Implementation of Smart Home Automation System with IoT

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***Abstract* - In this research paper, a system for automating home appliances is implemented with the help of Internet of things using a Wi-Fi-based microcontroller (ESP-32) that is interfaced with a JavaScript based Android app. This allows user to remotely operate their home appliances from the comfort of their smartphone. A highly responsive relay is used alongside an error reduction system for HTTP server which has higher throughput & lower fallback rate**.

***Keywords*- Automation, Internet of things, ESP 32, Android app, Relays.**

I. INTRODUCTION

IoT [1] is defined as things that may be administrated over the internet. This aim is achieved by using sensors on these objects with processing capabilities, embedded with software and serving technologies that communicate within the network to share data. The field has changed due to the integration of many technologies, including ubiquitous computers, hardware sensors, powerful embedded systems. Across the consumer electronics market, IoT technology is most synonymous [1] with merchandise referring to the postulation of "Automated home" [2], together with devices and home equipment that constitutes a common ecosystem of self-regulating systems, and may be managed via gadgets associated with that environment, which include smartphones and voice recognition system. IoT systems are widely used in healthcare structures to reduce human contact.

ESP32 is a single 2.4 GHz Wi-Fi and Bluetooth chip delineated with TSMC 40 nm low power technology. (fig. 1) Designed to achieve the best possible RF performance and performance, it demonstrates durability, flexibility, and reliability in a wide range of operating systems and power conditions. ESP32 is a unified solution for Wi-Fi and Bluetooth IoT applications, with about 20 external components. ESP32 includes an antenna switch, RF balun, power amplifier, low volume receiver amplifier, filters, and power management modules. Thus, the whole solution takes up little space for the Printed Circuit Board (PCB).

The Relay board used here is an active- Low 4-channel relay module, with a driving voltage of 5V and each station can handle home appliance switching with a current limit of 15-20 A. Its applicability lies around a great segment of next-generation devices and equipment using high frequency. It has a standard connection that can be controlled directly by a microcontroller. This module is visually separated from the high-power side by safety requirements and protects the ground loop when connected to a small controller.

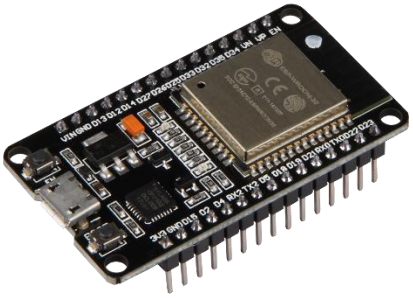

Fig 1. ESP-32 Dev Kit V1 Board

Android application is a special purpose software designed for android Operating system that facilitates easy access to various services on your fingertips.
Android application majorly contains three component that provides us the liberty to design the user interface & improvise the user experience. Those components are discussed in the following section of this paper -
Manifest: This section specifies application metadata, including its icon, version number, themes, etc., and additional high-level notes that can specify any required permissions, unit tests, and define computer hardware, screen, or field requirements.

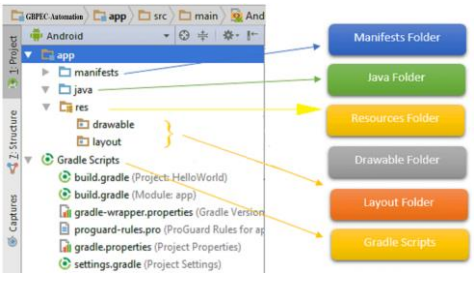

Fig. 2 Code structure of project in Android studio

XML: XML stands for extensible markup language and is used to define parameters related to User interface. It uses simple markups to generate a Segregated structure that simplifies complex UI standard problems. XML contains tags & identifiers, that facilitates the readability & reduces complexity during the development cycle of project.

JavaScript: JavaScript is a simplified version of java that has specific employment in cross platform applications. JavaScript acts as a brain to the application by providing logical capability to the android application.

JavaScript majorly provides the functionality to execute different intents (Client requests). In this paper IP headers are encapsulated with the commands and transmitted to the server as HTTP requests that will be further identified to perform operations at server's end.

The whole concept revolves around the term *internet-of-things* which comprises of its four major ingredients -

A. *Sensor/Devices:* These are specially designed components that measure's a physical phenomenon & transmit its data to the host as an electrical impulse that generates data.
B. *Connectivity:* The Sensors are thus connected to the central module with the help of different mediums either wired or wirelessly. Connectivity is the network between receiver transmitter & channel.
C. *Data Processing:* Processing of the received data from the sensors into useful information is carried out by the microcontroller. Here the instructions received from the client are implemented.
D. *User Interface:* The processed data is converted into human understandable form which is catered through an android application [11] in this paper.

