Predicting Weather Conditions by the Internet of Things Platform

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Abstract. Weather stations are built to collect quantitative data on the weather conditions of a place. Monitoring the weather conditions in the current environment is considered to be very important because the erratic weather changes every day. This study tried to create a weather station that can be accessed through the website using the IoT platform. Users can know the weather changes in an area without the need to come to the area. The design of this weather station uses the main components of the ESP32 microcontroller because this microcontroller is already integrated with Bluetooth and wifi. The design results of this tool can measure data weather consisting of temperature parameters, humidity, air pressure, rainfall, wind speed, wind direction as well as day, night, and cloudy conditions. The results of measuring the parameters of weather data are stored on the cloud firebase database server and can be accessed via an *android mobile phone*.

Keywords: Weather station · Esp32 · IoT. Firebase

1 Introduction

The impact of climate on human existence has always been enormous, so observing fluctuations in weather parameters is very important, because weather data reports are very important for many sectors such as the Agriculture sector, Aviation Institutions, and Financial Institutions[1].

Changes in weather conditions have been observed for centuries while the process of measuring weather conditions has occurred in several stages in history and there has been no modern development of equipment used to measure weather until the 1400s. Before this, weather observations were very simple, mostly based on the appearance of the sky and the nuances of the air. Most of the development of this weather tool was required not only by agriculture but also due to the improvement of sea travel. Since storms at sea can be deadly, and the ships are driven by wind, the ability to predict relevant weather conditions for sailing and flight is of paramount importance.

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Weather observations began to be developed in the early to mid-years. The 1400s. The measurement of weather parameters is carried out manually and separately and the accuracy of the measurement results is not as thorough, this is because the sensor technology used is not as sophisticated as it is today.

At this time the weather station is already working automatically so that it can increase the number and reliability of these weather observations. With the background that has been described above, a study is proposed to make a prototype of a weather data measuring instrument that is integrated into one that uses advanced and modern technology to improve the reliability of measurement results. In addition, the database of measurement results is stored in the *cloud* and monitored from computers and smartphones through the internet.[4].

Research on weather data stations has been widely carried out by previous researchers, namely low-cost weather monitoring systems that take weather conditions in any location from *a cloud* database management system and display the output on an OLED screen. The system uses The Wemos D1 which uses the main components of the ESP8266 and is implemented on the Arduino platform used to retrieve data from the *cloud*, see the weather conditions in any location and make it possible to access the latest data from any station[3].

1.1 Internet of Things

The Internet of things, or *IoT*, is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people equipped with unique identifiers (UIDs) and the ability to transfer data over a network without the need for human-to-human or human-to-computer interaction.

Something on the *Internet of Things* can be a person with a heart monitor implant, a farm animal with a biochip transponder, a car that has a built-in sensor to warn the driver when tire pressure is low, or other natural or man-made.

Increasingly, organizations in various industries are using *IoT* to operate more efficiently, better understand customers to provide enhanced customer service, improve decision-making and increase business value.

The *IoT* ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors, and communication hardware, to collect, send, and act on the data they obtain from their environments. *IoT* devices share the sensor data they collect by connecting to an *IoT gateway* or other edge device where data is sent to the *cloud* for analysis or analysis locally. Sometimes, these devices communicate with other related devices and act on the information they get from each other. Devices do most of the work without human intervention, although people can interact with devices, for example, to set them up, give them instructions, or access data[6].

1.2 Weather Station

A weather station is a set of tools or instruments used to observe the weather, climate, and atmospheric conditions or changes in a region and record them in the form of data. Once recorded, the data is stored in a data logger and then for study by users or researchers. In short, this tool is a weather measuring device.

