SUWANT!: Support Application for Seat Availability Determination on Trains

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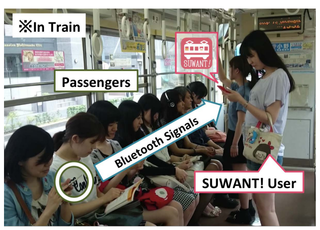

Figure 1: An example of using SUWANT!.

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Abstract
In the modern Japanese commuting scene, most Japanese people desperately want to find seats on the train to get some rest on their long commute. SUWANT![1] is a smartphone application using Bluetooth signals that helps users on a train to find passengers sitting nearby who will disembark at the upcoming stations; this applications is powered by crowdsourcing. The users of this application are motivated to contribute to crowdsourcing by being rewarded with an available seat. Upon startup, SUWANT! displays on the phone screen whether there are passengers around the user who are likely to disembark soon, and the distance between these passengers and the user. The user searches for such passengers by walking around sitting passengers and seeing the changes on the screen. On an experimental test, SUWANT! has succeeded in showing potential vacant seats once in every 5 rides on a specific train.

Author Keywords
Smartphone application, Bluetooth, Crowdsourcing, Train

ACM Classification Keywords
H.5.3 [Group and Organization Interfaces]: Collaborative computing

[1] SUWANT is a combination of “Suwaru” (take a seat, in Japanese) and “want.”

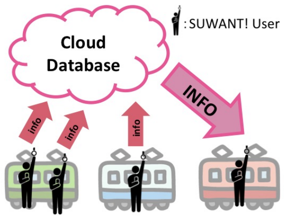

Figure 2: Schematic representation of SUWANT! crowdsourcing.

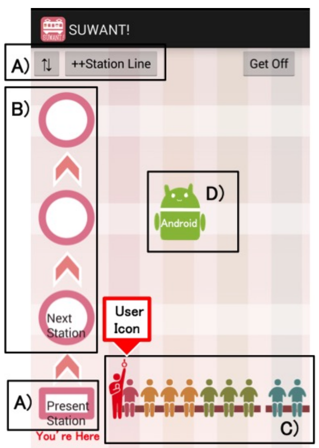

Figure 3: An example of screenshots of SUWANT! with some indicators: A) present train line and station, B) upcoming stations(y-axis), C) distance from the user(x-axis), and D) detected device type.

Introduction

Trains are a very important mode of transportation for the Japanese, particularly for those who live in the urban areas of Japan. In Tokyo, the most frequently used mode of transport for commuting is the train[2]. Further, in Japan, the average of a train commute is 1 h[3]. Considering this long commuting time, it would be natural that the commuters want to get a seat soon after getting on the train and want to get some rest during the 1 h commute. Many Japanese people even take a long nap during their train commute to compensate for insufficient sleep because of overtime work the previous evening. However, finding a vacant seat is pure luck. A passenger can get a seat when she fortunately stands near a sitting passenger who will disembark soon; otherwise, the seat may unfortunately get taken by another passenger who got on the train later than her. Thus, many train passengers in the urban areas of Japan hope that they get luck and a vacant seat during their commute. Therefore, we have developed a smartphone application that searches for sitting passengers who will be disembarking the train soon. This application also collects passenger information using Bluetooth signals by a crowdsourcing method for searching such people.

Our application uses Bluetooth signals on the train to understand the flow of people. Most Japanese workers and students these days have smartphones, and they regularly use Bluetooth for connecting to various devices. Moreover, it is expected that the number of passengers turning on their Bluetooth will increase even more with the spread of devices connected with Bluetooth such as headphones, smart-wristbands, and smart-watches. Our application can detect the unique Bluetooth IDs and received signal strength indication (RSSI) if the target Bluetooth devices are in a searchable mode and within about 10 m. Therefore, by tracking the Bluetooth IDs and its RSSI, our application can easily determine the station at which other passengers board and disembark.

