Smart Building:
Application of Intelligent Concept Through Upgrading Strategy and A Responsive Approach as A Catalyst of Change to Smart Integration Concept

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Abstract

Post occupancy stage is from the most essential stage in Smart integrated building as its directly touchable to residents. Smart technology integrated through building life cycle; starting from Design stage, execution, and ends with operation stage. a real measurement is made by the self-smart actuation to measure many features: functional, physical. Technical, environmental, and many other aspects that directly affect human comfort. a lot of designers focus on smart aspect without a real precise research on how to integrate smart techniques and principles in the design stage. Therefore, this research aims to signify smart principles in detailed and how to consolidate the smart concept during building lifecycle.

The diversity in opinions about the smart architecture and what the architecture smartness is (Is smart really smart?) and its technological conductivity is the main catalyst to search in smart technology, identifying its countenance and its relationship with eco-friendly determent and building learning ability.

This research is based on the author’s independent scientific thinking on the essence of the intelligent concept, for the purpose of establishing and debating for the smart concept. Furthermore, it’s affiliated the historical review. This technological debate offers a new orientation to the designers and provides extensive and enormous range to design such “SMART BUILDING”.

A criterion was utilized as a process that simulates international standards through elaborated evaluation criteria, that path with all project from Design, Construction, and ends with operation, to analyze smart features embedded in the building.

Decisions were drawn according to international and local standards, and an actual map implemented in integrating such a smart feature, and a new method arises and starts to take its first step global. A robust of choices were left for architects to attain this approach aiming in creating an intelligent cooperating approach that drops economical expenses and offer a brilliant life for human beings.

Key Words

Smart building. intelligent approach, building management system, building automation system, learning ability, operating system, responsive controllers

1. Introduction

This research reviews Smart approach in architecture starting from the very beginning of the smart concept and its wide deployment stating its historical review and stating its presence as a natural evolution of eco technological architecture. From an architectural perspective, intelligent buildings are not new. Primitive and indigenous forms of architecture exhibited sophisticated forms of intelligent design. These designs were intelligent because of their intimate relationship between the occupant and the technologies of built form. This intimate relationship was designed into the building by giving the user the capacity to interact with the building's various systems. The user could adjust, modify and adapt the building to changing situations, whether they were social, functional, or natural phenomena. Comfort, utility, and delight were achieved by the user's ingenuity in manipulating built form. The occupant was thus a critical element in the design and use of the building, and without the occupant's presence the building neither functioned nor had any intelligence. This continuous interaction between user and building (including its technologies) was responsive, it was intelligent architecture (Walter M. Kroner, 1989).

1.1. Smart Approach:

Through Deep architectural perspective, primitive smart building is not sophisticated as new intelligent design. Those embryonic designs were intelligent cause of their forms, materials, and orientation. Despite the great value of those old aspects a new one relationship took place between inhabitants and technologies of built form. This intimate correlation designed to make users interrelate with building’s numerous systems. These systems offer occupant a lot of facilities that make them to; adjust, modify, and adapting inner space and

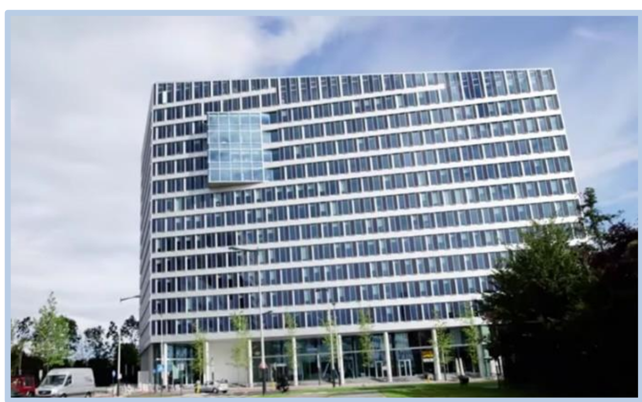


Figure 1 :the edge building in Amsterdam is one of the most smartness building in the world.

outer architectural features with the currently situation, whether this situation is functional or/and social, aiming to fulfill users with comfort atmosphere and a brilliant indoor quality (Walter M. Kroner, 1989).

Definition by (INTELLIGENT BUILDING INSTITUTE IN WASHINGTON DC):

intelligent building is the building which incorporates different frameworks, (for example, lighting, HVAC, voice and information correspondences, and other structure capacities) to successfully manage resources in a planned mode to amplify; tenant performance, investment, cost-saving, and adaptability.

Figure 2: Edge smart building (interior).

Different degrees of insight are given through intelligent controls and communication actuators. Common occupant services are; principally a voice and data media communications function which is shared among various independent users, is a component of intelligent buildings.

The National Research Council[1], Washington, DCA state in another term that smart building is 'electronically enhanced building', Furthermore it add that smart building is a building that is fully equipped with controllers and systems and a real infrastructure to help the utilization of cutting edge correspondence, information handling, and control advances by its inhabitants and operating staff. Such a building is outfitted with the essential wires, links, conduits, control supply, warming, ventilating, cooling, illumination, sound insulation, and security frameworks to help the performance requirements of today's office environs (Walter M. Kroner, 1989).

1.2. Chronological Progress from Traditional to Smart architecture

A historical development and a natural progress to architecture aspects occurs from traditional architecture to Smart architecture this progress is an ordinary transformation to occupant's essentials. On a concise level smart architecture becomes the most active approach in architecture as it takes up green challenges as an innovation criterion to accomplish. An alternative architecture called intelligent architecture comes to light under the slogan of excellency and never pessimistic. Consequently, smart architecture is environmentally aware, not only in protecting the surrounding environment but also in conserving, and producing energy.

