THE STRATEGY TO REDUCE LOST OF GREEN TIME AT NEARSIDE BUS STOPS FOR BUS ROUTE OPERATING ALONG TWO-LANE ARTERIALS*

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1. Introduction

The Bus routes service not only along multiple-lane arterials but also along two-lane arterials, approximately, a half of bus routes in Tokyo Metropolitan Area operating along two-lane arterials (Road Bureau & JSTE, 1999). Bus routes with signal priority system reveal a successful operating along multiple-lane arterials (e.g. 22% decreasing of bus travel time after installing signal priority system) however, it seems ineffective when operating along two-lane arterial (e.g. only 3% decreasing of bus travel time) (Chiba Police, 2004). The one of obvious problem is that the lost of green times at nearside bus stop, i.e. lost of intersection capacity, due to bus stopping at the nearside bus stop during a green time interval as shown in Figure 1. Consequently, bus loses its green time and also this event delays to the following vehicles, which unable to overtake the stopping bus due to no passing zone.

Therefore, this study attempted to solve lost of green time for bus system servicing along two-lane arterials with nearside bus stops.

Figure 1. Illustration of Lost of Green Time at Nearside Bus Stop at R296 in Chiba

2. Objectives of Study

The objectives of this study are 1) to propose the recommended facility for bus route operating along two-lane arterials with nearside bus stops and 2) to propose the improved signal control system, which can deal with bus stopping at nearside bus stop in order to reduce the lost of green time due to the bus stopping to load/unload passengers at nearside bus stop.

3. Recommendation for System Architecture

To implement the proposed control system, the infrared beacon should be installed at nearside bus stop, where its communication zone covers the bus stop zone because the proposed signal control system has to monitor the bus events, e.g. the bus arrival and departure at nearside bus stop.

*Keywords: Bus Route, Lost of green time, Nearside bus stop and Two-lane arterial

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4. Control Algorithm of Proposed Signal Control System

The concept of proposed signal control system attempts to change main street green interval to red interval when bus stop to load/unload passenger at nearside bus stop during green time interval in order to minimize the lost of green time along main arterial, The interval of bus arrival and departure time, i.e. the dwell time interval as shown in Figure 2, is monitored by the detector at nearside bus stop. The control algorithm of proposed signal control system was proposed as shown in Figure 3.

