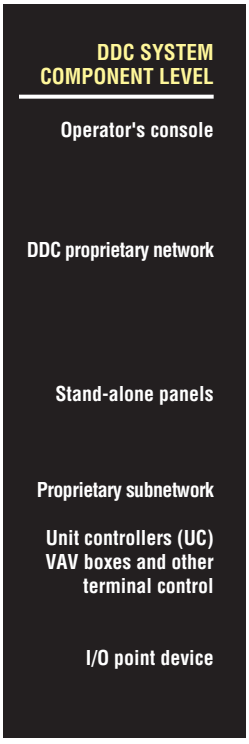
Pitfalls of protocol standards

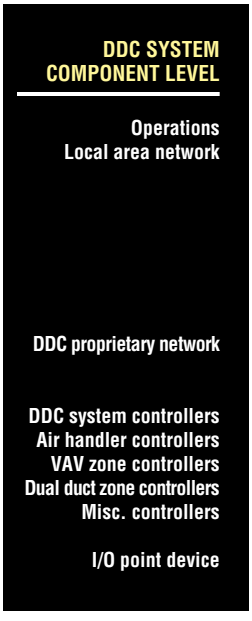
Some designers and building operators believe the development of communication protocol standards will solve our industry's problems with controls by simplifying the process by which control systems are designed and procured. These individuals may still believe a standard protocol will permit designers to treat DDC components as they remember treating pneumatic controls components—as interchangeable components. This is an unrealistic expectation for DDC-based systems. The utter simplicity of pneumatic controls, along with long-standing competitive forces, required each pneumatic control manufacturer to manufacture pneumatic devices that were functionally identical to other products. DDC controls by contrast are orders of magnitude more complex than pneumatic-based controls, and manufacturers have chosen substantially different development paths for their products. While many in the industry believe communication standards may foster a competitive environment in which certain functional characteristics are encouraged, even an optimistic scenario puts widespread interchangeable DDC products well beyond the horizon.

The introduction of standard communication protocols will not make controls design easier. Rather, it will add significant pitfalls in the path of such design work. Controls designs that rely on substantial intercommunication via standard protocols among products from different manufacturers will require special consideration. Such designs will very likely encounter startup and ongoing operational problems unless the exact nature of the intercommunication requirements are well understood by the designer and clearly expressed in the specifications.

The persisting idea that simply stating that each control component shall be compatible with a particular communication protocol standard will ensure the operational integrity of a DDC system network needs to be rebutted firmly. A



