Smart Sapporo Snow Information Experiment
- Personalized Road Weather information Services using XML Technology -

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ABSTRACT

In the winter of 2003, we carried out an ITS trial project called "Smart Sapporo Snow Information Providing Experiment". This experiment was carried out to deal with city roads traffic problems in winter in the Greater Sapporo area with the use of advanced information and communications technologies such as the Internet and mobile information terminals. We found that XML technique enabled us to offer personalized weather information for roads suitable for each user. The information provided is very detailed so that it enables us to make sure the information is very useful in smoothening the traffic in wintertime.

INTRODUCTION

The Greater Sapporo Area has a large population (two million) and extremely heavy annual snowfall (about 5 m). In winter, snowfall and road surface freezing perennially exacerbate traffic congestion. It is important to assure reliable and punctual winter road traffic so that the region may enjoy socioeconomic stability.

To meet these problems, a joint research group made up of members of the Civil Engineering Research Institute of Hokkaido and other private organizations including the author(Kagaya) has performed information-providing experiments beginning in winter 2001 with the help of road administrators, relative organizations and citizens. These information-providing experiments largely utilize web description language called RWML (Road Web Markup Language) for roads based on XML (Extensible Markup Language) [1)].

These experiments demonstrated that the provision of specific road and weather information was effective in mitigating urban traffic problems in winter. Also, they have shown that the use of an XML data format enables the information provider to efficiently construct systems for the collection of data from information sources distributed across the Internet, to compile the collected data according to user needs, and to provide users with the compiled data. This affords flexibility in adapting to specification upgrades.

In this report, we shall summarize the experiments in the winters in 2002 and 2003, and discuss the issue of providing personalized information for roads and weather with the use of XML technology.

OUTLINE OF THE EXPERIMENT

(1) Objectives

This experiment is to test providing personalized road and weather information by means of the latest communication technology and to study the degree of effectiveness of the provided information to smoothen the traffic in winter.

(2) Method

The duration of the experiment carried out was 3 months, from December 4, 2002 till February 28, 2003. With the use of the Web description language RWML (based on XML technology) information was selected, gathered, and organized from various resources available on the Internet, for the needs of each monitoring participant.

Information on road conditions of their commuting routes for the next day and the amount of snowfall around their houses from the night before was provided through the web and also sent through the e-mail to computers and mobile phones. Types of information offered are for commuters to workplaces and schools, for people who move within Sapporo city, and for businesses persons and workers who move around the inner city and suburbs as part of their job (see Table 1.).

Table 1. Outline of the experiment

Experiment period	December 4, 2002, to February 28, 2003 (about three months)
Experiment area	The ten wards of Sapporo, and the cities of Otaru, Ebetsu, Kitahiroshima, and Ishikari
Experiment	
Provision of Snow-Related Information to Commuters by E-mail	Information on snowfall, temperature, and road surface conditions was provided to commuters twice a day (early in the morning and early in the evening) via Web. E-mails were sent to monitors who wished to receive snowfall and temperature information (615 monitors registered for this).
Provision of Sapporo Snow Information on the Web	Weather information at transportation hubs, ski areas, and other places in the city was provided on the Web.
Snow-related information exchange among residents on the Web	Residents posted snowfall and road surface conditions in their neighborhoods and whether they would use public transportation. These reports were compiled for release over the Web.
Information on snowstorm in suburban areas	Information on snowfall or snowstorm in suburban areas was provided to drivers (pre-departure and while traveling).
Provision of Information to Businesses on the Web	For professional drivers traveling in Sapporo and its environs, road and weather information on their travel routes was offered on the Web.

The system of e-mail distribution for the commuters to workplaces and schools is set to enable the receivers to choose from various content options: the target area for the information, the delivery date, and morning delivery time for receiving, temperature or the amount of snowfall, etc. to suit their individual needs.

CONSTRUCTING THE INFORMATION PROVIDING SYSTEM

XML is an extended and extensible version of HTML, and was designed to define the method of extension so that any machine can recognize and dealt with information as machine readable data. This enables information to be efficiently circulated on the Internet. In this experiment, an information providing system was constructed, starting from the web description language RWML[2, 3)] which was designed by the joint research group to utilize the XML technology in the field of road and weather information.

