Incorporation of ABM-Derived Transit Demand into a DTA

Mark Hickman
University of Arizona
mhickman@email.arizona.edu

August 24, 2012
Research and Implementation

- Modeling the Urban Continuum in an Integrated Framework: Location Choice, Activity-Travel Behavior, and Dynamic Traffic Patterns
  - Sponsor: FHWA EAR Program
  - PI: Ram Pendyala, ASU
Research and Implementation

- SHRP2 C10-B: Partnership to Develop an Integrated, Advanced Travel Demand Model and a Fine-Grained, Time-Sensitive Network
  - Sponsor: SHRP2, Project C10-B
  - PI: Tom Rossi, Cambridge Systematics

- Modeling Dynamic Transit Travel for San Francisco County
  - Sponsor: SFCTA, University of Arizona
  - PI: Elizabeth Sall / Mark Hickman
Research Contributors

- U of A Transit Research Unit  http://transit.arizona.edu/
  - Hyunsoo Noh
  - Alireza Khani
  - Sang Gu Lee
  - Neema Nassir

- Sacramento Area Council of Governments  (SHRP2 C10-B)

- San Francisco County Transportation Authority
Dynamic Transit Demand Modeling

Motivating Questions:

- How do we model transit use on tours, not just trips?
  - Constraint on mode choice throughout tour
  - Restrictions on time-of-travel from transit schedule
  - Realistic transit path choice modeling
  - Intermodal path choice / station choice
  - Agent-based simulation

- How do we capture realistic passenger level of service?
  - Schedule-based transit services, by time-of-day
  - Operational dynamics of transit service
  - Allowing for delays, missed transfers, crowding
Software Requirements

Need for a versatile simulation and assignment tool that:

- Captures operational dynamics for transit vehicles
- Connects with Dynamic Traffic Assignment (DTA) software
- Captures individual traveler assignment and network loading in a multi-modal context
- Becomes and remains open-source

**Flexible Assignment and Simulation Tool for Transit and Intermodal Passengers**
High-level Design Approach

- Let the DTA models do what they do best
  - Assign paths to individual vehicles
    - Fixed-route transit vehicles have a pre-specified path, at a given time
  - Simulate traffic operations for millions of vehicles
  - Simulate transit vehicle movements
    - Vehicles follow traffic flow rules
    - Individual vehicle trips can have modest controls

- Create a separate tool that integrates with DTA
  - Assigns individual passengers to routes, by time-of-day
  - Simulates transit passenger movements based on DTA output
  - Provides skim information for feedback to travel demand models
  - Manages full assignment, transit simulation for intermodal trips
Transit Vehicle Movements in DTA

- Routes are designated by specific paths for transit vehicles
- Transit vehicles leave terminals at designated scheduled times or at specific headways
- Transit vehicles move through the network
  - Mesoscopic flow characteristics while in the traffic stream
  - Pull-outs and/or curbside traffic behavior
  - Specific modeling of hail stops, dwell times:
    - Track number of passengers at or desiring specific stops
    - Use incremental boarding and alighting time model
      \[ \text{Dwell time} = \max \{ b_1 B, b_2 A \} \]
- Trajectory output includes transit vehicle departure times at all stops, travel times along route
Transit Assignment

- Transit assignment: Passenger path choice
  - Deterministic model: Shortest or least-cost, time-dependent path
  - Stochastic model: Discrete choice among all paths serving origin and destination at a given time

- Solution method
  - Direct calculation of stop and path choice in uncongested conditions
  - Iterative convergence of an assignment to a user equilibrium, if capacity constraints apply (heavily congested routes)

- Time-dependent path calculations can exploit GTFS data, transfer stop / station hierarchy
Transit and Intermodal Loading

DTA Output
- Auto arrivals at Park-and-Ride Lots
- Transit Vehicle Trajectories

FAST-TrIPs
- Transit Passenger Assignment
- Passenger arrival time, stop, boarding behavior

Passenger Accounting (Simulation)
- Vehicle Pax 1 Pax 3 Pax 6 ...
- Stop Pax 4 Pax 8 Pax 12 ...

