Introduction

Transit priority at signalized intersections is an effective strategy to improve tram performance. Compared to buses, trams operating in mixed traffic have much higher impact on other road users, and vice versa.

- Trams block the entire link when they stop.
- Trams cannot change lane.
- It is comparatively difficult for early trams to stay on schedule.

We study the effect of different levels of tram priority currently used, or being considered, in Melbourne, Australia, by simulations on *large-scale networks* governed by *realistic adaptive signal systems* with open boundary conditions.

Transit priority variants

- Absolute priority starts the priority phase immediately after detecting a tram and keep a priority phase running until the tram traverses the approaching intersection.

- *Partial priority* has less disruptive priority tactics, which include a clearance phase and a green extension and operates up to 20% of the cycle time.

- *Conditional priority* is active only when trams are behind schedule.

Unconditional partial priority is the system currently employed in Melbourne.

Multimodal Traffic Model

We utilize a multimodal CA model extends the Net-NaSch unimodal traffic model, ([1]) on a generic 8 by 8 square-lattice, as shown in Fig. 1 (left), governed by SCATS (Sydney Coordinated Adaptive Traffic System). Each link is 750m long. Each tram links has two lanes: left car lane and right mixed-traffic lane, three tram stops and two tram detectors. A non-tram link has two car lanes plus a right-turn lane of 90m.

Each private car occupies one cell of 7.5m with maximum speed of 3, $v_{\text{max}} = 3$, and each tram occupies 3 cells, i.e. 22.5m long with $v_{\text{max}} = 2$ as trams travel more slowly than private cars in mixed traffic.

A Comparison of Tram Priority at Signalized Intersections in Melbourne Lele Zhang, Timothy M. Garoni and Somayeh Shiri School of Mathematical Science, Monash University, Victoria 3800, Australia



Figure 1: Left. Illustration of the studied network with each alternating east-west route being a tram route. All links carry bidirectional traffic. Boundary links are treated as ramps (buffering zones) for inputting and outputting vehicles. Right: Signal phases. Dashed paths are required to give way to continuous paths. Phases E and F are for tram nodes only.

Boundary conditions There are two peak directions: eastbound and southbound. The inflow rates in the peak directions are about twice as large as those in the counter-peak directions during the peak hours. The boundary condition follows an AM profile. We consider two scenarios: over-saturated (OS) and unsaturated (US). In the OS scenario the network density reaches higher than US.

Turing decisions Each link was assigned with a probability 0.9 of continuing straight ahead, 0.04 of turning into a non-peak direction link, and a probability 0.06 of turning into a peak-direction link.

Traffic signal systems

SCATS signal coordination (linking) was set in the eastbound direction, to establish green-wave behavior. Cycle length and split plan are adaptive, i.e. more congested, more green time [2].

Version Description

\mathbb{NT}	SCATS with no tram priority.
\mathbb{PU}	SCATS with partial and unconditional tram priority.
\mathbb{PC}	SCATS with partial and conditional tram priority.
AU	SCATS with absolute and unconditional tram priority.
\mathbb{AC}	SCATS with absolute and conditional tram priority.
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- \mathbb{NT} assigns 20% of the cycle length to either phase E or F (only tram nodes phases).

- When the tram has passed the middle-link detector, PU runs right-turning clearance phase to clear a passage ahead of the tram. When the tram has passed the end-link detector but has not traversed the intersection, \mathbb{PU} runs extension phase.

- When the tram priority process is triggered, AU starts the right-turning clearance phase and keeps running it until the tram has traversed the intersection.

- Throughput Total number of cars (trams) that have traversed the network during the simulation time.

- Aggregated travel time per car (tram) The expected value of travel time over all traversed cars(tram) during the simulation time.

- Travel time variability The variance of the aggregated travel time per car (tram).

Tram Performance Figs. 2(a-c) shows tram performance in OS case. In terms of mean travel time Tram priority reduces the average tram travel time in the eastbound direction, when compared to the no priority system \mathbb{NT} , and the improvement is more significant under the OS scenario than US. **Private Vehicle Performance** Figs. shows mean car travel times along different approaches in OS case in different routs. When tram

2(d-f)

priority process is active, both southbound and northbound travel times increase. The higher the priority imposed, the more the north-south traffic gets penalized. Interestingly, from Fig. 2(f) tram priority can penalize the traffic in parallel non-tram routes. Perhaps surprisingly, the penalty generated by \mathbb{PU} and \mathbb{PC} is larger than that by \mathbb{AU} and \mathbb{AC} .

Simulation Results

observables



Figure 2: performance of versions of SCATS. Error bars corre-sponding to one standard deviation are shown but are usually too small to observe

Person Performance Figs. 2 (g-h) give the average person travel time and throughput of the whole network as the number of occupants that each tram carries $(0_{t,p})$, varies. \mathbb{PC} provides the shortest average person travel time in both US and OS. Absolute tram priority provides shorter person travel time when tram occupancy is sufficiently high.

directions.

[1] J. de Gier, T. Garoni, O. Rojas, Journal of Statistical Mechanics: Theory and Experiment 4 (2011)

[2] L. Zhang, T.M. Garoni, J. de Gier, Transportation Research Part B: Methodological **49**, 1 (2013)

We gratefully acknowledge the financial support of the Roads Corporation of Victoria (VicRoads). This work was supported under the Australian Research Council's Linkage Projects funding scheme (project number LP120100258). This research was undertaken with the assistance of resources provided at the NCI National Computational Merit Allocation Scheme supported by the Australian Government.





Conclusion

Tram priority improves tram performance in terms of both travel time and variability. Regardless of the traffic condition, the absolute tram priority results in the best tram service in the priority direction at the expense of delaying other traffic in the non-priority

As the network becomes more saturated however, other road users suffer more from the disruptions caused by tram priority processes, especially the absolute tram priority.

For either the absolute priority or the partial priority, the conditional version achieves almost the same level of improvement of service as the unconditional version but with reduced impact on other traffic. Therefore, the partial conditional priority system appears worth trialling. In the case that the absolute tram priority is necessary, the absolute conditional priority should be implemented.

References

Acknowledgements

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