UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Optimising Traffic Operations at Signalised Intersections via Transit Signal Priority

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Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

Under the supervision of Dr. Michelle Zeibots, Prof. Xiaobo Qu, Dr. Kasun Wijayaratna

University of Technology Sydney
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Required wording for the certificate of original authorship

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, *Mina Ghanbarikarekani* declare that this thesis, is submitted in fulfilment of the requirements for the award of *PhD*, in the *School of Civil and Environmental Engineering/Faculty of Engineering and IT* at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Journal Papers

❖ **Published**

- Ghanbarikarekani, M., Qu, X., Zeibots, M, Qi, W., (2018), "Minimizing the average delay at intersections via pre-signals and speed control", Published in Journal of Advanced Transportation.

❖ **To be submitted**

- Ghanbarikarekani, M., Wijayaratna, KP., Zeibots, M., Qu, X., Slack-Smith, D., (2020) "A Novelty in Transit Signal Priority System to Reduce Private Vehicles' Time Penalties through Speed Optimisation of Light Rail Vehicles".
- Ghanbarikarekani, M., Wijayaratna, KP., Zeibots, M., "Incorporation of the Speed Optimisation of Light Rail Vehicle Algorithm with SCATS".
- Ghanbarikarekani, M., Wijayaratna, KP., Zeibots, M., "How to Implement the Transit Signal Priority Algorithm on Australian Traffic Light Systems".

Conference Papers

❖ **Published**

- Ghanbarikarekani, M., Zeibots, M., Qu, X., (2019), "Optimization of Signalized Intersections Equipped with LRV Signal Priority Systems by Minimizing Cars' Stop Time", 2019 IEEE Intelligent Transportation Systems Conference (ITSC).
- Ghanbarikarekani, M., Zeibots, M., Zou, Y., (2019), "An Algorithm for Reducing Vehicles' Stop Behind the Bus Pre-signals", Conference of Smart Transportation Systems 2019.
- Ghanbarikarekani, M., Zeibots, M., Qu, Q., Arab, A., (2019), "Minimizing the stop time of private vehicles at intersections with LRT signal priority systems", World Conference on Transport Research – WCTR 2019.

❖ **To be submitted**

- Ghanbarikarekani, M., Wijayaratna, KP., Zeibots, M., "A Novelty of Transit Signal Priority System: Introduction to Implementation".

Awards

❖ My paper titled 'An algorithm for reducing vehicles' stop behind the bus pre-signals' was selected as Best Student Paper – Runner Up (Road Transport) at KES International Conference on Smart Transportation Systems 2019 (KES-STS-19), Malta, 16-19 June 2019

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Abstract

Sustainable urban transport systems can only be achieved with a balance between private and public transport modes. Though private transport options are necessary for certain trip purposes, it is imperative to ensure that the mass transport of people using public modes achieves an acceptable level of service. Integrated road networks contain links that utilise private, public and active modes of transport. Intersections serve as the primary method of control to maintain safety and functionality of the network. However, as a result of the control, inefficiencies may occur, compromising the effectiveness of a multi-modal transport system. In particular, congestion may negatively affect public transport performance. The following dissertation develops novel strategies for the prioritisation of public transport vehicles to improve the efficiency, effectiveness and quality of service of the transport system as a whole.

Prioritisation of public transport can be achieved through the provision of dedicated road infrastructure (lanes), and operations — especially of intersections managed through a variety of signalisation strategies. Two widely used options for prioritisation of public transport can be through using pre-signals (for buses) and Transit Signal Priority (TSP). The focus of this thesis is TSP for Light Rail Vehicles (LRV)s. Pre-signals can be installed near an intersection to give priority to buses by stopping vehicles before the main intersection. LRV signal priority is a timing strategy that gives priority to LRVs at signalised intersections. It is based on changing the sequence of phases, extending the green time and reducing the red time of the LRV's phase to limit delays to the vehicle.

Bus pre-signals and LRV signal priority systems are becoming more popular in cities, reducing the average delay per passenger and making public transport more attractive.

However, they also impose additional stops, delay and travel time to private vehicles, compromising their overall efficiency.

The research conducted in this study focuses on improving pre-signals and LRV signal priority systems by changing the approach speed of public transport vehicles in order to reduce the green time needed to give public transport priority. The pre-signal model reduces the number of stops behind them so that vehicles can adjust their speed based on traffic conditions as well as the speed and approach of buses. The revised model for LRV signal priority systems minimises the green extension and red reduction of LRV phases by estimating the optimal speed needed to reach the stop line. As a consequence, the priority of LRVs and buses is maintained while at the same time improving the performance of private vehicles by keeping the red time to an absolute minimum.

This thesis advances the evolution of TSP in this way via two methods. First, a set of algorithms is developed to optimise the approach speeds of public transport vehicles to signalised intersections. Second, the algorithm set is then applied to a set of functioning, on-street light rail intersections in the city of Newcastle in the state of New South Wales in Australia. This second phase of the research has sought to test the algorithms by putting them through the early stages of testing and development that would be undertaken as part of an implementation process. This work has been undertaken in collaboration with professional technical staff from Transport for NSW with support from the agencies Research Hub.