Simulating work-leisure cycles in large scale scenarios

Models and implementation

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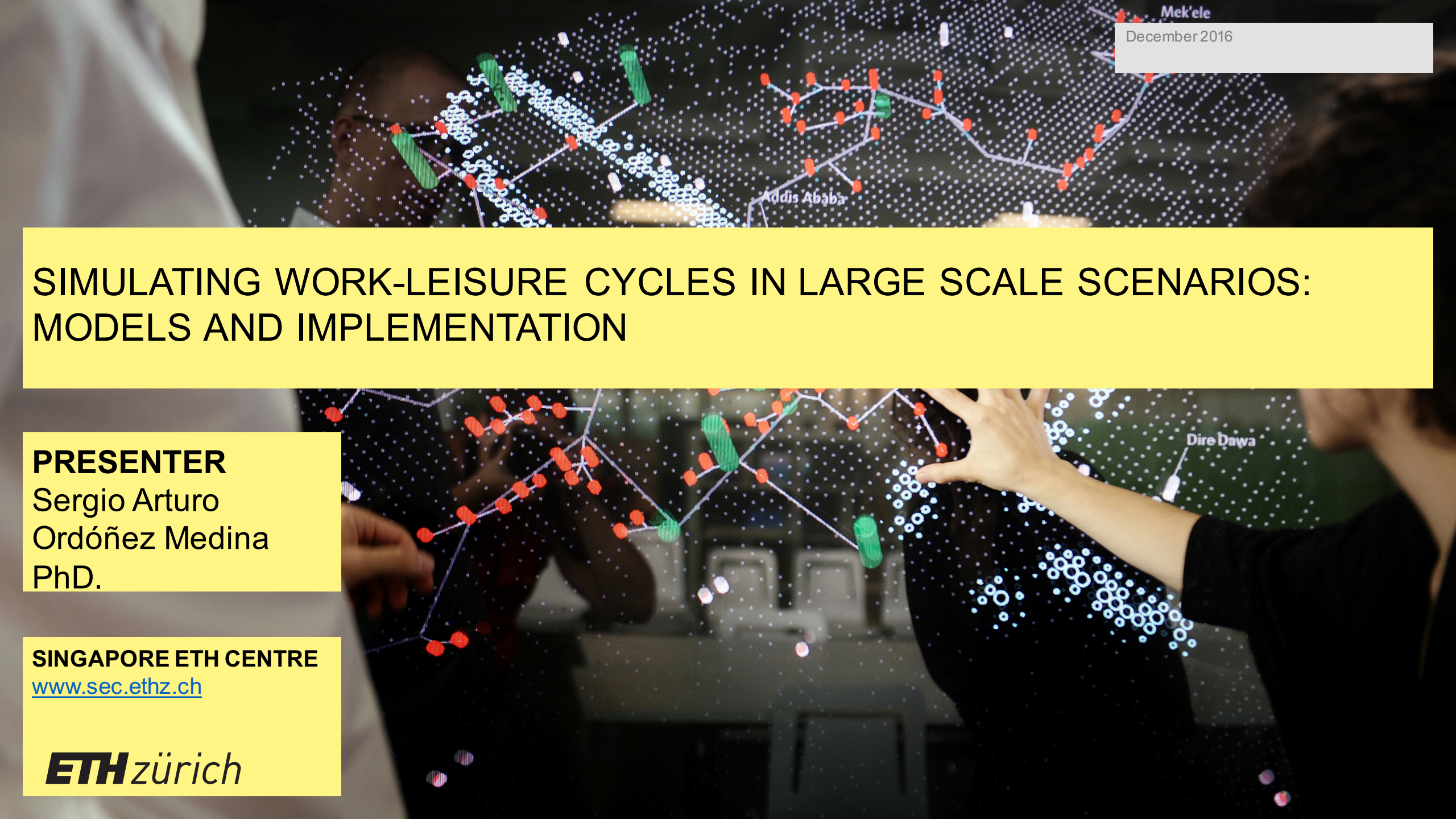

December 2016

SIMULATING WORK-LEISURE CYCLES IN LARGE SCALE SCENARIOS: MODELS AND IMPLEMENTATION

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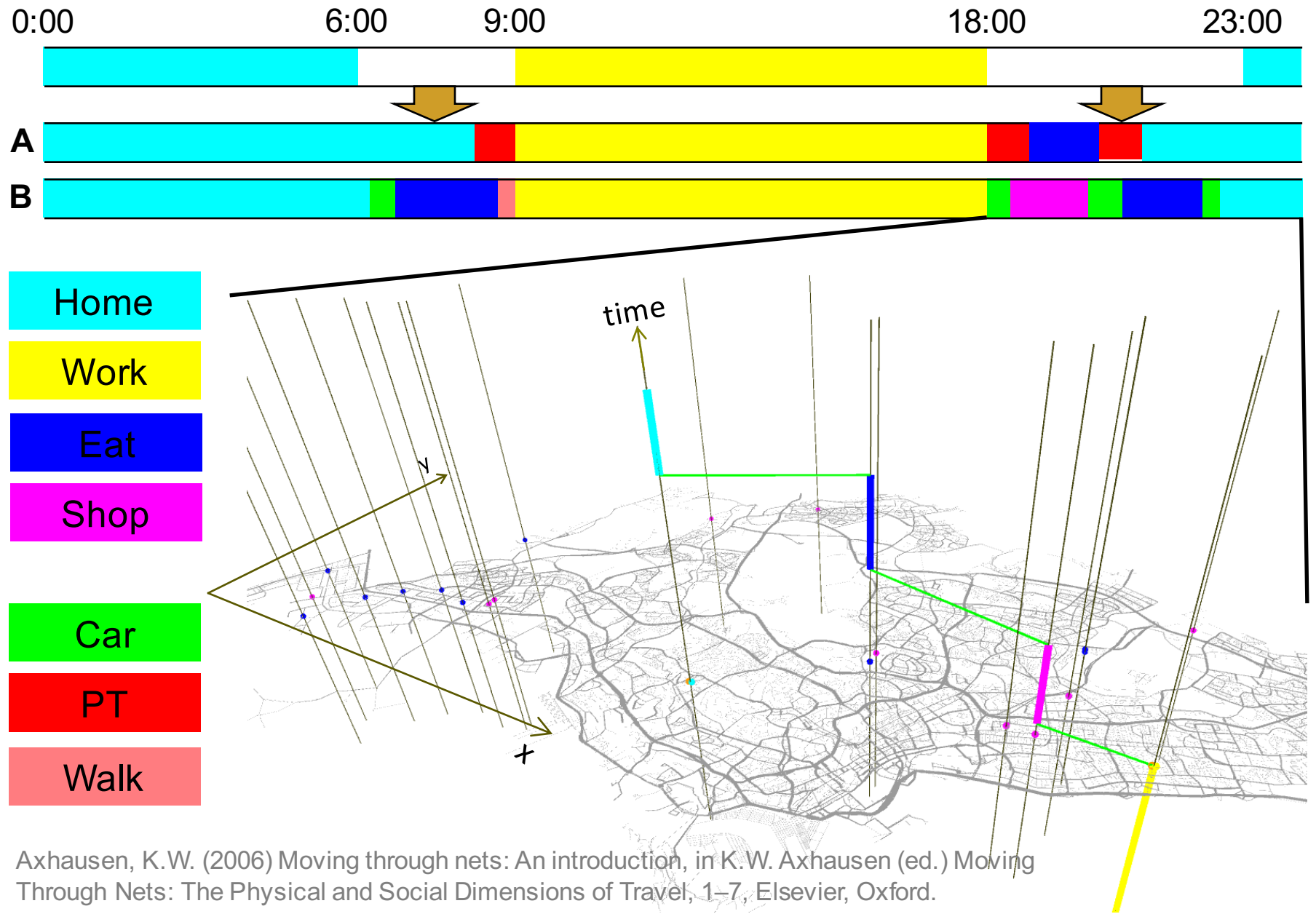
CHALLENGES OF MULTI-DAY ACTIVITY SCHEDULING