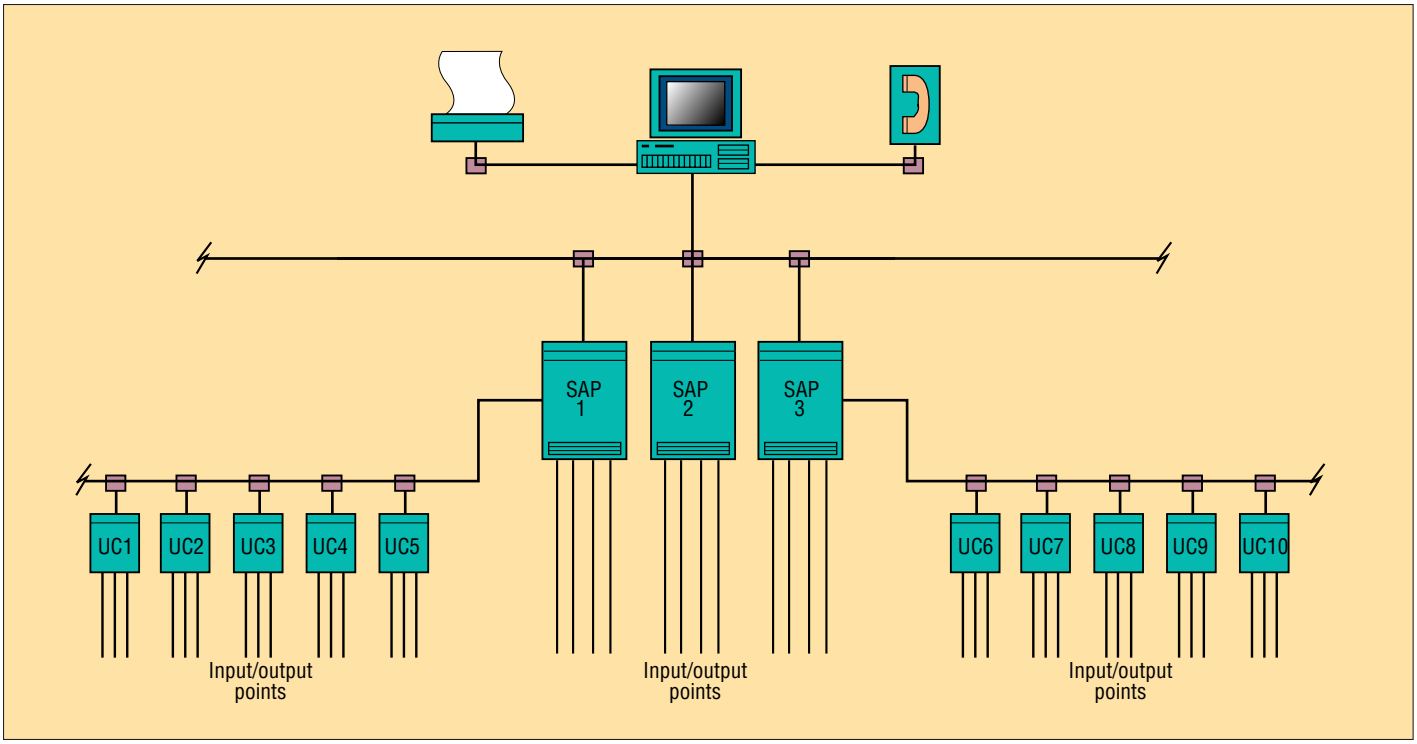




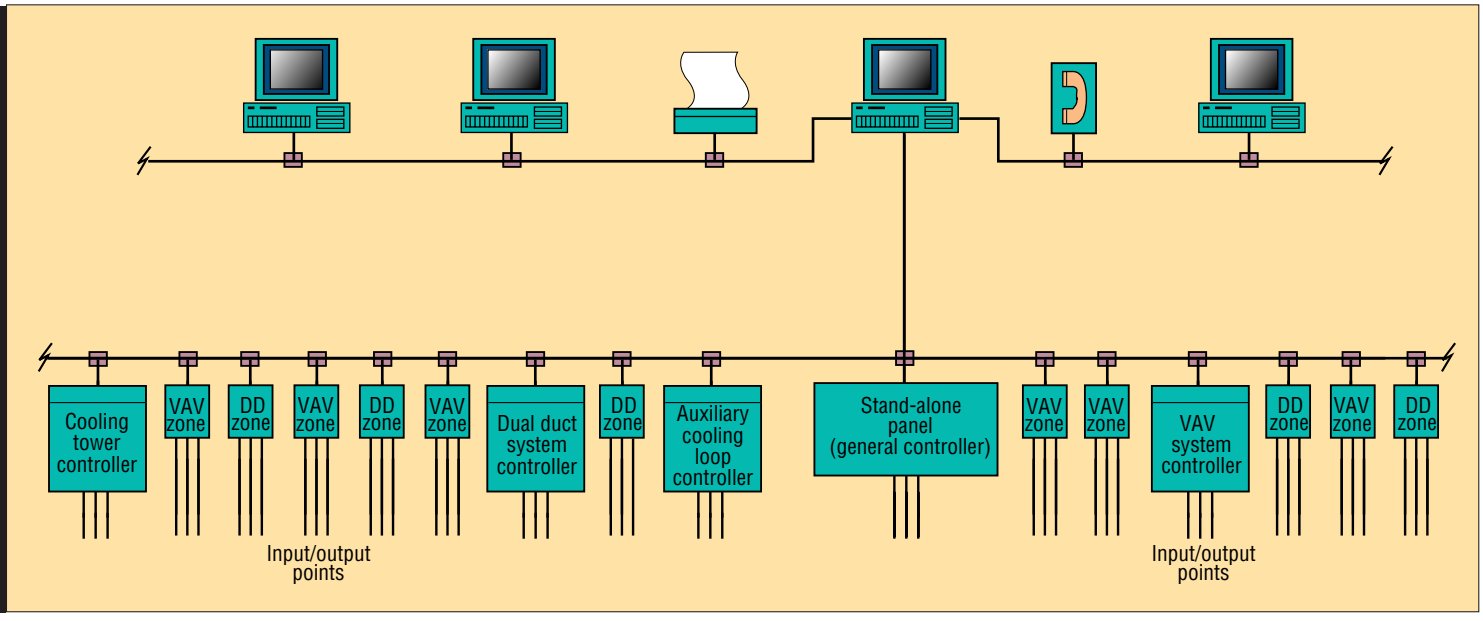
standard communication protocol may ensure that devices coexist on a network but not ensure that they will operate together. DDC controllers that are connected by a standard communication protocol network require the designer to provide a complete description of virtually all aspects of the connection and operating criteria in the specifications so that each supplier understands not only the communication requirements but also the interoperability requirements of the product to be supplied. Such descriptions are well beyond the level of specificity typically seen in building control specifications today.

