

SMART HOME PROTOTYPE REMOTELY CONTROLLED THROUGH INTERNET

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Abstract: The project aims to implement and use of an autonomous smart home prototype system, to remotely monitor the important parameters like temperature, atmospheric pressure, gas leaks, or burglary.

Keywords: Smart home, Raspberry PI, Arduino 2560, Arduino Software IDE, Internet of things, Lighting system control, Home automation.

1. INTRODUCTION

In general, a house is the place where people carry out the most important activities of daily life, that's why any house should be a safe and pleasant place. The most important aspects of a house are: security, safety, comfort and control.

Modern technology has evolved significantly in the last years and became more and more advanced in all fields, we can even affirm that that the technology is indispensable for some of us. From computer that were as big as a room we got to notebooks, tablets and smartphones that we take everywhere and last but not least to smart houses.

For some time it is talked more and more about smart houses and the way in which they can considerably change our life. The concept of the smart house started from the comfort simplification and improvement ideas.

A smart house differs from a typical house by the fact that it is controlled by a central processing unit that monitors the main aspects of a daily life: light and temperature adjustment, turning on the alarm system, doors and windows opening/closing and many others.

The functionality of installations is integrated in one system and can be remotely controlled through an easy to use graphic interface, using devices like personal computer, smartphone or tablet which have an internet connection and a web browser.

Security is an aspect that should not be neglected especially if we want things in our house to be safe when we are gone for a long period of time. For this, the installation of a simple movement sensor can alert us if someone gets in our home by displaying a message on a web page.

Safety is also very important when it comes to our house, for example to detect a gas leak or fire a sensor can be installed and an alarm will turn on when the sensor detects critical levels of gas or smoke.

The comfort and control of a house can be improved through a simple system, made from a temperature and pressure sensor and a web page. The data received from the sensor will be displayed on the web page and, based on their values, a button from the interface can be used for turning on or off the heating system, which will also minimize the consumption of thermal energy.

An autonomous system is made using different sensors and actuators that can be accessed through a web page from the internet. The paper will highlight the main aspects of the Smart Home concept. The purpose of the chosen theme is the automated control of a house with the possibility to control from distance the devices within and possibility to set basic rules for their functionality, creating a high degree of comfort, ease of use, security and power saving.

Intelligent home classifications:

- Homes with smart devices: houses with devices and systems that can run in a smart way.
- Homes with smart devices able to communicate: devices from this home are interconnected in a network and can communicate between them and with the user, creating an interactive space.
- Connected homes: those homes own systems that allow the owners to have control of the home, even when they are gone.
- Learning homes: those homes manage themselves in an automated way based on the owners behaviour; data is recorded and is used to anticipate the owners needs and the technology is controlled accordingly.
- Careful houses: houses capable of recording the user's position and objects handled, information being used to control the technology implemented in order to anticipate future needs.

In the last years, the concept of Smart Home became popular, bringing with it many companies that realize systems for it, like: Nest, Luxome, Orange. Those companies released some products on the market that can make our life much comfortable, as:

Z-wave technology: Z-wave technology is a completely new approach in the field of housing automation and is the most optimal solution on the market



Fig. 1. Z-wave technology

Each Z-wave devices from the network can receive or send commands, can monitor or control the functionality of home devices, everything being connected at a central processing unit. Unlike the wireless technology, where the signal is permanent, Z-wave communicate with interrupted radio waves, sending and receiving signals only when it is needed

or when a command is transmitted. Therefore, the risk for the human body is significantly reduced, life of appliance from the house is prolonged and the energy consumption is much lower. Z-wave can improve the comfort, it can create wake up or home-returning scenarios personalized for the needs of every person, for example, the coffee is made when we wake up, and windows and lights are opening, when we leave the house, the alarm sets on, the power from sockets can be turned off in a certain room when we are at work, and many others.

This technology is becoming more popular, in present being used by approximately 250 companies from the entire world.

Orange Smart Home: created by the people who wanted a safer, lower energy consumption and more comfortable living.



