REAL TIME SYSTEM AND INTERNET OF THINGS FINAL PROJECT REPORT
DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITAS INDONESIA

ForecastBuddy: Real-time Weather and Environmental Monitoring with ESP32 Using BMKG API and DHT11 Sensor

Group 20

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PREFACE

Praises and thanks are continuously offered to the Almighty God for his blessings and grace, which have enabled us to complete our final project titled 'ForecastBuddy: Real-time Weather and Environmental Monitoring with ESP32 Using BMKG API and DHT11 Sensor'. This report is designed to fulfill the requirements of the Real Time System and Internet of Things Practicum class of 2023 at the Faculty of Engineering, Department of Computer Engineering, University of Indonesia. Certainly, the preparation and completion of this final project report were not possible without the help and support of various parties. Therefore, we would like to express our heartfelt gratitude to all those involved, especially to:

1. Mr. Fransiskus Astha Ekadiyanto as the lecturer of the Real Time System and Internet of Things class of 2024.
2. The Digital Lab assistants who have assisted and guided us during the Real Time System and Internet of Things practicum.
3. Our team members who have contributed both in terms of materials and ideas.

We are fully aware that there are still many mistakes in the preparation of this report, both in terms of vocabulary, grammar, and content. Therefore, we expect the readers to provide their criticisms and suggestions as much as possible regarding this report. Thus, this final project report on Real Time System and IOT practicum is completed. Hopefully, this report will be beneficial for us as the authors and also for the readers as an introduction as well as improvement to the computer engineering field.

Depok, December 10, 2024

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CHAPTER 1
INTRODUCTION

1.1. PROBLEM STATEMENT

Real-time weather and environmental monitoring is a crucial aspect in various fields, such as agriculture, fisheries, and urban planning. One way to perform this monitoring is by utilizing temperature and humidity sensors like the DHT11, which provides local data about environmental conditions. However, to ensure the accuracy of the obtained data, it is essential to compare it with broader and verified data, such as that provided by the BMKG (Meteorological, Climatological, and Geophysical Agency).

This project aims to develop a real-time weather and environmental monitoring system using the ESP32, DHT11 sensor, and BMKG API. The system will read temperature and humidity data from the DHT11 sensor and compare it with the temperature and humidity data obtained from the BMKG API, to ensure the accuracy and relevance of the received data in both local and global contexts.

1.2. PROPOSED SOLUTION

To address the challenges in real-time weather and environmental monitoring, the **ForecastBuddy** project will integrate the following features and approaches:

1. DHT11 Sensor Functionality

   The DHT11 sensor will be used to measure temperature and humidity locally. This sensor provides accurate and reliable data for monitoring environmental conditions in real-time. By using the DHT11, we can gather essential data regarding local weather conditions without the need for multiple sensors.

2. BMKG API Integration

   The project will utilize the **BMKG API** (https://api.bmkg.go.id/publik/prakiraan-cuaca?adm4=32.76.06.1002) to fetch real-time temperature and humidity data from BMKG's weather forecast service. This data will be compared with the local data gathered from the DHT11 sensor to verify the accuracy and consistency of the readings in both local and global contexts.

3. Blynk Integration

   To make the data more accessible, the project will integrate with the **Blynk platform**, which allows users to view real-time weather parameters on their mobile devices. The Blynk app will display the temperature and humidity data captured by the DHT11 sensor, along with the BMKG forecast data. Users will be able to monitor both historical trends and live conditions, providing them with a comprehensive view of the environment.

1.3. ACCEPTANCE CRITERIA

The acceptance criteria of this project are as follows:

1. Design and Build the Weather Monitoring System

   The weather monitoring system using the DHT11 sensor and ESP32 is successfully designed and built.
2. Sensor Readings Work Well

   The temperature and humidity readings from the DHT11 sensor function correctly and provide accurate data under various environmental conditions.
3. Comparison with BMKG API Data

   The temperature and humidity data obtained from the DHT11 sensor can be compared with the data from the BMKG API and yield consistent results.
4. Successful Blynk Integration

   The system successfully integrates the Blynk platform with the DHT11 sensor and ESP32 to display real-time sensor readings through a user-friendly interface.

