Wireless Sensor Networks for Soil Nutrition to Increase Agricultural Productivity

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Abstract

Soil nutrition or plant nutrition is an important factor in plant growth which can be compared as food for plants. one of the factors that support plants to grow optimally is the availability of adequate nutrients in the soil. Nutrient content in the soil can be determined by taking soil samples and doing laboratory testing. In addition to Lab tests. sensors can be used to determine nutrients and as a monitoring system for planting land. This soil nutrient monitoring system can be integrated with a wireless system and form a wireless sensor network (WSN). WSN developed is an Internet of Things (IoT) based system so that it can be accessed through the internet network. This research was conducted using the Network Development Life Cycle (NDLC) method which consists of six stages namely analysis, design, prototype simulation, implementation, monitoring and management. This research resulted in a prototype WSN system to detect the availability of nutrients in the planting area and can provide certain treatment in accordance with the data obtained by the sensor. The prototype developed will be tested to determine the accuracy of the data obtained. After this research, the prototype was carried out using the Internet of Things (IoT) system

Keywords:
WSN Server, IoT, Crop Nutrition, Agriculture, Soil Moisture Sensor

1. Introduction

Internet of Thing (IOT) is a concept that aims to extend the benefits of Internet connectivity are connected continuously. As for capabilities such as data sharing, remote control, and so on, as well as the objects in the real world. Examples of foodstuffs, electronics, collectibles, any equipment, including all living things are connected to local and global networks through an embedded sensor and is always active (Deden Ardiansyah, 2017; Gronau et al., 2017; Stewart et al., 2017). Basically, the Internet of Things refers to objects that can be uniquely identified as virtual representations in an Internet-based structure. How it Works Internet of Things is by using an argument programming in which each command argument that resulted in an interaction among the machines are connected automatically without human intervention and within whatever, internet that be a liaison between the interaction of these machines, while humans only served as a regulatory and supervisory operation of the tool directly (Dos Santos et al., 2016).

Soil nutrition or plant nutrition is an important factor in plant growth which can be compared as food for plants. one factor that supports plants to grow optimally is the availability of sufficient nutrients in the soil (Soemarno, 2010). If the soil does not provide sufficient soil nutrition, plant growth will not be perfect. Rice is a very important food crop because rice is still used as a staple food for most of the world's population, especially in Asia. Data from the Central Statistics Agency in 2018 Indonesia's rice production reached 56.54 million tons.

Soil nutrition is one of the determinants of increasing crop productivity. Nutrient content in the soil can be determined by taking soil samples and doing laboratory testing. This process can take time and money to find out nutrients in the soil. Nutrient content can be known in addition to conducting laboratory tests can also use sensors that can detect the content of certain elements. This sensor can be used to determine nutrients and as a monitoring system for planting land (Haryono Supriyono dan Daryono Prehaten, 2014). Soil Moisture Sensor can be used to test soil moisture. When the soil lacks water, the sensor is at a high level, if not the sensor is at a low level. This sensor can be used in an automatic watering system at a factory that requires an automatic watering system (researchdesignlab, 2008).

In previous studies researchers have conducted research on wireless sensor network servers where the research is the creation of a server to hold all data in the wireless sensor network. Therefore in this study we made a wireless sensor network for nutrition. Wireless sensor network server (WSN) is a server that can retrieve data from wireless sensor network so that server can give service like normal server to be accessed by all client whenever and wherever. WSN Server to facilitate smart farming requires a server to serve all the needs of agricultural data so that the data can be processed and optimized for the needs of smart farming. Wireless sensor network server serves as a server and can receive data from multiple sensors through WSN. Then in the save to the database in real time, then visualized into the form of the website and can be accessed via the Internet network (D. Ardiansyah et al., 2019; Ojha et al., 2015).

This soil nutrient monitoring system can be integrated with a wireless system and form a wireless sensor network (WSN) within Internet of Things (IoT) system. IoT is a structure in which objects, people are given an exclusive identity and the ability to move data through the network without requiring two directions between humans to humans, namely the source to the destination or interaction of humans to computers (Talari et al., 2017). WSN is a group of sensors spread over a certain area to monitor and record field conditions and send them to the server. WSN can monitor conditions of temperature, noise, pollution, humidity, wind and so on. WSN boundaries are resources that must be used optimally (Kamal & Salahuddin, 2015). WSN soil nutrition to increase crop productivity is a sensor designed to detect nutrients in the soil. This tool will detect the nutritional needs of the soil and transmit data that has been obtained wirelessly (Ma & Pan, 2012). The process can provide accurate data after going through the calibration process and real time to farmers so that the nutritional needs of plants can be known quickly.

