Intelligent Buildings: An Application of Sensors and Structural Engineering

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Abstract: **Today, major changes are being made in the way buildings are designed, operated and used. An efficient building or a smart home leverages a state-of-the-art connectivity platform to address key corporate real estate, facilities and IT challenges to enhance energy efficiency, utilization of space and occupant satisfaction. These are referred as intelligent buildings. This paper gives a brief overview of implementation of Sensors and other smart technology to incorporate these Intelligent buildings which has revolutionarised structural engineering as Smart building management depends on networks of sensors to collect information from throughout the building. A historical perspective has been outlined as well.**

Keywords: Intelligent Buildings, Smart Buildings, Sensors

I. INTRODUCTION

Intelligent buildings are one which provide a productive and cost-effective environment through optimization of four basic elements: structure, systems, services and management, and the interrelationship between them. There is a difference between Intelligent and smart building. A smart building is any structure that uses automated processes to automatically control the building's operations including heating, ventilation, air conditioning, lighting, security and other systems as shown in Figure 1. Intelligent buildings creates an environment which maximizes the effectiveness of the building's occupants while at the same time enabling efficient management of resources with minimum life-time costs of hardware and facilities. Today, major shifts are occurring in the way buildings are designed, operated and used. Corporate real estate, facilities and IT departments stand to benefit greatly from the use of building intelligence in order to meet space optimization, energy efficiency and connectivity challenges at a time when changing workplace demographics come with increasing occupant expectations of modern and flexible space design, improved comfort, productivity, and pervasive connectivity. [1]

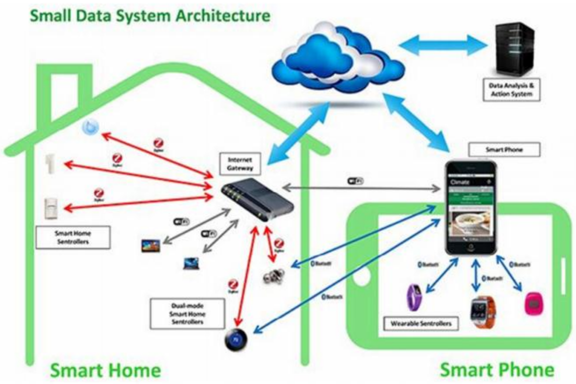

Figure 1: Smart Building Architecture[9]

An efficient building leverages a state-of-the-art connectivity platform to address key corporate real estate, facilities and IT challenges to improve energy efficiency, space utilization and occupant satisfaction. In an efficient building, the intelligent connectivity platform is easily adaptable to changes in space design or communications technologies. A high density sensor network integrates with other building systems to provide fine-grained occupancy-based control of building systems for optimal energy use and occupant comfort while providing a real-time and historical view of occupancy patterns. At a time when the design and utilization patterns of a building's individual and common spaces are undergoing significant changes, efficiency expectations continue to increase. This is fueled by the increase in connected devices, sensors and BIoT applications. As the definition of intelligent buildings continues to evolve, buildings are becoming increasingly connected and efficient. [1]

Industry professionals look at securing not only the building but also the networks in the building, when planning for safety and security such as Automated Infrastructure Management (AIM) systems that can help monitor the physical layer, alerting to changes both authorized and unauthorized considerations for in-building wireless systems. Security monitoring and sensors and Fire safety [2]

II. PROCESS

The methodology or the process of building an intelligent building deals with

A. Develop a strategy framework: addresses the current risks, as well as the new opportunities that result from industry and marketplace trends.

B. Determine Organizational Priorities: Determine organizational priority areas for budgeting time and money towards a smart building effort.

C. Segment the System Types:

D. Select the solutions: Selecting solution vendors is the final step in getting to action - but they must be a match for your organization

E. Manage the program: Program Development brings the strategy and architecture to life and requires a mix of experience to link the executive perspective to the realities of the field.[3]

The Real Estate industry is awakening to the significant cyber security risks for existing building monitor and control sysem (M&C) such as HVAC, lighting, fire life safety, elevators etc. Common IT Aspects in Building Systems Today's building systems leverage best-in-breed operating Systems such as Microsoft Windows and RedHat Linux as well as supporting software components like web servers and browsers, relational databases, remote desktop and access features allowing for rapid system deployment using low-cost, off-the-shelf IT computing equipment and end user interfaces. The consequence, however, is an insecure implementation of operating system and supporting software vulnerable to known exploits.[4]

III. COMPONENTS OF AN INTELLIGENT BUILDING

Advanced sensors have a critical role to play in transforming facilities into intelligent buildings. These intelligent devices contain sensing devices that deliver a digital output and are networked via wired or wireless configurations to support actionable insight that can improve building performance. Advanced sensors may be a component of an intelligent building solution with software and services or standalone devices for data acquisition.[5]

By monitoring temperatures, air quality and light levels throughout the building, and comparing the data with occupancy information, the smart building management system can help optimize energy consumption and assist with planning new services in the future to maintain comfort levels as usage patterns change. The data collected can also help building managers identify cost-saving opportunities. For example, if lighting in one area is found to be operating at its maximum level without dimming for extended periods, facilities managers may choose to install additional lights and increase dimming to boost reliability. Other services such as motion-tracked illumination can enable extra cost savings by enabling lights-out operation in some types of buildings such as warehouses or data centers.[6]

