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ELECTROTECHNICS, ELECTRONICS, AUTOMATIC CONTROL, INFORMATICS

CLIMATIC SYSTEM FOR A SMART HOUSE

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Abstract: This paper presents a didactic implementation of a climatic system for a smart house, designed according to the principles of the Internet of Things (IoT). In this smart home, certain devices are connected to the internet and are able to transmit environmental data obtained by means of the attached sensors. Remote users are allowed to view and analyze this data by accessing a web server, and also they can activate actuators to control - for example - the lighting and ventilation systems.

Keywords: Smart house, Internet of things, Ventilation system control, Home automation, Artificial intelligence, Raspberry PI, FRDM.

1. INTRODUCTION

The concept of "smart home" (Harper, 2006) was developped in the larger context of "ambient assisted living" - an environment capable to support the independent life of the elderly or disabled people (Demiris et al., 2004). Other features of smart homes have been described in the context of the research regarding a better energy management in buildings (Han et al., 2014).

In parallel, advances in the technologies for communication have made possible the development of the concept of Internet of Things - IoT (Ashton, 2009). The term IoT was coined by Kevin Ashton (2009), cofounder and executive director at Auto-Id Center, MIT, and refers to all the devices that are connected to each other, and can be monitored an controlled through the internet.

The IoT provides the means to connect "things" far beyond the boundaries of the "smart homes".

For example, by integrating certain medical devices in the IoT it is possible to create systems for surveillance and monitoring of certain diseases, or can alert about the occurrence of epidemics. On the other hand, some hospitals have implemented "smart beds" that can detect if someone is in bed or not, if a man wants to sit down or sit up they can offer assistance and they can offer high comfort by adjusting theirs characteristics. In some rooms there can be special sensors that can determine if the environment presents health risks , e.g. sensors that warn about the presence of toxic substances in the air, or wearable sensors to monitor certain physiologic parameters.

Fig.1. A smart home as illustration of the Internet of things

The concept of IoT is also present in transportation systems, where a network of infrastructure sensors, vehicle processing and communication devices is able to assist the drivers, recommend the best routes to save time and fuel consumption.

Initially, the devices connected to a network were limited to electronics from people homes and here we include phones, tablets, computers, modern web cams and even the house itself, (Datta et al., 2014), (Elkhodr et al., 2015). However, the rapid development of new communication technologies, pervasive computing devices, and AI applications creates the premises for a single huge network that connects people and "things" at a planetary scale (Lin et al., 2017).

This paper presents a didactic implementation of a climatic system for a smart house, designed according to the principles of the Internet of Things (IoT). A Raspberry Pi 3 module, provides the hardware support for collecting data from a couple of sensors, and the communication platform to deliver this data to a web server through the Internet. Remote users are allowed to view and analyze data by accessing the web server, and also they can activate actuators to control - for example - the lighting and ventilation systems.

2. IOT CONNECTION TOPOLOGIES

The most important element that transforms a common thing in a node of the IoT is the network connectivity. When designing a local network, we must first choose the topology that we want to build. There are two main topologies: star topology and mesh topology.

In the star topology, all the elements are connected to a central node. Specific to this topology is that large data blocks can be transferred, it has high interconnection speed and fast response time, (Tseng et al., 2014). However it depends of that we use: for example Bluetooth, used as central node, has the disadvantage that it can support a limited number of nodes. Another general disadvantage is represented by the costs that are pretty high.

In the mesh topology, as the name suggests, all the nodes are connected with each other, and only a subset of them may have the role of central nodes. The speed of data transfer from one node to another is relatively low because, usually, the distance from one node to another is large and the overall complexity is higher than in the star topology. Among the advantages of the mesh topology, we count its capability to provide multiple routes between any two nodes.

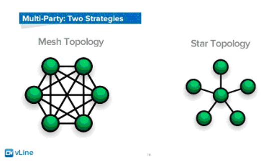

Fig.2. Main network topologies

3. TARGET FUNCTIONALITIES OF THE EXPERIMENTAL SETUP

Retrieving and transmitting data: is realized with the help of two sensors: one for the temperature and the other for motion. Data received from the temperature sensor will be analysed and will be used further to implement and send commands. Second, data from the motion sensor will be used just to send commands.

