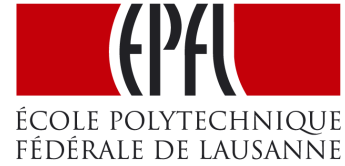


IATBR

The activity path approach to activity pattern modeling

Antonin Danalet, Michel Bierlaire

Windsor,
July 20, 2015

Outline

Motivation: Activity-based model for pedestrian facilities

An activity path approach to activity modeling

Choice set generation

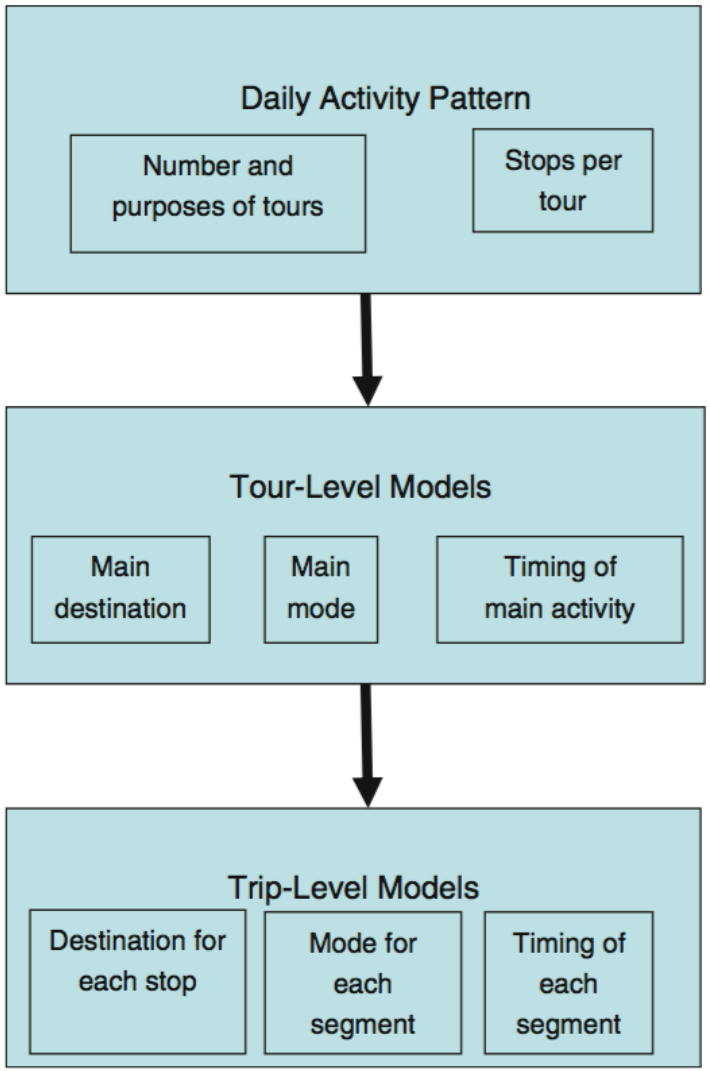
Case study: pedestrians on EPFL campus

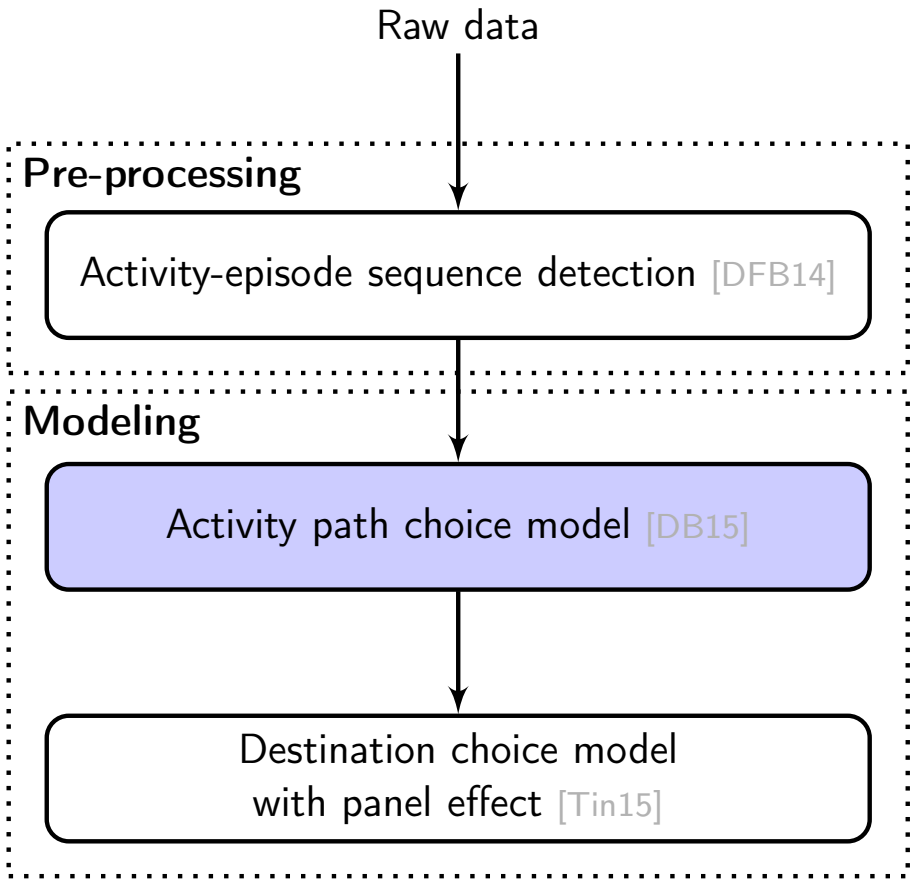
Outline

Motivation

- **Activity-based approach**: modeling the activity participation patterns
- **Not tour-based** (no "home" location in pedestrian facilities)
- **No hierarchy** of dimensions or aggregation (high temporal precision)

