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IT Basics for Energy Managers— The Evolution of Building Automation Systems Toward the Web

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ABSTRACT

The purpose of this article is to help prepare energy managers to understand some of the fundamental concepts of web-based building automation systems (BAS). We thoroughly examine each component of a BAS in today's BAS technology and what a BAS might look like in the future. This article is the second in the series addressing information technology basics for energy managers. The capability and use of information technology (IT) and the internet in the form of web-based energy control systems continues to grow at a rapid rate, and it is imperative that facility managers, maintenance managers, and energy managers become ready to work with current and future applications of internet-based control technologies in their facilities. The emphasis here is on the use of computer networking, use of facility operation databases, and sending and receiving control system data over the web using the TCP/IP communications protocol, and other features that make up a successful BAS.

INTRODUCTION

The combination of low cost, high performance microcomputers together with the emergence of high-capacity communication lines, networks, and the internet has produced explosive growth in the use of web-based technology for building automation systems. Many of these current BAS systems use a proprietary information structure and communications protocol that prevents the easy modification of the BAS operation and greatly limits the plug and play application and addition of interchangeable components in the system. Control solutions such as BACnet and LonWorks have helped this situation somewhat, but they have also introduced their own levels of difficulties. The BAS of the future will integrate state-of-the-art information technology (IT) using TCP/IP and the web that is available to almost all users and facilities. Open and standard approaches from IT using the internet, the web, and, in particular, the standard internet communications protocol TCP/IP, have become popular in the BAS area, and new players have developed BAS systems that are not as reliant on proprietary information structures and communications protocols. These new IT-based systems are rapidly overtaking the older BAS systems. All of the established BAS companies are quickly developing ways to interface their systems with the web and with TCP/IP, allowing the use of standard web browsers such as Internet Explorer and Netscape.

The internet standard communication protocol is TCP/IP, and all IT people understand it well. Network administrators commonly use TCP/IP as the communications protocol for the local area network (LAN) in facilities. This high-speed backbone is the heart of the network interconnection of computers, systems, and components of the facility's control and information system. TCP/IP continues to grow in use as the local communications protocol as well as the LAN protocol. Every day, more devices and controllers using TCP/IP directly are becoming available for our use, as is evident from advertisements and catalogs we see. As more use is made of TCP/IP directly, there is less need for other protocols, and especially less need for proprietary protocols. There will most likely always be a continued use of some proprietary protocols at the farthest points of our local control units, boards, and components. These proprietary protocols used at this level of our energy control system may represent the lowest cost and fastest communication capabilities.

The goal of this article is to provide a description of the principles and application of IT using TCP/IP to the design and operation of web-based BAS. However, since most of the BAS systems on the market today use exclusive or more extensive use of non-TCP/IP proprietary communications protocols, a significant part of this article describes the current operation of many of these BAS systems, and identifies the areas where IT and web-based BAS can be applied. As time goes by, more BAS systems will utilize web-based control and communications, and eventually—in the opinion of the authors—most BAS systems will utilize web browsers and TCP/IP communications for the majority of the operations and data exchanges in the overall system.

THE BASICS OF TODAY'S BAS

At a minimum, a BAS is used to control functions of a heating, ventilating, and air conditioning (HVAC) system, including temperature and ventilation, as well as equipment scheduling. Substantial additions to these basic functions are usually required to comprise a "true" BAS. They include monitoring utility demand and energy use, building conditions, climatic data, and equipment status. Often, the BAS reports results provided in the form of utility load profiles, trends and operation logs of equipment, and generation of maintenance schedules. Even basic BAS are generally expected to perform control functions that include demand-limiting and duty cycling of equipment.

More elaborate BAS can integrate additional building systems such as video surveillance, access control, lighting control, and interfacing with fire and security systems. However, in large organizations and campuses today, it is still more common to see dedicated systems for these additional building systems due to divisions in management functional responsibility, code issues, and features/performance of dedicated systems.

Today's BAS are expected to receive and process more sophisticated data on equipment operation and status, such as from vibration sensors on motors, ultrasonic sensors on steam traps, infrared sensors in equipment rooms, and differential pressure sensors for filters. Top-of-the-line BAS today also have additional capabilities, such as chiller/boiler plant optimization, time schedule/setpoint management, alarm management, and tenant billing to name a few. Most BAS manufacturers today have started to offer some form of web-based access to their existing control systems and are actively developing web-based capability for their future products.

The following sections introduce the hardware and software that make up some of the functions of a basic BAS commonly used today.

