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Implementation of the Internet of Things for Flood Mitigation and Environmental Sustainability

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***Abstract*—One of the components that support the smart city program is the existence of a smart environment. A smart environment is a form of environmental management by paying attention to the environment in future city development. The current problem is that smart cities in Indonesia are not optimal, especially regarding flood mitigation handling sources from rivers and river water quality. Floods in urban areas often cause material losses and cause fatalities, especially with the increasing significance of the impact of climate change, which is difficult to predict. Thus, there is a need for sustainable Internet of Things (IoT)-based river monitoring to monitor river water levels and quality. This research aims to apply the Internet of Things for flood mitigation and environmental sustainability. The architecture used is using Antares as a cloud media. The results obtained by monitoring the river showed that the influence of the provider in sending sensor data is influenced by the availability of network service facilities in locations. In addition, the fastest data transmission lasts five seconds. At the same time, the suitability of data transmission occurs in under two minutes.**

***Keywords*—Antares, Big Data, Flood, Internet of Things, Mitigation**

I. Introduction

The city of the future is a livable city that can anticipate various conditions. In an effort toward a future city, the smart city is an alternative to create a city ecosystem and sustainably improve the quality of human life. In 2035, it is estimated that 66.6% of Indonesia's population will live in cities [1]. In addition, in 2020, as many as 56.7% of Indonesia's population will already live in urban areas [1]. A strategic step in utilizing urbanization effectively, Indonesia's future city requires smart city governance towards a sustainable city by creating a smart environment, namely Technology-based environmental management, especially flood mitigation from rivers and river water quality.

In the future city, rivers play an essential role in supporting the balance of nature and human life. The current challenge is that river flow is very dynamic due to climate change which causes the distribution of rain and rainfall in each region to vary. One of the impacts of climate change is flooding. In recent months, floods often occurred in big cities caused by overflowing rivers due to high rainfall, such as Kuala Lumpur, Malaysia, Jakarta, Indonesia, and Bahia, Brazil. In addition, the impact of flooding that is very undesirable is the loss of life. As anticipation, monitoring is needed for mitigation in order to reduce casualties. Currently, monitoring is generally still manual, using river guards at the river water control post to find out the river's water level monitored by officers. This mitigation is ineffective because officers still have to inform officers and the community from upstream to downstream when the river's height can potentially flood. Therefore, the solution offered is flood mitigation based on IoT (Internet of Things) technology for monitoring river water levels and quality to anticipate river pollution.

In previous studies, river mitigation based on the Internet of Things was used for monitoring water level detection using a wireless sensor network in Samarinda, Indonesia [2]. In addition, IoT-based flood monitoring design [3], [4]; IoT-based monitoring of water quality in Citarum River in Indonesia using pH, TDS, and Turbidity sensors [5]; IoT-based polluted river monitoring [6], [7]; and monitoring of domestic wastewater pollution in residential areas using IoT: a case study in Bandung Indonesia [8]; IoT Application with Visual Analytics for Water Consumption Monitoring [9]. However, from research that has been done, the Internet of Things has not implemented mitigation by combining monitoring for flood mitigation and environmental sustainability. In addition, previous research has not discussed the timing performance in the notification of sensor data sending.

Therefore, this research aims to apply the Internet of Things to flood mitigation and river environmental sustainability. In addition, this study compares the performance of the Antares architecture in sending sensor data with different network service providers. Sensors used are Ultrasonic sensors to determine the river water level, pH and Turbidity sensors for river water quality, and Raindrops sensors to determine rain conditions.

II. Material and Method

A. Study Area

This research was conducted in Banyumas, Indonesia, precisely in Karanggintung Village. The research location is in the city center with densely populated conditions (Lat: 109.24; Long: -7.36). Karanggintung is traversed by the Pelus

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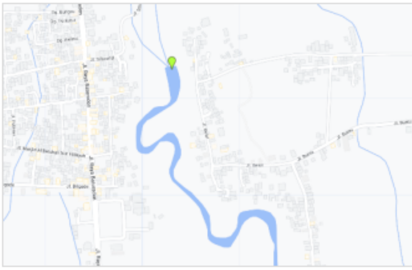

Fig. 1. Research location (Lat: 109.24; Long: -7.36)

river. The Pelus River flows through the city with a steady flow of water and tends to be swift. The Pelus River is representative of urban areas. This condition is a consideration for researchers to choose research locations for the Internet of Things application as mitigation and environmental sustainability in urban areas. The research location can be seen in Fig 1.

