Prototype of Smart Garden System for Monitoring Holticulture Plants Based on LoRa Technology

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***Abstract*— This paper proposes a development of smart garden sistem based on LoRa technology. The basic principles of the control system in this study use a smart garden system that has the ability to send inputs in the form of data information that aims to monitor air temperature, air humidity, soil temperature, and automatic watering of ground kale plants which can be accessed through the Android application. The communication tool used is LoRa EBYTE E32. The LoRa EBYTE E32 module is used as a data communication module between the sensor node and the LoRa gateway, as well as the MQTT protocol as a data communication gateway. We introduce a new system monitoring plants based Internet of Things (IOT) which can be accesed through the android application on the smartphone. The Smart Garden system based on LoRa technology can work according to configuration because it can monitor air temperature, air humidity, soil temperature, soil humidity, and automatic watering of ground kale plants according to the configuration, namely the water pump is able to turn on when the humidity sensor has a range value below 80% is 20%-79% and the water pump shuts down when the humidity value exceeds 80%. Then, the communication coverage distance between the sensor node and the LoRa gateway after testing obtained the maximum distance is 440 meters in the Semi Line of Sight (LOS) area while in the Non Line of Sight (NLOS) area a lower maximum distance of 240 meters is obtained, this is because in the NLOS area there is an obstacle that hinders the coverage of the LoRa signal.**

Keywords—LoRa EBYTE E32, Smart Garden, MQTT Protocol, Android.

I. Introduction

Horticultural crops are a branch of plant farming related to garden crops. There are various types of plants that are included in the horticultural plants, including types of fruit plants (fruitculture), flower plants (floriculture), vegetable plants (oleculture), and medicinal plants (biopharma ceuticals). Horticulture is somewhere between household gardening and field farming. In terms of growth, be it horticultural crops, agronomy or forestry, intensive care is definitely needed for growth and breeding of plants. The care given to plants consists of watering, fertilizing, eradicating pests, exterminating weeds and so on [1].

Some people consider that watering a plant with a certain period every day can keep the plant healthy. Plants get carbon dioxide and light from the sun easily every day, if they are placed in the right place. Plants that lack water or that get excess water can have a negative impact on plants. The parameters for knowing the plant in good condition can be seen from the temperature, soil moisture and air humidity [2]

One system that can be used to monitor the plantation or farm is the Wireless Sensor Network (WSN). WSN is an ad-hoc network created from small devices that have limited energy capacity and computational resources equipped with sensors that function to collect measurement data. However, there are aspects that can hinder the installation of WSN in agriculture or plantations. For example, the communiqué system cannot reach the territory too far and also the use of WSN power is fairly large, so it requires a wireless communication interface device that has a small power consumption and has a fairly long range [2].

The communication protocol that can support this is the Long Range (LoRa) protocol which is included in the Low Power Wide Area Network communication [2]. LoRa is a low power wireless protocol technology that utilizes the radio spectrum of the 433 MHz frequency band in Asia, 868 MHz in Europe or 915 MHz in North America. In Indonesia, the frequency regulation used according to the Regulation of the Director General of Resources and Postal Equipment of Indonesia No. 3 of 2019 the frequency of non cellular LPWA devices is frequency 920-923 MHz [2]. LoRa has a unique modulation acquired by Semtech Coporation with Chip Spread Spectrum (CSS) modulation with the option to add Spreading Factor and different bandwidths to maximize modulation to meet the range and information requirements so that it can cover a wide area [2].

The application of LoRa technology itself will not be separated from an interface made to connect humans with computers in this case the smart garden device made. Human and computer interaction is a discipline that examines communication or interaction between users and systems. The main role of human and computer interaction is to produce a system that is easy to use, safe, effective and efficient [3].

In this research, a system was created that can monitor and water plants by utilizing LoRa technology so that plantations or farms of kale plants that are not covered by the internet can access data or information received and displayed through applications on android using the MQTT

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protocol. The application is used by the user as a monitor. The information taken includes the temperature of moisture around the plant, as well as soil moisture. In this system, an automatic sprinkler system will also be made using a capacitive humidity sensor.