Control Unit Hardware

The control units used for a BAS provide the inputs, outputs and global functions required to control the mechanical and electrical equipment. Most BAS manufacturers provide a variety of control units tailored to suit the specific need. Shown below is a list of the most common control units:

Universal Processor Unit

Works with the universal I/O unit and contains the control logic and programs for the application. Module usually includes some onboard I/O.

Universal Input/Output Unit

Provides expansion I/O for the universal processor unit. Inputs include temperatures, relative humidity, pressures, and fan & pump status. Outputs include on/off and valve/damper control.

Primary Controller Unit(s)

Provides global functions for the BAS control network that can include communication interface between PC front-end software and lower-tier controllers, real-time clock, trend data storage, alarms, data transfer between lower-tier controllers, and higher-level programming support. Some BAS manufacturers combine all these functions into one primary controller, while other BAS manufacturers have separate controllers that are dedicated to each global function.

VAV Box/Fan Coil Controller

Self-contained controller with integral processor and I/O designed to control a VAV box or a fan coil unit.

DX Controller

Controller designed to control a multistage cooling and heating direct expansion (DX) air conditioning system.

For further reference, the Iowa Energy Center has an excellent web site (*http://www.ddc-online.org*) that shows a complete overview of the designs, installations, operation, and maintenance of most BAS on the market today.

Control Unit Programming

Control units typically contain software that can control output devices to maintain temperature, relative humidity, pressure, and flow to a desired set point. The software programming can also adjust equipment on-off times based on a time-of-day and day-of-week schedule to operate only when needed.

The software used to program the control units varies by BAS manufacturer and basically falls into three categories:

- Fill-in-the-blank programming standard algorithms;
- Line-by-line programming custom programming;
- Graphical custom programming.

Fill-in-the-blank

Uses pre-coded software algorithms that operate in a consistent, standard way. The user fills in the algorithm configuration parameters by entering the appropriate numbers in a table. Typically, smaller control devices use this type of programming, like those that control a fan coil or VAV box controller. These devices all work the same way and have the same inputs and outputs.

A few manufacturers have used the fill-in-the-blank programming for devices that are more complex where a variety of configurations can exist, such as air handlers. Standard algorithms are consistent for each individual component. As an example, the chilled water valve for an air handling unit is programmed using the same standard algorithm with only the configuration parameters adjusted to customize it for the particular type of valve output and sensor inputs. Programming all of the air-handler devices using the appropriate standard algorithm makes the air-handling unit work as a system.

The advantage of fill-in-the-blank standard algorithms is that they are easy to program and are standard. The downside is that if the standard algorithm does not function the way you want or there is not a standard algorithm available, the system requires development of a custom program.

Line-By-Line Custom Programming

Programmers use this to create control programs using the BAS vendors controls programming language. They start the code from scratch and customize it to control the system. In most cases, programs can be re-used for similar systems with modifications as needed to fit the particular application.

The advantage of line-by-line custom programs is that technicians can customize them to fit any controls application. The disadvantage is that each program is unique, and troubleshooting control problems can be tedious since technicians must interrogate the code line by line.

Graphical Custom Programming

Vendors developed this to show the control unit programs in a flow chart style, thus making the programming tasks more consistent and easier to follow and troubleshoot.

Below are some additional issues to consider regarding control unit programming:

- Can technicians program the control units remotely (either network or modem dial-in) or must they connect directly to the control unit network at the site?
- Does the BAS manufacturer provide the programming tools needed to program the control units?
- Is training available to learn how to program the control units? How difficult is it to learn?
- How difficult is it to troubleshoot control programs for proper operation?

Control Unit Communications Network

The control unit network used by control units varies depending on the manufacturer. Several of the most common control unit networks used today include RS-485, Ethernet, ARCnet and LonWorks.

RS-485

Developed in 1983 by the Electronic Industries Association (EIA) and the Telecommunications Industry Association (TIA). The EIA once labeled all its standards with the prefix "RS" (recommended standard). An RS-485 network is a half-duplex multi-drop network, which means that multiple transmitters and receivers can exist on the network.

Ethernet

The Xerox Palo Alto Research Center (PARC) developed the first experimental Ethernet system in the early 1970s. Today, Ethernet is the most widely used local area network (LAN) technology. The original and most popular version of Ethernet supports a data transmission rate of 10 Mb/s. Newer versions of Ethernet called "Fast Ethernet" and

"Gigabit Ethernet" support data rates of 100 Mb/s and 1 Gb/s (1000 Mb/s).

ARCNET

A company called Datapoint originally developed this as an office automation network in the late 1970s. The industry referred to this system as ARC (attached resource computer) and the network that connected these resources as ARCNET. Datapoint envisioned a network with distributed computing power operating as one larger computer.