Opportunities

What communication standards can do is aid those designers who are motivated to improve occupants' perception of comfort



3 Typical present day DDC system architecture.



4 Emerging DDC system architecture.

and air quality by economically integrating high-performance controls into HVAC and electrical systems. Knowledgeable designers will have the ability to employ standard protocols to develop more effective HVAC control strategies with economy. To show how this is possible, consider the integration of a standard centrifugal chiller with a building control system that is of different manufacture than the chiller. Traditionally, many such chillers have operated quite independently of the building controls. Such chillers often start and stop based on outside air temperature rather than demand for cooling and usually operate to a fixed preset chilled water temperature rather than what is required to meet current conditions.

Experienced designers know that such operation is often counterproductive to both comfort and economy. The chiller plant may operate many more hours than necessary, and the fixed low chilled water temperature set point may make it uneconomical to reset supply air temperatures upward in cool weather for improved comfort.

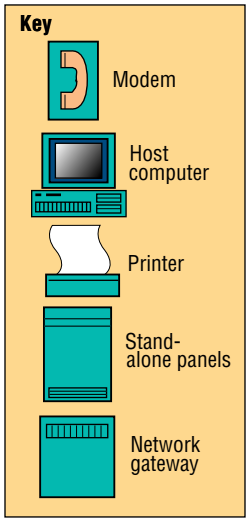
To achieve improvements in comfort and economy, many designers now look to integrate the chiller operation into the overall building control strategy. Fig. 1 illustrates how a typical DDC system instrumentation configuration can accomplish this. This interface includes a total of 10 DDC system points and would likely cost from $3000 to $6000 to accomplish. While the exact number of points and associated cost will vary depending on the interface requirements, the introduction of a standard communication protocol between the two systems will almost always reduce the interfacing cost. Fig. 2 shows how simple it may be to connect such a network.

However, simply having the capacity to connect a piece of equipment to a network does not ensure the equipment can be made to operate as desired. The chiller operating program may not permit the unit to be started or stopped over the communication network, or it may not permit the chilled water set point or the demand limit to be adjusted over the network. These features are operational and are not included in communication standards, but they are of critical importance to ensuring the success of the overall HVAC system operation.