[1] The National Research Council (NRC) of the USA is the working arm of the United States National Academies, carrying out most of the studies done in their names, it was organized in 1916 in response to the increased need for scientific and technical services caused by World War I.

This approach behaves intelligently as it uses sensors and controller with a responsive learning ability to interact in similar situations; system that learn, save action and interact.

Smart architecture is efficient; it expresses for itself, learns from environment. intelligent architecture tackle with technology not as an enemy of nature but as a natural ally (Ed van Hinte, etal,2003).

2. Intelligent Architecture Principles and Technologies:

2.1. Overview:

Smart features and technology was a normal result for human needs and architecture revolution. This study identifies the intelligent concept; stating its significance, different systems used intelligent building IB that saves time and money for occupants and gives great revenue for developers. This principles and technologies embedded in IB fulfill a comfortable atmosphere for users inside the building.

2.2. Smart Concept Connotation:

'Intelligence' relates to the possession of intellectual faculties, which provide a capacity for understanding. There is an inferred ability to perceive and comprehend meaning, and apply this acquired knowledge, through the thinking processes of reasoning (Michael Wigginton and Jude Harris, 2002). Intelligent buildings are becoming a trend of next-generation's commercial and administrative buildings, which facilitate intelligent control of the building to fulfill occupants' needs. The primary challenge in building control is that the energy consumption and the comfort level in a building environment often conflict with each other. To effectively manage the energy consumption and occupants' comfort, a multi-agent based control framework is proposed for smart building applications. The energy consumption and the overall comfort level are considered as two control objectives in the system design (Yang, Rui, Wang, Lingfeng, 2012).

The integration of building technology and energy systems is achieved in smart building. Smart building includes a lot of systems. These Systems may embed building automation, life safety, telecommunications, user systems, and facility management systems. Smart buildings recognize and reflect the technological advancements and convergence of building systems, the common elements of the systems and the additional functionality that integrated systems provide. Smart buildings offer great capabilities for the owner and/or occupant by providing actionable information about space to manage it or to control the whole building. Smart buildings provide the most cost effective approach to the design and the deployment of building technology systems. The traditional way to design and constructing building is to design, install, and operate each system separately.

Smart architecture is not complicated. Sometimes a simple and hence ostensibly 'dumb' building is smarter than a technology dominated living-and-working machine over which the user has lost control (Ed van Hinte, et.al,2003). Smart approach takes a different approach and integrates the design and installation of the systems. This process reduces the inefficiencies in the design and construction process, **saving time and money** (www.smart-buildings.com).

While operating smart building, technologies and systems are integrated horizontally among all subsystems and also integrated vertically. This integration allows information and data about the building's operation to be utilized by multiple systems as well as people Occupying and managing the building. Smart buildings integrate building technology systems at a physical, logical and application level. The foundations of a smart building Are; structure cable, open network protocols and standardized databases.

Smart Buildings also are a critical component to the energy use and sustainability of buildings, and smart electrical grid. The building automation systems (BAS) which are part of a smart building, such as HVAC control, lighting control, power management and monitoring; play an important role in determining the operational energy efficiency of a Building, and reducing energy consumption, aiming to enhance energy conservation (www.smart-buildings.com).

Abundant of technical firms and corporations in the technological disciplines agreed that the smart building is a system consists of:

- Building management system
- Office automation
- Telecommunications
- Space management
- Maintenance planning
- Business support
- Video system
- Audio system
- Security system
- Redundancy system (Tamer fouad, 2009).

A building is made smart through the application of intelligence or knowledge to automate the operation of building systems. In modern buildings, (Timothy I. Salsbury ,et al, 2009) the intelligence or smartness of building operation is encapsulated in algorithms, which are implemented in software on microprocessor-based computing devices.

Many of these computing devices are part of the building automation system, which can be decomposed into the following four main components:

- User interface – allows exchange of information between a human operator and the computer system
- Algorithms – methods or procedures for performing certain tasks such as control and automation
- Network – includes information transmission media (e.g., wiring), routers, and appropriate encoders and decoders for sharing information among devices
- Sensors and actuators – these represent the interfaces between the computing systems and the plant.

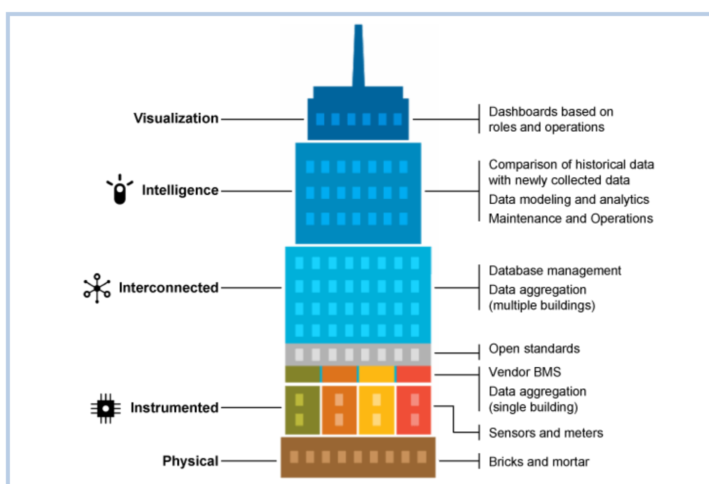
The user interface, network, sensors, and actuators are critical components of building automation system (BAS); these are all enabling technologies that only provide the means by which the intelligence inherent in the algorithms can be applied. The algorithms fundamentally determine the operational behavior of the controlled systems and are the source of the smartness. In a typical building, numerous objectives can be defined suitable for the application of control methods. Examples are; regulating a room temperature to a set level, turning off systems at a certain time, and controlling access to a room based on information read by a card reader. Controlling a variable, such as temperature, to a set level is probably the most common control objective and is most often carried out using feedback. Feedback is a fundamental building block of control and automation. Recent technological advances in information technology, including networking, computing power, and sensor technology, have meant that the number of controllable devices in buildings has proliferated. Not only are there more devices to control, but also information can now be shared more easily between disparate systems. Information is more easily accessible both within system groups as well as across different groups.

