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BuilConn: Cisco's Connected Real Estate Roundtable - The Vision of Integrated IP-Based Building Systems

By

Tobias Maile & Martin Fischer

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BuilConn: Cisco's Connected Real Estate Roundtable

The vision of integrated IP-based building systems

White paper

Tobias Maile (CIFE)
Martin Fischer (CIFE)

Abstract

CIFE research shows that Virtual Design and Construction emerges in phases: *visualization*, followed by computer-based data *integration* and finally *automation* of design, construction, and operational activities. Based on the BuilConn Conference Roundtable hosted by Cisco Systems in May 2006, this white paper lays out some of the owner requirements to support IP- and computer-based integration of building systems. The participants detailed the value proposition, challenges, and related engineering and business transformations of integrated building systems. While cost savings, new advanced services, and flexibility in building operations are the major benefits, the main challenges are the missing awareness and knowledge in the building industry, the implementation of appropriate security, and the realization of reliable critical building operations. Furthermore, the balance between IP and non-IP devices, benefits of the IP-protocol itself, and the need for more elaborate standards were discussed at the Roundtable. The Roundtable participants identified the following critical transformations within the building project environment to make integrated IP-based building systems a reality: more flexible contracts, earlier involvement of integration experts, and more flexibility in today's design process. The participants felt that only when these transformations are accomplished and the mentioned challenges resolved will companies be able to take full advantage of the benefits and realize the vision of integrated IP-based building systems.

Introduction

In a changing world where IT (Information Technology) is increasingly present in building technology, IP-based (Internet Protocol) communication becomes a key concept for integrating various building systems to deliver additional value to building owners. Today, different building systems such as BAS (Building Automation System), security system, facility management system, data and communication systems are loosely (if at all) coupled within a building. While historically IP is used for communication between personal computers through networks such as the Internet, a variety of new technologies are available today through IP communication. For instance, Voice over IP (VoIP) provides phone service over IP and is commonly present in new office buildings.

Integrating building systems is not a totally new concept and partial integrated building systems do already exist. Some of the past partial integrated systems include: the coupling of fire protection and HVAC systems to limit the spread of fire and smoke (Wong and So, 1997), the integration of component status information with the facility management system by providing web-based access to both databases (Wang and Xie, 2002), or the enhancement of HVAC controls based on actual and stochastic predictions of occupancy data (Loveday et al., 1997).

The vision described in this paper is based on an integrated system that resides on a common communication platform to enable integration across all systems rather than a series of totally independent systems. Furthermore, it addresses today's issues that need to be resolved to enable the widespread use of integrated IP-based building automation systems.

The accessibility of data from all building systems will enable the use of state-of-the-art information technologies such as artificial intelligence (e.g., knowledge bases). These advanced technologies can improve the functionality of an integrated building system to support and ease the work of building operators. Global building modes such as emergency or economy mode could be applied for all building systems resulting in building systems that operate together rather than in separate modes (Clark and Mehta, 1997). Such an intelligent integrated building system is able to account for the dynamics occurring in a building and perform more efficiently.

Cisco Systems' Connected Real Estate Roundtable at the BuilConn Conference provided a discussion forum for a variety of stakeholders, mainly owners, software and product vendors, consultants, and academic representatives. This Roundtable emphasized the owner's view, needs, and understanding of an IP-centric system within a building. After an introductory session, several owners presented their understanding of the topic followed by an open discussion of benefits and challenges of the convergence of IT and building systems. While participants commonly agreed on the understanding that an IP-centric solution is the right direction for the future, the main question raised was how its implementation can be realized on a technical, organizational, and process level. An implemented integrated building system can reduce installation and operating costs and also provide new business value through new services. Network security needs to address new challenges that result from this convergence. Crucial business processes must remain functional. Education of a greater share of stakeholders and engineers about possibilities and risks of new IP-based technology was also addressed at the Roundtable. In addition, the environment of the design, build, and operations processes needs to adjust to realize a

converged system. Finally, development of solutions and research of new services and technologies have to address the needs and requirements of building users.

