Re-Planning of Bus Timetable Based on Route Search Log to Get on Now

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***Abstract*—There are many web services developed for public transport recently. We developed the "Busnet" in 2006, which is a path planning system for route buses and trains in Tottori prefecture, Japan. This system search includes about 8,500 bus stops and stations and about 1,000 route search requests per day. These route searches of recent years show that people used the Busnet for searching "Now". As smartphone users increased, make plan for tomorrows is in a minority, and route search results have a lot of waiting time for riding because the number of bus is small. Then we get the direct data of waiting time from this search log. In this paper, for reducing these waiting times, we consider the possibility to propose a plan to remake bus timetable that mean to shift departure time of each bus, from analysis of this daily route search log. As a result, to shift median value of each bus's waiting times reduced average of waiting times by 5 minutes, otherwise, results in some conditions using Genetic Algorithm (GA) are reduced or increased by few minutes.**

Keywords-Busnet; route search; log analysis; optimization; genetic algorithm.

I. INTRODUCTION

Public transport systems are important for people who do not have a car, such as children and old people. However, in rural area, bus services and trains become unprofitable and as a result some lines are abolished or the number of buses decreased. This causes inconvenience and no one use buses, making it further unprofitable. For these reasons, we need to improve the convenience of using buses and stop the decline of bus usage.

The “Busnet” is a path planning web service system for buses and trains in Tottori prefecture, Japan for improving convenience [1]. It collaborates with bus companies and has some feature functions. One function is the Global Positioning System (GPS) tracing [2]. Each bus driver has a smartphone and enters a route-ID that is specified by each bus company when starts running on the route. A smartphone sends latitude and longitude using browser and JavaScript code to the server, and the Busnet plots real time bus positions on map web pages. From bus timetable information and nearest bus stop information, this system calculates delays of buses every minute and provides this information to the end users. Other functions are to generate index for route search to shorten search time, to mount a touch screen computer terminal in front of the station for visitors to introduce our service and try it out.

The last function of this system is the web view for smartphones. In the first place we generate only character (no-image and no-Cascading Style Sheets (CSS)) Hyper Text Markup Language (HTML) to access from old mobile phones. As android phone becomes popular, we generate and distribute search tools of android application [3][4]. However, due to performance improvements of smartphones and development of JavaScript and CSS library, we drop android only application, and rebuild web pages that can be used on any computer and mobile Operating System (OS) using responsive web design. From this system log, most users access from smartphones, and in many searched requests “departure time” was set to the current time. This can be interpreted as meaning users searching on their smartphone for the next arriving bus, in other words, that is the log of waiting time to get on. Previously scheduling was based on indirect data, such as ride number survey or questionnaire. In this paper, based on these actual usage data, to reduce waiting time we propose time shift plan of each bus. If one bus schedule shifts forward to reduce some user's waiting time, other users will miss the bus and need to wait for the next bus, and this causes the need to shift the next bus in order to reduce waiting time of these users. In some cases, it is better that the previous bus schedule shift backwards so passengers get on early without changing the schedule of the following bus. To optimize such complex combinations, we try to use Genetic Algorithm (GA).

The rest of this paper is organized as follows. Section II describes the analysis results of the recent route search log. Section III describes the proposal re-planning of bus schedule using the result presented in Section II. Finally, Section IV draws the conclusion and acknowledgement.

II. STATISTICAL DATA OF ROUTE SEARCH LOG

Some results of this system’s log analysis were reported at academic workshop. From route search log we found some trends, for example, tourists use it to make plans ahead of time, and local people use it for daily routine. Moreover, most users, about 60%, are smartphone users, not desktop PC and notebook PC. In many cases, about 90%, departure and destination search parameters are bus stops and some landmark, which are probably used by tourists. One can set latitude and longitude as departure or destination in place of a landmark, however these are rare cases. So, one common usage for this system users is to check departure time (= waiting time) using a smartphone while heading to the target

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bus stop. In rural areas, it is normal the number of buses is 1/hour, and the average of waiting time to get on the bus is about 15 minutes.

