EFFECT OF PROVIDING REGIONAL INFORMATION WITH REAL-TIME BUS INFORMATION ON PASSENGER CONSCIOUSNESS

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ABSTRACT

In Japan, those who don't have a driving license exist and the elderly who abandon driving a car have recently increased due to their old age. Therefore, many local governments have recently introduced a "Community-bus" for purposes of ensuring mobility for residents, reducing the areas without public transportation services and so on. Although the bus-location system is demanded for raising the level of bus service, it is practically difficult for a local government to introduce the bus location system because of the expense to introduce and even operate the system continuously. Moreover, if the bus location system is introduced, the system is financially supported by the local government so that a wide range of effects is expected such as regional vitalization and strengthening regional communities. We therefore develop a simple bus location system with a smartphone and construct a web page to provide regional information with real-time bus information. Then, we grasp the effects of providing the bus and regional information on passengers' consciousness by a questionnaire. As a result, it is found that the regional information added on the bus information obviously effects the motivation of going out. Moreover, there is also possibility of providing regional information with real-time bus information to promote bus usage.

Keywords: Bus Location, Regional Information, Real-time Information, Community-bus, Smartphone, Google Map.

INTRODUCTION

In Japan, the number of private cars per household is about 1.080 vehicles at 2012. The life with a car seems to be convenient and comfortable. Actually, people can go whenever and wherever he/she wants by a car. However, everybody cannot use a car. For example, there are those who don't have a driver's license. Recently, the number of the elderly who cannot drive a car has also increased due to an aged society in Japan. It becomes more important for those who cannot drive to ensure the means of trips to indispensable places in life such as a grocery store and a hospital. A bus is one of the means that anyone can be available for trips to those places. Many local governments have therefore introduced a "Community-bus" for purposes of ensuring mobility for residents who cannot drive, reducing the areas without public transportation services and so on. Since the community-bus service is provided as a part of residential services, the service is financially supported by the local government. The community-bus tends to run throughout in the local area in order to ensure the mobility for all residents equally. Consequently, it becomes very complicated for passengers to remember the bus routes and the timetable so that residents seem to avoid using the community-bus due to the complexity. Delay of bus arrival caused by traffic congestion may also lead to reduction of bus passengers.

Some bus companies therefore provide real-time bus information so as to improve the bus services and raise the customer satisfaction. Passengers are able to obtain the information on the bus route, the timetable and also the location where the bus is now running.

Necessity of real-time bus information has been revealed (Lei and Piyushimita. 2012; Kari et al. 2011; Stuart and Daniel. 2001; Novaĉko et al. 2011). Moreover, several researchers have addressed studies by using data from a location information system. Bo et al. (2010) and Bin et al. (2011) predict the bus arrival time at the bus stop for bus location system, and Steven et al. (2002) develop and apply a model to predict bus arrival time using automatic vehicle location (AVL) data. Wong and Hounsell (2010) study iBus system to provide improved public transportation information and applications for London. The iBus is a TfL's (Transport for London) new GPS-based Automated Vehicle Location System.

Although the bus-location system is demanded for raising the level of bus service and also using as management measures of bus operation, it is practically difficult for a local government to introduce the bus location system because of the expense to introduce and even operate the system continuously. An inexpensive bus location system is desired by a local government and also passengers of the community-bus in Japan. Moreover, as the system is financially supported by the local government, a wide range of effects is expected such as regional vitalization and strengthening regional communities.

We first develop a bus location system using an android smartphone available commercially which is inexpensive for introducing and also operating. Through the operational test of the developed bus location system on real buses, we verify the feasibility of the system. Then, we make web pages to provide the bus information using the developed bus location system. In the web pages, we provide not only bus information but also regional information when we investigate possibility of regional vitalization by providing regional information added on the bus information. Finally, we grasp the effects of providing the information on passengers' consciousness by a questionnaire and also estimate evaluations about regional vitalization and promotion of bus usage by improving regional information.