- Number of possible activity chains
  - Daily model, 4 activity types, 3 activites per day: 64 chains
  - Weekly model, 4 activity types, 3 activites per day: 4.4E12 chains
- Number of scheduling dimensions
  - Type of activities
  - Start time, Duration
  - Location
  - Number of activities
  - Mode of transportation
- Prioritization of dimensions
- Heterogeneity in human behaviour
- Shared decisions

PROPOSAL FOR MULTI-DAY ACTIVITY SCHEDULE

- Fixed and flexible activities
- Skeleton of fixed activities
- Mental map for flexible activities
- Plan flexible activities on-the-fly
- Longest time window



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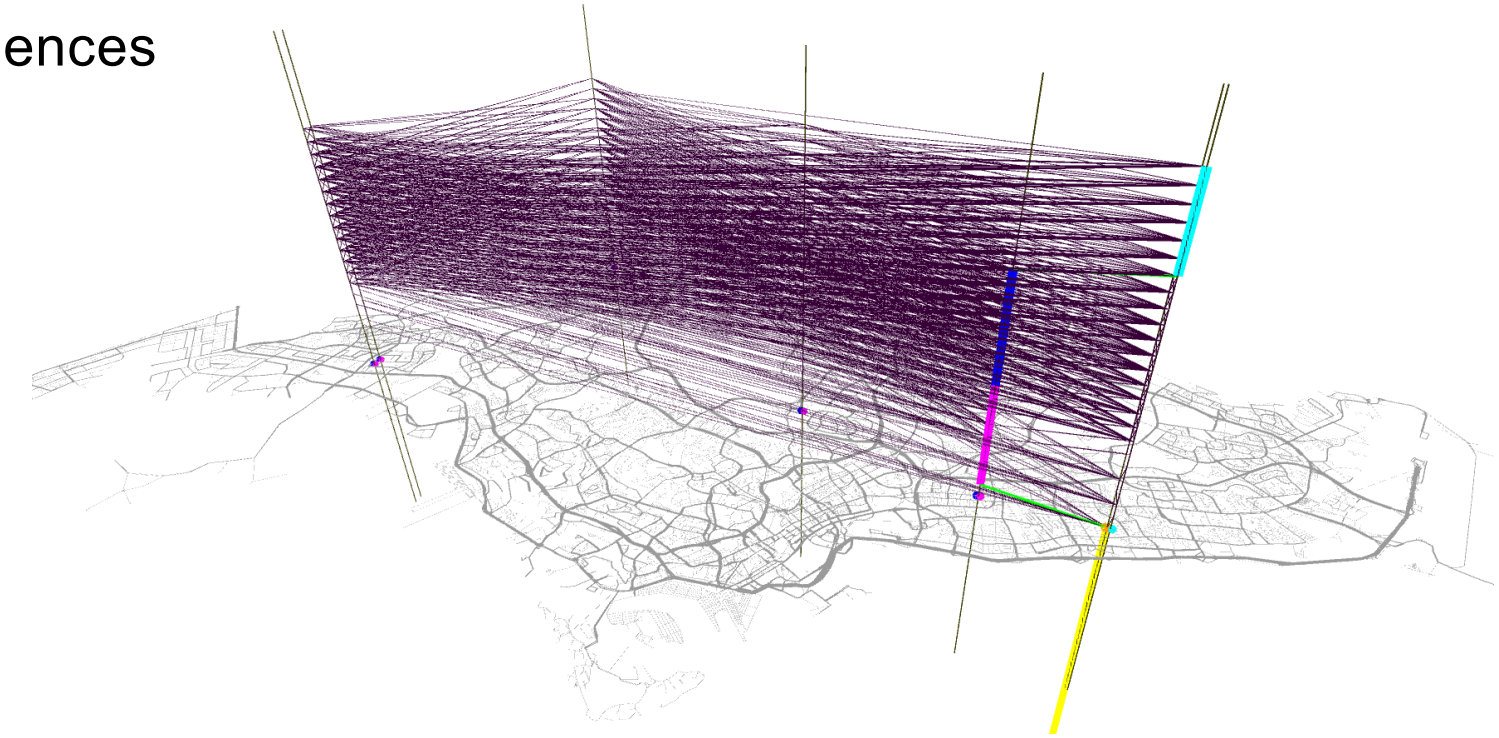
Axhausen, K.W. (2006) Moving through nets: An introduction, in K.W. Axhausen (ed.) Moving Through Nets: The Physical and Social Dimensions of Travel, 1–7, Elsevier, Oxford.

FLEXIBLE ACTIVITIES

NETWORK-BASED MULTI-ACTIVITY SCHEDULER

- Network represents possible experiences
- Links for activities and trips
- Spatio-temporal prism:
  - (i) initial location
  - (ii) final location
  - (iii) a time window.
- Recursive network construction
- Current maximum utility path
- Controlled size:
  - Few locations
  - Discrete time, time bin
  - Activities randomly discarded.



Output: fully specified activity chain:

activity types, start times, durations, locations and transportation mode

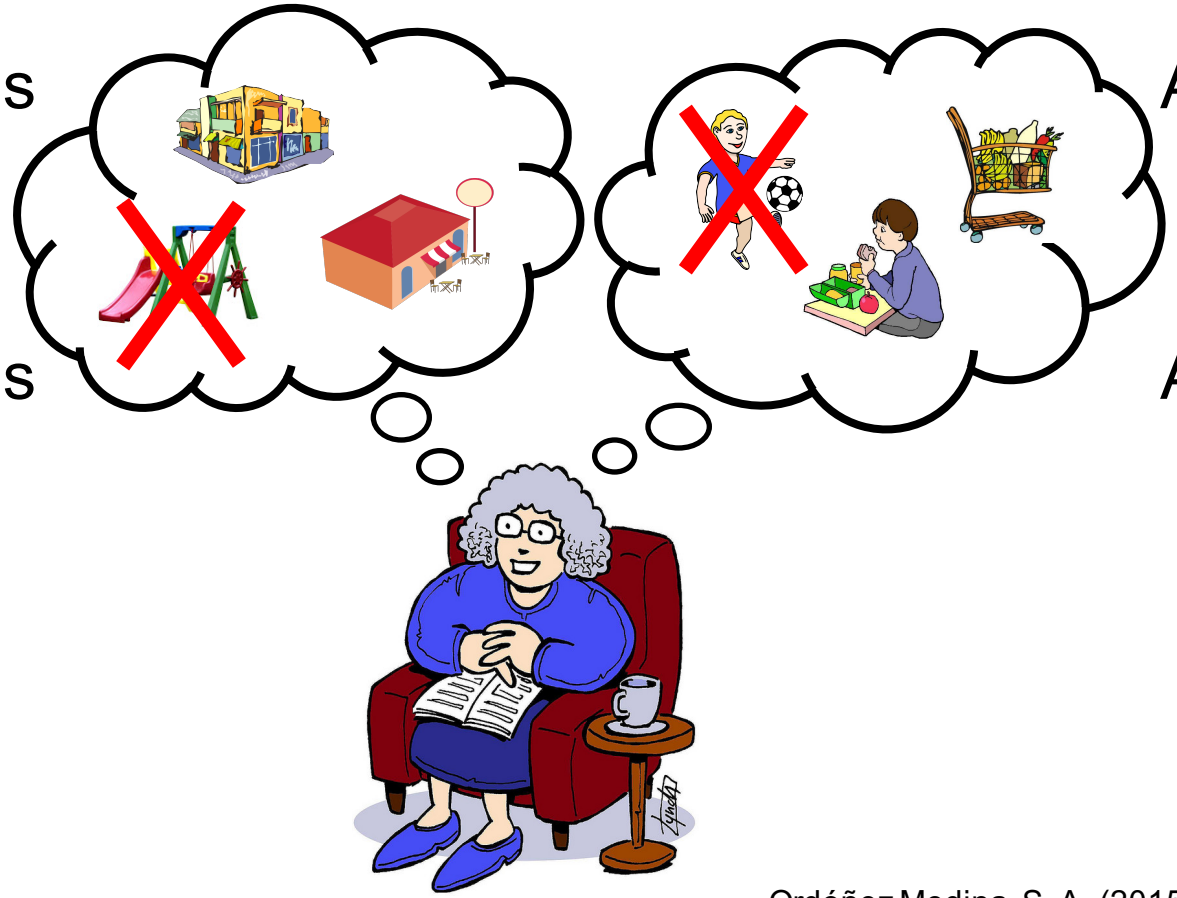
Hägerstrand, T. (1970) What about people in regional science?, *Papers of the Regional Science Association*, **24** (1) 7–21.

Arentze, T. A. and H. J. P. Timmermans (2004) Multistate supernetwork approach to modelling multi-activity, multimodal trip chains, *International Journal of Geographical Information Science*, **18** (7) 631–651.

MENTAL MAP FOR FLEXIBLE ACTIVITY SCHEDULING

Place types

Activity types



Set of evoked places

Activity agenda

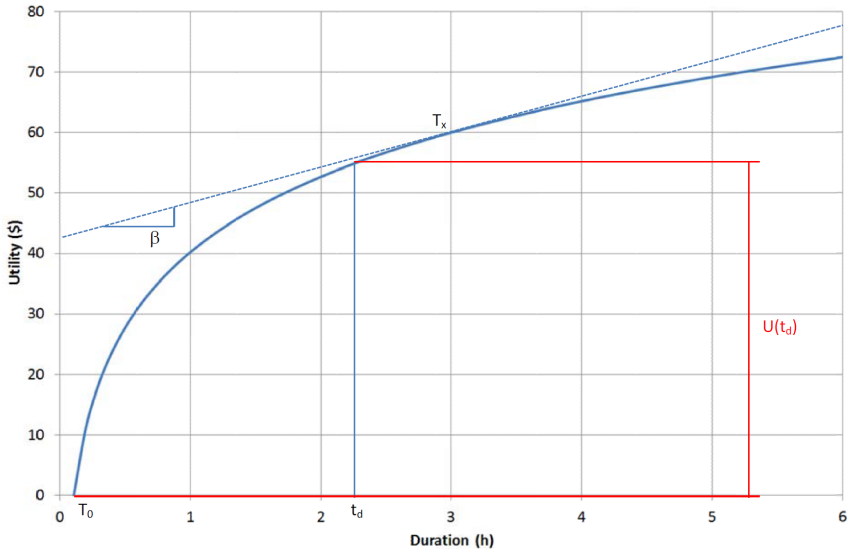
Ordóñez Medina, S. A. (2015b) Recognizing personalized flexible activity patterns, paper presented at the *14th International Conference on Travel Behaviour Research (IATBR)*, Windsor, July 2015.

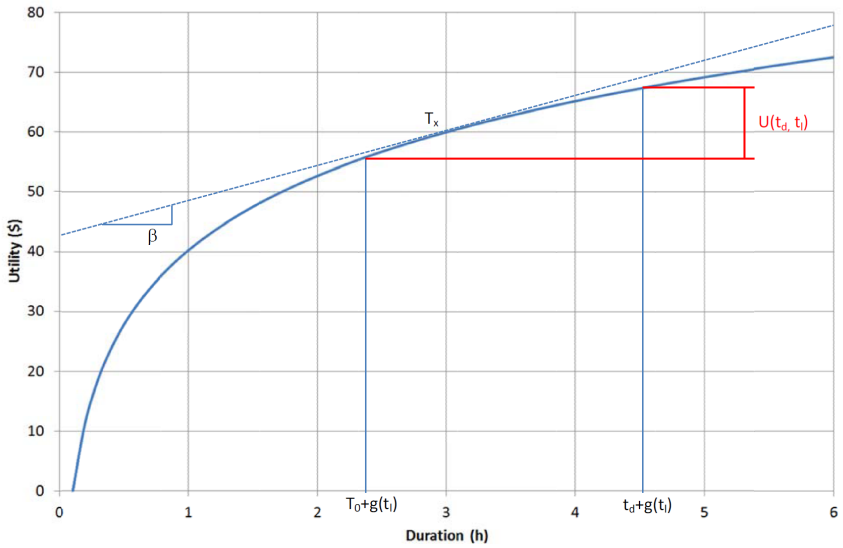
ACTIVITY PERFORMING UTILITY FUNCTIONS

Original model:

$$U(t_d) = \beta T_x ln\left(\frac{t_d}{T_0}\right)$$

$$T_0 = e^{\frac{-10h}{T_x p \beta}} T_x$$





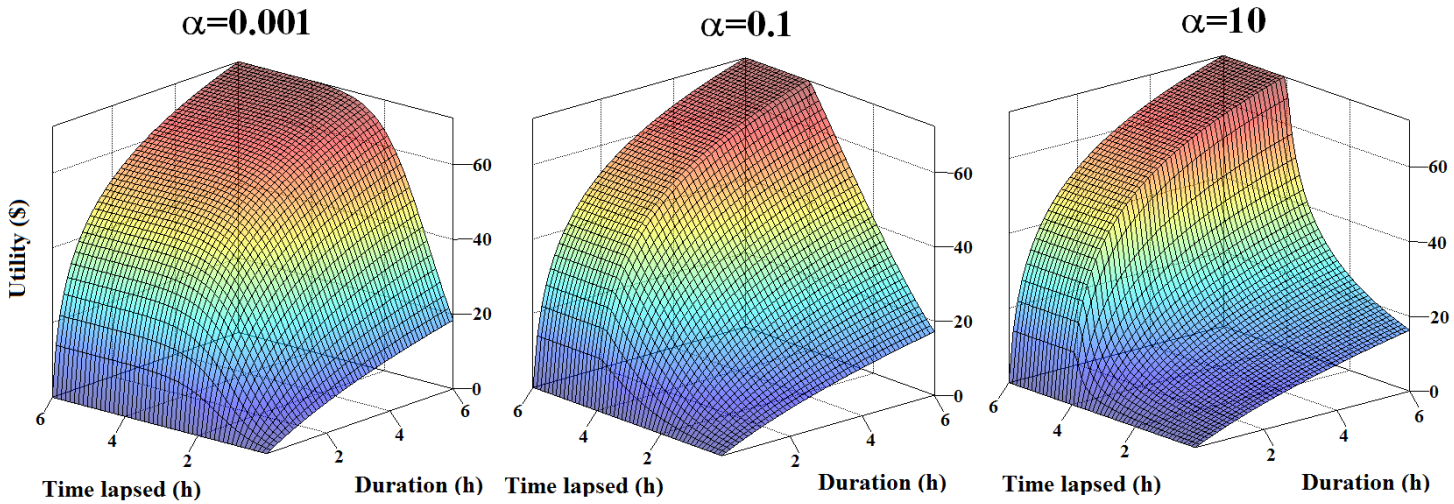
Proposed model:

$$U(t_d, t_l) = \beta T_x \left(\frac{t_d + g(t_l)}{T_0 + g(t_l)}\right)$$

$$T_0 = e^{\frac{-10h}{T_x p \beta}} T_x$$

$$g(t_l) = \begin{cases} \alpha(e^{\gamma(T - t_l)} - 1), & \text{with } t_l < T \\ 0, & \text{with } t_l \geq T \end{cases}$$

$$\gamma = \frac{1}{T} ln\left(\frac{T + \alpha}{\alpha}\right)$$



Charypar, D. and K. Nagel (2005) Generating complete all-day activity plans with genetic algorithms, *Transportation*, **32** (4) 369–397.

RECURSIVE SCHEDULING ALGORITHM

```
1:  procedure ADDEDGEVERTEX
9:  begin:
10:     currentVertex ← lastVertex(currentPath).
11:     isEndTime ← currentVertex.time == endTime.
12:     if currentVertex.place == endPlace AND isEndTime then
13:         if utility(currentPath) > utility(path) then
14:             path ← currentPath.
15:     else
16:         lastTravelTime ← bestTravelTime(currentVertex.place,
17:         endPlace, modes).
18:         time ← round(endTime – lastTravelTime, time_bin).
19:         while time > currentVertex.time do
20:             vertex ← createVertex(currentVertex.place, time).
21:             duration ← time –currentVertex.time.
22:             for activity ∈ currentVertex.place.activities do
23:                 if performAct(agenda, activity, times) then
24:                     createActivityEdge(currentVertex, vertex, activity.type).
25:                     addVertexPath(currentPath, vertex).
26:                     addEdgeVertex(currentPath, endTime, endPlace,
27:                     agenda, places, modes).
28:                     removeVertexPath(currentPath, vertex).
29:             time ← time – time_bin.
30:         for place ∈ places do
31:             for mode ∈ modes do
32:                 travelTime ← travelTime(currentVertex.place,
33:                 place, mode).
34:                 time ← round(currentVertex.time + travelTime, time_bin).
35:                 vertex ← createVertex(place, time).
36:                 createTripEdge(currentVertex, vertex, mode).
37:                 addVertexPath(currentPath, vertex).
38:                 addEdgeVertex(currentPath, endTime, endPlace,
39:                 agenda, places, modes).
40:                 removeVertexPath(currentPath, vertex).
```

Random discard according to observed behaviors

Recursive

Nodes in the same location, activity links

Nodes in different location, trip links

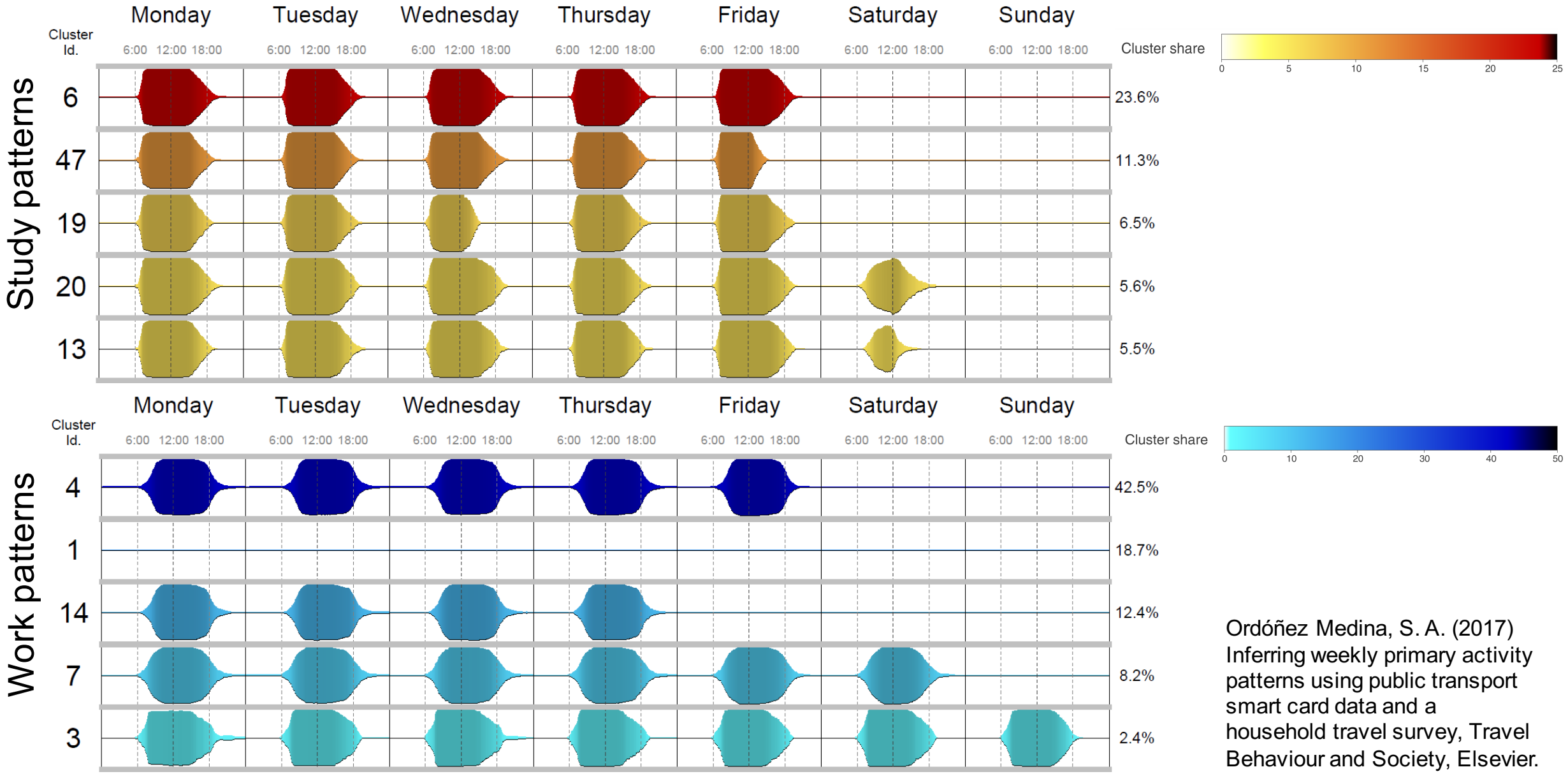
Complexity:

$$\Theta(a, p, m, T, b) = (a \cdot p \cdot m)^{T/b}$$

a	Number of activities
p	Number of places
m	Number of modes
T	Time window size
b	Time bin

