IoT based Power Consumption Monitoring and Automation in Home

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***Abstract*— Home automation, a rapidly advancing technology, transforms traditional homes into smart homes by enabling remote control and monitoring of various appliances such as lights, refrigerators, and air conditioners. This paper focuses on incorporating home automation with Android devices, Wi-Fi, and smart meters to provide an efficient and user-friendly system for managing home appliances and monitoring energy consumption. The system is designed using NodeMCU (Node Micro Controller Unit), with home appliances connected to its 10 ports via relays. A Wi-Fi-enabled smart meter is incorporated to track daily and monthly energy usage, promoting energy conservation based on user behavior. The Wireless Home Automation System offers the convenience of controlling home appliances through smartphones or computers, regardless of the user's location. This not only conserves energy but also enhances accessibility for elderly and disabled individuals by providing an easy-to-use interface and alerting them in essential situations. As the internet becomes increasingly integral to our lives, such automation systems are becoming more prevalent, reflecting the growing demand for smart, energy-efficient, and accessible living environments. This work explores the design and implementation of an IoT-based Home Automation System using NodeMCU through an open-source IoT platform for online record of energy consumption and control of appliances. This system enables users to have complete control over their home appliances from any location globally, through a public web application with internet connectivity. Home automation not only enhances security, energy efficiency, and ease of use but also provides a remote interface for appliance control and monitoring via a web browser.**

Keywords*— *Wireless Home Automation, Home Automation System, Node Micro Controller Unit.

I. INTRODUCTION

Home automation encompasses the control and management of power consumption by household appliances using IoT technology. This has become increasingly popular due to its ability to offer convenience, security, and efficiency. In such systems, smart meters and sensors monitor the status of home appliances and relay this information to a web server. This allows users to remotely access and modify the status of their appliances, such as turning them on or off, even when they are away from home. A local PC can also be used for controlling these devices. As technology continues to advance, daily life becomes progressively simpler, especially with the integration of smart devices. These devices reduce the physical effort required to perform everyday tasks by enabling control of electronic appliances through voice commands or even sound patterns. Consequently, smart devices have become an essential part of modern living. Moreover, the ability to acquire data and monitor systems remotely has also become a critical aspect of home automation.

II. LITERATURE REVIEW

The literature on home automation systems reveals a broad array of approaches aimed at enhancing security, accessibility, and efficiency in managing household devices. Early studies emphasize the importance of IoT technologies for seamless device integration and the use of secure communication protocols to protect data, with a focus on standardization to reduce costs and improve system interoperability [1]. Another significant area of research is the development of voice-activated systems for physically challenged individuals, particularly those with limited mobility, allowing them to control home appliances and request assistance via voice commands.

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This approach also highlights the importance of cost-effectiveness and accessibility in designing such systems [2]. Additionally, there has been a focus on intelligent home monitoring systems tailored for elderly care, where real-time tracking of daily activities is used to detect any deviations from normal routines, thereby enhancing safety and independence [3]. Moreover, SMS technology combined with voice recognition has been explored as a means of creating cost-effective and secure home automation systems that provide users with confidence through fault identification and high accuracy in automation [4]. Projects leveraging IoT frameworks with Raspberry Pi and Wi-Fi for web-based control of appliances, while incorporating safety features like smoke detection, further demonstrate the trend towards scalable and integrated automation systems [5]. The exploration of dual-mode systems that offer both manual and automated control based on sensor readings, along with security features like intruder alerts, underscores the adaptability and user-focused design of modern home automation solutions [6]. Meanwhile, multimodal wireless sensor networks have been developed to support ambient assisted living in multi-resident homes, addressing challenges such as sensor selection and data processing to effectively monitor wellbeing and detect potential health issues [7]. The qToggle system represents a user-friendly and flexible solution that uses a robust API architecture to control various home devices through smartphones, illustrating advancements in API-driven home automation [8]. Additionally, the Node MCU-based systems have been proposed to tackle the fragmentation of home automation by integrating climate control and security features, providing users with global remote access and streamlining device management across platforms [9]. Comparative studies on communication methodologies, such as GSM, IoT, Wi-Fi, and Bluetooth, offer insights into the advantages and limitations of each, aiding users in selecting the most suitable technology for their specific automation needs [10]. Finally, the development of Android-based applications for home automation, which allow users to control appliances via the internet and adjust settings based on sensor inputs, exemplifies the ongoing efforts to make these systems more accessible and beneficial for physically challenged individuals [11]. Collectively, these studies contribute to a comprehensive understanding of the current trends, challenges, and advancements in home automation technologies.

