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CONSTRUCTION OF WIRELESS SENSING NETWORK SYSTEM FOR LANDSLIDE DISASTER MONITORING

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Abstract: Sensing system to monitor natural disasters faces much hard conditions. Natural disaster occurs suddenly, and damages sensor system. Then, the sensor system should be designed as distributed node network. In addition to that, the network should have some characteristic functions like self-recovery, autonomous operation and effective data transmission in urgent. This paper describes the construction of autonomous sensing node network to recover the damage by landslide disaster and to transmit urgent data effectively. By switching operation modes autonomously, the sensing node network becomes robust system to the loss/insert of sensing node and the dynamic control of data transmission.

Keywords: Sensing Network, Landslide Disaster

1. INTRODUCTION

Recently, many natural disasters have occurred. Resulted, several damages and also gave a significant impact to Japan economic and global financial. In conjunction, there would be several countermeasure and system enhancement to mitigate the same loss in the future. This paper discusses the development of sensing node network system (SNNS) in detection of landslide. Miniaturized sensor nodes are deployed to operate autonomously in unattended environments. In addition to the ability to probe its surroundings, each node is installed with an embedded radio modem for communication within relay nodes to a host monitor. Nodes also programmed to independently control various function autonomously. Ability to re-construct the network and operate by switching the operation mode autonomously made SNNS a robust system with a dynamic control of data transmission.

2. SNNS STRUCTURE

2.1 Sensing Node Structure

System configuration used for sensing node is shown in Fig.1. Sensing node consists of wireless unit, sensors, GPS and control board. Sensors installed in the system are acceleration sensor and temperature sensor. As for control system, SH3-DSP board is used.

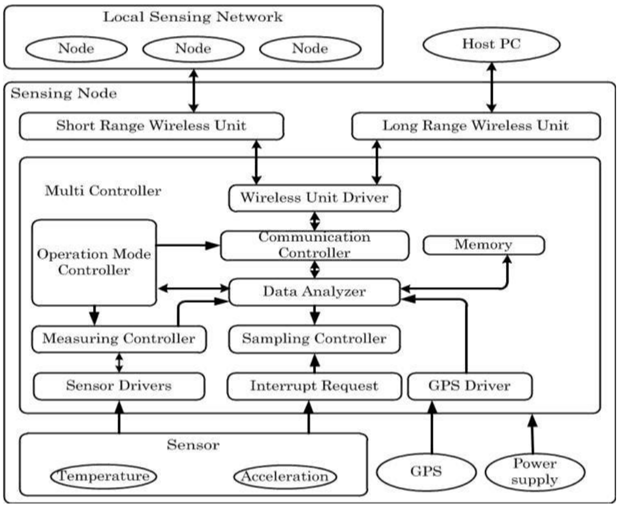

Fig.1 Structure of Sensing Node

Fig.2 shows sensing node prototype, Table 1 shows specification of node control board. It is experimenting using this equipment.

Fig.2 Prototype of Sensing Node

Table.1 Specification of node control board

CPU	32bit RISC processor
Clock	Maximum 200Mhz
Memory	Flash 4MB, cache SRAM 16kB
Port	8bit DIO 8 ports, Serial 3 ports
Voltage	3.3V
Power	0.683W
AD Converter	Input:8 channels (0 -3.6V) Resolution:10bits Conversion time:16s
DA Converter	Output:2 channels(0-3.6V) Resolution:8bits Conversion time:10s

2.2 Network Structure

SNNS is constructed from two main systems. (Fig.3) They are host system and local network system, which is consist of top node, and many local nodes.

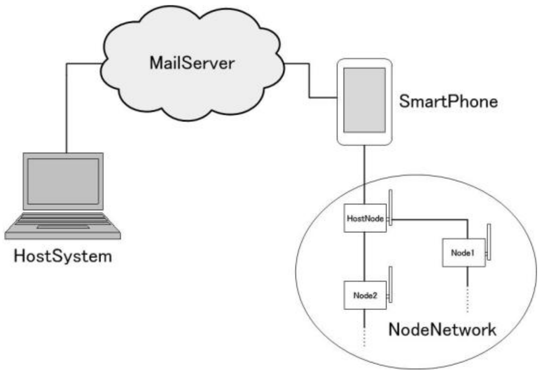

Fig.3 Overview of Landslide Monitoring by SNNS

The host system is a system to manage the state of the sensing node at the remote location. Top node can be sent to the data of each node in the smartphone by the use of Bluetooth.

