DESIGN PROCESS FOR VIRTUAL INTELLIGENT BUILDINGS

Mariana FRATU, Lucia BOERIU, Aurel FRATU
Transilvania University of Brasov, Romania

Abstract. This paper is focused on the various virtual architectures of the intelligent buildings. Building designers face exciting new challenges in incorporating new and innovative technologies in designing an efficient integrated intelligent building in areas of the building structure and its mechanical and electrical systems. The innovative design technologies would need to ensure that the end users achieve the utilization of its abilities in optimization of the projects. Creating an intelligent building does require an investment in advanced technology, processes and solutions. An ingenuous investment is required to realize a significant return later on. It is unrealistic to expect to make a project intelligent unless there is early acquisition in on investment. Over, these decisions need to happen prior to the start of design work. One of the challenges is to educate owners on the benefits of an intelligent building design. This makes the education of both owners and architects about the benefits of intelligent solutions for success.

Keywords: innovative design process, future building, intelligent building, virtual building

1. Introduction

The decision to make a project “intelligent” needs to come early in the design process for intelligent buildings. Making the decision to create a new project or modify an existing one to make it intelligent is similar to invest in a project with superior performance and value.

Intelligent buildings drives a proven, co-creative process that will generate long term, sustainable value by increasing quality utilization, aligning stakeholders and permanently changing cost structure.

The results from implementing innovative technologies and processes are buildings that cost less to operate and are attraction more to their occupants. For projects that are proprietor engaged, the benefits of an intelligent building provide immediate benefits in terms of higher employee productivity.

For commercial developments, these projects are expected to result in above market fees, improved maintenance, higher occupancy rates, and lower operating expenses. All around, this is a win-win situation.

The technologies and processes that are required to create such projects start with design and go through long-term operations, modify the building by adding newly developed parts that were not available when the building was made and eventual decommissioning.

Once this occurs, the design process can continue as usual.

2. Intelligent buildings design

The definitions of an intelligent building can be systemically classified by the information and control services that serve the needs and expectations of the occupants. The specially designed controlling software and actual electronic hardware and devices installed within the structure that manipulate the telecommunications and building automation functions are necessary to create such a facility. Thus, the study of Intelligent Building is now a common topic worldwide.

In our current quest for modernization in this particular scope, there are two areas which deserve added attention, both from the research and professional communities. Designers need to ensure that the building owner receives the best product possible. Hence, everyday, building designers are in face of the exciting new innovative technologies.

The innovative technologies would need to ensure that the end users achieve the utilization of its abilities in the home space optimization.

One of the first attributes in an intelligent design is to carefully evaluate the current and future use of the project. This starts by clearly identifying the purpose and needs of the targeted building occupants. This process will vary depending on whether it will be an owner occupied or a commercial development.

For an owner-occupied building, surveys and focus groups can be held with the building occupants, analyzing and prioritizing their needs to select proper project features.

The reality is that most innovations come from a process of rigorous examination through which great ideas are identified and developed before being realized as new offerings and capabilities. It is important to realize, however, that few projects are used as originally envisioned. A good intelligent design should incorporate flexibility to allow for easy change.

Examples of this type of design characteristic include communications, life safety, automation, structured cabling design, and open space with movable or demountable partitions.

An intelligent building needs to be designed to meet the needs of initial occupants and be flexible to meet the needs of future occupants.

An intelligent building design begins by looking at the site as it integrates with existing buildings; space planning as it is a new "green field" location, getting it in the right position for maximum solar efficiency.

Site integration is critical for environmental impact, and strongly affects how the building occupants interact with the building.

At a macro scale, community integration is determined by community space planning and zoning regulations. The attribute intelligent makes the building more marketable with a lower impact on the environment.

An intelligent building starts with an environmentally friendly design. Creating a project that is environmentally friendly and energy efficient connect in closely, with many of the intelligent attributes [1].

Intelligent buildings are designed for long-term sustainability and minimal environmental impact through the selection of recycled and recyclable materials, construction, maintenance and operations procedures.

Providing the ability to integrate building controls, optimize operations, and enterprise level management results in a significant enhancement in energy efficiency, lowering both cost and energy usage compared to non-intelligent projects.

