ENERGY EFFICIENCY AND SUSTAINABILITY ON BUILDING THROUGH "INTELLIGENT" PROCCESSES

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ABSTRACT

The construction industry has recently developed new technologies to tackle the increasing complexity of today's building facilities and systems. Therefore, the term "Intelligent Building" is becoming more often used to identify constructions that are able to integrate simultaneously coexisting systems and subsystems in a building. In addition we start using the term "Smart Building" implying further steps of system integration and interaction. Analysing this subject in detail, there still actually remains the so-called automation isles, as well as to apply extensively the concept of intelligent processing This communication intends to analyse the state of art of the Intelligent Building concept and how the term "intelligent processing" could be applied in order to search a high-level of energy efficiency and sustainability.

Keywords: Intelligent Building, Smart Building, Building Energy Management and Control, Artificial intelligence, Automation.

1. Introduction

The intelligent building concept has evolved from its definition 30 years ago, due to new technological challenges, leaving behind its old meaning, and updating it to present times.

The evolution of management systems, communication protocols like the introduction of IPv6 (http://techterms.com/definition/ipv6), the interaction between platforms creating new communication standards, information captures, increasingly advanced (intelligent counters, intelligent materials, intelligent sensors…) and especially the introduction of computer science, has significantly transformed the landscape.

In a short period, we have essentially changed our concept of intelligent building to one able to react, to even consider some sort of capacity to interact or intelligently manage resources.

Anyway, the fact demonstrates that the use of "Intelligent Building" or "Smart Building" in some commercial or pseudo-technical publications, is mostly a commercial attraction to real state companies or premise management. The fact is that many milestones, to reach the real meaning of this term, must still be attained.

In this case, without taking into account all sort of definitions, we will focus on the evolution of such terms and how these can bring us closer to the main goal; that it is Energy Efficiency and Sustainability.

2. Historical Reference

For over a hundred years, the primarily goal of construction and engineering was that buildings would endure over time. The great architectural works have succeeded, but their high cost makes these projects unqualified to be repeated.

The great evolutionary challenge of the following years, has been to improve the building value [1], reducing construction costs but increasing the level of comfort, satisfaction, performance and reducing energy consumption.

In Figure 1, Buckman summarizes the historical evolution of a building's different comfort features through the categorization of buildings.[2]

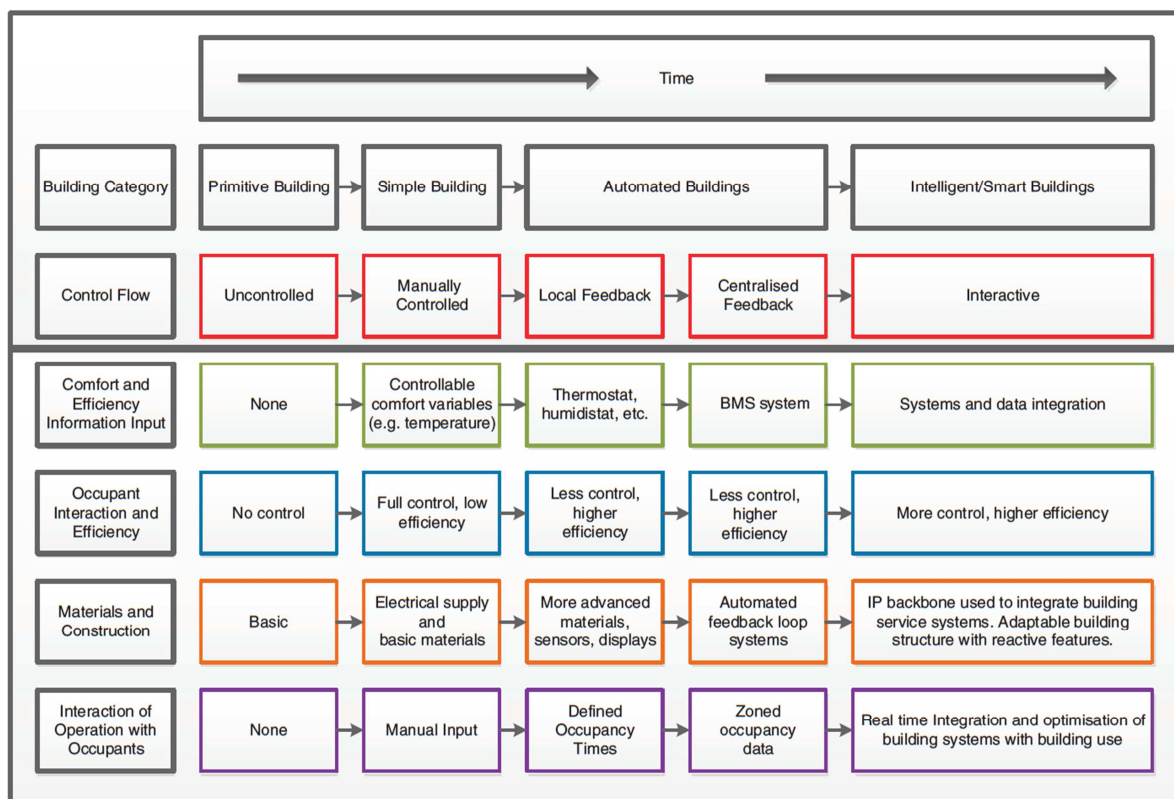|			Time		
Building Category	Primitive Building	Simple Building	Automated Buildings		Intelligent/Smart Buildings
Control Flow	Uncontrolled	Manually Controlled	Local Feedback	Centralised Feedback	Interactive
Comfort and Efficiency Information Input	None	Controllable comfort variables (e.g. temperature)	Thermostat, humidistat, etc.	BMS system	Systems and data integration
Occupant Interaction and Efficiency	No control	Full control, low efficiency	Less control, higher efficiency	Less control, higher efficiency	More control, higher efficiency
Materials and Construction	Basic	Electrical supply and basic materials	More advanced materials, sensors, displays	Automated feedback loop systems	IP backbone used to integrate building service systems. Adaptable building structure with reactive features.
Interaction of Operation with Occupants	None	Manual Input	Defined Occupancy Times	Zoned occupancy data	Real time Integration and optimisation of building systems with building use