Cisco's perspective

Cisco Systems mainly provides applications, services and devices for data, voice, and video communication within buildings. The connected building group within Cisco Systems is interested in creating new partnerships within the building industry to leverage a convergence of IT and building systems. To enable this convergence Cisco described the need to transform the building industry and their effort to help stakeholders, especially owners, to understand and leverage this change. The so-called 4th utility, the building information network is seen as an additional utility to the commonly provided water, gas, and electricity services. Based on a building information network a convergence of building technologies, physical security, and unified communication, becomes possible. This transformation enables new ways of delivering space, technology, and services. Cisco Systems' framework to accomplish this convergence is illustrated in Figure 1.
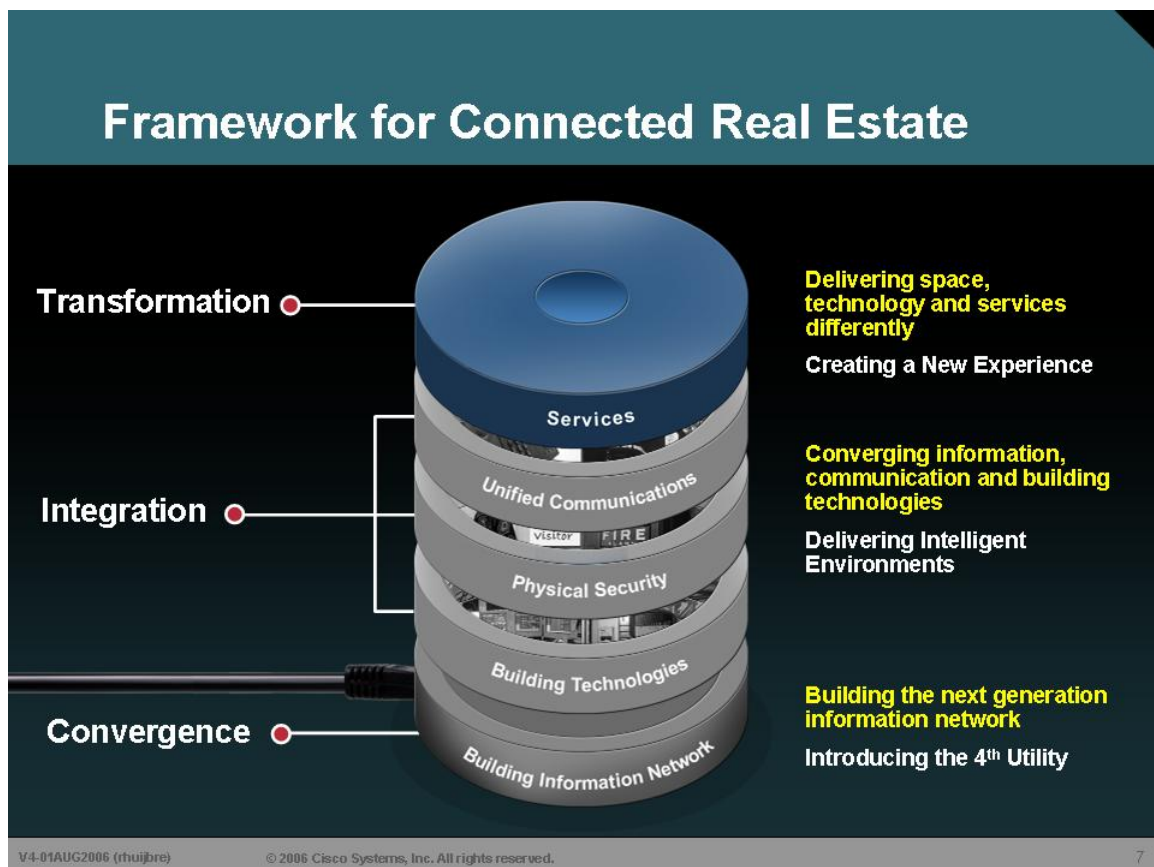

Figure 1: Cisco Systems' framework for Connected Real Estate (Huijbregts, 2006)

Cisco as a building owner and employer itself already demonstrated that new concepts of providing workspace to an increasingly flexible and rapidly changing workforce has

major benefits for the company in terms of cost savings and for the employee in terms of a more supportive, flexible, and productive work environment (Huijbregts, 2006).

