# Communication System Modeling Of Wireless Sensor Network For Early Landslide Detection

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## ABSTRACT

**This study aims to create an optimal communication path modeling of Wireless Sensor Network applied for early detection of landslide. It uses Network Simulator 2 (NS2) to design and analyze the QoS parameter on WSN network. Stages of simulation are started from designing, modeling and finally simulating the communication path. Based on the result of simulation, modeling analysis can be undertaken by parameters such as throughput, delay, packet loss and packet delivery fraction.**

**In communication path modeling being conducted, there are two scenarios; Scenario 1, where each central node that has several node sensors in it will transmit information directly to central monitoring. While Scenario 2, where each central node transmits information to the next central node and after the data are collected in data collector station, the data will then be transmitted to the central monitoring. Quality of data transmission is analyzed with the following parameters: throughput, delay, packet loss, and packet delivery fraction.**

**Keywords:** *Wireless Sensor Network, throughput, delay, packet loss, packet delivery fraction, landslide early detection.*

## I. INTRODUCTION

Landslide in some regions has become a substantially dangerous event for humans since it brings material losses. Disasters cannot be avoided, but what can be done is to minimize victims, material and environmental losses by undertaking an early detection of disaster events using sensor technology. However, the use of conventional sensor technology often finds difficulties such as data collecting related to landslide characteristics, considering that the possibility of wide range of area which will be detected, it thus causes inefficient and less optimal performance. One way to solve that problem is by the availability of an accurate detection monitoring system and early warning system of landslide. Wireless Sensor Network (WSN) technology is used as one of alternatives in early detection of the landslide events.

Wireless Sensor Network (WSN) technology is a smart sensor technology where each of its sensor point has ability to sense the situation around it, and to process acquired data, to undertake communication activity, and it is developed in a big scale and it can be connected to each other so that it can do a monitoring function in real time to an environment that is going to be sensed collectively by the wireless sensor network. Wireless sensor network is a new generation of sensory system [3].

The numbers of node sensor spread out in landslide-sensitive areas are aimed to capture a sign or phenomenon being investigated. Therefore, monitoring process of landslide early detection will be better and accurate. The node sensor has ability to route the data being collected to other nodes that are close. The data transmitted through radio transmission will be forwarded to the Base Station (BS) or *sink* which is a connector between node sensor and user. The information can be accessed by various platforms such as internet connection or satellite so that it enables the user to access information in real time [5].

In this research, the writers will make some alternatives for communication path modeling of wireless sensor network on Network Simulator-2 (NS2), analyze and compare the system performances of communication path modeling based on throughput, delay and packet loss parameters, and produce modeling form that has the most optimal performance so that it can be implemented to obtain information of landslide early warning. Significance of this research is to obtain an Early Warning System based on optimal wireless sensor network in detecting landslides.

## II. WIRELESS SENSOR NETWORK

Wireless Sensor Network (WSN) is an integrated system that consists of a group of sensor module node distributed and connected wirelessly on network topology and functioned in extracting various information that is going to be processed according to its application mode [1]. This system is categorized into Low-rate Wireless Personal Area Networks because bit rate is low and it does not need a long distance communication. Node sensor as network development consists of 4 main parts, which are sensor for detecting and measuring applicative parameters, activities of processing data into information, transceiver as a medium for data transmission, and power management for guarantying whether or not overall system can be optimally processed. WSN has ability to capture phenomenon around it. This is used to detect forest fire through the feature of temperature sensing. In addition, node sensor is also effective if it is spread out in disaster-sensitive areas. The location of disaster can be exactly known by micro sensor spread out and integrated with buildings around the location.

In WSN, node sensor is spread in order to capture signs or phenomenon that will be investigated. The numbers of node that are spread out can be determined based on needs and it depends on several factors such as area width area, sensing node ability, and others. Each node has ability to collect the data and to route it back to the Base Station. Node sensor can collect data in a big capacity from signs or symptoms occurred around it [5].

