Analysis of BRT Priority Signal Control System Implementation in Major Intersections of Khon Kaen City

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Abstract

Generally exclusive guideways for BRT (Bus Rapid Transit) sets up on surface and has to cross many intersections so that priority signal control such as Public Transportation Priority System (PTPS) is required to promise effective operation of BRT. However, such signal control can't be applied directly to BRT system in Asian cities because the traffic signal control in those cities is quite different with that in the city of developed country and there are many unique transportation modes such as para-transit. In this study, the impacts of introduction of PTPS at two major intersections on the planed BRT route which will pass through national highway route No. 2 (Mittraphap road) in Khon Kaen city were estimated by using a micro simulation model. Since the area at two intersections is wide and traffic rights used to be controlled by policemen during the peak period, introduction of exclusive guideways for BRT is expected to have significant impacts on traffic and operation of BRT itself. For developing a micro simulation model, we conducted traffic count survey on 23-25Aug., 2011 and observed traffic situation and traffic control. Though the simulation of 3 cases, namely the case with present signal control, the case introducing the traffic signal control system with point detection and the case introducing the traffic signal control system with detection of embarking and disembarking were examined. reductions of travel time of ordinary traffic on main streets and sub streets were employed as the indicator to evaluate above mentioned cases. Furthermore, sensitivity analysis was conducted by changing time headway of BRT from 3 min. to 10 min. and ordinary traffic volume from 90% to 110%. As the result, it was concluded that the traffic signal control system with detection of embarking and disembarking help to reduce travel time than the case of the traffic signal control system with point detection.

Keywords: Micro Traffic Simulation, VISSIM, Khon Kaen, Signal Control, PTPS

1. General Introduction

Generally exclusive guideways for BRT sets up on surface and has to cross many intersections so that priority signal control such as Public Transportation Priority System (PTPS) is required to promise effective operation. However, such signal control can't be applied directly to BRT in Asian cities because traffic signal control in those cities is quite different with that in developed country and there are many unique transportation modes such as para-transit. Therefore, in this study, the impacts of introduction of PTPS at two major intersections in Khon Kean city in where BRT is planned to introduce was estimated, and its feasibility was examined using micro traffic simulation.

2. Study area and data collection

In Khon Kaen city which is the central city of northeastern of Thailand, five BRT lines have been planned to be constructed within 15 years from 2007 to 2022. Exclusive guideways for BRT will be set up on 2 lanes of existing arterial roads. 2 km of the road section from 500 m north of Samliam intersection to 500 m south from Central Plaza intersection National Highway No.2 (Mittraphap road) which first BRT line will be introduced and two main intersections were included as shown in Fig.1.

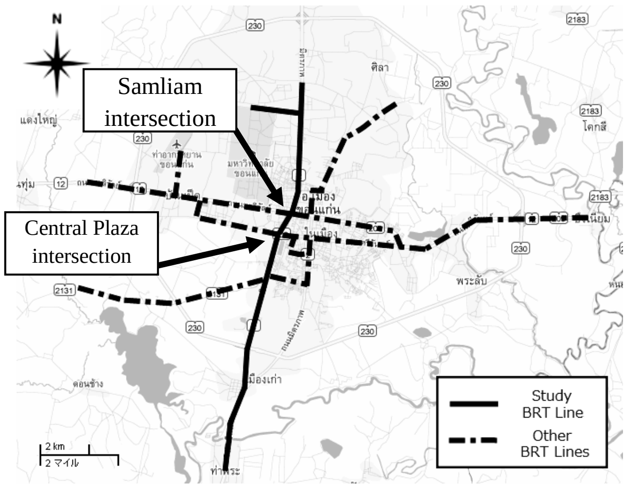


Fig.1 BRT study line

Data was collected as follows;
1. Signal phase : Video camera survey
2. Traffic volume : Video camera survey
3. Geometric design : Use of walking measure
4. Hearing : Hearing for Policeman

3. Existing traffic signal control in Khon Kaen

According to observation at targeted route, traffic signals are used to be controlled by fixed time except morning and evening peak periods. 3 and 4 signal phases are used as shown in table1 and table2.

Table.1 Signal phase at Samliam intersection

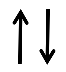
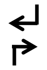
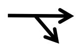
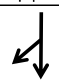
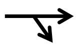
Phase	1Φ		2Φ	3Φ	Cycle Sec
Image					178sec
Green	51sec	35sec	40sec	30sec	
Yellow	3sec	–	3sec	3sec	
All Red	–	5sec	4sec	4sec	

Table.2 Signal Phase at Central Plaza intersection

Phase	1Φ	2Φ	3Φ	4Φ	Cycle Sec
Image					183sec
Green	30sec	30sec	55sec	40sec	
Yellow	3sec	3sec	3sec	3sec	
All Red	4sec	4sec	4sec	4sec	

During morning and evening peak periods, the sprit and cycle time are not constant and fluctuated because traffic signals are controlled by local policemen manually. Thus, it is rather difficult to simulate this traffic signal control. On this simulation, we used the directional traffic volumes during morning peak period with fixed time for the signal control during off-peak as shown in Fig.2 and Fig.3.

