Intra-household interactions in ABMs

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About me

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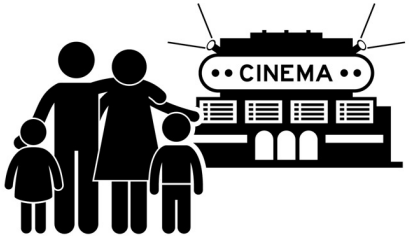
Introduction

- **Activity-based models (ABMs): Activity-based models** portray how people plan their activities and travels over a period of time such as a day.
- Traditional ABMs treat individuals as **isolated entities**.

- Individuals do **not** plan their day in **isolation** from other members of the household.
- Various **interactions**, **time arrangements**, and **constraints** affect the **in-home** as well as **out-of-home** activity schedules of individuals.

Example intra-household interactions

- **What are some examples of intra-household interactions?**
  - Individuals in a household synchronize their schedules to create time window overlaps for **joint activities**.



Joint participation in a recreational activity

A family dinner at home

Example intra-household interactions

- **What are some examples of intra-household interactions?**
  - Household members **coordinate their travels** as well.

Escorting children

Sharing a ride

Example intra-household interactions

- **What are some examples of intra-household interactions?**
  - The members of a household also **share responsibilities and resources** with each other to satisfy household needs.

Sharing household maintenance responsibilities

Sharing resources

Importance of capturing intra-household interactions in ABMs

- **How can intra-household interactions affect the schedule of individuals?**
  - Joint activities require coordination between the schedules of participating individuals.
  - Resource constraints affect the scheduling choices of individuals.
  - The escorting duty affects the schedule and travel patterns of the adult members as they should accommodate the pick-up and drop-off activities into their schedule.
  - Policies directly affecting the activity and travel patterns of an individual, such as earlier school starting times, can affect the schedule of multiple household members.

Hence, models dealing with individual choices need to be revisited to take account of the intra-household interactions and group decision-making paradigm.

Research question 1

1. How to incorporate **in-home** and **out-of-home activity scheduling** in a **single** scheduling model with **intra-household interactions**? (Rezvany et al. 2023)
   - A framework for joint simulation of in- and out-of-home activities, capturing intra-household interactions

Rezvany, N., Bierlaire, M., & Hillel, T. (2023). Simulating intra-household interactions for in- and out-of-home activity scheduling. Transp. Res. Part C Emerg. Technol., 157.

Household-level OASIS with interactions

- **Scheduling** process modelled as a **Mixed-Integer Utility Optimisation** problem.
- Assumption: Members of the household are **not independent** and are **altruist**.
- Agents schedule their day to **maximise the total combined utility** of the **household**.

$$\Omega = \max HUF$$

- Objective: Weighted sum of the utilities of agents in the household.

$$\Omega = \max \sum_{n=1}^{n=N_m} w_n U_n$$

agent priority parameter

Utility

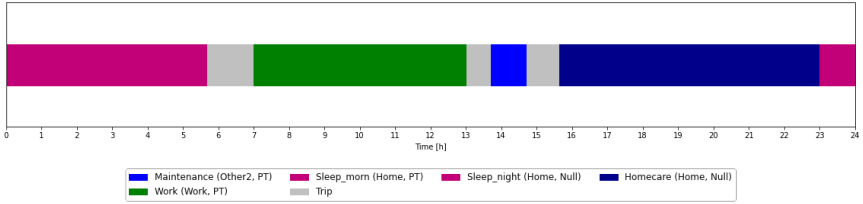
- Possible interaction aspects are captured in the utility function. For example:
  - (dis)utility of **joint activity participation** with other member(s) of the household, compared to solo participation in the activity.
  - Penalty of **escorting** other agent(s).

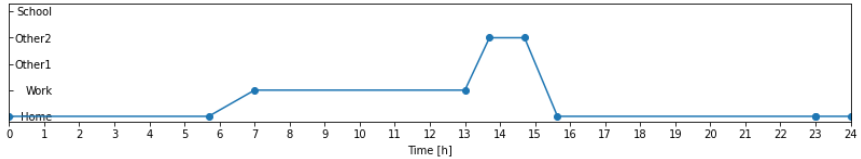
Constraints

- Subject to **both individual-level schedule feasibility constraints** and **explicit constraints** that appear due to **interpersonal dependencies**.
- **Within-household interactions** lead to **additional and more complex** constraints. For example:
  - Household private vehicle ownership,
  - Allocation of the resources to household members,
  - Sharing household maintenance responsibilities,
  - Joint participation of household members in activities,
  - Joint travels, and
  - Escorting.
- Interaction dimensions can be comfortably added!

