Wireless Sensor Node Energy Optimization Using Duty Cycle Method For Landslide Early Warning System

Roghib Muhammad Hujja, Lukman Awaludin

Abstract : Landslides have hit Indonesia for the past several years. The disaster killed many victims. Landslides are a natural disaster so that this disaster cannot eliminate. One rational solution that can do is minimizing the existing victims, where the solution represented by the Early Warning System (EWS) or an early warning system for the detection of the landslide [1]. Utilization of sensor network technology can be used to prevent an increase in loss of life, property, and environment in a natural disaster [2]. The operational mechanism of the developed EWS runs on the concept of Wireless Sensor Network (WSN) [3]. Until now, the WSN has a weakness in accommodating the use of power for each node. The existence of this weakness can disrupt the process of data transmission, which results in the system working less responsive and even lost information. The weakness influenced by the accuracy of the frequency of data transmission and supporting infrastructures such as processing units and battery sources. Therefore, this research focused on determining the appropriate infrastructure specifications supported by the design of the regulation of the frequency of data transmission in EWS landslides, on optimizing the use of power without losing important information.

Index Terms: Data transmission, Wireless sensor network, Landslide, Power optimization

1. INTRODUCTION

Indonesia is a country with a predominantly geographical structure in the form of mountains, which is vulnerable to the movement of its land. This condition certainly has a great chance to trigger natural disasters, especially landslides. It is undeniable that landslides have indeed hit Indonesia in the past few years. The latest data shows that the disasters during 2017 claimed 211 lives, 70 people died, 834 people were injured, and 124,485 people displaced from January 1 to August 22[4]. The landslide disaster itself is a natural factor in the category of natural disasters. That is what makes humans can not eliminate landslides [5]. Therefore, minimizing the impact of casualties is the only rational solution to avoid a disaster like a buzz made by UGM(Universitas Gadjah Mada) researchers. UGM researchers realize landslide detection devices, which are often called the Early Warning System (EWS) as a real effort to minimize casualties [4]. Judging by the system's operational mechanism, EWS implemented through the concept of a wireless sensor network or Wireless Sensor Network (WSN). WSN is a technology that consists of more than one sensor node communicating with each other for use as a monitoring and collecting sensor data directly. Concept taking based on the need to place sensors at several points prone to ground movement in one area to obtain accurate and mutually supportive data. WSN used for sending data and building monitoring systems, both indoors and outdoors[2][3]. WSN has many advantages, such as easy to develop, wide range, and more resistant to outside interference. WSN requires sensor nodes to capture the symptoms or phenomena that occur in sensor and sink data readings as a connector between sensor nodes and users [6]. Wireless technology in order to get functional connectivity requires the placement of receivers and transmitters appropriate for data transmission [2]. However, that does not mean that the EWS UGM is a perfect walking unit. Until now, some problems have not handled optimally. The problem is the weakness of WSN in accommodating power consumption. The existence of this weakness can disrupt the process of data transmission, which results in the system working less responsive and even lost information. The inefficiency of power consumption influenced by the accuracy of the frequency of data transmission and supporting infrastructure such as processing units, battery sources. Therefore, it is necessary to determine the appropriate infrastructure specifications supported by the design of the regulation of the frequency of data transmission in EWS landslides, to optimize the use of power without losing important information.

2 RESEARCH METHOD

2.1 Analysis of The Problem

The National Disaster Management Agency (BNPB) described the number of fatalities, assets, and the environment due to landslides. Utilization of Wireless sensor networks (WSN) technology can minimize the loss of lives, property, and the environment[6] [7]. WSN requires sensor nodes to capture the symptoms or phenomena that occur in sensor and sink data readings as a connector between sensor nodes and users. Wireless technology in order to get functional connectivity requires the placement of receivers and transmitters appropriate for data transmission [7][8]. Landslide WSN needs to operate in a long time because landslide can be happening at any time. Most WSN still using fixed energy sources like a battery, so in this research, we choose to optimized energy usage compared to increase battery capacity.

2.2. System Design

The design of the system aims to provide an overview of a system for analysis. The design divide into two parts, which include hardware and data transmission design.

2.2.1. Hardware design

The landslide EWS that will build has a node specification structure, such as the block diagram in Fig 1.

