An Overview of Dynamic Traffic Assignment Models

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How do you evaluate...

An important tool: DYNAMIC TRAFFIC ASSIGNMENT
Traffic Assignment Problem

What are the flows in each of the links given the above demand matrix

<table>
<thead>
<tr>
<th>i/j</th>
<th>3</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>125</td>
<td>90</td>
</tr>
</tbody>
</table>
Traffic Assignment Problem

- Supply-Demand Interaction

- Demand – how many trips are made, from where to where, which mode and what routes
  - Behavioral assumption on route choice – selfish routing/user equilibrium

- Supply – given the demand, how does the transportation network operate (uses flow models)
Static Traffic Assignment

- Widely used because
  - Well defined UE principle
  - Elegant mathematical formulation
  - Theoretical properties such as uniqueness
  - Efficient algorithm (Frank-Wolfe, Origin-based, B)

- Extensively used to determine important infrastructure investment decisions
Dynamic Traffic Assignment

- Dynamic Traffic Assignment (DTA) –
  - Traffic assignment problem considering time varying flows
  - Model traffic flow phenomena such as queuing, spillovers, shockwaves
  - Include temporal choice dimensions - departure time, schedule delay

- Address a range of operational applications
  - ATIS, Route guidance, ramp metering, dynamic traffic signals, managed lanes, dynamic pricing etc.
Static versus Dynamic Traffic Assignment

- Classic accuracy versus complexity trade-off
- Unlike Static Traffic Assignment,
  - DTA does not have a single, universally accepted formulation
  - No well-established solution properties
  - Difficult to solve - efficient algorithms are still in development
Traffic Micro-simulation vs. DTA

- Traffic micro-simulation: simulation models of traffic flow captured at the level of individual driver-vehicle entities.
  - Computationally intensive – works for small area networks
  - Supply side model of transportation networks; demand/traveller choice not represented
- DTA: micro-simulation + route choice behaviour
Dynamic Traffic Assignment

- Analytical Models
  - Good theoretical properties
  - Poor Traffic Flow Dynamics

- Simulation Models
  - Poor theoretical properties
  - Good Traffic Flow Dynamics
Existing Analytical Models (Friesz et al. 1993, Ukkusuri and Waller, 2008)

Simplistic e.g. Link exit flow models

Traffic Flow Reality

Strong proofs

More realistic e.g. Cell-transmission model

Theoretical Solution Properties

Weak / Absent

Existing Simulation Models (Mahmassani 2002, Ben-akiva et al., 2001)

Simplistic DTA models
## Analytical DTA Models

<table>
<thead>
<tr>
<th>Physical Queue</th>
<th>Traffic Flow Model</th>
<th>Link Exit Function</th>
<th>Mathematical Programming</th>
<th>Optimal Control</th>
<th>VI / CP</th>
<th>Algebraic/Graphical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Laval (2008)</td>
<td></td>
<td></td>
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<tr>
<td>Model</td>
<td>Traffic flow model</td>
<td>Transportation network</td>
<td>Convergence criteria</td>
<td></td>
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</tr>
<tr>
<td>DynaMIT</td>
<td>Mesoscopic simulation</td>
<td>Link/node</td>
<td>Stops when travellers experience same expected travel time</td>
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</tr>
<tr>
<td>DYNASMART</td>
<td>Mesoscopic simulation</td>
<td>Link/node</td>
<td>Stops when link volume does not change in two consecutive iterations.</td>
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<tr>
<td>Dynameq</td>
<td>Microscopic simulation</td>
<td>Link/node, lane level</td>
<td>Vehicles leaving the origin at roughly the same time have approx, same travel time</td>
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<tr>
<td>VISSIM</td>
<td>Microscopic simulation</td>
<td>Link/connector, lane level</td>
<td>Iterates till volume/travel time on links of network do not change significantly</td>
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<tr>
<td>Aimsun</td>
<td>Microscopic/mesoscopic simulator</td>
<td>Link/node, lane level</td>
<td>The actual travel time experienced by travellers departing at the same time are equal and minimal</td>
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<tr>
<td>Vista</td>
<td>Mesoscopic simulator</td>
<td>Links - Nodes</td>
<td>Stops when a defined gap function does not change significantly</td>
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Simulation DTA Models
DTA: Challenges and Needs

Limitation of simulation DTA models:

- Inability to derive math properties such as solution existence, uniqueness
  1. Develop analytical formulations using advanced traffic flow models with strong theoretical properties

- Solution accuracy vs computational efficiency
  2. Developing efficient heuristics to compute accurate DTA solutions faster

- Capture behavior realism better, particularly from an operational modeling context,
  3. need to consider additional choice dimensions
Route Choice
- DynaSMART (Mahmassani, 2002), DynaMIT (Ben-Akiva et al., 2001, 2002), VISTA (Z & Waller, 2000), Dynameq (Mahut at al. 2005) etc.

Departure Time

Activity Choices / Location
- Abdelghany et al. (2001, 2003), Lam and Huang (2003), Kim et al. (2006), Rieser et al. (2007)

Activity Duration
- Ramadurai and Ukkusuri (2008)
Thanks!

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