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An IoT Based Home Automation System

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Abstract: Industry experts, corporate heads, and chiefs of businesses all agree that we are on the verge of what is to be the Fourth Industrial Revolution – which will be more disrupting and impactful than any we’ve seen in the history of mankind. Automation is without a doubt, one of the pillars of this Industrial Revolution. Consumers worldwide prefer automated systems over manual ones. Today the Internet has become a part and parcel of daily life. We cannot imagine a life without the internet. In this paper we present to you an Automation System which is a real-world application of a fast- growing emerging Internet Technology, The Internet of Things (IoT). A Home Automation System, based on the IOT, makes the consumers life easier, more comfortable, faster and more secure. This cutting-edge technology allows the consumer to have complete control over his or her home appliances and devices from anywhere in the world, via a web browser with an internet connection. The simulation designed by us, in this paper, is a small approximation of a much larger real-world system, the concepts, approach and methodology however, remaining the same.

Index Terms: Fourth Industrial Revolution, Automation System, Internet of Things, Home Automation

1. Introduction

Problem Statement: To successfully design, implement and simulate an IoT based Home Automation System(HMS), using NodeMCU, which is an open source IoT platform, thereby enabling full control of all the loads in the system from anywhere in the world, via a public web application, with an internet connection.

Home Automation gives us access to control devices in our homes from a mobile device anywhere on Planet Earth. The term may be used for individual programmable gadgets, like thermostats and sprinklers, but “home automation” more accurately is associated with homes in which almost everything – from lights, fans to electrical outlets to heating, cooling and ventilation systems – are connected to a remotely controllable network. From a home safety outlook, this may also include any alarm systems, all the doors, windows, locks, smoke sensors, surveillance cameras and any other sensor, that may be attached to it.



2. Literature Survey

2.1 Bluetooth based HMS using mobile phones

In this sort of HMS, the home machines are associated with the Arduino BT board at information and yield ports utilizing relay. The program of Arduino BT board is based on the C language. The association is made by means of Bluetooth.

2.2 Zigbee based home automation framework, utilizing PDAs

To screen and control the home machines the framework is structured and actualized utilizing Zigbee. The gadget execution is record and store by system facilitators. For this a Wi-Fi organize is used, which utilizes the four-switch port standard remote ADSL current switch.

2.3 Home Automation utilizing RF modules

The essential objective of a HMS is to manufacture a home mechanization framework utilizing a RF controlled remote. In order to achieve this, a RF remote is consolidated to the smaller scale controller on transmitter side that sends ON/OFF signs to the recipients where gadgets are associated.

3. Proposed Methodology

3.1 Primary Objectives – Hardware

Successful design of a circuit with 5 loads, with a power adapter and relay switching circuits, and being connected to the IoT platform – NodeMCU[1-2]. Successful and complete implementation of the circuit with the necessary requisite material viz., NodeMCU, Power Adapter Circuit, Relay Modules, etc. on a plywood base. Design of the relay modules using sugar cube relays, on Printed Circuit Boards (PCBs). Writing the code to control the ESP8266 Wi-Fi module using Arduino IDE, and uploading the same onto the board, via a USB cable. This is followed by testing the code and all the circuit connections for loose/faulty connections, and also clamping/soldering certain parts of the circuit as and when required[3].

3.2 Primary Objectives – Software

Designing a web application that meets the necessary requirements of controlling the loads in the HMS. Choosing hosting server, selecting web hosting plan, buying server space, and registering the domain name. Designing the website using HTML, CSS and JavaScript, and using PHP, a server-side scripting language to process inputs/outputs and dynamic content on the webpage[3-4]. Creating and developing the necessary databases using MySQL, a relational database management tool, and linking the same with the PHP code. Publishing the web pages and testing the same before final deployment.

3.3 Secondary Objectives – Additional Features

1. *Login Feature:* The web application will be secured with a login feature. Only bonafide users who possess valid login credentials, username, password, will be able to login and access the web application.

2. *Password Change Feature:* Once successfully logged in, users will be able to proceed to change their passwords for the existing username. Once the password is successfully changed, a message stating the same will be presented to them on the screen.

3. *Run-time monitoring Feature:* Users will be able to monitor the time for which each device is On, after each On-Off period, simply by refreshing the webpage. The cumulative data of run-times of each of the 5 devices (loads) will get stored in the “Current Info” Tab, for each day, on a daily basis. This will get reset to zero at the start of each day. The previous usage, of each day right from the time of the development of the app can be viewed under the “Historical Info” Tab.

