BACNET TODAY

Photo 1: Operator workstations and remote stations of the building automation and control system: 1) mimic graphical panel for elevator system; 2) mimic graphical panel for power supply system; 3) mimic graphical panel for HVAC system; 4) BACnet operator workstations (B-OWS) for central plant operating support; 5) B-OWS for HVAC system; 6) B-OWS for power supply system; 7) B-OWS for building management system; and 8) closed-circuit TV.

BACnet® in Tokyo

By Takeji Toyoda

The World Trade Center Building (WTCB) constructed in Tokyo in 1970 is a transportation center, containing a major urban train station, the terminal of the monorail to Haneda Airport, and a subway station located in the building. An annex building has a long-distance bus terminal. The WTCB also contains a wedding hall, 40 eateries, offices of about 80 tenant companies, and a large bookstore. Approximately 8,000 people work in the building, and roughly 100,000 people pass through the building each weekday.

Building Automation & Controls

A central supervisory and control system was installed at the WTCB in 1970. It was the first minicomputer-based application of building supervision and control in Japan. By 1995 this system had been replaced three times due to advances in computer and networking technology. The third-and fourth-generation systems used high-performance 32-bit minicomputers. In 2004, it became difficult to maintain the existing system due to the unavailability of replacement parts, difficulty of repairing the system, the difficulty of keeping engineers who could maintain the old system, and other problems.

A fifth-generation central supervisory and control system was installed to keep the facilities in the building in good working order, to receive financial support from the New Energy and Industrial Technology Development Organization (a research and development organization funded by the Japanese government) for a building energy management sys-

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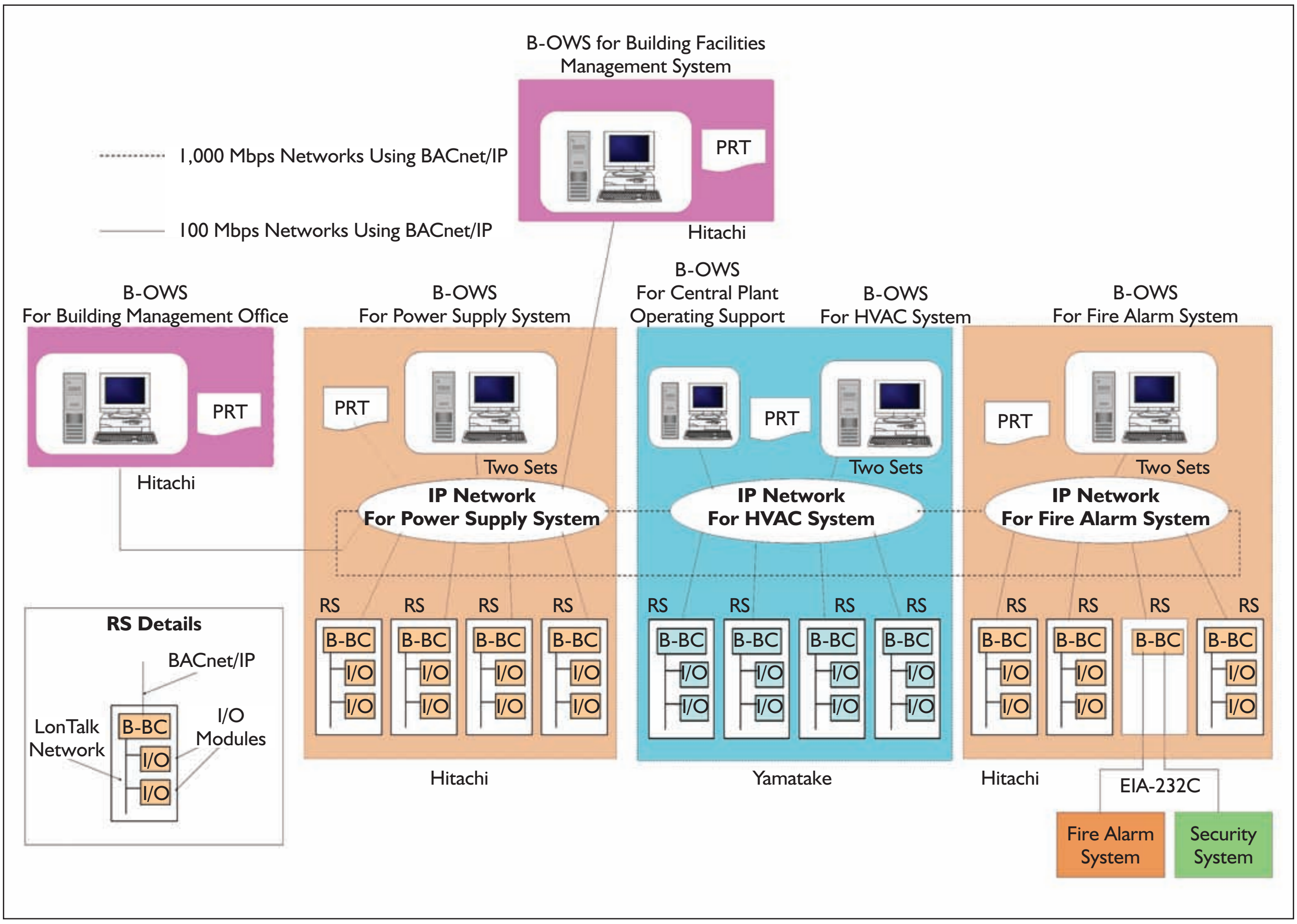