The use of WSN in detecting nutritional needs in plants can be added to the ability to provide the care needed by plants. This treatment will be adjusted to the sensor readings sent so that the treatment provided can be adjusted to the needs of the manufacturer. The treatment provided can be in the form of an automatic watering system and an automatic fertilizer system in accordance with the needs of the plant. From data sent by sensors and collected on the server, petadi can predict the need to grow rice. This tool can make it easier for farmers to be able to produce maximum results.

2. Methodology

The method used in this study is the Network Development Life Cycle (NDLC). This method consists of analysis, design, prototype simulation, implementation monitoring and management (Goldman & James, 2004). The flow of the method used can be seen in Figure 1.

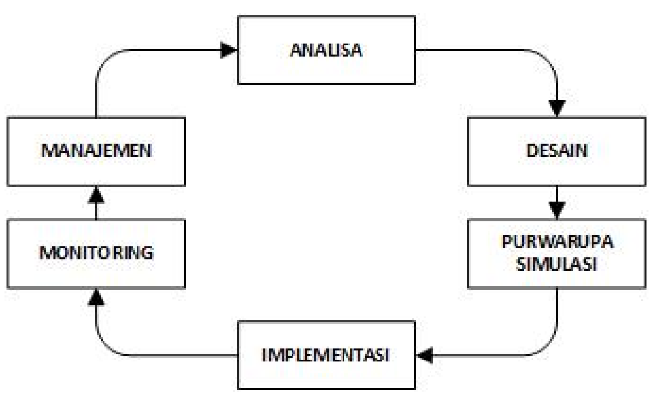

Figure 1. Research method

1. Analysis

The problem in this research is to find out and send the nutrient content in the planting land. Plant nutrition data is obtained from sensor readings sent wirelessly. Nutrition data is stored on the server so that monitoring and maintenance can be conducted in the planting area based on the data received.

2. Design

The system design carried out in this study can be seen in Figure 2.

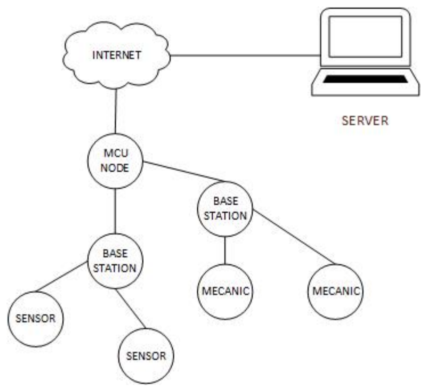

Figure 2. System design

The system design in Figure 2 shows the overall components used. This system uses many sensors that are connected to the base station. The base station performs calibration and conversion of values so that the sensor reading value can be sent using nodeMCU. NodeMCU is an open source Internet of Things (IoT) platform which is a firmware that is installed on a microcontroller. This microcontroller functions as a bridge between the microcontroller used on embedded systems and wireless networks and can run applications independently (Handson Technology, 2017). NodeMCU sends data through the internet which is then received by the server. Data received by the server is then stored and analyzed automatically to determine the nutritional needs of the plant in real time. The server sends instructions via the internet and is received by NodeMCU. NodeMCU then continues instructions to the base station. BTS conducts instructions received in the form of providing certain nutrients in accordance with the results of server analysis.

3. Prototype Simulation

The prototype was made in the form of a minimum WSN model to optimize system performance. The model built can be seen in Figure 3.

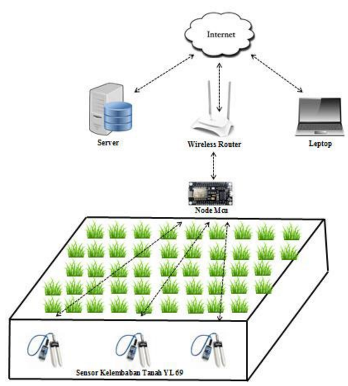

Figure 3. Prototype model

Figure 3 shows the position of the sensor placed spread on the model used. The model used is acrylic which has a length of 90 cm and a width of 60 cm with a height of 20 cm.

System simulation is conducted by testing the connectivity between the server and the sensor system. The server receives data from the sensor through a wireless network and stores it in a database. Router is used as a medium of communication between sensors and servers by utilizing an internet connection. Data stored on the server can then be viewed through a laptop.

4. Implementation

The research carried out is divided into three stages as follows:

1. Calibrate the calibration of the sensor field accurately.
2. The use of a wireless router as a communication medium between the sensor and the server to send data from the sensor reading.
3. The server computer receives data through the WSN system which is then stored in a database and can be accessed externally through the website.

5. Monitoring

Monitoring is carried out to determine the reliability of the system created, data flow, and connection stability.

6. Management

Management is carried out on the network so that WSN system communication between all connected devices can be maintained.

