Choice set generation for activities using importance sampling

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Outline

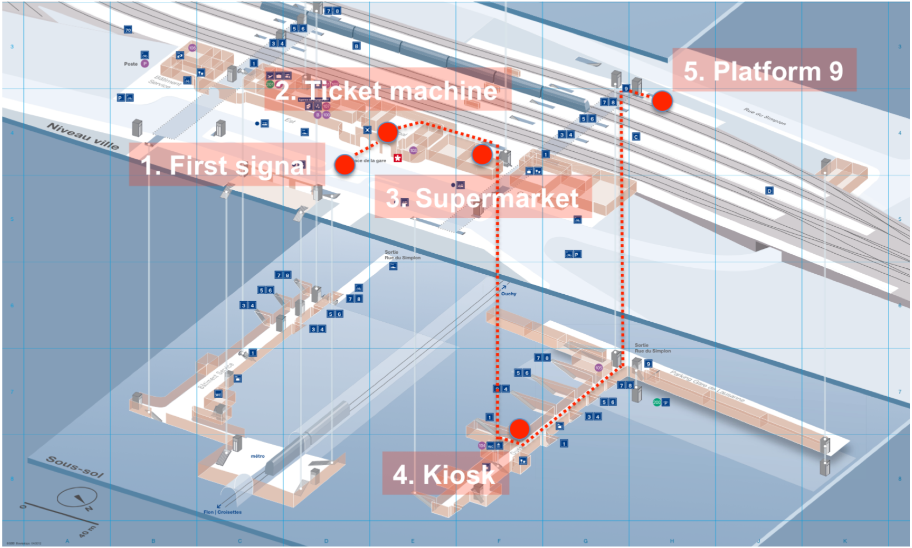
1. Motivation: Activity-based model for pedestrian facilities
2. Literature review: from consideration set to importance sampling
3. Importance sampling for activity modeling
4. Case study: A multimodal transport hub
5. Conclusion

Pedestrian demand management strategies

- Pedestrian facilities
    - Transportation hubs (train stations, airports, ...)
    - Mass gathering (music festivals, ...)
    - Shops
    - ...
- Challenges
    - Designing efficient buildings
    - Locating points of interest
    - Modifying schedules
    - ...

$\Rightarrow$ Forecast the impact of pedestrian demand management strategies on activity and destination choices of visitors

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
Number of destinations per activity type	1-5
Number of destinations per activity-episode sequence	5^{10}

Without considering time spent at each destination...

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 (e.g., Bowman and Ben-Akiva; 2001)
  - Dimensional: destinations $\times$ time $\times$ position in the sequence is not tractable

Here we focus on 1.

Examples of 2: Ton (2014); Kalakou and Moura (2014).

Choice set generation

- Universal choice set $\mathcal{U}$:
  - Computational: Too big, not usable
  - Behavior: Decision makers do not consider all alternatives
- Consideration choice set $\mathcal{C}_n$:
  - Not known
    - Manski (1977): $P_n(i) = \sum_{\mathcal{C} \in \mathcal{G}} P_n(i|\mathcal{C}) P_n(\mathcal{C})$
    - Set $\mathcal{G}$ of all non-empty subsets of $\mathcal{U}$ is exponentially large
    - Usual simplification: $\mathcal{G} = \{C_n\}$ and $P(C_n) = 1$
  - Coverage issue: the chosen alternative (supposedly the best) not in $\mathcal{C}_n$
- Sampling of alternatives from $\mathcal{U}$
  - Contains the chosen alternative and the considered alternatives
  - Assumption about biases:
    forgetting alternatives $>$ adding non-considered alternatives

(Frejinger and Bierlaire; 2010)

Choice set generation in route choice

Consideration choice set

Shortest-path based algorithms

- Deterministic algorithm
  - link elimination
  - link penalty
  - labeled paths
  - branch-and-bound (Prato and Bekhor; 2006)
- Monte-Carlo simulation
- Gateway algorithm (e.g., Bierlaire and Frejinger; 2008)

