New Technology Demonstration Program

FEMP

Federal Energy Management Program

Trends in Energy Management Technology – Part 3

State of Practice of Energy Management, Control, and Information Systems

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Introduction and Background

Introduction

In this report, the third in a series, we provide an evaluation of several products that exemplify the current state of practice of Energy Management, Control, and Information Systems (EMCIS). The available features for these products are summarized and analyzed with regard to emerging trends in EMCIS and potential benefits to the federal sector.

The first report [1] covered enabling technologies for emerging energy management systems. The second report [2] serves as a basic reference for building control system (BCS) networking fundamentals and includes an assessment of current approaches to open communications. Part 4 of this series will discuss applications software from a user's perspective.

It is important for energy managers in the Federal sector to have a high level of knowledge and understanding of these complex energy management systems. This series of reports provides energy practitioners with some basic informational and educational tools to help make decisions relative to energy management systems design, specification, procurement, and energy savings potential.

Background

Traditionally, energy related subsystems used in building controls performed either energy management or combined energy management and control functions. These systems were usually

called EMS or EMCS (see Glossary). However, current emerging energy related systems have expanded into information processing that includes data exchange and archiving, historical data visualization, and energy data analysis. In this series of reports, the term EMCIS (energy management control and information system) is being used to refer to these types of systems. [1]

With utility deregulation in the early 1990's and recent periods of energy crises, new products have emerged that augment or expand the basic functions covered by BCS's. These new energy information systems (EIS) include utility EIS, demand response systems (DRS), and enterprise energy management systems (EEMS) [3]. In many of the EMCIS products studied for this report, some features of this new wave of EIS products are supported.

Selected Vendors

Over 20 vendors were identified as possible candidates for this study. Each of the candidates was categorized into three vendor types; OEM/Equipment, Building Controls, and Software. Although there are many more than 20 BCS vendors, those identified make up a representative sample of the industry.

For the study, a group of eight vendors were selected; one from OEM/ Equipment vendor type, five from Building Controls vendor type and two from the Software vendor type. Building controls vendor types were further categorized into Large, "first-tier" and Small, "second-tier" vendors.

The selected vendors are:

OEM/Equipment Vendor
- Trane

Large Building Controls Vendors
- Johnson Controls
- Siemens Building Technologies

Small Building Controls Vendors
- Automated Logic
- Alerton Technologies
- Teletrol Systems

Software Vendors
- Tridium
- Electric Eye

These vendors were chosen because their offerings represent current trends in the industry. In particular, these vendors support two key concepts that are becoming prevalent not only in the BCS industry, but in many other industries; open systems and Web enabled. Open systems support in the commercial BCS industry means support for the BACnet standard and LonTalk,[1] either natively or by the use of a protocol gateway. Web enabled means support for access to the EMCIS using Web-based technologies either internally on the corporate Intranet or externally over the Internet. Web-based access can mean the use of a Web browser as a user interface to access EMCIS functions or the use of XML (Extensible Markup Language) applications for data exchange with the EMCIS.

[1] LonTalk is a subset of the BACnet standard (ANSI/ASHRAE-135) and is a standard for home automation (ANSI/EIA-709).

In general, the OEM/Equipment and Large BCS vendors sell and support their products directly. The Small BCS vendors mostly offer products and support through distributors/dealers or system integrators. Because Software vendors generally make no hardware, systems with Software vendor products are sold and supported through system integrators or are privately-branded under BCS or OEM offerings. For example, of the two Software vendors selected in this study, Electric Eye works almost exclusively with hardware products made by EnFlex Corporation. Products from the other software vendor, Tridium, are also available as third-party brands from both Honeywell and Invensys.

Organization of the Report

The remainder of the report is organized into three major sections. The first section is a EMCIS technology description with subsections on architecture, features and trends, and overall assessment. The second section discusses the potential of EMCIS products; their benefits, limitations, and cost effectiveness. The report ends with a summary and conclusions. There is also an appendix containing a concise roadmap of EMCIS product features for the selected vendors and another appendix containing a discussion of XML, SOAP (Simple Object Access Protocol), and Web Services.