Figure 1 [2]

This particular view, focuses mainly on showing the changes that have occurred in order to reach the current concepts of "Intelligent / Smart Building". As one can see, almost all changes are evolutionary, based mainly on the evolution of the technology, but keeping aside the largest contributor to the smart concept, which is the ability to learn from its environment and experience.

From the beginning, Intelligence is usually associated with the integration of platforms that make up the services of a building; thereby the evaluation of a building is associated with this level of integration. The more integrated the platforms are, the greater the level of intelligence. [3]. Other authors define intelligent buildings as those that help organizations achieve their objectives, facilitating the management of its resources and therefore increasing its effectiveness. In summary, dealing with the social and technological changes, to suit human needs. [4]

As we see, the lack of specificity regarding the definitions of these new terms has created gaps in the development of the concept itself and especially insecurity in the possible client/owner. [5]

This development has also been marked by the incursion of international standardization and regulation bodies, which have attempted to shed light on the definition. These agencies have integrated and structured not so much the definition

of IB (Intelligent Building) itself, but many of the elements that compose it. Thus, in the last decade, platforms (e.g. BAS Building Automation System) or elements (e.g. PLCs, PLC, etc.) are more easily recognized. [6]

In any case, what is certain is that the concept of IB continues to be built on Wong's visionary definition, based on the integration of three systems:

- Building Automation System (BAS)
- Telecommunications System.
- IT Management System

According to this, it would be possible to reach by the improvement, which should occur in the physical elements (Software and hardware), and in the conceptual elements (distributed intelligence, data management, system integration of company information, or communication protocol matching)

Looking at it twenty years later, most of the definitions are still valid [7]

3. Changing field description.

The key changes, some of them critical, which have contributed to this evolution, are focused on particular working areas.

3.1. Integration

Make different applications interact has unquestionably helped to improve the user´s perception about what an intelligent platform is able to offer.

Therefore, solutions such as person identification for the enhancement of building security control [8], [9], or integrated systems of fire detection (10), dynamic creation of building evacuation routes [11], [12], reduction of complexity regarding the use of devices via WiFi [13], [14] or efficient and adaptable illumination systems [15], clearly state that the integration factor has been essential to achieve a relevant added value.

3.2. Communication, Protocol

This integration we are talking about, had not been achieved without a change of the way the devices and platforms of the whole building infrastructure interact. Turning information isles into structured forms of information that could be centrally stored and shared, required important changes. That is why we have attained a great change through the internet communication protocol from IPv4 to IPv6 [16], to standard ways of sharing information between platforms as BACnet [10], [17], [18] or BACnet on OPC [19].

On the other hand, the advantages given by implementing platforms with the standard use of Web Services (the way to interchange data among developed applications of different programming languages), under the supervision of committees of standardization W3C or Ws-1 allows heterogeneous computer developments interact efficiently. [20]–[23]

3.3. Constructive Models

The new Energy Efficiency government policies and restrictions with an increasing awareness about sustainability in construction, has created the trend toward "ecological" construction. This implies a new way to design and directly introduces the eco actions from the project concept. The regulation structure also helps to transform the scene introducing environmental routes through certification programs like BREAM or LEED, which suppose the most accepted way to measure the carbon foot over a full life cycle of a building.

In the same way, the intelligent green building project (IGBP) initiative is in part a company business strategy but also is part of a project launch. Planning, project management and rating index merged to enhance the project performance

execution, make buildings energy efficient and reduce carbon emissions. The objective is projecting the sustainability criteria to all parts of engineering life cycle. [24]

3.4. Rules Compliance

The use of basic rules in building management system has been the best and easiest way to start in prediction models. Basically it is to establish some variables in design process that must be met in building operation time. The changes which appear in this variables during the building day life, help the operation subsystems to adapt or anticipate to new environment conditions fast and easily. (HVAC, Electricity, water, etc…). This model is closer to "reactive actions" than others, but allows easily to take under control and automatize simple variables.[25], [26]

3.5. Simulations

According to Malaga's architect Rafael Urquiza,

> "An intelligent building is not one to which we have added electronic equipment after its construction, it has to be one from conception"
> (Http://www.efefuturo.com/noticia/el-edificio-inteligente-nace-no-se-hace/).