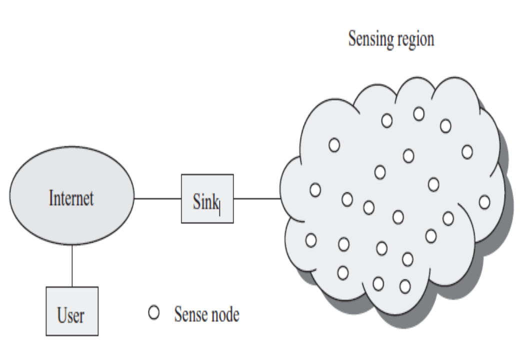



Fig. 1. WSN Architecture [2]

Small-sized node sensor is spread out in a sensor area. The node sensor has ability to route the data collected to other nodes which are close. The data transmitted through radio transmission will be forwarded to BS (Base Station) which is a connector between node sensor and user. The information can be accessed by various platforms such as internet connection or satellite so that it enables user to access it in real time through remote server.

## III. SOFTWARE PLATFORMS

A software platform can become an operation system that provides one set of service for application, such as file management, memory allocation, scheduling, peripheral software, and network, or it can also become a platform language which provides component library for programmers [2]. Software platforms for sensor network are like TinyOS, nesC, TinyGALS and Mot é. TinyOS is one of the earliest operation systems that support sensor network application in limited hardware resource platform, such as motes Berkeley. This system only uses 178 byte memory, but it supports communication modularity, multitasking, and code. It does not support file system, and only supports static memory allocation, implements simple scheduling tasks, and provides simple sets of equipment and network abstraction. NesC is the development of language C to support TinyOS design. NesC provides language construction and limitation to undertake TinyOS components and application. TinyGALS is a language for TinyOS and it gives more emphasis on congruency in system level rather than in component level. Mot é is a virtual machine for motes Berkeley. The machine defines virtual machine instruction for abstracting the general operations, for instance, investigation sensor of opinions and to access internal country. Therefore, software written in é Mot instruction does not have to be rewritten to accommodate new hardware platform that supports virtual machine.

### I. *NETWORK SIMULATOR-2 (NS-2)*

NS becomes one of tools that really useful to show a network simulation by involving Local Area Network (LAN) and Wide Area Network (WAN). However, the function of this tool has been developing in these recent years to include wireless network and ad hoc network [7].

NS-2 is one of software that can display a simulation process of communication and how the process is conducted. NS-2 serves simulations for communication wirelessly or not. In NS, there is a display with moving or unmoving node.

### II. QoS (*QUALITY OR SERVICE)*

QoS (Quality of Service) is the level of service quality that refers to ability in giving different services to network traffic also with different characteristics. QoS covers an ability of network in guarantying data flow by referring to some performance criteria to determine the level of satisfaction in the use of a service. QoS is designed for helping the end user become more productive by ensuring that the end user gets the best performance from network-based applications. Parameters often used for measuring QoS performance of a service are: Delay, Packet Loss, and Throughput.

## IV. RESEARCH METHODOLOGY

Research concept begins with data about indications of landslide event that will be sensed by node sensor, determine alternatives for WSN communication model and make a simulation through NS-2, and finally calculate the performance of the model. The research concept can be seen in Fig 2.

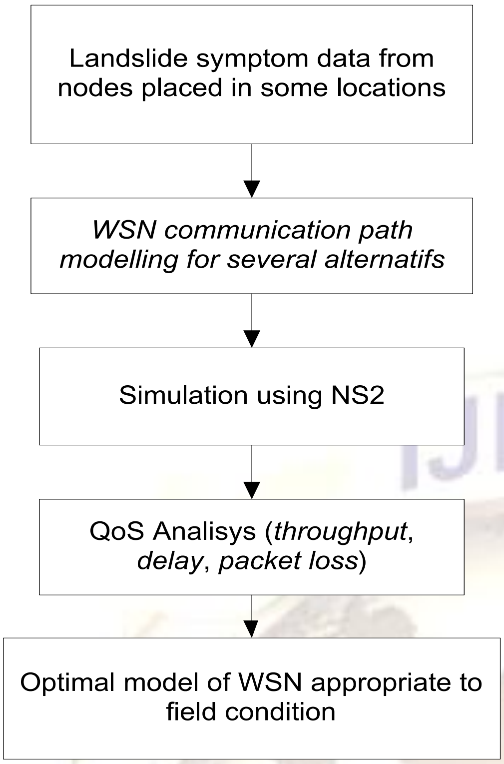



**Fig. 2. :** Conceptual Diagram

In the designing of WSN simulation on NS, order of program or simulation that is undertaken can be shown in a flowchart displayed in Figure 3. The simulation consists of 3 main procedures, they are procedure of environment setting and wireless communication, procedure of configuration and nodes making, and procedure of traffic setting on network. Procedure of environment setting and wireless communication is used to define the type of communication, routing protocol, type of propagation, numbers of node, and other general variables such as type of output file originated from the result of simulation.