The idea of combining information from different systems to implement new and smart control and automation strategies extends easily to system groups that traverse traditional boundaries (Timothy I. Salsbury, et al, 2009).

Nowadays the automation systems become more efficient, less cost, and more benefit Such as; “Lan Works “which is the system tackle with different systems in the building there is also “Bacnet” system. Computers and actuators are connected to others through one of these systems like the “Ethernet “in the computers (Tamer fouad, 2009).

Building operation is not only the way in which buildings have been made smarter, but also the lifecycle of a building includes its planning, design, construction, installation and commissioning, operation, maintenance, retrofit and remodeling, and destruction. Each of these tasks not only consumes energy and resources, but affects subsequent tasks. New and smart technologies are being utilized at each stage in the lifecycle to improve the overall process. A prime example is in being able to simulate the performance of a design before it is built. This is a powerful technology that can lead to cost and energy savings for a project. The ability to simulate building systems is also enabling the development of innovative algorithmic smart technologies such as automated design and optimization (Timothy I. Salsbury, et al, 2009).

Figure 3: Intelligent Building different Technology; visualization, intelligent comparison between data, connection between management system , and physical instruments and material used. (www.urenio.org)



2.3. Intelligent Building Systems:

The strongest link in intelligent building that if can perform through different aspects and features, smart building can be formed by using intelligent materials and structure cabling, which is connected to a multimedia communication system to transfer data (send or/ and receiving) between actuators and various management systems. As explained any smart system should acquire a specific framework that consist of management system to monitor and automate controllers and system to fulfill occupants needs (Andreas muller,2007). The basic criteria by which the building considered to be intelligent are:

- Info framework that gets data by means of info receiver.
- Preparing and information investigation and analysis
- Yield framework that responds to the contribution to type of a reaction.
- Time consideration that causes the reaction that occurs within the required time.
- Learning capability
- Brilliant intelligent materials

Intelligent building should comprise all of these features and systems(Sherbini, K & Krowczyk, R. 2004).

Technical system for smart building is a mean to test objective controllers by deploying A lot of points as a nervous limp all over the building. This nervous hitches regulate and supervise dwelling purposes and routine. Alternatively, all of this is connected to building management system that control, learn and response to action and save desired reaction(Sayed abd el fatah, Eman, 2010).

- Nodes: “devices” sensors and actuators.
- The Channels: the physical wire to which devices are attached.
- The Protocol: the language that devices use.
- Routers: used to extend the length and segment to network devices.

They are bridges that make products designed for different media to work together (Sayed abd el fatah, Eman, 2010).

2.3.1. BMS-Building Management System:

The BMS is a central processing unit receiving all of the information from the various sensor outstations, and determining the appropriate control response to the actuating elements. It can monitor weather changes and control the operation of both passive and active environmental systems to ensure the most efficient use of energy.

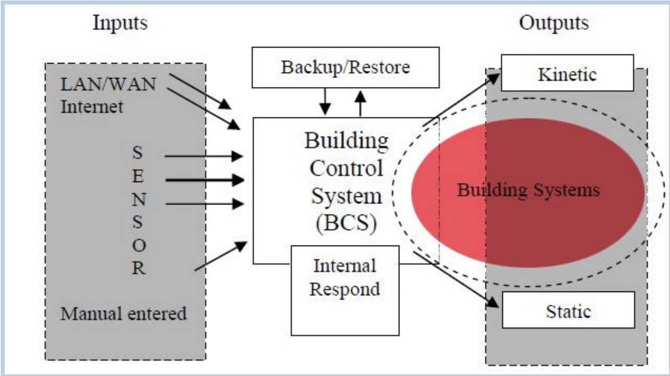
One of its most vital functions is to regulate temperature by activating all of the controllable elements in the building to achieve this naturally.

A. BMS Learning Ability:

It has the ability to learn. It can utilize current and anticipated weather data to calculate the optimum heating, lighting and shading levels for the building. Neural networks and knowledge-based software algorithms, incorporating fuzzy logic, can provide buildings with the ability to learn their energy status and thermal characteristics and relate climatic data to operating strategies (Sayed abd el fatah, Eman, 2010).

BM system can feel the increasing number of people, so it reduces the temperature from 75 to 65 degrees Fahrenheit to overcome the heat of 20 persons and then the authorized person reduces it to 58; the system should realize that its calculation was not very accurate. With 30 persons, the system should calculate the heat of each person according to the last experience. The ability to learn is very critical in case of fire and maintenance (Sherbini, K & Krowczyk, R., 2004).

