IOT-BASED ENERGY-EFFICIENT HOME AUTOMATION SYSTEM

A

Minor Project

Submitted in partial Fulfilment for the award of the degree of

BACHELORS OF TECHNOLOGY

IN

Computer Science Engineering

By

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CERTIFICATE

This is to certify that the work titled "IOT-BASED Energy Efficient Home Automation System" submitted by "Mohd. Tahzeeb Khan, (BETN1CS21011) & Sweksha Sikarwar (BETN1CS21021)" in partial fulfilment for the award of the degree of B.Tech. (CSE), ITM University, Gwalior has been carried out under my/our supervision.

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I with this declare that the work entitled "IOT-BASED Energy Efficient Home Automation System" submitted to the Department of Computer Science Engineering, School of Engineering and Technology, ITM University, Gwalior (M.P.) is our work done under the supervision of Guide name. The dissertation doesn't contain any part which has been submitted for award of any degree either in this University or in any other University.

We further declare that the work is free from any plagiarism.

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Acknowledgement

Firstly, I thank Lord Almighty for making it possible for me to complete this work. The success and outcome of this project required a lot of guidance and assistance from many people, and I am incredibly privileged to have got it all along with the completion of my project. All that I have done is only due to such supervision and assistance and I would not forget to thank them.

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Atlast but not least we would like to thank our parents who trusted us and helped us through the errand.

Abstract

The development and implementation of an energy-efficient smart IoT-based home automation system, leveraging advanced technologies including the ESP32 microcontroller and a variety of sensors. The system's main aim is to improve user comfort, convenience, and sustainability by seamlessly integrating motion sensors, light sensors, humidity sensors, and temperature sensors into a unified framework controlled by the ESP32 microcontroller.

The ESP32 microcontroller serves as the core processing unit, offering low power consumption and high computational capabilities. The system's ability to connect with a wide range of sensors and peripheral devices allows for real-time data collection and analysis, enabling the implementation of intelligent decision-making to optimize energy efficiency. Motion sensors detect occupancy and movement, enabling automated lighting control for energy savings. Light sensors adjust ambient lighting based on natural light levels, promoting energy conservation and user comfort. Humidity and temperature sensors provide valuable environmental data, enabling proactive measures to maintain optimal indoor climate conditions while minimizing energy expenditure. By utilizing these technologies, our system empowers homeowners to create intelligent environments that prioritize energy efficiency, comfort, and sustainability.

Contents

LIST OF ABBREVIATIONS

CSE – Computer Science Engineering

HOD – Head of department

IOT- Internet of things

WSN- Wireless Sensor Network

GSM-Global System for Mobile Communications .

IDE- Integrated Development Environment

HVAC- Heating ,Ventilation and Air Conditioning

USB- Universal Serial Bus

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Chapter 1 INTRODUCTION AND OBJECTIVES

1.1 INTRO

The Internet of things (IOT) is defined as an environment where all the devices communicate with each other without the interaction of human-to-human or human-to-computer.

In some ways, the Internet of Things (IoT) is laying the groundwork for a smart, computerised future. Computing will be integrated into everything as a result of ubiquitous computing, operating automatically and without human intervention. Usually, in our homes we have sockets and switches for power outlets with wired connections. To operate any home appliance one has to move physically and operate. If we are away from home then we are unable to control or keep an eye on the appliance's current condition. In this context Internet of things (IoT) offers a platform that can allows objects to be identified, linked, and remotely accessed or managed via a wireless network architecture.

Different home appliances, like lights, fans, air conditioners, electronic security systems and other devices can now automatically link thanks to the Internet of Things. Things that are working under IOT have the ability to sense, collect and share data over network from any part of the world where that data utilized for various purposes. Internet of Things (IoT) can make our lives easier by introducing the concept of Smart Homes. Smart home automation system facilitates its users with the power to control their electrical appliances with their single click on their mobile phones.

One of the main advantages of introducing IOT based Smart home is user can reduce the wastage of energy, electrical power and can improve the living environment. Furthermore, through smart home user can monitor energy consumption of appliances on daily basis. Once users know the status of unit consumption, they will put effort to reduce it ultimately result in less electricity bills.

1.1.1 Origin

The concept of the Internet of Things (IoT) dates back to the late 20th century, when forward-thinking researchers began to imagine a world where everyday objects could be interconnected and communicate over the internet. Mark Weiser's notion of ubiquitous computing, suggested in the 1980s, established a foundation for the idea of interconnected devices that could seamlessly integrate into our lives. The development of Radio-Frequency Identification (RFID) technology during the 1990s allowed objects to be uniquely identified and tracked wirelessly, while the emergence of wireless sensor networks (WSNs) in the early 2000s further advanced the concept. In 1999, while working at the Auto-ID Center at MIT, Kevin Ashton, a British technologist, coined the term "Internet of Things" envisioning a future where objects would be equipped with sensors and connected to the internet to facilitate communication and data exchange. These early innovations and concepts paved the way for the rapid growth and adoption of IoT technologies in the following decades, revolutionizing industries and reshaping the way we interact with the world around us.