Activity-schedule approach *vs* Activity path approach





[SBA11]

Goal

- Simultaneously model the choice of:
  - activity types,
  - order,
  - start times and
  - durations

  of activity episodes in a sequence.

- No mode choice.

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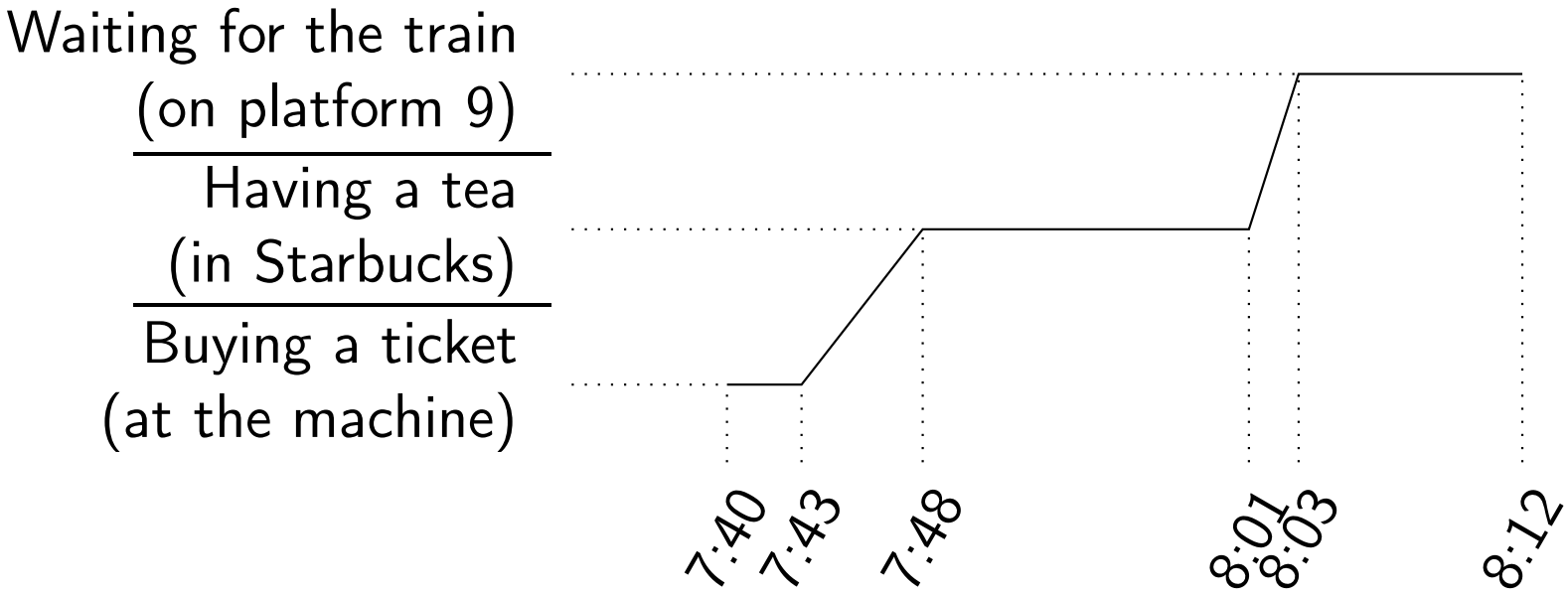
Modeling assumption

- Sequential choice:
  1. activity type, sequence, time of day and duration
  2. destination choice conditional on 1.
- Motivations:
  - Behavior: precedence of activity choice over destination choice
  - Dimensional: destinations $\times$ time $\times$ position in the sequence is not tractable

Today, we focus on 1. [DB15].
Example of 2. on the same data: [Tin15].

