

Implementation of Multiple Host Nodes in Wireless Sensing Node Network System for Landslide Monitoring

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Abstract. This paper proposes multiple host nodes in Wireless Sensing Node Network System (WSNNS) for landslide monitoring. As landslide disasters damage monitoring system easily, one major demand in landslide monitoring is the flexibility and robustness of the system to evaluate the current situation in the monitored area. For various reasons WSNNS can provide an important contribution to reach that aim. In this system, acceleration sensors and GPS are deployed in sensing nodes. Location information by GPS, enable the system to estimate network topology and enable the system to perceive the location in emergency by monitoring the node mode. Acceleration sensors deployment, capacitate this system to detect slow mass movement that can lead to landslide occurrence. Once deployed, sensing nodes self-organize into an autonomous wireless ad hoc network. The measurement parameter data from sensing nodes is transmitted to Host System via host node and “Cloud” System. The implementation of multiple host nodes in Local Sensing Node Network System (LSNNS), improve risk-management of the WSNNS for real-time monitoring of landslide disaster.

1. Introduction

Landslides are one of the most dangerous natural hazards which give a great impact upon occurrence, cause huge damage to infrastructures as well as loss of human life. They can strike in minutes when stability of a slope changed from stable to unstable condition. They usually triggered by heavy rainfall, but can also result from earthquakes, volcanic activity, and erosion. Although they cannot be prevented, they can be forecast. By reason of dangerousness, man power only cannot be used to observe this pattern of disaster. Therefore, in order to abate the damage and loss, a system that can monitor this disaster is necessary.

Wireless Sensing Node Network System (WSNNS) is an effective way to monitor landslide disaster in a wide area for long time. The system provides dual-way asynchronous communication between Host System (HS) and Local Sensing Node Network System (LSNNS). Host System is placed outside of the monitored area. Measuring person can access Host System; send commands to local sensor network (LSNNS) to get information about the monitored area without any risk. LSNNS then will transmit the measurement data required to the Host System. The mesh-type network formation in LSNNS enabled WSNNS to continue the landslide measurement even if some sensing nodes have been damaged during landslide occurrence.

2. Wireless Sensing Node Network System (WSNNS) Configuration

Wireless Sensing Node Network System (WSNNS) is structured into Host System (HS), Local Sensing Node Network System (LSNNS) and “Cloud” System (CS) as shown in Figure 1.



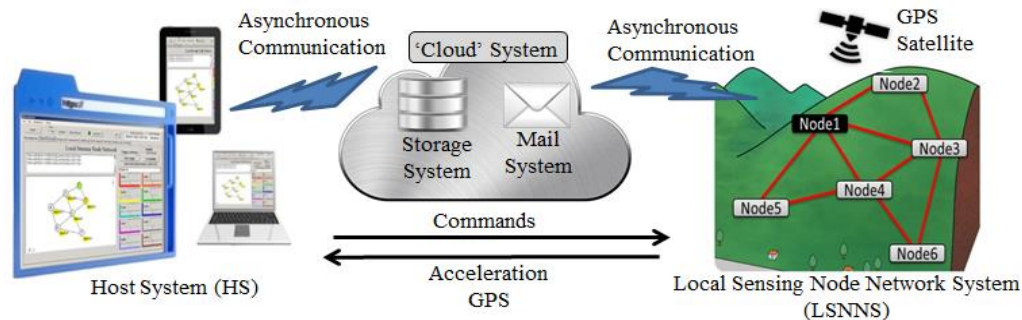


Figure 1. System construction of Wireless Sensing Node Network System (WSNNS).

2.1. Local Sensing Node Network System (LSNNS)

LSNNS is divided into host node and plural distributed sensing nodes.

