

Home automation system using Raspberry Pi

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Abstract: *there has been an exponential growth in population over the past decade. This population growth has led to an increase in energy consumption, mainly fossil fuels and electricity. The electricity consumption has increased with the same proportion. With the rise in demand the cost of electricity has gone up considerably. This is due to lack of energy management. People are unable to manage their electricity consumption due to the lack of information available to them. In all buildings and independent houses the electricity consumption is measured by an electricity meter in the meter room, the meter is read once a month by the electric company that provides the power. The consumer is unbeknownst to the meter reading until it shows up on the bill. Most of the wastage of electricity is due to negligence by consumers. Machines those remain active even after use is complete. The inability to control appliances and power sockets remotely has been out of the reach of masses. A simple yet robust web or mobile application coupled with a Raspberry Pi can help users be aware of their consumption habits and tune their homes to their specific requirements.*

Keywords: *Population growth; Energy management; Raspberry Pi; Mobility; Electronic appliances; Smart Home Automation; Web application; Android application*

I. Introduction

Houses of the 21st century will become extremely smart and safe, especially when deployed in a private home. A home automation system is a means that allows a user to control the appliances and electronic devices in his home environment. Many of the existing home automation and smart home systems in the market are mostly based on wired communication. This method of communication does not cause any issue if the system is planned well in advance and then incorporated into the electrical structure of the building during the physical construction of the building. The wired system presents an issue in pre-existing buildings or houses. In contrast, wireless systems can be of great advantage for automation and internet enabled systems. With the advancement of wireless technologies such as Wi-Fi, cloud computing and breakthroughs in cellular network development, wireless communication provides a robust and reliable means of communication.

Electronic and Electrical surroundings with relation to this context is any environment that consists of appliances like fans, television sets, air conditioners, motors, heating and ventilation systems, lighting systems, etc. A remotely accessible environment is an environment within which every aspect of it can be remotely monitored and managed using the software as an interface. A smart home system is one in which the environment is aware of the surrounding conditions and reacts to them within the user's set parameters. The software is a combination of both web application and android application. Such remotely accessible systems are already available in the market, however they have a variety of drawbacks. This paper will provide the proposed system that is an improvement on the existing systems in the market.

II. Literature survey

In the technical paper published by Vinay Sagar and K N, Kusuma S M, "Home Automation Using Internet OF things", International Research Journal of Engineering and Technology (IRJET), they have written about the project of Home Automation System using IoT wherein they have used Intel Galileo Microcontroller. They have used Wi-Fi as a medium for internet connectivity. They have even created an experimental setup of HAS where they have controlled two lights, a cooler, and alarm for a gas leak. They have even connected gas, light, temperature, and a motion sensor and they have set a threshold for each sensor's reading using which they control the appliances. For example- A cooler will turn on when the room temperature exceeds the set threshold and in turn reduces the room temperature. As a frontend part, they have created a HTML-based Web server page using which the user can handle the entire system.

Whereas, only switching on and off the appliances is just not enough for managing and reducing the power consumption of the system. "Design and Implementation of a Wi-Fi based Home Automation System" by

Ahmed Elshafee and Karim AlaaHamed, International Journal of Computer, Electrical Automation, Control and Information Engineering is an Arduino based distributed HAS system which consists of a server, hardware and interface modules. The webserver controls hardware, a single interface module and can be configured to handle more than one hardware interface module. The hardware interface module controls all alarms and actuators. They have used Wi-Fi as a medium for connecting to the internet. In this the user can create group events i.e. when a certain trigger is activated, the device will perform a series of tasks that are preset by the user. These events can be activated manually or as a reaction for certain trigger, for example, if external light source is detected, motion sensors and surveillance cameras. Since they have used Arduino as the base of the system, adding more hardware interface modules will require number of Arduino chipsets to be installed in the system which results in the increases of complexity and the overall cost of the system and also eventually increase the power consumption of the entire system.

The paper "Android based Home Automation Using Raspberry Pi" by Shaiju Paul, Aswathy B and Ashlin Anthony is very close to the paper we are proposing. They have created HAS wherein they have simply connected the home appliances to the Raspberry Pi using relay circuit and they have used an android application for a user interface. Their system consists of three main components a Raspberry Pi board, Wi-Fi dongle and a Relay circuit. Wi-Fi is used as a communication channel between android phone and the Raspberry Pi board. They have masked the complexity of the technicalities involved in the HAS by including them in a simple yet comprehensive set of related concepts. In their paper, they have not used sensors, due to which the project doesn't provide the base for an automated system. Only toggling the power supply to the appliances is just not enough for reducing the power consumption of the system.

