Dynamic Traffic Assignment (DTA)

“DTA describes time-varying network and demand interaction using a behaviourally sound approach” - TRB

What is DTA?
- Is a model to understand road network performance
- Input → demand, network topology
- Output → optimal solution to the problem
- Solution types: System Optimal (SO), User Equilibrium (UE), bi-level

Applications:
- Network modeling and analysis
- Inter-zonal travel cost
- Identify congested link → Network Design Problem (NDP)
The theme of the research

To propose realistic traffic signal control models for the Dynamic Traffic Assignment (DTA) problem

Objectives:

- DTA framework with embedded signal control
- Demand responsive control
- Linear formulation

Traffic Signal Control (SC)

- Controls the traffic movements at the intersection
- Control schemes:
  a) Fixed-SC: green splits are fixed or pre-timed
  b) Traffic actuated: decision variables determines green splits
- Most important property for DTA-SC: linearity
  1. Less complexity and easy to solve
  2. Can be applied to realistic size network
- Existing DTA frameworks with SC
  a) Mixed integer or non-linear: very high complexity and computationally intractable
  b) Continuous (Ukkusuri et al. 2010): Cycle time = discrete time interval of the Network Loading Model. So, unrealistic cycle length
How the roads are modeled?

**Network Loading Model of DTA:** Cell Transmission Model (CTM) → Roads are divided into number of homogeneous segments called cells

Cell length = free flow speed x discrete time interval

Example:

Impact of discrete time interval
Where is the problem?

The only linear-continuous model by Ukkusuri (Ukkusuri et al. 2010):

- 60s CTM = 1km cell length!
- 1s CTM would have 1s cycle length! Not realistic!
- We need a realistic signal control cycle length for reasonably short discrete time slots for maintaining the accuracy and usability of the solution.

Solution: our approach

\[
t = \text{time slot index}, \quad c = \text{cycle start index}, \quad m = \text{cycle length (multiple of time slots)}
\]

\[
c = \left\lfloor \frac{t - 1}{m} + 1 \right\rfloor,
\]

- Strikes balance between accuracy and complexity
- Enables us to set realistic cycle-length
- Linear, continuous, and computationally tractable
Results: the network

Cell representation

<table>
<thead>
<tr>
<th>Cells</th>
<th>All other cells</th>
<th>R1, R2</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qc</td>
<td>12</td>
<td>12</td>
<td>$\infty$</td>
</tr>
<tr>
<td>Nc</td>
<td>36</td>
<td>36</td>
<td>$\infty$</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.5</td>
<td>0.5</td>
<td>$\infty$</td>
</tr>
<tr>
<td>$\nu$</td>
<td>15.24 m/s</td>
<td>15.24 m/s</td>
<td>$\infty$</td>
</tr>
</tbody>
</table>

Structure of optimal green splits

Ukkusuri’s Approach $\rightarrow$ CSDT: Cycle-length Same as Discrete Time

Our method $\rightarrow$ SCRC: Signal Control with Realistic Cycle

MISC: Mixed-integer Signal Control
Performance Vs. complexity

Congestion and adaptation
Conclusion

• SCRC → a novel realistic traffic signal control model
• Linear model and attains solution faster
• Resolves the trade-off → cell-length and signal control cycle-length
• Attains comparable performance to CSDT model
• Adaptive to varying traffic conditions
• Reduces the complexity of the problem substantially