IoT Based Smart Home Automation System Over The Cloud

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Abstract: Due to the rapid development in the field of the Automation industry, human life is becoming more advanced and better in all aspects. In the present scenario, Automated systems are being preferred over the non-automated system. With the rapid growth in the number of consumers using the internet over the past years, the Internet has become an important part of life, and IoT is the newest and emerging internet technology. Internet of things plays an important role in human life as well as in the educational field because they are able to provide information and complete the given tasks while we are busy doing some other work. The proposed system consists of a hardware interface and software interface. In the hardware interface, the integration of ESP8266 Wi-Fi technology for controlling home appliances and sensors is manifested, and an application is provided for controlling to multiple users of home, with smart phones, tablets, and laptops. This system is one of the best methods for controlling home devices with ease with multiple users and one of the best method for an energy management system. The access to the whole system is given by its admin only to different users. This system is also expandable for controlling various appliances used at home and also for the security and safety purpose of the home through sensors as long as it exists on Wi-Fi network coverage. Home automation is based on multimodal application that can be operated using voice recognition command of the user using the Google Assistant or through a web based application. Thus, main objective of this work is to make our home automation system more secure and intelligent.

I. INTRODUCTION

Human-machine interaction (HMI) has become, the more realistic in day-to-day life due to the advancement in the technology. Today, HMI research has moved one step ahead and switched onto the Internet, which was previously used for communication and now used for things, i.e., IoT (Internet of Things). The aim of this application is to connect any things through the Internet that can be accessible from anywhere. IoT application are not limited to one particular field. It has shown the significant contribution from small scale applications to the large scale applications such as, Ecommerce, Coal Mine, Wearable device, Smart Grid, Laboratory Monitoring, Agriculture and many other domains. Though, we have received tremendous improvement in the technology, but still power consumption is one of the big issue all over the world. As per report, the Information and Communication Technologies (ICT) alone uses 4.7% of the world's electricity, which may likely to be increased to 10% as per report. India, share about the 17% of the world population has limited energy resources and share roughly 0.6%, 0.4% and 7%, for world gas, oil and coal reserves respectively.

However, in India, the electricity consumption due to ICT usage has increased from 24 TWh to 31 TWh in the last five years (for the period 2009-2014). This has resulted in electricity consumption of roughly 6.5% in 2015. Thus, saving of the power is the main concern, which is the basic aim of this project. To save the power consumption, we have proposed the smart, energy efficient home automation system using IoT. Thus, aim of this research to save the power consumption (reducing the electricity bills) and at the same time provide the safety and security of the home equipment's

II. SMART HOME AUTOMATION SYSTEM

As demand for electricity is increasing day-by-day, therefore, smart home is the upcoming area of research to provide the remote access for controlling the home appliance using IoT. IoT based application has also provided the boom for old aged people and the person having some sort of disability. This allows the user to control the home automation device such as fan, bulb etc., without even making any physical connection. Home automation using MQTT is presented in for sending/receiving data from the sensor. For this Raspberry pi is used as a gateway for accessing the data from the sensor which are used to measure the temperature and humidity of the room. Another home automation system is presented in which are based on Raspberry pi and user can control their home appliance using the web-based interface. In home automation using mobile is reported in which system is designed using ZigBee. IoT has provided the applications to turn non-smart device into smart device, which allow users to access these devices through the Internet. It converts the home into smart home and provides a more robust method of controlling the home appliance. Also, the security can be added with the help of installed camera in the home, which can be traced through the Internet. Thus, user can monitor their home and can turn ON/OFF their appliances which will definitely going to save both the electricity and electric bill. Other features that can be included in the smart home for security purpose is to include the sensors and cameras that can prevent the intruder from entering into your home. Also, making the system more intelligent, that can turn on the light and fan of the room as soon as it detects the presence of the person With this motivation, we develop IoT based home automation system which uses voice as well as web-based service for controlling the home appliance. Also for security purpose, the user-define command are set which enables to operate the system.