FIXED ACTIVITIES

WEEKLY PATTERNS OF FIXED ACTIVITIES

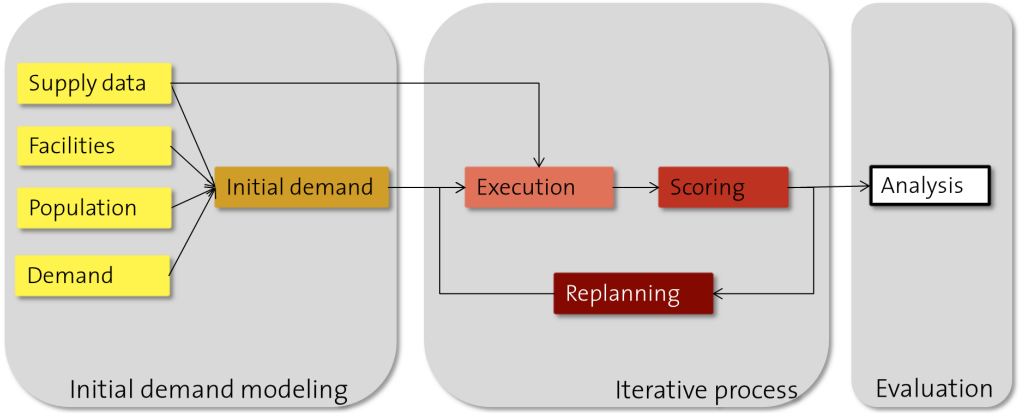


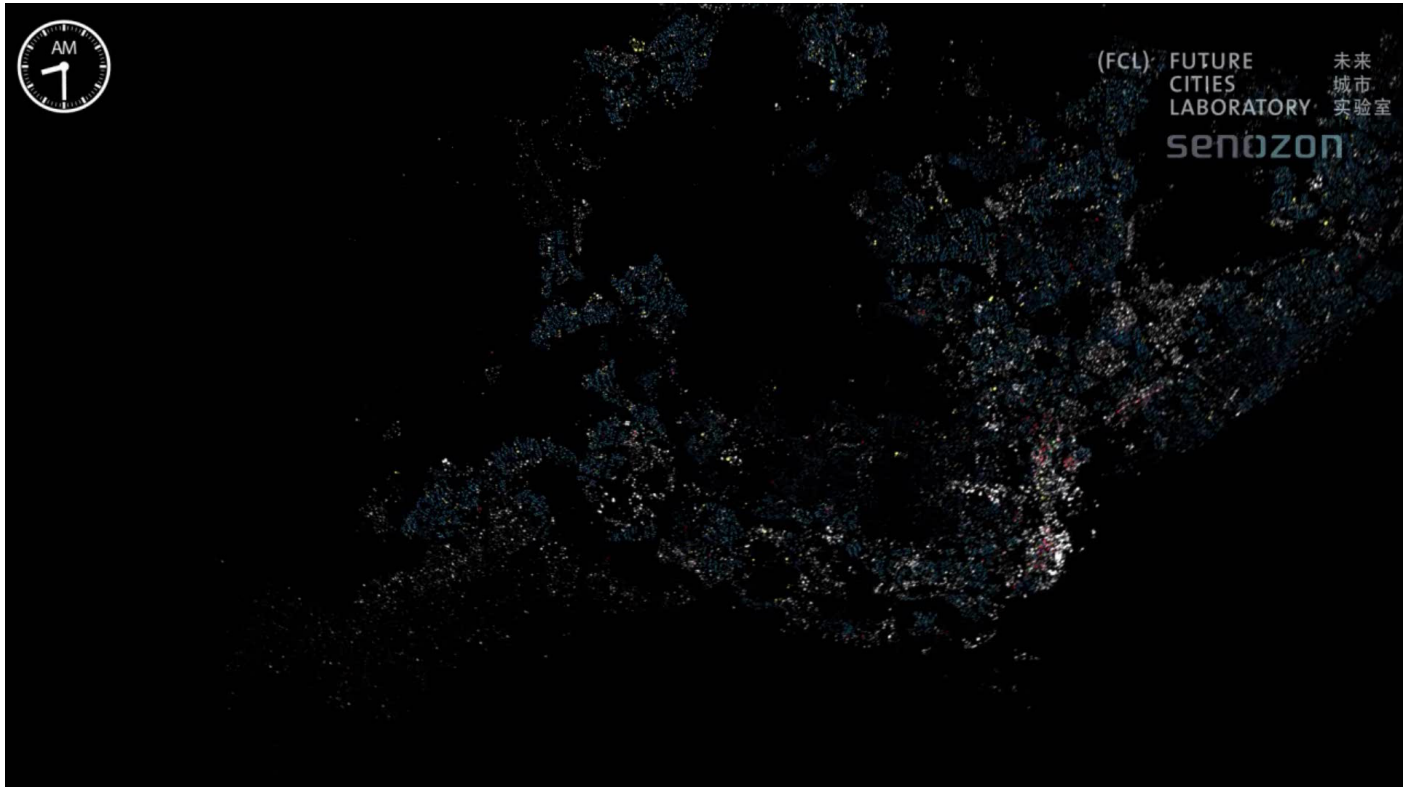
Ordóñez Medina, S. A. (2017) Inferring weekly primary activity patterns using public transport smart card data and a household travel survey, Travel Behaviour and Society, Elsevier.