Figure 1: Building automation and control system architecture.

tem (BEMS), and to reduce energy consumption. The new system included several general purpose high-performance workstations connected to a TCP/IP network and an autonomous decentralized open building supervisory and control system using the BACnet protocol.

The previous (third- and fourth-generation) systems were based on the Hitachi HIDIC V90/25 mini-computer system designed for industrial process control. There was one minicomputer for the electrical system, one minicomputer for the air-conditioning system, two minicomputers for the fire alarm system, a dedicated fiber optic network, and an I/O loop. There were also remote terminal stations for the electrical, air-conditioning, and fire alarm systems. This was a closed, single vendor system.

System Architecture of the Open BACS

Figure 1 shows the system architecture of the open building automation and control system (BACS) installed as a part of the project to install a new BEMS with financial support from NEDO.

The trunk network is an Ethernet LAN using BACnet/IP. *Figure 1* shows that the BACS for the power supply system, the BACS for the HVAC system, and the BACS for the fire alarm system each has its own network. These system-specific networks are connected to form a single internetwork.

Each of the BACS networks and remote terminal stations communicates at 100 Mbps. The networks are connected to form a redundant trunk network that runs at 1,000 Mbps. Each system's network connects to the autonomous decentralized remote terminal stations using optical fiber. The building facilities management system (BMS) is connected to the network of the BACS for the electrical system. To improve the reliability of the network, fault management functionality is included.

Communications Protocol Architecture

The exchange of monitoring and control data between various systems in the WTCB is accomplished according to international standard ISO 16484-5 (BACnet). The following devices communicate with each other using BACnet: the operator workstation for the electrical system, the operator workstation for the HVAC system, the operator workstation for the fire alarm system, and the remote terminal stations. BACnet was chosen for the following reasons.

- BACnet is the most advanced protocol to meet the communication needs of BACS.
- BACnet's object types and services are sufficient for BACS applications.
- BACnet is the most suitable protocol for multivendor open BACS.

The LonTalk network protocol is used for the exchange of monitoring and control data between field-level terminal unit controllers and the supervisory BACnet building controllers (B-BC).

Hardware Architecture

Figure 1 shows the operator workstations and remote stations of the BACS. The workstations use the Microsoft Windows® operating system and off-the-shelf applications software. Likewise, commercially available devices for autonomous and decentralized control were sufficient because of their high performance, economical price, compatibility and level of flexibility.

