Responsive Architecture: An Integrated Approach for the Future

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Abstract

An integrated approach towards a responsive architecture is presented. This new direction in architecture is based on recent scientific advances and on available technology in materials, telecommunications, electronics and sustainability principles. The integrated responsive architecture is not confined to offices or housing, but may well extend to intelligent neighborhoods and to intelligent cities. The dynamics of these future systems focus on security, comfort and health for the inhabitants.

1 Introduction

Traditionally, the intelligent building has been defined by the latest innovations in heating, ventilation and air conditioning (HVAC) systems, telecommunication technologies, electronics, security, automation and generally building control and management systems. According to Atkin (1988) the Intelligent Building (IB) is a building that “knows” what is happening inside it and immediately outside, a building that “decides” the most efficient way to provide an appropriate environment for its occupants and responds quickly to their requests. There is little doubt that in the future we will be moving towards advanced technology buildings and complexes of buildings in interactive environments that protect the occupants from several hazards (security, environmental pollution), as well as providing them with optimal individualized comfort, thus enhancing the quality of life and productivity and at the same time these buildings will be environmentally friendly.

In the last few years we are witnessing the emergence of “Responsive Architecture”, a result of the scientific and technological evolution in electronics, automation, artificial intelligence and their applications to the intelligent building. This new direction in architecture is based on the design process of the “Interactive Intelligent Building” a building that apart from the “intelligence” of the evolutionary technologies coexists with the inhabitant and is fully customizable and interactive. The present work is part of research done towards a Ph.D. thesis that, apart from the design process, includes algorithms that can be used with control systems and suitable algorithms in an integrated approach towards an intelligent, responsive dwelling.

2 Existing and Evolving New Technologies

The evolution of telecommunications and electronics today has expanded the capabilities of intelligent building systems. The range of services mostly applied in existing buildings have been summarized by Flax (1991) as follows:

- Energy Management
- Temperature Monitoring
- Lighting Control and Reduction
- Access and area locate
- Security
- Fire Safety
Although most of the existing intelligent buildings tend to be office complexes, the responsive architecture scheme includes all types of built environments, such as housing, offices, laboratories, hospitals, etc. Moreover, the before mentioned list is not exhaustive and does not include major dynamic interactions pertaining to an intelligent building. This is because of the ever-increasing speed at which science and technology are currently evolving. Current developments offer more services that can be added to the list such as pollution control, environmental comfort, noise suppression and advanced telecommunications utilizing the vast amount of information provided by the Internet and Local Intra-building Wide Area Networks.

If we explore further, we can distinguish some even more advanced concepts, such as dynamic modifications of the external envelope of the building and of the interior spaces, according to the needs of the occupants, as well as the extended use of new “intelligent” materials that extend the effectiveness of existing control systems. Architectural design has always depended on the materials and the technology available at each time period. Therefore, according to Kroner (1997), the invention of new materials such as concrete and glass, as well as the popularity of the automobile have had a major impact on the architecture of their time. The advanced technology of today could also have the potential of transforming a dynamic built environment with interactive buildings instead of static ones.

3 The Proposed Integrated Scheme

3.1 Integration

Kroner (1997) states that intelligent architecture refers to built forms whose integrated systems are capable of anticipating and responding to phenomena, whether internal or external, that affect the performance of the building and its occupants. Therefore, all the services and systems mentioned should be integrated to one building control system (BCS). This system is handled by a dedicated central workstation that collects data from various sources, processes and in turn outputs the resulting data to the BCS.

As described by Derek (1997), a centralized intelligent building may use sophisticated technology, but cannot respond effectively to the many changes the occupants need during the course of a working day. Decentralized control allows the environment to be managed in zones, but the ultimate refinement is the user intelligent building, where local centers are linked to the central information processes and give the individual some choice.

