The IoT-Based Monitoring Systems for Humidity and Soil Acidity Using Wireless Communication

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***Abstract*— On extensive agricultural land, a system for monitoring the quality of land that is spread over many points and uses data communication wirelessly needs to be made. This will facilitate the initial installation and maintenance of the system. This study aims to create a pH and humidity monitoring system for agriculture's soil with wireless sensor network technology based on internet of things (IoT). This system consists of two slave nodes and one master node. The master node and slave node use the RF433MHz radio module as a communication tool. Each slave node consists of a soil pH sensor and YL69 sensor to measure soil moisture. All data for each slave node is sent to the master node to be processed and then sent to the database using the Ethernet shield. Data contained in the database will be displayed on a web application that can be accessed anywhere. The maximum range of RF433MHz radio modules in open spaces is capable of receiving data from the transmitter at 50 meters. The monitoring system able to display pH and soil moisture values in real-time with an average error value of the soil pH sensor which is equal to 1.66% and YL69 sensor error average is 1% compared to commercial soil analyzer.**

Keywords—monitoring; pH; radio wave; sensor; soil humidity; YL-69

I. Introduction

Recently, the development of environmental monitoring system has been implemented in many applications in order to support people in their work and reduce cost and time. The applications of environmental monitoring have grown rapidly in farming monitoring, habitat monitoring, indoor monitoring, greenhouse monitoring, weather monitoring and forest monitoring [1].

These days, the environmental data (Temperature, rainfall volume, humidity etc.), construction data on the soil and the plant (Soil nutrition elements, monitoring of the diseases and pests, irrigation ,etc.) data on health in animal production (discrete identity, milk yield, vaccination etc.), Greenhouse, cold chain and traceability fields are promising application fields [2].

Soil is the main nutrient source for plants and has a significant effect on the plant growth cycle defends to its quality. Soil quality will be optimum if interactions between biological components (plant roots, insects, and microorganisms), physicochemical components (surface pores, organic compounds, and inorganic compounds) and soil minerals (clay particles, dust, and sand) are in balance. Soil quality can be determined from the physical, chemical and biological parameters of the soil. The value of soil moisture and pH is one of several important factors in determining soil quality. The monitoring of soil fertility parameters is an important key to improve farming yield [3].

Wireless sensor technology has great potential for monitoring different soil conditions with better accuracy than the current system. Thus, the benefit of agricultural producers is to produce a better decision support system that allows users to maximize productivity to improve the quality and quantity of agricultural products [4].

This paper discusses the implementation of monitoring soil fertility parameters, namely humidity, and pH, in real-time using Wireless communication with radio waves

II. State of The Art

A. IoT-based Monitoring System

Topics of IoT are currently being focused on by many companies, which realize this area as a potential for future development. This leads to the development of new platforms and proprietary results. IoT contains many technologies that developed for different purpose like GSM, Bluetooth, LTE, Wi-Fi, it also uses many technologies and networks specifically designed for use in IoT. Those are for example SigFox, LoRaWAN, IEEE P802.11ah (low power Wi-Fi), Dash 7 Alliance Protocol 1.0, RPMA, nWave [5].

The agricultural environment monitoring system collects environmental information such as luminance, wind direction,

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temperature, EC, pH, CO2, humidity, wind speed, etc. which affect the growth of yields and soil information through the sensors and soil sensors installed outdoors. The information is transformed into a database through the agricultural environment monitoring services to provide suitable information to users through to the variability of services [6].

The composition of IoT can be divided into three parts: object end, cloud end, and network end. Smart devices and local intelligent systems relate directly with the physical world to form the “object end” of IoT (also identified as "front end"). The cloud computing platform that provides computing, storage, and other resources perform blend processing and intelligent analysis of the sensing data from the object end and perform implementation control to create the “cloud end” (also stated to as “back end”) of IoT. The communication infrastructure of the construction and the cloud platform constitutes the “network end” of IoT[7].

B. *Wireless Sensor Network in Agriculture*

Smart Agriculture consists of more efficient agricultural production, environmental protection, and new data generation out of the ones collected. A wireless sensor network (WSN) consists of devices equipped with sensors, radio transceivers, a microcontroller that collaborate to form a fully connected network of a sensor node [2]. WSN technology has the ability to capture critical high-resolution data quickly, method, and communicate for real-time monitoring[8].

