Construction of Flexible Sensing Node Network for Monitoring Landslide Disaster

S. Takayama, K. Sato, M. Hiraoka, K. Kariya

Department of Electrical and Electric Engineering,
Faculty of Science and Engineering, Ritsumeikan University BKC,
Nojihigashi, Kusatsu, Shiga 525-8577, JAPAN
Email: s-tkym@se.ritsumei.ac.jp, kariya@se.ritsumei.ac.jp

Abstract. *Monitoring landslide disaster, sensor should transmit measuring data to host system urgently at the same time with the disaster. In some cases, the sensor disappears easily by the disaster. Additionally, it is necessary to observe broadly by distributed arrangement of many sensors because of difficult forecast of the disaster place. By these characteristic reasons, local sensing network is used to monitor the disaster. This paper describes the construction of sensing node network system which adapts flexibly to loss/addition of sensing nodes and urgent data transmission. The system operation is consisted by three characteristic operation modes (initialize mode, measuring mode and urgent mode). Switching those operation modes automatically by situation of mutual sensing node, the system realizes multiple data storage, effective data transmission and reconstruction of network link.*

Keywords: sensing network, autonomous network linking, disaster monitoring

1. Introduction

Most of natural disaster monitoring systems are unmanned remote systems[1]-[3]. There are two kinds of the system constructions. One is a centralized system depended on a host system. Other is an autonomous distributed system independent on the host system. Monitoring landslide disaster, the local sensors and the measuring data are lost frequently by the effect of disaster. Then it is necessary that the local sensing system is constructed as an autonomous network by plural sensing nodes. The characteristic of local sensing node network is to prevent the data loss by storage in common each sensing nodes. When the sensing node was lost by the disaster, the network needs to recover automatically. In addition to that, when new sensing node is inserted to expand monitoring range, the network needs to reconstruct autonomously. This paper describes the network construction with the autonomous linking functions.

2. Construction of local sensing node network

Fig.1 shows the local sensing node network. Fig.2 shows an external of the sensing node. This system is composed of Host SYSTEM(for network monitoring, data storage/processing) and sensing node(for measurement, storing data, operation mode switching).