New user Registration feature: Once successfully logged in, users will be able to go on to register new users – that is, create new valid user name, password combinations, to allow other individuals/families to have access to the HMS. It is important to note that this feature can be accessed only after a successful login by clicking on the ‘Settings’ Tab. This ensures that the feature

is not misused or the safety and security of the home is not compromised, as new users can thus only be created after authorization from a bonafide current user.

4. DESIGN APPROACH & DETAILS - HARDWARE

4.1 Components Required - NodeMCU, AC Power Adapter, IC 7805 Regulator, Relay Modules, Switching Circuit for fan, The Devices – 1 Bulb, 1 Tube light, 1 DC Fan, 2 AC Sockets(Figure.1).

4.2 Technical Specifications & Details

NodeMCU is a firmware, based on the open source LUA platform which is developed for a Wi-Fi module ESP8266. Since it is an open source platform, its hardware can be easily built, can be easily modified and can be easily edited. The ESP8266 is a low-price Wireless Fidelity chip developed by Espressif Systems. The Power Adapter Module is a general-purpose adapter, especially designed for Arduino and NodeMCU. It is used for power supply in small Robotics papers and other such Do It Yourself (DIY) Kits. It converts AC input voltage in the range of 100 V to 230 V, of frequency between 50 to 60 Hz to 12 V DC voltage. The Sugar Cube relays are superior quality 12 V Single Pole Double Throw (SPDT) relays(Figure.2.). They are rated up to 7 A at 240 V AC. They are completely enclosed, or sealed relays.

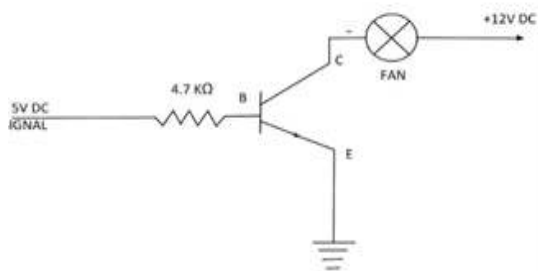


Fig. 1. Switching Circuit for FAN

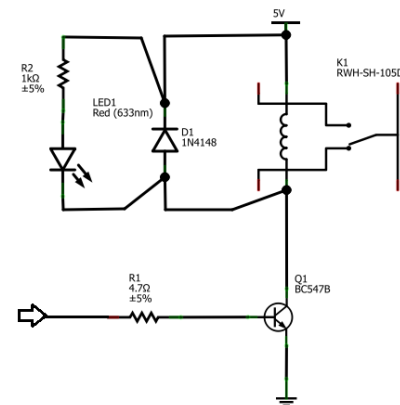


Fig.2. Relay Circuit

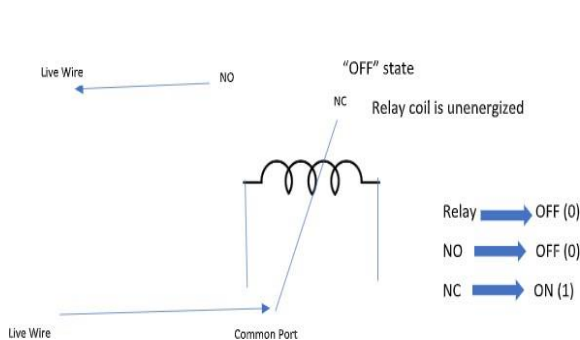


Fig.3. Unenergized Relay Circuit

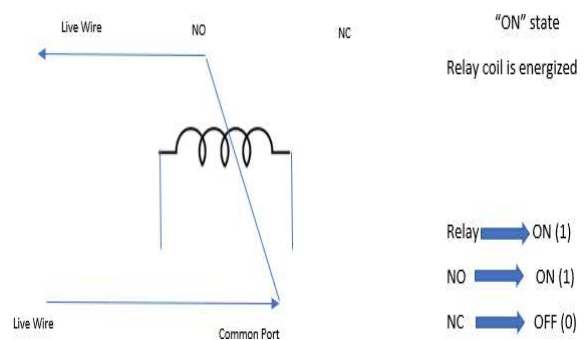


Fig.4. Energized Relay Circuit

The 5 V DC supply acts as a signal voltage for the relay. The NodeMCU cannot directly drive the relay, as it consumes a lot of current. Therefore, the NodeMCU drives the transistors which in turn drive the relay. The Live wire is connected between the “Normally Open (NO)” port and the “Common (COM)” port. In the ‘OFF’ state the relay switch is connected between the “Normally Closed (NC)” and the “Common (COM)” ports (Figure.3).

