Activity choice modeling for pedestrian facilities: Validation on synthetic data

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hEART 2014
3nd Symposium of the European Association for Research in Transportation
University of Leeds

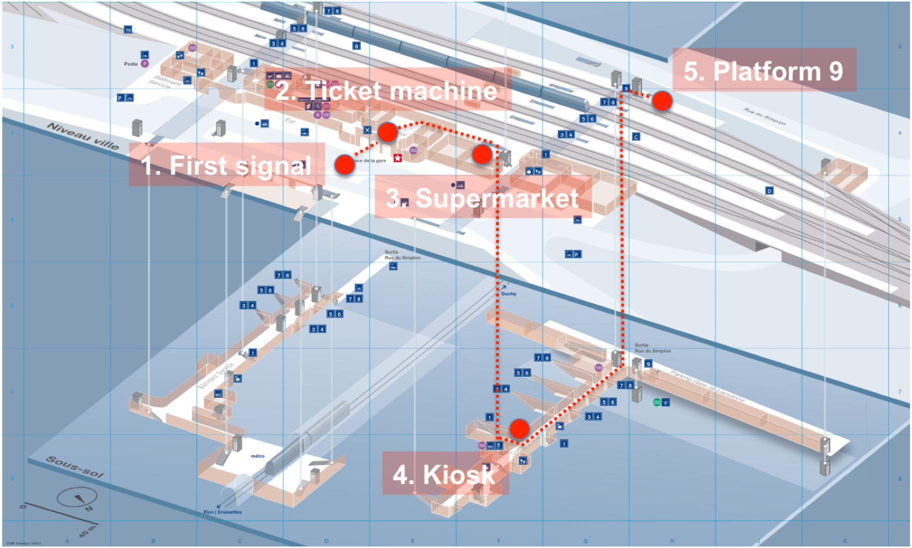
September 11, 2014

Outline

1. Motivation: Activity-based model for pedestrian facilities
2. Importance sampling for activity modeling
3. Validation with synthetic data

Activities in pedestrian infrastructure

Spatial choices in pedestrian infrastructure



The challenges of spatial choices: Large choice sets

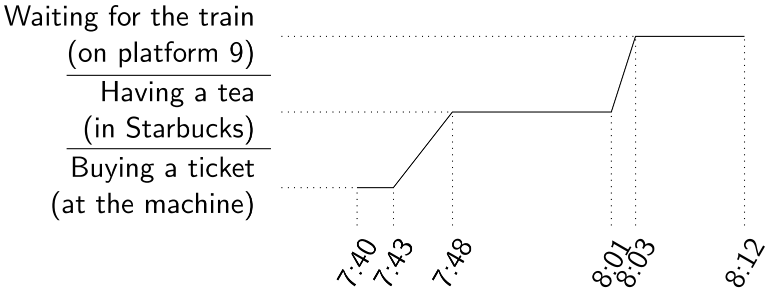
In a transport hub

Number of activity types	5
Number of activity-episodes per sequence	0-9
Number of activity-episode sequences	5^9

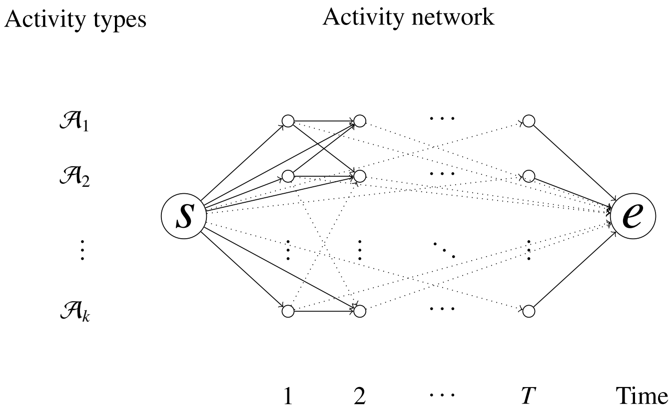
Without considering destination choice nor time spent at each destination...