Figure 4: Intelligent System Anatomy-
Source: Sherbini, K & Krowczyk, R. (2004)



B. Ecological Determinant:

Building can collect detailed real-time information relating to environmental conditions outside and inside the building. Typical measurements are made of wind speed & direction, outside temperature, facade and cavity temperatures, outside humidity, solar insulation, inside air and room temperatures, daylight levels and humidity. These data are essential determinant in the control decisions of the intelligent technologies (Abdel Moneim El Gindi ,Salwa., 2010)

BMS provides the most cost- effective means for staff to manage the building. This means that it’s able to respond quickly and efficiently to changes in function patterns and use of space (Wang Shengwei, 2010).

The intelligent building management system aims to keep temperature and air quality within a specified range, control lighting, monitor performance of all systems, and send out alarm signals to maintenance personnel when any fault occurs.

A BMS consists of software and hardware; the software program, usually configured in a hierarchical manner, can be proprietary, using such protocols as C-bus, Profibus, and so on. Vendors are also producing BMSs that integrate using Internet protocols and open standards such as SOAP, XML, BACnet, LonWorks and Modbus.

2.3.2. BAS-Building Automation System:

Building automation generally refers to the deployment of computer-based control system to monitor and control the physical environment, security access, or fire alarm systems in a commercial building. (Yang, Rui, Wang, Lingfeng, 2012).

Building automation system (BAS) is an umbrella term. It is used to refer to a wide range of computerized building control systems, from special- purpose controllers, to standalone remote stations, to larger systems including central computer stations and printers. BAS is one of the major intelligent building systems.

A BAS comprises several subsystems which are connected in various ways to form a complete system. The system has to be designed and engineered around the building itself to serve the services systems for which it is intended. Consequently, although the component parts used may be identical, there is no two systems are identical, unless they are applied to identical buildings with identical services and identical uses (Wang Shengwei, 2010).

Building services include HVAC systems, electrical systems, lighting systems, fire systems and security systems and lift systems. In industrial buildings they may also include the compressed air, steam and hot water systems used for the manufacturing process. A BAS may be used to monitor, control and manage all or just some of these services. There are good reasons and ultimate objectives in investing considerable sums of money in this way. These will vary, depending on the use of the building and the way the building is managed as well as the relationship between the value of the end product and the cost of operating the building. It may also depend on the level of sophistication of the building services and their capital cost uses (Wang Shengwei, 2010).

A. Typology

Most building automation networks consist of a *primary* and *secondary* bus which connect high-level controllers (generally specialized for building automation, but may be generic programmable logic controllers) with lower-level controllers, input/output devices and a user interface (also known as a human interface device).

The primary and secondary bus can be BACnet, optical fiber, Ethernet, ARCNET, or a wireless network.

Most controllers are proprietary. Each company has its own controllers for specific applications. Some are designed with limited controls: for example, a simple Packaged Roof Top Unit. Others are designed to be flexible. Most have proprietary software that will work with ASHRAE's open protocol BACnet[2] or the open protocol Lon Talk , as mentioned prior (BOS requirements).

Some newer building automation and lighting control solutions use wireless mesh open standards (such as ZigBee[3]). These systems can provide interoperability, allowing users to mix-and-match devices from different manufacturers, and to provide integration with other compatible building control systems.

B. Inputs and Outputs:

Inputs and outputs either digital or analog;

Analog inputs are used to read a variable measurement. Examples are temperature, humidity and pressure sensor which could be resistance temperature detector, or wireless sensors.

[2] BACnet is a communications protocol for building automation and control networks.

[3] ZigBee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low-power digital radios.

Digital input indicates if a device is turned on or not. Some examples of a digital input would be a 24VDC/AC signal, an air flow switch, or a Volta-free relay contact (Dry Contact).

Analog outputs control the speed or position of a device, such as a variable frequency drive, a I-P (current to pneumatics) transducer, or a valve or damper actuator. An example is a hot water valve opening up 25% to maintain a set point.

Digital outputs are used to open and close relays and switches. An example would be to turn on the parking lot lights when a photocells indicates it is dark outside. (www.kmccontrols.com)

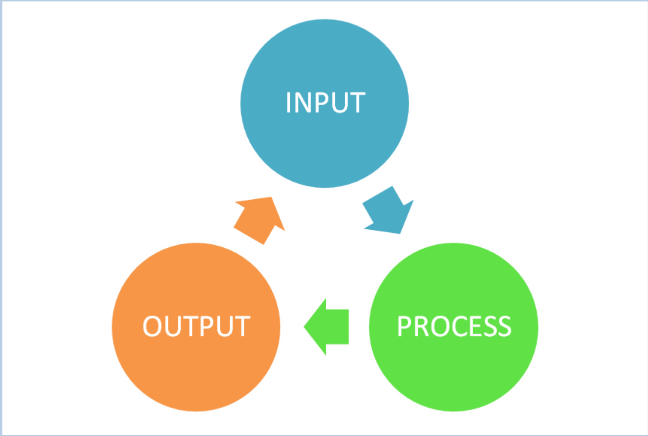


Figure 5: Processing inputs and outputs

2.4. Intelligent building Principles and Technology:

2.4.1. Regulator:

Most control systems have facilities for human override. However there may be an unchecked human control the BMS either reminds the user of the error or disallows continued functioning (Abdel Moneim El Gindi ,Salwa, 2010) Occupancy is one of two or more operating modes for a building automation system. Unoccupied, Morning Warm-up, and Night-time Setback are other common modes. Occupancy is usually based on time of day schedules. In Occupancy mode, the BAS aims to provides a comfortable climate and adequate lighting, often with zone-based control so that users on one side of a building have a different thermostat (or a different system, or sub system) than users on the opposite side.