III. SYSTEM DESIGN AND IMPLEMENTATION

Speech is one of the most important inputs used for man- machine interaction. Therefore, to make smart home more user friendly, Google assistance along with web based application can be used to control the home system. The advantage of multimodal is that in the presence of the noisy background surrounding the performance of the Google assistance degrades. Hence, in such scenario web based application can be helpful in controlling the appliance of the system. Thus, the proposed

model is designed to provide better flexibility and making the system more robust. Figure 1 shows the general architecture of the smart home automation system.

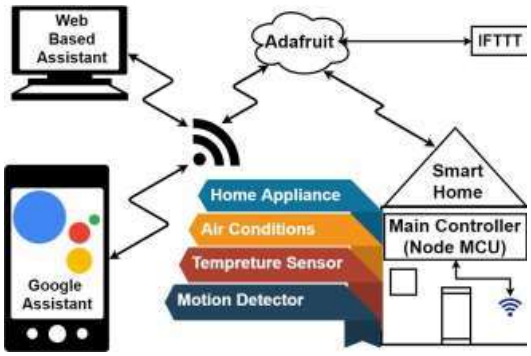

Figure 1 Smart home automation system architecture

As shown in the Figure 1 the smart home can be implemented with main controller unit (Main switching of the home circuit) that is connected with the 24-hour available Wi-Fi network. To ensure, that the Wi-Fi connection do not turn off, the main controller is programmed to establish automatic connection with the available network and connected to the auto power backup. Further, the sub-units are connected with the main controller so that the devices which are not smart (here in this case we are referring to the old home appliance system) can be turned into the smart appliance. Thus, users can access and controlled their smart home using Google assistant and web based service using an IoT based application that uses Adafruit and IFTTT to maintain the communication link.

