Dynamic Assignment Models and their Application in the Portland Metro Region

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Oregon Metro

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Dynamic Assignment Models
and Their Application in the Portland Metro Region

Peter Bosa, Metro Research Center

TREC Friday Seminar
March 17th, 2017
Presentation Outline

• Metro Transportation Modeling
• Macroscopic models (static assignments)
• Microscopic models (microsimulations)
• Mesoscopic models (dynamic assignments)
• Examples and Applications
• Next Steps
Metro Transportation Modeling
Metro Research Center, Modeling Services

- Metro is regional MPO

- Research Center provides data and analytics and data services to internal/external clients

- Modeling Services focuses on transportation and land use models
  - Regional land use / transportation planning
    - (Clackamas, Multnomah, Washington counties)
  - Multiple jurisdictions
    - (State, County, City)
  - Long-range plans (20+ years)
  - Corridor-level studies
  - Air conformity analysis
Metro Transportation Modeling
Past and current measures of system performance

• Comparison of differences between alternatives

• Traditional modeling
  • What are volumes, average speeds and travel times along major corridors?
  • Where are the trouble spots? (ex, v/c >0.90)
  • ‘Build’ way out of congestion…

• Moving forward…
  • Networks becoming increasingly congested
  • ‘Building’ way out of congestion no longer feasible
  • Emphasis is turning toward better management of the existing system
    – Queues, Duration of Congestion, Reliability

• Current tools…
  • Not enough temporal detail to capture congestion at a regional scale
  • Not capable of providing operation-level detail at a regional scale
Metro Transportation Modeling
Metro Transportation Modeling
Travel Demand Modeling

- Travel demand:
  - How much?
  - Between which locations (and when)?
  - By which method?
  - By which route?

- Travel demand modeling process
  - Trip Generation
  - Trip Distribution
  - Mode Choice
  - **Trip Assignment**

- Assignment
  - **Vehicle** (SOV, HOV, Truck)
  - Transit
  - Non-motorized (Bike, Ped)

Source: Metropolitan Washington Council of Governments - www.mwcog.org
Metro Transportation Modeling
Spatial analysis zones

• Region divided into 2,100+ Transportation Analysis Zones (TAZs)
Metro Transportation Modeling
Transportation networks

- Major transportation facilities connected to TAZs
  - Freeways, major/minor arterials, major collectors
  - Transit network
Macrosimulations (static assignments)

- Deterministic models based on relationships of speed and density of traffic on the network

- Trips are aggregated into time-periods by zone pair, NOT simulated as individual vehicles (ex., PM 2-hr, AM 4-hr, MD 1-hr)

- Vehicle classes (SOV, HOV, Truck) are homogenous
  - All SOVs are alike, all HOVs are alike…
Macrosimulations

• Pros:
  • Route choice capability
  • Integration with regional travel demand models
  • Computationally fast, work well at regional scale

• Types of outputs:
  • Total volume
  • Volume-to-capacity ratios
  • Average speed
  • Average travel times
Macrosimulations

- Example of path set from Portland CBD to downtown Gresham

<table>
<thead>
<tr>
<th>Path #</th>
<th>Travel Time</th>
<th>Speed</th>
<th>Length</th>
</tr>
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<tbody>
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<tr>
<td>2</td>
<td>34min 10s</td>
<td>23</td>
<td>13.01</td>
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<tr>
<td>3</td>
<td>33min 57s</td>
<td>23</td>
<td>12.79</td>
</tr>
<tr>
<td>4</td>
<td>34min 13s</td>
<td>22</td>
<td>12.55</td>
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<tr>
<td>5</td>
<td>34min 11s</td>
<td>28</td>
<td>15.96</td>
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<td>6</td>
<td>34min 12s</td>
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<td>11</td>
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<td>17</td>
<td>33min 6s</td>
<td>23</td>
<td>12.64</td>
</tr>
</tbody>
</table>
Macrosimulations

• **Cons:**
  - Total demand assigned regardless of capacity
    - Volume-to-capacity ratios can exceed 1.0
    - No queuing
  - No temporal information about analysis period
  - Aggregate trip tables

• **Cannot produce certain outputs:**
  - Queue formation, spillback
  - Duration of congestion
  - Individual vehicle profiles
    - Emissions, pricing
Macrosimulations

