

Modelling life trajectories and mode choice using Bayesian Belief Networks

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**Defense
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**Tuesday
February 23rd**

16h00

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Contents presentation

- Introduction
- Framework
- Bayesian Belief Networks
- Retrospective Internet-based survey
- Learned networks
- Validation
- Illustration
- Conclusions



Introduction

Transportation Models

Traditionally, primarily examined as a stand alone problem. Modelled as a function of various attributes of the alternatives.

Later, modelled as part of more comprehensive models (activity-based approach).

Limitations:

Static models and influence of changes (in life) are not taken into account and modelled in these models

Need for further research

Explore and model dynamics along various time horizons



Introduction

Other perspective

Structural lifecycle events could trigger shifts on activity-travel choice decisions of individuals

Dynamic network

Traditional models are static, not dynamic. Only changes in attributes are taken into account. In reality, behaviour may not be static, but always in motion toward an equilibrium

Focus and aim

Long-term dynamics: model life trajectory and the impact of life course events in activity-travel patterns using mode choice as an example



Introduction

Life course approach, central concepts:

1. Life trajectories
2. Transitions
3. Events

Life course approach, multiple careers:

1. Housing
2. Household
3. Education
4. Occupation

Timing, sequencing, duration and spacing used to describe the concepts



Framework

Life course events may trigger individuals and households to **rethink** their **habitual** activity-travel **patterns**. It may decide them to change one or more facets of their activity-travel patterns.

A **particular event** may also lead to **other** life course **events**. Thus, life course events may have direct and indirect effects on other life course events and on activity-travel patterns.

Critical incidents

Unexpected events such as accidents or policies

Lifecycle Event

Major event in a person's life such as birth of a child, change of job



Framework

Human Behavior

Individuals adapt their behavior until *the utilities* meets at least a certain aspiration level

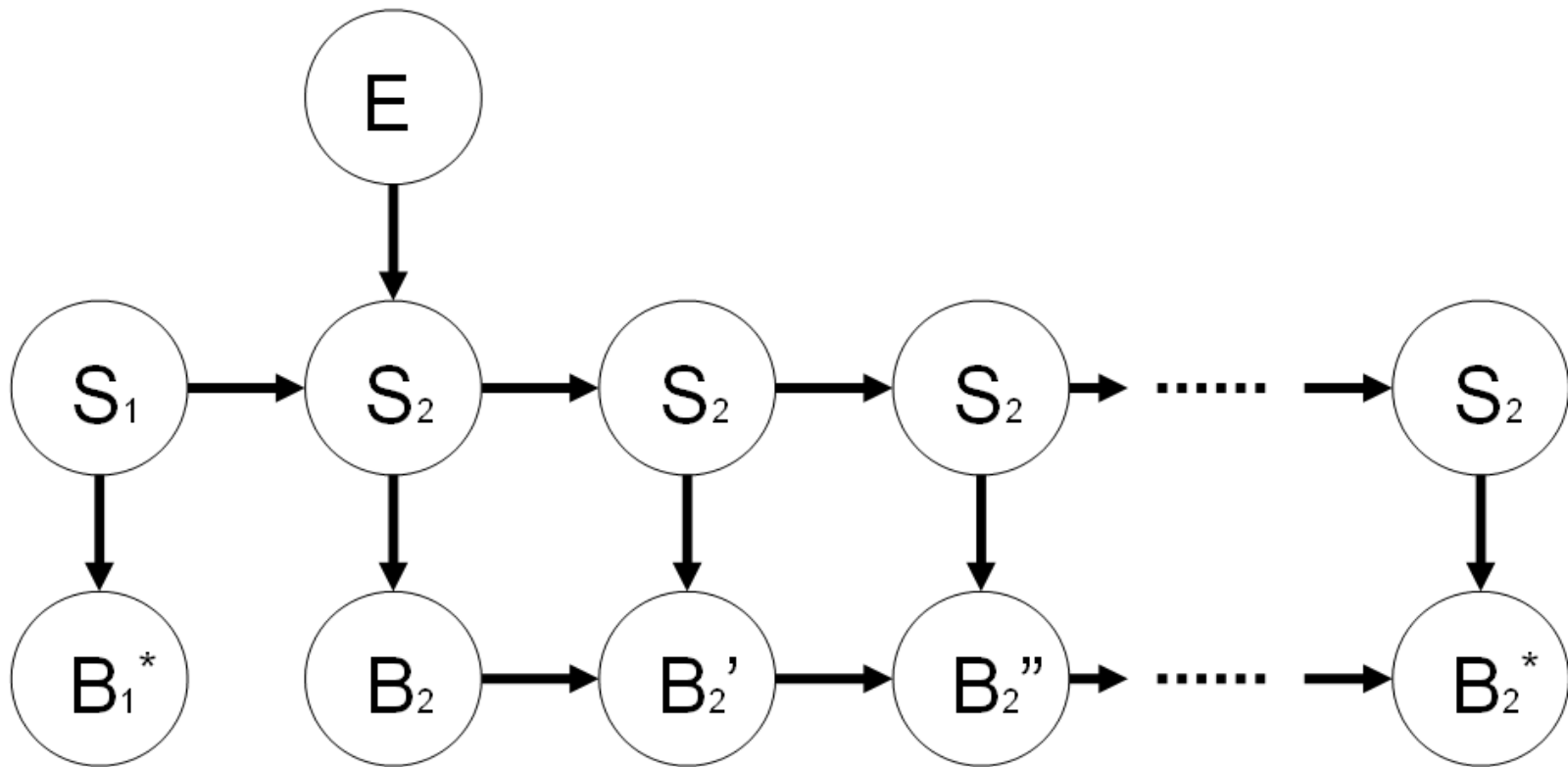
Individuals show habitual behavior under stationary conditions and after some period of time