- Viewing the data: a part of those data will be available to be viewed through a web server, being displayed on a web page together with a set of buttons for the control of the elements presented in the layout.

- Data analysis and transmission of commands, (Tseng et al., 2014): in order to send the commands, there is a data analysis, both at the software level and at the human level. The soft will analyse the temperature and depending on its values, will determine the air conditioner functionalities. In the same time, the owner can see on the web page if the lights are turned on/off. The user can turn them on/off.

A group of sensors can be used to monitor and control various electric systems, electronics and mechanics from the building, (Ursaru et al., 2009). From these, we notice that in all such developments, the following aspects are considered:

- Integration of a system to use the energy in a smarter way to reduce the costs;

- Real time monitoring of the tenants presence to reduce the consumption of energy;

- Integration of smart devices in the environment and the way that they can be used in other applications;

4. HARDWARE AND SOFTWARE RESOURCES

The hardware resources used are: a RaspberryPi 3 module, The Freedom FRDM-KL25Z platform for Kinetis KL25 MCUs, a passive infrared (PIR) motion detector, a temperature sensor DS17B20, LEDs, Actuator, Connection elements (wires, USB cables, power cable).

Software resources: Debian operating system for the Raspberry PI, the ARM software development platform, C compiler www.mbed.org , used to realize the program that need to be loaded on FRDM, Phyton, HTML, PHP used to realize the web server and the functions needed for the data transfers.

The system also supports an actuator for controlling a ventilation device. The actuator may run in one of three possible levels of speed: from a relatively low power to a higher level, depending of the room temperature. It also can be directly controlled by a human operator via the Internet.

The actuators will operate in three modes:

- Automatic mode – this mode is activated at the user choice and turns on the ventilation only if the temperature exceeds 23 degrees Celsius. If at the start time, the temperature is high above, the ventilation will be more intense as it follows: between 23 and 27 degrees Celsius, the ventilation will be done at speed 1; between 27 and 30 degrees it will be done at speed 2, and above 30 degrees it will be done using speed 3. In this mode of operation we are using only the data provided by one of sensors, the temperature sensor.

- Eco mode – assumes that the ventilation process is produced only if it detects motion. Saving energy reduces costs and in the same time helps to save the planet. To produce electricity other resources are consumed. We haven’t reached yet the point where all the energy used at a global scale to be green energy, therefore it only makes good to have an economic sense from this point of view.

- Manual mode – The 3rd mode, was included to let the consumer chose the way in which the ventilation works. It is obvious that a user may want to use the second speed of ventilation even though there are only 23 degrees in house. The web server will have buttons that will help to select one of the three operating modes, but also it will have buttons to turn on/turn off the lights. In the same time, it will have a section to monitor the collected data, so the user being able to find out the temperature values and also to turn on/turn off the air conditioning and the lights.

RaspberryPi3 Model B: It isn’t just a development board but it is much more than that. RPI is a miniature computer, but it has an extraordinary power and great capabilities. It’s properties makes versatile, suitable for various applications, from home entertainment to automation and robotics applications.

The hardware resources of the Raspberry Pi micocomputer are as follows (see figure 3): 1GB RAM, 4 USB ports, 40 GPIO pins, Full HDMI port, Ethernet port, Combined 3.5mm audio jack and composite video, Camera interface (CSI), Display interface (DSI), Micro SD card slot, VideoCore IV 3d graphics core, 802.11n Wireless LAN, Bluetooth 4.1, Bluetooth Low Energy (BLE).

DS18B20 temperature sensor: DS18B20 is a digital temperature sensor which, as the name suggests, takes over data about temperature from the environment. It can measure temperatures between -55 and +125 degree Celsius, with +/-0.5 degree error. It contains a 12 bit ADC with 750ms conversion time, which is satisfactory for this particular application.