LonWorks

Developed by the Echelon Corporation in the 1990s. A typical node in a LonWorks control network performs a simple task. Devices such as proximity sensors, switches, motion detectors, relays, motor drives, and instruments may all be nodes on the network. Complex control algorithms, such as running a manufacturing line or automating a building, are performed through the LonWorks network.

Control Unit Communications Protocol

A communications protocol is a set of rules or standards governing the exchange of data between control units over a digital communications network. This section describes the most common protocols used in a BAS.

BACnet

Building automation control network is a standard communication protocol developed by ASHRAE specifically for the building controls industry. It defines how applications package information for transportation between building automation system (BAS) manufacturers. The American National Standards Institute has adopted it as a standard (ASHRAE/ANSI 135-1995).

LonTalk

An interoperable protocol developed by the Echelon Corporation and named as a standard by the Electronics Industries Alliance (ANSI/EIA-709.1-A-1999). Echelon packages LonTalk on their "neuron chip" which is embedded in control devices used in a LonWorks network.

Proprietary RS-485

The protocol implemented on the RS-485 network is usually proprietary and varies from vendor to vendor. The Carrier Comfort Network (CCN) is example of a proprietary RS-485 communications protocol.

Modbus

In 1978, Modicon develop the Modbus protocol for industrial control systems. Modbus variations include Modbus ASCII, Modbus RTU, Intel® Modbus RTU, Modbus Plus, and Modbus/IP. Modbus protocol is the single most supported protocol in the industrial controls environment.

TCP/IP

Transmission control protocol/internet protocol (TCP/IP) is a family of industry standard communications protocols that allow different networks to communicate. It is the most complete and accepted enterprise networking protocol available today, and it is the communications protocol of the internet. An important feature of TCP/IP is that it allows dissimilar computer hardware and operating systems to communicate directly.

Proprietary vs. Open Protocol

With the introduction of LonTalk and BACNet protocols, the virtues of "open" and "interoperable" networks have been the buzz words of late. The term "open" has taken on a positive connotation, while the term "proprietary" has taken on a negative connotation. This section will discuss this perception in more detail.

In recent years, LonTalk has emerged as an "open" protocol and been embraced by numerous BAS manufacturers. However, to obtain a truly open BAS, Echelon's vision is that all BAS devices (sensors & actuators) be intelligent Lon-compatible devices interconnected in a LonWorks network. However, most BAS manufacturers that have developed LonWorks-compatible products continue to use a control unit with I/O connected to "dumb" sensors using proprietary control unit software. The only thing that has changed is that the system uses LonTalk as the communications protocol between the control units and other LonWorks-compatible devices in the BAS. Therefore, the degree of "openness" of these systems is debatable.

The negative connotation of using a BAS with a proprietary protocol may be offset by other benefits that may be more important to an end user, such as:

- Reliability
- Serviceability
- Standardization
- Ease of programming
- Expandable
- Low Cost
- Speed

Providing the most flexible BAS at the lowest cost is important to end users. To reach this goal, it is the opinion of the authors that BAS systems in the future will utilize the open and standard approaches found in web-based control and communications for the majority of the BAS operations and data exchanges.

Client Hardware/Software

Normally, a PC workstation provides operator access into the BAS. The PC workstation may or may not connect to a LAN. If a server were part of the BAS, the PC workstation would need LAN access to the server data files and graphics. Some smaller BAS use stand-alone PCs that have all the BAS software and configuration data loaded on each PC. Keeping the configuration data and graphics in sync becomes problematic with this approach

A graphical user interface (GUI) is one of the client-side software applications that provide a window into the BAS. The GUI usually includes facility floor plans that link to detailed schematic representations and real-time control points of the building systems monitored by the BAS. The GUI allows technicians to change control parameters such as set points, time schedules, or temporarily override equipment operation. Other client-side software applications include:

- Alarm monitoring
- Password administration
- System setup configuration
- Report generation
- Control unit programming and configuration

Server Hardware/Software

Servers provide scalability, centralized global functions, data warehousing, multi-point access, and protocol translations for a mid-size to large BAS. Servers have become more prominent in the BAS architecture as the need has grown to integrate multi-vendor systems, publish and analyze data over an intranet or extranet, and provide multi-user access to the BAS. While having a central server on a distributed BAS may seem contradictory, in reality, a server does not take away from the stand-alone nature of a distributed control system. Servers enhance a distributed control system by providing functions that applications cannot perform at the controller level. In fact, a BAS may have several servers distributing tasks such as web publishing, database storage, and control system communication.