Observations: activity patterns in a transport hub

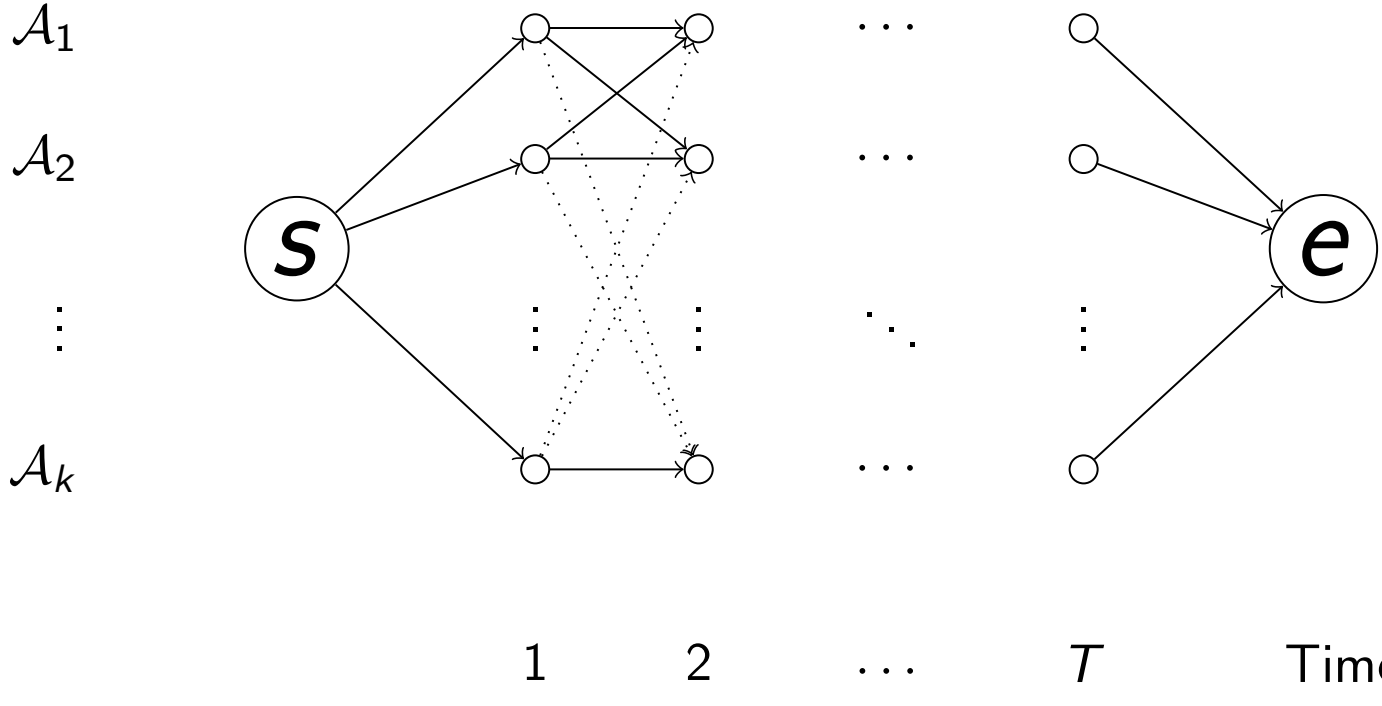
Activity types



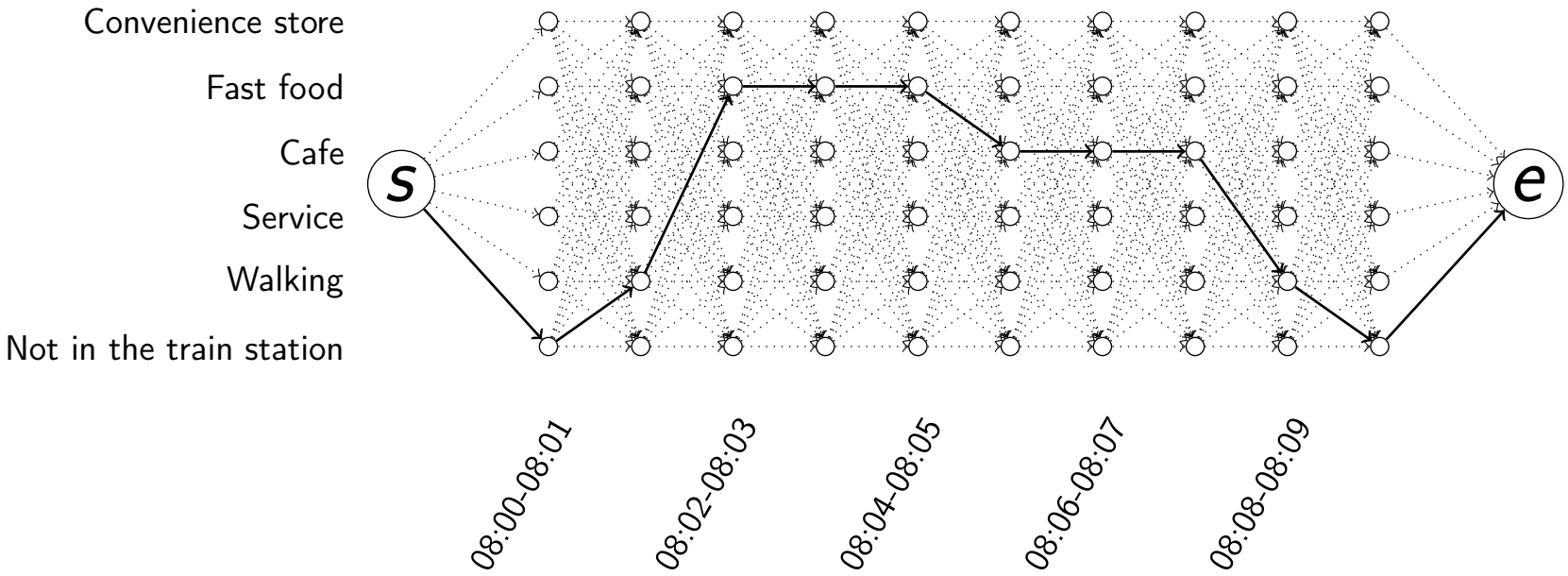
Activity network

Activity types

Activity network



Activity path



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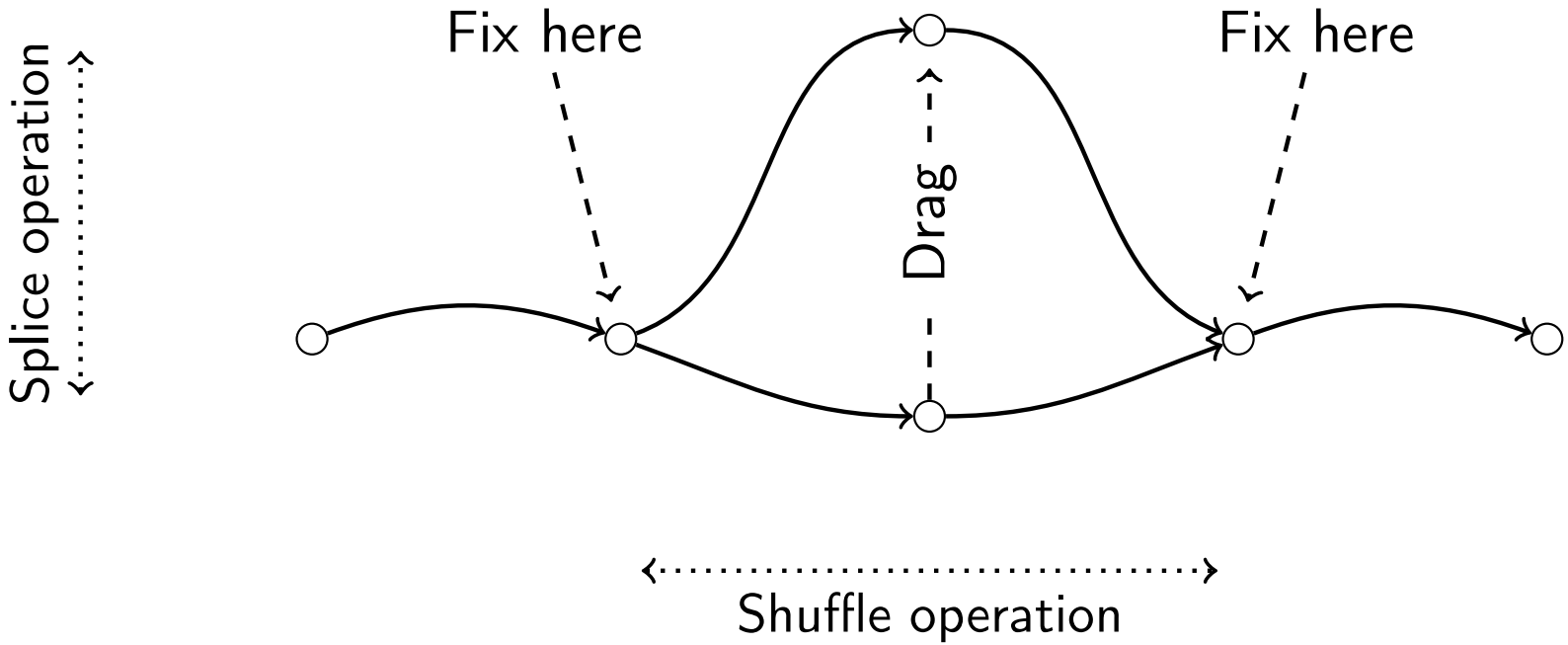
Sampling strategies

- Simple random sampling (SRS)
- Importance sampling
  using Metropolis-Hastings algorithm [FB13]
  - Observation score [Che13, DB15]
  - Strategic sampling [LK12]

Metropolis-Hastings algorithm



[FB13]

Metropolis-Hastings sampling of paths

- Sample paths from given distribution, without full enumeration
- To be defined:
  - Target weight:

$$b(i) = \exp\big(-\mu\delta(\Gamma)\big) \tag{1}$$

    Also with non-node-additive utility
  - Proposal distribution:

$$P_{\text{insert}} = \frac{e^{-\tilde{\mu}\delta_{SP}(origin,v)+\delta_{SP}(v,destination)}}{\sum_w e^{-\tilde{\mu}\delta_{SP}(origin,w)+\delta_{SP}(w,destination)}} \tag{2}$$

    Relies on shortest paths, node-additive cost.