B. Antares Platform

In storing and managing data traffic, implementing the Internet of Things (IoT) requires a virtual platform or place that can manage and create applications with various kinds of connectivity. One of the services that can be used for this arrangement is Antares. The Antares is a service provided by local producers from PT Telkom Indonesia. Antares prioritizes zero infrastructure management so that users do not need to provide server infrastructure because all data has been stored in the cloud. The data consumption is obtained through the API. This platform can communicate via standard protocols like MQTT, HTTP, and CoAP. Antares architecture makes connecting easier for users as needed; architectural details can be seen in Fig 2. In addition, to simplify configuration Antares also provides libraries for Android and Arduino-based microcontrollers [10].

C. Methodolodgy

The Internet of Things technology system was built through several stages in this research. Researchers determine several sensors as input data according to the needs of river conditions. The sensors used are Ultrasonic, Turbidity, pH,

Fig. 2. Antares data model architecture [11]

and raindrops sensors. The next step is to determine the control system using ESP32 Wi-Fi and Arduino IDE.

In the Internet of Things technology built, researchers also use solar panels as a power supply to ensure the power supply needed by sensors and controls. In addition, Antares IoT platform as a data storage and distribution controller and 4G Wi-Fi as a gateway for sending sensor data. Details of the design of the Internet of Things application system can be seen in Fig 3. Meanwhile, based on Fig. 3, the explanation of components and data transmission is as follows:

- Component System

The components used in this research focus on river mitigation and environmental sustainability. So that the selected components are adjusted to the needs for mitigation and monitoring river sustainability, details of the components used can be seen in Table I.

TABLE I. COMPONENTS OF THE IMPLEMENTATION OF INTERNET OF THINGS

Image	Components
	Ultrasonic HC-SR04 Sensor; As an indicator of the water discharge height in the river.
	Rain Sensor; As an indicator to determine the rain condition at the river's location.
	pH Sensor Kit PH-4502C Electrode Probe; As an indicator to determine the pH of river water.
	Turbidity Sensor; As an indicator to determine water quality by detecting the level of turbidity in river water.
	ESP32 WiFi; As control and transfer sensor data to the cloud or Antares.
ANTARES	Antares; As a data storage platform for sensor data settings received from ESP32.

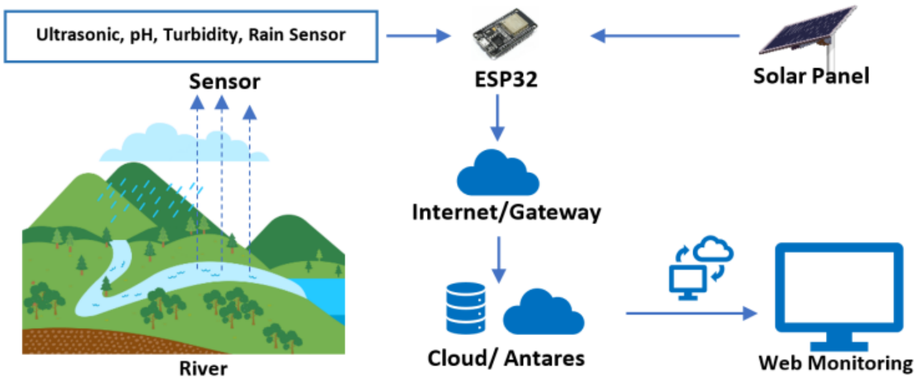

Fig. 3. Overall system design

- Data Transmission

This study uses a WiFi media gateway to transmit data between ESP32 or control. Then internet connection at the gateway using available cellular providers such as Telkomsel and Smartfren. In addition, the cloud used is the Antares platform. The Antares platform provides the Antares ESP32 Library to define the system as a configuration with a device. Furthermore, between ESP32 and Antares database using HTTP. The HTTP library installation is done through the Library Manager on the Arduino IDE.Several uses of Antares in IoT applications have been carried out: for Low-cost wireless sensor networks using Antares platform for gas measurement [12]; Automatic controlling system and IoT-based monitoring for pH rate in aquaponics [13]; System of Measuring PH, Humidity, and Temperature Based on Internet of Things (IoT) in plants [14].