Assumption

Discrepancy between aspiration level and actual utilities of an individual will trigger an exploration process which can lead to changes in behavior



Framework



E= event S= state B= behaviour



Bayesian Belief Networks (BBN)

A **Bayesian network** is a network representation of the interrelationships and conditional dependencies between a set of variables (Neapolitan, 1990).

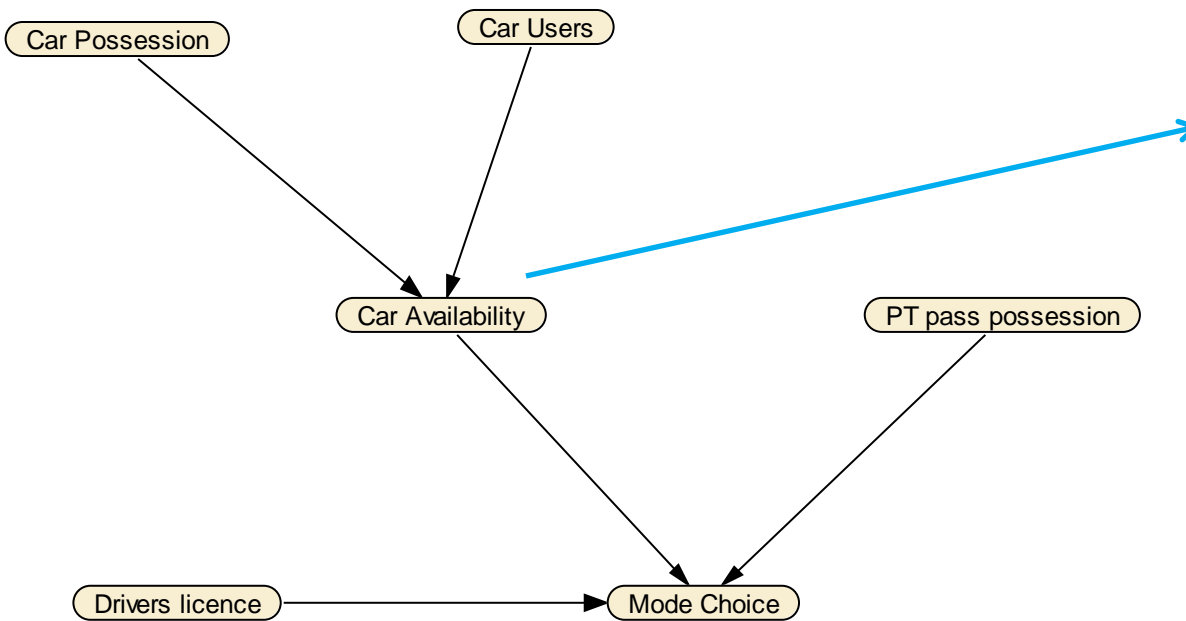
The potential advantage:

- more complex causation patterns can be included
- results can be directly interpreted in terms of the classified events
- direct and indirect relations
- based on probabilistic distribution and deals with uncertainty

BBN was used to represent and simulate life trajectories and the **direct and indirect effects** of life course events on mode choice behaviour.