The Owners' perspective

Given the focus on providing better solutions for building owners and users, the owner representatives were the biggest group at the Roundtable. The owners, in their function as clients, have a significant impact on implementation of new technologies and changes within the building industry, because they are paying for it. The owner community expressed their interest and the need in open standards based on IP. Several initiatives for open standards based on IP are under development, e.g., oBIX (oBIX, 2006). For integrated communication the IP standard by itself is not sufficient, but can be used as a basis for more advanced interfaces between building systems. These open standards aim to provide an environment that is independent of a specific manufacturer's solutions and products. Furthermore, within the building automation system space several standards are already widely adopted, such as BACnet (BACnet, 2006) or LonTalk (LonTalk, 2006). According to Bushby (2002), it is difficult for owners and engineers to specify integrated building systems based on available standards such as BACnet due to their complexity and ambiguity. Recent additions have been developed and need to be extended to provide simpler descriptions and guidelines for owners and engineers that enable a more widespread use of such standards.

The standards that are used today focus mainly on one domain of building automation and do not necessarily provide enough information to enable convergence between different systems. Thus, new and extended standards are needed to support advanced integration of building systems.

The owners also mentioned security concerns of an integrated network. While today every building system has its own security, a combined network would need either a common security strategy to ensure the appropriate level of security, or alternatively a separate security system. Also business critical and life-safety operations need to remain functional at all times even during emergency situations. If the underlying communication of all building systems relies on one IP network, the challenge persists how critical processes can remain functional if the network fails. Moreover, the owners pointed out an educational gap in the market place. There seems to be a mismatch between the state-of-the-art and the common understanding of available technology in the building industry. For IP-centric building systems to spread fast more decision makers, especially among developers, need to be educated about current and upcoming technology possibilities. Currently, a so-called "triple play" service, Internet, VoIP, and IP-TV is in its design phase for upcoming projects in addition to wireless services. In the near future more advanced services will become available, such as extended automated energy performance monitoring or data storage services provided by the facility. Besides providing and possibly selling more services to the building occupants the major benefit for the building owner is the physical integration of the building systems resulting in a so-called backbone infrastructure that is used for all building systems communication. This backbone makes it possible to use the facility more flexibly and change usage areas more easily.

The value proposition

An integrated IP-based building system has a huge potential in creating new business value and reducing installation and operation costs. First of all, the integrated physical network provides physical connections for multiple systems, so that cabling can be reduced in buildings. If designed thoroughly and at the right time savings of common cables could significantly reduce initial costs. Operating costs are likely to decrease if the various building systems can be accessed, maintained, and controlled in a more integrated manner. This physical integration, the so-called backbone, also enables more flexibility during the life of a building. Components of building systems that need to connect to the building network can be added or their location can be changed more easily than with separate physical networks. Building systems that each have their own network have limited coverage area in a building where an integrated network provides more access points.

New business processes and services will evolve based on an integrated system and account for additional revenue that can not be achieved by today's conventional solutions. Increased communication over IP makes more data available for all systems of the building. This interchange of data provides another huge benefit of the convergence. For example, advanced HVAC (Heating, Ventilation and Air Conditioning) control systems could access data from the building access system. If a specific occupant arrives at the lobby of a building, the air conditioning in his office could automatically turn on to provide a conditioned workspace only when it is actually needed. This and other scenarios can potentially lead to a more efficient and economic HVAC system. Another example is collective data services that can enable more founded management decisions related to the facility. Widespread data storage services could additionally be offered to persons in a building. These are only a few examples of new services that could emerge based on integrated IP communication; the list of possible services is growing almost on a daily basis. Establishment of advanced services that are tailored to user needs will provide a competitive advantage in the marketplace. Flexibility and connectivity are only two benefits, albeit the most important ones identified at the Roundtable that could prove to make a difference in competition.

