International Journal of Science, Strategic Management and Technology
Volume **02** Issue **05** May-**2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

Smart Home Automation System using Esp32

Kadve Khushi[1], Paithankar Nikita[2], Talekar Trupti[3], Mitke Aarti[4]
Department of Electrical Engineering, Savitribai Phule Pune University,India
Department of Electrical Engineering, Savitribai Phule Pune University,India
Department of Electrical Engineering, Savitribai Phule Pune University,India
Department of Electrical Engineering, Savitribai Phule Pune University,India
Email:khushikadve2202@email.com
nikitapaithankar0@gmail.com,talekartrupti0@gmail.com,mitakeaarti@gmail.com

https://doi.org/10.55041/ijsmt.v2i5.320
Cite this Article: Khushi, K., Nikita, P., Trupti, T. & Aarti, M. (2026). Smart Home Automation System using Esp32. International Journal of Science, Strategic Management and Technology, *02*(05). https://doi.org/10.55041/ijsmt.v2i5.320

----------***----------

Abstract

This paper describes an approach for developing a hybrid smart home automation system through the incorporation of the ESP32 microcontroller along with IoT, Edge Artificial Intelligence (Edge AI), MQTT communication protocol, and Firebase cloud. In essence, this approach has been formulated by focusing on the development of an intelligent, fast and scalable system capable of automating different household appliances through real-time monitoring and control. In this regard, sensors like PIR, DHT11, and MQ2 have been used for motion detection, temperature monitoring, and gas leakage detection respectively. On its part, the ESP32 microcontroller has been used for performing edge-based processing in order to minimize communication delay and enhance system reliability. Meanwhile, the use of MQTT protocol will facilitate lightweight real-time communication between different devices and cloud servers. Similarly, Firebase cloud service will facilitate remote monitoring as well as data synchronization of the system in question using web or mobile interfaces. Experimentation reveals that the proposed system offers fast and reliable performance in addition to scalable multi-device operation. From the experiments, it has been established that the hybrid approach has resulted in efficient and scalable performance compared to other approaches commonly used for home automation.

Keywords: ESP32, Internet of Things (IoT), Smart Home Automation, MQTT (Message Queuing Telemetry Transport) Protocol, Passive Infrared (PIR) Sensor, Edge Artificial Intelligence (Edge AI), Firebase Cloud.

INTRODUCTION

Intelligent home automation using embedded systems and IoT has become a prominent use case that enables intelligent monitoring and controlling of appliances within homes through interconnections among devices. The evolution of wireless communication, cloud computing, and edge computing has considerably improved the efficiency and flexibility of current home automation systems. Traditional automation systems

used wired communication and central control mechanisms, which made them relatively complex, costly, and difficult to maintain. The use of wireless communication technologies, such as Wi-Fi and Bluetooth, provided remote accessibilities and simpler connections, hence improving user convenience and operational flexibility.

Microcontroller-based IoT home automation systems have become very popular due to their inexpensive nature, ability to provide real-time monitoring of systems, and ease of implementing them. Among the many available controllers, the ESP32 controller has become very popular owing to its built-in communication capabilities via Wi-Fi and Bluetooth, as well as efficient processing capability and cloud-edge computing capability [3][4]. Current intelligent home automation systems include cloud-based platforms, lightweight communication protocols, and intelligent processing algorithms for real-time communication and automated control .

I. LITERATURE REVIEW

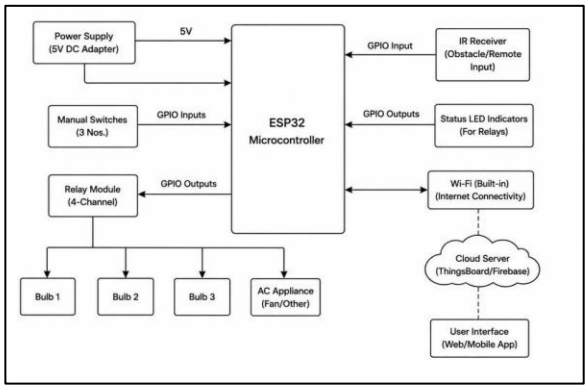
The current trend in automation in smart homes revolves around the utilization of Internet of Things (IoT), wireless technologies, cloud computing, and intelligent control systems in order to increase automation efficiency and user comfortability [11]. The initial automation systems in smart homes were based on wireless communications involving Bluetooth and FPGA-based communication networks that would control appliances in the house. Despite being functional and performing their tasks effectively, such systems had shortcomings in terms of communication range and scalability and lacked internet connectivity [6].

Through IoT technologies, there has been much focus on ESP32-based smart home systems that offer affordable solutions that involve both Wi-Fi and Bluetooth wireless connections and perform well. ESP32-based IoT home automation systems provide effective appliance control and remote monitoring. Nevertheless, most systems that use ESP32 rely heavily on pre-configured logic in performing automation activities.

II. Proposed System Architecture

The proposed system for smart home automation makes use of an IoT-based framework that incorporates edge processing and cloud communication in order to provide effective monitoring and control of appliances. The entire system is designed based on the ESP32 microcontroller that works as the main processor that is used for collecting information from sensors, making decisions, communicating, and controlling the appliances.