On getting energized it will deflect and close the NO and COM ports, thus completing the live wire circuit, acting like an electronic switch. A diode may be placed across the relay to counteract the effects due to Lens's Laws. All the components have been placed and soldered on a custom-made etched PCB (Figure.4).

Load #1 of the HMS is a Light Emitting Diode (LED) Tube light having a rating of 6 W. Load #2 is a 9 W LED Bulb, rated at 220-240 V at 50 Hz. Load #3 is a 6 W DC Fan, rated at 12 V and 0.15 A. It requires its own switching circuit. The switching circuit is as shown here:

This switching circuit is absolutely necessary as the DC Fan works on 12 V DC supply while all the other four loads in the HMS, work on normal household supply of 230 V AC.

Loads #4 & #5 are sockets / plug points, that supply the regular Indian household (domestic) supply voltage of 230 V with 50 Hz frequency. All regular household devices / gadgets can therefore be used or charged with these plug points, from smart phones and tablets to laptops, personal care devices, irons etc. Each of these sockets therefore symbolize a normal household power outlet.

4.3 Complete Circuit Design

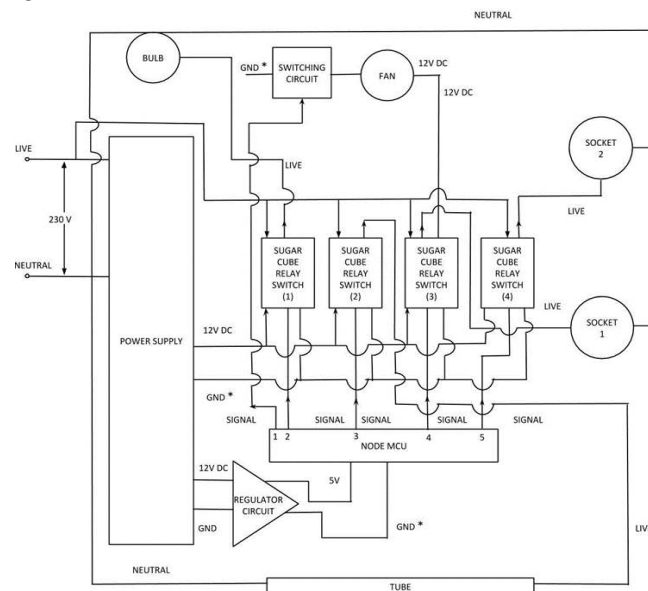


Fig.5. Proposed Circuit Design

The Power Supply Block shown in Figure.5. is actually the Power Adapter Module, which converts 230 V AC to 12 V DC. All the devices except DC Fan have a common ground (neutral). The household supply of 230 V AC will be converted to 12 V DC by the power adapter module. A regulator circuit, containing the transistor IC 7805, will further convert this 12 V DC to 5 V DC, and this in turn will be fed to the Node MCU, to be used as a signal voltage, toggled between 'High' and 'Low', or 5 V and 0 V, as per the command given in the software. Each of the 4 relay modules, will be connected to the Node MCU, so that the 5 V signal voltage can be provided as and when required. Further each of the 4 relay modules will be given the 12 V DC supply to keep the relay coil energized. The Live wire connection will be made to pass through the ports of the relay, the relay acting as an electronic switch. When the signal voltage is 'High (+5V)' the relay will be energized, moving to the 'ON' state, closing the Live Wire path, to the corresponding device. When the signal is low (0V) the relay will be un energized, in the 'OFF' state, making the Live wire path open. The DC Fan will work on the 12 V DC supply, it will have its own switching circuit. The transistor will be connected through the port D8 of the Node MCU.

