Total Facility Control – Applying New Intelligent Technologies to Energy Efficient Green Buildings

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Abstract

Energy efficiency through intelligent control is a core element of any "Green Building". We need smarter, more efficient ways of managing the energy consuming elements within a building. But what we think of as "the building" is only a small piece of the puzzle. We have to think broader in order to gain the greater energy savings and efficiencies that are possible. "Total Facility Control" is a concept that we need to embrace and consider when we design, commission, and retrofit our facilities.

Very often a single building is part of a larger campus or collection of buildings under a common management domain. Be it a university, public school district, office complex, or multi-use tenant space, there are often multiple "buildings" plus the connectivity between buildings: walkway lighting, signage, parking structures, and even the irrigation systems. We don't often think about the outdoor lighting, security, or irrigation as part of the building management plan, but it can be a significant contributing factor when looking at places to save on energy and improve operational efficiency.

We must change the way we design our buildings, facilities, campuses, and enterprises in order to be more energy efficient and be green. A variety of technologies and design principles are available to ensure we move in a positive direction. We must make our systems and processes more visible and, hence, more accessible.

At the core of this is the visibility and control of the systems within these environments. A majority of the building control systems in operation today are extremely limited in their ability to achieve higher efficiencies because there is no intelligent control or communication system available; and the amount of cross system interoperability is even scarcer.

What does an interoperable system architecture look like? It's one in which a wide variety of energy consuming, intelligent devices can share their information and be controlled by an energy management system.

Newer technologies use open systems, open protocols, and higher levels of interoperability, all of which have been proven to cost effectively provide competitive solutions. Better energy efficiency and improved operational costs start with better visibility and control of the myriad of systems within a facility. They must communicate together in a way that enables greater functionality and lower costs.

Total Facility Control must be considered as we look at the entire building envelope as well as the rest of the facility systems. Included in the mix are HVAC, indoor lighting, security, access, sun shading, indoor air quality, sound masking and alarm annunciation, elevators/escalators, appliances, power conditioning, irrigation, energy metering, outdoor/parking lot lighting, street lighting, co-generation stations, and much more.

This paper will discuss some of the basic concepts, architectures, and technologies that are being used today to implement a Total Facility Control model.

Technology Evolution

Building automation systems today are largely based upon a third generation of decentralized, open automation control system design. Prior generations of systems provided centralized, home run wired systems which were limited to master slave based systems with little "intelligence" at the end device. These older architecture systems were very limited in their ability to expand and to interoperate with additional components.

