INSTITUTION NAME -
BHARATI VIDYAPEETH'S JAWAHARLAL NEHRU INSTITUTE OF INSTITUTE OF TECHNOLOGY (POLYTECHNIC)

PROGRAM NAME -
ELECTRONICS & TELECO MMUNICATION ENGINEERING

CORSE NAME –
(22060)CAPSTONE PROJECT EXECUTION AND REPORT WRITING

PROJECT GUIDE:
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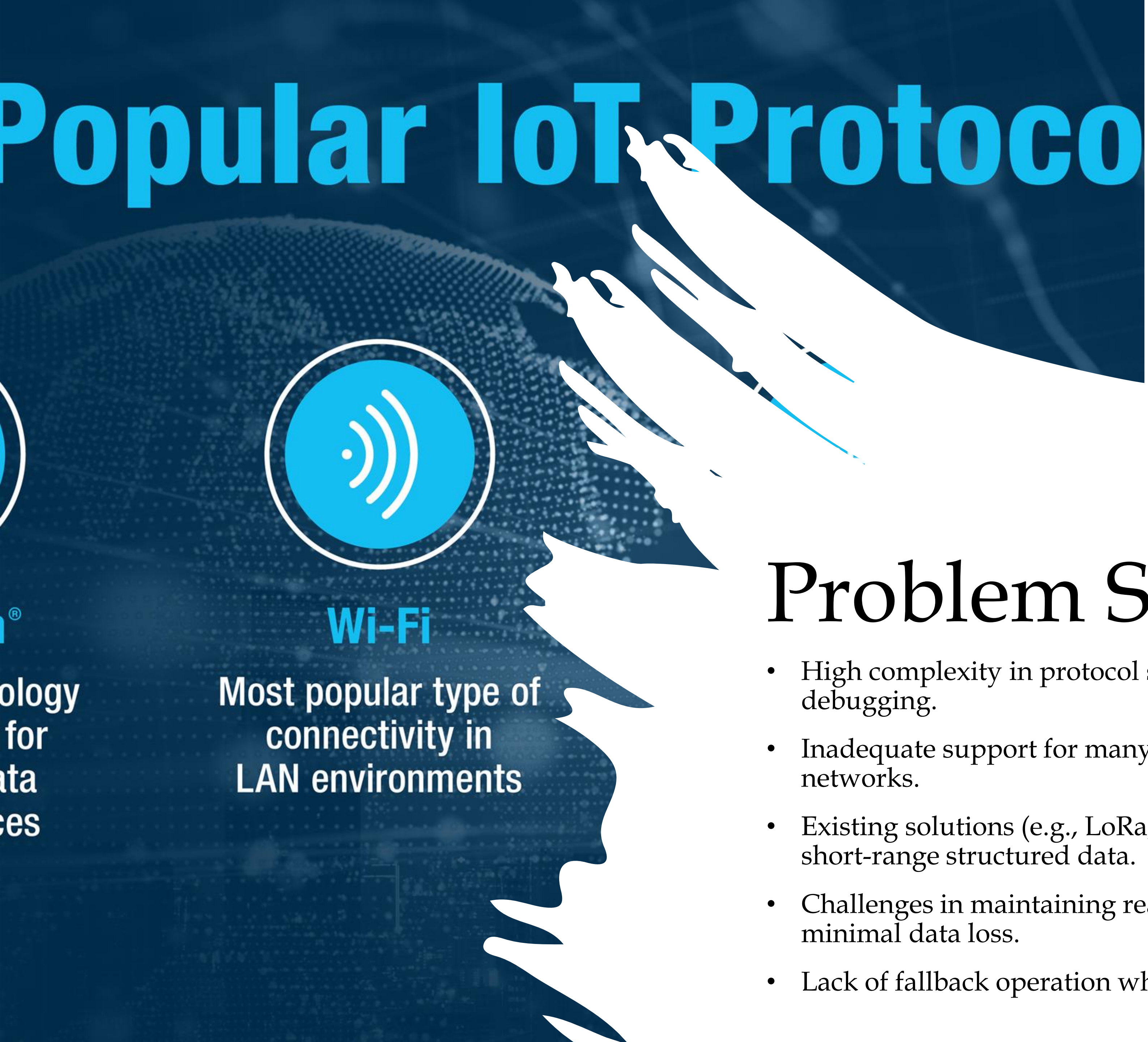
Smart AgroSense: IoT-Based Multi-Point Wireless Sensor System for Precision Farming



