Budapest University of Technology and Economics
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Multi-Agent Transport Simulation (MATSim)

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Outline

Travel demand modeling

MATSim in brief

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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?

Answers

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 inter relationship 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.**
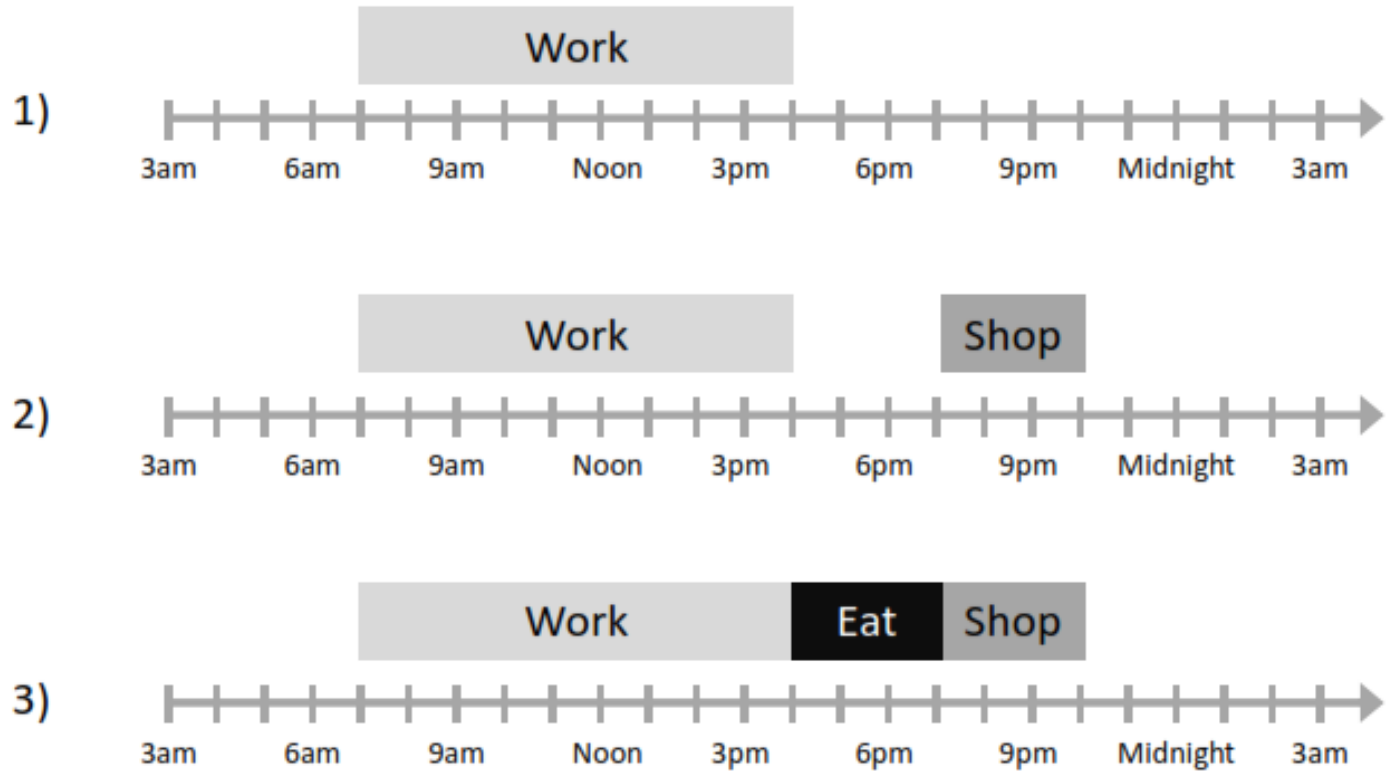
A tour with three legs/trips