An integrated building system also forms the infrastructure to support new workplace concepts that are more flexible and can adapt more quickly compared to traditional work concepts. For example employees who work mostly from home change the requirements of office spaces and homes. Companies need to provide more flexible work spaces to support the flexibility and productivity of employees and can hereby also reduce the necessary area of work space and costs significantly. This trend leads to improvements of workplaces to ensure that occupants have a better environment to work in. To provide employees with the desired flexibility the right infrastructure to support it has to exist. This also leads to new requirements for private homes that need to provide the necessary infrastructure to allow employees to sufficiently perform their work at home. These requirements for home offices include high-speed internet access, up-to-date computer equipment, additional phone lines, etc.

Wireless communication over IP becomes more and more present within our daily lives and can extend an integrated building system. Today it provides flexibility for internet connections, in the future there will be more communication based on wireless data

transfer. While the current technology can not replace every cable in a building, in the future information devices, such as sensors and security cameras, could be placed anywhere if they can reliably communicate over wireless IP.

The integration of building systems makes measured data more available for further services and more performance metrics of the building. Thus a closer connection between design and operation is possible to more reliably evaluate building designs based on the actual building operation. Virtual design models of buildings become more accountable if they can be verified and improved by actual observed data. There is clearly a need for more research and development in this field to match predictions and observations more closely. A related research project at CIFE (Center for Integrated Facility Engineering) at Stanford University focuses on comparing energy performance simulation results and actual measurements of the building's HVAC system to validate and improve the building operation (Fischer et al., 2006).

Challenges and boundaries

A common understanding at the Roundtable was that there is an educational gap among engineers and other stakeholders that needs to be overcome. Obviously the end result can only be as good as the understanding of the new technology. This clearly stresses the need for educational curricula that provide degrees and courses in systems integration. To spread the idea of IP-enabled and integrated building systems, success stories need to be published to demonstrate the actual power of the convergence and increase the awareness within the building industry. Moreover, field workers have commonly low level technical skills and need to adapt to install the integrated system correctly at the desired quality level. Interestingly, a similar roundtable discussion seven years ago already identified the educational gap (Ivanovich and Gustavson, 1999), which leads to the conclusion that there has not been enough effort to overcome the missing education.

Another concern is how mission-critical facility operations can be provided if the entire IP-system would fail. Alternative emergency communication or other solutions need to be developed to overcome a failure of all building systems including crucial emergency systems. If everything is based on one IP network, everything goes down if the network fails. The reliability of data networks and particularly integrated data networks is very important to provide all services sufficiently. This may be accomplished today if the design and installation is done correctly, but with more convergence new challenges with data transfer will arise.

As mentioned earlier security is one of the biggest challenges for IP-based building systems. While enabling access across building systems provides various benefits, it also makes the building systems more vulnerable to unauthorized access. In the context of security the connection to the outside world through the Internet illustrates a weak point that has to be addressed though appropriate security implementations. Depending on the actual system architecture, firewalls could be used to limit access from the outside world. Besides limiting access from the outside, access within the connected building systems needs to be restricted to ensure their functioning. Clearly defined access levels and access roles could be a strategy to ensure integration without being too vulnerable to unauthorized access within the system (Holmberg, 2003). Clearly, security issues need to be considered when designing an integrated building system, however, in today's rapid

changing Internet world security strategies may need to be reevaluated over the life of a building to ensure their appropriateness.

Retrofitting existing buildings towards a more integrated network will remain a major challenge, since as-built information is often missing and installing a building information network into an existing building can be troublesome, time-consuming, and costly, if the necessary physical network structure has to be put in place or needs to be extended.