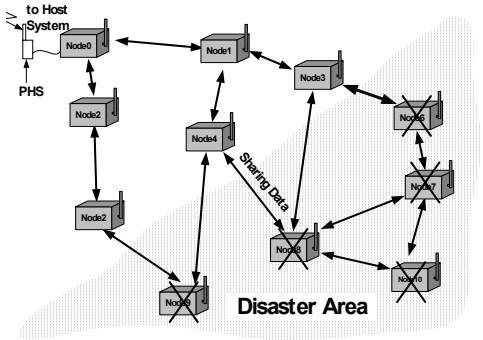


Fig.1 Local sensing node network

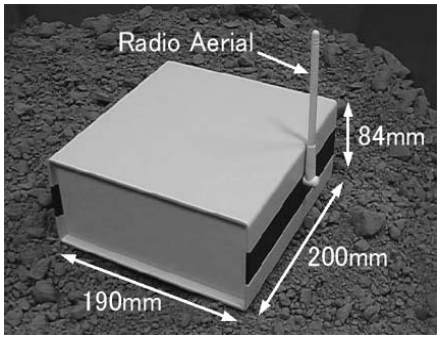


Fig.2 Sensing node

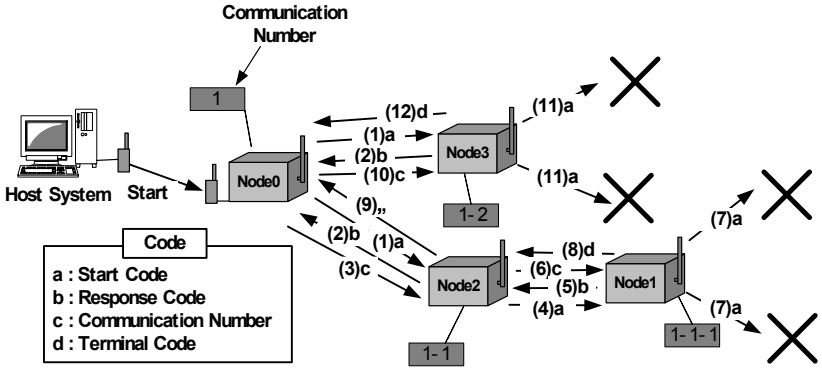
For disaster prevention, plural sensing nodes equipped with sensor, wireless machine, and control device are distributed at the disaster danger area. The sensing nodes form the network (tree type) autonomously with a wireless communication device, and communicate various kinks of messages each other. Neighbor nodes communicate directly. And also the node operates as a relay terminal between two nodes far away. Transmitted information is measurement data with the sensor, an existence confirmation of another node, and the decisions of the switch of the mode etc. An equal role is played regardless of the number excluding Node0 though a peculiar node number to each node is put beforehand. Host system doesn't participate directly in the network. Node0 is an only special node, and it communicates directly with host system, and the sensor for disaster prevention is not installed. The method of the network of Node0 participating is not different from a usual node. A wireless terminal that communicates with the outside is installed in Node0 besides the wireless machine for the communication between nodes. In a word, node0 is a node that doesn't measure data and concentrates on the communication with host system.

3. Operation modes of sensing node

Sensing nodes automatically switch over three kinds of operation modes by situation of network and measurement object..

Initialize mode

Because the sensing nodes are dispersed on the ground, the sensing nodes should establish the information transmission route to share measurement data. It aims forming a network of the sensing nodes that is initial state in the initialize mode autonomous mainly, and the communication number that means the order of each node's transmitting own measurement data to all nodes is assigned. The initialize mode to restructure the network formation when a part of sensing node disappears and when network shifts to the urgent mode, plays a center role of the control program. Fig.3 shows the method of constructing the network operation in initialize mode.



Node Number	0	2	1	3
Communication Number	1	1-1	1-1-1	1-2
Upper Node	None	0	2	0
Lower Node	2,3	1	None	None

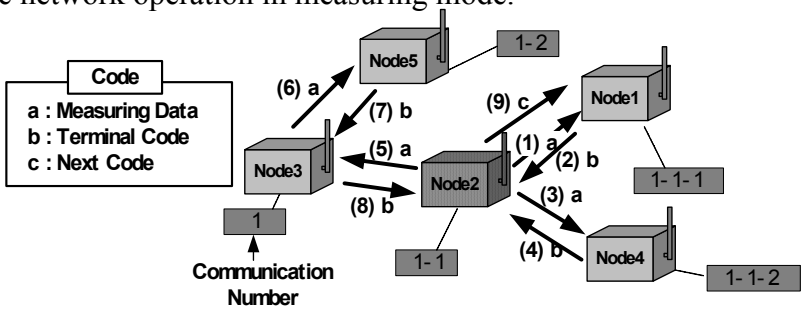
Fig.3 Operation in initialize mode

The manager transmits the initialization demand code from host system to Node0 with PHS [Fig.3 - (1)]. At this time, the communication number of Node0 automatically decides 1, and Node0 is located with the top upper node in the local sensor network. Node2 and Node3 that exists in the communication distance of Node0 returns Node0 the response code that means the answer to the start code. The response code is transmitted (One's Node Number * 0.5 [sec]) after the start code is received to move the transmitted timing each other. At this time, Node2 and Node3 that replies to the start code of Node0 are located with Lower Node of Node0. On the contrary Node0 is located with Upper Node of Node2 and Node3. Node0 that became a upper node assign the communication number of 1 - 1 to Node2 that has replied the response code earliest [Fig.3 - (3)]. Node2 that assigned the communication number transmits the start code in own communication distance, assigns communication number 1-1-1 to Node1 that has

replied to it [Fig.3 - (4)(5)(6)]. Because the lower node doesn't exist in the communication distance of Node1 [Fig.3 - (7)], the terminal code that means the terminal is returned to upper node (Node2). Node2 returns the terminal code to upper node Node0 further because it is not so though assigns the communication number like (1-1-2, 1-1-3…) if the lower nodes other than Node1 exist. At last, Node0 assign the communication number of 1-2 to Node3 at this time. And, the communication number is assigned to all nodes repeating similar. The initialize mode ends by this.