Sampling of alternatives

- Random walk (Frejinger et al.; 2009)
- Link sampling for recursive logit (Fosgerau et al.; 2013)
- Metropolis-Hastings path sampling (Flötteröd and Bierlaire; 2013; Chen; 2013)

(Frejinger and Bierlaire; 2010; Chen; 2013)

Choice set generation in activity/destination choices

Consideration choice set

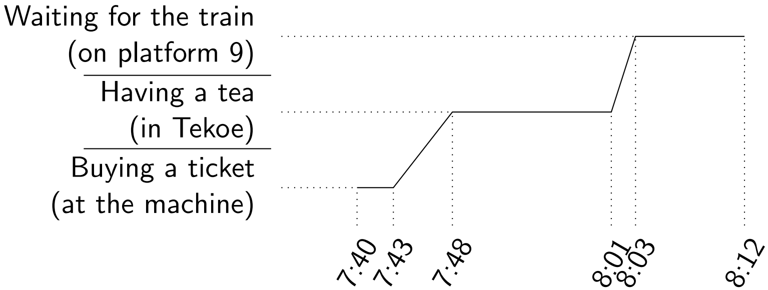
- General review before 2009 in Pagliara and Timmermans (2009)
- Dominance-based choice set in destination choice (Cascetta and Papola; 2009)
- Refueling decision (Pramono and Oppewal; 2012)

Sampling of alternatives

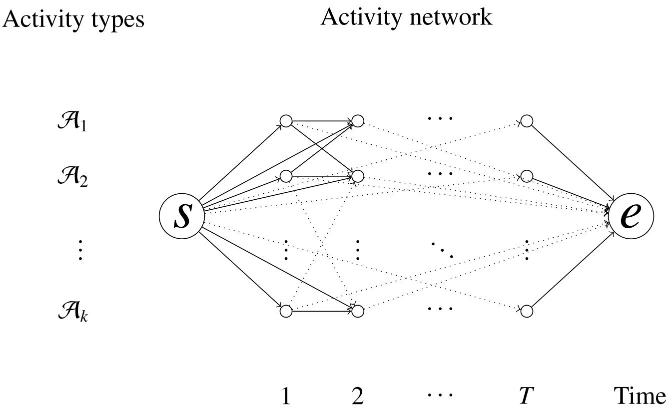
- Residential location choice (McFadden; 1978; Ben-Akiva and Bowman; 1998)
- Destination choice (Yagi and Mohammadian; 2008)