SIMULATION PLATFORM

MULTI-AGENT TRANSPORT SIMULATOR: MATSIM

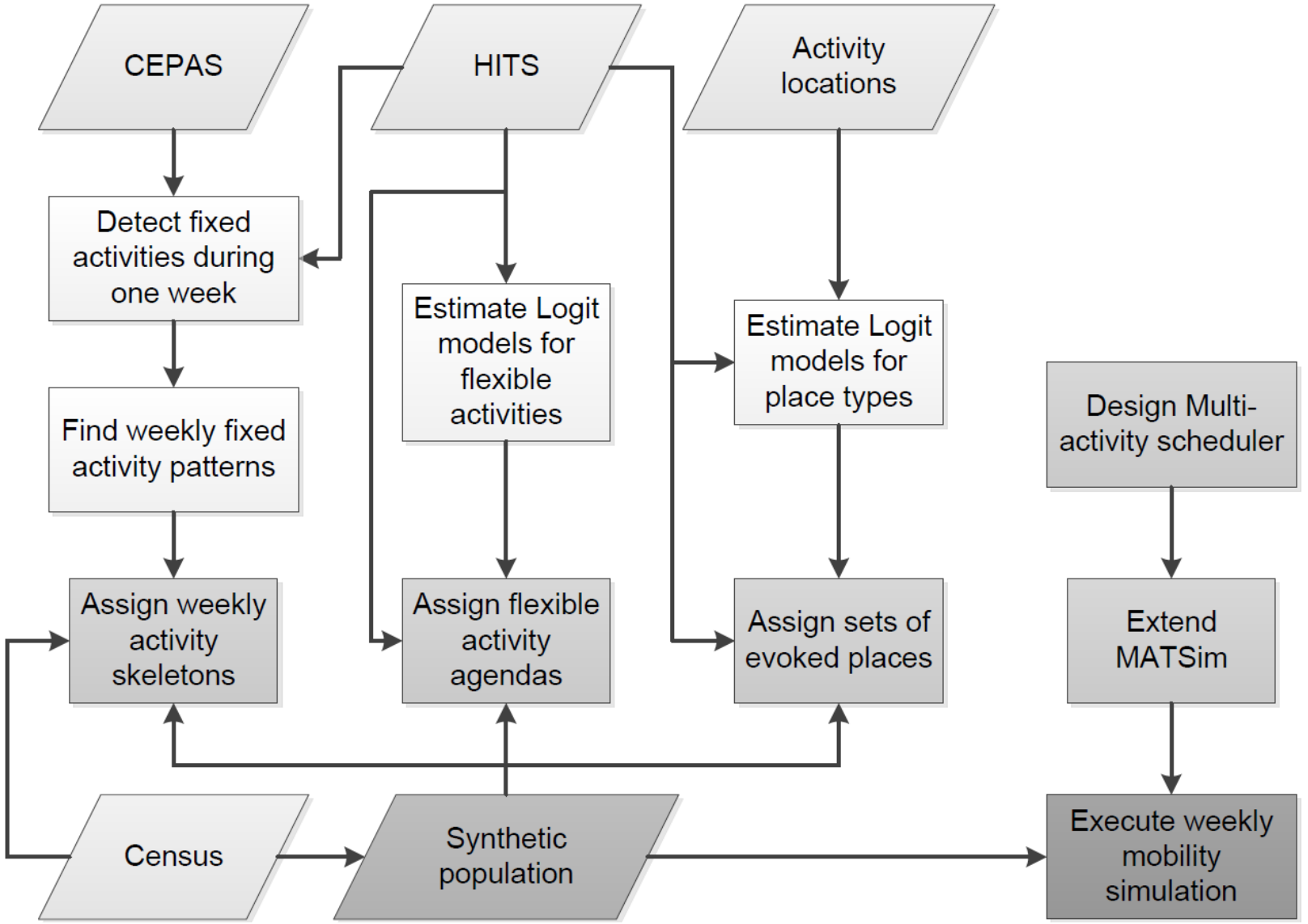
- Mesoscopic simulator
- Millions of agents interact in highly detailed transportation networks
- Evolutionary algorithm
- Designed for a one-day time horizon



