JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

Web of Thing Application for Monitoring Precision Agriculture Using Wireless Sensor Network

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Received 24 January 2019, Revised 16 February 2019, Accepted 26 February 2019

Abstract — Wireless Sensor Network (WSN) is a technology which can help humans solve problems in daily life for monitoring the environment. This can be done to help farmers in monitoring and making decisions for watering plants. In this study, temperature, humidity and soil moisture sensors were used to help farmers monitor web-based precision agriculture, and the system which be built could make a decision to automatically water plants based on soil conditions. The results of measuring precision agriculture from the sensor node will be sent to the gateway using Zigbee 802.15.4. The data will be stored in the MySQL database provided by the gateway. Then it will be synchronized to the cloud using IoT technology, so users can access it in real time by using web-based application. From the system which is developed, it really helps farmers to complete their work and make innovation in the digital era.

Keywords – Wireless Sensor Network, IoT, Precision Agriculture, Web-based, Zigbee 802.15.4

I. INTRODUCTION

Wireless Sensor Network (WSN) is a technology which has been widely used in everyday life to help solve problems as needed. Currently, WSN technology is widely developed in various fields, such as the military, smart environment, e-Health, smart lighting, smart city, agriculture, smart environmental and so on [1-3]. In addition, there are other technologies besides WSN which are also widely used and applied in human life, namely the Internet of Things (IoT). IoT is a concept which aims to expand connectivity through the internet to transfer data without requiring human-to-human or human interaction to computers [4] [9] [10].

Precision agriculture is a science or strategy in management to increase crop production using technology. This aims to reduce production costs, increase the quality and quantity of results. This is obtained by providing information related to agricultural conditions such as temperature, humidity, pressure, light, wind [11].

Georgieva, et al [5]. They are developing a system for monitoring soil quality using temperature, humidity, and conductivity acidity sensors. The results of these measurements will be displayed in the form of Graph User Interface (GUI) with Lab View.

G. Sahitya, et al [6], develop a design system for monitoring precision agriculture using sensors humidity, soil moisture, and LDR. For the communication using Zigbee. They just measurement and collect data and not informed to the public.

There are also several other communications that are used to monitor soil conditions such as [7], conduct station weather monitoring for application purposes in precision agriculture using Bluetooth technology. They developed this system at the Pedagogical and Technological University of Colombia Tunja. The results obtained will be displayed on the desktop.

In [8], they measured indoor and outdoor air pollution data using Wi-Fi communication to transmit data. In this study, a sensor node was implemented to measure the level of concentration of gas, temperature and humidity. The results of these measurements will be visualized into the form of the web application provided.

In [12] [13] [14] [15], measured about agriculture use IoT technology, where they build prototype to monitoring condition precision agriculture. The system overcomes limitations of traditional agricultural procedures by utilizing water resource efficiently and also In the research that will be done, the communication used is Zigbee with the standard IEEE 802.15.4, because it has advantages compared to existing communication as in previous studies [6], [7], [8]. Some of the characteristics are shown in Table 1.

Based on previous research, this system proposed to monitoring precision agriculture using communication Wireless sensor networks that can be accessed through web sites that have been developed so that farmers can monitor land conditions in real-time. In addition, we also provide information about land conditions on social media such as Twitter and Facebook. Thus, farmers can make land conditions in real time wherever they are as long as they are connected to the internet and farmers can access them through Personal Computers, Laptops and smartphones. In this paper, we developed from previous research [6-8], where research only shows information about soil conditions, while what we propose when soil conditions are dry, water pumps will automatically live and water the soil adaptively.

Table 1. Compression of Communication

	Zigbee	Bluetooth	Wi-Fi
Range	10-100 meters	10 meters	100 meters
Network Topology	Ad-hoc, peer to peer, star, mesh	Ad-hoc, very network	Point to hub
Power Consumption	Very Low	Medium	High
Standart	IEEE 802.15.4	IEEE 802.15.1	IEEE 802.15.1b

II. RESEARCH METHOD

A. System Architecture

In Fig.1, shows the system architecture for monitoring precision agriculture based on wireless sensor networks using web-based applications that we have developed. In this system, we develop a system to monitor agriculture it is requiring integration of hardware and software.