III. SYSTEM ARCHITECTURE AND IMPLEMENTATION

A. System Setup and Configuration

The system setup for IoT-based home automation involves both hardware assembly and software configuration. The architecture of the proposed model is shown in Fig.1. The primary hardware component is the NodeMCU, which serves as the central controller. The ESP8266 System-on-a-Chip (SoC), which has a CPU, RAM, and Wi-Fi, makes the NodeMCU an open-source development platform appropriate for Internet of Things (IoT) applications. The NodeMCU is connected to various electrical appliances through relays, enabling control over these devices. The software configuration involves using the Arduino IDE to write and upload code to the NodeMCU. Once the NodeMCU is connected to the local Wi-Fi network, it can communicate with the Sinric Pro cloud platform, which handles remote access and data management.

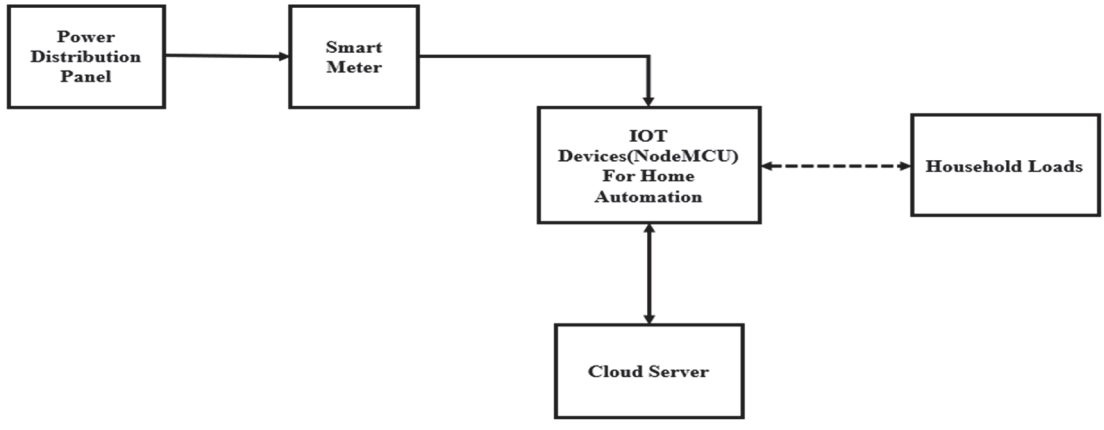

Fig.1. Architecture of the Proposed System.

The integration of IoT devices with cloud services is a crucial aspect. The methodology of integrating NodeSinric Pro is used as the cloud platform, providing a user interface to monitor and control the connected appliances remotely. The data from the appliances, including their operational status and energy consumption, is transmitted to the cloud. This setup ensures that users can access the system from any location with internet connectivity, providing flexibility and real-time control.

B. Data Acquisition and Communication

The system is designed to acquire data from connected appliances, including their power consumption and operational status. This data is processed locally by the NodeMCU and then transmitted to the Sinric Pro cloud platform. Communication between the NodeMCU and the cloud is facilitated by MQTT, a lightweight messaging protocol suitable for IoT applications. The processed data is then visualized on the Sinric Pro dashboard, allowing users to monitor activity logs and energy consumption over different time intervals shown in TABLE I (6 hours, 24 hours and one month). The power consumption during different time intervals are shown in the Fig.2, Fig.3 and Fig.4.

TABLE I POWER CONSUMPTION DATA

Time Duration	Power Consumed in kWh
6 Hours	16.41
24 Hours	101.95
1 Month	113379.89

