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Design and Implementation of Mount Agung Eruption Monitoring System Based on Internet of Things (IoT) Technology

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Abstract

Indonesia is known as a country which has more than 100 active volcanoes, including 20 with the status of Beware, Alert, and High Alert. Meanwhile, Mount Agung, located in Bali, is one of the five most dangerous volcanoes in Indonesia which in the last two years produced several eruptions. It is located on the island of Bali which is visited by huge number of tourists. The government of the Republic of Indonesia gives special attention of Mount Agung status to be continuously monitored by relevant institutions. This paper provides Mount Agung eruption monitoring system with Internet of Things (IoT) technology. It has many types of sensors: temperature, humidity, CO2 gas, wind speed, wind direction, and rainfall sensors. These sensors are connected to an Internet connection so they can be monitored remotely by a dashboard application. This monitoring system has been successfully implemented in three locations in Bali in early 2018.

Keywords; *volcano monitoring; disaster management system; internet of things..*

I. INTRODUCTION

Indonesia is a country located in the "ring of fire" or a meeting of two sets of world volcanoes thus it has many active volcanoes [1] with a number of more than 100, with 20 of them having the status of Beware, Alert, and High Alert [6]. According to information from the Geology Agency, there were five volcanoes erupted in 2018 including Mount Agung, Mount Soputan, Mount Anak Krakatau, Mount Sinabung, and Mount Gamalama[6].

Mount Agung is located on the island of Bali which is one of the most popular tourist destinations in the world, with tourists visits reaching five million per year [4]. Related to this, the government of the Republic of Indonesia (RI) gave special attention related to disaster preparedness in Bali due to the large number of foreign tourists coming there. One of the implementation of disaster preparedness in Bali is to build a monitoring system for Mount Agung eruption carried out by authorized institutions such as the Center for Volcanology and Geological Disaster Mitigation (PVMBG). In the field, PVMBG cooperates with several agencies to build this monitoring system, including PT Telkom Indonesia. In this paper, we describe the Mount Agung eruption monitoring system based on the Internet of Things (IoT) technology where the system uses electronic sensors and connected to the Internet so it can be monitored remotely. This system was developed by PT Telkom Indonesia, and has been implemented at the beginning of 2018.

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The composition of this paper is as follows: literature study in the second part, design architecture and application flow in the third part, analysis in the fourth section, and conclusions in the last section.

II. LITERATURE REVIEW

Some research has been carried out regarding the monitoring system of volcanic eruptions. One of them is Meyer et al. [3] who conducted research on monitoring volcanic eruption by improving the performance of remote sensing systems with radar. With photometry and remote sensing techniques from both satellites and unmanned aerial vehicle (UAV), visual data obtained from volcanic activity and data processing analyzes were carried out to produce more accurate information about volcanic activity.

The second study was from Sundari et al. [5] who conducted research on the development of a wireless sensor network (WSN) for monitoring volcanic activity. In the study several sensors were used, they are: piezo electric vibration sensors, CO2 gas sensors, CO gas sensors, Sulphur gas sensors, and temperature sensors. The sensors are connected to an ATMega16 microcontroller with a Zigbee connection.

The third study is research that also covers monitoring volcanic eruptions with WSN, where the parameters used are CO2 / SO2 gas emissions, soil deformation, temperature, hydrology, and remote sensing [2]. An illustration of this monitoring system is illustrated in Fig. 1 below.

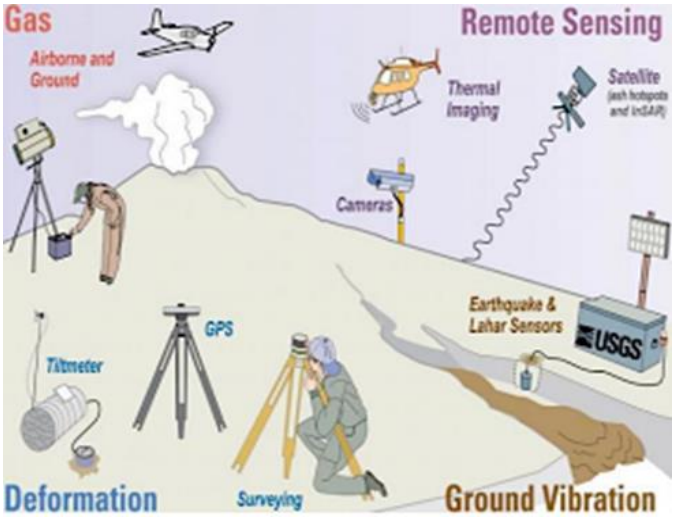

Fig. 1. Eruption Monitoring System with WSN [2]

III. DESIGN

A. Architectural Design

The Mount Agung monitoring system is built with several types of sensors, namely:

- Temperature sensor
- Humidity sensor
- CO2 gas sensor
- Wind speed sensor
- Wind direction sensor
- Rainfall sensors

These sensors are widely connected with an Arduino microcontroller as an IoT gateway which is in charge of collecting data, and then sent to a cloud server located in PT Telkom's data center. An overview of the simple architecture of this system is illustrated in Fig. 2.

