# ENERGY EFFICIENCY THROUGH INTELLIGENT MANAGEMENT OF BUILDING EQUIPMENT

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*In this article will be presented a way of how a building can reduce the amount of energy required for heating, cooling and lighting the building, using an intelligent unit. The article will not only present the concept for software and hardware infrastructure but also will present a description the ontology of the intelligent building.*

**Keywords**: Intelligent building, ontology, software.

## 1. Introduction

Energy efficiency represents a top priority for European Union, which adopted 20-20-20 Renewable Energy Directive. The target is to reduce with 20% in greenhouse gas (GHG) emissions by 2020 compared with 1990 levels, and 20% cut in energy consumption through improved energy efficiency by 2020 and a 20% increase in the use of renewable energy by 2020. From 1980 until today world energy consumption increased by 45% and for 2030 is expected to increase by another 70%. Residential and tertiary sector now has the highest final consumption of energy in Romania 37% (the percentage is specific for most EU countries) but also the largest potential savings estimated 41.5%.

To minimize energy consumption were identified main consumers: in both residential and tertiary sectors the biggest consumer is heating unit (57% in residential sector and 52% in tertiary sector) on the second position is domestic heat water in residential sector 25% and 14% for lighting in tertiary sector.

The intelligent unit is able to reduce heating/cooling and lighting losses by at least 30% through precise calculation and intelligent usage of resources.

## 2. Intelligent building concept

There is a short history for the concept of intelligent building. It occurred initially in early 1980s. The definition of intelligent building has been evolving with different emphasis, mainly driven by the development of relevant

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technologies and the changing needs for the built environment. The short history is summarized below:

•1985: intelligent buildings are buildings automatically controlled to function.

•1986 to 1991: intelligent buildings are buildings capable of responding to the changing needs.

•1992 to present: intelligent buildings are buildings with features effectively satisfying the changing needs.

Being a relatively new topic, intelligent building concept is understood differently by each company that wants to launch a finite product. In the classical, current approach, each device (equipment) is managed independently with a minimum set of instructions that does not allow interconnection and creation of complex and effective management structures. Efforts so far have focused more on the user comfort, lighting welcome lights, complex audio-video systems, secure control (video control, secure access, and automatic doors opening and closing). The definition of intelligent building is in a constantly changing and is closely related to advanced technologies in a certain period.

The new concept in this project proposal distinguishes from existing products by focusing on:

- Energy efficiency.
- Remote access (mobile, tablets, pda, web browsers) to intelligent unit of the building.
- Accurate delivery of electrical and thermal energy required for heating / cooling the building.
- Interconnection of a variety of systems for heating/cooling and energy sources when they are exposed to different environmental and operating conditions of the building.
- A intelligent and decision making unit which will learn (cognitive learning) manual actions and anticipate users decisions.

The new concept of intelligent building is taking all to another level and has as a main goal energy efficiency, minimal energy for a needed comfort.

The intelligent concept is using the philosophy of the OSI model (Open Systems Interconnection) and MCV architecture (Mode-View-Controller) to structure the concept hierarchically.

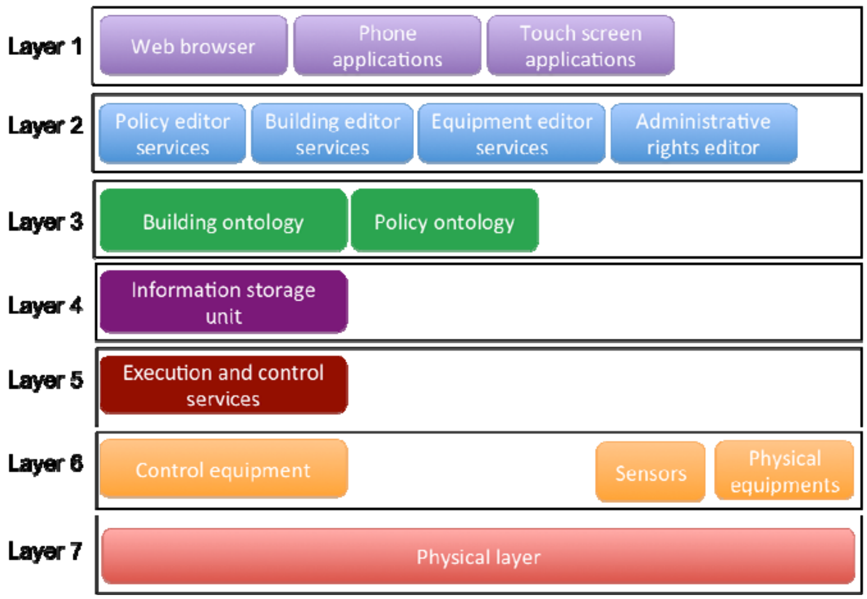


Fig. 1. Hierarchical structure of the intelligent building concept

**Level 1** is designated to interaction with users, an environment where a user can access, view, edit, share, control, and evaluate information related to building management. This level will also provide suggestions to help user to take right decisions for minimal energy consumption. Level 1 will also provide daily reports and monthly consumption (state building and others). The user will be able to access remotely intelligent unit through internet (i.e.: web browsers, phones, PDA's, tablets).

