Multi-Agent Transport Simulation (MATSim)
Outline

- Travel demand modeling
- MATSim in brief
- Optimization
- Utility function
- Applications
- Practical example
Why do we need a travel demand model?

- Transportation decision makers confront difficult questions and must make informed choices!
- **How** will the national, regional, or even local transportation system perform 30 years into the future?
- **What** policies or investments could influence this performance?
- **How** will economic demographic, or land use changes affect transportation system performance?
- **Will** travel demand management strategies or intelligent transportation systems alleviate congestion?
- **Will** a new transit investment attract riders?
Travel models are created to **support** decision making by providing information about the **impacts** of alternative transportation and land use investments and policies, as well as demographic and economic trends.

Travel models produce **quantitative information** about travel demand and transportation system performance that can be used to evaluate alternatives and make informed decisions.
Travel Model Definition

• A travel model is an analysis tool that provides a systematic framework for representing how travel demand changes in response to different input assumptions.

• Travel models may take many different forms. Some travel models seek to comprehensively represent multiple, interrelated aspects of regional travel behavior, such as what activities people engage in, where and when these activities occur, and how people get to these activities.
Trip-based Approach

- Focuses on ‘trips’ without explicit recognition of the motivation or reason for the trips and travel.
- Each trip is considered as independent of other trips, without considering the interrelationship in the choice attributes (such as time, destination and mode) of different trips.
- Time is reduced to being simply a ‘cost’ of making a trip and a day is viewed as a combination of broadly defined peak and off-peak time periods.
- Level of aggregation: aggregate level and consider the changing socio-demographic attributes in very limited fashion.
Activity-based Approaches

- Observes travel as a **demand derived** from the need to pursue activities, and focuses on activity participation behavior.
- **Tours** are chains of trips beginning and ending at a **same location**.
- Focuses on **sequences of activity participation** and travel behavior (using long periods of time as the unit of analysis).
- Observes individuals’ activity-travel patterns are result of their time-use decisions within a **continuous time domain**.
- **Level of aggregation:** accommodate virtually any number of decision factors related to the **socio-demographic characteristics** of the individuals who actually make the activity-travel choices, and the travel service characteristics of the **surrounding environment**.

A tour with three legs/trips

Traveler at home until 8:30am, when departs for work (trip #1).

Traveler arrives at work downtown at 9:00am. Stays until 5:00pm, when departs for supermarket (trip #2).

Traveler arrives at supermarket at 5:20pm, and shops until 6:00pm, when departs for home (trip #3).
Schedule and sequence/priority of activities

1) 3am-6am Work, 6am-9am Work, 9am-Noon Work, Noon-3pm Work, 3pm-6pm Work, 6pm-9pm Work, 9pm-Midnight Work, Midnight-3am Work

2) 3am-6am Work, 6am-9am Work, 9am-Noon Work, Noon-3pm Work, 3pm-6pm Work, 6pm-9pm Work, 9pm-Midnight Work, Midnight-3am Work, 3am-6am Shop

3) 3am-6am Work, 6am-9am Work, 9am-Noon Work, Noon-3pm Work, 3pm-6pm Work, 6pm-9pm Work, 9pm-Midnight Work, Midnight-3am Work, 3am-6am Eat, 6am-9am Shop
Software

- MATSim
- Cube (Voyager, Cargo, Analyst, etc.)
- PTV Visum
- TransCAD
MATSim

• MATSim is an open-source framework for implementing large-scale agent-based transport simulations.

• Currently, MATSim offers a framework for demand-modeling, agent-based mobility-simulation (traffic flow simulation), re-planning, a Controller to iteratively run simulations as well as methods to analyze the output generated by the modules.

• MATSim optimizes the experienced utilities of the schedule through the co-evolutionary search to reach steady state or what is called equilibrium.
**How does MATSim work?**

Initial demand: an individual (agent) based on its preferences develops a plan independently which reflects his desired activities, trips, schedule during a day.