Strategic sampling

- Target weight:
  previously estimated model
- Proposal distribution:
  previously estimated model using only time-of-day preferences (node-additive)

Utility structure

- Utility of activity pattern:
  - Node utility $V(\mathcal{A}_{k,t})$
    - time-of-day preferences
  - Activity-episode utility $V(a)$
    - satiation effects: decreasing marginal utility, $\eta \ln(\mathit{duration})$
    - scheduling constraints: schedule delay
  - Activity path utility $V(\Gamma)$
    - primary activity
- Sampling correction

$$\mu\left(\sum_{k=1}^{K}\sum_{\tau=1}^{T} V(\mathcal{A}_{k,\tau}) + \sum_{a\in\mathcal{A}_{1:T}} V(a) + V(\Gamma)\right) + \ln\frac{k_{\Gamma n}}{b(\Gamma)}$$

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Case study: pedestrians on EPFL campus

- 13'000 people per day
- 8 activity types:
  - classrooms,
  - shops,
  - offices,
  - restaurant,
  - library,
  - lab,
  - other and
  - not being detected
- 12 time units in the activity network, from 7am to 7pm
- WiFi traces [DFB14]

Proposal distribution (using simple random sampling)

Description	Coeff. estimate	Robust Asympt. std. error	t-stat
$\beta_{\text{NA, 17-19, employees}}$	0.263	0.0302	8.70
$\beta_{\text{NA, 14-17, students}}$	-0.222	0.191	-1.16
$\beta_{\text{NA, 7-8, students}}$	0.349	0.0281	12.44
$\beta_{\text{NA, 7-9, employees}}$	0.326	0.0262	12.43
$\beta_{\text{NA, 17-19, students}}$	1.14	0.187	6.09
$\beta_{\text{classroom, 12-14, students}}$	-0.336	0.337	-1.00
$\beta_{\text{classroom, 7-12, employees}}$	-0.723	0.397	-1.82
$\beta_{\text{classroom, 7-12, students}}$	0.598	0.262	2.28
$\beta_{\text{library, 14-19, employees}}$	-0.624	0.553	-1.13
$\beta_{\text{library, 12-14, employees}}$	-0.575	0.481	-1.20
$\beta_{\text{library, 7-12, employees}}$	-1.57	0.508	-3.09
$\beta_{\text{office, 14-19, employees}}$	1.41	0.246	5.73
$\beta_{\text{office, 7-12, employees}}$	1.12	0.228	4.92
$\beta_{\text{restaurant, 14-19, students}}$	-0.410	0.185	-2.21
$\beta_{\text{restaurant, 12-14, employees}}$	0.136	0.0259	5.26
$\beta_{\text{restaurant, 12-14, students}}$	0.665	0.286	2.32
	...		

Number of observations = 1087
Number of estimated parameters = 43
$\mathcal{L}(\beta_{\mathbf{0}}) = -5016.636$
$\mathcal{L}(\hat{\beta}) = -453.225$
$\rho^{\mathbf{2}} = 0.910$
$\bar{\rho}^{\mathbf{2}} = 0.901$

Target weight (using simple random sampling)

Description	Coeff. estimate	Robust Asympt. std. error	t-stat
$\beta_{\text{library 7-12, employees}}$	-2.08	0.422	-4.93
$\beta_{\text{office 7-12, 14-19, employees}}$	1.69	0.393	4.30
$\beta_{\text{restaurant 12-14, employees}}$	1.22	0.502	2.43
$\beta_{\text{shop 12-14, students}}$	-7.36	1.24	-5.92
$\beta_{\text{shop 7-12, 14-19, students}}$	-1.16	0.538	-2.16
$\beta_{\text{NA 7-8, students}}$	4.27	0.995	4.29
$\beta_{\text{NA 8-12, students}}$	1.40	0.498	2.82
$\beta_{\text{NA 17-19, students}}$	1.75	0.568	3.08
$\beta_{\text{NA 9-17, employees}}$	1.43	0.296	4.84
$\beta_{\text{NA 7-9, 17-19, employees}}$	3.34	0.554	6.02
$\eta_{\text{Office, Lab, Classroom}}$	5.22	0.764	6.83
$\eta_{\text{Restaurant, Library, Other}}$	7.85	1.11	7.10
η_{Shop}	7.33	0.894	8.20
η_{NA}	2.75	0.393	7.00
$\beta_{\text{3+ lab episodes}}$	-5.03	0.952	-5.28
$\beta_{\text{3+ resto episodes}}$	-2.50	0.759	-3.29
...			

