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PREFACE

We would like to present, with great pleasure, the second issue of Matrix: Jurnal Manajemen Teknologi dan Informatika in Volume 14, 2024. This journal is under the management of Scientific Publication, Research and Community Service Center, Politeknik Negeri Bali, and is devoted to covering the field of technology and informatics management including managing the rapid changes in information technology, emerging advances in electrical and electronics and new applications, implications of digital convergence and growth of electronics technology, and project management in electrical, mechanical or civil engineering. The scientific articles published in this edition were written by researchers from Universitas Dinamika, Politeknik Negeri Malang, Universitas Mercu Buana, UPN Veteran Yogyakarta and Universitas Warmadewa. Articles in this issue cover topics in the field of Monitoring and Temperature Control System for Fish Farming in an IOT-Based Bucket Using an Android Application, Laravel Framework and Native PHP: Comparison in the Creation of Rest API, Analysis and Visualization of Digital Advertising Data Using EDA on Payment Point Online Bank Applications, The Development of a Web-Based Internship Information System at DLHK-DIY Using the Waterfall Method, and Internet of Things (IoT) Design Based on Smart Farming with Solar Panels in an Agriculture Laboratory. Finally, we would like to thank the reviewers for their efforts and hard work in conducting a series of review phases thoroughly based on their expertise. We hope that the work of the authors in this issue will be a valuable resource for other researchers and will stimulate further research into the vibrant area of technology and information management in specific, and engineering in general.

Politeknik Negeri Bali, 30 July 2024

Editor-in-chief

Gusti Nyoman Ayu Sukerti, S.S., M.Hum.

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Monitoring and temperature control system for fish farming in an IOT-based bucket using an android application

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Abstract: This study seeks to create and implement an Internet of Things (IoT)-based system for monitoring and controlling temperature in fish farming within a bucket (Budikdamber) using temperature sensors. The main focus is to set the optimal temperature range for catfish farming in the Budikdamber, ensuring environmental conditions that suit the needs of catfish. Automatic controls are integrated to keep the water temperature in the bucket within the desired range. The system is also capable of automatically activating or deactivating devices such as the Peltier, lights, filling pump, and draining pump to achieve the appropriate temperature. In the test using a 50-litre bucket, a thorough evaluation and testing showed that the DS18B20 temperature sensor had an error rate of 0.8826%, while the Ultrasonic sensor had an error rate of 0.737%. Nonetheless, the other components in the device operate optimally with performance levels reaching 100%, according to their functions. Testing of the Android App on this device achieved an accuracy rate of 100%, indicating that this device can be effectively monitored and controlled remotely through the Android App. The conclusion of this research provides insight into the performance of temperature sensors, system optimization, and the effectiveness of remote control using Android Apps in the context of fish farming.

Keywords: Android App, Automatic Control, Budikdamber, Internet of Things

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Introduction

In the face of rapid growth in the development sector, there are land restraints that hamper activities including gardening and fish farming [1]. However, the need for both animal and plant protein continues to increase [2]. People living in urban areas, cannot fulfill this protein demand by keeping fish in lakes, ponds, rivers, or other bodies of water in the same way as people in rural areas. Limited land for fish farming in urban areas is increasingly becoming a constraint due to the ongoing development process. In contrast, the demand for animal protein continues to increase [3]. As a solution to deal with these conditions, the concept of Bucket Fish Farming or Budikdamber emerged, which can be a potential alternative solution for raising fish and gardening on limited land by using water appropriately. Bucket fish farming allows people to do fish farming at home at an affordable cost, thus meeting the nutritional needs of the community [4].

The Budikdamber method is a technique that can be utilized to cultivate various freshwater fish species, including snapper, catfish, shrimp, and tilapia. Additionally, it can be employed to grow water spinach. The choice of these crops in this context was selected based on several advantages, such as ease of cultivation, affordable prices, and short harvesting periods [5]. In Budikdamber, vegetables, and fish are treated with polyculture in the same bucket or container. Compared to complex aquaponic systems that require pumps, filters, large areas of land, and high investment, Budikdamber is a simpler method. The Budikdamber method has several advantages, including low water consumption, low waste production, simple maintenance, and no need for harmful chemicals.

By adopting the concept of Bucket Fish Farming, community groups can use limited areas efficiently and sustainably. Therefore, there is a need for a form of Bucket Fish Farming System that can be monitored and controlled even without the user being present at the location.

Research conducted by Nursandi in his journal entitled Fish Cultivation in a Bucket "Budikdamber" with Aquaponics in Narrow Land explained that the temperature needed for catfish in Budikdamber is between 25.0 to 31.5 ° C. The ideal water temperature can enhance fish appetite and speed up growth rates. However, temperature changes can occur within the Budikdamber system as it is influenced by ambient temperature, be it rainfall or intense sunlight. A significant increase in temperature can cause a reduction in the dissolved oxygen content in the water, which can cause stress to the fish. Therefore, it is important to keep the water temperature within an appropriate range for the catfish to grow well.

In a previous study entitled Turbidity and Water Level Monitoring System for Fish Cultivation in a Bucket (Budikdamber) Based on the Internet of Things conducted by Septian, in this study the tool has a feature of monitoring water levels and water turbidity levels and also controlling water levels, the application used is Blynk [6]. Research conducted by Faris Nidaul Haq with the title Designing an Automatic Feeding System for Fish Cultivation in a Bucket (Budikdamber) Based on Arduino Uno ATMega 328, in this study the tool only focuses on automatic feeding using RTC and Push Button without any mobile application [7]. However, these two studies did not consider other factors such as automatic control of water level and temperature and the use of an android platform for monitoring and control. A comparison of the author's research with previous research is described in Table 1 below.

Table 1. Research comparison

Fitur	Author's Research	Septian's research	Faris' research
Water Level	Control & Monitoring	Monitoring	Control
Water Temperature	Control & Monitoring	-	-
Water Turbidity	-	Monitoring	-
Fish feed	-	-	Feed Automation
Application Platform	Android Apps	Blynk	-
User Interface	LCD 16x2	-	-
Microcontroller	ESP32	ESP8266	Arduino Uno

Thus this research was developed to provide an alternative to maintaining the temperature condition of Budikdamber. By combining monitoring and control devices, Budikdamber owners can monitor water temperature, measure water level, and control existing actuator devices with ease. In addition, the system ensures that the water temperature in the bucket stays within the optimal range. If the temperature rises above the upper limit or falls below the specified lower limit, the system takes automatic action by activating or deactivating devices such as the peltier, lights, filling pump, and drain pump to regulate the temperature back into the desired range. The purpose of this Final Project research also involves providing remote access through a user interface that uses an LCD attached to the Budikdamber device and an Android application on a Smartphone. This allows the user of the Budikdamber system to get immediate notifications about detecting inappropriate water conditions and control the device remotely. Thus, the control and supervision of Budikdamber can be done easily even when the owner is not nearby.

Methodology

DS18B20 Sensor Testing and Water Temperature Monitoring

In this series of research, an evaluation of the DS18B20 sensor and water temperature monitoring through the Android Application was carried out. This sensor test involved a comparison in the form of a digital temperature thermometer, the experiment was run 30 times. The purpose of this experiment is to verify the performance and accuracy of the DS18B20 sensor and to observe real-time water temperature monitoring through the Android application on a smartphone. The distance between the two sensors is less than 5 cm.

Calculation of the error in testing the DS18B20 Sensor with a Digital Thermometer is done using the following Equation 1.

$$Error = \left|\frac{Thermometer - DS18B20}{Thermometer}\right| x\ 100 \quad (1)$$

Remarks:
1. A thermometer refers to a standard or reference thermometer used to accurately measure temperature.
2. DS18B20 refers to the DS18B20 digital temperature sensor that is being compared to the reference thermometer.

Ultrasonic Sensor Testing and Water Level Monitoring

In this research, an evaluation of the Ultrasonic sensor and water level monitoring via the Android App was conducted. The sensor test involved a ruler for comparison, and the experiment was run 30 times. The purpose of this experiment is to verify the performance and accuracy of the Ultrasonic sensor and to observe real-time water level monitoring through the Android application on a smartphone.

Error calculation in testing the Ultrasonic Sensor with a Ruler is done using the following Equation 2.

$$Error = \left|\frac{ruler - ultrasonic}{Ruler}\right| x\ 100 \quad (2)$$

4 Channel Relay Testing

In this research, an evaluation of the 4 Channel Relay was conducted. The experiment was conducted 30 times. The purpose of this experiment is to verify the performance and accuracy of the Relay. Calculation of success in Relay testing is done using Equation 3 as follows:

$$Result = \left|\frac{Many\ Data\ Successful}{Total\ Data}\right| x\ 100\ \% \quad (3)$$

Testing the Water Temperature Condition of the Peltier

In this research, the water temperature condition of the peltier was evaluated. The experiment was conducted 15 times. The purpose of this experiment is to verify the performance and accuracy of the water temperature of the Peltier. Calculation of success in testing is done using Equation 3.

Testing the Water Temperature Condition of the Lamp

In this research, the water temperature condition of the lamp was evaluated. The experiment was conducted 15 times. The purpose of this experiment is to verify the performance and accuracy of the water temperature of the lamp. Calculation of success in testing is done using Equation 3.

Overall System Testing

In this research, an evaluation of the entire system, which is a combination of sensors, components, and Android applications, was conducted 30 times. The purpose of this experiment is to verify the performance and accuracy of the system. Calculation of success in testing is done using Equation 3.

Budikdamber

Budikdamber, or bucket fish farming, is a system model that offers several prominent advantages. Known for its affordable cost, ease of application, and simplicity of execution, this system has attracted the interest of many. In bucket culture, fish are cultivated in a bucket or similar container, which allows the owner to manage the pond efficiently and effectively. The affordable cost advantage makes the system attractive to many fish farmers, while the ease of application allows new users to quickly adopt the technique.

ESP32

The ESP32, a microcontroller developed by Espressif System, comes as an evolution of the ESP8266, its predecessor. One of the prominent features of the ESP32 is the WiFi module incorporated into the chip. This provides significant support in the development of Internet of Things (IoT) devices [8]. The ESP32 provides several benefits, including high-frequency capability, affordability, integrated sensors (such as temperature and Hall effect sensors), and Wi-Fi and Bluetooth connectivity. The device includes speeds of up to 150 Mbps, a 10-pin ADC, a power management module, a receiver with a low noise amplifier, security features, filtering, and is easy to install [9].

DS18B20 Temperature Sensor

The DS18B20 sensor is one example of a sensor that is often used to measure temperature with water resistance. The sensor is equipped with an aluminum tube cover that protects water, allowing its use in situations where there is the potential for immersion in liquid [10]. In the DS18B20 sensor, the red cable is used to connect to the voltage source (VCC), the black cable is used to connect to the ground (GND), and the yellow cable acts as a data connection line. The width of the cable used is about 4 mm, and the total length of the cable reaches 90 cm [11].

HC-SR04 Ultrasonic Sensor

Ultrasonic sensors are devices that work by using reflected sound waves to detect the position of an object in the vicinity [12]. The HCSR04 sensor is designed specifically to measure the distance to an object. With its reliable capabilities, this sensor can detect distances within a range of between 2 to 450 cm. In other words, this sensor provides considerable flexibility in measuring distance, making it suitable for a wide range of applications, from DIY (Do It Yourself) projects to more complex industrial uses [13].

Push Button

A push button is a straightforward mechanical or electrical switch that operates when pressed [14]. Its presence inside the electrical box provides ease of access and use in controlling various connected electrical devices, while outside the electrical box, this device is often used as an additional switch to easily turn electronic devices on or off.

Relay

A relay is an electrical device that serves as a switch controlled by electrical signals. Comprising two primary components a coil of electromagnet and a set of mechanical switch contacts the relay operates by using the electromagnet to move the switch contacts [15]. Relays are used in a variety of applications due to their ease, longevity, and proven reliability. Their functions include monitoring, regulating, and controlling power [16].

Liquid Crystal Display 16x2 I2C

A Liquid Crystal Display, also known as a 16x2 LCD, is a type of visual display that utilizes liquid crystal materials and is executed using a dot matrix structure. In a 16x2 configuration, this LCD can display a total of 32 characters divided into two bars, with each bar representing up to 16 characters. In addition, 16x2 LCDs can communicate via the I2C protocol [17].

Blynk

Blynk is a platform designed to manage components such as ESP32, ESP8266, Arduino, Raspberry Pi, and so on. It may be connected via an internet connection, and it can be accessed through the iOS and Android operating systems [18].

Kodular

Kodular is an online platform that provides users with tools to create Android apps without having in-depth programming knowledge. The platform uses a block-based programming method, similar to the concepts found in MIT App Inventor [19].

System Block Diagram

The following is a block diagram of the designed device:

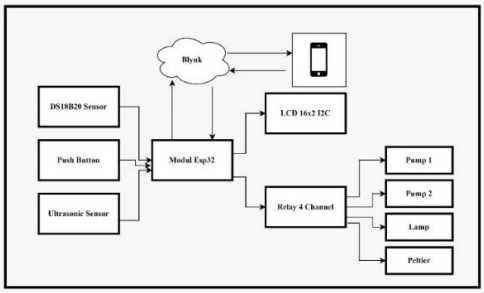

Figure 1. System block diagram

With reference to the block diagram in Figure 1, the system consists of several components. The operational way of this device or block diagram can be explained as follows The DS18B20 sensor is an input component that functions as a water temperature detector. An ultrasonic sensor is an input component that functions to measure the distance of the water surface. The ESP32 microcontroller is a module for controlling various sensors and actuators, the alternating arrows indicate communication between the ESP32 and Blynk and the user's smartphone. The 16x2 I2C LCD serves as a presenter of temperature value information from the DS18B20 sensor and water surface distance value data from the Ultrasonic sensor. Relay Module 4 Channel is used to control several functions in the water bucket management system.

Schematic Design

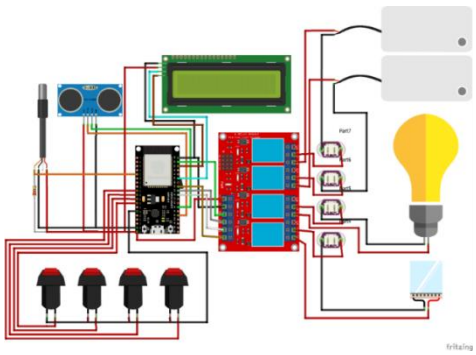

Figure 2. Schematic design

Based on the schematic circuit illustration in Figure 2, this Wiring Management Note describes the cable connections required to integrate the various components in this project using the ESP32 microcontroller. This project aims to control and monitor various sensors and devices through the ESP32 using the wiring connection.

System Flowchart

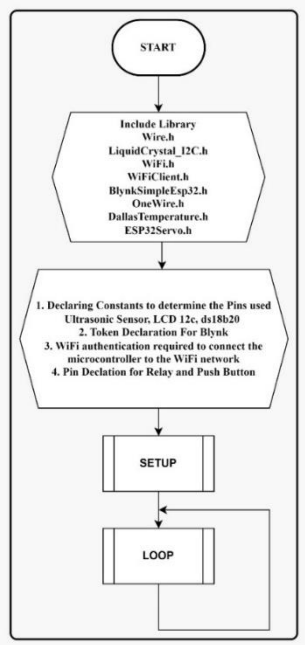

Figure 3. System flowchart

Based on Figure 3, the program starts by importing the library used and then continues with the declaration of the variables used. Next, the program has two main parts, namely Function Setup and Function Loop.

Automatic Control Plan

In this research, an IoT-based monitoring and temperature control system for fish farming in buckets is controlled using several controls that are designed in detail. The main control plan involves setting the temperature and volume of water in the bucket. The following is a detailed control plan for each aspect:

1. Temperature Control

a. High Temperature (More than 30°C)

Based on Figure 4, if the temperature exceeds 30°C, the drain pump is activated. The drain pump remains active until the water level reaches 30cm. After reaching a water level of 30 cm, the dewatering pump is switched off. Subsequently, the charging pump and Peltier were activated. The water level is increased until the water level reaches 10 cm. After reaching 10cm water height, the charging pump and Peltier were switched off. Repeat until ideal temperature. The system highlights the connection between temperature and water level, detailing how variations in water level contribute to effective temperature regulation and the maintenance of fish health.

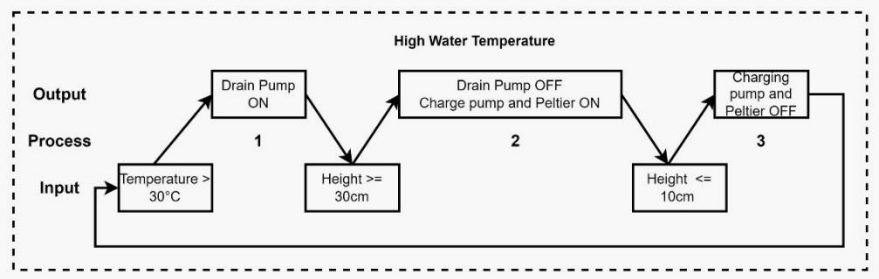

Figure 4. High water temperature

b. Ideal Temperature (25°C - 30°C)

Based on Figure 5, If the temperature is within the range of 25°C to 30°C, then all devices, including the drain pump, charge pump, Peltier, and lights, are turned off.

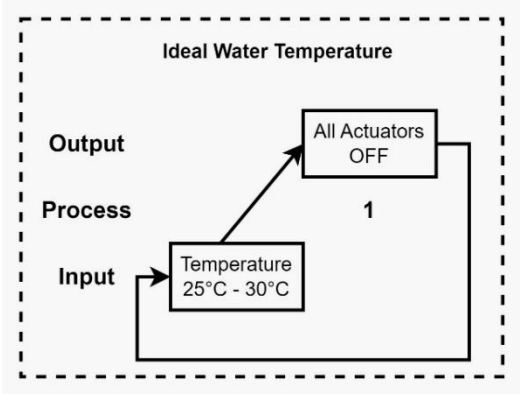

Figure 5. Ideal Temperature

c. Low Temperature (Less than 25°C)

Based on Figure 6, If the temperature drops below 25°C, the lamp is activated. The light is switched off when the temperature reaches or exceeds 25°C. The system emphasizes the relationship between water temperature and the use of heat lamps, explaining how heat lamps help maintain water temperature within the optimal range for fish health.

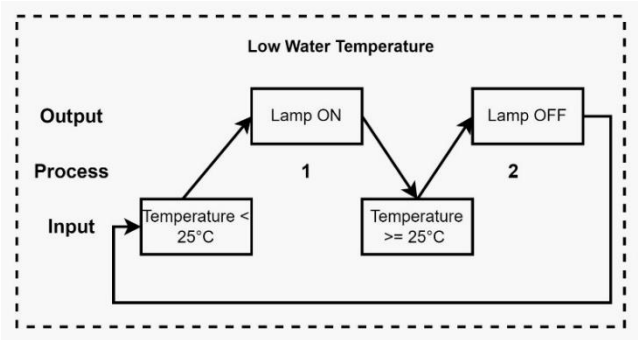

Figure 6. Low temperature

2. Water Volume Control

a. Low Water Volume (Lower than 20 cm)

Based on Figure 7, If the Ultrasonic Sensor detects water lower than 20 cm, the filling pump is activated. The filling pump is switched off if the Ultrasonic Sensor detects water already at or higher than 10 cm.