And in the same way indicates that

> "There are several types of intelligence, passive on its design, and another which has to do with active-energy systems and reactive, -energy, sensors- that act according to what happens. Passive intelligence applies in the building´s design.
> In this design phase analysis and simulation systems are used to predict how the building would behave in the real world with the prevailing winds, solar radiation or with respect to pedestrian flows, for example. "

These simulations allow for what is a much more balanced design based on variables that will influence the building during its use.

Incorporating all these variables in the life of a building, has led to the evolution in complexity of concept of IB, but at the same time (due to mere need) to something much more structured and systematized, which allows us to understand and enjoy the benefits of an evolved model of building management.[27]–[30]

4. Smart Building

After reviewing the historical evolution of the concept of intelligent building, one can advance towards a better definition of "Smart Building" (SB).

The difference between BI and SB is basically that the systems instead of reacting to stimuli (variables like temp, humidity, occupation, alarms, etc ...) they allow the adaptability of services through predictive systems that draw on both internal and external information and especially that have "learned" from past events. [2], [31], [32]

One can observe clear changes in the trend that is taking place and how they adapt to this new definition. Thus, the new SCADA include predictive models (IndasIBMS SCADA) [33] and these are being imposed on new designs. Furthermore the inclusion of other variables such as environmental ones, noticeably contribute to a better adaptation of systems [34], the widespread use of applications in various facilities that publish Web Services under OPC, allow applications to share information [35] or using new metrics based on the activity or user behaviour [36] are allowing new initiatives such as the integration of micro-networks of alternative energy in the overall supply of a building to become a reality [37]

All this is contributing in many ways to improve the user's management or comfort, but above all, it is making progress in introducing variables that contribute to the objective of improving energy efficiency and sustainability in buildings.

5. Energy Efficiency

Achieving the goals of reducing energy consumption by 20% is part of the Europe 2020 objectives adopted by the EEC. In the building industry, the trend is more ambitious and it speaks with consistency of low or even zero energy buildings. The efforts made to achieve this goal are quite broad, driven primarily by a more general awareness of reducing energy consumption, sustainability and reducing the carbon footprint to climate change. [38]

There are many changes taking place in the methodologies used to address a building project. Perhaps the most important is that all the new actions start on the initial phase of the project and include at least passive-design strategies [39] or the use of control systems based on artificial neural systems.

These latter systems allow a learning platform, based, for example, on user patterns in order to adapt the facilities and systems more quickly to changes and so to avoid peaks in energy consumption (especially in systems like heating), which are complex to optimise and involve a great waste of energy. [40]

Where major changes have also been introduced is in the buildings of increased energy consumption, such as commercial buildings. In these buildings the cost of the general infrastructures is shared between those who occupy the premises and therefore its dimensioning, and use make up a considerable waste of energy. One solution is for analysis and simulation. On the one hand, data from sensors in the building (temperature, humidity, etc ...) and electrical consumption are collected. A comparative analysis is performed with them and the corresponding simulation is performed; the extracted data gives an optimal scenario and will enable the optimization of consumption by the settings of these variables. [41].

The next evolutionary step was to integrate the values of supply and energy demand in the simulation, including alternative energy sources and different energy suppliers. This also allows the system to optimize the cost and source of energy services. [42]

6. Conclusions

These "intelligent" processes are those that ultimately can make the difference between current and future way in which we understand energy efficiency in future buildings, although with time and fashions one will want to call them in different ways. Making a building able to, not just manage its variables, but to include new ones (both internal and external), combine them and learn how they affect each allows for progress in the "logical" process that lacks even this evolutionary process.

On the other hand, we must lose the widespread fear of letting *someone* manage the so-called neural processes developed by machines. Largely due to misinformation encouraged by our consumption of science fiction, processes based on artificial intelligence, we produce a certain rejection yet, but at this point no one thinks to forget that the most effective way that our environment suffers as little as we passed by him, is that the spaces that welcome us behave actively temporarily to avoid waste of resources, but this also can depend on the greedy and selfish human activity.

As opposed, this loss of control over what will happen in future buildings will be compensated with new features that provide us the same. One will be the protection. In future buildings, with their complex and predictive systems, better take care of its occupants against possible and dangerous situations such as fire, (limiting their

consequences) or extraordinary like an earthquake (ahead of the tremor and evacuating the building). [32]

There is no doubt that the future is in this area is very promising, and certainly many satisfactions held in store in the coming years, especially if the effort to preserve the delicate balance between residents and environment that we have not respected is maintained

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