Problem Statement

- High complexity in protocol stacks limits rapid deployment and debugging.
- Inadequate support for many-to-one data flow in low-power sensor networks.
- Existing solutions (e.g., LoRa, Zigbee) are expensive or over-engineered for short-range structured data.
- Challenges in maintaining real-time communication with low latency and minimal data loss.
- Lack of fallback operation when cloud or internet access is disrupted

Core Functional Goals:

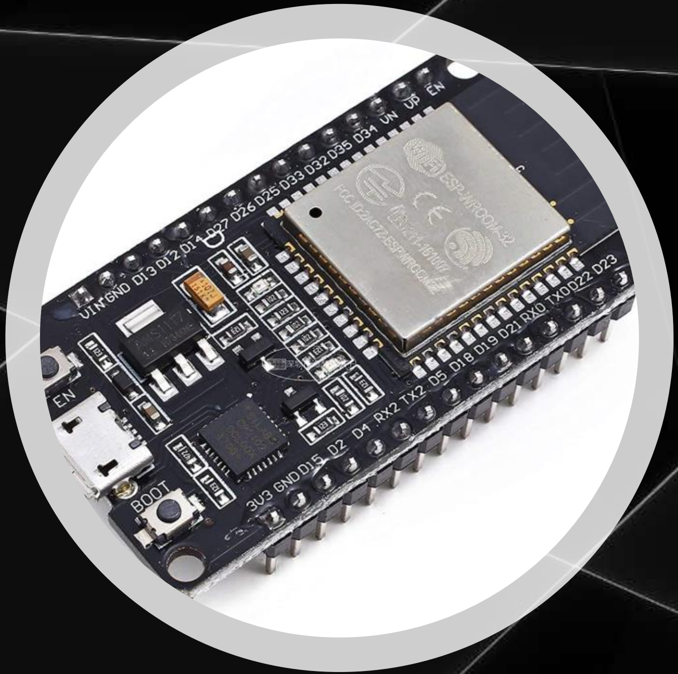
- **Wirelessly monitor** soil moisture, temperature, and humidity from multiple locations
- **Display real-time sensor data** on the mobile app using an IoT platform (Blynk)
- **Automatically activate irrigation** based on soil moisture thresholds
- **Send smart notifications** to the user when soil moisture falls below the safe limit

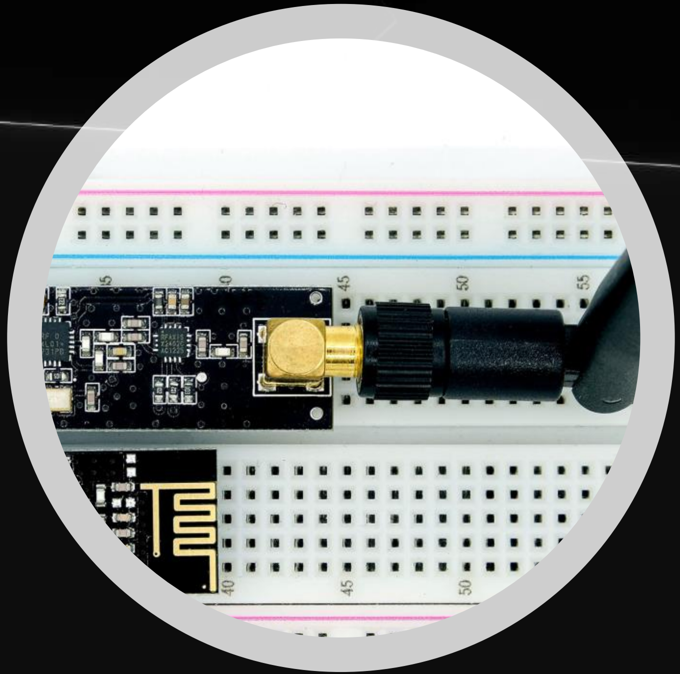
Comparative Analysis of Research and Our Contributions