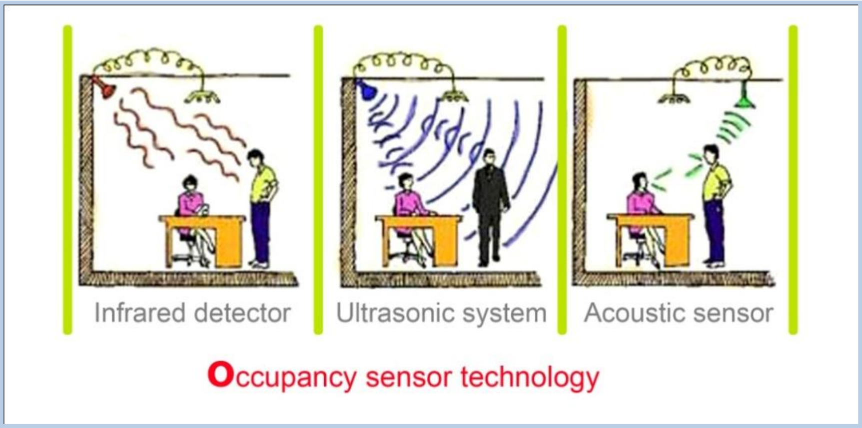


Figure 6: Occupancy sensor technology (www.iklimnet.com)

A temperature sensor in the zone provides feedback to the controller, so it can deliver heating or cooling as needed.

There are three types of sensor technologies: infrared, ultrasonic, and acoustic. **Infrared** (IR) it's a technology that sense body heat through a straight line in order to operate properly. **Ultrasonic** (US) technology emits a high-frequency sound that reflects off room surfaces. US sensors have good sensitivity and range where small motions must be detected. **Acoustic** technology called audible sensors it relies on voices, machinery sounds, keyboard tapping and other typical daily noises. This technology works well in areas with high partitions (www.iklimnet.com) .also many smart materials act as sensors or actuators. In their role as sensors, a smart material responds to a change in its environment by generating a perceivable response. Thus, a thermo chromic material could be used directly as a device for sensing a change in the temperature of an environment via its color response capabilities. Other materials, such as piezoelectric crystals, could also be used as actuators by passing an electric current through the material to create a force. Indeed, many common sensors and actuators are based on the use of smart materials (D. Michelle Addington Daniel L. Schodek, 2005).

If enabled, Morning Warm-up (MWU) mode occurs prior to Occupancy. During Morning Warm-up the BAS tries to bring the building to set point just in time for Occupancy. The BAS often factors in outdoor conditions and historical experience to optimize MWU. This is also referred to as Optimized Start. An override is a manually-initiated command to the BAS. For example, many wall-mounted temperature sensors will have a push-button that forces the system into Occupancy mode for a set number of minutes. Where present, web interfaces allow users to remotely initiate an override on the BAS. Climate conditioning is not often initiated directly by an occupancy sensor (www.kmccontrols.com).

2.4.2. Controller

Controllers are essentially small, purpose-built computers with input and output capabilities. These controllers come in a range of sizes and capabilities to control devices commonly found in buildings, and to control sub-networks of controllers.

Inputs allow a controller to read temperatures, humidity, pressure, current flow, air flow, and other essential factors. The outputs allow the controller to send command and control signals to slave devices, and to other parts of the system. Inputs and outputs can be either digital or analog, as discussed before. Digital outputs are also sometimes called discrete depending on manufacturer.

Controllers used for building automation can be grouped in 3 categories. **Programmable Logic Controllers (PLCs), System/Network controllers, and Terminal Unit controllers**. However, an additional device can also exist; in order to integrate 3rd party systems (stand-alone AC system) into central Building automation system.

PLC does provide the most responsiveness and processing power, but at a unit cost typically 2 to 3 times that of a System/Network controller intended for BAS applications. Terminal Unit controllers are usually the least expensive and least powerful. PLC's may be used to automate high-end applications such as clean rooms or hospitals where the cost of the controllers is a lesser concern.

In office buildings, supermarkets, malls, and other common automated buildings the systems will use System/Network controllers rather than PLC's. Most System controllers provide general purpose feedback loops, as well as digital circuits, but lack the millisecond response time that PLC's provide.

System/Network controllers may be applied to control one or more mechanical systems such as an Air Handler Unit (AHU), boiler, chiller, etc., or they may supervise a sub-network of controllers.

Terminal Unit controllers usually are suited for control of lighting and/or simpler devices such as a package rooftop unit, heat pump, VAV box, or fan coil, etc. The installer typically selects 1 of the available pre-programmed personalities best suited to the device to be controlled, and does not have to create new control logic (www.kmccontrols.com).

2.4.3. Lighting Responsiveness:

Artificial lighting is essential for the visual environment in spaces for living, working or other generic purposes where and when there is no sufficient daylight available. In some special spaces, such as spaces for entertainment, lighting is needed for creating a dramatic or dynamic environment. The lighting system is one of the major energy consumers in buildings, typically following the HVAC system in office and commercial buildings.

