Performance of Network Mobile Multi Node Wireless Sensor For Application to Landslide Movements

By Hafsah Nirwana

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Abstract

Landslides are the movement of slope-forming materials such as rocks, debris materials, soil, or a mixture of these materials, moving down or offslopes. In connection with an early warning of landslides, a very important thing to note is the process of collecting information or data on the occurrence of landslides (landsline). The more points of node sensorsare installed on landslide-prone areas, the more accurate the quality of an early warning system is. The research was aimed at creating a model of landslide movement and creating and analyzing models of multi-sensor data communication based on ZigBee IEEE 802.15.4. The research was to create a model of landslide movement based on the speed rate of soil movement by using a mobile Wireless Sensor Network/WSN and make the laying model of some WSNs (multi nodes) foran area coverage ± 300m2. This modeling usedthe software of Network Simulator version 2 or NS-2 with a range of scenarios. The results revealed that based on the network quality,the delay of some scenarios were very erratic; the packet delivery ratio value decreasedwhen the number of clusters and/or nodes increased; andwhen the number of clusters and/or nodes increased, the throughput got bigger.

Key words: Landslide, WSN, Mobile, Zigbee, Delay, PDR, Throughput

Introduction

Ground motion is the movement of land mass to a lower place due to gravitational force (Magetsari, 2001 in Ira, 2013). Landslides are defined as the movement of materials or soil from the surface of slopes downward slopes of the earth that is caused by gravity force (Sulistianto, 2001 in Ira, 2013).They are also definedas the movement of slope-forming materials such as rocks, debris materials, soil, or a mixture of these materials that move down or off slopes. The occurrence of landslides can be explained as follows.Water that seeps into the gorund increases soil weight. If water penetrates soil until it is impermeable and turns to be slip plane, it becomes slippery and the weathering soil on it will move followingand off the slope (VSI, 2011). In general, a landslide has a sliding area.

Early warning (Early Warning System) is a series of act of giving an immediate warning by an authorized agency to the public about the possibility of a disaster occurance in an area. The early warning system for landslides can reduce or prevent the loss of lives and propertieswhen landslides happen. In connection with the early warning of landslides, a very important thing to note is the process of collecting information or data on the incidence of landslides (landsline). The more points the sensor nodes mounted on landslide-prone areas, the more accurate the quality of an early warning system will be.

The research was aimed to create a model of landslide movement and create and analyze the models of multi-sensor data communication based on ZigBee IEEE 802.15.4.

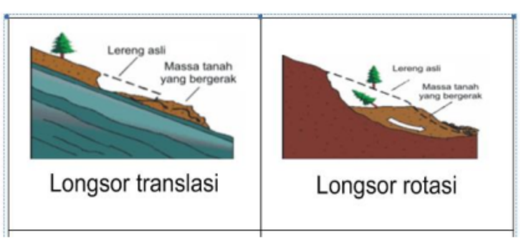

Figure 1.Landslide Condition

Wireless sensor network (Wireless Sensor Network/WSN) is a smart sensor in which each point on the senso has the ability to sense its surroundings (sensing), and processes the data obtained as well ascommunicates, but it is developed in a larger scale and can be connected to one another. Accordingly, it will be able to performan oversight function (monitoring) continuously (real time) on an environment that will be sensed by the wireless sensor network collectively. Wireless sensor network is a new generation of sensor systems(sensory system), althoughit is still limited to data processing ability only and has a limited bandwidth for communication(Ata E2005&GeorgeA, 2009).