1.1.2 Usage area of IOT

The usage areas of IoT are diverse and continuously expanding as technology evolves. Some prominent usage areas of IoT include:

1. Smart Home Automation: IoT enables the creation of smart homes where appliances, lighting, heating, and security systems are interconnected and can be controlled remotely via smartphones or voice commands.

2. Industrial Internet of Things (IIoT): In industries, IoT devices are utilized for asset tracking, predictive maintenance, remote monitoring of equipment, and optimizing production processes to increase efficiency and reduce downtime.

3. Healthcare: IoT devices such as wearables, remote patient monitoring systems, and medical sensors facilitate remote healthcare monitoring, personalized treatment plans, and early detection of health issues.

4. Smart Cities: IoT technologies are employed to improve urban infrastructure and services, including smart transportation systems, waste management, energy management, environmental monitoring, and public safety.

5. Agriculture: In agriculture, IoT sensors collect data on soil moisture levels, temperature, humidity, and crop health to optimize irrigation, fertilization, and pest control, leading to higher yields and resource efficiency.

6. Retail: Retailers use IoT for inventory management, supply chain optimization, personalized marketing, and enhancing the in-store shopping experience through technologies like beacons and RFID tags.

7. Energy Management: IoT devices monitor energy consumption in buildings, homes, and industrial facilities, enabling users to optimize energy usage, reduce costs, and integrate renewable energy sources effectively.

8. Transportation and Logistics: IoT-enabled tracking devices and sensors are employed in vehicles, shipping containers, and logistics networks to monitor location, condition, and status of goods, enhancing supply chain visibility and efficiency.

9. Environmental Monitoring: IoT sensors monitor air and water quality, pollution levels, and weather conditions to provide valuable data for environmental conservation efforts and disaster management.

10. Smart Wearables: Wearable IoT devices such as smartwatches, fitness trackers, and health monitors track users' activity levels, vital signs, and sleep patterns to promote health and wellness.

11. Smart Building Management: IoT systems manage building operations, including lighting, HVAC, security, and occupancy monitoring, to optimize energy usage, enhance comfort, and ensure safety.

12. Fleet Management: IoT solutions track vehicles, optimize routes, monitor driver behavior, and facilitate maintenance scheduling for improved fleet management and operational efficiency.

1.1.3 Challenges And Consideration

The Internet of Things (IoT) poses numerous challenges and factors that necessitate cautious attention for its effective implementation and extensive adoption. Prominently among these challenges are security and privacy concerns, resulting from the interconnected nature of IoT devices and the potential for cyber-attacks and data breaches. Another significant challenge arises from interoperability and standards, as the diverse array of devices, protocols, and platforms in the IoT ecosystem can obstruct seamless integration and data exchange. Scalability and manageability are also key considerations, as organizations grapple with the complexities of provisioning, configuring, and maintaining extensive IoT deployments. Data management and analytics present challenges in handling the vast amounts of data generated by IoT devices and deriving actionable insights from it. Reliability and resilience are crucial, particularly in mission-critical applications, necessitating measures to mitigate disruptions and maintain uptime. Regulatory compliance adds another layer of complexity, as organizations must navigate a complex landscape of regulations governing data privacy, security, and environmental considerations. Ethical and social implications, such as data ownership, consent, and societal impact, require careful consideration to ensure the responsible and equitable deployment of IoT technologies. Addressing these challenges and considerations calls for a collaborative and holistic approach involving stakeholders from various domains to unlock the full potential of IoT while mitigating risks and maximizing benefits.

1.2 OBJECTIVES

The main objectives of an energy-efficient IoT-based smart home automation system are primarily focused on enhancing convenience, reducing energy consumption, improving security, and providing comfort to homeowners.

Our project has two main objectives:

1.2.1 Energy efficiency:

Our primary goal is to optimize energy usage within the home by automating heating, ventilation, air conditioning (HVAC) systems, lighting, and other appliances to operate only when needed and at optimal levels. We will also integrate energy-efficient appliances and devices into the system to further minimize consumption.

By integrating smart technology into these systems, such as smart thermostats, occupancy sensors, and energy-efficient appliances, homeowners can achieve precise control over their energy consumption. For instance, smart thermostats can learn household routines and adjust temperature settings accordingly, minimizing HVAC usage during periods of low occupancy or when outside temperatures are moderate. Additionally, motion sensors and smart lighting controls can ensure that lights are turned off in unoccupied rooms, reducing unnecessary electricity usage.

By integrating energy-efficient appliances, further efficiency can be achieved by minimizing the energy consumption of devices. Through careful automation and the use of energy-efficient technologies, homeowners can significantly reduce their energy bills while maintaining comfort and convenience within their homes.

1.2.2 Cost savings:

By reducing energy consumption, our smart home automation system aims to lower utility bills, resulting in cost savings for homeowners over time. Real-time monitoring of energy usage and providing insights into where energy is being consumed can empower homeowners to make informed decisions about their usage habits.

Reducing energy consumption through a smart home automation system not only contributes to environmental sustainability but also yields tangible cost savings for homeowners. By implementing energy-efficient measures and optimizing the usage of heating, ventilation, air conditioning (HVAC) systems, lighting, and appliances, the system aims to lower utility bills over time.

