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On the Design of Watering and Lighting Control Systems for Chrysanthemum Cultivation in Greenhouse Based on Internet of Things

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Abstract. Two things that are very influential on the growth of Chrysanthemum are moisture and lighting. This research aims to make the system of watering and lighting control, and monitoring of soil moisture on the cultivation of Chrysanthemum in IoT-based Greenhouse. This research combines the concept of the Internet of Things and control system. The temporary results of this research are the application of lamp control and website-based pumps that are compatible on Android at least version 4.2, iOS, and windows also various browsers. The WEMOS D1 mini ESP8266 module is used as a controller and webserver of this Chrysanthemum irrigation and lighting system. The system is tested with wireless connections within a limited range, with an average response time of 0.5 seconds and an average connection speed of 58 Mbps.

1. Introduction

There are four categorizations of Internet of Things (IoT) system services, namely: Identity-Related Services, Information Aggregation Services, Collaborative-Aware Services, and Ubiquitous Services [1]. With IoT, communication no longer requires human assistance to entry data, the principle is Machine Two Machine (M2M). From the systemic point of view, humans are slow, error-prone, and inefficient mediators that lead to system limitations regarding the quality and quantity of available data. As an alternative, efficiency can be made if a number of sensors that measure and observe real conditions or events directly in the field, also serve as collectors of data over the internet. This is the vision of IoT [2]. In practice, IoT applications have been applied to various fields, such as transportation, environmental monitoring [3] electrical power control [4], smart home [5], as well as solar panel monitoring [6].

One potential area for "embracing" IoT technology is agriculture, including flower cultivation. The field of agriculture has an important role in the economy of a country. However, agricultural product is heavily dependent on climate [7]. With IoT, climates within the greenhouse can be created, ranging from regulating temperature, humidity, soil moisture, pH [8]. Furthermore, IoT is also used to monitor agricultural irrigation systems [9].

One of the flowers that require climate setting on the cultivation process is “Chrysanthemum". Chrysanthemum has a growing requirement, among them is the need for water on the one hand, but not resistant to rain water. Chrysanthemum flowers also require an average irradiation for 14-16 hours per day, so the tropical region like Indonesia, it takes additional light about 3-4 hours with light intensity ranges from 32 to 108 lux. Artificial light is best done between the hours of 22.00 to 02.00 in the morning. The best temperatures in cultivating Chrysanthemums range from 20^0-26^0 C. The required soil moisture at the beginning of root formation of 90-95%, as well as for young to adult shoots (ages 2 months and above) required moisture by 70-80% [10] [11].

The research on greenhouse control systems based on IoT has already begun. Liu Dan, in his research conducted monitoring of humidity, room temperature, lux, and CO2 [12]. Liu Dan also created a control system for lamps, irrigation, and ventilation, which does not work automatically, but is controlled through Lab View-based applications. A similar study was also conducted by Sukandar Sawidin. Sukandar Sawidin also established a monitoring and control system that was piloted on the cultivation of Chrysanthemum through Lab View and Website, but the control of the lamps and irrigation was done automatically [13]. The system uses Arduino as a controller as well as a webserver with additional ethernet shield. The connection to router is done with RG 45 cable.

Based on a review of some of the literature, this study aims to create a Chrysanthemum lighting and watering control system in the Greenhouse with the based-on Internet of Things that is designed as simple as possible, but able to work optimally. The system is designed to be able to control the actuator and sensor monitoring through a website-based application that can be accessed by different types of smartphones and computers. This study uses WEMOS D1 MINI as a controller and web server without additional ethernet shield. In addition, WEMOS D1 MINI can connect with wireless router.

2. Design system

In this section will be explained about system requirements and system design as a whole that became the target of research. The system specifications developed to the end of the study are as follows:

- Web-based monitoring
- The system is able to control the lights and water pumps through the web
- The system is able to monitor room temperature, soil moisture, air humidity, and Lux
- Can be accessed by various types of smartphones, as well as various browsers
- Sensor data is sent in real time
- Sensor data is stored in the database

The final system design is shown in Figure 1.

