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Comparative Analysis of Fare Collection System on Bus Operations

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Abstract: This study presents a comparative analysis of fare collection systems for inter-city bus operation. One of the important issues in the bus scheduling model is stops of buses in the bus stations (called dwell time -where buses have to stop for boarding and alighting passengers in the bus station). This issue has a direct impact on increased travel time. Subsequently, increased travel time for one bus mission can cause delay in the loops of bus scheduling. This article describes a survey of fare collection systems for bus operations, covering two fare collection systems: paying cash and using the touch-n-go card. We studied this issue in a real case inter-city bus operation. It has been highlighted that a fare collection system using the touch-n-go card has higher efficiency than other the cash method in relation to reducing dwell time of buses in the bus station.

Key words: Fare, bus schedule, touch-n-go card, level of services, dwell time

INTRODUCTION

A relative good public transportation bus line network should provide easy access and be cheaper in cost to the users (Sarkar, 2002). One of the important issues in the bus scheduling model is to stop the buses in the bus stations (called dwell time, where buses have to stop for boarding and alighting passengers in the bus station). Bus stations are divided into two general types: bus stop, which is along the bus route and bus terminal, which is usually at the origin, or at both the origin and destination node of the bus route.

The bus service schedule is a planning document for bus operations. It is prepared for working days and weekends. To achieve this purpose some parameters are required: establishment of physical facilities for the bus systems, determination of the layout of routes, ensuring good geographic coverage to attract the largest number of potential passengers and determining the total fleet of vehicles needed (Grava, 2002). Reliability is expressed as a percentage of vehicle arrivals with less than a fixed time deviation from schedule (Ghajary and Alesheikh, 2008). In the peak-hours traffic operation speed is very poor due to traffic congestion and more demand of passengers for using the bus (Waheed, 2003; Abu and Gordon, 2011).

Establishing the physical facility requirements for the bus system is an important step in establishing a bus service, because proper planning of the facilities can increase efficiency of the bus service. In relation to the layout of routes, if there is a specific lane for bus service, this can increase reliability of the bus service schedule (Hafezi and Ismail, 2011a).

Choosing a good geographic coverage, can maximize the potential passenger volume. The total number of passengers each day is a major issue in the scheduling of bus operations (Ziari and Khabiri, 2006; Becerril-Herrera *et al*., 2007). It can determine, headway, number of buses needed and bus capacity. Line capacity is maximum number of spaces, which includes seats and standing space. Productive capacity is the product of operating speed and capacity of the line (Weifang and Binyang, 2012). Productivity is the quantity of output per unit of resource space-km.

For determining the total fleet of vehicles, several cases must be considered, such as: number of passengers, distance, headway and mission time (Yu *et al*., 2008; Kolyaie *et al*., 2009). In the peak-hours traffic operation speed is lower than at other times, due to increased number of buses, greater passenger demand and crowding of buses (Amphawan and Abraham, 2002).

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The fare collection system is divided into two methods: paying cash and using the touch-n-go card (Pelletier *et al*., 2011). Traditionally, fare collection using cash takes up more time in bus operation. In particular, this time is higher in the bus terminal due to higher demand of passengers (Mamlook *et al*., 2011).

In recent times, bus companies have been using a new method of fare collection system (touch-n-go card) which can reduce the travel time and help to improve the bus scheduling model (Ismail and Hafezi, 2011). Although, this new method causes increase fixed cost, in the longer term, it will reduce the overall operating cost (Armstrong-Wright and Thiriez, 1987).

Furthermore, level of fares or the amounts of subsidy are related to the time taken in fare collection (Vuchic, 1981). In bus routes which are only one zone, calculating cash payment is easier and takes less time. Also, with one zone, touch-n-go card needs to be used once only for fare payment (Shadrokh and Nasiri, 2011). However, in bus routes which have more than one zone, calculating the fare is difficult and takes more time. So, passengers should use the touch-n-go card twice: when they want to board buses and when they want to alight from buses.

This article has described a survey of fare collection systems in bus operations covering two methods: paying cash and using the touch-n-go card. We study this issue in real case situation for inter-city bus operation.

