# Statistical Processing of Delay Time of Public Secondary Traffic and its Application to the Operation Plan

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***Abstract*— We have developed and maintained a system called "Busnet" with the aim of contributing to improve the convenience of using public transportation from the standpoint of information engineering. The Busnet is a system that enables route search as its basic function and has a function as a bus location system that shows the position of the running bus. In this paper, we report on a system that grasps the bus operation status by statistically processing the bus location system's log data of the Busnet combining with the weather conditions such as snowfall.**

***Keywords-Busnet; Location log data; Statistical processing.***

## I. INTRODUCTION

In recent years, the declining birthrate and aging population in Japan have become a social problem. In addition, depopulation of local cities is a major issue in close connection with the declining birthrate and aging population. Furthermore, the increase in the number of elderly people living alone is also a problem. These problems are urgent issues for local cities to take measures, and they become a major issue related to the survival of the local city itself. Therefore, although various measures have been taken in local cities, the present situation is that the results have not been achieved easily.

Tottori prefecture, where we live, locates in the Chugoku region of the western end of Honshu, Japan. It is a local city located about a couple of hours away by railroad from Osaka, the second largest city in Japan, and is one of the most decentralized prefectures.

In Tottori prefecture, we are actively working on various problems that occur with depopulation. Maintenance of public second transportation, such as route buses is one of the serious problems for such local cities. As depopulation progresses, the number of public transportation users decreases, and it makes difficult to maintain the number of routes and the busses. When the number of busses decreases, convenience for users decreases. This causes a continuous decrease in the number of users. Therefore, the prefecture provides many subsidies to bus operators and manages to maintain them, but it is financially difficult.

The development of motorization, such as private cars, can be cited as a cause of the decrease of the number of public transportation users. However, traffic accidents caused by elderly people driving cars have not decreased. It is difficult to think of a society that relies on the driving of its own private car, especially in a single living family. From this point of view, we believe that public transportation maintenance by local government such as prefectures and cities is essential to the functioning of an aging society.

## II. BUSNET SYSTEM

As a member of a university located in Tottori Prefecture, we have developed and maintained a system called "Busnet" with the aim of contributing to the maintenance of such public transportation from the standpoint of information engineering. The Busnet is a system that uses route search as its basic function and has a function as a bus location system that shows the current locations of the running buses. Several systems have been developed so far for bus and railway route search systems, and many systems are available even today. However, the Busnet system has various functions based on the characteristics of the route bus and are used by many general users. The biggest feature of Busnet is not to show the transfer between bus stops, but to give a route using public transport between the departure point and the destination point including walking route. Bus location function is also one of the biggest features of Busnet. To realize the bus location function, about 300 smart phones are equipped in all buses, and by using their GPS functions the location data of current buses are transferred into a server computer. The bus position information stored on the server will be used for various purposes as log data of location system. In this paper, based on these log data, we analyze travel situations of the route buses in the past and constructed a system to estimate the future travel situations depending on weather information.

## III. LOG DATA ANALYSIS OF BUSNET SYSTEM

About 300 smartphones are equipped in all local busses to realize the bus location function in the Busnet and transmit their current positions about every 20 seconds. On the server, location information of latitude and longitude of all bus stops, route information of each bus, operation timetable, etc., are stored. From the location information sent from each bus and the data on the server, it is possible to know which bus has passed through which bus stop, or the delay status of each bus.

There are 315 bus routes data and 8178 bus stops data stored on the Busnet server, and the log data recorded in one day is about 130 Mbytes. In addition, it is necessary to respond to changes in bus service routes and changes in bus stops locations for update of the schedule several times each

 ISBN: 978-1-61208-752-8 

year. This paper is based on three years of data, about 150 Gbytes.

The operation status of the buses is determined by obtaining the delay time at the bus stop of each bus. Since travel data from the bus is sent about every 20 seconds, these are not always sent from the bus stop locations. For this reason, data pairs before and after the actual bus stop are extracted from the log data, and the passage time at the bus stop position is calculated by linear interpolation from the transmission time and the latitude / longitude value. By comparing this value with the operation timetable on the server, the delay status of each bus can be determined.

Figures 1 and 2 show examples of the delay situation obtained by using proposed system. Figure 1 shows the delay situation of the all bus stops in the prefecture at 10:00 am on November 23, 2016 and Figure 2 shows the situation on February 10, 2017. In these figures, the bus delay time at each bus stop is indicated by a colored circle. It is green when the delay time is short and red when it is long, i.e., more than 30-minutes delay. Although Figure 1 shows the delay situation in the absence of snow even in winter, it can be seen that green circles are displayed at almost all location. On the other hand, in Figure 2, it can be seen that there are several delays mainly at bus stops in the mountains area due to snow. The delay time at each bus stop at a certain time indicates the delay time of the bus that passed immediately before the specified time. Considering the bus stops included in many bus routes, the delay time differs depending on the travel route of the passed bus. That is, the bus traveling in the urban area does not have a large delay time, but in the case of a bus traveling in the mountain area, the delay time tends to be long. In this system, in consideration of these, it is devised so that not only specification of date and time but also specification of bus route etc., can be considered to obtain past delay situation.

## IV. CONCLUSION

This paper reports the construction of a system that calculates the delay time of a route bus in a specific time zone at a specific bus stop based on data from the past three years. By using the results obtained by the proposed method together with weather information and learning by various AI methods, it is possible to estimate the delay information of the future bus. Predicting bus delays based on the weather at that time provides useful information to the users. In addition, indicating how much delay has occurred in which regional bus route during snowfall based on past results is important information for route managers such as prefecture road staffs and bus companies. This will give useful information in deciding which road to manage intensively.

## Acknowledgment

This work was supported by JSPS KAKENHI Grant Numbers JP17K01256, JP17K06600.

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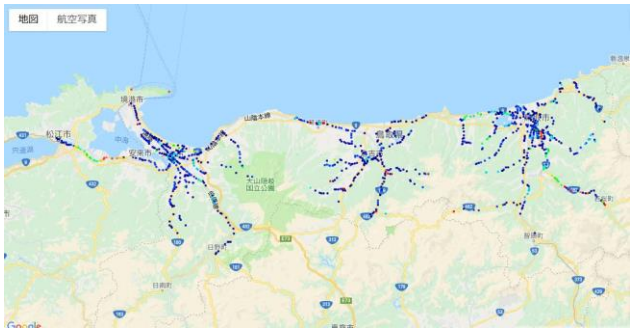


Figure 1. Bus delay on November 23, 2016 (Not in snow season)

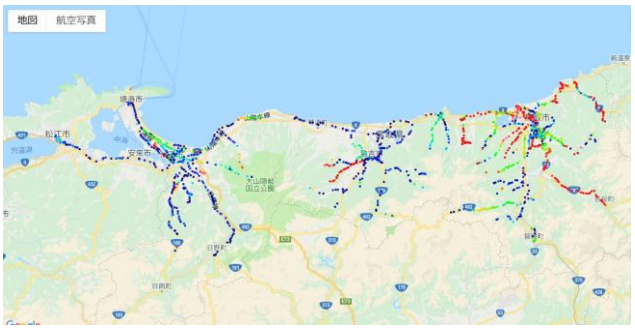


Figure 2. Bus delay on February 10, 2017 (Snowfall time)