Fig. 2. Orange Smart Home

With the help of the application, connecting phone, tablet or PC with the central device from which the user can control the entire home by programming the devices for different actions and scenarios, which will send notifications in the moment they activate. The Orange Smart Home packet can be personalized with the desired sensors, depending of customer's home needs.

iRobot Roomba 980: Roomba 980 is one of the most advanced cleaning devices created by iRobot. iRobot Roomba 980 is one of the most modern and advanced vacuum cleaner robot from the world; it is smart, easy to use, independent, having the capability of charging itself when it is needed, it doesn't fall of stairs, it passes any obstacle which isn't higher than 1.60 cm, it cleans without stopping a surface long enough to 185 square meters with a single charge.



Fig. 3. iRobot Roomba 980

This device can be accessed from anywhere with the help of one application on the mobile phone or tablet, in this way the vacuum cleaner can be turned on anytime it is desired or can be programmed to be powered on a certain date and hour.

2. APPLICATION DESCRIPTION

In this paper, the authors present the implementation of an autonomous system, in order to monitor, from distance, the important parameters from a smart home like: temperature, atmospheric pressure, gas leaks or burglary.

The system is composed by different sensors and actuators. Data received from the sensors will be send and displayed remotely on a device that has a web browser and is connected to the internet (PC, tablet, laptop, smartPhone, iPhone etc). The data received from home devices will be send to a server where will be processed. If an emergency situation will be discovered, the user will be directly announced through the web page, displaying a message or by an alarm sound.

In this paper are presented the highlights particularities of the Smart Home concept, like:

- detection of emergency situations: gas leaks;
- comfort: lights control;
- safety: possibility to detect burglaries;
- information: being connected to a computer, the system can allow the user instant access to data regarding the atmospheric conditions in each room, movement detection. It also can control from distance some of the devices in a comfortable way, with a click.

The system is composed by two main units connected each other through a USB bus.

The first unit is represented by the RaspberryPI 2 Model b+ mini computer that has Raspbian operating system installed and will have the role of a local NodeJS WebServer which will host the web page (on this page the main data received from sensors will be displayed) and will announce the user if an emergency situation happens. Also, in this unit, a webcam will be installed to track if a burglary happens.

The second unit is represented by Arduino Mega 2560 development board which has attached the sensors, actuators and the lighting system. The board is easy to use and as integrated development environment it provides the open source Arduino Software(IDE), which can be installed on a computer offering the possibility to write code in C/C++; in this way we can program the functionality of the components connected to the development board.

The components used are a simple ones and easy to implement because there is a varied understand documentation, their prices being quite affordable which leads to an important advantage.

Expected characteristics from the application:

The objective of this paper is to present the implementation of Smart Home particularities like comfort, security, information and emergency situation detection.

The application will have the following characteristics:

- house safety by activation of an alarm when a high gas concentration is detected;
- intrusion detection;
- house comfort through possibility of lights control using the graphical interface;
- informing residents about house conditions;
- low cost of the used components;

The structure of the system described in this paper is shown in the following figure:

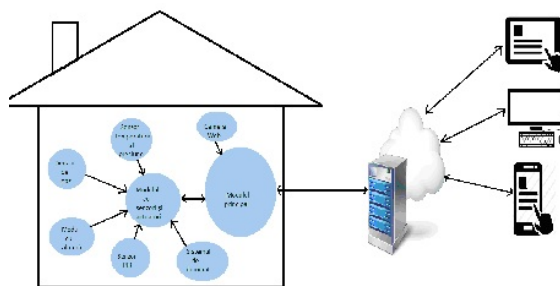


Fig. 4. Smart House Description

The main components of this intelligent housing system are the following:

- computer or phone devices with internet connection and web browser which allows the user to access the graphical interface;
- server, which will host the web page for remotely access;
- many interconnected modules – sensors, to get data about the house;

The main module of the application is represented by the development board Raspberry PI 2 model B+ which has the web server. The other components are connected to this one and can send information to the server only via the board, which makes it a gateway.

