The Rise of Smart Building

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THE omnipresence of the Internet via phone lines, power lines and wireless facilities has revolutionised many new emerging technologies. The rapid spread of Internet use at the workplace inspires new convenient ways for controlling and managing entities, which led to the conceptualisation of a smarter office or building.

The concept of smart building has been around for decades. A smart building is defined as an augmented entity that acquires and applies knowledge about the building's occupants and its surroundings to meet the goals of comfort. Engineering advances together with cost reduction in the consumer electronics sector have created opportunities to provide smart buildings with inexpensive heterogeneous subsystems for facilitating various building operations.

A typical smart building can manage the integration of climate, lighting, automation and security via heterogeneous subsystems. Smart buildings solutions are expected to become one of the fastest growing sectors in the area of building services. However, interoperability and flexibility are the main challenges for realising smart building technology towards diversified functionalities.

A smart building should be able to make a decision with a certain degree of intelligence and does not go too far by limiting the freedom of choice for its occupants. Engineering a smart building requires a unique breadth of knowledge and disciplines such as wireless networking, web technologies, databases, digital systems and pervasive computing. The task of processing information and network connection is hidden and takes place in a natural way beyond the awareness of the building's occupants.

We can categorise seven main subsystems as the core components that forms the interoperation and integration in a smart building. Figure 1 below shows the five main subsystems in a smart building:

Goals

A smart building addresses three major goals to achieve its functionalities. Those three major goals are safety and security, comfort and cost effectiveness. Safety and security, being the most important, are defined by identification mechanisms and surveillance facilities. Identification mechanisms contribute to security by allowing instant response and reaction, *e.g.* in the case of a break-in or intrusion. Similarly, the mechanisms contribute to safety factors by having sensors placed at strategic locations in a smart building that detect emergency situations or hazards, for example, caused by fire or electricity.

The goal of comfort is achieved in a smart building by automating tedious tasks with intuitive and well-designed interfaces. A certain degree of intelligence is embedded in the context of task automation and operation in a smart building to increase the comfort level of the building occupants. For example, when an occupant enters a building premise, the air-conditioner system is automatically switched on with preferred temperature settings. The third goal of a smart building is cost effectiveness. This relates to the installation and deployment of new systems that should be low in cost but effective in attaining the desired goal as well as complementing existing legacy systems.

A smart building should also be able to provide cost justification by reducing running costs with the interoperation and management of various services offered in a smart building system. For example, a smart building could save cost in energy consumption by deploying energy management services (i.e. automatically turning off lights and devices when not in use and shutting off air-conditioners when an occupant opens a window).

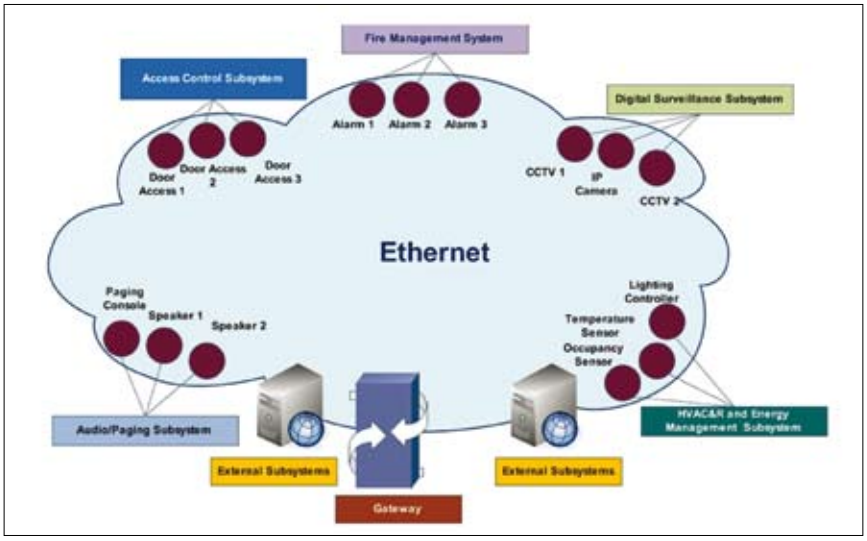

Figure 1: Smart Building Subsystems

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Standards and Interoperability

Smart building complexities lie in the different standards and protocols used to cater to the requirement of various services. In general, there are two types of physical connection among entities in a smart building environment, i.e. wired or wireless technologies. Each appliance as well as the services offered in a smart building requires a physical connection and media that are suitable for different purposes. Several standards and protocols have been initiated by consortia and the industry based on the physical media required for smart building connectivity. Table 1 categorises the standards and physical media involved.

Although an increasing number of standards are being proposed by industrial consortia, these only solve some parts of the integration problem by having specific protocols and standards for connectivity in a smart building. Most system integrators implement proprietary protocols which prevent data sharing and limit communication capabilities between different subsystems in a smart building. The real challenge is establishing a common framework or interoperability between those subsystems for interoperation in a smart building. This is important because of the existence of great heterogeneity of smart building components and a large variety of their embedding context.