- Prototype Design

This study's prototype design was based on adjustments to existing conditions in the river. The prototype design is equipped with part equipment, such as solar panels, as a power supply to charge the battery continuously. In addition, the prototype design is also equipped with a panel box to protect components from rainwater.

An equally important part is the position of the sensor: The raindrop sensor is located above the panel box along with the solar panel; the Ultrasonic sensor is under the panel box; and the Turbidity Sensor and pH below touch the water. Details of the prototype design in the design of Internet of Things technology can be seen in Fig 4.

III. Result and Discussions

The system of the Internet of Things as mitigation in this study was carried out through several tests. The tests carried out are sensor testing and data transmission testing. Based on several test scenarios, the test results are as follows.

A. Sensor Measurement

Sensor testing is done to determine the performance of the sensor. Each sensor has a different treatment. The ultrasonic sensor is compared between the actual object and the distance measurement results on the sensor, as shown in Table II. Then an error calculation is carried out to determine the difference between the two results with Formula 1.

$$Error = |(Y - Yi)/Y * 100\%| \quad (1)$$

Y is the reference (Object distance), and Yi is the actual data (Distance sensor output).

The calculation results show that the average error is below 3% from ten measurements. So, this threshold proves that the relative performance of the sensor works well.

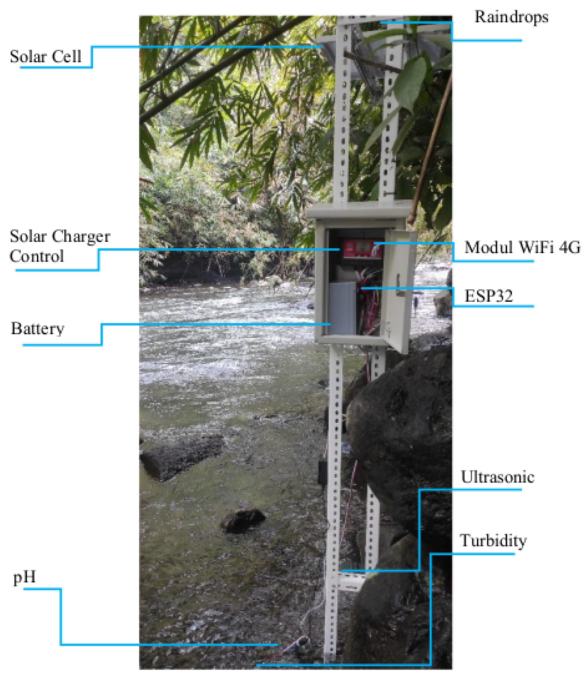

Fig. 4. Internet of Things technology prototype design for flood mitigation

TABLE II. ROXIMITY SENSOR MEASUREMENT

No	Ultrasonic Sensor Measurement		
	Object distance (cm)	*Distance sensor output (cm)*	*Error (%)*
1	5	5	0
2	10	10	0
3	15	15.2	1

No	Ultrasonic Sensor Measurement		
	Object distance (cm)	*Distance sensor output (cm)*	*Error (%)*
4	20	20.4	2
5	25	25.5	2
6	30	30.5	2
7	35	35.4	1
8	40	40.5	1
9	45	45.6	1
10	50	51	2

The next sensor is a water turbidity sensor to determine water quality. In testing this sensor, the researchers divided it into three scenarios, namely (1) clear water, (2) cloudy water, and (3) river water, which can be seen in Table III. Based on the measurement results, the average clear water value is 12.56. While river water is 39.93 and cloudy water is 265.91. This result shows that the cloudier the measured water, the higher the value obtained by the sensor.

