Report for Home Automation System Using ESP32

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Code :- https://github.com/IshanIITBBS/IOT_Smart_Appliances

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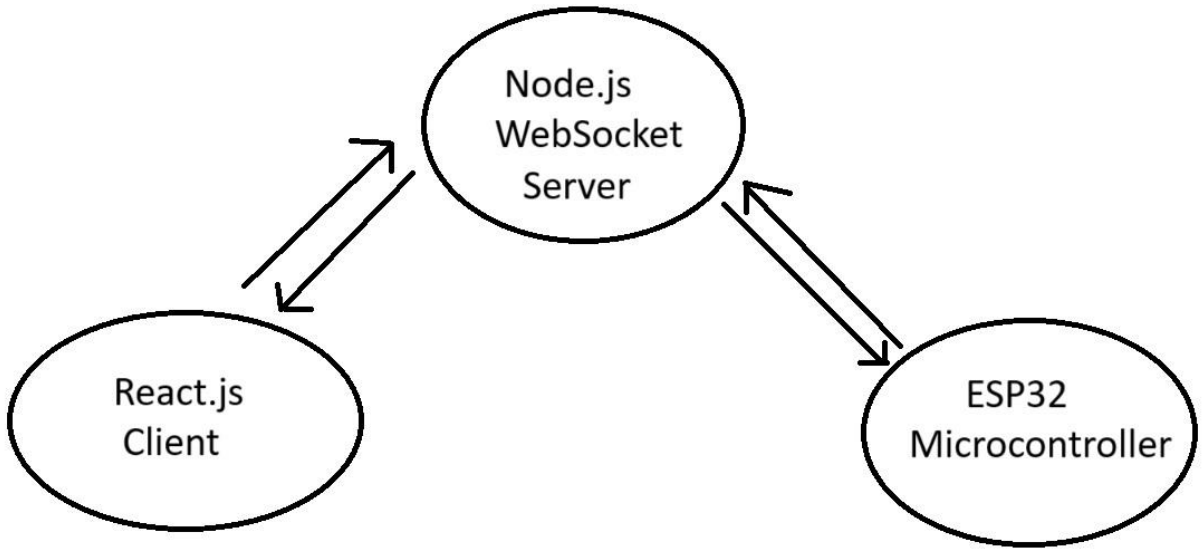
1. Aim/Objectives

The primary aim of this project is to design and implement a microcontroller-based prototype of an Home Automation System using ESP32 that utilizes IoT for real-time control and monitoring of household appliances. The system offers three distinct modes of operation: Manual Mode, Automatic Mode and Security Mode.

This project demonstrates the integration of IoT principles to provide efficient, flexible, and user-friendly automation solutions for home environments.

2. Design Overview



3. Working Principle

The system operates on the **ESP32 microcontroller**, which features a built-in Wi-Fi module which can be connected to the Internet via Mobile Hotspot or a Router. This connectivity allows the ESP32 to communicate with a **WebSocket server** we created, facilitating real-time interactions between the system and users.

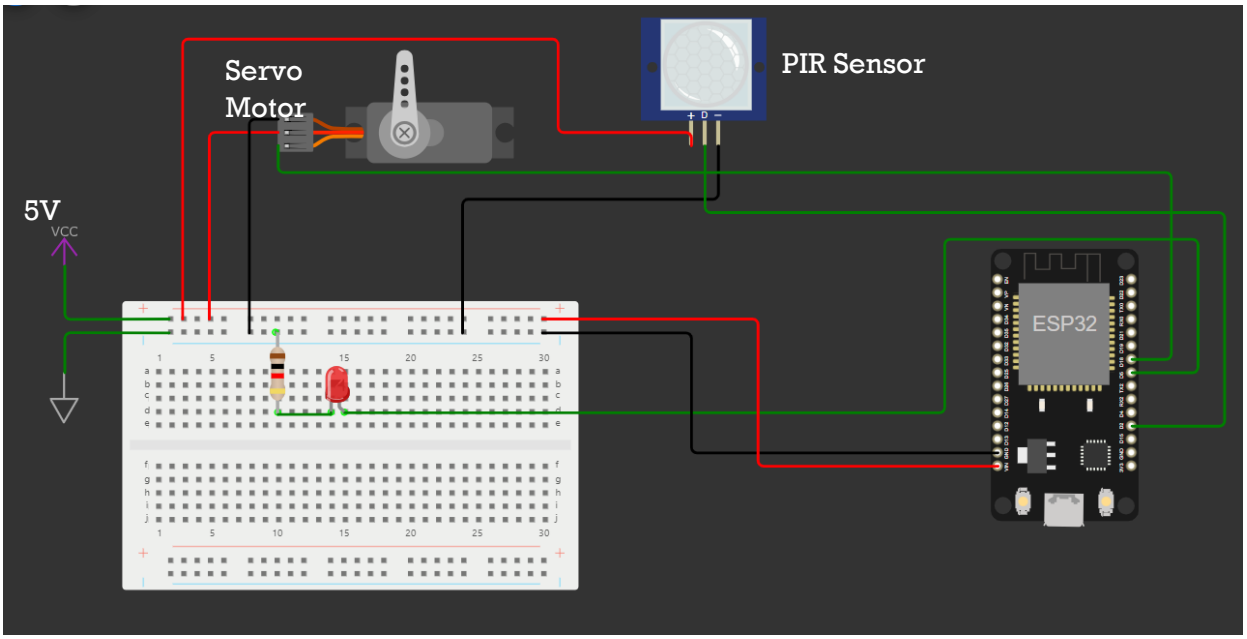
- A **user-friendly web interface** is created as the primary control point.
- The frontend contains **simple buttons** representing commands such as turning the LED on/off , setting fan speeds, setting the modes.