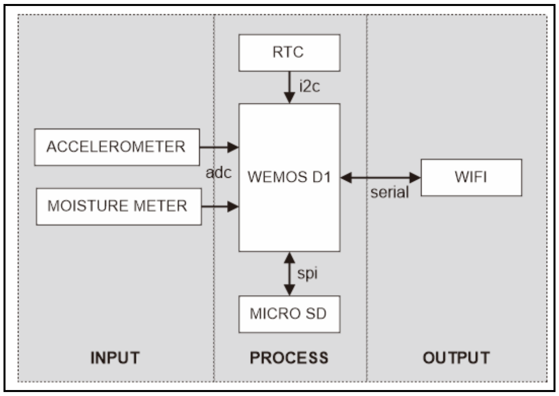

***Fig 1** Block diagram of a landslide early warning system*

Fig 1 explains the block diagram in which the devices classified as inputs, processes, and outputs. Input in the block diagram above consists of an accelerometer sensor and a moisture meter. The input is connected to the processing unit using the ADC(Analog to Digital Converter). The processing unit consists of Wemos D1 mini, RTC, and micro SD and the output is using WiFi communication [9] [10]. Then, the scheme supported by computer components in the form of mechanical and electronic physical forms. The electronic system will classified into three parts, including input, process, and output. The Mechanical System will build as a simulation for the Early Landslide Detection system and a sensor placement container. The visualization of the hardware explained in Fig 2.

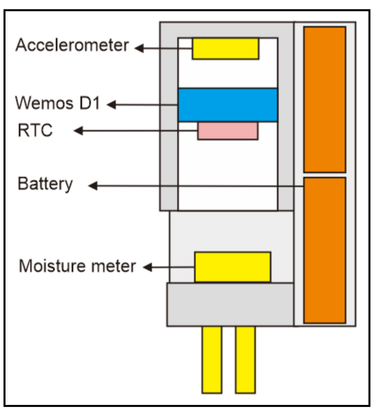

***Fig 2**. The mechanical system in the packaging and placement of electronic components*

The design of this device will be in direct contact with sand or gravel media in a Landslide Early Detection System simulation. The Landslide Early Detection System Design Kit is composed of an Accelerometer sensor that is used to measure ground motion, a Moisture Meter sensor that is used to measure temperature and soil moisture, a battery used for power supply, a Wemos D1 mini used for the control center of the system and an RTC used for time systems.

2.2.2. Data transmission design

To accommodate WSN communicating, then to transmit any sensor data obtained will be displayed on computer display media. Sending and receiving data between computer devices and EWS is done through internet network intermediaries. The communication generally described in Fig 3.

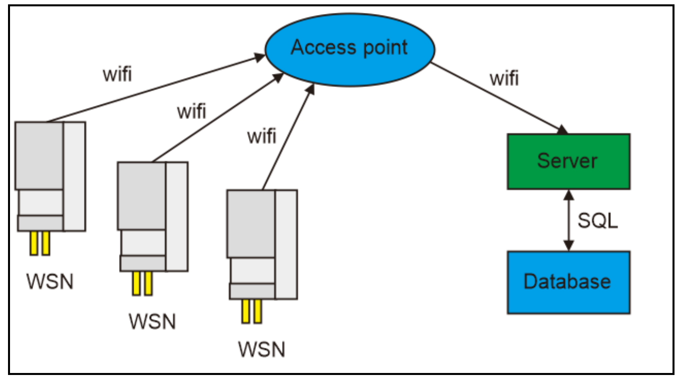

***Fig 3**. Transmission of data to a computer*

Data received by the computer displayed in the graphical form where the Graphical user interface (GUI) used as a display describing a command that is being run by the computer in the form of a graphical formation. GUI display will function to make it easier for humans to access programs that are on the computer. The node software divided into three central parts that are sensor nodes, delivery to servers, and databases. The central software part in sensor node shown in fig 4.

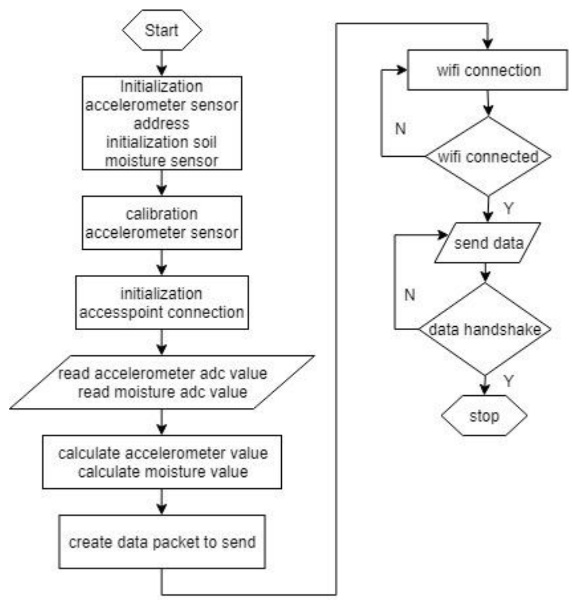

***Fig 4.** Primary flowchart of the wireless sensor node*

Fig 4 is a flowchart sensor node system used in this research. The sensor node runs first by initializing the sensor address, sensor, and Access Point address. When the sensor has read the data, WiFi access must turn on so that the sensor data sent to the server. This sensor node processing uses the Arduino IDE so that the sensor can read data and convert it into digital data on the microcontroller. The next part is sending sensor data to the server that has functions as data transmission. The data transmission program part works shown in Fig 5.