Sensing node is a node in LSNNS which capable of gathering measurement data needed in landslide detecting and it can perform communication with other connected nodes in LSNNS. A sensing node consists of 3D acceleration sensor, GPS, controller board, liquid crystal display (LCD), and wireless communication unit MU-1. 3D acceleration sensor is used to monitor ground acceleration. By analyzing 3D acceleration angles and power spectrum, types of landslides (sliding down, rolling down) can be recognized. Besides that, GPS provides ground position information for each sensing node. By analyzing the position information, Host System enables to determine network topology of LSNNS which is necessary in constructing routing table and analyzing data during landslide occurrence. The position precision of GPS in sensing node is within 5m. Sensing nodes are located at the area which has high land-sliding probability to sense the occurrence of landslides. Figure 2 shows a sensing node prototype and Figure 3 shows mesh-type network connection between sensing nodes.

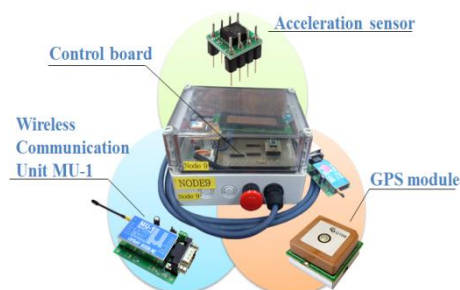


Figure 2. Sensing node prototype

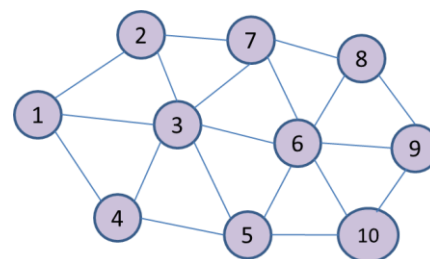


Figure 3. Mesh-type network

Host node is a gateway of LSNNS for receiving commands from Host System and transmitting measurement data from sensing nodes in LSNNS to Host System. The communication between host node and sensing nodes in LSNNS is by using long range wireless unit while the communication between host node and Host System is performed by using internet connection via Android. Host node is an important node which cannot be damaged during landslide disaster. Therefore, host node is set up at a place which has low probability of slope failure and has stable communication with Host System.

2.2. "Cloud" System (CS)

"Cloud" System contains storage system and mail system. Storage system and mail system are very useful as they transmit commands from Host System to LSNNS and measurement data from LSNNS to Host System. Host node in LSNNS can access the "Cloud" System by 13 messages per minute. Host node is connected to Android via Bluetooth in order to get internet access. Figure 4 shows series of data transmitted by mail messages in Android while Figure 5 shows the growth of LSNNS based on the measurement data from deployed sensing nodes.

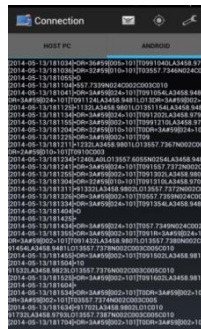


Figure 4. Series of data measurement

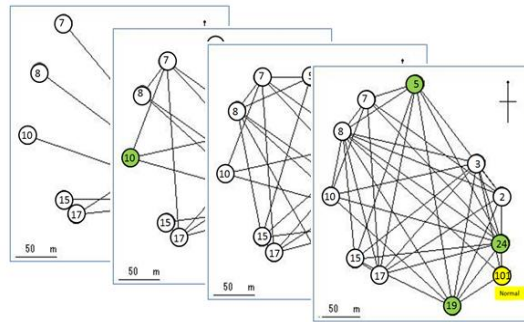


Figure 5. Growth of LSNNS topology

2.3. Host System (HS)

Host System sends operation commands to manage LSNNS. It also analyzes measurement parameter condition, construct routing table from network topology of LSNNS and alarm the occurrence of landslide. Figure 6 shows command operation window in Host System. Measurement data such as GPS and acceleration sensor data, network topology, routing table and node condition can be monitored from this command operation window.