To be certain a communication network that relies on a standard protocol operates effectively, system designers must very carefully select *all* operational features that must pass across the network to components of different manufacture and then be certain that these features are provided by the vendor. As time passes and our industry gains more experience with protocol standards, a number of operational features are likely to become universal. But initially, a great deal of diligence on the part of designers will be required to ensure we are not punished as our prayers are finally being answered!

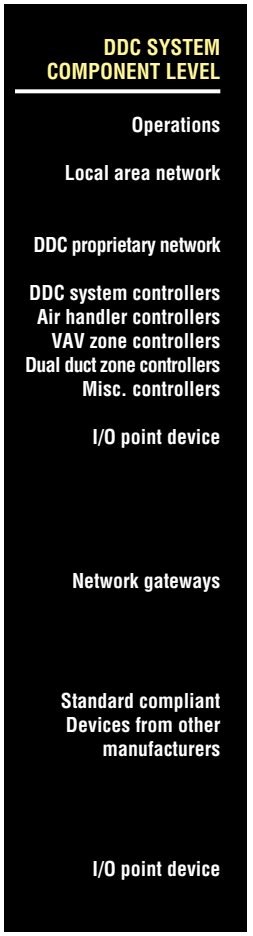
State of standards

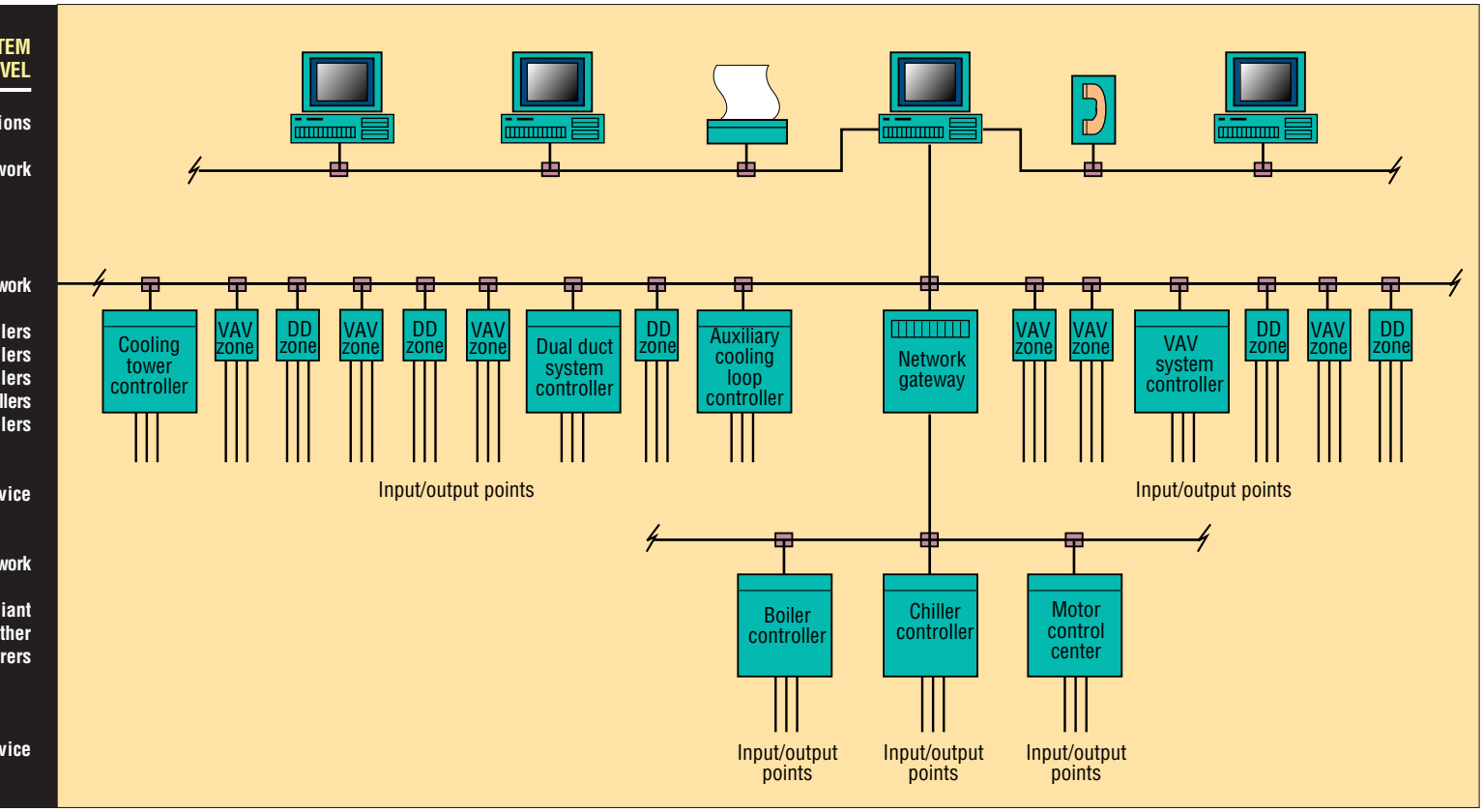
Currently, there are two major efforts underway within the industry to introduce communications standards, both of which are likely to have significant impacts over the next few years. The ASHRAE Standard 135P committee has been working diligently now for seven years to develop a communication standard. This standard is focused on HVAC controls and is expected to be released within the next year under the name BACnet. While the BACnet effort is to be applauded as a true "grassroots" movement, it should be approached with caution because it will likely be released without a definitive compliance testing format. Because compliance testing may initially be voluntary, manufacturers can claim compliance without demonstrating that such