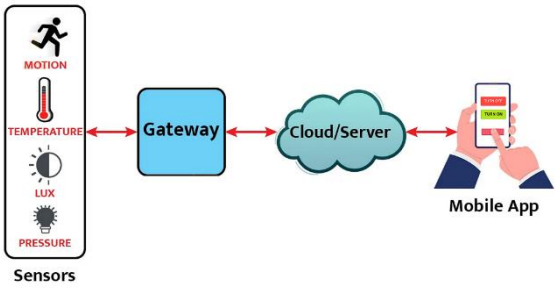

Fig. 3 Working of IoT

The main ingredient for any IOT based operation is a server. The centralized server acts as the heart of all the IOT rooted operations. A virtual connection between the server and the IOT devices is created here.

In this paper an extensive independent system is proposed where the user uses android app to make requests which is communicated through the LAN to the microcontroller which then, does all the necessary processing and sends instructions to the corresponding relay which are connected to the devices.

The ideation and execution of the particular project is highly influenced by the following literature surveys

Sopan Deu bring in a home automation system that could be used for usage analysis and a docile array of electronic devices implementing the things network [3] using Raspberry Pi. *Harsh Kumar Singh* devised the home automation system using Node MCU along with a multi-channel relay which is used to control electrical switches [4]. *Laura Gheorghe* proposed presents a solution for connecting more devices into a signal entity that can be easily accessed at any time. The enactment blends the ramification of different home automation devices into a unified application [5]. *Jeu Young Kim* delineates and scrutinizes to manage the aggregated home IoT data based on SWO (Smart home Web of Objects), and SWO conclusive platform [6]. *Progress Mtshali* dilated the applicability of remotely operated devices especially for physically handicapped peoples embedding controllers in their support equipment which shows that it has the substantial scope of scalability [7]. *Pinki Vishwakarma* worked over the security aspects of the things network with the help of Zigbee [13] modulation and came up with a conclusion that the security is optimum at its affordable worth [8]. *O. Jukić* in his paper formulated a cloud-based data processing and monitoring system, that includes fetching data from a large number of nodes & storing them under one centralized depot [9]. *Marek Babiuch* tested compatibility of ESP-32 board with application environments in sectors of data processing & transmission [10].

II. METHODOLOGY

The study of this project is divided into 5 parts as follows:

1. A microprocessor with better power consumption history and optimum processing power is chosen to act as the central unit of IoT devices.

2. An Asynchronous webserver is initiated at the microcontroller to accept HTTP requests and provide controlled access to the devices connected to the microcontroller.

3. All the controls and states are depicted over an interface such as a typical JavaScript android app that caters the explicit control.

4. A Low state high relay board act as a switching element that controls 230V operated appliances on a 5v intent from the microcontroller.

5.The device is tested for multiple stress test that provides us a preview of the long-run implacability of device and required changes are entertained before final binding components.

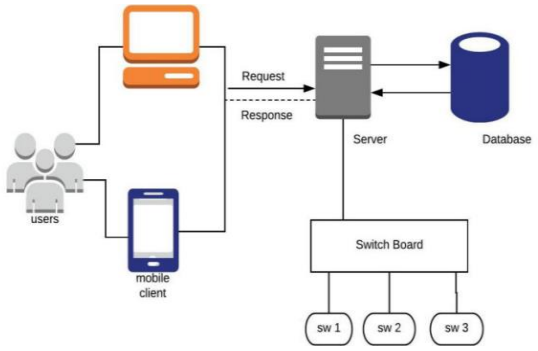

Fig. 4[4] flow diagram of the automation system

Fig. 4 depicts the implementation of a server-based control environment, which shows the flow control of connection & request management of home automation system.

III. ALGORITHM

1. Including Wi-Fi library
2. Static IP, gateway, subnets are declared
3. Server (ESP32) and client are declared
4. The function which read all the HTTP request coming from the client and assigns it to a local variable
5. Setup loop is declared
6. The serial monitor is declared which runs on a baud rate of 9600
7. Output pins are declared
8. Initializing the pins to OFF state
9. ESP32 starts establishing the Wi-Fi connection
10. If the connection is established, displays on the serial monitor
11. The setup loop ends and the void loop begins
12. Loop runs until the client is available
13. Requests are read that the client sends
14. Previous requests in the stack are removed
15. Requests which are beyond the limits are removed
16. Relays are given conditions

IV. FLOWCHARTS

A. Setting up the microcontroller

This flowchart depicted in fig. 5 computes the connection of ESP to the Arduino IDE where the source codes and conditions are passed to the ESP32 and an Asynchronous web server is executed which reads the HTTP requests from the client and changes the pin status correspondingly.

