Seamless Smart Home Control using Mobile App with Voice and Auto Modes

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Abstract

IoT revolutionizes industries, enabling real-time monitoring, predictive maintenance, and energy efficiency. While the IoT integration requires careful planning, design, implementation, and testing. Home automation systems that incorporate IoT technology offer numerous benefits, including comfort, convenience, security, and energy efficiency. However, challenges such as installation and maintenance, security, and reliability must be addressed to ensure successful deployment. A unique potential solution is the use of budget-friendly and simple smart home automation systems that utilize Bluetooth technology and a smartphone application for remote control. These systems offer the advantage of being easy to install and maintain, with the potential for online integration and voice command features. Another solution is the use of IoT-based home automation systems that utilize Node MCU boards and a smartphone (Android OS) for remote control. These systems offer the advantage of being flexible and user-friendly, with the potential for environmental monitoring and intrusion detection via IR sensors.

Keywords

NodeMCU, Home Automation, LDR (light dependent resistor), Mobile app, Alexa, Android IoT Cloud

1. Introduction

IoT stands for the phrase Internet of Things, where all the tests taking place come from the fact that it is the way we are living, delivering, and operating not only in business but in many other industries. Instantly IoT can be an application through which a (plethora of objects) that are assigned to the internet of things are interconnected mutually, with the end result of making a smart social environment that makes living convenient and enjoyable. In consumer spheres, IoT applications include smart houses which have smart devices connected and automatically perform tasks such as turning on lights, TVs or heat in case of need, thus reducing he energy consumption and improving the security [1**?**]. [Industry sector consists of predictive maintenance systems, real-time tracking the equipment and products, and supply chain optimization, all of

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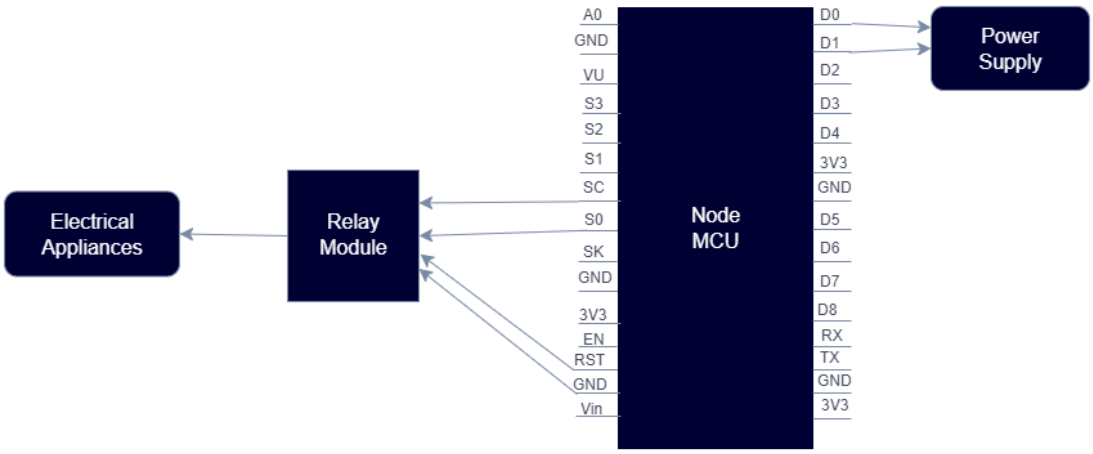

Figure 1: Circuit Design of Node MCU

these advances can be made by IoT. Just the phrase Internet of Things (IoT) itself demonstrates how this technical idea has hit the highest point nowadays. Hence, these connections involve millions of networked objects, devices, and systems interacting, communicating with each other, and exchanging data without any human intervention. Electronic gadgets may be in form of simple everyday items like household appliances and wearables to complicated items like industrial equipment and environmental sensors. In addition, IoT could be (tailored) to build innovations in different areas such as healthcare, transport, agriculture, and town planning. Organisations can derive valuable information from the device data that are connected through IoT whereby they could take better future steps and launch their new product lines and services [2]. IOT devices are commonly used in surveillance security applications and automation in agriculture also [3, 4, 5].