Real-time monitoring of energy usage allows homeowners to gain insights into their consumption patterns, identifying areas of inefficiency and opportunities for improvement. For instance, they can pinpoint devices or behaviors that contribute to high energy consumption and take corrective actions, such as adjusting settings, scheduling operation times, or replacing outdated appliances with more energy-efficient alternatives. With access to detailed energy usage data and insights provided by the automation system, homeowners can make informed decisions to optimize their energy usage habits, ultimately leading to significant cost savings on utility bills in the long run. This empowerment to manage and control energy consumption not only benefits the household financially but also fosters a sense of environmental responsibility and sustainability.

Chapter 2 LITERATURE SURVEY

Most of the papers included in this section are from developing countries, indicating that IoT is considered to improve their quality of life, as well as fill the gap with developed countries. Many research papers present various methods for home automation. Each of these has some distinctive features as well as some drawbacks. Some of these papers are discussed further below:

A. Mustofa, Y. A. Dagnew, P. Gantela, and M. Javed Idrisi et al., (2023) [2] conducted a study on "SECHA: A Smart Energy-Efficient and Cost-Effective Home Automation System for Developing Countries".

SECHA is developed with the goal of being energy-efficient, simple to use, and open-source for everyone's benefit. It incorporates Wi-Fi and GSM technology, enabling remote monitoring and control of appliances and developed using an ESP32 microcontroller equipped with Wi-Fi and GSM SIM800. They connected all the sensors to a single ESP32, which sends data to the Android app developed via a real-time database, making the system as cheap, energy-efficient, and simple to implement as possible. In the event of an emergency, the system could use GSM SIM800 to send SMS notifications even without an Internet connection.SECHA is dedicated to tackling affordability, power outages, and unstable internet connections in developing countries with a smart, energy-efficient, and cost-effective home automation system. Drawing from previous research, which emphasizes the significance of low-cost solutions for enhancing quality of life in such regions, SECHA leverages IoT technology, automatic energy management systems, and greenhouse monitoring. Components like the ESP32 microcontroller, alongside sensors such as the DHT11, MQ2 Gas Sensor, and LDR Sensor, are frequently employed in IoT-based systems for monitoring and control in these contexts. By amalgamating these technologies and approaches, SECHA endeavors to offer accessible solutions that could profoundly impact the lives of individuals in developing nations, mitigating challenges and fostering sustainability.

EEDC: An Energy Efficient Data Comummication Scheme Based on New Routing Approach in Wireless Sensor Networks for Future IOT Application

LEACH (Low Energy Adaptive Clustering Hierarchy): It's a popular clustering-based protocol for wireless sensor networks (WSNs). LEACH aims to reduce energy consumption by using randomized rotation of cluster heads among sensor nodes. It forms clusters and elects cluster heads, which collect data from cluster members and transmit it to the base station. LEACH-C (Centralized LEACH) centralizes the cluster head selection process to improve energy efficiency. M-LEACH (Mobile LEACH) introduces mobility to the cluster heads, allowing them to move strategically to balance energy consumption and prolong network lifetime.

EEDC Scheme (Energy Efficient Data Communication)

Region-based Hierarchical Clustering for Efficient Routing (RHCER): This proposed scheme utilizes hierarchical clustering, where clusters are formed based on the geographical region. It helps in efficient routing by reducing the overhead of cluster formation and maintenance. By organizing nodes into clusters based on their physical proximity, RHCER minimizes communication distances, thus reducing energy consumption.

Improved Chain-based Cluster Head Rotation (ICCHR): This algorithm aims to enhance energy efficiency and load distribution in WSNs. It organizes cluster heads in a chain-like structure, where each cluster head communicates with its neighboring cluster heads in a sequential manner. This approach reduces energy consumption by minimizing long-distance communication and ensuring that the workload is evenly distributed among cluster heads. Additionally, it facilitates efficient data aggregation and routing.

A Cost Effective Smart Home Automation System Using Node Mcu .

The Internet of Things (IoT) has revolutionized the way we interact with our environments, enabling remote control and monitoring of various devices from anywhere in the world. Utilizing platforms like NodeMCU, which is built on the ESP8266 microcontroller, alongside relay components, IoT enthusiasts and developers can create cost-effective and scalable home automation solutions. The NodeMCU, programmed using the Arduino IDE, serves as the brains of the operation, allowing the ESP8266 to connect to wireless networks and function as a web server. This integration facilitates practical and secure control over a wide range of electrical devices, enabling users to remotely access and manage appliances with ease. Whether it's adjusting room temperatures, turning lights on or off, or scheduling appliance usage for energy efficiency, this automation framework provides a seamless and customizable experience. By harnessing the power of IoT and the versatility of NodeMCU, homeowners can not only enhance convenience but also exercise greater control over their energy consumption, contributing to a more sustainable and efficient living environment.