- **Identified Gaps in Current Research**
  - • Protocol Complexity – Modern protocols like MQTT-SN require custom stacks that increase overhead [Springer, 2025].
  - • IoT Security – Many IoT devices lack secure configurations or insight into their software layers [Nozomi Networks, 2024].
  - • Energy Efficiency – Energy use during wireless data transmission remains high [MDPI Electronics, 2024].
  - • Real-Time Data Handling – Scaling systems while maintaining responsiveness is still a challenge [Springer, 2025].
- **Our Project's Contributions**
  - • Lightweight, Struct-Based Protocol using NRF24L01 for minimal overhead and fast transmission.
  - • Communication-focused architecture with offline fallback handling and modular expansion.
  - • Secure and energy-efficient communication tailored for microcontroller constraints.
  - • Real-time, many-to-one data handling across three active sensor nodes.

Why We Chose NRF24L01 Over LoRa, Zigbee, and Wi-Fi

Protocol	~Range	Power Usage	Cost/Node	Data Rate	Integration Ease	Suitability
NRF24L01	~700 m (w/ PA+LNA)	Low	₹150–₹200	Up to 2 Mbps	Easy (ESP32)	□ Ideal
Zigbee	~10–50 m	Medium	₹400–₹600	250 kbps	Moderate	Possible
LoRa	1–5 km+	Very Low	₹700–₹1200	< 50 kbps	Complex (custom stack)	• Unnecessarily complex
Wi-Fi	30–50 m	High	₹400+	High (~10 Mbps)	□ Built-in (ESP32)	For cloud only





Hardware Components

- ESP32 – Main controller and Wi-Fi module
- NRF24L01 – Wireless transceiver for nodes
- DHT22 – Temperature and Humidity sensor
- Soil Moisture Sensor – Analog soil sensor
- Relay Module – Controls water pump
- DC Pump – Waters the plants automatically

Node Architecture

- Each node includes DHT22 + Soil Sensor + NRF24L01
- Sends structured sensor data wirelessly
- Unique Node IDs for identification (N1, N2, N3) ==
- Data Handling Workflow per Node:

Sensor Sampling
-ESP32 reads DHT22 and soil moisture data every few seconds.

Struct Packaging Data is placed into a struct with fields:
Node ID, Temperature, Humidity, Soil Moisture, Relay State.

Relay Decision Logic :If soil is too dry, relay GPIO pin is activated to turn ON the pump.

Wireless Transmission via NRF24L01
ESP32 sends the struct to a central ESP32 receiver using a unique address like "NODE1".

