lot Based Home Automation System

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ABSTRACT

This project presents the overall design of Home Automation System (HAS) with low cost and wireless system. It specifically focuses on the development of an IOT based home automation system that is able to control various components via internet or be automatically programmed to operate from ambient conditions. In this project, we design the development of a firmware for smartcontrol which can successfully be automated minimizing human interaction to preserve the integrity within whole electrical devices in the home. We used Node MCU, a popular open source IOT platform, to execute the process of automation. Different components of the system will use different transmission mode that will be implemented to communicate the control of the devices by the userthrough Node MCU to the actual appliance. The main control system implements wireless technologyto provide remote access from smart phone. We are using a cloud server-based communication thatwould add to the practicality of the project by enabling unrestricted access of the appliances to the user irrespective of the distance factor. We provided a data transmission network to create a stronger automation. The system intended to control electrical appliances and devices in house with relatively low cost design, user-friendly interface and ease of installation. The status of the appliance would beavailable, along with the control on an android platform. This system is designed to assist and provide support in order to 1fulfil the needs of elderly and disabled in home. Also, the smart home concept in the system improves the standard living at home.

INTRODUCTION

Internet of Things (IOT) is a concept where each device is assigned to an IP address and through that IP address anyone

makes that device identifiable on internet. The mechanical and digital machines are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Basically, it started as the "Internet of Computers." Research studies have forecast an explosive growth in the number of "things" or devices that will be connected to the Internet. The resulting network is called the "Internet of Things" (IoT). The recent developments in technology which permit the use of wireless controlling environments like, Bluetooth and Wi-Fi that have enabled different devices to have capabilities of connecting with each other. Using a WIFI shield to act as a Micro web server for the Arduino which eliminates the need for wired connections between the Arduino board and computer which reduces cost and enables it to work as a standalone device. The Wi-Fishield needs connection to the internet from a wireless router or wireless hotspot and this would act as the gateway for the Arduino to communicate with the internet. With this in mind, an internet-based home automation system for remote control and observing the status of home appliances is designed.

Due to the advancement of wireless technology, there are several different types of connections are introduced such as GSM, WIFI, and BT. Each of the connection has their own uniquespecifications and applications. Among the four popular wireless connections that often implemented in HAS project, WIFI is being chosen with its suitable capability. The capabilities of WIFI are more than enough to be implemented in the design. Also, most of the current laptop/notebook or Smartphone come with built-in WIFI adapter. It will indirectly reduce the costof this system.

BACKGROUND

The concept of "Home Automation" has been in existence for several years. "Smart Home", "Intelligent Home" are terms that followed and is been used to introduce the concept of networking appliance within the house. Home Automation Systems (HASs) includes centralized control and distance status monitoring of lighting, security system, and other appliances and systems within a house. HASs enables energy efficiency, improves the security systems, and certainly the comfort and ease of users. In the present emerging market, HASs is gainingpopularity and has attracted the interests of many users. HASs comes with its own challenges. Mainly being, in the present day, end users especially elderly and disabled, even though hugely benefited, aren't seen to accept the system due to the complexity and cost factors.

PROJECT OBJECTIVES

Design of an independent HAS

To formulate the design of an interconnected network of home appliance to be integrated into the HAS. The objective to account for every appliance and its control to be automated and integrated into the network further formulated into the HAS.

Wireless control of home appliances (Switch and Voice mode)

To develop the application that would include features of switch and/or voice modes to control the applications.

Monitoring status of appliances

Being able to view the status of home appliances on the application, in order have a better HAS.

Secure connection channels between application and Node MCU

Use of secure protocols over Wi-Fi so that other devices are prevented to achieve control over the HAS. Secure connections are obtained by SSL over TCP, SSH.

Controlled by any device capable of Wi-Fi (Android, iOS, PC)

To achieve flexibility in control of the home appliances, and device capable of Wi-Fi connectivity will be able to obtain a secure control on the HAS.

Extensible platform for future enhancement

With a strong existing possibility of adding and integrating more features and appliances to the system, the designed system needs to be highly extensible in nature.

SCOPE

⇒ The aim is to design a prototype that establishes wireless remote control over a network of home appliances. The application is designed to run on android device providing features like, switch mode control, voice command control and a provision to view the status of the devices on the application itself. Considering its wide range of application, following are the scope of this prototype.