1.4. ROLES AND RESPONSIBILITIES

The roles and responsibilities assigned to the group members are as follows:

Roles	Responsibilities	Person
Programmer	Create ESP32 implementation code, sensor integration with LCD and blynk	Muhammad Billie Elian Fathin Umara Aero

Schematic Design	Create a schematic circuit for ESP32 and DHT11 sensor	Muhammad Billie Elian Fathin Umara Aero Adhelia Putri Maylani Muhammad Rifki Pratama
Circuit Design	Compose the original circuit	Adhelia Putri Maylani
Powerpoint and Reports	Compile reports and create powerpoints for projects	Adhelia Putri Maylani Muhammad Rifki Pratama

1.5. TIMELINE AND MILESTONES

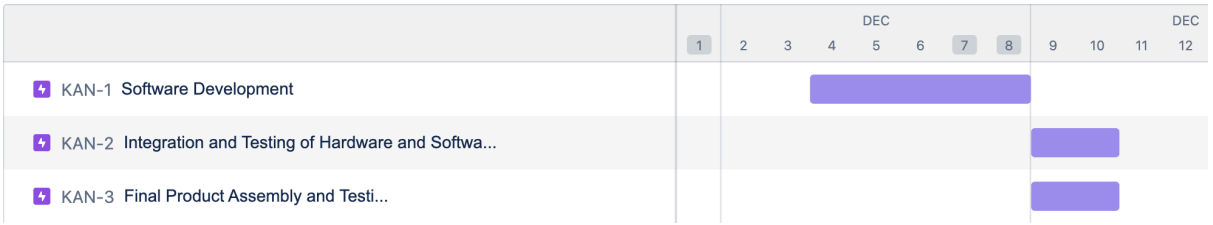

Fig. 1 Timeline Project

CHAPTER 2
IMPLEMENTATION

2.1. HARDWARE DESIGN

The hardware design for the ForecastBuddy system includes several key components that work together to collect and display real-time weather data. At the core of the system is the ESP32, a powerful microcontroller that acts as the central processing unit (CPU). The ESP32 is responsible for managing the communication between the various components, including the DHT11 sensor and the BMKG API. The DHT11 sensor, known for its high accuracy, is used to measure the local temperature and humidity. The sensor communicates with the ESP32 via a digital pin (GPIO4), while also receiving power from the 5V pin.

The data from the DHT11 sensor is then compared to the weather forecast data fetched from the BMKG API. The real-time data will be displayed on a Blynk application. The ESP32 communicates with Blynk over Wi-Fi to send temperature and humidity readings, as well as weather forecast information, to the app. This allows users to easily monitor both local environmental conditions and the weather forecast in a clear and convenient manner on their mobile devices. The ESP32 is powered through a 5V USB connection or an external power source, providing a compact and efficient setup for the system. For all these components to communicate seamlessly, jumper cables are used to connect the DHT11 sensor to the ESP32, and these connections are organized on a breadboard. The breadboard serves as the foundation, holding all the components securely in place and facilitating easy adjustments during the testing and prototyping phase. The system's power supply is provided through the ESP32. Overall, this setup ensures that the ForecastBuddy system is able to efficiently collect environmental data, process it in real-time, and provide users with valuable weather insights through the Blynk app.

2.2. SOFTWARE DEVELOPMENT

The software development for the ForecastBuddy project involves programming the ESP32 to interact with the DHT11 sensor, retrieve weather data

from the BMKG API, and display the results using the Blynk platform. All the necessary programming is written in a single .ino file, with the integration of various libraries for each component.

