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Muhammad Qomaruddin, Muhammad Syaban Mubarak, and Sri Mulyono

Plant Watering System on The Basis of Internet of Things (IoT) With Protocol of Message Queue Telemetry Transport (MQTT)

Muhammad Qomaruddin[a)], Muhammad Syaban Mubarak[b)], and Sri Mulyono[c)]

Teknik Informatika, Fakultas Teknologi Industri, Universitas Islam Sultan Agung (UNISSULA) Jalan Raya Kaligawe KM. 4 Semarang 50112, Indonesia

[a)]Corresponding author: mqomaruddin@unissula.ac.id
[b)]muhammad.mubarak@std.unissula.ac.id
[c)]sri.m@unissula.ac.id

Abstract. The construction of greenhouse has not been built according to the existing climate. As a matter of fact, the expectation of meeting the quantity, quality and production continuity has not realized well or at optimum level. Thus, the efforts in improving the quality of greenhouse are necessary. One of the ways to do that is by increasing the control on the greenhouse in the matters of monitoring and controlling. The controlling in this case involves the air temperature, the air humidity, the soil moisture and the water distribution control. Therefore, through this study, a plant watering system will be created which enables it to control the air temperature, the soil moisture and the air humidity on the plants automatically. This system will be built based on IoT with Protocol of MQTT so that the system can be monitored and controlled from the distance in realtime. With the existence of IoT-based automation system with Protocol of MQTT on the plant sprinkler, it can increase the time efficiency, power and energy, as well as optimize the process of plant growth and development.

Keywords— Plant Watering System; IoT; MQTT; Greenhouse

INTRODUCTION

The development of information and communication technology requires people to be more inclined to follow the development process and adapt to modern society that can optimize the role of technology both in industry and home.

In the agricultural or food industry, climate is one of the factors that influence the growth and production, but the irregularity of climate conditions because of climate change further worsens the quality and quantity of production due to the fact that the increasing rainfall raises the risk of pest and plant diseases, while excessive heat causes plants to experience dryness and wither. Meanwhile, from the other side, a certainty of quantity and quality is very important to meet the manufacturing needs and the suitability of the contract purchase so that the certainty of quantity, quality and continuity in production is needed. Accordingly, the existence of greenhouse in the agricultural industry is becoming increasingly important and needed.

The construction of greenhouses is not yet fully in accordance with the climate in which the greenhouse is built that the fulfillment of the quantity, quality and continuity of production has not been realized properly. Due to this condition, the efforts to improve the quality of a greenhouse are needed. One of which is increasing the control of the greenhouse itself such as by monitoring and controlling. The intended control here includes the air temperature, soil moisture and air humidity as well as water distribution control.

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Internet of Things (IoT)

In 1999 Kevin Ashton first introduced the concept of the Internet of Things (IoT)[1]. However, up to present there has not been a global consensus on the definition of IoT. The concept of IoT, in general, is an ability to connect a smart object with other intelligent objects and allows it to interact with objects, environments and other intelligent computing equipment through an internet connection[2].

Message Queuing Telemetry (MQTT)

Message Queuing Telemetry Transport is a transport protocol with publish / subscribe client server properties. It was released by IBM[3]. MQTT is a transport protocol with simple, open and lightweight characteristics designed to be easily implemented in order that MQTT can be used in many situations, including its use in machine-to-machine communication (M2M) and the Internet of Things (IoT). The MQTT protocol runs using TCP / IP[4]. Another paper stated that MQTT is a widely used application layer protocol to transmit data among the devices in IoT, and this protocol follows a TCP-based connection establishment procedure[5].

Advanced Message Queuing Protocol (AMQP)

Advanced Message Queuing Protocol is an open standard application layer protocol for Message Oriented Middleware and provides a variety of excellent features. One of the features is closely related to messaging. This protocol is designed for large companies which use messages to integrate or move data[6].

Constrained Application Protocol (CoAP)

Constrained Application Protocol is a special transfer protocol for the Web with node and network constraints on the internet of things (IoT). This protocol is specifically designed for machine-to-machine (M2M) applications[7]. The example of this CoAP can be seen in the applications of smart energy and automation system in building construction [8].