The construction of the system network from this experiment is shown in Figure 1.

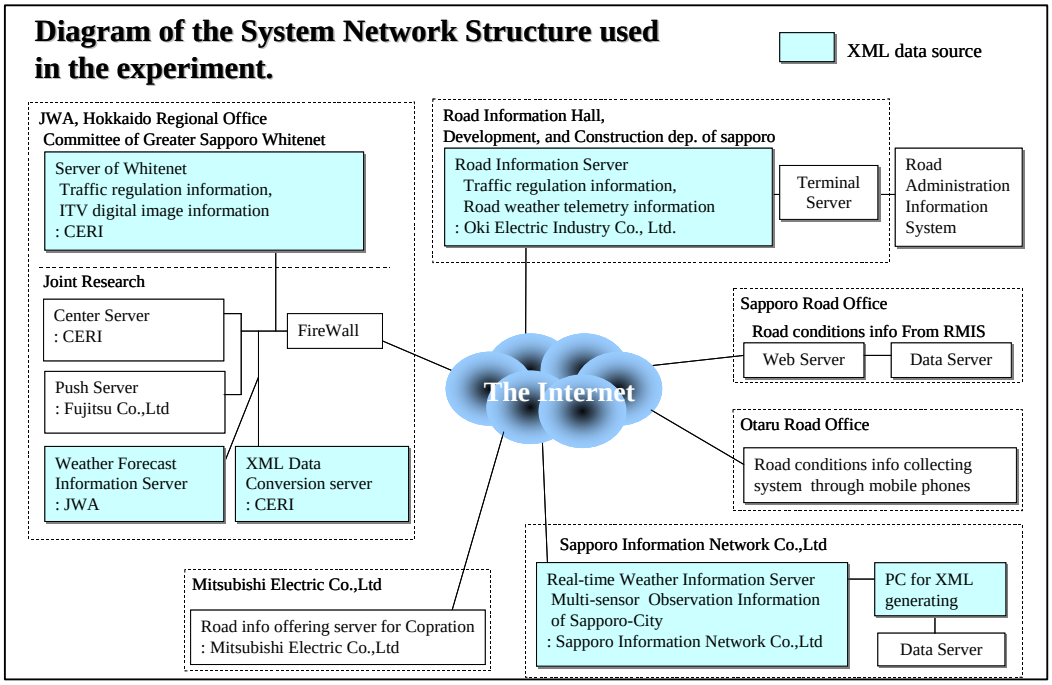

Figure 1. Diagram of the system network structure used in the experiment

Information, which each organization owns, is made available on the Internet from their own servers. If a server needs information which becomes available, it can obtain the information, translate and modify it as needed.

Information on the Internet for users is made available on the Center Server, shown on the left of the Figure 1. The information offered to the users is the modified data which was originally described in RWML, obtained from other servers through the Internet.

On the Center Server, e-mail, another key service of the information providing, is distributed, and other processes such as recording e-mail addresses, setting the contents to be distributed and storing the information are performed.

OFFERING WEATHER INFORMATION

The following is a detailed account of the weather information provided in the experiment carried out this winter.

(1) The amount of snowfall

The information regarding the amount of snowfall was offered with the following ranking system: 0-1 cm, 1-5 cm, 5-10 cm, 10-15 cm, 15-20 cm and over 20 cm.

Regarding the information for commuters to workplaces and schools, it was sent twice a day in the morning and late afternoon: the predicted amount of snowfall from 18:00 to 6:00 the next day was sent in the late afternoon and the actual amount of snowfall from 18:00 the day before to 6:00 the day were placed in the morning on the website and sent

through e-mail. For commuters within Sapporo city, predicted snowfall information up to three hours ahead was offered for each designated location and updated every hour.

(2) Temperature

For commuters to workplaces and schools, predicted minimum temperature for the next day is made available on the Internet in the late afternoon and the real-time snowfall at 6:00 is made available on the website in the morning for each designated location, and sent through e-mail. For moving within Sapporo city, the real-time temperature was offered and updated every hour.

(3) Road surface condition

For commuters to workplaces and schools, road surface condition at the designated 16 areas was categorized into 5 classes: dry, wet, snow-covered, ice-covered and very slippery. It was offered on the Internet for users twice a day, in the morning and late afternoon.