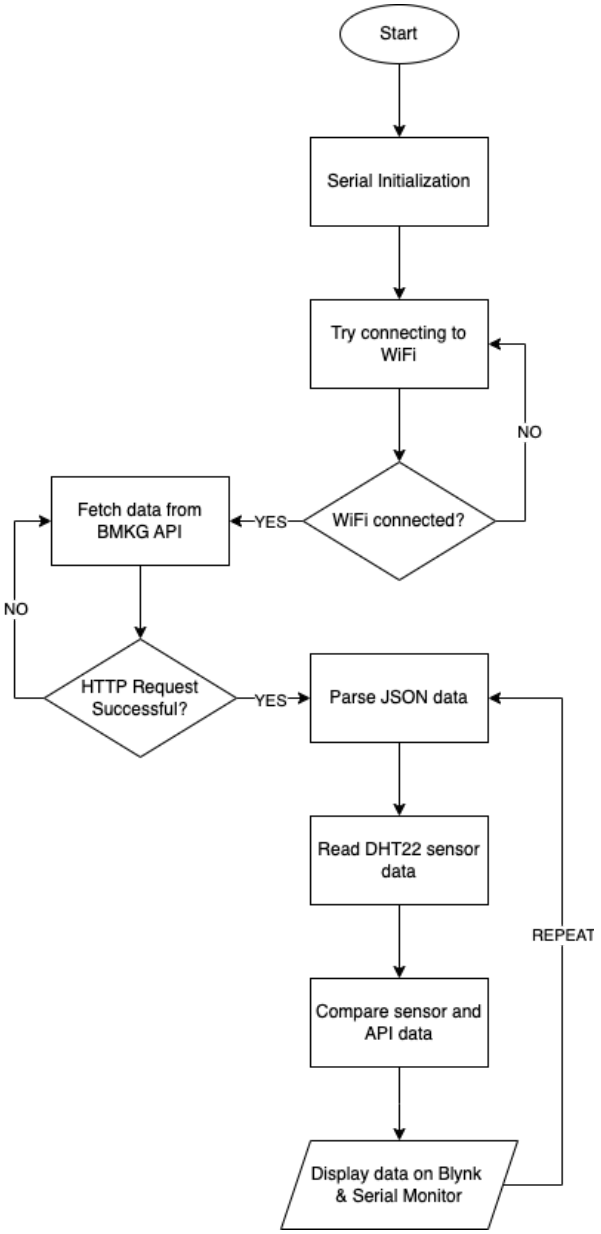

Fig. 2 Flowchart

ForecastBuddy project involves programming the ESP32 to interface with the DHT11 sensor, retrieve weather data from the BMKG API, and display the results through the Blynk platform. Initially, the ESP32 attempts to connect to a Wi-Fi network. If the connection is successful, it proceeds to access the BMKG API to retrieve weather data such as temperature, humidity, and weather conditions. If

there’s an issue with the connection or the API request, the system will retry until a successful response is received. Once the weather data is fetched, the program reads the local temperature and humidity from the DHT11 sensor. The data from the DHT11 sensor is then compared with the data obtained from the BMKG API, verifying the consistency and accuracy of both data sources.The final results, including temperature, humidity, and weather conditions, are displayed on the Blynk app in real time, allowing users to easily monitor the weather. Additionally, the same data is printed on the Serial Monitor for debugging and verification. The program ensures continuous operation by updating the weather data at regular intervals and includes error handling to ensure smooth functionality even if a failure occurs during data fetching or sensor reading.

2.3. HARDWARE AND SOFTWARE INTEGRATION SCHEMATIC

Finally, the hardware and software will be integrated by uploading the program into ESP32 and connecting all necessary components in place and configuring the communication protocols. Forget not the Blynk template for the IoT integration with Wi-Fi connection. Once the hardware and software are ready, the integration phase focuses on establishing communication between the components, and testing the system's functionality.

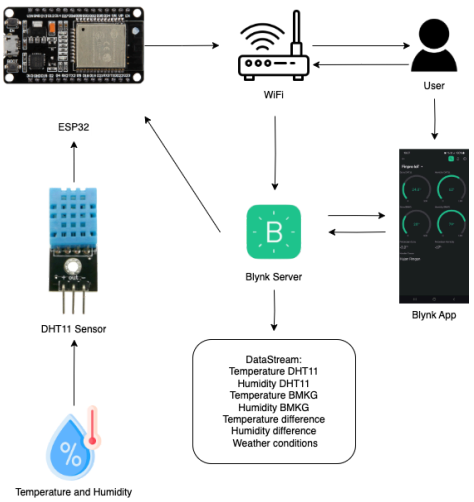

Fig. 3 Schematic

Comprehensive documentation is crucial, covering hardware assembly, software implementation, calibration procedures, and user instructions. This

documentation serves as a valuable guide for effectively utilizing and maintaining the **ForecastBuddy** weather monitoring system. The successful integration of hardware and software components ensures smooth operation and provides accurate and reliable readings of temperature, humidity, and weather conditions.