The WSN has characteristics like small size, cost, long battery and real-time. The use of wireless sensors in agriculture has grown rapidly. Different type of sensor built for specific sensing job, centralized control, GUI, gateways, and routers for communication, power supply are the important components of WSN to be implemented for smart farming[9].

With the rapid development of information technology, many wireless communication technologies have been proposed for a variety of implementation. Comparisons among wireless communication technologies presented in Fig. 1 [10]. Implementation of smart farming shows that ZigBee technology is better in terms of less power consumption. for usage over a radius of 5 km, power consumption will be more efficient if using low power wide area technology (LPWA) [10].

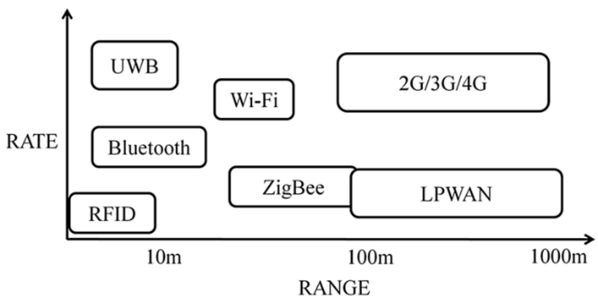

Fig.1 Comparisons among wireless communication technologies

Some applications such as precision agriculture or environmental monitoring often require a large number of wireless sensing modules for accurate data collection and decision support. As a result, it leads to a significant increase in the cost of the final system (for both sensing nodes and gateways)[11]. Some of the WSN generic challenges are the cost per unit, battery life, data fusion and quality, signal attenuation, authenticity and security, operating system lack[12]. Thus, many researchers develop an efficient and low-power consumption device to avoid the expensive cost in initial construction and maintenance. Integrating WSNs into the automation of the IoTs and its implementation is the part of green computing that has been a major concern in recent years and will remain so for the coming years[13].

III. System Design

The system design is illustrated by the block diagram presented in Fig. 2. This block diagram is divided into 3 parts, namely sensors, controllers and web servers. The sensor consists of a soil pH and humidity sensor, each of which is stored in 2 different locations. The value of the sensor measurement results is sent using the radio module from the transmitter to the receiver, then proceed to the microcontroller to be stored in the database using MQTT and then displayed on the webserver.

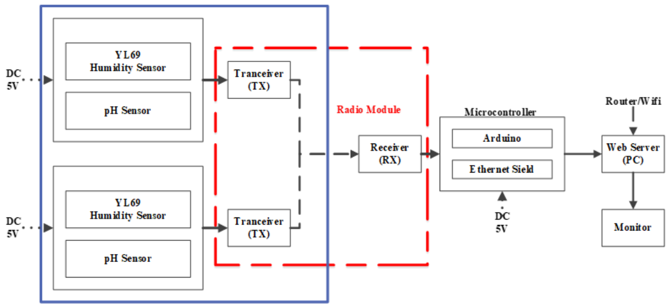

Fig.2. System diagram block

RF 433 MHz is used as a module sending data from the sensor to the microcontroller. RF modules use the one-wire protocol to communicate with microcontrollers. RF433MHz is a series of data senders and receivers based on Amplitude Shift Keying (ASK).

Ethernet Shield is used to providing IP services on Arduino and PC to be able to connect to the internet. How it works by connecting the Ethernet Shield with the Arduino board and then connecting it to an RJ-45 cable internet network, the Arduino will be connected directly to the internet. Data received from Ethernet Shield will be sent to the router using the MQTT protocol which will then be stored in the database to be displayed on the webserver that was previously created.

IV. Implementation

The quality monitoring system of agricultural land is made on a prototype scale using vessels with soil media and diameter 7.5 cm and height 10 cm. The physical form of the soil quality monitoring system prototype is displayed in Fig.3.

In this research, for the implementation of software, several libraries were used, including the Serial Peripheral Interface (SPI) to handle synchronous serial communication between the transmitter and receiver, Virtual Wire for radio modules with wireless communication, Ethernet for Ethernet Shield modules, and PubSubClient for MQTT protocols.