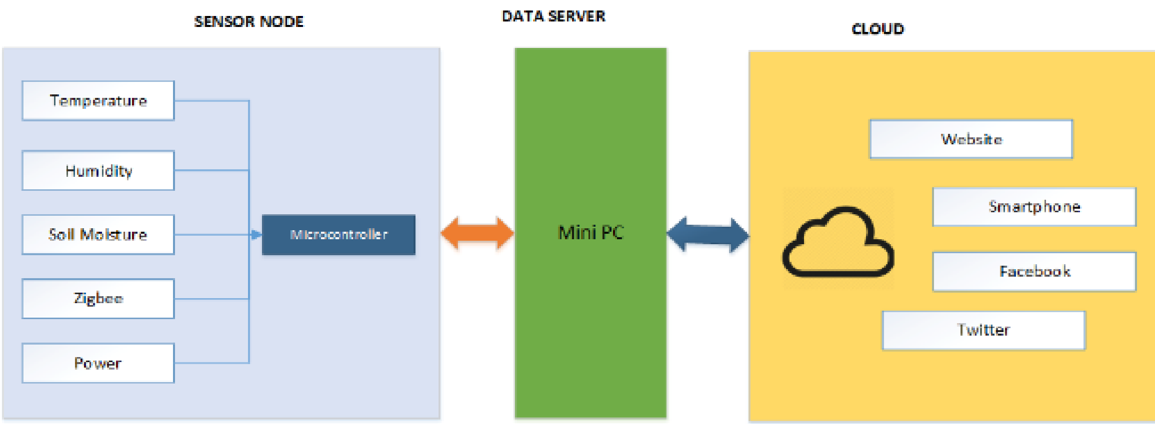

Fig.1. System Architecture for Precision Agriculture Using WSN

In this paper, we use sensors temperature, humidity, and soil moisture for monitoring soil conditions. The data from sensor node will be send to data server using communication Zigbee standard IEEE 802.15.4. Sensor data will be sent to the data server in the form of frames consisting of header and payload. The header is the ID information of the node, while the payload is sensor data that will be sent to the data server such as temperature, humidity, soil moisture and pump status which is used for watering the garden automatically. All of the information obtained from measurements from the sensor node is then stored in the MySQL database that we have developed in the data server. The data will be synchronized to the cloud using internet access, the goal is that users can access land conditions in real time using the website and smartphone that we have developed. And also, we provide information on social media like Facebook and Twitter.

B. Hardware and Software

Table 2 shows the specification we use in this experiment.

Table 2. Specification Hardware and Software

Name	Specification
End Device	Arduino UNO3, Microcontroller ATmega328P, Operating Voltage 5Volt, Flash Memory 32KB, Sensor Temperature LM35, Humidity DHT11, Soil Moisture, pump, cable jumper, Zigbee Pro S2 802.15.4, Xbee Shield, Arduino Shield, Power
Data Server	SoC: Broadcom BCM2837, CPU: 1.2 GHz quad-core ARM Cortex A53, GPU: Broadcom VideoCore IV @ 400 MHz, Memory: 1 GB LPDDR2-900 SDRAM, Network: 10/100 MBPS Ethernet, 802.11n Wireless LAN, Bluetooth 4.0, Memory 32GB, OS Raspbian, Web Server, Phyton, Xampp, Java

Name	Specification
Users	Intel Core i5 3.0 GHz, RAM 4GB, DDR3, Mozilla Firefox, HDD 500GB, Wifi 802.11b/g/n

C. Tier End Devices

In this experiment, end devices we use is microcontroller it is a computer system on a chip. It contains a processor core, memory (a small amount of RAM, memory), and input-output equipment. The microcontroller we use is Arduino Uno3 which is an electronic circuit that is open source, and has hardware and software that is easy to use. Arduino can recognize the surrounding environment through various types of sensors and can control lights, motors, and various other types of actuators.

In this research, was implemented a system for precision monitoring use the temperature, humidity, and soil moisture sensors. To connect between the sensors with the Arduino, we used the jumper cable in accordance with the rules of the pin connector. For the communication, we use the IEEE 802.15.4 standard Zigbee by impelementing the Xbee shield provided by the developer company. Afterward, power is used to turn on the end devices which have sensors and communication feature. We use two alternatives for power, the first is by using the electric power, while the second alternative is using batteries or power banks. Fig 2 shows the results of configurations of the end device.