Intelligent buildings are intended to be the preferred environment for occupants.

This requires focused attention to environmental factors that affect occupants' perception.

An intelligent design finds the balance, providing a superior indoor environment and minimizing energy usage and operating labour. This is where the technology becomes valuable [2].

The starting point for the development of the building system is based on informatics tools. Thus the quality and efficiency could be enhanced considerably. An intelligent building must be smart enough to vary the environment and also to provide various means of communication or network regardless of whether it is internal or external.

Intelligent building starts with monitoring and controlling information services known as Building Automation System (BAS). BAS is able to optimize environmental and safety aspects in an economical way. This can be achieved by using computers, together with function distribution control techniques, to optimize the usage of various pieces of equipment within the building such as the electrical facilities, the air-conditioning systems, fire-prevention equipments and security devices.

One of the most significant barriers to energy-efficient building design is that buildings are complex systems. While the typical design process is linear and sequential, minimizing energy use requires optimizing the system as a whole by systematically addressing building form, orientation, envelope, glazing area and a host of interaction and control issues involving the building's mechanical and electrical systems.

Intelligent building, with the use of automated control system such as BAS, enables both building owners and occupants enjoy the benefits of financial gain and enhanced accommodation / management quality.

BAS comprises of electronic equipment that automatically performs specific facility functions. The commonly accepted definition of a BAS includes the comprehensive automatic control of one or more major building system functions required in a facility, such as heating, ventilating, and air conditioning system, lighting, power, lifts, security and more. In short, BAS is to integrate the traditionally separate functions under one common operation.

BAS includes a collection of sensors that determine the condition or status of parameters to be controlled, such as temperature, relative humidity, and pressure. Similarly, output devices impart electronic signals or physical action to control the devices. Examples include electric relays or damper and valve actuators.

Building Automation Network (BAS LAN) provides the lowest level network structure interconnecting various LAN Controllers for electrical system. All LAN controllers are connected directly on to the BAS LAN. Once configured, controllers operate autonomously with no interaction required from other system. All the control application modules (power failure, auto restart time schedules, optimal start stop, etc) are resident in LAN controller memory for individual operation.

BAS is an important part of the overall Intelligent Building Management System (IBMS) [7]. It not only shows the energy consumed in the building, it also provides monitoring and controlling functions of all the building services within the building. The BAS Workstation is loaded with

Supervisory Control and Data Acquisition (SCADA) software along with the necessary drivers to interface to the controllers for monitoring and control.

3. Virtual building modeling

In architectural design, modeling is a process, either mental or externalized, of translating conceptual ideas into visual forms. Although at its root the idea of modeling has been the same throughout the history, it has taken on many forms of expression. These expressions are mainly the result of technological advances in producing imagery. Design thinking is a collaborative process by which the designer's sensibilities and methods are employed to counterpart people's needs, not only with what is technically feasible and a viable business strategy. In short, design thinking converts need into demand. It's an approach to problem solving, which helps people become more innovative and more creative.

In the past, building modeling has been widely used as a design tool and often for construction as well. This model will be used by new sophisticated tools that will actually be able to use the original modeling information to make decisions about optimization. Ideally, the model will follow through the lifetime of the building, be updated as necessary and serve as a digital document of the building [3].

An intelligent design needs to start with a complete model. This modelling process begins early on with CAD designs that evolve into project renderings. Using new standards such as AEC-XML and GB-XML, this information can readily be shared with heating, ventilating, and air-conditioning (HVAC) and other system models. Three-dimensional modelling and visualization in motion introduce a new dimension to architectural representation.

Building information modelling tools (such as Autodesk Revit, VectorWorks Architect) were developed to integrate design information with the geometry, however, studies indicated that such tools were primarily used by architects as visualization tools ignoring their other functionalities.

In architectural design, modeling is a process, either mental or externalized, of translating conceptual ideas into visual forms. Modeling of an intelligent building will be used not just in design, but will continue into construction and operation.

4. Virtual prototyping

A compact definition of the virtual prototype is the following: A virtual prototype is a computer simulation of a physical product that can be presented, analyzed, and tested from concerned product life-cycle aspects such as design / engineering, manufacturing, service, and recycling as if on a real physical model.