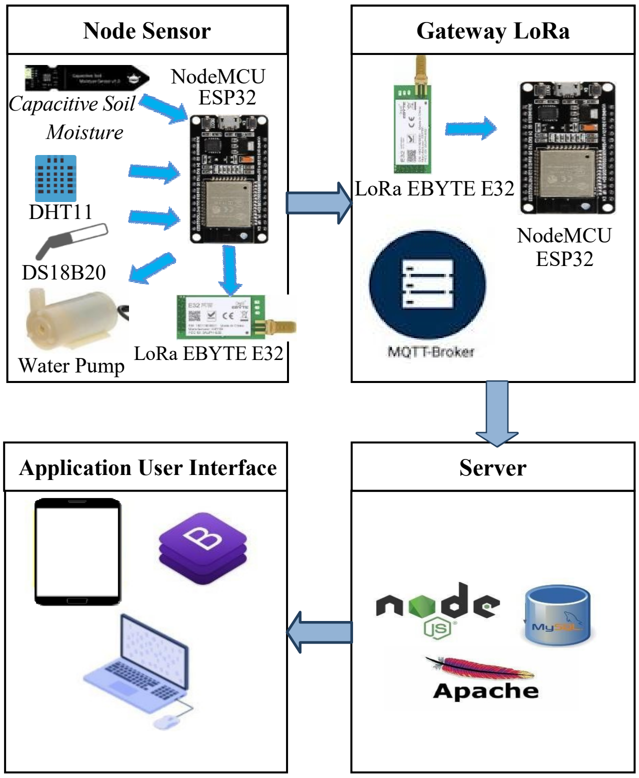

Fig. 1. Designing the overall system.

Overall the system diagram in Fig. 1 includes several systems. The hardware system consists of two systems, namely the sensor node and the LoRa gateway. The sensor node consists of a sensor, a microcontroller, a LoRa, and a water pump. Meanwhile, the user interface application, users access the monitoring data from the server received through the android application display.

Fig. 2. Wireframe user interface.

In Fig. 2, there is a dashboard view of the application used by the user.

II. SYSTEM MODEL

In this paper, we show the performance testing of Lora in the maximum distance of sensor nodes and gateway lora in semi Line of Sight (LOS) area.

TABLE I. TESTING OF LORA IN THE MAXIMUM DISTANCE IN SEMI LINE OF SIGHT (LOS) AREA.

No	Distance (m)	Condition
1	40	Connected
2	80	Connected
3	120	Connected
4	160	Connected
5	200	Connected
6	240	Connected
7	280	Connected
8	320	Connected
9	360	Connected
10	400 – 440	Connected
11	441 – 450	Unstable
12	> 451	Not Connected

Based on the data obtained listed in Table I, the maximum distance of communication between the sensor node and the LoRa gateway in the nearest Semi Line of Sight (LOS) area is 40 meters, at a distance of 40 meters, the condition is obtained that the sensor node and LoRa gateway can communicate well. The optimal distance of the test from the sensor node to the LoRa gateway is 0-440 meters, while in the test distance of 441-450 meters, an unstable condition was obtained in the communication between the sensor node and the LoRa gateway. And at the test of a distance of more than 451 meters, it was obtained that the condition of not being connected at all communication between the sensor node and the LoRa gateway.

Comparation of the maximum distance of each module tested in a Semi Line of Sight (LOS) area, namely a space in an area with a slight obstruction condition. This test is carried out to find out the comparation of the maximum signal coverage distance of each module. The modules in comparation are the LoRa module, the WiFi module and the Bluetooth module. The WiFi and Bluetooth module data are compared to this reasearch and the previously done one [7].

