ANALYSIS WEATHER CONDITION SYSTEM DESIGN BASED ON DATABASE BY INTERNET OF THINGS PLATFORM

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ABSTRACT

This research focuses on analyzing the design of weather conditions based on a database via the Internet of Things (IoT) platform. The Internet of Things is a rapidly developing technological paradigm, enabling devices to connect to the internet and communicate automatically. In the context of weather monitoring, IoT provides the potential to collect weather data from multiple sources in real-time, providing a deeper understanding of weather and climate change. The aim of this research is to improve the accuracy of weather monitoring and the efficiency of weather monitoring. In order to achieve this goal, this research will design and implement a system using ESP32 and a cloud database system using Firebase which can collect weather data from sensors spread across Surabaya locations. The weather data collected will be stored in a centralized database that can be accessed via the internet. The platform will enable sophisticated data analysis to understand weather changes and long-term weather trends. In addition, this research will make a positive contribution to the understanding of climate change. Weather data collected in large quantities can be used for long-term analysis, helping us understand ongoing climate change trends. This has significant implications in mitigation and adaptation efforts related to climate change. In conclusion, this research has the potential to provide a better understanding of weather and climate change and provide real benefits in various sectors. Through the use of IoT technology, we can maximize weather monitoring and face existing challenges in terms of understanding and handling increasingly dynamic weather changes.

keywords: *Weather conditions, Internet of Things, Esp32, Firebase*

1. INTRODUCTION

IoT is a rapidly developing technology paradigm, which allows devices and objects around us to connect and communicate via the internet. This has opened up new opportunities in various fields, including environmental monitoring. IoT allows us to collect data in real-time from various sensors placed in various locations.

Weather monitoring is a critical need in many aspects of human life, including agriculture, transportation, energy management, security, and more. Rapid and unpredictable weather changes can have a significant impact on daily activities and the economy. Therefore, having a reliable weather monitoring system is essential.

Utilizing IoT in weather monitoring brings many benefits. With various sensors connected to the internet, we can collect real-time weather data from various geographic locations. This data can be used to forecast the weather, identify potential weather changes, and provide important information to society and various economic sectors. In the background description above, the initial idea emerged to install a weather station at the airport so

that it could provide accurate weather information. This weather information can be used for flight safety. Some of the objectives of this research are:
to increase the accuracy of weather monitoring by utilizing Internet of Things (IoT) technology. By designing devices and systems that are capable of collecting weather data from various sources, this research aims to provide more accurate weather information, especially around airports, to the public and various sectors.
to optimize weather predictions. By collecting large amounts of weather data from various locations around the airport, the proposed system can enable deeper data analysis to better forecast weather changes.
This research also aims to make it easier to access weather data. With weather data centralized in a database, citizens, companies and government agencies can easily access relevant weather information through various platforms, including mobile applications and websites.

1. 1 Weather Station

A Weather Data Station is a facility or device used to collect, record and measure various atmospheric or weather parameters at a particular location. This station is designed to collect weather data continuously and accurately, so that this information can be used to monitor weather conditions, forecast weather, and for various other applications. Weather Data Stations typically consist of several important components, including:

- Weather sensors measure various atmospheric parameters, such as air temperature, humidity, air pressure, wind speed and direction, solar radiation, rain, and others. These sensors provide the data necessary to understand and predict weather conditions.
- Data generated by these sensors is recorded and stored for further analysis. This data can be stored in digital form and accessed in real-time or downloaded periodically.
- Weather Data Stations are usually connected to a communications network, such as the internet, to transmit weather data to data processing centers or other meteorological centers. This allows weather data to be shared and used by various parties.
- This station requires a power supply to run sensors and other electronic devices. This power supply can come from an electrical power source or solar panels, depending on the location and design of the station.

Weather Data Stations are used by a variety of agencies and individuals, including national meteorological agencies, weather researchers, farmers, pilots, and many others. The weather data collected by these stations is essential for daily weather monitoring, weather forecasting, scientific research, and a variety of other applications, such as agriculture, flood forecasting, and natural resource management.