IV. BLOCK DIAGRAM OF THE SYSTEM

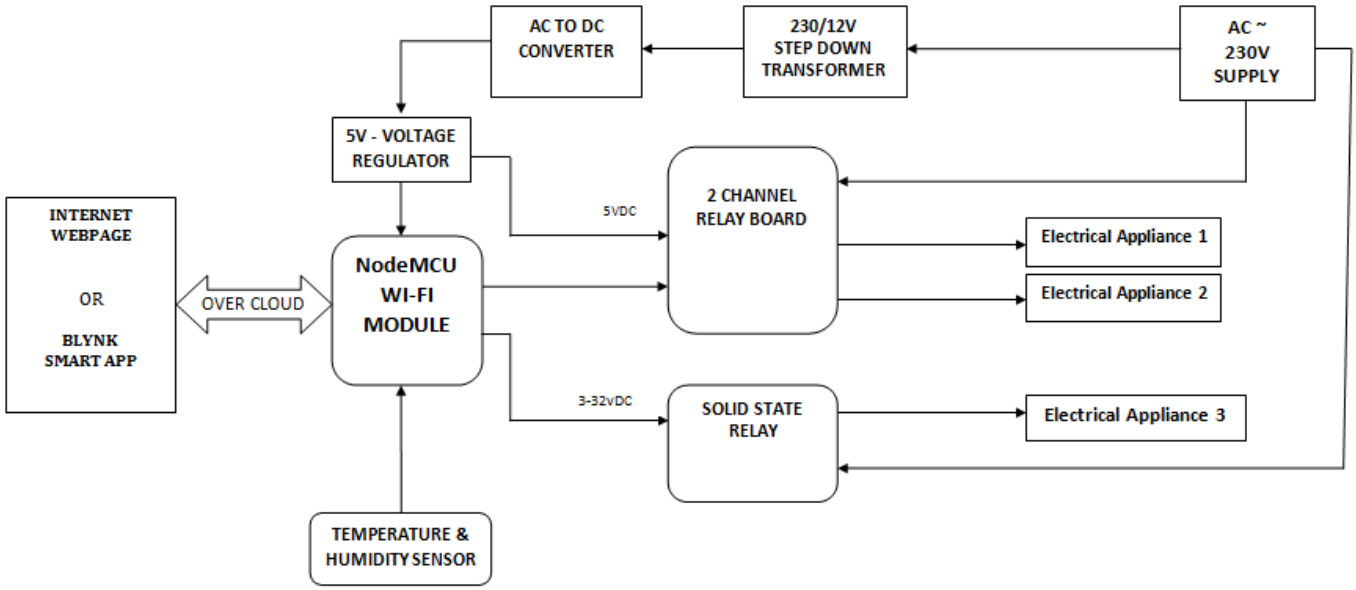

Figure 2 Block Diagram of the System

V. COMPONENTS REQUIRED

5.1 NodeMCU ESP8266 Wi-Fi controller board

NodeMCU has a 32-bit Tensilica Xtensa LX106 core clocked at 8 MHz's It is a self-contained Wi-Fi networking solution that acts as a bridge between existing microcontrollers to Wi-Fi and is capable of running self-contained applications. NodeMCU can easily connect to components, such as sensors and actuators, through its integrated built-in 20 kb of RAM, 10 GPIOs, 4 megabytes of on-board storage, and TCP/IP.

Figure 3 NodeMCU ESP8266

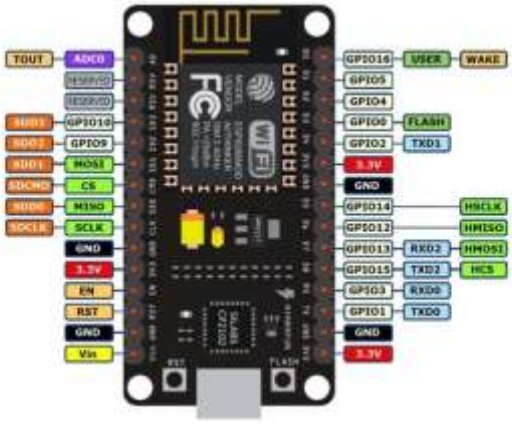

Figure 4 ESP 8266 Pin Diagram

A built-in USB connector links to the computer using a USB cable to upload the codes, which is similar to other development boards available in the market, such as Arduino and Raspberry Pi. Compared with Arduino UNO, NodeMCU has many other good features, such as low cost, simplicity, smartness, a built-in power regulator, and a powerful processor.

5.2 6-channel 5 V DC relay module

A 6-channel 5 V DC relay module is used in this study to perform the switching of various actuators, such as fans, lights, and pumps. The relay is energized or reenergized based on the received signals from the NodeMCU, which receives the commands from the user or the sensors. The relay board overcomes the limitation of the control voltage generated by the controller, and 3.3–5 V DC voltage is used to control 240 V ac appliances.

Figure 5. 6-channel 5 V DC relay module

5.3. DHT11 temperature sensor

A DHT11 temperature sensor is used because of its advantages, such as low cost, long-term stability, excellent quality, fast response, strong anti-interference ability, long- distance signal transmission, digital signal output, relative humidity and temperature measurement, and precise calibration. This temperature sensor is used to detect the temperature and humidity of the

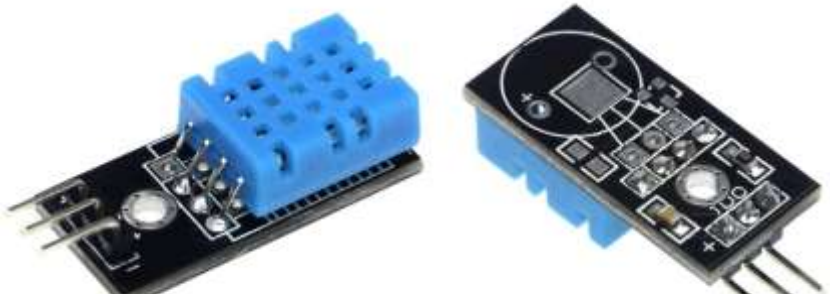

Figure 6 DHT Sensor

room. It triggers the buzzer when the temperature is higher than the room temperature. It also sends data to the NodeMCU, which sends a command to switch ON the air conditioning (AC) system in the real implementation of the system. convection is applied (with maximum centrifugal fan speed).