Over the years, building systems have become more sophisticated and complex due to more complex components and advancements in technology. This trend may increase with an integrated building system, since more data and functionalities are available. Solutions that are too complex in combination with human error may decrease the resulting building performance compared to simple solutions that are not as error-prone. This is especially true for an industry that does not place enough emphasis on commissioning these complex systems, which leads to building operators that are overwhelmed by the system's complexity. Building users are often left aside during the design of solutions which leads to solutions that are looking for needs rather than needs that create solutions. Interaction between building users and all stakeholders as well as proper commissioning are the keys for an appropriate solution.

The missing awareness and lack of installed systems to measure actual performance of buildings makes it hard to demonstrate benefits through integrated building systems. Building energy performance is not always at the forefront of building owners even though it provides opportunities to save operation costs. With greater transparency in building performance the owner will finally be able to value specific contributions of systems and contactors. It is likely, though, that not all contractors will readily support transparency and integrated building systems, since they will become more accountable.

Balancing IP-native and non-IP BAS

IP communication is already present in our buildings today. More integrated building system communications that are based on the IP-protocol will change the current architecture of building systems. A typical system architecture of integrated building control systems is shown in Figure 2. Components above the blue horizontal line are directly connected via IP. Components below the line do not have their own IP interfaces, but are connected to the network via middleware or gateways.
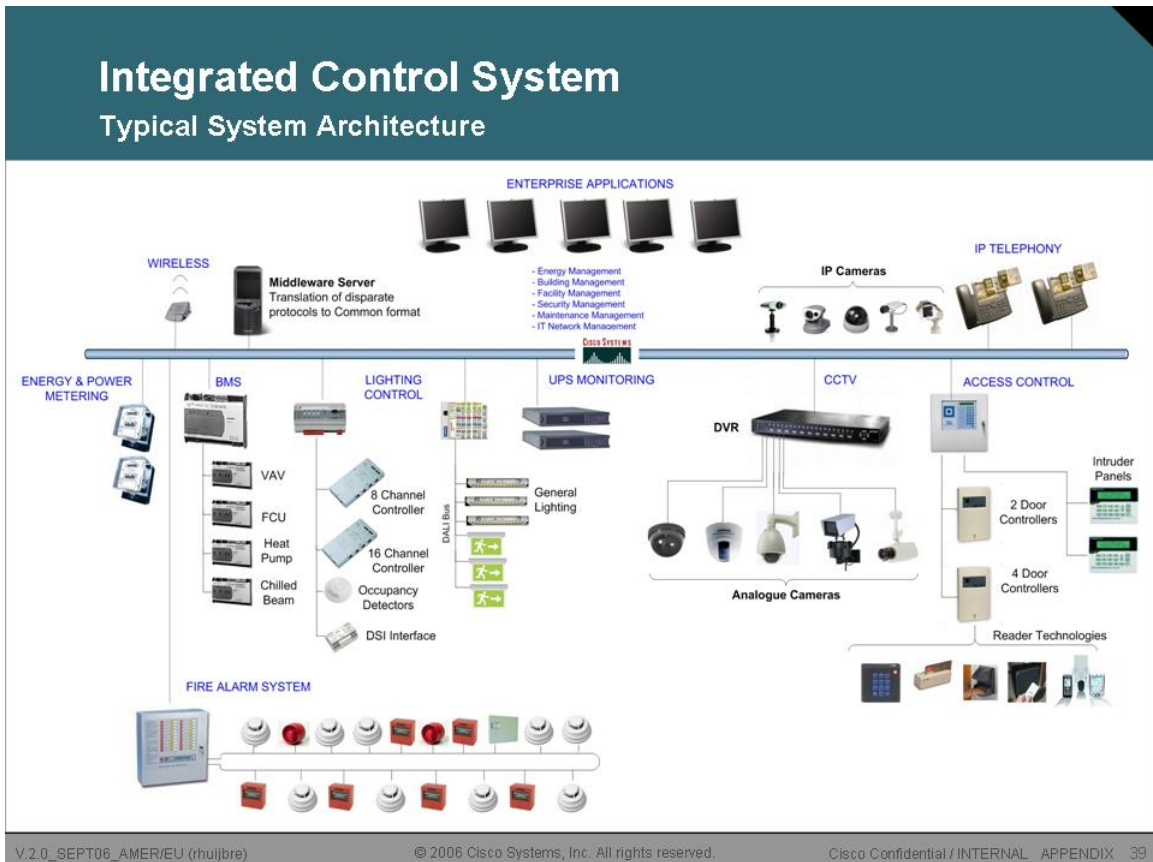
Figure 2: Typical system architecture of an integrated control system (Huijbregts, 2006)

