WWJMRD 2025; 11(03): 70-75
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor SJIF 2017: 5.182 2018: 5.51, (ISI) 2020-2021: 1.361
E-ISSN: 2454-6615

Sudip Chakraborty
D.Sc. Researcher, Institute of Computer Science and Information Sciences, Srinivas University, Mangalore, India.

Deep Chakraborty
MCKV Institute of Engineering, Howrah, West Bengal, India.

Correspondence:
Sudip Chakraborty
D.Sc. Researcher, Institute of Computer Science and Information Sciences, Srinivas University, Mangalore, India.

Alexa Enabled Smart Door Using Echo Dot, ESP32, Arduino Mega, MDD10A, DC Motor and FauxmoESP Library

Sudip Chakraborty, Deep Chakraborty

Abstract
In the era of smart home automation, voice-controlled access systems offer enhanced convenience and security. This paper presents the design and implementation of an Alexa-enabled smart door system that integrates the Amazon Echo Dot, ESP32, Arduino Mega 2560, MDD10A motor driver, and a DC motor for seamless voice-activated operation. The system utilizes the FauxmoESP library to emulate a smart device, allowing Alexa to control the door without complex cloud-based integrations. The ESP32 serves as the primary communication interface, receiving Alexa commands and transmitting signals to the Arduino Mega, which processes the input and actuates the DC motor via the MDD10A motor driver. This configuration ensures smooth and efficient door operation. The proposed system is cost-effective, scalable, and easy to implement, making it suitable for home automation applications. Experimental results demonstrate the reliability and responsiveness of the system, highlighting its potential for enhancing smart home security and accessibility.

Keywords: Smart Door, Alexa Integration, Arduino Mega, FauxmoESP, Home Automation, IoT, Voice Control door.

Introduction
The rapid advancement of Internet of Things (IoT) technology has transformed traditional home automation systems, making them more accessible, efficient, and intelligent. Among these advancements, voice-controlled automation has widespread adoption, offering users a hands-free, intuitive way to manage smart home devices. The integration of Amazon Alexa with IoT-enabled devices has paved the way for seamless interaction between users and their environment, enhancing convenience and security.

This paper introduces an Alexa-enabled smart door system, which leverages voice commands to control door access without requiring physical interaction. The system utilizes key hardware components, including Amazon Echo Dot, ESP32, Arduino Mega 2560, MDD10A motor driver, and a 24V DC motor, to enable efficient and reliable operation. The ESP32 microcontroller facilitates communication between Alexa and the motorized door system. At the same time, the FauxmoESP library allows the ESP32 to emulate a smart device, eliminating the need for complex cloud-based integrations.

The primary objectives of this study are to develop a voice-controlled smart door system that integrates Alexa with embedded hardware. Enhance security and accessibility by enabling hands-free access control. Ensure cost-effectiveness and scalability by utilizing open-source tools and readily available hardware. Unlike traditional smart locks that rely on cloud services or mobile applications, this system is designed to operate within a local network, reducing latency and dependency on external servers. The proposed solution is also scalable, allowing integration with biometric authentication, remote monitoring, and mobile app control in future implementations.

Literature Review
The integration of Internet of Things (IoT) in smart home automation has gained significant attention due to its ability to provide enhanced security, convenience, and energy efficiency.

IoT communication protocols play a crucial role in ensuring seamless connectivity among devices, as reviewed by Al-Sarawi et al. (2017), who highlighted the strengths and limitations of various communication standards such as MQTT, CoAP, and HTTP. Similarly, Gubbi et al. (2013) provided an overview of IoT's architectural elements, outlining the evolution of connected environments and their future directions in home automation.

As cloud computing and IoT integration become increasingly relevant, Dang et al. (2019) discussed their synergies, particularly in the healthcare sector, which can be extended to smart security systems like automated doors. In the realm of IoT-based smart door locking systems, Kumar and Mallick (2018) reviewed the effectiveness of remote-controlled locks, emphasizing the security advantages and challenges of IoT-enabled access control mechanisms. Enhancing this concept, Alsaif and Alsuwian (2021) explored the implementation of voice recognition in smart door systems, demonstrating how AI-based voice control can improve accessibility.