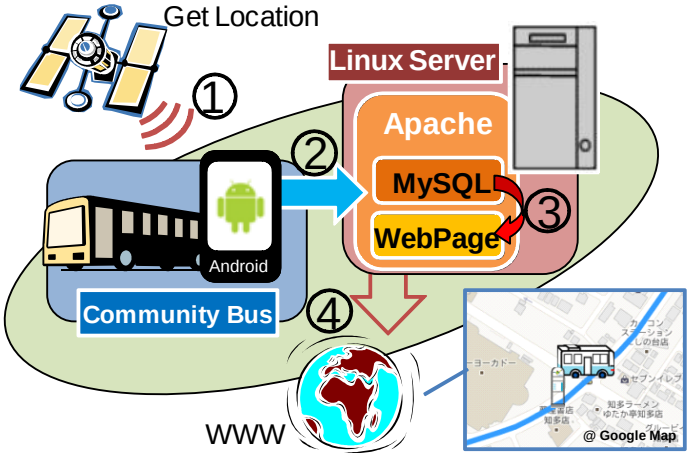

Figure - 1 Illustration of developed bus location system

DEVEOPMENT OF BUS LOCATION SYSTEM

Structure of developed bus location system

A bus location system is management system that monitors the current locations of buses with a wireless network and a GPS device. The developed bus location system in this study is for the use through the Internet. As more than 75% of passengers are able to use the Internet outside home according to the result of our questionnaire survey, this bus location system is useful for the passengers of community-buses despite a large part of the elderly passengers.
In the developed system, we use a smartphone on the market which has the GPS and some sensors, and is operated by Android 2.2.
Figure 1 is a simplified illustration of the system we develop. First, the smartphone which is put inside a bus communicates with GPS and gets the current location of the bus. Then, through the 3G mobile network and the Internet, the smartphone sends the data on the location and the movements of the bus to a database server located our laboratory. The database server takes out the newest information of the current bus location from the database and provides it to a web server. Furthermore, the web server communicates asynchronously with the provided newest information and plots the bus location on a map of web page periodically. As a result, the location of the buses can be seen on Google map with bus icons.

Using data of bus location and movement

The developed system provides not only the location of a bus but also static information such as a bus route map, timetables and pictures around a bus stop. In addition to the information on static and real-time bus information, we store the information on public facilities, supermarkets and retail shops in the area around a bus stop.

We have to judge which bus stop the bus already passed through and identify the section where the bus is now running accurately. Therefore, we generate a method of data processing for judging if the bus passed a certain bus stop or not. Only two kinds of information of the coordinates and the speed of the bus are used for the judgement.

Operational test and data collection

We conducted an operational test of the developed bus location system on community-buses operated by Chita city, Japan, from November 28 until December 25, 2011. Although the real-time bus information system was not introduced to buses in Chita city at that time of the operational test, we provided the bus information by the developed system. This community-bus in Chita City has 2 routes and seems to be suitable for the operational test because the number of smartphones used for the test was limited to two in this study. Passengers were therefore able to obtain the real-time bus information and also regional information such as public facilities and local shops through the Internet. As a result, the system was confirmed to run actually and correctly, and to be feasible to be operated with inexpensive cost.

QUESTIONNAIRE SURVEY

In order to grasp passengers' consciousness on the information provided by the developed bus information system, we conducted a questionnaire survey at Chita city on December 10 2011.

Outline of "Aiai-bus" operated in Chita City, Japan

Chita City is a city located in the northwestern part of Aichi Prefecture in Japan. The area of the city is 45.7 km2. The population of the city is about 85,000. The ratio of the elderly is about 18 % which is lower than the ratio of whole Japan.

"Aiai-bus" is a name of a community-bus operated by Chita City supporting motilities of residents from September, 2005. The Aiai-bus consists of an east route and a south route. The fares are 200 yen for adults and 100 yen for children. The elderly pass is sold at 2,000 yen a month for the elderly of 75 years old and over. At that time of the survey, there is no information service on real-time bus information.