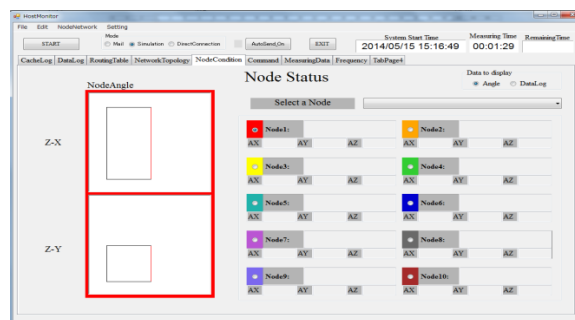


Figure 6. Command operation window in Host System

3. Implementation of Multiple Host Nodes in WSNNS

During landslide disaster, although a host node is set up at a place which has low probability of slope failure, there is still a possibility for the host node to be damaged. When the one host node is damaged, no command can be transmitted from Host System to sensing nodes in LSNNS and no measurement data can be received by Host System from deployed sensing nodes. Therefore, to avoid this kind of communication failure, it is a good solution to have more than one host node in LSNNS so that if one host node is damaged, other host node can still perform the data communication. Therefore, we propose the implementation of multiple host nodes in WSNNS for landslide monitoring. Figure 7 shows application of four host nodes in WSNNS.

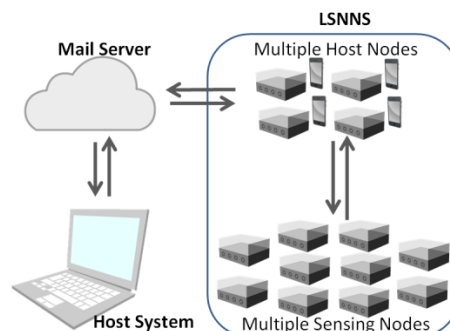


Figure 7. Application of four host nodes in WSNNS

3.1. Robustness of WSNNS by Using Multiple Host Nodes

In order to conduct an evaluation on WSNNS by using multiple host nodes, four host nodes (number 101,102,103,104) and six sensing nodes (number 2, 3, 7, 10, 15, 19) are deployed as shown in Figure 8. Four host nodes are located at different places so that in case of landslide occurs at one host node area and the host node is damaged, other host nodes can still survive. It is necessary to write four email addresses that commands will be sent to as shown in Figure 9.

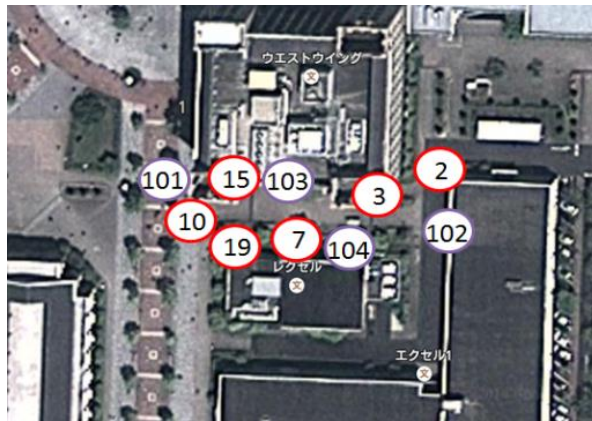


Figure 8. Arrangement of nodes

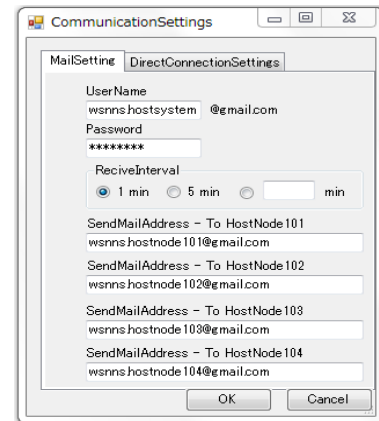


Figure 9. Mail Communication Setting

The evaluation started by sending a command to each host node to gather all sensing nodes measurement data information including GPS, acceleration sensor, and nodes adjacent information. Common data received by each host nodes are analysed at Host System. After each 3 minutes, one host node is artificially damaged starting from Host Node 101, 102 and 103. Measurement data received until the end of experiment is monitored at the Host System as shown in Figure 10, 11, 12 and 13.