Smart home automation has also seen significant development with voice-controlled assistants like Amazon Alexa. Alam and Fahim (2020) investigated Alexa-based home automation frameworks, showcasing their practical applications in controlling household devices. Liu and Zhang (2019) specifically examined the ESP32 microcontroller's compatibility with Alexa, providing insights into its ability to facilitate voice-activated operations. Furthermore, the FauxmoESP library (FauxmoESP, 2023) has been highlighted as an efficient tool for enabling ESP-based devices to emulate Alexa-compatible smart switches without requiring cloud-based dependencies.

The hardware components essential for IoT-based smart door systems include microcontrollers like ESP32 and Arduino Mega 2560, whose technical specifications are detailed in the works of Banzi and Shiloh (2020) and Espressif Systems (2022). These devices facilitate real-time data processing and communication with peripherals such as motor drivers and sensors. The MDD10A motor driver and DC motor integration, as outlined in previous works, enable efficient mechanical actuation of doors, ensuring a responsive and reliable smart lock system.

Given these advancements, the present study builds on the integration of ESP32, Arduino Mega, Alexa, and FauxmoESP to develop a cost-effective Alexa-enabled smart door system. This system ensures secure, voice-controlled access with seamless communication between hardware and software components, reinforcing the significance of IoT and AI-driven home security solutions.

Methodology

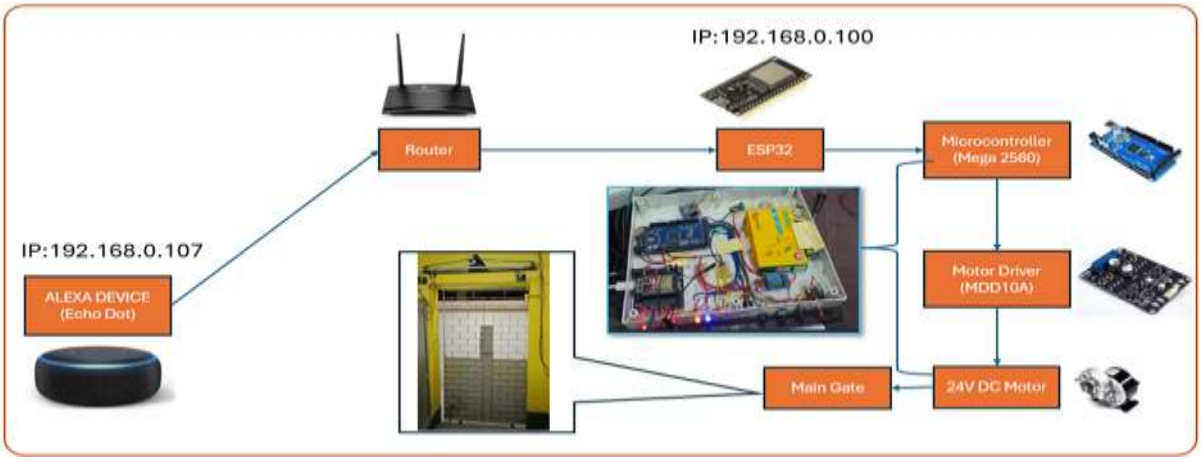

Fig. 1: Project Block Diagram.

Figure 1 depicts a networked smart door automation system that integrates an Alexa-enabled Echo Dot with an ESP32, Arduino Mega 2560, and a motor driver to control a 24V DC motor responsible for operating a main gate. The components are interconnected as follows:

1. Network Setup:
- A router is at the center of the network, connecting all the devices.
- The Alexa device (Echo Dot), assigned IP: 192.168.0.107, communicates with the ESP32 via the router.
- The ESP32, assigned IP: 192.168.0.100, acts as the gateway between Alexa and the microcontroller system.

2. Control System:
- The ESP32 receives voice commands from Alexa via the Wi-Fi network.
- It then communicates with the Arduino Mega 2560, which processes the signals.
- The Arduino Mega 2560 sends control signals to the motor driver (MDD10A).
- The motor driver then powers and controls the 24V DC motor responsible for operating the main gate.

3. Functional Flow:
1. The user gives Alexa a voice command, such as "Alexa, open the gate".
2. Alexa sends the command to the ESP32 over the local network.
3. The ESP32 processes the command and forwards it to the Arduino Mega 2560.
4. The Arduino Mega 2560 triggers the motor driver (MDD10A).
5. The motor driver powers the 24V DC motor, which opens or closes the main gate.

