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Shanghai Technology Museum

The Shanghai Science and Technology Museum plans displays of its BACnet system so that visitors can see how it works.

By Steve Tom, P.E., Member ASHRAE

When the Shanghai Muncipal Government set out to build the largest scientific and technical museum in Asia, it didn't focus only on the exhibits inside the building. It wanted the building itself to be a showcase for state-of-the-art building systems. It selected BACnet as the building automation protocol.

Covering 17 acres (7 ha) in Shanghai's Pudong financial district, the Science and Technology museum was designed to serve as a major social and cultural center. Built at a cost of $180 million U.S., the museum encompasses more than 1 million ft^2 (96 500 m^2) of floor space. A striking feature architecturally, the museum is built in a semi-circular shape that rises from one story to five stories, from west to east.

Inside, exhibits include a miniature hydroelectric plant, a 7,500 ft^2 (697 m^2) rain forest, a CAD/CAM center where visitors can design and build small objects, and a children's exhibit called Technoland. It also includes an aviary, an aquarium, two IMAX theaters, and an earthquake center — complete with a moving earthquake platform and video displays that allow visitors to experience a simulated earthquake.

President Jiang Zemin of China with U.S. President George W. Bush at the Shanghai Science and Technology Museum in October 2001.

A facility of this magnitude presents a significant challenge from an HVAC standpoint. A Beijing and an American controls firm worked together to design a Web-based BACnet control system with a bilingual user interface. The system included more than 3,200 BACnet control points. An additional 1,000 points in non-BACnet equipment were monitored by the BACnet system.

Control networks included a 10 Mbps BACnet/IP Ethernet backbone, 156 Kbps BACnet over ARCNET subnets, 38.4 and 9.6 Kbps BACnet over MS/TP subnets, and proprietary networks tied into the BACnet system through gateway (translator) modules.

The U.S. firm supplied much of the control hardware, but as shown in *Figure 1*,

'The museum is dedicated to the harmony of Nature, Man, and Technology and contains five major exhibition halls addressing the topics of Heaven and Earth, Life, Wisdom, Creativity, and the Future.'

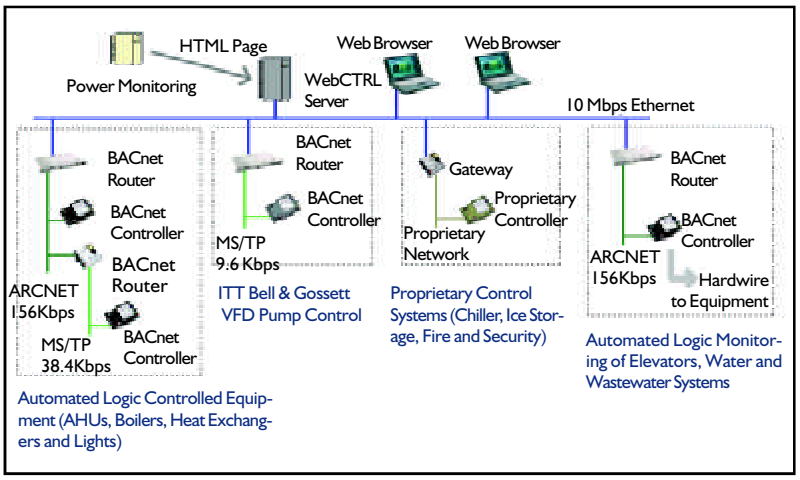

Figure 1: Schematic summary of building controls for Shanghai museum.

many other vendors were involved in the total project. BACnet provided the common protocol for these systems.

Native BACnet controllers were used in the air-handling units (AHUs), boilers, heat exchangers, and lighting systems. With more than 100 air-handling units, 350 separate lighting circuits, 300 fans, seven heat recovery wheels, five heat exchangers, and three boilers, this was a sizable project in itself. The air-handling system consisted of multiple constant volume single-zone AHUs and a large, variable air volume ventilation fan. Ventilation flow rates vary throughout the day based upon an adjustable schedule. Several different arrangements of single zone AHUs were used, depending upon the requirements of the zone. *Figure 2* shows a typical arrangement.

The lighting system consists of individual controllers for zone and room lighting. Lighting levels are controlled based upon adjustable schedules, with local override switches for unscheduled occupancy. BACnet objects and services are used throughout, including BACnet schedules, alarms and trends. BACnet network services (Read Property and Write Property) were used extensively to coordinate the operation of this equipment.

For example, the AHUs depend upon chilled water provided by a central chiller and ice-storage system. The AHUs respond directly to changes in the cooling load by opening or closing chilled water control valves. The position of this valve is communicated to the chiller system through the BACnet network, alerting the chillers to the change in the building load and allowing them to respond accordingly.

Multiple variable frequency drive control panels controlled the chilled water and hot water loop pumps (*Figure 3*). These panels were networked together with a 9600 bps BACnet MS/TP network. Since the panels were already using BACnet, it was a simple matter to connect them to the BACnet/IP backbone and make the temperatures, pressures, start/stop controls, alarms, etc., available to the building automation system.