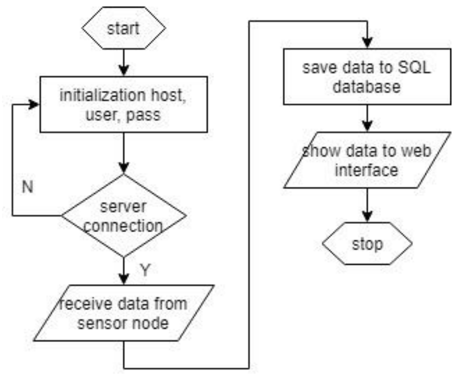

***Fig 5**. Data transmission flowchart*

Data transmission starts with initializing the Host, user, and pass after it is initialized then proceed with starting the server so that it can connect to the server. After data transmission finished and the server has been turned on, the device sends it to the database and then processed in the web interface. Database part used to store data readings from the sensor to the storage in the server. In fig 6, The database workflow can be seen.

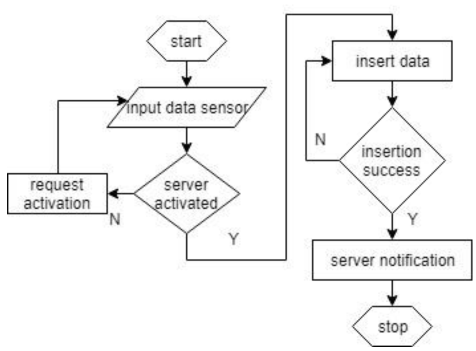

***Fig 6**. Database data insertion flowchart*

Fig 6 is a database design flowchart that is used to enter sensor data stored in the database. Data from the sensor node will pass through the server, and when the server is not active, then the data cannot be stored in the database. When the server is active, the data will enter the database, and the data from the sensor node has stored in the database.

3. IMPLEMENTATION

The duty cycle or energy cycle is a cycle of a period when a system is active and dead. In a sensor node, the duty cycle interpreted as the period of a node off and on. When the node is on, the node can send data to the base station. The duty cycle method controls the active time of the sensor node is sending data to the server and acquires data from the sensor to allow power savings.The research that has done so far uses landslide sensors that have been made before and then further modified to examine the level of energy use required. In Fig 7 can be seen the design of the sensor nodes used.

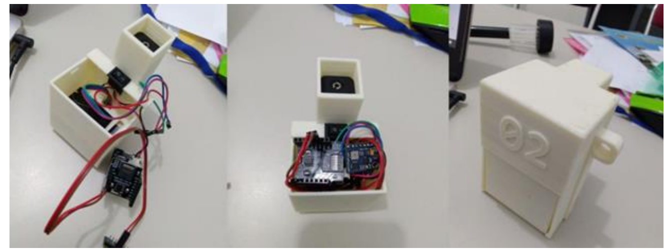

***Fig 7**. Wireless Sensor Node implementation*

4. RESULTS AND DISCUSSION

The wireless sensor node generally uses an accelerometer sensor and a moisture meter than using wifi communication to transmit data. In graph Fig 8, The power used by the node when using continuous reading can be seen.

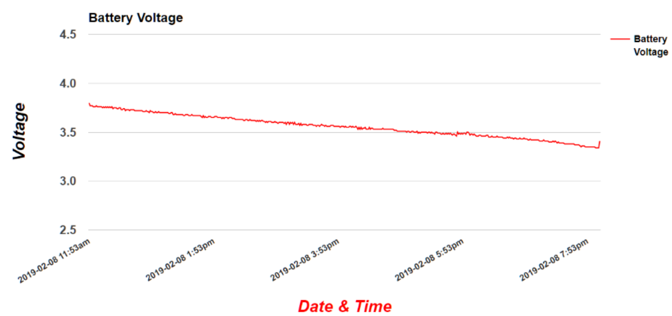

***Fig 8**. Typical power usage graph with 1-minute data acquisition interval and all sensors used*

In typical power usage with all sensors used and wifi delivery always on, a power reduction of 31% is obtained within 12 hours. Then the duty cycle method is used by design, as shown in Fig 9.