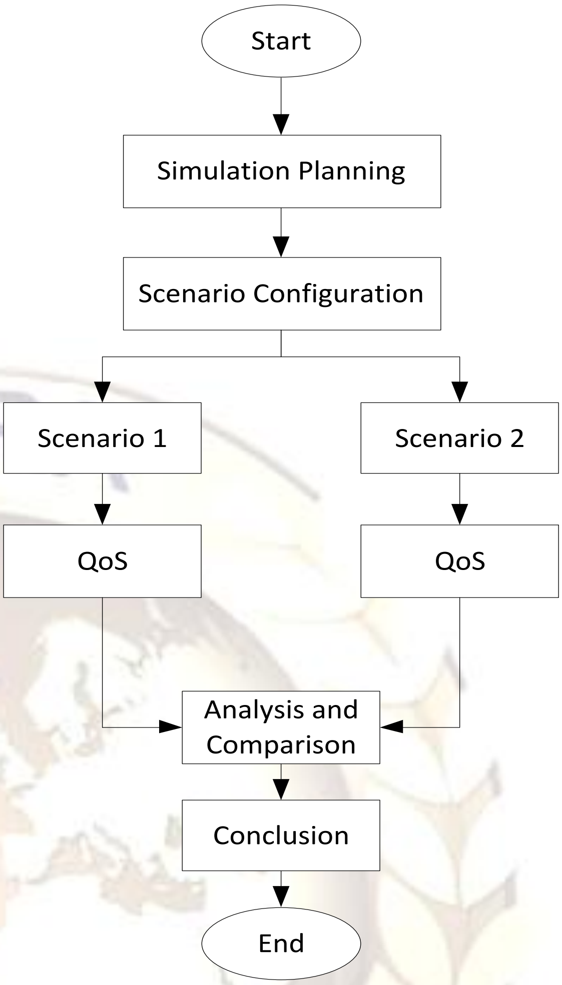



Fig. 3. Simulation Modelling Flowchart

Node configuration in this simulation consists of 2 conditions:

a. Condition I, number of node sensor is 25 that consists of 4 cluster nodes and there are 5 node sensors in each cluster node, 4 cluster head and 1 central monitoring.

b. Condition II, number of node sensor is 14 that consists of 2 cluster nodes and there are 5 node sensors in each cluster node, 2 cluster head, 1 central cluster and 1 central monitoring.

The analysis of data flow model for each condition that will be done through 2 types of simulation which has different purposes is shown as follows:

1. Simulation with scenario 1 that works directly.
2. Simulation with scenario 2 that works indirectly.

## V. RESULTS

Performance parameters that will be analyzed in this research are throughput, delay, and packet loss. Analysis is undertaken by comparing the values of those three acquired parameters as the result of simulation. The values are plotted in the form of graphics. The use of graphics is intended to facilitate the analysis because it can see comparison of performances from each modeling.

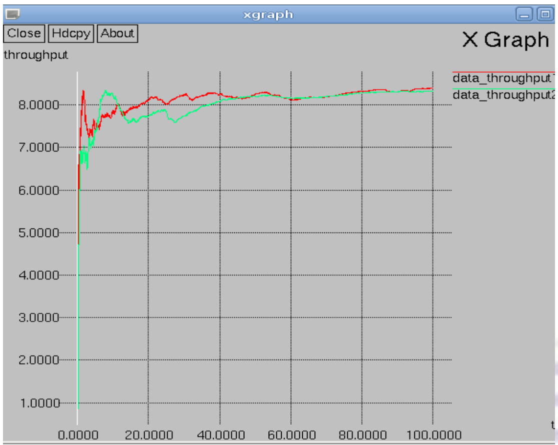



Fig. 4. Graphic of scenario 1 and scenario 2 throughput for condition I

Figure 4 sshows the comparison graphic of throughput data analysis between scenario 1 and scenario 2 in condition I. Based on the above comparison graphic of throughput data analysis, it is clear that there is no significant difference in throughput values for scenario 1 and scenario 2. It can be seen that both scenario have relatively similar values following the increase of time. In scenario 1, the highest output value is 8.40 kbps and for scenario 2 is 8.32 kbps.