Additionally, predicted road surface information for 8:00 the next morning was added to the information in the late afternoon. This prediction is done to ascertain whether the "very slippery surface" might occur, and the probability is ranked as high (50 to 100 %), medium (20 to 50 %) and low (0 to 20 %).

THE ACHIEVEMENT FROM THE INFORMATION OFFERING

(1) Usage based result during the course of the experiment.

The following shows the utilization of weather information during the experiment.

Total number of access to the website: 82,313 (average access: 946 per day)

Of the total, the number of access from PCs: 45,297

Of the total, the number of access from mobile phones: 37,016

Daily pattern of access is shown in Figure 2.

Figure 2. Time series for the access on the website against the snowfall in Sapporo.

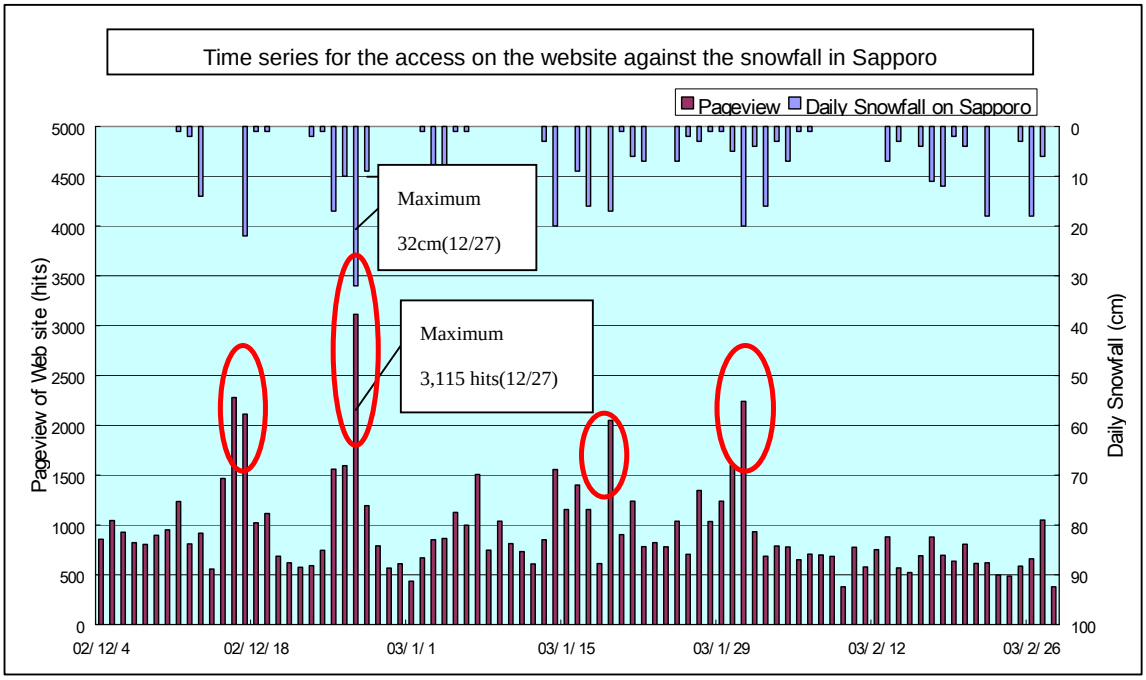

Figure 2. shows the daily access pattern on the website. When it is shown together with the daily snowfall amount data, the volume of access increased when a large amount of snowfall was seen (circled). The days which saw a maximum access correspond to the day which had a maximum amount of snowfall.

This indicates that information offered by Smart Sapporo is recognized as useful information when it snows and using the information has taken root.

Table 2. shows samples of the volume of e-mail sent in the late afternoon as a performance record of the e-mail distribution service. About 20 % of the total volume of the distribution was to Chuo ward in Sapporo, which is more than twice the average of others. This is a reflection of the fact that required information from users for two locations, work and home, was successfully sent in detail because the setting for the information receiving can be set by the user according to each user's needs.