When a considerable amount of information about the flow of passengers in trains is collected, it is possible to infer which passenger will be disembarking the train at an upcoming stations. However, it takes a huge amount of time to gather sufficient information from only one user; instead, we can gather the same amount of information sooner from many users. As shown in Fig. 2, the larger is the amount of information gathered by a large number of users, the greater is the possibility of the system to help a user find a seat. Since the database is powered by crowdsourcing and it is accessible to all users, it is expected that the accuracy of the system increases with an increase in the number of users. Our system motivates users to contribute to the information collection by rewarding them with information about potential vacant seats; moreover, the crowdsourcing process is automatically carried out in the background and will not bother the user.

SUWANT!

SUWANT! is a smartphone application that searches for sitting passengers nearby who will disembark at one of the upcoming stations for pointing out a potential vacant seat. This application gathers passenger information using their Bluetooth signals by a crowdsourcing method.

Fig. 3 shows an example of the screenshots of SUWANT! with some indicators. On the left side of the screen, the next few stations on the train line are listed from bottom to top. The bottom listing is the nearest station. These stations and the train line are inferred by our system from the present location data of the user. If it shows the wrong train

[2]http://www.stat.go.jp/data/kokusei/2000/jutsu1/00/04.htm
[3]http://www.mlit.go.jp/common/001001523.pdf

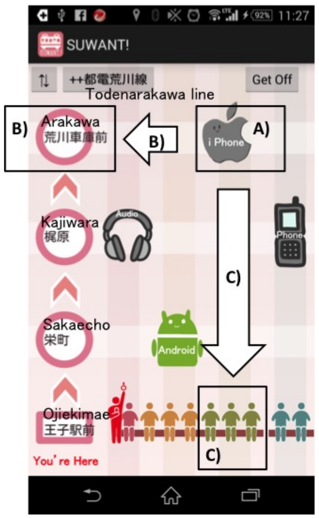

Figure 4: An example of a screenshot that indicates the following: A). an iPhone user, B). who is going to disembark at the Arakawa Station, and C). is seated 4-6 seats away from the user.

line, a user can select the correct one from a pop-up menu at the top of the screen. At the bottom of the screen, the distance from the user is visualized by using a pictograph of the sitting passengers. On the left of the pictograph, there is a picture of a standing person that indicates the user. The whole screen shows a two-dimensional (2D) graph with the distance from the user on the horizontal axis, and the next several stations on the vertical axis.

When a user gets on the train and starts SUWANT!, the screen of SUWANT! keep on changing according to the user's situation and the database built. If SUWANT! infers that there is a passenger who will disembark at one of the upcoming stations and is staying within 8 seats from the user, an icon that indicates the user appears as shown in the Fig. 3 D). The icon shape indicates the type of detected Bluetooth device, such as iPhone, Android device, or headphones. The example shown in the Fig. 3 shows that there is a nearby passenger who uses an Android device. This will help the user to identify the owner of the device by observing which passenger is using such a device. The position of the icon on the screen changes according to the user's situation. When the estimated distance between the target passenger and the user changes, the icon moves in the horizontal direction. When the train advances and the estimated destination station of the target passenger approaches, the icon moves in the downward direction.

In the following steps, the scenario of using SUWANT! is explained by using an example of the actual display of SUWANT! shown in Fig. 4.

1. When a user gets on the train, the user starts SUWANT!.

2. SUWANT! displays four Bluetooth devices around the user as shown in Fig. 4. For example, the apple icon on the upper part indicates the following:

   A). There is a passenger using an iPhone.

   B). This passenger is likely to disembark at the Arakawa station, which is the third upcoming station.

   C). The user stays at a distance of 4-6 seats from this target passenger.

3. The user tries to identify the target passenger indicated by the icon. One of the effective ways to locate the target is to walk around in the train and to monitor the display. When the user is walking around looking for the target passenger, the distance to each Bluetooth device changes and the corresponding icon will moves in the horizontal directions.
4. When the target passenger's icon moves to the leftmost position of the display, i.e., just above the user's icon, the user comes in front of the target passenger.
5. The user will finally find a seat when the target passenger eventually disembark at the inferred station.