While more and more subsystems and components will move over the line to the IP-based part of the system, it is still an unsolved issue if eventually all components and, therefore, all communication should be IP-based. The resulting overwhelming network in buildings would most likely exceed current manageable limits of organizing IP components and data transfer. Enabling non-IP communication within subsystems that are connected via IP to the network seems to be a more realistic goal for the near future. The next generation of the Internet Protocol (IPv6) is on its way and will address limitations of the current IPv4 protocol, such as address range, security, and many more (Hinden, 1995). The IP-centric network aims to allow data access and control down to the device level, which could alternatively be realized by having interfaces between the two layers that allow sufficient data exchange to enable the mentioned goals. Conclusively, it matters that all data can be received and the corresponding devices can be completely controlled. It is less important how the data transfer is realized in detail, i.e., whether single devices are IP-based or have only an interface to the IP-network. The correct balance between IP and non-IP communication is clearly dependent on the type of building system. For example, VoIP phones already enable IP communication at the device level. Thus the line between native IP and non-IP systems and components may actually be on different levels for each particular building system.

Besides communication over standardized IP, the data content needs to be described by standards. Such standards enable manufacturer-independent functionality of devices and

solutions so that structured data can be accessed and components controlled. Thus software and interfaces only need to provide support for one standard (or possibly a few standards) compared to a large number of manufacturer-specific proprietary formats to communicate with all the devices in a building. Several standards for different building systems are under development and/or already used in practice, such as oBIX and BACnet. Current PC networks demonstrate the positive effect of existing communication standards, since all computers can communicate despite their different manufacturers and operating systems.

In addition, IP as a technology has been around for several decades and several industries provide significant effort into its further development. IP communication as a technology provides characteristics, such as security, reliability, flexibility, interoperability, and mobility, that can support an integration of building systems. The remaining challenge is to adopt these properties and apply them to integrated building systems.