4.4 Configuring the Node MCU – The Arduino Code

The program includes the header files 'ESP8266WiFi' and 'ESP8266HTTPClient' with the help of the '#include' statement with the name of the package being enclosed within "<" and ">". Including the 'ESP8266WiFi' header file gives us access to specific Wi-Fi routines which we are calling to

connect to the network. The real connection to Wi-Fi is initialized by calling: “WiFi.begin (“network name”, “pass-to-network”). Here the network name is the SSID of the Wi-Fi network (which will be running in the home, or the Home Network) and the pass-to-network its password. Connection process can take time and we check for this to happen in this loop:

```
While(WiFi.status() != WL_CONNECTED) {
  delay(1000);
  Serial.print("Connecting...");
}
```

The While loop continue to loop till “WiFi.status” not equal to “WL_CONNECTED”. The loop exits only when the status changes to “WL_CONNECTED”.

Code: HTTP Client http ;

```
String url = http://www.sridip.online/files/bulb; // Dynamic API
http.begin(url);
int httpCode = http.GET();
String payload = ""; // Response
If( httpCode > 0) {
  payload = http.getString();

  Serial.println(payload);
  If(payload[0] == '1')
    digitalWrite(relay1,1);
  else
    digitalWrite(relay1,0);
  ....                               ... and so on.
```

The HTTP Client instance, in the subsequent lines, acts as a session to send HTTP requests and receive appropriate responses. The HTTP Client instance is a set of settings which are applicable to all requests executed by that instance only. Also, every HTTP Client instance uses its very own connection pool, thereby separating its requests from requests of other instances.

The String ‘url’ holds the URL of the web application of this HMS, with the extension ‘files/bulb’. The ‘Green/Red’ button on the web application interface has an associated data attribute (Green = 1, Red = 0). This is configured in the Web Application using HTML and JavaScript. These data attributes corresponding to each ‘ON/OFF’ command stored as a string variable, which gets continuously concatenated. This is stored in the ‘files/bulb’ file extension. The NodeMCU is programmed to fetch this.

In Arduino, C/C++ coding, a string is treated simply as an array of characters. The ‘get String’ function returns this string. The string gets continually concatenated, with the first five characters (index positions 0-4) having the latest ON/OFF values. The ‘http.getString()’ function returns this string, which gets stored in the ‘payload’ string variable(which is actually treated as an array of characters).

The first five index positions correspond to the state (ON/OFF or 1/0) of each of the 5 devices in the HMS. Therefore, 5 If-Else statements are required, one for each device, if the corresponding index position has the value ‘1’, the NodeMCU is programmed to send the signal voltage (+5 V) from the corresponding output pin (D0/D2/D4/D6/D8, which have been named as relay1/relay2/... relay5 respectively and have been previously configured in the program as output pins), with the function ‘DigitalWrite’. If the signal voltage is zero, the NodeMCU is correspondingly programmed, to not send the signal voltage.

The Code is written in the Arduino IDE and uploaded onto the NodeMCU via a USB cable.

5. DESIGN APPROACH & DETAILS - SOFTWARE

5.1 Stage One – Brainstorming & Design

(The Goal) The web application designed should be able to facilitate smooth control of all the loads in the HMS. The user should be able to control (i.e., switch ON and/or switch OFF) all the 5 devices

IOP Conf. Series: Materials Science and Engineering **623** (2019) 012014 doi:10.1088/1757-899X/623/1/012014 (loads) in the HMS, at will and without any delay/interruption. In addition, the webpage should also support the additional features viz., password protected interface, password change/modification, multi-user registration and the dynamic monitoring of usage of each device, and the ability to store a log of the same.

(The Solution) Web Hosting – it is essentially a service that is provided by many hosting companies, that hosts a website’s files so that they can be accessed on the internet.

Reference may be taken from this analogy: We have got a large number of files on our computer, and if we want to access them, we just open up the file. But, if we wanted to share this file with someone else, they would have to be in the same room as us, or we would have to transfer the files to them by some means.

In this analogy, the web host is the sender. All of our site’s files are kept in storage on our host company’s servers. Now, as and when a visitor types in our domain name, the server transfers these files onto the web browser. Our website is nothing but a repository of various files and media elements, such as photographs. So we rent a space on a web server and store all of our files there.

Advantages include improved site performance, outstanding technical support, and improved web security.

Stages of web hosting are – Deciding on the nature of the website, deciding on the type of hosting server, selection of a web hosting plan, changing the Domain Name Server (DNS) address, and uploading the website.