Method of questionnaire survey

For this survey, we brought some PCs which could communicate to the Internet to the Chita Civic Gymnasium where we conducted the survey. Two web pages were provided to subjects by Google Maps in order to grasp an effect of providing regional information in addition to the bus information on promotion of bus usage and regional vitalization. One page provided only static and real-time bus information and another page provided regional information in addition to the bus information. When a bus stop icon on the map is clicked, bus stop name, timetable of the bus stop and facility information around the bus stop are displayed (see the left figure of Figure 2). When a facility icon on the map is clicked, facility

Figure - 2 Developed bus location pages

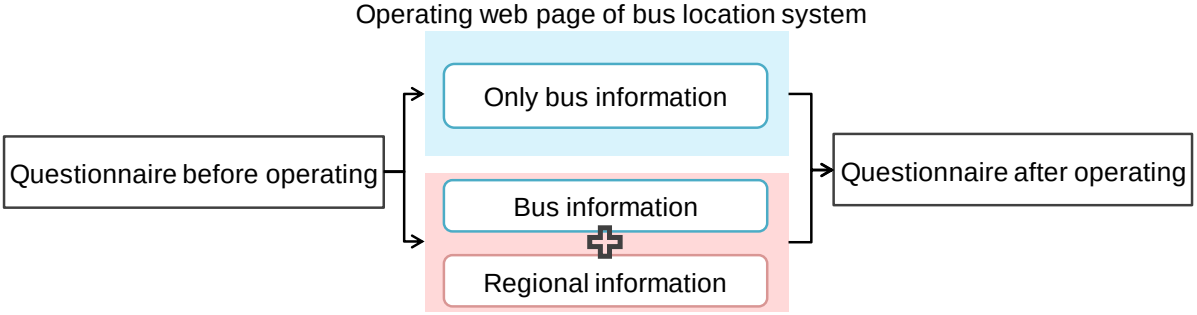

Figure - 3 Survey flow of subjects' consciousness

name, address, telephone number, a picture of the facility and business hours are popped up (see the right figure of Figure 2).

Figure 3 shows a survey flow of subjects' consciousness. First, we asked subjects' attributes and their consciousness on a bus before operating the bus information system. Next, we separated the subjects into two groups in which the numbers of subjects were equal. Each subject operated one of two pages, in which "Only bus information" page provided "real-time bus location", "bus route" and "location of a bus stop", and "Regional information added" page provided regional information in addition to the bus information. The regional information was obtained from the Chita chamber of commerce and Industry. After operating the web page of the bus information system freely, the subjects evaluated the developed system and their consciousness about going out by bus.

Results of questionnaire survey

Fifty five subjects participated in the survey. Among them, 27 subjects operated "Only bus information" page. The other 28 subjects operated "Regional information added" page. Figure 4 shows the subjects' attributes. An elderly male/female is defined as 65 years old and over. More than half of subjects are a male. The elderly occupies about 60% to 70% of subjects.

First, the questionnaire before operating the web page is analyzed here. Table 1 shows the evaluation terms on bus information and the abbreviation of each evaluation term. Figure 5

Table - 1 Evaluation terms of bus information

	Evaluation term	Abbreviation
1	Routes are understandable	Route
2	Bus stops are understandable	Bus stop
3	Timetables are understandable	Timetable
4	Bus passages are understandable	Passing
5	Delays are understandable	Delay
6	Transfer information is understandable	Transfer

