DEVELOPMENT OF THE REMOTE-CONTROL SYSTEM FOR MELTING-SNOW FACILITY USING RADIO PACKET COMMUNICATION

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1. Introduction

(1) The outline of Ishikawa Prefecture

Ishikawa Prefecture is located in the Sea of Japan side of the Honshu island's central part; in the east touches Toyama Prefecture, in the southeast touches Gifu Prefecture, in the south touches Fukui Prefecture, and in the northern and western sides faces to the Sea of Japan. With long and slender geographical feature of about 200 km from southwest to northeast, it is roughly divided into two parts; Kaga district which consists of white mountains foot and Kanazawa plain, and Noto district of peninsula part projected to the Sea of Japan from southeast to northeast.

Nanao engineering-works office that performed melting-snow facility management using radio packet communication is located in the center of Noto Peninsula. Nanao City faces to the Toyama bay in the east, and was the capital in the state of Noto country. Nanao City is the core city of the Noto district.

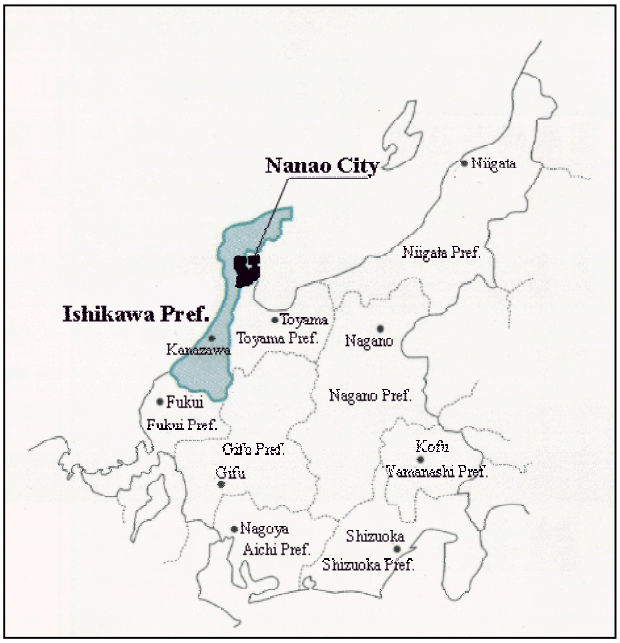

Fig. 1 Location of Nanao City

(2) Climate of Ishikawa Prefecture

Although the climate of Ishikawa Prefecture is mild and the typical Sea of Japan climate under the influence of the Tsushima warm current flowing along the coast, there is much snowfall in winter and precipitation's increases with 2,000 mm - 3,000 mm per year by the northwestern monsoon from the Siberia cold air mass. Whole Ishikawa Prefecture is in heavy snowfall area and six towns and villages of Hakusan foothills out of Ishikawa Prefecture is the special heavy snowfall area.

Noto district has comparatively little snowfall compared with Kaga district, and since they have had warm winter these several years within the Nanao engineering-works office jurisdiction, the maximum snow coverage is 20 cm – 30 cm.

(3) Improvement of melting-snow facilities of Ishikawa Prefecture

In Ishikawa Prefecture, the melting-snow facilities of 126 routes, 336 places, and total length 302.8 km of extension have been improved by the 2000 fiscal year. Within the Nanao engineering-works office jurisdiction, melting-snow facilities of 16 routes, 32 places, and 19.8 km of extension are managed. The remote-control system of radio packet communication is introduced to about 28 melting-snow facilities.

In Ishikawa Prefecture, the request of a melting-snow facility is strong and about 10 km road is improved every year. However, groundwater pumping and increase of expense in maintenance management have been future subjects. Therefore the remote-control system adopting the radio packet communication is able to attain data managements such as operation management with a personal computer, and the system is useful to groundwater control.