- \Rightarrow The system can be implemented in homes, small offices and malls as well, being in-charge of control of the electrical appliances.
- \Rightarrow For remote access of appliances in internet or intranet. The appliances in the above-mentioned environment can be controlled in intra-network or can be accessed via internet.
- ⇒ The development of technology friendly environment. The system incorporates the use of technology and making HAS. By the use of day-to-day gadgets we can utilize them for a different perspective.

PROJECT MANAGEMENT

Management of any project can be briefly disintegrated into several phases. Our project has been decomposed into the following phases:

ENVISIONED PHASE PLANNING PHASE	Information GatheringProject Initiation
MODELLING PHASE	 Hardware & software estimation Scheduling and distribution of task
	Analysis of projectDesign and architechture of project
CONSTRUCTIONPHASE	 Coding and hardware assembly Testing and Debugging
DEPLYOMENTPHASE	 Delivery of project Feedback

Figure 1. Model of phases in project management.

Experimentation

This phase involved discussions regarding necessary equipment regarding the project. The study of related already existing projects, gathering required theoretical learning. It also included figuring out the coding part, by developing simple algorithms and flowcharts to design the whole process

Design

This phase was, designing layout of the application, and the necessary features to be included. This involved the complete hardware assembly and installing the code to Node MCU. The power strip wasdesigned to connect the home appliances that can be controlled via GPIO pins.

Development and testing

This phase had the development of the application. The android device was connected to the NodeMCU via wireless network (WiFi) and the whole prototype was tested for identification and removalof bugs.

Real world testing

The prototype was ready to be tested into the real world and integrated with various real time electrical appliances.

OVERVIEW AND BENEFITS

The benefits of an established wireless remote switching system of home appliances include:

No legal issues

Obtaining access to or traversing properties with hard lines is extremely difficult.

Reduced wiring issues

Considering the increase in price of copper, thus increases the possibility of the wire to be stolen. The use of a wireless remote system to control home appliances means no wire for thieves to steal.

Extended range

As the system establishes control over Wi-Fi, it was a generally considered descent range. That is150 feet indoors. Outdoors it can be extended to 300 feet, but since the application is of a HAS, an indoor range is considered.

Security

As the connection of the control of the HAS is established over a secure network the systemensures security to the maximum extent.

Integrable and extensive nature

The prototype designed can be integrated to a larger scale. Also it has an extensive nature beingable to add or remove the appliances under control according to application.

Review of Literature

"Smart Energy Efficient Home Automation System using IOT", by Satyendra K. Vishwakarma, Prashant Upadhyaya, Babita Kumari, Arun Kumar Mishra.

This paper presents a step-by-step procedure of a smart home automation controller. It uses IOT to convert home appliances to smart and intelligent devices, with the help of design control. An energyefficient system is designed that accesses the smart home remotely using IOT connectivity. The proposed system mainly requires, Node MCU as the microcontroller unit, IFTTT to interpret voice commands, Adafruit a library that supports MQTT acts as an MQTT broker and Arduino IDE to code the microcontroller. This multimodal system uses Google Assistant along with a web based application to control the smart home. The smart home is implemented with main controller unit that is connected with the 24-hour available Wi-Fi network. To ensure, that the Wi-Fi connection donot turn off, the main controller is programmed to establish automatic connection with the available network and connected to the auto power backup.

"IOT Based Smart Security and Home Automation", by Shardha Somani, Parikshit Solunke, Shaunak Oke, Parth Medhi, Prof. P. P. Laturkar.

This paper focuses on a system that provides features of Home Automation relying on IOT to operateeasily, in addition to that it includes a camera module and provides home security. The android application basically converts Smartphone into a remote for all home appliances. Security is achieved with motion sensors if movement is sensed at the entrance of the house; a notification is sent that contains a photo of house entrance in real time. This notification will be received by the owner of the house via internet such that app can trigger a notification. So owner can raise an alarm in case of anyintrusion or he/she can toggle the appliances like opening the door if the person is a guest. The system uses Raspberry Pi, a small sized computer which acts as server for the system. The smart home consist two modules. Home automation that consists; fan light and door controller, and security module that consists; smoke sensor motion sensor and camera module.

"A Dynamic Distributed Energy Management Algorithm of Home Sensor Network for Home Automation System", by Tui-Yi Yang, Chu-Sing Yang, Tien-Wen Sung.