Data Distributed Service (DDS)

Data Distributed Protocol (DDS) is a real-time system used for OMG (Object Management Group) for machine-to-machine interaction (M2M). DDS is a data-centric standard for Publish / Subscribe (P/S), which was introduced in 2004 to address the challenges faced by mission-critical systems and systems-of-systems[9]. DDS works to collect and process data for IoT environments and to collect and process data coming from different IoT middleware. The DDS comprises two main components, namely data collection and data aggregation, both of them able to collect and process data in distributed and parallel processing[10].

Representational State Transfer (REST)

Representational State Transfer is architectural software for distributed systems such as the World Wide Web, with a conventional architectural style consisting of clients and servers where clients can make a request to the server, then the server processes the client's request and gives the appropriate response at that request[4].

Realtime

The definition of realtime is a state or time that is ongoing, what is felt, heard and seen at that time. Meanwhile, the term "realtime on the system / realtime system (RTS)" can be interpreted as a system which is able to provide the right response with a predetermined time limit, or refers to "A Real-Time System (RTS) is defined as a system in which the time where the outputs are produced is significant"[11].

REVIEW OF LITERATURE

In 2014 a study entitled "Implementation of Wireless Sensor Networks for Monitoring Classrooms as Part of the Internet of Things"[12] has begun to apply the IoT concept in its research, which in this study the researchers intended to create a healthy and comfortable classroom by using and combining sensors at nodes that are distributed evenly in each classroom, and all sensors are connected to a microcontroller.

In this study the microcontroller not only acts as a controller but also becomes a provider of data - measurement data or readings of sensor values which at any time can be used or read by other computers connected to computer networks, while for processing and storing data, researchers use a mini computer (small motherboard) as the medium. The data taken from the microcontroller will be stored and processed in this mini computer for two purposes, namely to monitor and secondly to automatically control air condition devices, and monitoring systems. The control in this research was built based on the web.

Around 2014 there was a study entitled "implementation of the MQTT protocol on open building based on open MTC" [4]. This study implemented the MQTT protocol to build smart buildings that can provide more services such as lighting, security, temperature control, etc. The researchers made an effort to implement the MQTT protocol on OpenMTC. OpenMTC is one of the M2M platforms with the communication protocol which provides HTTP. The results of this study indicate that the MQTT protocol can be applied to the OpenMTC platform. By comparing MQTT and HTTP protocols through testing which uses delay parameters, overhead protocol and packet loss, the researcher concluded that the delay in sending data to the HTTP protocol was less than the delay in the MQTT protocol due to the number of sensors (virtual sensors) used in the MQTT protocol affected average delay during data transmission. The average protocol over HTTP protocol, however, was greater than average protocol overhead on the MQTT protocol. The accuracy of data delivery on the protocol is 100% accurate and 0% packet loss[4].

ANALYSIS AND RESULT

The plant sprinkler system consists of several components, namely Wemos D1 Uno Based, Solenoid Sensor and solenoid controller, Cloud or server, Web client, special air humidity, special sensor of soil moisture. Users can monitor and control the sprinkler system from a distance through webclient with the help of an internet connection via a smartphone or computer, so that if there is a change in conditions (temperature and humidity) the user will be able to know this in realtime as the following block system diagram in Fig. 1.