Technology Description

EMCIS Architecture

The typical EMCIS system architecture consists of a 4-level hierarchical structure (see reference [2] for a diagram of this structure). Each level can be characterized by a network bus technology (a combined physical wiring or wireless specification and communications protocol specification).
(1) At the highest level is the *Enterprise/IT bus/network*. It consists of the day-to-day corporate desktop PC's, servers, printers, etc. The predominate Enterprise/IT network bus is TCP/IP over Ethernet (10 Mbps and 100 Mbps).
(2) The next level is the *building controls system backbone bus*. Here reside the large field panels or supervisory controllers, BCS workstations and other high bandwidth BCS hardware.
(3) Connecting to the supervisory controllers are terminal controllers. This level is called the *terminal bus* and typically has a lower bandwidth requirement than the backbone/equipment bus.
(4) Sensors and actuators are interfaced to terminal controllers by the *sensor bus*. In most instances, sensors and actuators are not interfaced via a sensors bus but are hardwired typically with 4-20mA, or 0-5/10 volt electrical signals. The level of the electrical signal (current or voltage) indicates a scaled analog value, an on/off digital status, or an on/off digital control. In the industrial process industry, there are emerging standards for a sensor bus [2]. One advantage of a sensor bus is the reduction of wiring cost. Instead of each sensor being wired directly to a controller, a single cable can be used to connect all the sensors. In this study, there was little evidence

that BCS vendors support sensor bus technology.[2]

Although the 4-level hierarchical architecture is typical, technologies are evolving such that the structure is being "flattened" [2]. For example, in some instances, the Enterprise/IT and BCS backbone/equipment bus co-exist on the same physical media. In another example, field panels and terminal controllers are on the same bus.

EMCIS Features and Trends

EMCIS systems, as represented by the systems in this study, are complex systems with a wealth of technologies and rich feature sets. The technologies and features for eight products in this study are summarized in the "roadmap" presented in Appendix B. These products exemplify the areas where advancements have been made in recent years. These areas include:

- Open Communications
- Applications Software
- *Web Access*
- *Energy Information*
- *Integration to Other Systems*

The first two items are covered in more detail in other parts of this series so only the last three will be emphasized in this report.

Open Communications

Clearly the BCS industry has embraced open communications. One of the main driving forces behind openness is the desire by customers not to be locked into any one particular vendor's products. BCS customers want the ability to choose the best products from various vendors and be reasonably sure that the products inter-operate. Another driving force is the customers' desire to share information between different systems; for example between a process control system and the building control system. A detailed assessment of the current state of practice of open communications is contained in Reference [2].

Applications Software

One of the most important elements of an EMCIS is the suite of software applications that users interact with on a day-to-day basis. This is where the intelligence of these systems is delivered. The most important applications from the users perspective include data visualization, alarm monitoring/management, graphical programming, and support for reporting energy information. A comprehensive assessment of these applications is the subject of Part 4 of this series. Included in the tables of this report is a detailed listing of applications software capabilities for the products studied.

Web Access

There are two Web access trends evident among the vendors; (1) browser-based user interfaces that locally and remotely access the EMCIS via the World Wide, and (2) Web-based access into the EMCIS for data exchange.

The remainder of this section will discuss these Web access trends.

Browser-based User Interface

[2] A sensor bus is supported by at least one of the 20 vendors reviewed for this study, Delta Controls.

A browser-based user interface has many advantages:

- The user interface is simply a Web browser. There is no need for any additional (thin client) software besides standard browser plug-in's (Java).
- There is no need to keep track of where workstation software are installed and to keep the client software up to date.
- Access to the EMCIS can be from any device that has a Web browser and has access to the EMCIS Web server either internally over a corporate Intranet or externally over the Internet.
- The BCS industry can take advantage of emerging Web standards developed in the computer and information industries where the standards are usually defined and accepted much more quickly. Adoption of these standards will ensure compatibility within the corporate and business world.

The level of Web access support differs among the EMCIS vendors. Some use Web access exclusively as the workstation software for their product line. Others have standard Windows-base workstation software and offer Web access only as an option.