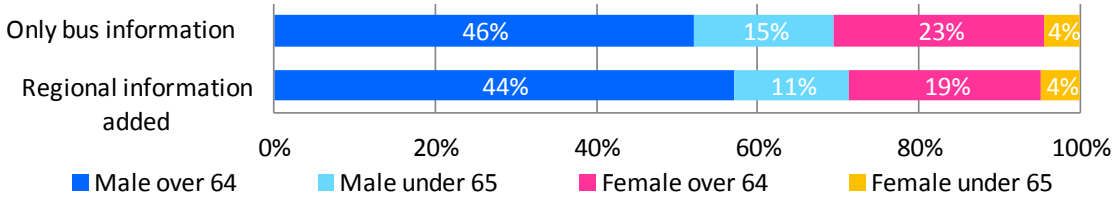

Figure - 4 Ratio of subjects' attributes

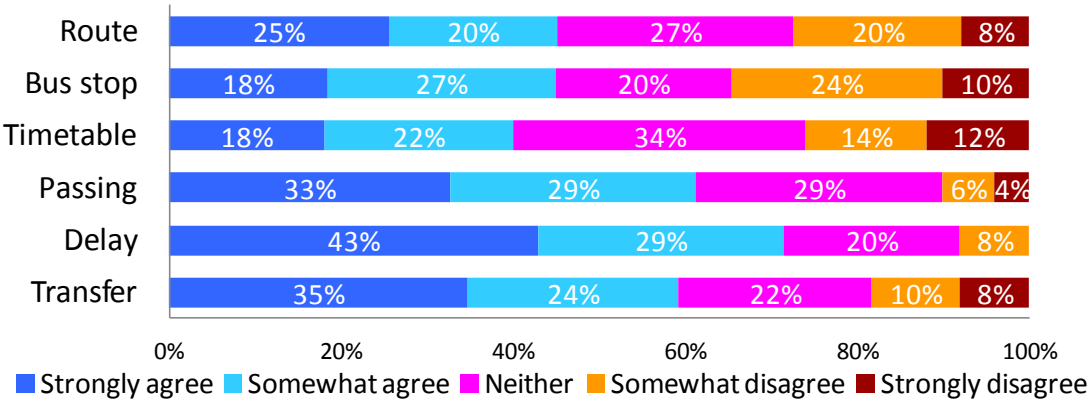

Figure - 5 Evaluation of each bus information

indicates the level of satisfaction to the bus information. The more difficult terms among the bus information in Table 1 for subjects are "Delay", "Passing" or "Transfer", in which 60% of subjects feel difficult to understand. Because "Delay" and "Passing" are able to be provided by the real-time bus information, the subjects cannot obtain such information without the bus location system. Similarly, because transfer information was not provided at that time, the subjects had to check a transfer ways by gathering all information of transportation modes such as a timetable, routes and fares. Therefore, the subjects feel delay information, pass information through a bus stop and transfer information as hard to understand. Conversely, it's easy for the subjects to understand "Route", "Bus stop" and "timetable" information because a route map and a timetable can be obtained on the Internet and also available by a printed one. However, about 50% of the subjects think such bus information as hard to understand overall. Thus, it is shown that the bus information is not provided enough to passengers of Aiai-bus.

After operating one of two web pages, the subjects evaluated changes of their consciousness and rated their intentions to use the bus location system. Figure 6 shows the result of the intention to use the bus location system. The upper of the graph shows the result by the operating "Only bus information" page and the lower part is the result by operating "Regional information added" page. The subjects who want to use the bus location

Table - 2 Evaluation terms of using the system

	Evaluation term	Abbreviation
1	Not irritated by waiting bus	Waiting
2	Easy to find out the way to reach destination	Finding way
3	Want to use bus	Using bus
4	Intend to use bus when going out	Going out
5	Want to visit shop around bus stop	Visiting
6	Want to know more about regional information	Information