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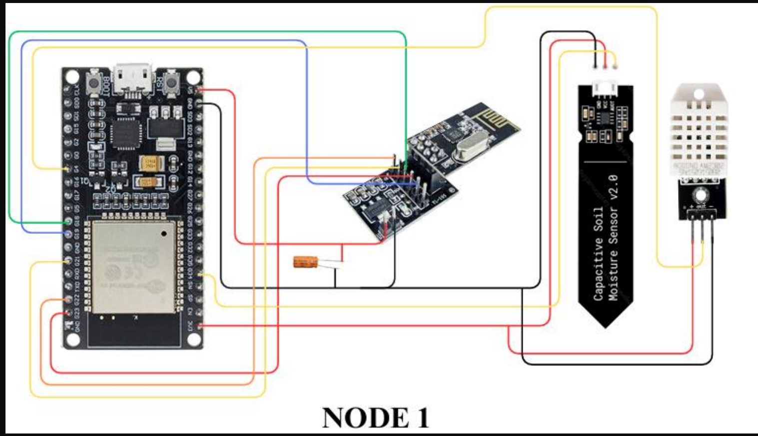
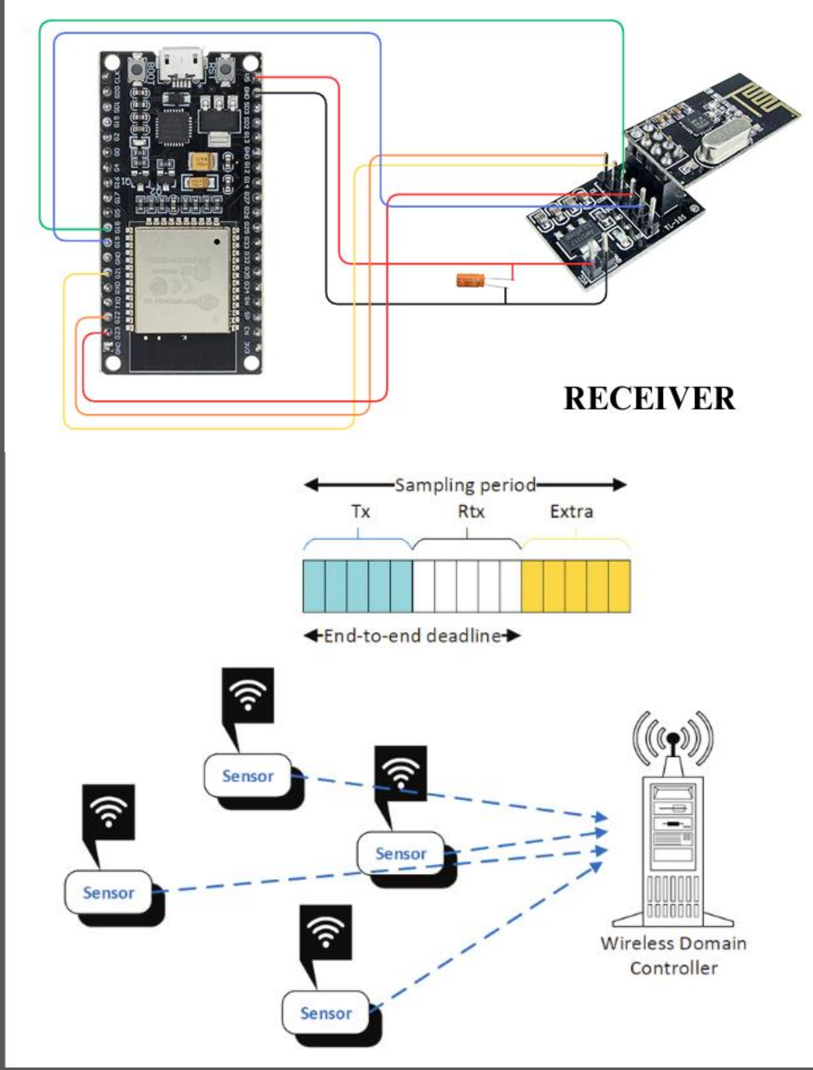


