The Effect of Mobile Information Services on Commuter Trains

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Abstract--**In this study we verified what kind of mobile information services passengers need on board through empirical research on commercial commuting trains. We provided rail information services as well as marketing tools such as news, shop information, advertisements and coupons for smartphones.**

A content server and Wi-Fi access points were newly installed on trains with the server connecting to an existing onboard train information management system. Line-related and location-based information can be provided to smartphones on board by using the server that obtains various data from the train management system or from on-ground networks. Content server access logs were then obtained and analyzed, and several questionnaire surveys were conducted in order to evaluate these information services during the test period.

This study revealed that almost 90 percent of passengers who answered questionnaires would use these mobile information services if the services were actually introduced, and that satisfaction in railway information content was higher than that of marketing contents. These contents can be divided into the following types according to different point of view, location-based contents and non-location-based contents. We also found that the satisfaction in location-based information content affected overall intent to use these mobile information services.

I. INTRODUCTION

The basic service provided by railway companies is transporting passengers to their destinations; however, there is a growing need for railway services to provide positive customer experience. For example, passengers want to take trains more safely, securely and punctually.

Many train lines spread out in the Tokyo metropolitan area in Japan and these lines most often run on time. Information services needed by frequent passengers and infrequent passengers differ. Frequent passengers need traffic information; for example, which line is delayed suspended and why trains are not on time. On the other hand, basic information such as stops and the destination on the train is required by infrequent passengers, including tourists from overseas.

East Japan Railway Company (JR East), a major railway company in Japan, has annually conducted customer satisfaction surveys via customer questionnaires. The survey mainly consists of 5-point Likert scale questions related to following six categories: amenity, barrier-free, hospitality, security, stable transport, information services. Fig. 1 shows the relationship between satisfaction with each item and the effect on overall satisfaction with JR East. This figure is made by the survey conducted in 2012. The vertical axis indicates the deviation of satisfaction with each item and the horizontal axis indicates the deviation of the effect on overall satisfaction with JR East, derived from correlation coefficient between overall satisfaction with JR East and satisfaction with each item. As seen in Fig.1, items related to the category of information services have effect on overall satisfaction with JR East. This tendency is not considered specific to JR East but rather common to all railway companies. Therefore, improvement of information services can be an important development for railway companies.

Reference [f] explores the effect of service quality, trust and perceived value on customer satisfaction of mobile services. It is insisted that the service quality consists of three dimensions: interaction quality, outcome quality and environment quality. Results of this study show that two dimensions of service quality (interaction quality and outcome quality) and perceived value have significant and positive effect on customer satisfaction. In addition, it is proposed that interaction quality include information as sub-dimensions [f, g]. Therefore, information is one of the important factors for improving quality and satisfaction of mobile services.

II. OBJECTIVE

The purpose of this study was to verify what kinds of mobile information services are needed by passengers, especially on board. Railway companies already have installed various information displays in stations and on trains and there have been several researches that study the effects of real-time information displays at stops [b, c]. Reference [b] investigates the effect of real-time information, located at stops and stations, on the public transportation customers. The main result of the study was that the perceived wait time decreased by 20 percent. However, It is impossible for information displays to show all desired data simultaneously.

As utilization of smartphones has been increasing in recent years, and high-speed and large-capacity communications environments also have been developed, we see an emerging environment in which detailed and diverse information can be delivered according to passengers' individual needs by using mobile devices. Mobile devices such as smartphones and tablets allow users to control when, where, and how they engage in chosen activities that serve their needs, saving time, complete a task, entertain users, or connect with others [a]. We then focused on mobile information services for railway users. A location-aware information service for smartphone, that provides bus stop and arrival information tailored to the user's location, has already developed [d]. It is found that significant positive

shifts in satisfaction with transit, perceptions of safety, and ridership frequency as a result of the increased use of real-time arrival information [e].

