Development of air temperature and soil moisture monitoring systems with LoRA technology

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Abstract. One of the problems in agriculture is the difficulty of monitoring agricultural field because its location is far from the farmer's house. Factors affecting agricultural crops are air temperature and soil moisture. Both factors are important to be maintained so that agricultural output can be optimized. LoRA is a spread spectrum modulation technique derived from spread spectrum chirp technology and the first low cost implementation of spread spectrum chirp. LoRA is able to transmit data within a distance of 7.5 km with a frequency of 433 MHz. In this study, machine-to-machine method with LoRA technology was used to send air temperature and soil moisture data. This method is advantageous because communication can be carried out at a frequency of 433 MHz and thus does not depend on cellular frequencies. Monitoring via the internet can be done by connecting LoRA with the ESP32 microcontroller which connected to an access point for sending data online through the Ceyene application. Test environment is build by giving variations in air temperature and variations in the depth of the sensor that was planted in the soil. The research proves that monitoring of soil temperature and humidity can be done with LoRA technology at a low cost.

1. Introduction
Long Range (LoRa) Radio is a unique modulation technique designed by Semtech. LoRa was using FM modulation. One of LoRa advantages is the range of communication between the sender and receiver could cover a very long distance, aside from low-cost devices, infrequent communication rate, and long battery lifetime[1]. LoRa is capable of communicate up to 7.5 kilometers [2]. The build up feasibility model using Lora for data collection and transmission for remote location stated that Lora was adequate for remote location communication [3].

In Internet of Things (IoT), specifically Agricultural IoT, the application of LoRa devices had been introduced. LoRa was used as communication module responsible for transmitting atmospheric temperature, atmospheric humidity, and light intensity data to server [4].

This paper discussed the application of LoRA as a communication system for air temperature and soil moisture which send the data to IoT platform.
2. Experimental
Figure 1 shows the block diagram of the system. On the Node Source, soil moisture, temperature and air humidity are measured using sensors. The sensor used for measuring temperature and air humidity is DHT-11 [5] and the sensor for measuring soil moisture is a FC-28 soil moisture sensor. The configuration setup for DHT-11 sensor and soil moisture sensor is shown in Figure 2. The data then transmitted using LoRa. Data from Source Node will receive by the Sink Node. All data will be processed by ESP32 microcontroller [6] and send to Cayenne IoT Platform for storage and visualisation.

![Diagram of System Design](image1)

**Figure 1. Diagram of System Design**

![Configuration setup for DHT-11 and Soil moisture sensor.](image2)

**Figure 2. Configuration setup for DHT-11 and Soil moisture sensor.**

3. Result and Discussion
In order to evaluate the performance of the proposed system, the system had been implemented and deployed on an environment which describes the typical agricultural field. The DHT-11 sensor measure the air temperature in Celsius (°C) and air humidity in percentage (%). The soil moisture sensor used to measure the soil moisture in percentage (%). Soil moisture shows the ratio between the weight of water contained in the soil and the total weight of the soil, show in Figure 3.
This tool uses 2 soil moisture sensors where all sensors can work simultaneously and effectively. Soil moisture sensor testing is by immersing gradually into wet soil and shown in Figure 4.

Implementation of the Garden Monitoring is carried out on small-scale plants which will measure temperature, soil moisture and air. Data will be displayed through a Smartphone so that it can know the state of plants in real-time and shown in Figure 5.

Testing this tool is carried out on a smartphone that has installed the Cayenne application, this application will display 4 indicators namely: Air Humidity, soil humidity 1 & 2 and Air Temperature. There is a delay of approximately one minute between the data sent in Cayenne and the data displayed on the ESP32 serial monitor due to a bad internet connection.
4. Conclusion

Monitoring via the internet can be done by connecting LoRA with the ESP32 microcontroller connected to the access point for sending data online through the Ceyene application. Test equipment is done by giving variations in air temperature and variations in the depth of the sensor that is planted in the soil. The research proves that monitoring of soil temperature and humidity can be done with LoRA technology at a low cost.

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