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Wireless Sensor Network Design for Earthquake's and Landslide's Early Warnings

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ABSTRACT

Indonesia is located at the junction of three tectonic plates, and the Maluku Island it self has 10 fault line zones, so the impact of frequent tectonic earthquakes there resulted in a domino effect, such as the frequent occurrence of soil landslides at several points in the city of Ambon. This research aims to design a monitoring system for measurements of earthquake indication and landslides integrated via Wireless Sensor Network (WSN) by implementing a star topology, ZigBee, WiFi technology Shield and GPRS (General Packet Radio Service). The Wireless Sensor Network (WSN) is utilized to acquire the data, which is monitored and controlled centrally and can be distributed widely. By detecting suspicious indications such as tremor or landslides through nodes or end devices, the system provides information to the number of monitors and warnings. The system can also be accessed in real-time via the website by accessing the IP address of the Wireless-LAN devices Wi-Fi Arduino Shield.

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1. INTRODUCTION

Indonesia is located at the junction of three tectonic plates Eurasian plate, the Pacific plate and the Australian plate. These plates meet in the Maluku islands forming a trough, which has a depth of between (4500-7000) meter, known as a subduction zone. The Ambon Island has ten fault zones, and three of them are in densely populated residential areas. The area from Pattimura Street to Batumeja Street is a region included in one of the fault zones. These fragments will be activated in case of a large earthquake [1].

Based on interviews with the Head of Data and Information Section Sta. Geof. Class I Meteorological, Climatological, and Geophysical Agency (Badan Meteorologi, Klimatologi, dan Geofisika Kota Ambon), they recorded that the earthquakes happened 88 times since Tuesday, October 31, 2017 at 20.31 WIT until Wednesday, 01 November 2017 at 11.30 WIT. Where the preliminary earthquake happened with magnitude 5.7 Richter scale (RS) at 20.31 WIT, followed by 5.6 RS earthquake at 20:34 WIT, 6.2 RS at 20.50 WIT, 5.2 RS at 20.59 WIT, 5.6 RS at 21.37 WIT, and 82 followed by Earthquake with relatively small magnitude until Wednesday, 01 November 2017 at 11.30 WIT. The cause of the earthquakes is a fault up in the southern seabed of Ambon City [2]. Regional Disaster Management Agency (Badan Penanggulangan Bencana Daerah Kota Ambon), verified the data point of the natural disasters that occurred in five districts of Ambon in the period from May to June 2017. The collected data are less than 124 points of disaster landslides, and as many as 218 houses threatened by the landslides. The period of May-June 2017 with 124 points landslides are scattered in five districts in the city of Ambon. There were slightly damaged 176 houses, were damaged 16 units, heavily damaged 52 units, embankments were damaged six points, public facilities were severely damaged and light of each of the units. The main factors of landslides in Ambon itself is heavy rainfall, earthquakes are relatively occur, and settlements on the slopes or steep slope.

Landslides are a displacement of material forming of the slope, may be the original rock, soil weathering, material pile or a combination of these materials which moves downward and out to the slopes or falling towards the base of the slopes because of gravity control. There are several types of landslides categorized based on the movement and the material. The type of landslide material is divided into the rocks, debris material and soil. Landslides of this type often happen in Ambon city. The topography of Ambon city is around 73% of the mainland region, which can be classified hilly to steep slope, with a slope of over 20% [3]. According to [1], the geography of Ambon City region consists of 359.45 square kilometers of lands and mostly consist of hilly terrain with steep slopes of up to 186.90 km2 or about 52% of the total land area. In terms of topography, most areas of Ambon City are hilly areas with a steep slope of 30º-45º to very steeper than 45º, and only about 17% of its land area can be grouped flat or sloping with a slope of less than 30°. Landslide disaster that occurred in Ambon is a type of translational landslide, namely the movement of soil and rocks in the field of slip-shaped sloping ramps. The main factor of the occurrence of landslide disaster it self are high rainfall [3], relative earthquake [2, 4], and residential areas on the slopes or steep cliffs [5].