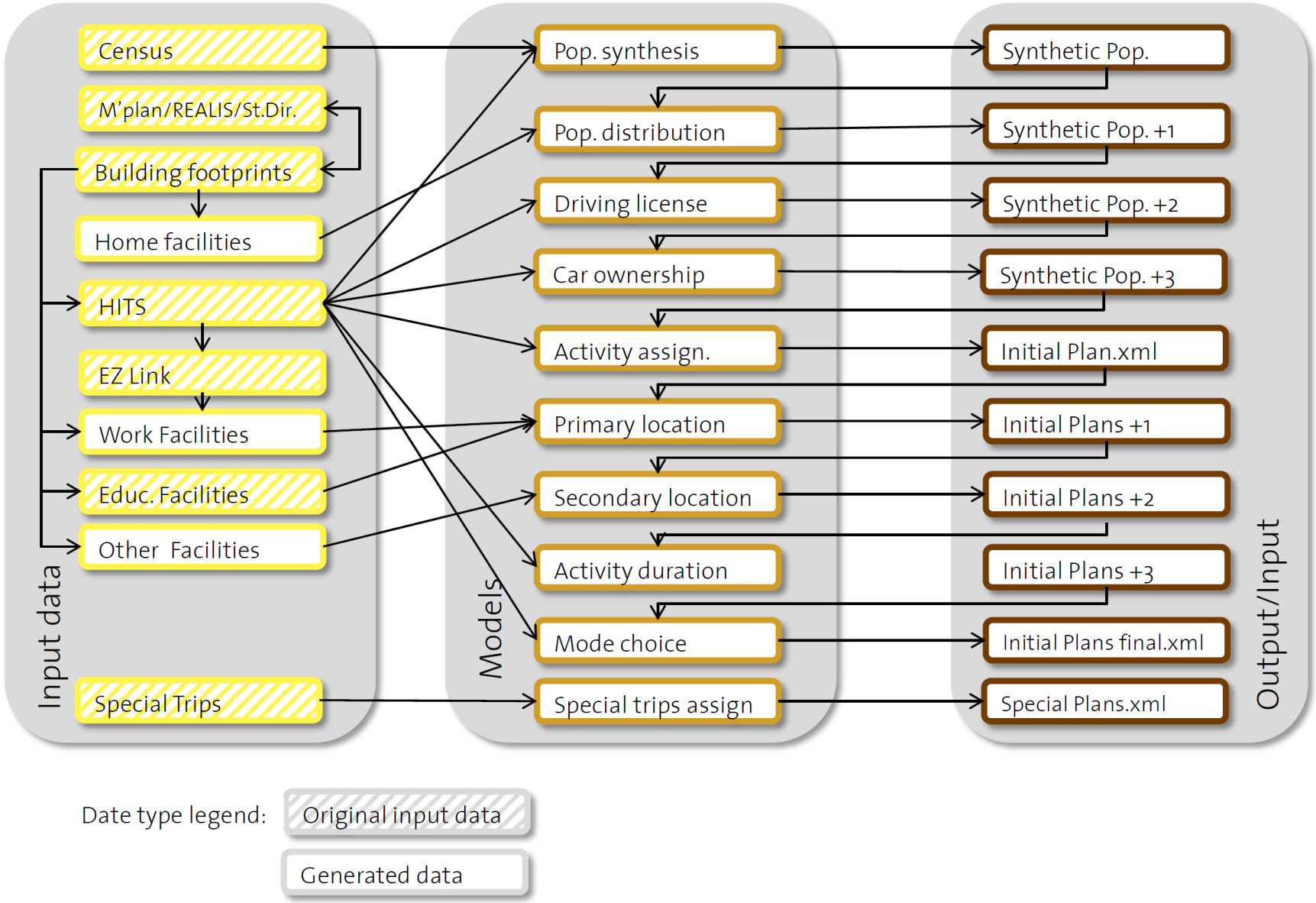


WEEKLY SIMULATION

PROPOSED METHODOLOGY



SINGAPORE DATA AND MATSIM SCENARIO



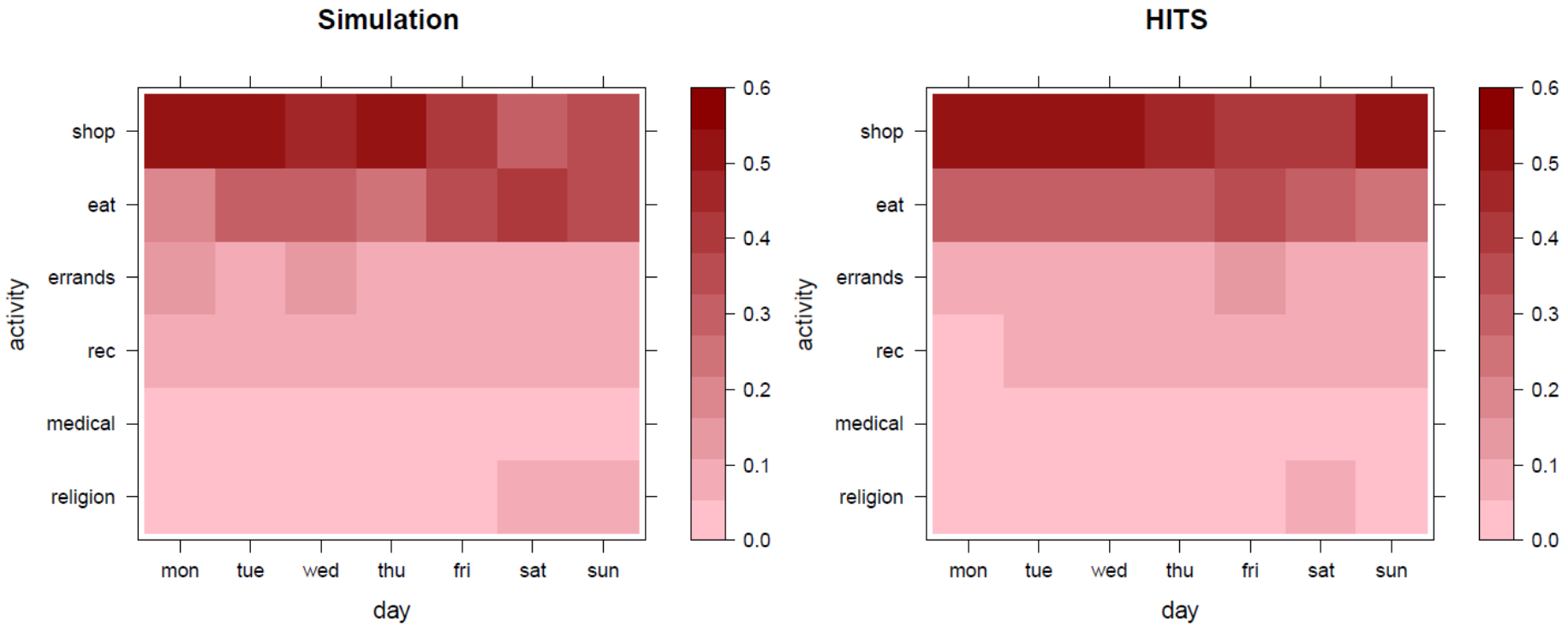
- 4.3 million agents
- 3.7 million agents traveling
- 100K activity facilities
- Home, work, and study locations
- Car availability
- Fully specified public transport system

WEEKLY SIMULATION SET-UP

Condition	Description
Scenario	Singapore
Sample	10%, 371,996 agents
Simulated time	0:00 - 174:00, 7 days plus 6 hours
Iterations	100
Fixed activities	home, 63 work activities, 87 study activities
Flexible activities	shop, eat, errands, rec, medical, religion
Number of facilities	105,412
Population with skeleton	100% first iteration, 30% other iterations
Memory size of agents	1 Plan
Number of threads	20

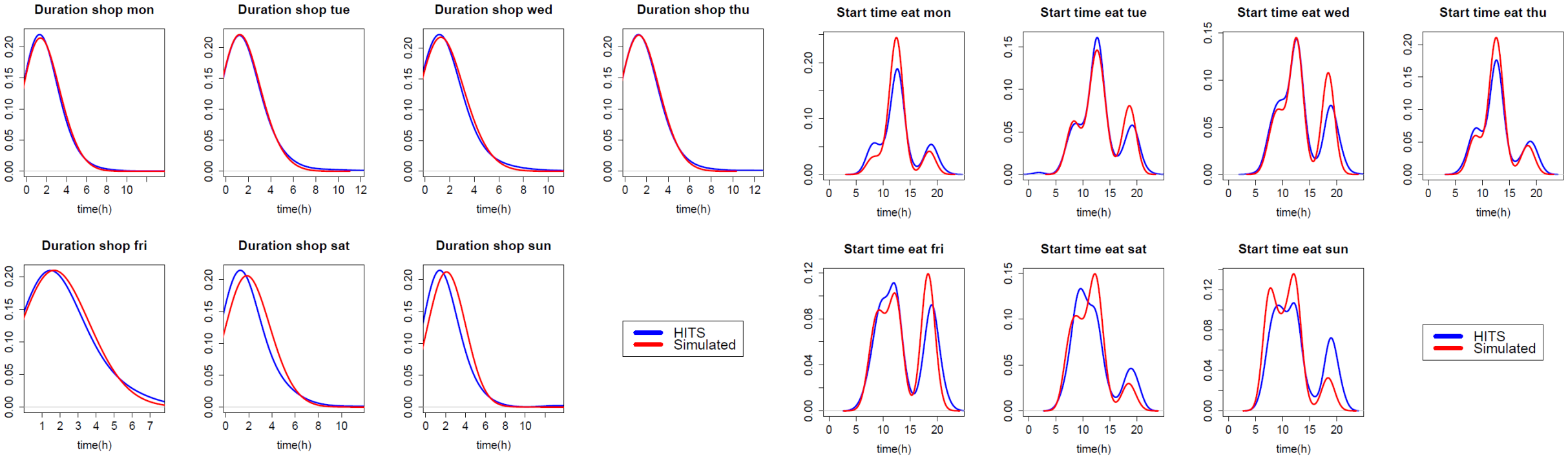
ACTIVITY TYPE VALIDATION

- Activity frequencies are well reproduced during the week.
- Monday is less accurate for border effect.
- Problem with simulated shopping on weekends