The comparison graphic of throughput data analysis between scenario 1, scenario 2, and scenario 3 for condition II is shown in Figure 5.

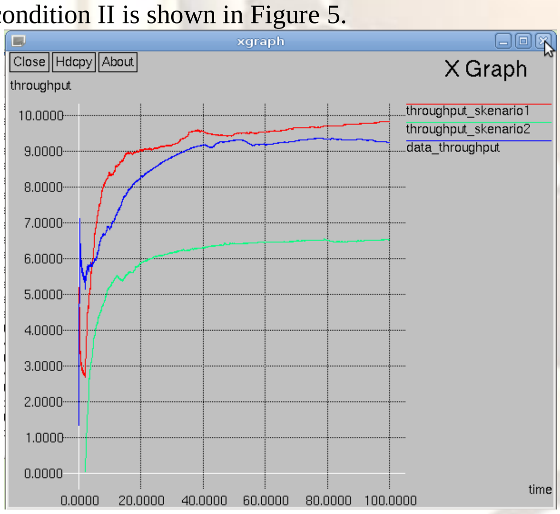
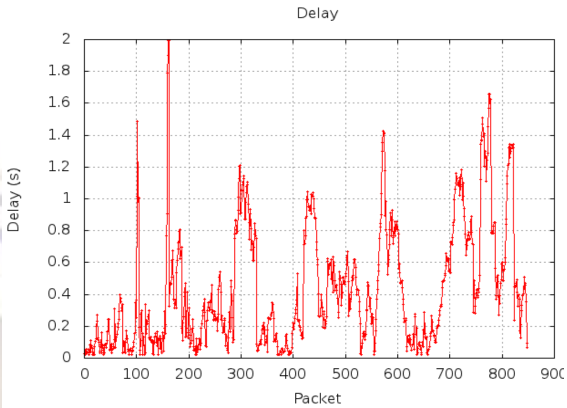


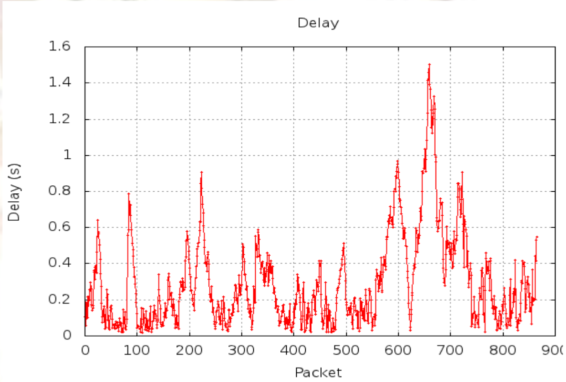

Fig. 5. Graphic of condition II throughput

From the above graphic of throughput analysis, it suggests that the value of throughput fro scenario 1 is better than scenario 2 and scenario 3, while if it is compared with the value of throughput in scenario 2, the value of throughput in scenario 3 is actually better. The highest value of throughput fro scenario 1 is 9.82 kbps. The highest value of throughput for scenario 2 is 6.53 kbps. The highest value of throughput for scenario 3 is 9.73 kbps.

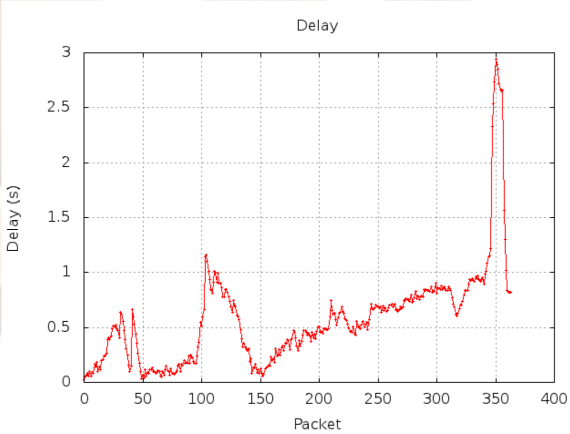
Value of delay is really important in WSN application because of communication being done in real time, thus the value of delay must be small in order to make the time for data transfer not to be slow and communication is not interrupted. Result of delay measurement is shown in Figure 6.