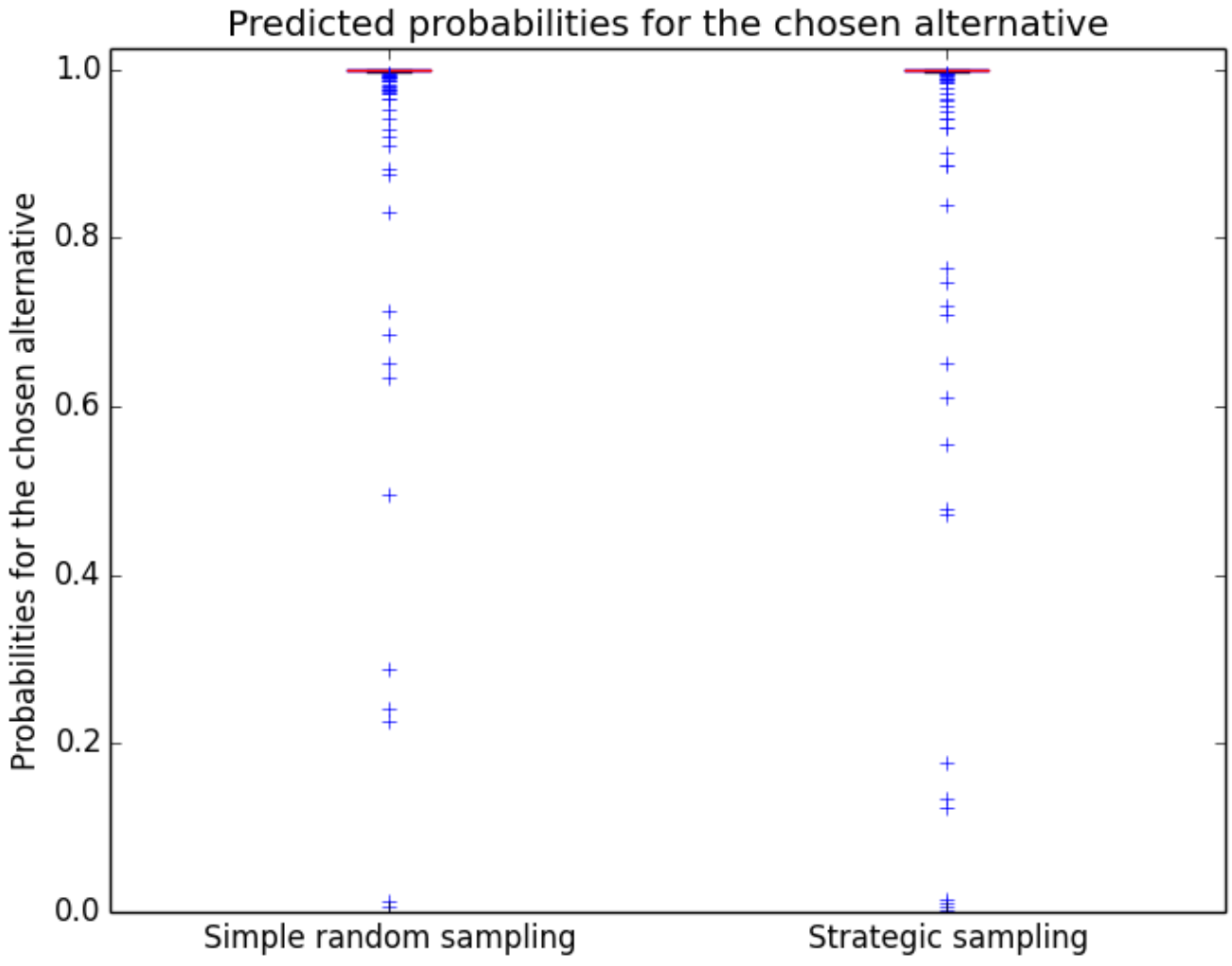
Number of observations = 1087
Number of estimated parameters = 22
$\mathcal{L}(\beta_{\mathbf{0}}) = -5016.636$
$\mathcal{L}(\hat{\beta}) =$ **-47.218**
$\rho^2 = 0.991$
$\bar{\rho}^2 = 0.986$

