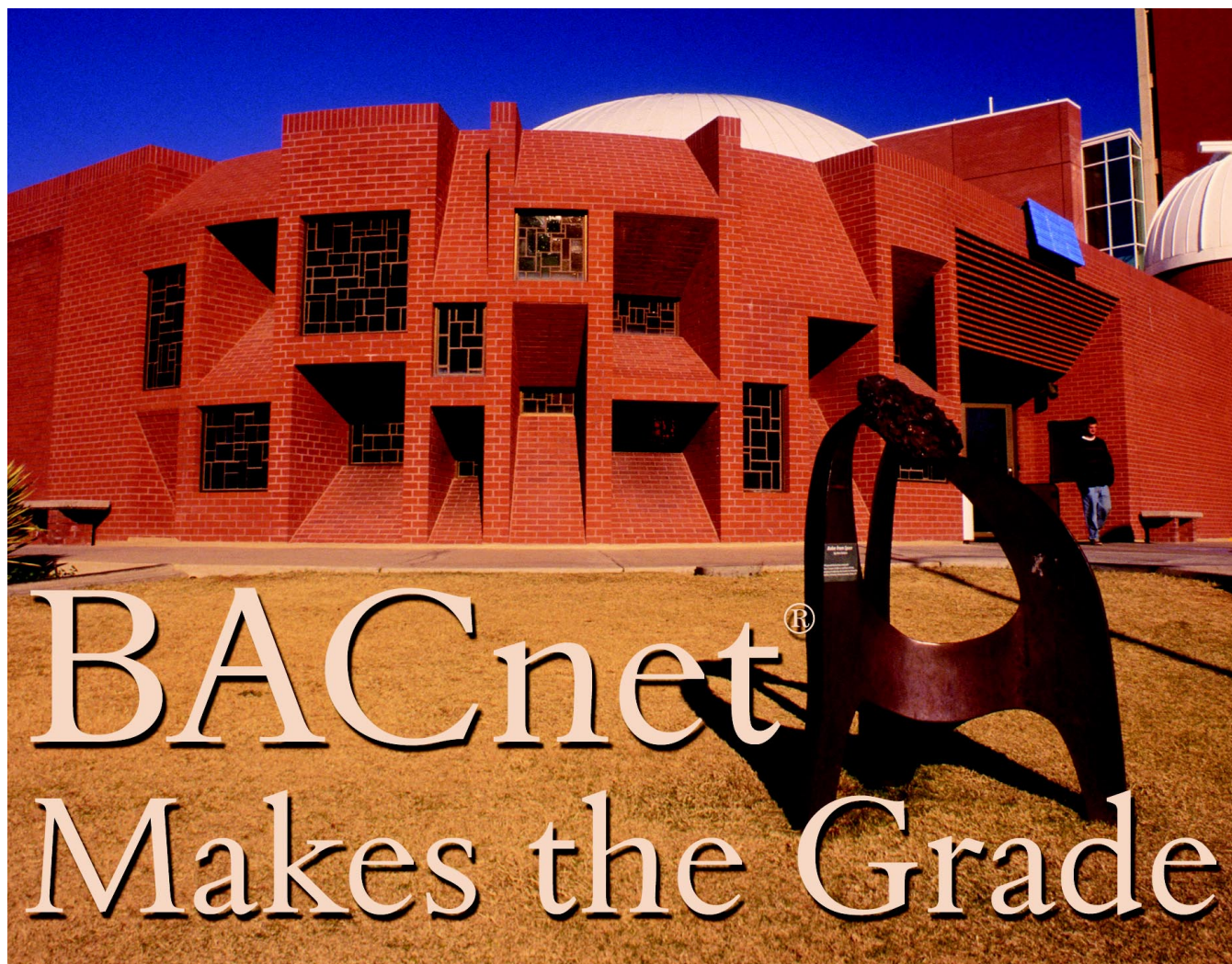


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By Steve Tom, Ph.D., P.E., Member ASHRAE

What do you do if you need to integrate fire systems, security systems, utility systems, and energy management systems made by more than 35 different vendors, located in 435 buildings, and spread over an entire state? And what do you do if some of these buildings are high-tech research facilities, where accurate control, fast response, and secure communications are absolutely essential? Now consider that the system needs to be operational all of the time, no excuses, but the budget and labor hours for this project are *not* unlimited. What do you do? You choose BACnet, of course.