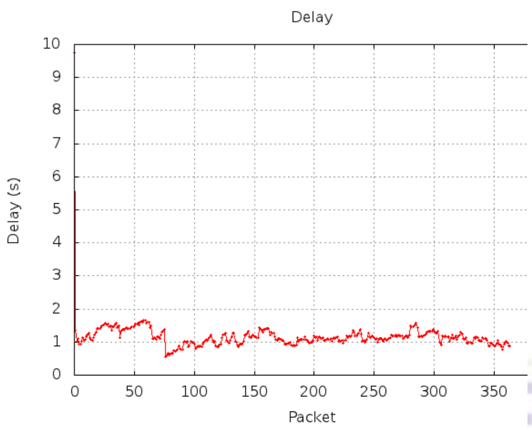

a.Graphic of delay data scenario 1condition I




b. Graphic of delay data scenario 2condition I




c. Graphic of delay data scenario 1condition II




d. Graphic of delay data scenario 1condition I
Fig. 6. Graphic of delay data

Based on the graphic above, it clearly suggests that the delay value for scenario 2 is better than scenario 1. For scenario 2, the average value of delay is stable with more transmitted packets.
For the result analysis of performance measurement of packet loss, average presentation of packet loss in condition 2 has smaller values compared to scenario 1 and scenario 3. But for the presentation of packet loss occurrence, scenario 3 is better than scenario 1. This is because scenario 3 is the combination of scenario 1 and scenario 2. The result is shown in Table 1.

**Table 1 : Packet loss comparison of scenario 1 and scenario 2 for condition I**

| Time (second) | Packet loss scenario 1 (%) | Packet loss scenario 2 (%) |
|---|---|---|
| 5 | 8 | 2 |
| 10 | 29 | 6 |
| 15 | 36 | 10 |
| 20 | 14 | 27 |
| 25 | 22 | 8 |
| 30 | 7 | 17 |
| 35 | 36 | 7 |
| 40 | 26 | 3 |
| 45 | 9 | 5 |
| 50 | 32 | 8 |
| 55 | 36 | 7 |
| 60 | 27 | 14 |
| 65 | 24 | 17 |
| 70 | 8 | 2 |
| 75 | 9 | 0 |
| 80 | 29 | 0 |
| 85 | 7 | 0 |
| 90 | 21 | 1 |
| 95 | 3 | 2 |
| 100 | 10 | 4 |

**Table 2 : Packet loss comparison of scenario 1 and scenario 2 for condition 2**

| Time (second) | Packet loss scenario 1 (%) | Packet loss scenario 2 (%) |
|---|---|---|
| 5 | 36 | 5 |
| **10** | 3 | 9 |
| 15 | 26 | 3 |
| **20** | 8 | 0 |
| 25 | 8 | 21 |
| **30** | 4 | 1 |
| 35 | 2 | 12 |
| **40** | 36 | 1 |
| 45 | 41 | 0 |
| **50** | 1 | 0 |
| 55 | 0 | 0 |
| **60** | 0 | 18 |
| 65 | 49 | 31 |
| **70** | 9 | 11 |
| 75 | 19 | 5 |
| **80** | 7 | 0 |
| 85 | 22 | 0 |
| **90** | 23 | 0 |
| 95 | 20 | 20 |
| **100** | 42 | 23 |

## VI. CONSLUSIONS

Based on the result acquired through simulation and analysis, the conclusions are:

*a.* Throughput value is increased in scenario 1 compared to scenario 2 both for condition I and condition II. This is because network topological modeling in scenario 1 where each cluster node directly send its data to the central monitoring, thus data accumulation in central cluster does not occur.

b. Delay Average Value in scenario 2 is better than scenario 1 and scenario 3 in both condition I and condition II. The delay is stable for scenario 2 in both condition I and condition II.

**c.** Packet loss occurred in scenario 2 is better than scenario 1 and scenario 3 for both condition I and condition II. In scenario 2, the occurrence of packet loss is smaller than in scenario 1.

**d.** Total ratio value of packet delivery fraction for scenario 1 is smaller than the value in scenario 2, which is 0.0811. Whereas in condition II, total ratio value of packet delivery fraction in scenario 2 is smaller than in scenario 1 and scenario 3, which is 0.0923.

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