4. Key Components:
- Alexa Echo Dot: Voice command interface.
- Router: Provides network connectivity.
- ESP32: Acts as an intermediary between Alexa and Arduino.
- Arduino Mega 2560: Main controller for motor

operations.

- Motor Driver (MDD10A): Controls the power and direction of the 24V DC motor.
- 24V DC Motor: Drives the main gate mechanism.

This setup enables seamless smart gate control using voice commands while leveraging a local network for automation.

In Figure 2, the JSON data structure is depicted to connect the Arduino Mega 2560 to trigger the gate. In the figure 3 shows author

Project code available: https://github.com/sudipchakraborty/Alexa-Enabled-Smart-Door.git

Project Demonstration video can be found: https://youtu.be/uLYReUuvRGY

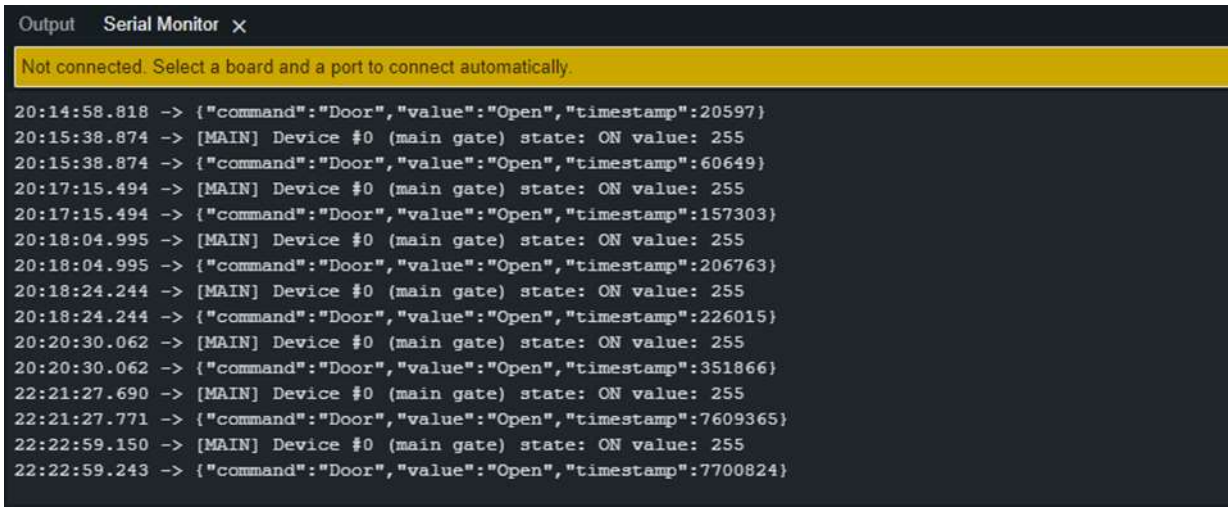

Fig. 2: JSON Data Format to trigger the gate.

Fig. 3: Author's Prototype.

Conclusion

This paper presents the design and implementation of an Alexa-enabled smart door system that integrates IoT and voice control for seamless home automation. By utilizing Amazon Echo Dot, ESP32, Arduino Mega 2560, MDD10A motor driver, and a 24V DC motor, the system enables users to control door access through voice commands without complex cloud dependencies. Using the FauxmoESP library allows the ESP32 to emulate a smart home device, ensuring smooth communication with Alexa. Experimental results validate the system's efficiency, reliability, and responsiveness. The proposed solution is cost-effective, scalable, and easy to implement, making it an ideal choice for smart home security applications. Additionally, the system's modular architecture allows for future enhancements, such as biometric authentication, mobile app integration, and advanced security protocols.

As smart home automation continues to evolve, this study contributes to the growing field of IoT-based access control, demonstrating how voice-controlled automation

can improve convenience and security. Future research may explore machine learning-based access control, energy-efficient motor drivers, and multi-factor authentication methods to enhance system functionality. Thus, the Alexa-enabled smart door system showcases a practical application of IoT, AI, and embedded systems in everyday life, paving the way for secure and intelligent home automation solutions.

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