Model using strategic sampling

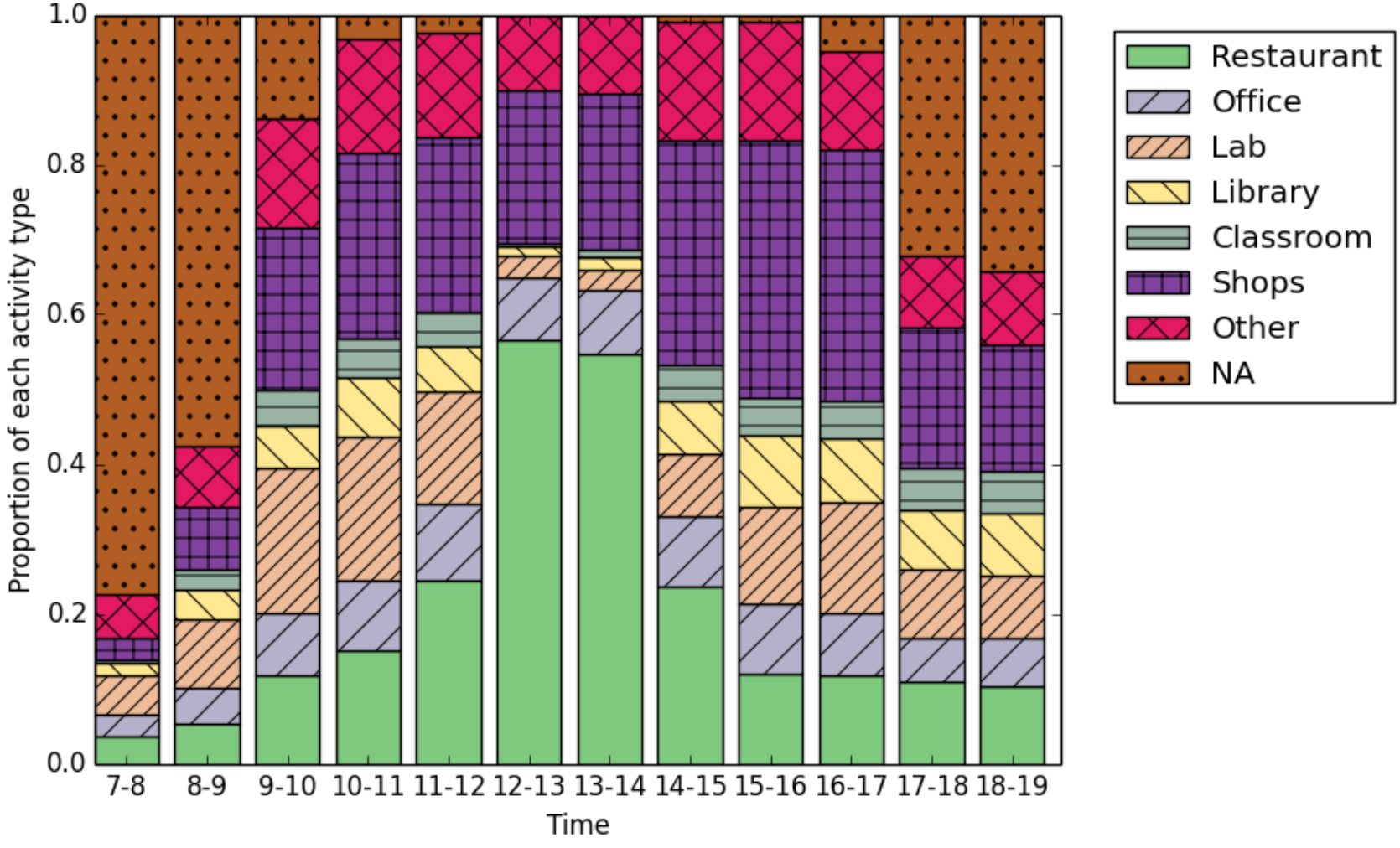
Description	Coeff. estimate	Robust Asympt. std. error	t-stat
$\beta_{\text{Library 12-14, students}}$	-1.45	0.235	-6.15
$\beta_{\text{Restaurant 12-14, students}}$	0.769	0.106	7.26
$\beta_{\text{Shop 14-19, students}}$	1.14	0.160	7.16
$\beta_{\text{NA 7-8, students}}$	2.15	0.223	9.63
$\beta_{\text{NA 8-12, students}}$	1.39	0.0792	17.52
$\beta_{\text{NA 17-19, students}}$	1.80	0.108	16.69
$\beta_{\text{NA 7-9, 17-19, employees}}$	1.59	0.0793	20.07
$\eta_{\text{Office, Lab, Classroom, Library, Other, NA}}$	-2.07	0.110	-18.81
$\eta_{\text{Restaurant}}$	-3.41	0.284	-11.98
$\eta_{\text{Shop, Library}}$	-1.35	0.120	-11.23
$\beta_{\text{1 Restaurant episode}}$	1.83	0.148	12.35
$\beta_{\text{2+ Classroom episodes, employees}}$	-0.736	0.0669	-11.00
$\beta_{\text{2+ Shop episodes}}$	-2.79	0.417	-6.69
$\beta_{\text{0 Library episode, employees}}$	2.60	0.252	10.32
$\beta_{\text{primary activity Library, students}}$	0.128	0.0474	2.71
$\beta_{\text{schedule delay, students}}$	-0.509	0.184	-2.77
...			