TABLE III. TURBIDITY SENSOR MEASUREMENT

No	Water Quality Measurement *(mg/L)*		
	Clear Water	*Cloudy Water*	*River Water*
1	12.89	266.41	41.58
2	12.52	265.62	40.87
3	12.6	265.72	38.01
4	12.52	265.38	36.33
5	12.57	265.97	36.21
6	12.62	266.06	40.31
7	12.77	266.04	44.41
8	12.94	265.87	42.41
9	12.18	266.33	37.52
10	12.01	265.77	41.67

In measuring the pH sensor, the researchers divided it into several scenarios. Scenarios (1) Buffer 4.1 (Table IV); (2) Buffers 7.1 (Table V); and (3) Buffers 9.1 (Table VI). From the three measurements, the average error measurement (Formula 1) sequentially from the lowest to the highest buffer was 1.58%, 0.53%, and 2.22%. Based on the three scenarios, Buffer 7.1 is relatively stable and has a small error value. Therefore, the researchers made Buffer 7.1 with an average error of 0.53% as a reference for using the pH sensor.

TABLE IV. ACIDITY SENSOR MEASUREMENT (BUFFER 4.1)

No	pH Sensor with Buffer 4.1		
	Actual pH	*pH Measurement*	*Error (%)*
1	4.1	4.07	0.732
2	4.1	4.02	1.951
3	4.1	4.05	1.220
4	4.1	4.18	1.951
5	4.1	4.1	0.000
6	4.1	4.09	0.244
7	4.1	3.9	4.878
8	4.1	4.01	2.195
9	4.1	4	2.439
10	4.1	4.09	0.244

TABLE V. ACIDITY SENSOR MEASUREMENT (BUFFER 7.1)

No	pH Sensor with Buffer 7.1		
	Actual pH	*pH Measurement*	*Error (%)*
1	7.1	7.08	0.282
2	7.1	7.08	0.282
3	7.1	7.23	1.831
4	7.1	7.14	0.563
5	7.1	7.06	0.563
6	7.1	7.07	0.423
7	7.1	7.07	0.423
8	7.1	7.09	0.141
9	7.1	7.15	0.704
10	7.1	7.09	0.141

TABLE VI. ACIDITY SENSOR MEASUREMENT (BUFFER 9.1)

No	pH Sensor with Buffer 9.1		
	Actual pH	*pH Measurement*	*Error (%)*
1	9.4	9.28	1.277
2	9.4	9.24	1.702
3	9.4	9.33	0.745
4	9.4	9.28	1.277
5	9.4	9.68	2.979
6	9.4	9.55	1.596
7	9.4	9.61	2.234
8	9.4	9.6	2.128
9	9.4	9.74	3.617
10	9.4	9.84	4.681

The last sensor measurement is the raindrops sensor (Table VI). This sensor works with an output of “0” indicating no rain. At the same time, "1" is raining. In measuring the output produced when the sensor is exposed to water, the sensor sends data "1" or rain

B. Data Delivery Test

Sending sensor data in the Internet of Things technology is very important. Generally, sending sensor data requires a tiered path. This technology can be an obstacle when monitoring in real-time. Sending data in real-time is very necessary, especially for flood mitigation related to human safety.

This study transmits data from the control sensor to the cloud (Antares platform). The data transmission test was tested with several providers to find out how fast and accurate the data sent from the sensor was until the user reads it. In addition to testing, it aims to determine the availability of the network at the service provider. Because one of the factors constraining data transmission in real-time is the availability of services, this test is needed to ensure speed and accuracy in sending sensor data to the user. Here is the flow to send data via HTTP on the Antares database with ESP32.

```
#include <AntaresESP32HTTP.h>
#define ACCESSKEY "your-access-key"
#define WIFISSID "your-wifi-ssid"
#define PASSWORD "your-wifi-password"
#define applicationName "your-application-name"
#define deviceName "your-device-name"

AntaresESP32HTTP antares(ACCESSKEY);
void setup() {
        Serial.begin();
        antares.setDebug();
        antares.wifiConnection(WIFISSID,PASSWORD);
      }
void loop() {
        // Fill variables with random values, with different data types
        int temp = random() ;
        float rainlv = float();
      // Inserting variable values into temporary data storage
        antares.add("temperature", temp);
        antares.add("rain_level", rainlv);
       // Send from data repository to Antares
        antares.send(applicationName, deviceName);
        delay();
      }
```