The features of each offering must be taken into consideration because of the impact on the cost, performance, user features, and reliability as well as any potential conflict with corporate IT policies. Things to consider are:

- **Browser support.** In general, this means the major browsers, Netscape and Internet Explorer. Almost all the vendors require Java as a plug-in because Java can provide real-time data access and other functions not possible on the browser.
- **User features.** For the case where Web access is optional, the feature set is normally not the same as the workstation software.
- **Web server platform.** The most commonly supported Web server platform is the Microsoft-Windows based server. A few vendors support Sun-Solaris and Linux platforms. One of the vendors, Alerton, offers its optional Web server via fully configured IBM hardware running Linux and Apache Web Server. Another vendor, Trane, offers its optional Web server as an embedded server. The embedded server may offer additional reliability, but may also lack the power to provide the features and the performance of standard server-based hardware.
- **Web page generation**. In most cases, tools are included with the Web server that facilitates the creation of Web pages. In other cases, standard third-party Web page authoring tools can be used. If the Web server is an optional feature, the Web pages are generated automatically from the standard workstation user interface. However if manual creation of the Web pages is required, considerable resources may be needed. This is a key issue that must be taken into consideration.
- **Internet connection security.** For secured Internet communications, a few of the vendors offer HTTPS (HTTP in secured mode) as the default connection method between

the browser and the Web server. Other vendors allow the Web server administrator to configure the Web server for HTTPS connection as an option.

As an alternative to supporting browser based user interfaces via standard web servers, some vendors offer Web access via the Windows 2000/XP and Terminal Services (TS) feature. With TS, remote PC's can access the EMCIS Windows 2000/XP server over the Internet using Microsoft's Internet Explorer browser. The browser session is a remote login into the EMCIS system. The advantages are that all workstation features available locally are also available in the remote session[3] and the browser/server connection is encrypted (RSA RC4 cipher). The disadvantage is that the browser must be Internet Explorer (an ActiveX[4] control must be used - ActiveX controls do not work in other browsers).

Data Exchange using XML[5]

One of the emerging Web standards is XML. XML is becoming a standard language for exchanging data in many business sectors. A few of the vendors in this study offer XML as a Web access method to retrieve data from their EMCIS product line.

Whereas XML is a standardized language being developed by W3C (World Wide Web Consortium - www.W3C.org), the data defining schemas are not standardized. Here lies a weakness of XML. The dilemma is that businesses can begin defining schemas so that data can be exchanged, but these schemas may not be compatible with other businesses and sometime in the future, a standard set of schemas may make earlier definitions obsolete. In a recent GAO report [4], it was concluded, "key XML vocabularies, tailored to address specific industries and business activities are still in development and not yet ready for government wide adoption". Further, "using them at this time would mean taking the risk that future developments could diverge from these early standards and limit interoperability with them."

To begin the process of standardizing XML for use in the HVAC industry, to date, two committees have been tasked to begin XML standards definition for HVAC. The ASHRAE SSPC 135 BACnet XML Working Group is in the process of defining various application areas for XML technology. The ASHRAE GPC 20 (Guideline Project Committee) is establishing a common data exchange format for the description of commodity data and HVAC&R information using XML.

SOAP and Web Services[6]

Beyond XML is SOAP. SOAP is used to invoke applications running on another platform without regard to what the platform is or what language the application was written in. In fact, the client can be completely incompatible with the server.

[3] Commercial software products that are similar to TS include Remote Desktop and PCAnywhere. There's also a free software product call VNC (Virtual Network Computing).

[4] ActiveX controls are the interactive objects in a Web page that provide interactive and user-controllable functions.

[5] A more detailed discussion of XML is presented in Appendix C.

[6] A more detailed discussion of SOAP and Web services is presented in Appendix C

SOAP is the basis for the emerging Web Services technology. Web Services perform functions, which can be anything from simple requests to complicated business processes. Once a Web Service is deployed, other applications (and other Web Services) can discover and invoke the deployed service [5]. The few vendors that are offering XML support, are also planning to offer SOAP support and thereby also offer Web Services. One vendor, Automated Logic, is planning to provide limited support by permitting Web Services access to virtually anything in the WebCTRL database. However, exactly how this all plays out in the long term and what Web Services eventual will mean to the BCS industry remains to be seen.