This system builds a system that can be managed from a distance by the host system to send and receive e-mail that contains the data from smartphone. (Mail Mode) The data can be managed directly to the top node connected directly to the host system. (Direct Connection Mode)

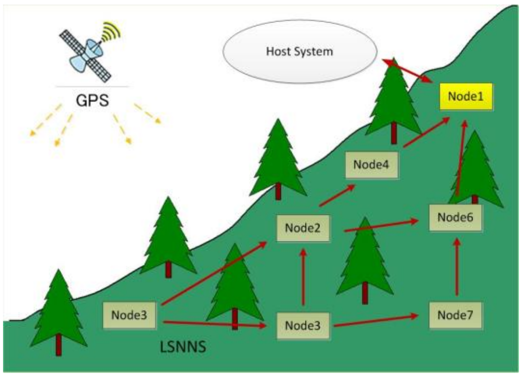

Fig.4 Overview of Local Sensing Node Network System

In the other hands, local network system communicates with short distance wireless unit, transmitting analyzed data from local nodes to top node directly or in multi-hop path.

Fig4. Show local network system communications. Top node is the only node that communicates directly to the host system; relay the data from local nodes to the host system. Hence, top node is installed at a position with the lowest possibility of slop failure and has stable communication with the host system. If slope failure is detected, related node will change to emergency mode and sent emergency alarm in high frequency to host node, while other nodes will be in low mode (idle) giving priority to emergency node for data transmission.

SNNS network construction and operation execute autonomously by local nodes. In SNNS, network communication use tree-mesh network to allow communication in various route.

Fig.5 shows Bluetooth Module. This module is used for communication of a top node and a smartphone. Table.2 shows Bluetooth the spec. of this module.

Fig.5 Bluetooth Module

Table.2 Specification of Bluetooth module

Version	2.1 (Backwards-compatible)
size	13.4 x 25.8 x 2 (mm)
Baud rate speeds	1200bps up to 921Kbps
Power	30mA connected
Wireless Path Length	About 100m
Frequency	2,402-2480 MHz

Small electric power consuming wireless modem (MU-1) is use in this system for the communication between sensing nodes. Fig.6 shows MU-1. Table.3 shows the spec. of this module.

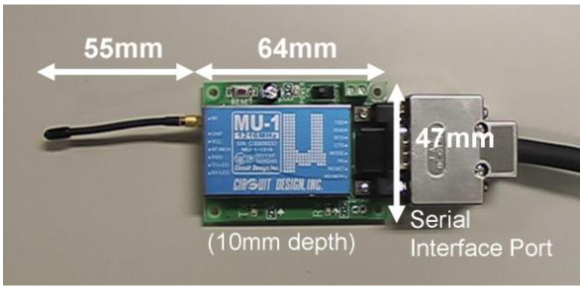

Fig.6 Wireless Communication Unit (MU-1)

Table.3 Specification of wireless communication unit

Communication Protocol	Simplex (9600bps)
Frequency	1216.0375 – 1216.4875 MHz 1252.0375 – 1252.4875 MHz
Transmission output	10mW
Supply Voltage	3.0 – 5.0 V
Consumption Current	Transmission: 60mA Reception: 35mA
Operation Temperature Ranges	-15 - +60 °C
Size	50 x 30 x 9 (mm)
Weight	23.5 g

3. OPERATION MODE

Fig.7 shows mode operation of local sensing network system.

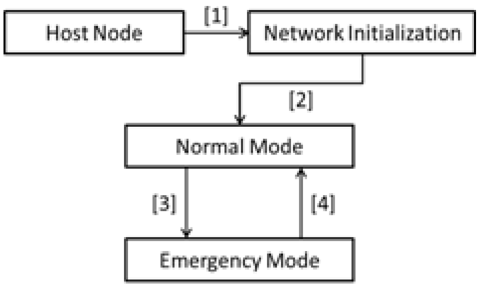

Fig.7 Mode Operation

[1] Beacon signal
[2] Start of system operation
[3] Detection of landslide disaster
[4] End of landslide disaster

The local sensing node network has characteristic operation modes.

In Normal mode, to monitor the indication of occurrence of landslide, the sensing node measures a signal and stores the measuring data in common among surrounding sensing nodes. In normal mode, there are three kinds of roles;

1) Waiting a command for data request,
2) Measuring data by mounted sensors,
3) Transmission of measuring data.