This paper proposes an optimization of home power consumption based on PLC (Power Line Communication) for an easy to access home energy consumption. This also proposes a Zigbee and PLC based renewable energy gateway to monitor the energy generation of renewable energies. ACSand DDEM algorithm are proposed for the design of an intelligent distribution of power management system to make sure ongoing power supply of home networks. To provide efficient power management the power supply models of home sensor network are classified groups viz. main supplyonly, main supply and backup battery, rechargeable battery power and nonrechargeable battery power. Devices with particular features are assigned to these groups. It targets to establish real time processing scheme to address variable sensor network topologies.

IOT (INTERNET OF THINGS)

IOT as a term has evolved long way as a result of convergence 1046

of multiple technologies, machine learning, embedded systems and commodity sensors. IOT is a system of interconnected devices assigned a UIDS, enabling data transfer and control of devices over a network. It reduced the necessity of actual interaction in order to control a device. IOT is an advanced automation and analytics system which exploits networking, sensing, big data, and artificial intelligence technology to deliver complete systems for a product or service. These systems allow greater transparency, control, and performance when applied to any industry or system.

Features of IOT

- Intelligence
- 📥 Connectivity
- 📥 Dynamic Nature
- Enormous Scale
- 📥 Sensing
- Heterogeneity
- 📥 Security

Advantages of IOT

- Communication
- Automation and Control
- Information
- Monitor
- Time
- Money
- Automation of daily tasks leads to better monitoring of devices
- Efficient and Saves Time
- Saves Money
- Better Quality of Life

Disadvantages of IOT

- \Rightarrow Compatibility
- \Rightarrow Complexity
- \Rightarrow Privacy/Security
- \Rightarrow Safety
- \Rightarrow Lesser Employment of Menial Staff
- \Rightarrow Technology Takes Control of Life

Application Grounds of IOT

✓ Wearables

- ✓ Smart homes
- ✓ Health care
- ✓ Agriculture
- ✓ Industrial Automation
- ✓ Government and Safety

IOT Technologies and Protocols

- Bluetooth
- Zigbee
- Z-Wave
- Wi-Fi
- Cellular
- > NFC

IOT software

IOT software addresses its key areas of networking and action through platforms, embedded systems, partner systems, and middleware. These individual and master applications are responsible for data collection, device integration, real-time analytics, and application and processextension within the IOT network. They exploit integration with critical business systems (e.g., ordering systems, robotics, scheduling, and more) in the execution of related tasks.

- Data Collection
- Device Integration
- Real-Time Analytics
- Application and Process Extension

BLOCK DIAGRAM

Block diagram of the proposed system



Figure: Block diagram of proposed system.

The block diagram gives the functionality of the overall project. The Node MCU unit is the microcontroller or the main controlling unit of the system. The user uses the mobile application in setting commands for functioning of the appliances. The mobile application interprets the command form in user in voice or switch mode and sends signal to the Node MCU unit, over a wireless network established by Wi-Fi communication. Hence the Wi-Fi module (actually inbuilt into Node MCU), helps the microcontroller establish Wi-Fi communication with a device and take commands from an application over wireless network. The Node MCU on further receiving the signal then turns on/off the appliance with the help of relay. The Node MCU, relay and the final appliances are physically connected. There is a power supply unit that powers the microcontroller, the relay as well as the final appliances. There is also a display unit that displays the status of the application.

Proposed system

The android OS provides the flexibility of using the open source. The inbuilt sensors can be accessed easily. The application used to control the system has the following features. Android Phone acts as a client and data are sent via sockets programming. The application takes command from user in twodifferent modes.

- **Switch mode:** Switch mode uses the radio buttons that are used to control the home appliances. The radio button sends the status of the switch.
- Voice mode: Voice Mode is used to control the home appliances using voice command. Using the inbuilt microphone of Smartphone, the application creates an intent that fetches the speech data to the Google server which responds with a string data. The string data are further analysed and then processed.

More detailed discussion about the modes of control and how they actually control the system is discussed if coming chapters.



FLOW CHART

Figure 25. Flow chart of prototype function.

This flow chart shows the working of the project. The process starts be initializing the Wi-Fi, the network name and password are written in the code and uploaded to Node MCU. The android device connected to Node MCU over Wi-Fi. The Blynk server is set up and connection is made, the devices is identified in the Blynk server using the generated authentication token. The command for controlling the load is given to the application, and this command, over Wi-Fi network is sent to the Node MCU.