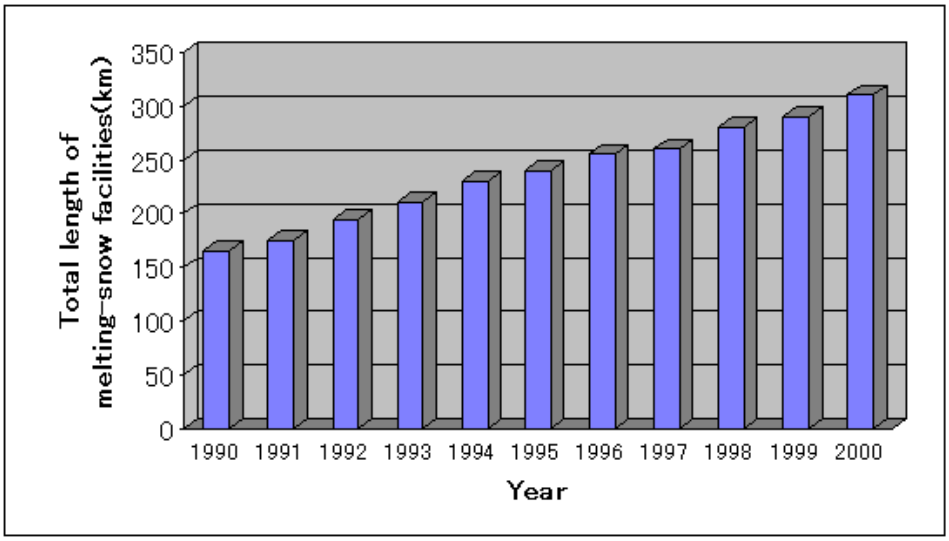

Fig. 2 Extension of melting-snow facilities in Ishikawa Prefecture

2. Measure for snow system (snow coverage information system) of Ishikawa Prefecture

Since Ishikawa Prefecture is a leading snow coverage area in the whole country, snow coverage during winter has big influence on daily life, industry, and economy. In Ishikawa Prefecture, construction of the information system on the basis of real time information has been carried out aiming at making strong roads against snow and the traffic jam during winter, considering such a situation (Fig. 3). Snow coverage information is gathered using ultrasonic formula snow coverage gauge (hereafter, snow coverage sensor) and the road surveillance camera which are installed in the snow coverage observation point, and reservation of quick snow removal system and road traffic are performed, being based on the system. Moreover, it is useful for preventing the accident beforehand and informing road users widely that information.

In Ishikawa Prefecture, the system started to perform snow coverage observation by the snow coverage sensor from the 1992 fiscal year. At the beginning, 10 sets of snow coverage sensors were installed in the Tsurugi engineering works office jurisdiction which manages Hakusan foothills, and they were utilized for gathering information on snow removal mobilization. After the 1992 fiscal year, 47 sets of snow coverage sensors are installed in whole a prefecture region in sequence, and now snow coverage sensors are working, and are utilized as judgment material of quick snow removal business. Moreover, from the 1999 fiscal year, the grasp of a road surface situation utilizing the road surveillance camera started, and it is combined by a snow coverage sensor, and quicker snow removal business can be performed now. 25 sets of road surveillance cameras are installed in whole a prefecture region, and the road surface situation is grasped. In order to aim at grasp of fine road surface situation more precisely, the road surveillance camera will be extended on the point of main trunk roads further. To perform quicker melting-snow facility operation using groundwater or river water began in the 1978 fiscal year, and remote control of the melting-snow facility by radio packet communication in 1999 fiscal year was introduced to the Nanao engineering-works office and from now on the control system will be installed whole a prefecture region. From the 2000 fiscal year, as latest new measure, operation management of the snow removal vehicles using the on-board integrated circuit card machine started, and it will use for the quickness and the accuracy of settlement-of-accounts business for snow removal expense. Information distribution and information offer to the Internet are performed. Regular observation information and a regular camera still pictures (road surface situation) are offered every hour on the hour. Although only the information on prefecture roads was distributed to the 1999 fiscal year, information within the prefecture will be linked with the information on the roads under the control of nation ,etc. from the 2001 fiscal year.