5.4. Solid State Relay 40DA & 60DA

Figure 7 Solid State Relay 40DA & 60DA

Owing to their nature, solid state relays contain no moving parts. Because no mechanical contacts are opened or closed within the relay, there is no arcing or pitting of contact surfaces, thus no wear-out mechanism. As a result, solid state relays can operate for many millions of turn on/turn off cycles with no deterioration in performance. The majority of solid state relays require much less power than electromechanical types to turn them on and are easily interfaced to PLCs. For example, solid state relays can be constructed to turn on with a control current as low as 1 milliamp, although 5 to 15 milliamps are more typical for most standard types, at control voltages as low as 3 Vdc. Another advantage of having no moving parts: solid state relays offer a very fast response time with absolutely no contact bounce

5.5 Adafruit.IO

Figure 8 Adafruit.IO

Adafruit.IO (Figure 8) is an open-source and free IoT server that utilizes the data. Adafruit.io is easy to use and allows simple data connection with minimal programming. In this study, Adafruit.io is used as the IoT server for our system to monitor home conditions and control home appliances through the Internet with MQTT protocol. The sensing data, which include sensor measurements and relay status (ON or OFF), are uploaded to the server through the NodeMCU microcontroller. The command is sent to the NodeMCU through the MQTT server when users remotely control the system using their laptops or smartphones. The

NodeMCU sends a signal to switch ON/OFF to the relay switches based on what the users pressed on Adafruit.io web GUI using their fingertips**.**

5.6 MQTT

MQTT is a TCP-based publish messaging protocol designed for lightweight machine-to-machine communications. At present, these IoT devices and sensors communicate with each other on the back end without human knowledge. MQTT is originally developed by IBM based on a hub-and-spoke model. Basically, an MQ broker is required to enable MQTT. The MQ broker is a full-featured, message-oriented middleware broker that allows clients to send short one-hop messages to the broker and receives messages when they subscribe to a certain topic. Furthermore, IFTTT is utilized in the software development of our project. This free web-based service is used to create chains of simple conditional statements called applets. An applet is triggered by the changes that occur within other web services. In this project, IFTTT operates on Adafruit IO web that uses a platform to send notifications to the user's smartphone when an abnormal situation is detected by Adafruit IO. In addition, it is used to connect Adafruit with Google Assistant. For example, a notification is triggered through IFTTT when the temperature sensor exceeds the normal value. Users can obtain up-to-date information on their house through IFTTT. Users can use Google Assistant to control their home appliances.

5.7 Arduino IDE

Arduino IDE is an application that is used to write codes and uploads them to the NodeMCU board. In this project, Arduino IDE is used for coding, debugging, and testing the functionalities of the IoT smart Home Automation system and its components. Arduino IDE has other features, such as a debugging area in case of abnormal conditions to support various Arduino boards, additional libraries, and a serial monitor for communicating with the board. Arduino libraries are usually expressed as dot CPP files based on software abstraction called wiring. Wiring allows the easy control of hardware ports through simple functions without
consulting data sheets and being delayed in pin mapping. Thus, Arduino uses the bits of C and C++, but the general flow and structure of the code are heavily based around C.