On the bases of the virtual prototype the designers manage to lower costs, reduce risks and enhance experience. The actors - the designers and the clients - cooperate in three key areas of interest: strategy development, solution architecture and program management. Once built, a virtual prototype can be used in the whole product life cycle from preliminary design to cost estimation, manufacturing, and marketing.

The construction and testing of a virtual prototype is called virtual prototyping. Virtual prototyping software not only simulates the way things appear but also the way things work. They enable designers to check for potential design problems, such as difficulty in accessing components and completing assembly sequences. Designers can perform several "what-if" tests prior to the development of the first real prototype.

The use of virtual prototyping optimizes the design performance, increases collaboration, reduces costs and shortens time to production.

Even if buildings have static structures, everything else related to architecture is dynamic. Functions and environmental conditions of buildings dynamically change during building life cycles. The types of such changes as recognized by open building literature include spatial changes, increasing or decreasing floor areas, changing functions and changing needs of different groups of inhabitants.

5. Building design stages

The purpose of the design stage is for the designer to use his knowledge and skills to interpret and shape the clients requirements identified in the design brief, and combine them with all of the issues identified during the analyzing stage. He can then produce an electronically stabilized, visual representation of the scope, arrangement, and proportion, of the project generally, but with only a limited regard for structural considerations.

The drawings that are produced are an advance on the client's line drawings, or wish list. They are of sufficient detail and precision to allow discussion on room dimensions, window placement, boundary clearances, furniture and fixture layouts etc.

These drawings are often more artistic in their presentation and do not seek to resolve any technical issues relating to construction [4].

They are the initial, necessary starting point from which further discussion can take place.

All information collected during the previous stages necessary to appropriately complete this stage should be available prior to commencement. The designer shall not proceed with this stage until authorized by the client.

The design development phase is the most important part of the design process. This stage provides the opportunity to refine the project from the original concept drawings to incorporate the many external factors that may have been realized by the previous stages but overlooked by the clients when preparing their initial lines drawing.

It also gives the client the opportunity to address any aspects of innovation or license that the designer may have incorporated during the design stage. It gives the client the occasion to further refine and individualize the project to suit their exact needs.

Most importantly it allows the client to seek opinions of probable costs from several builders to ensure that the finished project is on target to meet the construction budget. This is often the stage where selective down sizing of areas can take place, having regard for budget and the end use.

It often becomes apparent during this stage that better design solutions may not fully conform to the Standard Building Regulations [5]. This stage allows these types of scenarios to be explored and put before the appropriate authority for a decision prior to incorporation in the final drawings. This minimizes the risk of re-design should an unfavorable decision be handed down by the authority.

For the designer this stage allows him to discuss the various construction methods and options with the client as he moves further towards resolving the structural issues (how it will be built).

Any changes to the shape, arrangement, or materials during this stage may be made using the open building concept.

The open building concept aims to address changeability with individualized characteristics. Open building design aims to involve clients in the building process and to create buildings that have increased flexibility.

Flexibility of the building is designed with the facility to make changes at the various levels of technical composition of a building. For an open building design process an essential phase is the simulation as a means of imitating a real system and predicting its behaviour [6].

Computers have had the ability of simulating most of the aspects of design for a long time, but such applications are not widely used in practice. This is mostly due to the lack of integration between analysis and design tools.

Conventional simulation tools encompass building designers with a large amount of data, often in a format difficult to understand, so the practitioners are not very willing to use conventional simulation tools because of the non-graphical output and uncomfortable interface of such tools.

In conventional building design practices, form generation is followed by performance evaluation. In this “generate and test” model, form generation takes priority over performance evaluation.

The current international effort in building and engineering design is attempting to achieve a higher level of integration between form generation and performance evaluation [7].

Despite the gradual transformation of design techniques, experiencing design in an integrated way is yet only possible with the virtual prototyping approach.

In this paper one propose a non-conventional building design technique using Delphi programming platform. Delphi Object Oriented Programming language allows the programmers to create and manipulate objects.

Delphi, along with C++ and Java, is a fully object oriented language. The principles of object oriented programming are the same in all these languages, though of course the syntax is different.