- The operator workstations for the power supply system, HVAC system, fire alarm system, the BMS, the operator workstation for energy-saving control (central plant operating support), and the operator workstation for the building management office all use off-the-shelf PCs, servers, standard printers, color printers and Web servers. *Photo 1* shows the layout of workstations in the WTCB's central monitoring and control room. The network system uses off-the-shelf routers, hubs and switching hubs.
- The PC software environment includes Microsoft Windows®, Microsoft Excel®, and Java™.
- A remote terminal station is composed of a supervisory controller (B-BC) and input/output modules.
- Fourteen remote terminal stations were installed in the main WTCB and the annex. The total number of input/output points is 25,792.

Using BACnet

The operator workstations (B-OWS) and supervisory controllers (B-BC) that comprise the multivendor open BACS are autonomous and decentralized. It is necessary for information messages to be sent between the devices to achieve interoperability. Therefore, the operator workstations and supervisory controllers are connected using a trunk network. For the information exchange between devices supplied by various vendors and between the various systems to be seamless, a common communication interconnection method is needed.

BACnet/IP was selected as the BACS network protocol that would be used to effectively and easily integrate the operator workstations and supervisory controllers at the WTCB. There is worldwide support for BACnet/IP, and in Japan BACnet/IP is used as the BACS backbone network protocol in almost all large buildings.

BACnet Objects and Services

In the BACS at the WTCB, 22 BACnet object types provide the following network-accessible functionality: input data from a process, output data to a process, device characteristics, event/alarm notification, files, scheduling, trending, and other functionality needed.

BACS makes use of alarm and event services, file access services, object access services, remote device management services, and other services. In total, 20 different BACnet services were used.

Data Acquisition

In the WTCB's BACnet system, original data is created and stored by the B-BC devices acting as BACnet servers. In addition to the data stored in the Present_Value property of certain BACnet objects, many associated data also are available in other object properties. Alarm data, status change data, measurement data, and operational data are gathered at the WTCB:

- Alarm data such as failures are communicated by a B-BC to a B-OWS using BACnet's intrinsic event reporting mechanism. The B-OWS receives information such as the identifier of the object that generated the event, the object's present value, a time stamp, and the object's status in an event notification message transmitted by the B-BC.
- Status change data is sent by a B-BC to other devices using BACnet's UnconfirmedCOVNotification service. The B-OWS that receives such a notification can get the identifier of the object that triggered the notification, the object's present value and status from the notification message. A timestamp is added by the B-OWS upon receipt. In the future, there will be more cases in which an event notification message is used to communicate status change, in which case the timestamp is added by the B-BC.
- Measurement data is collected (periodically or on request) from B-BCs by a B-OWS using the ReadProperty service. When the Present_Value of an analog input object changes enough to exceed the Change-of-Value increment for that object, the B-BC containing that object notifies other de-

vices about the object's status using the change-of-value notification mechanism. When the Present_Value of an analog input object exceeds the configured upper limit or the configured lower limit for that object, the B-BC containing that object can send an event notification message using the BACnet's intrinsic event reporting mechanism.

- Equipment start and stop operations commanded by a B-OWS are done and confirmed as follows. The operation is initiated by changing the value of the Present_Value property of a Binary Output object in a B-BC, and the B-OWS receives the confirmation that the operation occurred by means of a change-of-value message or an event notification message from the B-BC. If the value of the Present_Value property is changed but this change is not reflected in the value of the feedback property of the same object within the permitted time period, the B-BC will notify the B-OWS of the command failure by means of the confirmed or unconfirmed event notification message.

Conclusion

The following benefits of BACnet were realized in the open BACS at the WTCB.

- By using BACnet, the number of meetings regarding interconnections between various suppliers' equipment were reduced, and confirmation of details about the communication protocol was made easier.
- The reliability and efficiency of data exchange has increased, and the system is expected to be reliable. The multivendor system was easy to integrate.
- By being able to choose the most suitable devices from various vendors for each facility, competition works to reduce prices, improve technologies, and enforce transparency to the market.
- Saving energy and increasing safety is achieved by adopting a coordinated control system using standardized objects and services between various devices provided by different vendors.

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