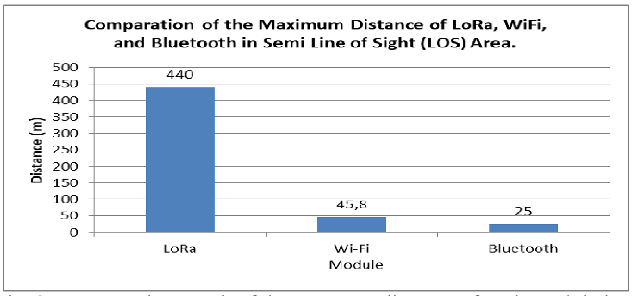

Fig. 3. Comparation graph of the coverage distance of each module in Semi Line of Sight (LOS) area.

Based on the results obtained by data from Fig. 3, it was found that the comparation of the maximum distance of signal coverage in the Semi Line of Sight (LOS) area was obtained by the LoRa module with the result of a signal coverage distance of 440 meters. The result is due to the fact that the LoRa module has a long signal coverage distance specification compared to other wireless technology modules such as the WiFi module and the Bluetooth module.

Testing of the maximum distance of communication from the sensor node with the LoRa gateway is carried out in order to obtain the optimal or maximum distance value of the two systems. Data from the results of this test are presented in Table II.

TABLE II. TESTING OF LORA IN THE MAXIMUM DISTANCE IN NON LINE OF SIGHT (NLOS) AREA.

No	Distance (m)	Condition
1	20	Connected
2	40	Connected
3	60	Connected
4	80	Connected
5	100	Connected
6	120	Connected
7	140	Connected
8	160	Connected
9	180	Connected
10	220 - 240	Connected
11	241 - 250	Unstable
12	> 251	Not Connected

Based on the data listed in Table II, the optimal distance of communication between the sensor node and the LoRa gateway in the nearest Non Line of Sight (NLOS) area is 20 meters, at a distance of 20 meters, the condition is obtained that the sensor node and LoRa gateway can communicate well. The optimal distance from the sensor node to the LoRa gateway is 0-240 meters, while when tested with a distance of 241-250 meters communication between the sensor node and the LoRa gateway obtained an unstable condition, then for testing at a distance of more than 250 meters communication between the sensor node and the LoRa gateway obtained the result of the condition not connected at all.

Comparation of the maximum distance of each module tested in a Non Line of Sight (NLOS) area, namely a space in an area with a slight obstruction condition. This test is carried out to find out the comparison of the maximum signal coverage distance of each module. The modules in comparation are the LoRa module, the WiFi module and the Bluetooth module. The WiFi and Bluetooth module data are compared to this study and the previously done one [7].

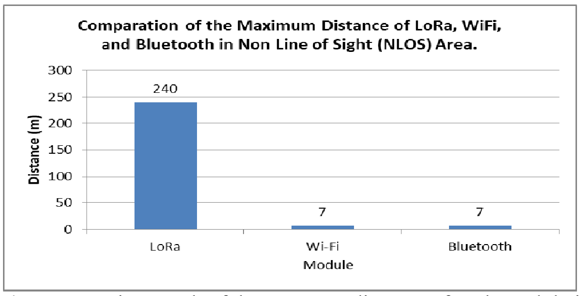

Fig. 4. Comparation graph of the coverage distance of each module in Non Line of Sight (NLOS) area.

Based on the test data already obtained, the data is visualized through the graph in Fig. 4, the graph shows that the maximum distance that LoRa has can reach 240 meters. This is influenced by the specification factor of the LoRa module which can include a longer signal distance than WiFi and Bluetooth.

Automatic watering testing on the smart garden system is carried out aimed at being able to find out the performance of automatic watering that has been set at a value of 80%. When monitoring land kale plants, the soil moisture value from the capasitive soil moisture sensor is obtained, the value is less than 80%, so the water pump will turn on. Meanwhile, when the humidity value is more than 80% then, the water pump will turn off. The test scheme is carried out by means of embedding a moisture sensor on the soil, then monitor the synchronization between the pump flame and the moisture value on the ground. In this test only ensured the on and off of the water pump based on the input value. The test was carried out by taking data from a total of 10 samples. The results of the automatic watering test can be seen in Table III.

