Government Connections

GEMnet Project Links Buildings in 3 States

The Walsh Courthouse shows that open protocol and wide area networking can be applied to an existing proprietary control system.

By Michael R. DeNamur

In 1996, the Pacific Rim Region of the General Services Administration (GSA), as part of its ongoing efforts to meet energy efficiency goals, embraced an ambitious plan to renovate building automation systems at the Phillip Burton Federal Building located at 450 Golden Gate Avenue in San Francisco — a 1.4 million ft^2 (130 000 m^2), 22-story structure. The project's design cycle coincided with ASHRAE's release of the BACnet standard for building automation communications. GSA and its design team decided to deliver this project as not only a major conservation effort, but also the first large-scale demonstration of a multi-vendor, BACnet automation network.[1]

450 Golden Gate: the first large-scale BACnet project.

GSA has applied the lessons learned at the Phillip Burton Federal Building to additional facilities, and over the past two years has completed an integration project connecting 11 existing buildings in three states via a wide-area BACnet/IP network and common database framework. This project represents the first phase of a broad initiative to integrate building automation systems (BAS) regionally, and interface them to other applications such as a computerized maintenance management system (CMMS).

In parallel, GSA has been customizing and fielding its CMMS, developing Web interfaces for remote access to a central database, experimenting with the use of third-party client software to directly poll remote building automation systems for point data (bypassing traditional BAS front-end software altogether), initiating a retro-commissioning program to bring existing BAS to an acceptable level of functionality, and has just completed installation of an extensive Modbus power monitoring system at the Phillip Burton Federal Building with the intent of eventual expansion to other sites.

Collectively, these components form the GSA Energy and Maintenance Network (GEMnet), an infrastructure that will permit GSA to support local building managers, provide a framework for management and analysis of maintenance and building performance data, automate certain CMMS functions, provide common interfaces, and monitor and control facilities remotely.

This article reviews the objectives in creating the wide-area infrastructure and data management strategies that represent the core of GEMnet delivered in Phase I, and describes the architecture and design of the pilot implementation involving real-time integration of eleven facilities ranging from a 6,000 ft^2 (557 m^2) office building in Tucson to the 1.4 million ft^2

(130 000 m^2) Phillip Burton Federal Building in San Francisco. We'll share the experiences encountered in evaluating and applying open protocols, wide-area networking technologies and database management standards to deliver an integrated and fully Web-enabled network.

Vision and Objectives

As one of the nation's largest property owners, the GSA maintains and operates a wide array of facilities spread over an extensive geographical area. The Pacific Rim Region (generally referenced as "GSA" in this article) alone has a portfolio of roughly 20 million gross ft^2 (1.8 million m^2) of federally owned space.

In 1999, GSA embarked on a plan to create a region-wide BAS infrastructure. This was motivated by a desire to better manage GSA's diverse holdings — buildings with a variety of existing BAS, in varying condition, with underused data acquisition potential and designed with little regard for enterprise IT concerns. In addition, each facility could not be expected to have a BAS expert on staff. The California energy crisis had not yet materialized, but the urgent need for demand reduction programs, apparent by late 2000 and early 2001, brought attention to the need to centrally trigger local temperature setback programs.

It became clear that GSA needed an IT framework for facility management that offered greater access to building data and a platform to share it between a variety of building management applications such as a CMMS that GSA was fielding at the same time. By necessity, this platform would need to integrate a variety of existing (legacy) control systems — some with open and others with proprietary communication networks — and serve as a common, vendor-neutral, enterprise level platform for future additions.

Goals of GEMnet include creating a wide-area IT framework for facility management offering:

- Data management platform for maintenance program information, performance benchmarking, equipment diagnostics
- Interface to complementary applications and automation of otherwise manual applications
- Integration and central technical support of multiple facilities (and existing systems) over a broad geographic area
- Selective region-wide energy management strategies

Another goal was to have common user interfaces overlying common data.

While the day-to-day maintenance and operation of its facilities was the main objective, GSA's facility management team also was interested in using the GEMnet network to feed a common database of facility information. GSA envisioned this database engine being queried for custom reports and used by third-party applications for maintenance management, system diagnostic analysis or energy reporting. For example, GSA hoped that through the common database, tenants might be able to generate their own service requests, and that out-of-range temperature alarms could automatically trigger service calls through the CMMS. GSA also was investigating an innovative approach to equipment diagnostics that would depend on third-party software analysis of operating data collected in a central database.