Energy Information

In recent years, there have been numerous Energy Information Systems (EIS) developed and deployed in a highly competitive market driven by energy deregulation and periods of energy crises [3]. These EIS are systems that typically: (1) collect and display metered usage data, (2) compare load profile data within and between facilities, and (3) correlate energy use with bill data and rate information [3]. The systems studied in [3] were Web-based EIS with some level of demand-response and monitoring/control capabilities. On the other hand, the systems under study in this report are primarily monitoring/control systems with some level of Web-based, demand-response, and energy information capabilities.

Energy Monitoring
Main meters and sub-meters have communications capability; supporting one or more Modbus, LonTalk, BACnet or proprietary protocols. In practice, any EMCIS can perform energy monitoring if the EMCIS has support for the protocol. However, some EMCIS products have setups and configurations dedicated to energy monitoring.

Energy Analysis
A few of the vendors are including more aspects of EIS as options in their systems. Customers with energy information needs can purchase the option from the EMCIS vendor instead of acquiring it from a third party. Graphs and reports available from these optional energy analysis add-ons can be used to:

- Adjust operations and scheduling to help minimize energy use.
- Negotiate energy contracts for more favorable terms.
- Benchmark against published statistical data to see if systems need optimization or upgrading.
- Cost allocate energy use.
- Validate utility bills.

Demand Limiting/Reduction
During peak electrical demand periods (e.g., mid-day during hot summer months), there is a high potential to reduce energy cost by limiting the electrical demand of the systems (HVAC, lighting, etc.) inside a building. Even if the building is not under a time-of-use or demand charge rate structure with the local electric utility, there are many curtailment programs with financial incentives sponsored by utilities and local and state governments to reduce energy use during peak demand periods.

Reducing electric demand by reducing HVAC load can be accomplished manually by creating new schedules or simply by manually turning off devices. A better approach is to have an automated system[7]. Many of the vendors have a demand limiting/reduction feature in their system. For example in WebCTRL (Automated Logic), devices can have different setpoints assigned to up to four demand levels. These demand levels can be triggered manually by an external input or automatically when a metering device reading exceeds the demand thresholds. In the automated case, the demand level trigger can be scheduled to be active or inactive depending on the time of the day, day of the week, or holiday.

Integration to Other Systems

Complementary to the trend towards open communications is the trend toward integration to other systems. These systems include various facility systems such as the lighting, security/access, fire/smoke, CMMS (Computerized Maintenance Management System), and CAFM (Computer Aided Facility Management) systems, as well as EMCIS from other vendors. The goal of the integration is to permit the use of a single system to monitor and manage multiple systems or to allow sharing of information between systems.

A few of the large vendors specifically offer non-EMCIS systems and support the integration to those systems natively. Other vendors specify support for integration to other systems by using gateways. However, all the vendors support either BACnet or LonTalk or both. By so doing, there is an implied support of integration to other systems if the integration mechanism is through the BACnet or LonTalk protocols.

In the case of integration to other EMCIS, the BACnet and LonTalk protocols again can be used as the integration mechanism. For example, the 450 Golden Gate Project [6] integrated systems from two of the vendors in this report using BACnet (the two vendors, Trane and Alerton were not specifically mentioned in the reference). For integration to EMCIS with legacy protocols (including the vendors' own legacy protocols), gateways are used.

Overall Assessment

The EMCIS products in this report all are complex systems with advanced hardware and software technologies. The products are rich in features and are

[7] In actuality, the system is not fully automated because the building operator needs to be notified of an impending curtailment by the utility.

indicative of trends in the industry. However, for each product, there are particular strong points that are summarized as follows:

- ***Tracer Summit (Trane).*** As an equipment vendor, *Trane* can provide complete turnkey systems that include chillers, air handlers, heat pumps, fans, VAV boxes, etc. in addition to a complete EMCIS.
- ***Metasys (Johnson) and APOGEE (Siemens).*** Both *Johnson Controls* (JCI) and *Siemens* have an extensive line of controls with numerous software and gateway options to third-party systems.
- ***WebCTRL(Automated Logic), BACtalk (Alerton), and eBuilding (Teletrol)***. These three products are completely native BACnet. BACnet is the direction the industry is heading and these products are positioned to take full advantage of the latest BACnet developments.
- ***WebCTRL (Automated Logic), eBuilding (Teletrol), and Vykon (Tridium).*** These three products have native Web-based user interfaces. These systems have one less component to worry about, the separate Web server. The Web is the future and these products are positioned to adapt the latest Web technology that is suitable to the industry.
- ***BACtalk (Alerton), Metasys (Johnson), APOGEE (Siemens), and Vykon (Tridium).*** These four products have integrated energy analysis tools or can be integrated with energy analysis tools. *BACtalk* has energy logs that trend energy demand and consumption as well as compute the averaged demand over a specified time interval. *Metasys* can be integrated into *Johnson Controls'* sophisticated *FX-TEM* product that has an energy bill rates database and can generate reports including usage, cost, and load profile. Similarly, *APOGEE* has the *Utility Cost Manager* option that provides reports for demand, consumption, and cost allocation. *Vykon's VES Energy Profiler* offers Web-based graphical reports that include energy trends, profiles, aggregate, summary, ranking, and relative contribution.
- ***Vykon (Tridium), and Electric Eye (Electric Eye).*** These two products are mainly software products. They are excellent candidates for retro-fit of systems for data gathering, archiving, and analysis. *Vykon* is particularly suited for systems with controls that use LonTalk. If needed, *Electric Eye* systems can also be implemented with controls from EnFlex.

Potential of EMCIS Products

Benefits

In general, the potential bottom line benefits of EMCIS are the reduction of operations and maintenance costs and the reduction of energy usage and cost without sacrificing occupant comfort. The specific benefits of EMCIS can be better summarized within the context of the categories of the emerging trends discussed in this report.

Web Access

- Reduce client software cost
- Allow system access from virtually any location
- Simplify data interchange between systems and across geographical locations

Energy Information

- Identify potential energy savings
- Energy usage data can be used to negotiate better utility rates

Integration to Other Systems

- Control and scheduling strategies can utilize data from multiple systems
- Integrate capabilities such as EIS with other business functions

Limitations

The numerous potential benefits of EMCIS are not totally free and automatic. The effectiveness of any system is compromised when:

- The system is not properly designed
- The system is not properly commissioned
- Features are not used or improperly used
- Results of data analysis and reports are not properly interpreted

To mitigate these compromises there must be:

- Management structure, support, and direction
- Proper operator training
- Correspondence between product sophistication and operator/user expertise

Cost Effectiveness

Analysis of EIA/DOE statistics [1] indicate a greater fraction of federal buildings have BCSs than does the overall U.S. building stock and a high percentage of large buildings have BCSs.

There is still significant untapped potential in both large and small federal buildings; i.e., buildings not yet fitted with BCSs amounts to 28% of overall floor space for small and 33% for large buildings.

What is the cost effectiveness of an EMCIS? One needs to compare the O&M cost of a system before an EMCIS is installed and the O&M cost after an EMCIS installation. One must also factor in the cost of the EMCIS itself because an expensive system may not necessarily save the additional O&M cost to justify the additional capital expense.

It is beyond the scope of this report to analyze the cost effectiveness of EMCIS. The issue of cost effective will be partially addressed in a future report that discusses case studies of actual EMCIS installations.

Summary and Conclusions

The EMCIS products reviewed in this report are some of the trend-setting products in the industry. These products have an impressive array of capabilities. Each of the EMCIS products supports several of the identified emerging trends. BACnet is clearly the most important open communications trend. Vendors have complete product lines that are totally BACnet compliant. It's a

statement that BACnet is here and will remain in the future.

Another significant trend is Web-enabled. All vendors have or are introducing Web access with browser-based user interfaces. Others are adopting the IT industry trends of XML, SOAP, and Web Services for data exchange and remote applications over the Internet.

Utility deregulation and restructuring and the specter of high energy prices have brought about the trend towards energy information capabilities. Standalone EIS products are available from non-BCS vendors, but several of the EMCIS vendors in this report have included EIS capabilities in their products.

With all this capability and technology comes the question, have these systems become too complex? Can common operators use them effectively? Does all this technology work and is it useful? What are the actual benefits and savings that can be achieved? A future report in this series will try to address these and other questions.

Appendix A. Acronyms and Definitions

Many acronyms used in this report can be found in the Glossary sections of References [1] and [2]. Additional definitions are included here.