Observations: activity patterns in a transport hub

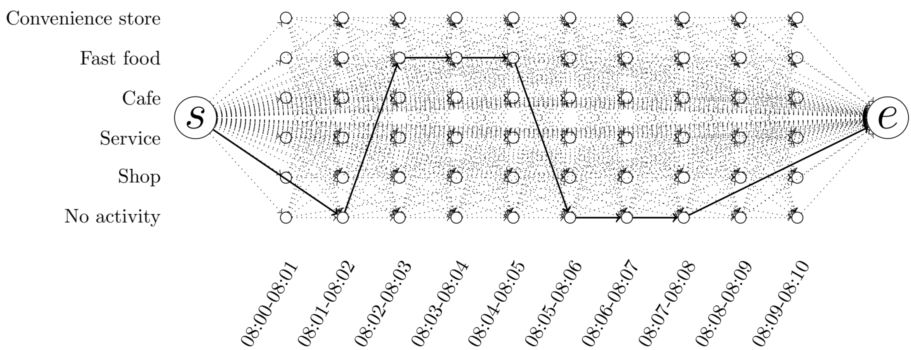
Activity types



Activity network



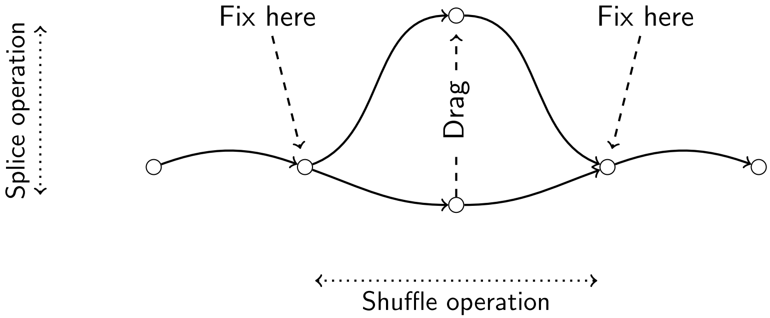
Activity network



Activity network and importance sampling

- Universal choice set is behaviorally meaningful in the activity network: Decision maker can consider all alternatives (consider all activity types and time duration, not all combinations)
- Unattractive paths will be assigned a very small choice probability

Choice set generation: Metropolis-Hastings algorithm



(Flötteröd and Bierlaire; 2013)

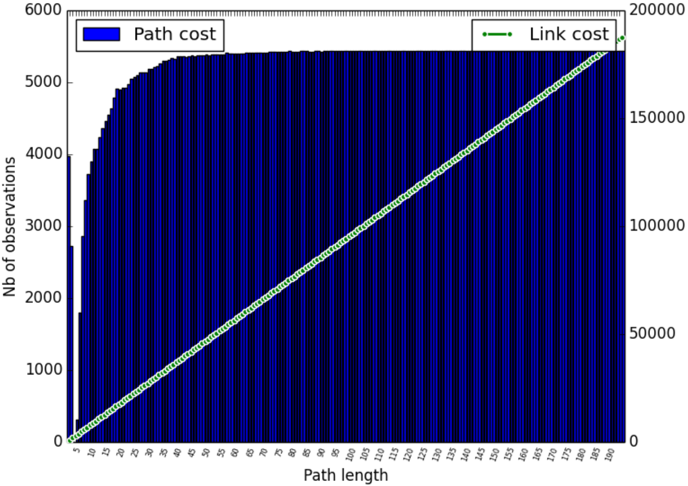
Choice set generation in the activity network

- Sample paths from given distribution, without full enumeration
- With Metropolis-Hastings algorithm, possibility to define non-link additive cost
- Target weight defined as

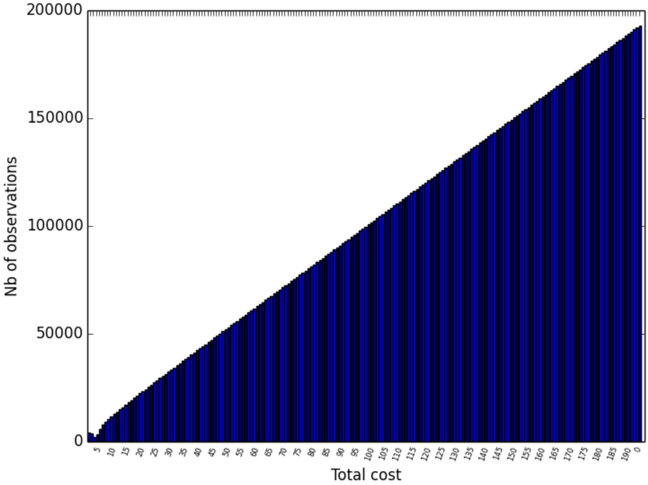
$$\delta(\Gamma) = -\mu_v \cdot \sum_{v \in \Gamma} \delta_v(v) - \mu_\Gamma \cdot \delta_\Gamma(\Gamma)$$

  with
  - link cost: frequency of observations
  - path cost: length of observed paths

