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Domotics Project Housing Block

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Abstract: This document develops the study of an implementation project of a home automation system in a housing placed in the town of Galapagar, in Madrid. This house, which is going to be occupied by a four members family, consist of 67 constructed square meters distributed in lounge, kitchen, three bedrooms, bath, bathroom and terrace, being this a common arrangement in Spain. So, this study will allow extracting conclusions about the adequacy of the home automation in a wide percentage of housings in Spain. Along this document a home automation proposal where develop based on the requirements of the client and the different home automation levels that the Spanish House an Building Automation Association has established, besides two parallel proposals relating to the safety and the technical alarms. The mentioned proposed systems are described by means of product datasheets and descriptions, distribution plans, measurements, budgets and flow charts that describe the functioning of the system in every case. An evaluation of each system is included, based on other studies conclusions on this matter, where it is evaluated the energetic saving that is expected from each one and, depending on the nowadays cost of light, water and gas, the expected economic amortization.

Keywords: home automation; energy-saving; digital home

1. Introduction

Usually, in building sector, it is forgotten that the right functioning of a building does not only and exclusively depend on its distribution, constructive features or facilities. Actually, the most important factor is the way the building is used.

In this field, home automation plays a vital role, getting the most of its facilities and constructive features. Home automation concept include all systems which are able to automatize the management of all or part of the building facilities by means of energy management, security, comfort or communication devices. Thus, the tasks required for a right building maintenance and functioning cease to be an only human being's responsibility to become machine's responsibility, increasing comfort and security levels and affecting building's energy efficiency, energy bills and CO_2 emissions.

One of the cornerstones in which more efforts are being carried out, is energy efficiency. By means of automatic systems which regulate energy devices, or even transform passive systems into active ones (blinds, awnings, grilles), demand can be controlled adapting it to use [1], and, in some case studies, it has been achieved to reduce consumption peaks until 46% [2]. The inclusion of more and better sensors improves the ability of a system to adapt to the environment and promote the requirements for keeping desired conditions using a minimum of energy for that performance. Examples might include the inclusion of rain, solar radiation (direct or diffuse), humidity or wind sensors among others. Furthermore, it is being developed home automation devices which are able to gather information via internet [3] by means of public APIs (Application Programming Interface) of meteorological forecast, anticipating the changes and improving the system response. This trend is not limited to housing, but is applicable to secondary and particularly to tertiary sector buildings. Greenhouses are a good example, there climatic conditions control is essential for the installation's function and automatic devices are proving to be very useful [4].

There are many manufacturers who have contributed to home automation advance, but there are two main technologies, LonWorks, who predominates in the American continent, and KNX, in the European one. In this paper, a home automation system implementation is evaluated. This system has been installed in a dwelling situated in Galapagar (Spain) and it is based on KNX technology [5] and UNE-CLC/TR 50491-6-3:2013 IN standard.

2. Design Home Automation

We have designed and installed a home automation in a flat located in Galapagar (Spain). This flat has a north orientation and consists of 66 m^2 usable space over a 79 m^2 constructed area, distributed in several rooms: a living room-kitchen-hall (26.80 m^2), a master bedroom (12.29 m^2), two additional bedrooms (10.24 and 8.34 m^2), a bathroom (3.72 m^2), a toilet (1.61 m^2), one corridor (3.40 m^2) and a terrace (12.24 m^2).

2.1. General Features of the Home Automation System

- Physical level: in this case, it was chosen TP1 wiring type for data transmission due to our simple and small flat. Wiring choice instead a wireless solution, which is nowadays a rising technology, is because this flat was to be integrally rehabilitated. This fact makes that the added costs of wiring were not so high.
- Topology: we have chosen a data bus which is divided in lines and areas joined by line-couplers (LC) and backbone/area couplers. Each line can host 64 devices and each area can be formed for up to 15 lines. Each line is powered by a 24Vdc power supply and each one supports 640 mA with a cushioning time of 100 ms

- Network design: each device in this system consists of a microcontroller with memory. This way, we have achieved a distributed architecture in which one device failure do not affect the whole system functioning. Furthermore, it facilitates possible future expansions of the system. Each device is individually programmed.
- Protocol: this system is based on KNX standard because it is an already-tested system and because of its reliability and compatibility with so many products of different manufacturers. The information is symmetrically sent by both conductors as an alternating signal superimposed on a 24 Vdc current.
- Devices: each device consists of three elements: bus coupler, which is composed of three memory chips (EEPROM, ROM and RAM), an external-physical interface and an application module.