VI. CIRCUIT DIAGRAM

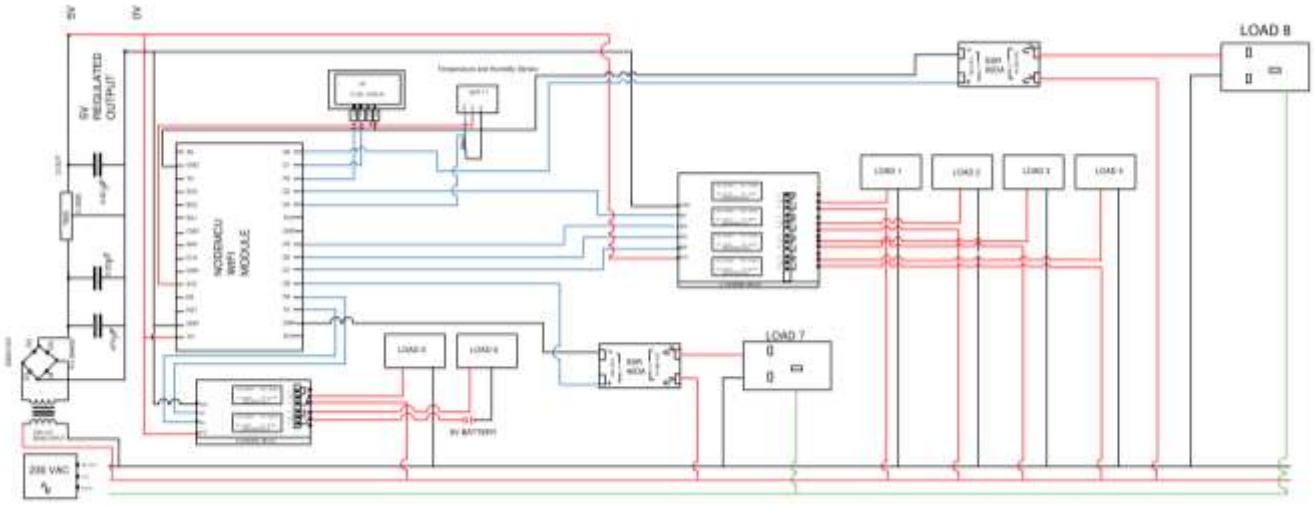

Figure 9. Circuit Diagram of the system

VII. WORKING MODEL

The working of the smart home automation is shown in Figure 11. As shown, initial requirement is the Internet connectivity to access your smart home. One can access their smart home either through the web based service or through Google assistance. After successful connection, users will be able to access their smart home appliance using an IFTTT statement command. It will be accessed through the Adafruit for creating the connectivity between the Google assistant and the NodeMcu which is the main control unit of the smart home automation. The home appliance is connected to the main controller unit with the sets of relay. The functions of these relays are to act as an ON/OFF switch on the main control unit.

Initially, Google assistant is used for controlling/monitoring our smart home and in case of noisy background home automation can be connected through web based service. For security purpose we have provided the user access code that will be asked by the Google assistant to verify which will prevent unauthorized smart home access In this paper we have shown the example of the main control unit that we have designed for your smart home. Figure 11 shows the connection of the main unit with the NodeMcu. For continuous operation of the circuit, power backup is also provided with the help of rechargeable battery. Figure 10 shows the IoT home automation dashboard developed on Adafruit.

Figure 10 IoT home automation dashboard developed on Adafruit

Finally, with the help of Google assistant, based on the Finally, with the help of Google assistant, based on the user command the home appliance can be turned ON/OFF with the help of the designed system as shown in Figure 6. Here, we have shown the example of turning the three bulbs. However, any home appliance can be connected through th proposed control unit.

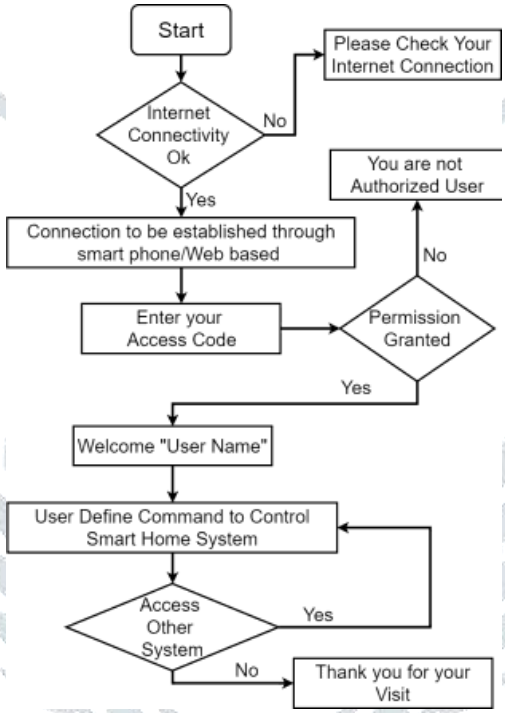

Figure 11 System flow on the smart home automation system using Google assistant

VIII. EXPERIMENTAL RESULTS AND VALIDATION

This section presents the results to verify the functionalities of the implemented Home Automation system in the prototype. Thus, Smart Home Automation System successfully controls home appliances (lights, doors, pumps, fans, and others) and monitors various stimuli, such as temperature, humidity, and motion using mobile phones/laptops through Adafruit IO, MQTT Dash, and Google Assistant. Users can monitor and control the Smart Home System prototype anytime and anywhere by connecting to the Internet. One of the achievements of this study is the utilization of artificial intelligence in controlling home appliances by enabling Google Assistant voice commands to help people with disabilities. Users have multiple options by developing multi-dashboards and can utilize any device by connecting to the Internet regardless of time and location to monitor and control the home.

