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Evaluation of the Impacts of Unconditional Active Transit Signal Priority in VISSIM, Case Study: A Corridor in Isfahan

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ABSTRACT: The implementation of the priority system for transit at signalized intersections with high traffic volumes will help reduce transit delays and red lights stop at these intersections. In this paper, we propose an unconditional active signal priority control method for the public transportation system, which includes regular buses and a Bus Rapid Transit. we examined 11 different modes of bus availability at the intersection, based on the estimated time of transit arrival. Reduce transit delays at the intersection, increase the convenience and reliability of public transportation, increase the total intersection efficiency and reduce the negative impact on personal vehicles are also considered. Finally, a simulation model was conducted by VISSIM by writing an algorithm modeling in VisVAP for the Keshavarzi-Daneshgah corridor with BRT and regular bus in Isfahan City, Iran. the results showed that, due to the implementation of this method, BRT passengers' delay decreased by an average of 65% and decrease regular bus passengers' delay by an average of 7% compared to existing signal control scenarios.

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1. INTRODUCTION

Traffic congestion is rapidly increasing in cities. It leads to an increase in transit travel time and loss in the reliability of transit vehicles, so increasing the usage of the public transportation system requires improved services and increased utilities. Using intelligent systems is one of the ways to solve the traffic problem. One of the results of the use of intelligent systems is the timing of traffic lights with implementing transit signal priority (TSP). The implementation of a priority system for transit at signalized intersections with high traffic volumes will help to reduce traffic delays and red lights stop at these intersections. However, previous research has shown that the impacts and benefits of a TSP application are subjective and depend on its surrounding environment (such as signal timing settings, congestion, levels, etc.) [1].

Transit signal priority at signalized intersections is an operational strategy that changes the timing of the lights in which the public transport vehicles can cross the intersection with minimum conflict with red lights. This priority is applied by increasing the green time or reducing red time in the bus approach, [2]. TSP can reduce unintended transit delays at signalized intersections, increase the convenience and reliability of public transportation and increase the total intersection efficiency. It also has the potential for reducing bus punctuality, [3]. At the same time, TSP attempts to provide these benefits with a minimum of impact on other facility users. On the other hand, TSP has two major negative consequences. Changing the lights settings for transit will increase the delay at the crossroads. Also, increasing the passage of a priority route may lead to more traffic in upstream flow [4].

This research presents a real-time, unconditional signal control system for signal priority on conflicting transits. It proposes a TSP method for a public transportation system which includes regular buses and a Bus Rapid Transit (BRT), that minimize total delay while it assigns priority to the transit vehicles. In this research 11 different modes of bus availability at the intersection, based on the estimated time of transit arrival were examined. Passenger delays at the intersection, increase the convenience and reliability of public transportation, increase the total intersection efficiency and reduce the negative impact on personal vehicles are also considered. Finally, a simulation model was conducted by VISSIM by writing an algorithm model for signalized intersections in VAP.

2. METHODOLOGY

An unconditional transit signal priority model is formulated to optimize intersection signal phasing for minimizing transit delay at an intersection by using four methods of green extension, red truncation, phase insertion, and phase rotation.

The proposed algorithm is based on the information

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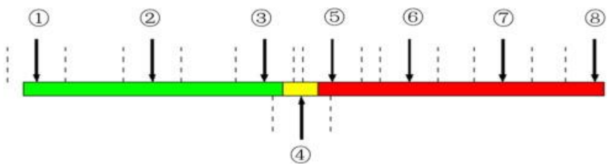

Fig. 1. Different modes of the arrival of transit to an intersection.

received from the detectors located inroads which obtain location information and speed of the vehicles. So the arrival time of transit is strictly predictable.

2.1. Transit travel time predicting model

· BRT

The arrival time of BRT to the stop line can be predicted immediately after its detection at the upstream flow. For BRT with a special line, the travel time predicting model is:

$$t_{ATS,R} = t_{s,r} + t_{t,r}, \quad (1)$$

$t_{ATS,R}$: Average amount of predicted bus arrival time to the stop line

$t_{s,r}$: The bus travel time from the detection point to the stop line at the intersection

$t_{t,r}$: The stopping time of BRT at the station for a condition that exists a station after the detector.