2.2. Common Elements

Regardless the home automation level, there are some elements which are common and they are implemented in all system levels. The first one is the power supply, it is necessary to generate the needed voltage in each line. Power supplies we have chosen are suitable with uninterruptible supply systems (UPS) in order to meet the line needs.

To control our system we have used a control panel. It consists of a touchscreen with which the user can interact. It is fed from the 230V mains, it allows for updating it via USB and it has password protection and remote-LAN programming. Furthermore, it includes the needed coupler for its integration in the system.

A KNX-IP gateway is necessary for provide external communication to the intermediate and advanced level, which allowed for accessing to the bus remotely. By this access, we have been able to carry out the programming of the system through a VPN configuration. System maintenance and diagnosis during the full operation of it, and device's management, have been carrying out by means of InSideControl® software. For line – main line connection or for the union of new areas to prior areas we have installed line couplers. This device allows us to set up, according to some parameters, its behaviour as a coupler or booster, which eases us the effective range expansion of the bus.

3. Basic Home Automation System

The system permits an automatic and efficient control over the lighting and climatic subsystem by means of several types of sensor and actuators which are summed up in table 1.

For the purpose of offering the user the possibility of managing the room's temperature it has been installed, next to each bed, a thermostat. With it, the user can control the environment basing on four stages, two hot/cold stages and two other auxiliary. In the event of voltage loss, the program saves itself and recovers automatically.

In addition, we have installed a split control interface to establish a link between KNX system and air conditioners. It enables a user's control over devices by means of thermostats, avoiding remote control use. Lastly, general features of our basic-level system are exposed in table 2.

Table 1. Installed Sensors and actuators overview

Device type	Number	Selection	Consumption (mA)	Comments
Opening actuator	8	1 / window 1 / Airflow door	---	It requires KNX interface
Presence sensor	7	1 / room	56	Installation at 2,20 m high
Motion sensor	4	1 / passing zone	16	It includes bus coupler and connection terminal
Temperature sensor	6	1 / room	---	---
Actuator for luminaires	12	It depends on the luminaires number	75	Binary input to dry contacts connection or conventional push button
Heating electrovalve	6	1 / room	5.2	---
Split control interface	4	1 / split	---	Bidirectional KNX gateway-Air conditioner

Table 2. General features of basic home automation system.

Number of devices connected to the bus	48	Lines (metres of wire)	1 (101)
Combined consumption (mA)	168.20	Power Supply	1x320 mA
Line couplers	0 (Only one line)	External communication	No
Control device	Control panel	UPS	No
UPS battery	---	Energy Self-sufficiency	---

Because the number of devices is less than 64, it is possible to use one only line, however the user will be limited if he will want to make enhancements. Due to this, we have installed lines in accordance with advanced system requirements. Our components (sensors, actuators, etc.) and line distribution all over the flat is reflected in Figure 1.

3.1. Technical Alarms Subsystem

This subsystem is attachable to any home automation system we are describing in this paper and it has the function of informing the user about possible disasters that may emerge like fire, gas leaks or inundations. The installation of this subsystem implies that an additional line has to be added with its own area configuration, a power supply and an additional line coupler. Needed sensors and actuators for this system could be observed in Table 3.

3.2. Security Subsystem

This subsystem is attachable, as the previous one [3.1], to any of the main home automation systems. Its function is to detect intrusions and mistakes that could result in them. It has external and direct communication with the user and it can be installed as an independent system. So, for get this service, it has been installed five opening sensors, five break sensors (one by each door or external window) and five presence detectors (one by each room).