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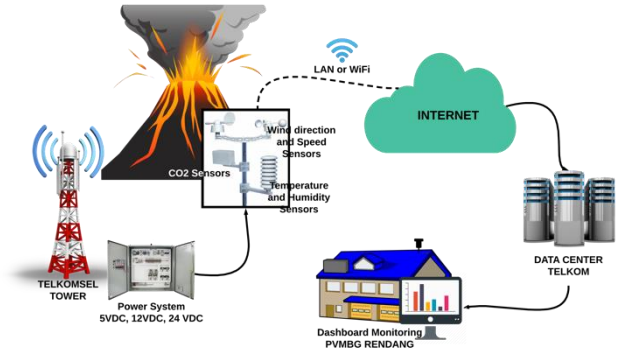

Fig. 2. A Simple Architecture Of Mount Agung Monitoring System

On the sensor side, the temperature and humidity sensors used are DHT11 electronic temperature sensors. This sensor is connected to the analog input of the Arduino microcontroller (Fig. 3). For measurement of temperature and humidity, one special Arduino is used, while for other parameter measurements different Arduino is used.

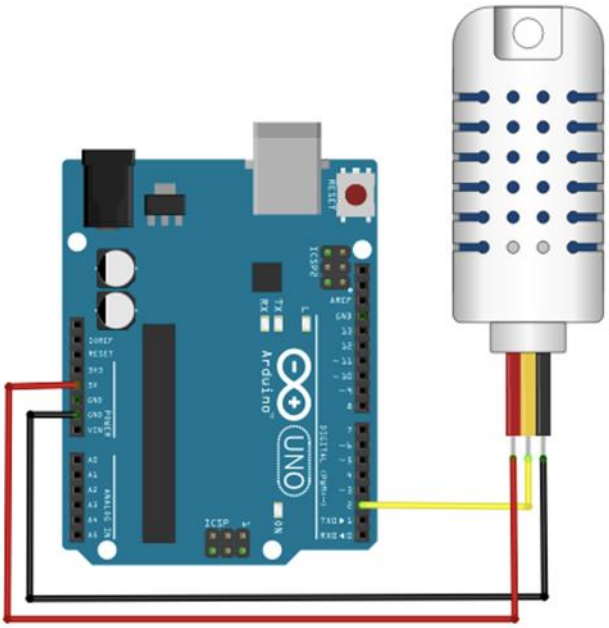

Fig. 3. Connection of Temperature/Humidity Sensor to Arduino[7]

For wind speed and direction sensors, anemometer is used (Fig. 4) which is connected to the Arduino analog input.

Fig. 4. Anemometer Wind Sensor

The CO2 gas sensor used for this study is an MG-811 based sensor which is compatible with Arduino, meanwhile the rainfall sensor uses rain gauge, a device that holds a number of rainwater and then translates into analog voltage input on Arduino.

B. Application Flow

The logic flow of the Mount Agung monitoring application is illustrated in Fig. 5 below.