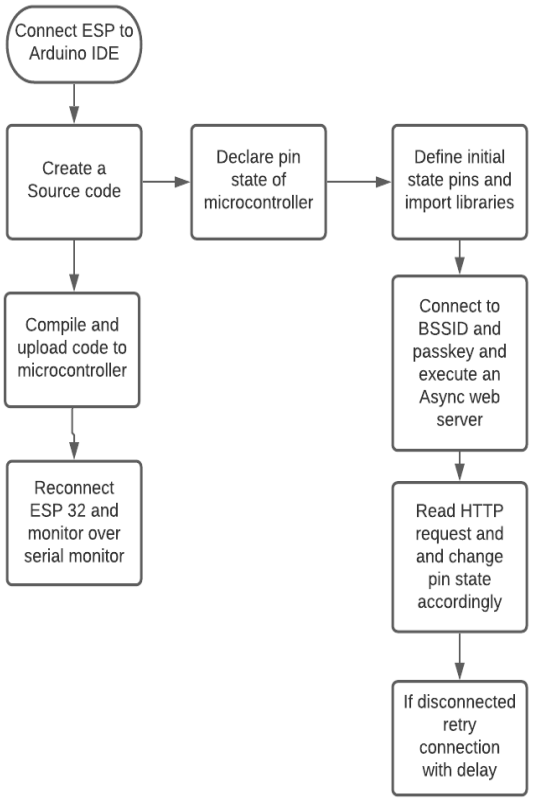

Fig. 5

B. Setting up the interface

This flowchart in fig. 6 computes the setting of the android application where the XML files and activities are updated with all the permissions granted from the manifest file and logics were written to send HTTP requests to the server and after testing the app it is exported.

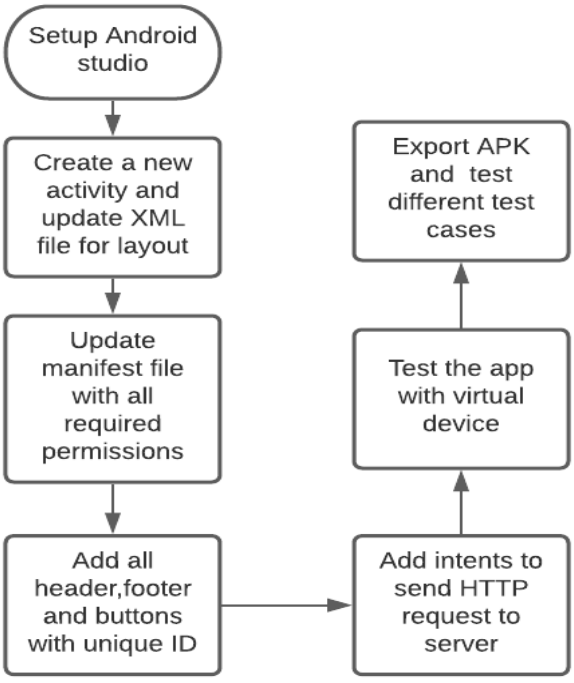

Fig. 6

C. *Assembling the project*

In the flowchart shown in fig 7, the microcontroller is connected to the assembly and all the pins are connected to the mentioned ports and LEDs are connected as per the logic, and power is supplied to the components.

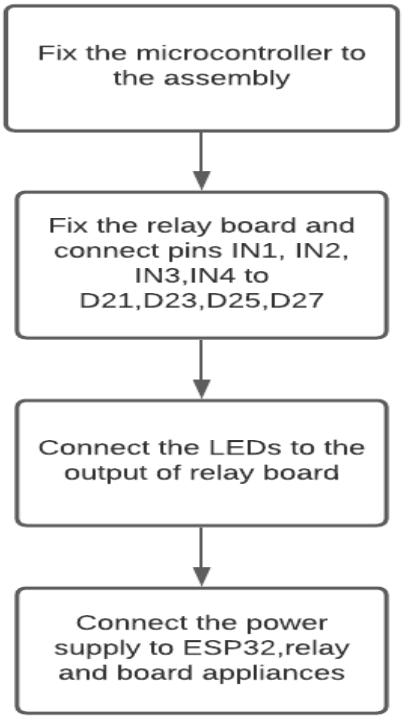

Fig. 7

V. RESULT

This paper achieves better performance, higher integrability, faster connectivity with a higher processing power as compared to solutions developed earlier. Along with better power efficiency as it offers both sleep & deep sleep mode that offers better battery life.