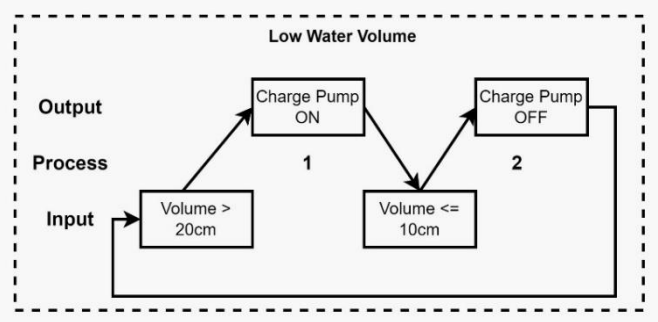

Figure 7. Low water volume

b. High Water Volume (Higher than 10 cm)

Based on Figure 8, If the Ultrasonic Sensor detects higher than 10cm, the drain pump is activated. The drain pump is switched off if the Ultrasonic Sensor detects lower or equal to 10cm.

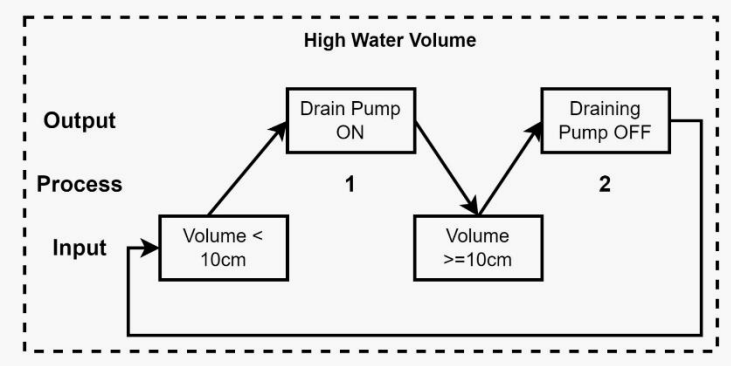

Figure 8. High water volume

Results and Discussions

Results

Table 2. DS18B20 sensor testing results

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Error (Percent)	Monitoring on Smartphone
1	26	25.9	0.387%	Data Displayed
2	26	25.7	1.553%	Data Displayed
3	27	27.0	0.370%	Data Displayed
4	27	27.1	0.370%	Data Displayed
5	27	27.4	0.733%	Data Displayed
6	27	27.4	1.48%	Data Displayed
7	27	27.6	1.449%	Data Displayed
8	27	27.7	1.446%	Data Displayed
9	28	28.1	0.357%	Data Displayed
10	28	28.2	0.355%	Data Displayed
11	28	28.1	0.357%	Data Displayed
12	28	28.3	0.354%	Data Displayed
13	29	29.5	1.695%	Data Displayed
14	29	29.6	1.351%	Data Displayed
15	29	29.4	0.680%	Data Displayed
16	28	28.7	0.69%	Data Displayed
17	28	28.7	0.69%	Data Displayed

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Error (Percent)	Monitoring on Smartphone
18	28	28.6	0.35%	Data Displayed
19	29	29.1	0.34%	Data Displayed
20	29	29.3	0.34%	Data Displayed
21	29	29.2	0.34%	Data Displayed
22	29	29.1	0.34%	Data Displayed
23	29	29.2	0.34%	Data Displayed
24	30	29.9	0.30%	Data Displayed
25	30	29.9	0.30%	Data Displayed
26	30	30.1	0.30%	Data Displayed
27	30	30.2	0.33%	Data Displayed
28	30	30.1	0.30%	Data Displayed
29	30	29.9	0.30%	Data Displayed
30	30	30.1	0.30%	Data Displayed
Average Error			0.3958%	

Table 3. Ultrasonic sensor testing results

Test To	Sensor Ultrasonic (CM)	Ruler Value (CM)	Error (Percent)	Monitoring on Smartphone
1	19	19.2	1.04%	Data Displayed
2	19	19.1	0.526%	Data Displayed
3	23	23.3	1.29%	Data Displayed
4	23	23.2	0.435%	Data Displayed
5	25	25.1	0.396%	Data Displayed
6	25	25.1	0.396%	Data Displayed
7	24.4	24.5	0.408%	Data Displayed
8	24.2	24.4	0.819%	Data Displayed
9	24.0	24.0	0%	Data Displayed
10	23.5	23.5	0%	Data Displayed
11	23.3	23.4	0.429%	Data Displayed
12	22.8	23.0	0.870%	Data Displayed
13	22.6	22.8	0.877%	Data Displayed
14	22.5	22.4	0.446%	Data Displayed
15	22.4	22.3	0.448%	Data Displayed
16	22.4	22.3	0.446%	Data Displayed
17	22.4	22.3	0.446%	Data Displayed
18	22.3	22.2	0.448%	Data Displayed
19	22.3	22.2	0.448%	Data Displayed
20	22.3	22.2	0.448%	Data Displayed
21	22.3	22.2	0.448%	Data Displayed
22	22.6	22.5	0.446%	Data Displayed
23	22.6	22.5	0.446%	Data Displayed
24	22.7	22.7	0%	Data Displayed
25	22.7	22.6	0.446%	Data Displayed
26	23.0	23.1	0.435%	Data Displayed
27	23.0	23.1	0.435%	Data Displayed
28	23.0	23.1	0.435%	Data Displayed
29	23.2	23.2	0%	Data Displayed
30	23.2	23.1	0.435%	Data Displayed
Average Error			0.3683%	

Table 4. Relay testing results

Test To	Control Status				Conditions
	Relay 1 Lights	Relay 2 Peltier	Relay 3 Pump 1	Relay 4 Pump 2	
1	On	On	On	On	On
2	Off	Off	Off	Off	Off
3	On	On	On	On	On
4	Off	Off	Off	Off	Off
5	On	On	On	On	On
6	Off	Off	Off	Off	Off
7	On	On	On	On	On
8	Off	Off	Off	Off	Off
9	On	On	On	On	On
10	Off	Off	Off	Off	Off
11	On	On	On	On	On
12	Off	Off	Off	Off	Off
13	On	On	On	On	On
14	Off	Off	Off	Off	Off
15	On	On	On	On	On
16	Off	Off	Off	Off	Off
17	On	On	On	On	On
18	Off	Off	Off	Off	Off
19	On	On	On	On	On
20	Off	Off	Off	Off	Off
21	On	On	On	On	On
22	Off	Off	Off	Off	Off
23	On	On	On	On	On
24	Off	Off	Off	Off	Off
25	On	On	On	On	On
26	Off	Off	Off	Off	Off
27	On	On	On	On	On
28	Off	Off	Off	Off	Off
29	On	On	On	On	On
30	Off	Off	Off	Off	Off

Table 5. Water temperature testing results of Peltier

Test To	Duration of Ignition	Initial Temperature (Celcius)	Final Temperature (Celcius)
1	1 Minute	30.1	29.9
2	1 Minute 30 Seconds	29.9	29.6
3	4 Minute	29.6	29.1
4	8 Minute	29.1	29.0
5	8 Minute 44 Seconds	29.0	28.9
6	1 Minute	32.2	31.9
7	3 Minutes 20 Seconds	31.9	31.5
8	5 Minute	31.6	31.4
9	7 Minute	31.4	31.2
10	10 Minute	31.2	30.9
11	1 Minute	30	29.8
12	2 Minute 30 Seconds	29.9	29.5
13	5 Minute	29.6	29.0
14	9 Minute	29.1	28.9

Test To	Duration of Ignition	Initial Temperature (Celcius)	Final Temperature (Celcius)
15	10 Minute 30 Seconds	29.0	28.8

Table 6. Water temperature testing results of lamp

Test To	Duration of Ignition	Initial Temperature (Celcius)	Final Temperature (Celcius)
1	10 Minute	28.0	28.3
2	10 Minute	29.2	29.4
3	10 Minute	30.4	30.5
4	10 Minute	27.1	27.2
5	10 Minute	27.2	27.4
6	10 Minute	27.2	29.4
7	10 Minute	25.6	25.7
8	10 Minute	32.1	32.2
9	10 Minute	25.1	25.2
10	10 Minute	25.2	25.3
11	10 Minute	25.4	25.6
12	10 Minute	27.1	27.1
13	10 Minute	28.2	28.3
14	10 Minute	28.3	28.4
15	10 Minute	28.4	28.5

Table 7. Overall test results of the monitoring system

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Sensor Ultrasonic (CM)	Ruler Value (CM)	Monitoring on LCD	Monitoring on Smartphone
1	29	29.5	15.6	15.5	Data appears	Data appears
2	29	29.3	16.2	16.1	Data appears	Data appears
3	28	29.0	16.1	16.0	Data appears	Data appears
4	28	28.7	15.9	16.0	Data appears	Data appears
5	28	28.4	16.0	15.9	Data appears	Data appears
6	26	26.2	19.2	19.3	Data appears	Data appears
7	26	26.1	19.3	19.3	Data appears	Data appears
8	26	26.0	19.7	19.9	Data appears	Data appears
9	26	26.3	20.1	20.2	Data appears	Data appears
10	25	25.1	20.1	20.2	Data appears	Data appears
11	25	25.1	20.4	20.4	Data appears	Data appears
12	27	27.0	20.5	20.6	Data appears	Data appears
13	27	27.2	21.0	21.2	Data appears	Data appears
14	30	30.3	21.1	21.2	Data appears	Data appears
15	30	30.2	21.7	21.9	Data appears	Data appears
16	30	30.2	21.0	21.2	Data appears	Data appears
17	30	30.1	21.0	21.2	Data appears	Data appears
18	29	29.3	21.7	21.9	Data appears	Data appears
19	29	29.2	21.7	21.9	Data appears	Data appears
20	29	29.3	21.7	21.9	Data appears	Data appears
21	29	29.2	20.5	20.6	Data appears	Data appears
22	29	29.2	20.5	20.6	Data appears	Data appears
23	28	28.0	20.5	20.7	Data appears	Data appears
24	28	28.1	20.5	20.6	Data appears	Data appears

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Sensor Ultrasonic (CM)	Ruler Value (CM)	Monitoring on LCD	Monitoring on Smartphone
25	28	28.0	20.5	20.5	Data appears	Data appears
26	28	28.1	20.5	20.6	Data appears	Data appears
27	28	28.0	19.7	19.8	Data appears	Data appears
28	28	28.2	19.7	19.7	Data appears	Data appears
29	29	29.2	19.7	19.7	Data appears	Data appears
30	29	29.2	19.7	19.7	Data appears	Data appears

Table 8. Overall testing results of the manual control system

Test To	Control Status				Control Condition via Push Button	Control Conditions via Android App
	Relay 1 Lamp	Relay 2 Peltier	Relay 3 Pump 1	Relay 4 Pump 2		
1	On	On	On	On	On	On
2	Off	Off	Off	Off	Off	Off
3	On	On	On	On	On	On
4	Off	Off	Off	Off	Off	Off
5	On	On	On	On	On	On
6	Off	Off	Off	Off	Off	Off
7	On	On	On	On	On	On
8	Off	Off	Off	Off	Off	Off
9	On	On	On	On	On	On
10	Off	Off	Off	Off	Off	Off
11	On	On	On	On	On	On
12	Off	Off	Off	Off	Off	Off
13	On	On	On	On	On	On
14	Off	Off	Off	Off	Off	Off
15	On	On	On	On	On	On
16	Off	Off	Off	Off	Off	Off
17	On	On	On	On	On	On
18	Off	Off	Off	Off	Off	Off
19	On	On	On	On	On	On
20	Off	Off	Off	Off	Off	Off
21	On	On	On	On	On	On
22	Off	Off	Off	Off	Off	Off
23	On	On	On	On	On	On
24	Off	Off	Off	Off	Off	Off
25	On	On	On	On	On	On
26	Off	Off	Off	Off	Off	Off
27	On	On	On	On	On	On
28	Off	Off	Off	Off	Off	Off
29	On	On	On	On	On	On
30	Off	Off	Off	Off	Off	Off

Table 9. Overall testing results of the automatic control system

Test To	Temperature Control			Volume Control		Conditions
	High Temperature	Ideal Temperature	Low Temperature	Low Volume	High Volume	
1	31.4°C	27.0°C	24.1°C	25 cm	9 cm	Retrieved

Test To	Temperature Control			Volume Control		Conditions
	High Temperature	Ideal Temperature	Low Temperature	Low Volume	High Volume	
2	32.1°C	27.2°C	24.5°C	28 cm	7 cm	Retrieved
3	35.7°C	29.7°C	23.8°C	30 cm	5 cm	Retrieved
4	34.0°C	30.2°C	23.7°C	29 cm	6 cm	Retrieved
5	36.4°C	28.9°C	23.9°C	24 cm	7 cm	Retrieved
6	31.5°C	25.5°C	24.5°C	21.5 cm	9.5 cm	Retrieved
7	30.8°C	26.8°C	23.8°C	22.8 cm	8.2 cm	Retrieved
8	32.2°C	27.2°C	22.7°C	23.2 cm	6.8 cm	Retrieved
9	30.5°C	28.1°C	24.2°C	25.1 cm	9.7 cm	Retrieved
10	31.7°C	25.9°C	23.1°C	20.7 cm	7.6 cm	Retrieved
11	33.0°C	26.4°C	22.9°C	26.4 cm	5.3 cm	Retrieved
12	30.3°C	29.0°C	24.0°C	24.8 cm	8.9 cm	Retrieved
13	32.8°C	27.8°C	23.5°C	22.3 cm	6.4 cm	Retrieved
14	31.2°C	25.7°C	22.4°C	21.9 cm	9.2 cm	Retrieved
15	30.9°C	28.5°C	24.3°C	23.7 cm	7.9 cm	Retrieved
16	32.5°C	26.2°C	23.7°C	27.0 cm	5.8 cm	Retrieved
17	31.1°C	29.5°C	22.8°C	25.6 cm	8.5 cm	Retrieved
18	33.5°C	25.3°C	24.1°C	20.5 cm	6.1 cm	Retrieved
19	30.6°C	27.0°C	23.2°C	26.1 cm	9.4 cm	Retrieved
20	32.1°C	28.7°C	22.5°C	24.3 cm	7.1 cm	Retrieved
21	31.4°C	25.8°C	24.4°C	22.9 cm	5.6 cm	Retrieved
22	33.2°C	29.2°C	23.9°C	28.2 cm	8.7 cm	Retrieved
23	30.2°C	26.9°C	22.2°C	29.7 cm	6.9 cm	Retrieved
24	32.7°C	27.5°C	24.7°C	27.5 cm	9.1 cm	Retrieved
25	31.9°C	28.3°C	23.3°C	21.2 cm	7.4 cm	Retrieved
26	33.8°C	25.2°C	22.6°C	28.9 cm	5.9 cm	Retrieved
27	30.4°C	26.7°C	24.6°C	25.3 cm	8.3 cm	Retrieved
28	31.6°C	29.7°C	23.6°C	29.1 cm	6.6 cm	Retrieved
29	33.1°C	27.3°C	22.3°C	23.5 cm	9.8 cm	Retrieved
30	30.1°C	25.6°C	24.9°C	20.3 cm	7.3 cm	Retrieved

Discussions

Table 2 records the experimental results using the DS18B20 sensor. After 30 tests, the DS18B20 sensor showed an average error of 0.3958% when compared to a digital thermometer, indicating a high level of accuracy. This minor discrepancy could be attributed to factors such as calibration differences, sensor precision, or environmental conditions during testing. Despite this small error, the sensor's performance is deemed highly reliable for practical use in monitoring fish farming environments, where precise temperature control is crucial for maintaining optimal conditions.

Table 3 records the experimental results using the Ultrasonic sensor. After 30 tests, the test results show that there is an average error of 0.3683%. This means, that in each measurement, the average difference between the value measured by the Ultrasonic sensor and the value of the Ruler is about 0.3683%. The test results fall into the Very Good category.

Table 4 includes the experimental results of the Relay. The test results show that the success obtained from the Relay test is 100%. This means that the Relay can work properly.

Table 5 includes the experimental results of the water temperature released by the peltier. The test results show that the success obtained from testing the water temperature of the peltier is 100%, which means that the peltier can reduce the water temperature properly.

Table 6 includes the experimental results of the water temperature released by the lamp. The test results show that the success obtained from testing the water temperature of the lamp is 100%, which means that the lamp can increase the water temperature properly.

Table 7 includes the experimental results of the entire monitoring system. The test results show that the success obtained from the test is 100%. Table 8 includes the experimental results

of the entire manual control system. The test results show that the success obtained from the test is 100%. Table 9 includes the experimental results of the entire automatic control system. The test results show that the success obtained from the test is 100%.

Prototype and Android App Documentation

Figure 9a. Prototype

Figure 9b. Android App

Figure 9a displays the prototype consists of a 50-liter bucket equipped with an ESP32 microcontroller, an HCSR04 ultrasonic sensor, a DS18B20 temperature sensor, and a 16x2 I2C LCD. The bucket lid can be opened halfway for easy access. A push-on button is located on the side of the bucket. The entire system is housed in a project box attached to the bucket.

Figure 9b illustrates the android application interface includes several screens: the first page, which is the main screen to access the login and sign-up menus; the login menu, which allows users to log in with their email and password; the sign-up menu, where users can create a new account by filling in their email and password; the main menu, which provides access to various features, including monitoring and control options; the monitoring menu, which displays real-time data from the sensors, including water temperature and water level distance; and the controlling menu, which contains controls for the system, allowing users to manage and adjust the fish farming environment.

Conclusion

Based on a thorough evaluation and testing along with data comparisons, several conclusions were drawn that need to be considered: (1) The DS18B20 temperature sensor is not capable of reading data to decimal values with an average error rate of 0.3958%, for the Ultrasonic sensor it has an average error rate of 0.3683%. The temperature and ultrasonic sensors can measure the temperature and volume of water and transmit the data in real time to the IoT platform. (2) Based on literature study and practical experience, the optimal temperature range for catfish farming in Budikdamber is found to range from 25 Celsius to 30.1 Celsius. (3) The automatic control of this system can ensure that the water temperature remains within the desired range. Peltier, lamp, filling pump, and draining pump are integrated to achieve this goal. (4) The Android App testing of the device achieved 100% accuracy, indicating that the device can be effectively monitored and controlled remotely through the Android App.