Monitoring through an integrated system is one of the solution that can prevent and minimize losses caused the earthquakes and the landslides undesirable. The well proprietary technology suited for acquiring data widely in nature or areas for a purpose such as monitoring and maintainance is via Wirelss Sensor Network (WSN) technology [4-8]. WSN is very effectively applied to large geographical areas. The area of use of these wireless sensors are such as pollution or air contamination monitoring systems, nuclear reactor controllers, fire detection systems, habitat monitoring areas, object tracking or other conditions [9]. It requires an integrated wireless system such as WSN that is early warning and able to detect early indications of natural disasters such as landslides and earthquakes and also monitor the large scale environmental conditions [4-7]. Wireless Sensor Network (WSN) collected the information from the environment to measure the incidence of mechanical, thermal, biological, chemical, optical or magnetic and transmit information collected from sensor node to a sink node or network coordinator [10].

In this research, we used Arduino ATMega 2560 microcontroller that is an open-source equipped with Arduino SIM900 GSM/GPRS Shield module. For the wireless connection, we chose the WizFi 250-based Arduino WiFi Shield device, high-integrity wireless module that supports IEEE 802.11b/g/n [8], and the other wireless module is the Arduino Zigbee (IEEE 802.15.4) for Wireless Sensor Network (WSN) implementations to monitor field-sensing indicators. The implemented sensors in the field are Arduino SW-420 as a vibration detection sensors, Arduino Raindrop sensor for detecting the intensity of rainfall, water levels ie the voltage divider sensor and the system comes with Alarm Buzzer Arduino as an alarm system. WSN monitoring system performance evaluation indicated the earthquake and landslides in this study is expected to provide the capabilities of the system in a real environment.

2. LITERATURE REVIEW

2.1 Landslides, Earthquakes and Rainfall intensity

The biggest factors of landslides are the high intensity of rainfall [4-7] and the earthquake's shakes factors. According to Regulation of Head of Meteorology, Climatology, and Geophysics Agency (BMKG), No. KEP.009 of 2010 on Standard Operating Procedures for Implementation of Early Warning, Reporting and Dissemination of Extreme Weather Information, explained in Table 1, that if the intensity of heavy rainfall (10-20 mm/h and 50-100 mm/day) and very heavy rainfall intensity (> 20 mm/h and> 100 mm/day), the potential occurrence land movement or landslides and flooding.

Table 1. Classification of Rainfall Intensity

No.	Rainfall intensity					Class
	Per hour (Mm)	Per day (Mm)	Per month			
			Rainy day (day)	Estimated Total Rainfall (Mm)	Cumulative Rainfall Month (Mm)	
1.	<1	<5	5-6	10-15	10-15	very mild
2.	1-5	5-20	6-7	60-70	70-85	mild
3.	5-10	21-50	6-7	180-210	250-295	moderate
4.	**10-20**	**51-100**	2-4	150-250	400-545	heavy
5.	**> 20**	**> 100**	1-2	110-300	510-845	very heavy

Based on interviews BMKG recorded that the earthquake happened 88 times, the cause of the earthquake is a fault up in the southern seabed of Ambon City. Judging from the depth of his hypocenter, the earthquake that occurred is a shallow species suspected as a result of fault activity to rise South Seram. This is in accordance with the results of the analysis of the source mechanisms indicating that all of the earthquakes that occur have a fault source mechanism. The cause of the earthquake is a fault up in the southern seabed of Ambon City. Energy from the fault is called still active, because aftershocks are still ongoing. According [1], The Molucca Sea collision zone lies in the area of the complex junction between the Eurasian, Australian, Pacific and Philippine plates. Both the Sangihe volcanic arc on the west and the Halmahera arc on the east are active and convex toward the Molucca sea. Earthquake foci define two Benioff zones, each dipping away from the Molucca Sea beneath the flanking volcanic arc. The magmatic arcs are seaparated by 250 km at their closest approach. Troughs up to 3 km deep border the arcs along the sides facing the Molucca Sea.