A Simple Smart Home Based On Iot Using Nodemcu And Blynk

The Internet of Things (IoT) encompasses the connectivity of devices and tools to the internet network, enabling remote control via websites, smartphone applications, and automated algorithms. In advanced systems developed using Python algorithms, connectivity via Wi-Fi or Ethernet links tools, equipment, and devices to be managed remotely. While IoT is commonly associated with smart home applications such as controlling lamps, its scope extends to security and industrial systems. For instance, it can manage security gates, operate industrial machinery, or regulate internet and communication ports. This research proposes an energy-saving solution for industrial or governmental institutions with extensive lighting needs. By integrating switches throughout the building and utilizing the Blynk application, security personnel can remotely control the lighting, reducing energy consumption. The research presents a simple prototype demonstrating the feasibility and cost-effectiveness of implementing IoT-based solutions for load control via Wi-Fi connections, with broader implications for academic and practical applications.

IOT-BASED HOME AUTOMATION USING NODE MCU ESP8266

Limited internet infrastructure in Papua poses significant constraints on conducting research related to the Internet of Things (IoT) and home automation.

This limitation necessitates pioneering efforts to overcome infrastructure challenges and initiate research projects aimed at implementing IoT technologies in the region.

The research methodology likely involved gathering data on existing infrastructure, internet availability, and the specific needs and challenges of the region regarding home automation.

Based on the collected data and identified requirements, researchers would have designed a miniature or a conceptual framework outlining the proposed home automation system tailored to the conditions and constraints of Papua.

This step involves the actual implementation of the designed system in a physical or digital prototype form, integrating various components and technologies to demonstrate the functionality of the proposed home automation system.

Lights: The lights are the output components of the system, controlled based on inputs received from sensors or user .

Relays: Relays are electromechanical switches used to control the flow of electricity to devices such as lights or appliances. They enable remote or automated switching of these devices.

Buttons: Buttons may be incorporated into the prototype to allow manual control or override of the automation system, providing users with additional flexibility and convenience.

The Blynk application serves as the user interface for controlling the home automation system.

Through the Blynk app installed on a smartphone, users can remotely monitor and control the connected devices, adjust settings, and receive notifications or alerts related to the system's operation.

R. K. Kodali and S. Yerroju,[3] proposed “Energy-efficient home automation using IoT”.

In their study on "Energy-efficient home automation using IoT," R. K. Kodali and S. Yerroju proposed an intelligent approach to address current energy usage challenges. They employed the Internet of Things (IoT) paradigm, utilizing a low-cost and low-power ESP8266 microcontroller with an integrated Wi-Fi module to control relay channels. While effective, the drawback lies in the ESP8266's limitations compared to its counterpart, the ESP32, which offers superior performance and additional features at a comparable cost. Despite this drawback, the study underscores the potential for ESP8266-based solutions to significantly enhance energy management in residential settings, paving the way for more sustainable and efficient home automation systems.

C. Nayyar, B. Valarmathi, and K. Santhi,[4] "Home security and energy efficient home automation system using Arduino".

The research project titled "Home security and energy efficient home automation system using Arduino" presents an affordable and efficient solution for automatic energy management in households, leveraging the Arduino UNO microcontroller board. This system not only addresses energy management but also integrates features to handle emergencies like fires, enhancing overall home security. However, one limitation of using the Arduino UNO is its relatively higher power consumption compared to the ESP32 microcontroller. This higher power consumption makes the Arduino UNO less suitable for battery-powered applications. Furthermore, despite not requiring a Wi-Fi shield, the ESP32 microcontroller is considerably less expensive than the Arduino UNO, costing approximately five times less. This cost disparity highlights a potential drawback of the Arduino UNO in terms of both power efficiency and affordability compared to the ESP32. Despite this drawback, the Arduino UNO remains a viable choice for applications where power consumption and budget constraints are not critical factors, offering a reliable and versatile platform for home automation and security projects.provides a low-cost, effective automatic energy management system for households using an Arduino UNO microcontroller board. It combines instruments to deal with natural disasters such as fire in addition to offer a cost-effective solution for managing household energy. The sole drawback of utilizing Arduino UNO is that, in comparison to ESP32, it consumes less power, making it unsuitable for use with a battery. Even without the Wi-Fi shield, the ESP32 is significantly less expensive than the Arduino UNO—about five times less so.

Youcef GUENFAF, Youcef ZAFOUNE [2023], "An IoT ML-Based system for Energy Efficiency in smart homes"

The paper titled "An IoT ML-Based system for Energy Efficiency in smart homes" proposes a comprehensive system architecture comprising four layers: the perception layer, network layer, data preprocessing layer, and application layer. The aim is to develop a system for home appliances that contributes to energy saving through the application of machine learning (ML) algorithms such as KNN, SVM, Bayesian, Random Forest, and MLP (Multi-Layer Perceptron).

The smart home system comprises four layers: Perception, Network, Data Preprocessing, and Application. Sensors in the Perception Layer collect data on temperature, humidity, light, and appliance usage, which is transmitted via MQTT through the Network Layer to the Raspberry Pi 400 for preprocessing. Here, raw data undergoes tasks like cleaning, normalization, and feature extraction before being analyzed by ML algorithms in the Application Layer. These algorithms, including KNN, SVM, Bayesian, Random Forest, and MLP, utilize data collected over a week to make energy-saving decisions based on patterns in energy consumption, appliance usage, and environmental conditions, ensuring efficient operation of home appliances.

