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Research Article

DESIGN AND DEVELOPMENT OF IOT BASED SMART ENERGY MANAGEMENT SYSTEM

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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 can provide information and complete the given tasks while we are busy doing some other work. This paper presents a prototype and implementation of an IoT based sensing and monitoring system for smart room automation (SRA) with Wi-Fi technology. The proposed design uses the ESP RainMaker with AIoT Cloud software and it is fully integrated into the AWS serverless architecture, which allows building, developing and deploying customized AIoT solution. The SRA system consists of a hardware interface and software interface. In the hardware interface, the integration of ESP with ESP32 Rainmaker Wi-Fi technology for controlling fan, light and projector from remote location using smart phone app, Alexa, IR & Manual Switch. The mobile application has provided for controlling access to multiple users of room with smart phones, tablets, and laptops. This system is one of the best methods for controlling room devices with ease with multiple users for an energy management system. Its admin user gives the access to the Energy Management system to different users. This system is also expandable for controlling various electrical items in the classroom.

Keywords: *IoT, Wi-Fi, AWS*

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Introduction

Automation has become one of the key interests in the modern-day technology. Everybody tends to use automated devices in his or her daily activities due to several reasons ranging from safety to ease of handling. Initially, the automation systems were limited to industries as it required significant investments, but with the development of the technology, automation has become available to everyone. Room automation systems are very popular in the world these days. Room automation involves introducing a degree of computerized or automatic control to certain electrical and electronic systems in a building for lighting, temperature control, security systems, garage doors, *etc.* A hardware system is installed to monitor and control the various appliances. The system would control the appliances based on its configuration. For example, it could automatically turn on the lights at a specified time or a person enter in the room or it could measure the ambient light using a hardware sensor and turn on the lights when it grows dark. It can also allow a person to control appliances from a remote location, such as over the internet. A typical home automation system allows one to control house hold appliances via a centralized control unit. These appliances include lights, fans, air conditioners, television sets, security cameras, electronic doors, computer systems, audio/visual equipment, etc. This project demonstrates a system that can be integrated into a room electrical system and allows one to remotely control lights, fans, and turn on or off any appliance that is plugged into a wall outlet. The system could be controlled via a Bluetooth or Wi-Fi enabled device such as a mobile phone and Alexa, IR & Manual Switch. As part of the systems configuration, it can automatically turn ON/OFF sockets at predetermined times such as 6:00PM to 9:00 A.M. The aim of this project is to develop a room automation system that could ease to operate and complete control over all electrical system in the classroom remotely.

Literature Review

The past 30 years has witnessed automation become increasingly common in non-industrial environments, such as private homes (smart homes), hospitals, and service areas. With the invention of the microcontroller, the cost of electronic control fell rapidly. Remote and intelligent control technologies were adopted by the building services industry and appliance manufacturers worldwide, as they offer the end-user easily accessible and/or greater control of their products. In an intelligent home automation system, there are many possible solution for how and form where to control the automation system and single device a user interface can be a computer-based system a mechanical switch a single light a loudspeaker with a microphone or a some kind of personal remote controller using normal PC, laptop or table PC by standalone software or web-based user interface. Soon all electronic appliances in a home will be networked [1, 2]. The internet of things (IOT) is the network of physical objects or “Things” embedded with electronics, software, sensors, and network connectivity, which enable these bjects to collect and exchanging data. IOT allows objects to be sensed and controlled remotely oacross existing network infrastructure, creating opportunity for more direct integration between the physical world and computer-based system, and resulting in improve efficiency, accuracy and economic benefits. This paper proposes a Home Automation system that employs the integration of multi-touch mobile devices, cloud networking, wireless communication, and power-line communication to provide the user with remote control of various lights and appliances within their home. This system uses a consolidation of a mobile phone application, handheld wireless remote, and PC based program to provide a means of user interface to the consumer [3, 4]. Objective of this Paper is to design and implement a control and monitor system for smart house. Smart house system consists of many systems that controlled by software as main controlling system.