System Overview

We implemented the smartphone application SUWANT! on the Android platform by using the Java language. We also built the server with the PHP language on a host machine at a cloud service provider. This smartphone application regularly tries to detect Bluetooth IDs every 12 s by using the Android application programming interface (API) . We expect that smartphones can detect IDs from Bluetooth devices owned by train passengers around the user. The expected Bluetooth devices are smartphones, headphones, laptops, and mobile phones. Besides detecting IDs, SUWANT! provides the following two functions.

Gathering information

Fig. 5 shows how to gather information about the stations at which the passengers nearby will disembark.

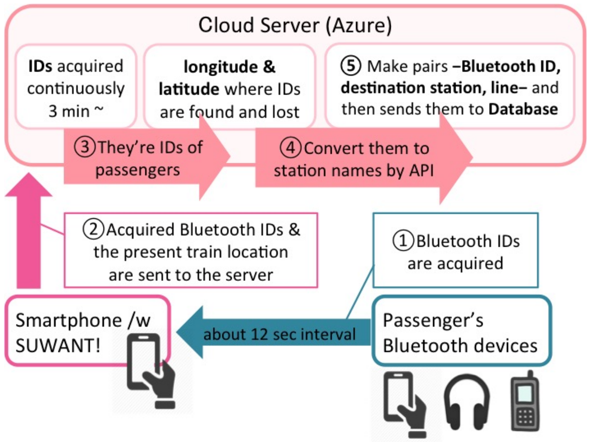

Figure 5: Schematic representation of the system gathering information.

The following steps are performed by the smartphone. When a smartphone with SUWANT! detects Bluetooth IDs, SUWANT! records the following information to a local text file: the detected Bluetooth signals (ID, RSSI), present train location, and timestamp. The present train location is expressed in terms of longitude and latitude, which are estimated by Android Location API. When a user disembarks the train, SUWANT! sends the local file to the server.

The following steps are performed in the server once a day. Before analyzing the flow of passengers, the server pre-processes the raw data sent by client smartphones to reduce noises as described in the following two processes.

The first pre-process is to reduces the unwanted interruption of Bluetooth ID detection. Because of the unstable characteristics of radio signal measurement, it often happens that a smartphone fails to detect Bluetooth ID, even when the device owner is still on the train. The ID is possibly found again as far as the owner does not disembark the train. The server regards that when the ID is lost, and then detected again within 1 h, the passenger is still riding on the train. The threshold value of 1 h is determined heuristically on the basis of the average commuting time in Tokyo, and this value should be adjusted when the application is deployed in other cities.

The second pre-process removes the unwanted Bluetooth IDs detected within a short duration. Eliminating data gathered within the short duration can filter out unwanted Bluetooth signals that come from outside of the train car. For examples, signals from devices at train platforms, from other trains passing by, and from houses or buildings along the train line can be omitted because they will be detected only for a short time. Therefore, the server ignores a Bluetooth ID that is detected within a 3 min duration. We also determine the threshold value of 3 min on the basis of the fact that the shortest interval between stations in Tokyo has a similar value. An adjustment of this value may be required in other train systems.

After there pre-processes, the server infers the source and the destination station of each detected Bluetooth ID on the basis of the assumption that points where the ID appeared and disappeared denote the boarding and exit locations. The server converts the longitude and latitude values of the points into station names by using a web API [4]. We also assume that passengers will disembark at the station where they boarded before, when the train runs in the returning direction. On the basis of these assumptions, the system regards the source stations also as the destination stations.

[4]http://express.heartrails.com/api.html

The server makes groups of data – Bluetooth ID, destination station, line– and then records them in the database. The larger is the number of users, the larger is the number of such groups in the database; thus, the finding rate and precision of the disembarking passengers will be improved.

Displaying information
The other function of SUWANT! is to inform the user about nearby passengers who will be disembarking soon at the upcoming stations. The detected Bluetooth ID and the above database are used for predicting the destination station of passengers, and Bluetooth RSSI is used for estimating the distance to the target passenger.

When a smartphone with SUWANT! detects a Bluetooth ID on the train, it queries the server if the ID was found before and registered in the database. If the database has the ID, it returns the estimated destination station names on the user's present line. In the disembarking database, more than one upcoming station may be found as the destination of the queried Bluetooth ID. In the present implementation, all these station names on the user's present line are sent back to the client smartphone. In a future version, we intend to improve the server so that it returns more useful information. For example, it can return the probability that each passenger may disembark at each candidate station on the basis of previous data such as frequency, time of the day, and day of the week.

