Development of Temperature Control and Monitoring System for Precision Aquaculture Based on the Internet of Things

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Abstract. The cultivation of cherax quadicarinatus is one of the aquaculture businesses with superior prospects. Meanwhile, it was also discovered that lobster has biological advantages, which include uncomplicated reproduction, adaptability, and are technically easy to cultivate with relatively high prices. Therefore, this study aimed to provide a monitoring system using the Antares Platform and a temperature control system that has not installed the Internet of Things (IoT). It is formed by three components, namely things, connectivity, and platform, which can be built in various ways according to the applications needs. Furthermore, each component has a different level of efficiency and effectiveness. The things component is divided into Sensors and Controllers. The DFRobot DS18B20, DS18B20, and Atlas Scientific (PT-1000) temperature sensors were discussed and compared. The results showed that there is a little difference between DFRobot DS18B20 and DS18B20, which are 23.9ºC and 24.0ºC, respectively, while the Atlas Scientific (PT-1000) has the large difference of 25.6ºC. Moreover, the controller, connectivity, and platform discussed ESP32, Wi-Fi, and the Antares Platform, respectively. Artemis is a prototype made for a temperature control system that does not have IoT installed. Based on the test results, the prototype maintained the spawning pond at an ideal temperature of 26ºC - 28ºC, and the monitoring test was successfully sent to the Antares Platform.

Keywords: Temperature, Internet of Things, Cherax quadicarinatus

1. Introduction

Freshwater lobster cultivation is one of the aquaculture businesses that have superior prospects. However, only a few people are involved in the business due to a lack of information about its existence, while most fishermen know about sea lobster. According to a previous report, the red claw type of freshwater lobster, with the Latin name *Cherax quadricarinatus,* is a commodity popularly found in Australia [1]. The species has several biological advantages such as uncomplicated reproduction, adaptability, and is technically easy to cultivate with relatively high or expensive prices [1]. Furthermore, the size and shape are quite similar to sea lobster but can be cultivated [2]. The success of freshwater lobster is significantly influenced by the practice of spawning techniques at the optimal temperature of 26°C-30°C [3], [4].

The Internet of Things (IoT) can allow the connection of a device to the internet in real-time for convenient monitoring. The IoT platform that was used for monitoring includes ThingSpeak, Ubidots, and the Cayenne [5]–[7]. The regulation of the Minister

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of Communication and Information in chapter VI article 20 [8] stated that every domain name server located in the jurisdiction of Indonesia must use an Internet Protocol (IP) Address. One of the platforms that use a domain server is Antares, which is owned by PT. Telecommunication. This platform supports various devices such as microcontrollers and programming languages. Furthermore, Antares also has protocols commonly used in IoT such as Message Queuing Telemetry Transport (MQTT) and Hypertext Transfer Protocol (HTTP) [9]–[11], but the control system is not yet connected. Therefore, this study discusses a monitoring system that is connected to IoT and a control system without connection.

2. Teori

IoT in this paper contains three types, first, things are divided into sensors and controllers. Both *connectivity* discusses wifi *communication*. The three *platforms* that will be used by the Antares *Platform*.

A. Things

- Sensors are elements that convert physical signals into electronic signals. The sensor used in this paper is the DFRobot DS18B20 temperature sensor. DS18B20 is a sensor that can detect the state of the ambient temperature. The waterproof version of the DS18B20 sensor can be used to record temperatures when wet or in liquid media. With this DS18B20, you can monitor the water temperature very easily [10], [12].
- The controller used in this paper is the ESP32 microcontroller. ESP32 is a successor microcontroller from ESP8266 which was introduced by Espressif System. The ESP32 is equipped with a chip built into the Bluetooth Low Energy and WIFI module [12], [13]. This ESP32 module has an Analog to Digital Converter feature in converting or converting analog signals to digital signals. This ADC pin has a role in processing and measuring objects that have analog signals.