Method and Plan

Many factors were considered in the definition of the Phase I GEMnet architecture and technical approach. The BACnet protocol was selected as the network communications standard. This was a logical evolution of the BACnet infrastructure already in place at 450 Golden Gate and several other sites completed more recently. BACnet also was recognized as robust and well supported for scheduling and alarm management applications, which would be key to central management of multiple, remote facilities. It was expected that other non-BACnet

Operating conditions and critical alarms at the Sandra Day O'Connor U.S. Courthouse in Phoenix can be viewed by GSA staff in real-time via a standard web browser.

systems — including existing proprietary control systems, and potential future additions employing standard protocols such as LonWorks® and Modbus— would need to be accommodated and would be integrated to the BACnet-based network via appropriate routers and gateways.

It was determined that a wide-area intranet would provide the networking media connecting all facilities. The performance of a networked connection far exceeded dial-up phone line connections, and the opportunity to integrate additional services — such as weather and utility information — offered much flexibility and promise for future expansion. Further, to meet the objectives for a simple, common user interface, the Phase I infrastructure of GEMnet was designed as a Web browser accessible control network. The BACnet/IP network would include a Web server hosting HTML pages reflecting real-time facility data. The operator interface would be via a traditional Web browser, allowing GSA's staff to easily view data and execute control requests.

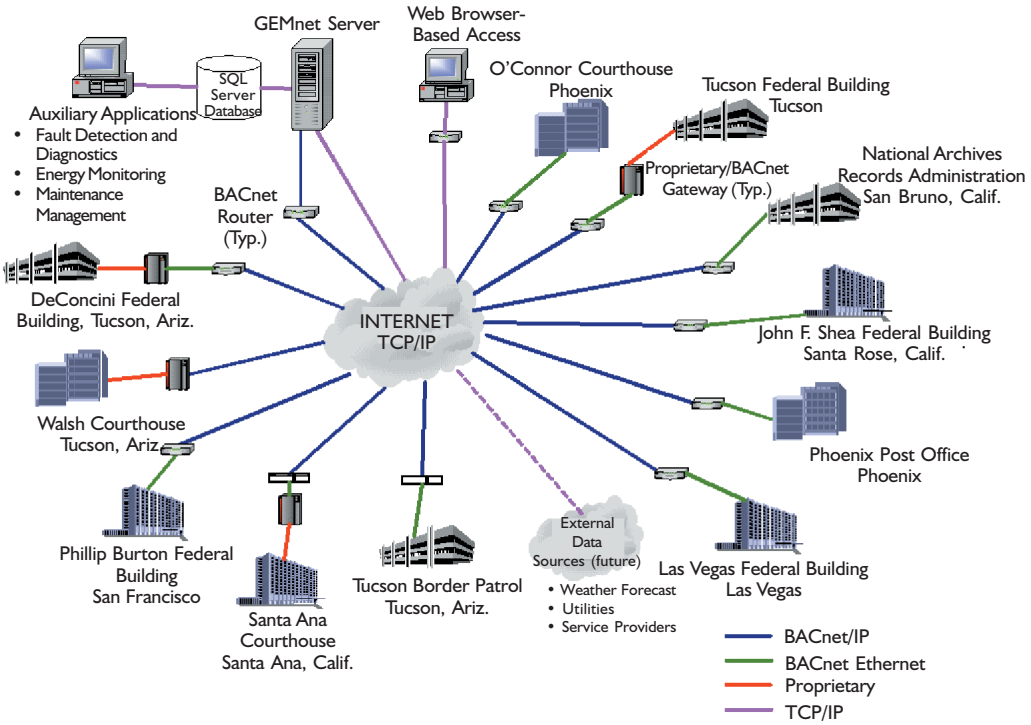

Figure 1: GEMnet architecture uses BACnet and Internet standards to create a wide area data and communications infrastructure.

Through GEMnet, GSA intended to create much more than an integrated BAS network. Rather, the objective has been to create an IT infrastructure that enabled a more proactive approach to facility management. Therefore, at the core of the GEMnet architecture is a database server, collecting and archiving critical facility data. Using well-defined and supported data structures, building operational and performance data would be available to those beyond the traditional facility management team. And, the same building data could be accessed by software applications with more powerful and specialized analysis tools than the typical operator workstation used for monitoring and control.

'GSA needed an IT framework for facility management that offered greater access to building data and a platform to share it between a variety of building management applications.'

GSA identified several candidate facilities for the pilot deployment of GEMnet. Like most property owners, GSA has a variety of existing buildings, and it was clear that GEMnet would need to integrate a number of legacy control systems. Therefore, the design of GEMnet was not dependent upon wholesale control system renovations. Among the criteria for selecting candidate facilities was the presence of an existing DDC system, and the opportunity to realize energy and operational improvements locally as well as part of coordinated regional initiatives.