PIR Motion Sensor: A Passive InfraRed sensor is an electronic device that senses gradients of infrared radiation emitted by objects within its sensing range in order to detect motion. They are called “passive” as a reference to the fact that this sensor doesn’t emit any kind of energy to detect motion, it relies on sensing the energy emitted by other objects

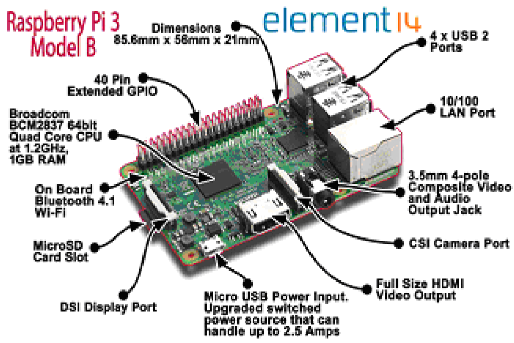

Fig.3. The resources of Raspberry Pi 3

Software resources: The Raspberry Pi module is provided with the Debian Operating System, based on Linux, which offers the means (PHP, Python, Apache) to implement the web server and the remote user interface.

On this mini-computer a web page server is created using the HTML, CSS, and PHP technologies.

The Python function executed by the Raspberry Pi, opens a port to FRDM, sends the ASCII '0' character, which selects the first mode of operation.

At the main level, firstly it is checked the value stored in “mod” variable after the receiving of data. Depending on this, the operation mode is selected, in this case, it is automatic mode which means that if temperatures exceeds 23 degrees but is below 30, the actuator will be triggered through pwm, with speed 1; if the temperature is between 27 and 30 degrees, the speed will increase and, lastly, the speed will reach its maximum if the temperature will be between 30 and 38 degrees.

In the same time, when the “ON” button from the user interface is activated, the “a” character will be sent – this will determine the lights to turn on, and if the “OFF” button is triggered, the “I” character will be transmitted and the lights will turn off.

5. APPLICATION TESTING AND EXPERIMENTAL RESULTS

At the software level, the application is relatively simple, mainly because it makes use of the extensive libraries offered by the embedded ARM platform, which greatly ease the task. For example, the DS1820.h library for the Dallas temperature sensor offers specific functions for initialization, temperature conversion and reading.

As soon as the Raspberry Pi is powered on, the system is initialised and the climatic system prototype starts in the automatic mode.

The experimental setup, with the Raspberry Pi module is shown in figure 4.

Figure 5 shows how the temperature data is presented. When the system is initialised, there will be no information about temperature displayed on the web page.

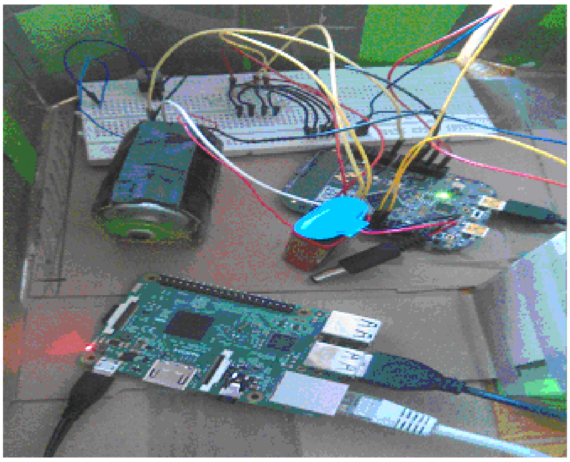

Fig.4. Experimental setup with Raspberry Pi

However, after pressing the "Temperatura" button, visible in fig. 5, the temperature will be displayed in the format shown in figure 6.

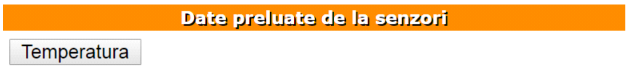

Fig.5. Temperature acquisition box with no data

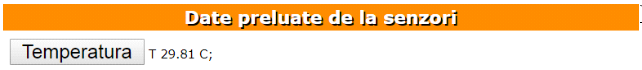

Fig.6. Temperature acquisition box when data is available

6. CONCLUSIONS AND FURTHER DEVELOPMENTS

The Smart House Model described here, (see also Tseng et al., 2014) is aimed to illustrate the concept of Internet of Things for didactic use, by creating a network of sensors and actuators connected to the Internet. The software application allows remote monitoring and control of two sensors, one actuator, and four LEDs. Remote users can view sensor data, and control the actuator and the LEDs by accessing a web server through the Internet.

We plan to extend the model by adding the following features/devices:

- A video camera to periodically transmit images of the premises;

- Additional sensors for intruder detection;

- Improved control of the climatic system, including an interface with standard heating, ventilation and air conditioning systems (HVAC)

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