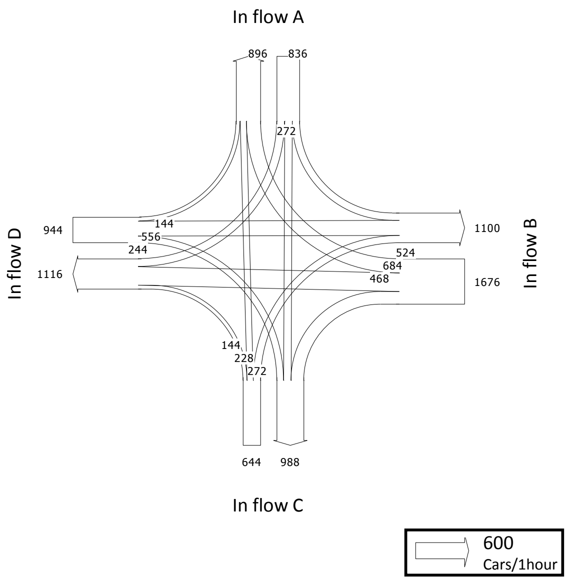


Fig.2 Traffic volume at Samliam intersection

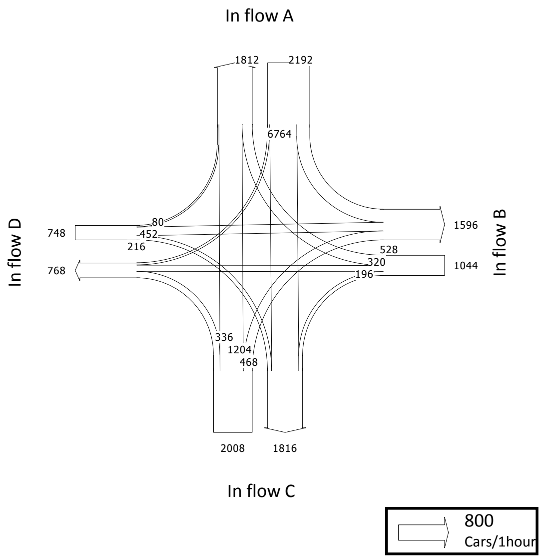


Fig.3 Traffic volume at Central Plaza intersection

4. Signal control

Two applicable traffic signal control systems which might give priority for BRT at two intersections were selected as follows;

4.1 Case 1: Traffic signal control system with point ditection[1)]

In this signal control system, approaching of BRT might be detected by a detector and priority might be given to BRT as follows;

a) If remaining time of green light on main direction when BRT passes under the detector installed near an intersection will be in certain period of time, green time might be extended as shown in Fig.4.

b) If signal will be red when BRT passes under the detector, the green time on dependent direction be shortened as shown in Fig.5.

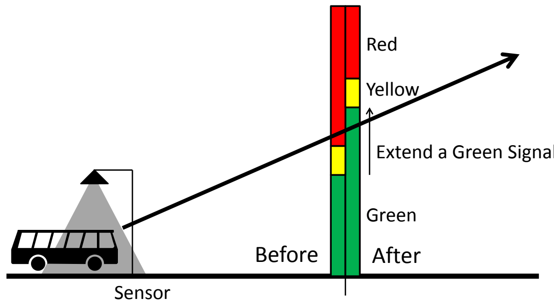


Fig.4 Execution of extra phase (Case1 a)

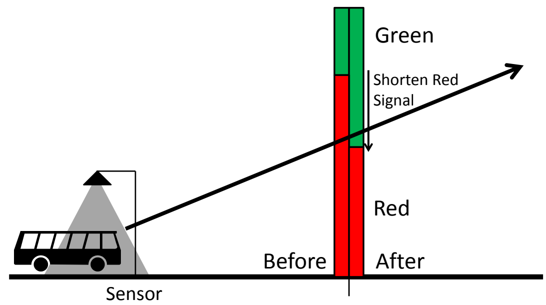


Fig.5 Execution of extra phase (Case1 b)

4.2 Case 2: Traffic signal control system with detection of embarking and disembarking [2)]

Since both intersections located near the bus stops, traffic signal control can be synchronized with embarking and disembarking of BRT riders as follows;

a) If traffic lights on main direction will be green when BRT stops at the bus stop, the green time will be shorten and the green time might be increased at the next cycle time as shown in Fig.6 and Fig.7.