Thus, the key components of the GEMnet architecture were determined: multiple facilities with existing DDC systems, gateways and routers connecting them to a BACnet/IP wide-area network, a central information database, third-party software applications, BAS Web server, and remote Web-browser user interface (*Figure 1*).

Process

Twelve candidate facilities were targeted for the pilot implementation of GEMnet. These federal buildings and courthouses were spread over seven cities in the states of California, Nevada and Arizona, and included existing control systems from three different manufacturers. Six facilities had existing BACnet control systems that had been installed or upgraded in the past

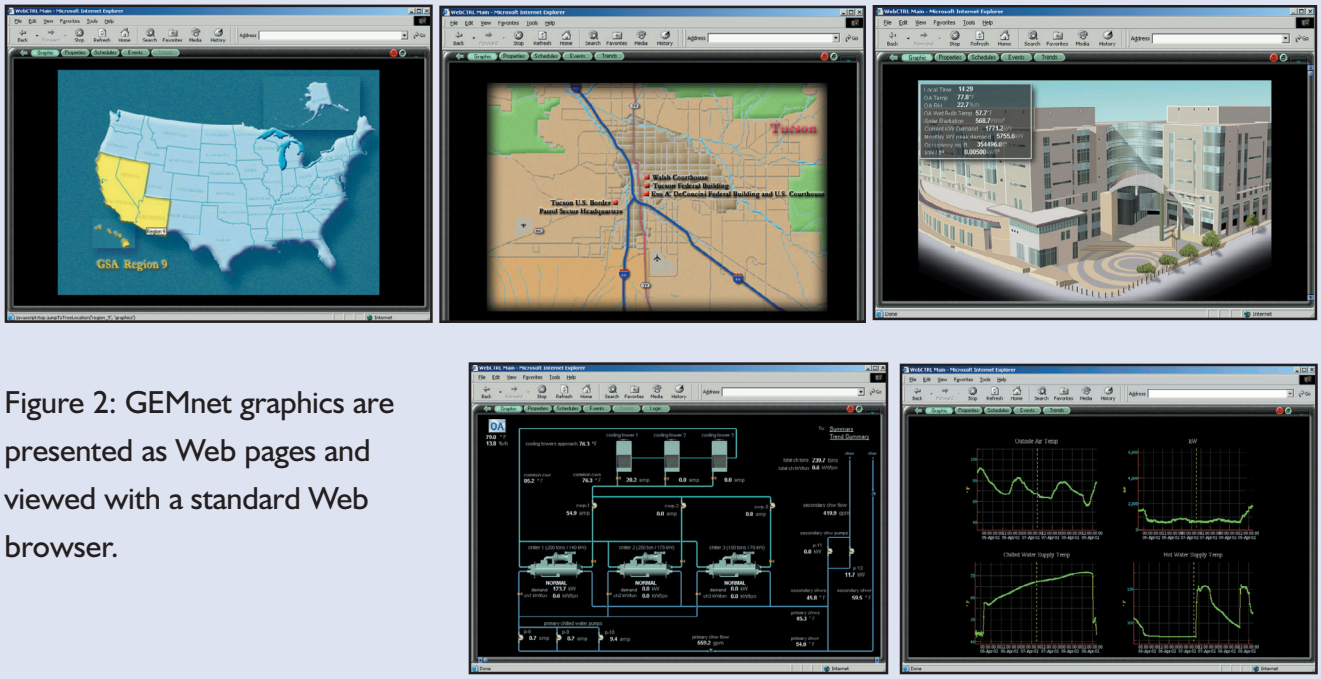

Figure 2: GEMnet graphics are presented as Web pages and viewed with a standard Web browser.

few years. For these facilities, the integration to GEMnet was straightforward. A BACnet/IP router served as the bridge between the local BACnet network in the building, and the GEMnet network connecting all facilities.

For the other buildings a variety of vendor-supported or third-party gateways were used to make existing proprietary (or otherwise non-BACnet) communication networks compatible with GEMnet's BACnet standard. These gateways served well for the purposes of the pilot installation, however they required additional setup and configuration and have inherent limitations that are not present for facilities whose existing control systems already supported BACnet. Nonetheless, they proved legacy systems can be reasonably and practically integrated with BACnet for basic operations such as remote monitoring and control. One of the original candidate buildings was deferred for future integration since no supplier-supported or third-party integration product yet existed to make it compatible with the BACnet/IP network.

'Users interact with all buildings in the same way, regardless of the brand of controls actually installed in the facility.'

Throughout the process, some limited amount of BAS expansion was completed by the addition of various energy-related input points to allow all buildings to communicate a common set of operational data. For example, kW meters were added in some facilities to provide energy data necessary to evaluate performance and enable regional demand management applications in the future. However, all of the pilot phase facilities were connected to GEMnet with no significant changes to their existing control systems.

