• Balmer, M. (2012), Stochastic user equilibrium in a fully integrated, agent-based travel demand modeling and traffic simulation environment, presentation at ITM 2012, Tampa, Florida, April 2012
Stochastic user equilibrium in a fully integrated, agent-based travel demand modeling and traffic simulation environment

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Transport Planning

THE CUSTOMER POINT OF VIEW
Questions

- Transport infrastructure providers (public and private)
  - Who uses (who has to pay for) a new motorway around a city?
  - Who and how should I charge for congestion?
  - Why does bus bunching at line X always occur after 9:30 am?
  - How to define optimal zones in a zonal pricing system for public transit?
  - Where can I find potential customers for public transport?
  - Where should I add new car sharing stations?
Questions

• Site assessment and location planning
  ◦ What is the market potential of locations for specific markets?
  ◦ How many potential customers / passers-by are in front of my shop?
  ◦ Where should I put my next shop such that I reach others than the customers I already have?
  ◦ Most of my employees have to have a degree in higher education. Where should I relocated my company to reach as many (potential) employees with that profile within 30 minutes commuting time with public transportation?

• And
  ◦ “I need something to show, that my boss understands.”
To summarize (from the transport planning point of view)

• “Person tracking” / “Moving” (socio-)demographics (customer groups) during the day
• Time dynamic demand & supply (availability)
• High level of spatial detail
• Interaction of different modes (e.g. multi-modal trips)
• “WYSIWYG”

Integrated, agent-based travel demand modeling and traffic simulation can actually cope with all aspects
Computational Aspects

“PERSON TRACKING”
Demand & Assignment: One mode, one group, static

Demand Modeling

Mental Layer
Physical Layer

C_i

C_{ij}

Q_{ij}

Routes

Assignment

Computation Time per Iteration

Complexity
Demand & Assignment: 4 modes, one group, static
Demand & Assignment: 4 modes, one group, dynamic

Demand Modeling

C_lmt
C_ijmt
Q_ijmt

Routes

Dynamic Assignment

Computation Time per Iteration

Complexity

Mental Layer
Physical Layer
Demand & Assignment: 4 modes, $n$ OD-groups, dynamic
Demand & Assignment:
4 modes, $n$ OD-groups, $m$ population groups, dynamic
Activity Based Demand & Simulation

Activity Based Demand Modeling + Routes

Mental Layer

Physical Layer

Agent-based Simulation

U_{i,t,a} \rightarrow \text{plan}_i

Computation Time per Iteration

Complexity
Activity Based Demand & Simulation

Mental Layer  Physical Layer

Activity Based Demand Modeling
+ Routes

U_{i,ta}  plan_i

Agent-based Simulation

Computation Time per Iteration

Complexity
Continuous Time versus Time Bins

TIME DYNAMIC SIMULATION
Continuous time

Coordinates versus Zones

HIGH LEVEL OF SPATIAL DETAIL
Coordinates versus Zones

• Level of detail defined by
  ◦ Network links
  ◦ public transit stops (coordinate)
  ◦ Facilities / activity opportunity (coordinate)

Multi-Modal Network Representation

INTERACTION OF MODES
A Bus in Congestion

Berlin Model, version Dec. 2010, 10% sample, not calibrated
Visualization

WYSIWYG
Agent-based approach

STOCHASTIC USER EQUILIBRIUM
Definition

• “In a SUE network, no user believes he can improve his travel time by unilaterally changing routes.” (Daganzo and Sheffi, 1977)

Operational

• The traffic flows from each OD-pair is derived from a choice distribution over a given (feasible) choice set

• The choice set itself is derived from a definition of the generalized costs of all routes from O to D
Agent-based SUE

Definition

• “An agent-based SUE [. . . ] is defined as a system state where agents draw from a stationary choice distribution such that the resulting distribution of traffic conditions re-generates that choice distribution. [. . . ] It implies that every agent considers a whole choice of (possibly suboptimal) plans and selects one of these plans probabilistically.” (Flötteröd and Nagel, 2009)

Operational

• “An agent-based SUE is defined as a system state where the number of agents which perceive that they can improve their state is minimized, given a dynamic environment where a constant share of all agents change their plans.” (Meister, 2011, Chapter 2)
SUE Example in MATSim (route and time replanning)

\[ \beta_{\text{score}} = 2.0, \quad \alpha = 1.0 \]

- \( \text{pctSUE}_\text{min} = 97.5\% \)
- \( \text{pctSUE}_\text{select} \)
- \( \text{pctSUE}_\text{router} \)
- \( \text{pctSUE}_\text{tam} \)
- \( \text{pctSUE}_\text{all} \)
- \( \text{avg}(\text{V}_{\text{plan, worst}}) \)
- \( \text{avg}(\text{V}_{\text{plan, best}}) \)
- \( \text{avg}(\text{V}_{\text{plan, executed}}) \)
Thoughts About the (Route) Choice Sets

Source: Google Maps (2012)
Open Questions

- What is a suitable share of agents for a SUE?
- Does the relaxation always reaches an SUE (considering any choice dimensions)?
- Does the relaxation process produce a suitable choice set?
- ...
• http://senozon.com
http://matsim.org
http://ivt.ethz.ch
http://vimeo.com/search?q=matsim


• Nagel, K. and G. Flötteröd (2009), Agent-based traffic assignment: going from trips to behavioral travelers, paper presented at IATBR, Jaipur.