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Laravel framework and native PHP: Comparison in the creation of rest API

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Abstract: As technology evolves, the need for data communication grows. One technology facilitating this communication between applications and databases is the REST API, widely used by companies to provide access to their data and services. REST APIs can be developed using PHP, known as PHP Native. However, PHP Native faces performance issues and a monotonous, repetitive code structure, making maintenance and scalability challenging. Consequently, developers have created PHP frameworks like Laravel. This research compares the Laravel framework with PHP Native in REST API development, evaluating aspects such as processing speed, code efficiency, URL routing structure, and architectural models. The analysis reveals four key points: REST API processing speed, code efficiency, URL routing structure, and project architectural models. In terms of processing speed, PHP Native is slightly superior to Laravel, with speeds of 18.3 ms compared to 344.52 ms, due to additional processes in Laravel like routes, controllers, and models. For code efficiency, Laravel excels due to its ORM feature, unlike PHP Native, which requires manual SQL query writing. In URL routing, Laravel is superior with a structured routing feature, whereas PHP Native requires process file inclusion in route calls. Lastly, Laravel's architectural model, which implements MVC, is superior to PHP Native, which lacks a standardized architectural model, leading developers to create their own.

Keywords: Code Efficiency, Laravel Framework, MVC Architecture, PHP Native, Rest API

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Introduction

As technology develops, the need for data communication is also necessary. The REST API is one technology that allows data to be shared between databases and apps. Resources and activities that can be performed on them make up a REST API. A web browser or client-side JavaScript code running in a web browser can be used to call the REST API's operations [1]. REST APIs are also used by many companies to allow others to access their data and services [2]. In creating a REST API, you can use the PHP programming language or it can be called PHP Native. PHP Native is a programming language or instructions that are created without the intervention of other developers in the process. However, native PHP has performance problems so it is necessary to create a better and faster REST API [3], then the code structure is still monotonous and repetitive which makes application maintenance and scalability sometimes difficult due to the unorganized structure [4], because of this some developers have started developing PHP frameworks called frameworks. An integrated collection of software elements, including objects, classes, and components, that work together to create a reusable architecture for a group of connected apps is called a framework. More specifically, frameworks improve program extensibility, flexibility, and portability by separating software application-dependent components from software application- and platform-independent parts [5].

Currently, there are many PHP programming language frameworks available, such as CodeIgniter Yii and Laravel. PHP is a programming language based on open source that is free to download. Until now, the latest version of PHP available is version 7.0.8, which can be down-

loaded from the official PHP website [6]. The majority of modern web servers have a PHP processor, and most operating systems offer a standalone interpreter [7]. Many web programmers such as HTML/CSS choose PHP as the programming language used [8].

The research uses the Laravel framework for analysis. Laravel serves as a PHP-based web platform for developing high-end web applications with meaningful and elegant syntax. Laravel was created by Taylor Otwell in July 2011 and published more than five years after Codeigniter. It includes a robust toolset and an application architecture. It also discusses numerous aspects of technologies including the ASP.NET, CodeIgniter, Ruby on Rails, and several others [9]. The Laravel framework is an open-source software with a copyright and is distributed with licensing terms designed to ensure the source code will always be available [10]. Using Laravel can create information systems more quickly, besides that, the features in Laravel can be easy to use [11].

As previously explained regarding the advantages and disadvantages of each PHP programming language, both the Laravel framework and PHP Native, the research carried out compared the Laravel framework with native PHP. This research aims to test the two PHP programming languages to obtain the advantages and disadvantages of each in REST API development such as REST API processing speed, program code efficiency, URL structure, and project architectural model used in the project.

Methodology

This research methodology explains the flow of comparative analysis stages of the Laravel framework with native PHP in creating a REST API. The research method is shown in Figure 1.

Figure 1. Research Methodology

Stage 1: Develop REST API
During this stage, the REST API is built with the Laravel framework and native PHP. The built REST API includes creating, reading, updating, and deleting operations on employee data. The detailed processes are as follows:
Create: Develop the process to add data to the database.
Read: Develop the process to retrieve data from the database.
Update: The process of updating data in the database is being developed.
Delete: Develop the process to delete data from the database.

Stage 2: Testing
In this stage, testing is performed on the previously developed REST API to ensure there are no bugs or errors in any of the processes. Testing is the procedure of confirming and validating that a software or app program complies with the business and technical requirements that guide its design and development, functions as expected, and identifies critical errors or deficiencies in the application that must be corrected based on severity.

Stage 3: Analysis Testing
In this stage, an analysis is conducted on the REST API created using both the Laravel framework and native PHP. The analysis includes:
Processing Speed of the REST API: Comparing the speed at which each platform executes API requests.
Code Efficiency: Evaluating the efficiency and cleanliness of the code written on each platform.
URL Routing Structure: Comparing the URL routing structures used by Laravel and native PHP.
Project Architectural Model: Assessing the architectural models used on both platforms' projects.

Results and Discussions

Results

The results obtained from several stages of the research method, namely developing REST API, testing, and analysis are comparisons of the Laravel and native PHP frameworks such as REST API processing speed, program code efficiency, URL routing structure, and project architectural model used in the project.

Develop REST API

In developing the REST API, the REST API allows you to create, read, update, and delete processes on employee data. For development using the Laravel framework and native PHP, see Figure 2 and Figure 3.

Figure 2. Creating a REST API using PHP Native

Figure 2 shows the steps involved in using PHP Native to create a REST API. This method uses creating, reading, updating, and deleting actions for employee data manually by developing PHP scripts. Setting up a database connection, creating queries, and processing query results are just a few of the manual SQL code authoring chores involved in these CRUD procedures. A slower development process and a higher chance of errors can result from the repeated code structure and the requirement for manual handling at every stage.

Figure 3. Creating an API that uses REST with the Laravel development platform

Figure 3 shows how to develop a REST API using the framework built on Laravel. This method implements CRUD for employee data through Laravel's built-in features that support REST API operations well. Laravel uses the Eloquent ORM to manage interactions with the database, and manual writing of SQL code is reduced. REST API development becomes more modular, maintainable, and scalable thanks to Laravel's features, such as organized routing, middleware, and MVC (Model View Controller).

Testing

At this stage, testing is carried out on the REST API which has been developed previously, there are no bugs or errors in each process. Testing was carried out with Postman software, which is software described on their website as an API platform that can be used to build APIs and can be used for testing [13]. For REST API testing, refer to Figure 4 and Figure 5.

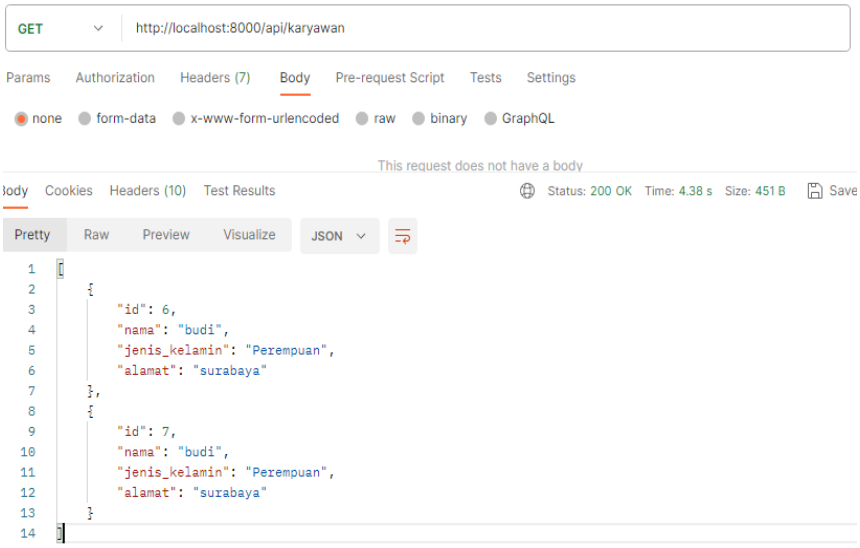

Figure 4. Testing the REST API in the Laravel framework using postman

Figure 4 shows the process of testing a REST API created with the Laravel framework and Postman software. Postman sends an HTTP request to a created REST API endpoint and verifies that the request was answered correctly. Testing is performed on all CRUD (create, read, modify, and delete) operations on employee data to ensure that each API function functions correctly and that there are no bugs or errors. With Laravel, REST API testing becomes easier because features such as routing and controllers are well organized.

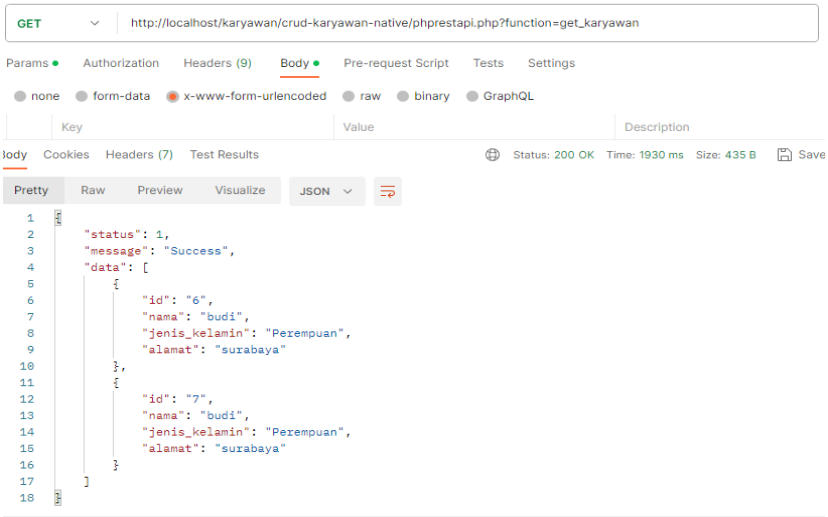

Figure 5. Testing REST API on PHP Native using postman

Figure 5 shows the REST API testing process developed using PHP Native using Postman software. As in testing with Laravel, Postman sends HTTP requests to the REST API endpoint and verifies the response. Testing includes all CRUD operations on employee data to ensure that the API functions work correctly and that there are no bugs or errors. In the Native PHP approach, every request and response is handled by a manually written PHP script, so testing helps ensure that the manual implementation works as expected without errors.

Analysis Testing

At this stage, an analysis of the REST API which has been created using the Laravel framework and native PHP is carried out, shown in Table 1.

Table 1. Analysis REST API

No	Analysis	PHP Native	Laravel Framework
1	Rest API Speed	18.3 ms	344.52 ms
2	Code efficiency in creating REST APIs	7 processes	1 process
3	URL structure in REST API	3 paths	2 paths

Discussions

Process Speed Analysis Results for REST API

The study was carried out on the rapidity of the REST API activity, totaling five endpoints for each technology used, namely using the Laravel framework and native PHP, which were produced in Table 2 and Table 3.

Table 2. REST API processing speed using the Laravel framework

Endpoint API	Speed
/api/karyawan (GET)	312 ms
/api/karyawan/create (POST)	499 ms
/api/karyawan/update/{id} (POST)	403 ms
/api/karyawan /{id} (GET)	324 ms
/api/karyawan/delete/{id} (DELETE)	546 ms

Table 3. REST API processing speed using PHP Native

Endpoint API	Speed
/karyawan/crud-karyawan-native/phprestapi.php?function=get_karyawan (GET)	680 ms
/karyawan/crud-karyawan-native/phprestapi.php?function=insert_karyawan (POST)	143 ms
/karyawan/crud-karyawan-native/phprestapi.php?function=update_karyawan&id={id} (POST)	126 ms
/karyawan/crud-karyawan-native/phprestapi.php?function=get_karyawan_id&id={id} (GET)	12 ms
/karyawan/crud-karyawan-native/phprestapi.php?function=delete_karyawan&id={id} (DELETE)	66 ms

Based on the analysis carried out from Table 2 and Table 3, the results obtained are that Native PHP is superior in speed of processing the REST API than the Laravel framework because the files for processing the REST API required in native PHP are much faster than the Laravel

framework. After all, the Laravel framework has several processes that must be passed, such as routes, controllers and models.

Results of Program Code Efficiency Analysis

The analysis carried out regarding the efficiency of the program code in communicating data with the database using the REST API is shown in Figure 6 and Figure 7.

```
public function get($id)
{
    return Karyawan::find($id);
}
```

Figure 6. Code for developing a REST API with the Laravel framework

```
function get_karyawan_id()
{
   global $connect;
   if (!empty($_GET["id"])) {
      $id = $_GET["id"];
   }
   $query ="SELECT * FROM karyawan WHERE id= $id";
   $result = $connect->query($query);
   while($row = mysqli_fetch_object($result))
   {
      $data[] = $row;
   }
   if($data)
   {
   $response = array(
                  'status' => 1,
                  'message' =>'Success',
                  'data' => $data
               );
   }else {
      $response=array(
                  'status' => 0,
                  'message' =>'No Data Found'
               );
   }
```

Figure 7. Software code for developing a REST API with PHP Native

Based on the analysis carried out in Figure 6 and Figure 7, it was found that the Laravel framework in writing program code is more efficient, or called clean code compared to native PHP. Clean code is code that is readable so that other people can understand the code directly [14]. Simple to follow code makes other software developers know it better, which leads to improved code maintainability [15]. Furthermore, clean code includes set guidelines and procedures that will help programmers in writing program code, such as utilizing meaningful names, indenting, minimizing replication, and a lot more [16]. Eloquent ORM is a Laravel component that maps an object-oriented core model to a database that is relational [17] compared to native PHP which is required to write SQL query syntax first when you want to create a data communication process with the database.

REST API Process Speed Analysis Results

The analysis carried out regarding the URL structure is the global address of documents on the World Wide Web, and it serves as the main means of finding documents on the Internet [18]. URLs in routing commonly called endpoints are resources used to build REST APIs and communicate data between client-server [19], the endpoint structure of the Laravel framework and native PHP is shown in Table 4.

Table 4. REST API URL Structure

Laravel	http://localhost:8000/api/karyawan
PHP Native	http://localhost/karyawan/crud-karyawan-native/phprestapi.php?function=get_karyawan

Based on the analysis carried out in Table 4, it was found that the Laravel framework's endpoint URL structure was superior to the endpoint URL structure of native PHP. The Laravel framework has a routing feature that can manage API endpoints in a structured manner, whereas in native PHP the route call must be included with the process file.

Project Architectural Model Analysis Results

The analysis carried out regarding the project architectural model in the Laravel framework and native PHP is shown in Figure 8 and Figure 9.

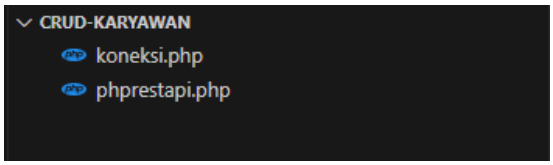

Figure 8. Project architecture model in PHP Native

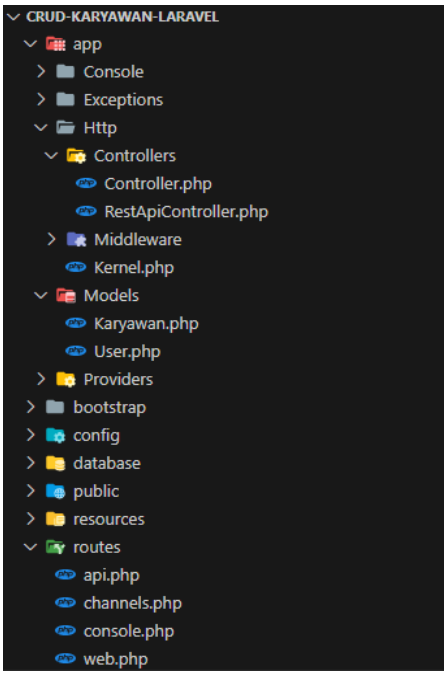

Figure 9. Project architectural model in the Laravel framework

Based on the analysis carried out in Figure 8 and Figure 9, it was found that the Laravel framework in the project architecture model was superior to native PHP. Because the Laravel framework implements a mode architecture, namely MVC (Model View Controller). MVC is a design pattern used to develop web applications, as it helps developers to have a clear understanding of all the modules. The MVC architecture separates the model, view, and controller layers [20]. Meanwhile, native PHP does not apply an architectural model and developers create their own architectural models.

Conclusion

Based on the results of the analysis carried out, this research compares the Laravel framework with PHP Native in the development of REST APIs, focusing on processing speed, code efficiency, URL routing structure, and architectural models. The study identifies four key findings. Firstly, PHP Native demonstrates superior processing speed with an average of 18.3 ms compared to Laravel's 344.52 ms. This advantage is due to the additional processes in Laravel, such as routes, controllers, and models. Secondly, in terms of code efficiency, Laravel excels because of its Object Relational Mapping (ORM) feature, which simplifies database interactions, whereas PHP Native requires manual SQL query writing, leading to a more repetitive and monotonous code structure. Thirdly, Laravel outperforms PHP Native in URL routing structure due to its robust routing features

that allow for more organized and intuitive API endpoints. In contrast, PHP Native necessitates including process files in route calls, making the structure less manageable. Lastly, Laravel's adherence to the MVC architectural model provides a clear separation of concerns, enhancing code organization and maintainability. PHP Native, lacking a standardized architectural model, often leads developers to create their own, which can vary in quality. Thus, while PHP Native is faster, Laravel offers superior code efficiency, URL routing, and architectural structure, making it a more robust choice for REST API development.

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Analysis and visualization of digital advertising data using EDA on payment point online bank applications

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Abstract: This research explores the effectiveness of digital advertising within Payment Point Online Bank (PPOB) applications using Exploratory Data Analysis (EDA) and data visualization techniques. With the rapid growth of internet users and online transactions in Indonesia, businesses face challenges in optimizing digital marketing strategies. By analyzing data from various digital ad campaigns, the study develops a comprehensive advertising dashboard to enhance decision-making and report generation. Key metrics such as cost, impressions, clicks, app installs, registrations, and purchases are examined to assess campaign performance. The dataset comprises advertising data, which includes campaign data (Region, Network, Device) and demographic data (Age and Gender) stored in spreadsheets. The total campaign dataset contains 20,151 rows, while the demographic dataset comprises 125 rows, collected from March to May 2023. Findings indicate that the majority of users (90%) access the application through mobile phones, while 10% utilize tablets. Regarding cost-effectiveness, the UAC_AppInstall campaign demonstrates the lowest Cost per App Install (CPI) at 3141 Rupiah, while the UAC_AppRegistration campaign has the most efficient Cost per Registration (CPR) at 8892 Rupiah and the UAC_AppRetention campaign boasts the most efficient Cost per Purchase (CPP) at 235 Rupiah. Moreover, regional analysis shows that areas like West Java, Jakarta, East Java, and Central Java have the highest acquisition rates, while the eastern regions of Indonesia face challenges due to lower internet accessibility and digital literacy. The study provides valuable insights for marketing teams to optimize their strategies, enhance targeting approaches, and improve the overall effectiveness of digital advertising campaigns.