Existing IoT has a number of challenges, including security, power consumption, data privacy, user experience, and cost [6]. We addressed all of these issues in our work by ensuring that there are no security breaches, meaning that hackers cannot access personal information or take control of household devices, and by creating user interfaces that are simple to use and comprehend, even for those without a formal educational background. In terms of cost-effectiveness, we chose to use Node MCU rather than Arduino because it is less expensive and has Wi-Fi connectivity.The existing home automation systems address the issues related to traditional home management, such as lack of efficiency, convenience, and security. The proposed solution involves the seamless integration of NodeMCU, [7] an Android application, [8] and Firebase to create a user-friendly smart home system. This system offers users a comprehensive platform that enables remote appliance control, energy-efficient lighting, and real-time security alerts. Where Fig 1 shows you how different hardware were connected to Node MCU. To achieve the above things, we need necessary components for this work that are Node MCU (ESP8266), a light-dependent resistor (LDR) for detecting ambient light levels, relay modules for managing electrical appliances, a Wi-Fi module for enabling Wi-Fi connectivity for the Node MCU, microcontroller parts for connecting sensors and controlling relays, and a suitable power source

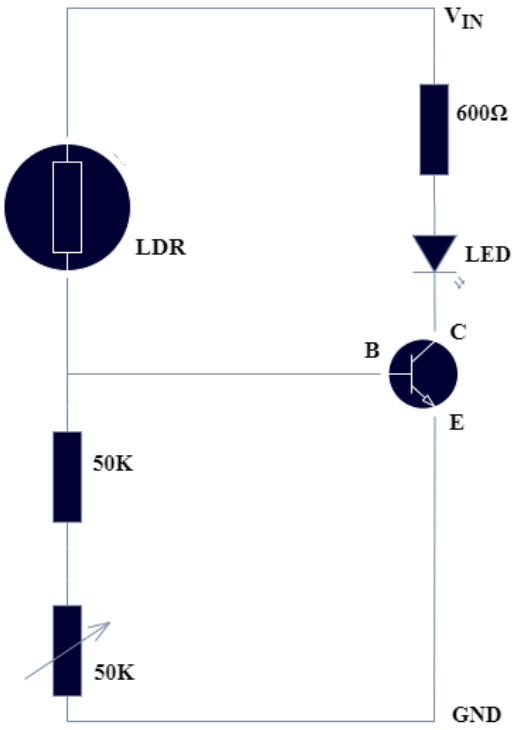

Figure 2: Circuit Diagram of LDR

for the Node MCU and its connected components. While coming to detail of each sensor, The ESP8266 Wi-Fi module serves as the foundation for Node MCU, an open-source development board and firmware. It enables easy programming and integration of Wi-Fi capabilities into IoT applications. The Node MCU functions as the primary Internet of Things device in this work, managing and keeping an eye on household appliances.

Alight-dependent resistor (LDR) operates based on photo conductivity. Photo conductivity is an optical phenomenon in which the material's conductivity increases. When Photons stimulate electrons in semiconductor material to conduction band. These photons in the incident light should have more energy than the semiconductor material's band gap to cause electrons to jump from the valence band to the conduction band. As a result, when high-energy light impacts the device, an increasing number of electrons are stimulated to the conduction band, resulting in a huge number of charge carriers. The result of this process as the circuit is closed, more current flows through the gadget, indicating a decrease in resistance [9].