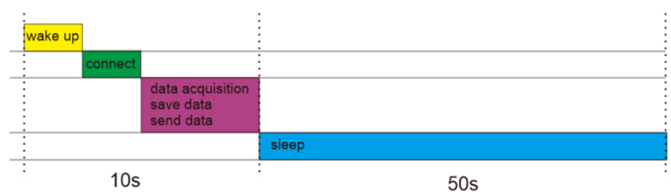

***Fig 9**. The design of the duty cycle method*

The duty cycle is used to divide the work every 1 minute. The main work of the sensor node is to establish a wifi connection, read the sensor, record data, and send data. Without using the duty cycle, energy will continue to be taken by the components in the sensor node so that it is very wasteful in its application. By using the duty cycle, the primary process only takes 10 seconds, while the remaining 50 seconds can do a sleep mode that does not require much power. Data on the use of the duty cycle shown in Fig 10.

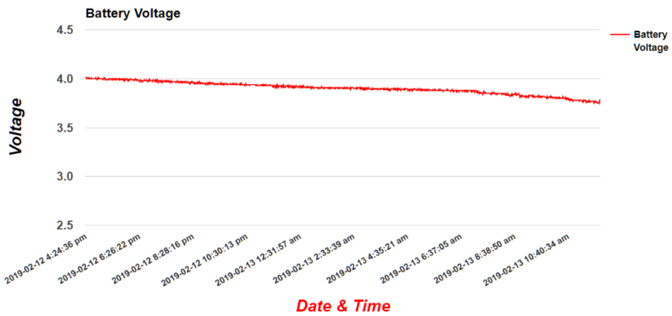

***Figure 10**. Power usage with sleep and data acquisition intervals and sending every 1 minute*

The use of the duty cycle method results in a power reduction of 2.5% within 12 hours so that the sensor nodes can be more optimal and last longer than without using a duty cycle. In reasonable conditions, the system can ready up to 1 day using standard power consumption, but if we use the duty cycle method, the system can ready up to 12 days.

5. CONCLUSION

Optimization with the duty cycle sleep and operational methods on the wireless sensor network for the landslide early warning system node results in a longer node lifetime With a duty cycle of sending data every 1 minute, the system's power is reduced by 2.5% every 12 hours, while without the duty cycle, the power reduced by 31% every 12 hours. So using the duty cycle method, power efficiency went up to 12,4 times better than before.

5. SUGGESTIONS

Further development, we recommend the analyze deeper on battery type and capacity so we can get better energy source for wireless sensor node especially in case of landslide early warning system.

ACKNOWLEDGMENT

This work was supported in part by a grant from the Department of Computer Science and Electronics Universitas Gadjah Mada.

REFERENCES

[1] T. Hidayat, “Sistem Pendeteksi Dini Longsor Menggunakan Teknologi Wireless Sensor Network (WSN),” J. Tek. Elektro ITP, vol. 6, no. 1, pp. 87–92, Feb. 2017.

[2] W. I. Lesmana and M. C. Wibowo, “Penerapan Wireless Sensor Network (Wsn) Dengan Topologi Tree Pada Pemantauan Tanah Longsor,” vol. 13, no. 1, p. 6, 2015.

[3] D. Hanto, “PENGEMBANGAN JARINGAN INKLINOMETER WAKTU NYATA UNTUK MONITORING PERGERAKAN TANAH,” 2012.

[4] P. N. Sutopo, “LEWS Longsor Selamatkan 100 KK di Aceh Besar - Badan Nasional Penanggulangan Bencana,” 2011. [Online]. Available: https://www.bnpb.go.id/lews-longsor-selamatkan-100-kk-di-aceh-besar. [Accessed: 18-Oct-2019].

[5] V. Gabriella, M. Pangemanan, A. Turangan, and B. Sompie, “ANALISIS KESTABILAN LERENG DENGAN METODE FELLENIUS (Studi Kasus: Kawasan Citraland),” J. Sipil Statik, vol. 21, pp. 37–46, Jan. 2014.

[6] L. Awaludin and O. Dhewa, “Low Cost Sensor Node Device for Monitoring Landslides,” IJEIS Indones. J. Electron. Instrum. Syst., vol. 8, p. 201, Oct. 2018.

[7] C. Zet, C. Fosalau, D. Petrisor, and I. Hogas, “Study of the power consumtion of a landslide sensor node,” 2016, pp. 1–5.

[8] D. Bhattacharya, “Power Optimization in Wireless Sensor Networks,” Int. J. Comput. Sci. Issues, vol. 8, Sep. 2011.

[9] N. A. Abdul Rahman and A. Jambek, “Wireless sensor node design,” 2016, pp. 332–336.

[10] E. Kyriakakis, “Sensor Node Board.” 02-Aug-2017.