Keywords: Data Analysis, Data Visualization, Digital Marketing Campaigns, Exploratory Data Analysis, PPOB Application

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Introduction

In the digital age, companies rely heavily on digital advertising for effective marketing. Indonesia's internet user count hit 210 million in 2022 [1], sparking a surge in online shopping interest [2]. Businesses are in a race to harness digital platforms for broader reach and impactful campaigns, fostering real-time connections between sellers and buyers [3]. Payment Point Online Bank (PPOB) stands out as a tech-driven solution for various financial transactions [4]. Initially user-friendly, PPOB has grown crucial due to swift tech advancements. PPOB operates entirely online, ensuring instant updates and transactions [4]. Global competition is fierce, prompting companies to run digital marketing campaigns. While Google Ads and Facebook Ads are common choices, the escalating competition drives up digital advertising costs. Hence, strategic budgeting is essential to avoid overspending without returns. To gauge platform effectiveness, analyzing digital ad campaigns through data visualization is key. This provides insights into the impact of marketing efforts.

Although the company has engaged in digital advertising campaigns, it still faces challenges in optimizing its marketing strategy. Issues include high customer acquisition costs, difficulty understanding customer behavior, identifying the right target market, and measuring the effectiveness of digital advertising campaigns. Problems also arise when the company's marketing department seeks performance reports on digital advertising; they struggle with interpreting data

due to the absence of a dashboard, hindering decision-making. An effective method to communicate detailed data in an easily understandable manner is through the use of data visualization. Therefore, analyzing and visualizing data become crucial steps for the company to maximize the performance of digital advertising campaigns and address these challenges effectively.

The research aims to create a comprehensive advertising data dashboard for streamlined report generation and faster decision-making. It also aims to gain a better understanding of customer behavior and evaluate the performance and impact of digital advertising campaigns by using data visualization and Exploratory Data Analysis (EDA) techniques.

Digital advertising encompasses marketing activities involving the sales, promotion, advertising, and pricing of products or services via online media [5]. Digital advertising plays a crucial role in modern marketing strategies [6], involving the non-personal presentation and promotion of ideas, goods, or services by specific sponsors in exchange for payment. Research indicates that digital advertising directly impacts sales. Research indicates that digital advertising directly impacts sales [7]. It has become a crucial part of marketing campaigns because of its wide reach and high effectiveness. Digital advertising is regarded as an effective and efficient strategy for promoting products because of its wide reach, flexible timing and location, and various marketing methods available. In contrast to traditional or conventional marketing limited by time, location, and user reach, digital marketing offers distinct advantages [8].

The bidding process in digital advertising platforms involves advertisers participating in auctions, and submitting bids for ad placement based on factors like relevance, ad quality, and bid value [9]. Different strategies can be employed in this process, such as CPC Bidding (Cost Per Click), CPM Bidding (Cost Per Mile), CPA Bidding (Cost Per Acquisition), and ROAS Bidding (Return On Ad Spend). These various bidding strategies cater to different advertising goals and objectives within the digital landscape [10].

Methodology

Data visualization is a method that uses computers to transform symbols into geometric shapes, enabling researchers to visualize computational simulations and enrich the process of scientific discovery, thus fostering a deeper and unforeseen understanding [11]. Data visualization is crucial in data analysis as it helps users depict patterns, trends, and relationships within the data. It serves various purposes, such as identifying market trends, forecasting future expenditures, and understanding customer behavior. Additionally, data visualization aids in communicating information in a more easily understandable way for everyone. The data visualization process comprises seven stages [12] acquiring, parsing, filtering, mining, representing, refining, and interacting.

Building upon the foundation of effective data visualization, Exploratory Data Analysis (EDA) stands out as a crucial process in the field of data analysis. EDA is a methodical approach to comprehending data and extracting valuable insights [13]. It encompasses the utilization of diverse data visualization techniques and statistical methods to guide users through the exploration of data, revealing intricate relationships between variables. Techniques such as histograms, scatter plots, box plots, and correlation matrices play a vital role in this exploration [13]. This process is instrumental in conducting initial investigations on data, unveiling patterns, identifying anomalies, testing hypotheses, and examining assumptions. Through the application of summary statistics and graphical representations, EDA aids users in discerning data distributions, spotting outliers, discovering missing values, and evaluating relationships between variables [14].

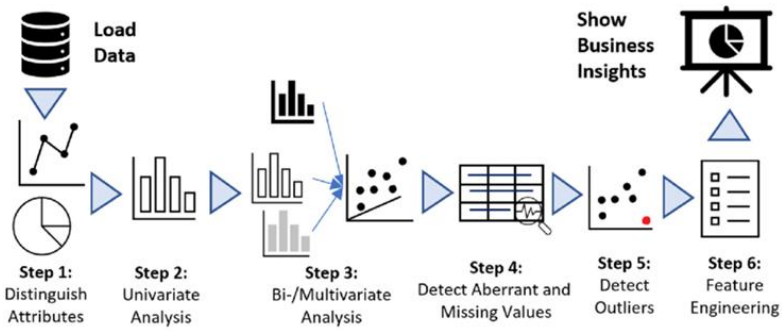


Figure 1. Exploratory Data Analysis Steps

Results and Discussions

In this study, the researcher conducted direct observations on the digital advertising campaign data of the PPOB application. The collected report data contains key objects necessary for data processing in this research, such as Channel, Network, Region, Gender, Age group, Cost, Impression, Clicks, AppInstall, Register, and Purchase. The collected data in the form of a dataset will undergo preprocessing using the Python programming language. This process involves managing/changing the data to clean missing values, remove noise, and ensure consistency. The total dataset for the campaign comprises 20,151 rows, with demographic data amounting to 125 rows collected within the timeframe from March to May 2023.

In this stage, Exploratory Data Analysis (EDA) is conducted, which is a process or activity to analyze patterns and trends in data that has undergone preprocessing in the previous stages. During this process, problem identification and the formulation of intriguing hypotheses are carried out through univariate and bivariate analyses, as well as the exploration of correlations among data points such as costs, registrations, sales, and others. The objective of this process is to provide deeper insights into the data, offering valuable information to management and relevant users based on the provided data and information.

1. What device categories do customers use the most?

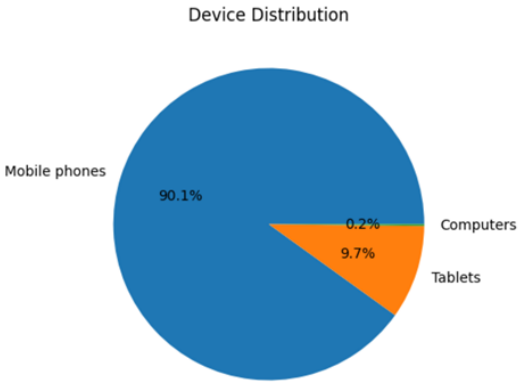


Figure 2. Device Distribution

Figure 2 shows the proportion of users on each device revealing that the majority, accounting for 90%, access the application through mobile phones, while 9.7% utilize tablets. This aligns seamlessly with the marketing target, where customers are predominantly application users.

2. Which campaigns cost the most money?

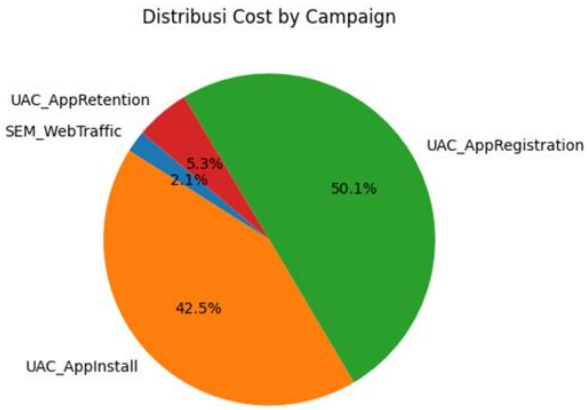


Figure 3. Cost Distribution by Campaign

Figure 3, In terms of advertising cost the UAC_AppRegistration campaign incurs the highest expense, amounting to 50.1%, followed by the UAC_AppInstall Volume campaign with a cost proportion of 42.5%. The reasons behind the significant cost proportions in these two campaigns are not yet apparent at this stage.

3. Which campaign was most effective in generating conversions in terms of App Install, Registration, and Purchase?

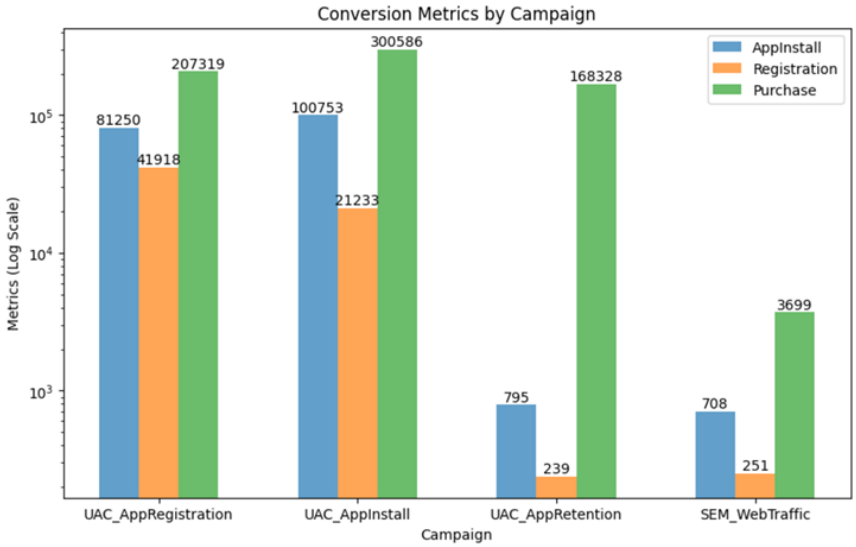


Figure 4. Conversion Metrics by Campaign

Figure 4, it is known that the reason why more costs are incurred in both UAC_AppRegistration & UAC_AppInstall campaigns is because they generate the most App Installs, Registrations, and purchases. Another interesting finding is that the UAC_AppRetention campaign generates a lot of Purchases even though in terms of cost it is very small when compared to the other 2 campaigns.

4. Which campaign is the best in terms of cost-effectiveness?

Cost-effectiveness is measured to find out whether the campaign is good and healthy from the company's financial point of view. Then each campaign needs to be measured for effectiveness by calculating the costs incurred for each 1 conversion metric, For example: Cost / AppInstall = Cost incurred to get 1 App Install. Cost / Register = Cost incurred to get 1 Registration. Cost / Purchase = Cost incurred to get 1 Purchase.

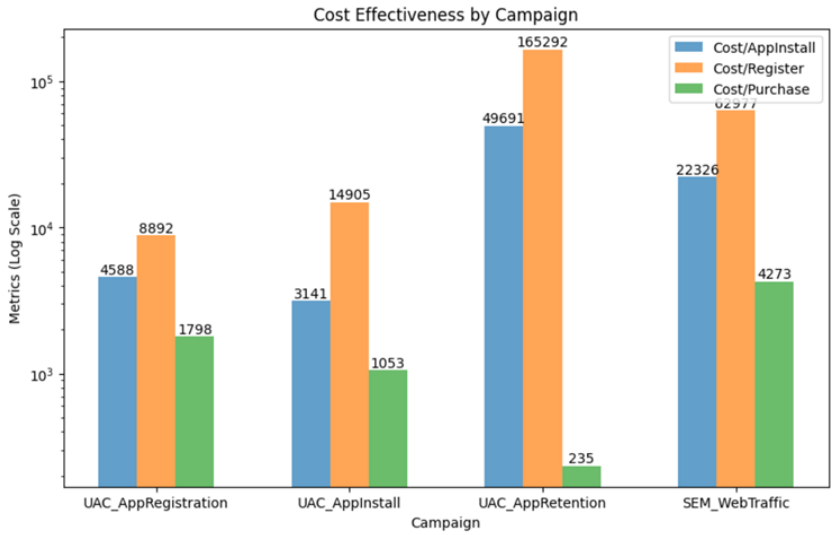


Figure 5. Cost Effectiveness per Campaign

Figure 5 provides insights from the cost-effectiveness analysis. The UAC_AppInstall campaign demonstrates the most efficient Cost per App Install (CPI) with a value of 3141 Rupiah, indicating that the cost incurred for one application installation is Rp 3141. The UAC_AppRegistration campaign exhibits the most efficient Cost per Registration (CPR), with the cost incurred for one registration being Rp 8892. For Cost per Purchase (CPP), the UAC_AppRetention campaign is the most efficient at Rp 235. However, it is crucial to note that in terms of CPI and CPR, this campaign is relatively expensive. Contrarily, the SEM_WebTraffic Campaign proves to be less effective and less efficient, as its CPI, CPR, and CPP are considered relatively expensive.

5. From which Network do users see ads, do App Install, Registration, and Purchase?

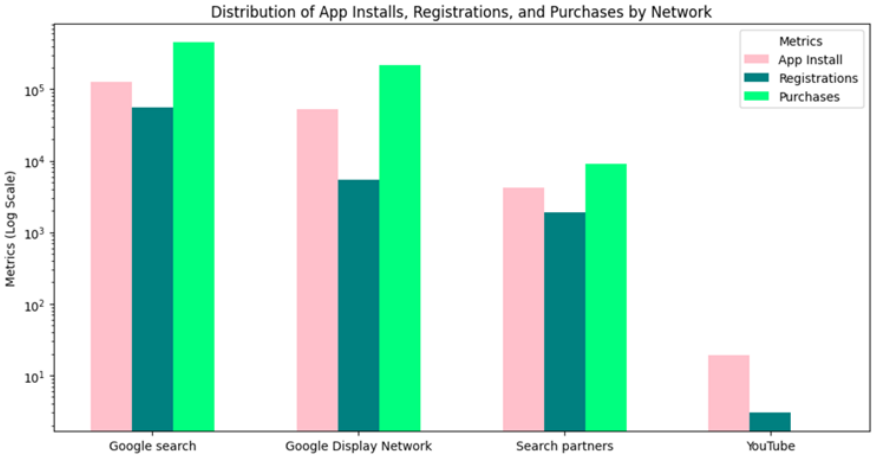
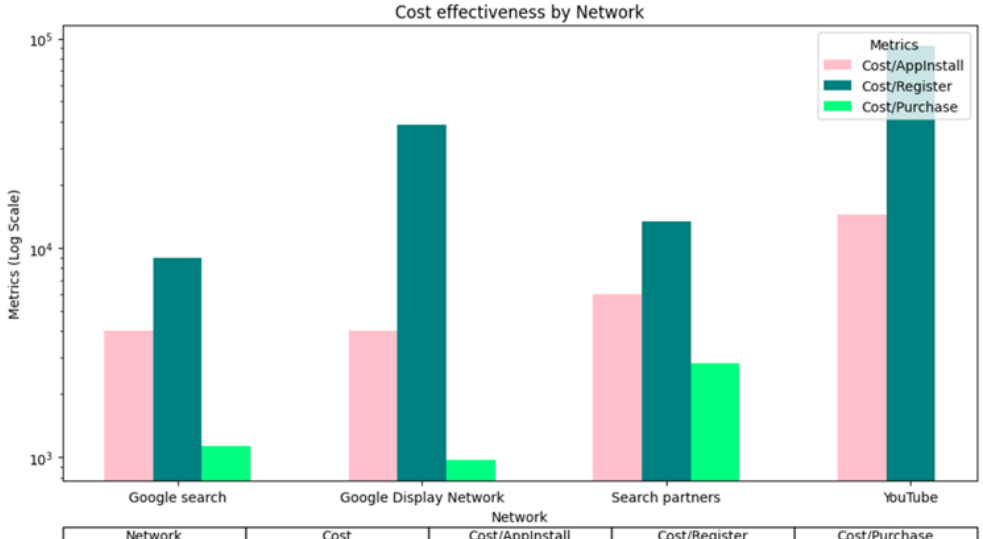


Figure 6. Conversion per Network

Figure 6, From the Network distribution analysis it is known that Google Search generates the most Installs, registrations & Purchases. This shows that many customers come by searching on search engines.

6. What is the cost-effectiveness of each Network?



Network	Cost	Cost/AppInstall	Cost/Register	Cost/Purchase
Google search	505993395.82	4010.57	8995.76	1123.71
Google Display Network	212775579.92	4008.73	38813.5	964.79
Search partners	25484180.0	6004.75	13356.49	2798.92
YouTube	275671.54	14509.03	91890.51	inf

Figure 7. Cost-effectiveness per Network

In Figure 7, the cost-effectiveness analysis reveals valuable insights, Google search emerges as the most efficient overall performer among various networks. The Google Display Network proves to be relatively expensive in acquiring registrations but highly efficient in generating purchases, indicating its effectiveness in driving purchase outcomes. In contrast, YouTube stands out as the most inefficient or costly network, attributed to its high price per Install and registration. Additionally, it has not yet generated any purchases, making the cost per purchase incalculable.

7. Region Analysis: Which region generates the most registrations and purchases?

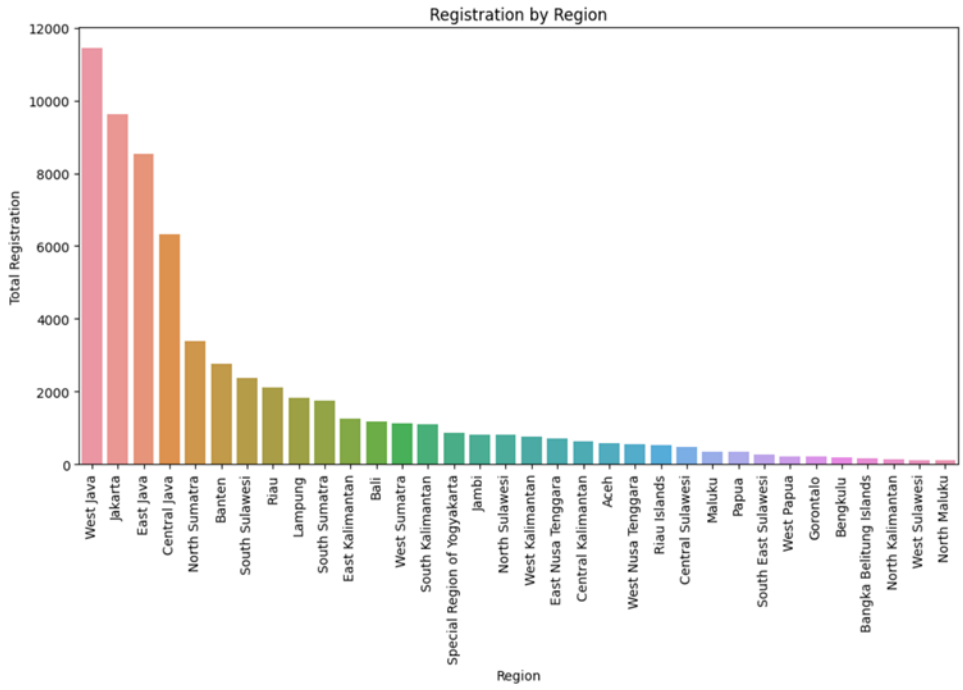


Figure 8. Number of Registration per Region

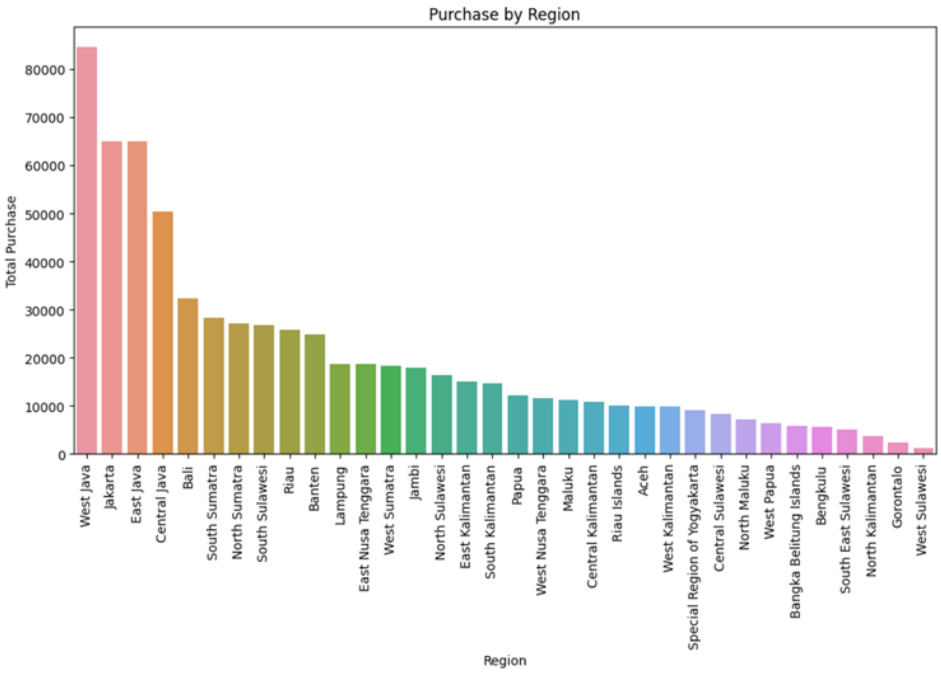


Figure 9. Number of Registration per Region

From Figure 8 and Figure 9, the region with the highest number of registrations and purchases is equally occupied by West Java, Jakarta, East Java, and Central Java. It can be concluded that these regions have the largest customer population and the market need for PPOB products is quite desirable. So that the campaign can be continued in these areas.