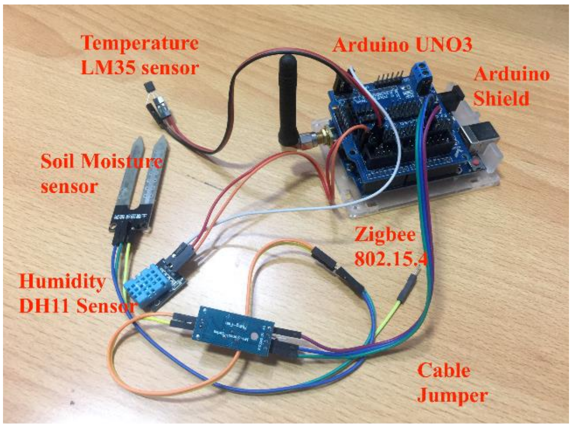

Fig.2. End Device Configuration

Below is a brief specification of sensors used:

a. **Sensor LM35** – is a small sensor which is convert analog value to temperatures values. The range measure between -550C – 1500C. This sensor LM35 can operates from 4V to 30V and also Low-Cost Due to Wafer- Level Trimming.

a) **Sensor DH11** – is a sensor completed with a calibrated digital signal output. The measurement range 20 – 90 %RH, Accuration ±5%RH, and package 4 pin single row.

b. **Sensor Soil Moisture** – is a sensor which is easily to measure the flow of current through the ground. Moisture levels can be felt by measuring soil resistance. Operation Voltage 3.3 V to 5.5 V, input current 35mA, and range value measurement 0-100 percent.

D. Tier Data Server

Fig.3 shows the data server used in this experiment. We use Raspberry pi 3 because its low cost with specification CPU: 1.2 GHz quad-core ARM Cortex A53, GPU: Broadcom Video Core IV @ 400 MHz, Memory: 1 GB LPDDR2-900 SDRAM, Network: 10/100 MBPS Ethernet, 802.11n Wireless LAN, Bluetooth 4.0, Memory 32GB, OS Raspbian.

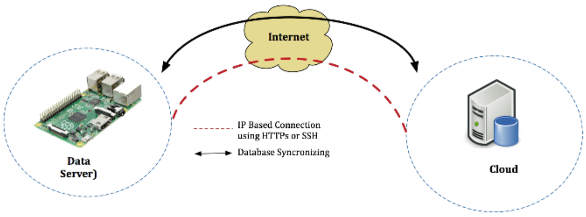

Fig.3. Configuration Data Server

In the data server, we installed the NetBeans application using Java programming language which to open serial ports and create a script for storing data to the database. Next, we install the MySQL database in data server to hold data from the end device. Then to post to social media such as Facebook and Twitter using the Python programming language.

E. Tier Cloud

Fig.4 shows configuration for synchronizing data from sensor data to the cloud. Here we use the internet network to synchronize data to the cloud. Users can access sensor data via websites and smartphones. And also, we provide precision agriculture information through social media such as Facebook and Twitter.

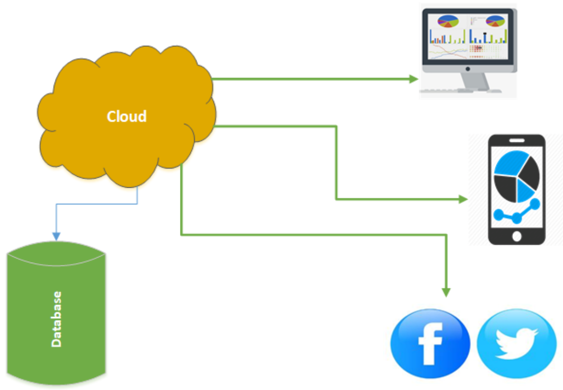

Fig.4. Cloud Design

F. Tier Database Configuration

Our system has been design database MySQL in the data center server for data sensor storage. As shown in Fig.4, there are one database Table, the database name is SoilMonitoring and table name is tabel_tanah.

Table 3. Table Database

Name Field	Type (Size)
Id_tanah	Int (5)
Temperature	Int (5)
Humidity	Int (5)
Soil_mouisture	Int (5)
Status	Varchar (50)
Time	Timestamp

The table_tanah table is used to store about the sensor information like the id_tanah, temperature, humidity, soil_moisture, status, and time. So, sensor data taken and sent to a data server and stored into a database that has been provided.

III. RESULT

In this section, we explain about precision monitoring based on Wireless Sensor Network using Web of thing. Fig.5 presents topology used in the implementations.

