EXECUTIVE SUMMARY

FINAL REPORT ARTI-21CR/611-30050-01
AUTOMATED INTERGRATION OF REAL-TIME INFORMATION INTO BUILDING MANAGEMENT SYSTEMS

BACKGROUND AND OBJECTIVES

As building owners strive to reduce operating costs while avoiding occupant complaints, they are likely to increasingly utilize Building Automation Systems (BAS) to save energy and to increase occupant comfort. While investment in smart-building technology has been increasing, the science or art of using real-time information in adaptive building management systems is in a relatively immature state. Automated building systems traditionally have utilized either no local sensors or only a limited number of such sensors. As local sensors require routine maintenance, gathering this information by other means (e.g., via the Internet) could result in considerable cost savings and efficiencies.

Internet technology has now progressed to the point where it can be a source of real-time information for predictive purposes in managing buildings. Proactively managing and operating building systems in accordance with actual or anticipated conditions should increase space comfort while reducing operating costs. Although the Internet is becoming a viable source of real-time information, two aspects of the information technology are unclear at present: (1) the types of predictive information available in real time; and (2) which of the available information items can be integrated automatically into building management systems. Ancillary issues of importance include the reliability, integrity, and guaranteed availability of information, along with appropriate methods to accredit the information and the organizations/sites that provide it.

ARTI sponsored this project to provide for a detailed examination of the issues identified above. The fundamental research objective was to investigate the possibility of

using predictive, real-time information from the Internet as an input to building management system algorithms. Seven specific objectives were to:

1. Identify the types of information most valuable to commercial (primarily) and residential (secondarily) building owners, managers, and system designers;
2. Comprehensively investigate and document currently available electronic real-time information suitable for use in building management systems;
3. Verify the reliability of the information and recommend accreditation methods for data and providers;
4. Assess methodologies to automatically retrieve and utilize the information;
5. Characterize equipment required to implement automated integration;
6. Demonstrate the feasibility and benefits of using the information in building management systems; and
7. Identify evolutionary control strategies.

METHODS

GEOMET staff used a combination of approaches – web-based survey and focus-group discussions involving building owners/managers, along with a review of technology and major considerations for integrating real-time web data streams – in an effort to satisfy the project objectives. In order to determine types of useful information for building owners or managers, GEOMET undertook a survey of selected representatives of this community over the web. The web-based survey included respondents in four cities who operated a variety of building types. GEOMET also held focus groups in Washington, DC, and New Orleans, LA. The topics covered in these discussions included:

- Should tenants have control of the space temperature?
- Can a skilled building operator control a building better than a state-of-the-art BAS?

- Would up-to-the-minute information about events at other regional facilities increase the stability of your control system?
- Would Internet access to OEM equipment data and product updates, or access to remote diagnostic services, improve building system maintenance?
- What kind of information would be useful for building operations?
- What do you consider the "perfect" BAS?

The technology review of possible real-time web data streams included: (1) web searches of real-time web services; and (2) consideration of the needs of building or technology types within the building system. GEOMET identified broad categories of real-time web data from the search strategy according to the following characteristics: parameter(s) of interest; data source and latency issues; method of data acquisition; sponsorship (private versus government); data collection methods for energy applications; fee structures if any; quality of the data; and other significant attributes of the web data stream.

An examination of building types and technology provided a check against the web searches. GEOMET developed a master checklist at this stage to examine how real-time web data could benefit different building technologies of the present and future. In compiling the list, we used more commonly known systems/technologies and input from the web-based survey and focus-group discussions. A review of considerations for integrating real-time web data streams addressed the remote client/server interaction and real-time data management, with the latter having four main steps of (1) data acquisition, (2) validation, (3) channeling and (4) utilization. In exploring accreditation of real-time websites, we included a search for existing strategies or approaches that might apply here.

GEOMET examined evolutionary control strategies by developing an initial list based on available data streams and associated parameters. After prescreening the list, we analyzed the control strategies along four dimensions: (1) cost and savings; (2) reliability of the real-time data; (3) feasibility of the technology; and (4) validity of the proposed approach.