Transforming the building project environment

One of the major challenges to successfully implement integrated building systems is the current planning, design, budgeting, and contracting approach for buildings. This traditional process is mostly unable to adopt new changes easily. To successfully include the 4th utility within a building project, it must be considered early in a building's life-cycle, and all stakeholders, in particular data communication experts, need to be involved early to enable an integrated design solution. Figure 3 illustrates the importance of an early entry based on the ability to impact cost and functional capabilities of the project. The figure also implies that an integrated building system needs an even earlier integration into the design process due to its increased interconnections with other disciplines.
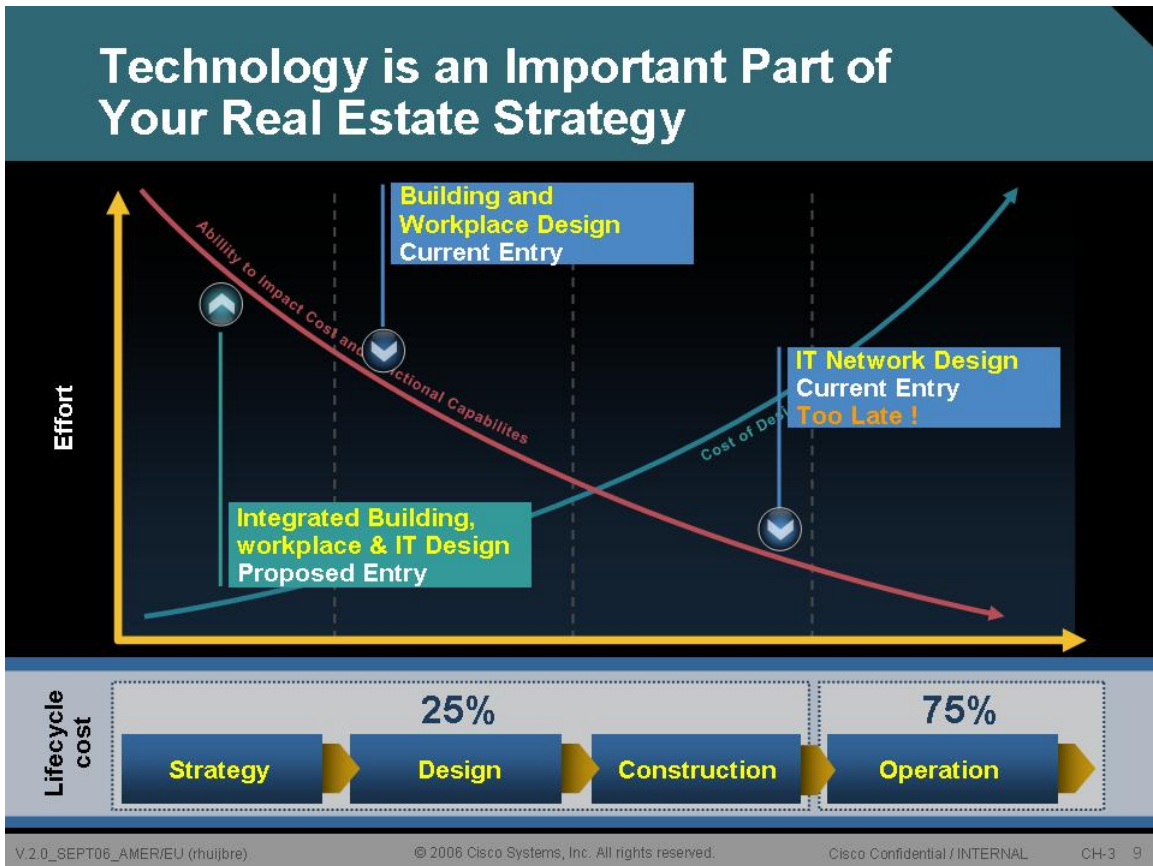
Figure 3: The entry of building information network experts into a building life-cycle (Huijbregts, 2006)

Another reason for the early involvement of data and communication experts is that the financial aspects of data communication must also be considered to ensure a sufficient budget in the right categories for its realization. Traditionally, a building's budget is divided into the different disciplines and, therefore, does not support a common infrastructure and integrated network. For example, all building systems, such as fire protection, HVAC, etc. include a budget for a communication system. Since the budget for the communication system is part of each building system budget it is difficult to set enough money aside for an integrated communication system. Such an integrated system would be cheaper than all the communication systems combined, but more costly than any of the individual communication systems for the various building systems. To capitalize on such integration opportunities, they need to be recognized very early in a building's design process. If all aspects of a building project are considered from the early design stages, a better and more integrated product can be designed and built. To be able to manage the changing business world, companies need to cooperate with partners to leverage the benefits of the convergence. A team-based approach of the building systems contractors could lead to a better end result. Moreover, the decision makers need to be aware of the new challenges and opportunities that come with an integrated solution. Contracts between stakeholders need to reflect the convergence of building systems and enable performance-based contracts to increase the incentive of keeping the

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operating costs within reasonable boundaries and the implementation focused on end-user value. An integrated building system can provide the owner with a tool to validate the performance of a building accurately. While this will not only ensure a better quality of the building, it makes a variety of stakeholders accountable for their work.

Owners with huge numbers of buildings such as universities often have guidelines that outline a basic set of design rules to which each new building project must comply. These need to be updated regularly based on a thorough and good understanding of current technology, otherwise the guideline will collide with new requirements of new technologies and changes caused by an increasing integration of systems. The timeframe between writing project-specific specifications and installing an actual component usually spans over years, during which components and technology change. This traditional way of specifying building components could be improved to allow the installation of up-to-date equipment.