Table 1: Physical Media for Smart Building

Media	Protocol
Wireless	Several types of short-range wireless protocol are used for appliance control, security devices, and some entertainment systems in a smart building environment. Protocols for wireless technology included Wireless LAN, Bluetooth, IrDA, BuildingRF, ZigBee, Ultra-Wide Band (UWB) and Near Field Communication (NFC).
Wired	Structure cabling and wiring systems are used specifically to support data communication between the device and services offered in a smart building environment. This includes CAT5 wire and RG-6 (coaxial) for audio/video and data for multimedia and entertainment systems. Popular standards are USB (www.usb.org), Ethernet and IEEE 1394 (FireWire).
Powerline Communication	Power line communication refers to electrical wiring facility that is already available as outlets throughout the building. Generally, power line communications are used for low data rate appliances. Some main power line communication standards are X10 technology (www.x10.org), LonWorks (www.echelon.com), Home Plug (www.homeplug.org) and Power over Ethernet (PoE).

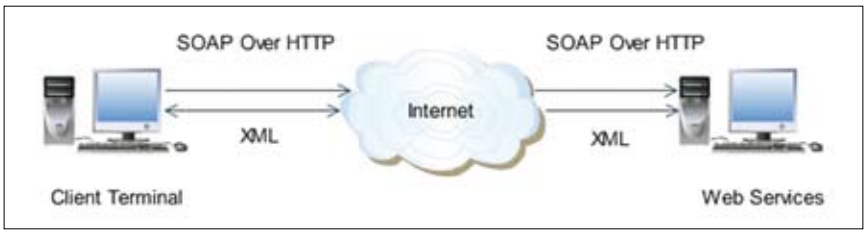

Figure 2: Web Services operation model

Table 2: Smart building features with Web Services

Smart building Features	With Web Services
Universal solution	Gluing platform for various smart building standards and protocols.
Integration and Interoperability	Smart building interoperation using XML and Web Services.
Business Integration	Use of Web Services as business integration among multiple smart building service providers.
Databases	Extending building databases to utility service providers at the enterprise level. Manage customer feedback, billing tariffs and queries.
Security	Web Services for building control, managing utility services, perform banking remotely and for e-commerce.
Remote Execution	Web Services as remote execution method for smart building event. Use of wired and wireless media in smart building as hybrid solution.

Web Services for Smart Building

In a smart building, there are many subsystems operated by different service providers and integrators. High cost is also becoming an issue for a smart building due to the rise of dedicated gateways for particular services offered. On the other hand, manageability also seems crucial for building occupants with many devices and services deployed. To address these problems, a standardised integration approach was needed to manage smart building components and services. The standard integration approach also needs to complement the existing legacy systems with new services. Legacy systems signify prior investment made by building occupants to operate the building facilities. Therefore, the standardised approach should be able to act as 'protocol glue' between various protocols and service providers to access multiple subsystems in smart building architecture. The solution for the approach finally arrived from the world of information technology known as Web Services. Web Services is a standardised model to implement applications that support communication over the Internet using any operating system. Figure 2 shows the Web Services operation model.

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Core technologies associated with Web Services are SOAP technology, previously known as Simple Object Access Protocol, Web Services Description Language (WSDL) and Universal Description, Discovery and Integration (UDDI). SOAP technology is a simple and easy-to-use protocol for a smart building environment. SOAP specification contains envelope on message transmission and procedures for encoding data which is becoming the common standard for Extensible Markup Language (XML) messaging. In a smart building, SOAP could invoke procedures appliances and services offered that is platform independent.

The second core technology, Web Services Description Language (WSDL), is used in describing programmatic interface of web services. WSDL refers to messages and protocol bindings that need to address or understand the differences between the smart building subsystems. The WSDL file is used as a published guideline to access valuable data sources and acts as an agreement between a data producer and a data consumer. The published service refers to different smart building systems on the core functionality and data offered for interoperation among the specified components.

UDDI, on the other hand, registers and locate Web Services. UDDI is defined as an electronic business registry where it can describe the type of business offered and register their Web Services as well integrate it with other businesses that offer Web Services in a smart building environment. Smart building vendors and service providers are expected to benefit from UDDI to offer their services in the near future. Table 2 shows some of the features of a smart building that could be enhanced using Web Services.

The trend of smart building development is rapidly moving towards a convergence of services and facilities. Web Services are expected to support this development by providing a standardised platform for multiple vendors and integrators. One of the challenges for vendors and system integrators is that there has never been a simplified and standardised platform connecting their facilities and services in a smart building. Therefore, by leveraging on Web Services, smart building vendors could provide access to various services and perform interoperation with other facilities.

Web Services will also bring smart building services enterprise wide by providing a bridge to connect utility service providers with the building's occupants. For example, a building user could monitor energy consumption in the building by accessing a web-based user interface that is directly updated via real-time from a utility service provider (i.e. electricity) and perform management and control based on the usage required. This scenario could be extended to any energy consuming equipment simply by providing an extension to Web Services.

Web Services also allow utility companies to have two-way feedback with their customers. On the other hand, Web Services also allows building occupants to submit queries and requests for billing tariffs from service providers. Real-time feedback using Web Services could be efficient to gauge success and service feedback from customers. Standards and protocols such as Ethernet, TCP/IP in smart building, makes it a lot easier to adopt Web Services that could automate and coordinate tasks between smart building vendors and their customers.

CONCLUSION

Today, most buildings have applications dedicated to safety, security, energy management and automation. These systems are autonomous in nature as their deployments were at different times and by different service providers. This highlights the importance of having Web Services as a standardised platform to support all smart building components and services in a coordinated manner. Some obvious benefits of deploying Web Services in a smart building are having dissimilar systems operate together and utilising standard web based interface for every entity in a smart building. The usage of Web Services eliminates learning curves and makes infrastructure support in a smart building easier and leverages the use of existing legacy systems by complementing each other. ■

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