Development of IoT- Based Volcano Early Warning System

Virginia Fahriza Amaliya¹, Husein Lakudo², Afrida Hafizhatul Ulum², Lisa Destarina², Sensius Seno², Frida agung Rakhmadi¹, Nina Siti Aminah², Maria Evita² and Mitra Djamal²

¹Faculty of Science and Technology, Sunan Kalijaga State Islamic University. Jalan Laksda Adisucipto, Caturtunggal, Yogyakarta 55281, Indonesia
²Faculty of Mathematics and Natural Sciences, Bandung Institute of Technology, Ganesha 10, Bandung 40132, Indonesia

E-mail: nina@fi.itb.ac.id

Abstract. Monitoring volcanic activity this is indispensable for both research and disaster mitigation strategies. Therefore, the presence of volcano monitoring allows the monitoring, data recording and early warning system of volcanic activity from a distance that is real time. Volcanic monitoring system aims to detect any changes in volcanic status. Temperature and humidity become parameters of increased magma activity. Concentration of gasses includes SO2 and CO2, indicates of the depth of magma in volcanic conduit. Magma movement also triggers the earthquake.

The instrument that used in this research are temperature and humidity sensor DHT11, SO2 sensor TGS2602, CO2 sensor MG811, and vibration sensor ADXL345. Temperature and humidity sensors used DHT11 sensors that serve to detect temperature and humidity in the air. DHT11 sensors can detect temperature between 0-50°C and humidity between 20-90% RH. SO2 emissions were detected using TGS 2602 sensors that detects SO2 gas between 0-100 ppm. While CO2 gas emissions used MG811 sensors that detect the presence of CO2 gas between 350-10000 ppm. Furthermore, the vibrations were detected using a digital accelerometer ADXL345 that detects vibrations between 0,1-3200 Hz.

Data from all sensors processed using arduino promini microcontroller and then sent to ESP8266. ESP8266 is a wifi module that serves as a microcontroller enhancement to connect to wifi and create TCP / IP protocol. This module is also used to create an IoT project so that it can be accessed at any time on the web service page. This system will be assembled solar cells as a source of power supply.

1. Introduction
Indonesia has around 177 volcanoes, 76 of which are active volcanoes [1]. More than less 5 million people living around it. These volcanoes has erupted at least about 1171 times, which placing Indonesia second after Japan to experience a high level volcanic activity. The risk of losses caused by
the eruption of volcanoes are not only human life, damage to property, crop lost, and also deaths. Therefore, monitoring of volcanic activity is very necessary as a disaster mitigation strategy.

The most important part of detection volcanic eruption is monitoring volcanic activity. The main purpose of volcano monitoring is to detect signs of change that forewarn of volcanic awakening caused by magma movement. So, we’re combining sensors to detect physical parameters of a volcano based on wireless sensor networks (WSN) which is accessible via the internet (IoT). WSN or sensor network is an embedded system in which some sensors work without using cables. Sensors in this system are used to capture or gather the information that matches the characteristics of the sensors. Information in the form of analog signals will be converted into digital signals and transmitted to a node through wireless or wireless networks such as wifi, Bluetooth, infrared, and so on. WSN is also equipped with a radio transceiver as a sender-receiver or other supporting device so that one container node can collect the results of the other sensor node readout process. The information obtained can be accessed remotely via gadgets, laptops, servers and so on. Therefore, WSN is a tool that can be used for remote monitoring in real-time via the internet (IoT) under various conditions.

This system is made by combining gas, temperature and humidity sensors. These sensors will be installed to observe a volcano, whose data can then be easily accessed by the user. The sensors that we used are DHT11 sensors that serve to detect temperature and humidity in the air. Temperature and humidity will become parameters of increased magma activity. TGS2602 and MG811 sensors to detect SO2 and CO2 emissions. The concentration of gasses includes SO2 and CO2, indicates the depth of magma in a volcanic conduit. Magma movement also triggers the earthquake that can be detected using the ADXL345 sensor. ADXL345 including an accelerometer that measures and detects vibration or measure acceleration due to the earth's gravity. All sensors connected to arduino promini as microcontroller which process data from sensors and then sent it to ESP8266 as a module wifi to connect to wifi and create TCP / IP protocol. Data sent to cloud can be access anytime on the web service page. This system will be supplied by power solar cells generator.

2. Methods

2.1 Internet of Things

Internet of Things is a network of physical object or things in which to see, think, share information by using internet [2]. The Internet of Things (IoT) is the network of physical objects, devices, vehicles, and other items embedded with electronics, software, sensors, and network connectivity that collect and exchange data[3]. Internet of Thing has many benefits and making things easier, as long as it connected to the internet which can us to monitoring and control in the cyberspace.

