Train Location Display System for Customers by Utilizing Data of the Transport Operation Control System or the Global Positioning System

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Abstract
JR East has been working with IT (Information Technology) to inform passengers of easy-to-understand train location. This paper introduces two types of systems that provide train location information, the system for Tokyo Metropolitan area and the other is the system for rural area. These systems were tested at various stations and have operated almost stably for each test period. And we also conducted passenger surveys by questionnaire about the systems at each station. These results show that most passengers appreciate the systems. We will develop the systems more so that they can be installed for practical use in the future.

Introduction
Providing train running information to passengers is railway operator’s important mission which effect customer satisfaction. However, we find out that customers are not satisfied with quality of our information services at stations when we conduct an annual survey for the customer service. Therefore, JR East has been working with IT to provide passengers easy-to-understand train running information service. One of the services is the train location display system.

LED boards are installed on the platform at most of the stations in the Tokyo Metropolitan area. When operations are disrupted, they sometimes provide incorrect departure time or temporarily no information. Then, passengers can not get the information where trains are, and try to get on the coming train even if the train is very crowded and the next train will come soon. Train location display system is useful to solve these problems.

We would also like to narrow such service gap between the metropolitan area and the local area as much as possible. Therefore, it is necessary to develop a train location display system which does not require information from the train operation system.

This paper introduces two types of train location display systems that we developed as follows:
1. The system utilizing the current transport operation system
2. The system using the Global Positioning System (GPS) data from trains

The system utilizing the current transport operation system
Trains in the Tokyo Metropolitan area are operated by transport operation control system, ATOS (Autonomous Train Operation control System). This system deals with train location information, and we developed systems to inform the train location to passengers by utilizing the ATOS information.

There are two approaches of development based on equipment displaying the information. One is to use current train departure LED boards, and the other is to install large LCD (liquid crystal display) on the platform to show the information.

1. Train location guidance on train departure LED boards
Current train departure LED boards indicate train locations in text message such as “The next train left XX station”. The problems with this method are, 1) foreign passengers cannot understand this because the display system does not support English, 2) passengers who do not know names of neighboring stations cannot understand the information, and 3) information is difficult to read since the system displays those text messages in scrolling text. Thus, we discussed the problem with related sections and developed a new display design that can be indicated on current LED boards.(Figure 1)

This development has been introduced coincidentally to all stations along the Nanbu line in spring 2006 when the ATOS is introduced on the line.
2. Train location guidance on large displays

There is limitation in design and expression for train location guidance using LED boards, so we also developed a system that provides easy-to-understand train location information on large displays. Figure 2 shows the outline of the system.

![Figure 1: Train location guidance under the departure information on the LED board](image1)

**Figure 1: Train location guidance under the departure information on the LED board**

This system indicates train locations by two data sources, train location data which transport operation control system (ATOS) has and the train approaching data which is currently sent to train departure LED boards at platforms.

Now we have a system to send some ATOS data to station staffs’ PDA. The data includes train location, so we utilized the current system in this development project. In addition, we set up a new web server to output XML files of train location data under a database server for output from ATOS. We also created a program to enable train location display terminals at stations to acquire those XML files via the Internet and operate the terminals.

While the aforementioned display terminals can get train location data, it could not obtain accurate train approaching data from the ATOS because the timing which the approaching information sent varies by station. Therefore, we designed the system to take train approaching data from the input line to current train departure LED boards in stations.

In terms of the visual design which indicates train location, we illustrated two patterns; “platform sign type” and “3D type”. As is shown in the name, “platform sign type” imitated platform sign which is familiar to passengers. (Figure 3)

![Figure 2: Outline of the system utilizing the train operation system](image2)

**Figure 2: Outline of the system utilizing the train operation system**

![Figure 3: Visual design for train location; “platform sign type”](image3)

**Figure 3: Visual design for train location; “platform sign type”**
On the other hand, “3D type” is illustrated with motion and a three-dimensional feel. (Figure 4)

Figure4: Visual design for train location; “3D type”

Figure 5 shows visual design for “train approaching”. When the train location display terminal receives train approaching data, the large displays show this image.