When the destination station is known by the server, the smartphone program estimates the distance to the target passengers by using Bluetooth RSSI. For estimating the distance between the target passenger and the user by using Bluetooth RSSI, we calibrated the RSSI and the distance in an actual train. Although the measurement results were not stable possibly because of the fluctuations in the radio environment or noise, we calibrated them as follows:

· More than -64 dBm : Directly in front of the user
· -65 dBm to -74 dBm : 1-3 seats from the user
· from -75 dBm to -84 dBm : 4-6 seats from the user
· Less than -85 dBm : 7 seats from the user

On the basis of the above results of the destination station name and the distance from the user, icons showing Bluetooth devices are displayed on the smartphone's screen, as shown in the previous figures.

Evaluation

We have evaluated SUWANT! from two points of view, namely the ID collection efficiency and the success rate.

To verify the ID collection efficiency, 20 users of SUWANT! gathered groups of – Bluetooth ID, destination station, line – data by using this application during their daily train commute. They used SUWANT! daily for 2-67 days. The total number of days that all users used SUWANT! was 392 days. Consequently, the SUWANT! database had 1675 groups. Considering that each user rode a train twice per day for going to and returning from his/her office or school, on average, per ride, our system gathered the data of two disembarking passengers that were not in the database.

To verify the success rate of getting a seat on the train by using SUWANT!, one of the authors used SUWANT! to find a seat between February 16 and 20, 2015, on a train to Shinjuku departing from Sengawa at 8:52 am and on another train to Shinjuku departing from Tachikawa at 10:16 am. On these trains, the car occupancy rate was about 70%. As these trains ran from a residential area to the terminal station in the center of the city in the morning, the number of passengers continued to increase as the trains approached to the terminal station. The intervals between stations of these trains were relatively long compared to the other train lines in the town. Thus, these trains were proper situation for using SUWANT! because more passengers want to find seats in these difficult situation to sit. Before the start of this experiment, the SUWANT! database had more than 100 groups data of – Bluetooth ID, destination station, line – in the each target section of these lines. Consequently, SUWANT! successfully indicated a potential vacant seat once every 5 rides. As described above, 2 groups will be found in one ride. Therefore, the 100 groups of data used in this experiment could be gathered by 50-person rides on the target train. Thus, users will get a chance to sit if users gathered by 50-person rides on the target train.

Related Work

There are other smartphone applications that assist commuters in getting a vacant seat on a train. “Train Net”[5] shows the percentage car occupancy by measuring the weight of each car. “Komi Report”[6] shows the car occupancy by word of mouth. Passengers can choose less-crowded cars on an approaching train and get a chance to sit by using these two applications. Although these two applications do not show the passengers who will disembark soon, SUWANT! gives more chance to sit. Some studies have used RSSI for positioning Bluetooth devices. Maekawa et al. [1] developed the system for estimating the car occupancy and the position of a user on a train by using the passengers' mobile phones. SUWANT! requires users to walk around passengers for compensating for the unstable characteristics of radio signal. Some researchers have gathered various data by using many anonymous smartphones through crowdsourcing. For instance, Mizukami et al. [2] developed a system that uses a crowd of smartphones to gather various types of environmental data at each location where an iBeacon is placed. SUWANT! do not need iBeacons, only smartphones.

[5] http://www.jreast-app.jp/

[6] http://www.navitime.co.jp/?ctl=0171

Conclusion

We proposed a smartphone application SUWANT! that shows passengers who will disembark soon at one of the upcoming stations. This application collects passenger information using their Bluetooth signals by a crowdsourcing method. We have deployed and evaluated this system in actual train lines in Tokyo. In the ten trial rides, we found that a user had the opportunity to get a seat twice. In the future, we will make the database more accurate by gathering the information from more users and infer the destination stations more accurately by using a more efficient algorithm. We will also consider deploying this method in other places or modes of transport besides the train, such as a cafeteria or a taxi.

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