Dynamic Traffic Assignment with Dynameq

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Agenda

1. Overview of primary DTA components
   1. Traffic/supply model
   2. Assignment/routing model

2. Overview of the Dynameq traffic simulator

3. Data requirements

4. Calibrating a DTA model
iterative solution framework

START

Network definition

Time-dependent OD matrices

Traffic Control Data

Compute initial paths

Allocate input flows to paths

Compute the new set of available paths

Traffic simulation: Collect results for each movement, link and lane

7:00 - 7:15

Calculate path travel times

Stopping criteria satisfied

no

yes

DONE

Dynamic Traffic Assignment with DynaEq
iterative solution framework

1. Network definition
2. Time-dependent OD matrices
3. Traffic Control Data
4. Compute initial paths
5. Allocate input flows to paths
6. Compute the new set of available paths
7. Traffic simulation: Collect results for each movement, link and lane
8. Calculate path travel times
9. Stopping criteria satisfied

inputs

Routing/assignment model

Supply/traffic model

time-dependent shortest path (TDSP)
supply/traffic model

three basic components

- Longitudinal dynamics (flow propagation)
- Lane-based effects
- Intersection model and traffic control options
  - not elaborated upon here: level of detail closely tied to the above two bullets
### Overview of Model Types

<table>
<thead>
<tr>
<th>MODEL TYPE</th>
<th>SUB-TYPE</th>
<th>PARADIGM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical</td>
<td>Modified analytical</td>
<td>volume-delay function (VDF) with additional constraints</td>
</tr>
<tr>
<td>Flow-based</td>
<td>Hydrodynamic</td>
<td>speed-flow-density relationship</td>
</tr>
<tr>
<td>Microscopic</td>
<td>Simplified car-following (CF)</td>
<td>position(t) = F(\cdot)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or, speed(t) = V(\cdot)</td>
</tr>
<tr>
<td></td>
<td>Conventional car-following (CF)</td>
<td>acceleration(t) = A(\cdot)</td>
</tr>
</tbody>
</table>
Dynamic Traffic Assignment with Dynameq

flow propagation

speed-flow-density (v-q-k) relationship

BPR function

Flow vs. Density

Travel time vs. Volume

[Graphs showing flow vs. density and travel time vs. volume]
Flow propagation

Speed-flow-density (v-k-q) relation properly represents both congested and uncongested regimes.

**Flow vs. Density**

- **Flow (veh/hr)** vs. **Density (veh/km)**
- Curves for BPR and v-q-k models

**Travel time vs. Volume**

- **Travel time (min)** vs. **Volume (veh)**
- Curves for BPR and v-q-k models

Dynamic Traffic Assignment with Dynamiq

1 - 8
lane-based effects

Properties of traffic on multi-lane facilities

- Non FIFO (First-In-First Out) behaviour
- Capacity reductions, due to *interactions between vehicles exiting by different movements*
  - Single-lane queue spilling across to neighbouring lane: chokes off link capacity
  - Weaving effects on freeways
- Example: evaluating impact of interchange design
  - on-ramp moved from outside edge of roadway to inside edge in order to reduce weaving: model must capture weaving effects in order to measure the improvement
Traffic Models: Summary

- Different DTA models have different levels of fidelity of the traffic representation.
- Different model applications require different levels of fidelity:
  - must think critically about the required level of fidelity before deciding which model to use.
- DTA models are more realistic than static models, but also more sensitive (less forgiving) to errors in input data.
No DTA model that satisfies even the minimum desired criteria for traffic realism (e.g. flow propagation) can simultaneously have the “nice” mathematical properties found in static models, i.e. existence and uniqueness of solution.

However, reasonable inputs will produce reasonable outputs:
- Stable solution and well converged

DTA models that have been proven in practice have “similar” routing models: i.e. with the same supply model they would produce similar results.
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4. Calibrating a DTA model
Overview of the Dynameq traffic simulator

Link Model

- Longitudinal dynamics: uses “simplified” car-following model
- Lane selection / lane changing captures various traffic phenomena specific to multi-lane facilities

Node Model

- Employs detailed traffic signal plans
- Default gap-acceptance parameters for priority (yield) behavior at stops, merges, & roundabouts

Traffic Control

- Pre-timed (fixed) multi-plan schedules for intersections and ramps
Properties of model on multi-lane facilities

- Non FIFO (First-in-first out) behaviour
  - E.g: vehicles going straight through overtaking vehicles waiting to turn

- Lateral spill-over of congestion across lanes
  - Interaction between vehicles exiting by different lanes: over-saturation of one movement has choke-effect on other movements

- Weaving effects
  - Leads to drop in capacity
“Simplified” car-following model

\[ x(t,n) = \text{MIN}[x(t - R, n) + VR, x(t - R, n - 1) + L] \]

variables
\( t \quad = \text{time} \)
\( n \quad = \text{vehicle number by order of arrival to lane} \)
\( x(t,n) \quad = \text{position of } n \text{ at } t \)

parameters
\( L \quad = \text{effective vehicle length} \)
\( R \quad = \text{driver/vehicle response time} \)
\( V \quad = \text{free-flow speed} \)
Fundamental diagram

\[ V = \text{free-flow speed} \]

\[ Q = \frac{1}{L/V + R} \]

\[ K = \frac{1}{L} \]

\[ W = \frac{L}{R} \]
Vehicle trajectories (1)

Traffic signal at link exit

![Vehicle trajectories graph](image)
Vehicle trajectories (2)

Freeway merge at link exit
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Data for model building and calibration

- **System description**
  - Network and traffic signals
- **Empirical traffic data**
  - Traffic counts, queue lengths, travel-time runs
- **Demand data**
  - Time-varying O-D tables
Network and traffic control

- Generally has the *lowest* uncertainty of the 3 groups
- Errors that are found can usually be corrected: i.e. can always find out what the correct value is in the field

Traffic measurements

- Should have good spatial coverage; time varying
- Typically come from different sources: can be contradictory and requires data cleaning / adjustment
- Concept of splitting data into 2 sets (calibration and validation): better to use as much data as possible for calibration
Demand data

- Generally has the *highest* uncertainty of the 3 groups
- Adding a time-varying profile adds even more uncertainty: avoid tendency towards high precision
  - E.g. rarely need to go below 30 minute intervals
- When calibrating: the higher realism of DTA also makes it harder on (less forgiving of) the inevitable errors in the demand data:
  - Generally, some amount of demand adjustment, automated or manual, is expected in order to produce a calibrated baseyear application
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Some basic observations

- Must always check convergence and stability before investigating the more detailed outputs:
  - Do not take for granted that solution is valid
- Most challenging issues in analysing outputs are probably:
  - Extent to which effects can be non-local (example next slide)
  - Extent to which a single error can produce extreme congestion (example next slide)
- Path analysis (e.g. select link analysis) is probably the most powerful tool for (manual) calibration
  - Example next slide
Calibration – 2: Example

Select Link analysis at 8:00 am

Due to coding error the road is blocked, resulting in re-routing and excessive congestion here.