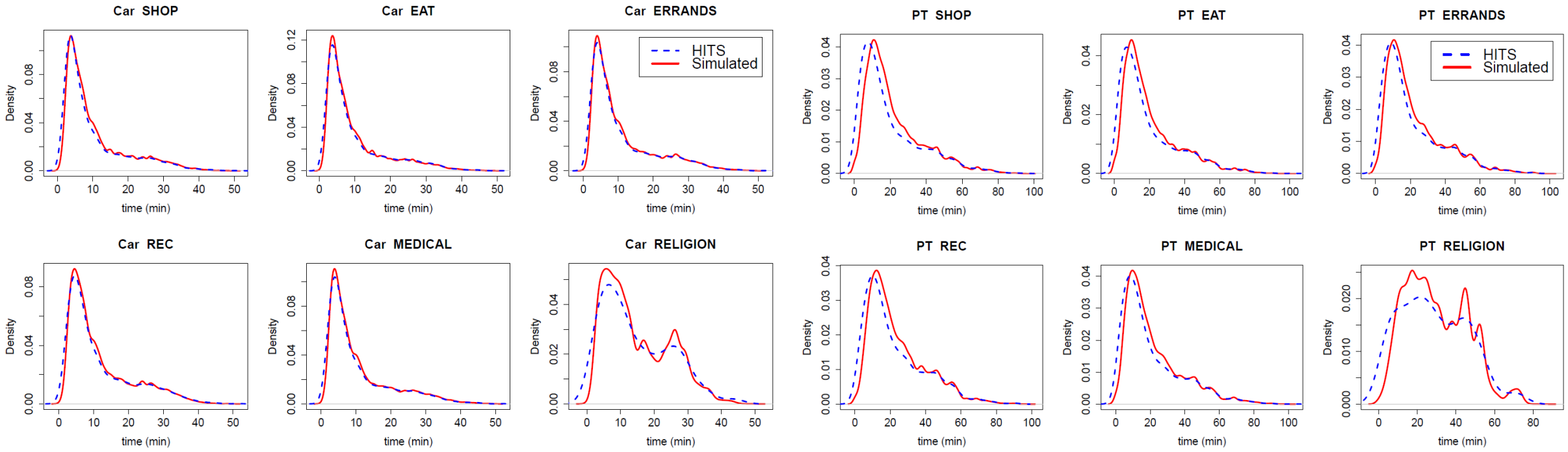
TEMPORAL VALIDATION OF FLEXIBLE ACTIVITIES

- Duration and Start time of scheduled flexible activities reproduce observed distributions.
- Scheduled eating activities reproduce 3 peaks on weekdays a 2 clear peaks on weekends.
- Fewer dinner activities are scheduled on weekends than reported.



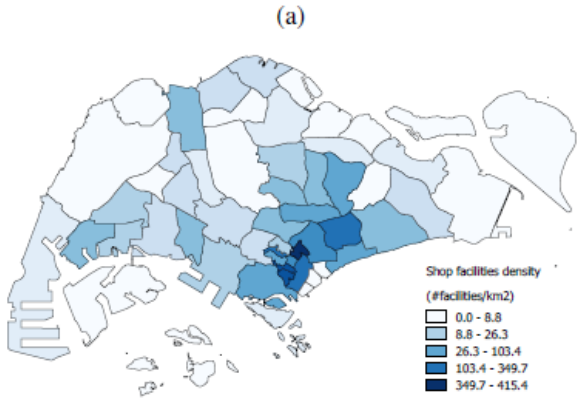
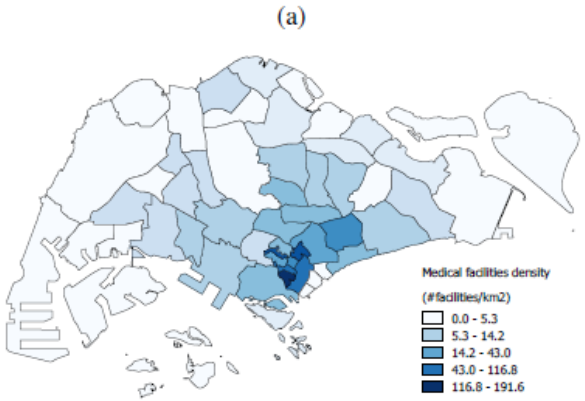
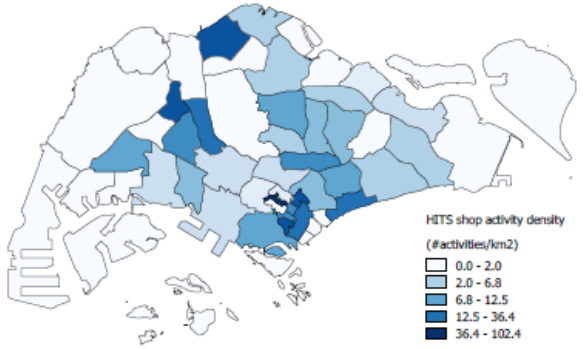
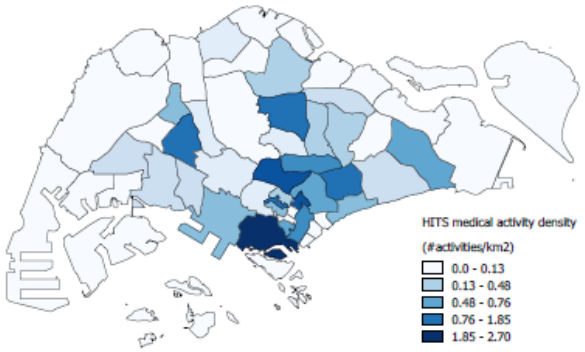
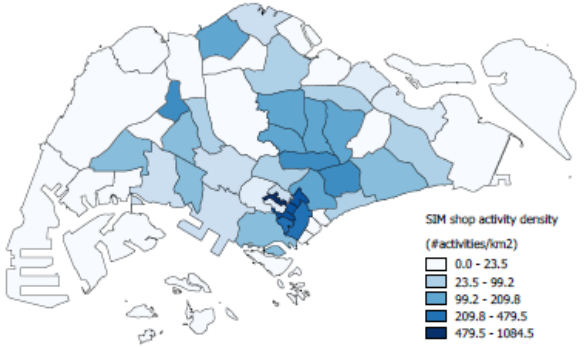
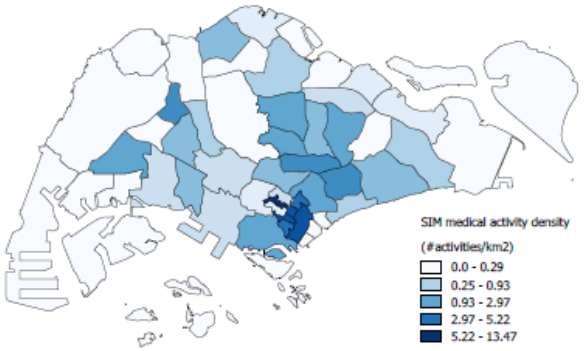
SPATIAL VALIDATION

- Evoked places are located at very accurate travel times from main locations of agents with and without car availability.
- Public transport travel times to evoked places are simulated longer than reported trips



SPATIAL VALIDATION

- For shopping, simulated distribution is more accurate to HITS than the distribution o activity facilities.
- As medical facilities were not classified as public and private and no models were estimated, the distribution is not accurate.

	Shop	Medical
Facilities distribution		
HITS activity performing distribution		
Simulated activity performing distribution		

CONCLUSIONS AND OUTLOOK

CONCLUSIONS

- A multi-day activity based model was proposed and implemented
- Based on previously proposed concepts:
  - Fixed and Flexible activities
  - Fixed activity skeleton
  - Flexible activity agenda
  - Set of evoked places
  - Planning activities on-the fly
- Models estimated with commonly available data
- Network-based multi-activity scheduler, controlled complexity, it doesn't prioritize any scheduling dimension
- Large scale mobility simulation of Singapore (10% sample) with accessible computation resources
- Validation of spatial, temporal and activity performing show promising results

FUTURE WORK

- Model with larger sample
- Speed up multi-activity scheduling processes
- Planning flexible activities at the beginning of the week or at the beginning of the day
- Generative probabilistic graphical models to generate fixed activity skeletons and/or flexible activity chains.
- Shared activities, Drop-off and Pick-up activities

THANK YOU