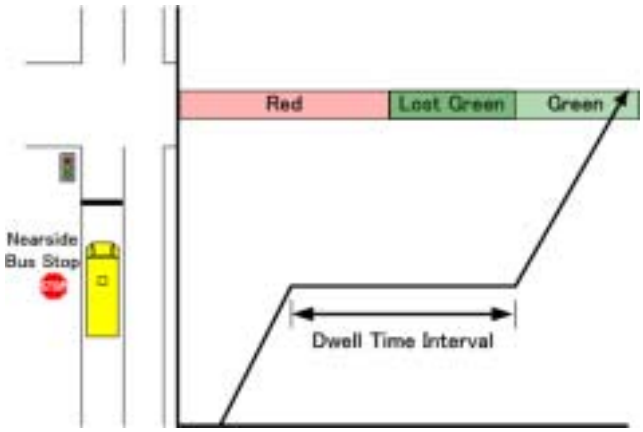

Figure 2. Illustration of Lost of Green Time during Dwell Time Interval

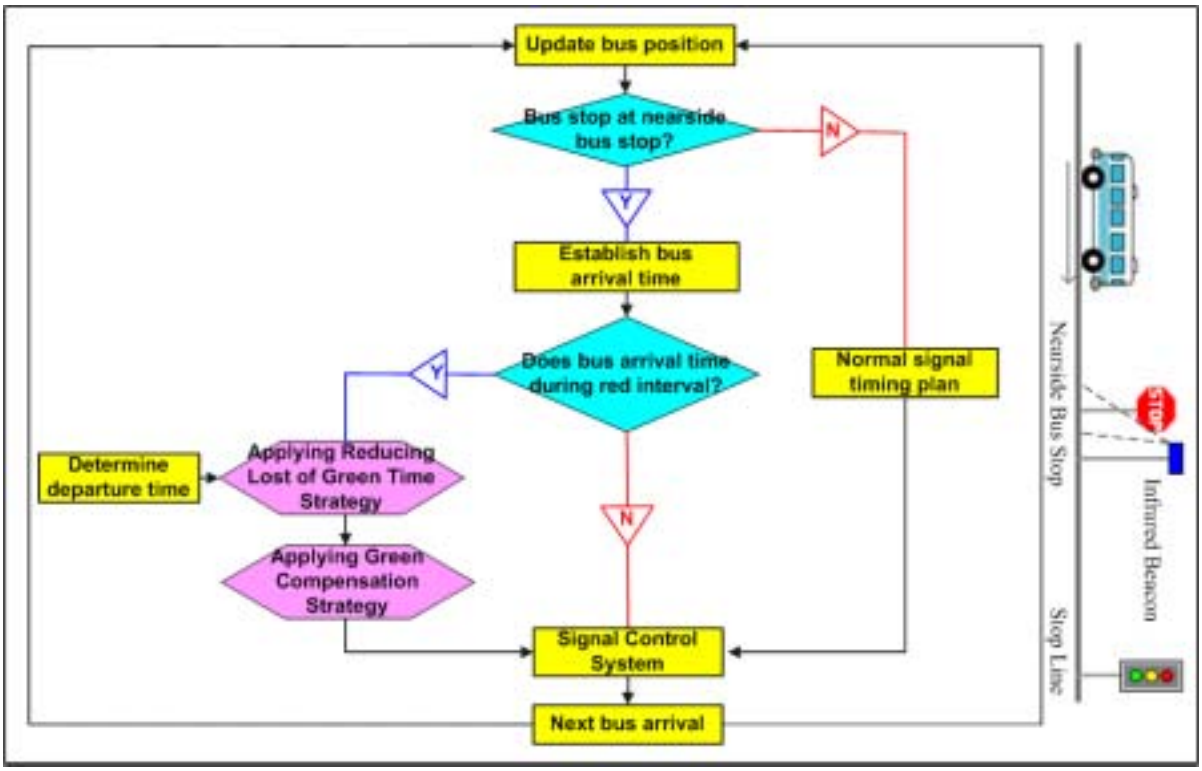

Figure 3. Functional Diagram of Proposed Control Algorithm

5. Signal Strategies for Minimizing Lost of Green Time

In developed signal control system, there are two signal strategies for nearside bus stop (bus arriving at the nearside bus stop). It consists of Reducing Lost of Green Time and Recovery Strategies. To apply the signal strategies, the start and end points of the dwell time interval, ω′ and ω″, are examined with respect to the background signal timing plan. The objectives and operation functions of those signal strategies are revealed as follows.

(1) Reducing Lost of Green Time Strategy

This study proposed this additional signal strategy to reduce the lost of green time, when the bus stops to load/unload passenger at nearside bus stop during green interval of main street. This strategy will reduce the lost of green time by extending the green interval of previous phase, ϕ_4 (i.e. extending red interval of main street) until the bus finish to load/unload passenger. The implementation of this strategy is started to actuate when the ω′ is in the red interval of main street phase (i.e. green interval of previous phase).

(2) Green Compensation Strategy

This additional signal control strategy was proposed to compensate the green time to main street phase, ϕ_1, which is truncated from extending the red interval of Reducing Lost of Green Time Strategy. This strategy will start early green interval of main street phase, ϕ_1, of the next cycle by reducing the green interval of previous phase, ϕ_4. The illustration of implementation of Reducing Lost of Green Time and Green Compensation Strategies is shown in Figure 4.