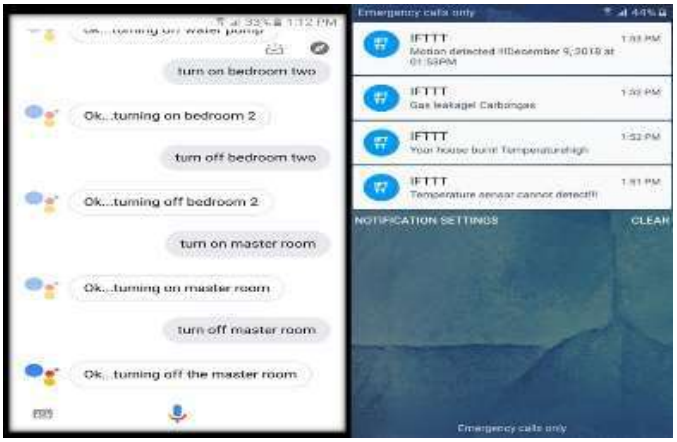

Figure 11 (a) Google Assistant and (b) IFTTT notification

Google Assistant is an add-on functionality that enables the control of home appliances using voice commands, as demonstrated in Figure 11 (a). Furthermore, all utilized sensors can be used in the next step to fully automate the light and home appliances to reduce energy consumption. The data obtained from the sensors are utilized for subsequent processing to increase the safety and security of Smart Homes. IFTTT is utilized with Adafruit IO to define the limits for abnormal sensing data and sends notifications to users 'smartphones when these values exceed the predefined limits. For example, the bar color changes from yellow to blue when the gas sensor exceeds the value of 650, the data are sent through IFTT, and a notification is sent to the user's smartphone, as shown in Figure 11 (b). A DHT22 sensor can detect abnormal temperature that may be due to a fire at home, and Adafruit sends feeds to IFTTT to notify users on their smartphones when the temperature exceeds the threshold. The motion sensor can detect any motion at the main entrance and notifies the residents. Such functionality can increase the safety and security of Smart Homes.

The effectiveness of the developed system is validated by evaluating its functionalities on the Smart Home prototype. All electrical appliances and sensors can be controlled and monitored using Adafruit IO, MQTT Dash, and Google Assistant. Maintaining rapid and accurate reading of the sensors is one of the issues encountered during the testing phase in this study. Using NodeMCU as the controller in our project was an advantage and a challenge at the same time. In existing home automation systems, several microcontrollers, such as Arduino Mega, Arduino UNO, Raspberry Pi, and NodeMCU, have been utilized.

IX. Conclusion and Future Work

In this paper, we have presented the step-by-step procedure of smart home automation controller unit. With the help of the design control unit, home appliance can be converted into a smart and intelligent device using IoT. The developed Smart Home Automation system can be easily implemented in a real house to allow real-time monitoring of home conditions and control of home appliances. Several sensors and actuators were connected to the NodeMCU controller, which updated the data to the IoT server The obtained data from the sensors can be monitored via MQTT Dash mobile application and Adafruit IO Web via laptops/PC. For security and safety purposes, the user receives notifications on their mobile phones about any abnormal condition at home via the IFTTT server. Control of home appliances can be easily and efficiently conducted by using MQTT/Adafruit IO GUI or through voice commands using Google Assistant. The results of this study are promising, and the developed system can increase the safety, security, intelligence, and comfort of users. Proposed system has two advantages. First, using the IoT connectivity, we can monitor and access our smart home easily from anywhere, which will definitely will prove to be energy efficient. Secondly, it acts as a helping hand for the old age and differently abled person. The proposed system can be expanded with additional sensors and actuators. The developed system can also be improved to make it suitable for future commercialization. We can optimize all circuits using printed circuit boards to save space and minimize the risk of connection losses or short circuits.

X. References

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