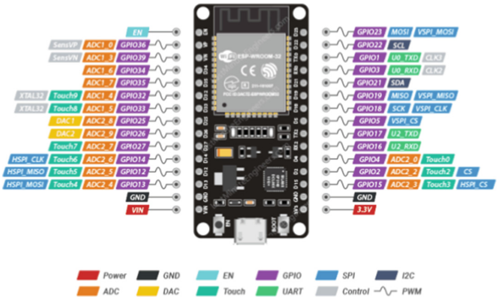


Fig. 1. ESP32 Pin Configuration

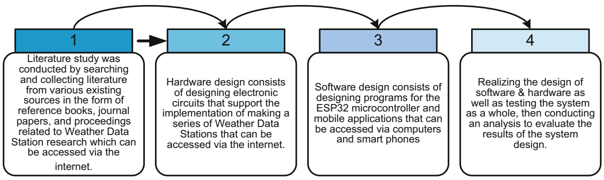


Fig. 2. Flow of Research Implementation

The way the weather station works is by detecting changes in light, wind, temperature, and humidity in a free (outdoor) environment. The sensor will detect the change and record it automatically, then the data is transmitted to the data logger via cable to be processed with a microprocessor and stored the data that has been processed in the form of a log file. Currently, log files can already be converted into text or graphs displayed on the web specifically for its weather station tool.

1.3 ESP32 Microcontroller

Microcontroller ESP32 which is the successor to ESP8266. The ESP32 not only has WiFi support but also features *Bluetooth 4.0* (BLE/Bluetooth Smart) making it perfect for almost any IoT project. One of the advantages of the ESP32 is that it has more GPIO than the ESP8266. The ESP32 has a total of 48 GPIO pins, only 25 pins connected to the header pins are located on either side of its development board (ESP32 board development). The following specifications of the ESP32 can be seen in Table 2.1 and the construction of the ESP32 pinout can be seen in Fig. 1.

2 Methodology

The methodology of the implementation of the research to be carried out in the electronic laboratory of the aviation polytechnic can be seen in Fig. 2

A block diagram of the IoT device hardware design for monitoring weather data can be seen in Fig. 3.2. The diagram of the block consists of several parts, namely:

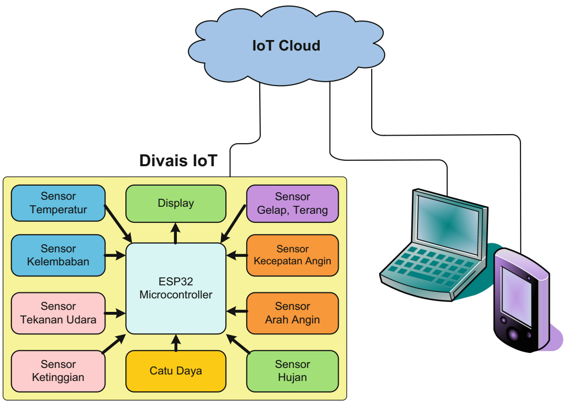


Fig. 3. Weather Station Tool Block Diagram

a) Microcontroller ESP32

It is a micro-control center that functions to read weather change data that has been detected from sensors.

b) Weather Data Sensor

The weather data sensor consists of 8 sensors, namely, temperature sensors, humidity sensors, air pressure sensors, and altitude sensors. The four sensors have been integrated into a BME 280 sensor module. Other sensors are rain sensors, sensors for measuring wind speed and direction, and sensors for detecting the dark and light of the sky (cloudy sensors)

c) Android Smart Phone and Computer

Smartphones and computers are used to monitor real-time changes in weather data.

Software design uses C++ and Android using the MIT App Inventor. The flow chart of such devices can be seen in Fig. 3. To program the ESP32 using C++ through the Arduino IDE while creating mobile applications that use web and android programming languages use the MIT App Inventor. The first thing to do is to create a pin-pin initialization program for the ESP32 microcontroller as input and output as needed.

3 Discussion

3.1 Rain Sensor Circuit

The rain sensor is made of PCB designed as Fig. 4. The way the rain sensor works is quite easy. Sensor plates with a series of exposed copper traces, together act as variable resistors (such as potentiometers) whose resistance varies according to the amount of water on the surface [8] (Fig. 5).