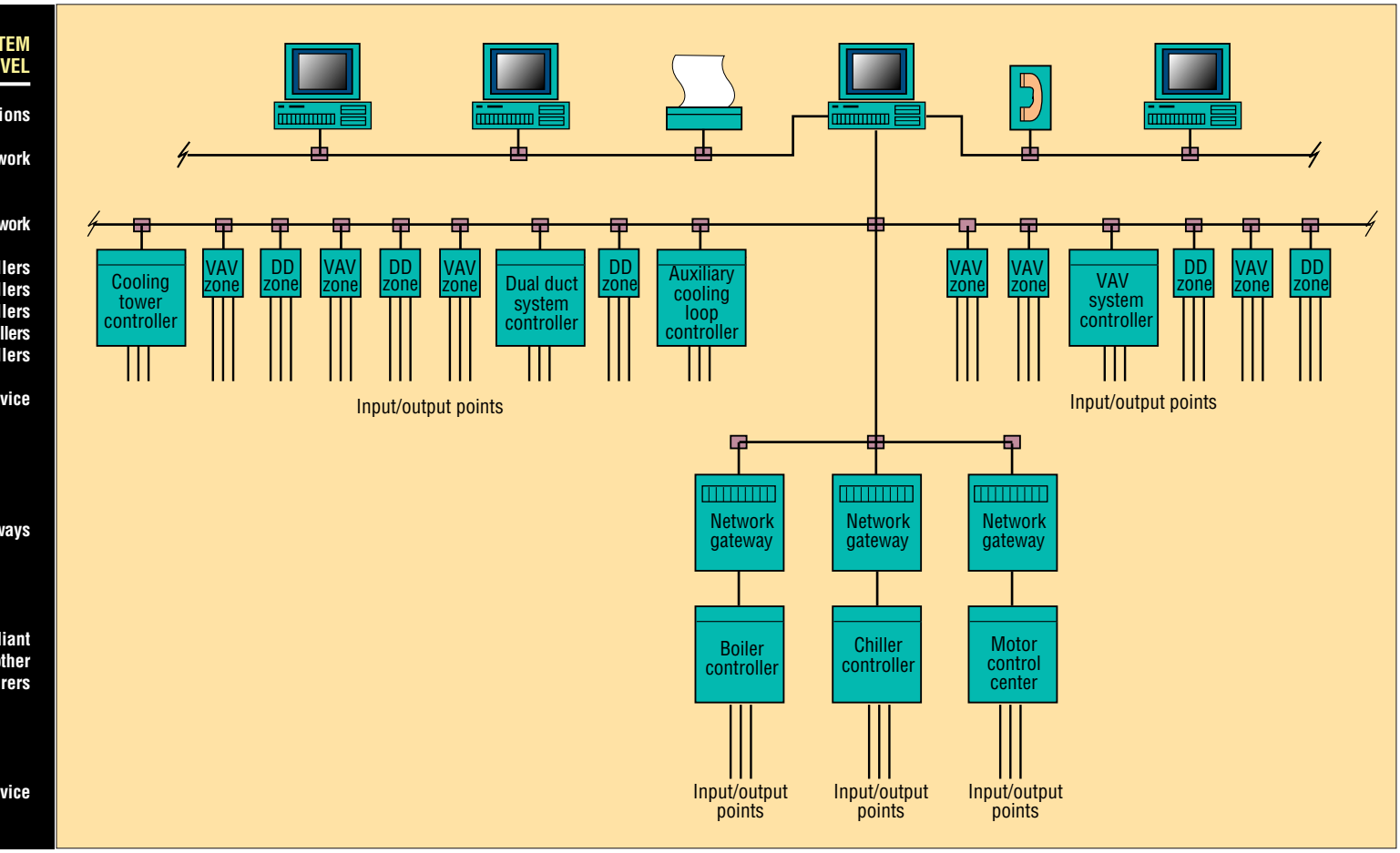
compliance actually exists. In fact, manufacturers have already claimed compliance to BACnet features in their communication protocol. Since the final standard does not yet exist, these claims are obviously exaggerated. Designers should not react negatively to such claims because they may be demonstrating manufacturers' good faith effort to support industry standards. But while we welcome such bold behavior by equipment manufacturers, we must also understand that in the short term, a high degree of diligence will be required on the part of designers to interconnect components in the BACnet environment successfully.