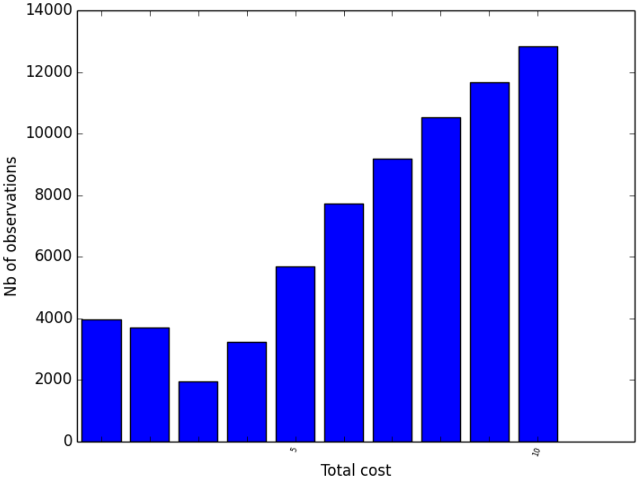
Path and link cost for different path lengths.



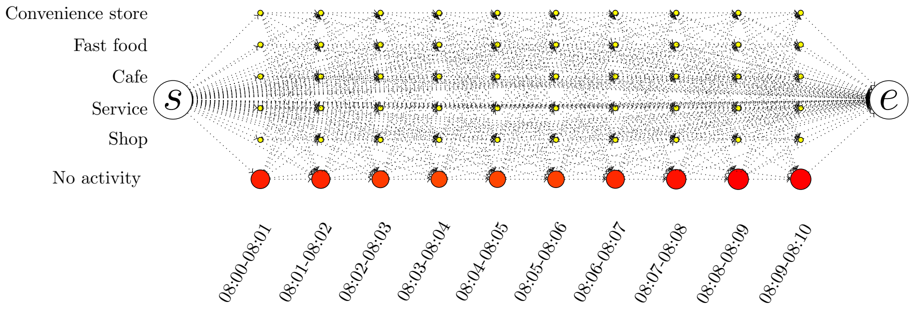
Sum of path and link cost per length, weight ratio of 1



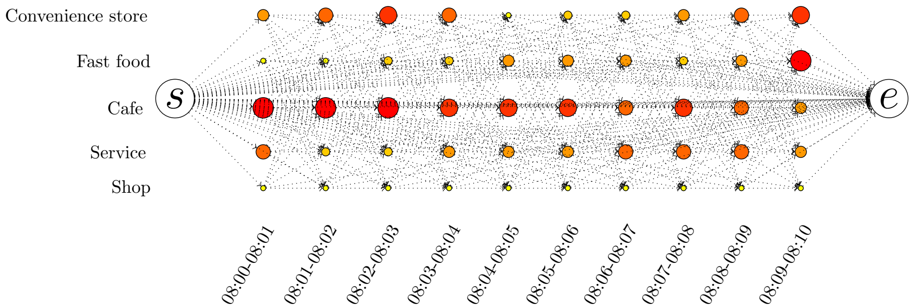
Sum of path and link cost per length, weight ratio of 1



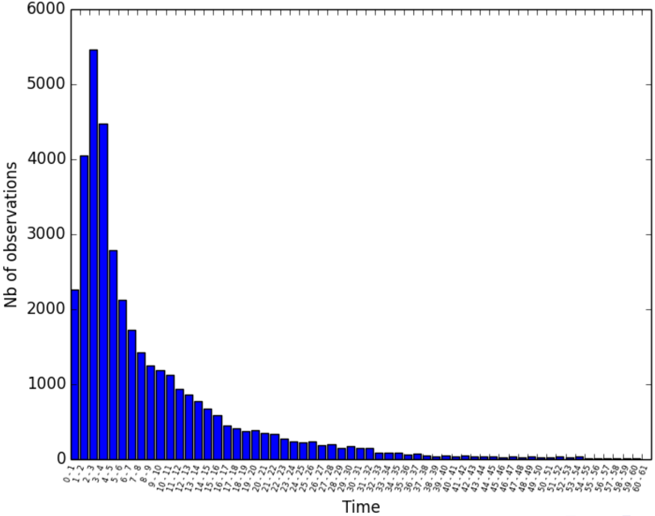
Activity network: frequency of observations