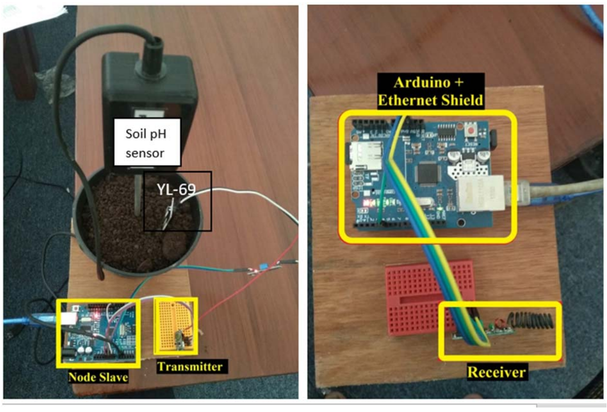

Fig.3. System implementation

Visualization on the web with the MQTT protocol uses Node-RED. This application serves to connect hardware with protocols and databases. The web interface can be accessed by entering the server IP. This research uses localhost facilities so that web applications can only be accessed on one network. The XAMPP application is used to create a server on a local network. The implementation of website interface showed at Fig.4.

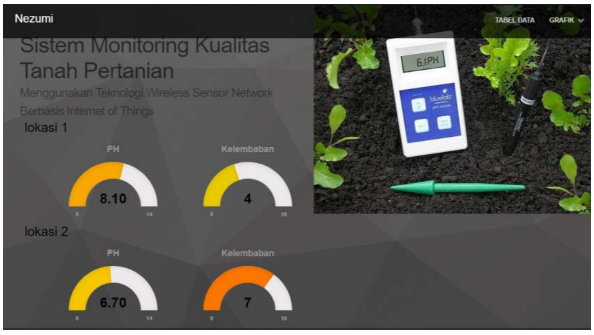

Fig.4. Website interface

Measurement of hardware performance is done by testing sensors and radio modules used in the research. The soil quality monitoring testing phase includes the calibration of the soil-pH sensor, YL69 sensor calibration, soil-pH sensor testing, YL69 sensor testing, and maximum distance measurement that can be accessed by radio module receivers.

The next step after system implementation is the testing phase to determine the system performance that has been made. The system measurement results are compared with the results of measurement tools available on the market, namely soil testers as displayed at Fig.5. Soil tester can measure soil pH, soil moisture and light intensity at once in one tool.

Fig.5. Soil tester

From the soil-pH test results and soil humidity, obtained the difference 1,66 % and 1%, respectively, between the system measurement and the soil tester.

The next test is to find out the maximum range of data that can be transmitted from the transmitter to the receiver. testing the system by taking a straight-line distance starting at a distance of 5 m. From the test results, the maximum range of transmitters to the receiver is 45 m.

According to the RF 433MHz data sheet [14], the maximum range that can be captured is 200 m, depending on the power consumption used. According to Ahmed [15] research, the 433MHz RF range is 90 m if using Arduino as a microcontroller. To get the maximum range, a 23 cm long wire antenna is needed for the receiver circuit. Whereas in the research that has been done, the receiver only uses an 8 cm wire antenna, so the receiver can only receive data from the transmitter for ± 45 meters. other than that. maximum reach can be longer by increasing the power on the system.

Testing the MQTT protocol is done by displaying the debug results of messages sent by Arduino to the MQTT broker on the laptop. Arduino will send messages using an Ethernet Shield addressed to the MQTT broker that is already installed on the laptop. The message sent will be addressed to the topic on the broker. To find out whether the message sent by Arduino was successfully sent, the debug results will display the message received by the topic addressed by Arduino to the broker MQTT. After the broker can receive the message correctly, then the broker's next test is tested by sending several messages from the sensor simultaneously. Each message sent from the sensor has a different device ID.

The incoming message measures 7 bytes and has the contents of 1 6.6 3 which is the data on pH and soil moisture values. Each message sent by the sensor node has a different device ID to present the message from a different sensor node. The value of the sensor data sent is the device id which shows the location of the sensor is in location 1, the soil pH is 6.6, and soil moisture is 3, each data received separated by spaces.

Web display testing is done by accessing various browsers with the aim of ensuring the application can be accessed by a personal computer (PC) and smartphone. the test results show that the monitoring system can be accessed in the browser: Internet Explorer, Google Chrome, Mozilla Firefox, Chromium and Opera mini.

V. Conclusions

The agricultural quality monitoring system has been implemented to monitor pH and soil moisture values in two soil sample points. Data collected from sensor measurements at each point can be monitored through web-based applications using Wireless Sensor Network technology. The RF433MHz radio module used has a maximum range of 45 meters in open space. Agricultural soil quality monitoring system is able to display pH and soil moisture parameter values in real-time with an average difference for YL69 sensor value of 1% and soil pH sensor of 1.66%, compared to commercial soil tester.

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