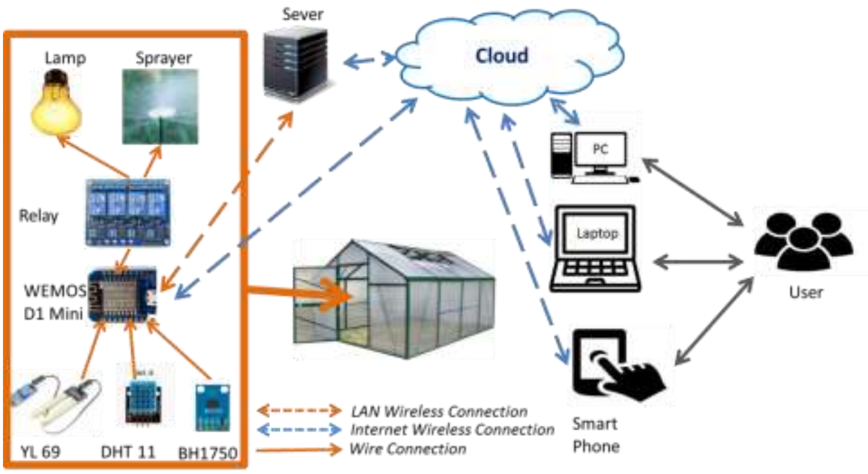

Figure1. System Design

WEMOS D1 Mini works as a controller and webserver. Sensor data is processed and displayed directly to the websites and then sent to the database of local server connected to the internet. Users can monitor the room temperature as well as the humidity of the DHT11 sensor. The soil moisture monitoring uses YL 69 sensor and the lux rate monitoring uses BH1750 module. Users can turn on and off lights and pumps from web-based applications, anywhere and anytime.

Users can use applications from various platforms of smartphones, laptops, or PCs to control lamps, water pumps, temperature monitoring, humidity, and lux in Greenhouse via 1 device connected to the internet. Users can also monitor system development by accessing the database. In the database there is the track record of the transmission of sensor data per 5 seconds. The data is stored in the local server, so that the process of sending data to the server is more quickly and safely. Then the server is connected to the internet, so users can see the data anywhere and anytime.

3. Preliminary results

3.1. Design of system

The system is designed with one YL 69 sensor which is used to measure soil moisture, 2 relay modules which are used as switches for lamps and pumps, and one ESP 8266 type WEMOS D1 Mini which functions as web server.

The type of control system used to control the lamp is a closed-loop manual control, so the user manually controls the lamp through a web-based application. While the control system used for the pump, is a combination of manual control with automatic control. Turning on the pump is done manually by the user, while turning it off is done automatically, according to the reference data of the soil moisture sensor set at a certain value, so that when the soil moisture value is equal to the reference value, the pump will stop working.

The reference rate for moisture content of the soil is based on the age of Chrysanthemum. Chrysanthemum, in the nursery phase until the age of 2 months, requires soil moisture of 90-95%, the flowers aged over 2 months require humidity of 70-80%. Soil moisture monitoring system helps farmers to water the plants, if the water content is below the reference rate, farmers can do watering through web-based applications with 1 push, while controlling off of the pump is done automatically. The flow of this initial system is shown in Figure 2.

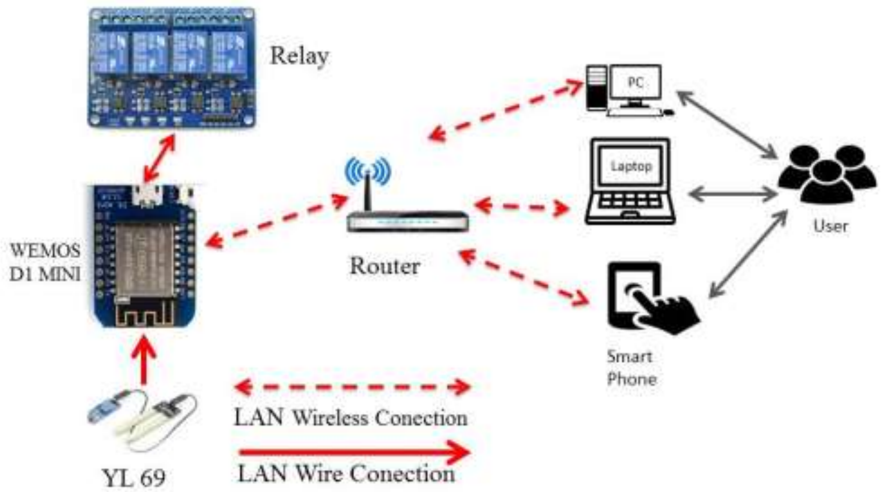

Figure 2. Preliminary Design

Farmers or users, using smart phones, laptops or personal computers which are connected locally to the webserver to control and monitor watering and lighting of Chrysanthemum at Greenhouse. IP Address of a web-based application is made static, so that no IP changes occur when there are additional clients in the system. In this research, the IP Address used is 192.168.0.73, with gateway 192.168.0.1. The system is built with the Client-Server concept. The circuit of this system is shown in Figure 3.