These mobile services, however, are providing only traffic information for customers and target users are passengers who are NOT onboard. In this study, we evaluate effects of providing information services for passengers' mobile devices on trains on customer satisfaction with content and intent of use. Moreover, we provide various contents that are not only related to traffic information but also to lineside news/topics, information on in-station malls, shop coupons and advertisements. Onboard space is a particular location in which passengers' activities are not only limited but they are also all heading in the same direction. Clarifying what kinds of mobile information services satisfy people in such a space is the differentiator of this research.

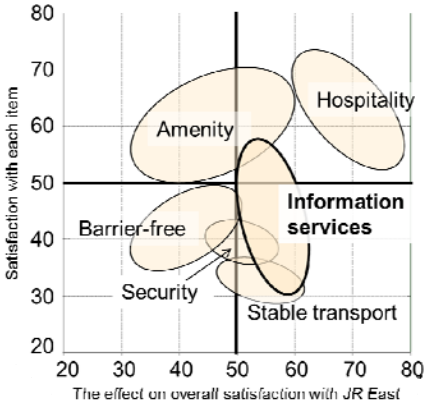

Fig.1 Relationship between satisfaction with each item and its effect on satisfaction with JR East

III. SYSTEM DEVELOPMENT FOR THE EMPIRICAL RESEARCH

A. Information providing system configuration

In order to verify what kind of mobile information services passengers need on board, we conducted empirical research on a commercial commuter train in Tokyo. Since there had been no train which could provide information for passengers' mobile devices, onboard contents servers were developed and system operation tests conducted [2]. Fig 2 shows an overview of the configuration of the onboard system for this empirical research. Content servers, Wi-Fi access points and WiMAX antennas were newly installed on a train. One device was installed for every two cars in one trainset.

Content servers were connected to the existing train information controllers that controlled onboard displays. Passengers could connect to the content server using smartphones via Wi-Fi and see the content stored on that server. The content server obtained two kinds of data, one being railway information content obtained via the onboard train information management system (TIMS). TIMS is connected to digital train radio to receive information on operations such as delays from points at fixed intervals along the line. TIMS itself possesses information on current location and cabin conditions (congestion level, room temperature, etc.), to be transmitted to the content server. The other type of data content is marketing information content (area information, coupons, etc.) obtained via content providing system on the ground. These two types of content are then delivered via Wi-Fi to passengers' mobile devices.

With the above, the system can provide:

(1) Direct information delivery from the train to individual passenger mobile devices onboard
(2) Delivery of useful railway operation information and marketing information according to current location and situation
(3) High-speed content delivery via Wi-Fi

In this test system, content was stored in an onboard device, and passengers' smartphones could obtain only content data in that device. In other words, while accessing the onboard network, passengers could not access the Internet. Furthermore, we did not adopt push notifications such as sending text-based messages as mobile information services in this study as push notifications may cause irritation [5].

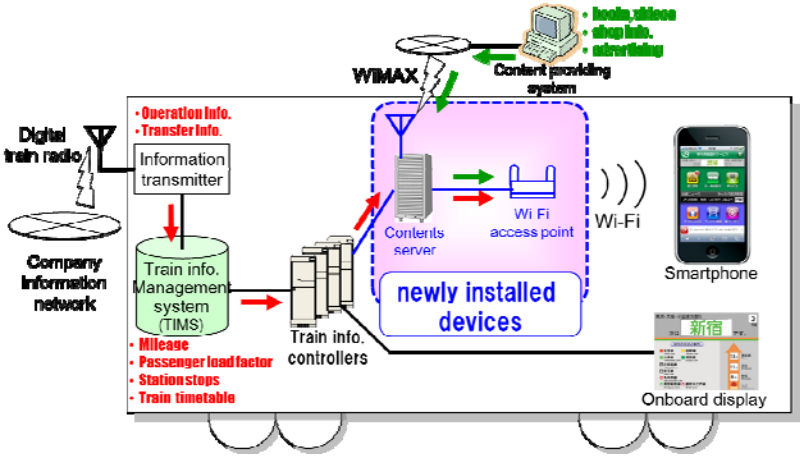

Fig.2 System configuration

B. Overview of content

This section provides an overview of the content delivered by the installed system. Fig 3 shows the initial screen of tested mobile information services on board. Users can notice that the service delivers dynamic content according to location by showing the current location always at the top, regardless of which content screen is viewed. The top half is allocated for railway information and the bottom half for marketing information, with three icons each.