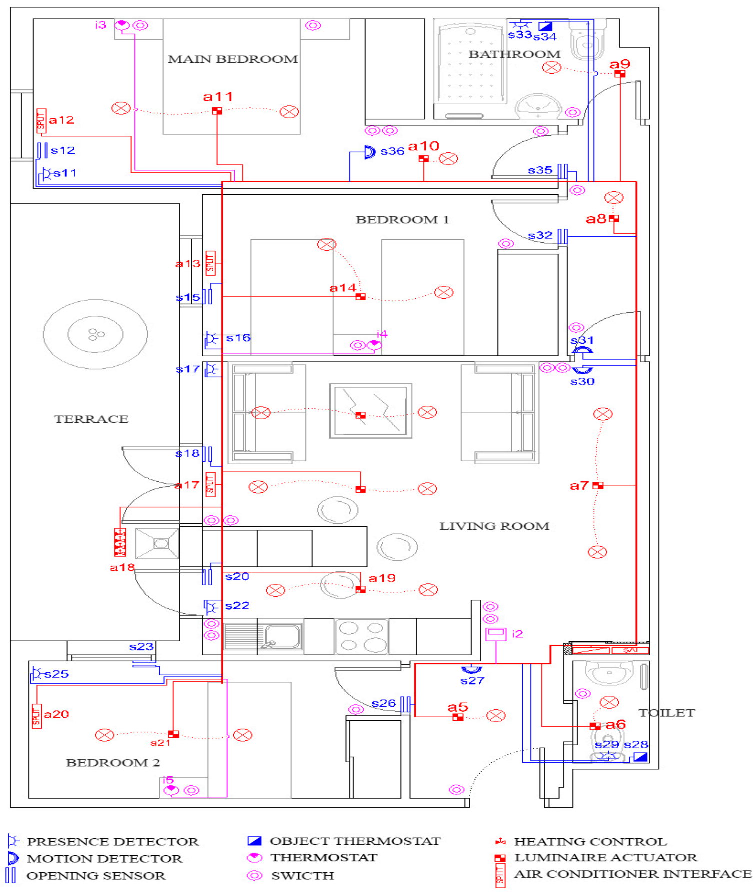

Figure 1. Components distribution for basic home automation system.

Table 3. Installed Sensors and actuators overview.

Device type	Number	Selection	Consumption(mA)	Comments
Flood detector	1 / 3	1 Central device / 1 Sensor by wet area	65	---
Optical smoke detector	6	1/ Bedroom , 1 over each sofa and 1 in the kitchen	2	---
Methane gas detector	1	1 next to the boiler	132	---
Binary electrovalve for water driving	3	1 / Wet area	6	Power supply from the mains. It requires KNX interface
Binary electrovalve for gas driving	1	1 in the boiler	2	It requires KNX interface

4. Results

After we installed the home automation system, several surveys about its energetic, economic and environmental impact have been done based on the four people who leave in this flat. These surveys results showed that our system achieves energy savings of 19.88% on lighting and 16.09% on air conditioning per year, as can be seen in table 4.

Table 4. Summary of energy and economic savings.

<table>
<tr><th></th><th>Characteristics</th><th colspan="2">Saving (kWh/month)</th><th colspan="2">Energy saving (%/year)</th><th>Saving (€/año)</th></tr>
<tr><td>Lighting (kWh)</td><td>-Regulating by presence
-Regulating for luminosity</td><td colspan="2">6.80</td><td colspan="2">19.88</td><td>10.44</td></tr>
<tr><td colspan="2"></td><td>Heating</td><td>Air conditioner</td><td>Heating</td><td>Air conditioner</td><td></td></tr>
<tr><td>Air conditioning (kWh)</td><td>-Regulating by presence
-Hourly programming</td><td>147.02</td><td>64.58</td><td>17.82</td><td>14.35</td><td>289.56</td></tr>
</table>

In the same way, we show in table 5 reduction of CO_2 emissions of 76.03 Kg/year obtained with the domotics proposed.

Table 5. Summary of savings in CO_2 emissions.

	Conversion factor (gr CO_2/kWh)	**Energy saving (kWh)**	**Decreased emission CO_2 (kg)**
Electricity	645	71.38	46.04
Gas	204	147.02	29.99

Apart from measurable factors, there are other not-measurable benefits that the user consider when implementing home automation systems. These are the acquired comfort and security feeling because of the security and technical alarms systems.

5. Conclusions

The implemented system in this dwelling offers a great number of objective advantages having as its mainstay the energy savings which also leads to economic savings and to a reduction of CO_2 emissions, which is, nowadays, so valuable. It is also important to value positively the increase in comfort and security that this system provides to the user.

On the other hand, the 20-years amortisation is insufficient to conclude that the system is economically viable. This fact becomes a pending task that we will have to improve in the future to enter individual user market.

Acknowledgments

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Conflicts of Interest

The authors declare no conflict of interest.

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