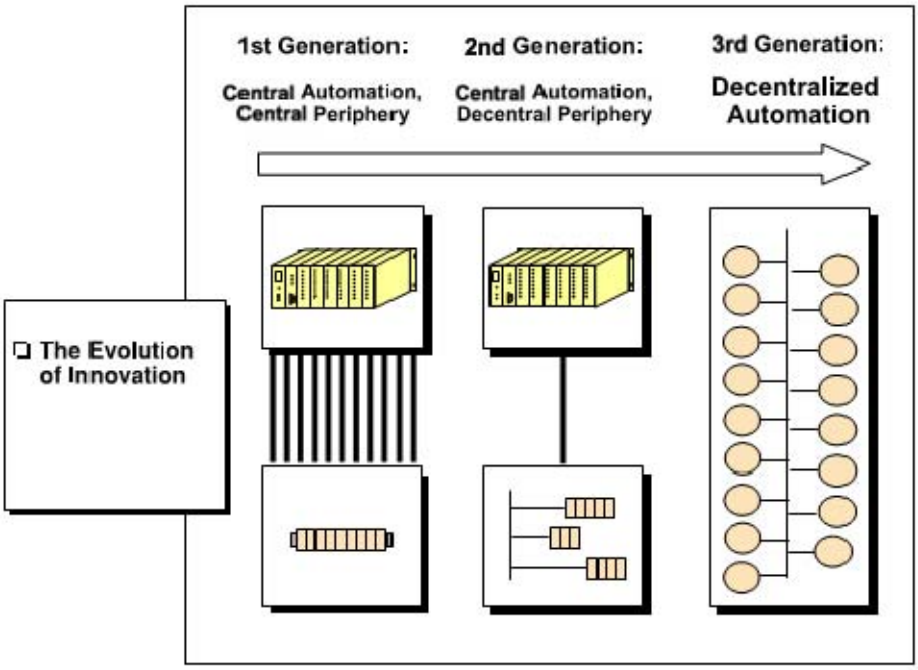

Figure 1 – The Evolution of smart device level control systems

With the advent of smart micro-controllers, the ability to put intelligence down at the point of control has changed the control market forever. "Smart Devices" now have the ability to act and react as independent sensors and actuators in a system. They can consume or produce information and make intelligent decisions based upon software applications programmed internally. No longer are we in need of master slave, dumb sensor/actuator designed systems. These newer systems use a peer-to-peer system architecture based upon open international standards and provide a whole new level of ability based on sharing of data from one device to another. Single point-of-failures are dramatically reduced due to the fully distributed nature of the architecture.

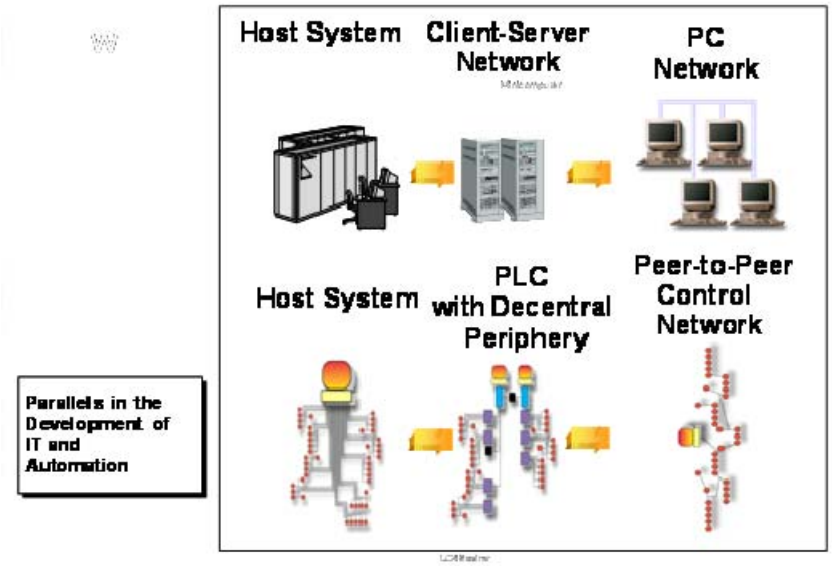

Figure 2 – Control and IT system evolution parallels

The controls market evolution has directly paralleled the computer evolution over the last 30 years or so. In the computer market where we once had centralized host computer systems where individual peripherals were only available from one source, today we have more open architectures where computers, monitors, keyboards, software from multiple vendors can be integrated into a common system. This open architecture model in the IT world has dramatically enhanced the usability and flexibility of systems.

In the controls world this is also true. As more open, flexible control components have become available, more systems and subsystems have been integrated into the entire automation system. Today system integrators can combine a wide array of devices and subsystem components into a complete building automation system.

The advantages of an open system approach are wide and varied and are driving the changes in the industry today. Key control system project drivers:

- Energy Efficiency
- Improve Operational Performance
- Achieve Green Building Status (LEED, Energy Star, Building Star)
- Improve Comfort
- Reduce Maintenance
- Full or Partial System Integration
- Common GUI
- Fair Competitive Bidding

As more products from more vendors are combined into one common system architecture costs are reduced and interoperability is increased. New technologies for open communication systems have enabled all of a building's controls to be more interoperable.

Control systems which were once limited to primarily HVAC or Lighting can now incorporate all subsystems.