2.2 The Component of Wireless Sensor Networks

Wireless sensor network (WSN) is a wireless network that uses a sensor that is connected in a network to monitor the state of physical or environmental conditions. WSN implementation in a system has several advantages over cable implmentasion basis. WSN is formed by a number of sensor dots scattered in an area called the sensor field, as depicted in Figure 1. Each sensor node has the ability to collect data and communicate with other sensor nodes.

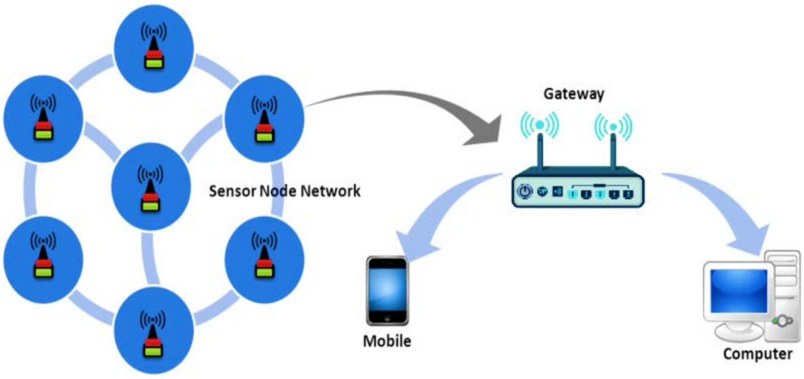


Figure 1. Scheme of Wireless Sensor Network

The target nodes is in charged stimulation signals, then the sensor node will instantly find the latest data obtained from the sensing head to the sink node [11]. The topologies of the WSN implementation could be star topology, cluster/tree Topology, and mesh topology [8].

Arduino microcontroller board is an open source and derived from platform designed for ease of wiring and in building a wide range of electronic applications [6, 8]. In this research, uses Arduino ATmega2560 with GBoard Pro for coordinator node, that the mainboard microcontroller Arduino compatible with WIFI SHIELD FI250 module, and provided the module SIM-900 GSM / GPRS service (short message service) module, these module operates at a voltage of 3.0 - 5.5V DC. For the station nodes in this research, uses Arduino Uno that the microcontroller-based board at Atmega328. This series has 14 digital input/output pins (where 6 pins can be used as a PWM output), 6 analog inputs, 16 MHz crystal ocillators, USB connection, and an electrical jack reset button [8, 15].

In this study, uses Arduino Shield Wi-Fi device as an interface application on monitoring through a website designed using html. Arduino WiFi Shield is based WiznetFi250 wireless module with a small size that has a high level of integration, supports IEEE 802.11b/g/n [11, 12]. The other wireless module is Zigbee device, zigbee is a wireless networking standard technology that intended for remote control and sensor applications are suitable for operation in indoor and outdoor environments and remote locations that are difficult to reach. Zigbee uses three different bands that used in global is 2.4GHz, and 915MHz or 868 MHz bands for European American. 250kbps data rate in the 2.4GHz, 915MHz and 868MHz 40Kbps in at 20kbps [12-14]. XBee Series 2C device has 20 pins with different functions and it works on a voltage of 3.3V. The pins for sending and receiving data are the data pin OUT (TX) by 2 pins and data pins IN receiver (RX) of 3 pins [13].

In this study, we use two sensors on station nodes, which are compatible with Arduino sensor products. The Arduino SW-420-NC on east station node is intended to detect any indication of earthquake vibrations and the node on the south station uses raindrop sensor for detecting the rainfall intensity to measure indicatives of the occurrence of landslides. Arduino vibrating sensor module SW-420-NC consists of LM393 comparator. The comparator is used to detect whether there are vibrations beyond the threshold.