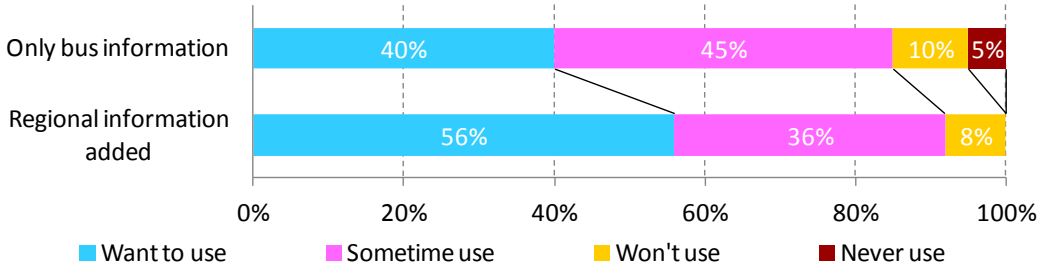

Figure - 6 Intention to use bus location system

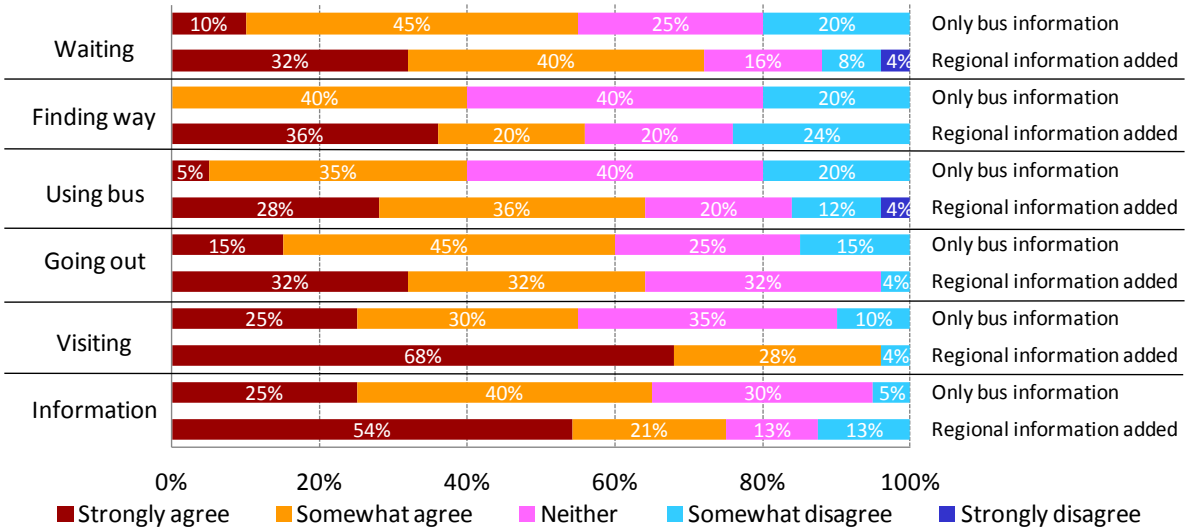

Figure - 7 Consciousness on using the system

system are about 40% for “Only bus information” page and about 60% for “Regional information added” page. It’s obvious that adding the regional information on the bus location information impresses all the users as a useful system. About 90% of the subjects evaluated positive for the bus location system with the regional information.

Changes of their consciousness after operating the system were evaluated by 5 ranks. The 6 evaluation terms on using the system are shown in Table 2. The result of the evaluation is illustrated in Figure 7. The ratios of positive evaluation for “Regional information added” page are more than those for “Only bus information” page and are all over 60%. Especially, there are large differences in the evaluations for “Visiting” and “Information” between “Only bus information” page and “Regional information added” page. The evaluations of “Regional information added” page for “Waiting” and “Using bus”, which have no relation with the providing regional information, are rated higher. This means there is possibility of providing regional information added on real-time bus information to promote bus usage. However, the ratios of negative answers of “Finding way” and “Information” for “Regional information

Table - 3 Evaluation terms of developed bus location system

	Evaluation term	Abbreviation
1	Understandability of bus position	Understandability
2	Update interval of bus position	Update interval
3	Easy to use	Usability
4	Information of surrounding facilities	Surrounding information