B. Connectivity

Connectivity that will be used is wifi communication. Wifi is a wireless data communication medium that can be used by electronic devices to communicate using radio waves in the 2.4 GHz to 5 GHz range [14], [15]

C. Platform

The *platform* serves as the main container for running the system. The platform used is from the owner of PT. Telecommunications named Antares. Antares is an open Platform based on one M2M and is a generic Platform that can store different types of data. Antares is a Platform engaged in the Internet of Things, particularly in Internet of Things Connectivity and management cloud databases. Antares connects IoT devices with user interfaces. The advantage of Antares compared to other Platforms is that it supports IPv6, supports 4 standard protocols such as: HTTP, MQTT, CoAP, Web Socket, and is developed based on one global M2M standard. [9]–[11].

Proposed system

The IoT device uses the DFRobot DS18B20 temperature sensor for water temperature. Based on Figure 1, the monitoring system has a microcontroller device, namely ESP32 which reads the data received from the DFRobot DS18B20. It also displays the results on a 3.5in TFT, stores data on a Micro SD, and sends information via wifi communication through the Antares Platform. Meanwhile, the control system that is not connected was equipped with a water heater and a cooler for the controlled temperature. Figure 2 showed that the system is equipped with (+) buttons to increase numbers, (-) to decrease numbers, and (SET) to process the program.

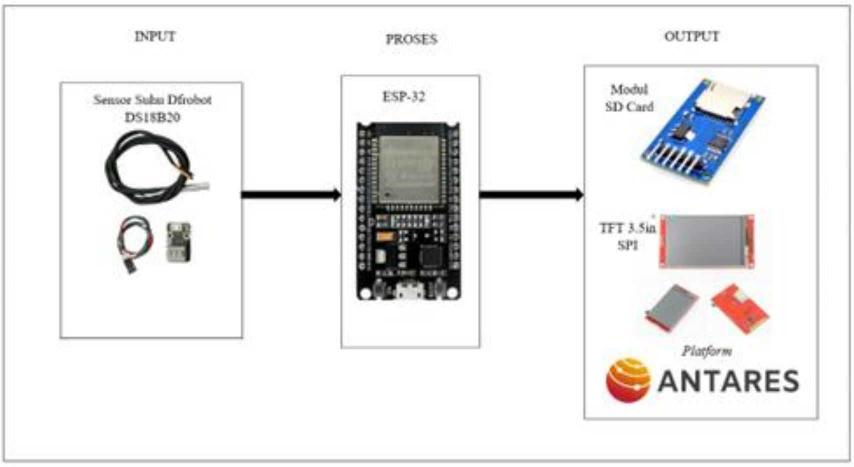

Figure 1. Monitoring System

Figure 2. Control System

The control system that has been created is version 1 which will be redeveloped with a control system connected to IoT devices in other words version 2 where the monitoring system and control system are already connected to IoT and can be accessed by mobile phones.

3. Results

Sensor calibration tests have been carried out by comparing the Dfrobot ds18b20 sensor, ds18b20 sensor, PT1000 sensor, and the Thermo Scientific.

Table 1. calibration

Sensor DF	Sensor DS 1	Sensor DS 2	Sensor PT-1000	Thermo Scientific
41,50	42,50	42,48	41,75	40,90
41,00	41,06	41,77	41,56	40,50
40,50	40,63	41,26	41,13	40,20
40,13	40,19	40,76	40,63	39,80
39,69	39,81	40,27	40,19	39,20
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
28,00	27,81	27,85	28,37	28,10
27,87	27,69	27,70	28,19	28,00
27,75	27,56	27,57	28,06	27,90
27,62	27,44	27,43	27,94	27,80
27,50	27,31	27,26	27,81	27,60

Table 2. Analysis

	Sensor DF	Sensor DS 1	Sensor DS 2	Sensor PT1000	Thermo Scientific
Mean	33,28266667	33,17116667	33,35783333	33,66683333	33,199
Standard Error	0,52752818	0,544081203	0,558865836	0,534587253	0,505525274
Median	32,685	32,47	32,735	33,155	32,7
Standard Deviation	4,086215715	4,214434876	4,328956148	4,140895053	3,915781932
Minimum	27,5	27,31	27,26	27,81	27,6
Maximum	41,5	42,5	42,48	41,75	40,9
Confidence Level (95,0%)	1,055581451	1,088703973	1,118287954	1,069706622	1,011553736