Measuring mode

If the initialize mode ends, and the information transmission route are established, the network shifts to the measuring mode. It is a purpose to measure the data, share the measurement data of each node in the measurement mode, and to observe the sign of the disaster generation. The data transmission is done by using the communication number assigned in the initialize mode. Fig.4 shows the network operation in measuring mode.



Node Number	3	2	5	1	4
Communication Number	1	1-1	1-2	1-1-1	1-1-2
Upper Node	None	3	3	2	2
Lower Node	2,5	1,4	None	None	None

Fig.4 Operation in measuring mode

In the measuring mode, the node that exists in the turn that transmits own measurement data is called a measurement node. The case that Node2 becomes a measurement node is indicated in Fig.4. The measurement node transmits the measurement data to the node that the communication number is the smallest in the lower node in the beginning. in this case, Node1 corresponds to it [Fig.4 - (1)]. Next, because the lower node of Node1 doesn't exist, Node1 returns Node2 the terminal code. And, Node2 transmits the measurement data to Node4 that is the following lower node, and Node4 also returns the terminal code. If the transmission to the lower node ends, the measurement data is transmitted to Node3 that is upper node. If the lower nodes other than Node2 exist, Node3 transmits the measurement data. Next, if an upper node exists, the measurement data is transmitted. Repeating the above, finally, the last terminal code is returned to the measurement node (Node2).

The method of knowing timing to which Node1 transmits the measurement data is necessary though it is Node1 becoming the measurement node next to Node2. The measurement node that received the last terminal code transmits the next code to the following measurement node and it corresponds. Node2 only has to transmit the next code to Node3 in the case with Fig.4, and when Node1 transmits the next code to Node4, Node1 requests transmission to Node2 because both nodes are not in the relation that can be communicated directly. Additionally, Node4 first requests transmission to Node2 for the turn of Node4 to end, and to transmit the next code to Node5 that is the following measurement node, and Node2 requests transmission to Node3. And Node3 transmits the next code to Node5 at the end. As mentioned above, the measurement data is transmitted in the measurement mode along the communication number to which three codes are assigned in the initialize mode.

A new addition of the node recognizes that oneself is a new node autonomous by a new node, and informs that to the node with in the local sensor network. The node to which it was informed demands the initialization for the

new node addition from the entire network, and, as a result, the new node addition is completed. Fig.5 shows the network operation of new node addition. In Fig.5, the measurement data of Node1 is passed on to Node6 [Fig.5 - (1)] and Node6 transmits to Node3. At that time, new node Node7 set up in the communication distance of Node6 will receive the data that Node6

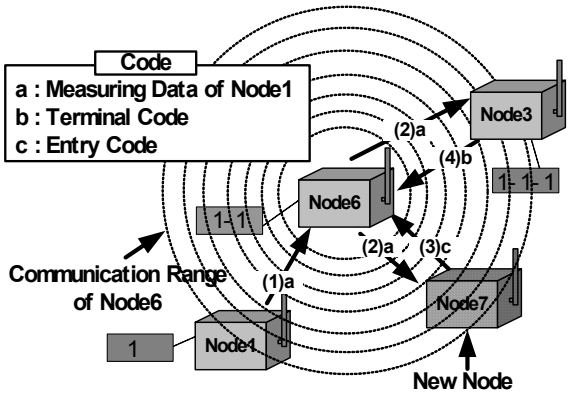


Fig.5 Operation at new node addition

transmitted. Node7 is initial state. And, it can be recognized that it is a new node by receiving the codes other than the start code. And, the entry code that means a new addition is transmitted to Node6 at once. Node6 informs all nodes of a new addition along the procedure for transmitting the measurement data when own turn has turned. After that, Node6 becomes top upper node, the network initializes, and Node7 is added to the network.