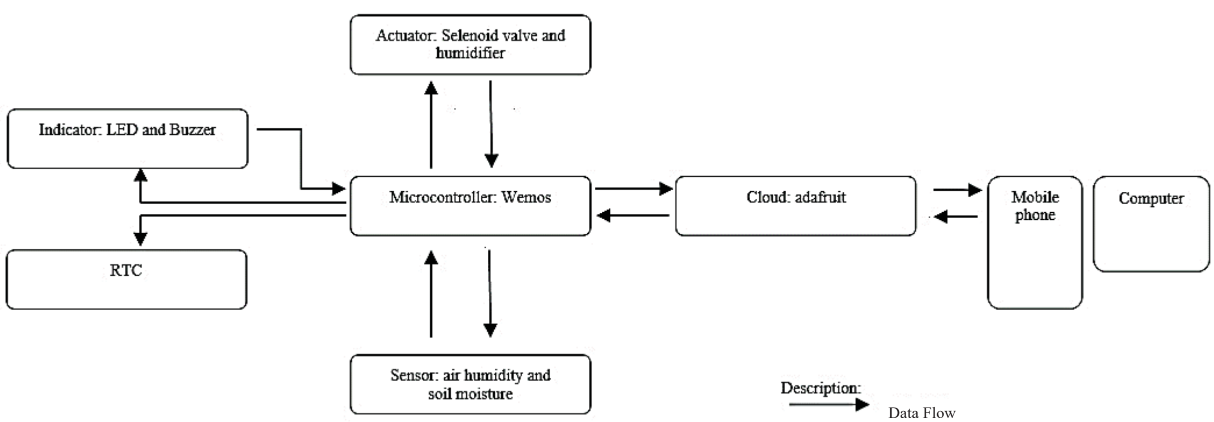

FIGURE 1. Block Diagram of system

The need for making this system is divided into the needs of hardware and software. Hardware needs include: Sensors, Actuators, Drivers, Microcontrollers, Adapters and Wifi (Wireless Fidelity). For software needs involve Server or cloud, Arduino IDE and Web Client.

The process requirements in making this system are as follows:
1. The process of making a flow chart design system
2. The process of designing sensors, actuators with microcontroller
3. The process of making source code
4. The process of webclient design
5. The process of implementing IoT with the MQTT method on the system

System Design

The following is the system design that is used to build an IoT based watering system with the MQTT protocol.

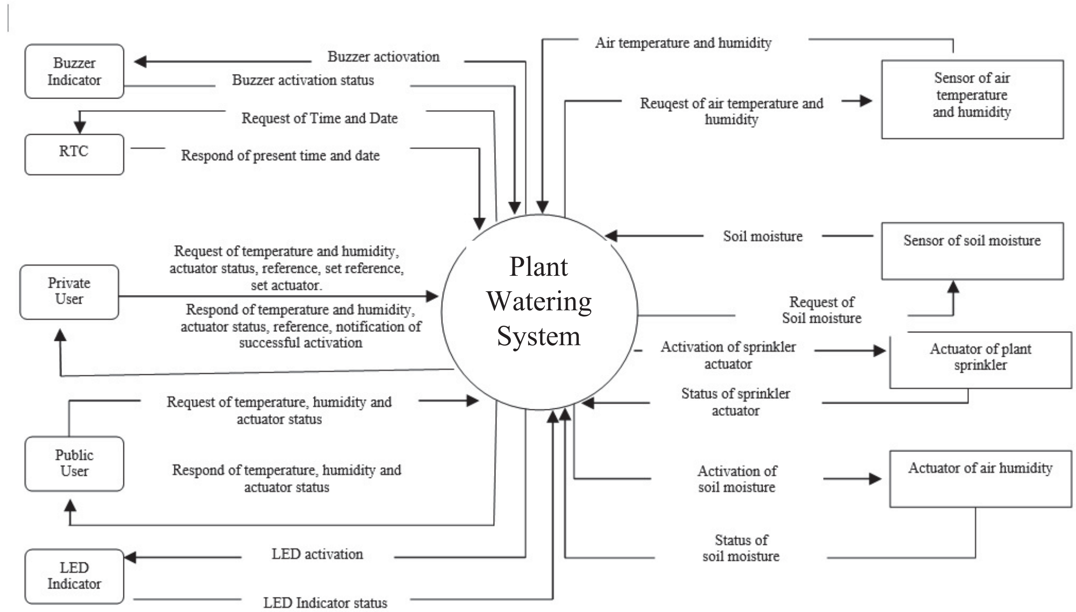

FIGURE 2. Context Diagram of System

Fig. 2 illustrates the diagram of the entire flow of data input into the system and output of the system, where in the diagram there are nine entities namely public user, private user, plant sprinkler actuator, air humidity actuator, temperature sensor & air humidity, soil moisture sensor, RTC, LED indicator and buzzer indicator.

Design of the flow chart system

In Fig. 3 it can be seen that wemos D1 uno based becomes the center or sensor controller (input device) and actuator (output device), all connected by using a cable including an adapter that is useful as an electric power supply to turn on the wemos while connecting the control system with the server (cloud) and servers with smartphones or computers by using wireless (wireless communication lines) with the MQTT method and external assistance in the form of the nearest internet or wifi connection.