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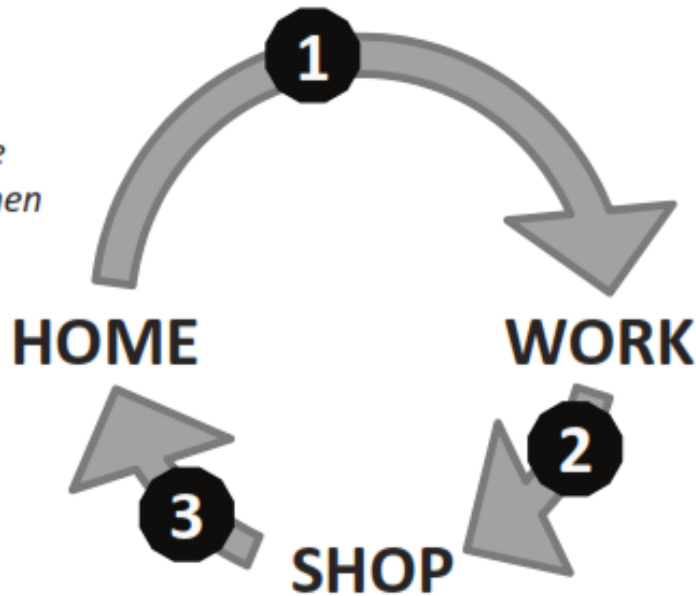
Traveler arrives at supermarket at 5:20pm, and shops until 6:00pm, when departs for home (trip #3).

HOME

WORK

SHOP

Schedule and sequence/priority of activities

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 **Controler to iteratively run simulations** as well as **methods to analyze the output generated by the modules**.

- **<u>MATSim optimizes the experienced utilities of the schedule through the co-evolutionary search to reach steady state or what is called equilibrium.</u>**

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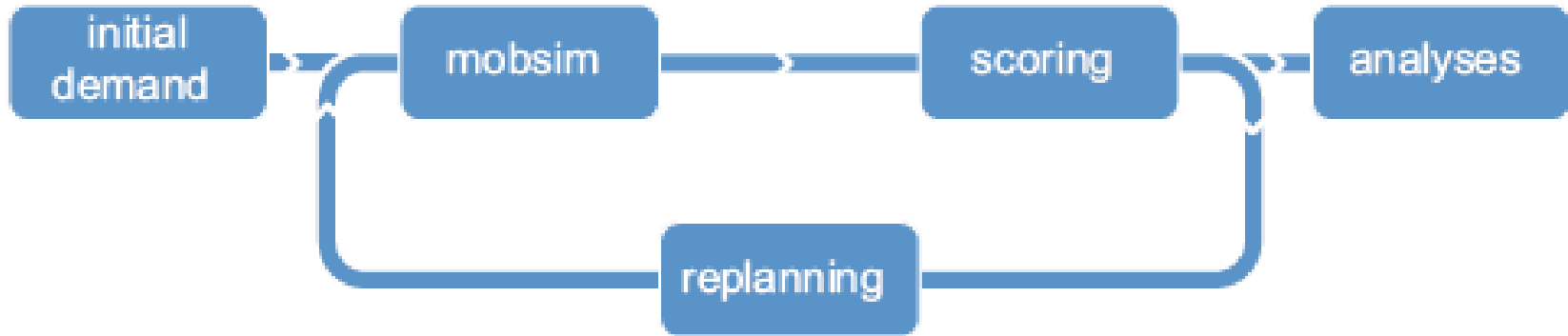
Initial demand: an individual (agent) based on its preferences develops a plan independently which reflects his desired activities, trips, schedule during a day.

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).

