IOT Based Climate Monitoring System

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Abstract. In this paper, an IOT based climate monitoring system for rural area is proposed. The selected location for IOT sensor placement is Sumberbrantas village which is vulnerable for flood, landslide and strong wind disasters. For these reasons wind behaviors, rainfall and temperature sensors are installed in IOT stations. Based on information from local residents, strong winds always blow every year. The wind flowed for several days causing residents to be unable to move outside their homes. This wind is flowing so fast that it can damage the roof of the house. However, currently there is still no device that accurately measures changes in air pressure or wind speed in the area. To collect data, as well as to anticipate problems caused by these strong winds, an IOT-based monitoring system was built to observe the weather that occurred in the area. Experiments show that the proposed monitoring system is able to send monitoring data every 5 minutes. The monitoring data consist of temperature, humidity, wind direction, wind speed, barometric pressure and rainfall.

1. Introduction

The world is always vulnerable toward disaster, whether natural or un-natural. Un-natural disaster is prone to be easier to cope with, since most of them are anticipated since in the design phase. On the other hand, natural disasters generally come suddenly, making it difficult to predict. The United Nations [1] investigated the vulnerability of cities with a population of more than 300,000 in 2018 to disasters.

As a result, there are 6 natural disasters that have the potential to occur in the coming years, namely strong winds, floods, drought, earthquakes, landslides and volcanic eruptions. The results of the study are also relevant for Indonesia. A study conducted by the World Bank [2] shows that up to 2018, there were three main natural disasters in Indonesia, namely floods, strong winds and landslides. Figure 1 shows a comparison of data on natural disasters in Indonesia according to World Bank data.

In the past, the main response to natural disasters was through emergency response and post-disaster recovery programs. Although these two things still have to be done, mitigation programs against natural disasters also really need to be improved. With good disaster mitigation, the number of casualties and damage caused by disasters can be minimized [3]. Some researchers suggest disaster mitigation by predicting the occurrence of a disaster using a stochastic approach [4]. The Internet of Thing (IOT) technology [5], which combines advancement of sensor technology and the internet, is the answer to the real-time data needed for disaster mitigation. By utilizing IoT technology, stakeholders will be able to make the right decisions in a relatively short time for disaster mitigation [3]. Several studies on the use of IOT technology for disaster mitigation can be found in [6][7][8]. Paper [6] proposed IOT in flood monitoring system, while [8] emphasizing on IOT based disaster
User participatory sensing in urban environment is used as complimentary technique for IOT in [7].

In this paper, we propose IOT based climate monitoring system for rural area. The selected location for IOT sensor placement is Sumberbrantas village which is vulnerable for flood, landslide and strong wind disasters. For these reasons wind behaviors, rainfall and temperature sensors are installed in IOT stations. Separated IOT based river monitoring system is also installed in nearby area, but it is not reported in this paper. Based on information from local residents, strong winds always blow every year. The wind flowed for several days causing residents to be unable to move outside their homes. This wind is flowing so fast that it can damage the roof of the house. However, currently there is still no device that accurately measures changes in air pressure or wind speed in the area. To collect data, as well as to anticipate problems caused by these strong winds, an IOT-based monitoring system was built to observe the weather that occurred in the area. The rest of this paper is organized as follows; section 2 described proposed system. Section 3 present the results and discussion and finally concluded in section 4.

2. Proposed System

Weather station systems are an important device to collect the weather historical data and predict the weather forecast. Wind Direction sensors are required in many implementations. One example of its application is for airlines since their schedules rely on the weather condition. Therefore, the design and implementation planning of the system is very important to confirm the durability of the system. The block diagram of the climate monitoring system displayed in Figure 2. The proposed system consists of six sensors. The key requirements of the proposed systems are inexpensive for periodically observing a large area. This paper proposed a weather monitoring system based on the IOT concept. The collected data is sent and stored on the cloud server.

The most popular minicomputer, Raspberry is the brain of the proposed system. Four sensors attached to Raspberry to build a mini weather station resulting in six measurement parameters. Those sensors are follows.

- The Anemometer sensor measures the wind speed.
- The Wind Direction sensor to measures the wind direction
- The DHT sensor to measure the Humidity and Temperature
- The Barometric Sensor to measure current air pressure.

Raspberry Pi employs the GSM/GPRS Module to send the collected data to the cloud server. The complete diagram of the proposed system shows in Figure 2. The details component builds the system will be described in rest of the paper.

The wind speed sensor (anemometer) used a switch to measure the number of anemometer rotation. It shows that if the switch is closed once per second equal to the wind speed of 1.492 MPH. The wind direction sensor is designed with a combination of magnetic switch and resistors. the direction of the wind measured by the output voltage of the resistor block. There are possibilities that the magnetic
switch activates two switches at once to improve the resolution of measurement. However, grouping the measuring result to 8 positions gives the better understanding.

![Figure 2. Block Diagram of The Climate Monitoring System](image)

### 2.1. Raspberry Pi
Raspberry Pi is known as a cheap and powerful on-board computer (shown in Figure 3) It was introduced in 2012 and works as a standard PC. Its performance and price make it a perfect device to connect with other hardware systems. Raspberry Pi consists of CPU, GPU, audio and communications hardware and has 512 MB memory. Raspberry Pi processor is an ARM Based 32-bit, 700 MHz System On Chip. The “hard drive” of this system is SD Flash memory. It’s required 5v power to power up the board, and it has many connectivity options such as Wi-Fi, USB or Ethernet. Wifi is an important key for building wireless connectivity to the internet for IOT Devices.

