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Smart Farming by Implementing Lora (LPWA) and Iot

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ABSTRACT: This research paper investigates the implementation of a smart farming system utilizing LoRa (Low Power Wide Area Network) and IoT (Internet of Things) technologies. The primary objective is to optimize agricultural practices by providing farmers with real-time data on critical environmental parameters, such as soil moisture, temperature and humidity. The Long-Range, low-power capabilities of LoRa, combined with the robust data processing and connectivity features of IoT, offer a promising solution to the inefficiencies of traditional farming methods.

KEYWORDS: XIAO ESP32-C3 mini, SX1262HF LoRa, Sensors&Actuators,LPWA(Low Power Wide Area Network).

I. INTRODUCTION

This paper focuses on developing a Smart Farming solution that utilizes LoRa and IoT. The system will consist of solar panel as well as battery operated sensor nodes capable of measuring key environmental parameters, such as temperature, humidity, and soil moisture which are most essential parameters for a quality crop yeald. These nodes will transmit the collected data to a central receiver using the LoRa module. From the receiver, the data can be stored to a storage device and used for analysis of the environmental conditions. Bycontinuously monitoring these parameters, individuals can make informed decisions to optimize irrigation, manage crops more effectively, and ultimately increase agricultural productivity. Smart Farming represents a significant leap forward in agricultural practices. Traditional farming methods often rely on manual observations and reactive measures, which can lead to inefficient use of resources and sub optimal crop yields. Smart Farming, on the other hand, enables proactive and precise management of agricultural processes.

LoRa (Long Range) technology is a key enabler of Smart Farming. LoRa is a modulation technique that allows for long-range communication with low power consumption, making it ideal for applications where devices are often deployed in remote areas with limited power sources.

The successful implementation of this project will demonstrate the potential of IoT and LoRa technology in revolutionizing agriculture. By providing farmers with a reliable, energy-efficient, and cost-effective solution for monitoring environmental conditions, this project is aimed at contributing to the advancement of Smart Farming practices. The insights gained from this project can serve as a foundation for future developments in precision agriculture, ultimately leading to increased agricultural productivity and sustainability.

II. LITERATURE SURVEY

Smart farming, also known as precision agriculture, refers to the application of modern information and communication technologies (ICT) into agriculture. This paradigm shift from traditional farming to smart farming aims to enhance the efficiency, productivity, and sustainability of agricultural practices. The concept of smart farming encompasses various technologies, including sensors, robotics, big data analytics, and IoT, which work together to provide real-time monitoring, data collection, and automated decision-making.

LoRa (Long Range) is a wireless communication technology developed by Semtech Corporation. It is a type of LPWA (Low Power Wide Area) network that enables long-range communication with very low power consumption covering large distances of upto some kilometers which the Wi-Fi or other wireless can't cover. LoRa operates in unlicensed radio frequency bands, such as 865-867 MHz in INDIA and 900-915 MHz in North America which are licence free bands made available to public by the governments, makes it accessible and cost-effective for various applications.

LoRa is a Transceiver module working in Half Duplex Mode which transmit and receive data but not simultaneously. A LoRaWAN Module can be used to make a Lora end device transmit and receive data simultaneously.

III. ANALYSIS & DESIGN

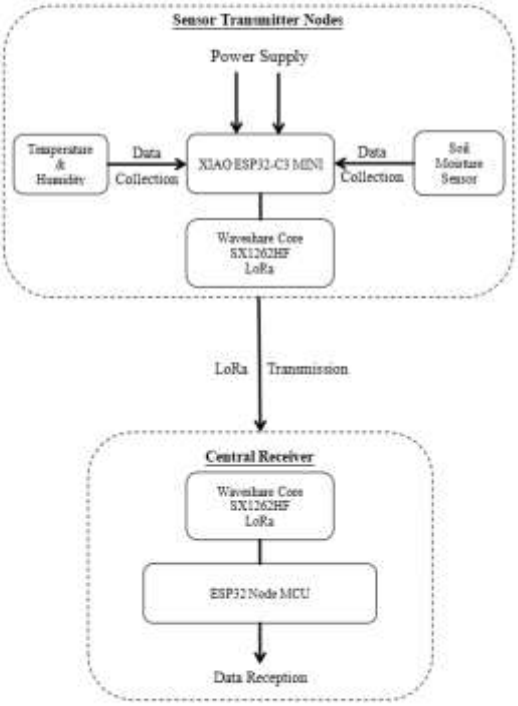

Fig : Device Architecture Design

The system architecture for the Smart Farming solution consists of multiple sensor nodes, a central receiver, and a data storage with access point and a python analysis platform.