Integration between hardware and software components involves numerous steps and considerations in which each role plays a great job to ensure seamless operation as a single unit. First it begins with the design of hardware components entitled to various utilities namely sensors, micro-controllers, actuators, and communication modules. These are the components carefully chosen and configured to meet requirements as per the size and cost of the work [**?** 10, 11]. Moreover, the next step in the development of IoT devices is software, where firmware is made

to manage hardware parts, gather valuable data from sensors, process data, and connect with other devices. Depending on the limitations of the hardware, programming languages like C, C++, Java, C#, or Python are frequently used for this purpose [12]. Communication protocols are essential for allowing Internet of Things devices to communicate with central servers and each other. Network Infrastructure, bandwidth, dependability, security, and other considerations are taken into account when selecting protocols such as HTTP, Android Applications, and proprietary ones [10, 13]. To guarantee the integrated hardware and software components operates as intended, testing and validation are essential. This includes validating against functional requirements and user expectations as well as unit testing, integration, efficiency, and safety testing. Successful integration of software and hardware components in IoT demands necessary planning, design, implementation, and testing [10]. The Scope of IoT has a wide range of applications in home automation, providing an array of features that are intended to turn living spaces into intelligent, networked areas. Controlling light systems is a key component of IoT home automation. Users of smartphones or voice commands can remotely control lighting with IoT capabilities, such as brightness, colour, and scheduling. In addition to ease of use, these systems provide security features like energy optimization based on occupancy patterns and natural light levels in daytime. Additionally, wearable technology, smart beds, and connected health monitors are some of the ways that IoT home automation supports wellness and health monitoring by offering insights into individual health metrics and enabling preventive care practices. The desire for smarter, more connected living spaces and technological advancements have led to an overall expansion of IoT in home automation. In section 2, we described literature review.

2. Literature Review

In this section we are discussing about the literature review of Seamless Smart home Control System.

T. M. Rubaith Bashar Sezan et. al (2019) [1] in this paper it outlines a smart home automation system which is budget friendly and has been especially designed towards simplicity, especially for developing countries. Adopting Bluetooth technology and a smartphone application, the system provides the users with an ability to control home appliances when away from home. The system does its job properly by adapting components like Arduino and relay switching circuits to make it fully cooperative with the given instructions. Disadvantages might be intimidating of installation and maintenance, but information technology is somehow and someway capable of standard users with little or no technical knowledge. Figure demonstrates core system structure which includes Arduino, Bluetooth modules and relay networks. The future plans include online integration for remote control and voice command features with the purpose of additional simplification of usage by both manual and voice control. Mostly speaking, the system could be seen as an appropriate remedy for home automated, which is certainly oriented at acquiring more features and upgrowth.

N. Singh et. al (2014) [2] in this paper it deals with the possibility of home automation systems being remotely controlled, and it is a question of the challenges to be faced and the issues solved using various network technologies. It illustrates the need to examine the home

Table 1
Analysis of various State-of-the-art works

Work details	Hardware components used	Technology used	Security used	Pros	Cons	Results & conclusion
[2]	ATMEGA 16 microcontroller, LCD Screen, Motion Sensors, VSPE (Virtual Serial Port Emulator)	Eclipse Helios editor, Java, MySQL, React Native	Yes	Low power consumption, a foolproof switching circuit, and complete security	No voice command support	Administering devices remotely, lowering power usage easy-to-edit switching circuit, enhanced efficiency and power savings
[7]	DHT-11,Ultrasonic, Touch and PTR sensor, Node MCU, LDR, Relay modules, Power supply	Blynk app	NA	Message alert, if any short circuit and power usage limit exceeds.	The automation can be used by anyone and not have a secure database	Node MCU and an Android phone is used to connect various sensors via a micro web server, enabling wireless operation or automation of home appliances through IoT technology.
[8]	Raspberry Pi, Pi-camera, Resistors	App Development	NA	The cost-effective system enables elderly individuals to set schedules for automatically turning home appliances on or off at their convenience.	The work does not support iPhone (iOS) and Windows Mobile user.	The objective of this work is to enhance home safety with monitoring systems and improve domestic life quality by using control buttons for targeted devices.
[14]	Arduino, Relay, GSM HC-5 Bluetooth Module, IR Remote	Arduino IDE	NA	home automation from anywhere and manual switching	Ethernet based, does not work on WI-Fi	Cost Effective, Bluetooth for mobile phone integration, and GSM's
[15]	Arduino UNO, HC-5 Bluetooth Module relays and I/O ports, Servo Motor Position control, LED lights, D.C Motor speed control	App Development	Yes	servo-motor position and speed of D.C motor control using smart phone.	Incorporation of voice recognition module, auto sensing system to check the status of various devices.	Utilizes Bluetooth modules for fast and reliable communication between the remote user and home devices.

