An Integrated Real Time Transit Signal Priority Control For High Frequency Transit Services

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1 Introduction

The problem of buses bunching in a short headway bus line has been largely studied in the literature [1], [2]. This phenomenon is produced by two main factors (i) the variability in travel time between stops, which are extremely influenced by the presence of traffic lights along a corridor and (ii) variations in passenger demand.

In order to tackle this phenomenon a wide range of control strategies have been proposed. According to [3]., such control strategies may be divided into three categories: (i) station control, including bus holding, stop skipping and boarding limits; (ii) interstation control, such as operating speed control, bus overtaking and traffic signal priority mechanisms; and (iii) other control measures such as adding vehicles.

Even though, remarkable works regarding control strategies have been developed, none of them have considered together both station and interstation control. In this study we tackle this problem aiming to determine the optimal vehicle control strategy for the various stops and traffic lights in a transit system that will minimize the total time users must devote to making a trip taking into account both transit and general traffic. Based on a high frequency urban transit service were real time information about bus position (GPS) and bus load (APC) is available, this study will focus, on strategies for traffic signal priority together with vehicle holding and boarding limits.

This study differs from previous works in the area in the following ways:

- We consider an active, relative and conditional transit signal priority in the form of green extension, considered together with holding buses at stops and passenger boarding limits at stops.
- The strategy considers a high frequency capacity constrained and unscheduled service (no timetable).
- The decisions regarding transit signal priority are taken based on a rolling horizon scheme where the passengers waiting downstream are taken into account.

2 Transit System Characteristics

The system underlying our model is a one-way loop transit corridor with *N* stops and *S* traffic lights operated by a single high-frequency service consisting of *K* vehicles each with its own capacity and speed, as shown in Figure 1. Vehicles start their run at a terminal defined as Stop 1, visiting all stops (2, 3,..., *N*) and traffic lights (1, 2,..., *S*) downstream before returning to the same terminal (*N+1*) where all remaining passengers must alight. The buses are numbered in strict order of advance along the corridor, bus 1 being furthest ahead and *K* furthest behind.

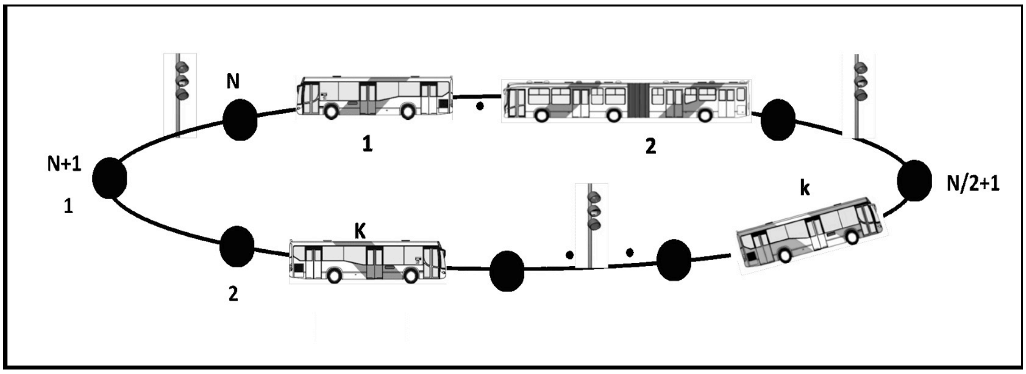

Figure 1: Transit system model

3. Problem Formulation

We formulate a deterministic mathematical programming problem that extend the problem of vehicle Holding and Boarding Limits with Real Time information (HBLRT) presented in [4] and [5] in order to include the possibility of extending the green time when a bus arrives at a traffic light. The objective function is given by the minimization of the total travel times of passengers from the moment they arrive at a stop to the moment they reach their destination, taking into account also the expected delay produced by the green extension to general traffic.

4 Preliminary Results And Final Comments

The proposed model is applied to an imaginary public transport corridor with the characteristics shown in Table 1

Table 1: Corridor Characteristics

Parameters	Value	
Corridor length	10	Km.
Stops	30	
Traffic lights	29	
Bus capacity	100	Pax.
Bus speed	26	Km/h
Boarding time	2.5	sec./pax.
Alighting time	1.5	sec./pax.

For comparison purpose we propose two benchmarks strategies: i) No control and ii) HBLRT proposed in our previous work, where the control actions are holding and boarding limits.

Table 2 and 3 shows that the best results are achieved by the proposed control with reductions to Transit users close to a 34% while general traffic only increases a 2%.