2.3 Quality of Service of WSN

Quality of service (QoS) of WSN calculated is throughput, packet loss ratio, delay and Received Signal Strength Indicator [8, 10]. Analyzing the WSN network was conducted to determine the quality of system performance real environment. To demonstrate the performance of WSN, the parameters are calculated, among others:

$$\text{Throughput (kbps)} = \frac{\text{Number of Packets Sent}}{\text{Time Taken}} \tag{1}$$

Packet Loss Ratio is a value that states the number of packets that failed to be submitted to the specific objectives through the transmission medium . It can be formulated in the following equation [8],

$$\text{Packet Loss Ratio (\%)} = \frac{\text{Number of Packets Sent} - \text{Number of Packets Received}}{\text{Number of Packets Sents}} \tag{2}$$

The delay or latency is the time it takes the data to travel from origin to destination. It can be formulated as follows [8],

$$\text{Delay (seconds)} = \frac{\text{Packets Receiving Time} - \text{Packet Delivery Time}}{\text{Packets Receiving Time}} \tag{3}$$

The Received Signal Strength Indicator (RSSI) is an indicator for the level of received power of a wireless transmitter device measured in -dBm accessible by the end device [9],

$$\text{RSSI (dBm)} = 10 \log P_{Rx}\,(\text{mW}) \tag{4}$$

3. RESEARCH DESIGN

3.1 Goals and Objectives

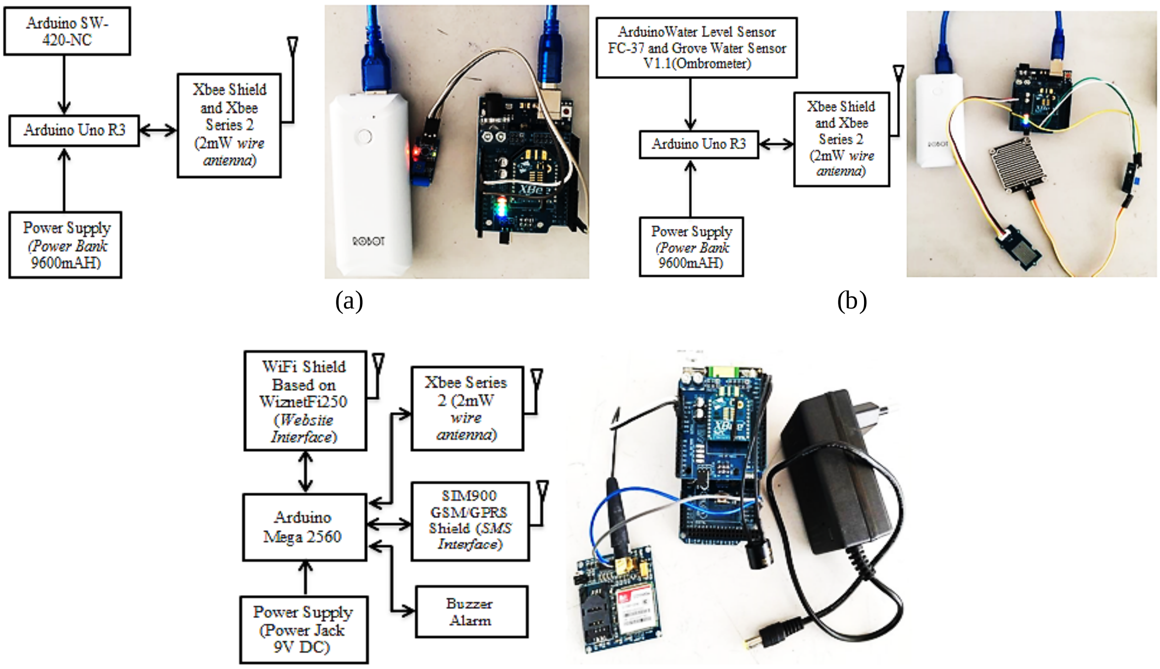
Here, an integrated system for monitoring an earthquake and landslides indication is designed. The nodes inside the system are linked in a Wireless Sensor Network (WSN), and the WSN is connected to the internet via a coordinator node by a WiFi technology shield and GPRS (General Packet Radio Service). This study includes the creation indication WSN monitoring system of earthquake and landslide by filing a star topology as well as utilizing ZigBee technology for wireless data transmission in WSN and GSM (Global System for Mobile Communications) or GPRS for communication via SMS (Short Message Service). In addition, information on real time earthquakes and landslides is shown applicative web-based interface.