PRINCIPLE AND OPERATION

Node MCU is an open source IOT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoCfrom Espressif Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espress if Non-OS SDK for ESP8266. It uses many open-source projects, such as lua-cjson, and spiffs.

Advantages of Node MCU

- Low cost, the Node MCU is less costly compared to any other IOT based device.
- Node MCU has Arduino Like hardware I/O. It is becoming very popular in these days thatArduino IDE has extended their software to work in the field of ESP 8266 Field module version.
- Node MCU has easily configurable network API.
- Integrated support for Wi-Fi network: ESP 8266 is incorporated in Node MCU, which is aneasily accessible Wi-Fi module.
- Reduced size of board.
- Low power consumption.

Disadvantages of Node MCU

- The operation of the circuit depends on the working internet connection. If the workinginternet connection is not available then it will not run.
- Node MCU also depends on the free server provided by the third party, if the free server isnot working then it will not run.
- > Node MCU has less resources of official documentation

- Need to learn a new language and IDE
- Reduced pinout
- Scarce documentation

BLYNK APPLICATION

The Blynk application was designed for the primary purpose of Internet of Things. **Blynk** is a platform with IOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where graphic interface for a prototype can be built by simply dragging and dropping widgets. It can control hardware remotely, it can display sensor data, can store and visualize data and possessed a lot more functionality. There are three major components in the platform:

- **Blynk Application:** allows to you create amazing interfaces for your projects using variouswidgets we provide.
- Blynk Server: responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynk server locally. It's an open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.
- Blynk Libraries: for all the popular hardware platforms enable communication with theserver and process all the incoming and outgoing commands.

Every time a radio button is accessed in the Blynk application, the message travels to the Blynk Cloud, where it finds the specific hardware by the unique generated authentication token. It works the same way for the opposite direction.



Figure 26. Working principle of Blynk application.

WIRELSS COMMUNICATION NETWORK

The prototype aims to wireless control over home appliances with the technology of IOT. As discussed earlier, IOT supports various wireless communication protocols, like Bluetooth, Z-Wave, Zigbee etc. this prototype uses Wi-Fi as wireless communication network to establish remote access over home appliances. This is because Wi-Fi has its own advantages over other wireless communicationprotocols.

Advantages of Wi-Fi over other wireless technologies like Bluetooth and ZigBee

Bluetooth is generally used for point-to-point networks and Bluetooth operates at a much slower rate of around 720 Kbps which is very small for video transfer or moving large amount of data like the image captured from a camera, whereas the bandwidth of Wi-Fi can be up to 150Mbps and very ideal for video transmission.

Wi-Fi is very much secure means of communication than Bluetooth.

Wi-Fi connection to send video, audio, and telemetry operation, while accepting remote control commands from an operator who can be located virtually anywhere in the world.

Robots are already being eyed for obvious tasks like

conducting search-and rescue missions during emergencies or hauling gear for soldiers in the jungle or woods. The mechanics of the robot uses the concept that has been developed to ensure robust navigation, search and transportation in rough terrain.

STANDARD	BLUETOOTH	UBW	ZIGBEE	WI-FI
IEEE specification	802.15.1	802.15.3a	802.15.4	802.11a/g/b
Frequency band	2.4 GHz	3.1-10.6 GHz	868/915 MHz; 2.4 GHz	2.4 GHz; 5 GHz
Maximum signal rate	1 Mb/s	110 Mb/s	250 Kb/s	54 Mb/s
Nominal range	10 m	10 m	10-100 m	100 m
Nominal TX power	0-10 dBm	-41.3 dBm/MHz	(-25) -0 dBm 10-20 dBm	
RF channels	79	1-15	1/10; 16	14 (2.4 GHz)

Channel bandwidth	1 MHz	500 MHz- 7.5 GHz	0.3/0.6 GHz; 2 MHz	22 MHz	
Modulation type	GFSK	BPSK, QPSK	BPSK (+ASK), O- QPSK	BPSK, QPSK, COFDM, CCK, M-QAM	
Spreading	FHSS	DS-UBW, MB- OFDM	DSSS	DSSS, CCK, OFDM	
Co-existence mechanism	Adaptive frequency hopping	Adaptive frequency hopping	Dynamic frequency selection	Dynamic frequency selection, transmit power control	
Basic cell	Piconet	Picomet	Star	BSS	
Extension of basic cell	Scattemet	Peer-to-peer	Cluster tree, Mesh	ESS	
Maximum cell nodes	8	8	>65000	2007	
Encryption	E0 Stream chipper	AES block cipher (CTR, counter mode)	AES block cipher (CTR, counter mode)	RC4 stream cipher (WEP), AES block cipher	
Authentication	Shared secret	CBC-MAC (CCM)	CBC-MAC (extention of CCM)	WPA2 (802.11i)	
Data protection	16-bit CRC	32-bit CRC	16-bit CRC	32-bit CRC	

Table 3. Comparison chart of Wi-Fi with other wireless communication protocols.