TABLE III. AUTOMATED WATERING TESTING.

No	Moisture (%)	Soil Condition	Water Pump
1	20	Dry	On
2	25	Dry	On
3	45	Damp	On
4	46	Damp	On
5	56	Damp	On
6	66	Damp	On
7	70	Damp	On
8	78	Wet	On
9	80	Wet	On
10	83	Wet	Off

Based on the results of the automatic watering test in Table III, the results of soil conditions are obtained which are divided into three, namely wet, moist and dry. Wet soil conditions are when the moisture value of the soil is more than 70%, damp is when the humidity value is 31%-70% while dry soil conditions are when the moisture value of the soil is less than 30%. Based on the data listed in Table III, results are obtained according to the configuration, namely when the soil moisture value is less than 80% then, the state of the pump is on, on the contrary, when the soil moisture value is more than 80%, the pump will be in a dead state.

III. RESULT AND DISCUSSION

This section presents the performance of monitoring application android. Testing the user interface application in the application for temperature and humidity monitoring aims to determine the suitability of the information obtained from the sensors and outputs in the application. The results of testing the user interface application are listed in Table IV.

After 10 tests, the results of testing the user interface application are obtained as listed in Table IV. Based on Table IV, the information listed on the application dashboard corresponds to the information read by the sensor. This indicates that the user interface application is working according to the instructions given. The user interface image on the application is shown in Fig. 5.

TABLE IV. USER INTERFACE APPLICATION TEST RESULT.

No	Node Sensor	Dashboard Application
1	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 46	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 46
2	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 46	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 46
3	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 85 Air Humidity: 45	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 85 Air Humidity: 45
4	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 85 Air Humidity: 45	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 85 Air Humidity: 45
5	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 84 Air Humidity: 46	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 84 Air Humidity: 46
6	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 45	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 45
7	Data sent from Sensor Node Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 44	Data received by application dashboard Soil Temperature: 27 Air Temperature: 27 Soil Moisture: 86 Air Humidity: 44

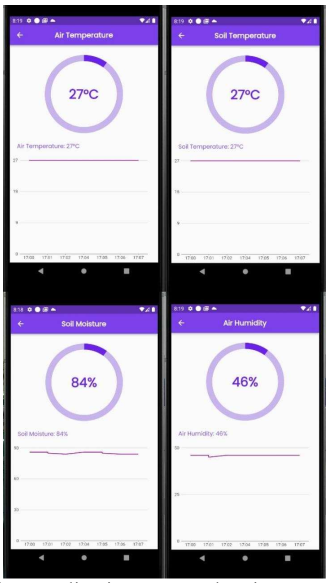

Fig. 5. User interface application test results view.

From the application display picture shown in Fig. 5, the results of the information obtained are soil temperature 27 °C, air temperature 27 °C, soil humidity 84%, and air humidity 46% in realtime. This indicates that the application's user interface or application dashboard is working according to the instructions given as shown in Fig. 5.

IV. CONCLUSION

Based on the result, several conclusions were obtained from this study.

1. Design of a smart garden system based on LoRa technology for plant monitoring can be completed by using two systems, namely sensor nodes and LoRa gateways to communicate with each other, servers as processors and user interfaces on applications as the output. In its implementation, the maximum distance that can be reached by the sensor node and LoRa gateway is 440 meters in the Semi Line of Sight (LOS) area and 240 meters in the Non Line of Sight (NLOS) area.
2. Design of a smart garden based on LoRa technology for automatic watering of kale plants can be completed by using a transistor as a switch and a water pump as an actuator. In its implementation, results were obtained in accordance with the configuration, namely the water pump was able to turn on when the humidity sensor had a range value of 20%-79% or below 80% and the water pump turned off when the humidity value exceeded 80%. And the information listed on the application dashboard corresponds to the information read by the sensor. This indicates that the user interface application is working according to the instructions given.

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