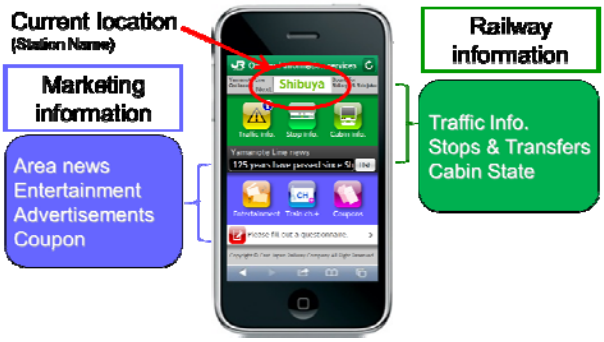

Fig.3 Initial Screen

1) Railway information content

Content related to railway operation is as follows:

(a) Traffic information

This displays any operation delays or information on disruption for lines in the greater Tokyo area (Fig. 4 left). This information is also provided on the onboard LED or LCD displays, but the difference is that passengers can obtain such information when they need it. The screen is designed to display information about the line being travelled (the Yamanote Line in Fig. 4 left) always at the top.

(b) Stops and transfers

This consolidates basic railway information such as stops along the line, platform facilities of each station, and transfer information (Fig. 4 center). The system can display delay information down to the minute on the transfer guide screen. This feature was achieved by making use of the information originally made available for conductor announcements, from the existing transport operation control system.

(c) Cabin status

This displays real-time changes in information on each car of the train, such as the congestion level and cabin temperature from TIMS, and fixed information such as which cars have wheelchair spaces and reduced air conditioning. (Fig. 4 right)

2) Marketing information content

The content introduced here was content distributed during the field tests conducted in 2011.

(a) Lineside news/topics

Lineside news and event information was classified in six separate areas (Tokyo, Ueno, Ikebukuro, Shinjuku, Shibuya, and Shinagawa areas) and distributed. Content was updated on a weekly basis. Scrollable area-related news was displayed at the center of the initial screen.

(b) Entertainment content

E-books, film clips, and other entertainment content that can be enjoyed on the train, including clips of skits by comedians, electronic editions of magazines or comics. Contents was updated on a weekly basis.

(c) Televised commercials linked to onboard ads

Seeking new possibilities for advertising, we delivered commercials linking to ads on LCD displays above the doors with the hanging ads (Fig. 5 left). These ads were not updated during the test period.

(d) Information on in-station malls, shop coupons, and promotional campaigns

We delivered information on in-station shopping malls along the Yamanote Line (Fig. 5 center) and coupons for those shops (Fig. 5 right) along with JR East Group promotional campaigns. To make information more searchable, shop info of nearby stops was displayed with priority. Most content is static and some event information for shops and coupons are only updated once a week.