Additionally, the normal mode insert new sensing node in the local network to expand the monitoring area and to supplement a lack of sensing node. Fig.5 shows data flow in normal mode.

Emergency Mode is the mode to transmit measuring data urgently in local network when a sensing node discovers an indication of landslide disaster and senses the occurrence.

In a host system, routing table creation is performed into Network Initialization.

Routing table is sending position information and the channel information of the node first installed in the mesh type to a host system, and is generating a course.

The HOP number of networks is used for creation of routing table, and when it is the same HOP number, the direction to which it came for the host system previously has priority, and is creation.

4. HOST SYSTEM

Host system is a system to manage the state of the sensing node at the remote location.

To the host system has Host Monitor that can check the status of each node; we can check the status of the send and receive data. To make use of this monitor, we can be viewed on each node; measuring data, network topology, frequency, communication, buffer log, node status and send command.

In order to create routing table, host system is collected channel information from sensing nodes. The data of a red within the limit of Fig. 8 expresses collected data.

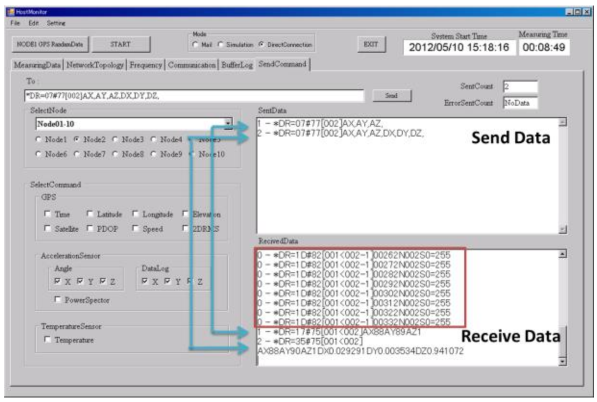

Fig.8 Data transmission and reception of a Host System

After routing table creation can obtain data needed by transmitting a command. Data can be obtained by transmitting, after choosing each item, as shown in Fig.9. The node number which wants to acquire data is chosen. Next, data to acquire from the GPS data (time, latitude, longitude, elevation, satellites number, PDOP, ground speed, 2DRMS) is chosen. Next, the acceleration data (each angle and raw data of the X-axis, the Y-axis, and the Z-axis, power specter) and temperature sensor data are chosen. Data needed is replied from a node by transmitting.

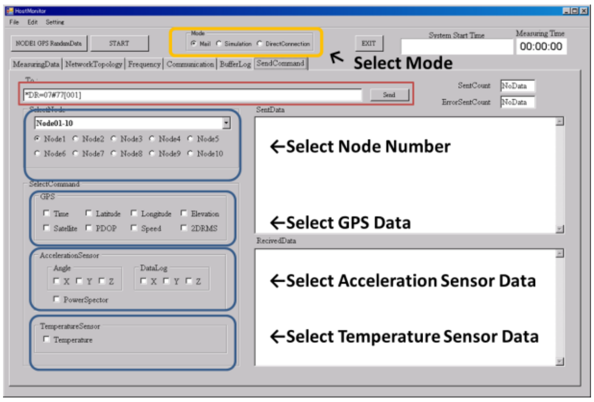

Fig.9 Command transmission of a Host System

Fig.10 shows network topology of a host system. The information on a position of a top node is inputted beforehand. The sensing nodes obtain the GPS information. The position of the sensing nodes arranged, respectively can be displayed on a map from there. The mode of sensing nodes can be checked.

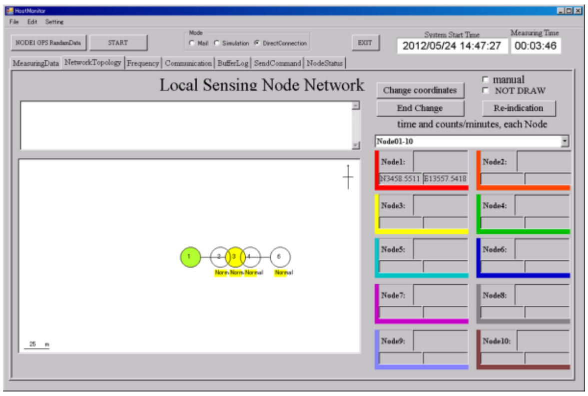

Fig.10 Network Topology of a Host System

Fig.11 shows communication log of a host system. In this tab, the situation of various communications can be checked as a log.