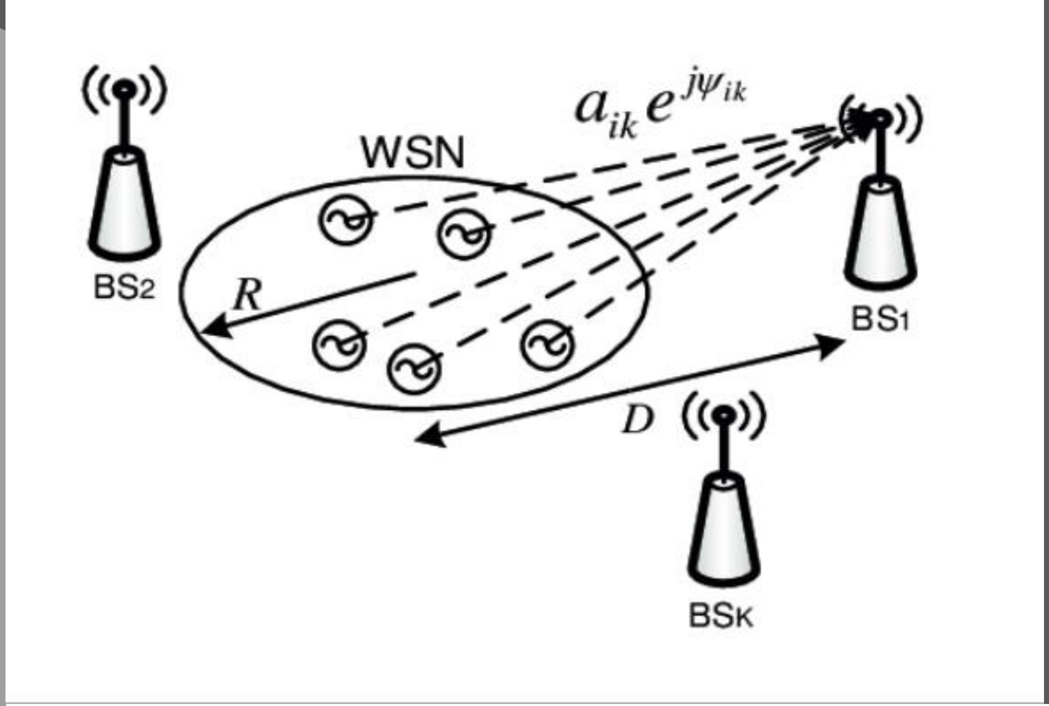
Receiver (ESP32)

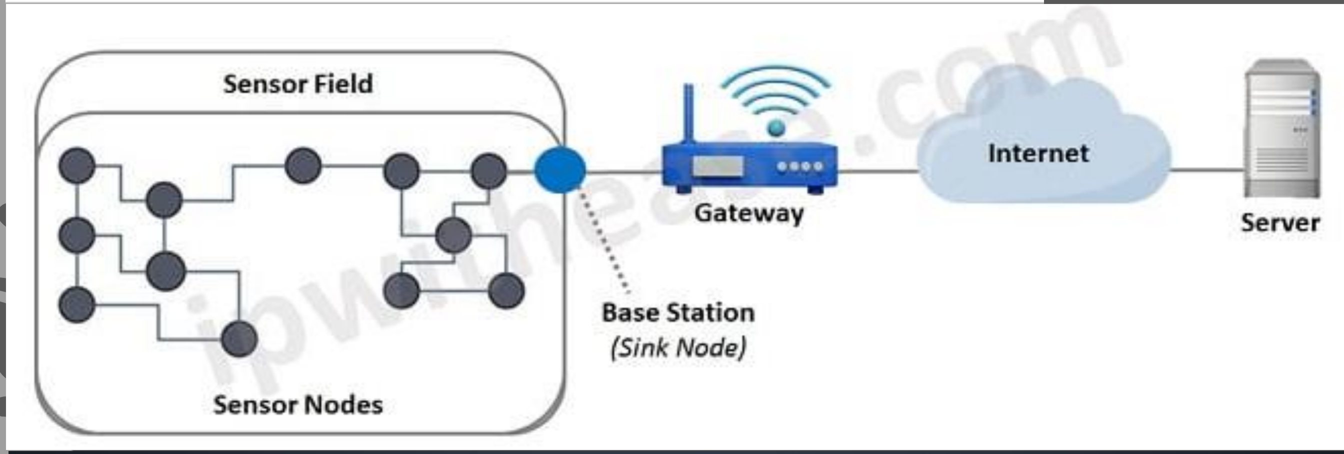
- Receives data from multiple nodes using NRF24L01
- Parses and forwards sensor values to Blynk cloud
- Sends notification alerts based on soil threshold



System Overview

- Sensor Nodes (N1, N2, N3) with DHT22 + Soil Sensors
- NRF24L01 transmits data to ESP32 Receiver
- ESP32 sends data to Blynk Cloud
- Mobile app displays real-time data and alerts