1.2 ESP32 microcontroller

ESP32 is a very popular WiFi and Bluetooth based microcontroller. Here are some key specifications of the ESP32:

- Dual-Core Microcontroller
  The ESP32 is equipped with two CPU cores supporting the Xtensa LX6 architecture. This allows the ESP32 to run multiple tasks in parallel, which improves performance and energy efficiency.
- High Clock Speed
  The ESP32 has a clock speed of up to 240 MHz, which makes it very fast at executing instructions and data processing tasks.
- Wi-Fi
  The ESP32 supports Wi-Fi 802.11 b/g/n connectivity. It allows the device to connect to a Wi-Fi network and communicate with other devices or servers via the Wi-Fi protocol.
- Bluetooth
  Apart from Wi-Fi, the ESP32 also supports Bluetooth 4.2 and BLE (Bluetooth Low Energy). This allows the ESP32 device to communicate with other Bluetooth devices, such as smartphones.
- Flash Memory
  The ESP32 has internal Flash memory that can be used to store programs and data. This Flash memory can vary depending on the ESP32 variant used, ranging from 4MB to 16MB.
- RAM
  The ESP32 has sufficient RAM, usually around 520 KB available for applications.
- GPIO (General-Purpose Input/Output)
  The ESP32 has a number of GPIO pins that can be used to connect various external devices such as sensors, motors or displays.
- Audio Processing Hardware
  Some ESP32 variants are equipped with an audio processing unit that allows the device to perform audio processing tasks, such as recording and playing sound.
- UART, SPI, I2C, PWM
  The ESP32 has various communication interfaces such as UART, SPI, I2C, and PWM that allow connection to various types of external devices.
- USB-Serial Converter
  The ESP32 is equipped with a USB-Serial converter that allows programmers to connect it to a computer via USB to program the device.
- Security
  ESP32 includes security features such as data encryption, hashing, and support for SSL/TLS certificates, which are important in applications that require secure communications.
- Low Power Consumption
  One of the advantages of the ESP32 is its ability to minimize power consumption in sleep mode, which makes it ideal for battery-powered applications.
- Power Management System (Power Management)

The ESP32 has an advanced power management system to optimize power usage, including the ability to wake the device from sleep mode with low power consumption.

ESP32 has become a popular platform for IoT projects and connected device development, due to its ability to integrate Wi-Fi, Bluetooth, and other features in a powerful and efficient package. It also has a lot of support and documentation available to help developers.

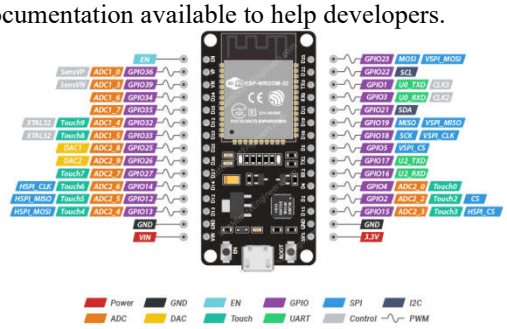

Figure 1. ESP32 Pin Configuration

- **Firebase**

Firebase is a mobile and web application development platform managed by Google. The platform provides a variety of services and tools that enable developers to build, manage, and host applications more efficiently. Firebase has several key concepts that form the basis of understanding the platform:

- **Realtime Database**
  Firebase has a cloud database (database in the cloud) that allows developers to store and access application data in real-time. This means that when there are data changes in the database, those changes will be immediately updated on all connected devices. This is especially suitable for applications that require fast data synchronization, such as chat applications or collaborative applications.
- **Authentication**
  Firebase provides authentication services that allow developers to easily integrate user login and authentication systems into their applications. Users can log in with a Google account, Facebook, or with email and password authentication.
- **Cloud Firestore**
  A part from Realtime Database, Firebase also provides Cloud Firestore services, which is a NoSQL database that can be used to store and access application data flexibly. Firestore supports features such as powerful queries and scalability.
- **Hosting**
  Firebase Hosting allows developers to easily host websites and static web applications on Firebase infrastructure. This allows fast access and high scalability.
- **Cloud Functions**
  Firebase Cloud Functions allows developers to add backend logic to their applications without needing to manage their own servers. You can write JavaScript code that will run in response to certain events in your application.
- **Cloud Storage**
  Firebase provides a file storage service in the cloud that allows you to store and manage files such as images, videos, and other documents easily.
- **Authentication**
- Firebase provides authentication services that allow users to register, sign in, and manage their accounts. This includes integration with third-party authentication providers such as Google, Facebook, and Twitter.
- **Cloud Messaging**
  Firebase Cloud Messaging (FCM) is used to send push messages to mobile applications. This is important for sending notifications to users and keeping users engaged.
- **Performance Monitoring and Analytics**
  Firebase provides tools to monitor your app's performance and analyze user behavior. You can understand how users interact with your app and make improvements based on this data.