Control of the lighting system is required to meet the following purposes typically, which may be achieved manually or automatically:

- Functional need and flexibility of the space;
- Energy saving;
- Visual comfort of the occupants;
- the requirements of legislation;
- Creating a dynamic or dramatic environment.

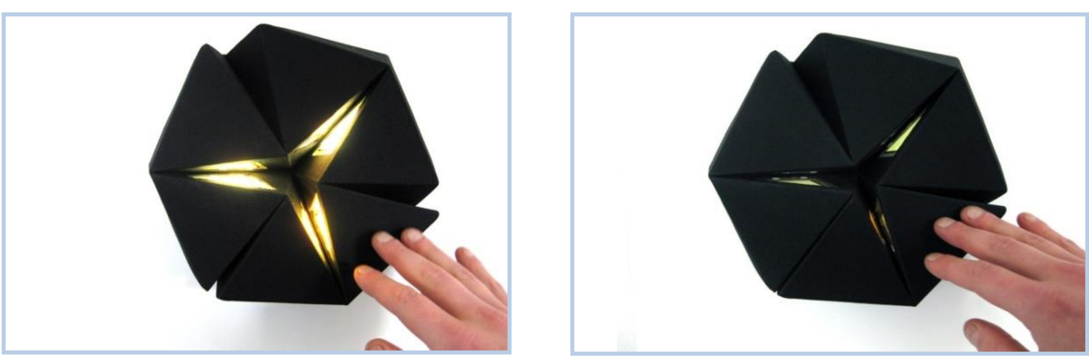


Figure 9:Adaptable lighting technology

The lighting system should also be adaptable to the changes in the space, such as office layout, some lighting units feel human presence through sensor and adapt to provide required light (as shown in figures). Energy efficiency is one of the important issues concerning lighting system control. A very significant proportion of building energy is consumed by the lighting systems. Providing lighting only in the areas and in the periods lighting is needed and providing the right level of lighting as needed are effective means of reducing the energy use of the lighting system. The main control actions for this purpose are on/off switching and dimming. Lighting is one of the major contributors to create a stimulating and comfortable environment for working and living. It is one of the major environmental factors affecting the satisfaction of the occupants in the buildings. The visual environment adaptable to individual requirements or controllable by individuals will also increase the satisfaction of users with the visual environment and lighting systems (www.daintree.net) .

2.4.4. Automated Ventilation system:

Most air handlers mix return and outside air so less temperature change is needed. This can save money by using less chilled or heated water (not all AHUs use chilled/hot water circuits). Some external air is needed to keep the building's air healthy.

Analog or digital temperature sensors may be placed in the space or room, the return and supply air ducts, and sometimes the external air. Actuators are placed on the hot and chilled water valves, the outside air and return air dampers. The supply fan (and return if applicable) is started and stopped based on either time of day, temperatures, building pressures or a combination.

- **Constant volume air-handling units**

It is a type of heating, ventilating, and air-conditioning (HVAC) system. In a simple constant air volume system, the supply air flow rate is constant, but the supply air temperature is varied to meet the thermal loads of a space (ASHRAE Handbook, 2004), the less efficient type of air-handler is a "constant volume air handling unit," or CAV. The fans in CAVs do not have variable-speed controls. Instead, CAVs open and close dampers and water-supply valves to maintain temperatures in the building's spaces. They heat or cool the spaces by opening or closing chilled or hot water valves that feed their internal heat exchangers. Generally, one CAV serves several spaces (www.kmccontrols.com).

- **Variable volume air-handling units**

A more efficient unit is a "variable air volume (VAV) air-handling unit," or VAV. VAVs supply pressurized air to VAV boxes, usually one box per room or area. A VAV air handler can change the pressure to the VAV boxes by changing the speed of a fan or blower with a variable frequency drive or (less efficiently) by moving inlet guide vanes to a fixed-speed fan. The amount of air is determined by the needs of the spaces served by the VAV boxes. Each VAV box supply air to small space, such as offices

Some VAV boxes also have hot water valves and an internal heat exchanger. The valves for hot and cold water are opened or closed based on the heat demand for the spaces it is supplying. These heated VAV boxes are sometimes used on the perimeter only and the interior zones are cooling only. There are two primary advantages to VAV systems. The fan capacity control, especially with modern electronic variable-speed drives, reduces the energy consumed by fans, which can be a substantial part of the total cooling energy requirements of a building. Dehumidification is greater with VAV systems than it is with constant-volume system, which modulate the discharge air temperature to attain part load cooling capacity (ASHRAE Handbook.,2004)

- **VAV hybrid systems**

Another variation is a hybrid between VAV and CAV systems. In this system, the interior zones operate as in a VAV system. The outer zones differ in that the heating is supplied by a heating fan in a central location usually with a heating coil fed by the building boiler. The heated air is ducted to the exterior dual duct mixing boxes and dampers controlled by the zone thermostat calling for either cooled or heated air as needed (www.kmccontrols.com).

<u>(HVAC) Direct Digital Control systems (DDC) consist of:</u>

- Sensors: Heat sensors, CO2 sensors. It collects data of room temperature and ventilation.
- Sensors responsible for air flow in the room.
- Actuators: electronic actuators for adjustment of airflow through the "VAV" Variable Air Volume boxes.
- Control units obtain data from sensors and give signals to the electronic actuators.

