Bus Priority Procedure for Signalized Intersections Based on Bus Occupancy and Delay

SUMO User Conference 2024

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Berlin, 15. May 2024
Motivation and Research Questions

A near-future scenario in which the bus prioritisation is not first-come, first-served-based, but uses additional information transmitted with V2X communication (ETA, delay, occupancy).

How do the priority levels determine the timing of the prioritisation, depending on ETA?

What does a practical assignment of priority levels based on delay and occupancy look like?

The prioritisation schemes must:

- be scalable depending on ETA and
- be flexible and easy to adapt because the bus to be prioritised can change
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Methodology
Methodology

Intersection at which prioritisation takes place
Methodology: Prioritisation Logic

Simulation start

Bus Dataframe

get_highest_priority_bus(df)

Every simulation second

prio_bus
**Methodology:** Prioritisation Levels

```python
get_highest_priority_bus(df)
```

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Priority Degree</th>
<th>Green Time Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=5</td>
<td>E5</td>
<td>ETA – 20 sec</td>
</tr>
<tr>
<td>&lt;=15</td>
<td>E4</td>
<td>ETA – 10 sec</td>
</tr>
<tr>
<td>&lt;=30</td>
<td>E3</td>
<td>ETA</td>
</tr>
<tr>
<td>&lt;=45</td>
<td>E2</td>
<td>ETA-10</td>
</tr>
<tr>
<td>&gt;46</td>
<td>E1</td>
<td>ETA-20</td>
</tr>
</tbody>
</table>

Delay in sec

- <=59: E5
- <=119: D5
- <=239: C5
- <=420: B5
- >420: A5

Priority A
Green as soon as possible

Priority B
Green at ETA – 20 sec

Priority C
Green at ETA – 10 sec

Priority D
Green at ETA

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Methodology: Control Strategies

Green Extension

Red Truncation

Red Truncation Extended

Current Phase

Desired Phase

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Methodology: Prioritisation Levels – ETA Function

1. \texttt{traci.vehicle.getRoute(veh)\quad\text{Find subroute: current location to intersection}}
2. \texttt{get\_ETA(veh, distance)\quad\text{Check for bus stops before intersection}}

- Current distance and speed data
- Service time of last stop
- Distance from stop to intersection and speed data

\[\text{ETA} = \text{current distance and speed data} + \text{service time of last stop} + \text{distance from stop to intersection and speed data}\]
Methodology: Prioritisation Logic

- **prio_bus** receives priority scheme at selected timing.
- Priority scheme is implemented.
- Scheme is checked for correctness.
- ETA > maximum switch time:
  - **False**: Return to normal signal program.
  - **True**: Scheme is checked for correctness.
**Methodology: Simulation Scenarios**

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SameRegSamePrio</strong></td>
<td><strong>SameRegDiffPrio</strong></td>
<td><strong>DiffRegDiffPrio</strong></td>
<td><strong>SameRegDiffPrio_Off</strong></td>
</tr>
<tr>
<td>Same Priority Level</td>
<td>Different Priority Levels</td>
<td>Different Priority Levels</td>
<td>Different Priority Levels</td>
</tr>
<tr>
<td>A</td>
<td>A and D</td>
<td>B and C</td>
<td>A and D</td>
</tr>
</tbody>
</table>

- **Registration at the same time**
  - Scenario 1: SameRegSamePrio, Same Priority Level A
  - Scenario 3: DiffRegDiffPrio, Different Priority Levels B and C

- **Registration at different times**
  - Scenario 2: SameRegDiffPrio, Different Priority Levels A and D
  - Scenario 4: SameRegDiffPrio_Off, Different Priority Levels A and D

- **Time Periods**
  - 7 - 8 am
  - 10 - 11 am
Results
Results: Travel Time

Mean Travel Time for each Scenario compared to the Non-Priority Scenario

- 87% (-56 sec)
+ 126% (+18 sec)
No change

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Results: Number of Stops

Mean No. of Stops for each Scenario compared to the Non-Priority Scenario

1: SameRegSamePrio  2: SameRegDiffPrio  3: DiffRegDiffPrio  4: SameRegDiffPrio_Off

- Prioritised Bus: + 44% + 0.38 stops
- No change
- Eliminating all stops
Results: Summed Queue Lengths

Start of Prioritisation

2: SameRegDiffPrio

+ 120 %

Elimination of queues

Start of Prioritisation

4: SameRegDiffPrio_Off

Quick improvement to pre-prioritisation levels

+ 500 %
Limitations and Next Steps
Limitations and Next Steps

1. Accuracy of ETA function
2. Limited testing scenarios
3. Spatial limit of prioritisation effects

1. Addition of simulation scenarios and improved prioritisation functions
2. Extension of prioritisation procedure to more intersections
Summary
Summary

Flexible prioritisation procedure feasible
Based on V2X communication
In a near-future scenario

Prioritisation hierarchy developed
Based on delay and occupancy instead of FCFS
Prioritisation timings based on ETA and priority levels

Testing scenarios showed
High reductions in travel time, stops and queue lengths possible
Temporary negative effects are less than prioritisation benefits
Thank you for your attention!