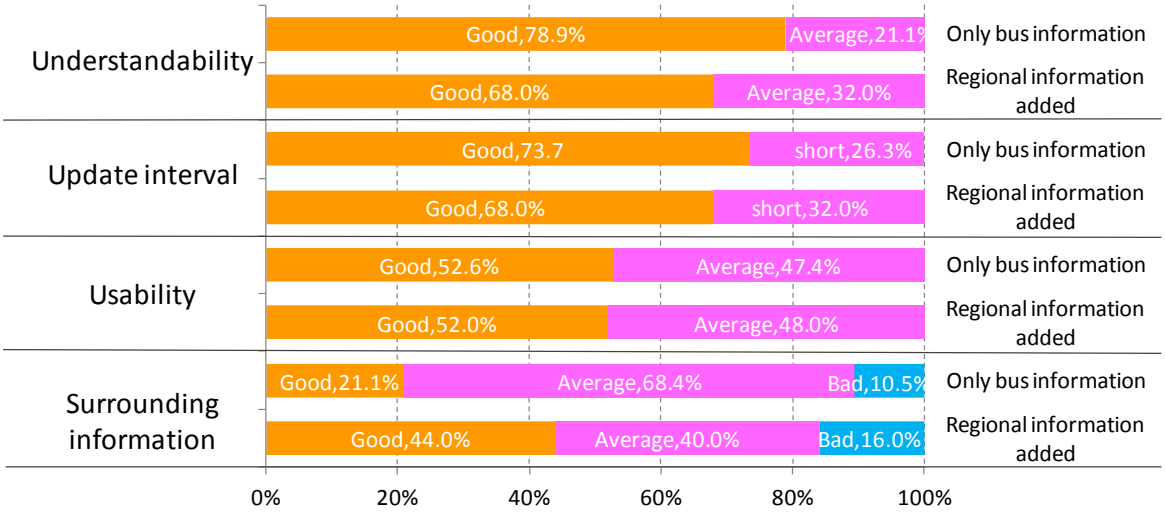

Figure - 8 Evaluation of developed bus location system

added" page are higher than those for "Only bus information" page. It's conceivable that the pages with the added regional information provide too much information for some subjects, which affected the page operation negatively.

Evaluation of the developed system

The developed bus location system was evaluated by the subjects. Table3 shows the evaluation terms of the developed bus location system and the abbreviation of each evaluation term. Figure 8 shows the result of evaluating the developed bus location system. The evaluation of "Understandability" and "Update interval" are about 70 % positive. "Usability" is evaluated as about 50% positive for both of the web pages. Because the both web pages use Google Map, there are few differences of the evaluation between two pages. In terms of "Surrounding information", the ratio of the positive evaluation for "Regional information added" page is twice larger than that for "Only bus information" page. However, the ratio of positive evaluation of "Understandability" for "Regional information added" is lower than that for "Only bus information". This is considered the map becomes too complex for subjects to understand easily when the regional information is added on the web page of the bus information.

