Design of monitoring and automation systems for greenhouse environment based on IoT

Heri*, Rian K. Nasution, Billie C. Guptan, Dody K. O. Larosa, Destri Sofhani, Hendrik Siagian, Despaleri Perangin-angin and Eka Dodi Suryanto

Faculty of Technology and Computer Science, University Prima Indonesia, Medan, Indonesia

*Email: heri.zeng@gmail.com

Abstract. In this paper, the greenhouse is controlled by a microcontroller module unit. Some sensors installed to detect soil moisture, temperature, and light intensity. The sensor measurement will be sent to the server via a microcontroller and displayed to web pages. It will control a pump, fan, and LED for adjusting the environment in the greenhouse. On the automatic controller, a pump installed for the moisture of soil, fan for temperature and humidity and LED growth if the lighting is lacking. The test from the sensors can run well, if the soil moisture below 40%, a pump will be automatic on. For temperature above 31°C, two fans will on. For light below 50%, LED will on. The system can control fans by dht11 temperature for 90%. The LDR can control LED for 85%. The soil moist can control a pump for 80%. The greenhouse can still run well in maintaining appropriate conditions on the plant. With the advancement of technology, we can control and monitor greenhouses using IoT.

1. Introduction
Before entering the main topic, we will discuss what is a greenhouse. The greenhouse also called a house plant is a place where plants cultivated. An area under the greenhouse is cover with a glass or transparent plastic roof. This very important in vegetation in cooler regions to bring to the outside environment. Now we will discuss the greenhouse effect, the greenhouse effect is a process in which various greenhouse gases entrap infrared light from the sun so that it leads to an increase in carbon dioxide levels which further helps increase the amount of chlorophyll and thus leads to the growth and yield of plants which impressive [1].

The world climate change has brought about unpredictable weather conditions that have resulted in the global food shortage being experienced. A possible solution to this problem will likely involve households growing a reasonable percentage of the vegetables and crops they need in a greenhouse which does not require too much land space [2]. The greenhouse is an important part of the agriculture and horticulture sectors. It can be used to grow plants under controlled climatic conditions for optimum production [3]. The greenhouse is a building that is designed for artificial climate control made of glass or a transparent plastic roof that is used for various applications in planting vegetables, ornamental plants, acclimatization of planting material, fruit plants, and plant breeding outside the environment of the area [4]. Plant growth depends on water, nutrition, and soil moisture where the plant is planted. Moisture, soil, and salt form a soil solution that is rich in nutrients for plants. Temperature and light intensity plays an important role in the process of respiration and photosynthesis in plants [4].

In some countries, there are food shortages. This happens because of the increasing population in the world. Our food crops need some specific environmental conditions for their growth. Each region has large variations in current environmental conditions, this affects the growth and supply of food and medicinal plants. As a result, the cost of basic needs increases, in poor countries will experience...
famine due to food shortages. Therefore, we realize that the food and medicinal needs of plants are urgently needed, so an automatic monitoring and control system for greenhouses was created where we can process plants in the conditions of the area. [5]. Control on weather conditions like temperature, humidity, soil moisture can improve crop production & quality both [6].

With the development and advancement of technology, especially in the field of IoT (Internet of Things), it has been widely used in various fields [7]. There are four categorizations of Internet of Things (IoT) system services, namely: Identity-Related Services, Information Aggregation Services, Collaborative-Aware Services, and Ubiquitous Services [8]. with the expansion of the internet and technological advancements, this has led to the advancement of IoT in computing device systems that are interrelated between mechanical and digital machines, objects, animals or people that are provided with unique identification (UID) and the ability to transfer data over a networks without requiring humans-humans or human-computer interaction. Several application areas ranging from Green-IT and effectiveness of vitality to coordination are now beginning to benefit from the idea of the Internet of Things [9, 10].

Most of the agricultural sector in the country is facing low economic resources, but some of the greenhouse running in the low tech. So many researchers have been focusing on the automated wireless embedded intelligent monitoring system for greenhouse [11]. By utilizing IoT technology advances, it is currently very helpful in completing various human works. One example is the use of IoT technology in agriculture. Nowadays greenhouses have been widely applied in the process of controlling plants so that their conditions can be maintained. However, with IoT technology, the work of controlling plants in a greenhouse can be made automatically or remotely controlled.

In this case, the research focuses on greenhouse control systems based on the Internet of Things (IoT) technology and microcontrollers to run all the desired commands to support smart greenhouses. The advantage of IoT itself is that it can connect users more easily to interact with all equipment connected to the internet.

2. Method

The automatic greenhouse control system, whose block diagram is depicted in Figure 1, consists of two main parts: a sensor station and an automatic control station. The monitor system consists of sensors for light (Light-dependent resistor), temperature and humidity (DHT11) and soil moisture (Soil Moisture Sensor). The control system consists of fans, pumps and led plants. All units are connected to a microcontroller board with additional power from the power supply. The sensor/actuator station is the heart of the system responsible for regulating the greenhouse environment. Sensors obtain environmental data. After the data is filtered to remove noise, the data is available for the Arduino board which then calculates the current value of the controlled variable and compares it with the specified threshold. If one of the controlled variables is outside the safe limit, the associated actuator is activated to restore optimal conditions [4]. The Arduino board also reads the status of the actuator and transmits information along with the current value of the variable controlled to ethernet devices to be stored on the server and displayed on a web page with the IoT concept. The following methods are shown in Figure 1.
2.1. Hardware design
The design of the hardware is divided into designing a monitoring system and a control system. To simplify design, it starts from the initial stage, which is making block diagrams. The purpose is to make it easier to analyse the relationships between the components one block with another. The following block hardware diagram is shown in Figure 2.
3. Results and discussions
3.1 Hardware design
The design of the instruments was adjusted to the physical shape that resembled a greenhouse in general. After that, some test results will be collected in the quantitative data form. The design of the greenhouse and the instruments can be seen in Figure 3.
3.2 Soil moisture sensor test
Soil moisture for plants requires around 40% to 50% of the state of wet soil. If the condition of soil moisture is below 40%, the pump will turn on. If the soil moisture exceeds 50%, the pump will turn off automatically.