For web applications, usually the hosting company rents out server space to the paying customer. These servers are housed inside datacenters. The hosting service company used by us is HostGator India. The type of hosting used is Shared Linux based Hosting. In Shared Hosting, one’s website is placed on a common server along with many others, ranging from a few hundred to a few thousand. All domains share some common resources such as the CPU and RAM. In Linux Hosting, Linux is used as the operating system on the server. Linux is an OS like Unix, which is free and open source. Registering a certain name for a website, on the internet, is called domain name registration. Domain names are used to differentiate between one or more Internet Protocol (IP) addresses. They are a substitute for the IP Address. For our website, the name chosen was ‘Sridip’s Paper’, URL ‘https://www.sridip.online/index.php’, and domain name ‘sridip.online’.

5.2 Stage Two – Coding

Language Used – PHP (Hypertext Preprocessor– originally called “Personal Home Pages”, hence the name)

Web pages designed using – HTML (Hyper Text Markup Language), CSS (Cascading Style Sheets), and JS (JavaScript).

Databases managed using – MySQL (A relational database management tool. Role of PHP – PHP is a server-side programming medium, which allows the developer to perform complex processes and display the requisite code. PHP lends functionality to the website, such as saving data in the databases, responding to inputs given by the user, etc.

Role of HTML – HTML allows us to put content (in the form of images, text, videos, etc.) in the web page, and define how the content would be placed/presented. Anything that the user can read/view on the webpage is being presented, by means of a browser, with the help of HTML.

Role of CSS – CSS is used to improve and enhance the layout, style and presentation of the webpage(s) involved. It allows the developer to define the overall look and feel of the website. While HTML predominantly deals with content and structure, CSS deals with presentation related elements such as fonts, layouts and colors. Before CSS came into use, all of this had to be defined in the HTML file itself, which made the code very complex and cumbersome.

Role of JS – JavaScript (JS) is a client-side scripting medium, which makes web pages more dynamic as well as interactive. It makes the web-pages smoother, user-friendly and helps bring about easy navigation for the user. If the developer so wishes, they can also implement visual effects to their web pages using JavaScript. JavaScript, along with HTML and CSS make a very powerful combination for web application development. Unlike PHP, JS is a client-side programming language while PHP is a server-side scripting medium.

Role of Relational Databases – A relational database is a group of multiple data sets which are streamlined by tables, records and columns. RDBs create a well-defined relationship between database tables. Tables interact with each other and share information, which allows smooth data search ability, management and presentation. There are several Relational Database Management Systems (RDBMSs) in use such as MS SQL Server, My SQL, Oracle, PostgreSQL, Oracle Database to name a few. The database management tool used for our web application is – My SQL, which is provided by the hosting service company, as an in-built feature.

5.3 Stage Three – Testing & Debugging

The final stage of any web application development is testing and debugging. There are several aspects of the web application which had to be tested, both with appropriate as well as extraneous inputs. Below is the complete list of items which had to be tested (at the time of development, and also at later stages, to ensure no issues developed later) and the results of testing.

6. EXECUTION & COMPILATION OF RESULTS



Fig.6. Hardware Setup

The final hardware circuit, containing the NodeMCU, power adapter circuit, sugar cube relays, the switching circuit for DC Fan, as well as the 5 loads(Figure.6.). The Tube light, the lamp (bulb), and a socket (charging a smart phone) has been switched on, using the mobile web application. The verified results are given in Table1 and Table2.

Table1 Primary Objectives

DEVICE	ON	OFF
LOAD #1 – LAMP	✓	✓
LOAD #2 – TUBE	✓	✓
LOAD #3 - DC FAN	✓	✓
LOAD #4 - SOCKET1	✓	✓
LOAD #5 – SOCKET2	✓	✓

Table 2 Secondary Objectives

FEATURE	RESULT
Login feature	Success
Password	Success

validation	
Change of password	Success
On time of each device	Success
Date wise log of on times	Success
New user registration	Success

7. CONCLUSION

This paper is special as effective yet, simplistic simulation of a complete HMS has been realized in this paper, using components and raw materials easily available commercially, at reasonable prices, and using design and implementation concepts of Electrical and Electronics Engineering. The system automates 5 different devices/loads, via a webpage which can be accessed from anywhere in the world via an internet connection. The webpage thus provided is secured with a login feature. Innovative usage monitoring feature has been provided, which measures the duration of usage of each device after each ON-OFF period. This will allow the user to monitor usage, and strategically reduce usage, energy consumption and thus utility bills.

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