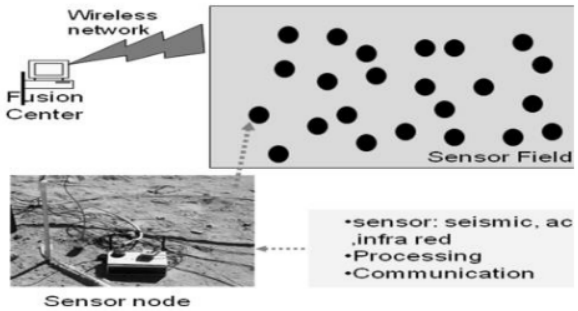

Figure 2. Wireless Sensor NetworkSystem (Abdul H dkk,2009)

In a *Wireless Sensor Network*there are 2 kinds of topology (Sri A,2011), namely:

1. *Hierarchical*
2. *Flat- type*

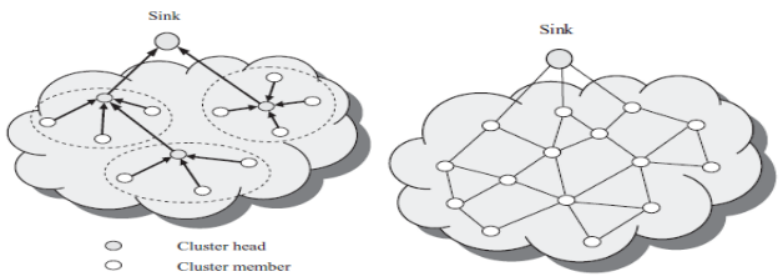

Figure 3. Single-hop cluster typeFigure4 Topology*flat-type*

The hierarchical architecture can be seen in Figure 3 and 4 above. In this topology, the sensor nodes are grouped in clusters. Sensor nodes are arranged in a hierarchical arrangement so that there are 3 kinds of nodes, i.e. the sink node, the cluster head, and cluster members. Sink node functions as a regulator of multiple cluster head in its application. Several cluster members become the members of a cluster head.

Research Methodology

The research was to create a model of landslide movement by using Wireless Sensor Network/WSN that is mobile and make the laying model of some WSNs(multi-node) for an area coverage ±300m2. This modelling used the software Network Simulator version2 or NS-2.

Data Communication Simulation Designing of Mobile Multi Node Wireless Sensor

For modelling the data communication path from the cluster node to the head node using ZigBee IEEE 802.15,the cluster head is positioned in the middle of the cluster nodes with a typology form of ad hoc type where one of the nodes will be assigned as a proxy to perform coordination among nodes in a group.

The concept of data communication path modeling consists of two nodes:

a. Node point of lanslide data of WSN; in this location several wireless sensor nodes are installed, which are divided in multiple cluster nodes. And each cluster node is equipped with a local alarm.
b. Head node; this point serves as the data centre of avalanche that originate from some node clusters. This section is also equipped with an alarm and automatic stop signs for road users who will cross the road in the area.

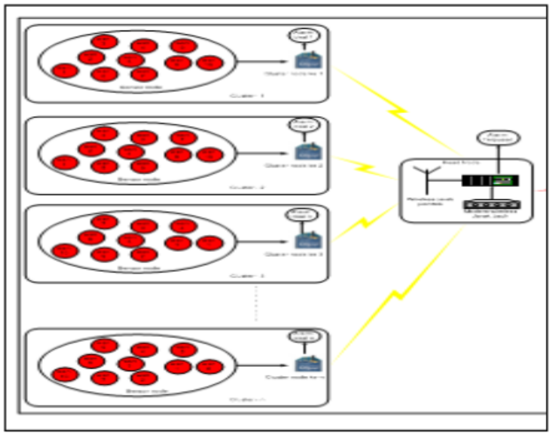

Figure 5. Model of data communication path of WSN *Multi Node* (Hafsah N, 2014)

The scenario rules of thereserachare as follows:

a. The conditionof WSN is mobile.
b. The position of WSN is fixed
c. The number of clusters ranges from 2 to 10 clusters.
d. The number of nodes/WSN in each cluster varies, i.e. 3, 5, 7, and 10 nodes.
e. The performance calculated is Delay, Packet Delivery Ratio and Throughput.

So, if scenario F1 has 10 clusters, it means that there is a WSN with 30 nodes. There is a situation where scenarios have the same number of nodes but the nodes are placed in different positions, for example scenario F1 with 10 clusters and scenario F4 with 3 clusters. Both scenarios have WSN with 30 nodes.