Transit Skims and Passenger Measures
- Passenger experience

Transit Vehicle Operating Statistics
- Transit vehicle movements

Feedback to next iteration
Transit Simulation / Passenger Loading

- Passenger “loading” to queue at stops
  - Origin departure time + bike or walk access time
  - Arrival time at stop for auto access, transit transfers
  - Priority treatment based on arrival time

- Vehicle “loading” at stops
  - “Hail stop” operations
  - Passengers “alight” from vehicle: transfer to another stop queue, or egress (bike, walk, auto) to destination
  - Passengers “board” from stop to vehicle, according to individual assignment (in priority order)
  - Transit vehicle held until max of \{ dwell time, holding time \}

- Passengers denied boarding / missing a vehicle are re-assigned
Iterative Process through Dwell Times

1. ABM Output: Trip and Tour Rosters
2. Google GTFS and transit line information
3. Transit Route Network and Stops
4. Route Schedule (Stop-Times)
5. FAST-TrIPs Transit and Intermodal Assignment and Simulation
6. Dwell Times updated by passenger loading from latest transit vehicle trajectories
7. AUTO Access trips
8. AUTO Skims for $O,D,t$
9. Transit Vehicle Trajectories
10. DTA Assignment and Simulation
Transit Skims and Operating Statistics

- Transit operating characteristics
  - Transit vehicle trip travel times, by route segment (DTA)
  - Transit vehicle loads, by route segment (FAST-TrIPs)

- Passenger experience
  - Passenger travel times, costs from experienced paths
  - Passengers denied boarding due to capacity constraints
  - Passengers missing connections on scheduled service
Experience with FAST-TrIPs

- FHWA EARP: Modeling the Urban Continuum
  - ABM: OpenAMOS
  - DTA: MALTA (Mesoscopic Assignment and Loading of Traffic Activities)
  - ABM and DTA simulate the day in parallel, then iterate
  - Phase I case study (Phoenix / MAG) uses auto mode only

- SHRP2 C10-B
  - ABM: DaySim
  - DTA Model: DynusT (Dynamic Urban Systems in Transportation)
  - ABM and DTA simulate the day in series, then iterate
  - Entering transit model calibration and scenario modeling with SACOG
Experience with FAST-TrIPs

- **SFCTA: Modeling Dynamic Transit Travel for San Francisco County**
  - ABM: SF-CHAMP
  - DTA: Dynameq
  - ABM and DTA simulate the day in series, then iterate
  - SFCTA has a stochastic transit path choice model

- **Case study:**
  - Develop network interface with Dynameq
  - Generate transit network and schedule using GTFS
  - Estimate time-of-day use from automated passenger count data
  - Apply deterministic and stochastic path choice models
  - Validate using passenger boarding, alighting, loading
Travel by Time of Day from APC data
SFCTA Stochastic Path Choice Model Weights

Coefficient values relative to in-vehicle time = 1.0

<table>
<thead>
<tr>
<th>Mode</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Wait</td>
<td>2.23</td>
</tr>
<tr>
<td>Transit Access Walk</td>
<td>1.83</td>
</tr>
<tr>
<td>Transit Egress Walk</td>
<td>5.39</td>
</tr>
<tr>
<td>Transfer Walk</td>
<td>7.45</td>
</tr>
<tr>
<td>Bike (mode)</td>
<td>2.56</td>
</tr>
<tr>
<td>Walk (mode)</td>
<td>2.70</td>
</tr>
</tbody>
</table>
# FAST-TrIPs and DTA Results: PM Peak Period

<table>
<thead>
<tr>
<th></th>
<th>Deterministic</th>
<th>Stochastic</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Global Iterations</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Dwell Time Gap (%)</td>
<td>61</td>
<td>64</td>
</tr>
<tr>
<td># of FAST-TrIPs Iterations</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>CPU Time (min)</td>
<td>92</td>
<td>203</td>
</tr>
<tr>
<td>Transit Demand (trips)</td>
<td>85,665</td>
<td>85,665</td>
</tr>
<tr>
<td>Capacity Violation (%)</td>
<td>1.67</td>
<td>1.72</td>
</tr>
<tr>
<td>Avg Travel Time (min)</td>
<td>25.31</td>
<td>25.94</td>
</tr>
<tr>
<td>Avg # of Transfers</td>
<td>0.71</td>
<td>0.72</td>
</tr>
<tr>
<td>Avg Dwell Time (sec)</td>
<td>8.1</td>
<td>8.8</td>
</tr>
</tbody>
</table>
Transit Capacity Violations
FAST-TrIPs Load Profile Results

- Route 38 outbound, PM peak average load
Load Profile Results

- Route 38 outbound, 17:47 vehicle trip
Convergence Measures (Dwell Time Gap)
On-going Research

- SHRP2 C10-B
  - Model calibration for SACOG
  - Scenario development using Line files -> GTFS
  - Formal open-source release

- SFCTA
  - Further model validation
  - Feedback with DTA (Dynameq) and with ABM (SF-CHAMP)
  - Experiment with service reliability

- EAR Program
  - Possible Phase II application with transit