VOICE MODE CONTROL

The prototype works in both switch mode and voice mode of control. The switch mode is simply be accessing the radio buttons on the Blynk application, and the process of control has beendiscussed earlier in this chapter in the section before. Here we will discuss the voice mode control of the prototype. We use application IFTTT and Google assistant on smart phone to achieve controlby voice commands. IFTTT stand for 'If This Then That', is an interface that provides web-based service in which devices are connected to mobile application.

We cannot connect the Google Assistant to the Node MCU directly, and that is the only reason we are using the Blynk app. Blynk app can directly connect to the Node MCU and send datato it. So, if we can send the voice commands interpreted by Google assistant directly to the Blynk app, the Blynk app can then forward those commands to the Nedelcu. But the problem is GoogleAssistant cannot directly understand foreign commands like "turn on the fan" or "turn on relay one" etc. on its own. So, to solve this we use another intermediate application/website called 'IFTTT'.

Simply, to control our home appliances over the internet we are using Node MCU and to connect Node MCU with the home appliances we use a relay board. Now to send on or off signals to the Node MCU we use our smartphone, and we do this using the Blynk app. But we want to sendthe on or off signals using voice commands. To do this we use google assistant in our smartphone and an app called IFTTT.

So, in the end what will happen is, when we say a voice command like "ok google turn on the light" to the Google Assistant, Google Assistant sends that this foreign command to IFTTT. IFTTTinterprets this command and sends an on or off signal to the Blynk app via the Blynk Server. Blynk will then send this signal to the Node MCU and then to our electrical appliances.



Figure 27. Voice and switch mode control.

COST ESTIMATION

SL. NO	COMPONENTS	QUANTITY	PRICE
1.	Node MCU	1	₹350
2.	4 channel relay board	1	₹120
3.	9V battery	1	₹50
4.	LED	4	₹8
5.	2.2K Ω Resistor	4	₹4
6.	Blank PCB (KS100)	1	₹40
7.	Male pin header	1	₹5
8.	Female pin header	1	₹5
9.	Jumper wires	8	₹40
10.	USB Cable	1	₹50
Total			₹672

Table 4. Costing of Project

Conclusion and Future Scope

RESULT

The experimental model was made according to the circuit diagram and the results were as expected. The home appliances could be remotely switched over Wi-Fi network. Both the switch mode and thevoice mode control methodologies were successfully achieved. The Blynk application was also successful in displaying the status of every application.

LIMITATIONS

Android devices having lower API version than 16 requires internet access to convert the speech data to string data. Currently, the application is made for Android Smart Phones; other OS platform doesn't support our application. During voice mode, external noises (voice) may affect our result. Thespeech instruction that we command in our voice mode may not give exact result as expected. There hence lies an ambiguity in result.

FURTHER ENHANCEMENT AND FUTURE SCOPE

Looking at the current situation we can build cross platform system that can be deployed on various platforms like iOS, Windows. Limitation to control only several devices can be removed by extendingautomation of all other home appliances. The prototype can include sensors to implement automatic control of the home appliances like; an LDR that can sense daylight and switch lamp accordingly, a PIR to detect motion and be used for security purposes making an alarm buzz, or a DHT11 sensor that's senses ambient temperature and humidity of atmosphere and switch fan/air conditioner accordingly. Scope of this project can be expanded to many areas by not restricting to only home, but to small offices

CONCLUSION

It is evident from this project work that an individual control home automation system can be cheaplymade from low-cost locally available components and can be used to control multifarious home appliances ranging from the security lamps, the television to the air conditioning system and even the entire house lighting system. And better still, the components required are so small and few thatthey can be packaged into a small inconspicuous container. The designed home automation system was tested a number of times and certified to control different home appliances used in the lighting system, air conditioning system, home entertainment system and many more . Hence, this system isscalable and flexible.

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