◆ Sensor Nodes:
Each node consists of sensors for measuring temperature, humidity, and soil moisture.
The nodes are powered by solar panels and batteries, ensuring continuous operation.
Data from the sensors is collected by an XIAO ESP32-C3 MINI development board.
The XIAO ESP32-C3 MINI transmits the data using a Waveshare Core SX1262HF LoRa module.

◆ Central Receiver:
□ The central receiver is built using an ESP-WROOM-32 Node-MCU development board with Waveshare Core SX1262HF LoRa module.
□ It receives data from multiple sensor nodes and processes it for storage,
□ The receiver can be connected to the internet via Wi-Fi, an access point is created to access .csv files where data is stored which can then be loaded to a analysis program developed using Python and Tkinter for visualization.

IV. DATA FLOW

✧ Data Collection:
Multiple sensor nodes collect temperature, humidity, and soil moisture data from different points placed across a large plot of land.
The XIAO ESP32-C3 MINI processes and formats the sensor data into packets.

✧ Data Transmission:
The XIAO ESP32-C3 MINI initializes the Waveshare Core SX1262HF LoRa module connected to the MCU for data transmission.
The Module is set at 867MHz Frequency which is Licence Free Band For Public. Data is collected and transmitted at an intervals of every 9 seconds.

✧ Data Reception:
A LoRa module at the Central Receiver node receives the packets from multiple sensor nodes placed across a large plot of land.
The ESP-WROOM-32 processes the packets and extracts the sensors data and logs it in a storage unit.

✧ Analyzing and Visualization:
The data from storage unit is accessed through an access point provided by ESP-WROOM-32. The

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data is aggregated and plotted into graphs with the Analysis program developed using python and its integrated interface Tkinter.

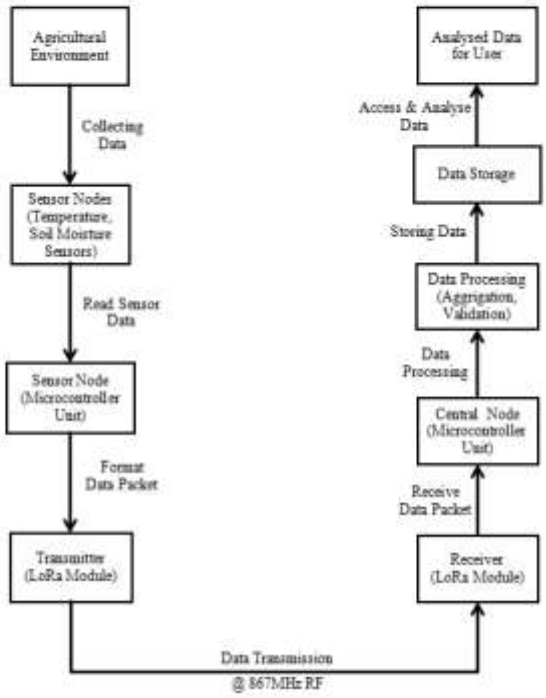

Fig : Data Flow

IV. TESTS& RESULTS OBESERVATIONS

XIAO ESP32-C3 MINI Testing:

Description: Verified the micro controller correctly reads data from sensors and formats data packets.

Procedure: Simulate sensor inputs and check the formatted data packets.

Result: Data packets contains accurate and correctly formatted sensor readings, node ID, and time stamp.

✧ Waveshare SX1262HF LoRa Module Testing:

Description: Verified the LoRa module correctly transmits and receives data packets.

Procedure: Send test data packets from one LoRa module and verify reception at another module within the expected range.

Result: All data packets were received correctly without loss or corruption.actual force required inthe application is need to move the engine valve along with spring that must be considered.