3. HARDWARE PLATFORM ANALYSIS

To implement this system, boards with microcontrollers from different manufacturers have been used. For their choice, there was taken into

account certain features that the boards needed to have, to facilitate the project.

Among these features we include:

- the performance of the microcontroller of which board;
- ease of use;
- extensive documentation to help understanding the way it works;
- resistance, reliability;
- wide range of peripherals that can be used with the boards(ex: ports, connectors, buttons, etc);

Therefore we chose as development boards, Arduino Mega 2560 and Raspberry PI2 model B+.

Arduino mega 2560 has an ATmega2560 microcontroller that works on 8 bits. Arduino offers a large collection of software and, also, has an accessible IDE, open-source based. The high number of digital pins, together with a large memory, makes this board an ideal one to carry out demanding applications.

The second development board is Raspberry PI model B+. It was used because of the accessible price, easy to use Linux base applications. Since the board has low energy consumption, there are a multitude of examples and a varied documentation.

Another reason for this choice is the ease connectivity, the connection of modules are being realized through USB bus with serial communication.

As previously stated, two development boards and many types of sensors and actuators were used to realize this project. These components communicate with each other through different types of connections: wires will be used to connect sensors and actuators with Arduino Mega. The connection between Arduino and Raspberry PI will be made through USB bus.

4. MAIN MODULE - GATEWAY

This module is represented by the Raspberry PI board. It is considered main module because only with its help, the link between components that receive data and the web server is made. At this main module, a USB WiPi module is connected which makes possible the connection of Raspberry PI board to a local internet connection; in this case it will connect to a smartphone with the function of a wireless router - this method being preferred for simplicity.

The main module, Raspberry PI Model B+, has the following technical specifications:

- 1.8A – 5V supply voltage;
- 512MB RAM memory;

- ARM Cortex-A7 900 MHZ quad-core CPU;
- 4 USB ports;
- 40 GPIO pins;
- HDMI port;
- Ethernet port;
- Camera serial interface (CSI);
- Display serial interface (DSI);
- SD card slot;

Wipi Dongle is a high performance WLAN module which use the latest wireless technology 802.11n. It connects the Raspberry PI to a local wireless network.

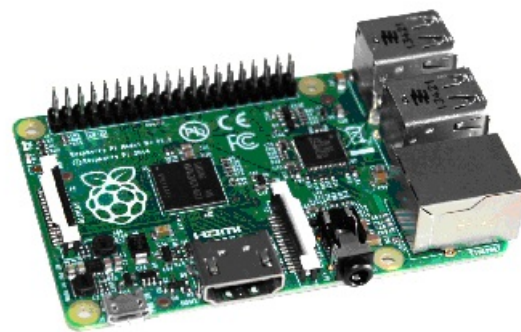


Fig. 5. Wipi Dongle

The module with sensors and actuators is made up of the Arduino 2560 development board at which will be connected some sensors and actuators, the lighting system and the alarm. This module has the role to collect data from room, temperature, pressure, gas concentration and intrusion detection. Those information will be sent to the main module, which hosts the server and process the data, different decisions being made depending on the parameters. For example, if a person is detected then the lights will turn on, or if the gas concentration is high, an alarm will be activated to notify the tenants about a possible danger.

The following components are used:

Arduino development board: Arduino Mega2560 development board is perfect for high scale, creative projects that need many analog and PWM communication pins. This board includes ATmega2560 microcontroller and CH340 serial USB convertor, also it offers SPI, UART, TWI communication.

Temperature and pressure measurement: to measure temperature and pressure from the house, the BMP180 temperature and pressure sensor was used. Main characteristics of this sensor are:

- 1.8 – 3.6V supply voltage;
- 5uA current (1 sample/sec);
- it measures pressure between 300-100 hPa;
- 12C interface;
- 14mm x 12mm dimensions;

Gas leak detection: MQ-2 sensor module was used to monitor the concentration of different types of gas from the house. This module has the following characteristics:

- 5V power supply;
- 150mA current;
- 33R heater resistance;
- work temperature: -20 C – 50 C;
- digital or analog output;
- 33 x 14 x 1.6 mm dimensions;

Detection of intrusions: PIR HC-SR501 sensor module was used to detect the presence of people, it is a sensor based on infrared technology; its sensitivity is adjustable which helps to detect a person within the range of 3 to 7 meters. This sensor as a small size, low price, low energy consumption, it's easy to use and has a high life expectancy. For this reasons, it is often used in devices and gadgets.