The second major protocol standard effort in the industry has been developed by Echelon, an independent com-





5 DDC architecture with gateway to standard protocol network.



6 DDC architecture with gateways to standard protocol devices.

puter communications firm. This firm hopes to be the supplier of choice for communications chips in a fashion similar to the way Intel supplies microprocessor chips to the computing industry. Echelon's product is called LonWorks. The concept behind LonWorks is that computer manufacturers whose products require communication among processors can buy these chips, which are preprogrammed to provide the network services. Such a scheme may be attractive to manufacturers because they could concentrate their efforts on the performance of their products and not on communications issues.

Echelon is in the business of selling chips and development packages and is not really concerned with what protocol is employed in its chips, so long as it works. In that sense, Echelon is not really competing with BACnet. In fact, Echelon asked the ASHRAE Standard 135P committee to approve it as one of the environments for operating BACnet, but the committee turned Echelon down. Echelon has already developed its own proprietary protocol and has aggressively entered the DDC system industry marketing its chips to operate with that protocol.

Protocol wars

HVAC designers are soon to find that BACnet, LonWorks, and a number of open protocols that are being offered by some manufacturers will be competing over the next few years to set the standard for building control communications. For LonWorks, the motive is financial; for BACnet, the motive is more altruistic. If BACnet is found to be a workable standard, and if our industry has the energy and finds the resources to support, improve, and extend the standards, then it may very well flourish. Otherwise, BACnet will likely wither on the vine and be limited to a few esoteric applications noteworthy only for their distance from the beaten path of DDC technologies.