Figure 5: Visual design for train approaching

To verify the operational stability of this system and to evaluate these display designs, we conducted an empirical test on the platform at Ebisu station on Yamanote line from October 2006 to February 2007. Field introduction is as follows:

- Ebisu station
  The Ebisu station is one of largest stations in the central Tokyo area and approximately 135,000 passengers use it a day. It is nineteenth-ranked scale in the JR East area in 2006.

- Yamanote line
  The Yamanote line is one of the busiest and most important commuter lines in Japan. Running as a circle, it connects most of Tokyo's major stations and urban centers.

We used 46 inch LCDs. These displays were installed above existing LED boards so that we can put together various train running information on the platform.(Figure 6)

Figure 6: State of the large display installed on the platform

The system had operated almost stably for 4-months test period. However, some trouble occurred. One of the causes is that train location information from web server is delayed about 30 seconds. Therefore, the display sometimes showed that the train, which had already arrived at Ebisu station, was before Ebisu station.
And we conducted passenger survey by giving questionnaire about this system on the platform at Ebisu station. According to the questionnaire result, over 90% passengers responded that they could easily understand where trains were.

We also asked that which design is easier to understand train location. Figure 7 shows the result. The number of respondents who prefer “platform sign type” is almost the same as the number of those who prefer “3D type”. However, the questionnaire also revealed that the passengers who are not used to Ebisu station preferred “platform sign type”. (Figure 8) Therefore, it is considered that we should adopt “platform sign type” design.

![Figure 7: Visual design which is easier to understand train location](image)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Platform sign type</th>
<th>3D type</th>
<th>Neither</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 5 days/week</td>
<td>40.7%</td>
<td>47.5%</td>
<td>12.1%</td>
</tr>
<tr>
<td>3~4 days/week</td>
<td>41.0%</td>
<td>47.5%</td>
<td>10.5%</td>
</tr>
<tr>
<td>1~2 days/week</td>
<td>47.6%</td>
<td>49.8%</td>
<td>2.6%</td>
</tr>
<tr>
<td>1~3 days/month</td>
<td>59.5%</td>
<td>44.6%</td>
<td>5.0%</td>
</tr>
<tr>
<td>under 1 day/month</td>
<td>56.5%</td>
<td>34.1%</td>
<td>9.4%</td>
</tr>
</tbody>
</table>

![Figure 8: Usage frequency of Ebisu station by passengers to whom we conducted a questionnaire](image)

We also conducted a questionnaire to station employees. The result shows that over 70% employees could tell passengers to trains location quickly. And then, one of the employees answered the number of passengers asking questions about train location have drastically decreased.

We continue developing the system for practical use. Specifically, we develop it which can deal with train location data at complex stations where various lines pass through or terminate. We will study not only on software but also on hardware. For example, we try to take countermeasures against LCD’s degradation. We plan to conduct a next field experiment at Shinjyuku station from May 2008.

This display design was selected for the Good Design Award 2007 in Japan and Japan Sign Design Association Award.

### The system using the Global Positioning System (GPS) data from trains

It is possible to construct aforementioned location display system in the lines which is operated by transport operation control system such as ATOS. However such train operation system is not introduced in the rural area, and thus in such area there are by no means to learn whether the train is operating regularly or not.

We would like to narrow such service gap between metropolitan area and local area as much as possible. Therefore, a train location display system which does not require information from train operation system is developed. In this system, we installed a GPS mobile phone in each train and tracked the train location.