The smart room automation system was connected to the internet to monitor and control the room equipment's from anywhere in the world using software [5]. The prime objective of this paper is to assist people to control the system from remote location. It gives basic idea of how to control various home appliances and provide a security using Android phone /tab. The design consists of Android phone with home automation application, Arduino Mega ADK [6, 7]. User can interact with the android phone and send control signal to the Arduino ADK which in turn will control other embedded devices/sensors [8, 9].

Proposed Class Room Automation System

The proposed study has designed to reduce the wastage of electricity in lecture room. While moving around in corridors of academic blocks, number of unoccupied classrooms during lunch hours at which no classes are noticed with switched ON lights, fan, computer , projector and audio system etc. due to negligence of users resulting in more energy loss in terms of electricity. This motivated to us to propose an IoT enabled, automated smart classrooms for optimized utilization and control of electric energy without going for infrastructural system redesign just by using low power ad-ons for existing classrooms using sensor technologies and relay circuits. The proposed system will be able to automatically detect the identification of students in the classroom using motion detection sensor. The IoT based Smart energy system using ESP32 device, which enables or disables the current flow for entire switch board based on the input received from motion detection sensors in terms of human identification. With the help of motion sensors, the system can take decisions in automatic shutdown of all fan and light in a classroom. In addition to this the switch can be controlled using controlling fan, light and projector from remote location using smart phone app , Alexa, IR & Manual Switch.

Material and methods

ESP32 IoT project using ESP RainMaker with ESP32, sensors and relays are used to control electrical items. The ESP32 will automatically connect with the ESP RainMaker IoT cloud if the WiFi is available. Then the user can control the lights and fan speed from anywhere in the world through the internet.The user can control the relays with IR remote and manual switches without WiFi. If the Wi-Fi is available, the ESP32 will automatically connect with the Wi-Fi. when the control pins of the relay module receive the LOW signal the relay will turn on and the relay will turn off for the HIGH signal in the control pin.

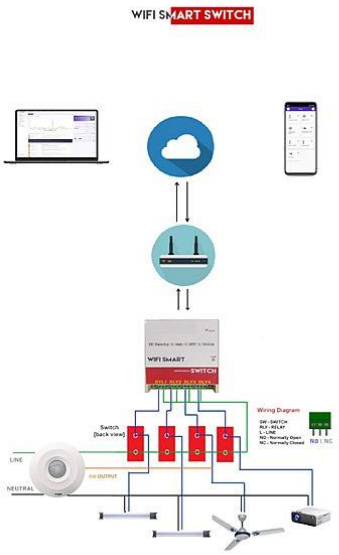


Fig-1 IoT Based Smart Energy System

ESP RainMaker Workflow

The ESP32 is programmed with ESP RainMaker firmware, and QR code will be generated using ESP32. The generated QR Code can be scanned using the ESP rainmaker app. The app will initiate Bluetooth Low Energy communication with the ESP32 SoC. After connecting with the ESP32, we can start provisioning the SoC by providing the WiFi credentials. The ESP32 will establish the connection to the ESP RainMaker Cloud through the WiFi and transfer the relevant data. ESP32 will be connected to the cloud and data can be communicated using cloud service or the mobile app.

Smart Energy Device

The figure shows the smart energy device installed in the lecture hall. The device have a control two lights, fan and power supply.

Fig-2 Smart Device

Components Required

For designing of smart energy system the following components are used. The Components are ESP32, relay module, switches, jumper cables , breadboard ,PCB Board , IR Receiver, 12V DC Adaptor.

Circuit Diagram

5-volt supply to ESP32, the relay module and the sensor and the switches are connected across the GPIO pins and ground pins.

WiFi Connection

The blue LED glowing on ESP32 then it indicates that ESP32 is connected to WiFi Network.