Chapter 3 RESEARCH GAP And PROPOSED SYSTEM

3.1 GAPS

- **Scalable and Affordable Solutions:**
- There is a need for further exploration and development of scalable, affordable solutions tailored to the context of developing countries.

- **Limited Research Coverage:**
- Despite existing research highlighting the importance of energy efficiency, affordability, and accessibility, there is a lack of comprehensive studies addressing the unique challenges faced by individuals and communities in these regions.

- **Optimizing Energy Consumption:**
- Research is required to focus on optimizing energy consumption while considering the limited resources, infrastructure constraints, and socio-economic factors prevalent in developing countries.

- **Socio-Cultural Dynamics:**
- There is a gap in understanding the socio-cultural dynamics and user preferences that influence the adoption and acceptance of these systems in diverse cultural contexts within developing countries.

3.2 PROPOSED SYSTEM

3.2.1 Hardware And Sensors Requirements

1. NODE MCU v3 :

NodeMCU is a popular development board platform based on the ESP8266 microcontroller. It combines the capabilities of the ESP8266 Wi-Fi module with a convenient form factor and easy-to-use programming interface, making it a popular choice for IoT projects and home automation.

1. ESP8266-Based: NodeMCU version 3 is based on the ESP8266 microcontroller, similar to previous versions of NodeMCU boards. The ESP8266 provides Wi-Fi connectivity, making it suitable for IoT applications that require wireless communication.

2. Enhanced Features: While retaining the core functionality of previous NodeMCU versions, the version 3 board may include enhancements such as improved power management, additional GPIO pins, or updated hardware components. These enhancements aim to provide better performance and functionality for IoT projects.

3. Compatibility: NodeMCU version 3 is typically compatible with the Arduino IDE, Lua scripting language, and other programming environments commonly used for ESP8266 development. This allows developers to leverage existing libraries, examples, and tools to accelerate development.

4. Community Support: Like previous versions of NodeMCU, version 3 benefits from a large and active community of developers and enthusiasts. This community provides support, resources, and tutorials to help users get started with NodeMCU development and troubleshoot any issues they encounter.

5. Open-Source: NodeMCU is an open-source project, which means that the design files, firmware, and software libraries are freely available for modification and redistribution. This fosters innovation and collaboration within the NodeMCU community, leading to continuous improvements and new features.

2. 4 CHANNEL RELAY :

A 4-channel relay module is a versatile electronic component used in various applications to control multiple high-power electrical devices or circuits using low-power signals. Typically featuring four independent relay channels, each capable of switching a separate load, it allows for the remote or automated control of appliances, lights, motors, and other electrical devices. These relay modules commonly interface with microcontrollers, Arduino boards, or other control systems, enabling users to toggle the state of each relay channel through digital signals. With its compact size, ease of use, and compatibility with different control platforms, the 4-channel relay module finds widespread use in home automation, robotics, industrial automation, and DIY electronics projects, offering a reliable solution for switching multiple circuits with minimal effort.

3. PIR SENSOR :

Passive Infrared (PIR) sensors are motion detectors that detect infrared radiation emitted by objects in their field of view. These sensors consist of pyroelectric sensors that generate a voltage when exposed to changes in infrared radiation levels caused by movement. Typically used in security systems, lighting control, and automation applications, PIR sensors are known for their simplicity, reliability, and low cost. They operate by detecting changes in heat patterns within their detection range, triggering an output signal when motion is detected. PIR sensors are often integrated into electronic circuits alongside microcontrollers or relay modules to activate alarms, lights, or other devices upon detecting motion, making them invaluable components in creating smart and responsive environments.

4. LDR SENSOR :

Light Dependent Resistors (LDRs), also known as photoresistors, are passive electronic components that change resistance based on the intensity of incident light. These sensors are widely used in various applications such as streetlights, camera exposure control, and automatic brightness adjustment in displays. LDRs operate on the principle of the photoconductivity effect, where their resistance decreases as the ambient light level increases. This change in resistance can be utilized in electronic circuits to detect changes in light intensity and trigger corresponding actions, such as turning on or off lights, adjusting the brightness of displays, or activating security alarms. LDR sensors offer simplicity, low cost, and ease of integration into electronic systems, making them popular choices for light-sensing applications where automatic control based on ambient light conditions is desired.

5. DHT22 SENSOR :

The DHT22 sensor, also known as the RHT22 or AM2302, is a digital temperature and humidity sensor widely used in various applications requiring accurate environmental monitoring. With its compact size and simple interface, the DHT22 provides reliable readings of temperature and humidity with high precision and stability. This sensor utilizes a capacitive humidity sensing element and a thermistor to measure temperature, delivering digital outputs that can be easily interfaced with microcontrollers or other electronic devices. Commonly used in weather stations, HVAC systems, and indoor climate control, the DHT22 sensor offers a cost-effective solution for real-time environmental monitoring, enabling users to maintain optimal conditions for various purposes.