Operating System and Server Hardware

The key to any server operating system (OS) is robustness. Whether the server operates on Unix, Linux, Mac, or Windows, it is imperative that the server OS has the ability to handle all of the tasks required of it. This usually requires a true multi-tasking, multi-threaded OS with very flexible networking capabilities. Windows 2000 is a very popular choice for this task, not only because it fits the criteria, but also because many IT departments support it. IT support is critical to the success of any mid- to large-scale BAS installation. When designing a BAS, it is in all parties' best interest to involve the IT department and designate a BAS champion from that department early on. Even though the manufacturer of BAS server software may be able to operate on a wide variety of hardware platforms, many times the IT department will dictate the server hardware and OS. Since backing up the server database usually falls under the IT department's responsibility, it is imperative that the server hardware meets the necessary criteria. This may include hot-swappable hard drives, dual network interface cards, rack-mounted PCs, and server versions of a particular OS.

Control System Programs

Servers provide the ability to globally control a BAS. Facility-wide time scheduling, load-shedding, or set point resets are examples of global functions a BAS server can perform. Since these types of functions are overrides to the standard BAS control programs, having them reside in the server requires that steps be taken to insure continued control system operation should the server go down for any length of time. The distributed BAS should have the ability to "time out" of a server override if communication with the server is lost. When the server comes back on line, the BAS should have rules that govern whether the override should still be in effect, start over, or cancel. Servers also can perform computational tasks, offloading this work from the BAS control units.

Custom Programs

Most server-based control programs are a combination of custom and standard control applications. Since there are individual needs at every site, server-based control programs must be flexible enough to meet those needs without a complicated set of procedures for the end user. A common approach is to provide some basic level of control with a standard, vendor-supplied software product, then having the vendor provide the "hooks" into the software for custom application development. Since many software products work with the Microsoft Windows OS, standards such as dynamic data exchange (DDE), object linking and embedding (OLE) or dynamic link libraries (DLL) are common interfaces to standard applications.

Server to BAS Network Communications

Servers communicate with the BAS through a variety of electrical and network protocols. The most common communication method is a direct RS-485 multi-drop connection to the lower tier controllers. Depending on the size of the BAS, the server may have several communication ports connected to multiple RS-485 communication busses, or it may have one communication port connection. Some servers may use a combination of TCP/IP network connections and RS-485 communications busses to lower tier controllers. When TCP/IP is used, usually the server encapsulates the same communication messages that would normally travel over the RS-485 wire into a standard internet protocol (IP) packet. Once the packets reach their destination IP address (either another computer or a dedicated Ethernet to RS-485 converter), the network transfers the packets to the RS-485 bus for communication to the lower tier controllers. See Figure 1 for a schematic of today's BAS network.

Servers may also support modem communication to both the BAS lower tier network of controllers and to off-network monitoring sites. Through an OS standard such as remote access communication (RAS), modems can be set up to dial directly into the server and access many or all functions that the server provides, such as dynamic graphics, historical data, and controller interrogation or programming. Modems can also be used as dedicated communication interfaces to the lower tier BAS network, providing users access directly to the BAS controllers for system status information, schedule changes, or even programming changes. Whether the modem accesses the server or the BAS network directly, the connection must be secure to ensure that unauthorized users cannot dial into the system and cause harm. Many BAS manufacturers utilize a combination of password levels and communication encryption to accomplish an acceptable level of security. RAS connections can employ the same security measures installed for the IT network security since it is actually a dial-up network connection. Modems serve one other purpose for BAS systems: they can be used to dial out alarms when they occur to a workstation or pager, and they also can be used to dial out and transfer historical data to a remote site based upon rules set up for transferring the data.

INTEGRATING THE WEB INTO BAS

Servers and the Web

Web-based server applications are becoming the standard for most mid-size to large BAS installations. Applying web technology and standards to a BAS provides several advantages. Since the web and the protocols that access the web have become mature, defined standards, the BAS can inherit these standards, making connectivity and interoperability between enterprise level applications and the BAS easier to achieve. Current XML standards allow a BAS manufacturer to publish its control network data over an intranet or internet in a standard format that another application or control system vendor that supports XML can read.

Extensible Markup Language (XML)

XML organizes data into a predefined format for the main purpose of sharing between or within computer systems. Furthermore, its uses include data organization and transfer, data presentation, data caching, and probably some that we have not invented yet.

Web-based servers can share real-time data, historical trends, and control signals, as well as provide multi-vendor connectivity by following internet standards. Some BAS manufacturers have implemented an open JAVA standard for building automation and control. Whether the BAS uses HTML, XML, JAVA, or any other internet standard, a key advantage of using the internet is that all of the standards are hardware and operating system independent. Web-based servers also have the advantage of allowing multiple user access to the BAS with a standard web browser, making the overall installed cost of the BAS very attractive.