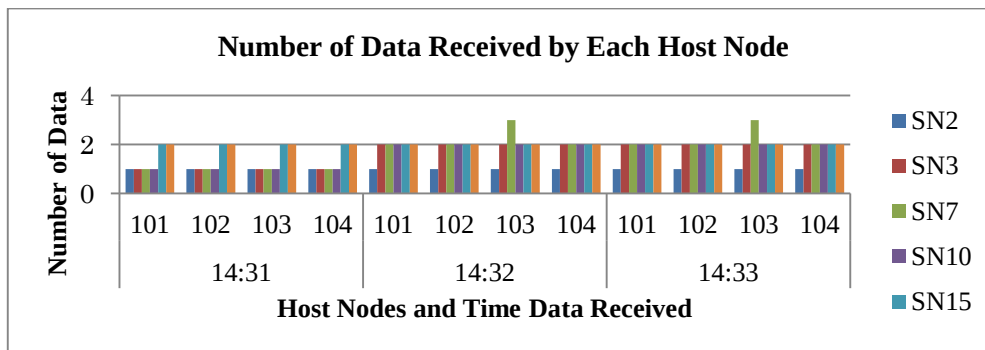


Figure 10. Number of data received by each host node

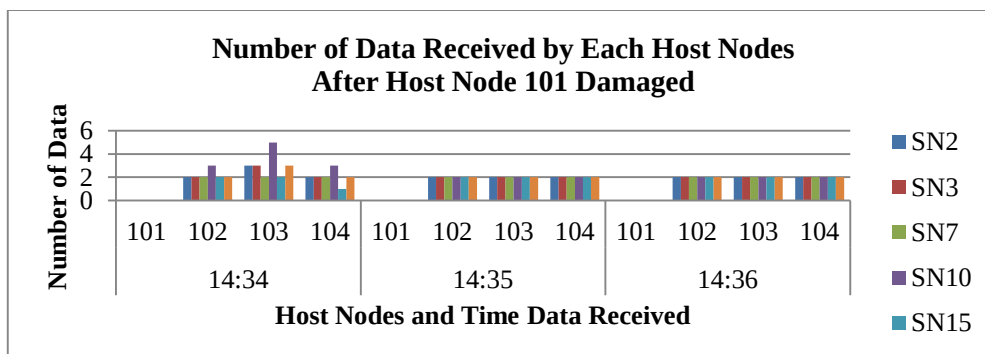


Figure 11. Number of data received by each host node after one host node is damaged

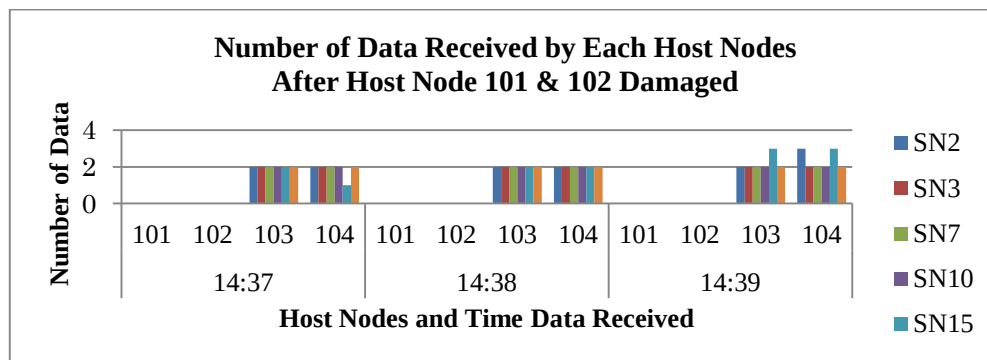


Figure 12. Number of data received by each host node after two host nodes are damaged

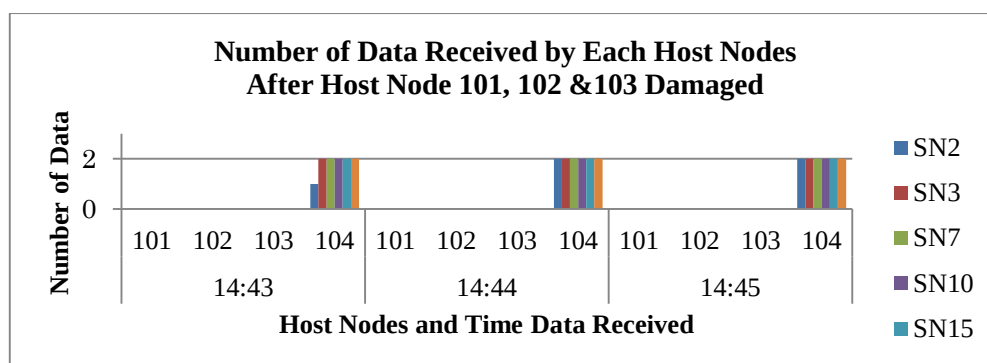


Figure 13. Number of data received by each host node after three host nodes are damaged