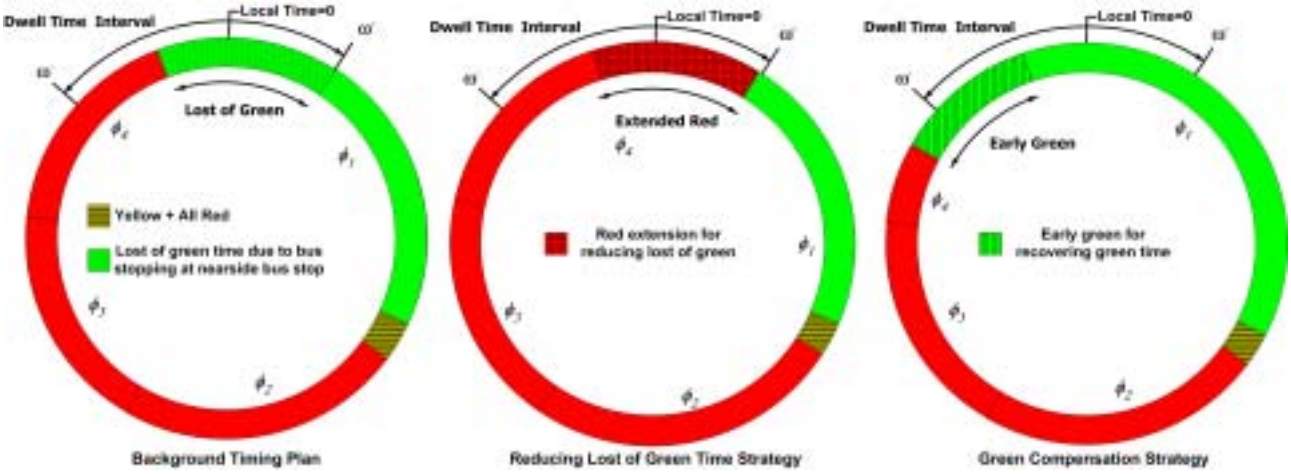

Figure 4. Illustration of Reducing Lost of Green Time Strategy and Green Compensation Strategy

6. Evaluation of Proposed Signal Control System

The proposed signal control system would be compared with the normal signal control system, fixed time signal control system, in order to evaluate its operation performance. The both control systems would be simulated with PARAMICS along selected arterial. The information of traffic flow and bus service operation used to simulation was collected in the morning peak period, from 7 AM to 9 AM. The saturation flow rate was 0.6 during this study period. The collected mean head way, reaction time and degree of saturation at intersections would be applied to calibrate and validate the developed models. The average delay of bus, main street traffic as well as entire system obtained from simulation were used to compare the operation performance of both control systems. The statistical analysis, Independent-Sample T-Test with 95% level of confidence, was utilized to compare the average delays of bus and main street traffic of both signal control system.

7. Results and Discussions

The comparative results of statistical analysis are illustrated in Table 1. The results reveal that the proposed signal control system could successfully decrease a bus delay with 10% significant decreasing from the normal signal control system. This improvement resulted from the proposed control algorithm of nearside bus stop, including signal strategies for reducing lost of green time, which could reduce lost of green time when bus stopping at nearside bus stop. In addition, the proposed control system also could successfully decrease the delays of main street traffics with 5% significant decreasing average delay from the normal signal control system. These exceptional improvements could be explained that its delay was also decreased from implementing the signal strategies for reducing lost of green time by reducing the events, which following vehicles were waiting for the stopping bus at the nearside bus stops during green interval. As considering for entire system, the proposed control system could decrease significantly 9% total delay.

Table 1. Summarization of Results of Comparison between Normal and Proposed Signal Control Systems

Movement	Average Delay, sec/veh		Difference, sec/veh (%)	Results of T-Test
	Normal Signal Control System	Proposed Signal Control System		
Bus	20	18	-2 (10%)	Significance
Main Street Traffic	21	20	-1 (5%)	Significance
System	43	39	-4 (9%)	Significance

8. Conclusions

This paper proposed the recommended system architecture and the signal control system for bus operating along two-lane arterials with nearside bus stops in order to reduce the lost of green time when bus stopping at nearside bus stops. The control algorithm of proposed signal control system includes the signal strategies for reducing lost of green time and green compensation. The proposed control system was compared with normal signal control system in order to evaluate its performance. The results of comparative analysis reveal that the proposed control system performed successfully under existing traffic condition with significant decreasing delays of bus and entire system traffic.

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