8. What is the cost-effectiveness of each region?

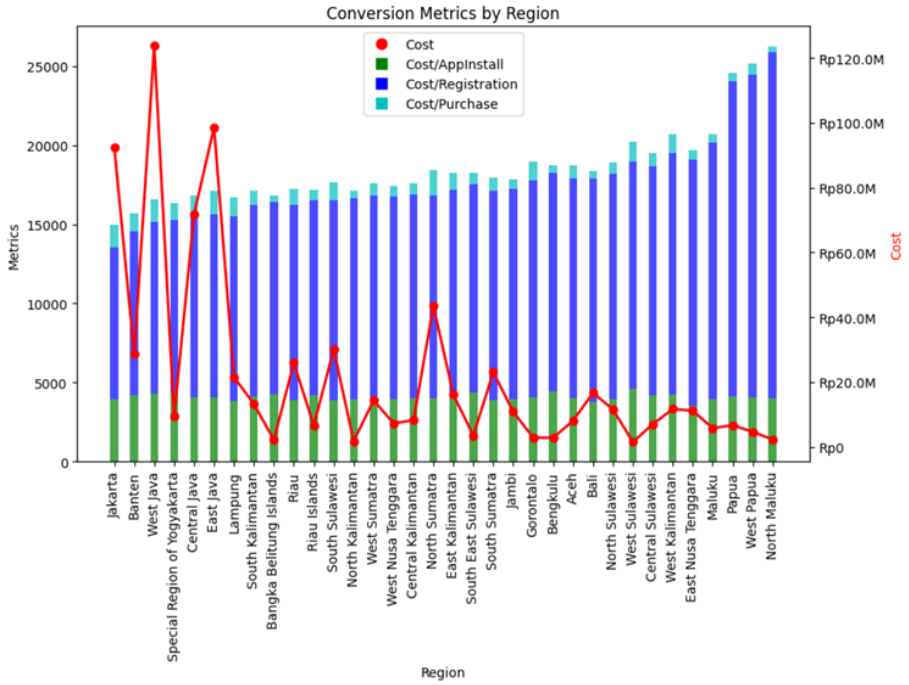


Figure 10. Cost-effectiveness per Region

Figure 10 measures which region has the most effective cost-effectiveness, a bivariate analysis can be conducted between the Cost and Region variables by measuring their cost-effectiveness. The results are known, Regions with the most effective cost-effectiveness include Jakarta, Banten, West Java, Yogyakarta, and Central Java. Although the cost-effectiveness is quite low in Banten

and Yogyakarta, the cost of advertising is also low, therefore, it is recommended that more advertising be done in these areas so that it can maximize new customer acquisition. If we look at the Eastern part of Indonesia, the acquisition cost is more expensive, especially in Sulawesi, Nusa Tenggara, Papua, and Maluku. It can be assumed that the digital understanding of the region is quite low, as well as limited internet access so there is not much market demand for PPOB products.

9. How Gender compares to campaign metrics

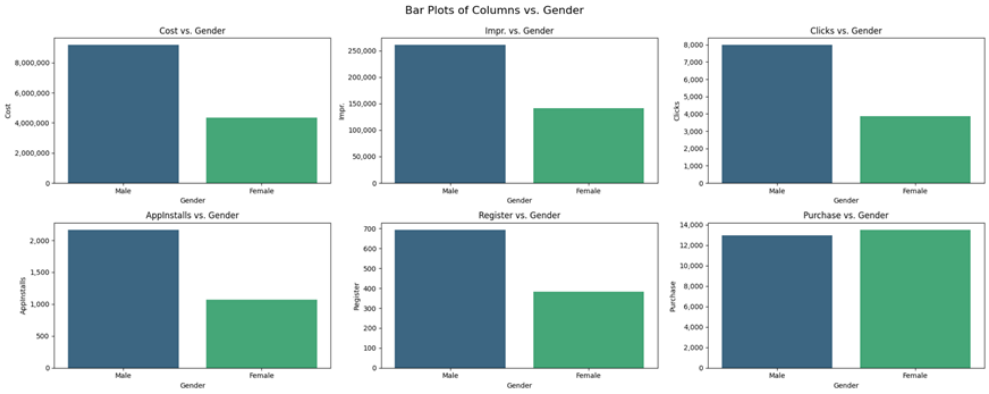


Figure 11. Gender compares to campaign metrics

Figure 11 shows that men are exposed to more advertisements than women. The number of purchases per registration is lower for males compared to females. Female customers tend to make more purchases than Males.

10. How does age group compare to campaign metrics?

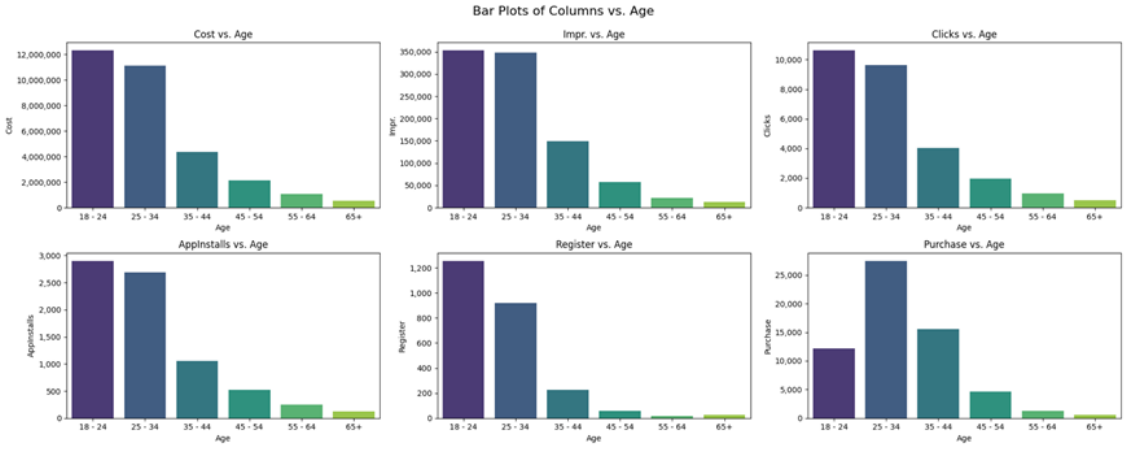


Figure 12. Age group compares to campaign metrics

Figure 12 shows that ages 18-24 & 25-34 are most exposed to ads. The number of AppInstalls & Registrations is highest in the age of 18-24. However, in terms of purchasing, ages 25-34 & 35-44 are higher than the age group 18-24, it can be concluded that the age group 18-24 does not have high purchasing power or financial capability compared to other age groups.

11. What is the correlation between the metrics and are there any interrelationships that affect the effectiveness of the campaign?

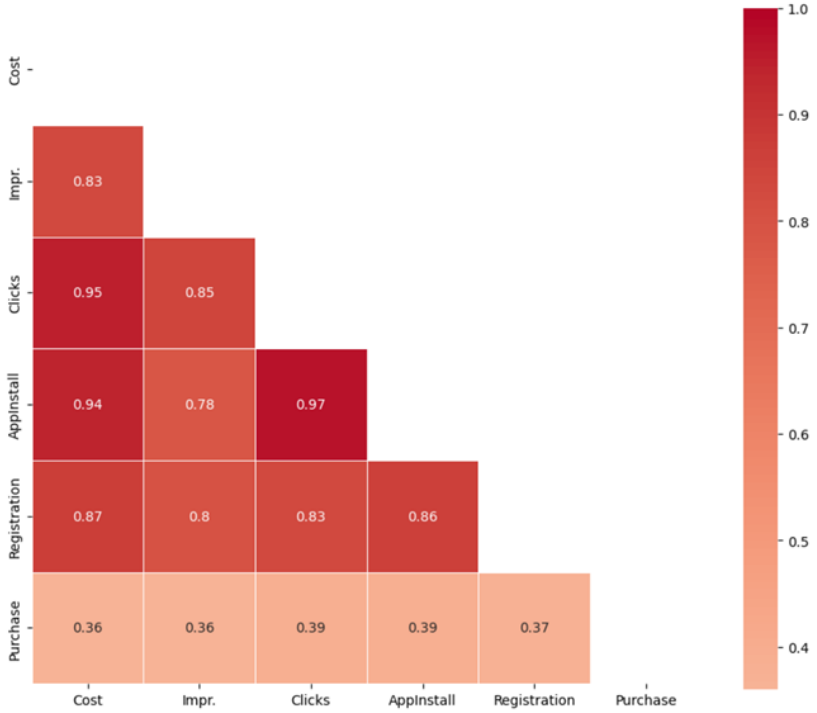


Figure 13. Correlation Matrix

Figure 13 shows a very strong correlation was found between Cost and Clicks, AppInstall, and Registration. This indicates that the more money spent, the more users will click on ads, install apps, and register. The correlation between AppInstall and purchase shows a positive value (0.39) but is quite weak, indicating that there is no guarantee that users who install automatically make a purchase. Likewise, the correlation between Registration and Purchase shows the same thing. The positive correlation between AppInstall and Registration is quite strong (0.86), this can be interpreted that users who do AppInstall tend to register. However, users who register do not necessarily purchase as shown by the positive value of the correlation between the two (0.37) is not strong enough.

Conclusion

Based on the research results employing the EDA method, several key findings have been unveiled. Mobile devices are predominant, accounting for 90% of users. While male customers dominate in terms of acquisition, women lead in transaction numbers. The age group of 18-24 is prevalent among customers, yet the purchasing power peaks in the 25-34 age range. Big cities like West Java, Jakarta, East Java, Central Java, and North Sumatra exhibit the highest acquisition rates, in contrast to the eastern part of Indonesia, where accessibility to the internet and digital literacy remains low.

Interestingly, the UAC_AppRegistration and UAC_AppInstall campaigns excel in generating acquisitions, but most purchases stem from retention campaigns with considerably lower costs. These insights are invaluable for marketing and management teams, providing a reference point to expedite decision-making, adjust campaign strategies, and refine targeting approaches based on the research findings.

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The development of a web-based internship information system at DLHK-DIY using the waterfall method

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Abstract: The Department of Environment and Forestry of the Special Region of Yogyakarta (DLHK-DIY) encounters a significant challenge related to the insufficient integration of information services for the admission of internship and research programs. This has resulted in difficulties for applicants who seek up-to-date information from the offices or departments within DLHK-DIY, as well as challenges in the inefficient management of data by the institution. This research aims to resolve these challenges through the development of a web-based platform designed to optimize the processes of information and data management. As a result, the deployment of this platform will allow applicants to access information with greater ease and efficiency, while simultaneously improving the institution's ability to manage applicant data. The development methodology for this platform employs the Waterfall approach, encompassing phases such as Needs Analysis, System Design, Implementation, and Testing. The results of this study are projected to enhance the efficiency and effectiveness of the internship and research program implementation at DLHK-DIY. The progress of information technology in the realm of public services, as exemplified by this initiative, is expected to significantly influence service enhancement and data management within the institution.

Keywords: Internship, DLHK-DIY, Platform, Waterfall, Web-Based

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Introduction

The Department of Environment and Forestry of the Special Region of Yogyakarta (DLHK-DIY) bears the responsibility for preserving and protecting the sustainability of the environment and natural resources, particularly in the forestry sector. A crucial effort to achieve these goals is by supporting research, internships, and field practices for students and researchers. However, challenges persist in providing fast, accurate, and integrated information regarding the available research or internship services at DLHK-DIY. This can hinder the interest of students and researchers in conducting research or internships at DLHK-DIY. A survey conducted by DLHK DIY staff showed that there was a high demand for a centralized and easily accessible platform to obtain information on internship and research opportunities. Respondents highlighted difficulties in finding up-to-date information, which led to missed opportunities and decreased engagement with DLHK-DIY programs.

The ongoing industrial revolution in information technology, especially the internet, presents significant opportunities to enhance public access to information and provide more efficient services. Therefore, the development of a web-based information service program becomes a suitable solution to address these challenges. This aligns with the regulations of Law Number 14 of 2008 concerning public information transparency (UU KIP). The law emphasizes that to achieve efficient, accurate, and straightforward services, every public entity is required to appoint an official responsible for information and documentation management. They are also tasked with designing and developing a system that delivers information quickly, conveniently, and simply, following the technical standards applicable to public information services nationwide [1].

The development of a web-based information service program can provide simple, comprehensive, and transparent information access for students, researchers, and the general public interested in conducting research, internships, or field practices at DLHK-DIY. Through the utilization of innovative web technology, this service will offer unprecedented convenience for prospective researchers or interns in accessing information related to requirements, quotas, offers, and procedures applicable at DLHK-DIY. Additionally, the platform introduces innovation in facilitating more efficient communication between internal departments or offices.

Based on the literature review, several previous studies have explored the development of web-based information services for research or internships. The research conducted by Nur Aini et al., titled "Development of Internship Information Service Information System at Malang State Polytechnic," has the advantage that the waterfall method has clear and structured steps, facilitating researchers in developing complex information systems. However, having structured stages may make it difficult for researchers to make changes to the information system after certain stages have been completed [2].

Furthermore, studies conducted by [3], [4], [5], [6], [7] offer the advantage of presenting comprehensive and integrated information, thereby enhancing efficiency. However, these studies are limited by the lack of integration with related information systems, and their focus tends to be on isolated functionalities rather than a holistic system that serves all stakeholders effectively. The primary gap identified in previous studies is the lack of a fully integrated system that not only offers comprehensive and detailed information but also seamlessly connects with other related systems, thereby improving usability for all stakeholders. While previous research has successfully developed systems with specific functionalities, they often fall short in providing a unified platform that integrates all necessary features, including administrative modules, user management, and data handling, which are essential for a more streamlined and efficient user experience.

This study aims to address these gaps by designing a comprehensive, integrated, and efficient web-based information service system for research and internships at DLHK-DIY. This study goes beyond the scope of previous research by ensuring that all necessary functionalities are not only included but also fully integrated, enabling fast, accurate, and seamless access to information for students, researchers, and the general public.

Methodology

In this context, the waterfall methodology will be employed to develop the Internship Information System at DLHK-DIY. The waterfall methodology is a systematic approach to software development, distinguished by its sequential progression through distinct phases: requirement analysis, system design, implementation, testing, and maintenance. Each phase must be fully completed before moving to the next one, which helps in understanding both system and user requirements thoroughly, thus facilitating the systematic development of the system [8].

For the Internship Information System, the waterfall methodology will guide the process from initial requirements gathering with DLHK-DIY to the final deployment. This process begins with requirement analysis, where detailed needs are collected from stakeholders and users to define the system's features and functionalities. In the system design phase, design documents and prototypes are developed based on the gathered requirements. After this, the implementation phase involves building the system in accordance with the design specifications. The process culminates in the testing phase, where the system undergoes thorough testing to verify that it meets the specified requirements and functions as intended.

While the waterfall method provides a clear, structured approach, it has limitations in accommodating changes once the project progresses beyond the design phase. This rigidity can be challenging if user requirements evolve or if issues are discovered late in the development process [9]. To mitigate this, continuous stakeholder engagement and comprehensive testing are essential to identify and resolve issues early in the development cycle.

The Research Stage

The solution design flowchart in this study employs the Waterfall methodology, which follows a sequential progression in the software development life cycle [10], This process initiates with analysis, followed by design, coding, testing, and concluding with the support phase [11].

Implementing a computerized system will improve efficiency and precision while enhancing security. Furthermore, data retrieval will become more streamlined [12]. The stages of the Waterfall methodology utilized in this research are illustrated in Figure 1.

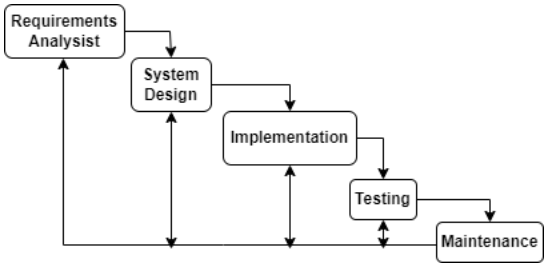

Figure 1. Waterfall diagram

This stage begins with the analysis of requirements, followed by system design. Subsequently, the solution is implemented, and testing is conducted using Black Box Testing. Black Box Testing, also known as behavioral testing, is a method of evaluating software where the tester does not have access to or knowledge of the internal structure and logic of the system being tested. Testers refer to the requirements specification and do not require an analysis of the code. In this Black Box Testing, the approach is conducted from the perspective of end users [13].

Requirements Analysis

In the Waterfall method, the initial stage involves requirement analysis, where information is gathered through interviews and field observations to discover necessary information for system development [14]. This phase identifies needs, including software and hardware requirements, for the website's creation. The results of the problem excavation are then analyzed and converted into a business process as depicted in Figure 2.