Figure 2. Stations nodes and coordinator node

The theoretical study was done in laboratory of Telecommunication and Electromagnetics at Universitas Mercu Buana University, Jakarta, whereby; the testing of the system was performed in the neighborhood of the resident BTN Kanawa, Jl. BTN Kanawa Batu Merah, District of Sirimau, Ambon. Figure 2 shows the location of the station and coordinator nodes installed in the field.

3.2. Hardware and Software

The hardware modules used in this study are Arduino SW-420-NC modules (end devices implemented on North and South sides of the coordinator) and sensors modules for rainfall intensity detection (implemented in the end devices eastern and east sides of the coordinator). Microcontroller modules used are the Arduino Mega (Atmega2560) with Gboard Pro-900 GSM SIM. For communicating purposes, XBee Socket communication boards, XBee 2mW Wire Antenna - Series 2, and WiznetFi250-based Arduino WiFi Shield are used. The overall designed system is shown in Figure 3. The software used in this study is the Arduino IDE, Wireshark V2.4.5 and X-CTU.



(a) (b)

(c)

Figure 3 (a). Implementation of the eastern station node; (b) southern station node; (c) Coordinator node

3.3. System Testing

The system was tested by measuring the parameters of Quality of Service (QoS), namely Throughput (1), Packet Loss Ratio (2), Delay (3) and also measuring the signal strength in term of Received Signal Strength Indicator (4). Analyzing the WSN network was conducted to determine the performance of a real system environment and some measurements on the eastern station node (earthquake sensor) for 4 days were done to see the reliability of the system. Furthermore, the system was tested in real time by accessing the website of the local host WiFi Shield system, which displays the current status of the state of the sensors or end devices.

4. RESULTS AND DISCUSSION

4.1 Analysis Throughput, Delay, Packet Loss Ratio, Respons Time of System

Table 2 shows the measured results of the Quality of Service (QoS) analysis of the system, and the RSSI. Table 2 shows an optimum throughput with an average value of 1488 Kbps, the average delay of 0.045 seconds, the average packet loss ratio below 0%, and the RSSI of -31 dBm, in a 20 meter node station distance scenario to a coordinator node monitored through a monitoring center. The results are not too far from measured at another distance scenarios, 1470 Kbps for the throughput average, delay average is 0.049

seconds, packet loss ratio 0.02%, and RSSI -40 dBm in scenarios of 40 meters. In 60 meter scenario, the results are 1465 Kbps for throughput average, delay average is 0.048 seconds, packet loss ratio 0.11%, and RSSI -56 dBm. In 80 meter scenario, the results are 1432 Kbps for throughput average, delay average is 0.051 seconds, packet loss ratio 0.42%, and RSSI -79 dBm. At last in 100 meter node station distance scenario to a coordinator node, the results are 1385 Kbps for throughput average, delay average is 0.052 seconds, packet loss ratio 0.68%, and RSSI -85 dBm. The communication system can still pass the data packets from each node station in the field to the node coordinator and monitored through the monitoring center. So, the communication system is acceptable and reliable to pass the data packets from each node station in the field to the node coordinator and monitored through the monitoring center.

Table 2. Measured Throughput, Delay, and Packet Loss Ratio

Distances from station nodes to coordinator node (meters)	Throughput Average (Kbps)	Delay Average (seconds)	Packet Loss Ratio (%)	RSSI (dBm)
20	1488	0.045	0	-31
40	1470	0.049	0.02	-40
60	1465	0.048	0.11	-56
80	1432	0.051	0.42	-79
100	1385	0.052	0.68	-85

In the earthquake and landslide vibration respons time analysis (east node station), the real test and measured data acquisition process conducted for 4 days (19-22 December 2017) from 07.00 WIT to 12.00 WIT for the scenarios, we observed it again at different distances as shown in Figure 2. Table 3 gives the data acquisition taken from the eastern station node. The Data in the form of calculation and value analysis of the sensitivity of system performance through the response time displayed with SMS interface application and website interface application that can be accepted in monitoring center.