6. JUMPER WIRES :

Jumper wires are essential components in electronics projects, consisting of insulated wires with connectors at each end, typically male pins or female sockets. These wires facilitate the temporary or permanent connection of electronic components on breadboards, circuit boards, or between various modules or devices. Available in various lengths, colors, and connector types, jumper wires enable quick and flexible wiring arrangements, allowing for easy prototyping, troubleshooting, and modification of circuits without the need for soldering. Their versatility and convenience make jumper wires indispensable tools for hobbyists, students, and professionals alike, streamlining the process of circuit assembly and experimentation in electronics projects.

7. TYPE-B CABLE :

A Type B USB cable, also known as USB 3.0 Type B or USB 3.1 Type B, is a high-speed data transfer cable commonly used to connect peripheral devices such as printers, scanners, and external hard drives to computers or other devices. It features a rectangular connector with a square-shaped plug and is designed to deliver faster data transfer speeds compared to previous USB standards. The Type B cable is backward compatible with USB 2.0 ports and devices but offers improved performance when used with USB 3.0 or higher ports. Its durable design and high-speed capabilities make the Type B cable ideal for transferring large files or streaming high-definition multimedia content between devices.

3.2.2 SOFTWARE REQUIREMENTS

1. ARDUINO IDE :

The Arduino Integrated Development Environment (IDE) is a user-friendly software platform designed to simplify the programming and development of Arduino-based projects. It provides a comprehensive set of tools, including a code editor with syntax highlighting and auto-completion features, a compiler that translates Arduino sketches into machine code, and a uploader that transfers the compiled code to Arduino boards for execution. The IDE also offers a library manager for easily adding and managing additional libraries, as well as a serial monitor for debugging and monitoring communication between the Arduino board and a computer. With its intuitive interface and extensive documentation, the Arduino IDE caters to both beginners and experienced developers, enabling them to quickly prototype, test, and deploy a wide range of electronic projects and applications.

2. SINRIC PRO :

Sinric Pro is a cloud-based IoT platform that facilitates seamless integration and control of smart devices, enabling users to create custom automation scenarios and interact with their smart home ecosystem remotely. With support for a wide range of popular smart devices and platforms, including Amazon Alexa, Google Assistant, and Apple HomeKit, Sinric Pro offers a unified solution for managing and controlling diverse smart home devices through voice commands, mobile apps, or web interfaces. The platform provides developers with APIs and SDKs for building custom applications and integrations, allowing for personalized experiences tailored to individual preferences and needs. With its intuitive interface, robust functionality, and extensive compatibility, Sinric Pro empowers users to create sophisticated smart home setups and automate everyday tasks with ease.

3. GOOGLE HOME

Google Home is a smart speaker and voice-controlled assistant developed by Google. It's designed to simplify and enhance daily tasks by providing hands-free access to information and control over smart home devices. With Google Home, users can interact with their devices and access a wide range of services using just their voice.

Equipped with Google Assistant, Google Home can perform various tasks, such as playing music from popular streaming services, setting alarms and timers, providing weather forecasts, answering questions, and even controlling compatible smart home devices like lights, thermostats, and plugs.

Google Home comes in various models, including the standard Google Home, Google Home Mini, Google Home Max, and Google Nest Hub. Each model offers different features and capabilities, catering to different user needs and preferences.

3.2.3 METHODOLOGY

In the proposed system ,we have focused on energy efficiency.Our system will allow remotely control of Fans, bulb, and Inverter Acs.

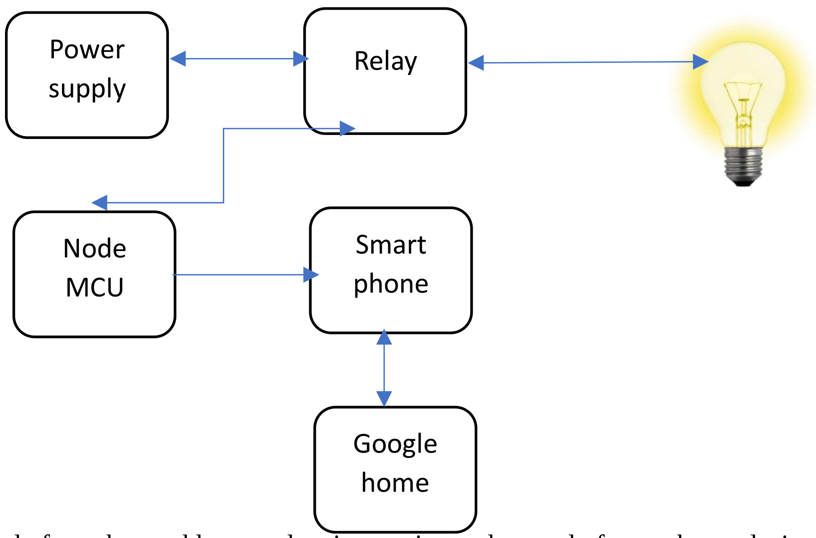
In our work we use hardware Node MCU and Relay.The NodeMCU, an open-source development board based on the ESP8266 microcontroller, can be connected with a relay to control high-power devices such as lights, fans, or appliances through the internet or local network.

