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# Learning Lessons With BACnet®

By Jack McGowan

Nearly two decades ago when the ASHRAE BACnet standards committee met for the first time, the Internet was barely a blip on the radar. The challenges that this group set out to solve were significant, but the outcomes of that standard development have outdistanced its ambitions. For example, the kindergarten to higher education BACnet applications discussed here may come as a surprise to some.

The goals initially tackled by Standards Project Committee 135, which developed BACnet, was to achieve system standardization. Proprietary systems made owners feel locked into legacy product families. The emphasis of automation standards was primarily open systems, and focused on system operations after installation and commissioning. At that time, manufacturers developed custom protocols because easily accessible standards were non-existent for specialized systems like HVAC control. Off-the-shelf software for system interface and to expand system functionality also was limited to spreadsheets.

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The committee clearly understood that this effort was about information. Managing building systems is data-driven and requires access and the ability to manipulate extensive amounts of information. That remains true and is the thread used to weave together case studies in this article.

Today, a host of systems built on BACnet produce comfortable and productive learning environments in schools around the world. IP (Internet Protocol) existed before BACnet. Yet in recent years applications of BACnet based systems that leverage IP, and new standards such as XML (extensible markup language), are making it possible for technology to be deployed in novel ways and to generate benefits that could not have been envisioned initially.

The availability of a standard building automation protocol was needed to achieve enterprise-wide system functionality and benefits. Standardization offers the ability to integrate wide-ranging building systems from air handlers to chillers and other prime movers from different manufacturers.

It becomes really interesting when these familiar systems are blended with information technology (IT), renewable energy and educational technology. Educational institutions discussed here are using BACnet for comfort and to enhance learning opportunities.

The Santa Fe Public Schools system in New Mexico uses BACnet. A BACnet Testing Laboratory (BTL)-listed system is applied across the district.

The BTL ensures that devices conform to the requirements of the applicable standard device profile and *lists* products. By specifying the standard device profiles, it is possible for multiple vendors to compete for future projects.

At the district office, the system optimizes control of heating and cooling, and is part of a fully redundant computer room air-conditioning system. The district had a number of challenges maintaining required temperature in its computer room. This system was the solution when implemented in conjunction with two 5 ton (17.5 kW) HVAC units.

A Web-based interface monitors critical computer room conditions, while a controller provides temperature control and lead lag on the units to maintain this critical environment and avoid

downtime due to environmental conditions. Even more importantly, this controller allows for interface via Ethernet, which makes it possible to communicate over the district network.

In this case the system uses BACnet/IP for Internet monitoring and alarming on computer room conditions 24/7. Internet-based monitoring of graphics such as the one in *Figure 1* has become common with BACnet systems.

In direct alignment with Santa Fe Public Schools' education mission, the controls system controls classroom temperature conditions. Studies have correlated the quality of education with temperature conditions in the classroom. A recent study, *For Generations to Come: A Leadership Guide to Renewing Public School Buildings*, was released by the 21<sup>st</sup> Century School Fund. The guide states that "student achievement is adversely affected by problems with lighting, noise, and temperature—all a result of the design and condition of the school."

Santa Fe schools uses BACnet to create quality learning environments at sites such as Capital High School. It was built in phases during two decades, and has a range of mechanical equipment including constant and VAV air handlers with packaged heating and cooling, boilers and evaporative cooling. The system incorporates direct digital control (DDC) down to the zone level, including VAV boxes and fan coils. BACnet/IP is used at Santa Fe for 24/7 high-speed communication.

The district expanded the system at several schools to include Internet-based digital video surveillance and is also implementing electronic access control. Web-based software is hosted on district servers and allows interface using encrypted IP tunnels for access to systems district-wide.

Santa Fe Schools built the BACnet system on a foundation of building control, but the full range of features includes access control and integration with cameras. Information from building systems is still the critical element, but information on cost of operations is also important.

