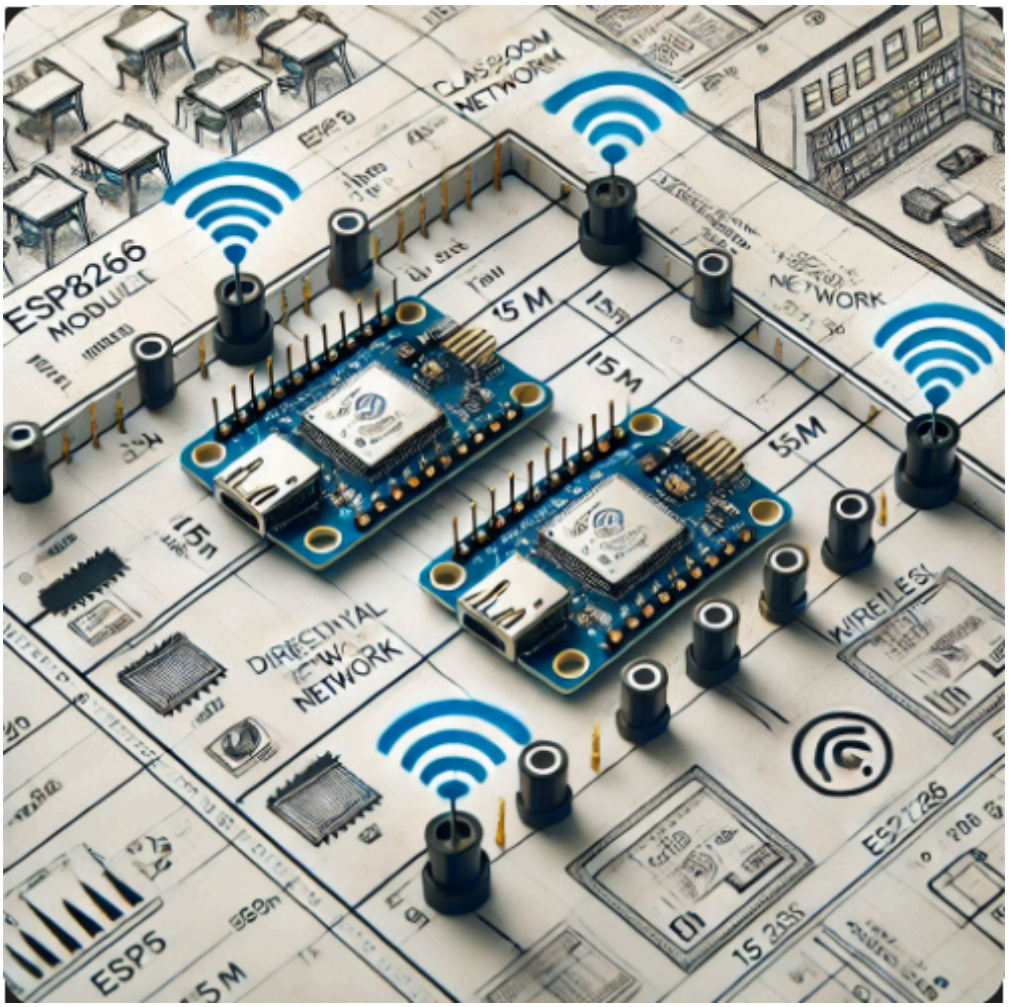
Specification Document Draft



Smart Light Switching System Specification
For Light Switch Project

Prepared by:
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Date: *12/12/2024*

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1. Introduction

Objective:

The goal of this project is to design and implement an automated, energy-efficient light-switching system for INSAT reducing energy wastage caused by lights being left on in classrooms. The system will use **ESP8266** nodes to control lighting in each classroom, with a centralized system for monitoring and control.

Challenges:

Maintaining Reliable Communication

- Ensuring stable communication between nodes and the central server across fixed distances (e.g., 15 meters).

Signal Strength and Latency

- Managing signal strength and minimizing network latency across the system.

Network Reliability and Failures

- Handling communication failures and ensuring the system remains operational through redundancy.

Secure Communication Protocol

- Implementing a secure, reliable protocol to avoid collisions and ensure message integrity.

