Faculty of computers and AI Benha University

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Project Documentation

Smart Irrigation System

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Project Requirements

The smart irrigation system shall:

1. Monitor soil moisture levels in real-time.
2. Monitor ambient temperature and humidity levels in real-time.
3. Automatically initiate irrigation when soil moisture falls below a predefined threshold (30%).
4. Allow users to manually control the water pump remotely via the Blynk IoT platform.
5. Provide notifications to the user when the irrigation system starts watering, either automatically or manually.
6. Utilize a NodeMCU ESP8266 microcontroller for system control and connectivity.
7. Employ a soil moisture sensor to measure soil hydration.
8. Utilize a DHT11 sensor to measure temperature and humidity.
9. Control a water pump using a relay module.
10. Provide a user-friendly dashboard on the Blynk platform to visualize sensor data and control the pump.

1. Problem Statement

Traditional irrigation methods often lead to inefficient water usage, either by overwatering or underwatering plants. This can result in wasted water resources, increased costs, and suboptimal plant growth. There is a need for an intelligent system that can optimize water usage based on real-time environmental conditions and plant needs, while also providing users with remote monitoring and control capabilities

2. Objectives

The primary objectives of this project are to:

1. Develop a smart irrigation system capable of autonomously watering plants based on soil moisture levels.
2. Implement remote manual control of the irrigation system through the Blynk IoT platform.
3. Provide users with real-time data on soil moisture, temperature, and humidity.
4. Generate notifications to inform users about irrigation events.
5. Design a cost-effective and scalable smart irrigation solution.

3. Scope

This project encompasses the design, development, and basic testing of a prototype smart irrigation system. The scope includes:

- Selection and integration of hardware components (NodeMCU ESP8266, soil moisture sensor, DHT11 sensor, relay module, water pump).
- Development of embedded software for the NodeMCU using the Arduino IDE to read sensor data, control the water pump, and communicate with the Blynk platform.
- Configuration of the Blynk IoT platform to create a user interface for data visualization and manual control.
- Implementation of automated irrigation logic based on a predefined soil moisture threshold.
- Integration of event notifications for irrigation activities.
- Basic functional testing of the developed prototype.

The scope does not include:

- Advanced features such as weather forecasting integration, plant-specific watering schedules, flow rate monitoring, or multi-zone irrigation control.
- Long-term field testing or deployment.
- Development of a custom mobile application.
- Water source management or pump safety mechanisms beyond basic relay control.

4. Proposed Solution

The proposed solution is a smart irrigation system that utilizes a network of sensors and actuators controlled by a WiFi-enabled microcontroller (NodeMCU ESP8266). The system monitors soil moisture, temperature, and humidity levels. When the soil moisture level falls below a critical threshold, the system automatically activates a water pump to irrigate the plants. Users can also manually trigger or stop the irrigation process through a user interface created on the Blynk IoT platform. Real-time sensor data is transmitted to the Blynk cloud, allowing users to monitor their plants' environmental conditions remotely via a mobile or web dashboard. Notifications are sent to the user's registered device whenever the irrigation system starts watering.

5. Inputs and Outputs

Input	Description
Analog Soil Moisture Sensor	Measures the volumetric water content in the soil.
DHT11 Temperature Sensor	Measures the ambient air temperature.
DHT11 Humidity Sensor	Measures the relative humidity of the ambient air.
Blynk Manual Control (Button)	User input from the Blynk app to turn the water pump on/off.
Power Supply	Provides electrical power to the system components.

Output	Description
Water Pump Activation	Electrical signal to the relay module to turn the water pump ON/OFF.
Blynk Data Display (V0-V3)	Real-time soil moisture (%), temperature (°C), and humidity (%) data sent to the Blynk dashboard.
Blynk Notification	Alert sent to the user's device when irrigation starts.

6. Device Layer Sensors and Actuators

Sensors:

- Soil Moisture Sensor (Analog): Detects the level of moisture in the soil.
- DHT11 Temperature and Humidity Sensor: Measures the ambient temperature and humidity.

Actuators:

- Water Pump: Dispenses water for irrigation.
- Relay Module: Acts as an intermediary switch to control the power supply to the water pump, driven by the microcontroller.

7. Sensors and Actuators with Functions

Component	Type	Function
Soil Moisture Sensor	Sensor	Measures the moisture level in the soil.
DHT11 Temperature Sensor	Sensor	Measures the ambient air temperature.
DHT11 Humidity Sensor	Sensor	Measures the relative humidity of the ambient air.
Relay Module	Actuator	Electrically switches the water pump ON or OFF based on the control signal.
Water Pump	Actuator	Transfers water to irrigate the plants.

7.System Architecture:

The system follows a three-layer IoT architecture:

1. **Device Layer:** Consists of the physical sensors (soil moisture, DHT11) and actuators (relay, water pump) that interact with the environment. The NodeMCU ESP8266 microcontroller is also part of this layer, responsible for collecting sensor data and controlling the actuators.
2. **Network Layer:** Facilitates communication between the device layer and the application layer. In this project, WiFi connectivity provided by the ESP8266 module is used to transmit sensor data to the Blynk cloud and receive control commands.
3. **Application Layer:** Encompasses the Blynk IoT platform, which provides a user interface (mobile and web dashboard) for visualizing sensor data, manually controlling the water pump, and receiving notifications. The Blynk cloud acts as an intermediary, enabling communication between the NodeMCU and the user interface.

8. Test Strategy

The test strategy aims to verify the correct functionality of the smart irrigation system, ensuring that each component operates as intended and that the system as a whole meets the defined requirements. The testing will involve unit testing of individual components and integration testing of the complete system.