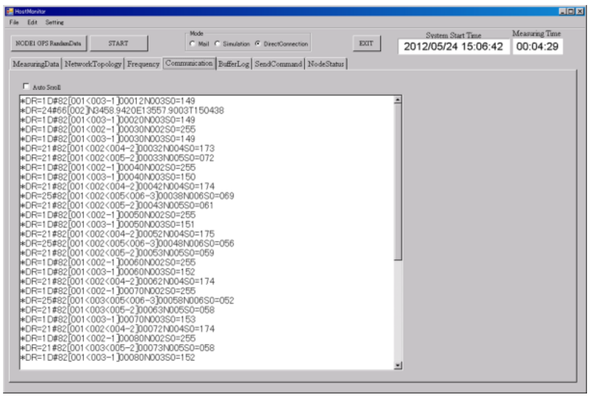

Fig.11 Communication Log of a Host System

5. EVALUATION FOR NETWORK SYSTEM

In order to check relation of a network, it experimented outside. As shown in a Fig.12, the host node and the sensing node were installed. After routing table created, it tried to receive acquisition data by transmitting a command.

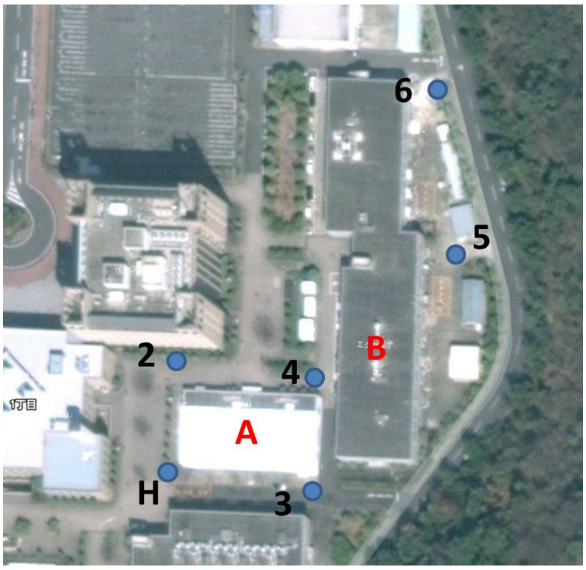

Fig.12 Sensing Nodes arrangement plan

Fig.12 shows sensing nodes arranged around the building A and B. H means the top node. Data is collected for routing table creation.