Firebase is a very useful platform for developers who want to build mobile and web applications quickly without having to spend a lot of time managing backend infrastructure. This allows for greater focus on feature development and user experience.

2. METODOLOGI

The research was carried out in the following stages:

- Study of literature
  As reference material for designing a weather data processing system that applies internet of things technology taken from previous research results in the form of published papers and reference books.
- Electronic Circuit Design
  Designing an electronic circuit that can implement a weather data station with internet of things technology using the main component of the ESP32 microcontroller
- **Software Design**
  Designing two types of software, namely for weather data station system hardware and for mobile applications using Android and creating a cloud database using Firebase
- **System Testing and Evaluation**
  Carry out system testing to determine whether its performance meets the objectives or not, then carry out evaluations and make modifications so that it meets the objectives.

The block diagram of the weather data station system design can be seen in Figure 2 and Figure 3. which consists of hardware and software. The system hardware uses the main component ESP32 as a control center, namely reading sensors that can detect and measure changes in weather parameters. These parameters consist of temperature, humidity, air pressure, rainfall, wind speed, wind direction and weather conditions (sunny and

cloudy). Meanwhile, the software is designed using C++ and Android.

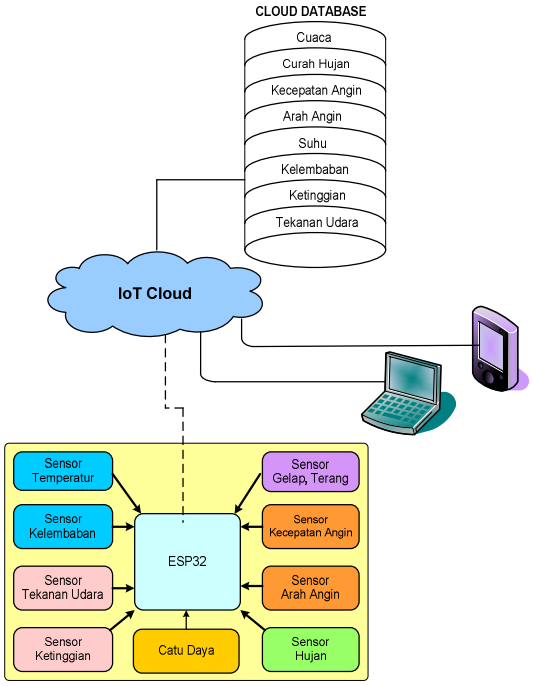

Figure 3 Weather Station Device Block Diagram

3. DISCUSSION

3.1 System Hardware

The hardware design uses the main components of the ESP32 and sensors related to the weather parameters to be measured. The sensor components related to measuring weather data are the DHT 22 sensor which is used to measure temperature and humidity parameters, the rain sensor uses a PCB piece which is designed to have a striped path connected to an amplifier circuit. The rainfall sensor can be seen in Figure 4.