- When a user presses a button, the frontend sends an HTTP/WebSocket request over the internet to the WebSocket server.
- The WebSocket Server and the ESP32 (as client) are linked using the code. The **server** acts as a real-time communication bridge, ensuring low-latency interactions between the user and the ESP32.
- The server forwards the request to the ESP32, which interprets it and executes the corresponding action (e.g., toggling an LED or controlling fan speed or changing modes).

Modes of Operation:

- **Manual Mode:** Users can send commands for turning the Light ON and OFF and also for changing the FAN speeds
- **Automatic Mode:** In this mode we use the PIR sensor. It activates devices when motion is detected. Fan and Light turn off automatically after 20 seconds of no motion to conserve energy.
- **Security Mode:** The PIR sensor continuously monitors for motion. Upon motion detection, the system sends an **intrusion alert** message to the web interface via WebSocket. It also activates a strobe LED effect to deter intruders.

A simplified block diagram is shown below:



4. Observations

1. The **ESP32's Wi-Fi capability** provides seamless integration with IoT platforms, ensuring real-time communication between the user interface and hardware.
2. WebSocket communication enables reliable two-way data transfer with some latency, critical for responsive system behaviour.
3. The three modes of operation offer versatility for different use cases, from daily appliance control to advanced security.

5.Learning Outcomes

1. **IoT Implementation:**
    - Established real-time communication using WebSocket protocols for low-latency control.
    - Explored Wi-Fi-enabled hardware design for IoT systems.
2. **Microcontroller Programming:**
    - Utilized ESP32 GPIOs for sensor input LED Control.
    - Used PWM(Pulse Width Modulation) Pins to control the servo Motor enabling precise speed Control for our purpose.
    - Designed a mode-based system architecture, demonstrating modularity and scalability.
3. **Frontend-Backend Integration:**
    - Developed a user-friendly web interface to simplify appliance control.
    - Achieved seamless interaction between the frontend, WebSocket server, and ESP32 hardware.
4. **Future Scope**
    - Can be extended to an actual Home Automation system if we connect an Actual Fan and Lights.
    - The PIR sensor has a motion sensitivity of 2-6 m. So it is enough for a small room. For a big room we can connect 2 or 3 such sensors at different places around the house.

6. Key Takeaways

- Practical Automation: Mode-based operation allows the system to seamlessly transition between manual, automatic, and security functionalities, offering convenience and enhanced safety.
- Hardware-Software Synergy: The project highlights the importance of effective coordination between hardware (sensors, actuators) and software (WebSocket handling, ESP32 programming).
- This project is an excellent demonstration of microcontroller programming, IoT integration, and the design of a practical and user-friendly automation system for real-world applications.

Conclusion

The Home Automation System using ESP32 highlights the potential of IoT in revolutionizing home management. By integrating a Wi-Fi-enabled ESP32 with a user-friendly web interface, the system offers a practical and efficient solution for appliance control and home security. This project serves as a comprehensive demonstration of IoT, frontend-backend communication, and microcontroller programming in a real-world application.

To View the Code please follow the below link :-

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