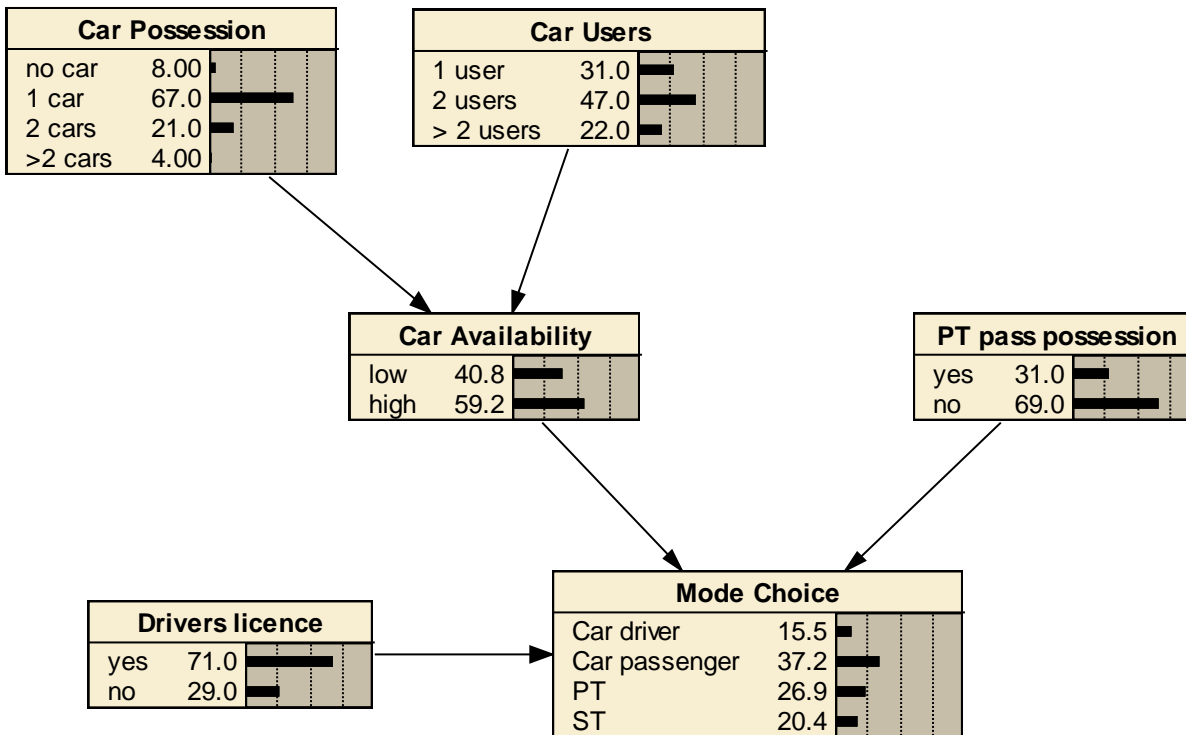
Bayesian Belief Networks (BNN)



Car Possession	Car Users	Low	High
no car	1 user	100	0
no car	2 users	100	0
no car	> 2 users	100	0
1 car	1 user	0	100
1 car	2 users	50	50
1 car	> 2 users	100	0
2 cars	1 user	0	100
2 cars	2 users	0	100
2 cars	> 2 users	50	50
> 2 cars	1 user	0	100
> 2 cars	2 users	0	100
> 2 cars	> 2 users	0	100



Bayesian Belief Networks (BNN)



Retrospective Internet-based survey

Internet Based Survey, components:

1. Personal and Household Characteristics
2. Availability, Possession Transport Modes
3. Structural Events
4. Current Transport Behaviour

Seven Structural Events:

1. Change in residential location
2. Change in household composition
3. Change in work location
4. Change in study location
5. Change in car availability
6. Change in PT pass
7. Change in household income



CHANGE IN RESIDENTIAL LOCATION

- moving to the first student room
- move to another studentroom (not within the same house)
- independent living
- living together
- rent a (different) house
- buy a (different) house
- moving in with parents

Month indicate the month of the recalled occurrence, 'no idea' is also an option

Year indicate here the year of the recalled occurrence.

Before indicate the street and city of the old residential location.

After indicate the street and city of the new residential location.

Type of change choose a pre-coded answer.

Housing type indicate the type of your new house.

Bought/Rent indicate if the new house is rent or bought.