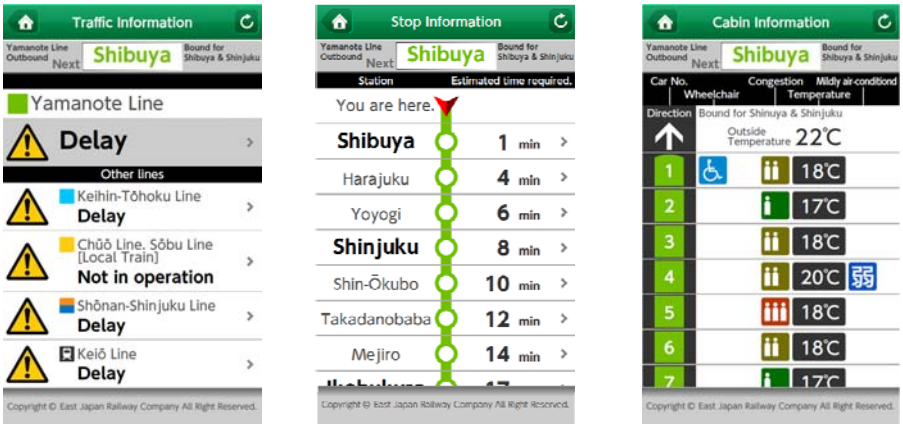

Fig.4 Railway information screen

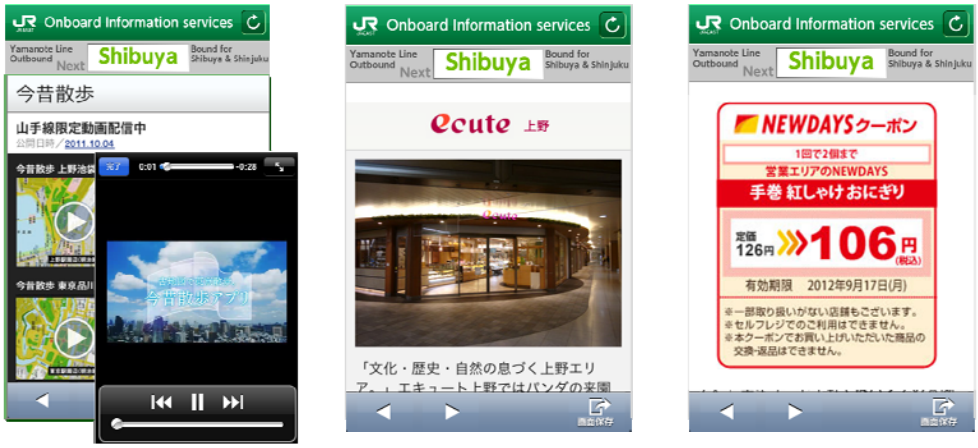

Fig.5 Marketing information screen

IV. EMPIRICAL RESEARCH

To assess and verify mobile information services on commuter trains, we equipped a train on the Yamanote Line with the above-mentioned system and conducted empirical research.

A. Test circumstances

For about one month from October 4 to November 2, 2011, we installed the developed system which is introduced in section 3 to a train on the Yamanote Line and conducted empirical research. As shown in Fig. 6, we announced the test and encouraged passengers to take part in the test using ads inside the test train (stickers, hanging ads, displays above doors) and ads on the car body. Users could access all content free of charge by accessing the onboard Wi-Fi network and opening a dedicated app or a browser. The content delivered was as introduced in section 3.

B. Test results

The results of the month-long empirical research can be summarized as follows:

1) Access log

The details of access logs over the one-month test period are as follows:

(a) Number of service users

The number of unique users was approx. 30,000, and the number of accesses to the initial screen of the mobile information services displayed onboard was approx. 240,000 in total (daily mean approx. 8,000). The number of downloads of the iPhone application was approximately 12,000 and for Android terminals approximately 6,000.

(b) Characteristics of users

Table 1 shows characteristics of users. It was found that more than 80% of users were male. Users in their 30s had the highest proportion, followed by users in their 40s and 20s. Those users accounted for nearly 90% of the total users. It was found that approximately 80% of the total users were company or public employees.

(c) Content browsing time

Fig. 7 shows browsing time of content provided by the information services. This figure indicates that average browsing time is 4.6 minutes and there is little difference between browsing time by gender. Furthermore, we can find that with age, the rate of browse time under 1 minute is lower. Occupation-wise, it was found that the rate of browse time under 1 minute by students is higher than other occupations.

(d) Number of unique users who access each type of content

Fig. 8 shows the numbers of unique users who accessed each type of content during the test period. The most accessed information was found to be "traffic information", followed by "cabin status" and "coupons".