Table 2. The total number of predicted information transmissions sent in the late afternoon to each area

Chuo, Sapporo city	Kita, Sapporo city	Higashi, Sapporo city	Shiroishi, Sapporo city	Toyohira, Sapporo city	Minami, Sapporo city	Nishi-, Sapporo city
14,374	7,058	6,276	6,841	6,658	3,394	5,983
Atsubetsu, Sapporo city	Teine, Sapporo city	Kiyota, Sapporo city	Otaru city	Ebetsu city	Kitahiroshima city	Ishikari City
4,655	3,917	5,174	3,873	3,327	2,145	1,613
					Total	75,288

(2) Achievement of information accuracy during the course of the experiment.

Prediction for the amount of snowfall

The most important information in this experiment proved to be the prediction for the amount of snowfall, and the results are organized bellow. The accuracy for the actual information for the snowfall sent in the morning and the predicted information for the snowfall sent in the late afternoon the previous day is compared and evaluated. If the predicted information is in the same rank as the actual information, the information is evaluated as accurate, and the accuracy (where 1 is 100%) is shown below.

Table 3. Accuracy level for the amount of snowfall prediction in each area.

Chuo, Sapporo city	Kita, Sapporo city	Higashi, Sapporo city	Shiroishi, Sapporo city	Toyohira, Sapporo city	Minami, Sapporo city	Nishi-, Sapporo city
0.70	0.59	0.63	0.68	0.60	0.70	0.72
Atsubetsu, Sapporo city	Teine, Sapporo city	Kiyota, Sapporo city	Otaru city	Ebetsu city	Kitahiroshima city	Ishikari City
0.72	0.62	0.61	0.58	0.62	0.70	0.59

The degree of accuracy is distributed in the range between about 0.6 and 0.7, which produces the average of 0.65 as a whole. This shows that the information offered had enough accuracy for practical use. Thus, to have been able to offer accurate information for practical use is thought to be one of the reasons for that the information was utilized as much as it was, which can be seen from the number of access on the website which increases when it snows.

Prediction for ice-covered road surface

In all 16 designated locations, daily updates of predicted information for frozen road surface shows the result that 69 % was low probability, 15 % was medium probability and 16 % was high probability.

In practice terms, this winter did not see a large amount of snow and the temperature was quite high. Subsequently there was a low incidence of Slippery Road Surface, and as a result, the slippery road surface tended to be over-estimated.

It was the first attempt to predict the incidence of Slippery Road Surface and to offer the information to citizens. Consequently, the system is assumed to need improvements for the future use, and the aim is to offer more accurate information which can be applied to the actual situations.

SURVEY FROM QUESTIONNAIRE

(1) Outline of the questionnaire survey

Monitors who registered to receive e-mails were surveyed by questionnaire during and after the experiment. The questionnaire during the experiment sought to survey changes in travel behavior, i.e., how and why the behavior changed, the post-experiment questionnaire investigated how travel behavior was changed by the information, and the level of satisfaction with weather and other information (e.g., how such information helped winter commuting). (see Table 4.).

Table 2 shows the result based on the questionnaire to those who use their own cars. It is thought that this group shows a particularly high correspondence between the weather information provided and change in transportation behavior.

Table 4. Outline of the questionnaire survey

	Questionnaire during the experiment	Post-experiment questionnaire
Outline	At the start of the experiment a questionnaire was sent by post. The monitors were asked to fill out the questionnaire regarding their commuting behavior. The questions differed for drivers and non-drivers.	At the end of the experiment, a questionnaire was sent by post. The monitors were asked to send it back enclosed with questionnaire during the experiment. The questions differed for drivers and non-drivers.
Questions	Transportation mode for commuting Alternative transportation mode in case of change Reasons for changing Duration of commute	Change in travel behavior Level of satisfaction with the currently provided information Evaluation on the information provided Willingness to change travel behavior Value of information
Respondents	Drivers: 74 (Total instances of travel behavior: 2,989) Non-drivers: 128 (Total instances of travel behavior: 5,436)	Drivers: 96 Non-drivers: 156
Response rate	41% (252 of 615 monitors responded.)	

(3) Changing behavior in view of weather condition

During the experiment (total of 87 days), a total of 2,989 instances of commuting behavior, or an average of 34 per day were collected.

(a) Overall tendency for changing transportation behavior

) For the reason that this winter was quite warm and did not see much snow, the number of people who changed the type of transportation itself considering the weather and road surface condition were 100 (3 % of total). Of the 100, the majority, 58, are those who changed the time to leave their homes, etc.