Table 3. Measured node stations response time

Distances from station nodes to coordinator node (meters)	Vibration Simulation (RS)	Vibration Results (logic input voltage : website)	Response Time Through SMS-Based Interface Application (seconds)				
			Scenarios				
			I	II	III	IV	Average
20	4.1	699	1.99	2.4	1.78	1.46	1.91
40	4.1	699	2.51	3.25	3.16	3.01	2.98
60	4.1	698	3.04	3.02	3.09	3.23	3.09
80	4.1	701	4.01	4.29	3.89	5.70	4.47
100	4.1	-	-	-	-	-	-

The average value of the optimal response time is 1.91 seconds at a distance of 20m east station node and the south station node to the coordinator node. The system was able to detect the simulated vibration and performed the warning process through SMS and alarm buzzer. At the distance of 80 m, the average response time is unstable because the coordinator node is not optimal to capture the data, just captured of 4.47 seconds. And at a distance of 100m, the monitoring center does not get the data information in the form of SMS delivered by the system.

4.2 Testing of Reliability and Optimal System Performance

Table 4 shows the measurement results of rainfall intensity in the real research location conducted for 29 days on south node station, it started on 02/12/2017 until 30/12/2017. Through measurement using water level sensor and ombrometer level sensor (south node station) on the system, heavy rainfall was detected with the intensity 60.61 mm or 803,208 logic (on 02/12/2017) and 83.86 mm or 718,617 logic (on 11/12/2017). While very heavy rain occurred with the intensity of 159.65 mm or 443,154 logic (on 09/12/2017) and 108.08 mm 630,411 logic (on 16/12/2017). The phenomenon of heavy and very heavy rainfall are detected by the system and the system follows up the information by activating the alarm buzzer and sends a warning SMS notification to the monitors. By analysing the measurements as given in Table 4, the landslides can potentially occurs by a very heavy rainfall factor with 159.65 mm or 443,154 logic (on 09/12/2017), this condition is supported by detection of mild shakes for a while around the location by the systems through a 751-logical digital input- display on the website page or equivalent to 4.2 RS and it released with notifications including SMS notification at 12.32 WIT.

Table 4. Measured of Rainfall Intensity

Date	Rainfall Intensity per 24 Hour (ml)	Rainfall Intensity per 24 Hour (logic input voltage)	Rainfall Intensity per 24 Hour (mm)	Classification of Rainfall Intensity	SMS Notification in Monitoring Center
02/12/2017	304.5	803.208	60.61	Heavy	Yes
03/12/2017	0	1023	0	-	No
04/12/2017	0	1023	0	-	No
05/12/2017	0	1023	0	-	No
06/12/2017	34.2	998.418	6.81	Very Light	No
07/12/2017	111	942.747	22.10	Moderate	No
08/12/2017	0	1023	0	-	No
09/12/2017	802.1	443.154	159.65	Very Heavy	Yes
10/12/2017	0	1023	0	-	No
11/12/2017	421.3	718.617	83.86	Heavy	Yes
12/12/2017	0	1023	0	-	No
13/12/2017	10.1	1015.77	2.01	Mild	No
14/12/2017	102.3	949.254	20.36	Mild	No
15/12/2017	0	1023	0	-	No
16/12/2017	543.4	630.411	108.16	Very Heavy	Yes
17/12/2017	0	1023	0	-	No
18/12/2017	0	1023	0	-	No
19/12/2017	38.5	995.526	7.66	Moderate	No
20/12/2017	32	999.864	6.37	Moderate	No
21/12/2017	0	1023	0	-	No
22/12/2017	112.1	942.024	22.31	Moderate	No
23/12/2017	10.4	1015.77	2.07	Moderate	No
24/12/2017	0	1023	0	-	No
25/12/2017	0	1023	0	-	No
26/12/2017	36.2	996.972	7.20	Mild	No
27/12/2017	28.1	1002.756	5.59	Mild	No
28/12/2017	0	1023	0	-	No
29/12/2017	109.1	944.193	21.70	Moderate	No
30/12/2017	0	1023	0	-	No