Fig. 6 Empirical research

TABLE 1 CHARACTERISTICS OF USERS

	Attribute	Number	Percentage
Gender (n=29,813)	Male	24,635	82.6
	Female	5,178	17.4
Age (n=29,813)	Under 20	1,240	4.2
	20–29	7,517	25.2
	30–39	10,369	34.8
	40–49	7,952	26.7
	50+	2,735	9.2
Occupation (n=29,813)	Junior or senior high school student	796	2.7
	University student	2,710	9.1
	Company or public employee	23,337	78.3
	Freelance professional or self-owned business	1,302	4.4
	Part-time employee	634	2.1
	Others	1,034	3.5

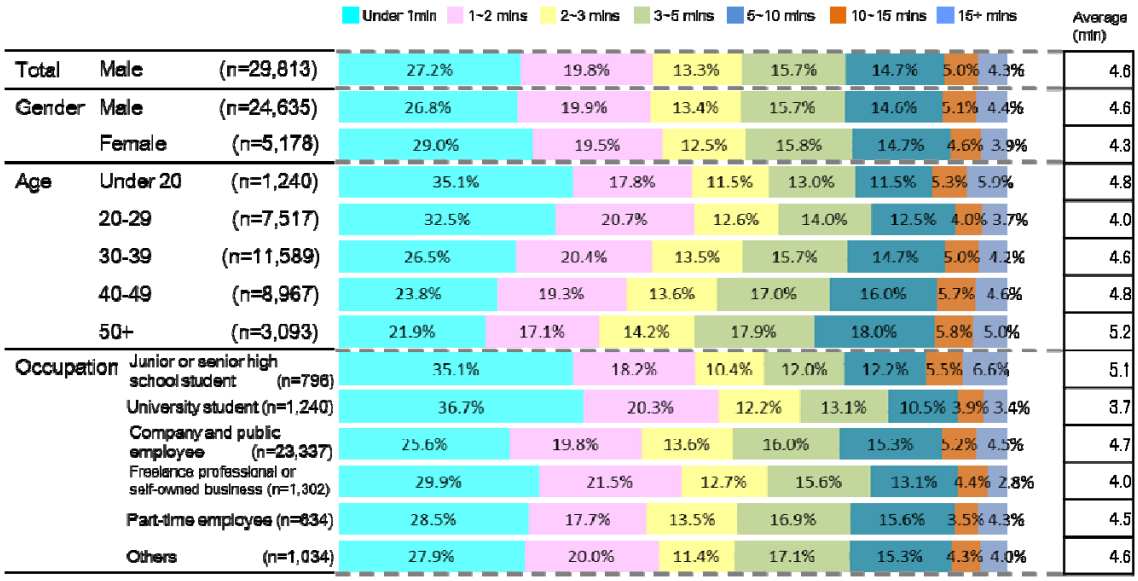

Fig. 7 Content browsing time

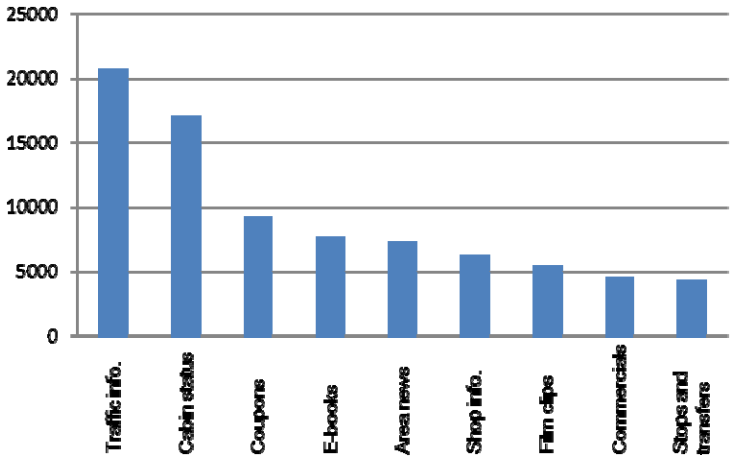

Fig. 8 Number of unique users accessing by content

The top three types of content accessed show no gender difference, however, the order differs for the next three:
[Male]
Fourth: E-books (n=6,401), Fifth: Area news (n=6,280), Sixth: Shop information (n=4,903)
[Female]
Fourth: Shop information (n=1,432), Fifth: E-books (n=1,282), Sixth: Area news (n=1,024)
The results indicate that female users are more interested in shop information.

