

# An Effective Tracking Technique of Public Transportation toward Passenger Generated Vehicle Location System

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## ABSTRACT

This paper proposes an automatic vehicle locating (AVL) system which gains the geographic location data of a vehicle by passengers' sending the data via their smartphones in order to support public transportation users. While the existing AVL systems with specialized facilities costs a large amount of money and currently only large cities can introduce the system to their public transportation system, such user-generated approach will reduce the costs to collect the location data of a vehicle, and will enable small transportation system to adopt an AVL system. This paper developed a matching technique of location with a timetable, and demonstrated the system in the route buses in Tottori Prefecture with 70 smart phones, and evaluated its performance.

**Author Keywords** Public transportatin, Automatic vehicle locating, user generated content.

**ACM Classification Keywords** H.3.5 [Information Storage and Retrieval]: Online Information Services – commercial services, data sharing.

**General Terms** Experimentation.

## INTRODUCTION

Public transportation is one of the important fields of ubiquitous computing research, where various ubicomp technologies such as context-aware technology, mobile and social application technology can be applicable. With these technologies, users of public transportation can overcome many difficulties such as cognitive disability [2], anxiety if the transportation is going to the right place [1], impatience how much time he/she needs to wait for his/her bus or train [3].

Trains and buses generally run following the timetable. Thus location, arrival time and future direction of every train and bus is supposed to be predictable. When developing an application that improves usability of public transportation with ubicomp technologies, a developer usually assumes such predictability. The application might guide a user to take a train that will come within 5 minutes at the station, might announce a user to get off at the next bus stop.

However, buses and trains often delay due to bad weather, traffic congestion and many other unexpected accidents. In order to improve quality of ubicomp services, to overcome such uncertainties by knowing true location and schedule of transportations is important.

This paper proposes the passenger generated vehicle location system, and conducted preliminary experiment for two months using real buses in service. We demonstrated how to process location information of passenger to make a true timetable of public transportation.

## LOCATION OF PUBLIC TRANSPORTATION

Finding the current location of a running vehicle is an important factor of ubicomp services. We argue several possible methods to detect the location of a public vehicle.

### Automatic Vehicle Location

Automatic vehicle location (AVL) is a technology to determine the geographic location of a vehicle and aggregate the location data to manage the transportation system [4]. It uses GPS to determine the location and sends the data via wireless communication. There are many examples of AVL for route bus services in large cities all over the world including Tokyo, San Francisco, and London. The technology enabled to acquire the precise location of public transportation in real time, however, only large cities can adopt the technology due to the high cost.

### Passenger Generated Vehicle Location

This paper proposes the passenger generated vehicle location system, where a passenger sends his/her location while riding a bus with his/her smartphone. The vehicle location system collects the data of the locations of the passengers in real time and tracks the route buses that the passengers are riding with precise locations. The application that sends users' location should benefit users by providing useful services such as an alarm on arriving at his/her destination, coupons of the stores on the route, and a tourist guide for the scenery. A user of the ubicomp services on a bus contributes to other potential passengers just by enjoying the services.

## CHALLENGES IN PASSENGER GENERATED VEHICLE LOCATION SYSTEM

When developing the passenger generated vehicle location system, just aggregating the location data from smartphones of passengers does not complete its functionality. It is needed to incorporate the location with the timetable. With

the timetable that reflects the observed departure time, future directions and the schedule of the vehicle will be predictable.

### Matching Location to the Timetable

It is difficult to determine the certain entry on the timetable from the location the smartphone has observed. The number of bus routes in an average city is more than hundreds, and dozens of buses run on the same route in different time within a day. Therefore, it is needed to find an exact entry on the timetable among thousands of schedules of buses by using location as a clue.

We developed a semi-automatic matching mechanism of the location and the exact entry on the timetable. Firstly the application on the smartphone asks a user if the bus delays less than 10 minutes. If so, then the system gives a list of the possible buses based on the user's location. If there is only one bus, the system determines it to be the exact bus. If there are two or more, then the system asks a user to select. Even a user does not select, the system narrows the possible buses down as the bus runs, and automatically determines the exact bus. If the delay is more than 10 minutes, the system gives a list the possible buses based on the user's location and conditions of other buses, and asks a user to select the exact one.

### Transform the Location to the Delay on the Schedule

In the timetable, each entry of bus schedules is expressed as a series of departure time at the every bus stop on the route. Since a smartphone does not necessarily send its location data exactly when the bus departs a bus stop, it is needed to estimate the departure time at a certain bus stop. The system measures the ratio of the distances to the nearest two bus stops from the current point, then estimates the delay by comparing with the theoretical time of passage that is calculated from the timetable.

### PRELIMINARY EXPERIMENT

As a preliminary experiment, we developed an application for smartphones, and conducted the experiment on the buses in service in cooperation with bus companies in Tottori Prefecture, Japan. As the aim of the experiment was to demonstrate the mechanism to match locations to the timetable of the bus, we settled the smartphone on the dashboard of the buses (Figure 1), and asked the drivers to operate the smartphone when he/she starts the bus. We conducted the experiment for two months since December 2010 with 70 smartphones.



Figure 1. A smartphone on the dashboard.

We extracted the result of the first one week, which contains 341 trials in total, and investigated if the matching mechanism works. As illustrated in Figure 2, automatic or semi-automatic matching works in 80% of the trials. The rest of the trials require examinees to select the bus manually.

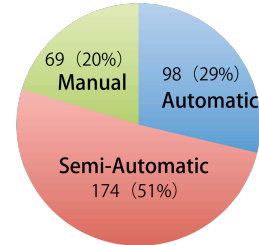


Figure 2. The ratio of the matching mechanism.

### CONCLUSION

We demonstrated the possibility of the AVL system using location data sent from smartphones on buses. Our automatic and semi-automatic mechanism of matching location data to the timetable overall worked fine. We can say that the matching mechanism can be the basis of the passenger generated vehicle location system. We are continuing to improve the mechanism to enable fully automatic matching.

While deploying the technology, privacy is an important concern. A user may doubt whether he/she can keep secret of his/her movement. We need to develop a technology to keep anonymity of the contributors to the AVL system.

Now we have just started distributing our widely used public transportation guidance mobile application, with which a user can search the best route between arbitrary two points in Tottori Prefecture, for smartphones. It also provides useful information while riding a bus or a train. As a future work, we are planning to install the proposed system to this application, and demonstrate with the large number of users of the application.

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