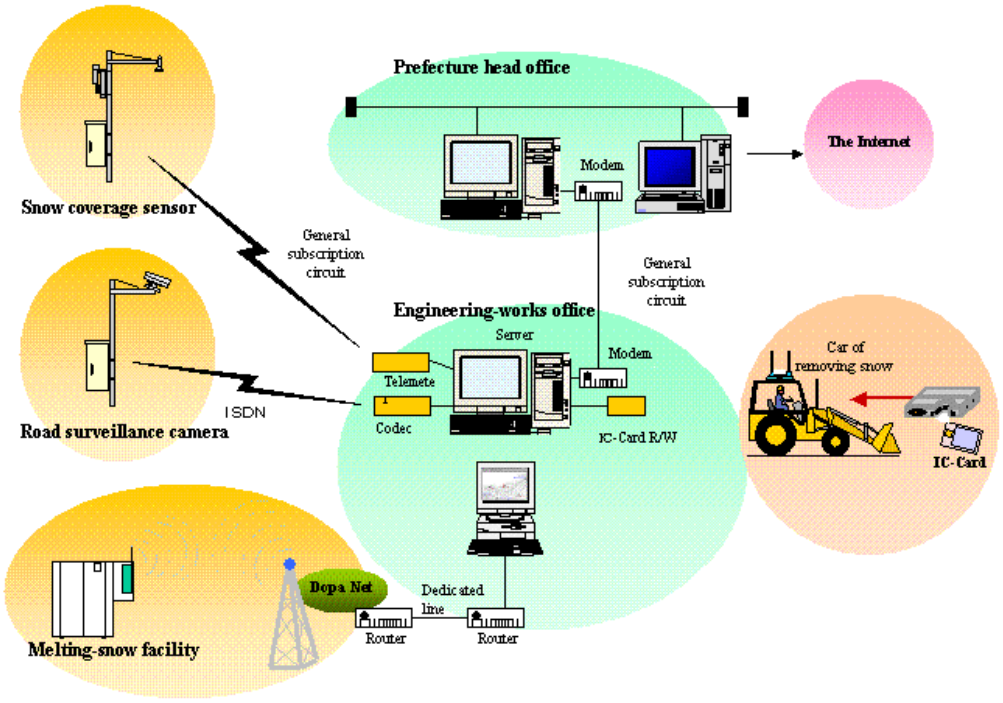

Fig. 3 Composition of present information system for snow coverage in Ishikawa Prefecture

3. Adoption of radio packet communication

(1) Circumstances of adoption

The conventional melting-snow facility such as control of starting and stopping at the spot has been performed by remote control using dedicated telephone circuit or by man's operation. In recent years, the method using the telephone circuit is in use. However, in connection with the increase in melting-snow facilities, a large space is needed in an engineering-works office side for control board installation of the dedicated line use. And the increase of a telephone circuit use charge also has been enhanced. Then, new system construction aiming at the formation of a low space by change of a communication means and mitigation of a telephone circuit use charge has been needed.

The system construction, using fullness of the infrastructure by the spread of the mobile communications of a cellular phone in recent years, does not have any merit in respect of calling cost for the conventional radio-communications service. However, the problem of a circuit use charge is solved by radio packet communication service.

Thus the conditions of three points conformed to the business of remote control of melting-snow facility are as follows.

1) Telephone circuit equipment is not needed for the service for mobile communications.

2) The charge per packet is cheaper than other systems.

3) When there are few amount of communication and there are many facilities using the service, it becomes advantageous in charge compared with a dedicated line.

System construction using radio packet communication was performed for the purpose of the

formation of a low space, and reduction of a communication circuit use charge.

Running cost comparison of the charge of communication is shown in Fig. 4. In remote control in a dedicated line, since it becomes the product of number of facility and dedicated line rental fee, it increases with the increase in the number of installation. Although a line segment surely needs to pay a dedicated line charge once as initial expense when radio packet communication is used, the use of radio packet communication will become cheap as for a running cost, since the circuit charge of equipment is cheap for a certain amount of number of equipment.

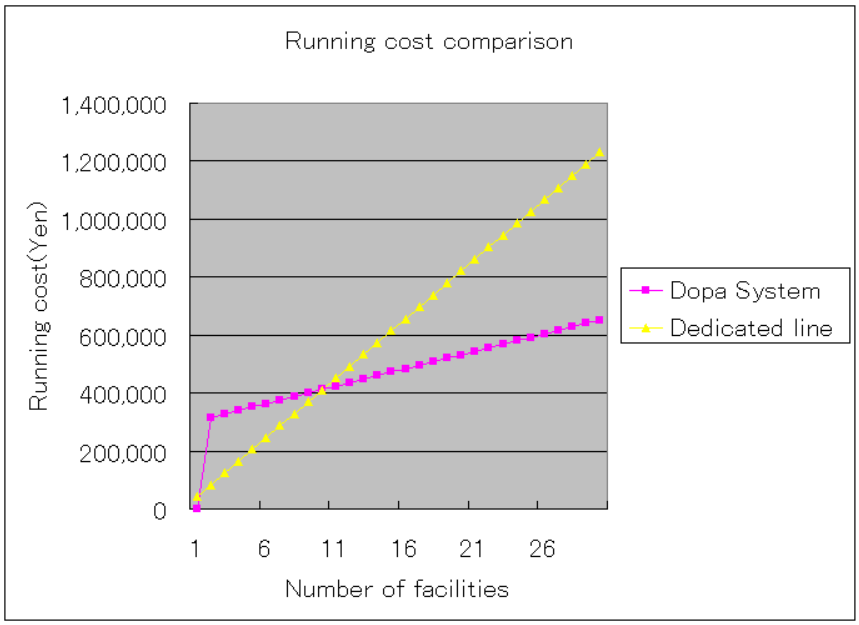

Fig. 4 Running cost comparison

(2) System outline

An outline of a network composition system is shown in Fig. 5.