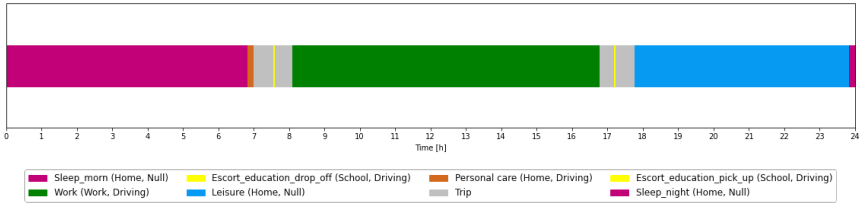
Example Simulation
Family of 3; 2 adults and 1 child…

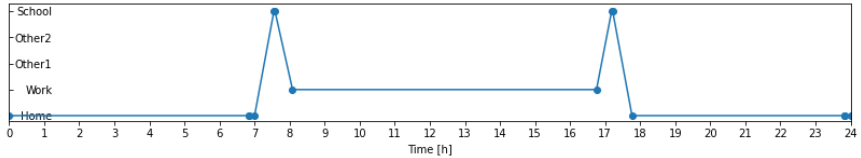
Adult1



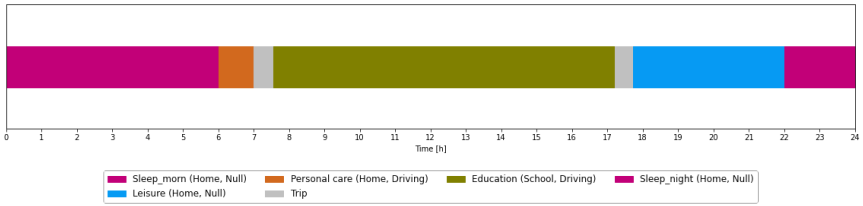


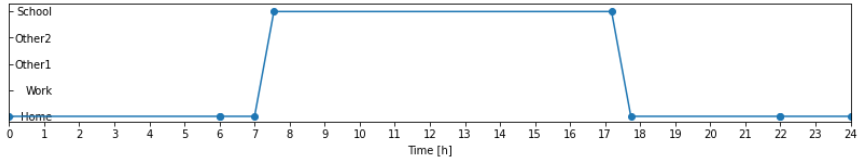
Adult2



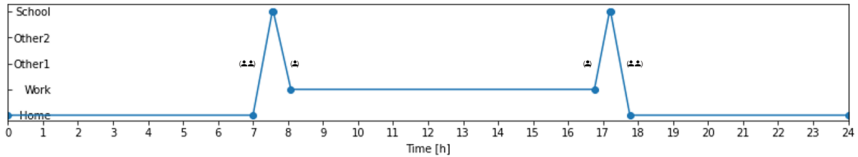


Child





Car



Operationalisation considerations

- Need for **calibration of maximum likelihood estimators of the parameters** of the utility functions.
- Requires **complete enumeration of the alternatives** in the **choice set**.
- The **full choice set** of alternatives in activity-based context is **combinatorial** and **unobservable**.

Research question 2: Household-level choice set generation

- Generate significant and meaningful parameter estimates, estimated on a sample choice set with **consistent alternatives** for all household members.
- **Individual-level** choice-set formations**: separate choice set formation** procedures with **no feedback**.
- **Parallel generation** for all household agents, encompassing **household-level choices**, **time arrangements**, and **group decision-making mechanism**.
- Strategic sampling with Metropolis-Hastings algorithm *(Pougala et al. 2021)*.

- **Output:** An ensemble containing **clusters of schedules** for all individuals in a household.

To conclude

Summary:

- General framework
- Group decision-making mechanism; household activity scheduling
- Explicit interactions; ensures consistency of choices
- Multiple interaction dimensions within the same model
- Capture resource constraints
- Flexible framework
- Household-level choice set formation

Challenges:

- Latent preferences
- Systematic validation
- Application testing

Thank you!

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