3.3 Temperature sensor test
The optimum temperature range is very important for agriculture and is to be maintained for maximum dry matter accumulation. The optimum temperature for the plants required is 28 °C. We set the upper threshold value of temperature at 30°C and the lower threshold value at 29°C.
If the temperature in the greenhouse is above the lower threshold, the fan will automatically turn on, and vice versa if the temperature is below the upper threshold, the fan remains off. The following is the result of testing the temperature sensor with time.

| Test | Temperature (°C) | Fan 1   | Fan 2   |
|------|------------------|---------|---------|
| Test 1 | 30               | Off     | Off     |
| Test 2 | 29               | Off     | Off     |
| Test 3 | 28               | Off     | Off     |
| Test 4 | 31               | On      | On      |
| Test 5 | 33               | On      | On      |

3.4 Light sensor test
The intensity of the light drops rapidly the further the plant is moved from the window. A simple move of two or three feet away from a window can reduce the light intensity by more than 50 percent. When you buy a plant you'll find an indication of light intensity it needs. Then, when the light sensor receives a beam below 50%, the plant LED will turn on automatically.

| Test | Intensity © | LED |
|------|-------------|-----|
| Test 1 | Lower       | On  |
| Test 2 | Medium      | On  |
| Test 3 | Light       | Off |

3.5 Result
The results obtained from the experiments above, there are still some obstacles. On the microcontroller still experiencing delays in sending data to process output, besides that in sensor readings still experiencing obstacles such as the influence of cloudy weather that can affect temperature, humidity, and light intensity.

| Number | Sensor   | Measurement     | Control | Result % |
|--------|----------|-----------------|---------|----------|
| 1      | DHT-11   | Temperature     | Fan     | 90%      |
| 2      | LDR      | Light Intensity | LED     | 85%      |
| 3      | Y-L 69   | Soil Moisture   | Pump    | 80%      |
4. Conclusions
The system of the greenhouse that was created was successful and could run well. Soil moisture sensor can determine the condition of moist soil well if the soil is below 40%, the pump will automatically turn on and wet the plant. For room temperature conditions, the sensor can provide the desired value. If the greenhouse temperature above 31°C, fans will automatically turn on. For lighting, the light sensor greenhouse can provide value even though the weather conditions are sometimes cloudy. If the light is shining less, the sensor will read lower or medium, the LED growth will automatically illuminate the greenhouse. But sometimes the sensor reading is delayed so that the control system is late in carrying out its functions. This can happen because the instructions carried out by the microcontroller are executed every one of the clock cycles so that the function being run has a delay of a few seconds. This is not a significant obstacle because the needs of greenhouses for plants can be fulfilled properly.

Acknowledgments
The authors gratefully acknowledge that the present research is supported by the Ministry of Research and Technology and the Higher Education Republic of Indonesia. The support is under the research grant Faculty of technology and computer science, University Prima Indonesia.

Reference
[1] Aadil I, Deepak G 2018 Smart Greenhouse Monitoring using the Internet of Things 7 519-523
[2] Jonathan A E, Theophilus O O 2015 An Automated Greenhouse Control System Using Arduino Prototyping Platform 1-13
[3] T Saha, M K H Jewel, M N Mostakim, N H Bhuiyan, M S Ali, and M K Rahman, H K Ghosh, and Md Khalid Hossain 2017 Construction and Development of an Automated Greenhouse System Using Arduino Uno 3 1-8
[4] Priyanka M D, Bhakti V N, Prerana R E, Pushkar T, Prof. (Dr.) S A Patil 2017 Greenhouse Parameters Monitoring and Controlling System Using Arduino and Android 5 321 – 326
[5] Rameez R, Mudassir H, Deekshith, Jayantha Saliyan K N 2018 IoT Based Green House Monitoring and Smart Farming 5 679-685
[6] Raju B and Dr. Ajita Pathak 2017 An Arduino Based WSN to Control and Monitor the Greenhouse Parameters 1501-1508
[7] Affan B, Eko W S 2017 Automatic Plant Watering Prototype with Atmega-Based Soil Moisture Sensor 328 Jurnal 2 5-10
[8] N Fajrin, I Taufik, N Ismail, L Kamelia1 and M A Ramdhani 2017 On the Design of Watering and Lighting Control Systems for Chrysanthemum Cultivation in Greenhouse Based on Internet of Things 2 1-6
[9] Zaidon F S, Ali F M, Abbas A J 2017 IoT Based Intelligent Greenhouse Monitoring and Control System 17 61-69
[10] Irvan, Husaini T, Simanungkalit E, Sidabutar R and Trisakti B 2018 Automation of temperature sensor in biogas production from palm oil mill effluent (POME) IOP Conf. Ser: Journal of Physics 1116 042015
[11] S Muthupavithran, S Akash, P Ranjithkumar 2016 Greenhouse Monitoring using the Internet of Things 2 13-19