Observations: activity patterns in a transport hub

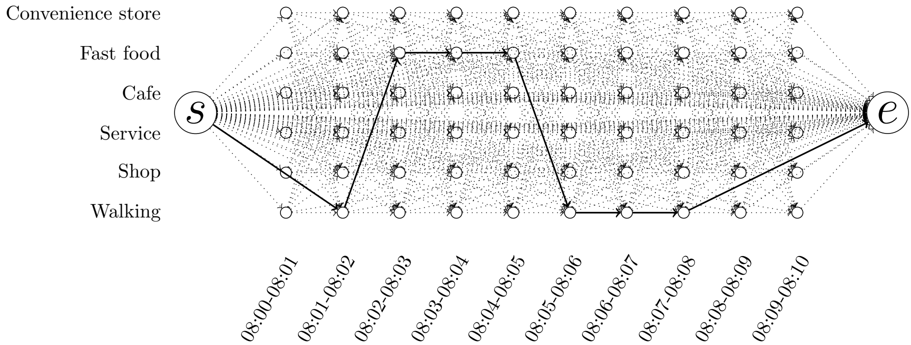
Activity types



Activity network



Activity network



Utility structure

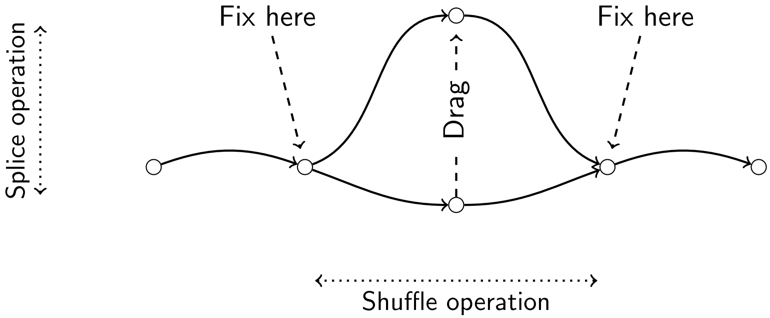
- Utility of activity pattern:
  - **time-of-day preferences**
  - **satiation effects**: marginal utility decreases with increasing duration

$$V(duration) = \eta \ln(duration)$$

  - scheduling constraints: schedule delay

(Ettema et al.; 2007)

Choice set generation: Metropolis-Hastings algorithm



(Flötteröd and Bierlaire; 2013)

Choice set generation in the activity network

- Sample paths from given distribution, without full enumeration
- Possibility to define non-link additive cost
- Path cost defined as

$$\delta(\Gamma) = -\sum_{v \in \Gamma} \delta_v(v) - \mu_\Gamma \cdot \delta_\Gamma(\Gamma)$$

  with
  - link cost: frequency of observations
  - path cost: length of observed paths
- Target weight defined as

$$b(i) = \exp\big(-\mu\delta(\Gamma)\big)$$

  with μ a scale parameter

Time-invariance

- Different time discretisation and costs $\Rightarrow$ different scale parameters.
- Let's define the scale parameter as

$$\mu = \frac{\ln 2}{(\zeta - 1)\delta_{SP}}$$

- Path of cost $\zeta\delta_{SP}$ sampled twice less than the shortest path.
- $\zeta = 1$ only samples the shortest path;
  $\zeta \rightarrow \infty$ sample paths independently of their cost.

Utility function

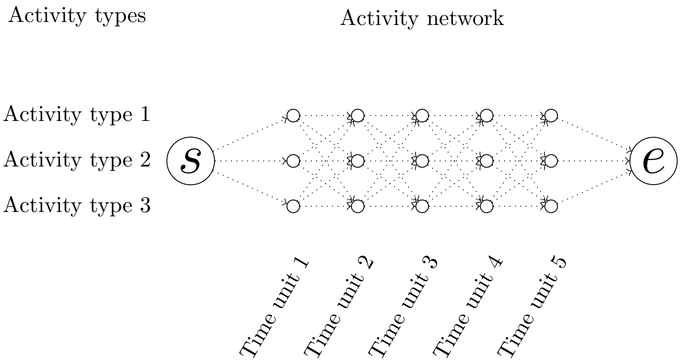
- Utility of activity path Γ with correction term for importance sampling:

$$V_\Gamma = \sum_{k,\tau} \beta_k I_{k,\tau} + \sum_{\text{episodes } e} \eta_k \ln(t_{k,e}) + \ln \frac{k_\Gamma}{b(\Gamma)}$$

- Fix one β to 0 for identification.
- Application to WiFi traces on a campus: Danalet and Bierlaire (2014)

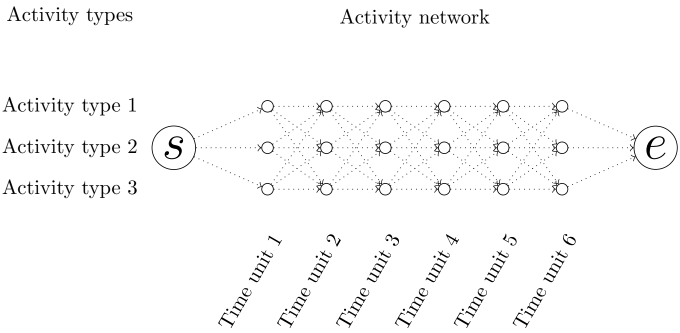
(Frejinger et al.; 2009)