Many BAS manufacturers today provide some sort of web connectivity. Some achieve connectivity through conversions of existing software products and platforms that export information to the web, while others have taken the approach of providing a stand-alone web server device that takes their proprietary protocol or multiple protocols and ports them to TCP/IP. The dedicated stand-alone web server can have several advantages over the software conversion approach:

- The server is typically written in a portable language such as JAVA, making it hardware independent.

- The server becomes a "black box" with an IP address on the LAN/WAN, making it easier to administer and troubleshoot.

- The server is upgradeable over the LAN/WAN without regard to the currently running operating system.

- The server becomes a two-way portal between the BAS and enterprise level applications, reducing the number of layers between the BAS and the enterprise.

JAVA-based servers provide the closest thing to open protocol. JAVA provides a hardware and OS independent platform for development of communications and data transfer between IP based objects. Most operating systems support a JAVA virtual machine, allowing JAVA code to run unmodified from one type of system to another. This greatly reduces development costs, as the programmers need only write the JAVA code once. In addition, since the JAVA virtual machine does not touch the client or server's hardware directly, it provides the necessary security required in today's networking environment. JAVA applets can perform all kinds of BAS functions. Here are just a few examples:

- Displaying dynamic data on a graphical HTML page;
- Converting data;
- Trending data and storing it on a remote server;
- Performing calculations on data from various sources and sending the result to the BAS controllers;
- Accessing XML or SQL databases to display data graphically or perform data analysis.

Since JAVA is part of the toolset used with TCP/IP based systems, it communicates directly with HTTP, XML, and any other web-based standard in existence today. A good example of a JAVA-based web server that incorporates all of the above-mentioned technologies is the CarrierOne Comfort Integrator (*www.carrier.com*), powered by the Niagara Framework™. The Niagara Framework™ is a JAVA-based object model that provides web access between multi-vendor BASs and enterprise level applications.

Future Treads in BAS Web Integration

The BAS of the future will likely see web technology implemented further down the wire. As the cost of 32-bit microprocessors continues to fall, many manufacturers will find it cost effective to put the TCP/IP protocol directly into their controllers in the field.

In the future, we may see BAS controllers that use TCP/IP protocol directly. A BAS manufacturer could either create plug-ins or generate an XML schema that would define the data communications. The idea is to share the plug-ins among systems requiring access to the BAS. They would typically be JAVA applets. Each controller would be, in essence, a mini web server. HTML graphic pages for that particular device could be stored directly in the controller's memory, serving up dynamic controller data, allowing edits to controller configuration, or having hyper-links to other controllers or systems. Tasks such as data collection, global communication, scheduling, etc. could be handled by either a controller designated as a master server, or another TCP/IP device on the network. See Figure 2 for a schematic of the BAS network we might see in the future.

XML Schemes

This is a language, written in XML, which describes the data structures and constraints found in a XML data file.

There are some technical and network management challenges that come with this future BAS vision however. TCP/IP over Ethernet is the current standard for transporting data between systems. Ethernet has several drawbacks when trying to push this technology down to the BAS controller level. First, when compared with 3-wire twisted shielded pair cable, the wiring is costly to purchase and install. It must be home run to a hub or router, which would cause raceways and conduits to grow exponentially on a project. In addition, it becomes a management nightmare for the IT department, since every device would require greater bandwidth and security supervision. The TCP/IP protocol will need to evolve to support a multi-drop network to economically compete with RS-485 proprietary communication. Several manufacturers are already either experimenting with or providing TCP/IP over an RS-485 connection, but some hardware, such as RS-485 to Ethernet converters and RS-485 routers have yet to make it to the mainstream electronics marketplace. Once all of these products mature, along with the management tools IT will require to maintain network security and uptime, web servers at the controller level will become mainstream technology.

USING A BAS FOR DATA COLLECTION, STORING AND PUBLISHING

Before we answer the question "*How* is BAS data storing and collecting evolving?" perhaps we need to understand "*Why* is BAS data storing and collecting evolving?" Simply put, the internet has changed the way we share data. In the past, the BAS was the only system that could access and display the data collected. Only a few people in any one organization could turn that raw data into something meaningful. Now, publishing this data or its derivatives is becoming more popular. Sharing the data with others, perhaps across the globe, is a reasonable expectation.

The following sections describe how to get the most out of the data collection capability in today's BAS and what we might see in tomorrow's BAS.

Traditional Methods for Collecting BAS Data

Most BAS on the market today have some method for collecting data from sensors, control devices, and meters attached to the system.

The first step is to program the BAS software to collect the desired BAS data and to output a data text file once a day on the BAS Server. At this point, the user can look at the data using a text editor or spreadsheet program.