3. Discussion result

1. Prototype model

The main part of the soil moisture control system model is the soil moisture sensor which functions to control soil conditions whether wet, humid, or dry. The ultrasonic sensor is integrated with the cellphone function to read the water capacity whether the water capacity is full, wants to run out or has run out, then send a report in the form of a notification via WiFi Shield. The prototype model can be seen in Figure 4

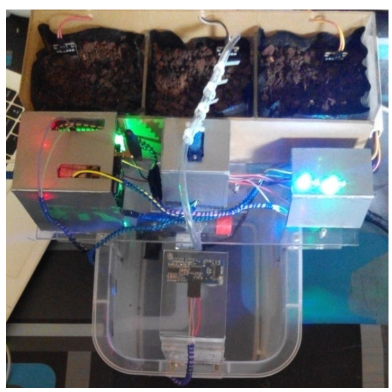

Figure 4. Main Parts of the Soil Moisture Control Model

Figure 4 shows The watering system part includes the adapter, servo, relay, water pump, and NodeMCU as the system controller, the ground sensor as the data input processor which will then be controlled via NodeMCU and as output on the servo, relay, and water pump. The water monitoring system section includes the NodeMCU module as a system controller, the ultrasonic sensor functions to read the level of water capacity whether full, exhausted, or exhausted. And then it will send a report in the form of a notification via WiFi Shield.

This system is supported through the NodeMCU, the soil sensor reads soil moisture with an air / dry range of 997 to 1023, a water / moist range of 312-563. with a radius of 37mm or 3.7 cm. because the scale of the system model used is not too large at 540cm3, the placement of the ground sensor on the ground must be considered so that the watering system can run normally. In cold air conditions, the soil does not really matter while in hot air conditions the soil will dry more easily. The box for the ground is given a hole at the bottom which aims to drain the water so that the soil is not too wet and the soil is not floating.

The system LED indicator has 3 flashing lights that indicate that the system is active. If the LED on the wrong ground indicator shows the state of dry soil, the servo will move directing the hose to the dry ground, the servo movement and the hose in the watering process continue to move because the servo moves in the direction of 35 degrees, 90 degrees, 135 degrees. and the relay will turn on the pump to flush. the water pump used in this study does not regulate the speed of the exit water, but the water pump can regulate the speed of the exit water using the PWM calculation. If the soil is wet and there is no dry soil, the pump will shut down and the servo will move to its original position. The basic material used to make this system is acrylic, to anticipate the effect of the reading of the soil sensor on acrylic before being given a soil box in a polybag layer first and then given a small pot-sized soil.

2. Validation Result

Validation Test is carried out to test the value of possible errors that might occur in the components that are applied in the water monitoring system contained in the soil control system. The function of the WiFi Shield in the water monitoring system is to provide reports / reports on the condition of water capacity through notifications. This experiment is carried out by testing the system compatibility that has been made by validating each block of the circuit to get the appropriate results. The validation test shown in Table 1.

Table 1. Validation test

No	Testing	Expected results	Test result	Status
1.	When Water Capacity Is Changing	Connect with a mobile phone	wifi shield send a message every time the water capacity changes	Aktif
2.	Connect Wireless with the indicator LED condition on the Wifi Shield not on	Not connected with a mobile phone	unable to send sms messages	Not Aktif
3.	Full Water Capacity, Already Want Out, and Out	Arduino CH340 sends data obtained by ultrasonic sensors	The GSM shield sends the latest water capacity data	Aktif
4.	Power key on is not pressed	Not connected with a mobile phone	Unable to send data to server	Not Aktif

4. Conclusion

This research uses NodeMCU, WiFi Shield, soil moisture sensor, servo, relay, LED, water pump and Ultrasonic sensor. The input system uses soil sensors in irrigation and Ultrasonic systems as input systems for water monitoring systems. System output in the soil moisture control system is in the form of automatic watering and in the water capacity monitoring system, the system output is in the form of reports through notifications. The soil sensor cannot read the entire ground because the distance is not large, therefore in this study the placement of the ground sensor is highly considered. reports via WiFi depend on the strength of the internet network used because the better the network the faster the report will be sent in the form of notifications whereas if there is interference or no network, sending reports in the form of notifications will be delayed or even not sent.

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7. Biographies

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Abdul Talib Bon is a professor of Production and Operations Management in the Faculty of Technology Management and Business at the Universiti Tun Hussein Onn Malaysia since 1999. He has a PhD in Computer Science, which he obtained from the Universite de La Rochelle, France in the year 2008. His doctoral thesis was on topic Process Quality Improvement on Beltline Moulding Manufacturing. He studied Business Administration in the Universiti Kebangsaan Malaysia for which he was awarded the MBA in the year 1998. He's bachelor degree and diploma in Mechanical Engineering which his obtained from the Universiti Teknologi Malaysia. He received his postgraduate certificate in Mechatronics and Robotics from Carlisle, United Kingdom in 1997. He had published more 150 International Proceedings and International Journals and 8 books. He is a member of MSORSM, IIF, IEOM, IIE, INFORMS, TAM and MIM.