In this study, we have focused on a system for public transportation to achieve information linkage. Due to differences at transportation operators, it is difficult for more than one to work together to achieve consistent service delivery. However, methods of achieving cooperation between different operators are emerging with the development of information technology in recent years. Therefore, we developed an information system for cooperation between public transportation operators using ICT technology in this study through the provision of information to users, and we identify issues and confirm the system's effectiveness.

**Keywords:** Intelligent Transport System (ITS), Smartphone, Provision of information

1. **Introduction**

Innovation in the method of providing information has been progressing in the transportation sector in recent years as ICT devices such as smartphones have rapidly become commonplace. Particularly, communications functions of smartphones have enabled easy provision of real-time information, and the excellent image rendering, GPS, and other functions of smartphones also have been propelling day-to-day advances in navigation services.

Under these circumstances, technical development with an aim of advancing transport systems using ICT is under way in the Intelligent Transport System (ITS) field. In the road and private car transportation sector, in particular, development has been done in technologies that are useful both for users and facility operators. Prominent examples include car navigation systems and electronic toll collection (ETC) systems. In contrast, the current situation in the public transportation sector sees no harmonized efforts between operators, due to barriers such as difficulty in coordination and difference of type and mode of operations.

As expressed in "JR East Group Management Vision V", we need to enhance cooperation with local communities, so we must advance research in service design taking into account the use of buses and other secondary transport modes beyond stations as well as the use of railways in order to promote further use of railways. In this context, we developed and carried out evaluation of effectiveness for an information linkage system for public transportation in cooperation with Suda Laboratory (Institute of Industrial Science, University of Tokyo), Kashiwa City, and operators of buses and railways that run from/to Kashiwa Station. This article will report on the results of development and evaluation.

2. **Development of an Information Linkage System for Public Transportation**

2.1 **Interface Design**

In development of an information linkage system for public transportation, we first laid down a design framework as follows.

1. Display the information many people first look for on the top page.
2. Design easy-to-understand flow leading to detailed information
3. Decentralize information so as to secure maintainability of the linkage system.

The interface was designed based on those requirements.

2.1.1 **Home Page**

The home page is the screen that is displayed at startup (Fig. 1). Operational information is shown at the top of the screen. When new operational information for the JR Joban Line or Tobu Noda Line is delivered, the system switches the screen layout so a link to that operational information is displayed.

At the middle of the screen, the timetable of the next three JR East trains departing from Kashiwa Station is displayed. The display includes departure time, type of train, destination, and any delays. When a delay occurs, the display takes that into account. For example, if at 17:30 the train that was to depart Kashiwa Station at 17:28 is delayed for five minutes, the timetable of that train remains displayed on the screen. The screen is changed over to the timetable of the next three trains departing on the Tobu Noda Line from Kashiwa Station by flicking to the left.

At the bottom of the screen, twitter information on Kashiwa City and the area around Kashiwa Station is displayed.

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2.1.2 Menu
The menu is displayed by tapping the menu icon at the left top of the home page. The information included in the menu is as follows.
- JR Joban Line train location information
- JR Joban Line timetable
- Tobu Noda Line Kashiwa Station timetable
- Buses from Kashiwa Station
- List of alarms
- How to use

Displays locations of the nearest trains on JR Joban Line.
Displays timetables of the stations on JR Joban Line.
Displays timetable of Tobu Noda Line trains at Kashiwa Station.
Displays a list of buses from Kashiwa Station.
Displays a list of alarms set based on the timetables.
Displays a link to information on how to use the information linkage system for public transportation.

The menu is closed by tapping the area outside of the menu area or the menu icon at the top left of the home page.

2.1.3 JR Joban Line Train Location
This screen displays line occupation information for trains of the JR Joban Line (Fig. 2 left). Due to system limitations, this information always has a delay of around one minute from the real-time information. The train location information is displayed for the section between Ueno and Torigase with different types of lines shown per train type. By tapping one of the station name signs on the right, the timetable of the station tapped is displayed.

The lines with upward-facing train icons are inbound lines (to Ueno) and those with downward-facing icons are outbound lines (to Torigase). The display is automatically updated once a minute. When updated, icons of individual trains are shown moving to their latest locations. If a train is delayed more than five minutes, the area around the icon of that train flashes in red (Fig. 2 middle). By tapping one of the train icons, the train information (current operational status and timetable) of that train is displayed.