DRS	Demand Response System
EEMS	Enterprise Energy Management System
FDD	Fault Detection and Diagnosis
NMS	Network Management System
RF	Radio Frequency
SGML	Standard Generalized Markup Language
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
TP	Twisted Pair
TS	Terminal Service
W3C	World Wide Web Consortium

Appendix B. EMCIS Products Roadmap

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Product Name	**Tracer Summit**	**WebCTRL**	**BACtalk**	**eBuilding**	**Metasys**	**APOGEE**	**Vykon/ Niagara Framework**	**Electric Eye - EnFlex**
Estimated Market Share[8] (1=>15%, 2=10-15%, 3=5-10%, 4=<5%)	4	4	3	4	1	2	4	4
Vendor Type								
OEM/Equipment	•							
Building Controls		•	•	•	•	•		
Software							•	•
Sales Channel								
Direct from Vendor	•			•	•	•		
Distributors/Dealers		•	•	•	•			•
OEM							•	
System Integrator				•			•	•
Network Architecture & Protocols								
Enterprise/IT								
BACnet (Ethernet = BACnet over Ethernet, IP = BACnet/IP over Ethernet)	Ethernet IP ARCNET	Ethernet IP	Ethernet IP	IP	IP	IP		
JAVA RMI		•						
CORBA, IIOP		•						
TCP/IP - HTTP/HTML/XML				•			•	
COM/DCOM, DDE, OLE, OPC			COM/DCOM	OPC	OPC	OPC		
SNMP		•			•			
Proprietary					N1 Bus on ARCNET or Ethernet	•		•

[8] Market share estimates were extrapolated from "North American Building Control Systems Market", Frost & Sullivan, 1996.

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Backbone/ Equipment Bus								
BACnet (Ethernet = BACnet over Ethernet, IP = BACnet/IP over Ethernet)	Ethernet IP ARCNET	IP ARCNET MS/TP	Ethernet IP	IP	Ethernet IP			
TCP/IP - HTTP/HTML/XML				XML				
Proprietary					N1 bus on ARCNET or Ethernet	P2	●	●
Terminal Bus								
BACnet (IP = BACnet/IP over Ethernet)	PTP	MS/TP PTP	MS/TP PTP	MS/TP	PTP		IP MS/TP	
Lontalk	●				●	●	●	●
Modbus on RS-485							●	●
Proprietary	● (Legacy)	● (Legacy)		● (Legacy)	N2 Bus	P1		●
Gateways								
Gateway Offerings (Product name)	●	WebPRTL	BACtalk Ports	Integrator Controllers (legacy)	Metasys Integrator	APOGEE Open Processor	●	●
OPC	●			●		●	●	
Modbus	●	●	●	●	●	●	●	
Lontalk	●	●		●		●	●	
Profibus	●			●	●		●	
Allen Bradley (PLC)	●	●		●	●	●	●	
Simplex (Fire Panel)		●	●		●	●		
Vendor's legacy protocol(s)			●		●			
Various 3rd-Parties	●	●	●	●	●	●	●	●
Frontend / WS Software								
Standalone or Client/Server	Tracer Summit		Envision		M3, M5 Workstations M-Explorer	Insight		Electric Eye
Web-based (Thin-client)		WebCTRL		Envoy			Web Supervisor	

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Web-Enabled								
Web Server Product Name	Tracer Summit Web Server	WebCTRL	Webtalk Iport	Site Manager	M-Web Server & Web Access	APOGEE GO & Insight 3.4	Web Supervisor	Electric Eye
Web Server Platforms supported								
Windows		NT/2000/XP		NT/2000	● M-Web Server 98/NT ● Web Access 2000 with Terminal Service	● APOGEE GO NT/2000 ● Insight 3.4 2000 with Terminal Service	NT/2000	
Solaris		●		●			●	
Linux		●		●				●
Proprietary	Embedded Platform		IBM Hardware Linux OS Apache Web Server					
Web Page Builder Tool	Automatic	MS Frontpage with ALC extensions	Automatic	Edifice	Automatic	Automatic	Workplace Pro	
Internet Connection Security	HTTPS	HTTPS		HTTPS	● Web Access RSA RC4 cipher	● Insight 3.4 RSA RC4 cipher		
WS Features Supported by Server (F=Full or L=Limited)	L	F	L	F	F	● APOGEE GO L ● Insight 3.4 F	F	L
Client Browsers Supported	Netscape & IE	Netscape & IE	Netscape & IE	Netscape & IE	● M-Web Server Netscape & IE ● Web Access IE 5.5 or >	● APOGEE GO Netscape & IE ● Insight 3.4 IE 5.5 or >	Netscape & IE	Unknown
Additional Client Software	Java	Java	Java		● Web Access MS TSAC ActiveX control	● Insight 3.4 MS TSAC ActiveX control	Java	Java
Other Web Access Protocols		XML		XML			XML	
Database								