Control Switches with Mobile App

Using Rainmaker app, to control the light and FAN switches

Google Assistance

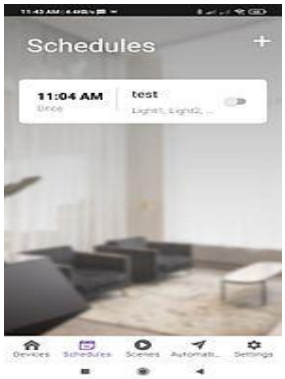
The user can control it with Google Assistant and Alexa. "Hey Google, turn on switch-1". You can see the light turned on. "OK Google, turn on switch-3" we can give multiple commands at once to google assistant. "Hey Google, turn off switch-1 and switch-3". As you can see the led bulbs connected to switch-1 & Switch-3 are off.

Control Appliances with Amazon Alexa

The user can control the switches with Alexa. "Alexa turn on switch 2 and Switch 4". you can see the light turn on. and I can also easily turn on and off all the lights with a single command. "Alexaturn on all switches". "Alexa, Turn off all the switches" As you can see all the lights turn on and off together. Using Alexa or Google assistant supported device then the user can control appliances from them directly.

Control Appliances with Manual Switches

We can use manual switches to control lights ,fan and projector. The user can turn off the Wi-Fi manually after turning off the Wi-Fi the use can view the blue LED turn OFF. So, the user can control the switches manually. let me turn on the Wi-Fi again. if the Wi-Fi is available, the ESP32 will automatically connect with Wi-Fi and the blue LED will turn on.



Add Automation on ESP RainMaker

The user can set the predefined time schedule to control the relay automatically. To create a time schedule, first click “add schedule“. Give a name of the schedlue, then click ok. Now select a time. The user can also repeat this automation 2nd . 3rd relay and 4th relay to turn on.

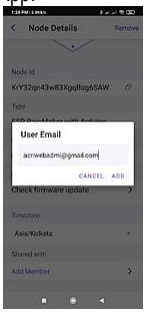
Control Appliances with IR Remote

The following settings are made to operate the fan, light and projector.

Number	Setting
1	Fan on
2	Light on
3	Light on
4	Projector on
5	Fan off
6	Light off
7	Light off
8	Projector off
Help	All switches off
Infor	All Switches on

Multiple User Access

The admin user can give permission to other user to control fan, light and projector using ESP Rainmaker App.



Notification

The user can receive the notification if the fan , light and projector is on/off.

PIR Motion Sensor

when people walk into the sensor range, and the sensor can detect the spectral change of the human body infrared ray,during this time, the switch will connect the load automatically until the person leaves the sensor range.

Automatic Control

Salient Findings

The Room automation IoT project to control fan and light and projector with Mobile App, Alexa, IR Remote and manual switches. The user can monitor the real-time feedback and the sensor readings on smartphone from anywhere in the world. The user can control the switches manually when there is no internet. It saves electricity cost.

Product values

The IoT device can be used for our various features of lives and enhance comfort of individuals. To analyse the impact of efficiency of our product can be calculated for 90 days are estimated. To do so, we first calculate the electricity cost of running a traditional 100w fan for the whole summer (90 days, 10 hours per day) in classroom. Energy costs Hours used 900 Energy consumption(Kw) 90kW Price (kWh) 0.35 Electricity cost Rs.6 Our smart product might be able to reduce this electricity cost by 50%. Comparing our estimated product price and the potential cost saving shows a significant gap. Specifically, more than 10 years electricity saving is required to justify the price. Thus, it can be argued that the electricity cost saving cannot attract customers and other values such as customers’ comfort should be the focus which can affect our pricing model as well.

Conclusion

In this paper, we have presented the systematic 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 working of the proposed model was experimentally shown with help of connecting the three bulbs. 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 act has a helping hand for the oldage and differently abled person. For future work we would like to add up more controlling units that can make our smart home more intelligent that can be practically deployed in the real time situation.

Application of research: Our life is becoming more comfortable and smarter with the help of rapid upgrade of technology. Internet of things (IoT) is playing a massive role in this. One of the major sides of IoT is a smart home. As we are in the era of never-ending growth of the internet and its application, smart room automation system is highly increasing to provide comfort in life and improving the quality of life.

Research Category: IoT Based Automation system

Abbreviations: IoT - Internet of Things

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Ethical Committee Approval Number: Nil

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