At Yucca Elementary School in Alamogordo, N.M., cost is a major focus. BACnet control technology is used, but new features take it further. Administrators recognize that enhanced education requires a quality learning environment, which is provided by a controls system.

However, schools across the country also face increasing energy costs. At this writing, oil is more than \$60 a barrel. The price of electricity has remained stable, but natural gas price volatility is hitting schools in two ways. Heating costs this winter will present major challenges for schools. Also, since 80% of power plants built in the last 15 years are gas-fired, more electric utilities may adopt fuel-use charges that will drive electricity costs up.

At Yucca Elementary School, a strategy to address this challenge is the implementation of geothermal heat pumps (GHP) with BTL-listed controllers for heating and cooling. The earth heat exchanger condenser loop is controlled by DDC controllers and variable frequency drives as well. The controller has an Ethernet port to allow the district's local area network (LAN) to be used for interface anywhere, anytime, and also uses BACnet/IP for Internet access.

Shared network infrastructure has been widely discussed, but because of viruses, worms and other data system threats, many network administrators will not support this approach. The system integrator company worked with the district's networking team to assign IP addresses to controllers and build in data security. The integrator used Secure Sockets Layer-based security for data protection and integrity.

The school district also has integrated energy generation with classroom comfort. This technology incorporates a BACnet system for energy efficiency with renewable energy, including GHP systems and solar. Later this fall, when the system is fully on-line, it will include a photovoltaic solar electric generation array. With BACnet/IP-based enterprise energy management, the system monitors building conditions and solar electricity generation.

Another use of BACnet that likely was never anticipated is using system data in the curriculum. Organizations such as the National Energy Foundation ([www.nef1.org](http://www.nef1.org)) and the U.S. Department of Energy have developed energy-focused learning materials, lessons and activities for use from kindergarten through higher education. A clearinghouse of such materials is available at [www.eere.energy.gov/education/lesson\\_plans.html](http://www.eere.energy.gov/education/lesson_plans.html).

With widespread implementation of BACnet-based automation systems capable of migrating information to the Internet, it is now possible for lessons to become real-time events. Many schools are experimenting with Web pages that allow students to see energy and building systems in action. Many educators are embracing the opportunity to use system data as the basis for math, science and other learning experiences.

Quality learning environments and energy information tech-

nology are not just important in kindergarten through 12<sup>th</sup> grade. Higher education is aggressively pursuing BACnet systems. Fordham University in New York, consists of multiple buildings in the heart of Lincoln Center. The Lincoln Center campus had multiple buildings operating with pneumatic controls, which require continuous maintenance that was difficult for facility staff to complete consistently. It was difficult to track historical performance within the buildings and, therefore, maintaining quality learning environments was a major challenge. As a result, campus equipment operated inefficiently and energy savings were not achieved.

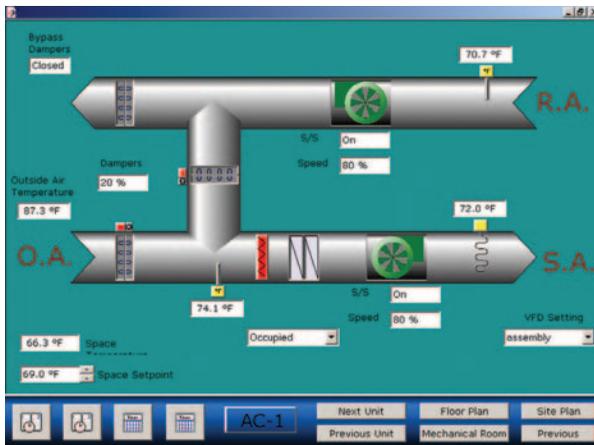
Fordham faced an added challenge common to many university campuses—legacy building control equipment from four different manufacturers. Therefore, the university integrated the legacy systems into a single control system without disturbing Fordham's existing computer network. Working with campus network staff, a BACnet solution was developed to merge the university's existing network. This effort resulted in monitoring of control equipment from four different companies. The system incorporates complicated plant optimization strategies for air handlers, VAV terminal units, boilers and fan-coil units.