CHAPTER 3
TESTING AND EVALUATION

3.1. TESTING

In the testing phase of our ForecastBuddy project, several tests were conducted to ensure the proper functioning of both the hardware and software components. The main objective was to verify that the ESP32 could successfully connect to the Wi-Fi network and retrieve accurate weather data from the BMKG API. Upon establishing a successful connection, the program was tested to ensure that data was correctly fetched from the API and displayed on the Serial Monitor.

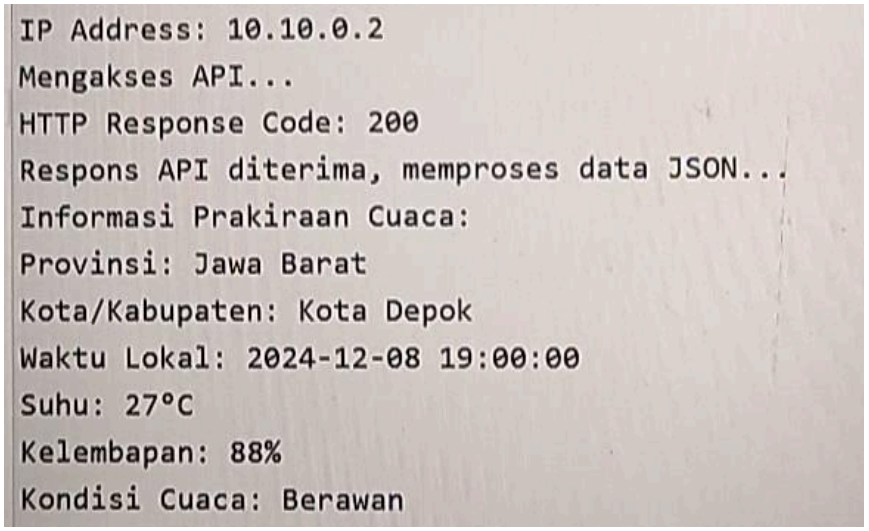

Fig. 4 Serial Monitor Testing Result BMKG API

During the first phase of testing, we verified that the ESP32 was able to retrieve and display weather data such as the province, city/district, local time, temperature, humidity, and weather condition. This data was displayed accurately on the Serial Monitor, confirming that the program could successfully interact with the BMKG API. The results showed the correct values of temperature, humidity, and weather conditions, as well as the corresponding location information.

Next, we focused on testing the sensor data. The DHT11 sensor readings for temperature and humidity were compared to the weather data obtained from the BMKG API. The results were consistent, ensuring that both data sources were

accurate and could be used for comparison. The sensor readings were also successfully displayed on the Serial Monitor, showing the local temperature and humidity.

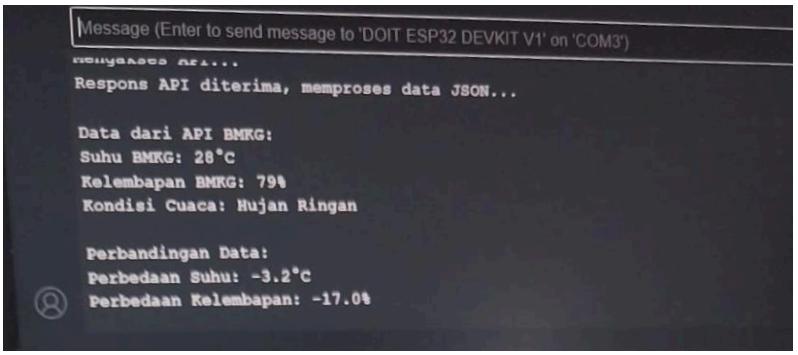

Fig. 5 Serial Monitor Testing Result Read DHT11 and Compare

In the next phase, we tested the Blynk mobile app integration. The data from the sensor and API was successfully sent to the Blynk app, where it was displayed in real-time. The Blynk interface showed the temperature, humidity, and weather conditions, offering a user-friendly platform to monitor the weather data remotely.