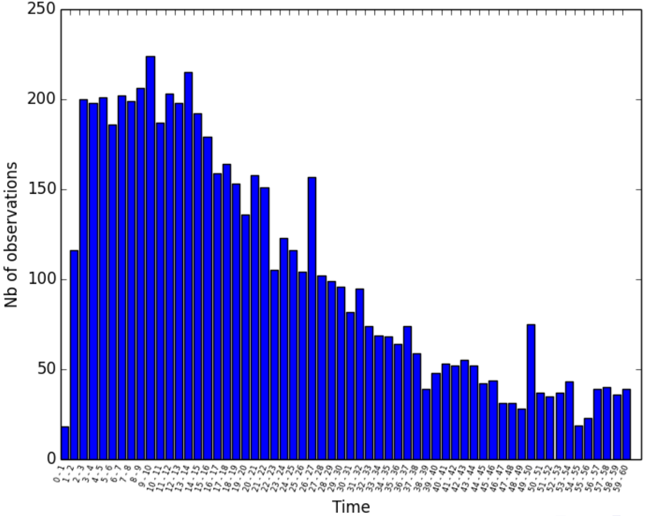
Activity network: frequency of observations: Zoom



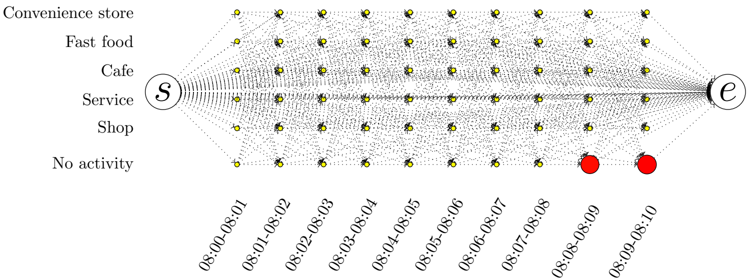
Activity network: Length of observations



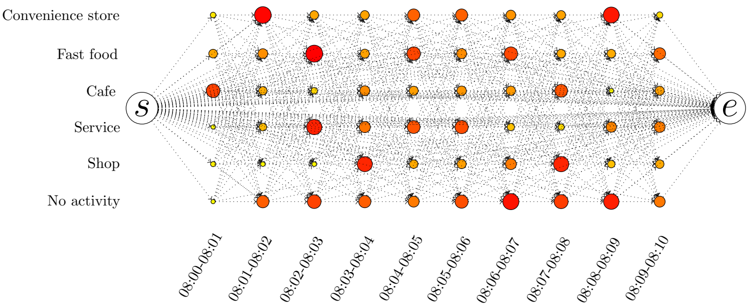
Activity network: Length of observations with activities



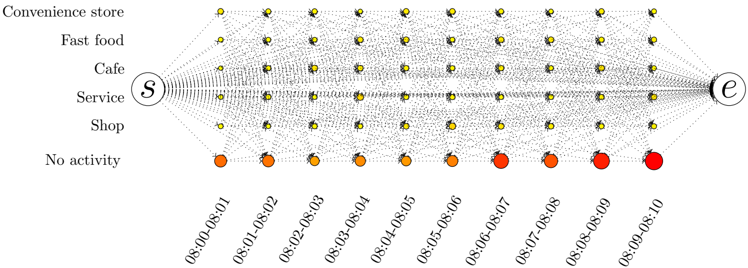
Generated path with $\mu_v = 1$ and $\mu_\Gamma = 0$