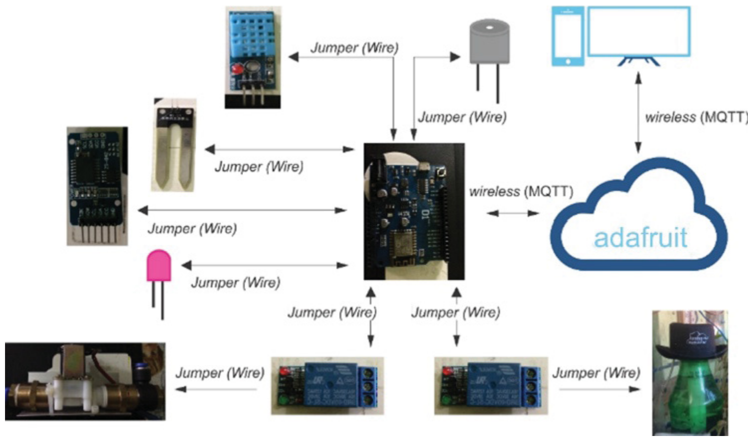

FIGURE 3. Design of flow chart system

Monitor

The following Fig. 4 shows that the system will always update the data in realtime. Humidity sensors will send data in the form of temperature values and soil moisture and air to cloud every second without having to wait for a change or a long pause time. This condition is very possible for users to monitor the system via a smartphone or computer without limitation of time and certain conditions along with one prerequisite that the user has logged in first.

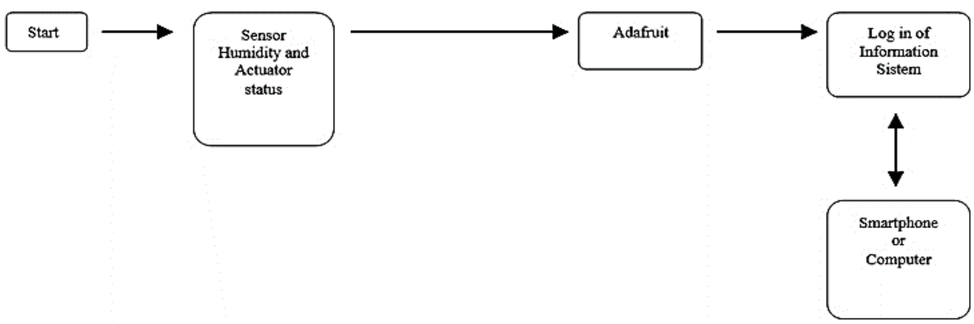

FIGURE 4. Data Monitor

Control

In Fig. 5 shows a block diagram for the actuator control process. First of all, the user logs in, after that the user will be able to connect to the control which can then connect the user with the system or controller. Then the user can check the status of the actuator connected to the control.

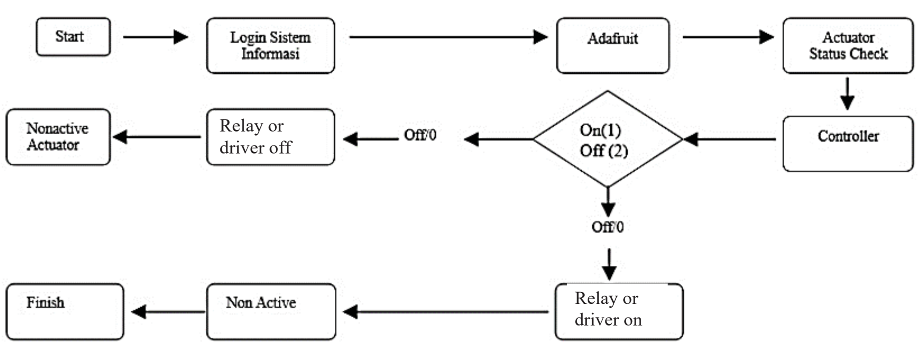

FIGURE 5. System Controller

The user interface of the system is divided into two classes. They are general / public class and private class. The difference between the two classes is the limitation of access to the general class which becomes a deficiency or inability to send commands through the browser / server to the client, which means that in that class there is only one feature, namely the monitoring feature. Nontheless, in that class there is an advantage that no session is needed to log in to the system to be able to see the system. Fig. 6 is a page view of the user interface of a system with a general class.