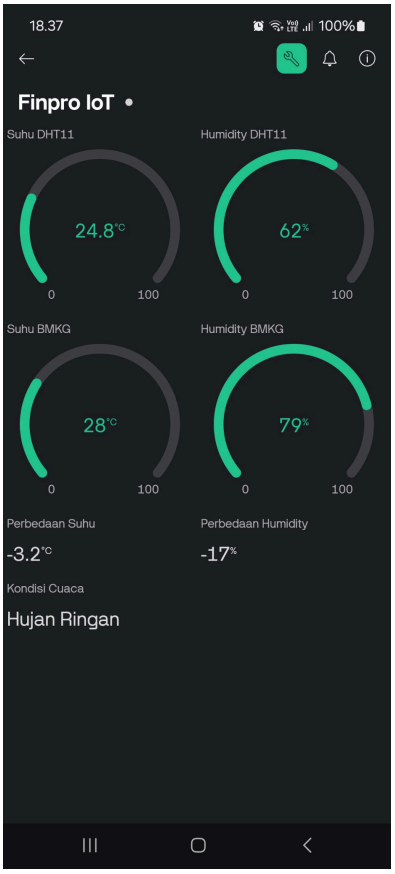

Fig. 6 Blynk Result

Overall, the testing phase confirmed that the ForecastBuddy system is able to successfully connect to the Wi-Fi, fetch data from the BMKG API, read data from the DHT11 sensor, and display both sensor and API data on the Serial Monitor and Blynk app for user monitoring.

3.2. RESULT

The results from the testing phase of the ForecastBuddy project align with the expectations and predefined criteria, confirming that the system functions as intended. Throughout the testing process, both the hardware and software components were thoroughly evaluated to ensure smooth integration and optimal performance, particularly in how the ESP32 interacts with the BMKG API, the DHT11 sensor, and the Blynk platform.

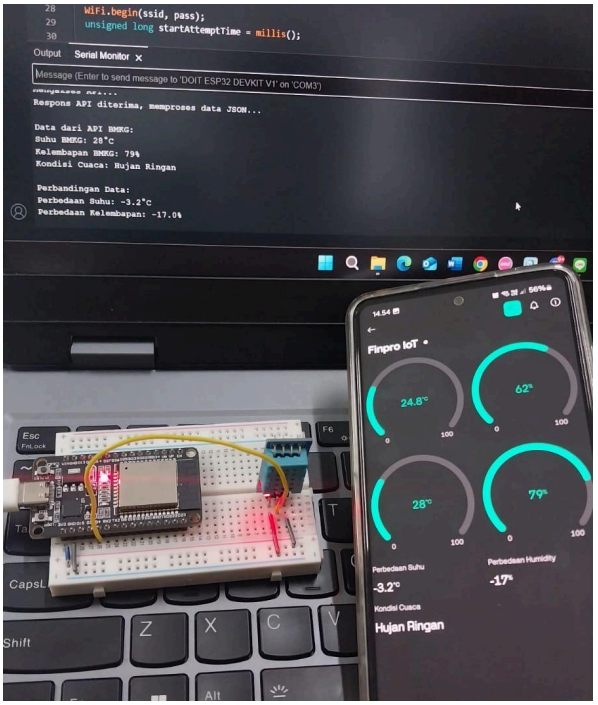

Fig. 7 Final Result

Based on the comprehensive testing outcomes, the ForecastBuddy system successfully integrated both hardware and software components to provide a functional and reliable weather monitoring system. The system not only reads and displays temperature and humidity data from the DHT11 sensor, but also effectively

fetches weather data from the BMKG API for a complete forecast. The integration with Blynk ensures that users can access and monitor the data remotely, making it a user-friendly and efficient solution for real-time weather monitoring.