Please answer the questions below for each change in residential location.

	month	year	before	after	type of change	housing type	bought/rent
most recent	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
previous	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

- first student room
- other student room
- independent living
- living together
- renting a house
- buying a house
- moving in with parent
- different change

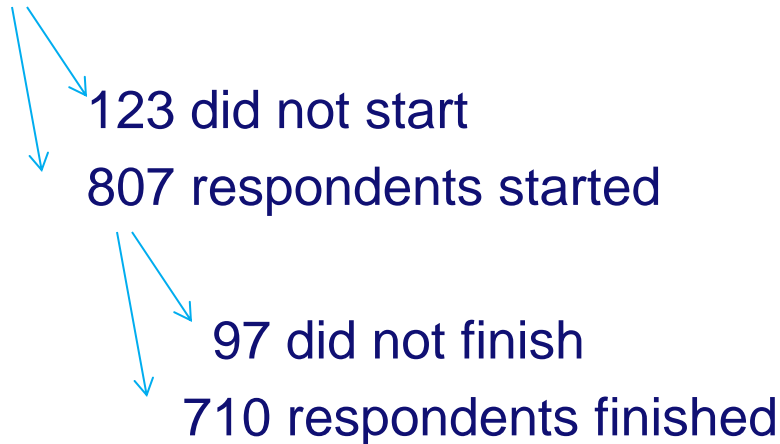
10 changes

back next

Retrospective Internet-based survey

Respon survey 2004:

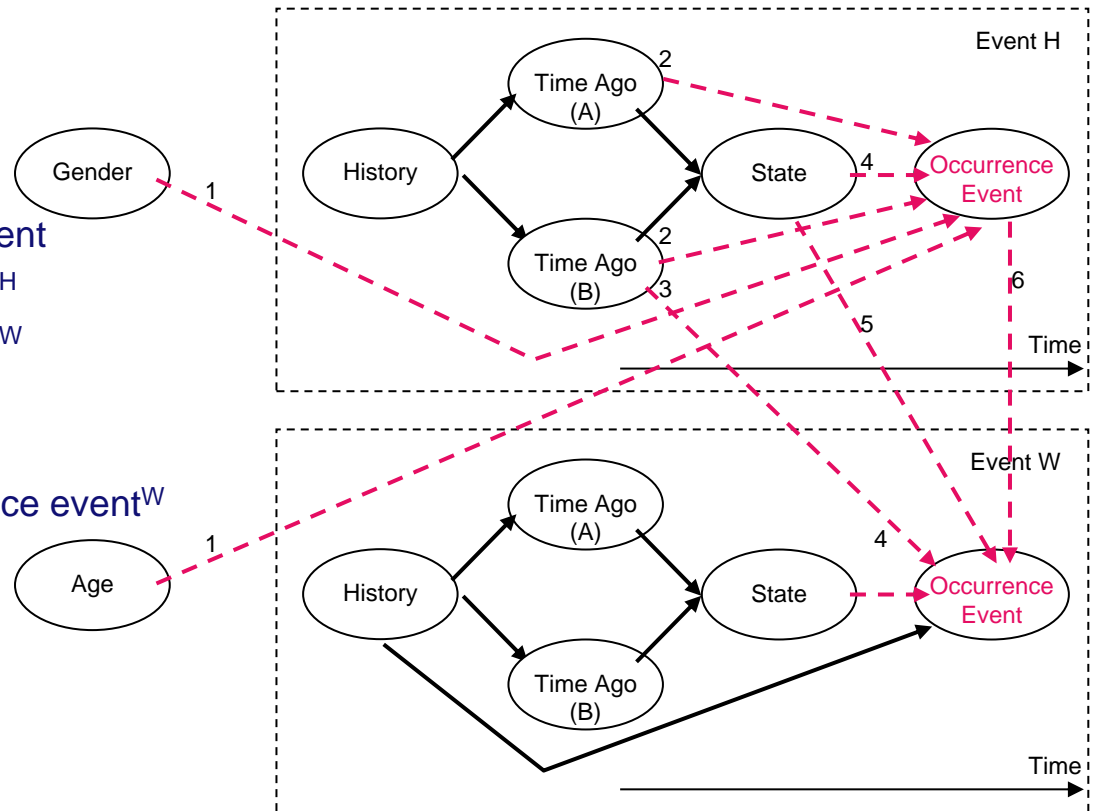
939 potential respondents registered for survey



