At AsiaWorld-Expo in Hong Kong, BACnet gateways pull together disparate systems and protocols into one interoperable system.

BACnet® Connects Expo

By Cecil Man and **Raymond Rae,** Associate Member ASHRAE

AsiaWorld-Expo (AWE) is a world-class exhibition and event venue located at the center of an extensive and efficient air, land and marine transport network connecting Hong Kong with China's Pearl River Delta and the world's business capitals. It offers more than 70,000 m^2 (750,000 ft^2) of rentable space for exhibitions, conventions and entertainment events, as well as full integration with a busy international airport and the service of an in-venue railway station.

AWE was not going to be a conventional building. Its usage pattern would change continuously, so owners needed the capability to make changes quickly and easily without being tied to the successful BMS bidder. With a budget of $303 million, AWE is a public-private partnership involving funding from the Hong Kong SAR government and a private sector consortium including Dragages Hong Kong Limited and Yu Ming Investments Limited, with the Airport Authority Hong Kong contributing the land. A major criterion for selecting the building management system (BMS) and the provider was future independence and a spirit of partnership.

BMS Selection Process

Five BMS contractor/vendors prequalified as approved bidders on a functional

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specification. Two short-listed companies then performed live interoperability demonstrations on their ability to interface with the Modbus and Batibus protocols and the selected computer maintenance management system. This interoperability requirement was a major factor in the selection process, as the air-handling units and fan coil units were preordered with factory-installed controllers (which used Modbus and Batibus, respectively).

The complexities of the thermal storage plant dictated that, at the end of the construction phase, AWE personnel would have to be competent to undertake daily operation, modifications and improvements to the system as demanded by the variety of venue usages. To accomplish these ends, a comprehensive training and support program was a fundamental requirement of the successful BMS contractor.

Facility Design Details

Despite the size of the AWE site, the installed equipment is relatively simple. Also, AWE contains several design firsts in Hong Kong, including a thermal storage system using a patented phase change storage medium and the use of textile diffusers in the halls. The diffusers have the appearance of long ducts made of a woven material that "leaks," allowing conditioned air to diffuse gently into the space. The restaurant uses a full fresh air displacement ventilation system, with no recirculation. Air is introduced to the space at a low velocity, (so low as to be almost imperceptible), and extracted via the kitchen exhausts. This has the added benefit of automatically ensuring a positive pressure differential between the restaurant and its adjacent kitchen, eliminating the possibility of food smells in the restaurant. The remaining spaces generally are of conventional design employing a variety of air handlers and return air fans, extract fans, fan coils and primary air units.

"There are many first-time-of-its-kind in Hong Kong, such as the scale of ice-storage, the scale of high-level interfaces, the use of fabric diffuser, and so on. Teaming approach, support and quality service is utmost important in this project. The BMS supplier and the BACnet system have met our expectation," said Jerome Furge, general manager of BYME Engineering (HK).

Physical I/O—2,538 Objects

System	Quantity	Native BACnet Devices
Ice Storage	Three Tanks	
Chilled Water Distribution	16 Pumps	
Exhaust Fan	84	
Smoke Exhaust Fan	25	
Transfer Air Fan	2	
Emergency Generator	4	
UPS	7	
Lighting	350 ccts	
Plumbing And Drainage	Six Sumps	
Plumbing And Drainage	Four Flush Tanks	
Plumbing And Drainage	34 Flushing Valves	
Elevator And Escalator	18	
Security	16 Door Contacts	
Fire Alarm	30 Zones	

Device	Qty	Communications
B-BC	14	BACnet IP
B-AAC	227	BACnet MSTP

Integrated I/O—7,332 Objects Via Gateways in Native BACnet Devices

System	Quantity	Communications
Chiller	9	ModBUS/BACnet MSTP
AHU	92	ModBUS/BACnet MSTP
Fresh AHU	12	ModBUS/BACnet MSTP
Electrical Power Analyzer	54	ModBUS/BACnet MSTP
MCC	37	ModBUS/BACnet MSTP
Low Voltage Switchboard	141	ModBUS/BACnet MSTP
Fan Coil Units	245	BatiBUS/ModBUS/BACnet MSTP

Table 1: Systems, BACnet devices and communications.

Chiller Plant and Ice Storage System

AWE consists of three ice storage tanks, each with a volume of approximately 470 m^3 (16,600 ft^3) and cooling storage capacity of 25 MWh (7,100 ton-hours). Nine rooftop mounted air-cooled screw-type chillers each rated at 706 kW (200 tons) during night charging mode and 1,100 kW (313 tons) during day normal mode provide cooling. The ice-storage tanks are charged during off-peak hours and cooling capacity is released during peak demand hours. Required cooling capacity is projected by an energy consultant's program that estimates cooling demand from raw data such as people anticipated to attend events, ambient conditions, heat generated by indoor equipment and lighting, etc. The projected cooling capacity is fed into the BMS program, which then calculates the optimum number of chillers required to charge the tanks during the off-peak period. The resulting stored cooling capacity is used in the next peak-demand period.