![Figure 3. A Raspberry Pi board](image)

### 2.2. Wind Speed Sensor (Anemometer)
Anemometer (shown in Figure 4) is part of weather station instrument to measure the wind speed. It consists of a rotated part with four wind cups mounted on horizontal arm. In the middle of this arm, connected with vertical shaft to rotate the magnetic based switch. The switch will be close once every single rotation. The anemometer sensor used in this system shows that the if switch is closed once per second equal to the wind speed of 1.492 MPH.
The proposed system connects an anemometer sensor with GPIO port of Raspberry Pi. Python code is used to read the signal from the sensor to measure the wind speed. The result of measurement is current wind speed and maximum wind speed in a period time. Both results are stored locally and sent to the cloud server every 5 minutes.

2.3. Wind Direction Sensor
The wind direction sensor, or generally called wind vane shown in Figure 5. It combines 8 magnetic switches and 10K ohm resistors. The output voltage of the resistor combination shows the wind flow in 8 directions. Even though there is a possibility that the magnetic switch activates two switches concurrently and resulting in 16 possible combinations, but for the general cases, only 8 directions are recognized as the standard wind direction.

2.4. Temperature/humidity Sensor
DHT Sensor is one of the most used Temperature and Humidity sensors these days (Figure 6). It measures the Temperature and Humidity values periodically based on the update period. DHT sensor employs the resistive type element to read Humidity and negative temperature coefficient for temperature. It is a low-cost humidity and temperature sensor, providing 8-bit data and has a good reliability, sensitivity, stability, high response without any interference. The data pin of DHT is connected to the GPIO port of Raspberry Pi. Other pin is connected directly to VCC and GND of the power source.
2.5. Rain Gauge
To measure rainfall, the proposed system uses a rain gauge (Figure 7. (a)). This sensor uses the concept of two buckets with the same capacity connected by a horizontal arm that accommodates raindrops (Figure 7. (b)). If one of the two buckets is full of water, the raindrops will flow into the other empty bucket, and the bucket filled with water will empty its load. Each time the bucket position changes, it provides a single output signal. The rainfall value is measured by the size of the water in one bucket multiplied by the number of switching between buckets in a period of time.

![Figure 7. Rain Gauge](image)

(a) Physical appearance
(b) The concept of rain gauge

2.6. GSM Module

In order to send the collected data to the cloud, the proposed system uses GSM Network. GSM network is the main mobile communication standard in Indonesia and most countries in the world based on the GSMA Report. GSM technology has reached 5G for data communication. However, because in most areas in Indonesia telco BTS only supports GPRS up to 4G, the proposed system uses GPRS (2G). To take advantage of the advantages of the GSM Data Network, a GSM module for the Raspberry Pi is required. To use GSM technology from GSM Provides, a sim card from the selected telecommunication provider is required. The proposed location survey shows that only Telkomsel as
one of the GSM Providers has a good signal quality. Every 5 minutes, raspberry pi will activate the GSM Module to send data to the cloud server. In addition, the GSM module is set to standby to prevent power waste.

2.7. Cloud system and Client Dashboard
This system employs cloud based system to collect all sensor data. This component play an important role to store all data, generate the dashboard and provide an user friendly views to all users through the client gadget. All data send to the server using API and stored to MySQL Database. The sensors data that stored in the cloud database are humidity, temperature, wind direction, wind speed, air pressure and rain gauge.

3. Result and Discussion

Figures 9-13 show the results of the measurements. It compares the data between hours in days. The result of measurement before 20 Oct, is the testing in the laboratory, and the result on 20 Oct (Figure 13), shows the real measurement on the location displayed as a monitoring dashboard. It is clearly shown that our IOT based climate monitoring system can provide hourly monitoring data for the villagers.

![Temperature by Hour](image)

**Figure 9.** Chart of Temperature

Figure 9 shows the chart of temperature. It shows that the temperature changes inside the laboratory is not significant. The result of the measurement shows that the temperature is between 30 to 32 degree Celsius. However, the sensor result changes significantly when the sensor is located outdoors, on the target location. The temperature dropped below 20 degree after 18PM.

Figure 10 shows the result of the humidity sensor. The sensor reading value is between 40 - 55 percent. However, this result changes significantly when the sensor is deployed in the target location. It shows that the humidity level is increasing after 18PM with more than 75% humidity.

Figure 11 shows the result of the air pressure sensor. Inside the laboratory, the air pressure is constantly in between 940 to 960. However, the result drops to 840 when deploys in the target location.
Figure 10. Chart of Humidity

The result of Wind direction readings is shown on Figure 12. The reading show instability in measurement. however, the result should only divide to 8 values that show the compass direction.

Figure 11. Chart of Barometric Pressure
Figure 13 shows the dashboard design for the users. Each box on the dashboard shows value of different sensor. All sensors information shows the data that stored on server and the last data that received from each physical sensor. The right box shows the location of the weather station sensor.

4. Conclusion
An IOT based climate monitoring system is successfully build for disaster mitigation in Sumberbrantas village. The system can provide hourly data of temperature, humidity, wind direction, pressure, rainfall rate and wind speed. These information are presented in a monitoring dashboard.
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