Typically, a BAS does an adequate job of collecting data, but a poor job of publishing and analyzing the data. To make this data more meaningful and useful, the data needs to be added to a relational database and displayed in the web-based energy information system.

Relational Database

A relational database is a collection of tables with rows and columns. Application developers use them to store, organize and access data according to relationships between data. Examples of relational databases are FoxPro, SQL and Oracle.

The key to extracting the data from the individual text files into a relational database is the format and fields that are stored in the data text file. The data format used by most BAS manufacturers today is CSV. Relational database and spreadsheet programs can read this common format.

CSV

Comma separated value. Each record of a CSV file is a set of ASCII values separated by commas and surrounded by quotation marks (“,”). If a value contains the separator “,”, then the value is put between “”. If a value contains ,” it is replaced by “”.

Example: 123,”123,521.2",”Mary says “”Hello, I am Mary”””

Another important feature of this data text file is that the first column of each row contains an identifier that indicates what data is contained in each row. This makes it easier to pull the data into the relational database so it will include the desired data and exclude extraneous data from the data text file. See figure 3 for an example of this feature.

Analysis of the data in these files can be quite difficult, and it is time consuming to take raw data and turn it into meaningful and presentable data. This is where the end user should take over and create a custom program to extract the data into a relational database. Important issues to deal with in this custom program include:

- Dealing with "bad" data and making sure not to duplicate or omit data if an application error occurs.
- Archiving the data likely will require combining data into monthly or even yearly database tables to conserve space.
- The data collection application must achieve a delicate balance between the size and number of tables in which to store data.
- Storing data in a table that is too large will not produce results as quickly as a smaller table.
- Storing data in tables that are small, but too numerous, make it inconvenient to produce comprehensive reports covering long time sequences.

The final step is the development of a custom energy information system (EIS) that can publish this data over an intranet or internet. These data are effectively shared with all users in the organization that need to see the data—on their PCs using a standard web browser or via e-mail.

Future Trends in BAS Data Collection—XML

The data text files that were once the framework of BAS data collection programs are beginning to give way to a new method of storing and moving data. Now, as our computer applications and networks become so diverse and complex, a way to standardize the storage of energy data emerges in the form of XML.

A typical use for XML is to transport reasonably large amounts of data over long distances via TCP/IP networks. A database-driven web application or EIS would import the raw XML data into a relational database for archiving and publishing purposes. Relational databases are still more efficient to filter, sort, and query large amounts of utility data compared to leaving the data in XML format. Many conversion programs exist to convert XML data to and from relational databases. As complex as this whole process may seem now, it is still a step in the right direction toward a more "open" BAS with more accessible and transportable data.

Small web servers located in a facility can bridge the gap between the BAS sensors, control devices and meters, and the LAN or WAN. As an example, the i.LON 100 Internet Server manufactured by Echelon (*http://www.echelon.com*) is a high performance interface that connects a LonWorks network to the internet, a LAN or a WAN. The i.LON 100 offers a built-in web server. Data from devices on a LonWorks network are collected in the log and, when convenient, uploaded as an XML file, dispatched as an e-mail message, or displayed as an HTML web page.

Data collected at these local collection devices and stored as XML using XML schemas have attributes associated with them to describe them. Data stored in XML files contain both the database structure and the data in the same file. This eliminates at least some of the proprietary programming required to translate the data into meaningful information. Databases can create a table from a CSV file but it does not really know what all the possibilities for the data structure are. With XML, all that information—and much more, if desired—can travel right in with the data values as attributes. The application to import it is then much more "general" in its design. That is how database vendors have created conversion tools to convert database tables to XML and vice versa.

Looking at the big picture, you can imagine a system transferring hundreds of different CSV files all around a large facility with all kinds of data. There would be hundreds of different custom applications to import each different CSV file. With XML files, you only need one conversion application. You can find an example of an XML file at: *http://utilityreporting.com/utilitydata.xml*. A web browser can also display small amounts of XML as a web page. You can find an example of XML data displayed as a web page at: *http://utilityreporting.com/utilitydata.xml*. For additional information on XML, refer to *http://www.xml.com*.

It is no surprise that collecting, storing, and publishing BAS data is evolving toward the web. TCP/IP networks provide the most convenient and economical way to transport data. Traditional storage mediums such as text and relational database tables transport over those networks just as well as any other data. However, XML provides a means of bypassing all the proprietary methods of handling the data. Of course, new methods arise from its acceptance, but they will be more standard than before. The data are more transportable, accessible, and possibly better defined. There is hope that acceptance of XML is also leading to a standard XML schema or set of XML schemas for utility data transfer. A common understanding of this data can encourage competition, lower support costs, and eventually lead to a better BAS.