(e) Content views by time

Fig. 9 shows the number of accesses to the initial page per hour during the test period.
We found that the peak was 8:00 - 8:59 in the morning, with the second peak at 18:00 - 19:59 in the evening. Separated by gender, the evening peak for female users was 18:00 - 18:59 and for male users 19:00 - 19:59, while the morning peak was the same at 8:00 - 8:59.

2) User questionnaire survey

During the month-long test, we conducted a questionnaire survey for passengers using the services. A link to questionnaire pages was placed at the bottom of the initial page of the mobile information services and 1,890 users voluntarily accessed the questionnaire pages and answered several questions. The survey mainly consists of 5-point Likert scale questions about each type of provided content and the overall service.

(a) Attributes of responders

Table 2 shows attributes of responders. It was found that the composition of attributes of responders was almost as same as that of users overall.

(b) Assessment of content

We asked users to evaluate the content which they had accessed. Fig. 10 shows the rate of evaluation for each type of content. The quantity of responses to each differs since the user can evaluate only what they have accessed. It is found that the rate of positive responses (good and relatively good) to railway information content (traffic information, stops and transfers, and cabin status) is much higher than other content. Therefore, providing railway-related content is necessary for railway companies to be able to improve customer satisfaction with information services. Underlined items in Fig. 10 are location-based contents which differ according to passengers' location. We find that it does not correlate with positive evaluation of content.
Moreover, such content can be divided into two types, that is, whether change occurs according to time or not. Traffic information, transfer information and cabin status are updated real time, and area news, film clips, e-books and coupons are updated on a weekly basis. This content are more highly evaluated than other content; therefore, providing dynamic information is considered an important factor for mobile information services on board.

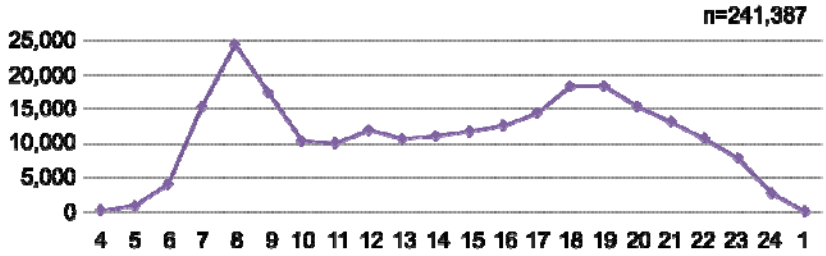

Fig. 9 Accesses to the initial page of onboard content

TABLE 2 ATTRIBUTES OF RESPONDERS

	Attribute	Number	Percentage
Gender (n=1,890)	Male	1,572	83.2
	Female	318	16.8
Age (n=1,890)	Under 20	93	4.9
	20–29	450	23.8
	30–39	624	33.0
	40–49	541	28.6
	50+	183	9.7
Occupation (n=1,890)	Junior or senior high school student	59	3.1
	University student	163	8.6
	Company or public employee	1,525	80.7
	Freelance professional or self-owned business	70	3.7
	Part-time employee	38	2.0
	Others	36	1.9