Once the principles learned, however no matter which language one learns them with, the knowledge is transferred easily to other languages [8]. Basic concepts and data abstraction are the same in C++, Java, and Delphi; it’s just the language syntax that differs.

Virtual prototyping on Delphi platform allows looking at a system as a whole. A building is a perfect example for such system. Virtual prototypes enable several “what-if” scenarios to analyze the results of change. The scene showed in Figure 1, presents a virtual intelligent building.

The virtual building system makes it possible to implement a range of different housing plans and to adapt these plans to correspond at changing housing needs [9]. However, the users (occupants and buyers) did not become involved just after completion; therefore, any design modifications - to meet the needs and demands of future occupants - could not be made in the construction stage [10].

Figure 1. Virtual prototyping for design evaluation in a new building: virtual model with controls to investigate the effects of change in design parameters

Inevitably, traditional ways of thinking and working had to make way for more innovative approaches. One innovative approach is the virtual prototyping. Virtual prototyping offers new characteristics that make it a distinctive and unique world-class experimental R&D infrastructure designed for the evaluation and optimization of new construction components and solutions, systems and services.

The main distinctive feature of the Virtual prototyping is its capacity to create realistic scenarios, its “openness”, to perform experimental research regarding the intelligent buildings [11].

It is important to note the contribution of Virtual prototyping for the activities related to the new product development for buildings.

6. Validation of the models

Validation of simulation models and representations for visualization is an important stage of the design process.

Validation of the model is required for any type of simulation to ensure that the virtual model effectively represents the reality.

Visualization techniques and virtual representations should well respond to the needs of the building design process.

The purpose of the pre-design stage is to provide an opportunity for the designer to gather information from the client that will identify the extent of the work required. It also gives the client the opportunity to assess the design firm’s capabilities, consider the fees proposed and compare the standard of service offered. It also allows both parties to commence communication and dialogue to ensure that both feel comfortable with the other, prior to entering into a formal business arrangement.

Currently, the technical development of a product begins with the numerical analysis and simulation of the product, carried out in a virtual scenario. The prototype building structures - starting from the most basic problems and leading up to more complicated cases - includes numerous scenario of building frames.

The virtual product is then tested in a laboratory in accordance with standardized procedures, and is finally launched on the market.

The strategy for dynamic simulation or animation, using different computation algorithm is an iterative process which continuously inserts and deletes the object, as the objects move in a dynamic environment. The simulation method purely exploits the spatial arrangement of the objects without any other information.

For spatial tests to reduce the number of virtual pairs judicious comparisons, the authors assume that the environment is quite free and the objects move in such a way that the geometric coherence can be preserved.

7. Conclusion

In this paper, a structure intelligent building prototype with innovative technologies is analyzed. The construction of an intelligent building starts with early planning in the design stage.

The paper contains a virtual intelligent building and design example drawn for a future construction and is joined by a large library which covers background analyses and computer subroutines.

The authors consider this analysis a planning technique necessary to ensure the edification of the future buildings. They provide a large range of computer subroutines with reference to the scenario of prototype structures and their components.

The in-depth consideration given to the major design problems associated with virtual prototype structures will reduce the effort and expense involved in future construction.

Prototype building structures will provide very useful guidance for practicing engineers, researchers, designers, technologists, mathematicians, and specialists in computer aided techniques of construction.

Long before construction begins, architects sketch their visions. From casual sketches to intricate architectural drawings, a concept emerges. Next come elevation drawings, section drawings, and detailed plans.

The architectural firm will use CAD software to create complex renderings and 3D views. Each stage of the creative process gives insight into the architect's imagination. Here's a sampling of architectural drawings for a variety of projects, from famous structures to visionary structures that were never built.

The informatics design process serves to planning, designing, and constructing buildings in their totality, taking into account their environment in accordance with the principle of utility and beauty.

This paper purposes and suggests the innovative tools for design the intelligent buildings for avoid the limitations of conventional design methods. The scope of the paper is to facilitate the further studies in the virtual building prototypes. The authors hope that this paper would be useful and attempts to discuss many aspects of the subject with her students.

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