Unit Testing:

- **Soil Moisture Sensor Test:** Verify that the sensor provides varying analog readings corresponding to different levels of soil moisture. Manually change the moisture content of the soil and observe the sensor readings.
- **DHT11 Sensor Test:** Verify that the sensor accurately reads ambient temperature and humidity. Compare the readings with a calibrated thermometer and hygrometer.
- **Relay Module Test:** Ensure that the relay module correctly switches the water pump ON and OFF when a control signal is applied from the NodeMCU.
- **Water Pump Test:** Verify that the water pump operates correctly when powered through the relay module.

Integration Testing:

- **Automated Irrigation Test:** Simulate low soil moisture conditions (below 30%) and verify that the NodeMCU triggers the relay and turns on the water pump. Observe if the pump turns off after a defined period or when moisture levels theoretically increase (this might require manual intervention in a dry setup).
- **Manual Control Test:** Use the Blynk button widget to manually turn the water pump ON and OFF. Verify that the relay and the water pump respond accordingly.
- **Data Transmission Test:** Monitor the Blynk dashboard and verify that the soil moisture, temperature, and humidity readings are displayed correctly.
- **Notification Test:** Trigger both automatic and manual irrigation and verify that a "watering_done" notification is received on the registered Blynk account.

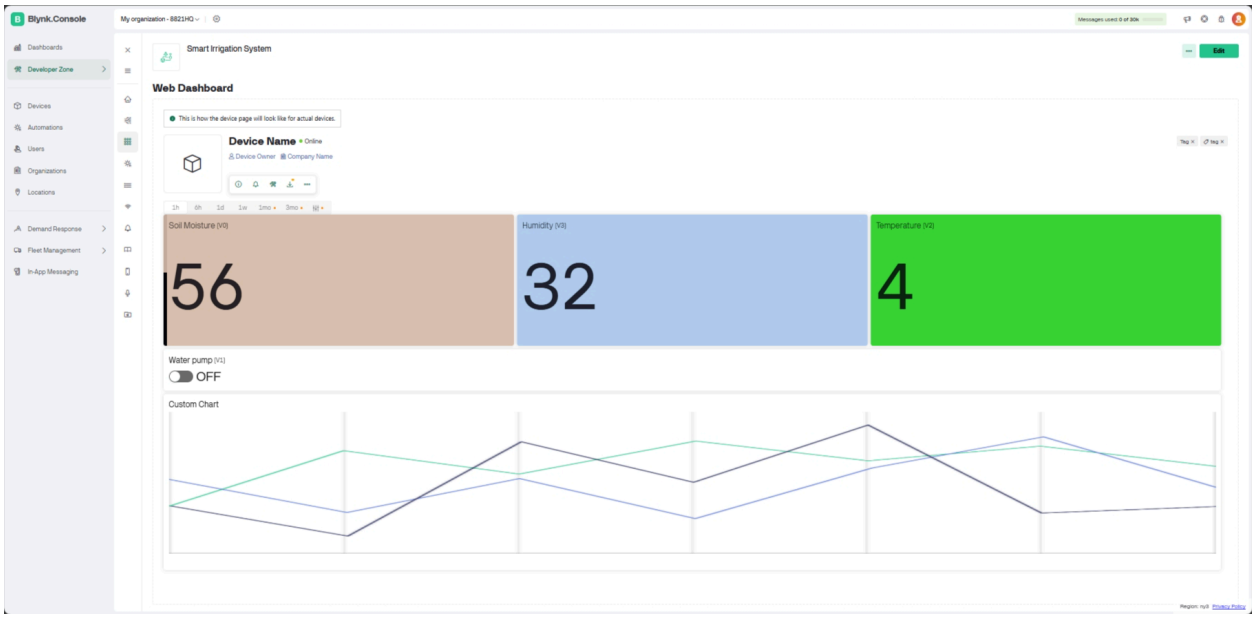
9. Test Cases

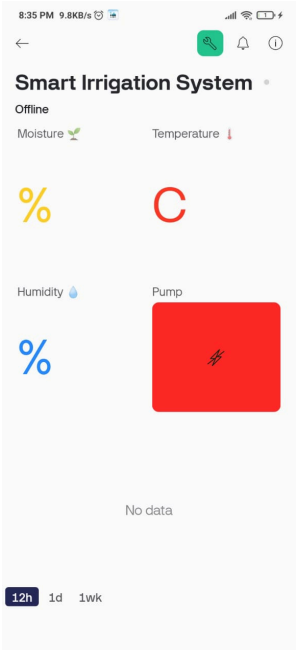
Test Case ID	Description	Preconditions	Test Steps	Expected Result	Pass/Fail
TC-01	Verify soil moisture reading accuracy.	Soil moisture sensor connected to NodeMCU. Arduino code uploaded.	Observe Blynk dashboard for soil moisture readings under different soil conditions (dry, moist, wet).	Readings should reflect the actual soil moisture levels.	
TC-02	Verify automatic irrigation when soil moisture is low.	Soil moisture < 30%. Automatic irrigation enabled in code.	Observe if the water pump turns ON automatically.	Water pump should turn ON.	
TC-03	Verify water pump turns OFF after automatic irrigation (simulated).	Water pump ON due to simulated low moisture			

10.Dashboard Design

The Blynk dashboard include the following widgets:

- **Value Display (V0):** Display real-time soil moisture percentage.
- **Button (V1):** Manual control for the water pump (On/Off).
- **Value Display (V2):** Display real-time temperature in Celsius.
- **Value Display (V3):** Display real-time humidity percentage.
- **Notifications:** Display event notifications, specifically when "watering_done"





“ Mobile & Web Dashboard”