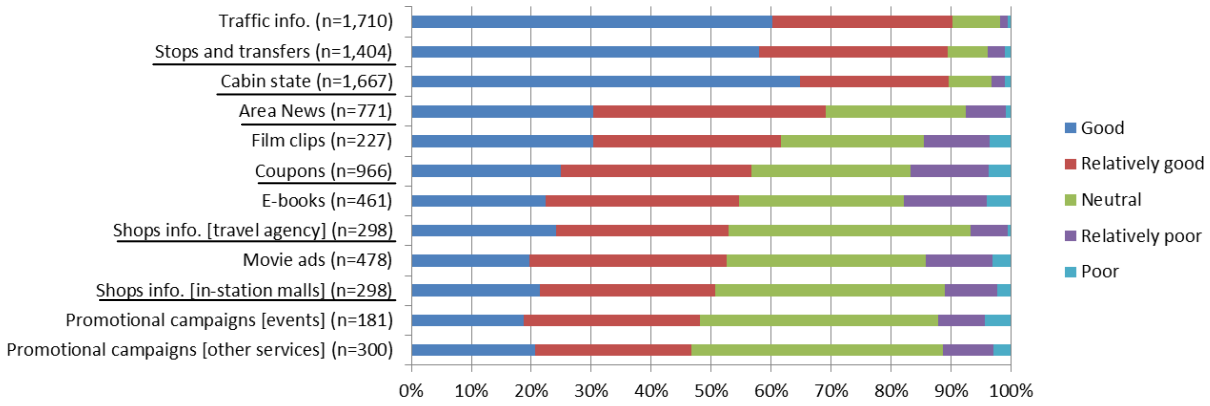

Fig. 10 Assessment of content

(c) Overall intent of use

Fig.11 shows overall intent to use the mobile information services. We asked in the survey if the user would use these mobile information services if the services were actually introduced. We found that almost 90% of respondents showed positive responses, such as "agree" or "relatively agree".

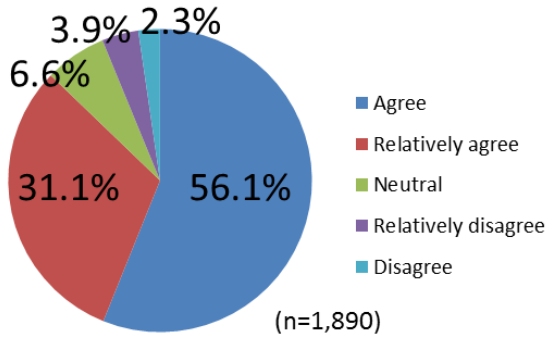

Fig. 11 Overall intent to use the mobile information services

(d) Correlation between satisfaction and intent of use

In order to clarify the relationship between satisfaction with each type of content and overall intent to use the mobile information services, correlation between satisfaction with the contents and intent to use the services was calculated. The level of satisfaction with each type of content is derived from the sum of the rate of positive responses ("good" and "relatively good") to each content category in Fig. 10. The rate of positive to traffic information, for example, is 90.1%, and that of promotional campaigns for other services is 46.7%. The correlation between satisfaction with the contents and intent to use services is calculated from the rate of positive responses in Fig. 10 and overall intent to use the mobile information services in Fig 11. Table 3 shows satisfaction with each content category and correlation coefficient between satisfaction with each content category and overall intent to use the mobile information services. The deviation of each parameter is also calculated and described in this table.

TABLE 3 SATISFACTION WITH EACH CONTENT AND CORRELATION COEFFICIENT BETWEEN SATISFACTION WITH EACH CONTENT AND OVERALL INTENT TO USE SERVICES

(n = 1890)

	Sum of the rate of positive responses	Sum of the rate of positive responses (deviation)	Correlation coefficient between satisfaction with the contents and intent to use services	Correlation coefficient between satisfaction with the contents and intent to use services (deviation)
Traffic info.	90.1	66.44	0.19	63.47
Stops and transfers	89.6	66.13	0.06	49.83
Cabin state	89.5	66.07	0.17	61.37
Area News	69.0	53.39	0.09	52.97
Film clips	61.7	48.88	0.00	43.53
Coupons	56.7	45.79	0.10	54.02
E-books	54.7	44.56	0.01	44.58
Shops info. [travel agency]	52.8	43.38	0.18	62.42
Movie ads	52.5	43.20	0.04	47.73
Shops info. [in-station malls]	50.7	42.08	0.07	50.87
Promotional campaigns [events]	48.1	40.48	−0.17	25.69
Promotional campaigns [other services]	46.7	39.61	0.00	43.53