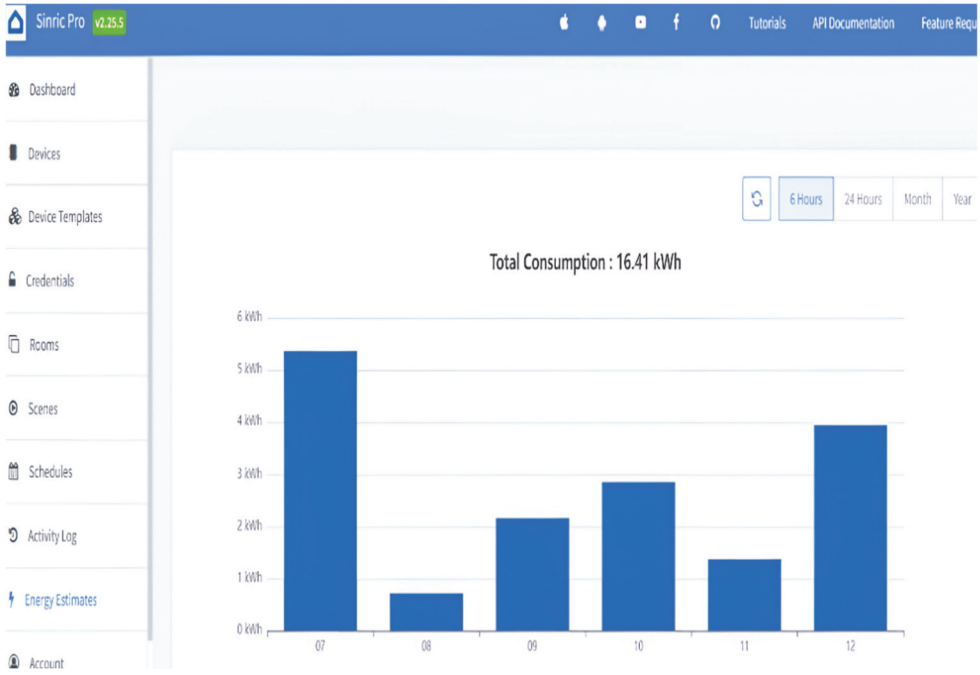

Fig. 2. Total Power Consumption for 6 Hours.

Fig. 3. Total Power Consumption for 24 Hours.

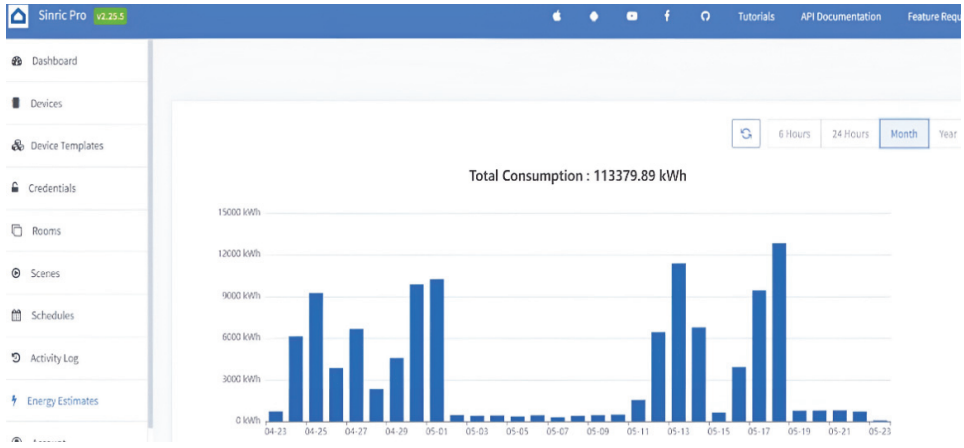

Fig.4. Total Power Consumption for 24 Months.

C. *Features and Functionality*

Control Mechanisms: The system uses the Sinric Pro platform to enable remote control of household appliances. To control device operations automatically, users can create schedules and automation rules.

Energy Monitoring: The system tracks the energy consumption of connected appliances, providing insights into power usage patterns. This data can be crucial for optimizing energy usage and reducing costs.

Security Features: The system employs secure communication protocols and user authentication to protect against unauthorized access. This ensures that only authorized users can control the appliances and access data.

User Experience: The system is designed for ease of use, with an intuitive interface on the Sinric Pro platform. Users can customize settings and control devices through a simple and accessible dashboard.

The system is tested under various conditions, including different network environments and load scenarios, to ensure reliability and efficiency. Feedback from users was gathered to assess the usability and functionality of the system. This feedback helped in refining the user interface and overall experience. The system's impact on energy usage was analyzed, showing potential for significant cost savings and improved energy efficiency.

IV. CONCLUSION

The development and implementation of the IoT-based home automation system using NodeMCU and the Sinric Pro platform encountered several challenges, including the integration of different platforms, ensuring secure communication, and maintaining stability in varying network conditions. Despite these challenges, the system was successfully developed, providing remote control and real-time data storage of power consumption. However, the current system has limitations, such as its dependency on a stable internet connection and the need for compatibility across a wide range of appliances. Addressing these limitations, future work could involve enhancing offline capabilities, expanding device support, and integrating advanced technologies such as artificial intelligence for predictive maintenance. Additionally, implementing more robust security features and improving interoperability with other smart home ecosystems would further strengthen the system's functionality and user experience. In conclusion, this research demonstrates a significant step forward in the integration of IoT technology with home automation. It offers valuable insights into energy usage and simplifies the management of household appliances, making it a practical tool for modern smart homes. As IoT technology continues to advance, this system lays the groundwork for future innovations that could further enhance energy conservation, user convenience, and the overall smart home experience.

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