ANALYSISY OF WEB PAGE COMPONENT

Analysis of web component by covariance structure analysis

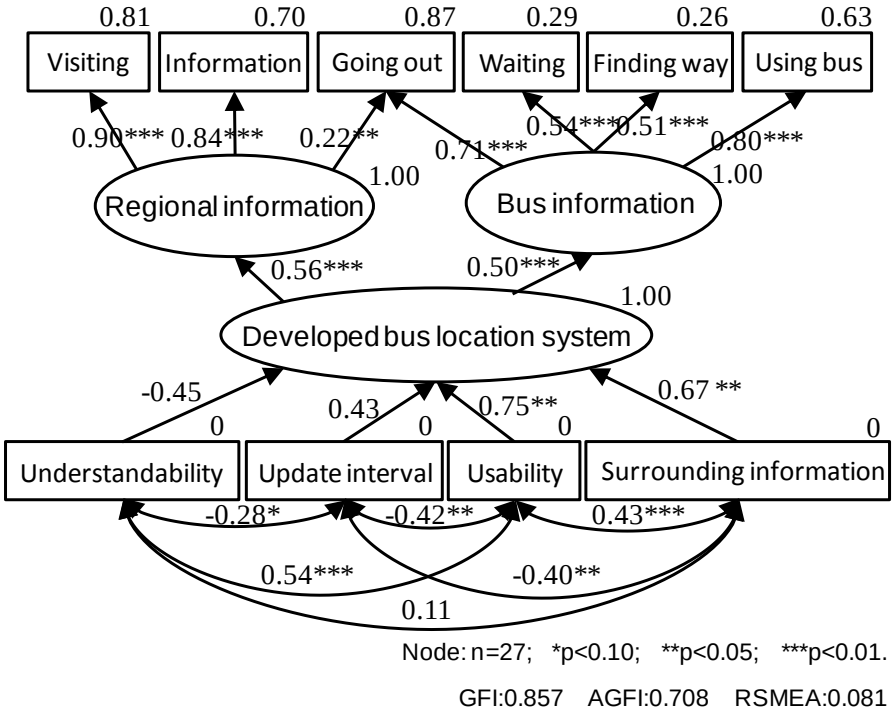

Figure - 9 Result of covariance structure analysis

We analyze the components of the bus location web page contributing the good evaluation in order to construct a better page for the bus location system. The covariance structure analysis is known as a structural modeling technique designed to test simultaneously hypothesized relationships of multiple observed and latent variables.

We analyze a relationship between the evaluation terms of using the bus location system in Table 2 and the evaluation terms of the developed bus location system in Table 3. Those variables become observed variables. Latent variables are hypothesized “Developed bus location system”, “Regional information” and “Bus information”. “Developed bus location system” means a comprehensive evaluation of the developed bus location system including the regional information. This “Developed bus location system” is hypothesized to be composed of two evaluation factors on the regional information and the bus information, which are “Regional information” and “Bus information” respectively.

The results of the covariance structure analysis for the web component model are illustrated graphically in Figure 9. The paths are estimated with standardized variables. The numerical value at the top right corner of each observed variable denotes a coefficient of determination. GFI is 0.857 and AGFI is 0.708. Most standardized coefficients of the path are positive and are statistically significant at 10% or less.

First, the effect of the web component is gathered to “Developed bus location system” of the latent variable. From the figure, we find that the contribution of “Usability” and “Surrounding information” are larger than other evaluation terms. The gathered effect of the web component is divided into two latent variables. One is “Regional information” that is assumed to affect regional vitalization. The other is “Bus information” that is assumed to affect bus usage. The coefficients of determination of “Visiting”, “information” and “Going out” and “Using bus” are higher than 0.6. The standardized coefficient of “Using bus” is the highest at

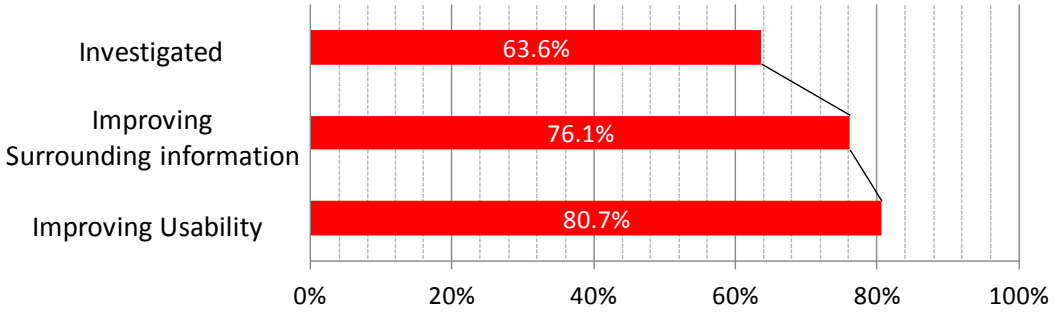

Figure - 10 Ratio change of agreement for "Going out" after improvement of "Usability" or "Surrounding information"

"Bus information" and the standardized coefficient of "Visiting" is the highest at "Regional information".

As a result, it is found that we should enhance "Usability" and "Surrounding information" in our web page in order to improve "Visiting" , "information", "Going out" and "Using bus". On the contrary, it can be seen from Figure 8 that less than half of the subjects are only satisfied to "Usability" and "Surrounding information" of our web page. We should therefore make some changes in our web page to raise these evaluations and promote bus usage and vitalize the region.