) Based on the information offered in this experiment (information on weather and road surface condition for commuters to workplaces and schools, information sent from citizens), the days that they changed their commuting behavior were 55 days (55 % of changed behavior). This revealed that the information offered in this experiment was referred to and used at a high rate.

(b) Changing commuting behavior with regards to snowfall conditions (shown in Figure 3.)

) When the rate of changing the commuting behavior with respect to the snowfall condition is examined, the more the amount of snowfall from the previous day become large, the more people change their transportation behavior. When more than 15 cm snowfall was seen, approximately 15 % changed their behavior.

) Among these cases, many participants (40 to 80 %) changed their transportation behavior based on the information transmitted. The rate of participants referring to the provided information was particularly high when a more than 15cm snowfall was seen.

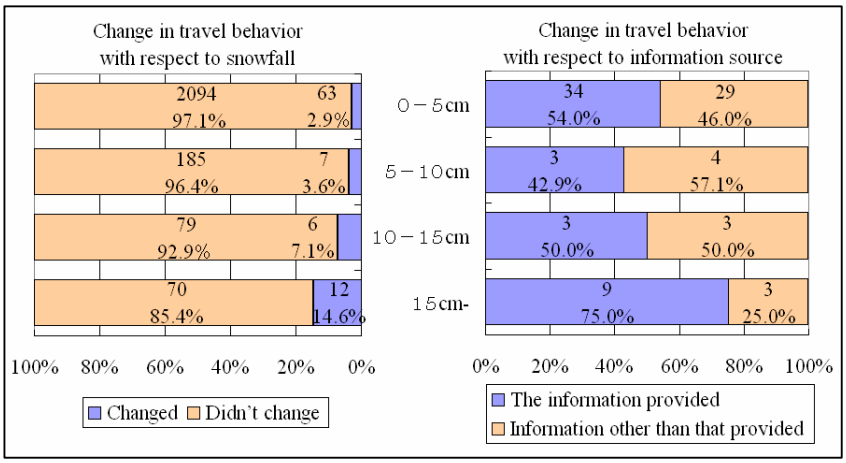

Figure 3. Instances of change in travel behavior with respect to snowfall and information source

(c) Changing the commuting behavior with respect to temperature.

) When the rate of changing transportation behavior was compared against temperature, the rate of change was between 2 % and 6 % and there is no particular tendency to change transportation behavior remarkably in accordance with the cases when low temperature.

Although the rate of change in transportation behavior became higher in accordance with the increase of the amount of snowfall, this tendency did not occur in correspondence with temperature change. This indicates that the change in transportation behavior is largely influenced by the amount of snowfall. As for the utilization of the information offered, the rate of change in transportation behavior based on the information did not become particularly high when the information offered on the days with specific weather condition was analyzed. This seems to be because information sent via e-mail was referred to under any weather conditions, not only in cases of harsh weather. In this circumstance, the information offered in this experiment became a reliable basis for changing transportation behavior, and it shows that offering information was useful to users under all weather conditions.

CONCLUSION

From the results of the experiment carried out this winter, construction of an information providing system using XML technology to organize and manage dispersed information from various network servers, and the potential to use this system to provide individualized information which is suitable for each user were clearly attested.

It is obvious that needs for road and weather information are much higher in winter, as the usage based result showed. Thus, if the required information is offered to road users appropriately, it is possible to urge people who use their own cars for commuting to workplaces and schools to change their usual commuting behaviors, as shown in the results of questionnaires.

This especially leads to the possibility for improving and smoothening traffic situation, such as traffic congestion, for the reason that offering appropriate information regarding weather and road surface condition suitable for each user’s commuting circumstance will encourage the users to change their usual commuting behavior, e.g. changing departure time or from car use to public transportation.

Lastly, I would like to thank Civil Engineering Research Institute of Hokkaido, Hokkaido regional development bureau, Hokkaido, Sapporo city, Japan Highway Hokkaido Branch, Sapporo Information Network, Mitsubishi Electric Corporation, which cooperated and participated for this Smart Sapporo Snow Information Providing Experiment Council, as well as citizens who kindly participated to this experiment.

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