✧ Sensor Node Integration Testing:

Description: Verified the sensor node correctly collects data from all sensors and transmits it using the LoRa module.

Procedure: Connect all sensors to the ESP32-C3-MINI, simulate environmental conditions, and monitor the data packets transmitted via LoRa.

Expected Result: Data packets contained accurate and consistent readings from all sensors.

✧ Central Receiver Integration Testing:

Description: Verified the central receiver correctly receives data packets from multiple sensor nodes and processes them.

Procedure: Simulate data transmissions from multiple sensor nodes and monitor the receiver's data processing.

Result: The receiver correctly received, validated, and aggregated data packets from all nodes.

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V. IMPLEMENTATION

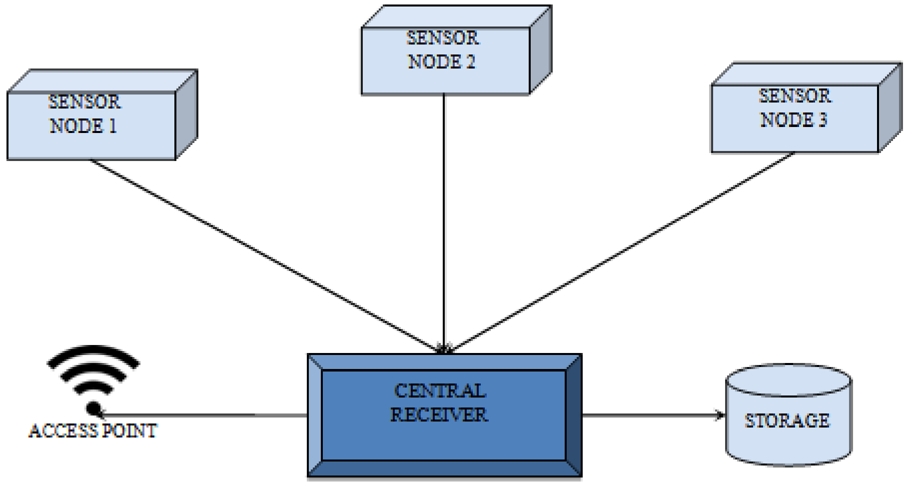

Fig :System Architecture

The project set up is very simple and can also be used as a generic purpose. Three sensor nodes are placed across plot of agricultural land at different points, though any number of sensor nodes can also be introduced into the system. These nodes collect temperature, humidity & soil moisture data from the sensors at an intervals of 9 seconds, each time data is processed and formed into packets with header, these packets are transmitted through the LoRa module set @ 867Mhz frequency which is a licence free radio frequency band.

A central receiver which is continually looking for packets at the same frequency as the transmitter, this will collect the packets and verifies for any errors by performing cyclic redundancy check(CRC) error detection technique. The data from the packets are extracted by the ESP-WROOM-32 micro-controller unit which can be seen in the Arduino IDE’s serial monitor. Simultaneously the data along with time-stamp is stored in a micro SD card in the form of Comma Separated Value(.csv) format. An Access Point Server in the MCU provides access to the files in storage that can be downloaded to device which is connected by Wi-Fi.

The Analysis program is run on a PC, the data file is uploaded to the program which cleans and aggregates the data. The visualization of the data is plotted in the form of graphs and charts.

Fig : Data Analysis & Visualization

VI. CONCLUSION

The Smart Farming project leverages LoRa and IoT technologies to enhance agricultural practices by providing real-time monitoring and data-driven insights. Through the implementation of solar and battery-operated sensor nodes, the system measures temperature, humidity, and soil moisture, transmitting this data over long distances using the Waveshare Core SX1262HF LoRa module connected to the ESP32-C3-MINI development board. A central receiver node, built using the ESP-WROOM-32 Node-MCU development board connected to LoRa, receives and aggregates data from multiple sensor nodes and saves it to a storage unit, which is downloaded by access point and analyzed with the help of python program.

Outcomes:

- Improved Resource Management:By continuously monitoring soil moisture, temperature, and humidity, farmers can optimize irrigation schedules, reducing water usage and improving crop yields.
- Cost Effectiveness:By utilizing licence free networking technologies, off-the-shelf components and open-source software, the project minimizes costs while providing a robust and reliable solution.

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