Execution: mobility simulation (MobSim) is used to conduct all plans of initial demand. As an output, agents appear on the network and interact with each other.
The developed plans are evaluated using the utility function for comparison purposes (*scoring*).

Re-planning process is used to improve the selection of the plan through scoring and iteration and assigning random *mutation* to make the suggestion approximate fit the traveler preferences in what is called *strategy module*. MATSim iterates between plan generation and traffic flow simulation.

Analysis: the cycle is run until the system has reached an equilibrium, where no agent can get benefit from changing its plan (i.e. increase its score).
The Current Charypar-Nagel Utility Function

- MATSim scoring function was formulated by Charypar and Nagel (2005), loosely based on the Vickrey model for road congestion, as described by Vickrey (1969) and Arnott et al. (1993).
- Originally, this formulation was established for departure time choice.
- It is, however, almost certainly not appropriate for activity dropping and activity addition.
Utility of a plan

$$S_{plan} = \sum_{q=0}^{N-1} S_{act,q} + \sum_{q=0}^{N-1} S_{trav, mode(q)}$$

$$S_{act,q} = S_{dur,q} + S_{wait,q} + S_{late.ar,q} + S_{early.dp,q} + S_{short.dur,q} \cdot$$

$$S_{trav,q} = C_{mode(q)} + \beta_{trav, mode(q)} \cdot t_{trav,q} + \beta_m \cdot \Delta m_q + (\beta_{d, mode(q)} + \beta_m \cdot \gamma_{d, mode(q)}) \cdot d_{trav,q} + \beta_{transfer} \cdot x_{transfer,q}$$
## Required data

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plans</strong></td>
<td>Activity type, activity location, multimodal travel chain, activity duration, and scheduling.</td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>Demographic data (gender, age, income, employment, family size), license, vehicle ownership.</td>
</tr>
<tr>
<td><strong>Road network</strong></td>
<td>Link and nodes (coordinates), flow directions, number of lanes, speed, capacity, length, allowed modes in each link, and toll road and strategy.</td>
</tr>
<tr>
<td><strong>Public transport</strong></td>
<td>Routes, locations and name/number of stop stations, schedule, vehicles types and number/id, capacity, speed, fleet size, working hours, fare.</td>
</tr>
<tr>
<td><strong>Facilities</strong></td>
<td>Locations (coordinates), type and active time (opening hours).</td>
</tr>
</tbody>
</table>
Budapest case study

Data manipulation, analysis, filtering, reformulating, checking, etc.

Collected data (representative sample)

Plan/Diaries (activity chains, locations, leg mode, travel time, etc.)

Population

Facilities (coordinates, duration, types)

Input files (XML format)

Road network

Road network (links, modes, capacity, number of lanes, etc.)

Parameters and settings

MobSim (Qsim)

Connected by configuration file

Initial demand

Public transport network (routes, transport network, transit schedule, etc.)
Stream of events
## Applications

<table>
<thead>
<tr>
<th>Electric vehicle</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomous vehicle</td>
<td>Noise</td>
</tr>
<tr>
<td>Multimodal</td>
<td>Road pricing</td>
</tr>
<tr>
<td>Car sharing</td>
<td>Traffic signals</td>
</tr>
<tr>
<td>Taxi</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td></td>
</tr>
<tr>
<td>Parking</td>
<td></td>
</tr>
</tbody>
</table>
Practical example

• Data preparation
  – Road network
  – Transit network (schedule and network)
  – Plans
  – Vehicle characteristics
  – Facilities

• MATSim run
  – Config file
  – Input file

• Reading the output
• Visualization of the output
Highlighted points

Obtaining road network:

• JOSM is a free software desktop editing tool for OpenStreetMap geodata created in Java.

Obtaining transit network and schedule

• BKK GTFS to be converted to MATSim file
References


THANK YOU!