As shown in Figure 1, the collected data come basically from sensors, which are placed indoor and outdoor of the building, as well as a Wide Area Network (WAN). The sensors communicate their measurements to a data processing application, which includes algorithms that can process each type of data and provide an integrated result that in turn is sent to the BCS for application and transfer it to other building control systems for processing. Finally, the BCS processes the resulting data and distributes it to the interior and exterior control systems for operation. The occupants can also modify the control settings. In this case, the central workstation sets priorities so that the occupants may also have individual control of the whole system.

3.2 Sensors

The data to be processed is mainly collected by sensors. These sensors, shown in Figure 2, are divided into two categories: indoor and outdoor. Each one of the categories collects different types of data, which are distributed, to the central workstation. The processing application contains algorithms to be able to process each and every type. The type of data collected is described in the following paragraphs.

3.3 Indoor Sensors

The indoor sensors are subdivided into two categories providing information, the environmental information and the human presence information sensors. In turn the environmental information
sensors collect data for lighting intensity in a space, monitor the indoor temperature, humidity and fire detection and with air quality monitors give detailed information about the pollution that penetrates the buildings’ envelope. On the other hand the human presence information sensors indicate the presence of humans in the different interior spaces of the building.

3.4 Outdoor Sensors
The outdoor sensors are also subdivided into the before-mentioned categories. However, the environmental information sensors, apart from temperature, humidity, fire detection and pollution information, also collect solar radiation and noise pollution data. The human presence sensors serve the same purpose: to provide human presence information outside the building.

3.5 Telecommunications
Telecommunications play a vital role in modern life and since we live in the information age, the intelligent building should be up-to-date with the current technological trends. Therefore, the central workstation collects data from the Internet and from a Local or even Wide Area Network (LAN or WAN) and outputs the information to the processing application. This information combined with the sensor data, described above, produces the final results that are, in turn, sent to other intelligent buildings, (or part of the building if there is a complex of buildings) in the immediate area for evaluation and processing. This is the concept of the “intelligent neighborhood”, a neighborhood where the buildings exchange information about hazards and comfort issues in their immediate area. Details about the types of data being collected and sent are described below.

3.6 Collected Data
Data can also be collected through the Internet and LANs or even WANs. The Internet can provide the central workstation with information concerning weather forecasts and pollution data, to help evaluation and prediction of hazards for the occupants and the building itself. The above networks provide local types of information to the system such as security, noise and immediate pollution data, which is evaluated and processed by the processing application.

3.7 Sent Data
After the final results for each type of data are produced, they can be sent to other intelligent buildings as stated above for evaluation and processing.

3.8 Control
In the final stage, the BCS collects the resulting data from the processing application and distributes orders to the controllers (Figure 3). There are two types of controllers: Interior and Exterior, which are described below.

3.9 Interior Controllers
Interior controllers control security, energy efficiency and indoor comfort issues. Security controls the data received by the human presence and fire detection information sensors. Energy efficiency is subdivided in: lighting, heating, ventilation, air-conditioning and power prioritization issues. Finally, indoor comfort controls indoor air quality, lighting, temperature and humidity, as well as any other customizable comfort control issues (such as music control).

3.10 Exterior Controllers
Exterior controllers consist of external envelope and security controllers. As before security controls the data received by the human presence and fire detection information sensors, while the external envelope controllers modify the façade dynamics and optics to control solar radiation and noise pollution. In the façade dynamics, the form of the external envelope dynamically changes for
optimal control, while in the façade optics, the colors of the external envelope, whether glass or wall, change. All these controllers are based on existing technology and are available in the international market.

4 Conclusions
This work proposed an integrated approach towards an Intelligent Building of the future. This approach, termed Responsive Architecture by earlier scholars, is based on the need to live and work in a healthier, safer and more sustainable shelter. The integrated approach consists of complex algorithms incorporated in central workstation connected with a variety of Networks including the Internet and WANs. State of the art outdoor and indoor sensors output their measurements, and complex algorithms collect them and control dynamic changes in the interior spaces and the external envelope of the building. The proposed WANs can remit to intelligent neighborhoods and why not, intelligent cities.

References