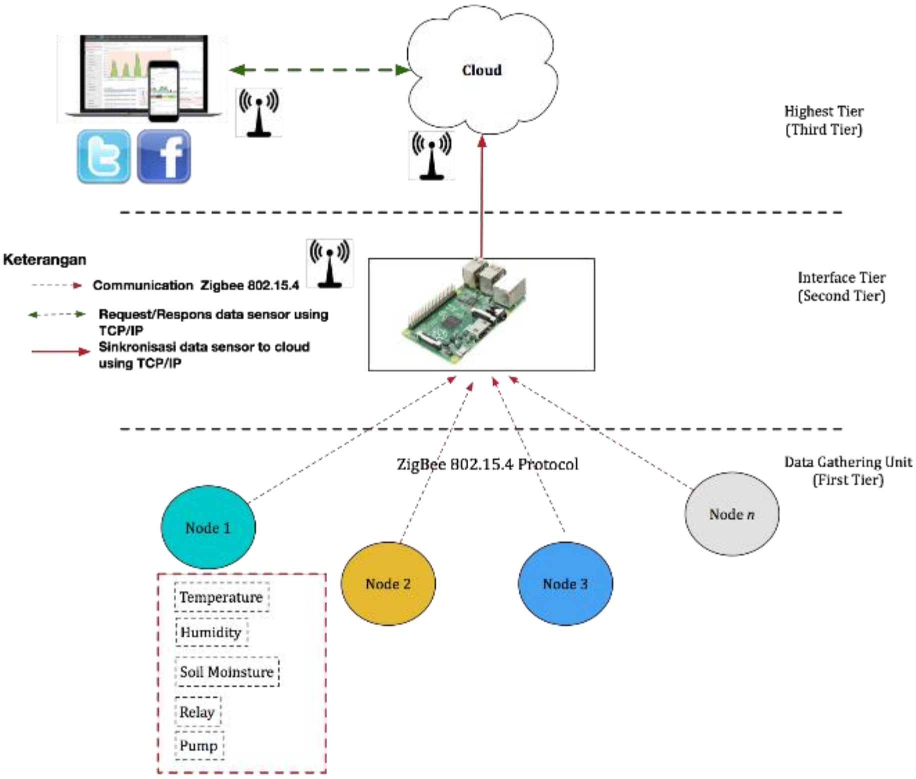

Fig.5. Proposed Topology for Precision Monitoring Based WSN

In this system, will be provided information on soil conditions that has been measured by real time. Besides displaying information on soil conditions through the website, this tool also updating the status of land conditions to Twitter and Facebook. The information which is displayed on the website in the form of graphs about temperature data, humidity, soil moisture and soil status. If the status of the ground is dry, the relay will be ON and the water machine will switch on to do watering nursery land. So if the land is wet and humid, then the relay and the water machine back OFF as well as update the status of the land condition to Twitter and Facebook. Fig.6 shows the location measure for precision monitoring.

Fig.6. Test-Bed Location and Sensor Placement

In this experiment, we take measurements from 14.00 - 16.00. The data will be sent to the data server every 10 seconds. Fig.7 shows the result measure data precision agriculture where user able to do monitoring via website.

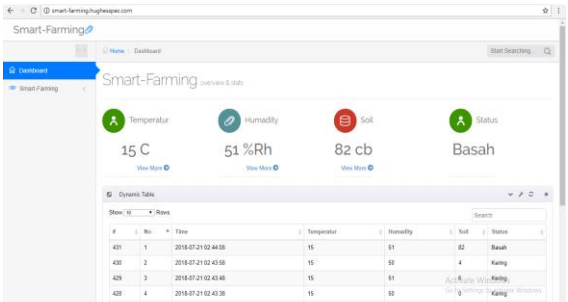

Fig.7. Dashboard Web of Thing Precision Agriculture

Figure 8 shows the graph condition temperature by real-time where user able to access from anywhere and anytime as long as they connected to the internet.

