Smart Home Simulation Project Proposal

Course: Internet of Things (IoT)
Academic Year: Second Year
Submission Date: Late July 2025

Group Members

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Project Overview

Project Title

Smart Home Simulation System

Project Description

This project aims to develop a comprehensive IoT-based smart home automation system using ESP32 microcontroller, multiple sensors, actuators, and real-time data visualization through Node-RED dashboard. The system will demonstrate autonomous control of various home appliances based on environmental conditions while providing remote monitoring and control capabilities through MQTT protocol.

The smart home simulation will integrate multiple subsystems including climate control, security monitoring, lighting automation, and environmental safety features, all interconnected through a centralized IoT architecture.

Technical Specifications

Hardware Components

- **Microcontroller:** ESP32 (WiFi-enabled)
- **Temperature & Humidity Sensors:** 2x DHT22 (Bedroom & Hall)
- **Motion Detection:** 2x PIR Sensors (Hall & Toilet)
- **Environmental Monitoring:** Gas Sensor (MQ-2), Photoresistor (LDR)
- **Distance Measurement:** Ultrasonic Sensor (HC-SR04) for door monitoring
- **User Interface:** Potentiometer for manual blinds control
- **Actuators:** Servo motor, RGB LED, 2x Relays, Buzzer
- **Display:** OLED Screen for local status indication

Software & Technologies

- **Programming Language:** C++ (Arduino Framework)
- **Development Environment:** Visual Studio Code with PlatformIO
- **Simulation Platform:** Wokwi Online Simulator
- **Communication Protocol:** MQTT
- **Data Visualization:** Node-RED Dashboard
- **Database:** SQLite for data logging
- **MQTT Broker:** HiveMQ Cloud Service

System Features & Functionalities

1. Automated Climate Control

- **Bedroom AC Control:** Automatically activates air conditioning when temperature exceeds 25°C
- **Real-time Temperature Monitoring:** Continuous monitoring of bedroom and hall temperatures with humidity levels
- **Energy Efficiency:** Smart scheduling to optimize power consumption

2. Environmental Safety System

- **Gas Leak Detection:** MQ-2 sensor monitors kitchen gas levels
- **Automatic Exhaust Fan:** Activates when gas concentration exceeds safety threshold (3000 ppm)
- **Audio Alerts:** Buzzer activation for immediate safety notifications
- **Emergency Protocols:** Automated response system for hazardous conditions

3. Intelligent Lighting System

- **Motion-Activated Hall Lighting:** RGB LED responds to PIR sensor detection
- **Ambient Light Adaptation:** Color intensity varies based on photoresistor readings
- **Toilet Automation:** Simple LED control for toilet motion detection
- **Energy Saving:** Automatic timeout after 20 seconds of no motion

4. Automated Blinds Control

- **Manual Override:** Potentiometer allows user-controlled blinds positioning
- **Servo Motor Integration:** Smooth 0-180° positioning control
- **Position Feedback:** Real-time angle monitoring and display

5. Security & Monitoring

- **Door Status Monitoring:** Ultrasonic sensor tracks door open/close status
- **Motion Logging:** Timestamp and location recording for all motion events
- **Real-time Alerts:** Immediate notifications for security breaches

6. Data Management & Visualization

- **MQTT Communication:** Bi-directional data exchange between ESP32 and Node-RED
- **Real-time Dashboard:** Live sensor readings and system status visualization
- **Historical Data Logging:** SQLite database for trend analysis
- **Remote Control Interface:** Web-based control panel for manual overrides

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System Architecture

Communication Flow

Sensors → ESP32 → WiFi → MQTT Broker → Node-RED → SQLite Database

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Web Dashboard ← User Interface

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Control Commands → ESP32 → Actuators

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Data Processing Layers

1. **Hardware Layer:** Physical sensors and actuators
2. **Firmware Layer:** ESP32 C++ code for data processing and device control
3. **Communication Layer:** MQTT protocol for reliable data transmission
4. **Application Layer:** Node-RED flows for business logic and visualization
5. **Data Persistence Layer:** SQLite database for historical data storage

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Project Objectives

Primary Objectives

- Demonstrate practical IoT sensor integration and data collection
- Implement autonomous decision-making algorithms for home automation
- Establish reliable wireless communication using MQTT protocol
- Create intuitive user interface for system monitoring and control
- Develop scalable architecture for future smart home expansions

Learning Outcomes

- Hands-on experience with ESP32 microcontroller programming
- Understanding of IoT communication protocols and data flows
- Proficiency in sensor interfacing and actuator control
- Knowledge of real-time data visualization techniques
- Experience with database integration in IoT applications

Expected Deliverables

1. **Complete ESP32 Firmware Code:** Fully documented C++ source code
2. **Node-RED Flow Configuration:** Exported flows with database integration
3. **Database Schema:** Complete SQLite database structure with sample data
4. **System Documentation:** Technical specifications and user manual
5. **Demonstration Video:** Live system operation showcasing all features
6. **Project Report:** Comprehensive analysis of implementation and results

Project Significance

This smart home simulation project demonstrates the practical application of IoT technologies in creating intelligent, responsive living environments. The system shows how multiple sensors and actuators can be orchestrated through a central microcontroller to create autonomous behaviors that enhance comfort, safety, and energy efficiency.

The project serves as a foundation for understanding modern smart home technologies and provides hands-on experience with industry-standard IoT protocols and tools. The modular architecture ensures scalability and provides a platform for future enhancements and additional feature integration.

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