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Implementing Specific Lane Length on Bus Route for Operation Delays Reduction

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Abstract: Buses are the most widely used in transit technology today because bus networks are easily accessible and cheaper than other kinds of public transportation. Proper Schedule of bus service is a main issue in the reliability of bus operation. To achieve this, minimizing of delays is one solution for increasing its reliability. In fact, static structure and the real operation of bus scheduling have some difference with each other, due to some cases, such as traffic congestion and the accumulation of delays of buses missions. This article describes an analysis of bus routes that included two sections: mixed traffic lane and exclusive traffic lane. Using the specific lane for bus operation can decrease delays in bus mission. We studied this issue in a real case inter-city bus operation. It has been highlighted that by using two types of lane in bus route included mixed traffic lane and exclusive bus lane delays of bus operation will be reduced. This high performance level can be shown by using statistical analysis.

Key words: Efficient bus lane, waiting time, Average speed of bus operation, Journey time

INTRODUCTION

In developing countries, demand of passenger trip is higher, due to economic growth (Yan and Chen, 2002). Nowadays, bus network plays a major part of the public transportation network in city areas because bus networks are easily accessible and cheaper than other kinds of public transportation (Kolyaie *et al*., 2009). They operate in the most of the cities as a major of part of their transit modes. Usually, standard buses look largely alike and they have basically the same configuration: overall capacity is typically 83 persons, the engine in the rear, doors along one side, where each door has two channels, a single person up font driving the vehicle and usually supervising fare collection. Average speed of bus operation is around 15 to 20 km h^{-1} during off-peak hours and 8 to 14 km h^{-1} during peak hours (Vuchic, 1981).

There are several reasons for using the bus to compare to other public transportation. They include its ability to operate on most streets, its low investment cost and its capacity (Vuchic, 1981). According to the width required for bus service and the width of streets, its ability to bus operate is possible for most streets where breadth is more than 7.50 m (two lines for traffic). Investment is lower compared to other public transportation such as subway, mass rapid transit and light rail transit, due to the proportion between passengers and operating costs using the bus from where there is more demand is not economical (Ismail and Hafezi, 2011). Two reasons for preferential treatment of buses are greater importance of public transport due to it is a basic role in the city, greater overall economy and fewer negative side effects. And another reason is buses network occupy less space in city streets. Due to the limited other types of public transportation and being cheaper, passenger demand for using the bus network is higher (Mamlook *et al*., 2011).

Generally, bus operation includes scheduling, crew resting, running and supervision of vehicles, fare collection and system maintenance (Grava 2002; Vuchic, 1981). Scheduling of bus service is a plan for travelling each of the buses, which are made by the Transport Company. This planning includes itinerary, service frequency and recovery time (Hafezi and Ismail, 2011a). Crew resting is a form of recovery time due to the transport drivers need a rest break between missions in a day. Usually in the central terminal, a swing

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room is provided for them. Supervision of vehicles is an important issue for increasing performance system. Studies on people problems of transportation and trying to improve it are needed to increase people's satisfaction. Furthermore, supervision of vehicles can help in the implementation of schedules (Ziari and Khabiri, 2006). For fare collection systems which concerns how systems are to be selected or structured. This is not the place to discuss the level of fares or the amount of subsidy that transit systems get (Hafezi and Ismail, 2011b). Using the magnetic cards instead of cash for fare payment has some advantages, such as less time to pay the fare. It takes about 8 sec for each passenger in dwell time; the time consumed will be about 4 sec on average as it takes 10 to 15 sec for using the magnetic cards and cash, respectively (Hafezi *et al*., 2012). Furthermore, using the magnetic cards has health benefits. System maintenance is one of the operating costs. They include supplying spare parts, cleaning buses vehicles and updating newer systems used such as touch-n-go card system, automated passenger counting and wireless communication (Dessouky *et al*., 2003).

Overall, bus service performance measurement is based on unit departures per hour (Vuchic, 1981).This is achieved in the evaluation of these parameters; service frequency, operating speed, reliability, safety and line capacity. Service frequency is the period buses are in motion during their mission, throughout the day. Operating speed usually is defined with average speed in total travelling time (Shadrokh and Nasiri, 2011; Habibi *et al*., 2008). Reliability is expressed as a percentage of vehicle arrivals with less than a fixed time deviation from the schedule. Safety is measured by the number of fatalities, injuries and accidents. Line capacity is the maximum amount of space, which includes seats and standing space. Bus service may be made with one type or a combination of them, such as: local, express, feeder and commuter (Wirasinghe and Vandebona, 2010). Generally, the type of bus lanes is classified into three parts: first, Mixed Traffic Lanes (MTL), second, Regular Bus Lane (RBL) and third, Exclusive Bus Lane (EBL). In MTL, bus routes are dedicated to the urban mixed traffic. In other words, buses move alongside other motor vehicles and non-motorized vehicles on a street. In RBL, there is a specific lane for bus services during peak period traffic where the route is separate from other vehicles. Besides this, a contra-flow bus lane can allow buses to travel in the opposite direction to other vehicles (RBLS). In EBL, there is an exclusive bus lane for the use of the buses separated from other traffic at all times of a day. Using a specific lane for bus operation can decrease delay of bus mission and indirectly increase the bus service performance. But due to the limited width of streets, the specific lane cannot be used everywhere (Vuchic, 1981). The objective of this paper is to show the performance of the implementing specific lane length on bus route for operation delays reduction.