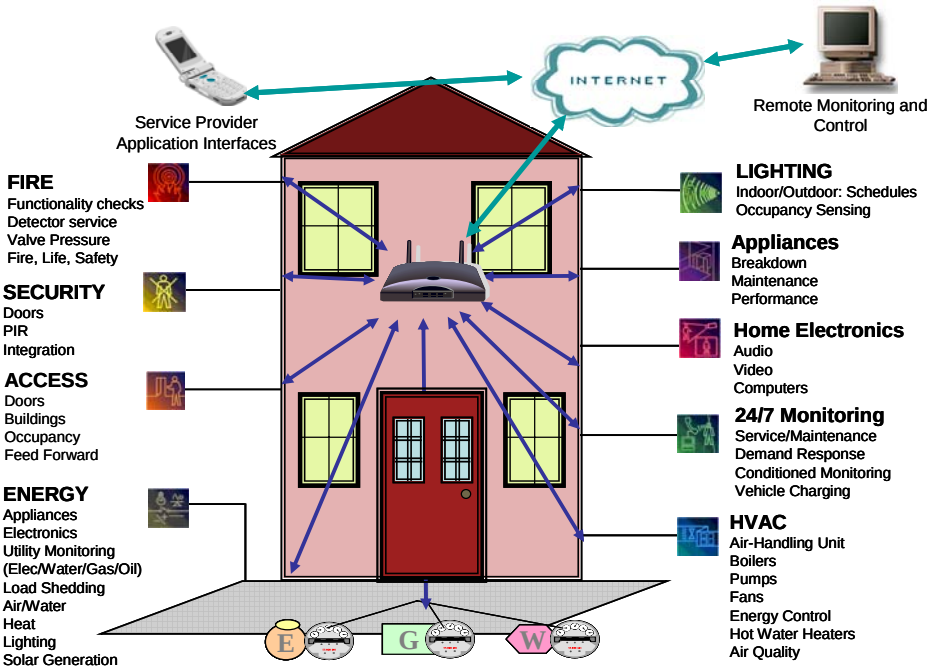

Figure 3 – Building sub-systems integrated into a common architecture

A building control system can now incorporate many subsystems and components where all of the information can be monitored visualized from a common front end. This architecture enables a single-seat "view" into all of the buildings operations and simplifies the operation and maintenance.

Open Standards

In order for this architecture to be applied, a common communications structure needs to be employed at the device level. Open communications protocols standards like ISO/IEC 14908 have been developed specifically for this purpose. They incorporate all control communication layers into one common structure and are easily and cost effectively implemented in each device.

The ISO/IEC 14908 suite of open standards, commonly referred to as "LonWorks" or Local Operating Networks, was developed by the industry to solve the open interoperable control networking communication needs of the building controls market. There are currently over 800 products that have been developed and tested to comply with this standard. According to recent market research over 90 million devices have been shipped using this standard and have been implemented in hundreds of thousands of systems worldwide. Hence the usage of this technology has become the standard for smart control systems that reach not only into buildings but into all aspects of control.

Ongoing specification and standards development has ensured continued adoption and relevance to the growing smart systems market. An industry trade association called LonMark International was created over 15 years ago to manage and maintain the open LonWorks standards. Today this non-profit trade and standards development association continues to enhance the interoperability guidelines and provides a forum for organizations to develop and adopt interoperable controls using ISO/IEC 14908.

Energy Efficiency – Driving Smart Controls

Energy efficiency, energy conservation, and energy reduction are key drivers in the buildings market today. Energy costs have risen dramatically in recent years and facility managers are no longer being complacent about their energy usage. Most facilities are looking for any way to reduce energy.

According to the US Department of Energy, buildings represent **70%** of U.S energy consumption. Energy consumption represents **30%** of a typical commercial office building's operating costs. And a **30% reduction** in energy use can yield the equivalent of a 5% increase in Net Operating Income.

There are many approaches to gaining a better energy footprint for a building but common to many of them are understanding how to control the buildings energy usage. You can't control what you can't see. In order for a facility manager to gain better energy efficiency, he needs to be able to see into the control system and make effective changes. Implementing a smart control system is fundamental to achieving energy reductions.