The designing of the mobileWSN consists of several stages: determiningthe parameters of communication devices, the position of the sensor nodes and their topology and the number of clusters and nodes. Then the simulation was constructed with the simulator of Network Simulator 2 (NS-2) version 2:34 with a modification of PHY and MAC QoS support, language programming C++ and Tcl. The result of the simulation was file traces, which weredisplayed in the form of data and graphs using AWK scripts and Gnuplot application.

Result And Analysis

A mobile condition isthe visualization of condition of sensor that hasa movement, which means that land movement takes place. The land movementis observed in terms of distance so that the condition can be calculated if it is still secure, unsecure, or a landslide is taking place. Making a decision on the condition is based on the speed rate of the land movement.

1. Results of mobile Zigbee WSN network performance

The parameters used for measuring the results of mobile Zigbee WSN network performance were Packet Delivery Ratio (in %), Throughput (in bps), and Delay (in milliseconds). Each table of the measurement results includes the three parameters for comparing the results with a variety of scenarios. The performance measurement results in Table 1 and the graph shapes for the results of performance measurement of the data communication systems from the table are displayed in some images below.

Table 1. WSN mobile Zigbee

Amount of Cluster (WSN)	PDR (%)				Traoughput (bps)				Delay (mili detik)			
	F1	F2	F3	F4	F1	F2	F3	F4	F1	F2	F3	F4
2	96.55	98.69	93.44	70.12	4.97	8.29	10.87	10.60	25.51	74.11	118.99	46.76
3	100	99.19	85.28	60	7.52	12.09	12.87	13.33	46.76	34.02	46.11	444.93
4	99.41	89.49	77.77	46.74	9.52	13.62	14.87	13.49	21.69	91.06	52.17	134.63
5	90.94	75.68	61.06	38.97	11.66	15.01	16.31	15.16	94.71	121.74	122.79	203.08
6	83.39	62.03	48.32	30.73	11.43	14.91	16.29	14.08	141.5	248.29	230.87	115.35
7	85.48	61.41	50.86	32.76	13.11	15.95	18.44	17.75	229.94	135.46	309.17	221.69
8	75.06	52.67	48.36	30.40	13.67	16.12	19.83	18.24	218.02	463.52	158.15	163.75
9	74.47	49.02	37.55	24.59	15.61	17.30	18.34	16.00	527.11	215.93	323.68	220.16
10	66.59	47.76	37.31	22.52	15.33	18.13	19.05	17.01	398.48	244.85	185.63	301.67

After having conducted the simulation with NS-2,one of the outputs was in the form *file Namtrace* that was used as an input for graphical display of simulation called *Network Animator* (nam). The result wasaform of WSN positioningcondition in landslide-prone locations. Below is a form of namtrace outputs from the scenario of fixed position of 10 clusters and 10nodes/clusters, which was scenario F4.

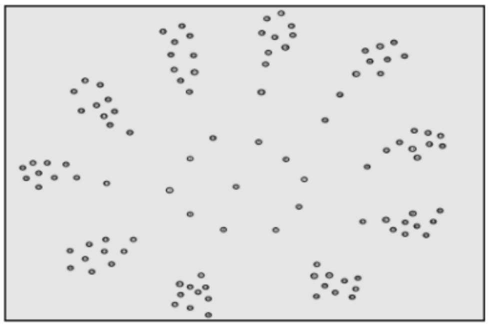

Figure 8. *Wireless Sensor Network* (WSN) positioning

2. QOS Measurement of Networks

a. Delay performance

- ✓ ForallscenariosF1, F2, F3andF4, the delay valuesvariedwhen the number of clusterorWSN increased. Sometimesthe delayvalues increasedwhen the number of clusterorWSN increased,butsometimesreduced as well.
- ✓ The shortest delay, which was 21:49 ms, happened to scenario F1with a number of 4 clusters, while thelongestdelayoccurred to scenario F1 with 9 clusters.