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Relational	MS Access	MS Access MS SQL My SQL Oracle IBM DB2	MS Access	My SQL	MS Access	MS SQL Objectivity	SQL	
Flat File					InfoPlus.21		●	●
ODBC				●	●		●	
JDBC		●		●			●	
Product Offerings								
Field Panels	Building Control Units (BCU)	M-Line S-Line	Integrator (BTI) Lsi VLCP	Network Controller (eNC)	NCM N30	MBC MEC	JACE-NP JACE-5 JACE-4	EnFlex G-100 MG-200
Display Panels	Optional Touch Screen on BCU 320 x 240 pixel	BACview 2 x 16 char. 4 x 40 char.	Viewport 4 x 20 char.	2-Line LCD on eNC	● LDT on N30 4 x 20 char. ● NT on NCM 16 x 40 char. 256 x 128 pixel	Local User Interface (LUI) 2 x 40 char.		
Terminal Units	Unit Control Modules (UCM)	U-Line	VLC series VAV series	eTRAC, TSC, iVAV	DX series VMA series AHU, UNT, VAV controllers	TEC		EnFlex LIO-21, IO-12
Sensors/Actuators (F=Full line, L=Limited, N=None)	L	L	L	L	F	F	N	N
Tools								
Programming								
Graphical	TGP	Eikon	VisualLogic (requires Visio)	Easel	GPL		Workplace Pro	
Menu/Table/Template			●				●	Site Manager
Line	CPL			ECMScript	JC-Basic	PPCL	Java	
Program Debugging and Testing								
Simulator		●		●	●			

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Real-time data monitoring	•	•	•				•	
System/Network Configuration		Site Builder	Device Manager	Edifice	M-Tool		Workplace Pro	Site Manager
Applications								
Monitoring,, Data Visualization, and Reporting								
Graphical equipment monitoring	•	•	•	•	M-Explore M-Graphics	•	•	•
Performance monitoring displays					Analog Profile Comfort Chart Color Spectrum River of Time Starfield System Analysis Tool			
Complex archive data plotting (xy, statistics, 2D/3D)		•		•	•		•	XY 3D Surface
Trends, (M= multivariable)		M	M	M	M	M	M	M Multi-day
Energy analysis graphs and reports			Energy Logs		FX-TEM	Utility Cost Manager	VES	
Energy monitoring (interval meter data displays)		•	•	•	•	•	•	•
Real-time data visualization	•	•	•	•	•	•	•	•
Historical Data Playback (VCR)				•	•			
Report Generation	•	•	•	•	•	InfoCenter Suite	•	
Other								

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Alarms (Additional notification methods)	●	●	●	●	●	●	●	●
SNMP		●			●		●	
E-mail		●		●	●	●	●	●
Instant Messaging					●		●	
Pagers		●	●	●	●	●	●	●
Telephone Call-Out					●	●	●	
Fax				●	●		●	
Scheduling	●	●	●	●	●	●	●	
Tenant Services (Override)	●	●	●	●			●	
Dial-up modem access	●	●	●	●	●	●	●	●
Demand Limiting/Reduction	●	●	●	●	●	●	●	
FDD (Fault Detection and Diagnosis)					●			
Integration (N=Native, G=Gateway)								
CMMS (computerized maint.)					N		G	
CAFM (facility documentation)							G	
Lighting	N			G	N	G	G	
Security/Access				G	G	G		
Fire/smoke	N		G	G	N	G		
Weather Data				G				
Utility Billing				G	N: FX-TEM			
Other			G: Hotel Check-In System				G: Tenant billing, maintenance & management	
Support & Costs								
Documentation								
On-line Help	●	●	●	●	●	●	●	●
Printed Manuals	●		●	●	●	●	●	●
CD-ROM		●	●	●	●		●	
Download from Web/FTP site	●			●	●		●	
Support								