The data analysis in **Tables 1** and 2 showed the highest and lowest temperature values for each sensor, where DF has 41.5 and 27.5, DS 1 has 42.5 and 27.3, DS 2 has 42.4 and 27.2, respectively. On the PT1000 sensor, the highest and lowest temperature values are 41.7 and 27.6, respectively. Meanwhile, when the initial data approach the calibrator value, it is necessary to calibrate where the linear regression temperature sensor is used with the formula.

$$y = a + bx$$

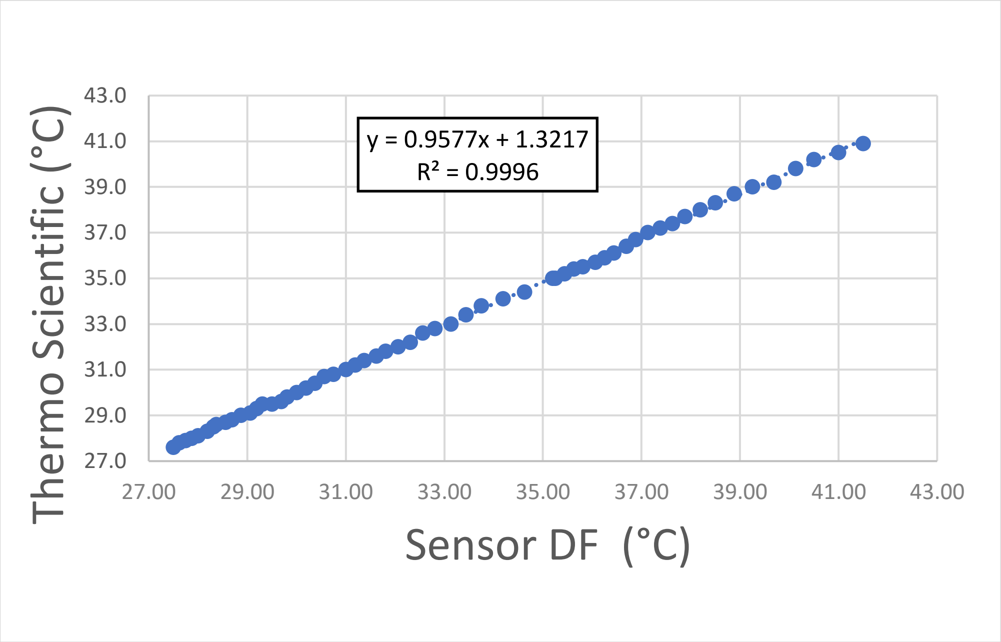

Figure 3. DF sensor calibration data graph

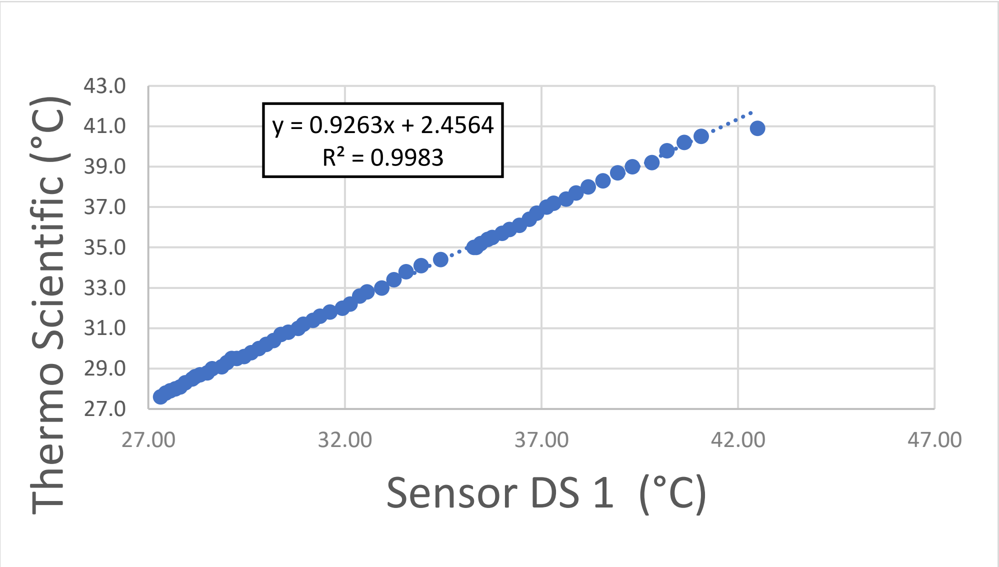

Figure 4. DS 1 sensor calibration data graph

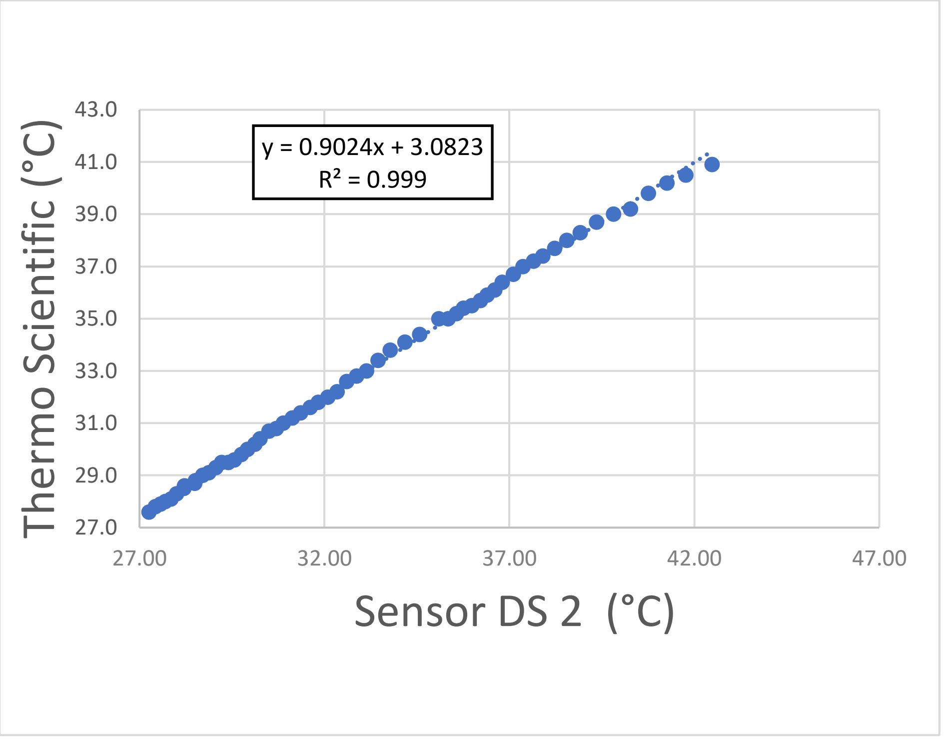

Figure 5. DS 2 sensor calibration data graph

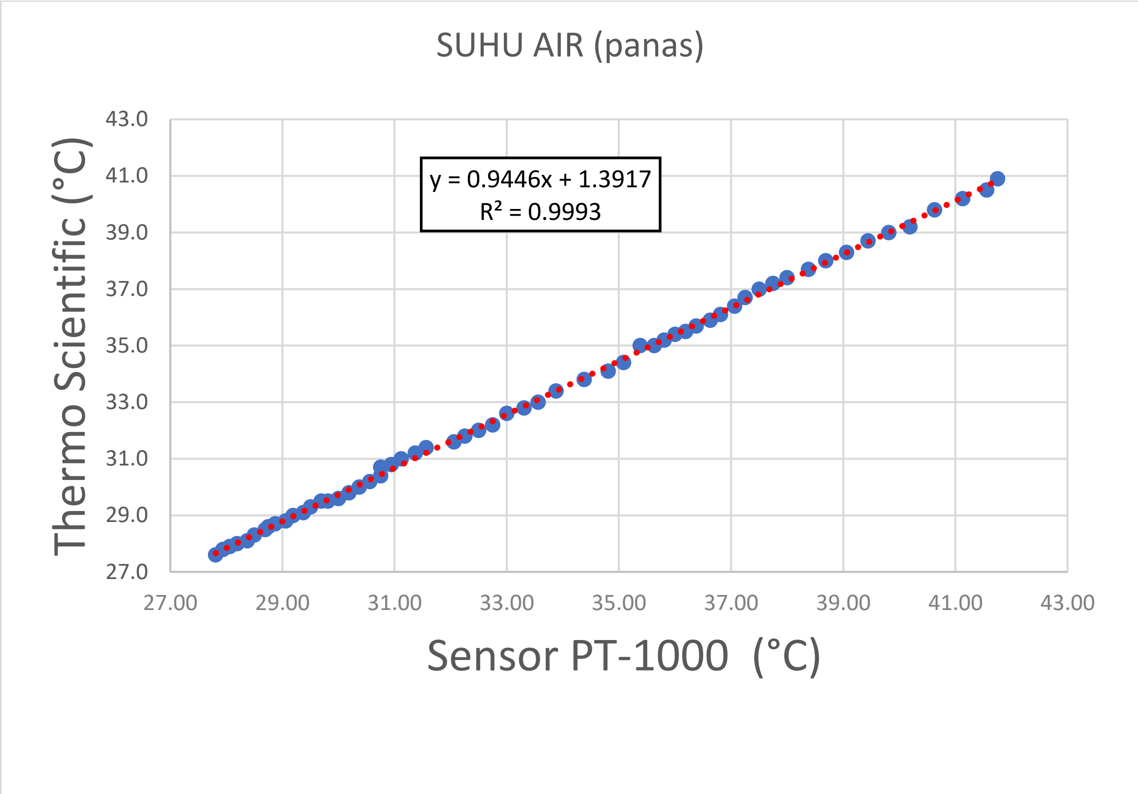

Figure 6. PT-1000 sensor calibration data graph

The results of these calibration values can be close to the calibrator temperature values that are already known with the Thermo Scientific calibrator.