Several of the building subsystems used proprietary control protocols, including the chillers, ice storage system, fire alarms, and building security system. The chiller and ice storage system used a network of program loop controllers (PLC) that was integrated into the BACnet system through a gateway (*Figure 4*). This allowed the central automation system to monitor and adjust temperatures, setpoints, pump status, etc., from approximately 300 points. Additionally, once the data was brought into the gateway, it was linked to BACnet trends, alarms, and schedules, which were also accessed by the central system.

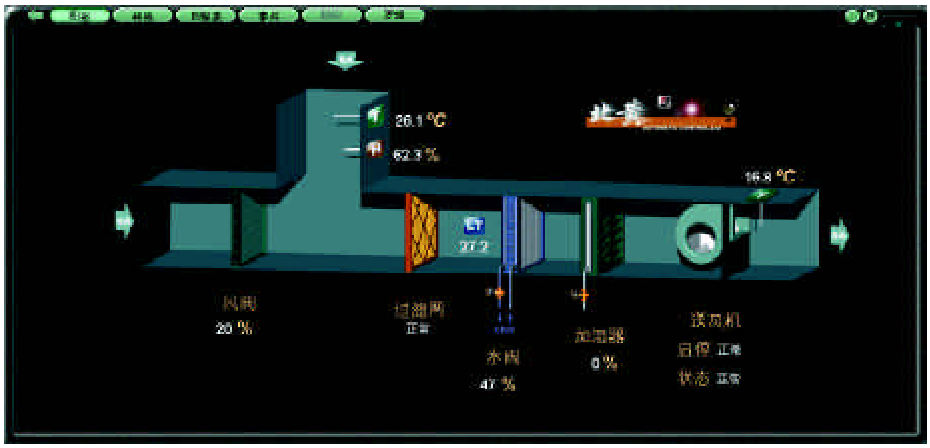

Figure 2: Typical air-handling unit. The museum has more than 100 air-handling units.

The fire and life-safety system was similarly linked to the central system through a gateway. This made approximately 200 data points available to BACnet, including the status of pull stations, smoke detectors, and fire suppression pumps. The gateway module made this information avail-

Figure 3: Variable speed pumps are controlled by variable frequency drive control panels.

Figure 5: The cover graphic for the lighting system. As with many other graphics in this project, it highlights the fact that BACnet is in control.

able to the central system, generated BACnet alarms as appropriate, and controlled safety interlocks with other BACnet equipment such as fans and AHUs.

A third type of interface was used to connect to the elevators, domestic water, and wastewater systems. These systems did not use networked controls but instead were controlled by conventional electric and electronic packaged controls. For these systems, BACnet control modules were hardwired to monitoring points in the conventional control systems. This made the status of these systems available to the building automation system, and also allowed the controllers to generate BACnet trends and alarms based on the data read from the points.

One non-BACnet interface was used with the building automation system. A power monitoring station came with a built-in Web page interface. Since the BAS also used a Web interface, it was a simple matter to integrate the power system screens into the building automation system. However, a limitation to this interface is that it does not provide a machine-friendly interface to the building control system. The HTML data provided by the power monitoring station is designed to "draw" Web pages, which are viewed by the system operator. This operator can then use the BACnet control system to turn equipment on and off and adjust setpoints as required to optimize power use. The HTML data is, therefore, easily integrated into the Web-based front end, but it does not provide automated control.

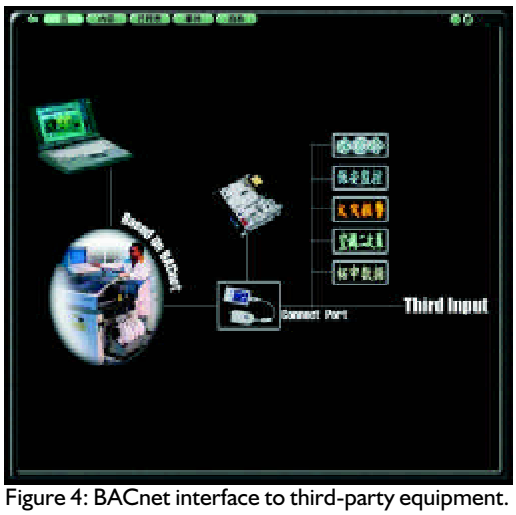

Figure 4: BACnet interface to third-party equipment.

Two major milestones occurred in the construction program. The first was to complete the meeting halls and conference facilities needed to host the Asia-Pacific Economic Cooperation (APEC) Summit in October 2001. The second was to complete the exhibition halls and open the museum to the public. The first phase was completed on schedule and the leaders of 21 Pacific Rim nations met in the museum's new conference center. Following the APEC Summit, construction focused on the museum itself and this opened to the public in December 2001. As with any museum of this stature, construction is never really finished, and new exhibits and facilities are already in the works. Among these is a plan to add kiosks where the building automation system will be on display, and visitors will be able to navigate through the system and see BACnet in action (*Figure 5)*.

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