Volume-to-Capacity Ratios > 1.0

No real bottlenecking / queuing
Microsimulations

- Stochastic models based on car-following and driver behavior rules and infrastructure design
  - Accelerating, Decelerating, Merging, ‘Politeness’, Gap Acceptance…
  - Ramps, aux lanes, traffic signals, decision points
- Simulation of individual vehicles in very small time frames (sub-second)
  - Able to extract data with continuous temporal dimension
- Vehicles confined to ‘capacity’ of roadway
  - Development of bottlenecks, queues
Microsimulations

**Pros:**
- Very precise, high detail
- Operational characteristics of infrastructure design
- Individual vehicles
- Temporal dimension to data

**Sample outputs:**
- Space-time diagrams
- Individual vehicle trajectories
  - Emissions, pricing
- Queue analysis
- Intersection analysis
Microsimulations

Source: commons.wikimedia.org

Source: www.youtube.com
Microsimulations

- Space/Time speed diagrams
- Temporal analysis of data
Microsimulations

Cons:
- Time consuming to develop, calibrate
- Computationally intensive
- Vehicle paths are often fixed
  - Route choice capability not always present
  - Diversion to other paths limited by size of network
- Can overestimate delay, underestimate speeds
- Not ideal for use with raw outputs from regional travel demand models
Microsimulations

Source: commons.wikimedia.org
Mesosimulations (dynamic assignment)
Mesosimulations

- Model large sub-areas / regional networks
- Maintain route choice capability of macro-models
- Simulate individual vehicles continuously through time like micro-models
- Can be either deterministic OR stochastic
Mesosimulations

- Vehicles are limited to carrying capacity of networks
  - Traffic builds through time
  - Bottlenecks / queues develop
  - Trip characteristics change through time
    - ex, 4pm vs. 5pm vs. 5:30pm

- Provides necessary detail for answering current policy questions
  - Location and duration of congestion
  - Congestion management / pricing (tolling)
  - Reliability
  - GHG analysis
Mesosimulations

Media #1
Mesosimulations
Temporal advantages of DTA

**Flow rates at location between 3PM and 6PM**

- **Detector**
- **DTA**
- **Static**

<table>
<thead>
<tr>
<th>Time</th>
<th>Vehicles per lane per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00 PM</td>
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<td>3:15 PM</td>
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<td>1440</td>
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<tr>
<td>5:30 PM</td>
<td>1445</td>
</tr>
<tr>
<td>5:45 PM</td>
<td>1450</td>
</tr>
</tbody>
</table>
Mesosimulations
Temporal advantages of DTA

Change in travel time for vehicles traveling entire route between 4PM and 6PM
Mesosimulations
Measuring reliability using DTA stochasticity

- DynusT simulation is stochastic
  - Simulation of trips every 6 seconds can be allowed to vary randomly

- 20 assignment runs with same network and trip tables
  - Each assignment run to acceptable convergence (50 iterations)
  - Graph differences in travel time

Vs.
Mesosimulations
Measuring reliability using DTA stochasticity

Change in travel time for vehicles traveling entire route between 4PM and 6PM

Original network
Mesosimulations
Measuring reliability using DTA stochasticity

Change in travel time for vehicles traveling entire route between 4PM and 6PM

Original network
Mesosimulations
Measuring reliability using DTA stochasticity

Change in travel time for vehicles traveling entire route between 4PM and 6PM

Addition of lane to relieve bottleneck
Mesosimulations
Measuring reliability using DTA stochasticity

Change in travel time for vehicles traveling entire route between 4PM and 6PM

Comparison of original network to alternative network
Mesosimulations

Media #2 and #3
Application - SHRP2 L35 Research
Variable Message Signs (VMS)

Source: Wikimedia Commons
Application - SHRP2 L35 Research
Impact on Transit Mode Share

- BRT in mixed traffic
- BRT in exclusive ROW via add lane
- BRT in exclusive ROW via take lane
Mesosimulations

Media #4
Next steps

• Continue applying in corridor-level studies

• Implement at regional scale for use in regional studies

• Develop transit components of DTA
  • Necessary to create comparable travel times for use in demand model

• Integrate with current trip-based travel demand model

• Integrate with future regional dynamic transportation activity-based model
  • Simulates individuals, no longer just households
  • Continuously update potential departing time and mode choices

• Integrate with MOVES (air quality and emissions analysis)

• Eventually, every assignment will be DTA
Questions?

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DTA Primer
Available from Transportation Research Board’s Transportation Network Modeling Committee
www.nextrans.org/ ADB30