The key to the success of LonWorks will be cost. DDC manufacturers incur costs both in purchasing each LonWorks chip as well as the expense of developing interfaces to their controllers. The current explosion in distributed processing for DDC systems today means that a typical building of the future may employ hundreds or thousands of separate DDC controllers communicating together. What looks like a small marginal cost for an individual controller may soon become a large cost in an increasingly competitive environment. For LonWorks to be widely employed, it will have to compete with the costs of employing BACnet or proprietary communications networks in such installations.

Implementing standards

While the rapidly approaching competition for the hearts and minds of communication networks may become interesting, HVAC designers will do better if they take a very practical and conservative approach over the next few years. Designers should understand that a far more important development is now underway in the DDC industry. Fig. 3 shows DDC system architecture as it commonly exists today. The basis of many DDC systems today is the stand-alone panel (SAP). Generally, unitary controllers that operate terminal boxes or other unitary devices exist on subnetworks at the SAP level. However, networks of the future are more likely to connect all controllers at a single network level. Such architectures have been shown to improve the consistency of controller operation as well as integration capacity. Such future control networks may more closely resemble that shown in Fig. 4. Additional devices such as communication controllers and/or routers may be employed to direct messages along this busy network.

Many manufacturers are now developing networks similar to that shown in Fig. 4. This network configuration makes every controller more like the stand-alone panel with which we are familiar. As this trend toward further distribution of processing capabilities continues, the demands upon the communication network are increasing rapidly; and fast, efficient communication networks are becoming necessary.

It is within this environment that manufacturers are now being asked to develop standard compliant networks. These new demands on throughput brought on by the increasing distribution of processing resources make control manufacturers nervous (and should make designers nervous too!), especially when they are being asked to connect to equipment manufactured by others as well.

Designers need to be very careful about their designs that depend on standard networks to connect components of different manufacturers to operate together. To be certain adequate accountability exists when the equipment is installed, the following rules should be followed in developing such designs.

- Focus control system specifications on a complete system that will be the responsibility of a single vendor.
- Require that the control system vendor supply the gateway to the protocol standard network(s) that will be employed to connect equipment of different manufacture.
- Include precise descriptions of information that must be exchanged between the control system and equipment that may be of differing manufacture. Such descriptions must be included in the control specifications and the equipment specifications as well.
- Include a procedure for assessing and resolving network problems that may appear. Remember, startup failure is only one possible problem and probably the easiest to solve. Occasional

malfunctions or sporadic losses of communications may be more common and certainly are more troublesome types of networking problems.

Until the industry has more experience with the emerging protocol standards and their use in DDC networks, I recommend that designers develop their designs around gateways. Fig. 5 illustrates a DDC communications gateway connecting a chiller, boiler, and motor control center to a DDC system network. The gateway may or may not be an actual physical device, but it is a point of responsibility transfer. The DDC system vendor is responsible for maintaining the DDC system network and gateway. The chiller, boiler, and motor control center manufacturers have the responsibility of providing and accepting information as selected in a format compatible with the standard network.

Initially, I recommend designers consider a separate gateway for each different manufacturer's equipment that is intended to be interfaced to the DDC system. Such a network is shown in Fig. 6. This approach limits the finger pointing in the event of an interface problem to no more than two separate entities. It also may provide clues to the culprit. For example, if the chiller and boiler are communicating well with the DDC network but the motor control center is not, then likely the problem is in the motor control center controller. However, if each is experiencing similar faults, then the problem likely resides in the DDC gateway module.

Things to remember

The imminent arrival of communication standards in the building control industry can be an enormous opportunity or a punishment, depending on how they are employed. Building operators and designers who look to communication standards as a means of simplifying the procurement and operation of building control systems may be very disappointed with the results. Those who rise to the challenge and put forward the extra effort to provide effective controls designs will find that protocol standards provide more economical interface capabilities, resulting in integrated control strategies never before practical. At least for the short term, designers should be very cautious with the application of networks employing standard protocols. Selection should clearly and completely describe all communication and interoperating requirements and establish accountability in case of problems associated with such networks. Ω