CONCLUSION

The BAS of old relied heavily on a collection of separate systems that operated independently, and often with proprietary communication protocols that made expansion, modification, updating and integration with other building or plant information and control systems very cumbersome, if not impossible. Today the BAS is not only expected to handle all of the energy and equipment-related tasks, but also to provide operating information and control interfaces to other facility systems, including the total facility or enterprise management system. A BAS can only accommodate these expanded functions using the speed, capacity, and interoperability of the internet, the web and the standard TCP/IP communications protocol. These requirements, together with the need for remote entry of data requests and operational changes through standard web browsers, among other features, are driving the BAS of today to the web, and into the domain of information technology. It is imperative that all energy managers and facility managers become prepared to operate, modify and improve their web-based energy information and control systems, as well as become comfortable with specifying and purchasing new web-based BAS and other facility enterprise management systems.

Measuring, monitoring and maximizing energy savings is a fundamental task of all BAS, and is the primary justification for many BAS installations. Improving facility operations in all areas through enterprise information and control functions is fast becoming an equally important function of the overall BAS or facility management system. The web provides the means to share information easier, quicker, and cheaper than ever before. There is no doubt that the web is having a huge impact on the BAS industry. The BAS of tomorrow will rely heavily on the web, TCP/IP, and high-speed data networks. If you have not done so already, it is a good time for energy managers to get to know their IT counterparts at their facility. The future BAS will be here sooner than you think. Get ready—and fasten your seat belts!

ABOUT THE AUTHORS

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David Green has combined experience in intranet/internet technology and database queries and has developed programming for energy information systems. David has been the president of his own consulting company, Green Management Services, Inc., since 1994. He has a Bachelor of Science degree in chemistry and a Master of Arts degree in computer science. David is also a lieutenant colonel in the Illinois Army National Guard and has 18 years of military service. David has successfully completed major projects for Walt Disney Company, ABB Group, Cummins Engine Company, ECI Telematics, the M.A.R.C of the Professionals and The Illinois Army National Guard. (*dcgreen@dcgreen.com*)

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ADDITIONAL INFORMATION

More information about energy information systems as well as links to many of the tools discussed in this article is available at *http://www.utilityreporting.com/*.

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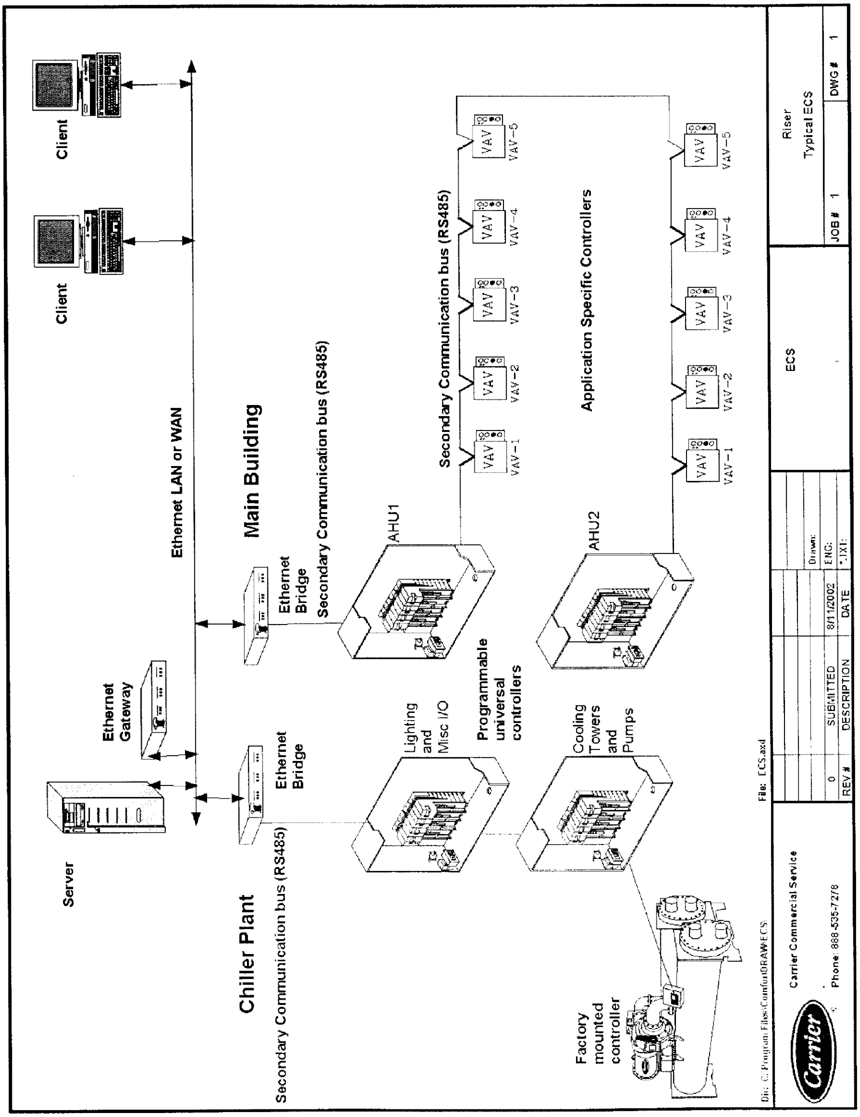