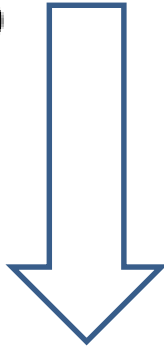# Optimization
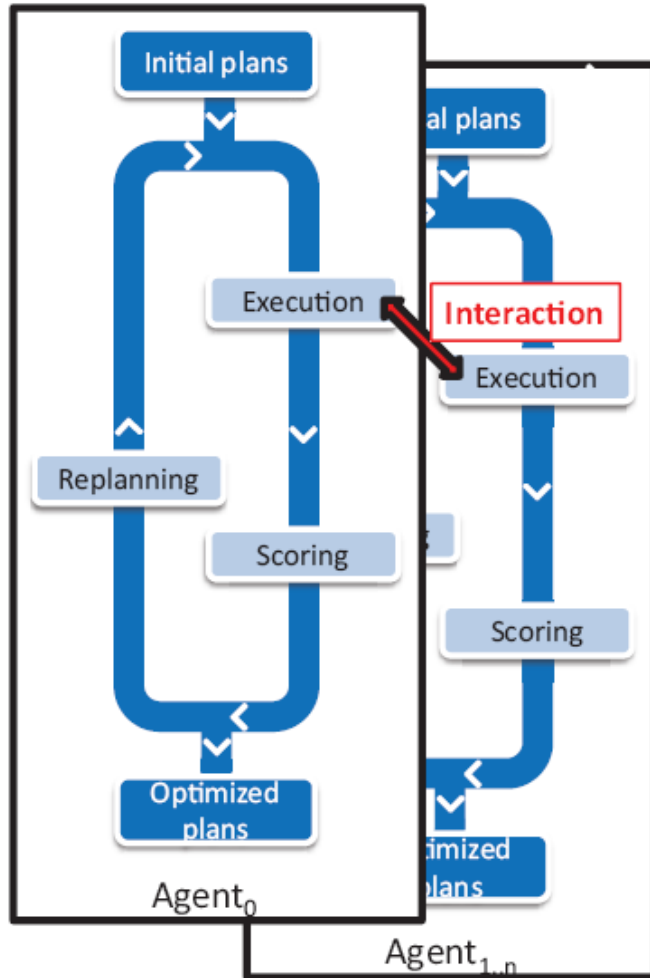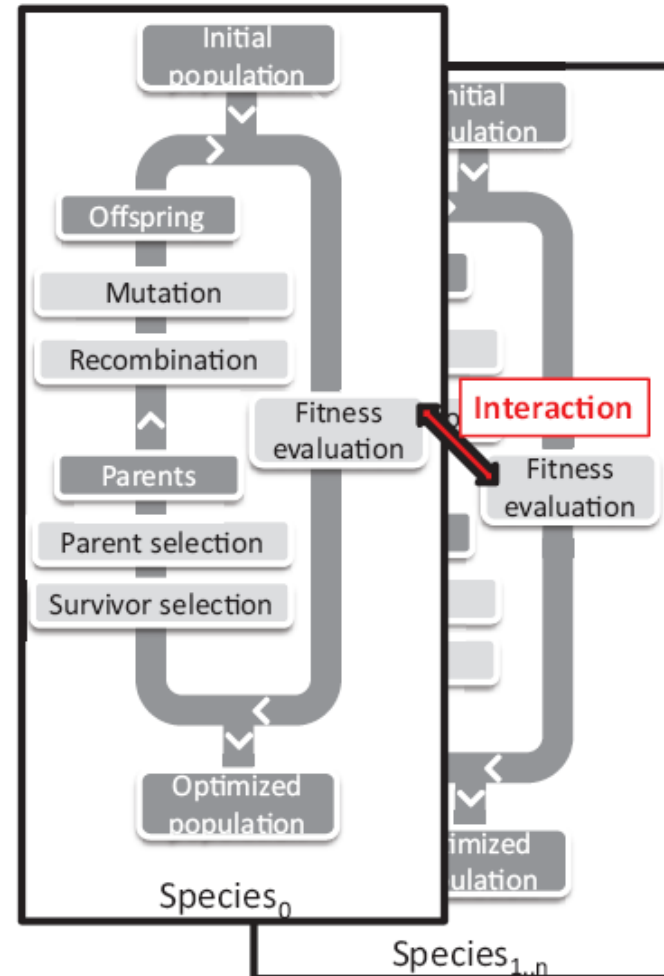
MATSim   Co-Evolutionary Algorithm