FINDINGS AND CONCLUSIONS

Responses to the web-based survey and focus-group discussions were disappointing. Although there were survey respondents from four cities, the total number of respondents was only 19. Focus-group discussions were limited to two areas – Washington, DC, and New Orleans, LA. Candidate participants who ultimately declined cited time constraints and the requirement to commute from homes outside the city for evening/weekend sessions as reasons for not participating in the focus groups.

Despite the small sample size, certain recurring themes, issues or concerns were apparent from the survey and focus groups:

- Critical incidents in building management can be avoided by (1) detailed inspection and maintenance at regular intervals (including system "self analysis"), and (2) predictive diagnostics (to detect potential problems before they occur or become severe).
- Buildings could be operated at maximum efficiency with state-of-the-art equipment, variable frequency drivers, occupancy-based ventilation/lighting, automatic paging, access to building controls via the Internet, weather stations, automatic blinds, solar generation, and software for energy efficiency.
- Current information about events at regional facilities (e.g., weather-related phenomena such as rain and snow or tracking of frontal system) would be useful in increasing the stability of control systems. However, such information would be of use only for fairly small regions, as there can be too much variability within larger regions.
- One critical aspect of building maintenance – validation against plans, both in terms of adherence to schedule and covering all prescribed activities – could be completely or at least partially Internet-based.
- Internet-based weather information can be useful for building operations, particularly in relation to schedules for major regional/local events. The web could play a role in scheduling meeting or conference rooms and in tying that information into the BAS. Links to security systems and to real-time information

on traffic, catastrophic events, fuel pricing, and energy consumption also may be useful.

Building managers concurred that an ideal system would be self-calibrating with diagnosis capabilities. It would be user-friendly and not overly complex. It would also have remote access and would need to be checked routinely by humans. Ideally, the system should be able to implement some adjustments before "calling" an engineer and should be capable of providing a log of key events and preparing routine or special reports. Potential barriers to success in implementing such a system include security concerns for Internet-based operations, occupant privacy, cost issues, and training requirements.

The technology review of possible web data streams revealed the most available type to be real-time weather data. There are, however, other types of useful data elements available, including air quality, energy pricing, local traffic, and geophysical/astrophysical parameters. Candidate parameters or groups of parameters from the review of real-time data web streams are listed in Table ES-1, with an indication of how they could be used. Section 3 of this report provides further details on illustrative uses of the parameters in template form for easy reference.

Unfortunately, the technology review indicated that accreditation of real-time websites will be a difficult task. However, many real-time sites have their origin in the U.S. government; in such cases, accreditation may be a moot point, as these sites tend to have some of the best management and quality control around. The healthcare field has done extensive work in the area of accreditation. Adaptation of the healthcare web accreditation model to the subject of this study resulted in identification of eight key areas: (1) mission and purpose of the accreditation process; (2) clear definition of terms; (3) disclosure of services; (4) content and service delivery; (5) linkages; (6) data security; (7) accountability; and (8) policy and procedures.

Real-time data system architecture is constrained by the type of data interface needed. The varied types of data interface were grouped into three categories: (1) broadcast; (2) simple request/response; and (3) Structured Data Services. Different sampling needs for different types of data suggest that it would be beneficial for the BAS to interact with the Internet data server using a Structured Data Services interface. Many steps in the data-retrieval process could be managed on the client or the data server. Control algorithms for novel types of building controls using real-time data could reside entirely off-site, sending only needed control inputs to the BAS.

Important considerations for integrating real-time data include the remote client/server interaction and real-time data management, with the latter having four main steps of data acquisition, validation, channeling and utilization. Three levels of potential benefit from using remote real-time data as BAS inputs are: (1) improvement of environmental conditions in the facility; (2) improvements in the operational efficiency and effectiveness of building systems; and (3) improvements in the building's interaction with the community (e.g., with building occupants through scheduling tools and with the community via alerts and alarms).

