SimMobility Freight: An Agent-Based Urban Freight Simulator for Evaluating Logistics Solutions

Presenters
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MIT-ITS Lab
Outline

• Overview of SimMobility (*Peiyu Jing*)

• Urban Freight Modelling (*Takanori Sakai*)
  - Business-to-Business
  - E-Commerce

• Application to Last-mile Solutions (*André Alho*)

• Conclusion
Overview of SimMobility


SimMobility: Overview

• **SimMobility**
  An agent-based demand and supply urban transportation simulation platform including passenger and freight (B-to-B & E-commerce)

• **Key Features**
  - Temporal dimensions (long-term, mid-term, short-term)
  - ‘Smart’ mobility services (e.g. on-demand and shared)
  - Dynamic plan-action activity-based
  - Supply agents (inc. fleet/infrastructure management)
  - Open source
SimMobility Agents

• **Demand**
  - Individuals
  - Households
  - Establishments/firms (shippers, receivers)

• **Supply**
  - Transit operators
  - Fleet operators/managers
    (on-demand services, taxis, freight carriers)
  - Network regulators
    (pricing, information, traffic control)
  - E-commerce vendors
  - Real-estate developers
SimMobility Structure

Households and establishments

**LONG-TERM**
Locations and shipments

HH/Firm locations
Fleets/Parking
Shipments

Accessibility
Logistics performances

**MID-TERM**
Activities and deliveries

Tours
Trip chains
Fleet operations schedule

Performance measures

**SHORT-TERM**
Operations
SimMobility Applications

- New modes and services
- Traffic management
- Last-mile solutions
- Post-pandemic scenarios
- Disruptions
- Land-use
- Infrastructure
Prototype Cities

**Auto Sprawl**
- Metro
- Network
- BRT
- Sustainability
- Inefficiency
- Congestion
- Population
- Wealth

**Auto Innovative**
- Metro
- Network
- BRT
- Sustainability
- Inefficiency
- Congestion
- Population
- Wealth

**Innovative Heavyweight**
- Metro
- Network
- BRT
- Sustainability
- Inefficiency
- Congestion
- Population
- Wealth

*Cities:* Baltimore, Boston, Singapore
Urban Freight Modeling


<table>
<thead>
<tr>
<th>Freight Models</th>
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</thead>
<tbody>
<tr>
<td><strong>Long-term</strong></td>
</tr>
<tr>
<td>Establishments/Fleets/Overnight Parking</td>
</tr>
<tr>
<td>Shipments</td>
</tr>
<tr>
<td><strong>Mid-term</strong></td>
</tr>
<tr>
<td>Preday Logistics Planning</td>
</tr>
<tr>
<td>Within-day Vehicle Operations</td>
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<tr>
<td>Mesoscopic Traffic Simulation</td>
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<tr>
<td><strong>Short-term</strong></td>
</tr>
<tr>
<td>Microscopic Traffic Simulation</td>
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</tbody>
</table>
B-to-B Shipments

Establishments

Freight Generation
  Commodity Choice
  Annual Production and Consumption

Shipper Contracts
  Contract Allocation
  Shipper Selection

Shipment Size & Frequency

Shipments
E-Commerce Demand

- E-commerce *shipments* to households
- *Groceries, HH Goods,* and *Others*
- *Demand* (frequency, expenditure) is sensitive to *delivery options* (speed, fee, home delivery/pickup)

Example of Home Delivery Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Speed</th>
<th>Fee</th>
<th>Window</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2-5 days</td>
<td>US$0</td>
<td>No window</td>
<td>Daytime</td>
</tr>
<tr>
<td>2</td>
<td>One day</td>
<td>US$12</td>
<td>No window</td>
<td>Daytime</td>
</tr>
<tr>
<td>3</td>
<td>Same day</td>
<td>US$18</td>
<td>4 hr</td>
<td>Daytime and evening</td>
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</tbody>
</table>
E-Commerce Shipments

Households

Household-based E-Commerce Demand

- EC Adoption
- EC Expenditure
- Order Value
- Delivery Option

Delivery Order

Distribution Facility

Shipments
Freight Mid-term

Pre-day Logistics Planning

- Carrier Selection
- Vehicle Operations Planning

Vehicle Tours

Within-day Vehicle Operations

- Route Choice
- Parking Choice

Supply

Day-to-day Learning
Freight Demand Example

- Freight (and Passenger) models applied to Auto-Innovative Prototype City (Boston as archetype)

- B-to-B and E-commerce demand were calibrated based on available statistics
Recent Freight Applications

• Overnight freight vehicle parking
• Freight consolidation centres
• Night/Off-peak deliveries
• Route restrictions

In this presentation
• Freight-on-Demand
Application to Last-mile Solutions

Case Study: Freight on Demand

- E-commerce deliveries
  - Increasingly on-demand
  - Smart solutions...leverage Mobility-On-Demand (MOD) capacity?

Source: https://www.straitstimes.com/
Freight on Demand Questions

• Potential deliveries by MOD vehicles:
  - how many deliveries can be handled?
  - time gap between request and pickup/delivery?

• Impact on passenger trips: how service levels may change when adding freight demand?
Freight on Demand Scenarios

- Singapore 2030
- MOD algorithm by the ITS Lab
  - Schedule solo and shared passenger rides
- Assign E-commerce shipments to previously committed and/or idle MOD vehicles

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Freight in MOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOD only (Base)</td>
<td>None</td>
</tr>
<tr>
<td>A</td>
<td>MOD shared</td>
</tr>
<tr>
<td>B</td>
<td>MOD shared and idle vehicles</td>
</tr>
<tr>
<td>C</td>
<td>Restricted &quot;B&quot;</td>
</tr>
</tbody>
</table>
Freight on Demand Results

- Increase in requests handled by the MOD operator
  - Small change to MOD passenger service.

- Scenario
  - A: ~50% delivery demand; long waiting times
  - B: ~100% delivery demand; shorter waiting times
  - C: reduces impact on passenger peak period travel

- Small reduction in total VKT observed

- Potential for emissions reduction by using electric MOD vehicles
Conclusion

• SimMobility is a comprehensive platform that jointly simulates passenger, B-to-B, and E-commerce flows.

• Ongoing research:
  - Enhance E-commerce model (supply-side, trip/E-commerce interaction)
  - Application to congestion pricing with passenger and freight
  - New technologies for last-mile solutions
  - Post-pandemic scenarios
Open Source Release

- MT Models code
- Input Demo data (low computational requirement)
- Wiki and User Forum

https://github.com/smart-fm/simmobility-prod
Thank you for listening

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