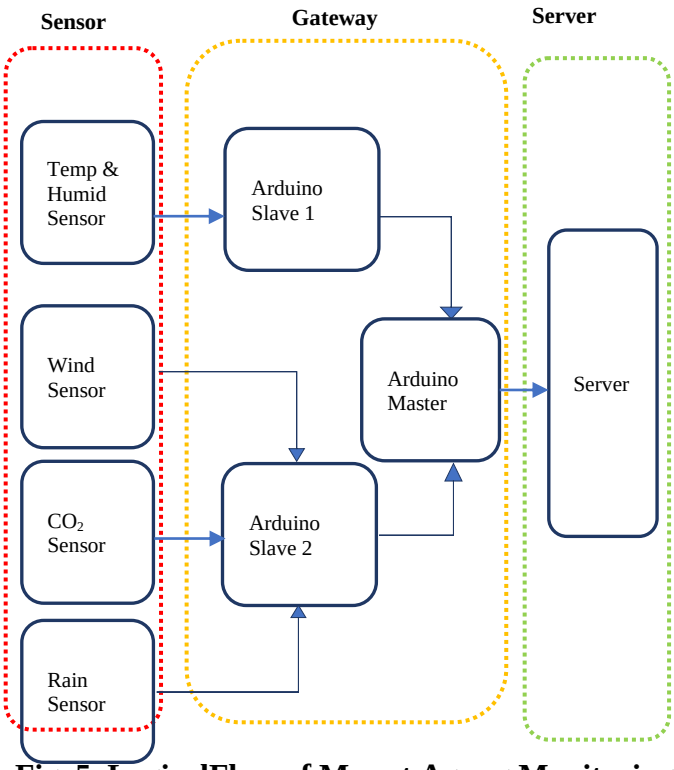

Fig. 5. LogicalFlow of Mount Agung Monitoring System

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The monitoring system works as follows:

- Sensors read data from the surrounding environment and then release data.
- Data output from the sensors are read by Arduino Slave first to reduce the risk of errors if read directly by Arduino Master.
- Arduino Slave sends sensor data to Arduino Master.
- Data transmitted from Arduino Slave is read by Arduino Master, then Arduino Master will send the data to the cloud server via HTTP protocol, using the existing API (JSON) format through a fixed broadband Internet connection.
- The server receives the data from Arduino Master and sends a response back to Arduino Master for validation that the data has been received properly.
- Data on the server will be displayed on the dashboard in the form of a website application.

II. Implementation Result

The Mount Agung eruption monitoring system has been implemented in three locations around Mount Agung: PVMBG Monitoring Center Rendang, Tulamben Monitoring Site, and Bebandem Monitoring Site, which are approximately 10 kilometers away from Mount Agung. The physical and hardware design forms of this system are illustrated in Fig. 6 and 7.

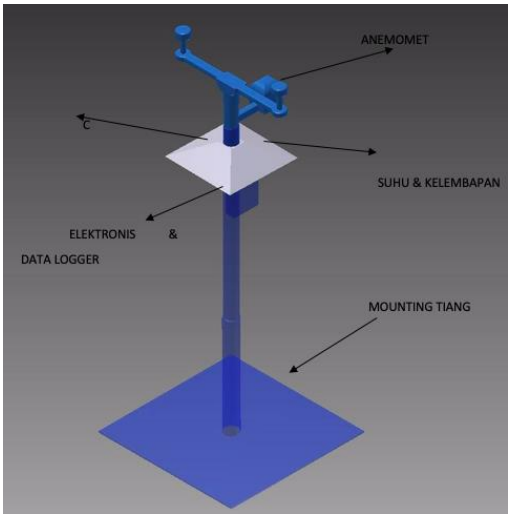

Fig. 6. Physical Design of Mount Agung Monitoring System Device

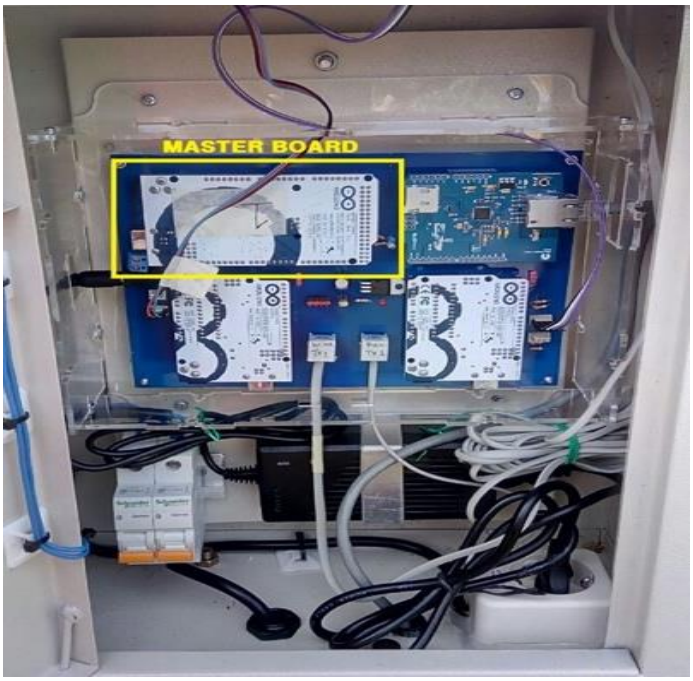

Fig. 7. The Hardware of Mount Agung Monitoring System

Fig. 8, 9 and 10 shows the excerpt of the CO2 gas, rainfall and the wind direction graphic in the dashboard of Mount Agung monitoring system.