Urgent mode

In the measuring mode, it is a purpose to observe the sign of the disaster generation regularly**.** In the measuring mode, this local sensor network shifts to urgent mode when a certain sensing node judges the emergency based on own measurement data. Fig.6 shows the procedure of the shift to urgent mode. In urgent mode, the role of each node is different because of the arrangement place. The node that is urgent is called urgent node, and the node that connects an urgent node and Node0 is called a relay node. In addition, it becomes a preservation node, the node that exists in the communication distance of urgent node excluding the relay node receives and preserves the measurement of own data and the measurement data sent from urgent node. Other nodes become the measurement nodes, and concentrate on the measurement of own data.

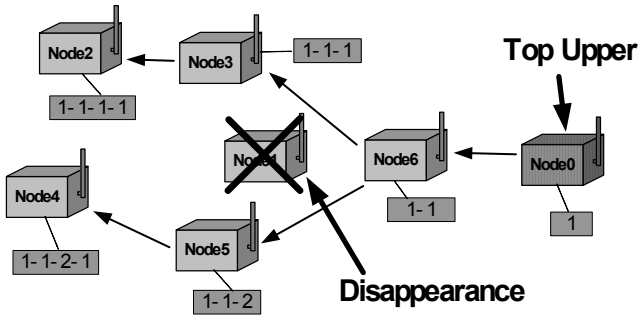


Fig.6 Operation in urgent mode

Urgent node becomes top upper node, and network is initialized. As a result the network is a shift from the measuring mode to urgent mode when initialized. When each node transmits the start code, and it looks for the lower node, Node0 can be found. The node that became upper node of Node0 becomes a relay node. And, all nodes that connect urgent node with Node0 become relay nodes. Urgent node transmits the measurement data to Node0 via the relay node.

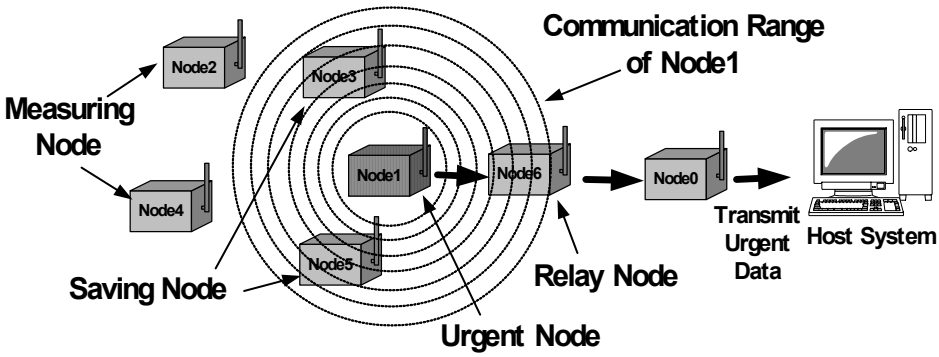


Fig.7 Initialization for network recovery

After transmitting the data to host system, even Node0 transmits the terminal code to urgent node via the relay node. When the terminal code is received, urgent node transmits the following measurement data.
There is a possibility that urgent node disappears in an urgent mode due to the disaster enough. The network is restructured with the initialization of Node0 as the top upper node in that case, and to return to the measurement mode, it is designed in this system. Fig.7 shows behavior on the network at that time.

4. Conclusions

Natural disasters occur suddenly and also damage monitoring system easily. Then it is necessary to construct robust and flexible sensing system. In this paper, an autonomous monitoring system by using local sensing node network has been proposed. And, it also has shown some functions like node self-recovery, flexible node arrangement and effective data transmission at disaster.

References

[1] Information – Communication System of Disasters Prevention Association, “Information – Communication System of Disasters Prevention”, Sankaido, pp.1-73 (2003)
[2] Kyoto University Disasters Prevention laboratory, “Foundation Disaster”, Sankaido, pp.9-21 (2003)
[3] A.Takei, “Landslide, collapse, mudslide – Prediction and Measure – “, Kashima publishing, pp.65-77 (1980)