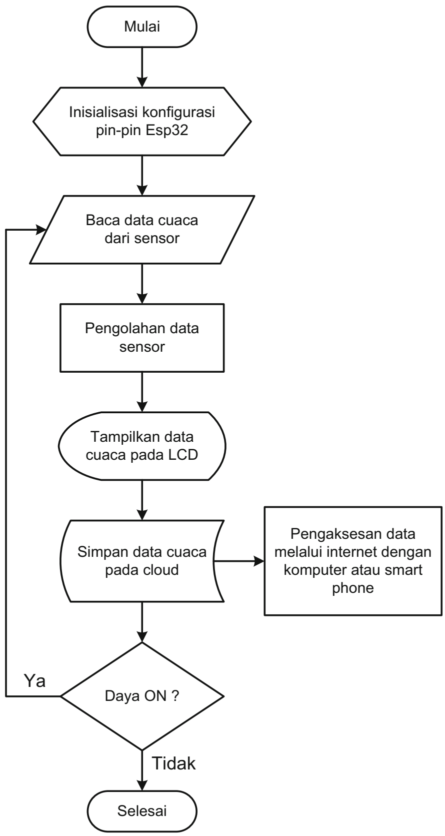


Fig. 4. System Software Flowchart

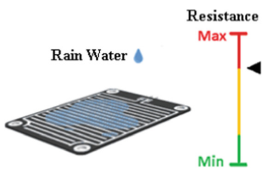


Fig. 5. Rainfall Sensor

An electronic circuit that detects the occurrence of rain and precipitation can be seen in Fig. 6. The D0 output evokes the logic of HIGH or LOW. When the D0 output is low, the sensor circuit detects rain and vice versa if it is HIGH there is no rain. Output A0 in the form of an analog voltage VA0. The output of A0 can be calculated by the following formula:

$$VA0 = \frac{R\_rain\_sensor}{R1 + R\_rain\_sensor} \times 5V \tag{1}$$

will cause rainfall.

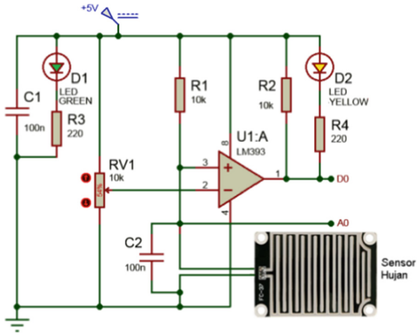
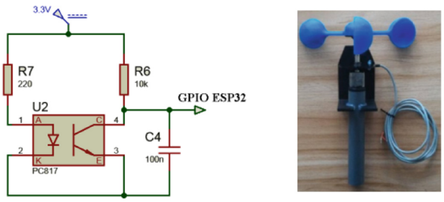


Fig. 6. Rainfall Sensor Circuit



a. Electronic circuits b. Mechanical Construction

Fig. 7. Wind Speed Sensor

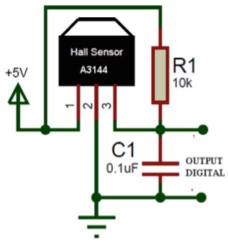


Fig. 8. Magnetic Sensor Circuit

3.2 Wind Speed Sensor Circuit

The circuit for measuring wind speed in principle uses an *optocoupler* that is coupled with a disk. Mechanical construction and one electronic circuit can be seen in Fig. 7.

3.3 Wind Direction Sensor Circuit

A series of sensors for detecting the position of the wind direction using the main components of the Hall Sensor A3144 can be seen in Fig. 8 and the mechanical construction can be seen in Fig. 9.