environment first before devising automated systems in the long run and talks about unification of standards which lowers the barriers to the automation. Security, reliability and cost are definitely in the limelight when it comes to developing the system. Component designs is associated with two android phones, some laptops AS servers, micro controllers and switching circuits. It is possible to switch around home appliances by using the web interface or mobile application. Implementation aspects to be covered are software of micro-controller, relay circuits configuration, back-end server, and app design for Android based smartphones.

K. L. Raju et. al (2019) [7] in this paper discusses the theme of Internet of Things (IoT) in relation with the home automation technology which is mainly about connecting and monitoring different devices and sensors over the internet. It brings a design prototype which utilizes Node MCU Board and a smartphone (Android OS) for remote control. Node MCU acts as the system's aorta, allowing a micro web server to work and being an interface for hardware components. The system provides control of switching on and off of devices, environmental monitoring (e.g. temperature, humidity) and detection of intrusions via sensors. The control execution takes place via the Blynk app, resulting in offering a simple, user-friendly interface. Sensor instruments like DHT-11, ultrasonic, touch, and PIR sensors are connected and controlled through the Blynk app. Based on sensor data readings, notifications and alerts will be provided to the system owner. The work intends to offer a cheap and adaptable option for managing and monitoring homes that could be expanded through artificial intelligence and added amenities such as access control and voice command.

M. Nor Azni et. al (2016) [8] in this paper the work portrays a united innovation that is the undeniable home computerization framework fit for controller of gadgets like lights, fans, and entryways by remote means. Two strategies for control are illustrated: on an intuitive stage that incorporates a web server and an Android application. The Raspberry Pi works the machines remotely and as a correspondence part between your cell phone and the apparatuses. The framework tries to build the solace, comfort, and energy reserve funds, which will ultimately add to the bigger objective of cost reserve funds. The ecological viewpoints are limiting batteries' waste considered and welbeing highlights serve the uniquely able people as needs be. Another element gave is security framework and incorporated control which further advances the expanded expectations for everyday comforts. The framework can be moved up to help a telephone based applications which is an additional Benefit to the current framework.

A. Shinde et. al (2017) [14] in this paper the work begins with making an air conditioner machines control framework that depends on the utilization of IR remote, Bluetooth, and GSM advances to be worked by an Android application. The goal here is to limit the wastage of energy and improve on the typical approaches to controlling AC apparatuses. It handles the issue of home mechanization giving equivalent load to its effect in the present residing and furthermore energy preservation while focusing on the need of reasonable and simple to utilize devices. The proposed framework depends on Arduino control and coordinates different conveying modules, for example, getting signals from machine and sending orders to cell phones. Schematic charts and materials/strategies are given. A real execution and testing do by various kinds of Android gadgets. The framework's viability, materialness, and future turns of events, including the chance of adding more sensors or expanding computerization limit, will be talked about, to show its adaptability which might be reached out to different areas other than homes.

3. Proposed Methodology

The proposed smart lighting system is designed for convenience and automation, utilizing a NodeMCU ESP8266 microcontroller, jumper wires, a switch, a Hi-Link 220v to 5v converter, an LDR sensor, a relay module, and four light bulbs. Voice control through Alexa and remote management via the Arduino IoT Cloud dashboard are incorporated for user-friendly control options. Components and Functionality:

- NodeMCU ESP8226: Acts as the system's brain, enabling Wi-Fi communication with the internet and cloud services.
- Jumper Wires: Connect the various components, ensuring proper data flow and power supply.
- Hi-Link 220v to 5v Converter: Converts household AC voltage to a lower DC voltage suitable for powering the NodeMCU and other low-voltage components.
- Switch: Provides manual control for the lights.
- LDR Sensor: Detects ambient light levels for automatic light control.
- Relay Module: Controls the light bulbs based on signals from the NodeMCU.
- Light Bulbs: Demonstrates scalability by controlling multiple lights.