Cost-Effective and Scalable Solution

- Balancing cost, performance, and scalability while ensuring the integration of embedded, web, and electronics teams.

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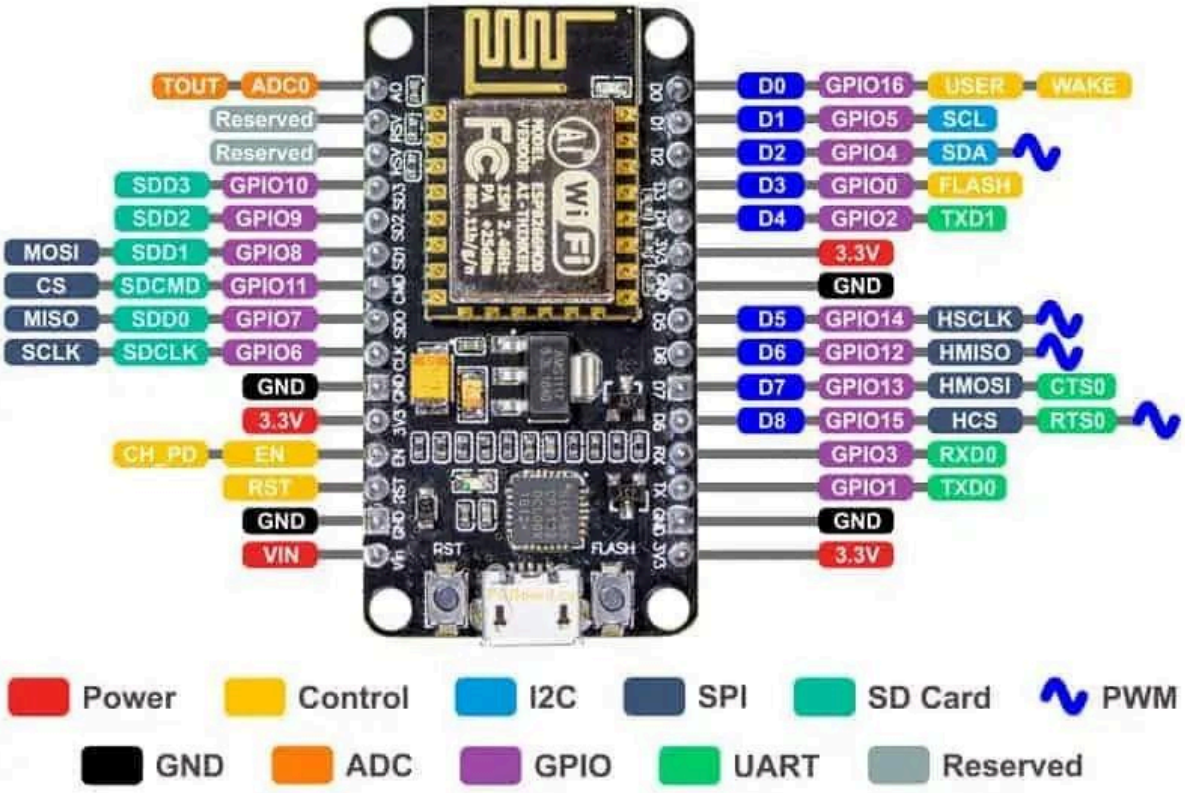
2. System Architecture

Why ESP8266?

The **ESP8266** was chosen for its **affordability**, being significantly cheaper than alternatives like LoRa modules. It integrates a **Wi-Fi module** directly on the chip, eliminating the need for external wireless components. With a fast **CPU** and sufficient **GPIO pins**, the ESP8266 allows for efficient control and monitoring of the system, making it an ideal choice for this embedded solution. Its low cost, compact size, and built-in Wi-Fi capability offer the perfect



balance of performance and value for this project.