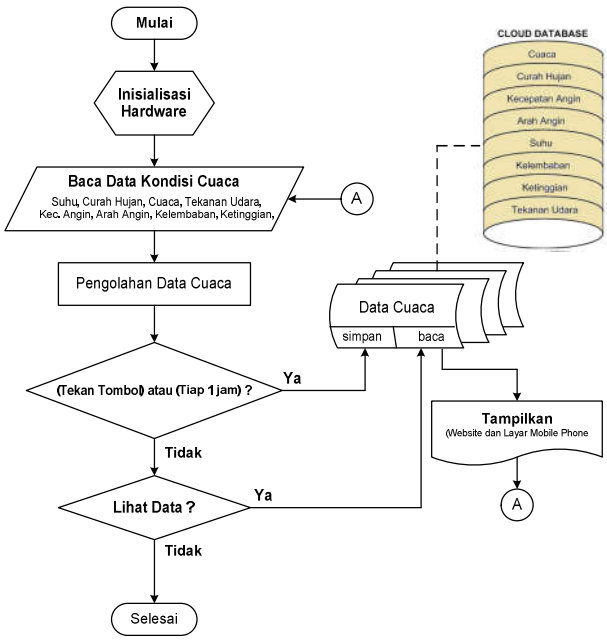

Figure 3. System Software Flow Diagram

The way the rain sensor works is quite easy. The sensor plate with a series of exposed copper traces, together acts as a variable resistor (like a potentiometer) whose resistance varies according to the amount of water on its surface.

Figure 4 Rainfall Sensor

The electronic circuit that detects rain and rainfall can be seen in Figure 5. Output D0 generates HIGH or LOW logic. When the D0 output has a LOW logic, the sensor circuit detects rain and vice versa, if it has a HIGH logic, no rain will occur. The A0 output is in the form of an analog voltage VA0. Output A0 can be calculated using the following formula:

$$VA0 = \frac{R\_rain\_sensor}{R1+R\_rain\_sensor} x5V \quad (1)$$

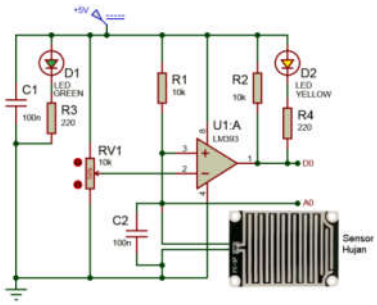

Figure 5 Rainfall Sensor Circuit

The other sensor components are speed sensors and wind direction indicators. The concept of the wind speed sensor is to convert the rotation of a propeller blown by the wind into a square wave with an amplitude of 3.3 volts. The box waves are processed by the ESP32 to determine wind speed. The sensor for wind direction uses the TCR5000 optical reflector component. This sensor detects light reflections from objects in front of it. Then, to determine the weather conditions (sunny or cloudy, use a photo resistor or LDR (Light Dependent Resistor). The circuit can be seen in Figure 6. The circuit functions as a voltage divider circuit, so that the voltage output at point x (Vx) can be calculated using the following formula :

$$Vx = \frac{Rldr}{R1+Rldr} x\ 3.3V \quad (1)$$

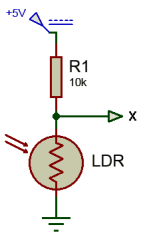

Figure 6 Light Dark Sensor Network

Then Vx which is an analog voltage will be converted into a digital voltage via the GPIO (analog input pin) of the ESP32. The conversion result is in the form of a positive integer. The positive number is used to determine sunny or cloudy conditions. Air pressure measurement using the BMP280 module. The BME280 sensor interface circuit with ESP32 can be seen in Figure 10.

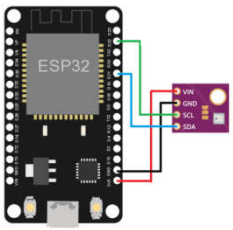

Figure 7 ESP32 interface with BMP280

3.1 System Software

The system software was designed using C++, Android and a cloud database using Firebase. C++ software is used to create a program that is uploaded to the ESP32 which functions to retrieve weather parameter data from sensors that are connected to the ESP32. To upload the program using the Arduino IDE. The software for reading weather data parameters is designed in the form of a function program which can be seen in table 1.