Governmental rules and regulations and industry norms and practices, such as LEED (U.S. Green Building Council 2006), provide some incentive for more sustainable building projects; however the existing rules and regulations do not provide enough guidelines and are lacking a long term building performance strategy particularly in the U.S. While there could be more push from the government towards more strict regulations, the Roundtable participants felt that an integrated building system will provide enough benefits and business value by itself.

Classification into research and industry related issues

The following table summarizes the discussed issues in this paper and classifies them into issues that need to be resolved by the industry and/or that need more research:

	Industry	Research
Open standards based on IP		X
Security enhancements	X	
Emergency reliability of IP-networks	X	X
Educational gap	X	
Physical integration	X	
New services	X	X
New workplace concepts	X	X
Wireless communication	X	X
Consistency of solutions	X	
Missing metrics of building performance	X	X
Current design process	X	X
Early involvement of integration specialists	X	
Outdated guidelines	X	
Need for rules and regulations	X	X

Table 1: Categorization of discussed issues

Measuring the success of integrated building systems

Appropriate metrics need to be defined to provide evidence that integrated building systems increase the value of buildings and improve building performance. The challenge is to find metrics that can reflect improvements compared to other buildings that may not have the ability to measure the same properties.

For HVAC systems energy consumption and thermal comfort are the two major metrics that can describe the performance of the system. Today, one of the shortcomings to measure building performance is the availability of sensors in buildings. While the energy consumption on a building level is most often available, it may not provide enough detail to describe the performance of an integrated building system sufficiently. The overall building energy consumption is dependent on a variety of factors and may not reflect the improvements of a particular new service accurately. Therefore, the energy consumption metrics need to be defined on the level where enhancements are implemented to enable a better evaluation of the improvement. Thermal comfort is more difficult to describe through metrics, but may be evaluated by using standardized indices such as PMV (Predicted Mean Vote) (ISO, 2005) or actual complaints about thermal comfort from building occupants. While collecting metrics for new buildings with integrated systems may be easy, the main challenge is the baseline for the measurements from existing buildings.

For most of the other building systems the actual operations costs can provide a measurement of success for the particular enhancement. New services that result from building integration could be evaluated by using metrics on additional revenue. Since some new enhancements are based on an integration of building systems, metrics may need to account for multiple building systems to evaluate the effect on all related subsystems.

Other metrics could include the installation costs of physical equipment in relation to operating costs. For an integrated physical building system there should be a significant decrease in first cost but also in operating costs, when multiple systems use the same infrastructure. Establishing metrics is not only useful for each specific building project, but can also clearly illustrate the benefits of a particular technology to others and it can be used to provide evidence for success stories.

Conclusions

The requirements summarized in this white paper lay out a large, valuable but complex set of issues and "next steps" for both industry and research. The path to the most effective approaches will involve close collaboration among researchers, vendors, owners, and AEC professionals who build these new buildings. In particular, this white paper addresses the benefits, challenges, and necessary changes discussed at the BuilConn Roundtable. The change of proprietary separate building systems into IP-based integrated building systems provides opportunities for building owners in both operating costs and additional business value. In addition, the physical integration reduces installation costs. Based on an IP-centric system new services will evolve for various users that will provide new benefits for them. For instance, more advanced services that improve building operation by comparing predicted and observed building performance

metrics will become possible. The IP protocol will play an important role within the convergence as a basis for advanced standards that need to be developed or extended. While the details of the structure of IP-networks in buildings are still open to discussion, it is clear that more standards based on IP are needed to provide more advanced data transfer among different building systems. The current educational gap in the building industry needs to be further addressed and the knowledge and vision of IP-based integrated building systems disseminated. Furthermore, an integrated building system can provide the necessary flexibility for workspaces that will become more and more important in the business world. The integration of building systems has a huge potential for future buildings, however, the surrounding project environment needs to be transformed to overcome today's fragmented delivery of building design and construction services.

Acknowledgments

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