EMPIRICAL EVALUATION OF BUS AND CAR DELAYS AT PRE-SIGNALS

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Motivation

• In urban environments, where buses and cars operate in mixed fashion, bus delays can be exacerbated at signalized intersections due to the interactions with cars.

• Dedicated bus lanes can be used to give priority to buses
  • In urban setting this is typically done by converting an existing regular (i.e., car) lane to bus use only
  • However this is not always feasible

• Bus delays at signalized intersections can still be reduced without taking a lane fully away from cars, especially when bus flows are low.
Goal

- Investigating the use of additional signals to provide priority to buses at signalized intersections.
  - i.e., a pre-signal upstream of the main signal to allow buses to jump the car queues.
- Cars can still use all lanes at the main intersection to fully utilize the capacity of the signal when buses are not present.
Pre-signal

- Car Lanes
- Pre-signal
- Mixed Lanes
- Bus Lane
- Section of lane where lane allocation is changed intermittently
- Main Signal
Background

• Shared lane strategies targeted at links:
  • For signalized arterials:
    • Intermittent bus lanes (IBL) (Viegas and Lu, 2001; 2004)
    • Bus lanes with intermittent priority (BLIP) (Eichler and Daganzo, 2008)
  • Field tests:
    • Lisbon, Portugal → Increase bus speeds by 15-20% (Viegas et al., 2007)
    • Melbourne, Australia → Increase in bus speeds not as significant as in Lisbon (Currie and Lai, 2008)

• Shared lane strategies targeted at nodes:
  • Pre-signals (Wu and Hounsell 1998)
  • Implementations found in London, U.K. and Zurich, Switzerland
Pre-signal site in Zurich

- Pre-signal at langstrasse
Operation of pre-signal
Data collection

- Data collected during morning peak (7:30 am to 8:30 am)
- Cumulative car counts collected at 7 locations along bus route
- Travel times of buses collected
Results of data collection

- Transformed cumulative curves of car arrivals to:
  - Upstream location,
  - Pre-signal, and
  - Main signal
Results of data collection – car delays

<table>
<thead>
<tr>
<th></th>
<th># of cycles</th>
<th>Upstream of pre-signal</th>
<th>Between pre-signal and main signal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus not present</td>
<td>22</td>
<td>13.5</td>
<td>5.9</td>
<td>19.4</td>
</tr>
<tr>
<td>Bus present</td>
<td>5</td>
<td>16.1</td>
<td>8.0</td>
<td>28.3</td>
</tr>
</tbody>
</table>

- Car delays upstream of the pre-signal > car delay between pre-signal and main signal.
- Also note that, car delays upstream of pre-signal are significantly higher during cycles which buses are present as compared to cycles during which buses are not present.
- The presence of a bus during a cycle also increases the car delay observed between the pre-signal and the main signal.
# Results of data collection – bus delays

<table>
<thead>
<tr>
<th>Bus #</th>
<th>Delay (sec)</th>
<th>Percentage of wasted green time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>

Duration of green time wasted → the duration during which cars would have normally discharged from the main signal but could not because of a red pre-signal.
Interpretation of results

- Evidence for reduced discharge flows in cycles which buses are present seen in disaggregate data.
  - Discharge flows when buses are present: 780 veh/hour
  - Discharge flows when buses are not present: 1166 veh/hour
- The cycles during which green time is wasted are not necessarily the ones with the lowest discharge rates
  - Low discharge rates can be observed even if pre-signal does not starve the main signal of flow.
- Bus delay (10.9 sec) < Car delay (19.4 sec when bus not present, 28.3 sec when bus present)
Conclusions

- Average car delays at the intersection increase when a bus is present.
- The presence of a bus reduces the discharge flow from the main intersection.
- Bus delays were found to be significantly lower than average car delays
  - The effects of existing transit signal priority?
  - Even without transit signal priority expect that pre-signals would reduce bus delays.
    - A pre-signal allows buses to move in front of car queues which otherwise could not be cleared with the use of transit signal priority.
Thank you for your attention
Questions?

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