DDC collects data from sensors and stores it and this helps in; Making automatic maintenance; Taking more accurate decisions; Integrating between different technologies (Abdel Moneim El Gindi ,Salwa., 2010).

2.4.5. Ventilation Controllers:

Ventilation can be automatically regulated for increased effectiveness by operable Elements of the building fabric, such as retractable roofs, motorized windows and pneumatic dampers. These movable elements can be automatically closed by unfavorable conditions such as inclement actions of wind and rain. Intelligent control mechanisms help to overcome undesired problems faced by natural ventilation like air and noise pollution. Buildings can operate mixed-mode approach to ventilation and intelligent control systems can determine when to best activate mechanical ventilation. They can be programmed to use mechanical ventilation only in extreme conditions, thus maximizing natural ventilation and minimizing energy use.

Technologies like Self-regulating vents can maintain constant airflow in changing wind speeds. Also Local fan units which can be operated only when occupants presence is detected (Abdel Moneim El Gindi ,Salwa., 2010).

2.4.6. CCTV and Audio Visual Security and Monitoring System:

Smart building has a lot of system to control alarm capabilities, fire alarms always used alongside of burglar alarm systems. Separated control boxes were often used to interface heat and smoke detectors to an alarm bell. Nowadays, abundant of alarm system incorporate a specific channel for fire alarm inputs. When alarm is detected the BMS notified that there is a fire in a certain zone, at this moment intelligent management system start to take a lot of procedures to secure occupants and seize the fire.

Smoke detectors are also a very important part of an integrated fire alarm system. Smoke detectors play major role in delivering the problem to BMS which by its turn take specific procedures to guarantee safety for users.

Figure 0-12:Security Camera

Figure 0-14: Alarm Detector

Figure 0-13: Smoke Detector

Fire and smoke alarm systems can change Building Automation actions; For example; Outside dumpers will be closed if the smoke alarm is activated, to isolate the fire area and prevent air from coming to fire area (Thomas petruzzellis, 1994).

2.4.7. Indoor Air Quality Controller:

Control systems ensure the optimized operation of low temperature hot water circuits. The sun is also utilized for water heating; some can be equipped to track the sun automatically for maximum exposure.

2.4.8. Generators:

Intelligent building strives for electrical autonomy through self-generation. This can be achieved by incorporating either photovoltaic, wind turbines and combined heat and power systems (Abdel Moneim El Gindi ,Salwa., 2010)

2.5. IB Systems from Ergonomic to Efficient Integrated Management Systems:

The early designs of integrated building management systems merely collected the outputs from the local Controllers dedicated to fire protection, security, HVAC and energy management for central monitoring of all these services. Basically, these inputs to the central computer were exceptional inputs; showing deviations from the norm which required the operator's attention. Thus integration was an overlay on the existing systems, requiring substantial additional wiring and offering improved management response and automatic logging of system actions. In the case of a computer or communications failure the essential local control functions were still operative (G. Clark, P. Mehta, 1997).

The idea of integration between different systems is to share the information between enterprise component and by its turn it leads to signify building efficiency.
And it's divided into:

- Facilities management; life safety system, and energy management systems
- Information and work systems; telecommunication systems, and work place automation (Osama hanfy ,nirvana ,2009)

2.5.1. Facilities management:

Facilities management implies a computerized system that oversees and controls building operations, generally energy and life safety. Although the potential exists to integrate all facilities management activities into one large system, practical and economic considerations deject this. Since 1987, the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) have operated on the development of an open data communications protocol named BACnet. This protocol allows control systems from multiple, competing manufacturers to communicate or "inter-operate" with one another. [4]

A. Life safety system:

Life safety system Consists of the use of high technology to maximize the performance of fire alarm and security systems while at the same time minimizing costs. Life safety factors involved in intelligent buildings include:

• Reduced manpower dependence,
• Card access control,
• Intrusion alarms,
• Closed-circuit television,
• Smoke detection,
• Uninterruptible power supplies
• Emergency control of elevators, HVAC systems, and doors

B. Energy Management Systems

Energy efficiency is the most important point in intelligent building design 35 years after the oil crisis in the early 1970s. Computerized systems are used such as; Building Automation System (BAS), Energy Management System (EMS), Energy Management and Control System (EMCS), Central Control and Monitoring System (CCMS) and Facilities Management System (FMS) to reduce energy use to the minimum without relinquishment from occupant comfort (Bayram, Ayça, 2003).
Strategies used by facilities management systems to reduce energy consumption in intelligent buildings include:

• Programmed start/stop
• Duty cycling
• Electric demand limiting
• Chiller/Boiler optimization
• Optimal start/stop
• Set point reset
• Adaptive control
• Optimal energy sourcing (Tamer fouad, 2009)

[4] BACnet system Mentioned before and its interoperability with other systems in BOS

2.5.2. Information and work systems:

A. Communication systems:

Smartness according to the communication system in the smart building represent some developed communication advantage for users, putting in consideration cost minimizing as it's the same actuators and tools used by more than user, and from this developed systems:

•Private telephone exchange systems •Cable vision

•Audio-visual and video conferencing •Satellite communications

•Electronic mail, intranet and internet access (Sayed abd el fatah, Eman, 2010).

B. Work place systems:

Intelligent here comes in the frame of using high technology in managing the administrative office spaces with the electronic systems; so as to signify work efficiency. The systems used are:

- Centralized data processing
- Word processing
- Computer aided design
- Information services (Tamer fouad, 2009).