*DR=17#75[001<003]AX87AY92AZ3
*DR=17#75[001<002]AX88AY87AZ3

Route **Data**

Fig.13 Data obtained in the experiment

Fig.13 shows the data of an experiment. It turns out that the data demanded in this way is directly sent to a top node. "Route" has transmitted data to the top node (001) from which node. AX, AY, AZ of "Data" expresses the angle. By checking this data, the state of a sensing node can be known now.

```
*DR=24#66[005]N3458.9514E13557.9625T151816
*DR=24#66[005]N3458.9546E13557.9593T151819
*DR=24#66[005]N3458.9516E13557.9648T151821
*DR=24#66[002]N    0.0000E     0.0000T000000
*DR=24#66[002]N3458.9319E13557.9016T151644
*DR=24#66[002]N3458.9310E13557.9027T151646
*DR=24#66[002]N3458.9301E13557.9024T151648
*DR=1D#82[001<005-1]00022N005S0=056
*DR=1D#82[001<003-1]00031N003S0=152
*DR=21#82[001<003<004-2]00033N004S0=176
*DR=1D#82[001<003-1]00061N003S0=151
*DR=21#82[001<005<006-2]00030N006S0=071
*DR=1D#82[001<005-1]00061N005S0=052
*DR=25#82[001<002<005<006-2]00040N006S0=056
*DR=1D#82[001<002-1]00071N002S0=255
*DR=1D#82[001<003-1]00071N003S0=151
*DR=21#82[001<003<004-2]00073N004S0=169
*DR=1D#82[001<005-1]00074N005S0=051
*DR=1D#82[001<002-1]00081N002S0=255
*DR=21#82[001<002<004-2]00083N004S0=168
*DR=1D#82[001<003-1]00081N003S0=149
*DR=1D#82[001<002-1]00101N002S0=255
*DR=1D#82[001<003-1]00101N003S0=149
*DR=1D#82[001<005-1]00102N005S0=052
*DR=1D#82[001<005-1]00118N005S0=052
*DR=21#82[001<002<004-1]00102N004S0=169
*DR=1D#82[001<002-1]00111N002S0=255
*DR=21#82[001<002<004-1]00113N004S0=170
*DR=1D#82[001<003-1]00111N003S0=149
*DR=21#82[001<003<004-1]00123N004S0=169
*DR=1D#82[001<002-1]00141N002S0=255
*DR=1D#82[001<003-1]00141N003S0=147
*DR=21#82[001<005<006-2]00119N006S0=050
*DR=25#82[001<002<005<006-2]00109N006S0=050
*DR=25#82[001<002<005<006-2]00129N006S0=049
*DR=21#82[001<002<005-1]00151N005S0=052
*DR=1D#82[001<002-1]00161N002S0=255
*DR=1D#82[001<003-1]00161N003S0=142
*DR=21#82[001<002<004-1]00163N004S0=170
*DR=21#82[001<002<005-1]00162N005S0=052
*DR=1D#82[001<002-1]00171N002S0=255
*DR=1D#82[001<003-1]00171N003S0=141
*DR=1D#82[001<005-1]00172N005S0=053
*DR=1D#82[001<003-1]00174N003S0=143
*DR=21#82[001<003<004-1]00183N004S0=173
*DR=1D#82[001<005-1]00182N005S0=053
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*DR=21#82[001<005<006-2]00192N006S0=050
*DR=1D#82[001<003-1]00174N003S0=141
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*DR=17#75[001<003]AX87AY92AZ3
*DR=1D#82[001<005-1]00202N005S0=052
*DR=1D#82[001<003-1]00174N003S0=140
*DR=17#75[001<002]AX88AY87AZ3
*DR=1D#82[001<005-1]00208N005S0=052
*DR=21#82[001<003<004-2]00233N004S0=162
*DR=21#82[001<003<004-2]00253N004S0=164
*DR=1D#82[001<005-3]00208N005S0=051
*DR=1D#82[001<003-3]00174N003S0=144
*DR=1D#82[001<003-3]00174N003S0=146
*DR=1D#82[001<003-3]00174N003S0=147
*DR=1D#82[001<003-3]00174N003S0=148
*DR=21#82[001<005<006-4]00372N006S0=050
*DR=1D#82[001<003-3]00174N003S0=149
*DR=21#82[001<005<006-4]00432N006S0=049
*DR=1D#82[001<002-3]00172N002S0=255
*DR=24#66[002]N3458.9393E13557.9071T152827
```

Fig.14 Receive data of a Host System

Fig. 14 shows the data received in the experiment. The data of red underline parts received by command transmission. The other data is the channel information for creating routing table. By checking this data, the state of a sensing node can be known now.

The green underline part of data shows the course of data from the node No. 6. When two or more routes exist from this result, data will be transmitted by a shortest path.

Fig.15 shows the route of the data from sensing node number 6. Route a is sent to the top node via 5. Route b is sent to the top node via 5 and 2. Route c is sent to the top node via 3 and 2.

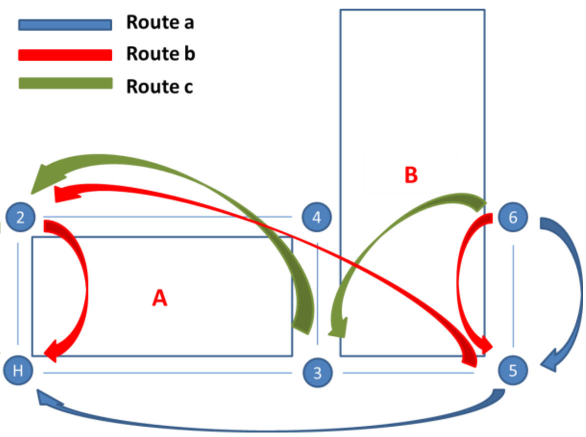

Fig.15 The route of the data from No. 6

A host system creates routing table from this data.

Many routes exist. The optimal route selection is performed. The optimal thing for which route selection is made becomes the most important.

Thus, many data paths exist. It turns out that it is most important to make a course setup the optimal.

6. CONCLUSION

In this paper, an autonomous monitoring system by using local sensing node network has been proposed. It has shown that the sensing node network has some characteristic functions like node self-recovery, flexible node arrangement and effective data transmission at disaster.

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