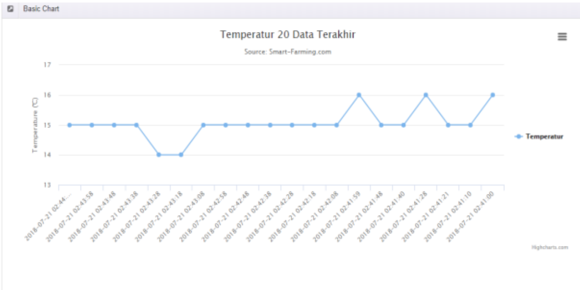

Fig.8. Graph Data Temperature

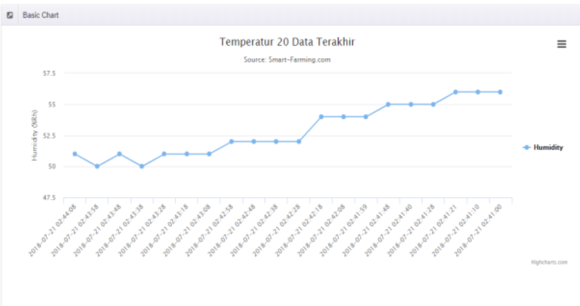

Fig.9. Graph Data Humidity

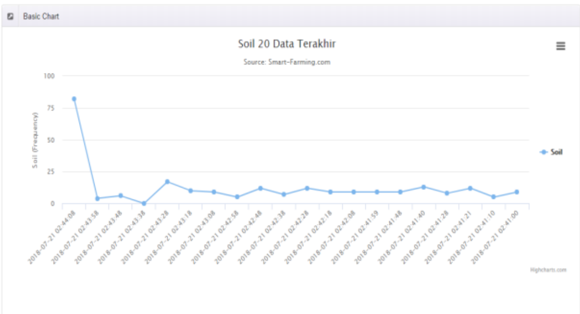

Fig.10. Graph Data Soil Moisture

Furthermore, we also provide information on precision agriculture condition on Social media such as Facebook and Twitter in the form of time and land conditions. The system also automatically updates the status to Social Media using Twitterbot. The Twitterbot was built on a Mini PC using the Python programming.

Fig.11 (a). Status on Twitter

Fig.11 (b). Status on Twitter

From the picture above, the information about precision agriculture conditions will be updated on Facebook and Twitter by real-time. In the case, we set to update status based condition agriculture.

Table 4 shows the data sensor agriculture from measurement. In this experiment, we use 3 conditions for measuring soil conditions. First dry, the range of values of dry soil conditions between 0-40Cb, humid between 41-70Cb, and wet 71-100Cb. From the 3 conditions above, the pump engine will automatically turn on when the soil conditions are dry.

Table 4. Data Sensor Agriculture Measurement

NO	Temp (^{0}C)	Humidity (%RH)	Soil (Cb)	Status	Pump Status
1	13.69	88.00	15.35	Dry	ON
2	14.17	88.00	15.15	Dry	ON
3	14.98	88.00	20.63	Dry	ON
4	13.69	86.76	42.72	Humid	OFF
5	15.43	80.05	43.99	Humid	OFF
6	15.04	80.03	50.83	Humid	OFF
7	14.17	79.08	72.31	Wet	OFF
8	14.39	79.34	72.92	Wet	OFF
9	14.09	79.25	74.98	Wet	OFF

Table 5. Comparison Between Time Local and Server

No	Timestamp (Local)	Timestamp (Server)	Time Difference (s)
1	14:40:40	14:40:41	1
2	14:40:48	14:40:49	1
3	14:40:58	14:41:00	2
4	14:41:08	14:41:10	2
5	14:41:18	14:41:21	3
6	14:41:28	14:41:28	0
7	14:41:38	14:41:40	2
8	14:41:48	14:41:48	0
9	14:41:58	14:41:59	1
10	14:42:08	14:42:08	0

And also, we test the data transmission between local sensor data and the server. Table 5 shows the comparison between time local and server.

Fig.12. Graph Time Data Delay Time Local and Server

From the Table 6 and Fig.12 above, it can be concluded that there are differences in the time of some data between data on the local and on the server. This is caused by network instability so that the data on the server is a little slow in about 1 to 3 seconds. When viewed in terms of the amount of data entered, this is no difference in the amount of data in the local and the amount of data on the server

IV. DISCUSSION

A. Analysis Data of Agriculture Measurement

Table 4 shows the result data of agriculture measurement. In this experiment, we try to measure temperature, humidity, and soil moisture. The result from table above show the pump will be ON if status of moisture is Dry. Furthermore, pump will be OFF if status moisture Humid and Wet. The first experiment, we collect data with temperature 13.690C, humidity 88.00%RH and soil moisture 15.35 Cb, the status of moisture is Dry and pump status is ON. The next experiment, we try to measurement the status temperature 13.69^{0}C, humidity 86.76 %RH and soil moisture 42.72Cb then the status of moisture is Humid and the status of pump is OFF.

B. Analysis Data of Comparison Times

Table 5 shows the comparison of time between local time and server time during transmission. In the first test, the data entered first at 14:40:40 in the local server data then on the cloud server entered at 14:40:41. From the results of observations, there was a delay of 1 second of data entering the cloud server. This happens because the network connection has a delay between the local server and the cloud server. In this observation, the amount of data entered between the local server and the cloud server has no difference in number.