From Figure 10, we can see that each host node received measurement data from all sensing nodes. All host nodes have the same characteristics and load balance data collection and they can connect to the Host System at the same time. Figure 11, 12 and 13 shows that after one host node is damaged, other host nodes can still perform the data communication. There must be a backup host node at one time. If we use only two host nodes at the first place, after one host node is damaged, the other one host node will not have any backup. Therefore, we propose the use of not only two host nodes in LSNNS but three or four host nodes are necessary to improve the robustness of WSNNS in landslide monitoring.

3.2. Less Number of Hop for Transmitting Warning Information

In emergency mode (landslide occurrence), it is important to determine route taken by sensing nodes in sending the emergency data to Host System. Three host nodes (number 101, 102, 103) and six sensing nodes (number 2, 3, 5, 7, 10, 24) are deployed as shown in Figure 14 while Figure 15 shows the number of data received by each host nodes during normal mode. All data sent to each host node contains different routing information that later will be used to transmit warning information.



Figure 14. Arrangement of nodes

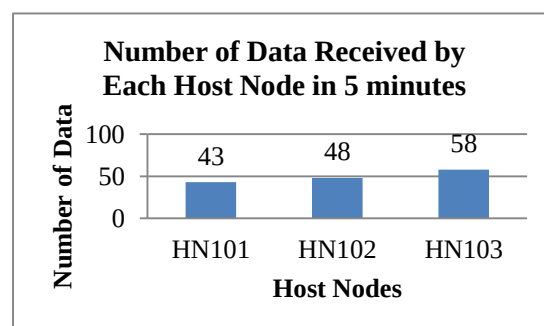
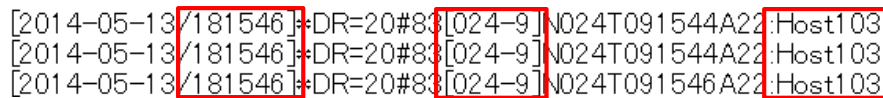


Figure 15. Number of data received by each host node

In the middle of the experiment, one sensing node (number 24) is artificially damaged and the route taken for emergency data transfer is analysed. Figure 16 shows the emergency data received at the Host System. “[024-9]” means that the emergency data is transmitted directly from sensing node number 24 to host node. “Host103” means that Host System received the emergency data via Host Node 103 which is the nearest host node for sensing node number 24.



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[2014-05-13/181546]**DR=20#83[024-9]N024T091544A22:Host103
[2014-05-13/181546]**DR=20#83[024-9]N024T091544A22:Host103
[2014-05-13/181546]**DR=20#83[024-9]N024T091546A22:Host103
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Figure 16. Number of data received by each host node

The presences of more host nodes enable sensing nodes to be closer to a host node. Therefore, sensing nodes can transmit the emergency data via the shortest route to the Host System. This can help minimize the time difference between time of landslide occurrence and time of Host System receives the emergency data. The result shows that Host System received the emergency data at 18:15:46 which is 46 seconds after the artificial landslide. This is because it takes time for sending and receiving email between host node, “Cloud” system and Host system.

4. Conclusion

The combination of Host System, “Cloud” System, and Local Sensing Node Network System in WSNNS enables this system to be a reliable system in monitoring landslide disaster. The implementation of multiple host nodes in LSNNS improves the robustness of WSNNS and enables warning information to be transmitted to Host System with less number of hops. Thus, emergency warning can be informed faster to take earlier safety precautions. Besides that, evaluation of multiple host nodes implementation in WSNNS at larger space area with more number of sensing nodes will be a good method to determine its merits and demerits.

References

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