DWELL TIME IN BUS OPERATION SCHEDULE

The bus operation schedule consists of four components; length of route, (d_i), average velocity of bus ($\bar{v}$), dwell time, (D_n) and recovery time (RC). The number of stations along the bus route is usually embedded, according to the length of the route. Also, the number of depots is determined in relation to the distance to recovery time place. Velocity of buses is considered on an average basis, because this amount varies in line with time of operation during the day (Dessouky *et al*., 2003). Dwell time of buses occurs in the bus terminal and at each bus stop. New passengers join the bus at the start of their travel and leave when their travel with the bus line is finished. Recovery time is one part of the bus operation schedule. There are two main issues in recovery time: first is the crew rest period, since the drivers need to take a rest break. And second is schedule adjustment.This paper focuses on the dwell time of buses in terms of fare collection systems in bus operations.

Ismail and Hafezi (2011) presented a formulation of the bus scheduling model for inter-city bus operations to determine adjustment headway of bus carriers (Hafezi and Ismail, 2011b):

$$JT = \sum_{i} \frac{d_i}{\bar{v}} + \sum_{n=1}^{j} D_n + RC \quad (1)$$

$$D_n = \max [\alpha . TB_n, \beta . TA_n] \quad (2)$$

α is the coefficient of time for boarding per each passenger, β is the coefficient of time for alighting per each passenger, B_n is the number of boarding passengers of buses at bus stop n and A_n is the number of alighting passengers of buses at bus stop n.

The boarding passenger time is equivalent to the coefficient time for boarding one passenger on bus multiplied by total number of boarding passenger divided to number of channels on bus and given by:

$$TB_n = \frac{(\alpha . \sum_{n=1}^{j} B_n)}{C} \quad (3)$$

The alighting passenger time is equivalent to the coefficient time for alighting one passenger on bus multiplied by total number of alighting passenger divided to number of channels on bus and given by:

$$TA_n = \frac{\beta_o . \sum_{n=1}^{j} An}{C} \quad (4)$$

Constant coefficient α and β can be experimentally determined. Number of boarding and alighting passengers for each bus stop along the bus route is obtained through statistics methods.

Also, calculation of the number of new boarding passengers at a bus stop depends directly on the headway of buses:

$$B_n = \delta * H \quad (5)$$

δ is the arrival rate of passengers, which is obtained experimentally according to geographic coverage of the bus line and H is the headway of buses.

Values of α and β on Eq. 2 can be experimentally determined. These parameters are dependent on the number of passengers in the bus who will be alighting at the bus stop, the number of passengers at the bus stop who will be boarding the bus and the number of bus channels (Hafezi and Ismail, 2011c).

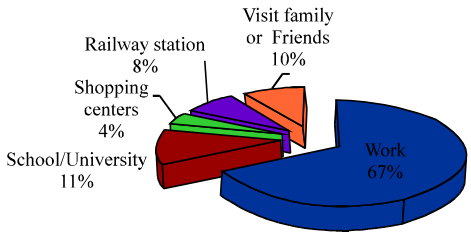

Fig. 1: Pie graph percentage of different users of buses

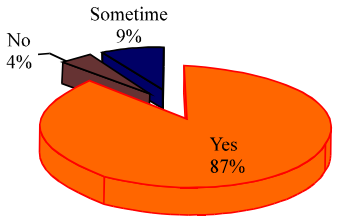

Fig. 2: Percentage of passengers for using round-trip

During peak-hours of traffic, demand of passengers for using the bus network is higher (Nurdden *et al*., 2007; Gershenson and Pineda, 2009). Also, the most disorganization for the bus scheduling occurs during rush periods, where, bus routes are involved in traffic jams (Idris *et al*., 2009). In this situation, bus companies look for some ways of improving their bus service, such as; adding spare buses, sending buses at shorter time intervals (Haghani *et al*., 2003) and using the touch-n-go card system instead of cash for collecting bus fares.

This study focuses on the advantages of using the touch-n-go card system, as well as helping to develop proper implementation of the bus schedule with effective measurement of above-mentioned parameters.

A COMPARATIVE ANALYSIS FOR TWO METHODS OF FARE COLLECTION SYSTEM

We have collected data by questionnaire and analysis forms related to point to point of bus service. Statistical society consists of around 500 people and 9 bus lines. Data collection is done during peak hour's traffic in the morning and in the evening for around 4 weeks. Simulation for longer periods will be more expensive and the results will not vary noticeably (Gleason, 1974).

Figure 1 represents different users of buses and the percentage of passengers who use buses for round-trip is shown in Fig. 2.