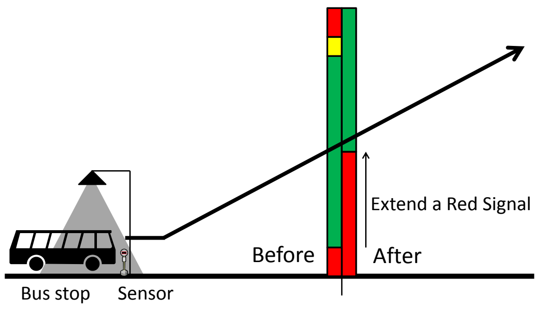


Fig.6 Execution of extra phase (Case2 a1)

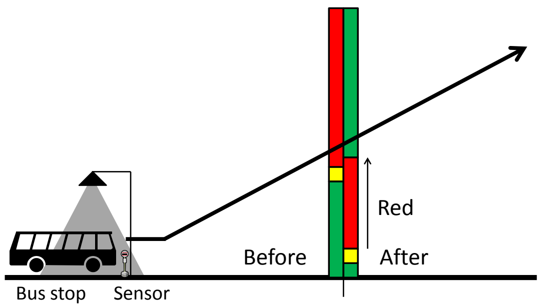


Fig.7 Execution of extra phase (Case2 a2)

5. Analysis method

The reduction of travel time passing though each of intersections was estimated using by comparing between the case introducing BRT with the existing traffic signal control and the VISSIM signal control which gives priority for BRT operation.

6. Validation

GEH[3)] which is indicator to represent the model accualacy at all measured points is shown less than 5 so that result of simulation has goodness of fit. As the result that applied GEH indicator to reproduction models, all GEH were less than 5.

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}} \qquad (1)$$

M: Traffic volume in Simulation (Unit/hour)
C: Traffic volume in real (Unit/hour)

7. Simulation results

In this study, it was considered by 3 scenarios which introduced BRT for present situation, traffic signal control system with point detection and traffic signal control system with detection of embarking and disembarking. In addition, the travel time reduction estimated by comparison with present and above cases for general vehicle of sub street and main street, the BRT. Furthermore, sensitivity analysis was conducted as BRT frequency changes from 6 units/hour to 20 units/hour and general vehicle traffic volume changes from 90% to 110%.

7.1 Effect of BRT travel time reduction

The effects of BRT travel time reduction are shown in Fig.8, Fig.9, Fig.10,

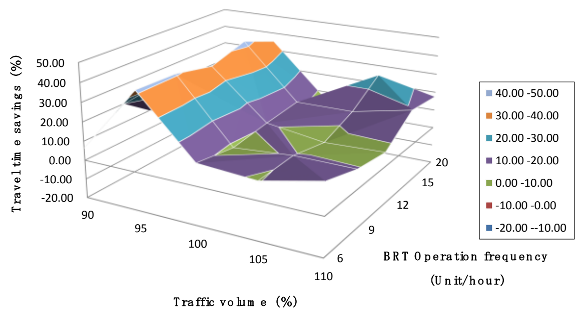


Fig.8 Result of Travel Time for Case1 (Samliam, BRT, To North)

Fig.11. In the case1 and case2 which introduced the PTPS, it is found that the travel time of BRT reduced on all observation points.

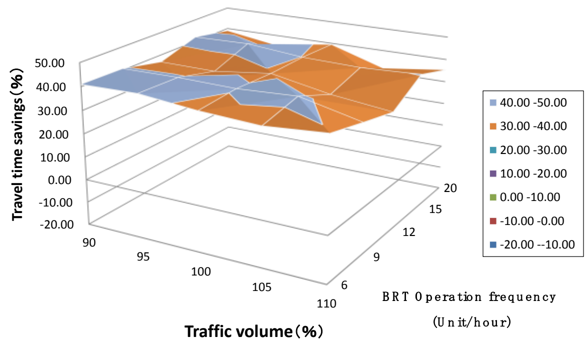


Fig.9 Result of Travel Time for Case1 (Samliam, BRT, To South)

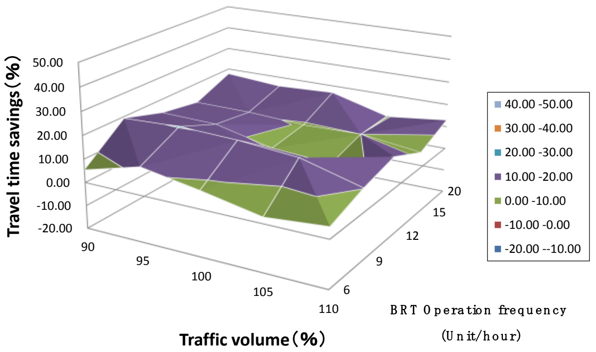


Fig.10 Result of Travel Time for Case1 (Central Plaza, BRT, To North)