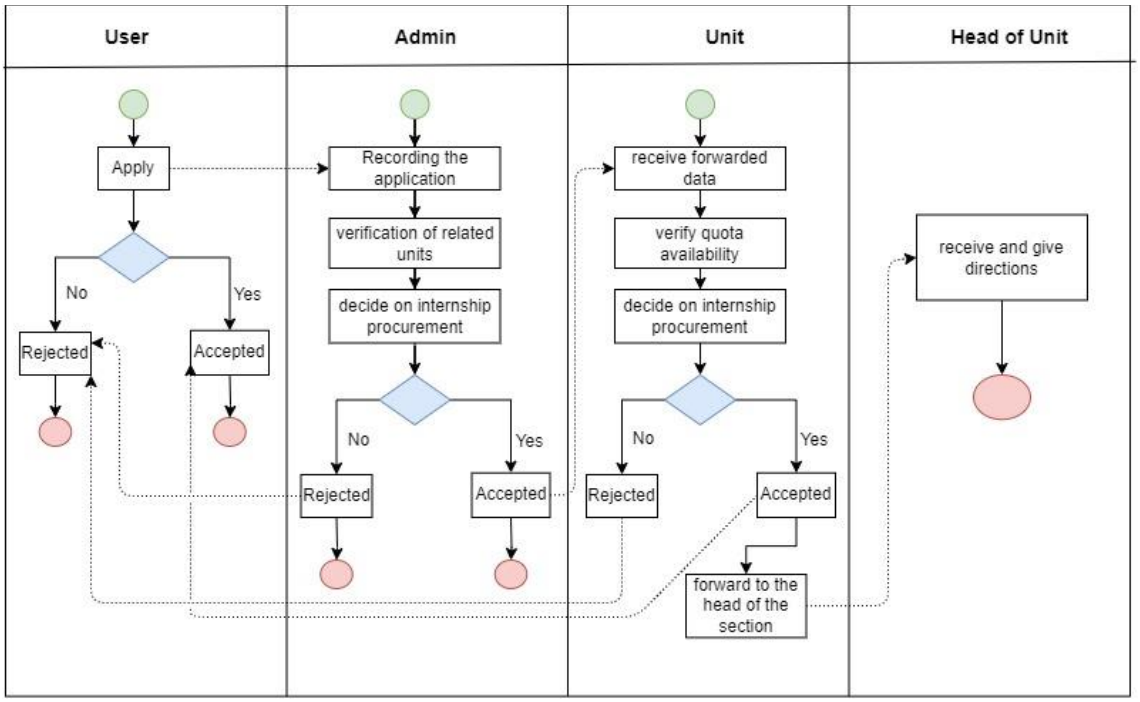

Figure 2. Business process

In the past, internship applications were submitted manually. In this updated business process, the system can now facilitate the submission of internship application letters. The system's users include Interns, Units, and Unit Heads. Available features in the system include submitting internship applications, viewing internship-related information, and managing registration, login, and logout activities. These features are detailed in the functional requirements: the system

should allow the submission of internship applications with registration documents and be capable of storing data related to registration, login, and logout.

System Design

The system design for the Internship Information System includes a detailed diagram of the business processes. This diagram visualizes the specific workflows involved in managing internship applications, from login for Admin and User to view tracking status. The system architecture within this informational framework employs the Unified Modeling Language (UML), a widely recognized and suitable tool for graphically illustrating the relationships between software components [15] or a standard language for specifying, visualizing, and constructing software [16]. Unified Modeling Language (UML) is also employed to facilitate system development by illustrating and documenting the outcomes of the preceding phase, specifically the requirements analysis stage, and subsequently providing a visual representation of these results [17].

The Use Case Diagram serves to depict the activities that users can execute within the operational system. This diagram illustrates various activities or interactions that occur between the system and actors [18]. It is useful for identifying each function in the system and determining who has access to or uses these functions [19]. Information about the admin use case can be found in the diagram presented in Figure 3.

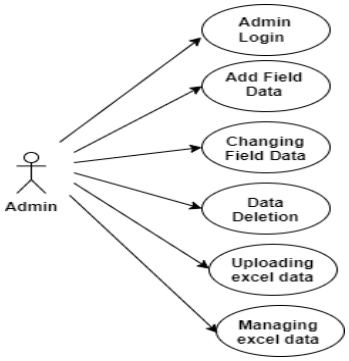

Figure 3. UCD for admin

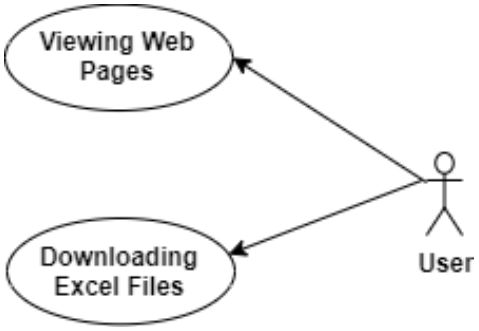

Figure 4. UCD for user

Furthermore, the Use Case Diagram (UCD) delineates the access privileges and functionalities available to users, elucidating the dynamic interplay between users and the envisaged system. The delineation of user-centric use cases also embodies the envisioned user-system interaction in accordance with anticipated requirements and functionalities. The Use Case Diagram for users can be found in the diagram presented in Figure 4.

An Activity Diagram is a type of diagram that visualizes the workflow and activities involved in the operation of a website when accessed by a user, such as an admin.The activity diagram is used to detail the expected functions that operate within the system. These activities are described using specific characters or symbols that represent activities in the system [20]. This diagram displays the sequence of activities sequentially and is used to illustrate the activities that occur in the website's operation. The following is Figure 5, the Activity Diagram for Login.

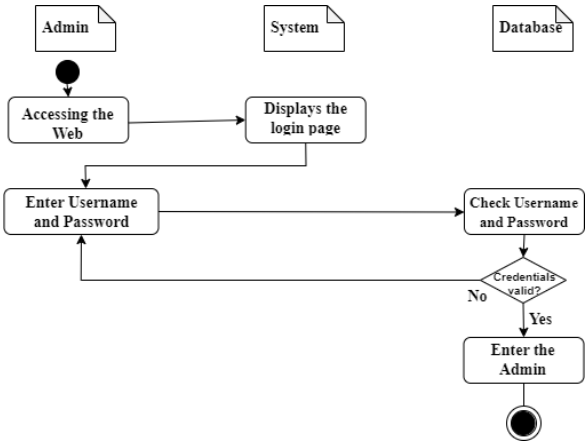

Figure 5. Activity diagram for login

For instance, the activity diagram for this website can commence with the activity "Accessing the Website," represented by a circular symbol as the starting point. Subsequently, there is an arrow leading to the activity "Admin Login" as the next step. Then, there is the activity "Enter Username and Password," followed by "Verification" as part of the login process. These activities continue until entering the Admin Dashboard page and conclude with an oval symbol as the endpoint. The Activity Diagram for viewing detailed information about a department or office is illustrated in Figure 6.

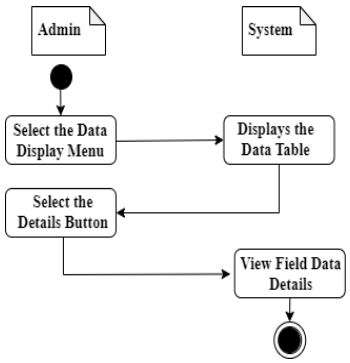

Figure 6. Activity diagram for view details

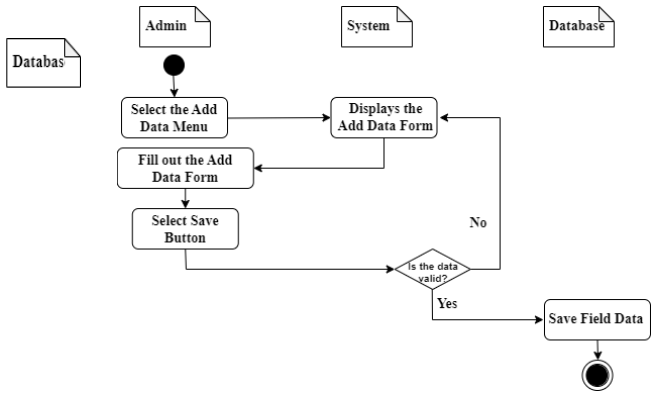

Figure 7. Activity diagram for adding hall data

This is an Activity Diagram illustrating the process of adding department or office data on the website's admin page in Figure 7. It starts with "Accessing the Admin Page" after user login. The next step is "Select Add Department or Hall Data," leading to "Fill in Department or Office Information," where users input necessary data. After successful input, the system verifies data in "Data Verification." If successful, it proceeds to "Save Data," signifying storage of the new data. This diagram visually guides users in efficiently and adding department or office data on the admin page.

In the activity diagram, each activity or process within the website is represented by geometric symbols. A black circle indicates the start or end of an activity, arrows connect the activities, and rectangular shapes represent the actions or processes occurring within the system. The Activity Diagrams for editing and deleting hall data are depicted in Figure 8 and Figure 9.

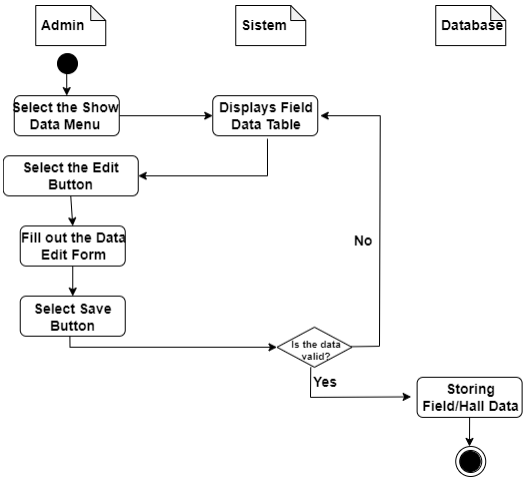

Figure 8. Activity diagram for editing data

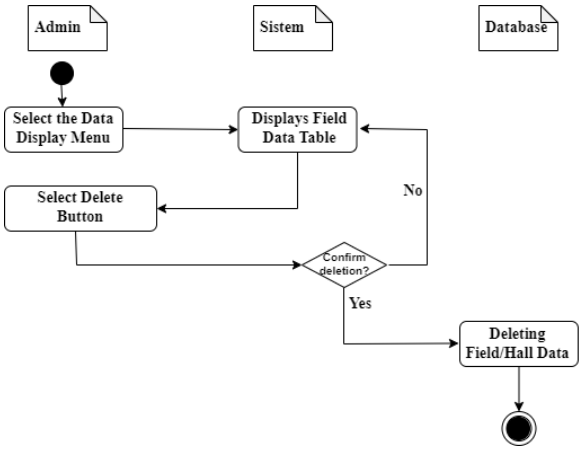

Figure 9. Activity diagram for deleting data

In this website, an activity diagram is employed to provide a more detailed overview of how users interact with the website and how the system responds to user actions in facilitating internship, research, and fieldwork information services at the Environmental and Forestry Agency of Yogyakarta Special Region. Figure 10 is the Activity Diagram for uploading an Excel file on the admin side.

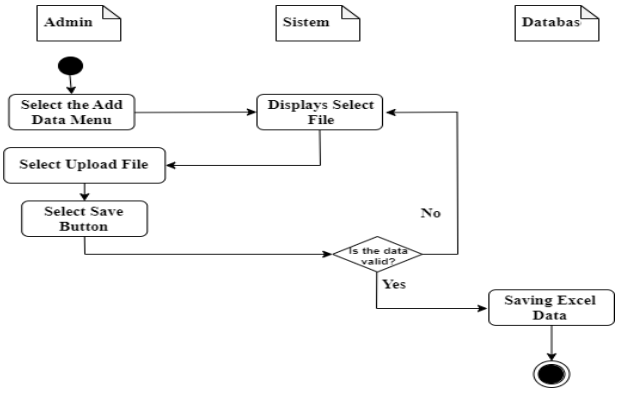

Figure 10. Activity diagram for upload excel data

By utilizing the activity diagram, users can clearly understand the flow and sequence of activities that occur within this website. This diagram aids in analyzing and designing the performance processes and user interactions with the website in a more detailed and efficient manner. Through detailed graphical representation, users can identify critical points in the user experience, facilitate better understanding, and support the overall development and enhancement of the website's functionality.

The Data Flow Diagram (DFD) serves as a structured analytical and design technique utilized as a graphical instrument for elucidating the logical framework and elucidating data alterations within a given system. DFD encompasses mechanisms for modeling data flow and supports decomposition to detail data flow and functions. While DFD may not present information about the sequence of operations, it is not a process or procedural modeling method. The DFD used in this research currently under construction can be outlined in Figure 11, Figure 12, and Figure 13.

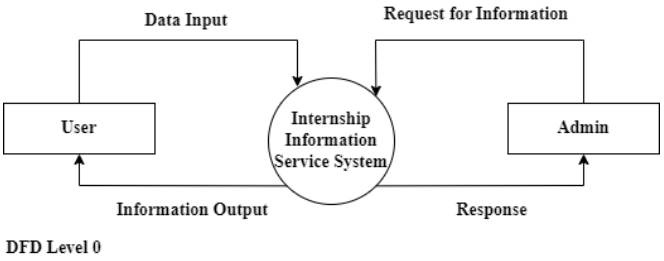

Figure 11. DFD level 0

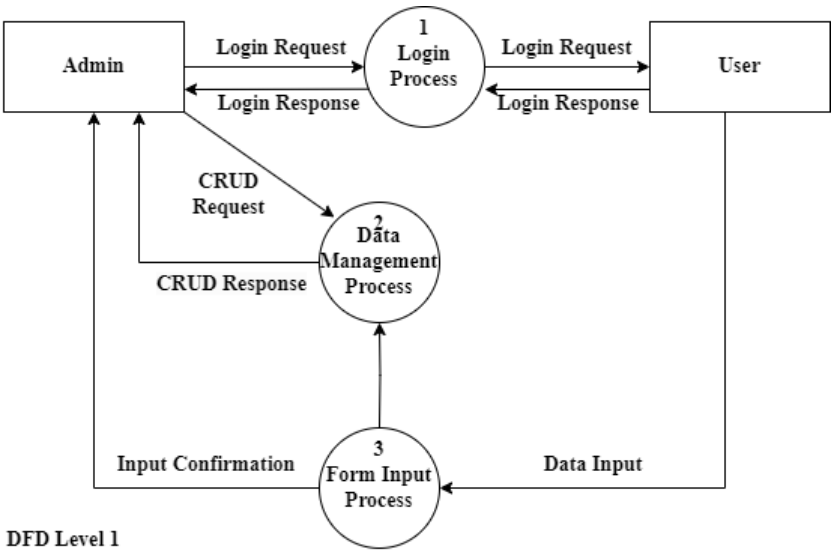

Figure 12. DFD level 1

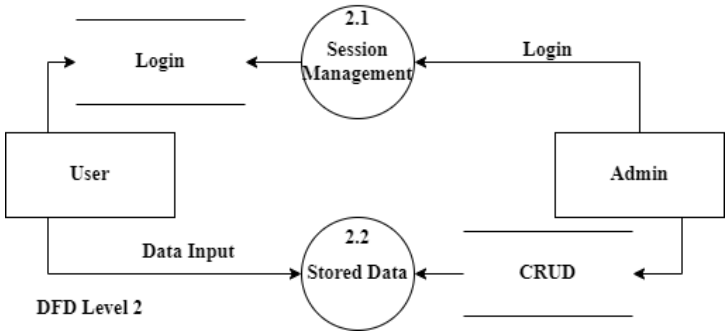

Figure 13. DFD level 2

Subsequently, the design must be translated into software programming code. This process results in the creation of a computer program that aligns with the design specifications established during the design phase.

Implementation

The third stage in the applied waterfall method is the implementation phase. Implementation involves combining physical resources with previously conceptualized ideas to create a cohesive system. This phase also entails specifying the hardware and software components to be utilized in building the website. The hardware specifications include an Intel® Core i5 10th gen 3.8 GHz processor and 12 GB DDR4 RAM. For software, the specified operating system is Microsoft Windows 11, the browser is Google Chrome, and the server is XAMPP, featuring an Apache web server, PHP, and MySQL. The code will be edited using Visual Studio Code (VSCode).

This comprehensive program is accessible through the GNU (General Public License) and serves as a user-friendly web server capable of displaying dynamic web pages [21]. In the implementation phase, these hardware and software specifications will guide the development and execution of the website according to the previously conceived design. The conceptualization of the design should be implemented through the translation into software program code, thereby yielding a computer program that conforms to the design plan established in the preceding design phase [22].

Testing

The fourth step is the testing phase. System testing is implemented using the Blackbox Testing approach, which focuses on the software's functionality [23]. Subsequently, testing will be conducted on various browsers such as Chrome, Microsoft Edge, and Mozilla Firefox. This aims to ensure that the website functions well and consistently across different browsers. If the test results meet expectations, the next phase involves testing with users and administrators. This testing aims to assess the comfort, security, and responsiveness of the website when used by regular users and administrators.

The principal objective of a website is delineated as an assemblage of pages presenting diverse forms of content encompassing text, images, static or animated graphics, audio, video, and their combinations, whether static or dynamic, interlinked within a structured framework, wherein each page is interconnected via hyperlinks, is to operate proficiently [24].

The importance of Blackbox testing is pivotal in assessing the quality of internship, research, and fieldwork information web services at DLHK-DIY. This method scrutinizes the execution outcomes by employing test data to ascertain the conformity of system functionality with pre-established specifications [25]. Identifying errors or weaknesses in the application early is crucial, allowing for quick action and the implementation of specific testing phases to evaluate the developed program. Any identified concerns encountered during the testing phase will be diligently rectified and optimized to augment both the quality and performance of the website before its official launch [26].

Results and Discussions

Results

This section is utilized by the administrator to manage the entire website. This management includes the ability to modify the content of data or information within the website, such as adding or reducing information about departments or offices, altering the registration flow, updating quotas and application statuses, and other actions. To obtain access permission, the administrator must have a combination of a username and password to log in to this page. The admin login interface is depicted in Figure 14.

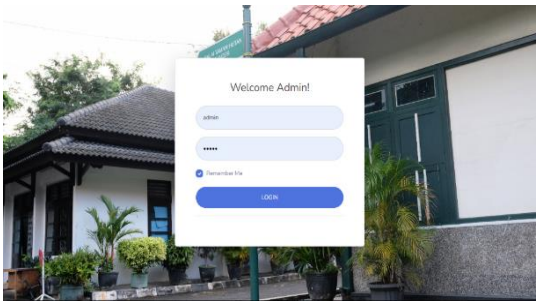

Figure 14. Login page

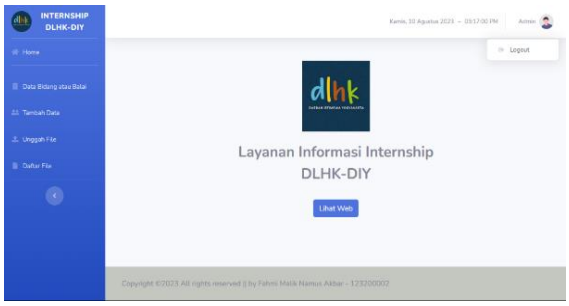

Figure 15. Home page

After successfully logging in, the admin will be directed to the main page. This page will display a list of various menus on the website using a sidebar. This page also functions as the administrative area where the admin can add, modify, or reduce information on the page and make adjustments if the information seems inconsistent with the website. Additionally, there is a footbar displaying copyright or author information, and a top bar showing the profile and real-

time clock. When the cursor is directed to the profile icon, a dropdown feature will appear, allowing the admin to log out of the admin page. An illustration of the main page view can be seen in Figure 15.