2.2 Hardware sensor

The instrument that used in this research are temperature and humidity sensor DHT11, an NTC (Negative Temperature Coefficient) type thermistor using a resistance value to read the temperature value. NTC Thermistor is a resistor that works based on ambient temperature. With the temperature changing, the resistance in the component will change. The resistance value will decrease if the temperature rises and the current through this resistor is even greater. DHT11 sensors can detect temperature between 0-50°C and humidity between 20-90% RH.

TGS 2602 sensors that detects SO2. The main component of TGS 2602 is a metal oxide semiconductor. TGS sensor has a resistance whose value depends on the concentration of oxygen in contact with the metal oxide semiconductor. It can detects SO2 gas between 0-100 ppm. While CO2
gas emissions used MG811 sensors that detect the presence of CO2. Inside the sensors there is a heating coil component that is in the Al2O3 ceramic pipe. The sensors structure consists of solid electrolytes and heaters. MG811 sensors that detect the presence of CO2 gas between 350-10000 ppm.

The vibrations were detected using a digital accelerometer ADXL345. Accelerometer is a transducer that functions to measure acceleration. Principle of this sensors if a conductor is driven through a magnetic field, or if a magnetic field is driven through a conductor, then an induction voltage will arise on the conductor. Accelerometer placed on the surface of the earth can detect acceleration of 1g (the size of earth's gravity) at vertical and horizontal points. ADXL345 can detect and describe vibration in 3 axis namely x.y, and z axis and detects vibrations between 0.1-3200 Hz.

Using arduino pro mini the sensors will connect to Wi-Fi module. Data from the sensors will send in the MQTT program written in esp8266. This module is also used to create an IoT project so that it can be accessed at any time on the web service page.

2.3 Platform of the Internet of Things (IoT)

The platform of IoT is a software interface that connects everythings in a IoT system. Many kinds of platform IoT, we used Node-Red Fred as a middleware. Node-Red Fred is platform IoT that can connect data from a variety of hardware, APIs, and various online services in new and interesting ways [3]. It makes easy to organize data in the cloud and makes user easy to use. The runtime is built on Node.js, so it can run on the backend system in the cloud, non-blocking model. With over 225,000 modules in Node’s package repository, it is easy to extend the range of palette nodes to add new capabilities.

In this study the cloud server used is emoncms. Emoncms is a open-source web application for processing, logging and visualizing energy data and environmental data. All data from sensors are posted to the emoncms server using HTTP request in Node-Red.

3. Result and Discussion

IoT based volcano early warning system can be explained by diagram block system in figure 1.

![Diagram block system](image)

**Figure 1.** Block diagram system

Solar cell panel as power supply showing 50 watt peak (in strong sunlight) and voltage 0.5 volt. Before we integrate the system, first we test the sensors in the laboratory. There are DHT11 sensors
that serve to detect temperature and humidity in the air, SO2 emissions were detected using TGS 2602 sensors, CO2 gas emissions used MG811 sensors, then the vibrations were detected using a digital accelerometer ADXL345 [4]

Development of IoT is done after the instalation of the system complete. The data will be stored on the cloud and can be accessed by user with the concept of web-based o the internet[5][6].

By IoT technology, these parameters are obtained through sensors data stored on the cloud (emoncms) The graph of the result of this experiment is shown in figure 3. The sensors detect the parameters and shown in display of platform Node-Red Fred.

![Figure 2. a) Data from the sensors send to the MQTT program](image)

![Figure 2. b) Parameters of the DHT11 sensor, MG811 sensor, TGS2062 sensor shown in graph](image)

ADXL345 accelerometer sensor will detect vibration. The sensor measures acceleration resulting from motion. Data forwarded by sensor towards arduino, then will send in the MQTT program and the program is injected in esp8266. To plot and monitoring the output a web was developed.
Figure 3. Web visualization of the acceleration recorded by ADXL345

Figure 4 shown acceleration in the x, y, and z axis when no vibration occurs. The perturbation signal produced by hand movements can be recorded, only to test the sensor it can be shown in figure 5.

Figure 4. Perturbation recorded by the sensor

4. Conclusions
The purpose of this research is to create a system that will be used to monitor volcanic activity. The sensors will be placed at the foot hills and the data gathered by the sensors will be transmitted through the IoT system, so it will be real time remote measurement.
DHT11 sensors that serve to detect temperature and humidity in the air. Concentration of gasses includes SO$_2$ and CO$_2$ detected using TGS 2602 sensors and MG811 sensors. Magma movement also triggers the earthquake detected using digital accelerometer ADXL345. Furthermore, we still develop its performance.

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