**Smart Greenhouse – IoT Project**

**Project Description**

The Smart Greenhouse project represents an automated irrigation system that combines hardware and software components to create an efficient IoT solution. The execution side of the system is managed by the ESP8266 microcontroller, which controls the sensors and water pump, while the web application serves as the user interface for monitoring and control.

**Hardware and Software Components**

The system consists of an ESP8266 NodeMCU microcontroller connected to several key sensors:

* **DHT11**: Measures temperature and humidity.
* **Analog Soil Moisture Sensor**: Monitors soil moisture levels.
* **HC-SR04 Ultrasonic Sensor**: Measures the water level in the reservoir.

For visual indication of the system's status, four LED indicators are used, while a relay module controls the water pump. The software side includes Arduino code for the ESP8266 and a web application developed using HTML, CSS, and JavaScript, connected through Firebase Realtime Database.

**System Functionality**

1. **Control Interface (Hosted)**: [**https://esp8266-firebase-demo-6e68a.web.app/**](https://esp8266-firebase-demo-6e68a.web.app/)

The web application provides an interface for managing the system. Users can monitor real-time values from all sensors, view historical data through interactive graphs, and control the pump's operation mode. The interface allows switching between automatic and manual modes, as well as setting thresholds for automatic irrigation.

1. **Execution Side**

The ESP8266 continuously collects data from the sensors at 15-second intervals. In automatic mode, the system activates the pump when the soil moisture falls below a predefined threshold (default 20%), provided that the water level in the reservoir is above the minimum (default 20%). LED indicators provide a visual representation of soil moisture levels: red for critical levels (<10%), two yellow for low and medium levels (10-60%), and green for optimal levels (>60%).

1. **Communication**

The system uses Firebase Realtime Database for two-way communication between the ESP8266 and the web application. The ESP8266 sends sensor data and pump status, while the web application sends commands and new threshold settings. All data is stored with timestamps, allowing for detailed historical analysis of the system's operation.

**Operating Modes**

The system supports two primary operating modes:

**Automatic Mode**: The system autonomously manages the pump based on sensor readings and set thresholds. When soil moisture falls below the specified threshold, the pump activates and runs until the desired moisture level is reached or the water level drops below a safety minimum.

**Manual Mode**: The user directly controls the pump through the web interface.

**LED Indicators**

The system uses four LED indicators for visual representation of soil moisture levels in the form of a progress bar:

* **Red LED**: Lights up when moisture is critically low (below 10%).
* **First Yellow LED**: Activates for low moisture (10-30%).
* **Second Yellow LED**: Indicates medium moisture (30-60%).
* **Green LED**: Represents optimal moisture (above 60%).

**A diagram of a diagram

AI-generated content may be incorrect.FSM Diagram**