The time interval at which the BRT reaches the intersection can be obtained using t_{ATS} and σ_r:

$$\left[t_{ATS,R} - \sigma_r, t_{ATS,R} + \sigma_r\right] \quad (2)$$

The following equation is used to determine the location of the BRT arrival time cycle:

$$\operatorname{mod}\left(\left[t_{now,r} + t_{ATS,R} - \sigma_r, t_{now,r} + t_{ATS,R} + \sigma_r\right], C_T\right) \quad (3)$$

$t_{now,r}$: the moment BRT detected

C_T: cycle time

· Bus

Bus arrival time to the stop line can be predicted after its detection at the upstream flow. For a bus moving with traffic flow, the travel time predicting model can be written as:

$$\begin{cases} t_{ATS,B} = t_{s,b} + t_{t,b} + \dfrac{N_{j,T}^{b}}{s_j} & t_{b,T} \in G_{i,T} \\ t_{ATS,B} = t_{s,b} + t_{t,b} + \dfrac{N_{j,T}^{b}}{s_j} + \left(t_T + R - t_b\right) & t_{b,T} \in R_{j,T} \end{cases} \quad (4)$$

$t_{ATS,B}$: Average amount of predicted bus arrival time to the stop line

$t_{s,b}$: The bus travel time from the detection point to the stop line at the intersection when there is no vehicle

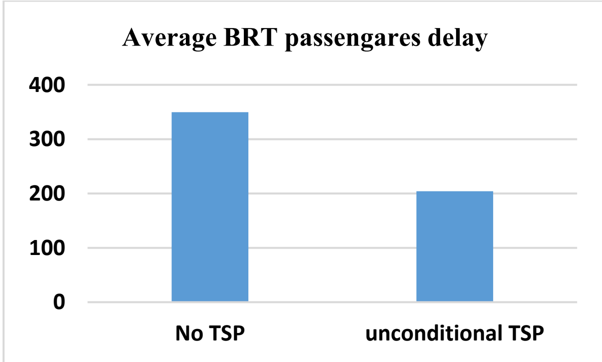

Fig. 2. Average BRT passengers delay.

$t_{t,b}$: The stopping time of the bus at the station for a condition that exists a station after the detector

s_j: saturation flow rate

$N_{j,T}^{B}$: The number of vehicles in front of the bus to reach the stop line at the intersection

t_T: The cycle start time

R: Spent time from the beginning of cycle T to the end of the red phase where the bus is detected.

t_b: the moment of bus detected

The time interval at which the bus reaches the intersection can be obtained using $t_{ATS,B,}$ and σ_b:

$$\left[t_{ATS,B} - \sigma_b, t_{ATS,B} + \sigma_b\right] \quad (5)$$

The following is used to determine the location of the BRT arrival time cycle:

$$\operatorname{mod}\left(\left[t_{now,b} + t_{ATS,B} - \sigma_b, t_{now,b} + t_{ATS,B} + \sigma_b\right], C_T\right) \quad (6)$$

Eight arrival modes may occur based on the location of the transit arrival time to the stop line, as shown in Fig. 1. Each arrival mode has its prioritization method.

Other arrival modes of transits to an intersection which considered in this paper are as follows:

9. The transits of two facing approaches that have different phases arrive at the same time at the intersection.

10. More than one bus is reaching the intersection from one approach.

11. Transits arrive at the intersection from conflicting approaches

ESULTS AND DISCUSSION

To test the TSP model, a simulation model was conducted by VISSIM by writing an algorithm model for signalized intersections in VAP for Keshavarzi-Daneshgah corridor with BRT and regular buses in Isfahan City, Iran.

The results showed that, due to the implementation of this method, BRT passenger's delay decreased by an average of 65%, and regular bus passenger's delay decrease by an average of 7% compared to existing signal control scenarios. Also, the total intersection efficiency increase by 4%. The results showed that BRT stops decrease by 78% which leads to decrease fuel consumption and also increase reliability.

CONCLUSIONS

TSP is arousing increasingly research interests all around the world, mainly because of its benefits to the road network. Unconditional TSP appears to be a more feasible alternative due to its easier satisfied technical requirements. This method can extend to the entire urban transport network as a new method to encourage travelers to choose transit mode for their travels hence mitigate traffic congestion. It also reduces fuel consumption that improves environmental indicators. It also reduces operational costs and passenger costs. However, unconditional TSP can increase total passenger's delay in peak hours.

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