According to the US department of energy the following chart shows a typical building's energy usage:

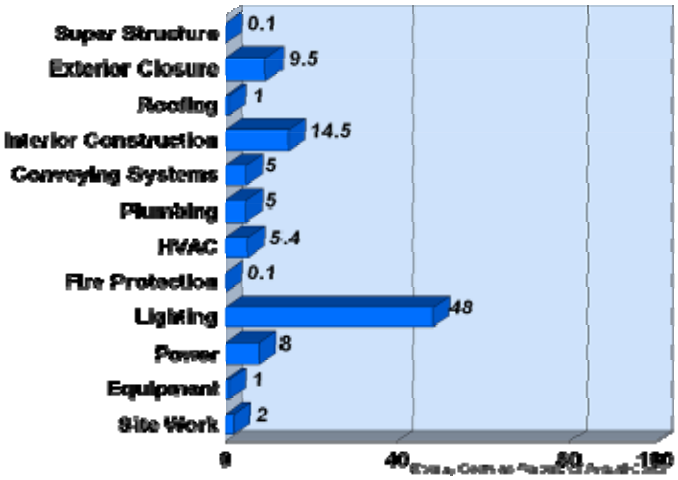

Figure 4 – US Department of Energy – Energy costs as a percentage of annual costs

Arguably these figures may be different in hotter climates where HVAC is a prime energy cost, but it does relate to the various elements involved in their study. Key to this is the wide assortment of areas that contribute to the overall costs.

As more facilities strive to reduce their energy footprint and improve their "Green Status", new approaches must be taken. Programs such as LEED, , Energy Star, Building Star and many others around the world are pushing facility owners to recognize the importance of taking leadership in this area. More adoption is needed and not just on the initial construction and installation, but on the ongoing operational and maintenance efficiencies. A good control networking solution is paramount to success, but it also ensures that ALL facility systems are incorporated.

Total Facility Control

Expanding the view of a large facility to include additional areas of energy consumption, a case can be made to incorporate an even wider array of systems into the building automation footprint. The concept of Total Facility Control has evolved from beyond the building core structure and its components to integrating all available systems into a common structure. An IT network is the backbone for all data communication of an enterprise including:

- Email messaging
- File storage and retrieval
- Website access
- Process reporting control
- Security and firewalls
- Multimedia access
- Communications (VOIP)

Similarly a control networking system can incorporate a wide variety of data monitoring and control sources:

- HVAC
- Lighting
- Security and Access
- Energy Metering
- Fire and Life Safety Systems
- Streetlighting/Parking Lot Lighting
- Sound Masking and Annunciation
- Sunblind and Shading Control
- Weather Station Data
- Occupancy and Usage Monitoring
- Asset Monitoring
- Process Control
- Toxic Gas Monitoring
- Occupancy Comfort Control
- Irrigation Systems
- Gas and Water Metering
- Sub-tenant Energy Metering

All of these systems can and have been implemented on a common control networking platform using LonWorks (ISO/IEC 14908). Access to the sensors and actuators of the system are typically from a common data information exchange model where a variety of host applications can provide access and visualization on the network simultaneously. Typical enterprise applications include:

- Graphical User Interface (GUI)
- Reporting Systems
- Safety Monitoring
- Maintenance Scheduling
- System Trending and Analysis
- System Diagnostics
- Retro-commissioning and System Retuning
- Web Based Access
- Remote Monitoring and Control
- Automated Demand Response
- Asset Tracking

Social consciousness of energy usage is of high importance to owners as it provides a favorable view of the organization. Many organizations are engaging the occupants (employees) in the need to "Go Green". In some cases employers are organizing contests that encourage energy savings. These organizations may even provide individual user controls via a web browser to the occupants' energy loads including the ability to adjust temperature set points, adjust dimmable lighting, and even control when the occupant will be in their office via a scheduling application tied to their computer network. These applications enable the occupant to "take control" of their own spaces and be part of the solution.

Echelon Corporation is a pioneer in this approach and enables each office occupant access to a unique graphical user interface to their space with very simple controls. Each person is encouraged to set their energy loads to a low value while maintaining optimal performance efficiency. Additionally each office has an Energy Star setting such that if the building needs to immediately shed energy load by request from the power company, each office has a minimum set point level for temperature and lighting that enables the occupant to continue working while shedding the maximum amount of load. Echelon's headquarters building has received several awards and accolades for is progressive use of open control networking strategies and has even hosted UN Secretary Ban Ki-moon and California Governor Schwarzenegger for a discussion on energy conservation measures.