System Operation: Hardware Setup: Connect the NodeMCU to the jumper wires, which then connect to the Hi-Link converter for power supply. Further connections will be established between the NodeMCU and the LDR sensor, relay module, and the switch using jumper wires. Finally, the relay module will be wired to control the four light bulbs.

Software Programming: Program the NodeMCU using Arduino IDE to manage functionalities like reading sensor data, recognizing voice commands, enabling remote control, and providing manual control.

1. Component Acquisition: Procuring the necessary components like NodeMCU, jumper wires, converter, LDR sensor, relay module, and light bulbs.
2. Hardware Assembly: Setting up the hardware connections between the NodeMCU, LDR sensor, relay module, lights, and switch using jumper wires.
3. Software Development: Programming the NodeMCU with Arduino IDE to integrate various functionalities.

This smart lighting system combines readily available components and cloud services to provide a convenient and automated home environment with improved convenience, enhanced user experience, energy efficiency, scalability, and cost-effectiveness.Where Fig. 3 presents the operational flow of the Seamless Smart Home Control system, which is a cutting-edge system that enables remote control of household appliances via a mobile app that includes voice and auto modes. The system is built on NodeMCU, an open-source development board, and uses relay modules for appliance control and a light-dependent resistor (LDR) for ambient light detection. The IoT system integrates hardware design, software development, and communication protocols to streamline remote home appliance management, ensuring energy efficiency and user convenience [**?**]. Users can initiate commands through the mobile app or voice prompts, which are processed by the NodeMCU to operate appliances via relay modules. The LDR adjusts