The next page is the Department or Hall Data Page. On this page, detailed information is available regarding the departments or offices associated with DLHK-DIY. Additionally, some features allow the administrator to edit or delete this data. The Department or Office Data Page view can be seen in Figure 16 attached below and on the Department or Office Data page, each department or office name that is highlighted in blue can be clicked to navigate to a detailed data page for that specific department or office, as exemplified in Figure 17.

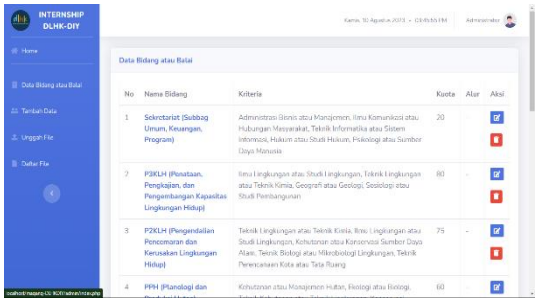

Figure 16. Department of hall data page

Figure 17. Details of department or hall data page

In the data management process, the administrator can edit the information contained in each department or office entry. If the admin desires specific changes or adjustments, the steps are straightforward. The admin simply needs to click on the blue edit data icon located on the far left in the "action" column. This action will redirect them to the edit data page specifically designed to facilitate information editing. The edit data page, as seen in Figure 18, provides space for the administrator to update and modify relevant information. Each department or office has its edit data page displaying editable details such as department name, location, and other information. This provides flexibility for the admin to ensure that the recorded data is always accurate and up-to-date in line with the latest developments. This process demonstrates the advantages of a data management system that gives full control to the administrator to maintain and synchronize information with current needs. On that page, the admin can edit data and save it by clicking the blue "save" button located at the bottom. Automatically, the data is updated in the database, and the updates can be seen on the web page. Furthermore, there is also a feature to add department or hall data, as shown in Figure 19.

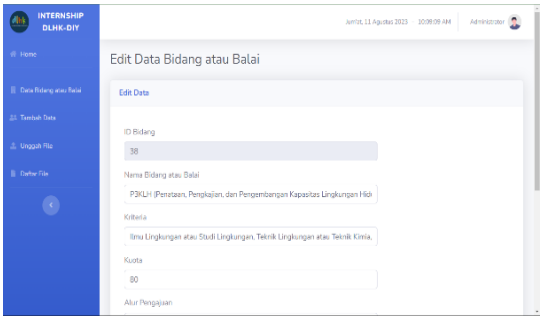

Figure 18. Editing department or hall data page

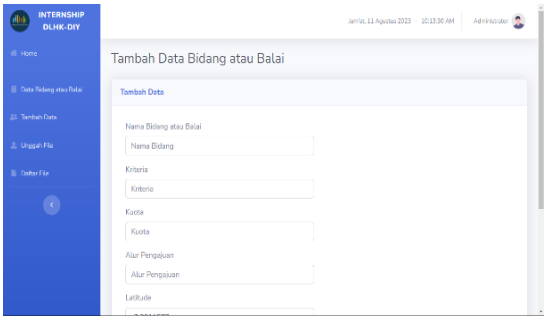

Figure 19. Adding department or hall data page

The next feature is the page for uploading an Excel file. Only Excel files can be uploaded as they are automatically filtered through coding. This Excel file contains the quotas of departments or offices and a list of application statuses, which will be displayed on the user's home page and allows users to download them qnd the last feature on the admin interface is the file list page. This page contains uploaded files, allowing the admin to delete them, and an Excel file that allows the admin to be directed to Google Drive as the editor. Figure 20 illustrates the upload file page and Figure 21 illustrates this page.

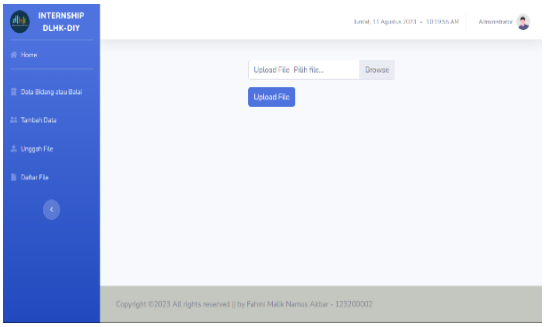

Figure 20. Uploading file page

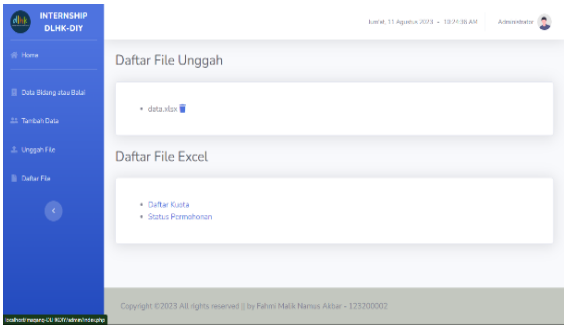

Figure 21. List file page

On the homepage, users can choose to register through the menu at the top of the screen, leading them to the internship, research, or fieldwork registration form via Google Form. The illustrated banner view on the user's homepage can be seen in Figure 22.

Figure 22. Banner of user page

Users can also explore detailed information about fields or offices by selecting the "Lihat Bidang/View Field" button in yellow on the homepage. This will take them to a page that displays detailed field information, as shown in Figure 23.

Figure 23. Details of hall data page

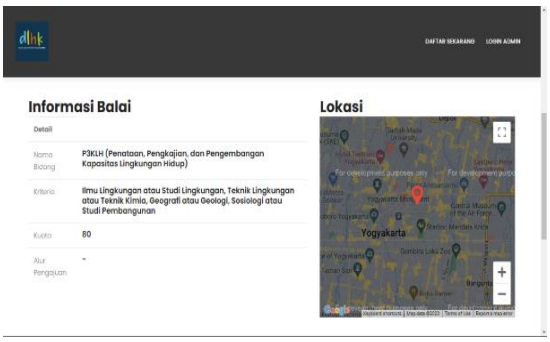

Figure 24. Details and locations page

On this page, users can obtain further information by choosing the "Details and Location" button in blue. This will open the "Informasi Balai" or Field Information page, as illustrated in Figure 24. This page provides users with in-depth information about the fields or offices in the DLHK-DIY environment. Additionally, there is an integrated map with Google Maps, allowing users to determine the location of internships, research, or fieldwork destinations. On the homepage, if users scroll down, they can see the general flow illustrated in Figure 25. It should be noted that each field or office may have a slightly different flow than the general flow displayed on this page.

Figure 25. General flow

Further information includes a list of quota availability for each field. This data is directly taken from the spreadsheet managed by the administrator and is updated in real time. This makes it easy for prospective applicants to know the available quota for each field or office in the DLHK-DIY environment. Additionally, this information is also available in the form of an Excel file that users can download, as illustrated in Figure 26.

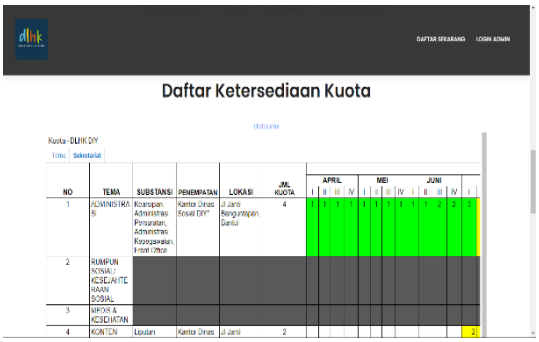

Figure 26. Quota availability

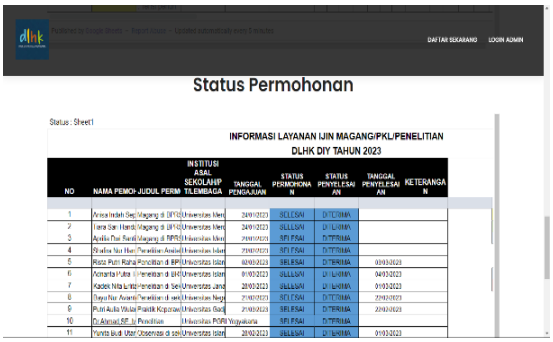

Figure 27. Applications status

The next section is a list of information about the status of incoming applications. Here, applicants can view the progress of their applications in detail. This list is managed by the administrator through a Google spreadsheet accessible via the admin page in the file list feature. The illustration of this page can be seen in Figure 27.

In the course of this research, the system underwent testing employing the black box method, aiming to verify its alignment with the intended operational specifications. The black box testing methodology is primarily utilized to evaluate the software's compatibility by analyzing the correlation between input parameters and resultant output, emphasizing the absence of internal structure knowledge. The outcomes derived from the black box testing are presented in the subsequent Table 1.

Table 1. Result testing

No	Scenario	Test Case	Expected Result	Result
1	Visiting the website page	The user visits the website page	The browser displays the desired outcome	Successful
2	Navigating through available menus	User clicks on available menus	Displays the selected menu page	Successful
3	Performing CRUD on the website	The user performs create, read, update, and delete actions on data linked to the database	The database is updated with these actions	Successful
4	Logging in and logging out	The user logs in and logs out	Displays the admin page and logs out of the admin page	Successful

5	Uploading an Excel file	The user uploads a file Excel	The file is uploaded to the website	Successful
6	Downloading an Excel file	The user downloads a file	The file can be downloaded from the website	Successful
7	Launching a link	The user clicks on a link on the website page	Displays the intended page according to the link address	Successful
8	Accessing location on maps	User views the location on maps	Displays the location on Google Maps on the website	Successful

Next, browser testing has been conducted to assess the overall output of the website creation process, including the layout, menus, and other features, to ensure that everything aligns with the plan. The following table provides a comparison before and after DLHK-DIY implemented the information service website for internships, research, and fieldwork in Table 2.

Table 2. Result testing

Before	After
Insufficient maximum dissemination of information regarding internship, research, and fieldwork services at DLHK-DIY.ser visits the website page	Information is more easily disseminated through a website that is easily accessible to the public.
The community faced difficulties obtaining detailed information and the location of departments.	The public can easily obtain detailed information and the location of available offices
The public had limited knowledge of the various departments or offices available at DLHK-DIY.	It is easy to know which departments or offices are present in DLHK-DIY.
Applicants and internal parties encountered challenges in accessing quota information and application statuses.	It is also easy to view real-time lists of quotas and application statuses on the website.

Discussions

Development of internship, research, and apprenticeship information services at DLHK-DIY's web-based platform, the activities follow the Waterfall methodology. This method outlines a phased approach to software development, beginning with needs analysis and progressing through the implementation and testing stages. The process initiates with an in-depth analysis of user requirements, followed by a design based on the analysis findings. Implementation proceeds once the design is deemed adequate, with testing conducted to ensure consistency with the established plans and specifications.

The design process in constructing this website involves the utilization of several visual tools such as UML, UCD, and Activity Diagrams. Through UML, diagrams like use cases and activities are employed to visualize interactions among system components, facilitating a better understanding of the overall system workflow. During the implementation phase, key features such as Admin Features, file uploads, Excel file management, and field or pavilion details are successfully developed to provide an optimal user experience and meet diverse user needs.

Following the implementation phase, the system is examined using the black box testing methodology to verify that its functionality aligns with the predefined specifications and designs.

By elucidating the acquired understanding, the author can correlate research findings with the theoretical knowledge framework previously discussed, enabling the integration of research outcomes with broader knowledge and fostering a deeper understanding of software development and development methodologies.

Conclusion

This research concludes that the developed website successfully presents comprehensive information about the departments and offices within DLHK-DIY, as well as detailed guidance on the procedures and requirements for submitting research, internships, and apprenticeships. The website provides easy access for users to explore the opportunities available at DLHK-DIY, facilitating research, internships, and apprenticeships.

Key functionalities of the website include an administrative module that enables login, logout, and CRUD operations, along with Excel file uploading and administration, thereby ensuring efficient data and information management. The development of this website adhered strictly to the Waterfall methodology, ensuring coherence and quality across all phases, including analysis, implementation, and testing. The use of UML, UCD, and Activity Diagram methodologies enriched the design process by offering a comprehensive system view and focusing on user needs.

Quantitative results from the testing phase support the effectiveness of the system. The black box testing methodology confirmed the system's adherence to initial designs, with a 100% success rate in test cases. Additionally, user feedback gathered from participants during the usability testing phase showed an overall satisfaction rate of 80%, with 90% of users finding the website easy to navigate.

In summary, this research has effectively achieved its objectives by developing a website that provides detailed information about the departments and offices within DLHK-DIY, offers comprehensive instructions for research and internship applications, and facilitates easy monitoring of ongoing progress. The system's quantitative performance metrics demonstrate its robustness, usability, and efficiency, further validating the quality of the implementation.

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Internet of Things (IoT) design based on smart farming with solar panels in an agriculture laboratory

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Abstract: The implementation of smart farming still uses AC electricity resources which is estimated to be less effective in its implementation due to wasted electricity costs. As well as the lack of a crop monitoring system by farmers, crop yields are not optimal. This research aims to produce a smart farming system that is used for hydroponic plants to monitor plant conditions periodically and the automatic watering process and nutrient measurements are more efficient, online to the network with the IoT concept, and saves energy by utilizing solar panels. This research is quantitative research with experimental methods. The stages in this system include flowcharts and block diagrams to make it easier to read the workflow that will be created and tested. The results of this research are that the monitoring system with the Blynk Smartphone application turns on if the pH sensor gets a result of 7.2 causing it to open and the pH solution drops in the solenoid which will make nutrients flow into the water container. The solenoid will experience a closed condition because the sensor gets results in the range of 6.2 to 7.2 in pH units. The water level gets an average height of 18.5 to 19.5 cm with the sensor, nutrients are filled into the water container when the solenoid is triggered and turns off when it gets to the maximum value limit. Solar panels as an energy source for detecting acid bases in pH units and hydroponic nutrients are proven to be able to operate all devices within 24 hours during the period of growth.

Keywords: Internet of Things (IoT), Monitoring, Smart Farming

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Introduction

Use of alternative energy in Indonesia for clean energy efforts, a country rich in natural resources but facing significant environmental challenges. By prioritizing the development and deployment of renewable energy technologies, clean energy for the future of life can be applied in Indonesia apart from reducing dependence on fossil fuels, preserving energy resources, and trying to reduce the global climate. The world of agriculture is becoming more advanced day by day with advances in digital technology in monitoring [1]. Apart from that, a hydroponic system requires a fairly large source of electrical energy because the pump is turned on continuously for 24 hours [2], because the pump will continue to run for hydroponic nutritional needs in the water container provided because it can be said to be a waste of energy and electricity costs [3].

Hydroponic plants require more care than plants grown using conventional methods [4]. Therefore, plants grown using this method require good control in terms of nutrition, water quality, light intensity, and air temperature to obtain quality results.

Based on the problem of difficulties in controlling and wasting electricity costs, an idea emerged, how to monitor and make the process of watering and measuring nutrients in hydroponic plants automatic and efficient, integrated with the notion of the Internet of Things (IoT) and conserving energy through the use of solar power (Solar Energy). Previous researchers have recorded it.

The design of the application that has been developed is covered in this earlier study. It can display temperature, pH, and nutritional sensor measurements, set ideal values for these

parameters, and show graphs of temperature sensor readings. The application runs smoothly via application of the SIPEDRO 1.0 in Android [5].

This previous study discusses about the design of Smart Urban Farming Hydroponics can provide nutrition, decrease, and increase PH, and monitor the condition of nutrient containers, pH up and pH down containers and reservoirs so that we can know the available capacity [6].

This previous study discusses about design of green power that is sustainable is critical to the survival of humankind. The integration of Internet of Things (IoT) applications with solar panel applications is presented in this publication. The ability to communicate in real time between farmers and plants is the true benefit of the Internet of Things [7]. For best management, the smart electric pump can also be managed by a WiFi-based controller [8].

Another discusses about design of Solar power can be an excellent solution for generating electricity as a replacement for electricity from PLN in hydroponic plants to guarantee optimal power output, the Internet of Things' application in PV system monitoring must be closely watched. For remote hydroponic monitoring, plants can be monitored on an Android smartphone with the help of the BLYNK application.

Compared to the earlier research, the authors created a monitoring system, a prototype will be created with a Solar Panel as a source and supply electrical power for the IoT system as a sensor to control PH and hydroponic plant nutrition digitally which can be accessed online with a smartphone.

Methodology

The research methodology includes a review of the literature, a framework for research (a flow chart layout), wiring schematics, designing software, hardware and software development, and the conception and build of an Internet of Things (IoT)-based smart farming system for monitoring with solar energy power. The study was conducted in the Agriculture Laboratory of Universitas Warmadewa, one of the private universities located in Bali.

Framework for Research

To assist in organizing and concentrating our research efforts, the research framework describes what is important and offers research questions and objectives. It will be used to put the decisions made throughout the research into practice. Usually, the researcher utilizes it as a guide to help them stay more focused on the parameters of their research process [9]. Figure 1 illustrates how the research was performed.

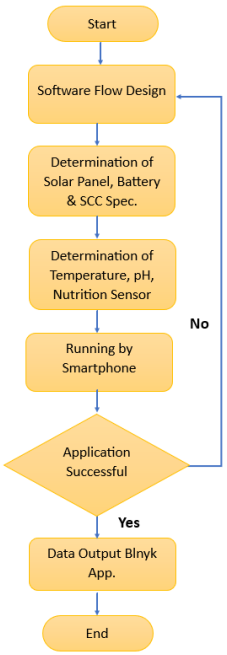

Figure 1. Flowchart Smart Farming System

A literature study was carried out first regarding the concept of Deep Flow Technique (DFT) hydroponic planting until problems were found with the conventional DFT system. Then the design for pump cycle automation, monitoring of temperature and humidity conditions, and the nutritional conditions of the hydroponic system were formulated. After that, the hardware that has the potential to be used as a microcontroller and sensor is determined to fulfill the design objectives as well as design a prototype of the planting media and place all system components. Followed by designing the software flow and calculating the power required by the system. This calculation aims to determine the capacity and specifications of the solar panels, batteries, and SCC that will be used. When appropriate, a report is prepared in the form of a system design blueprint

The Figure 1, it can be explained that the nutrient delivery automation system in the cycle time of a DC water pump is the basis of DFT hydroponics operation. So, the system makes pumps not have to be on continuously while still maintaining water flow requirements (2L/min). The environmental condition monitoring system for planting media and nutrients works based on the reading values of the sensors used, namely the DHT11 temperature and humidity sensor, Ph sensor, nutrient sensor, and water level sensor, water level sensor, nutrition sensor, Ph sensor, and humidity and temperature sensor DHT11. When the sensor reading value is at the abnormal threshold according to plant standards, a buzzer will trigger as a notification to the user. Apart from that, renewable energy sources are also designed through the use of solar panels, batteries, and SCC. Because this energy source produces DC power, all components also use DC current, including the water pump [10]. Apart from that, the data processed by the NodeMCU ESP8266 will be stored in the Blynk Cloud and then displayed via the SmartPhone [11].