Key Competitive Features:

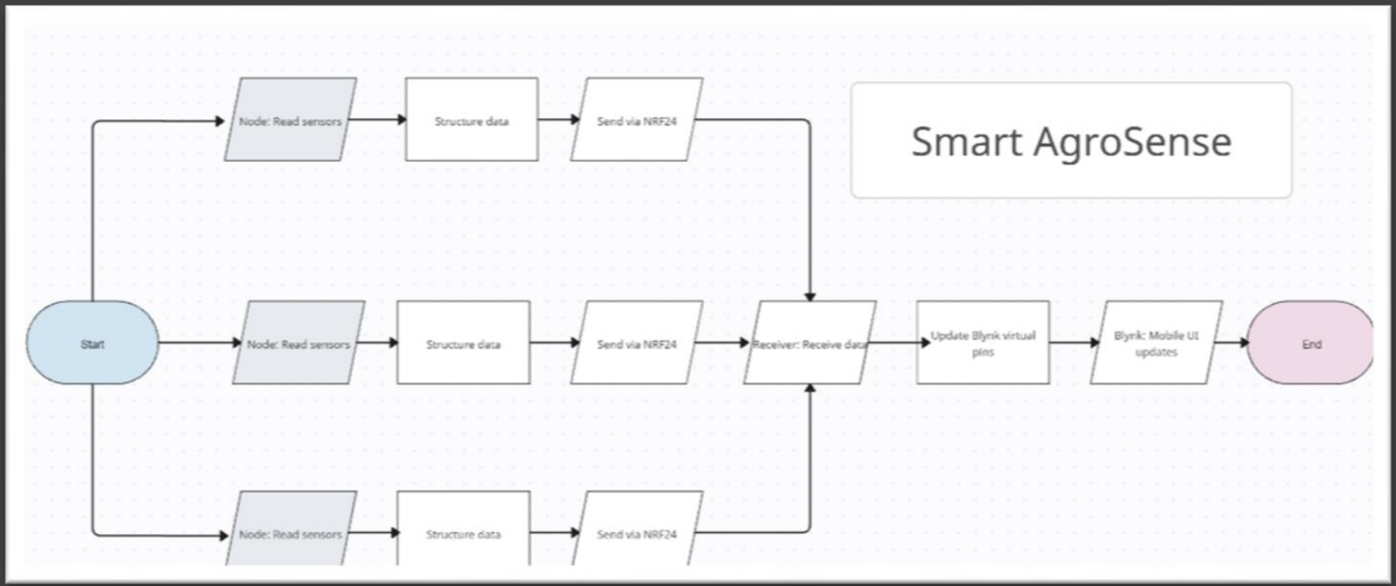
- Many-to-One Wireless Architecture
 – Seamless data transmission from multiple sensor nodes to a single ESP32 receiver
- Offline Auto-Control with Plan B Integration
 – Node 3 autonomously controls the water pump even if Wi-Fi or receiver fails
- Compact & Structured Data Transmission
 – Efficient, low-latency communication using lightweight struct packets
- Hybrid Cloud + Local Monitoring
 – Real-time cloud sync with Blynk + Serial fallback for network downtime
- Smart Alerting System
 – Intelligent flag-based alerts that notify only when conditions change, avoiding spam

Blynk Cloud Integration

- ESP32 uses Wi-Fi to send sensor data to Blynk
- Blynk dashboard displays temperature, humidity, and soil moisture
- Push notifications sent when soil is dry

Software Workflow

- Node: Read sensors → Structure data → Send via NRF24
- Receiver: Receive data → Update Blynk virtual pins
- Blynk: Mobile UI updates → Trigger alerts if needed



Future Scope

NRF-based long-range nodes

Solar-powered nodes and pumps

Mobile app threshold customization

SD card data logging with real-time clock

Increasing number of nodes

Conclusion

- Smart AgroSense enables remote farm monitoring
- Provides reliable soil health alerts
- Combines wireless sensors, cloud, and automation
- Flexible fallback modes ensure robustness