A Dynamic Bus Guide Based on Real-Time Bus Locations

A Demonstration Plan

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***Abstract*—Motorization liberated our life from timetables of the public transportation. As the cars became more affordable, the buses became more unpopular and less frequent. Too many cars flooding on the streets caused heavy traffic jam, which made the buses even more unpopular for their arrival got almost unpredictable. Now the bus transportation in small cities has only sparse and unreliable timetables. That forms a negative spiral for our community to keep losing efficiency in both fuel and time. Even though we cannot operate buses punctually to a fixed timetable, we can still operate them precisely relative to a dynamic timetable that is based on the location of buses actually running in real time. This dynamic timetable will be a first step toward regaining popularity for the buses and breaking the negative spiral. This paper presents our project of implementing a dynamic timetable of buses in a small city in Japan. Each bus carries an Android tablet with GPS and 3G wireless connections. The tablets transmit the bus positions to a server. The server shows the real-time bus locations on a map and also predicted future locations. Passengers can check this dynamic timetable to plan their travel.**

Keywords—Bus location; web service; GPS

I. INTRODUCTION

Motorization liberated our life from timetables of the public transportation. As the cars became more affordable, the buses became more unpopular and less frequent. Too many cars flooding on the streets caused heavy traffic jam, which made the buses even more unpopular for their arrival got almost unpredictable. Now the bus transportation in small cities has only sparse and unreliable timetables. That forms a negative spiral for our community to keep losing efficiency in both fuel and time.

Even though we cannot operate buses punctually to a fixed timetable, we can still operate them precisely relative to a dynamic timetable that is based on the location of buses actually running in real time. This dynamic timetable will be a first step toward regaining popularity for the buses and breaking the negative spiral.

This paper presents our project of implementing a dynamic timetable of community bus system in a small city in Japan. Each bus carries an Android tablet with GPS and 3G wireless connections. The tablets transmit the bus positions to a server. The server shows the real-time bus locations on a map and also predicted future locations. Passengers can check this dynamic timetable to plan their travel.

II. EXISTING INFORMATION SYSTEMS FOR PUBLIC TRANSPORTATION NETWORKS

A. Train route finder

Web-based services [1-3] to find train routes have been popularly used for planning travel by trains from a station to another. They suggest routes optimized for traveling time, fare, and number of transfer connections. The routes and travel plans with the time for transfers taken into account are sought on the basis of train timetables of the day. The resulting travel plans are very useful under the assumption that all the concerned trains are punctually operated.

Those services have been expanding their coverage of transportations to include major bus routes. To buses, however, the punctuality assumption is hardly applicable.

B. Bus location service

A traditional information service for bus arrival and departure is based on detection of buses passing by at the bus stops. An electronic signboard is built at each stop that has a radio receiver to communicate with a transmitter mounted on the bus by short-range radio communications. At stops ahead of the bus, it is displayed how much the forthcoming bus is running behind the schedule. This system has been in service since 1978 in Tokyo.

Recent services utilize the GPS measurement of bus locations and the mobile digital communications to collect the location data to the central server. It has become possible to monitor long-distance buses and airport shuttle buses that have only sparse stops.

C. Dynamic bus timetable service

Tottori Bus Net [4] developed by Tottori university is a leading project in bus information service. It started as a bus location service to monitor visually buses running currently.

Now the real-time bus locations are being used to calculate the plans for traveling by a bus after another toward the destination.

D. Dynamic scheduling of on-demand buses

On-demand bus system is a solution for very rural areas where regular operation of buses is financially unsustainable. A very intelligent system has been developed for re-scheduling the route of running bus as new demands are coming in [5].

III. DYMAMIC BUS GUIDE APPLIED TO COMMUNITY BUS

A. Problems with community bus service

In small cities not very urban or very rural, there is a different category of bus service called *community bus*. The community bus service is operated regularly but is different from ordinary bus network in its mission. It aims at providing inexpensive and convenient transportation for shopping and medical care to mainly elderly people within a limited area. It is optimized not for traveling time but for covering the resident area densely in space and frequently in time.

Figure 1 shows three examples of community bus circuits in the target field, the city of Hitachi-Naka, along with two train lines. The green and red train lines share a central station of the city. Three bus circuits in yellow, pink and blue cover three different resident areas quite densely and share the same stop in front of the main station. The buses are supposed to be operated regularly in circle according to the timetable. But the buses are often delayed due to the car traffic. Because there are only three buses for the three routes, delays may accumulate to affect operation in the next round especially on rainy days.

In that situation, bus arrival time becomes almost random to potential passengers. Some of them ring up the city hall in attempt to know when the bus would come or just to complain about lazy work of the municipal officers. The officers have been working hard to optimize the routes and to make the timetable as precise as possible. They had to insert relatively long time margin between the rounds in order to absorb the delay and prevent its propagation to the next round. That makes the bus operation less frequent and the bus service less convenient for the passengers. There seemed to be no solutions.