Utility Function

- **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

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

Budapest case study
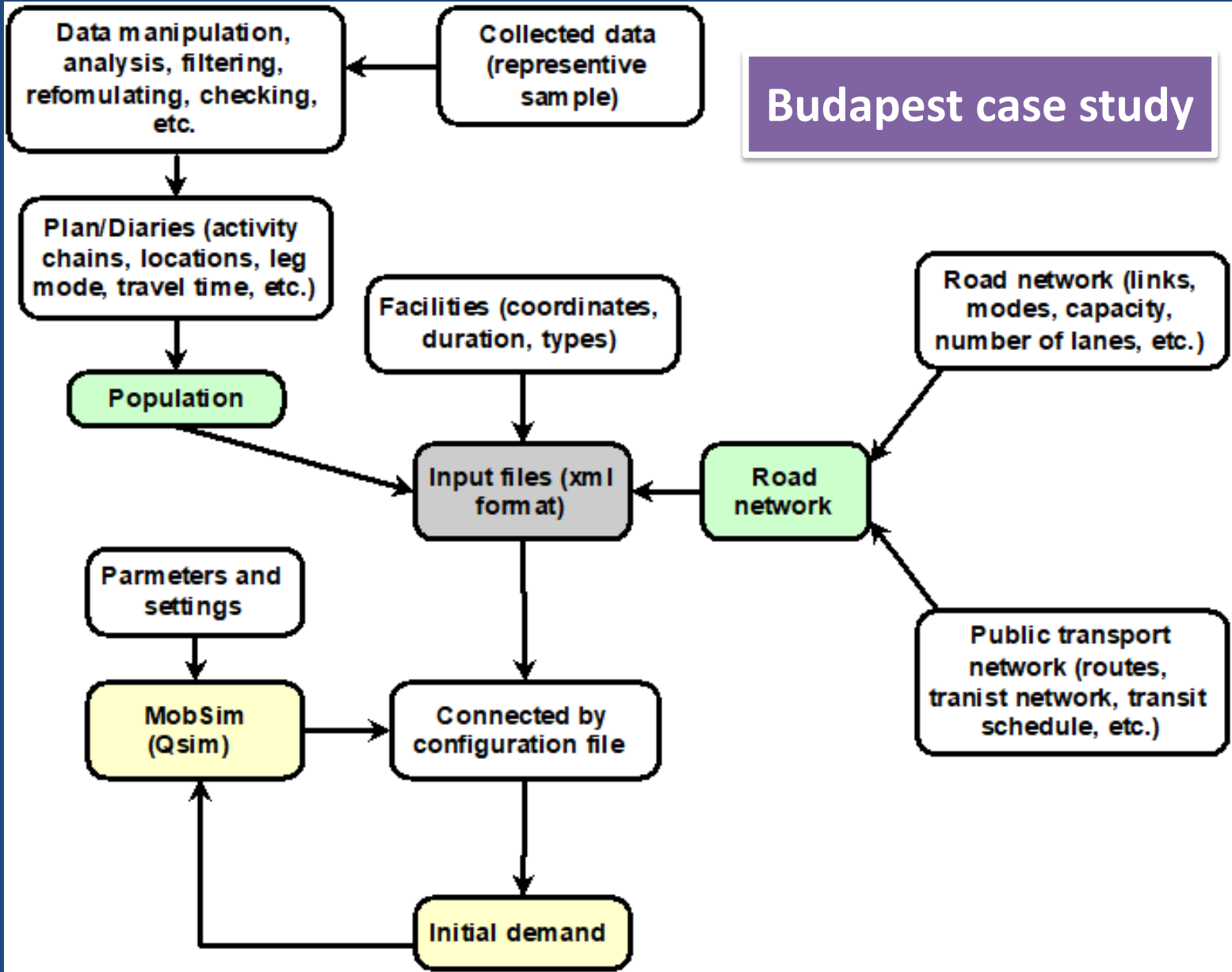
Stream of events
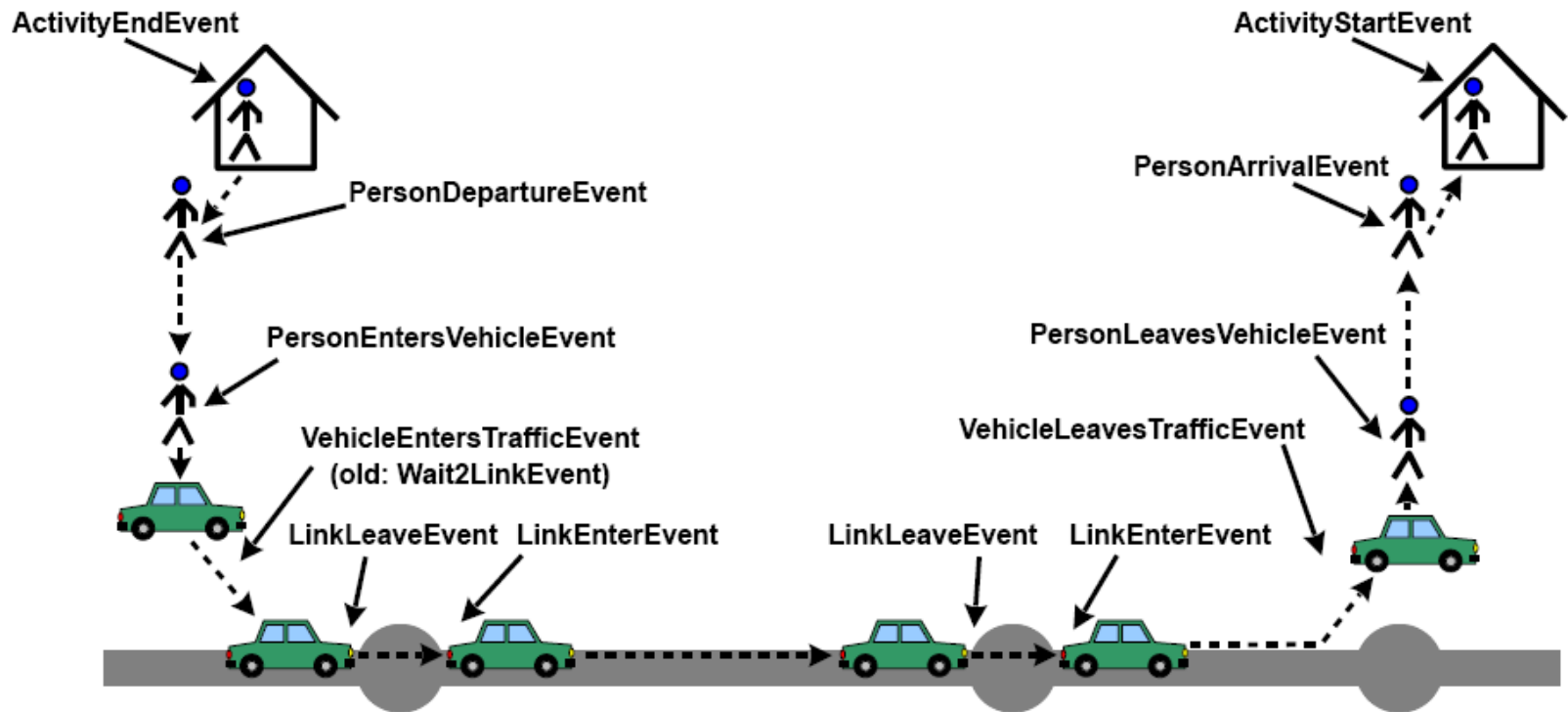
Applications

Electric vehicle

Autonomous vehicle

Multimodal

Car sharing

Taxi

Freight

Bicycle

Parking

Emissions

Noise

Road pricing

Traffic signals

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

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- Poletti, F. (2016). *Public Transit Mapping on Multi-Modal Networks in MATSim.* (Master), Swiss Federal Institute of Technology, ETH Zurich. Retrieved from https://www.ethz.ch/content/dam/ethz/special-interest/baug/ivt/ivt-dam/publications/students/501-600/sa530.pdf

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