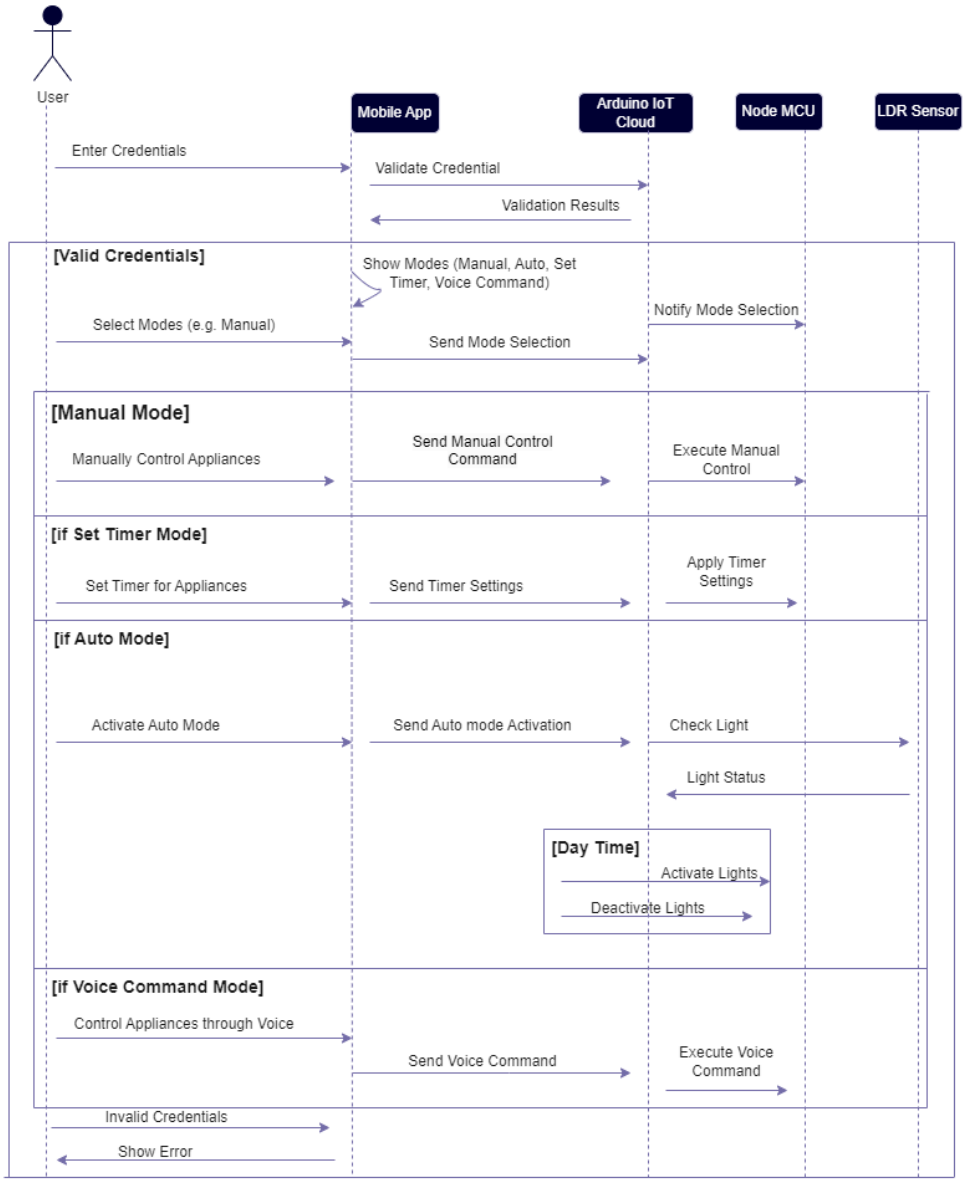

Figure 3: Control Flow Of Seamless Smart Home Control System.

lighting in auto mode based on ambient light, while a set timer mode allows scheduled appliance operation. Overall, the system provides a smart and efficient solution for remote management of household appliances.