Parameters	Arduino	Raspberry pi	Node MCU	ESP32
Core	Single	Dual	Single	Dual
Clock	16 MHz	133 MHz	160 MHz	240 MHz
Wi-Fi	No	No	Yes	Yes
Bluetooth	No	No	No	Yes
Deep sleep	No	Configurable	No	Yes
Digital pins	14	4	16	36

Table 1- Comparison of ESP32 with other microcontrollers

It may be concluded from table 1 that the ESP32 is the most efficient and capable microcontroller over all the conventional microcontrollers which are in use.

As we have discussed creating an independent home automation system using ESP-32 that accomplishes the goal of advancing next-generation infrastructure at low cost. After successfully embedding the prototype with all the components & testing them under different stress tests, we observed that the system has a good response time, & an easy user interface.

After assembling the proposed model, the device is being tested for different test cases & thus monitored for heating issues with the help of an inbuilt temperature sensor of ESP-32. It is observed that device show's stability & favourable temperature variations.(fig. 8)

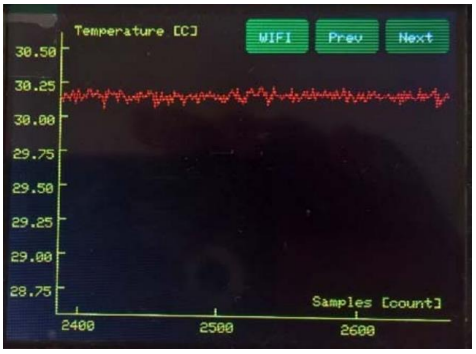

Fig. 8

The User Interface of the JavaScript based android app is shown in fig. 9.

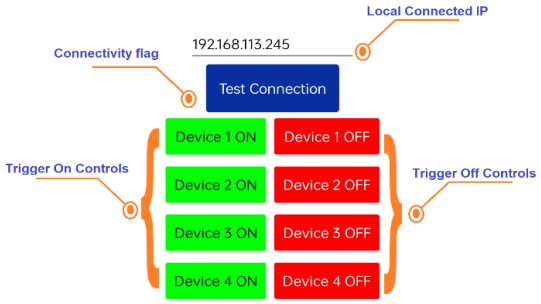

Fig. 9

The operations are performed successfully and are reflected over the serial monitor as shown in Fig. 10.

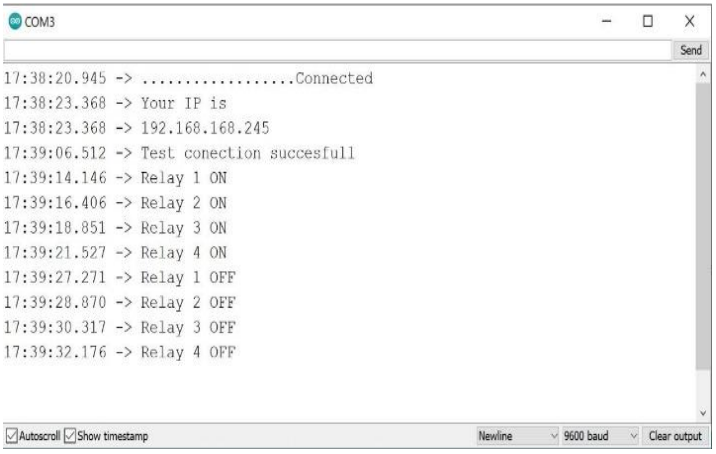

Fig. 10

VI. CONCLUSION

In this paper, it is discussed about the Internet of things and how it simplifies human life and makes a self-dependent system. The paper proposes a proof of concept of a besuited home system that can be easily adapted to a real house. This paper explains how the smart home mechanism is implemented using ESP32 and relays. Here it is described what physical components it needs, the communication between them, the architecture of the application, and details of implementing the mentioned functionalities.

VII. FUTURE SCOPE

After the pandemic [12] contactless devices are being appreciated on a larger scale & this paper also promotes hygienic automated control to the users. It found it's applications in facilitating physically challenged people for their day to day operations.

Along with its connectivity is concerned the follow up technological advancements such as introducing Long Range modules as a connectivity medium for applications in military operations and security deployments.

This paper aims to improvise security environment of embedded systems with almost negligible dependency on external libraries to prevent, inviting security breaches to the system.

Additionally, the Internet of things has a wide scope in the healthcare industry which provides massive medical facilities to doctors, patients and researchers as it minimizes the treatment cost and treatment of patients who are in a remote area also becomes possible.

VIII. REFERENCES

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