Vendor	**Trane**	**Automated Logic**	**Alerton**	**Teletrol**	**Johnson Control**	**Siemens Building Technologies**	**Tridium**	**Electric Eye - EnFlex**
Direct from Vendor	•	•		•	•	•	•	•
Distributors/Dealers		•	•		•		•	•
System Integrator				•			•	•
Helpdesk Hours	Available to Trane personnel	Vendor 8:30 AM - 7:00 PM (EST)	Depends on Dealer		24 hours	24 hours	8:00 AM - 6:00 PM (EST)	Depends on Dealer or System Integrator
Cost								
Pricing model (HW=hardware, SW=software)	Pricing based on complete engineered system.	HW: by equipment SW: number of concurrent users and number of 3rd party points.	HW: by equipment SW: number of devices in system (1-50, 51-150 or 150+).	HW: capacity based SW: number of concurrent users.	Pricing based on equipment type, building type and size, and control specifications.	HW: by equipment SW: license fee Other: installation, coordination, Commissioning .	Vendor price to channel partners. Channel partners adds charges for engineering, installation, commissioning, and markup.	Complete systems are priced by the number of points plus. Pricing also available for retrofits to existing systems.

Appendix C. XML, SOAP, and Web Services

XML

What is XML? XML is similar to HTML, both being based on SGML (Standard Generalized Markup Language). HTML is used to format and display information on a web page when viewed by a browser. While good at displaying information, HTML does not have the ability to structure data in a manner suitable for data exchange. XML, on the other hand, uses tags[9] to define the relationship between elements of the data. XML is being developed and defined by W3C.

For example, on an EMCIS web access page, an outside air temperature may be displayed as "OAT 68 °F". If the HTML code representing the displayed text was to be processed by an application, the application would need to parse the text to determine if the data being exchanged is 68 with a unit of degrees Fahrenheit and it is the outside air temperature. If the HTML code is slightly different from the above example (OAirT instead of OAT), then the data would not be parsed properly. With XML, there would be tags that identify the data value as 68, the data unit as degrees Fahrenheit, and the data represented as outside air temperature. The definition of these tags and their relationship is called an XML schema.

Example XML Schema:

```
<OutsideAirTemperature>
        <Units>Fahrenheit</Units>
        <Value>68</Value>
</OutsideAirTemperature>
```

In order for the proper exchange of data, the sender and the receiver must use the identical schema. In order for a whole business sector to exchange data between each individual business, a standard set of schemas must be agreed upon within the business sector. The dilemma is that businesses can begin defining schemas so that data can be exchanged, but these schemas may not be compatible with other businesses and sometime in the future, a standard set of schemas may make earlier definitions obsolete.

SOAP and Web Services

SOAP is used to invoke applications running on another platform without regard to what the platform is or what language the application was written in. In fact, the client can be completely incompatible with the server. SOAP relies on HTTP to transport XML based messages that are encapsulated in a SOAP envelope. Like XML, SOAP is being developed and defined by W3C.

[9] An XML tag is descriptive text that is wrapped around content (i.e. data) and is used to identify the content within the structure of the XML document.

SOAP is the basis for the emerging Web Services technology. Many of the major Enterprise Software vendors have Web Services initiatives, including Microsoft's .NET, IBM's WebSphere, Sun Microsystem's SunOne, and Oracle's 9i among others [7]. An IBM tutorial describes Web Services as "self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web Services perform functions, which can be anything from simple requests to complicated business processes. Once a Web Service is deployed, other applications (and other Web Services) can discover and invoke the deployed service" [5]. One early example is Microsoft Passport, an authentication Web Service hosted by Microsoft [8]. Many believe that Web Services technology will eventually replace some of the current object-oriented architectures such as CORBA, DCOM, IIOP, OLE (OPC) and RMI.

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