Table 1. List of Function Programs in ESP32

Function Program	Description
void arah_angin()	To detect wind direction
void kec_angin()	To measure wind speed
void cuaca()	To find out weather conditions (clear or cloudy)
void bme280()	To measure air pressure
void Hujan()	To measure rainfall
void SensorDht22()	To measure air temperature and humidity

The following is one of the function programs uploaded to the ESP32, namely the function program for detecting wind direction shown in Figure 8.

```
void arah_angin(){
  if (digitalRead(pin_N) == LOW){
    Arah_mata_angin = "Utara";
  }
  else if (digitalRead(pin_NE) == LOW){
    Arah_mata_angin = "TimurLaut";
 else if (digitalRead(pin_W) == LOW){
    Arah_mata_angin = "Barat";
  }
  else if (digitalRead(pin_NW) == LOW){
    Arah_mata_angin = "BaratLaut";
  }
  else Arah_mata_angin = "";
  Serial.println(Arah_mata_angin);
}
```

Figure 8 Wind Direction Detection Function Program

Android software is used to create applications that can read weather parameter data stored in the cloud and display it on the mobile phone layer. The program was created online using Kodular. A snippet of the Android program can be seen in Figure 9. In making the Android program, it consists of a program for storing and viewing weather parameter data on the mobile phone layer. Meanwhile, Firebase is a program for processing weather parameter databases stored in the cloud, which can be seen in Figure 10.

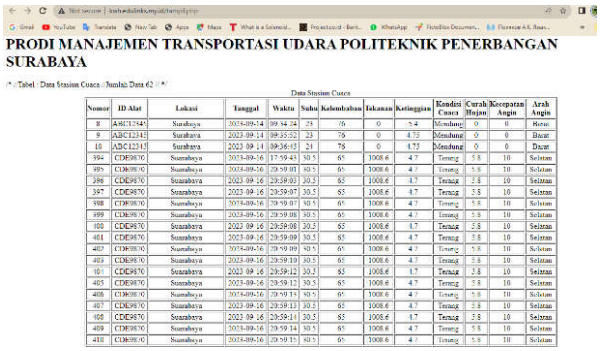
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Figure 10. Realtime Data Base on the Cloud

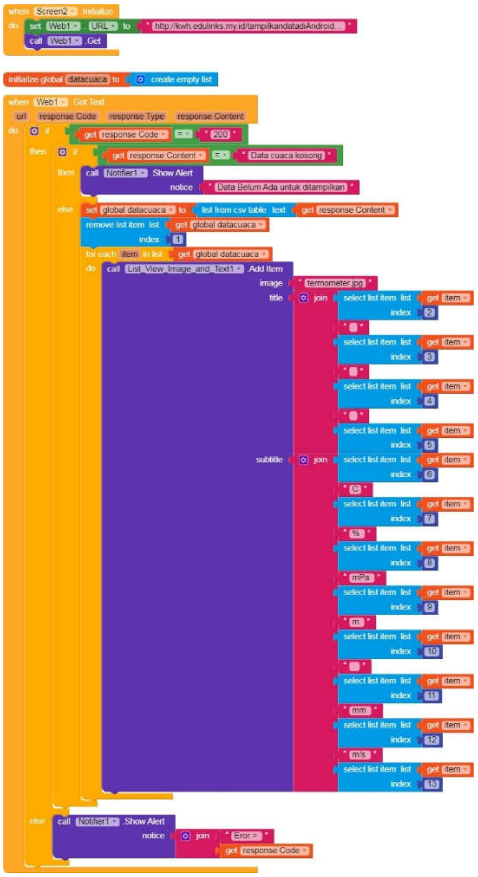

Figure 9 Android Program

3.2 Test Results

The results of testing the tool to determine weather conditions online which are stored in a cloud database

using Firebase can be seen in Figure 11. Which displays the current conditions online and in Figure 12 displays the database of weather data parameters stored in the cloud at certain locations, days and hours. So the weather data is scientific data that can be processed to predict surrounding weather conditions.

4. KESIMPULAN

Some conclusions from this research are as follows:

- This research succeeded in designing an IoT system that can collect weather data from sensors installed in the Surabaya location. This helps in the collection of extensive and representative weather data.
- Weather data collected by this IoT system is stored in a database, which allows for deeper data analysis and keeps historical records of weather conditions.
- Weather data analysis through IoT platforms can provide valuable insights, such as long-term weather patterns, climate change, and early warning of extreme weather such as storms and floods.

Figure 11 Mobile Application Display

Figure 12. Weather Database Display

- The results of this research can be used as a basis for further development in IoT-based weather monitoring and also as a contribution to improving natural resource management and mitigating the impacts of climate change.

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