Transit Signal Priority based on Connected Vehicle Technology (TSPCV)

**Presenter:** Jia Hu, PhD

Diagram showing connected vehicle technology (V2I, V2V, V2I) interactions with traffic signals and vehicles.
How TSPCV Looks Like

- Signal adjusts timing schedule to let transits pass
- Transit changes speed to cooperate
- Estimate flow using CV information
Highlights: Green Re-allocation

- Move green time instead of “add” green time
- Remaining queue is considered
- Optimize green start time to minimize per person delay
How Much Benefit?

Bus Travel Time

Green Extension

Green Truncation

Bus Travel Time (Sec)

TSP Activation Time (Sec)

How Much Benefit?

Green Extension

Green Truncation

Bus Travel Time

TSP Activation Time (Sec)

How Much Benefit?

Green Extension

Green Truncation

Bus Travel Time

TSP Activation Time (Sec)
Conflict Requests

Upgrades: Multiple buses accommodation
1. Simultaneous accommodation
2. Sequence accommodation
3. Partial accommodation

TSPCV Logic (Conflict Requests)

Fig. 3. The structure of TSPCV-M.
Highlights: Green Re-allocation

Upgrades: Simultaneous accommodation
Other Technical Highlights

**Transit-Signal Cooperation:** not only the traffic controller alters its timing plan to accommodate the buses, but also the bus adjusts its speed to match the granted green window.

**Simultaneous TSP:** capable of providing TSP to multiple buses within one single TSP green time.

**Conditional TSP Grant:** TSP green time is granted conditionally based on two criteria which are schedule adherence and delay per person.
## Performance

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delay Saving</strong></td>
<td><strong>Trade-off</strong></td>
<td><strong>Insights</strong></td>
</tr>
<tr>
<td>Beneficial under all levels of v/c ratios. It reduces average bus delay between 5% and 48%.</td>
<td>No adverse effect was observed under all congestion levels. Hence, the proposed TSP minimizes installation and maintenance cost.</td>
<td>Provides more preference to buses major street under most traffic conditions, but switches its preference to the minor street under near capacity condition</td>
</tr>
</tbody>
</table>
Progression

Additional TSP green ➔ Maintain Progression
TSP w/o progression ➔ No benefit
It is not a problem conventional TSP bears

TSPCV Logic (Progression)

Component I

Start

Bus detected?

Yes

Behind schedule?

No

No

Identify downstream intersections that are closely located

Compute TSP timing plan so that buses can get through the intersections without impedance

Determine recommended speed for the bus

Component II

Component III

Compute delay per person at the intersections with & without TSP

Run the normal signal

Will delay per person increase?

Yes

No

Run the TSP solution

End
Technical Upgrade Highlights

**Rolling Horizon Framework:**
optimize signal plan for the adjacent downstream intersection only; optimization starts again as soon as the bus passes the first intersection.

**Coordination Among Signals:**
Closely located intersections are considered together as a whole system.
### Performance

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delay Saving</strong></td>
<td><strong>Trade-off</strong></td>
<td><strong>Insights</strong></td>
</tr>
<tr>
<td>Beneficial under all levels of v/c ratios. It reduces average bus delay between 35% and 75%.</td>
<td>Almost no adverse effect was observed under all congestion levels. Hence, the proposed TSP minimizes installation and maintenance cost.</td>
<td>Benefit changes with v/c ratios (peak at 0.7) and intersection spacing (best between 0.24 to 0.5 mile)</td>
</tr>
</tbody>
</table>
Implication: Eco Approach

Fuel Saving 10-44%

Throughput <11% Increase

This vehicle controller optimizes the entire traffic flow (including CAVs and human-driven vehicles) for mobility and fuel efficiency by giving speed commend to CAVs.

Contact

Dr. Jia Hu

• Email: jh8dn@virginia.edu

• ResearchGate Link
  • https://www.researchgate.net/profile/Jia_Hu15
  • All my related papers are available through the link