We then created Fig. 12. The vertical axis indicates the deviation of satisfaction with each content category and the horizontal axis indicates the deviation of correlation coefficient between satisfaction with each content category and overall intent to use the mobile information services. Underlined items in Fig. 12 are location-based categories. We can find that the deviation of correlation coefficient of almost all location-based content is over 50. That means that the satisfaction of contents which consist of location-based information affects overall intent to use these mobile information services more than the satisfaction of contents which does not consist of location-based information. In other words, there is a high possibility that intent to use the information service increase if satisfaction with location-based content increases.

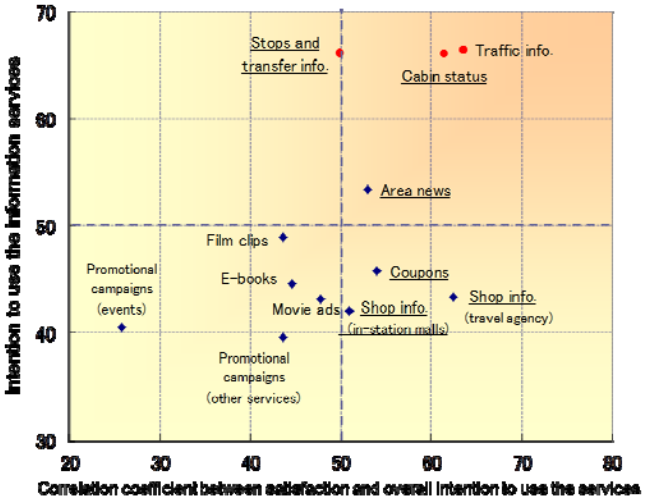

Fig. 12 Correlation between satisfaction and overall intent to use the information services

V. CONCLUSION

In order to clarify what kind of mobile information services passengers need on board, we conducted empirical research on commercial commuter trains in Tokyo. An information providing system that provides information for passengers' mobile devices was newly installed on board a train for purposes of this research. Content was divided into two types, namely railway information and marketing information.

However, from access logs to installed content servers on board, it was found that railway information is more frequently accessed than marketing information, and that the satisfaction of railway information content is much higher than that of marketing content according to the results of the user questionnaire survey.

Thus, we changed our perspective and divided content into location-based content and non-location-based content. We found that satisfaction of location-based content affected overall intent to use these mobile information services. It has been suggested in [3] that conditional value perceptions trigger mobile service use. Conditional value has subcategories of value depicting time, location, access and uncertain conditions. This suggestion agrees with the findings of this research.

However, other studies have revealed that simply adding context-aware features to mobile service does not necessarily provide added value to users, but rather the contrary. The potential added value of insight in users' location and availability is offset by people's reluctance to share location information with others [1], [4]. It is considered that the reason why passengers do not feel uncomfortable being provided location-based information in this study is that the installed information providing system only uses rough location information of passengers such as being at a station or between stations.

We also found that content that changes according to time received higher evaluation than other content. The provision of dynamic information is considered an important factor for mobile information services on board.

VI. FUTURE RESEARCH DIRECTIONS

The subject of this research is mobile information services for passengers on commuter trains. Though we obtained several findings by conducting empirical research, it is necessary to identify whether these results are specific to onboard information services or not. Therefore, we will further conduct empirical research of the effect of mobile information services not only on trains but also out of trains; for example, at stations, in town, at home, etc.

We would also like to further delve into the relation between content characteristics (reflecting changes occurring in response to location information and/or time) and satisfaction with content or intent of use.

Rail is one of the world's major infrastructures. Most major cities have extensive rail networks. Therefore, the insights about providing mobile information services for commuter trains obtained by this study contribute to understanding the effect of information services in public transportation.

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