Generated path with $\mu_v = 0.001$ and $\mu_\Gamma = 0$



Generated path with $\mu_v = 0.005$ and $\mu_\Gamma = 0$

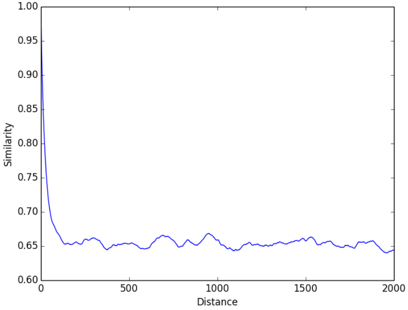


Similarity measure

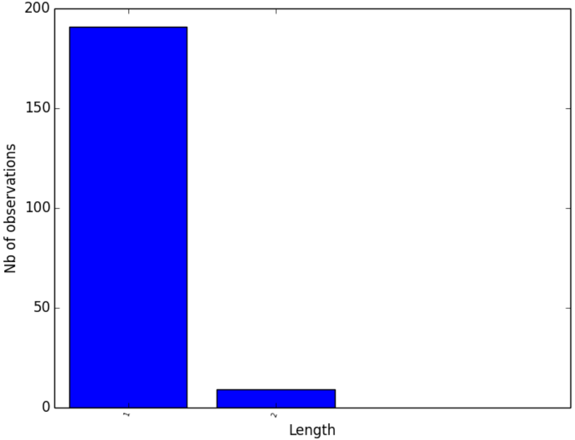
- Transition distribution is local, similar states generated in iterations
- Similarity measure:

$$\frac{1}{K}\sum_{k=1}^{K}\frac{|\Gamma^k \bigcap \Gamma^{k+d}|}{\frac{1}{2}|\Gamma^k| + |\Gamma^{k+d}|}$$

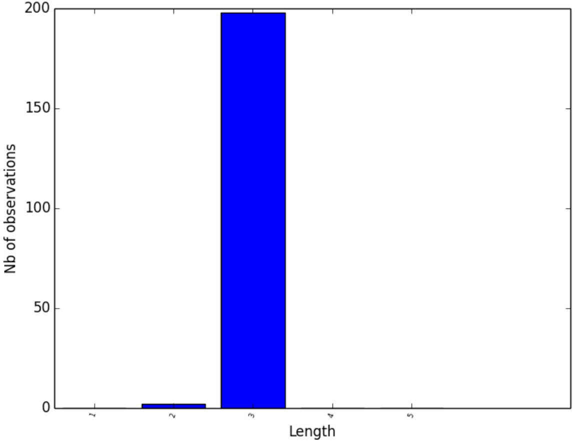
with $|\Gamma^k \bigcap \Gamma^{k+d}|$ nb of identical nodes, k nb of iterations



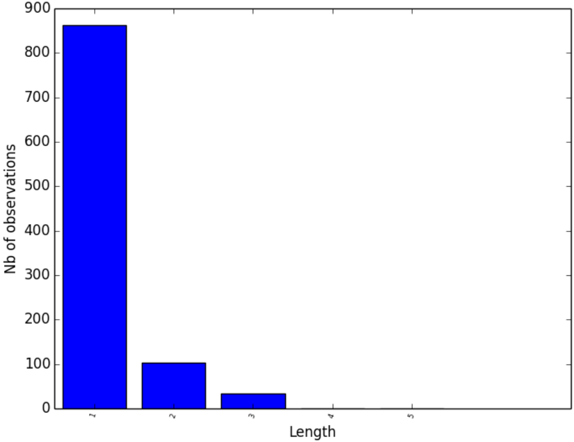
Generated path length with $\mu_v = 0.005$, $\mu_\Gamma = 0$ and sample interval of 200