Smart building management depends on networks of sensors to collect information from throughout the building. By combining occupancy sensing with monitoring of temperature, air quality and other aspects of the environment, the sensor network represents the eyes, nose and fingertips of the system. With knowledge of occupancy using video-based techniques as well as Passive Infrared (PIR) or ultrasonic detection and environmental conditions throughout the building, the smart management system can also help improve safety and security, by controlling safety equipment such as fire dampers and providing accurate information about occupants' whereabouts in the event of an emergency. Wireless sensors can be installed without interfering with existing structures, which can be especially helpful in older buildings where modifications may be undesirable or in some cases not permitted. Self-powered wireless sensors deliver even greater freedom by eliminating any need to replace batteries throughout the life of the unit. The wireless standard ISO/IEC 14543-3-10 caters for this type of application, and is optimized for wireless devices with ultra-low power consumption such as battery-less sensors that are powered purely using energy harvested from the ambient environment.[6]

Intelligent buildings are composed of numerous sensors, effectors and control units interconnected in such a way as to effectively form a machine. In theory, a wide range of sensors and controllers could be utilised. For example, sensors used might include temperature and light-level detectors, movement or occupancy sensors (such as passive IR), pressure pads, and smoke or gas detectors. Less commonly, status sensors (giving information on the current status of, for example, electronically operated windows or household appliances) and tagging systems (to detect the location of specific individuals) could also be used. Devices being controlled by the system, on the other hand, could include heating, lighting, ventilation, alarms, electronically-operated blinds, doors and windows, and standard household appliances (such as kettles or televisions).[7]

IV. A HISTORICAL PERSPECTIVE

Intelligent Buildings based on computer technology have been around in one form or another for over 20 years. Perhaps the most significant developments were the introduction to building control systems of embedded processors, dedicated networks and intelligent agent approaches. The following taxonomy for technologically based intelligent-buildings can be proposed: ·

A. First-generation Intelligent Buildings consist of numerous independent self-regulating (automatic) sub-systems. These sub-systems might be relatively sophisticated (eg HVAC or security systems), but they are essentially disconnected, and operate independently of each other. ·

B. Second-generation Intelligent Buildings are formed when building control systems, such as those described in the previous paragraph, are connected together via a network. By interconnecting them in this way, it becomes possible either to control them remotely (from a building services manager's office), or to facilitate some central scheduling or sequencing (such as securing areas, or turning systems on or off at specific times). Several specialised networks, designed for this purpose, are commercially available and fairly widely used.

C. Third-generation Intelligent Buildings have, in addition to the processors and networks of the first two generations, the capability of learning about the building and its occupants, and hence adapting their control behaviour accordingly. This functionality arises from the application of intelligent agent techniques (already widely used in other areas, such as robotics). [7]

V. A CASE STUDY

The Essex IB Model - A Multi-Agent Distributed Architecture

Buildings may be regarded as being made up of rooms of different types. In addition, control and learning functions can be seen to be based around a room (i.e. our behaviour is often associated with the type of room that we are in, and thus so are our control needs). Most large buildings have a great deal of concurrent human activity distributed widely throughout them. (In particular, in residential and nursing homes, each occupant usually has his own individual bed / sitting room). Our proposed solution is based upon distributed processing and the fact that the physical and logical unit of an Intelligent Building is a single room. Each room contains

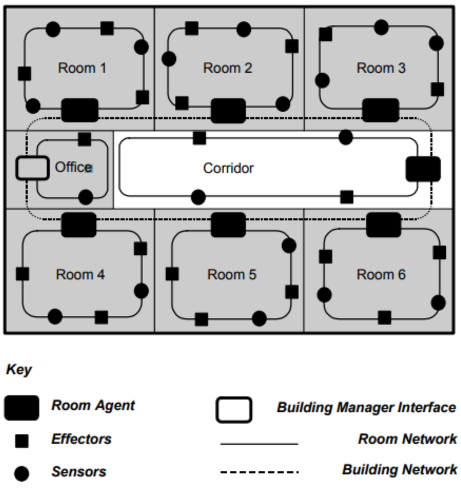

Figure 2: Multi-Agent Distributed Architecture[7]

sensors and output devices, which are monitored and controlled locally by an agent (a small embedded processor). All these agents are connected together via a network, forming a decentralised architecture that enables building-wide collaboration.

It is therefore dealing with a number of parallel distributed agents, each of which is monitoring a room (or room-like entity, such as a corridor), and responding individually to whatever is occurring there. In this way, each agent is focused on responding as well as possible to the particular needs of the person in the room, rather than finding an efficient way of satisfying the generalised needs of all the people in the building. Of course, there are still some matters that do require communication and co-operation between these distributed agents (e.g. responding to an emergency). The building-wide network allows the agents to selectively share their information when circumstances require, enabling them to make better decisions regarding situations that have a wider impact on the occupants and building, such as the presence of an intruder, or a fire, for instance. By utilising this decentralised approach, in which most of the control is localised to a particular room, inter-agent communication is minimised, resulting in network bandwidth requirements which are only a fraction of the capacity of most existing building networks. [7]

VI. CONCLUSION

In today's energy-sensitive world, smart building management systems offer a clear value proposition to commercial premises owners and their tenants. Although lower utility bills are a key attraction, additional benefits such as improved comfort and safety further enhance the value these systems can deliver. With clever software, tomorrow's building-management systems could deliver even greater efficiency, convenience and comfort, the sensors that can identify where people are and the environmental conditions they are experiencing at any time of day or night.

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