BUS MISSION: STATIC STRUCTURE

Scheduling for bus service is a closed loop where buses are sent to the mission as frequent as possible. Generally, there are three main parts in the bus-network structure: travellers, buses and traffic (Meignan *et al*., 2007). Indeed, static structure of bus schedule is composed of four elements: running time, spend time in the terminal, dwell time and recovery time.

Running time is the travel time along the route, which it is the total travel time between bus stop i to j for inbound and outbound route. This is achieved by total distance between bus stop i to j for both directions $\sum|d_{ij}|$ divided by average speed bus ($\bar{v}$) along the route. And spend time in terminal is, when the bus goes out the parking space and arrival at the first bus stop for boarding passengers and when the bus after dropping passengers in last bus stop goes into parking space. In some terminals where there is embedded a situation for boarding passenger in the inside terminal, spend time is lesser than where terminals do not have this situation (Hafezi and Ismail, 2011c). Spend time is determined by ts_{ij}. Dwell time is the time bus stops in each bus stop. This time includes time for boarding and alighting passengers in bus stops. It is determined by td_{ij}. Finally, recovery time is the extra time for rest crew and schedule adjustments in bus terminal. It is determined by tr_{ij}.

T_{rt} is the round-trip for the bus mission between origin and destination station, given by:

$$T_{rt}=\frac{\sum|d_{ij}|}{\bar{v}}+ts_{ij}+\sum td_{ij}+\sum tr_{ij} \quad (1)$$

Also, H is the headway for bus mission is determined by:

$$H=\frac{T_{rt}}{N_b} \quad (2)$$

where, N_b is the number of buses.

DIFFERENT CONDITIONS BETWEEN STATIC STRUCTURE AND ACTUAL IMPLEMENTATION

Generally, scheduling of bus service is composed of two parts: workday and weekend. Actually, there are

peak-hour traffic and non-hour traffic in a workday. With regard to lower demand of business and education trips in the weekend, commonly it can be said that at all time of the day there is traffic flow. And some of the factors which can cause disorganization in the scheduling are traffic congestion, volume of passengers and recovery time (Hafezi and Ismail, 2011d).

One of the factors which directly affect the schedule disorganization is existing traffic. Bus service along the Mix Traffic Lane (MTL) causes a decline in speed of the bus in the different sections of the route. In other words, this issue causes a decrease in the average speed along the total route. For a solution to this issue, an Exclusive Bus Lane (EBL) for bus service can be devoted. In EBL there is an exclusive bus lane for the use of the buses separated from other traffic at all times of a day. Volume of passengers is another factor in the schedule disorganization. Demand of passenger is different at the different times in using a bus. Commonly, during peak-hour traffic, when passengers want to go to their journey or return to their home, passenger demand for using the bus network is higher. This issue causes an increase in dwell time in each bus stop.

Finally, recovery time is the extra time for the rest crew and schedule adjustment. In this time bus and operator do not engage in any activity. According to distance travelled, a longer route can cause a different recovery time. If a bus service is conducted according to the schedule, there will be no delays and the crew can rest longer until the next frequency.

Statistical analysis: The statistical analysis has been applied to a bus service of Tehran, Iran. The bus line to be studied in this paper is about 10,950 m from west to east where the transfer of passengers from suburban areas to the city centre takes place. The total number of passenger transfers with this line is 18,700 per day. It has 15 bus stops and two terminals where the origin and destination line terminals were used only for parking buses and crews rest and not for boarding and alighting passengers. The total number of buses is 22 and all of them are of one make.

From the route information of the bus line to be studied in this paper, the distance and layout table between bus stops given in Table 1 can be derived. This bus line is composed of two parts: Route between origin station to bus Number 8 and also route between buses Number 16 to destination station is Mixed Traffic Lanes. And the remainder of the route which is between bus Number 9 and 15 is the exclusive bus lane.

Generally, the traffic route is divided into four periods: first, peak-hour traffic in the morning, second, peak-hour traffic in the noon, third, peak-hour traffic in the afternoon and fourth, non-peak hours during the day.