Table 5. Measured Ricter scale

Time	Measurement of Vibration Intensity Value							
	Day 1 (19/12/2017)		Day 2 (20/12/2017)		Day 3 (21/12/2017)		Day 4(22/12/2017)	
	logic input voltage	Richter Scale	logic input voltage	Richter Scale	logic input voltage	Richter Scale	logic input voltage	Richter Scale
07.00	3	1.2	3	1.2	238	1.4	238	1.4
07.10	221	1.3	221	1.3	221	1.3	221	1.3
07.20	221	1.3	221	1.3	221	1.3	221	1.3
07.30	238	1.4	238	1.4	238	1.4	238	1.4
07.40	221	1.3	3	1.2	221	1.3	221	1.3
07.50	221	1.3	221	1.3	221	1.3	221	1.3
08.00	221	1.3	221	1.3	238	1.4	238	1.4
08.10	221	1.3	221	1.3	221	1.3	238	1.4
08.20	272	1.6	221	1.3	238	1.4	238	1.4
08.30	221	1.3	221	1.3	221	1.3	221	1.3
08.40	221	1.3	3	1.2	221	1.3	221	1.3
08.50	221	1.3	221	1.3	221	1.3	221	1.3
09.00	255	1.5	238	1.4	221	1.3	255	1.5
09.10	221	1.3	221	1.3	238	1.4	238	1.4
09.20	221	1.3	238	1.4	221	1.3	221	1.3
09.30	238	1.4	238	1.4	221	1.3	221	1.3
09.40	221	1.3	221	1.3	221	1.3	221	1.3
09.50	238	1.4	238	1.4	238	1.4	255	1.5
10.00	221	1.3	221	1.3	221	1.3	221	1.3
10.10	238	1.4	238	1.4	221	1.3	221	1.3
10.20	221	1.3	221	1.3	221	1.3	221	1.3
10.30	221	1.3	221	1.3	221	1.3	238	1.4
10.40	238	1.4	221	1.3	221	1.3	221	1.3
10.50	221	1.3	255	1.5	221	1.3	238	1.4
11.00	221	1.3	3	1.2	221	1.3	221	1.3
11.10	238	1.4	221	1.3	255	1.5	238	1.4
11.20	221	1.3	221	1.3	221	1.3	221	1.3
11.30	221	1.3	221	1.3	221	1.3	221	1.3
11.40	238	1.4	221	1.3	221	1.3	238	1.4
11.50	221	1.3	221	1.3	221	1.3	221	1.3
12.00	272	1.6	238	1.4	238	1.4	238	1.4

Table 5 shows the results of vibration intensity on east node station (Arduino SW-420-NC) in real location for 4 days measurement from 19/12/2017 until 22/12/2017. Measuring sensitivity and reliability of the performance of the eastern station node, the minimum detectable vibration result is worth 3 logic or equivalent to 1.2 RS as compared to the result obtained by the Netigen Kluzowicz Smart Vibration Meter. The value of logic-digital input voltage starts to change drastically when the vibrations received by the east station node are more than 1.2 RS. The maximum vibration value that can be detected by the eastern station node is worth 272 logic or equal to 1.6 RS on Day I (19/12/2017) at 08.20 WIT. The calibration is done through vibration table or seismometer from Meteorology Climatology and Geophysics Agency of Ambon City towards east station node and Kluzowicz Smart Vibration Meter application is value 0.1 RS or 170.214 logic every 0.1 RS increase in website interface application.