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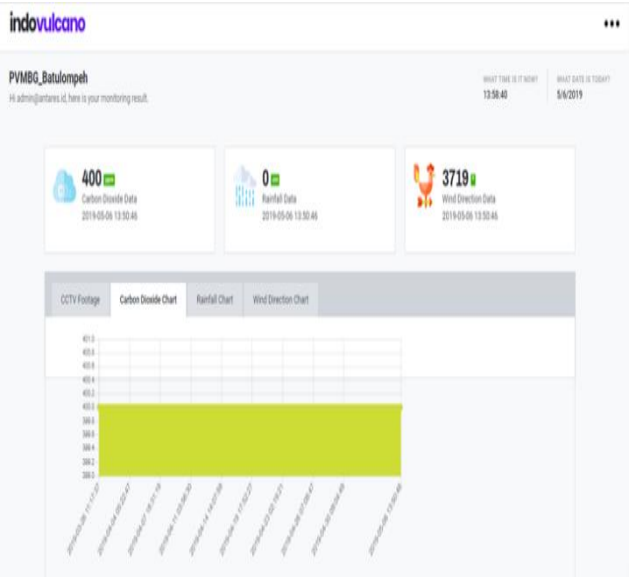

Fig. 8. The CO2 Gas Graphic

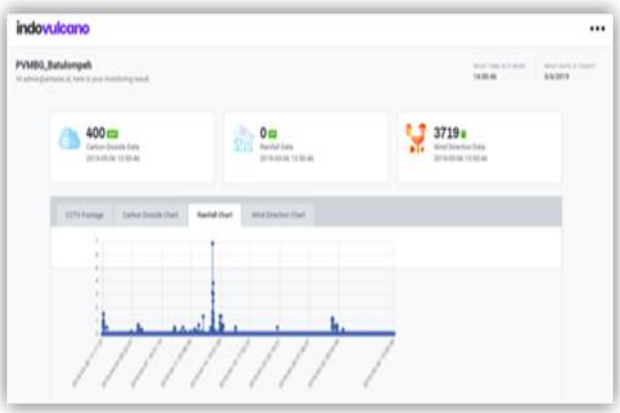

Fig. 9. The Rainfall Graphic

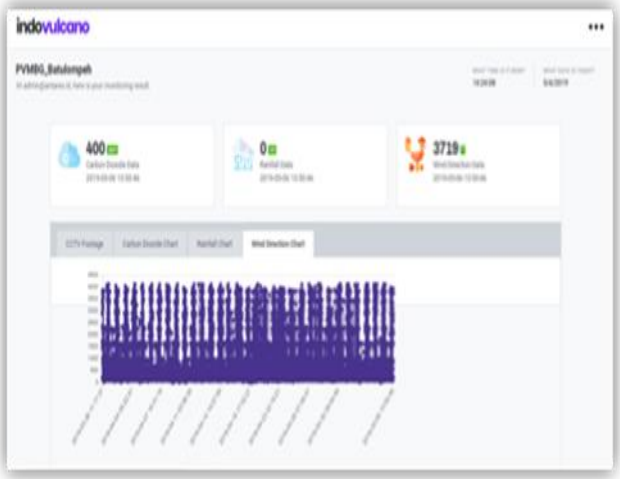

Fig. 10. The Wind Direction Graphic

The system has been implemented and become a reference for PVMBG and PT Telkom Indonesia in the disaster preparedness system, especially in monitoring the eruption of Mount Agung which has erupted several times in 2018. This system can also be used in monitoring other volcanoes.

IV. CONCLUSION AND FUTURE WORK

This study aims to build an IoT based eruption monitoring system on Mount Agung. It consists of the sensors which are temperature sensors, air humidity sensors, CO2 gas sensors, rainfall sensors, wind direction sensors, and wind speed sensors. The data from these sensors are sent to the Arduino microcontroller which functions as an IoT gateway to collect data and then sends it to the cloud server. On the server, the data is processed and displayed on the website application-based dashboard for monitoring functions.

This system has been implemented in three locations around Mount Agung (Rendang, Tulamben, and Bebandem monitoring sites) and has become one of official references for monitoring Mount Agung eruption activities. This system can actually also be used for monitoring other active volcanoes. In the future, this system is expected to use an Internet connection based on Low Power Wide Area Network (LPWAN) so it can be placed in a location closer to the volcano, which may not be reached by conventional broadband Internet access.

V. ACKNOWLEDGMENT

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