Simulation of effects of improving web component

We simulate the effect of improving the evaluation of "Usability" or "Surrounding information" on the positive evaluation of "Going out". We assume that "Average" evaluation of "Usability" or "Surrounding information" in Figure 8 changes to "Good" evaluation by appropriate improvement of our web page. Similarly, we assumed that "Bad" evaluation of "Surrounding information" in Figure 8 changes to "Average". Figure 10 shows the ratio change of the agreement to "Going out" (ratio of "Strongly agree" and "Somewhat agree" to all evaluations) after the improvement of the evaluation to "Surrounding information" or "Usability". From the figure, we find that ratio of the agreement to "Going out" is raised by about 12.5% when the "Surrounding information" is assumed to be improved. If we improve the "Usability", the ratio of the agreement to "Going out" increases about 17.0%. This suggests that there is possibility to promote going out for residents by improving the usability and the surrounding information of the developed bus location web page.

CONCLUSIONS

The number of the elderly who cannot drive a car has increased in accordance with the progress of an aging society in Japan so that many local governments have introduced a community-bus and support it financially for the purposes of ensuring residents' mobility, reducing the area without public transportation services and so on. Although the bus location system to proved real-time bus information is demanded for improvement of the level of bus service, it is practically difficult for a local government to introduce the system because of the expense to introduce and operate the system continuously. We therefore developed a simple

bus location system using a smartphone available commercially and constructed a web page to provide real-time bus information. The operational test using real buses by the developed bus location system was conducted for 4 weeks, in Chita city and we confirmed that the system worked correctly and accurately.

In order to grasp passengers' consciousness on the information provided by the developed bus information system, we conducted a questionnaire survey at Chita city. We prepared two web pages, one was the page providing only bus information such as a route, a timetable and a real-time bus location and another was the page providing regional information added on the bus information. After operating one of two web pages, the subjects evaluated changes of their consciousness and rated their intentions to use the bus location system. As a result, it revealed that many subjects intended to use this system and wanted to go out by bus. In addition, more subjects wanted to know regional information by providing the regional information added on the bus information. These results show that the provision of regional information can improve not only intention to go out but also promotion of bus usage.

We then analysed the components of the bus location system contributing the consciousness of subjects on intention to use the system and also to go out by the covariance structure analysis. As a result, it was seen that the terms of the usability of the web page and the information on surrounding area have influences more than others. However, it was found that these terms should be improved in the current system. The improvement of 18% for the intension to go out was estimated when these terms of the web page were improved.

In future research, analysis of the effects based on attributes of subjects is expected by getting more subjects to use this bus location system. Furthermore, behaviour and consciousness changes of passengers who actually use this bus location system are needed to be observed.

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REFERENCES

Lei T. and T. Piyushimita (2012). Ridership effects of real-time bus information system: A case study in the City of Chicago. Transportation Research Part C, 22, 146-161.

Kari E. W., F. Brian, B. Alan, G. S. R. and L. David (2011). Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. Transportation Research Part A, 45, 839-848.

Stuart D. M. and D. J. Daniel (2001). Real-time bus information on mobile devices. Intelligent Transportation Systems 2001, Proceedings 2001 IEEE, 988-993.

Novaĉko L., I. Ćavar and D. Barić (2010). A survey of passenger requirements on pre-travel/travel information in the public transport of the city of zagreb. CD of Selected and Revised Papers of the 12th WCTR, Lisbon.

Bin Y., L. K. H. William and T. L. Mei (2011). Bus Arrival Time Prediction St Bus Stop With Multiple Routes. Transportation Research Part C, 19, 1157-1170.

Steven I-Jy C., D. Yuqing and W. Chienhung (2002). Dynamic Bus Arrival Time Prediction with Artificial Neural Networks. Journal of Transportation Engineering. 128, 429-438.

Wong A. and N. Hounsell. (2010). Using the iBus system to provide Improved public transport information and applications for London. CD of Selected and Revised Papers of the 12th WCTR, Lisbon.