3. Summary and Conclusion:

Designing a smart building should be made in a highly matured way that use different techniques, principles and technologies, which are energy efficient, associated with environment protection and well-being of the building's occupants, construction workers, the general public, or future generations. Smart building concept involves the consideration of many issues, including land use, site impacts, Cabling integration, and time management, lifecycle impacts of building materials, and solid waste (Landman Miriam, September 1999) . smart technologies and principles operate, manage, conserve energy, and offer human comfort inside the building entity. Not only aiming to control all the unnatural variables in a way to serve the human efficiency inside the work space, but also make use of the natural variables without harming the environment. It also explains the idea of integration between different systems and integration between abundant of protocols.

Educing from this research a specific point that affect the smart building these points comes from the different types of technological principles to achieve an elaborated criterion to investigate summarized in; Building Management system and building Automation system (BMS, BAS). Automation and responsiveness are intelligent building (IB) backbone, implementing those two aspects is mandatory to create an intelligent building that accedes user's needs.

This investigation also reviews the intelligent connotation, chronological progress, and smart concept deployment. Identifying IB operating systems from its management systems BMS, which responsible for the whole building operations to energy conservation through BEMS, and its Automation Systems. The achievement of IH system becomes highly connected to cabling concept. Implementing all principles and system in the initial fit up of IB may not be necessary, however, it’s mandatory to recognize the basic overall concept and implement a full communication cabling backbone structure from the start in order to accommodate future user needs and offer a real diminution in contemporary home overall cost.

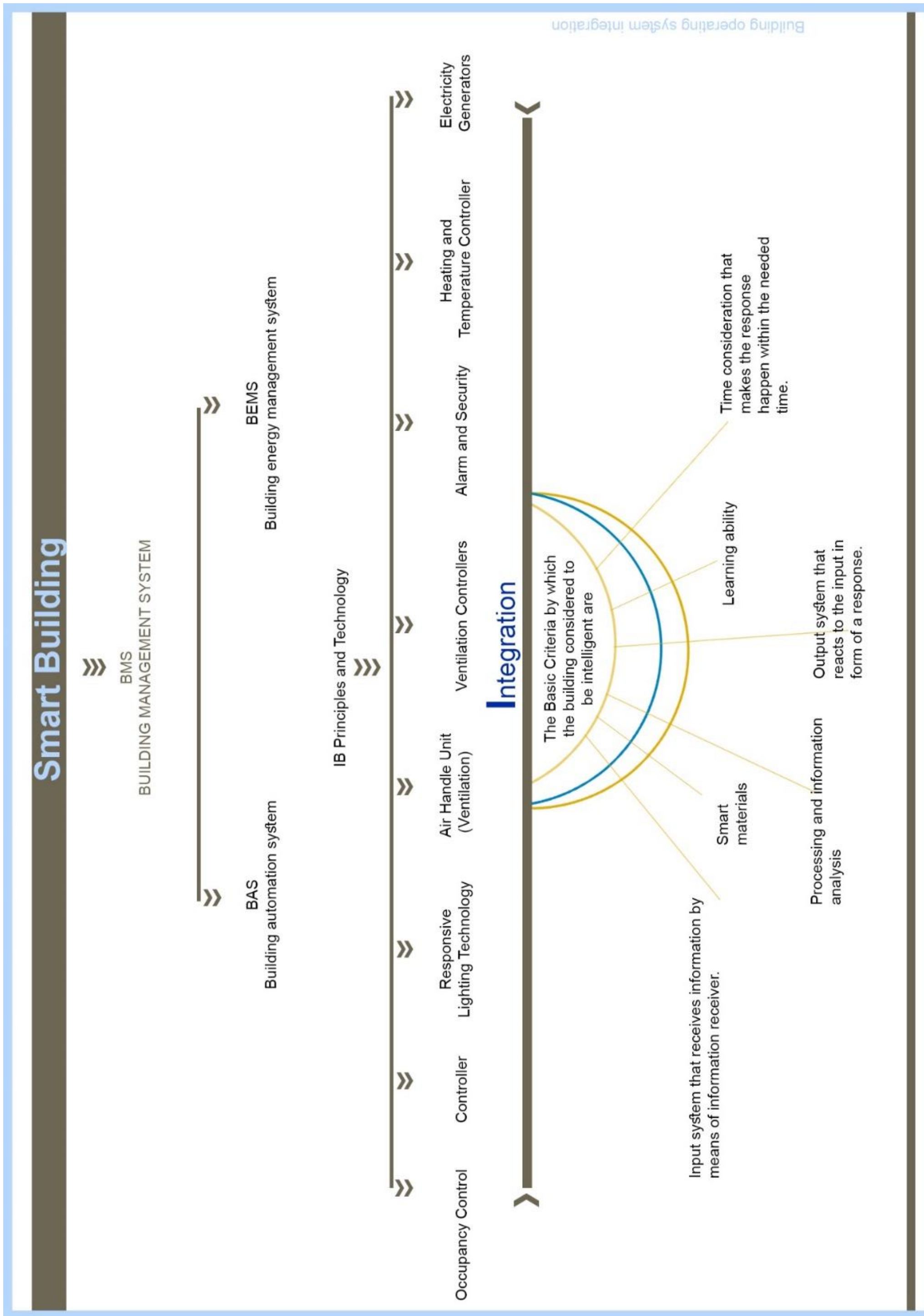


Figure 15: Intelligent Building Principles.(researcher)

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