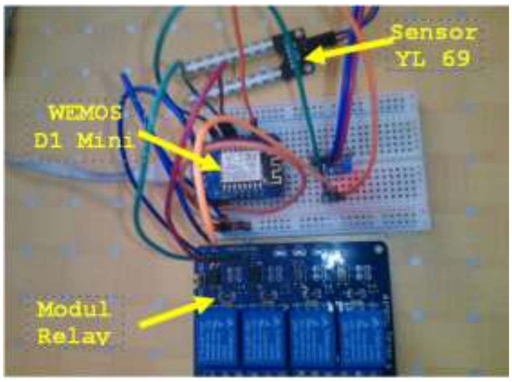

Figure 3. System Series

Channel 1 on the relay module is used for the lamp switch, and channel 2 on the relay module is used for the pump switch. The moisture rate of the YL 69 sensor, used as information for the user, and becomes feedback for the pump. WEMOS D1 Mini is used as a controller and acts as a webserver, so HTML text is created directly in it.

3.2. Web based - control system

Web-based applications feature soil moisture monitoring in the scale of %, as well as On Off control features for lamps and pumps. App display on smartphone is shown in Figure 4.

Figure 4. App View on Smart Phone

The app view when accessed using the computer is shown in Figure 5.

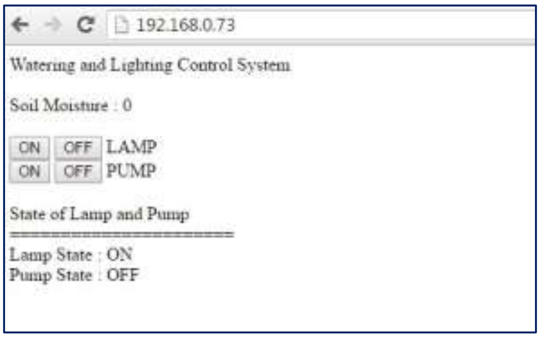

Figure5. App View from Computer

3.3. Testing and analysis

Testing is done by using smartphones and laptops with different versions of Operating System (OS). One test is done for 24 hours, by monitoring the humidity and controlling the lights and pumps. The distance between the router and the server is 5 meters. The system testing radius is 10 meters away from the router. In addition to testing the response time, testing is also done to see the compatibility of the system against various OS variations. The results of the test are presented in Table 1.

Table 1. Testing and Analysis

Operating System	System Compatibility	Average of Respon Time (second)
Android 4.2	Compatible	0.5
Andorid 4.3	Compatible	0.5
Andorid 4.4	Compatible	0.5
Andorid 4.5	Compatible	0.5
Android 5.0	Compatible	0.5
Android 6.0	Compatible	0.5
iOS 10.3.2	Compatible	0.5
Windows 7, 64 Bit	Compatible	3.0
Windows 8, 64 Bit	Compatible	3.0

Based on the above testing data, it can be seen that apps are well-accessed via smartphones and laptops with a variety of browsers ranging from Internet Explorer, Google Chrome, Chromium, and Mozilla Firefox. The response time when controlling lights and pumps using a smartphone with connections using WiFi is 0.5 seconds with an average speed of 58 Mbps. Meanwhile, when using Laptop (AMD E1 with RAM 2GB), the response time is average 3 seconds with the speed of 72 Mbps.

4. Conclusion

Applications that are made compatible with Android smart phone at least version 4.2, iOS, Windows 7, and Windows 8. The response time of the control system using a smartphone is faster than using a computer. The response time using a smartphone has an average of 0.5 seconds, while using the PC has an average of 3 seconds.

The design of the chrysanthemum control and lighting system in the greenhouse based on internet of things can only be accessed locally. The features created are limited to monitoring the soil moisture, controlling lamps and pumps in real time. The extensions of this research are as follows:

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- Development of a database with a local server connected to the cloud.
- Added DHT 11 sensor to calculate air temperature and humidity, and Lux Mater BH1750 Module to measure Lux in greenhouse.
- Final test system in the greenhouse, where the cultivation of chrysanthemum is done.

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