Hardware Overview:

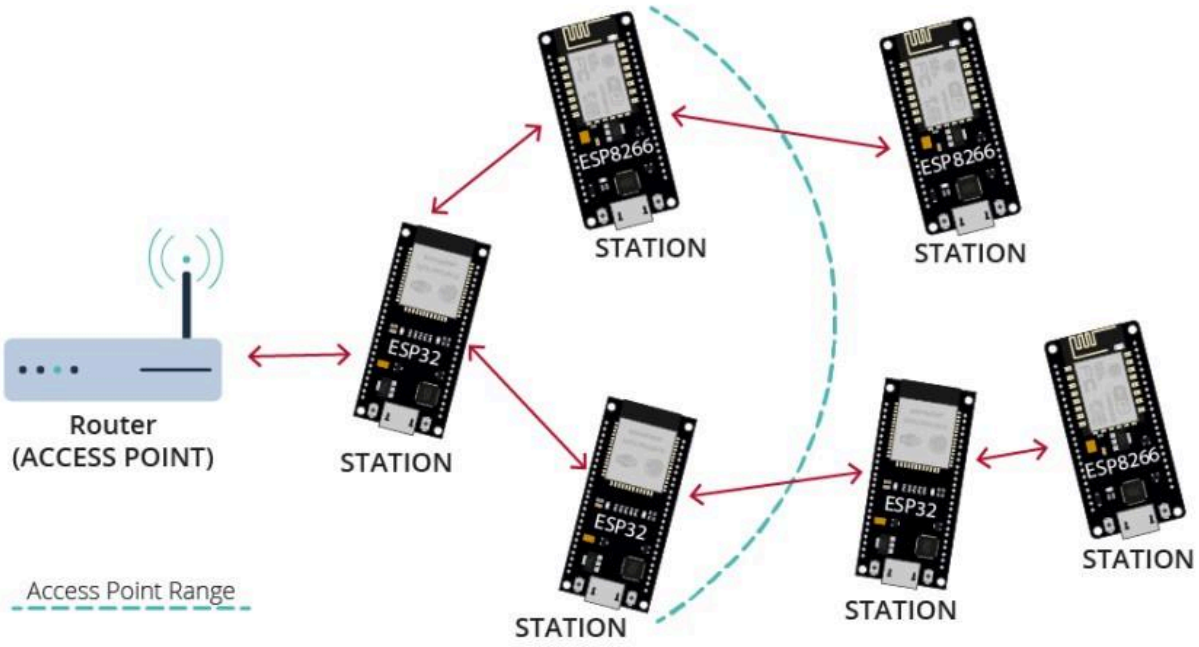
- **ESP8266 Nodes**:
  Each block of 4 classrooms will have **two ESP8266 nodes**. These nodes will control relays to turn the lights on and off. The nodes will communicate directionally within a **mesh network**, linking each block until the final node connects to the main server (router).

- **Relay Control**:
  SPDT (Single Pole Double Throw) or **latching relays** will be used to manage the light switching. Each relay is controlled by the ESP8266 through GPIO pins, ensuring efficient control of the lighting system.
- **Centralized Control System**:
  The nodes will relay their communication to a **central router/server**, which will monitor and manage the system. This setup enables centralized oversight while maintaining scalability for additional blocks.

Network Design:

- The system will use a **Mesh Network** topology for communication between ESP8266 nodes, ensuring redundancy and scalability. Each node will communicate with neighboring nodes to transmit light status and control commands.
- **Bridges:** For larger gaps (e.g., 14 meters), additional ESP8266 bridge nodes will be placed to ensure seamless communication.

Network Diagram:



3. Technical Specifications

Component	Specification
Microcontroller	ESP32 (Master Node) and ESP8266 NodeMCU(slave nodes)
Communication	Wi-Fi (Mesh network using ESP-MESH)
Power Supply	5V DC (with step-down converter for some modules)

Relay Type	SPDT or latching relays
Safety Features	Optoisolators, fuses, and proper grounding for relays

Communication Protocol:

The ESP8266 nodes will communicate using a **Mesh Network** protocol, over Wi-Fi. This will ensure that each node can relay data to its neighbors, maintaining system reliability and scalability. Simple data packets will be exchanged, including commands to turn lights on/off and status updates for each node.

4. Conclusion

The **Smart Light Switching System** offers a scalable, energy-efficient solution for automating lighting control across INSAT. By using **ESP8266 nodes** for wireless communication and **relays** for switching lights, the system ensures easy management of lighting. The centralized control system will monitor the status of all lights, while the mesh network ensures reliable operation across multiple classrooms.