Noce MCU is connected with B-Type cabel for power supply,NodeMCU boards have an onboard LED that indicates power status. When powered on, this LED may light up, indicating that the NodeMCU is receiving power. After that NodeMCU is connected with 4-Channel Relay with the help of jumper wires ,which will then convert the 3.3V of DC to AC current. And all the other devices such as Fans, Bubls are connected to Relay which will work according to command.

When the NodeMCU is activated through its USB port, it searches for the wireless network to which it was previously connected using the SSID and password. This access point allows users to connect to the Internet via wired, wireless, or cellular networks.

To get the code and libraries onto the NodeMCU, the Arduino IDE is used.After receiving the code from the Arduino IDE to the NodeMCU, the NodeMCU executes the instructions outlined in the code to control the 4-channel relay module. Upon powering on or resetting, the NodeMCU initializes and executes the setup() function. In this function, pins are configured, and any necessary initialization tasks are performed.After initialization, the NodeMCU enters the loop() function, where it continuously executes the instructions contained within the loop. In this case, the code likely contains instructions to control the relay channels based on certain conditions or events.Depending on the functionality of the code, the NodeMCU may also be communicating with other devices or services. For example, it could be receiving commands via Wi-Fi from a smartphone app, a web server, or an IoT platform, instructing it to control the relays.

In addition, we programme using the Sinric Pro application and the Arduino integrated development environment. The Arduino Integrated Development Environment (IDE) consists of a text editor for composing code, a message box, a text console, a toolbar with icons for frequently used functions, and numerous menus. A connection is required to upload code and communicate with the Arduino and Nodemcu hardware. When using the Arduino IDE, sketches are written using computer code. The terminal presents all error messages and other information generated by the Arduino Software (IDE). In the lower right corner of the screen, the configured board and serial interface can be seen.



Sinric Pro is a platform that enables seamless integration and control of smart home devices. It provides developers and users with tools to connect and interact with various IoT (Internet of Things) devices, such as smart lights, switches, thermostats, and more. Sinric Pro allows users to integrate their smart devices into a unified ecosystem. This enables centralized control and management of all connected devices through a single platform.

Creating Device Interface:

To create a device interface with Sinric Pro, start by registering your device on the platform and configuring its properties and capabilities. Integrate your device with the Sinric Pro SDK for your preferred programming language, enabling communication with the platform. Implement device control and monitoring functionalities using the SDK to send commands and receive updates. Develop a user interface (UI) incorporating controls and visual elements for interacting with devices, ensuring seamless communication through the SDK. Test the interface thoroughly for functionality and user experience before deploying it to your desired platform or environment, such as a mobile or web application or smart home automation system.

Connection with Google Home:

After integrating all the devices, Sinric Pro is connected with google homes, Google Home is a smart speaker and voice assistant developed by Google. It allows users to interact with their connected devices, access information, and control various aspects of their smart home using voice commands. With Google Home, users can play music, get answers to questions, set reminders and alarms, control smart home devices such as lights and thermostats, and much more—all through simple voice commands. It's designed to seamlessly integrate into the home environment, providing hands-free convenience and personalized experiences for users.

Google Home can be connected with Sinric Pro to extend its capabilities to control a wider range of smart home devices. By integrating Google Home with Sinric Pro, users can leverage the voice control features of Google Assistant to interact with their devices managed through Sinric Pro. This integration allows users to control various smart devices such as lights, switches, thermostats, and more using simple voice commands directed through Google Home.

Chapter 4 RESULTS AND DISCUSSIONS

- **Device 1 (Light-10W)**
  Daily Energy Consumption: The light consumes 10 watts of power and operates for 5 hours each day, resulting in a daily energy consumption of 50 watt-hours.

  $$10 \text{ watts} \times 5 \text{ hours} = 50 \text{ watt-hours.}$$

  Monthly Energy Consumption: Over the course of one month (30 days), the light's total energy consumption amounts to 1500 watt-hours or 1.5 kilowatt-hours (kWh).

  $$50 \text{ watt-hours/day} \times 30 \text{ days} = 1500 \text{ watt-hours or } 1.5 \text{ kWh}$$

- **Device 2 (Fan- 45W)**
  Daily Energy Consumption: The fan has a higher power rating of 45 watts and operates for a longer duration of 12 hours each day, resulting in a daily energy consumption of 540 watt-hours.

  $$45 \text{ watts} \times 12 \text{ hours} = 540 \text{ watt-hours}$$

  Monthly Energy Consumption: Over the course of one month, the fan's total energy consumption amounts to 16,200 watt-hours or 16.2 kWh.

  $$540 \text{ watt-hours/day} \times 30 \text{ days} = 16{,}200 \text{ watt-hours or } 16.2 \text{ kWh}$$

- **Device 3 (AC Inverter)**

  Daily Energy Consumption: The AC inverter, being the most power-hungry device with a power rating of 1500 watts, operates for 8 hours each day, resulting in a daily energy consumption of 12,000 watt-hours.

  $$1500 \text{ watts} \times 8 \text{ hours} = 12{,}000 \text{ watt-hours}$$

  Monthly Energy Consumption: Over the course of one month, the AC inverter's total energy consumption amounts to 360,000 watt-hours or 360 kWh.

  $$12{,}000 \text{ watt-hours/day} \times 30 \text{ days} = 360{,}000 \text{ watt-hours or } 360 \text{ kWh}$$