Highlighting the importance of information, Fordham implemented a custom-designed Web browser that featured animated graphics, including floor plans that changed color to reflect temperature variations. Doug Mitchell, Fordham University facilities manager, says that plant

equipment is easier to maintain regularly due to accurate load monitoring. The open system allows Fordham's IT department to program and maintain it for longer equipment life. The system has helped the school realize substantial energy savings Mitchell says.

A second phase of this project was recently completed that includes a central plant conversion from absorption to more efficient centrifugal chillers. This system incorporates sequences for one remaining absorption chiller to enable automatic switch-over. This state-of-the-art sequencing allows the university to cool with steam for electric peak shaving or based upon an evaluation of total plant Btu output and kW.

A next-generation strategy also implements automated demand response. Demand response is initiated when an automated SMNP Internet request is received as a voluntary program to help the utility shed power during a peak demand period or to avoid a power outage. The importance of information comes through in this case where energy savings and maintenance management are critical features that extend the system beyond environmental control.



Web graphic of air handler in Santa Fe schools district office.



*The Santa Fe school district uses a BACnet system for energy efficiency with renewable energy, including a photovoltaic solar electric generation array.*

Universities such as Fordham are blazing new paths in the application of energy management and information systems. It is common for universities to span millions of square feet of building space that is used for activities including education, research and health care. These institutions often consist of buildings that are one-year to 100-years old. Deferred maintenance and energy cost are topics of great interest, but equally important, is that most university managers also understand that building and equipment conditions directly impact learning.

Data security is also critical for universities, but current and accurate information is essential. Data must be available at many sites across campuses. Therefore, integrators must be well-versed in network security. Institutions such as Fordham are using BACnet to better control building systems and to improve education, but they also are interested in energy metering for measurement and verification of savings. The recurring themes of control, energy data, information technology and data security can be seen in university projects across the country and world.

The University of New Mexico in Albuquerque is investing in both BACnet and integration technology to provide campus control and energy metering. It has a campus environment spanning more than 10 million ft<sup>2</sup> (930 000 m<sup>2</sup>). It is the largest public research university in New Mexico with more than 25,000 undergraduate and graduate students.

UNM uses BACnet technology from two manufacturers. Before the current integration project, it had legacy systems from seven manufacturers and a metering system. These systems are being integrated with BACnet throughout the campus.

Of significant interest on the UNM campus is a program that the university has started to integrate legacy systems with BACnet-based technology and to further integrate energy metering



*The University of New Mexico has started to integrate legacy systems with BACnet-based technology and to further integrate energy metering and building management data to offer a campus-wide energy information system.*

and building management data to offer a campus-wide energy information system. This is done through facility automation and allows for central and remote monitoring of systems. These BACnet systems are interfaced to the Ethernet fiber-optic campus network and allow monitoring via a Web browser.

These cases demonstrate that BACnet has made the grade. Through further initiatives, it will remain the basis for next-generation systems. Initiatives that are leveraging XML and other standards are being developed. Many BACnet-based interface systems, for example, can export data in XML. Enterprise functionality will become the defining theme of the next decade.

One area where enterprise functions will be critical is energy, particularly with \$60+ per barrel oil. It will be a major issue facing all organizations. BACnet systems also could be a central focus of the transformation from intelligent buildings to intelligent enterprises and ultimately to the intelligent electric grid.

In the future, sequences such as the automated demand response routine at Fordham University will be essential to maintaining electric grid reliability. These systems also will create tremendous energy and cost savings opportunities for schools and universities that would not detract from the learning environment.

Futurists talk about disruptive technologies that completely reshape markets. With the resurgence of interest in energy management, BACnet-based building technologies have that potential. Any technology that blends cost savings with quality learning environments will be worth watching for schools as well as other building owners.

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