Table 2: Objective Function Value for Transit

	No Control	HBLRT	Proposed
t_first	14825.33	9737.63	9262.60
%reduction	-	-34.32	-37.52
t_extra	4091.97	1178.75	1060.79
%reduction	-	-71.19	-74.08
t_holding	0.00	1794.57	1702.84
%reduction	-		
t_stop_sem	4243.17	4461.32	3306.27
%reduction	-	5.14	-22.08
t_Transit	23160.46	17172.27	15332.50
%reduction	-	-25.86	-33.80

Table 3: Objective Function Value for general traffic

	No Control	HBLRT	Proposed
delay_comp	19278.57	19278.57	19696.69
%reduction	-	0.00	2.17
delay_same	1414.43	1414.43	1413.13
%reduction	-	0.00	-0.09
t_Traffic	20693.00	20693.00	21109.81
%reducción	-	0.00	2.01

Figure 2 shows the trajectories of buses for all strategies. While Figure 2a) shows how buses bunch under no control, Figure 2c) shows how the proposed control can dynamically react in order to keep regular headways, even better than the HBLRT control presented in Figure 2b).

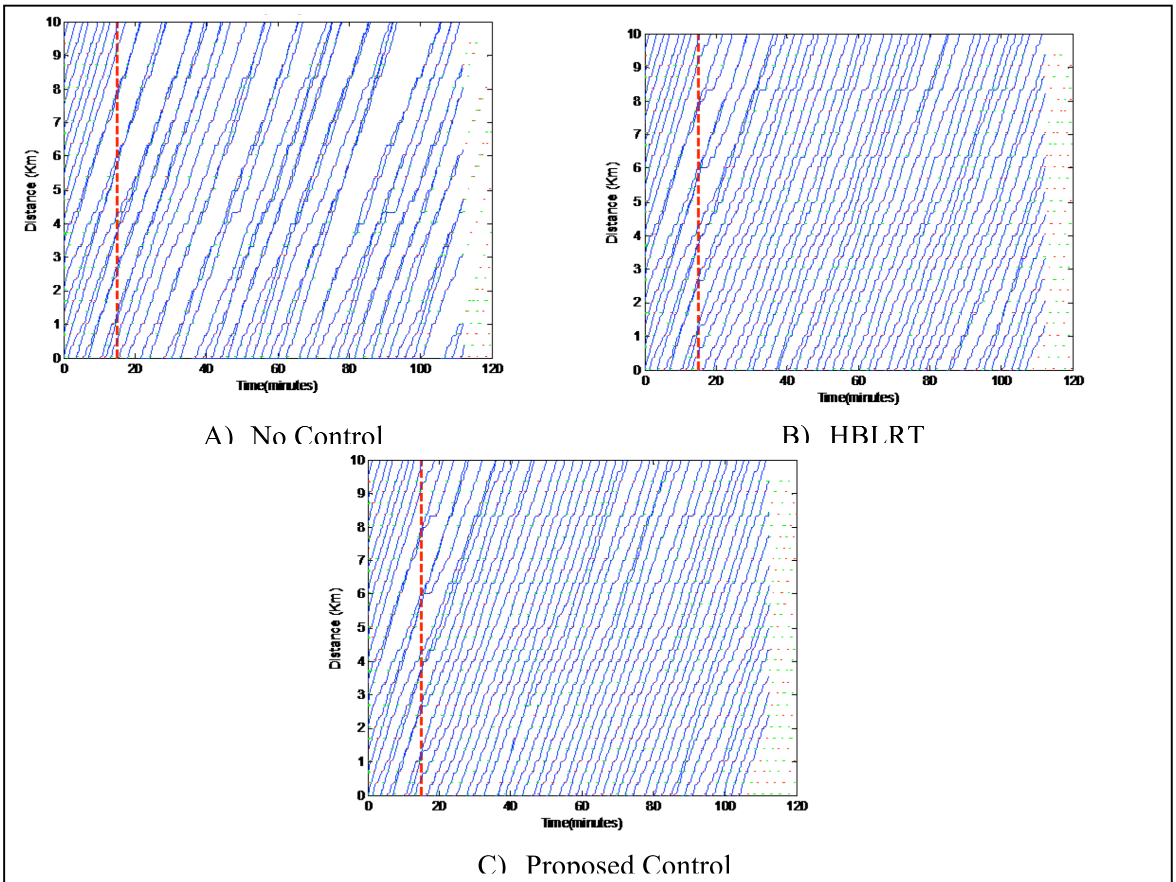

Figure 2: Trajectories of buses for the different strategies: a) No control; b) HBLRT; c) Proposed control.

References

[1] Newell, G. F. & Potts, R. B.. Maintaining a bus schedule. *In: Proceedings of the 2nd Australian Road Research Board*, 388-393, 1964.

[2] Potts, R. & Tamlin, E. Pairing of buses. *In: Proceedings of the 2nd Australian Road Research Board*, 3–9, 1964.

[3] Eberlein, X.-J.. *Real Time Control Strategies in Transit Operations: Models and Analysis*. PhD, Massachusetts Institute of Technology, 1995.

[4] Delgado, F., Muñoz, J. C., Giesen, R. & Cipriano, A. Real-time control of buses in a transit corridor based on vehicle holding and boarding limits. *Transportation Research Record: Journal of the Transportation Research Board*, 2090, 59-67, 2009.

[5] Delgado, F., Muñoz, J. C. & Giesen, R. How much can holding and limiting boarding improve transit performance? Submitted for publication, 2011.