III. TIME SHIFT OF BUS SCHEDULE

In some cases, this system shows transfer routes. To simplify the problem, we consider the first transfer landmark as destination in this experiment and consider the request that get on near time from near bus stop.

Fig.1 shows each day's average waiting time of 2019/9/2(Mon) ~ 9/4(Wed) that is labeled "base". It used cleaned logs of smartphones access only, searching from current time ±60 minutes, a bus waiting time of 60 minutes or less, fixed departure is a bus stop, and destination is a bus stop without a stopover (it is not a tourist spot, and not a landmark after transfer). Three columns of Table. 1 show the number of logs when cleaned under the above conditions. For example, on 9/2, 867 requests are arrived totally to the system and the system showed the resultant routes to each request. 593 requests in total requests are from mobile phone users and as shown in Colum (3') 474 busses are examined in this work. These 474 busses are chosen to have same departure and destination bus stops as the resultant route and to have around 60 minutes departure time. Here, the length of the gene in GA search method can be set to 474. A code number of each gene corresponds shifting departure time of each bus. By using GA method, the proposed system tried to find the optimum departure time with the probability of the existence of multiple users on the same bus is about 50%. It means half buses can be scheduled thinking only one user in a plan, and half buses need shared scheduling.

In Fig.1, labeled "median" shows the set shift time to waiting time's median value of each bus. When nobody gets on it, we set shift time to 0. Waiting time's average is under 6 minutes. It is the best in this figure. Situations of others are as follows. GA(15): a code range is ±15 minutes, a mutation rate is 0.1%, a population size is 10, a generation limit is 100, used alternating swap method and discrete generation model, and in fitness evaluation, max waiting time limited to 60 minutes, and when no bus exists to get on is evaluated as this limited max, too. GA(60): same parameters of GA(15) but a code range is ±60 minutes, a population size 50, and a generation limit is 500. GA(max): same parameters of GA(15) but a code range is -1 * max waiting time of that bus ~ 30 minutes. It is better than GA(15) or GA(60). GA(15) and GA(60) are worse than "base".

From results of GA(15) and GA(60), changing a population size and a generation limit are not expected to have effects. From other results adjusting a code range is expected to have effects.

IV. CONCLUSION

In this paper, we selected route search log of web service that a user wants to get on instantly from some bus stop using a smartphone, and we defined it as real waiting time of bus users. Based on it, we proposed new service timetable with shifting departure time according to the GA outputs which makes users convenient with small waiting times. On one day data sets, these were real and small data sets, the set shift time to waiting time's median reduced the average to 5 minutes, and GA optimizations were worked in some code patterns, and were unusable in some cases.

In future work, we need to evaluate large data sets, such as weeks or months that have transfers, many code patterns, analysis of complex combination, and other machine learning optimizations such as neural networks.

TABLE I. NUMBER OF EXTRACTED LOGS

Date	(1) Search count	(2) Search from mobile	(3) Search forward in 60min (Fitness evaluation)	(3') Bus count around time (Genes length)
9/2	867	593	242	474
9/3	782	463	207	442
9/4	2097	490	250	461

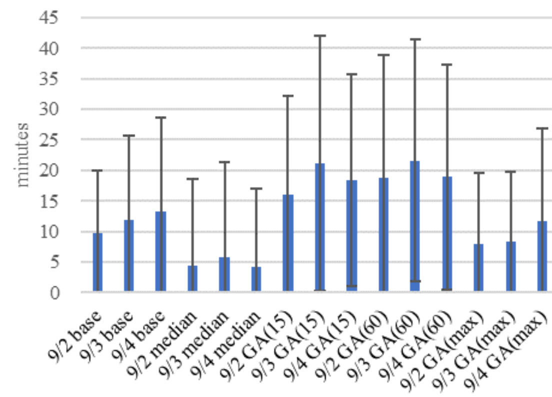

Figure 1. Waiting time's average and standard deviation.

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