Hardware Design

Figure 2 shows the microcontroller with type ESP8266 as a control center for sensors and other components, as well as connecting IoT via its WIFI feature. This controller is used because it has a powerful Analog pin feature and built-in WIFI which allows connection to the internet and IoT server [12]

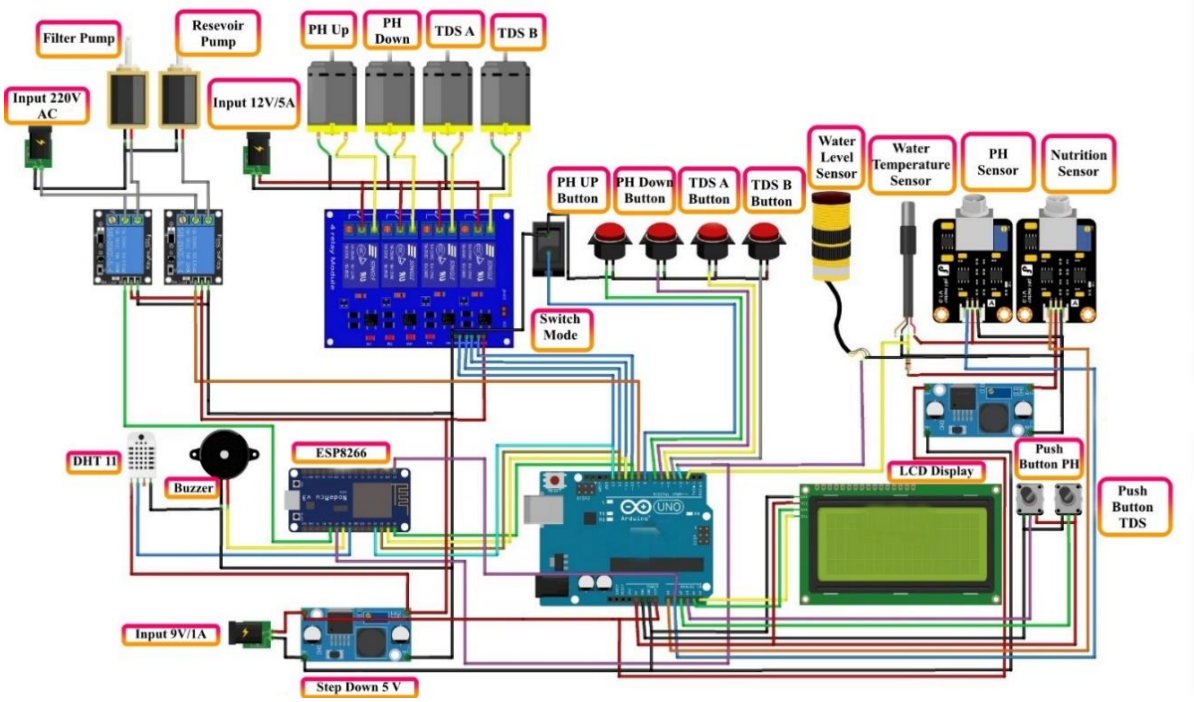

Figure 2. Smart Farming with IoT Wiring Diagram

The monitoring system uses a DHT11 sensor with a digital pin connection, a PH sensor with an analog pin connection, and a nutrition sensor and water level sensor with an analog pin

connection, When the sensor reading value is at the abnormal threshold according to plant standards, a buzzer will trigger as a notification to the user [13]. The automation system uses a 5V relay connected to a digital pin which will regulate the 12V electric current from the SCC to the DC pump. It uses a battery of 12 volts with characteristics that will be determined later, a solar charge controller, with connecting solar panel elements to provide power [14]. Because the microcontroller and other components require a 5V voltage supply, a voltage-reducing component such as a step-down is used. To be able to connect to the IoT server, the ESP8266 is first connected to a WIFI connection from a router that has internet access. So, ESP can communicate with Blynk's IoT server. With Blynk, it is possible to monitor sensor conditions, input cycle pump threshold parameters, and input threshold alarm sensor measurements via the available Blynk mobile application.

Software Design

The Arduino default software is used to execute the coding procedure. The Arduino IDE (Integrated Development Environment) is the common name for this program. The process of writing a source program, building it, uploading the output, and then running it on the serial interface are the first steps in using an IDE for microcontrollers [15].

Figure 3. Programming NodeMCU ESP 8266 in the Arduino IDE Application

The system for monitoring is developed in the Arduino application, as seen in Figure 3 above. Typically, this monitoring program includes initializing, naming, choosing data formats, and providing logic to DC pumps and sensors. The pH, water level, temperature, and nutrition sensors are used, and a DC pump is used for distribution. Through the analog pins, the sensors are included in the Arduino programming [16].

When connecting the analog pins, DC pumps are incorporated into the Arduino program. The data from the sensor is connected to the DC pump through this pin. The rationale for the distribution of bases, acids, and nutrients that are in conventional program listings is supplied based on data from the connected sensors. With an Android smartphone, the Blynk app can be used to access the monitoring system [17].

Result And Discussion

Hardware Build Result

Figure 4, that when turned on the ESP will Connect the WIFI and Blynk server until it is successfully connected. Then continue with initializing the pins used by sensors, LCD, and buzzer. Then the loop function (void loop), ESP will receive temperature, humidity, PH, and PPM sensor data input from the sensor.

Figure 4. Hardware Monitoring of Smart Farming-based IoT

The threshold input (normal measurement range) for conditioning sensor values from the server Blynk. The threshold results are used as a reference in the branching program for switching on the buzzer as an alarm [18]. Followed by sending sensor data to the Blynk server and displaying it on the LCD. A delay of 1 second is given before the looping again program.

Pump cycle regulation automation system based on the time threshold specified by the user on the Blynk server. For example, the pump will turn on for 20 seconds and turn off for 180 seconds. So, after turning on the relay, the ESP will loop with a delay of 20 seconds after turn on the relay. During the loop, the ESP can be inserted into a condition-monitoring program sensor

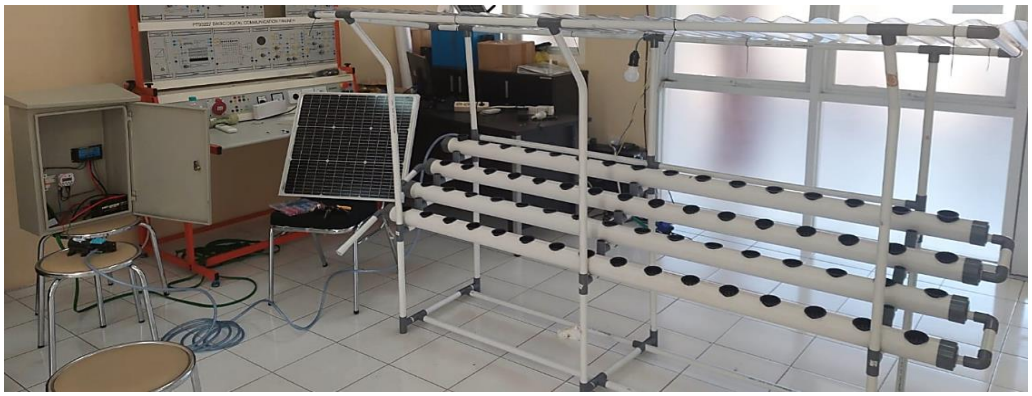

Figure 5. Hardware Solar Panel of Smart Farming

Figure 5 shows the framework of the DFT hydroponic system planting media which is arranged in layers and resembles a half-triangle shape [19]. So, it is possible to plant at a slope. The framework is designed using 1.5-inch pipes with a size of 1 meter each. The frame has a maximum height of 150 cm. So, the pump specifications with a maximum height of 2m assuming 32 Liter/minute (L/min) of flow rate, can theoretically meet the flow requirements exceeding the standard requirement of 2 L/min for PVC pipes. By using PVC pipe material, it is hoped that it will have a long service life. Considering the sturdy nature of PVC and cannot rust. In assembling it requires around 4 pieces of 2,5-inch pipe with a length of 2 meters. Then proceed with the placement of 4 pipes measuring 2.5 inches with a length of 2m which have been given 20 planting holes in each pipe. So that the overall system has 80 planting holes. The pipes are installed in stages by maintaining the appropriate water level in the pipes. DFT hydroponic system with a discharge of 2 liters/minute. Figure 5, the installation of solar panel on the system, Solar Charge Controller, Voltmeter, ACCU and DC delay timer installed in the IP66 Outdoor Type panel box IoT monitoring consists of a microcontroller, LCD, buzzer, and relay. There is also a nutrient water reservoir at the bottom which contains a DC water pump, TDS sensor, and Ph sensor.

Discussions

Figure 6, Analysis of pH and water level sensor monitoring tests using the Blynk application by smartphone. The purpose of the test is to find out how long the monitoring system needs to respond when the sensor picks up a value for a parameter that is different from what is expected. Testing pH parameter control is used by conditioning the value of pH to acidic conditions, namely less than 6, and alkaline conditions, namely more than 7.

Figure 6. Hardware Solar Panel of Smart Farming

The pH measurement data can be seen in Figure 7. In this graph, information can be obtained that from 06:00 AM to 06.00 AM the next morning for 24 hours, the pH value remains within the range of values needed by hydroponic plants. At 1:00 PM the pH value exceeds 7, As a result, after 15 minutes, the pH down liquid flows to the nutrition container when a solenoid valve for pH down instantly opens.

Namely from 1.15 PM onwards, the pH returns to the range of values required by hydroponic plants. The highest pH value is 7.21 at 1:00 PM, this proves that during the day the plant absorbs oxygen to the roots which causes the pH condition to change towards alkaline (basic) and the lowest pH is 6.20 at 11:00 PM. because at that time the plants do not get enough sunlight, so the plants only carry out the process of respiration (breathing) and the pH changes to an acidic level.

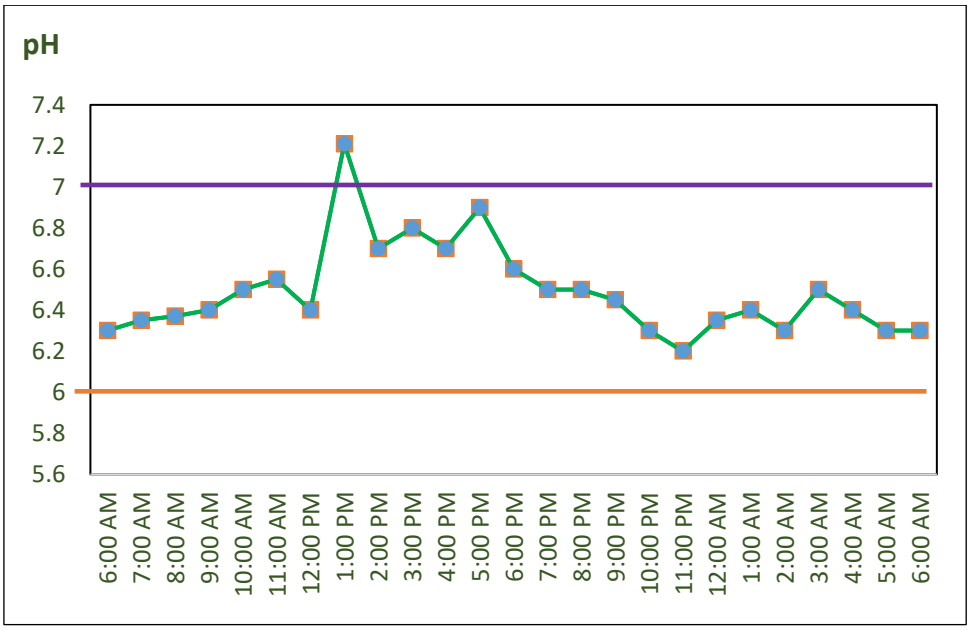

Figure 7. Output pH Measurement

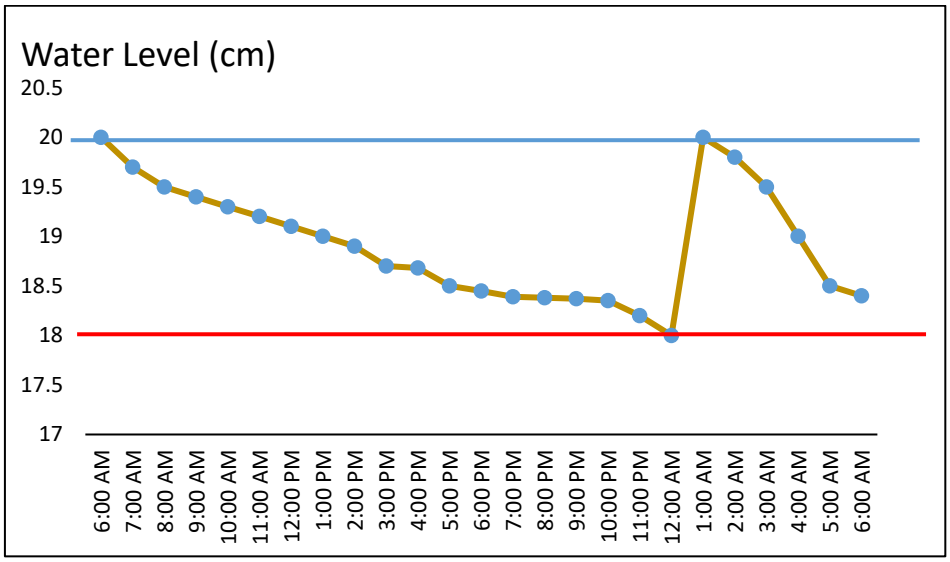

Figure 8. Output Water Level

Figure 8 is monitoring data for nutrient water levels. The graph shows that the water level has decreased. The initial height is 20.0 cm. At noon the water level reaches 18.0 cm, so the solenoid valve automatically opens and flows the nutrient water to the main nutrient tank. After 15 minutes the water level is at a height of 20.0 cm and the solenoid valve closes automatically.

The system for controlling and monitoring pH parameters and water levels for hydroponic plants uses energy sources from solar panels. The loads used in this research are a 60-watt hydroponic pump, 4-watt solenoid valves (32 watts) each, and 0.2-watt Arduino Uno. The total load on the hydroponic system is 92.02 watts. The loads that work continuously are the pump and Arduino Uno. When the sensor identifies a value that is different from the reference value, the solenoid valve needs to be opened. The solar panels used have a maximum power of 50 WP and the maximum power that the solar panels can produce is 250 watts. However, in its application, Figure 9 is the amount of power on the solar watt meter with data collection carried out from 06:00 AM to 16:00 AM with the highest result being 239.3 watts at 01.00 PM, while the amount of power consumed by the load from 06:00 AM to 06.00 AM with the highest result is 127.1 watts, so the highest result of power stored on the battery is 112.2 watts.

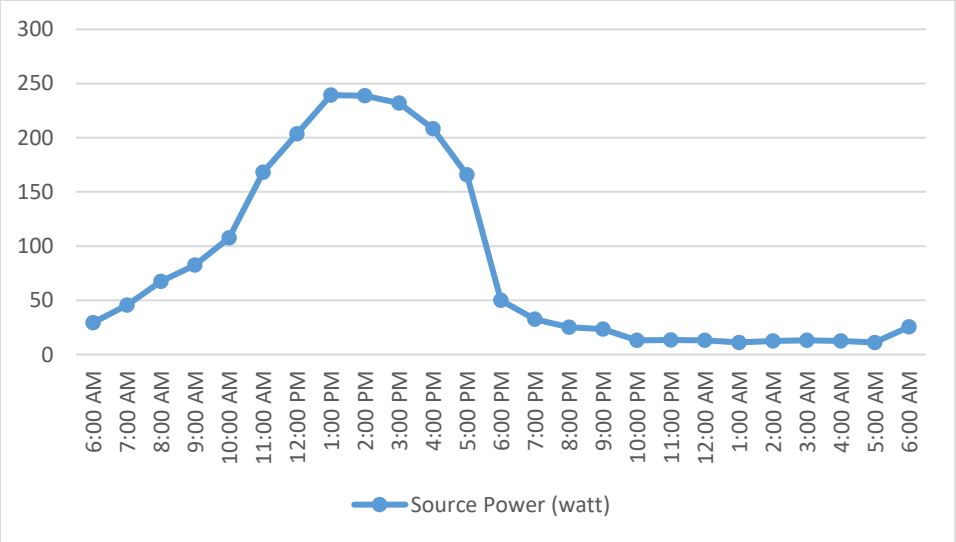

Figure 9. Data Result Produce by Solar Panel (06.00 AM to 06.00 AM Next Day)

Figure 9 shows the energy generated by solar panels between 6:00 AM and 6:00 AM the next day. The data collection that started at that time refers to the solar charger controller, namely after 07:00 PM the solar panel indicator was not readable, because the solar panel did not receive light or it was said that after 07:00 PM it was dark. The graph is fluctuating, meaning that the power produced and consumed goes up and down all the time. Hydroponic in daytime production, Solar panels generate electricity when exposed to sunlight. Typically, the highest production occurs around midday when the sun is at its peak. Hydroponic in nighttime production, Solar panels do not generate electricity at night when there is no sunlight. Production drops to zero during these hours.

Morning (6:00 AM - 12:00 PM), Solar panels start generating electricity after sunrise. Hydroponic loads such as pumps for nutrient circulation and initial lighting may be activated to coincide with increasing solar production. Midday (12:00 PM - 6:00 PM), Solar production peaks. This is an ideal time to power high-energy-consuming devices like grow lights, as solar output is strongest. Evening (6:00 PM - 6:00 AM), Solar production diminishes and eventually stops after sunset. Battery storage, if available, can supply power during this period to maintain essential hydroponic operations like pump circulation and minimal lighting.

Conclusion

When the pH sensor reports a value of 7.2, the valve with a solenoid activates, enabling the pH-down solution to enter the nutritional solution and function as part of the system for monitoring via the Blynk smartphone application. When the sensor reads a pH in the range of 6-7, the valve with a solenoid will close once more. The solenoid valve opens to allow nutrient water to enter the nutrition container when the sensor reports a measurement of 18.5 cm, and it closes again when the sensor reports a value of 20 cm. This is how the water control system operates.

It has been shown that using solar energy systems as a power source to regulate the pH levels and concentration in hydroponic fertilizer solutions can power all equipment during the period of growth.

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