Facility Master System Integration (FMSI) is a new concept where all control systems in a facility are integrated into a common networking model. Key implementers of this strategy include New York City Schools, NASA, The US Army Corps of Engineers, The City of Masdar NIST project. These notable projects are typically more complex and incorporate many buildings integrated over multiple phases by several competing contractors. In order to maintain a common data information model, a single IT/control architecture was implemented and, in some cases, a separate contract for the master integration has been awarded to maintain consistency for the facility managers and operators.

In other applications a common control networking structure was implemented in order to achieve a specific outcome. A few examples include parking garage lighting and ventilation, outdoor lighting and streetlighting, process control within the facility including equipment monitoring and energy load profiling, and even energy metering and sub-metering.

Case Study #1 – Parking garage ventilation and lighting systems can be heavy consumers of energy. In a project implemented in Los Angeles,

California, a system integrator was contracted to evaluate and retrofit a high-traffic parking garage with better lighting control and better ventilation control to help reduce the facilities energy costs. The ventilation fans were a very large energy cost for the facility and all fans were running 24 hours a day. Enerlon, a California system integrator and a LonMark Certified Professional commissioned a LonWorks system to monitor the CO levels and lighting levels in the parking garage. The ventilation fans were fitted with controls to turn them on and off as CO levels increased or decreased with traffic. Additionally the lighting control system was retrofitted to implement occupancy and motion detectors such that as a car entered a floor or a person exited a stairway or elevator, lighting levels in those areas were increased. When no motion or occupancy was detected for a period of time, the lighting levels were decreased. The entire control system was monitored from a single web site interface and could be accessed remotely via the internet. The overall energy savings reached enabled the facility to outperform over 75% of similar buildings according to Energy Star, a joint US Department of Energy and Environmental Protection Agency program. The retrofit project received an Energy Star rating for being a highly energy efficient system.

Case Study #2 – The city of Oslo, Norway, has implemented a smart streetlighting system in an effort to reduce energy costs for the city while improving safety. Oslo implemented a solution based upon LonWorks using a smart streetlighting ballast and fixture and communication system using ISO/IEC 14908 standards. The system enables each streetlighting fixture to be monitored and controlled remotely using a powerline communications media. Each lamp can be turned on and off or dimmed from a central office. As conditions change such as weather or usage patterns, the streetlighting can adapt to the needs while reducing energy costs. In areas were there is little traffic the lights are dimmed. As traffic approaches as sensed by motion detectors, the lighting is adaptively increased to ensure safety. During rain conditions it was found that reducing the overall lighting was beneficial and improved safety due to reduced glare.

Case Study #3 – McDonald's restaurants have recently begun employing smart kitchen equipment based upon LonWorks to reduce energy and gain operational improvements. Equipment such as fryers, ovens, refrigerators, and more are retrofitted with ISO/IEC 14808 LonWorks communications so that store owners and managers can interact and control their facilities more efficiently. Web based dashboards show energy consumption, operational traffic flow, product production statistics, and more using a common networking control environment. Future plans include incorporating the facility's building control system, including HVAC, indoor lighting, and outdoor parking lot lighting/façade lighting, into one common control environment. The objective is to reduce energy consumption while improving operational efficiencies. Energy savings returns are expected to reach 30% or more annually.

Conclusion

New approaches to facility control systems require thinking outside the typical HVAC and indoor lighting systems in order to achieve the greatest efficiencies. Applying open controls strategies using industry best practices and international communication protocol standards are a fundamental approach to saving energy. Energy efficiency starts with establishing a good control strategy and then applying new methods to reduce and conserve energy.

Developing a common, single-seat view into the vast array of facility systems is an important step in first understanding energy usage, and second, implementing changes. Open system protocols such as LonWorks (ISO/IEC 14980) provide an easy to implement, cost effective international standard for interoperable controls. A wide assortment of interoperable products and solutions are available around the world to help facility managers implement the best control strategies.

Facility owners and managers are encouraged to develop a master plan that looks at all of the typical building systems and also consider some of the less typical systems that may dramatically affect energy usage.

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