B. Toward dymamic timetable for community bus service

Tottori prefecture Bus Net [4] demonstrated how useful the real-time bus location is for shortening the time to wait for the bus. Applied to the circular community bus service, the real-time dynamic bus timetable will allow us to forget completely about scheduled timetables if we can only let the potential passengers know when their bus will actually come.

Figure 2 illustrates the paradigm shift from fixed timetables to dynamic ones. In the long past, we had no information systems so that passengers could do nothing but patiently wait for the bus to come. Then it became possible to measure delay by detecting the bus passing by a stop via short-range radio so that passengers became able to know how much the bus is currently delayed. Now it will be possible to track the bus all the time by GPS and to give estimated arrival time at each bus stop in near future.

Fig. 1. Examples of community bus routes (yellow, pink, and blue circuits) along with two train lines (green and red).

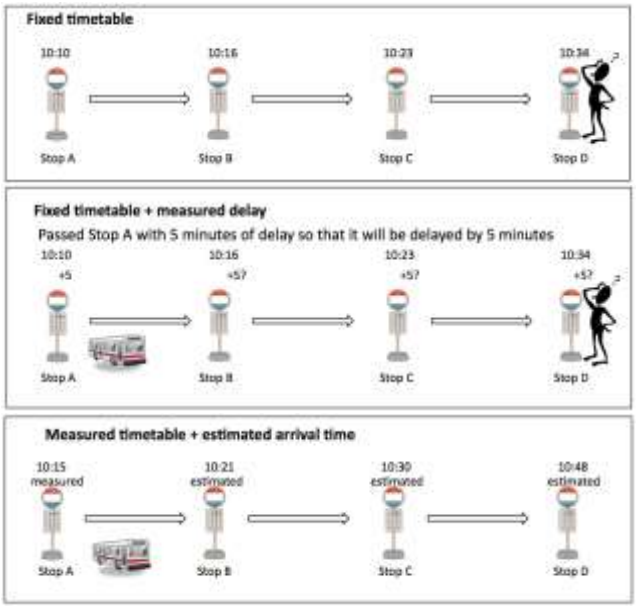

Fig. 2. Transition of fixed bus timetables to dymanic ones.

The community bus service has an advantage that its frequent operation in a circuit gives us plenty of historical data to be used for estimation of arrival times. We can make use of machine learning or data mining to predict the arrival times as shown in Fig. 3 on the basis of current and past positions of the bus and the historical data.

C. System overivew

Figure 4 illustrates the overview of our system being implemented. The system is composed of (i) GPS-enabled Android tablet with a bus application for the bus driver, (ii) Central server, and (iii) GPS-enabled Android tablet with a passenger application for the potential passengers.

The bus driver selects the route on the bus application and carries the tablet on the bus. That is all the driver has to do in

addition to driving the bus and taking care of the passengers. The bus application keeps sending the current position to the central server via the 3G wireless data link.

The central server collects position data from the bus application and estimates the arrival times at forthcoming stops on the basis of historical data collected in the past. The traveling times between adjacent stops constitute a feature vector in conjunction with other parameters such as weather and calendar days. Given a vector currently available from the bus, the sever finds the closest vector in the historical data that indicates the likely traveling times in due course.

The current and estimated positions of the buses are presented on the passenger application as well as Web browsers on PC.

D. Demonstration plan

We are now developing the server and application software to be applied to the community bus service in the city of Hitachi-Naka. It is yet to be known which algorithm of machine learning or data mining works successfully in estimation of arrival times.

Fig. 3. Predicted arrival times.

IV. CONCLUSION

Need of dynamic timetables for the community bus services was addressed in this paper. A demonstration plan was described with the target field taken from a small city not so rural nor urban. The dynamic timetables would make the community bus services more popular and convenient.

After reaching this goal, there would arise another problem of estimating the number of passengers since elderly people would be interested in getting seats during the travel in case the community bus is so successful and crowded.

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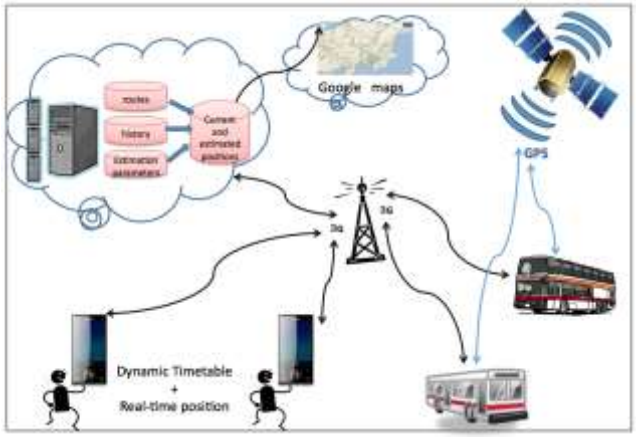

Fig. 4. System overview of dynamic timetables for the community bus service.