It was determined that a virtual private network (VPN) would be created to support this first phase deployment. Firewalls were included at each site to secure the GEMnet VPN from the rest of the Internet. While the GEMnet network infrastructure uses the Internet as a communication highway, it is effectively isolated from all other non-GEMnet nodes. As further protection, the Web-server software supports secure socket layers (SSL) — the same 128-bit encryption used to secure online credit card transactions.

With one exception, the facilities connected to Phase I GEMnet network use digital subscriber line (DSL) connections operating between 150 kbps and 6 Mbps. In the remaining case, DSL service was unavailable and an ISDN (integrated services digital network) connection operating at 128 kbps was provided.

Users connect with GEMnet facilities by pointing their standard Web browser to the GEMnet BAS server address and logging in with an assigned user ID. Security is maintained by password control. Once validated, operators are able to view, and if authorized, control data points from any location with an Internet-connected PC. A progression of nested images allows operators to easily navigate through the system to select the specific building and level of detail view they desire (*Figure 2*). Each image is presented as a Web page. Java applets provide animation to show fan and pump operation in the same way that more traditional Web pages show corporate logos and banner advertisements. Similar applications are provided for time of day scheduling, trending and alarm management (*Figure 2, lower right screen*). Users interact with all

buildings in the same way, regardless of the brand of controls actually installed in the facility.

A central structured query language (SQL) database was created to host information on the GEMnet network. Trended data from facilities connected to GEMnet is collected and archived for review and analysis. This information can be used to derive performance metrics to compare building energy consumption, or to describe historical performance of a system or piece of equipment.

GSA contracted an engineering firm with previous standard protocol and system integration experience to deliver GEMnet as a design-build solution. In cooperation with GSA, they developed the system design and technical approach and were responsible for construction management, working on GSA's behalf to coordinate suppliers and subcontractors, and oversee installation and commissioning.

The existing BACnet compatible system at the Lloyd D. George U.S. Courthouse in Las Vegas streamlined its connection to the GEMnet wide area communication network.

In most cases, the local contractors responsible for original controls installation at the subject sites were employed to add and configure gateways and routers required to integrate a standalone building with GEMnet. Due to the groundbreaking nature of the project scope, the direct involvement of the BAS Web-server manufacturer was also secured as the overall architecture and data storage scheme were defined.

Results and Planned Enhancements

The Phase I implementation constitutes a relatively large, core component of a more comprehensive GEMnet initiative. The first sites were sufficiently functional in Summer 2001 to participate in the California Independent System Operator (ISO) Demand Response Program.

The implementation of the GEMnet core infrastructure and pilot facilities presented a number of challenges not surprising for a project of its scope: the poor condition of many existing BAS installations, the inconsistent performance of local BAS contractors, and the difficulty in maintaining stable communications for a dispersed real-time, Internet-based data network. Nonetheless, all were overcome and the GEMnet Phase I implementation was substantially complete in Spring 2002.

Moving forward, GSA will focus on making full use of the database, which includes evaluating and expanding the point data currently collected. GSA also has been collaborating with Lawrence Berkeley National Laboratory and the National Institute of Standards and Technology to research appropriate approaches to performance benchmarking and diagnostics.

The GEMnet architecture also creates alternate paths for integrating various additional systems and components; i.e., real-time communication via a direct BACnet network connection, or archived data exchanged through an interface to the central database server. The relative usefulness of these approaches will be evaluated.

GSA plans to add more facilities to GEMnet. The original controls contractor is being engaged at three facilities to add an OEM BACnet server linking the sites to GEMnet network. Also, GSA has created guide specifications so that future construction and replacement BAS projects will be designed to easily integrate. The guidelines address local communication protocol (permitting both BACnet and LonWorks, with standards for each), networking, instrumentation and general quality control.

Summary

GEMnet builds upon the success of the 450 Golden Gate project and the proliferation of BACnet by creating a network linking multiple controls systems over a wide geographical area using standard protocol. The groundbreaking aspect of GEMnet is how it merges IT and BAS to create an infrastructure allowing access to facility data by more people and third-party software applications. The GEMnet infrastructure provides a platform and flexibility that will allow GSA to imagine and then realize new ways to manage their facilities in response to market and operational dynamics well into the future.

References

1. Applebaum, M.A. and S.T. Bushby. 1998. "450 golden gate project: BACnet's first large-scale test." *ASHRAE Journal* 40(7):23–30.

Michael R. DeNamur is director of business development for facility automation services at Comfort Systems USA.