Figure 1. Block Diagram of the Proposed Hybrid Smart



III. METHODOLOGY

The suggested smart home system design based on the hybrid model of smart home automation system was designed using the ESP32 processor along with IoT technology, cloud services, relay modules, and environmental sensors. The suggested design aims at implementing real-time appliance management and control using improved communication efficiency and flexibility. The ESP32 acts as the controller and communicator in the design by taking input from sensors, performing automation tasks and controlling other connected appliances by relay modules. The Wi-Fi and Bluetooth connectivity provided in ESP32 make

communication possible with the sensors, cloud platform, and user interface. Below Table 1 illustrates the components used in the suggested design. Below Table 1 summarizes the hardware components, software tools, and communication technologies used in the proposed implementation.

Component	Function
ESP32 Microcontroller	Main controller with Wi-Fi and Bluetooth support
PIR Sensor	Motion detection for automatic lighting
DHT11 Sensor	Temperature and humidity monitoring
MQ2 Gas Sensor	Gas leakage and smoke detection
Relay Module	Switching control for appliances
Power Supply Unit	Provides regulated power supply
Arduino IDE	Programming environment for ESP32

IV. Results and Analysis

The proposed design incorporates a PIR sensor, DHT11 sensor, and MQ2 sensor for detecting motion, environmental parameters, and gas leakage, respectively. Sensors' data is collected continuously and analyzed locally in the ESP32 using pre-defined automation rules. Edge computing in the system reduces reliance on the cloud and enhances efficiency during real-time operation. When temperature surpasses a certain level, the fan turns on, while gas leakage activates alert notifications.

The communication model was implemented using the MQTT protocol through Wi-Fi communication to ensure light-weight, real-time data exchange between the ESP32 and cloud server. The Firebase cloud platform was employed to provide remote data synchronization, device monitoring, and user authentication functionality. Web/Mobile-based user interface was

developed to enable users to remotely monitor the status of appliances and carry out ON/OFF control actions. The web/Mobile-based user interface ensures real-time synchronization between the cloud database and connected devices.

Experimental evaluation was conducted under different operating conditions to analyze system performance in terms of response time, communication reliability, scalability, and automation accuracy.

Fig 2 Project Model Pic

The hybrid smart home automation system has been experimented upon under varied operating environments in order to study the response time, reliability, and scalability of the system. Figure 3 depicts the user interface for remotely controlling

appliances from the proposed smart home automation system. Using this interface, users can check status and turn appliances ON/OFF by communicating with them via the cloud.

Overall, the results of the experiment show that the designed system offers reliable real- time automation with stable communication and effective functioning on multiple devices. The incorporation of edge computing and MQTT communications increases the speed of implementation, minimizes the cost of communications, and ensures scalability of the system. When compared with the traditional Bluetooth-enabled home automation systems, the developed system offers enhanced communication range, higher responsiveness, and greater flexibility of use.

Figure 3. A Sample User Interface

V. DISCUSSION

The hybrid smart home automation system has been experimented upon under varied operating environments in order to study the response time, reliability, and scalability of the system. Figure 3 depicts the user interface for remotely controlling appliances from the proposed smart home automation system. Using this interface, users can check status and turn appliances ON/OFF by communicating with them via the cloud.

CONCLUSION

The proposed hybrid smart home automation system effectively integrates ESP32, IoT communication techniques, edge AI processing, MQTT protocol and cloud monitoring system to create an intelligent and efficient home automation system. The developed smart home automation system is capable of providing reliable real-time monitoring and automation for household devices through environmental sensing and local decision-making processes. According to the experimental results obtained during this study, the system was found to deliver reliable performance characterized by minimal response time, stable communication performance, and efficient multiple devices management. Furthermore, PIR, DHT11, and MQ2 sensors have been utilized in order to enhance the capabilities of the smart home automation system, allowing its users to control lighting, temperature-based fan operations, and gas leakage. The use of MQTT protocol allows minimizing the communication overhead and providing reliable real-time data exchange. Meanwhile, Firebase cloud platform enables remote access and synchronization of all the devices connected to the network. Overall, the developed architecture provides a cost-effective, reliable, and intelligent smart home solution suitable for modern IoT-enabled living environments and future smart city applications

References

[1]Wilson, Charlie, Tom Hargreaves, and Richard Hauxwell-Baldwin. "Smart Homes and Their Users: A Systematic Analysis and Key Challenges." Personal and ubiquitous computing 2015, vol. 19, no. 2: 463-476.

[2]Al-Qutayri, M. A. "Smart Home Systems." 2010, In InTech eBooks.

https://doi.org/10.5772/182.

[3]Ibrahim, Usman Isah, Henry Ohize, Usman Aaze Umar, and Yusuf Aliyu. "Design and Construction of Voice-Controlled Home Automation Using Arduino." ABUAD Journal of Engineering Research and Development 2024, vol. 7, no. 1: 144-152.

[4]Singh, Simar, Sourabh Anand, and M. K. Satyarthi. "A Comprehensive Review of Smart Home Automation Systems." Advances in computer science and information technology (ACSIT) 2023, vol. 10, no. 2: 61-66.