Figure 1: Today's BAS Network Schematic

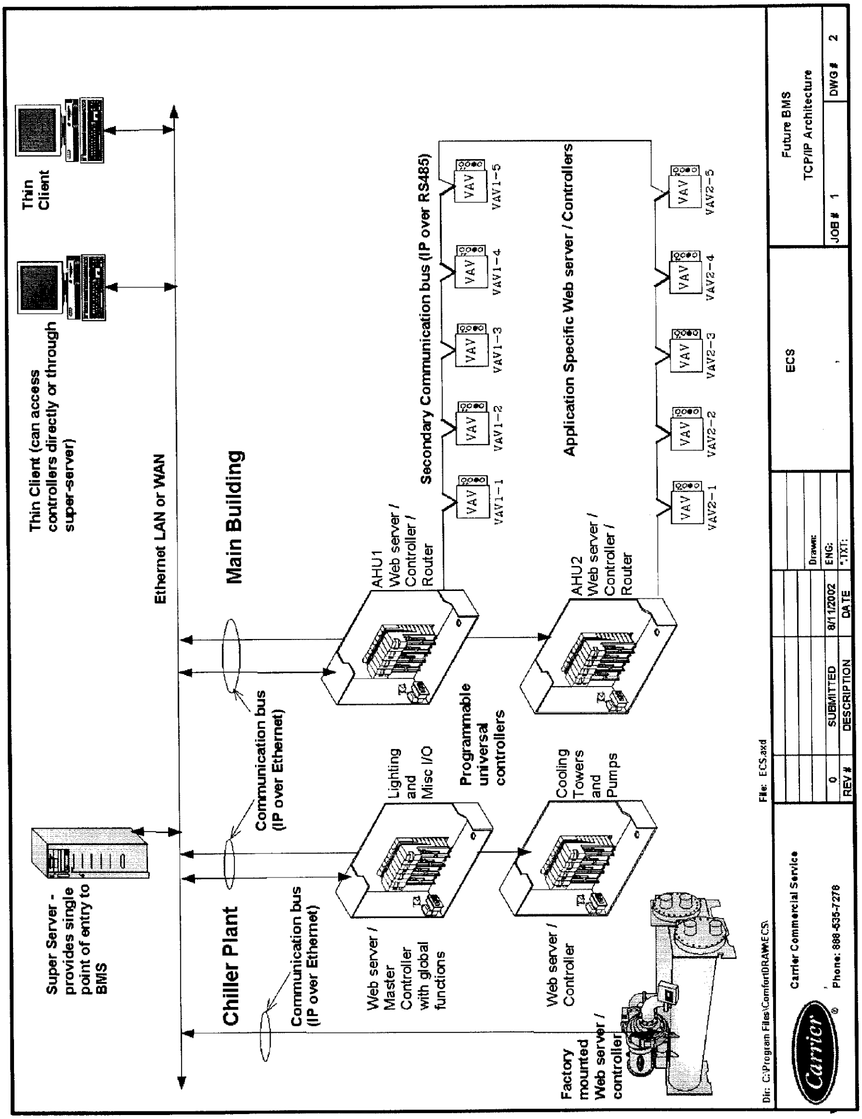
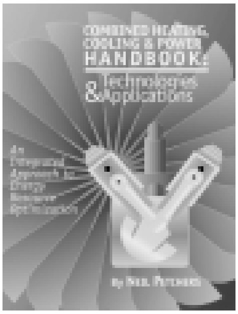


Figure 2: Future BAS Network Schematic



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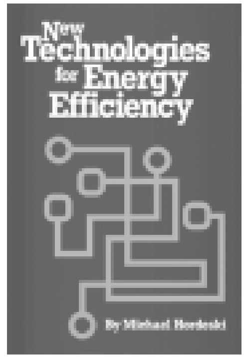

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              E:129.GCM_01.LCM_00.SIM.VAV
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Figure 3: BAS CSV File Showing Identifier Field