Activity network



243 alternatives

Activity network



729 alternatives

Time-of-day preference is Cauchy distributed

- Utility of activity pattern:
  - **time-of-day preferences**: symmetrical Cauchy distribution

$$V'(\tau) = \frac{V_{max}}{c\pi\left(\left(\frac{\tau - b}{c}\right)^2 + 1\right)}$$

  - **satiation effects**: marginal utility decreases with increasing duration

$$V(duration) = \eta \ln(duration)$$

  - scheduling constraints: schedule delay

(Ettema et al.; 2004)

True values

Parameters	True values
$V_{max,1}$	3.0
b_1	2.5
c_1	2.0
$V_{max,2}$	4.0
b_2	4.0
c_2	3.0
η_1	2.0
η_2	1.3
η_3	0.8
γ_e	-1.2
γ_l	-1.8

Estimation with full choice set

Description	Coeff. estimate	Robust Asympt. std. error	t-stat (true value)
$V_{max,1}$	3.25	0.322	0.78
b_1	2.42	0.104	0.77
c_1	2.11	0.190	0.58
$V_{max,2}$	3.91	0.723	0.12
b_2	4.34	0.370	0.92
c_2	3.18	0.646	0.28
η_1	1.98	0.0512	0.39
η_2	1.38	0.0477	1.68
η_3	0.792	0.0522	0.15

Number of observations = $10'000$

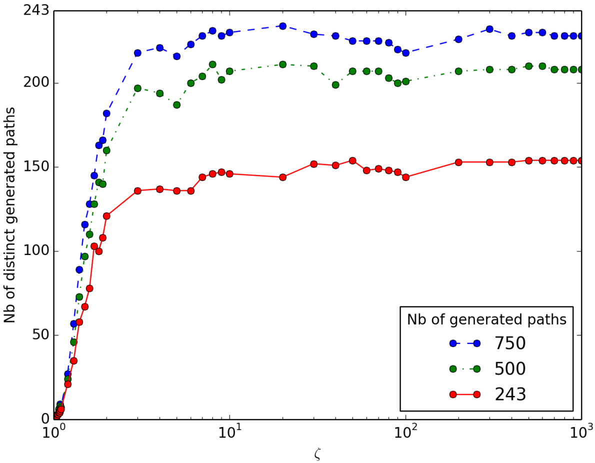
Importance sampling

- Utility function:

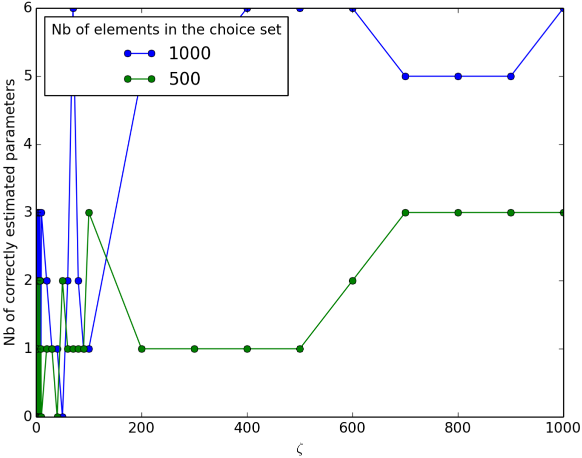
$$V_\Gamma = \mu \cdot \left(\sum_{k,\tau} \frac{V_{max}}{c\pi\left(\left(\frac{\tau-b}{c}\right)^2+1\right)} + \sum_{\text{episodes } e} \eta_k \ln(t_{k,e}) \right) + \ln \frac{k_\Gamma}{b(\Gamma)}$$

with the true value for one node fixed, and the scale μ estimated.

Number of distinct paths generated (only time of day, 5 time units)



Estimation with importance sampling (only time of day, 5 time units)



Future work

- Sensitivity analysis / 6 time units
- Define clear rules for how to define
    - Cost function in the Metropolis-Hastings algorithm
    - The scale parameter ζ
    - The size of the choice set
- Gunnar's idea: Define the scale parameter ζ sequentially (Lemp and Kockelman; 2012): draw alternatives in proportion to updated choice-probability estimates

Thank you

Questions / suggestions?

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