The four major modes of operation are:

1. Tank charging during off-peak period;
2. Tank charging together with chilled water supply to the load when events are in progress during off-peak period;
3. Running optimum number of chillers only (within electrical demand charge limit) during peak demand period to meet cooling load; and
4. Running optimum number of chillers (within electrical demand charge limit) together with tank discharging during peak demand period to meet cooling load. During tank charging, the chilled water, which is a glycol-water mixture, is super cooled to –5.5°C (22°F) to enable phase change at the thermal storage media. During peak demand period, the chillers are running with chilled water temperature at around 7°C (45°F). During discharging, the discharge pumps are modulated based on the cooling demand.

Five variable volume chilled water distribution circuits serve terminal devices. Two port valves regulate the cooling capacity of the terminal devices (i.e., air handlers, fan coils, etc.).

BMS and BACnet Details

The communications backbone for the facility is a 100/10 MB fiber optic Ethernet local area network (LAN). The BMS system has been implemented as a virtual network on this Intranet. The building controllers are mainly located in plant rooms, areas of higher I/O concentrations. Fourteen controllers meet the BACnet building controller (B-BC) device profile all communicating using BACnet IP (Annex J) and connected to the LAN via 10baseT network ports. From these controllers there are 10 MSTP networks (baud rate 76.8 k) going out to the miscellaneous systems within the facility. The controllers connected to the MSTP network meet the device profile requirements of the BACnet advanced application controller (B-AAC) and also act as gateways to interface the large number of Modbus and Batibus controllers that came factory mounted on most mechanical and electrical equipment. The selected B-BC and B-AAC controllers are powerful and versatile. They all have BTL listing and all have local I/O, routing and gateway functions.

Workstations are provided with 100BaseT connection to improve throughput. There are two operator workstations (OWS) located in the plant room and the facility management office and one Web server located at the security control center, which is staffed around the clock. The Web server uses the same graphics as the OWS and permits local access to the BMS via the AWE Intranet and remote connectivity to the site, allowing supervisory staff to connect at a moments notice even during non-shift hours when offsite.

The BMS has more than 900 linked graphics to provide an easy and user-friendly interface for daily and occasional users. Systems monitored and controlled from the BACnet OWS include:

- Fire alarm system, providing fire alarm summary and locations within the facility;
- Security access doors, monitoring vehicle access doors at the halls and linking with fresh air control;
- Plumbing and drainage equipment, status and run-hours for equipment and maintenance alerts;
- Power analysers, monitoring the power consumption of equipment for energy consumption analysis trends;
- HVAC equipment, such as chillers, ice-storage tanks, packaged air units, AHUs, exhaust fans, etc.;
- Lighting controls, based on schedule and usage of the building integrated with light level sensor; and
- Toilet flush water valve control, based on the space usage schedule.

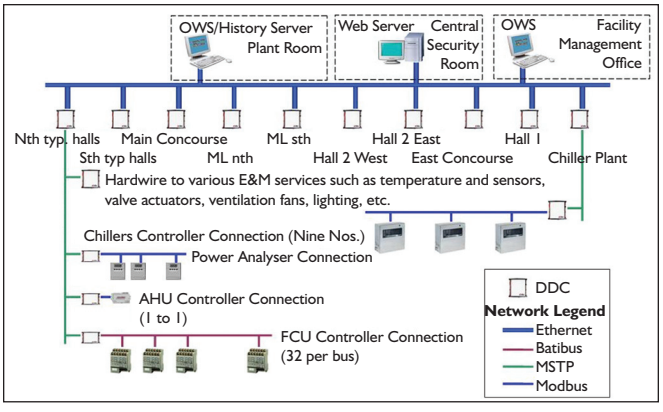

Figure 1: AsiaWorld-Expo system architecture.

There are more than 2,500 physical points for the BMS, more than 7,000 high level interfacing points, and more than 2,000 software points in the system. Also, more than 1,000 other objects exist, such as trends for trending power consumption, chilled water temperatures, totalizers for totalling equipment runtime and accumulation of chilled water flow.

"This simplified BACnet solution is flexible, adaptable,and user programmable, and has resulted in a single-seat operation that makes the tasks of the AWE building management team easier, said Allan Cheung, executive director of Hensen Engineering Ltd.

Delivery of a BMS in a design-and-build project requires effective and efficient coordination by BMS sub-contractor/specialist among all relevant parties to accomplish desirable results.

BACnet Benefits for AWE

The choice of BACnet for the BMS has fulfilled the owner's immediate requirement of vendor independence and ability to make changes quickly for future phases. BACnet gateways enabled the design-build team to pull together disparate systems and protocols into one cohesive and interoperable system.

"The use of native BACnet devices will open for us a wider choice of control systems in the next phase of facility development. This is why we approved of using BACnet BMS manufacturer and their equipment." said Jaime Pang, the head of building management and services, AWE.