The University of Arizona was faced with the same situation that plagues many campuses. New building construction and building retrofit projects spread over many years left them with a variety

of HVAC control systems, representing several generations of products made by multiple manufacturers. Some buildings were still controlled by pneumatics, and the rest were controlled by a diverse as-

sortment of direct digital control systems. Similar conditions existed in their fire, security, and utility systems. University officials knew they could improve the performance and efficiency of these systems by tying them all together in a unified monitoring and control system, but it was a daunting challenge.

The approach they chose was to use a standard protocol running on the campus Ethernet system as the backbone for their control network, and to tie each building into this network, project by project. In-house facilities staff handled some projects, and some were competitively bid using prequalified suppliers. Before any of these projects could begin, however, they had to choose a standard protocol.

435 Buildings, 35 Vendors, 1 Protocol

"We chose BACnet because it was the most readily adaptable protocol for integrating existing equipment and for adding new equipment" said Joe Branaum, manager of the Integrated Systems Group at the University of Arizona. "The fact that it is an open protocol was very important to us." Indeed, the flexibility and openness of BACnet allowed them to write custom programs for their SCADA (Supervisory Control and Data Acquisition) computers to allow them to gather data over the BACnet system and analyze system performance. These

computers didn't just pull information from the HVAC system, they also pulled data from multiple vendors' fire, security, utility, and energy management systems. They named their integrated campus BACnet system "BACNIE[®]" for Building Automation Control and Network Information Exchange.

Once a standard protocol was selected, they evaluated several vendors' front ends, comparing the features and capabilities against their needs. They performed hands-on testing of the most promising candidates, and eventually settled on a Web-based system. This system gave them the power and flexibility they needed, was compatible with their modified BACnet protocol, and allowed them to access the system from laptops, desktop computers, and cell phones. It also allowed them to easily create custom Web pages that served as the system graphics, a capability that's especially important if your system includes equipment like a scanning electron microscope not found in most HVAC systems.

Having selected a network standard and a front end, the next step was the actual programming to bring data into the system and tie it all together. Since they were primarily tying into existing control systems that were not BACnet, this involved a lot of point mapping in gateway (translator) modules, integrating data from multiple proprietary protocols into the BACnet system. To date, they have brought approximately 38,000 points into the system. This effort included much more than simply programming the gateways to translate data into BACnet. Since the building-level control systems did not use BACnet trends, schedules, or alarms, these features needed to be programmed into the front-end computers. Trend data, for example, had to be gathered, one value at a time and archived in the front end.

The front-end computers also maintain building schedules, writing stop or start values to the building equipment at the appropriate times, and monitoring specific points to generate alarms if their value went outside acceptable limits. This approach increases network traffic, and a potential drawback to doing all of these functions at the front end is that the network must be operational 100% of the time, or data and control functions may be lost. The facilities staff works closely with the

Center for Computing and Information Technology (CCIT) department during the planning phase before bringing a new building online, ensuring the network wiring, IP addresses, and all other networking requirements are worked in advance and there are no last-minute surprises.

The engineering effort also includes preparing custom graphics for the user interface, writing custom reports to analyze system performance, and building software to integrate the operation of what used to be independent, stand-alone control systems. The effort to date has required more than 2,800 labor hours of work by two engineers. That works out to less than five minutes per point — not bad when you consider all the translations,

graphics, and other programming involved.

Has all of this work been worth it? Definitely! Funding has come from a variety of sources, including Energy Service Company (ESCO) projects that require careful documentation of the performance and payback. The university was practicing energy conservation before the new system went in, but even so the payback period for integrating an existing building into the BACnet system was under five years. They also found they could throttle back their fans and pumps when a building was not at peak load, extending the equipment life as well as saving energy. The extensive trending and analysis performed through their BACnet integration also allows them to run their campus utilities more efficiently. By correlating energy consumption, weather, building usage, and other factors, they can now forecast energy demand 12 hours in advance, allowing them to make optimum use of their cogeneration plant generators. As they gather more data and more experience, university officials hope to be able to forecast demand three to four days in advance.



The university's administration building.

The benefits of integrating multiple systems through BACnet are not limited to energy savings. Maintenance personnel can monitor fire systems, utility systems, and security systems as well as HVAC systems through a common “point and click” interface. Maintenance also benefits from the trending and data analysis capabilities of the system, as in some cases they can spot potential problems and schedule maintenance before equipment fails. *Figure 1* shows an example of a trend that spotted an imminent problem with an electric motor and allowed them to replace it before the bearings failed.