TABLE VII. TESTING SPEED AND SUITABILITY OF DATA TRANSMISSION BASED ON SEVERAL PROVIDERS

Provider	Start Time	Receive Time	Sensor			
			Raindrops	*Turbidity*	*pH*	*Ultrasonic*
Smartfren (A)	09:00:00	09:01:35	No rain	41.58	7.14	60.3
		09:03:42	No rain	40.31	7.06	60.5
		09:04:21	No rain	44.41	7.07	60.7
		09:05:52	No rain	42.41	7.14	60.3
		09:06:11	No rain	42.41	7.06	60.5
		09:07:32	Rain	265.77	7.23	40.6
		09:08:54	Rain	265.77	7.23	40.7
Telkomsel (B)	09:00:00	09:00:05	No rain	44.41	7.21	60.4
		09:00:10	No rain	42.41	7.14	60.3
		09:00:15	No rain	42.41	7.06	60.5
		09:00:20	No rain	41.58	7.07	60.5
		09:00:26	No rain	40.31	7.07	60.2
		09:00:31	No rain	44.41	7.09	60.7
		09:00:36	No rain	42.41	7.23	60.4
		09:00:41	No rain	43.41	7.14	60.5
		09:00:46	No rain	41.58	7.07	60.5
		09:00:51	No rain	40.31	7.09	60.6
		09:00:56	No rain	44.41	7.23	60.3
		09:01:01	No rain	42.41	7.07	60.4
		09:01:06	No rain	41.41	7.09	60.3
		09:01:11	No rain	41.58	7.14	60.2
		09:01:16	No rain	40.31	7.06	60.2
		09:01:21	No rain	41.58	7.07	60.3
		09:01:26	No rain	40.31	7.14	60.4
		09:01:30	No rain	44.41	7.06	60.4
		09:01:35	Rain	265.72	7.23	40.5
		09:01:40	Rain	265.38	7.23	40.2

Fig.5. Web-based Internet of Things monitoring interface

Table VII the tests were carried out at river locations with the same treatment. Each sensor is treated the same. The raindrops sensor was given a water splash stimulus, and the Turbidity Sensor and the pH were given a cloudy water stimulus. Then the ultrasonic sensor is given a stimulus object closer than before.

Based on the tests in Table VII. The two providers have significant differences. For provider A to transmit data continuously, the average delivery speed is above one minute for one data transmission. Then for the accuracy of data transmission, there is a delay of seven minutes from the initial stimulus on the sensor, namely 09:00 to 09:07. While in provider B, the speed for sending data is continuous. The average speed reaches five seconds for one data transmission. In addition, the accuracy for data transmission is under two minutes from the initial stimulus on the sensor, which is 09:00 to 09:01:40.

The test results from the two providers follow Table VII; not all of these tests can be equated at every location. These results can also be influenced by the provider availability of service networks in each region. However, it is necessary to pay attention to the implementation of the Internet of Things, which requires real-time data or human safety. Consideration of service providers becomes crucial in sending data.

Furthermore, based on Fig 5. The river monitoring interface is built on top of the Antares platform features. Data from sensors sent, data recorded in a cloud-based database provided by Antares. The interface is built web-based. Visualization of data transmission is done in real-time.

IV. CONCLUSION

The application of the Internet of Things for flood mitigation and environmental sustainability is functioning well. IoT mitigation technology with Antares platform architecture is relatively easy with various features that can be integrated. In addition, in the application of IoT, the availability of network services in sending sensor data is essential, especially for real-time data transmission related to human safety. This is evidenced by the difference in speed and accuracy in data transmission. Provider A, the speed of sending data is under 1 minute, and the accuracy of sending data is 7 minutes. While in provider B, the speed of sending data is under 5 seconds, and the suitability of sending data is under 2 minutes.

Suggestions for future work, monitoring can be done to find out the power used in Internet of Things devices. In addition, visualization also uses the location coordinates of each river flow.

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