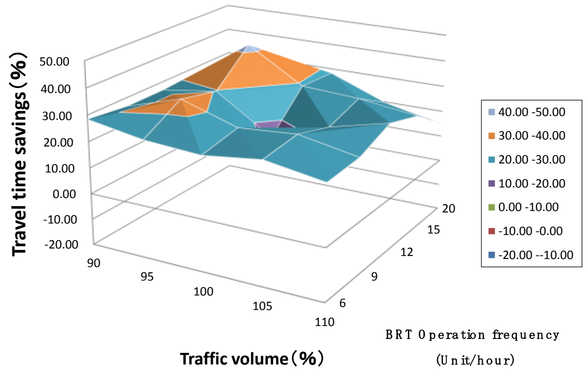


Fig.12 Result of Travel Time for Case2 (Samliam, BRT, To North)

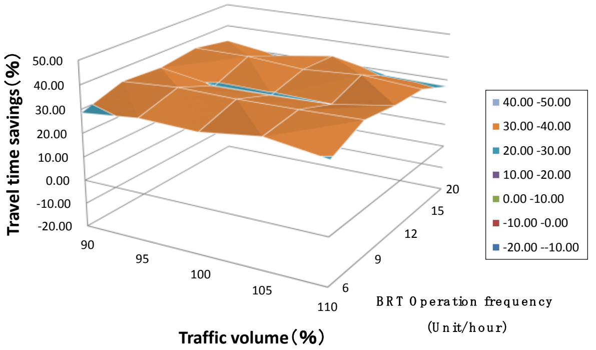


Fig.11 Result of Travel Time for Case1 (Central Plaza, BRT, To South)

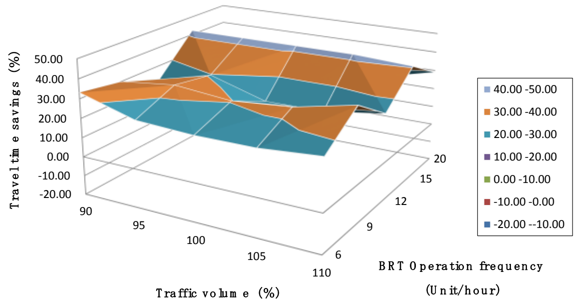


Fig.13 Result of Travel Time for Case2 (Samliam, BRT, To South)

7.2 Impacts of General vehicle

Since there are so many traffics in this study area, the travel time of both, main and sub street were increased as shown in Fig.12, Fig.13, Fig.14, Fig.15, individually. Especially, the travel time of sub street was increased by increasing the BRT operation frequency.

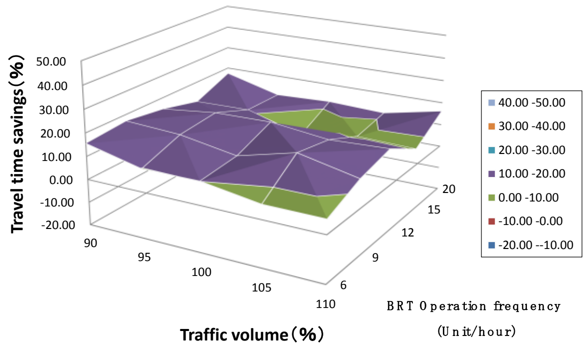


Fig.14 Result of Travel Time for Case2 (Central Plaza, BRT, To North)

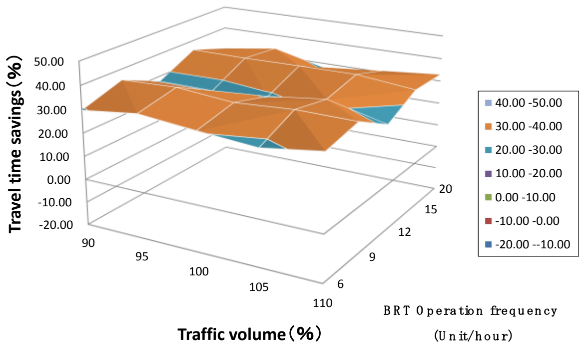


Fig.15 Result of Travel Time for Case2 (Central Plaza, BRT, To South)

8. Conclusion

In this study, we examined the impact of introduction of BRT priority signal control system on travel time passing through the intersections. As the result, it was found that this priority signal has significant impacts on reduction of travel time. However, travel time on north direction could not get the good result than that on south direction. For further study, it is nessesarry to collect more data.

Acknowledgment

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