Table ES-1. Parameters of Potential Use as Real-time Data Elements

Parameter(s)	**Potential Use**
Local outside temperature (with dew point or relative humidity)	Determine whether economizer functions are to be activated or evaporative cooling is to be used, or as an input to a hygrothermal model for building moisture management
Local outside temperature, dew point, precipitation, wind and solar radiation	Determine the configuration/setting for operable windows
Local outside temperature (with a precipitation parameter)	Determine whether walkways or driveways need to be de-iced via heat or chemical reaction
Predicted outdoor temperature (up to 12-24 hours in advance)	Input to energy model, to suggest pre-heating or cooling strategies or determine whether to use on-site thermal storage for greater energy efficiency
Barometric pressure	Optimize combustion settings, or as an input to a model for airflows within or around a building
Air quality indicator (e.g., ozone)	Automatically close fresh-air intakes under certain conditions (i.e., poor outdoor air quality)
Energy pricing data	Support the decision to sell excess power from cogeneration back to the grid (for larger facilities or complexes)
Weather warnings/watches/advisories	Automatically shut down selected building systems or prompt display of appropriate disaster plan information
Solar radiation (including predictive data)	Determine the most opportune times for strategies such as solar shading or daylighting
Local lightning strikes	Automatically activate selected backup systems or take actions to protect building assets/personnel
Space weather (e.g., solar flares)	Prompt actions to protect susceptible systems
Chemical/biological sensor systems	Prompt building use for sheltering in place
Local precipitation (predicted)	Rain harvesting applications
Geophysical parameters (e.g., tides)	Buildings susceptible to water table fluctuations
Astrophysical parameters (e.g., moonlight)	Potential effects on security systems
Local traffic data	Potential effects on parking facilities
Intelligent tags	Track movement of cars into/out of parking areas, as a preliminary predictor of building occupancy
Aircraft/rail arrival times	Determine potential delays in guest arrival (e.g., for hotels)

Based on the considerations of cost and savings, reliability of the data, feasibility of the technology, and validity of the proposed approach, the following control strategies appear to be viable for use within a real-time data system:

- Advanced set point control based on forecast conditions external/internal to the building
- Moisture management based on predicted dew point and rate of precipitation
- Occupant interface for services such as comfort improvement, transportation links, traffic updates, express food delivery assistance, and security assistance with deliveries/visitors
- Alarms and notifications to on-call and remote technicians for system maintenance.

Smart buildings of the future may be able to handle tasks such as parking, office scheduling, food services, digital recreation services, and waste services. Greater granularity in the delivery of HVAC services to building users, with smart control devices, will significantly increase a building's capability to respond to interior and exterior airborne contaminants. This increased capability also would improve the ability of the BAS to deliver thermal and lighting services with greater specificity, improving the energy efficiency of the building.

RECOMMENDATIONS

This report has identified some evolutionary control strategies and associated real-time data parameters that appear to hold the promise of benefits to building owners, managers, and occupants. However, proof of concept and feasibility of implementation must be demonstrated for such strategies and parameters. There are additional strategies, beyond those highlighted in Section 5 of this report, that warrant further investigation and development of specifications.

Potential benefits of using predictive, real-time information need to be assessed in comparison with more traditional approaches involving use of local sensor information for HVAC-related control strategies. In parallel with this exercise, potential methodologies for implementation need to be proposed to address issues such as data latency, proactive versus reactive actions, feedback, and alternate controls when real-time information is unavailable.

It also is important to demonstrate representative hardware, software, and tools that can automatically retrieve reliable, predictive, real-time information from the Internet and make it available to a building management system. As part of the demonstration, the building management system would need to use the information in a traditional or evolutionary control strategy to increase space comfort while reducing operating costs. Ultimately, formal pilot or demonstration projects will be required to address the full realm of cost and logistical issues for selected approaches that are deemed the most promising.