3.3. EVALUATION

The ForecastBuddy project was evaluated based on its ability to meet the established objectives and functionality criteria. The system successfully integrates the ESP32 microcontroller, the DHT11 sensor, the BMKG weather API, and the Blynk platform to provide real-time weather monitoring and analysis. Below are the key evaluation aspects:

1. Functionality

   The ESP32 effectively communicates with the DHT11 sensor to gather local environmental data, including temperature and humidity. The system also retrieves weather forecast data from the BMKG API, displaying relevant information such as province, city/district, local time, temperature, humidity, and weather condition. Data is seamlessly displayed both on the Serial Monitor for debugging purposes and on the Blynk mobile app for display. The integration between the components was stable and performed as expected during the testing phase.

2. Accuracy

   The comparison between the data from the DHT11 sensor and the BMKG API forecast showed that the system was able to accurately retrieve and display the weather data. The temperature and humidity readings from the sensor were consistent with the forecasted values, validating the accuracy of both the local environment data and the weather forecast.

3. Reliability

   During the testing process, the system operated reliably without major issues. The ESP32 was able to maintain a stable Wi-Fi connection and consistently fetch data from the BMKG API and the DHT11 sensor. The system was able to handle the retrieval of weather data and local environmental measurements without errors or crashes.

4. Performance

   The system responded promptly to data requests, with minimal delays in retrieving weather data from the API or reading from the sensor. The data was

updated in real-time on the Blynk mobile app, and the performance of the system met the expected standards.

5. Scalability and Future Improvements

   While the ForecastBuddy system is functional in its current form, there are potential areas for future enhancement. For example, adding more sensors to monitor other environmental factors such as air quality or UV levels could expand the capabilities of the system. Additionally, improving the mobile app interface or adding push notifications for significant weather changes would enhance the user experience.

CHAPTER 4
CONCLUSION

The ForecastBuddy project successfully met its objective of providing real-time weather and environmental monitoring by integrating the DHT11 sensor, the BMKG weather API, and the Blynk platform. The combination of these components enabled the system to measure local temperature and humidity through the DHT11 sensor while comparing the data with weather forecast fetched from the BMKG API. The use of Blynk provided an intuitive, mobile-friendly interface for users to monitor these data in real-time.

During the evaluation phase, the system's performance was found to be reliable and accurate. The data retrieved from the DHT11 sensor and the BMKG API were consistently synchronized, with clear and accurate readings displayed via the Blynk app. The integration with Blynk allowed users to easily access the weather data from their mobile devices, ensuring a smooth user experience. The system also performed well in terms of response time and reliability, with minimal lag when retrieving data and displaying it on the Blynk platform.

However, there are still opportunities for further enhancement. Future iterations could involve adding additional sensors for more comprehensive environmental monitoring or improving the system's power efficiency for extended use in remote locations. Additionally, integrating more detailed weather parameters from the BMKG API, such as wind speed and pressure, could enhance the system's forecasting capabilities.

Overall, the ForecastBuddy system is a robust, functional solution for real-time weather tracking. It demonstrated its ability to provide accurate environmental data, and with further improvements, it could become an even more comprehensive tool for weather and environmental monitoring.

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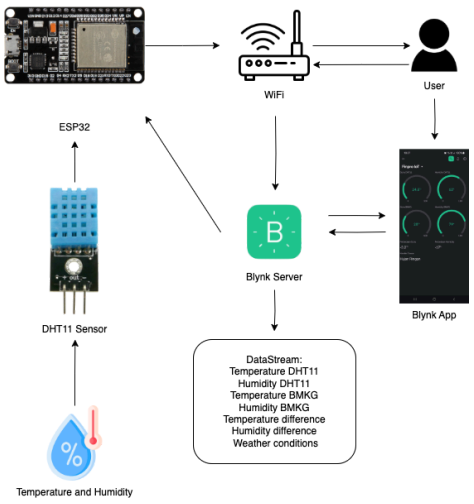
APPENDICES

Appendix A: Project Schematic



Appendix B: Documentation