TCP/IP protocol is adopted as a communication means. The private address which is a closed network address is assigned to a melting-snow facility side (following, terminal). Each terminal and the radio packet communication network are always connected through a radio packet network. The engineering-works office side apparatus (following, key station) and radio packet network side is communicating the communication between routers through a dedicated line.

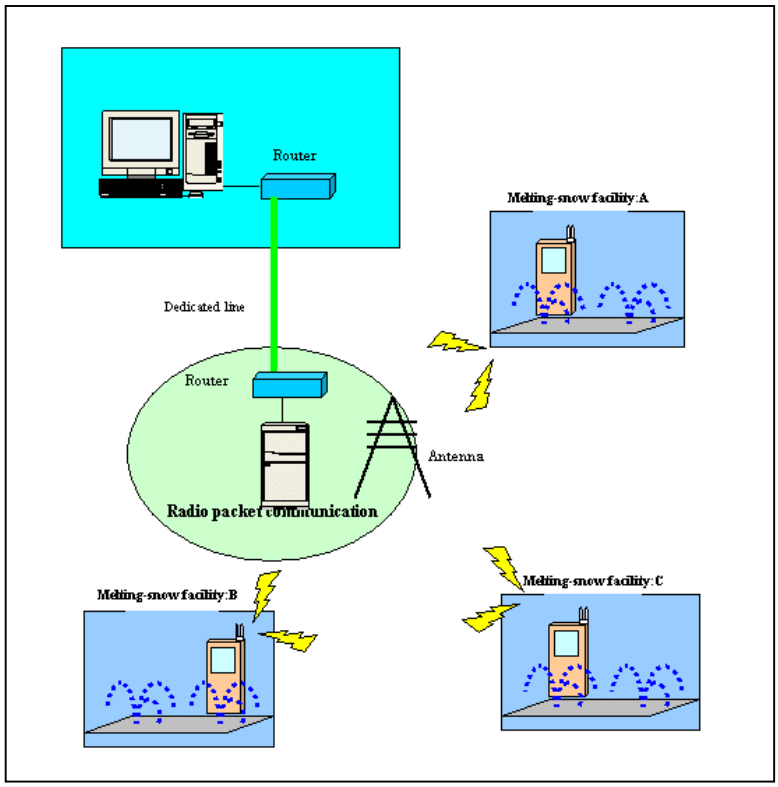

Fig.5 Outline of network composition

Operating software is shown. The failure situation and operation situation of the location of each melting-snow facility and each surveillance point are shown using the user interface which uses the map as shown in Fig. 6. Moreover, it is also possible to output various lists and operation management of facility, and the amount of used electric power and pumping up of facility (Fig. 7), etc. can be checked. It is also checked if operation and watering will be proper, and it is a very effective function considering the present condition that land subsidence etc. has been a problem.