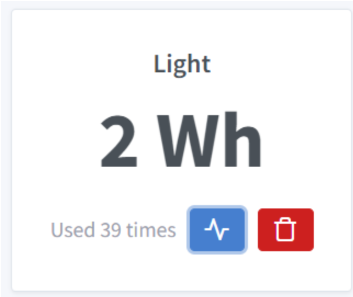
<u>Energy Consumption analysis after using IoT devices and a smart home automation system:</u>

- **Device 1 (Light-10W)**

Energy estimates

Energy consumption breakdown

TURNED ON	TURNED OFF	WATT HOURS	DURATION (HRS)
2024-05-01 00:45:40	2024-05-01 00:46:04	0.07	0.007
2024-05-01 00:46:49	2024-05-01 00:46:54	0.01	0.001
2024-05-01 00:55:35	2024-05-01 00:55:40	0.01	0.001
2024-05-01 01:00:34	2024-05-01 01:00:38	0.01	0.001
2024-05-01 01:00:39	2024-05-01 01:00:41	0.01	0.001



Daily energy consumption: 2 watts × 5 hours = 10 watt-hours

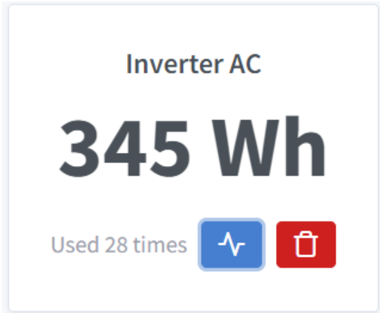
Monthly energy consumption: 10 watt-hours/day × 30 days = 300 watt-hours or 0.3 kWh

- **Device 3 (AC Inverter)**

Energy estimates

Energy consumption breakdown

TURNED ON	TURNED OFF	WATT HOURS	DURATION (HRS)
2024-05-01 00:45:59	2024-05-01 00:46:02	1.50	0.001
2024-05-01 00:55:36	2024-05-01 00:55:40	1.50	0.001
2024-05-01 01:00:36	2024-05-01 01:00:38	1.50	0.001
2024-05-01 01:00:40	2024-05-01 01:00:41	0.00	0
2024-05-01 01:00:42	2024-05-01 01:00:47	1.50	0.001



Daily energy consumption 345 watts × 8 hours = 2760 watt-hours

Monthly energy consumption: 2760 watt-hours/day × 30 days =82800 watt-hours or 82.8 kWh

Chapter 5 Conclusion And Future Work

5.1 CONCLUSION

In conclusion, the integration of NodeMCU, various sensors, and Sinric Pro in an energy-efficient IoT-based smart home automation system offers a streamlined and effective solution for optimizing energy consumption while enhancing overall convenience and comfort. By leveraging NodeMCU as a versatile microcontroller platform and integrating it with a range of sensors to gather real-time data on environmental conditions and appliance usage, the system gains valuable insights into energy usage patterns. The utilization of Sinric Pro further enhances the system's capabilities by providing seamless integration with voice assistants like Amazon Alexa and Google Assistant, enabling intuitive voice commands for controlling smart devices .

Through the collective functionality of NodeMCU, sensors, and Sinric Pro, the smart home automation system can intelligently monitor and manage energy usage.The integration with Sinric Pro adds an additional layer of convenience by allowing users to control smart devices through their smart phone on a single click, further enhancing the user experience.

Overall, the combination of NodeMCU, and Sinric Pro represents a comprehensive and scalable solution for energy-efficient smart home automation. By leveraging the power of IoT technologies, this system not only reduces energy consumption and lowers utility costs but also promotes sustainable living practices and enhances the quality of life for users. With its flexibility, modularity, and integration capabilities, it represents a significant step towards creating more environmentally friendly and user-friendly living spaces in the era of smart homes.

5.2 FUTURE WORK:

This project is a work in progress in the feild of IoT applications in home automation systems, it includes some of the following things in future.

Integration of Energy Storage Systems: Incorporating energy storage systems such as batteries or capacitors into the smart home setup could enable better management of energy surpluses and shortages. By storing excess energy generated from renewable sources or during off-peak hours, the system could optimize energy usage further and provide backup power during outages.

Enhanced User Interfaces: Improving user interfaces and interaction methods could enhance user experience and encourage greater engagement with energy-saving practices. Intuitive mobile apps, web interfaces, or even augmented reality (AR) interfaces could provide users with real-time insights into energy usage, personalized recommendations for energy-saving actions, and easy control over smart devices.

Collaborative Energy Management: Implementing collaborative energy management strategies that involve coordination between multiple smart homes or buildings could further optimize energy usage at a community level. By sharing energy data and coordinating appliance schedules, communities could collectively reduce peak demand, lower energy costs, and improve grid stability.

Continuous Monitoring and Optimization: Implementing a continuous monitoring and optimization framework that adapts to changing environmental conditions, user preferences, and energy tariffs could ensure ongoing efficiency improvements. Machine learning algorithms could continuously analyze data, identify emerging patterns, and dynamically adjust energy-saving strategies in real-time.

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