The technical specifications are:

- 5V-20V operating voltage;
- 65mA current;
- TTL 3.3V/0V digital output;
- 0.3 sec – 5 min adjustable delay;
- 110-5m range of action;
- L/H (Low/High) trigger;
- dimensions: 32mm x 24mm;
- -15C – 70C operating temperature;

Home surveillance: to be aware of the possible events that occur in the house when the residents are gone, a webcam connected to the main module will be used. The webcam will take pictures from the house and will send them to the user interface. The webcam used to take this pictures is camera V2 module for Raspberry PI. This camera module is an Sony IMX219 image sensor able to record in formats like 1080p30, 720p60 and 640x480p60/90.

Lighting system control: to control the lighting system from the house, a module with 4 relays and 4 channels was used. The module is able to control devices that work at very high voltages with the help of the development boards, Arduino board in this

case, which is why it is often used in projects like Internet of Things.

Technical specifications of the device are:

- 250 VAC or 30 VDC voltage;
- 10A maximum current;
- one optocoupler for each relay;
- 5V power supply;
- 5mA necessary intensity for control;
- dimensions: 7.5cm x 5.5cm x 1.85cm;

Technical specifications of the webcam are:

- 8MP photo resolution;
- 1080p 30 fps, 720p 60fps and 640x480p 60/90 fps video resolution;
- CSI (Camera Serial Interface) connection;
- dimensions: 25mm x 23mm x 9mm;
- 4 grams weight;

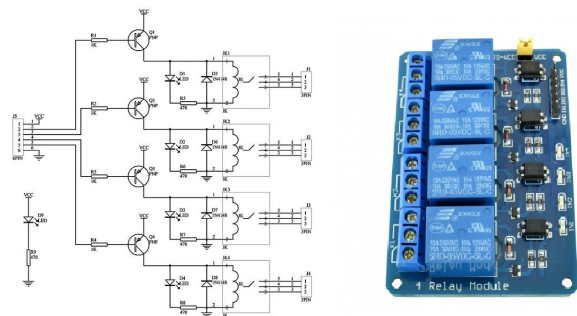


Fig. 6. Lighting System Control

Software components used to realize the user interface will be represented by a web page, where the data received from the sensors will be displayed. These data will be sent to a local server where will be processed and displayed on the page, and depending of some parameters, some decisions will be made.

To realize this page, the following components are used:

- Node.js for the server part, is an open-source JavaScript programming language platform. It is realized in Chrome V8 engine and is used for server and network applications. Its main benefit is that servers based on Node.js can work in asynchronous mode based on events (evented.io), this mode being named non-blocking.



Fig. 7. Node.js

As previously stated, Arduino Mega2560 development board is used to control the hardware components, being made possible by Arduino Software (IDE) integrated development environment, based on Processing project, which includes support for C and C++ languages. In this case, we will use C++ language to program the hardware components with the purpose to offer them the desired functionality.

5. IMPLEMENTATION

As has been said previously, this modular system is made of 2 modules namely: main module (gateway), sensors and actuators modules. These 2 modules communicate each others with the graphical interface through the gateway module.

Hardware implementation:

- Raspberry Pi model B+ development board;
- Dongle Wi-Pi USB stick for wireless connection;
- webcam for Raspberry Pi;
- connection wires;

This module realize the connection between sensors and actuators module, namely Arduino Mega2560 development board. There are many ways to implements this like using the GPIO pins and serial pins or using the I2C protocol. However, the connection can be made much easily using one USB cable.

To realize the communication of this module with the web service, an internet connection is needed, the Wi-Pi Dongle USB stick making this possible connecting the module to a local network; in this case it will connect to a smartphone network. This stick is connected to one of the USB 2.0 ports of the Raspberry Pi board.