4.3 The Monitoring Integrated System via Website and SMS

Additionally we show the notification of the monitoring system of earthquakes and landslides through website and SMS. We connected the Wifi network-shield to the system, and used the url: http://192.168.4.1. Figure 4 shows the page display of the real-time monitoring.

MITIGASI BENCANA GEMPA BUMI DAN TANAH LONGSOR

OLEH : HAZIEL LATUPAPUA DAN ANDRIAS IZAAC LATUPAPUA
KONTAK : +6282310948969 / hazielvanlatu@gmail.com : HAZIEL

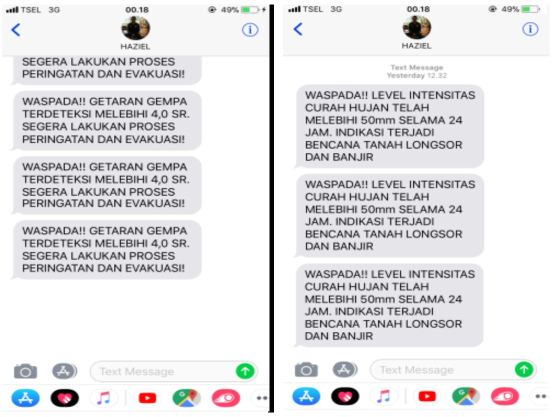
NODE STASIUN TIMUR	GETARAN: GEMPA / TANAH LONGSOR (5)
NODE STASIUN SELATAN	TETESAN HUJAN / RAINDROP (TIDAK)
NODE STASIUN SELATAN	LEVEL INTENSITAS CURAH HUJAN (404)
BUZZER ALARM	TIDAK

KETERANGAN:

1. NODE STASIUN TIMUR (SENSOR ARDUINO SW-420-NC)
2. NODE STASIUN SELATAN (RAINDROP GROVE WATER SENSOR V1.1)
3. NODE STASIUN SELATAN (LEVEL INTENSITAS CURAH HUJAN ARDUINO FC-37

Figure 4. Real Time Monitoring by Website Interface App

After testing by accessing website air monitoring system in real-time running properly. The system is able to provide information about the value of rainfall intensity and vibration status in real-time. For the scenario the system detects vibrations of 3.0 magnitude and intensity of rainfall over 50 mm per day, so that the system automatically provides information in the form of SMS to the researcher is shown in Figure 5.



SEGERA LAKUKAN PROSES PERINGATAN DAN EVAKUASI!

WASPADA!! GETARAN GEMPA TERDETEKSI MELEBIHI 4,0 SR. SEGERA LAKUKAN PROSES PERINGATAN DAN EVAKUASI!

WASPADA!! GETARAN GEMPA TERDETEKSI MELEBIHI 4,0 SR. SEGERA LAKUKAN PROSES PERINGATAN DAN EVAKUASI!

WASPADA!! GETARAN GEMPA TERDETEKSI MELEBIHI 4,0 SR. SEGERA LAKUKAN PROSES PERINGATAN DAN EVAKUASI!

WASPADA!! LEVEL INTENSITAS CURAH HUJAN TELAH MELEBIHI 50mm SELAMA 24 JAM. INDIKASI TERJADI BENCANA TANAH LONGSOR DAN BANJIR

WASPADA!! LEVEL INTENSITAS CURAH HUJAN TELAH MELEBIHI 50mm SELAMA 24 JAM. INDIKASI TERJADI BENCANA TANAH LONGSOR DAN BANJIR

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Figure 5. Real Time Monitoring by SMS Interface App

5. CONCLUSION

The system was built to monitor and to provide information on the rainfall intensity and vibration through access to the website in real-time. The information such as rainfall intensity on the pitch in millimeters was monitored over 24 hours. The information on vibration, in Richter scale, was observed by Arduino SW-420-NC sensor calibrated through Netigen program Smart Vibration Meter, which was able to detect tremors >3 RS. The rainfall intensity was detected more than >50 mm by the raindrop sensor. We have also measured the throughput, delay, packet loss ratio and RSSI with Wireshark program

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