Table 1: Distance and layout of bus stops

Stop No.	Distance (m)	Layout
1	0	MTL
2	950	MTL
3	650	MTL
4	450	MTL
5	360	MTL
6	900	MTL
7	600	MTL
8	380	MTL
9	1400	EBL
10	550	EBL
11	400	EBL
12	550	EBL
13	1100	EBL
14	330	EBL
15	380	EBL
16	1100	MTL
17	850	MTL

MLT: Mixed traffic lanes, EBL: Exclusive bus lane

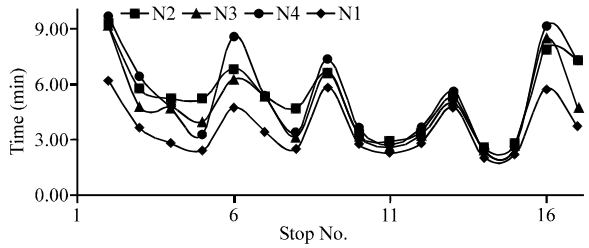

Fig. 1: Simulation of round-trip time duration of bus service

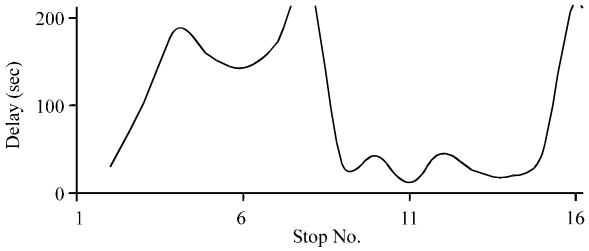

Fig. 2: Simulation of round-trip time duration of bus service (between two consecutive buses)

Figure 1 plots the simulated measure of round-trip for bus mission from origin to destination station. N1 is the round-trip according to static structure. N2, N3 and N4 are the round-trip for peak-hour traffic in the morning, noon and afternoon, respectively. Amount of spend time and recovery time in the terminal are constant for all types of data.

Delays between two bus operation with 15 min headway are as shown in Fig. 2.

Also, the bus delay is related of demand of passenger (Nagatani, 2001). Observance of real-time departure of all buses existing in origin station according schedule can reduce delays in their missions (Lam *et al*., 2009; Van Oudheusden and Zhu, 1995).

In duration of peak traffic, standard deviation of static schedule is more than non-peak traffic, due to use people their private cars (Hwe *et al*., 2006). At the same time, when using the exclusive bus lane for bus service, this amount is lower and finally increasing reliability (Sun *et al*., 2008).

RESULTS AND DISCUSSION

According to Fig. 1 where bus service is done in exclusive bus lane section, reliability of static structure and actual implementation are close together. Furthermore, to compensation the accumulated bus delays in the mixed traffic lane, can devote a part of the bus route as an exclusive bus lane. Between bus stop 9 to 15, where there exists an exclusive bus lane mission duration during peak-hour traffic is close to schedule planning. Figure 2 shows gradually, when bus is moving on the route along the traffic, delays are additive. So, in the last bus stop passengers have the most delays. Also, these delays cause disorganization in headway.

Scheduling of bus services is a plan for operating each of the buses, which is made by the Transport Company and it is a closed loop where buses are sent to the mission as frequently as possible. It means the delay created in previous bus stop will be delivered to the next bus stops and finally in the last bus stops, bus delays have the highest value. It will be occur to delays in starting the new operation. In this situation, by using the exclusive bus lane in some part of the route, the buses can to compensate the previous delay and arrive on-time to the destination terminal. Buses during operating in the exclusive bus lane can increase their speed and decrease dwell time.

CONCLUSION

One of the factors which directly affect the schedule disruption is existing traffic. Bus service along the Mixed Traffic Lane (MTL) causes a decline in speed of the bus in the different sections of the route. In other words, this issue causes a decrease in the average speed along the total route. Subsequently, by decreasing average speed of buses, journey time will be increased and it will have an effect on total-trip time.

By using an Exclusive Bus Lane (EBL) as part of the route can reduce the bus operation delays. Buses after operation in MTL with low speed enter to an EBL where they can increase the average speed and compensate for time lost. In EBL there is an exclusive bus lane for the use of the buses separated from other traffic either at all times of the day, or during rush traffic period. By this method buses can arrive on time at the destination terminal. Average speed of buses in EBL is around 15 to 20 km h^{-1}. Average speed of buses in the mixed traffic lane in the morning and evening rush traffic period is obtained by real site observation or traffic flow theory and in the exclusive bus lane is assumed 20 km h^{-1}. The devoted length of EBL is depend on the route layout and delays variance. Journey time of buses is obtained by total value of operation in mixed traffic lane and exclusive bus lane. In fact, journey time in the EBL part is less than MTL, so that it can to help to arrive on time at destination terminal. In other words, in the EBL section buses can compensate delays of their mission in MTL section.

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