2.1.4 Train Information
This screen displays the information of the train chosen on the JR Joban Line train location information screen (Fig. 2 right). At the top of the screen, detailed information of the chosen train is shown. That includes the time data was obtained, train type, destination, direction of travel, train number, operational status, and current location. At the bottom of the screen, the timetable of that train is shown. On the right of individual station names, departure time from each station is shown. If that train is delayed, expected departure time based on the delay time is shown to the right of the scheduled departure time.

2.1.5 JR Joban Line Timetable
This screen displays timetables of stations on the JR Joban Line (Fig. 3 left). The initial screen shows the timetable of Kashiwa Station. When this screen is transitioned to from the JR Joban Line train location information screen, the display automatically moves to the timetable of the station chosen there.

The names of stations shown at the top can be scrolled through by flicking left or right. Tapping a station name changes the screen to the timetable of the station tapped. The station chosen is enclosed in a red frame.

The timetable at the bottom automatically scrolls to the time nearest to the current time. For example, if the user opens the screen in the screenshot shown below at 17:19, it shows the local train departing at 17:20 at the top. By pressing and holding the timetable of the desired train, an alarm can be set. Pressing and holding the timetable calls up a dialog screen for setting an alarm, and an alarm can be set for the departure time, five minutes before departure, and ten minutes before departure of the desired train.

2.1.6 Tobu Noda Line Kashiwa Station Timetable
This screen displays the timetable of Kashiwa Station on Tobu Noda Line (Fig. 3 right). Days of the week and direction can be chosen by pressing the button at the top. As on the screen for the JR Joban Line timetable, the screen automatically scrolls to show the train nearest to the current time at the top, and alarms can be set by pressing and holding the timetable of the desired train.

2.1.7 Buses from Kashiwa Station
This screen displays a list of buses that depart from Kashiwa Station (Fig. 4). The buses are displayed grouped by bus stop.
they depart from. For Tobu Bus, current operational status is displayed by individual buses, while that is displayed by bus line for Bando Bus.

2.1.8 Bus Line Information from Kashiwa Station: Choice of Bus Line

This screen displays timetables of buses from Kashiwa Station. The timetables are displayed grouped by bus stop. By choosing the bus line, the timetable of the line chosen is displayed.

2.1.9 Bus Line Information from Kashiwa Station: Timetable Display

This screen displays the timetable of bus lines from Kashiwa Station. The display automatically scrolls to show at the top of the screen the bus that is to depart at the time nearest to the current time. By pressing and holding on the desired bus, alarm can be set.

3 Proving Tests of the Information Linkage System for Public Transportation

3.1 Outline of the Proving Tests

We conducted tests on effectiveness of the system from October 1 to December 27, 2013 where users actually used a newly developed application (for iOS only) that could be freely downloaded. In order to acquire the data to be provided in that application, East Japan Railway Company (JR East) worked in cooperation with Tobu Railway Co., Ltd., Tobu Bus East Co., Ltd., and Bando Bus Inc. Suda Laboratory of The University of Tokyo took charge of arrangement and coordination of the tests as a whole and issuance of the application, and Kashiwa City was in charge of interview surveys and coordination with local communities. For the evaluation, we identified actual usage of the application by analyzing the server access logs and evaluated the effectiveness of the application based on the responses to a questionnaire in the application.

3.2 Proving Test Results

The numerical results of the test are as follows.

Period: October 1 to December 27, 2013
Number of times application was downloaded: 4,298
Total number of unique visitors: 26,527

3.2.1 General Analysis

As the general analysis results, Fig. 5 shows the numbers of unique visitors and the number of times the application was downloaded per day.

The graph above also shows the possible reasons for localized sharp increases in the number of accesses. Possible reasons for those increases are the following two events.
(1) Operation disruptions lasting a long time time occurred
(2) Release or update of the application

In the long operation disruptions, sharp increases in the number of accesses tend to be observed when train delays continue for a long time. In particular, at the approach of a typhoon on October 16, 2013, such a peak probably occurred because the impact of strong winds began to be seen on the previous day and some trains were delayed as much as four hours. Another access increase occurred on November 26, 2013, corresponding to a peak in trains being delayed due to strong winds at the evening rush hour when commuters were returning home.