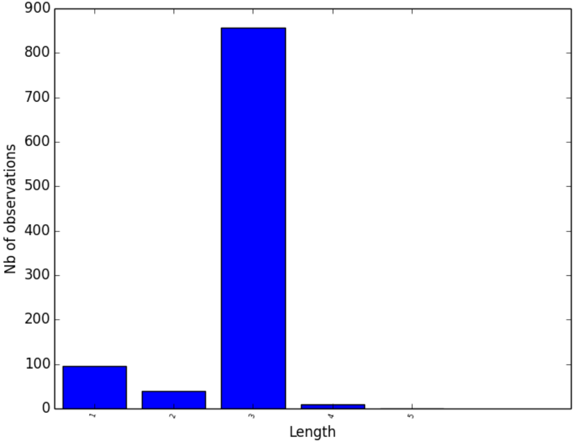
Generated path length with $\mu_V = 0.005$, $\mu_\Gamma = 1$ and sample interval of 200



Generated path length with $\mu_V = 0.005$, $\mu_\Gamma = 0.001$ and sample interval of 200



Generated path length with $\mu_V = 0.005$, $\mu_\Gamma = 0.002$ and sample interval of 200



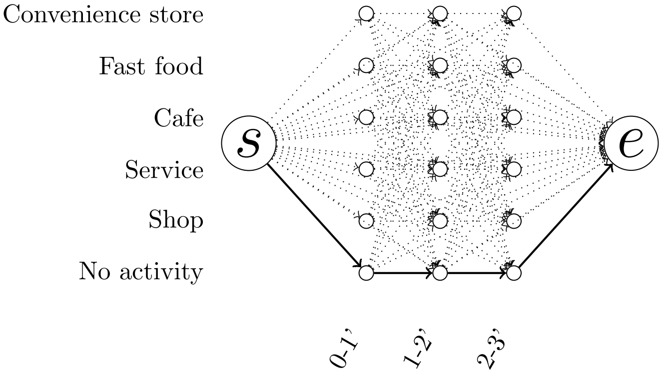
Conclusion

- New approach to activity-based modeling
- Importance sampling based on
  - time-of-day/activity attractivity
  - activity-episode duration
- Probability $q(\Gamma)$ of generating path Γ can be then used in choice model, as in Danalet and Bierlaire (2014)

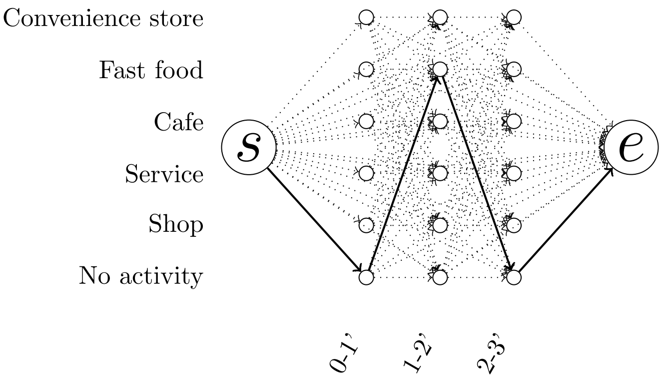
Open questions

Are node attractivity and path length the best measure of an "attractive" activity path?

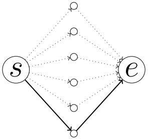
Most common activity path in relative time



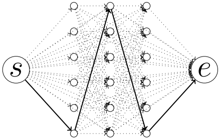
Most common activity path in relative time including at least one activity



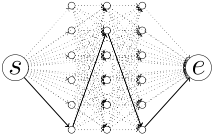
Different sequences of activities, independent of time



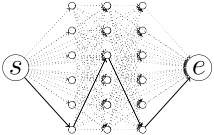
(a) 40'897 obs.



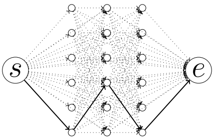
(b) 706 observations



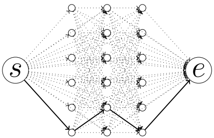
(c) 548 observations



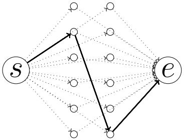
(d) 360 observations



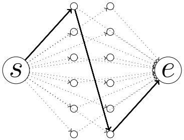
(e) 270 observations



(f) 98 observations



(g) 39 observations



(h) 24 observations

Thank you!

Questions?

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