V. CONCLUSION

In this paper, we implemented a system for monitoring precision agriculture based on Wireless Sensor Network using Web of Things. All the data information precision agriculture will shows di website and smartphone. And also, user can access data precision agriculture via Media Social such as Facebook and Twitter. Furthermore, we experiment the data transmission and calculate the delay. The average delay in 10 trials 1 was 1.2% while in experiment 2, it was 1.4%. From the system that we developed, it really helps farmers to complete their work and make innovations in the digital era.

REFERENCES

[1] V. Potdar, A. Sharif, and E. Chang, “Wireless Sensor Networks: A Survey”, International Conference on Advanced Information Networking and Applications Workshops, Bradford, UK, pp. 636-641, 2009.

[2] N Fahmi, S Huda, E Prayitno, MUH Al Rasyid, MC Roziqin, and M. Unggul Pamenang, “A prototype of monitoring precision agriculture system based on WSN”, International Seminar on Intelligent Technology and Its Applications (ISITIA), Surabaya, pp. 323-328, 2017.

[3] N Fahmi, S Huda, A Sudarsono, and MUH Al Rasyid, “Fuzzy Logic for an Implementation Environment Health Monitoring System Based on Wireless Sensor Network”, Journal of Telecommunication, Electronic and Computer Engineering (JTEC), Vol. 9, No. 2-4, pp.119-122, 2017

[4] M. Ammar, G. Russello, and B. Crispo, “Internet of Things: A survey on the security of IoT frameworks”, Journal of Information Security and Applications, ScienceDirect, Vol.38, pp. 8-27, 2018

[5] T. Georgieva, N. Paskova, B. Gaazi, G. Todorov, and P. Daskalov, “Design of Wireless sensor network for monitoring of soil quality parameters”, International Conference Agriculture for Life, Life for Agriculture, ScienceDirect, Vol. 10, pp. 431-437, 2016

[6] G. Sahita, Dr. N. Balaji, Dr. C. D. Naidu, and S. Abinaya, “Designing a Wireless Sensor Network for Precision Agriculture using Zigbee”, International Advance Computing Conference, pp. 287-291, 2017

[7] D. F. G. Junco, M. S. C. Forero, D. F. D. Caro, and I. A. R. Ruge, "Agrometeorological monitoring station based microcontroller and Bluetooth communication", Colombian Conference on Automatic Control (CCAC), Manizales, Colombia, 2015

[8] O. A. Postulate, "Smart Sensors Network for Air Quality Monitoring Applications", IEEE Transactions on Instrumentation and Measurement, Vol. 58, No.9. pp. 3253 – 3262, 2009.

[9] A.A. Zulfikri, D. Perdana, and G. Bisono, "Design and Analysis of Trash Monitoring System Prototype Based On Internet of Things (IoT) Using MQTT Protocol", Jurnal INFOTEL, Vol. 10 No. 3, pp. 113-124, 2018.

[10] N. Fahmi, Rosmida, and E. Prayitno, "Online QoS Modelling Untuk Cloud Menggunakan Teknologi WSN dan IoT Untuk Monitoring CO2 Secara Real Time", Jurnal Teknologi Informasi dan Terapan, Vol. 5, No. 2, 2019.

[11] M. J. O'Grady and M.P. O'Hare, "Modelling the smart farm", Information Processing in Agriculture, Vol 4, No. 3, pp. 179-187, 2017

[12] Mohanraj, I, K. Ashokomar, and Naren J, "Field Monitoring and Automation Using IOT in Agriculture Domain", Procedia Computer Science, Vol. 93, pp. 931-939, 2016

[13] M. A. Zamora-Izquirdo, J. Santa, J. A. Martinez, V. Martinez, A. F. Skarmeta, "Smart farming IoT platform based on edge and cloud computing", Biosystem Engineering, Vol. 177, pp. 4-17

[14] Tse-Chuan. Hsu, H. Yang, Yeh-Ching. Chung, and Chng-Hsien Hsu, "A Creative IoT agriculture platform for cloud fog computing", Sustainable Computing: Informatics and Systems, 2018

[15] K. Gunasekera, A. N. Borreo, F. Vasuian, and K. P. Bryceson, "Experiences in building an IoT infrastructure for agriculture education", Procedia Computer Science, Vol. 135, pp. 155-162, 2018.