At the release and update of the application, the number of accesses probably naturally increased because people started up the application right after installing it. But the number of times users become clearly aware of application update is tending to decrease as the latest version of iOS performs the update automatically. In light of that, we will need to take measures such as notifying users of operation disruptions and of application updates using the push notification function. Those could lead to a constant increase in users.

3.2.2 Number of Unique Visitors

Regression analysis of the results indicates uninterrupted increase in the number of unique visitors, so we can suppose that there were few cases where a user stopped using that application. However, daily fluctuation was large, with an average of 308 accesses and a standard deviation of approx. 101. This can be seen as a natural result of the application being useful in operation disruptions. But, in order to increase the frequency of use of users, we will probably have to increase the frequency of them starting up the application. An example of possible measures is notifying users of current operational status in commuting hours.
3.2.3 Number of Times the Application Was Downloaded
The number of times the application was downloaded tends to increase at release of the application and in large-scale operation disruptions. The application was downloaded a large number of times for about a week after typhoon No. 27 (typhoon Francisco) on October 26, 2013. It seemed to the authors that the application was often talked about on Twitter in that period, which may have greatly affected the number of downloads. As shown here, the most important factor in increasing the number of times the application is downloaded is how to reach as many potential users as possible. We therefore have to carefully consider approaches to accomplish that.

3.2.4 Time Slot Analysis
Next, we carried out comparison of the numbers of accesses per time slot. A histogram of the number of accesses per time slot is shown below (Fig. 6). Lighter (whiter) shades mean a larger numbers of accesses, and darker (black) shades mean a smaller numbers of accesses.

![Fig. 6 Histogram of Number of Accesses per Time Slot](image)

The histogram shows a tendency for the number of accesses to increase in commuting hours of 6:00 to 9:00 and 17:00 to 22:00. One interesting fact is that a significant amount of accesses was gained in the morning even on holidays (Saturdays and Sundays). This result suggests that the application was not used just in commuting hours, but also in other daily situations where people rode trains.

The system this time did not cover information such as for special trains on holidays that operate across multiple lines. In light of such daily use of the application, however, appropriate display and notification of information on those special trains too could tap into further needs of users.

4 Conclusion and Future Outlook
In this research, we created an evaluation model and carried out development, construction, and operation of an information provision system for Kashiwa Station in cooperation with Kashiwa City and the University of Tokyo focusing on information linkage and provision of information. The aim of the research was to achieve user-friendly railways and other public transport. To provide users with information, we implemented an iOS application and made it available to the public on the App Store. Analysis of access logs confirmed that it was used particularly in long operation disruptions and continuously used during the period when it was available.

In closing, we will cover the issues found in the research and outlook for the future.

(a) Need to improve from real-time information to predictive information
In this research, we built a system that integrated and provided static data of railways and buses (timetables) as well as dynamic data (operational information, delays, location information). The number of accesses proved that the system was continuously used, and that confirmed to us that the system had a certain level of effectiveness. From the development stage, however, ways to incorporate prediction information into the system had been pointed out as an issue that needs to be covered. For buses, in particular, users need information more on expected arrival time due to road congestion and the like than on current delays. Such comments were already picked up in user interviews and the like at the development stage.

(b) Need for search function
Information was provided individually in the system studied. Ideally, however, the system will need to provide information covering many transport operators. To achieve that, we need to implement notification and recommendation functions that are linked to functions such as travel route searches and schedulers.

[Future outlook]
The outlook on overcoming the aforementioned issues and promoting future use of public transportation based on provision of information will be as follows.

As prediction and search functions have many issues that cannot be overcome by transportation operators only, we need to facilitate data linkage and create a larger project framework. Especially, we need to consider user-friendly services by incorporating open data and data acquired from outside sources.

Moreover, in the Olympic and Paralympic games to be held in Tokyo in 2020, it will be crucial to appropriately provide information to various users, including people who are not familiar with how to use public transportation. Localized demand for travel is generated in a short period of time in such a large event, making it vital to provide on-demand operation and create information and service linkage between transport operators so as to achieve efficient transport services.

With those needs in mind, we will promote research and development and make efforts to achieve more convenient railways and public transportation.