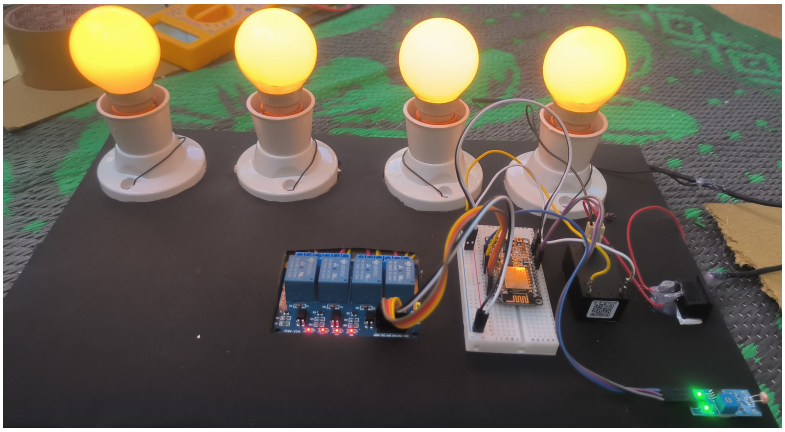

Figure 4: Experimental setup of seamless smart home control system

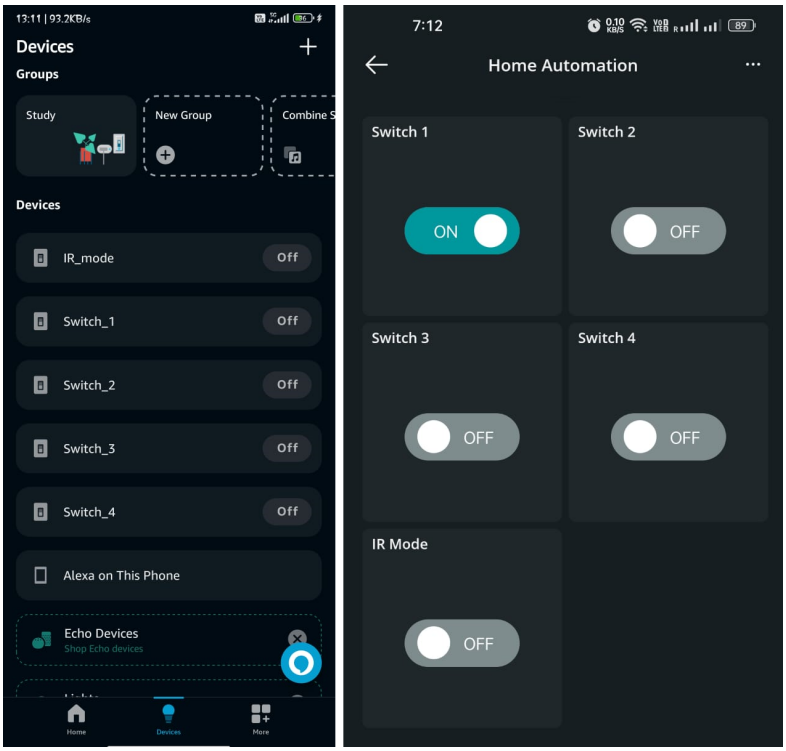

Figure 5: User Interface of Seamless Smart Home

4. Results and Discussion

The purpose of our Seamless Smart home control is used to control the home appliances like television, lights, fans, Air conditioner, etc through the Mobile app and through the voice control commands via mobile app. Our work results in different unique features like Manual mode

Table 2
Cost Analysis Comparison

Components	Developed System (INR)	Existing System (INR)
Hardware Components	800-1000	1918-2919
IOT monthly services	300-500	420-830
Hard-wired Connection	500	4200
Total Cost Analysis	1600-2000	6538-7949

where user can hit the switches to ON/OFF switches physically, SET TIMER MODE – where in this mode the user can set the time to Off and On the specific appliance in the scheduled time that the user has set, Auto mode – where the user selects this auto mode to control lightning , based on ambient light conditions and the last feature is Voice control mode - which can be accessed through voices like Alexa. This work is efficient as anyone can, which means the user who registers in this app can control their home appliances not only in the home but can control from anywhere in the world. And here we have used node MCU model instead of Arduino board where the Node MCU is capable of handling or controlling the advance technology like home appliances that are wifi portable. While coming to Security, only the actual user of the app can control or have the access to operate these devices through app but whereas, if that user wants any other person to access then that would also be possible by making certain changes in the settings and where the main user can list the people who can access and who cannot and can also remove them accordingly.

Node MCU is going to be heart of this work. Node MCU connects all the other instruments or systems and can control the whole system. It receives commands from the user via mobile application or through the sensors. And then it will make a decision based on the command the user will give then it sends the processed command to the relay switch and then, this relay switch can operate ON and OFF any device based on the command that user gives. Fig. 4 shows the hardware set up of Seamless Smart Home Control System.

To operate the system, we created the two user interfaces that were Fig. 5 and Fig. **??**. Where Fig. 5 interface was created with voice control features that had been integrated with an Alexa app. And Fig. 6 user interface was created in Arduino IoT Cloud Remote app. User can use any of the user interface to operate the system. We have tested the system and app in Realme X7, Samsung A31 and OnePlus Nord.

The comparison of cost analysis between developed system (Seamless Smart Home Control) and existing system [1] is shown in Table 2. By comparing the table data, we can say that this Wi-Fi portable Home based appliances system is much more cost effective.

5. Conclusion

The Seamless Smart Home Control is a mobile app that allows users to control home appliances like televisions, lights, fans, and air conditioners through voice commands. It offers unique features such as manual mode, set time mode, auto mode, and voice control mode. The work is efficient, allowing users to control their appliances from anywhere in the world. The Node MCU model is used instead of an Arduino board, allowing advanced technology like Wi-Fi-

portable appliances to be controlled. The Node MCU connects all other instruments and systems, receiving commands from the user via the mobile app or sensors. The cost analysis reveals that Seamless Smart Home Control is more cost-effective than existing systems, with components costing between 1600-2000 INR.

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