The location of the field testing was carried out by the UPTD Balai Benih Ikan Dinas Pertanian dan Pangan Kabupaten Bandung (**Figure 7**).

Figure 7. Device testing

Installation of monitoring system tools and control systems that have not been connected to IoT, which is named ARTEMIS V1 (Figure 11). 10 LATs have been entered. 6 females and 4 males are ready for spawning. The monitoring device and control device for the temperature part are the same where the monitoring device and control device can withstand the temperature controlled by the ARTEMIS V1 control system by maintaining a temperature of 26 °C (***Figure 9***). Many LATs have already laid eggs (***Figure 10***) because the temperature for spawning with the optimal temperature is from 26-30°C [3], [4].

Figure 8. Monitoring System and Control System

Figure 9. The temperature on monitoring and control is the same

Figure 10. LAT spawn

Monitoring System that has been connected to the Antares Platform (***Figure 11***). It can be accessed via the web and cellphone by logging into the Antares account. Because here it is still in terms of prototype or version 1.

Figure 11. devices connected to the Antares Platform

4. Conclusion

Implementation using the Antares Platform and communication by WiFi was successful, but there is a delay of about 1 to 4 seconds. Furthermore, the display functions properly, while the monitoring and control system (ARTEMIS V1) also maintained the temperature from the set value before starting the next program. The temperature read by the sensor from the monitoring and control (ARTEMIS V1) has the same value of 26°C-28°C according to the water temperature. Therefore, a control system that is connected to IoT can be created in the future.

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