This system is almost same as above-mentioned one except that it obtains train location information from GPS instead of ATOS. (Figure 9)
The GIS management server has been set up to get the locations from GPS mobile phones in trains, and the web server is fixed under the GIS management server to output XML files of train location information. Packet communications on public network is used to communicate between GPS mobile phones and the GIS management server. The train location display terminal, located at a rural station, downloads the XML file via the Internet, and interprets the file as train location data. The terminal sends the data to information displays, which show a graphical picture and make a voice guide, based on the train location.

![Figure 9: Outline of the system utilizing the GPS data](image)

We developed the mobile phone’s application which detects the location and uploads the data automatically. In order to reduce the load on the central servers, we design the system to distribute the processing autonomously. The outline of processing is below.

**Step1: Measurement by GPS**
- Measure by the MS-based GPS
- Measure every 20 seconds

**Step2: Report to the GIS management server**
- If the phone moves more than 55 meters from the previous location
- If 10 minutes passes, so that we know whether the phone is active or not

The location data in the GIS management server is just numerical. Therefore, we developed a function for the web server to judge the direction and location of a train on the line. In addition, we defined an XML tag to exchange the data between the web server and the local terminal. A sample XML file is the following.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<line id="gps-KURURI">
  <car id="KURURI-GPS-1">
    <position>13000</position>
    <direction>downtown</direction>
  </car>
</line>
```

The logic concerned with a direction and location is below.

**Direction:**
- Compare the location data received with the one just before received.
- If the calculated result is more than the default number (e.g., 200 meters), set the direction to “downtown” or “uptown” according to the sign of the result.

**Location on the rail:**
- Calculate the nearest point on the rail

Figure 10 shows the visual design of train locations. As stated before, the questionnaire at Ebisu station revealed that the passengers who are not used to Ebisu station preferred “platform sign type”. Then we adopted the design.
We also developed an information equipment called “IT Kakashi (=scarecrow)” on the platform. (Figure 11) The Kakashi has a LED board, speakers and web camera. The LED board and speakers which provide train location by image and voice, and a web camera observes the platform. The equipment is also controlled by the aforementioned terminal.

A field experiment was conducted at Makuta station on Kururi line from April 2007 to May 2007. A 32 inch LCD was installed in the station waiting room. And we also located the “IT Kakashi (=scarecrow)” on the platform. Field introduction is as follows:
- Makuta station
  The Makuta station is a typical rural station. There is no staff, but local volunteers maintain the station. About 320 passengers use it a day.
- Kururi line
  The Kururi line is a local line in Chiba prefecture. It has 13 diesel cars and 14 stations, running at about a 1 hour interval.

By conducting the field test, we confirmed the stability of GPS measurement and communication between mobile phones and the GIS management server except when the train is in a tunnel. However, there were some troubles as follows:
- Mobile application freeze
  The application within a mobile phone stopped twice for unknown reasons during the experimental period.
- Battery error
  On the third day of the experiment, one mobile phone didn’t work due to the battery being down. This was caused by a faulty wiring.

We also conducted passenger survey by giving questionnaire about the system at Kururi station. According to the questionnaire result, 87.9% passengers could understand trains location by the LCD and 89.3% passengers could understand by the IT Kakashi. (Figure 12)
Then, the questionnaire revealed that 70.5% passengers need the train location information by the LCD and 71.8% passengers need the information by the IT Kakashi. (Figure 13)

After the experiment, the system was removed. However, we have a plan to install the system for 2 other rail lines. In addition, staff of our company mention that the system is also useful for the maintenance staff. The reason is that when there is the problem in a car, the staff can easily detect it.

The “IT Kakashi” was also selected for the Good Design Award 2007.

Conclusion

We developed two types of systems that provide train location information. These systems were tested at respective stations. Both systems had operated almost stably for each test period. And we also conducted passenger surveys by giving questionnaire about the systems at each station. These results show that most passengers appreciate the systems. We will keep developing the systems so that they can be installed for practical use in the future. We believe such systems to become one of the essential equipments that improve customer satisfaction and provide uniform information service both in metropolitan area and local area.

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