For the hardware implementation of this module, the following components were used:

- Arduino Mega2560 development board;
- BMP180 temperature and pressure sensor;
- HC-SR501 human movement detection sensor;
- MQ-2 gas sensor;
- active buzzer;
- 4 relays module;

- light bulb;
- energy source;
- connection wires;

The main task of this module is to monitor certain conditions from a room using 3 different types of sensors. Also, with the use of this module, we can control the lighting system with the help of relays, the alarm system for emergency situations. The alarm is being represented by a buzzer which is active when the gas sensor reads a critical value.

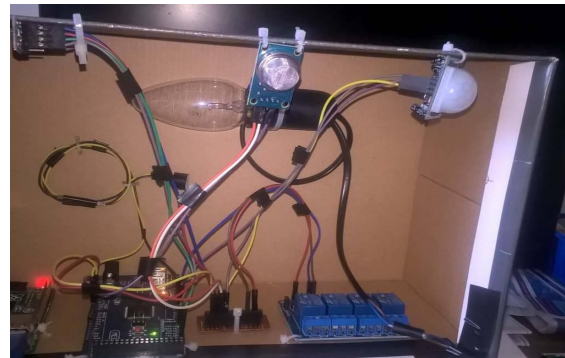


Fig. 8. Smart Home System Prototype

To prove the functionality of this system, a house simulation was monitored. In the test application were used one components of each type, but in a real house the system can be extended for each room apart. To simulate the functionality of the system we will illustrate different situations that can happen, for instance, a change in temperature and pressure, the occurrence of a large gas concentration, detection of a human movement.

The following picture illustrates the final results and implementation of the Smart Home System Prototype.

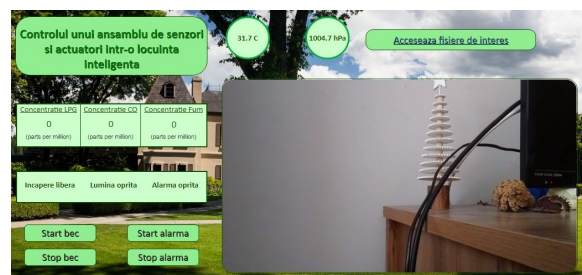


Fig. 9. Smart Home System Interface



Fig. 10. Smart Home System Results

6. IMPROVEMENT DIRECTIONS AND FURTHER DEVELOPMENTS

- Homes of the future may very well come with smart home features built in, considering the rate at which these technologies are being developed and integrated into our everyday lives. Still, some people may want to install and further customize home automation devices themselves.

- Customers are increasingly looking for customisable devices, so that their experiences can be tailored precisely to their preferences. Additionally, they're looking for a service that goes beyond just keeping their devices connected. After all, these devices are made to act as a personal assistant to homeowners. They want a system that's cohesive and runs as one unit, that issues commands that are thoughtful and well suited for the homeowner's lifestyle without them having to say it. Whether through one-time programming or by learning to analyse activity and act on its own, these programs are built with the customer in mind.

- Smart home systems will only continue to evolve and become more advanced. These days, the range of options available for purchase are constantly expanding, so that you are not limited to one size, color or shape. Many gadgets and systems are designed to either blend in with surroundings or even stand out as a statement piece. So while smart home systems may take some time to understand and master, they will, and already are, making life easier.

- Home automation technology seeks to reduce your stress by ensuring your home is secure even when you are far away. It is also meant to reduce the amount of effort you put every day into running your household so you can focus more on yourself and the people inside of it. Imagine if your home could automatically save you money, time and effort. With many of these already established and actively improving systems, these ambitions are possible.

- Right now, home automation is continuing to evolve. Manufacturers are creating and innovating products to better suit consumers' needs. They have taken everyday belongings – coffeemakers, lamps, fans and window blinds – and turned them into automated devices, to capture information about your personal usage habits and adapt to them.

- As the technology for smart homes continues to evolve, the range of capabilities is only going to grow.

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