The Web-based nature of the University of Arizona system also provides additional benefits. Engineering, maintenance, and other facilities staff can access the system from any computer on the university network, greatly improving accessibility. Technicians can carry a laptop computer with them and plug into any available Ethernet port to adjust or troubleshoot the system. Key personnel are provided with Web-enabled cell phones, which can also be used to access the system. The alarm network is configured to automatically send e-mails to appropriate maintenance personnel when something goes wrong. Thus, a technician can receive an alarm on via cell phone and then use the same phone as a browser to troubleshoot the system. Of course, the amount of text and graphics that can be displayed on a cell phone is limited by the size of the phone’s display. However, if the technician needs more information, a laptop PC can be plugged into the cell phone to connect to the Internet, and the technician can access the full capabilities of an operator workstation — anywhere — any time. Some indication of how powerful this feature can

be is indicated by the fact that the university originally planned on a full-time alarm center, attended by two people 24 hours a day, to handle emergencies and after-hours calls. Experience shows an alarm center is unnecessary, as the same capabilities can be provided by on-call personnel, working from home, with a cell phone and laptop. They can handle

most situations without driving to campus, either by fixing the problem over the phone or by diagnosing the problem and calling the appropriate on-duty maintenance person.

Integrating the diverse HVAC, fire, security, and utility systems into a unified system was a major undertaking that required much cooperation. Within the facilities management group at the University of Arizona, engineers and technicians responsible for all the affected systems

worked together and formed a Centralized Computer Command (C-3) team. They worked closely with various university vendors to implement the Web-based operator interface. They also worked closely with the Center for Computing and Information Technology staff on the university to ensure a smooth integration of the BACnet system into the campus Ethernet network. (This may seem like an obvious requirement, but on too many projects of this type it is overlooked until the last moment, leading to confusion and conflict between the IT staff and the facilities personnel.) Finally, they had what Branaum describes as the most important thing to make a project like this work — support from the campus administration. “They understood the importance and benefits of this project,” said Branaum. “And gave us the support we needed.”

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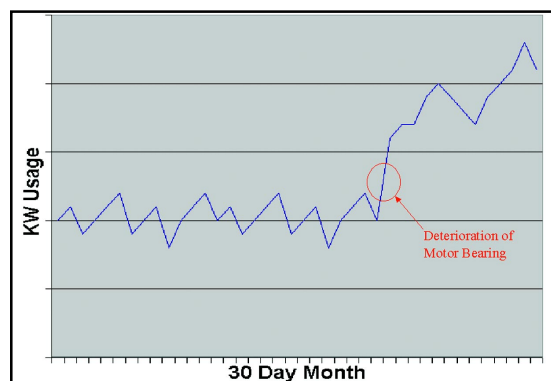


Figure 1: Trend showing failing motor bearings.

Specifying BACnet

The University of Arizona faced the most difficult system integration task imaginable—integrating multiple existing proprietary systems into a unified system. They solved this problem through clever engineering, but how to avoid this problem in the first place? How can a specifying engineer ensure all new control systems conform to the BACnet standard, without getting tied to a sole-source vendor, and without spending hours and hours studying network protocols? One solution is to use CtrlSpecBuilder (Control Spec Builder), a free online tool for preparing HVAC control specifications.

CtrlSpecBuilder is based upon ASHRAE Guideline 13-2000, *Specifying Direct Digital Control Systems*. Using a simple point-and-click interface, a specifying engineer can select the types of equipment to be controlled, including configuration options such as the run conditions, damper controls, number of DX stages, etc. They can also select overall

project options, such as new construction vs. retrofit, whether or not a Web-based interface is required, and even whether or not BACnet will be required. CtrlSpecBuilder will automatically generate a project specification, including point lists and sequences of operation for the equipment included in this project. If a project includes special equipment not included in CtrlSpecBuilder’s menus, the user can create a custom piece of equipment and define their own points list and sequence of operation. The completed specification can then be downloaded as a Microsoft Word file. If the user chooses, a copy of the specification can be maintained online for later revision or for review by others.

As with any technique to simplify the writing of specifications, the completed document needs to be carefully reviewed and approved by a qualified engineer. There may be unique aspects to the project that require revisions, but revising a document is a lot easier than starting from scratch. For more information, visit www.CtrlSpecBuilder.com.