The paper "Home automation using Raspberry Pi" by Monika M Patel, Mehul A Jajal and Dixita B Vataliya. In the paper, they have made use of a Raspberry Pi model B as their central processor, a Wi-Fi dongle for their internet connectivity, a relay circuit for connecting appliances to the system. A WebIOPi for IoT framework. Their relay circuit operates at a 5-12V output. WebIOPi is an integrated IoT framework for Raspberry Pi. The system in this paper, when turned on, will first check the current situation of rooms and state of lights. This system provides the user with remote control of various lights and appliances within their home.

In this system, the sensors are not used which gives us the information about the conditional intensity with which the appliances should work. They are not using the Android based application which is a widely accepted system. Also, they are not manipulating the intensity with which the appliances will work, which could have reduced the power consumption greatly.

III. Proposed System

A. System Architecture

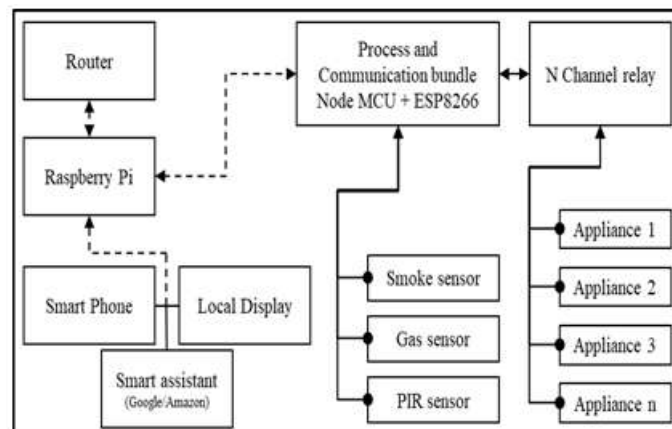


Figure 1

The proposed model of Home Automation System using Raspberry Pi is as shown in the figure above. The primary control centre of the system is a Raspberry Pi, it is responsible for making decisions according to the input from the user or data from sensors. The model consists of different sensors like gas sensor, temperature and humidity sensor and motion sensor. Initially the Raspberry Pi connects to the internet through Wi-Fi or LAN cable. When the connection is established it will start reading the parameters of the sensors. The threshold levels for the required sensors are set as per user preferences. The sensor data is updated in the database maintained in the web server. Since the data is stored on a database on a web server it can be accessed and analyzed at all times. If the sensor readings are greater than the threshold level set by the user, then the user is notified so that the decision for required actuation is done for controlling the environment to reach a state of equilibrium. In the proposed model, the temperature, gas leakage, motion in the environment is monitored. The

temperature and the motion detection are stored in cloud for analysis. If the temperature exceeds the threshold level then the cooler will turn on automatically and it will turn off when the temperature reaches the user set parameter. Similarly when there is a leakage of gas in the house, alarm is raised giving the alert sound. If the user opts for it then as an extra safety measure the circuit breakers can be tripped. Lights are toggled automatically by detecting the intensity of light outside the house. The user can also remotely monitor the home environment through the mobile application via web server. If the lights or any electrical appliances are left on accidentally, the user will be notified and they can turn it off remotely through the mobile application.

The system is also capable of working with modern virtual assistants, like the Google Home (Google now) and Amazon Echo (Amazon Alexa). These devices provide the user with a great degree of convenience and flexibility. This integration makes the whole operation of toggling of appliances as natural as a conversation. The integration also lets the user set their own custom routines, such as activating the coffee maker in the morning when they wake up. The audio feedback from the smart device adds to the convenience of not needing to recheck the status of a device.

B. Functions

The proposed home automation system has the capability to control the following appliances and monitor the following sensors in the user's house:

- a) Temperature and humidity (Sensor)
- b) Motion (Sensor)
- c) Fire and smoke (Sensor)
- d) Light fixtures
- e) Power outlets
- f) Appliance connected to smart socket

The system can be controlled using multiple methods:

- a) Mobile application
- b) Web application
- c) Local display
- d) Voice command, through a virtual assistant like Amazon Alexa or Google assistant

IV. Implementation

The system is a combination of both hardware and software. Since the processing is done by a Raspberry Pi that is connected to the internet, updating the system can be done via OTA (Over the Air) updates.

C. Hardware

The primary component is the Raspberry Pi. The Pi will contain the code that connects to the webserver to update the database with the sensor values as well as the current condition of the switches. If there are any changes made to the values in the table, the Pi takes the appropriate action. The Pi will also be connected to a display that will act as a digital switch board as well as a central console for the house.