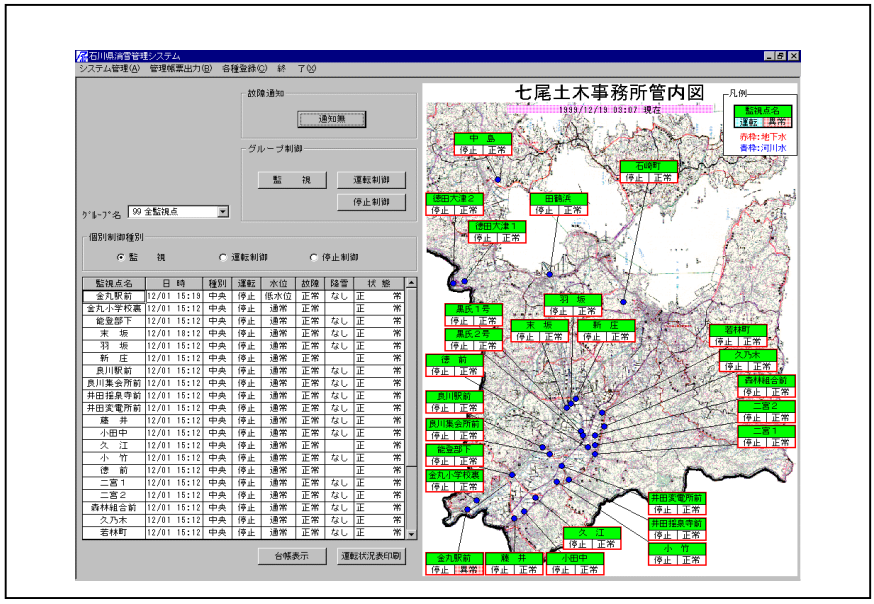

Fig. 6 User-friendly operating software

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監視点名	金丸駅前			金丸小学校裏			能登部下			実 験		
日付	運転回数	稼働時間	揚水量	運転回数	稼働時間	揚水量	運転回数	稼働時間	揚水量	運転回数	稼働時間	揚水量
1	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
2	2	3:25	246.0	3	2:31	139.1	2	3:24	306.0	2	3:24	194.6
3	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
4	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
5	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
6	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
7	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
8	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
9	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
10	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	1	0:05	4.7
11	1	3:38	261.8	1	2:39	155.8	1	3:38	327.0	1	3:43	212.9
12	1	3:46	271.2	1	3:51	229.3	1	3:46	339.0	1	3:46	215.5
13	1	2:09	154.8	1	2:09	128.4	1	2:09	193.5	2	3:53	222.5
14	1	4:16	307.2	1	4:13	247.9	1	4:12	378.0	1	4:11	239.7
15	1	3:13	231.8	1	3:21	196.9	1	3:20	300.0	1	3:13	184.3
16	0	0:00	0.0	1	0:56	54.8	1	0:39	58.5	1	2:50	162.3
17	1	2:26	175.2	1	2:26	143.0	1	2:27	220.5	1	2:27	140.3
18	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
19	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
20	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
21	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
22	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
23	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
24	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
25	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
26	1	0:55	69.0	1	0:55	53.8	1	0:55	82.5	1	0:55	52.5
27	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
28	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0	0	0:00	0.0
月計	9	23:48	1713.8	11	22:57	1343.5	10	24:30	2205.0	12	28:27	1630.1
累計	29	118:10	8508.0	38	109:51	6459.1	31	121:10	10905.0	41	141:46	8125.1

Fig. 7 Image table for groundwater pumped up

(3) The feature of the system

The following four points are mentioned as a feature of this system;

(1) Remote observation can perform trouble correspondence at the time of failure quickly.

(2) The system leads to sewerage saving.

(3) It can water uniformly.

(4) Communication cost is cheap compared with the general remote-control system.

4. Effect of radio packet communication

The system currently introduced in this paper performs remote control and surveillance of many points. In the comparison with the conventional dedicated line, it is known that there is a remarkable merit in respect of cost as shown in Fig. 4. Moreover, by adopting TCP/IP protocol communication as remote control and surveillance, very flexible points in extension of apparatus, and low space remarkably in the comparison with a dedicated line can be attained (Fig. 8).

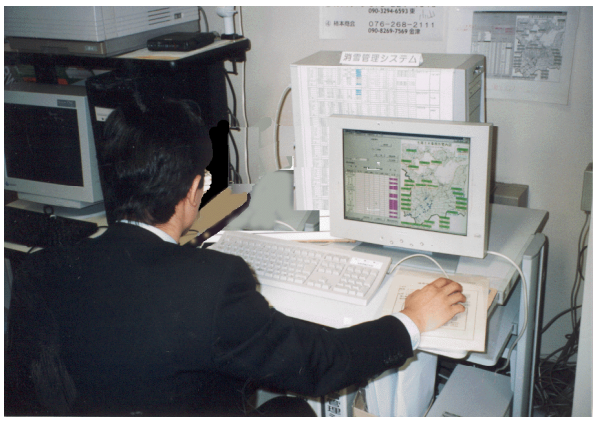

Fig. 8 Under working

5. Future deployment object

There are much merit, such as proper management record and a cost cut of the charge of communication, in the melting-snow facility management by radio packet communication. However, since a large amount of reconstruction expense is needed for change to radio packet communication from the melting-snow facility remote control by the established dedicated line, it is difficult to change all remote control at once. We will change the system at the updating time of remote control equipment. From now on facilities which have been still commissioned to the private sector for melting-snow facility operation are aimed to be improved one by one.

6. **Conclusion**

Radio packet communication was adopted as melting-snow facility management. This system has more flexible and more powerful. Although conventional system is operated to gather the information on snow coverage, snowfall, and temperature, such as a snow coverage sensor by using a general subscription circuit, the system can be changed to radio packet communication. Quick and exact information gathering and facility management have become important for answering the diversification of prefecture people's needs and the needs for the improvement in a service level about road snow removal in recent years. Shift to high advancement in information technology of a system will be an important subject from now on.