The magnet has attached to the bottom of the wind direction, while the hall sensor is attached to the PCB in as many as 8 pieces and is located under the magnet. When

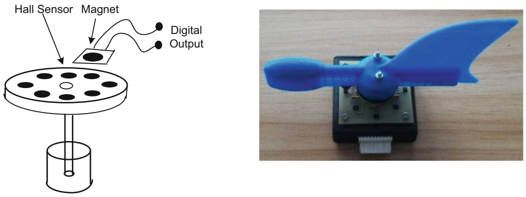


Fig. 9. Mechanical construction of wind direction indicators

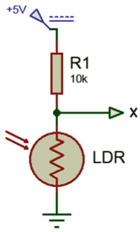


Fig. 10. Bright Dark Sensor Circuit

the wind indicator moves, the position of the magnet also changes in front of the hall sensor which is located under the magnet, so that the output of the hall sensor circuit is in high condition, and the opposite condition is low. Because there are 8 hall sensors, the overall output of the hall sensor is in the form of an 8-bit binary number which is the position code of the wind direction.

3.4 Light Dark Sensor Circuit

A light dark sensor is useful for detecting the time of day or night**.** The realization of this sensor uses LDR (Light Dependent Resistor) electronic components serialized with a 10K resistor, which can be seen in Fig. 10. The circuit serves as a voltage divider so that the voltage output at point x (*Vx*) can be calculated by the following formula:

$$Vx = \frac{Rldr}{R1 + Rldr} x3.3V \tag{2}$$

Then the Vx which is an analog voltage will be converted into a digital voltage via the ESP32 GPIO (analog input pin). The result of the conversion is in the form of a positive integer. The magnitude of the positive number is used to determine the time of day and night.

3.5 BME280 Sensor Range

The BME280 sensor is a sensor used in the manufacture of weather stations to measure altitude, humidity, air pressure, and temperature in a short time. The sensor is quite easy to use, as it has been pre-calibrated and does not require any other additional components. The BME280 sensor interface circuit with the ESP32 can be seen in Fig. 11.

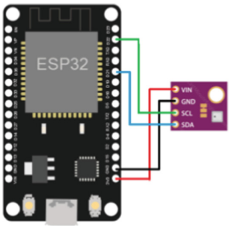


Fig. 11. ESP32 interface with ESP32

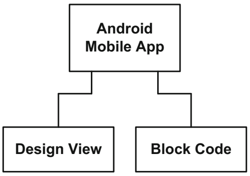


Fig. 12. Weather Station Application block diagram

Fig. 13. Firebase Block Code Section

3.6 Weather Station Application Program

The Weather station Application Program is designed using Modular. Modular is software used to design car applications that use block code. The application design is divided into 2 parts, namely, the display section (*design view*) and block code (*block code*) (Fig. 12).

The block code section for creating a *cloud* database (firebase) can be seen in Fig. 13 (Fig. 14).

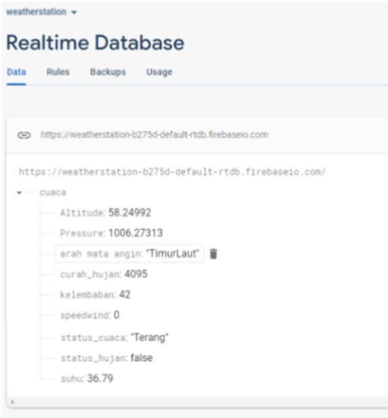


Fig. 14. Realtime Data Base on the Cloud

Fig. 15. App View

3.7 Test Results

The test results of the weather station tool with a display on an *android mobile phone* can be seen in Fig. 15. The measured parameters are temperature, humidity, air pressure, altitude, weather conditions (dark or light), precipitation, again speed, and wind direction.

4 Conclusion

Conclusion of the research results of making weather tools:

1. The tool has worked following the research objectives, namely being able to monitor the weather in the area where the tool is installed.
2. The tool is designed in portable form and the weather measurement results can be monitored via an android smartphone.
3. Weather data can be used to predict events caused by weather conditions.

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