The Pi is connected to the Node MCU Wi-Fi transceiver, this acts as a communication bridge between the Pi and the relay board. The MCU is responsible for toggling the relay board switches as well as sending the sensor data to the Raspberry Pi. The relay board has mechanical switches that carry out the physical switching. The existing wiring of the switch board is connected to the relay board. The sensors are connected to the Raspberry Pi directly onto the board. The sensor values are updated at regular intervals to the webserver. The sensor values are monitored and compared with user set parameters at regular intervals.

D. Software

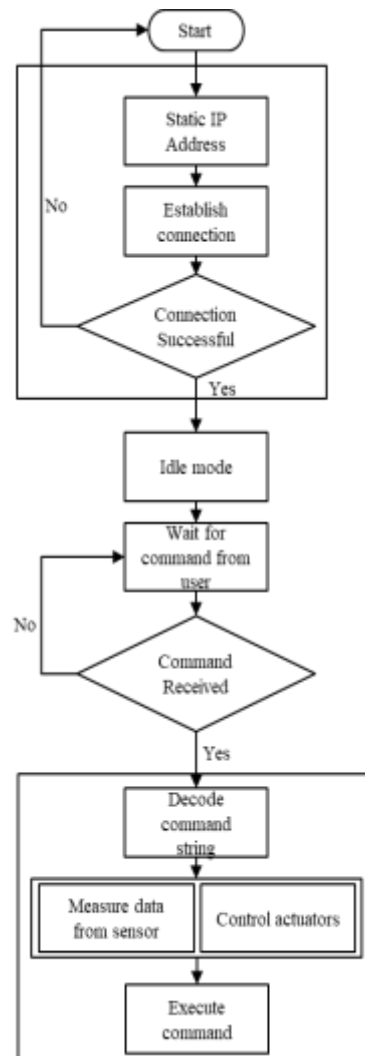


Figure 1

The flowchart (Figure 2) shows the process flow involved in the initialization of the device as well as the steps involved in execution of a command.

The system after powering up will first establish a connection with the webserver. The user will then login to their account. During the initial setup, the user will have to pair the Raspberry Pi to their account. The Raspberry Pi will then access the particular user's database, where the sensor readings and switch values are stored and update them with the current values of the environment.

The system will then go into idle mode. It will wait for a command from the user, be it from a local network or through the internet. Once the command is received, the sensor data is measured for any clash with pre-set user parameters, if there is no clash then the command is executed, else the user is notified of the error caused due to clash of protocols.

The sensors values are updated in the webserver at regular intervals. If the values are out of the range set by the user then the user is alerted so that the appropriate action can be taken to bring the situation under control. The PIR sensor is used to detect any type of motion, this is useful in tracking any unauthorized access when the user is not at home, thus improving the safety of the house. The monitoring of movement also helps ascertain if a particular room has no occupants but appliances are active, then the user is notified about the same.

The user can access the system via the web application, mobile application or via the touch console, which is an optional extra. On first use of the application, the user has to register themselves. On logging in they will have to then pair their account to the device. Once paired they can log into their account from anywhere and make changes to the system.

V. Result and discussion

The device is connected to the existing wiring system. Once it is powered up it'll first connect to the user's mobile device. Then the user will be prompted to register the device to their account. Once connection has been established, the device will then take the current condition of the environment and update the database.

Once the user enters the mobile application, they will be welcomed with a login screen. After successful authentication the will then be brought to the home screen, this screen consists of the devices that the user has added to their profile. It can be configured to display the readings from the various sensors in the system like gas sensor, temperature and humidity sensor and any other additional sensors that the user opts to install.

The user can then see the status of their switches and the environment of their house. They can control the switches by simply tapping on the icons representing the respective appliance. The on-board current and voltage sensors send data periodically to the raspberry Pi. This data is stored on the database, this data can also be used to generate a rough estimate of the electricity bill and provide a detailed consumption analysis.

VI. Conclusion

The Home Automation using Raspberry Pi has been analytically proven to work adequately by connecting appliances to it and the appliances were successfully controlled remotely through internet. The designed system not only monitors the sensor data, like temperature, gas, motion, current and voltage consumption but also actuates a process according to the requirement, for example switching on the light when it gets dark or deactivating an outlet that has been active but idle. It also stores the sensor parameters in the webserver in a timely manner. This will help the user to analyse the condition of various parameters in the home anytime anywhere.

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