Based on the results obtained, the delay performance graphis shownin Figure 9.

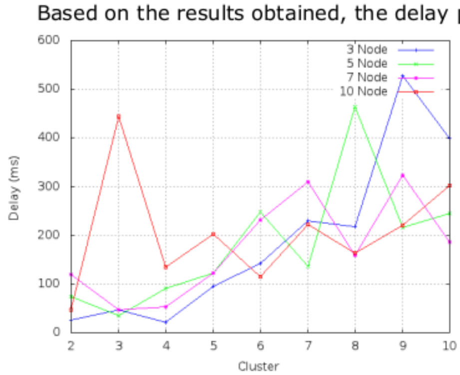

Figure 9. Delay graph of Zigbee Mobile WSN with a fixedposition of WSN

b. Packet Delivery Ratio performance

PDR performance measurement is a parameter to determine the ratio of the number of packets received by the receiving node to the total packets sent in a certain time period. The results are shown in Table 1.

The bigger the number of nodes was, the smaller the PDR was;andthe bigger the number of clusters was, the smallerthe PDR was. This means that more data sent will be received successfully if the number of nodes or clusters is small. For more details, this is visualized n graphical form in Figure 10.

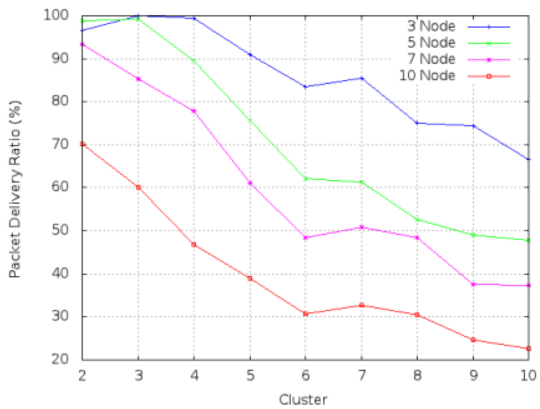

Figure 10. PDR graph of Zigbee Mobile WSN for fixed position ofWSN

c. Throughput performance

Throughput is the total number of success full packet arrivals at the destination observed during a specific time interval divided by the duration of the time interval. The comparison of throughput of each scenario shows the amount of data that can be transmitted in a time unit.

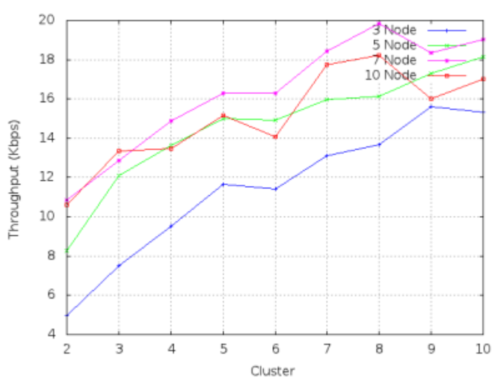

Figure 11. Throughput graph of Zigbee Mobile WSN for a fixed position of WSN

The bigger the number of cluster nodes and/or nodes was, the greater the throughput would be. However, although scenarios had the same number of nodes, they would result in different values of throughput when they had different topologies;for example, the results of scenario F1 with 10 clusters and scenario F4 with 3 clusters. Even though these two scenarios had the same node number of 30 WSNs, they resulted in different throughput,that is, 15.33 bps and 13.33 bps respectively.

Conclusions

1. Based on its quality, the Wireless Sensor Network using ZigBee could be used as a Landslide Early Warning.
2. The delivery time of information (delay) of the network was uncertain for a various numbers of clusters and nodes.
3. The Packet Delivery Ratio will decrease in value if the number of clusters and/or nodes increases.

4. Increased number of cluster nodesand/or nodes will increase throughput.
5. NS-2 can only model the soil movement speed rate at Grade/Category 5, 6, and 7, that is,big landslides, landslides, and lanslides will occur.

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