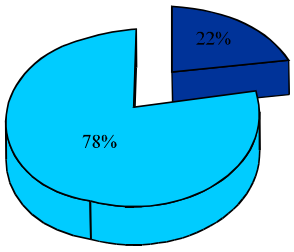

Fig. 3: Percentage users for paying fare according to with academic education

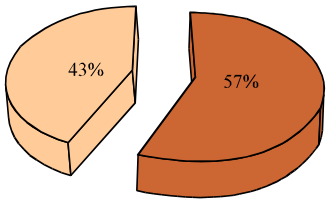

Fig. 4: Percentage users for paying fare according to without academic education

Figure 3 shows the payment method used by passengers with an academic education and indicates that around 78% of thempay the fare by using the touch-n-go card and theremainder paysthe fare by cash. The comparative ppercentages between payment methods for passengers who are without academic education are shown in Fig. 4. This figure indicates around 57% of them, pay by cash and the remainder pay by using the touch-n-go card.

These analysis shows that people with academic education use the touch-n-go card system more than paying cash for their fare-probably due to their knowledge of the advantages of magnetic card in improving bus service and to save money on the card.

Figure 5 plots simulated average dwell time of four bus lines at the bus stops. Where, fare collection system on the buses is provided only by using the touch-n-go card.

Average dwell time of five bus lines at bus stops for servicing passengers where the bus driver (or fare collector) collects fares only by cash is shown in Fig. 6.

Average dwell time in all bus stops is around 63 sec for buses that use the touch-n-go card system for fare collection. However, average dwell time for buses where the fare is collected by using cash is 168 sec in all bus stops.

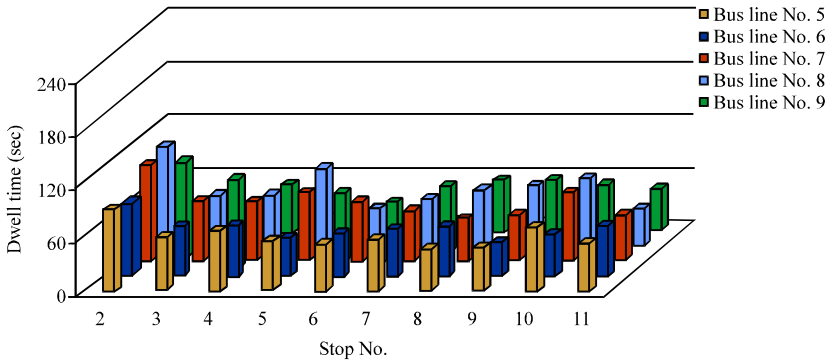

Fig. 5: Average dwell time of buses (fare collection system is provided by using touch-n-go card)

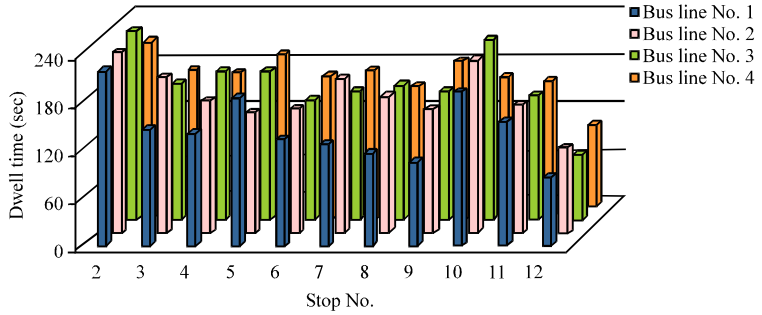

Fig. 6: Average dwell time of buses (fare collection system is provided by paying cash)

CONCLUSION

In this study, a survey on using the touch-n-go card system versus paying cash for collection of traveler fares has been presented. It has been highlighted that using the touch-n-go card helps to decrease dwell time of buses at the bus stops. In addition, this system can automatically save information about passengers, such as; number of passengers in each station and actual boarding and alighting times.

In preparation of the bus scheduling model, more slack time was put into the planning to allow for adjustment for delays in the bus service that occur during implementation of the bus journey (Sarkar and Pawlikowski, 2002; Hafezi and Ismail, 2011d). According to a comparative analysis of Fig. 5 and 6, using the touch-n-go card on the fare collection system, with a decrease in dwell time of around 2.67 times compared to collection by cash, reductions in dwell time can approach the desired time in the scheduling model.

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