**Level 2** consists of three key services:

- Policy editor services will help users to provide their own operating policies. Policies are structures in: global policies (can be applied to many devices), local policies (applies to individual devices) and temporal policies (which depends on the weather or others events).
- Building services editor will provide 3D graphics editing for construction elements of the building, building orientation towards the North, desired luminance level, building shading, a tool for matching common zones, partitioning the building in zones (Zone = a delimitation of conditioned space in the building). The services will also provide instruments for testing user input information, thus helping him to correct errors.
- Equipment editor services will allow through its services to add, edit and compose complex equipment systems that are specific to a particular building or area of the building. Through this service it will be possible to

add, edit and test equipment and building facilities, sensors and renewable energy sources of the building.

**Level 3.** On this level is located the intelligent unit of the building. Once the user has entered all the information about the building, equipment, devices, sensors, ontology building will be the one that will represent the conceptualization of a world (building world) by describing the concepts, relationships, events which may exist between entities, equipment hierarchy (master-slave setting). Ontology is composed of sophisticated algorithms that allow calculation of energy needs and cognitive learning (learning manual user actions). Ontology building also will manage energy consumption from renewable sources (if they are present).

**Level 4.** Information storage unit will provide a data storage service. Storage system will keep a log of all events, decisions taken by users, equipment incompatibility errors and more. Information storage level will be accessed, for safety reasons, only the top level which will provide information to higher levels.

**Level 5.** Execution and control unit will communicate with physical equipment through a set of instructions. Module located on this level will transmit commands sent by level 3 which will be performed by devices located on level 2. Also level 5 will receive the status, events or other information of equipment, which will be passed to level 3.

**Level 6.** On this level are located the physical equipment related to the concept of intelligent building. Control equipment will store all intelligence architecture described above. Also on this level are located physical devices: Air heating / cooling, lighting installations and renewable energy devices photovoltaic and thermal panels, wind turbines, building sensors (sensors for presence, smoke, $CO2$, CO).

**Level 7.** Physical environment is reserved for communication protocol stacks that allow communication with physical devices. BACnet which is a data communication protocol for building automation and control networks, a set of rules governing the exchange of data over a computer network that covers everything from what kind of cable to use to how to form a particular request or command in a standard way. What makes BACnet special is that the rules relate specifically to the needs of building automation and control (BAC) equipment, i.e., they cover things like how to ask for the value of a temperature, define a fan operating schedule, or send a pump status alarm.

### 3. Hardware and software infrastructure of intelligent building

In a building instrumented and interconnected building owners and people who use it can make better decisions about energy consumption and can lay on decisions taken by the building itself. The concept of intelligent building consists of two distinct components: hardware and software. Software component will command hardware component and hardware component will execute commands and will communicate the current status and events of connected devices.