FIGURE 6. The page display of user interface from the system in the general class

Information on air and soil conditions in the general class is displayed in two types of blocks, namely information in the form of line diagrams / charts that contain data from previous measurements to the latest and in the form of bars that only contain the latest values from the measurement result

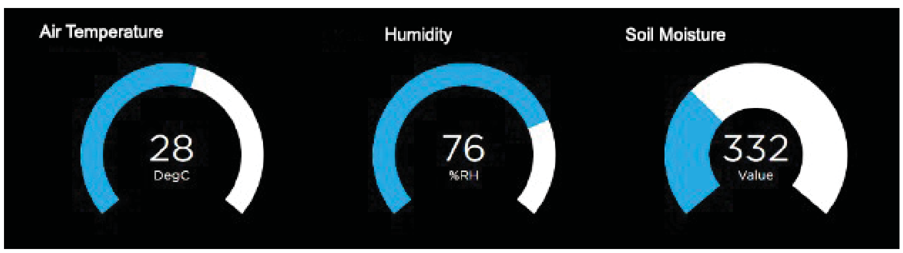

FIGURE 7. The data from the past measurements up to the newest in the form of bars

Fig. 7 shows how the blocks describe or the conditions of air temperature, air humidity and soil moisture in the media (greenhouse simulation box), where the air temperature at that time shows a temperature of 28 degrees Celsius, with a humidity level of 76% RH and soil moisture of 332 (10 bit analog data).

The overall information on the history of data / feeds can only be accessed by the user (syaban_mubarak). Fig. 8 is an example graph and table data on air temperature feeds.

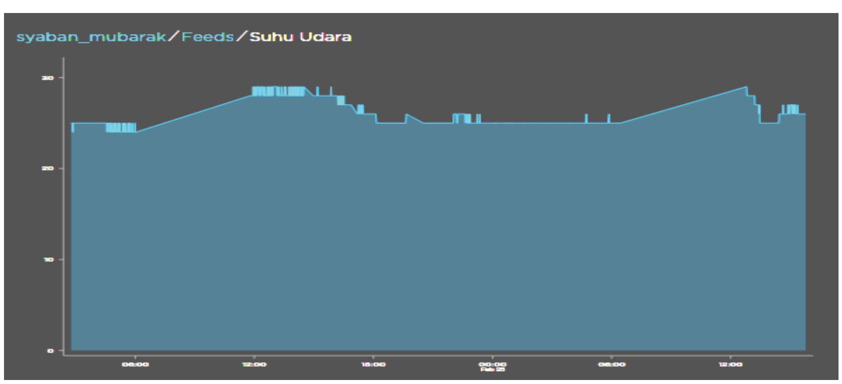

Figure 8. Graphic feeds of air temperature

☐	26	20 minutes ago	2017-02-25 3:41:34 pm
☐	26	21 minutes ago	2017-02-25 3:40:33 pm
☐	26	22 minutes ago	2017-02-25 3:39:33 pm
☐	26	23 minutes ago	2017-02-25 3:38:32 pm
☐	26	24 minutes ago	2017-02-25 3:37:31 pm
☐	26	25 minutes ago	2017-02-25 3:36:30 pm

1 2 3 4 5 Next Last

Figure 9. Table of data feeds of Air Temperature

Fig. 9 is an example graph from Fig. 8 which is a table data of feeds. The graph illustrates the rise and fall of air temperature while the table data displays all data from the beginning of the feeds created or stores data until the feeds store save the latest data.

CONCLUSION

The conclusions that we can take from this research are as follows:

1. By combining microcontrollers and some electronic circuits (sensors and actuators), a plant watering system can automatically condition the air humidity, air temperature and soil moisture.
2. The concept of IoT with the MQTT protocol can be used as a solution to control and monitor the condition of a plant watering system in a greenhouse from distance in realtime through an internet network connection.

ACKNOWLEDGMENTS

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