Number of observations = 1087
Number of estimated parameters = 31
$\mathcal{L}(\beta_0)$ = −5016.636
$\mathcal{L}(\hat{\beta})$ = -1411.965
ρ^2 = 0.719
$\bar{\rho}^2$ = 0.712

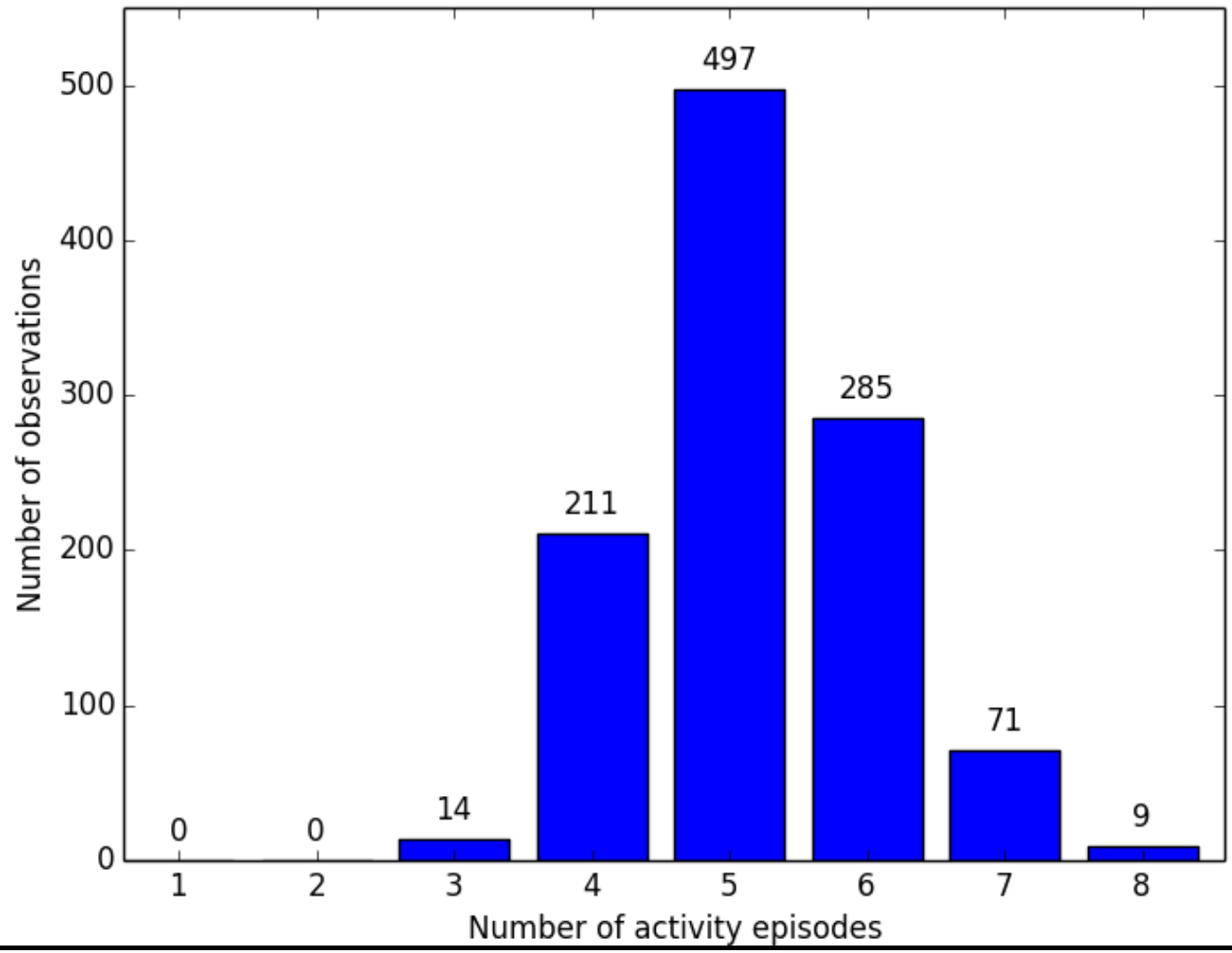
Validation


Predicted probabilities for the chosen alternative
Probabilities for the chosen alternative
1.0
0.8
0.6
0.4
0.2
0.0
Simple random sampling
Strategic sampling

Forecasting



Forecasting



Conclusion

- Simultaneous choice of
  - activity type,
  - time of day,
  - duration,
  - order.
- Not home-based, nor tour-based.
- Importance sampling: allows to include more parameters.
- Important feature: allows to add variables related to the path.
  - patterns (e.g., a office-restaurant-office pattern for lunch) or
  - primary activity.

Thank you

IATBR:
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