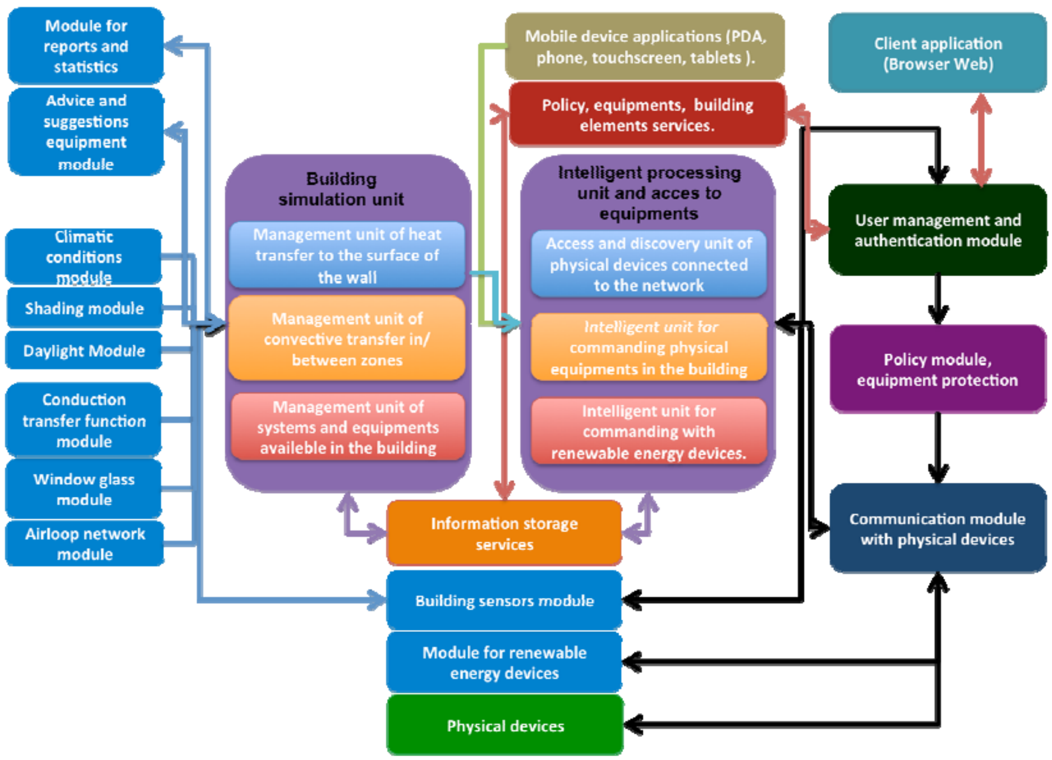


Fig. 2. Modular structure of the intelligent building.

The software entity that represents central intelligence has a modular structure and is able to effectively manage consumption and energy production from renewable sources of the building.

Intelligent system concept of a generic building, shown in Fig. 2, is designed as a bicephalous entity with modular structures. The existing concept will allow extending the structure by integrating new modules related to the security access, video surveillance and others. Its main components are:

**Building simulation unit** will take as input: climate data, internal heat contributions, human presence, lighting, constructive elements of the building, building orientation, location and height above sea level, and others, generating the output data power consumption and thermal utilities for various operating policies specified by users and zones. To optimize dynamic calculation all components described above will have a flag to mark whether has dynamic or static behavior (this will increase the working speed and intelligent processing component). Solutions manager will check for user errors in describing the building or construction elements (i.e.: wall mismatches, gaps in network design for ventilation).

**Window glass module** will calculate all parameters of the glass surface, using two methods:

***Calculation layer by layer***, window layer-by-layer are considered to be composed of the following components, only the first of which, glazing, is required to be present:

*Glazing*, which consists of one or more plane/parallel glass layers.

*Gap*, layers filled with air or another gas that separate glazing layers.

*Frame*, which surrounds the glazing on four sides.

*Divider*, which consists of horizontal and/or vertical elements that divide the glazing into individual lites.

*Shading device*, which is a separate layer, such as drapery, roller shade or blind, on the inside or outside of the glazing, whose purpose is to reduce solar gain, reduce heat loss (movable insulation) or control daylight glare.

***Simple calculation***, reuses the layer-by-layer approach but converts an arbitrary window performance into an equivalent single layer.

**Intelligent processing unit and access to devices** will discover access and control devices that are part of the intelligent network. One of the tasks of this unit will be to achieve a precise synchronization between the minimum consumption of energy for heating/cooling, lighting and electrical and thermal energy production from renewable sources, for a desired user comfort. The surplus energy generated will be delivered to the national grid of electricity. Intelligence unit will be the one who will know how to program their resources in a way to generate maximum efficiency, reducing energy consumption. Intelligent unit learns user behavior through decisions which it takes and try to anticipate the future desires.

**User management and authentication modules.** This module will help to edit users' rights (read, write, execute), access to various components, modules of intelligent unit, access to policy-editor. The module will use also use grouping rights and individual profiles; this will allow a strict control of user access to the intelligent unit.

## 4. Conclusions

The present article doesn't propose to solve all issues related to the concept of intelligent building, rather an opportunity to create the skeleton of an infrastructure composed of hardware and software infrastructure and also an explanation of how these two entities can be organized. The current trend is to migrate to web applications, create web services and all this because in the future operating systems will be composed only of services. The current solution described in this article takes into account the current trend and creates a service-oriented architecture specifically designed to communicate with users using only web services. The hardest part to manage remains cognitive intelligence of the building. For a building where is just one source of heating/cooling unit is easy to determine but if we consider an airport or a hospital with multiple heating/cooling units randomly distributed can appear complications because the calculation method must have a low input parameters and must determine heating/cooling requirement very quickly. Nevertheless software oriented architecture is a learning system, constructed in a way that intelligent building will be capable in the future to make a choice based on decisions made in the past.

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