Learned networks

Modelling framework Life trajectory

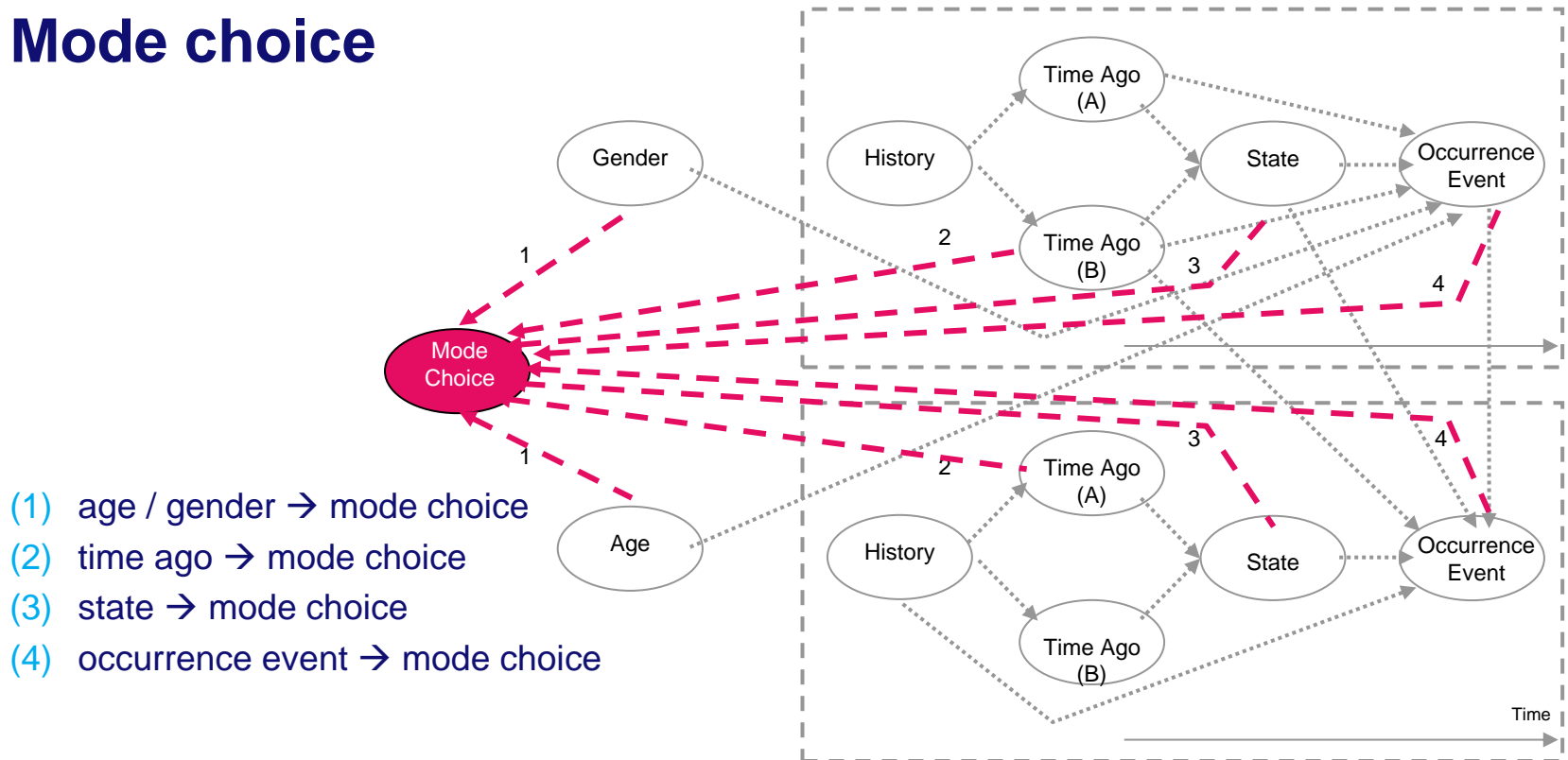
- (1) age / gender \rightarrow occurrence event
- (2) $\text{time ago}^H \rightarrow \text{occurrence event}^H$
- (3) $\text{time ago}^H \rightarrow \text{occurrence event}^W$
- (4) $\text{state}^H \rightarrow \text{occurrence event}^H$
- (5) $\text{state}^H \rightarrow \text{occurrence event}^W$
- (6) $\text{occurrence event}^H \rightarrow \text{occurrence event}^W$

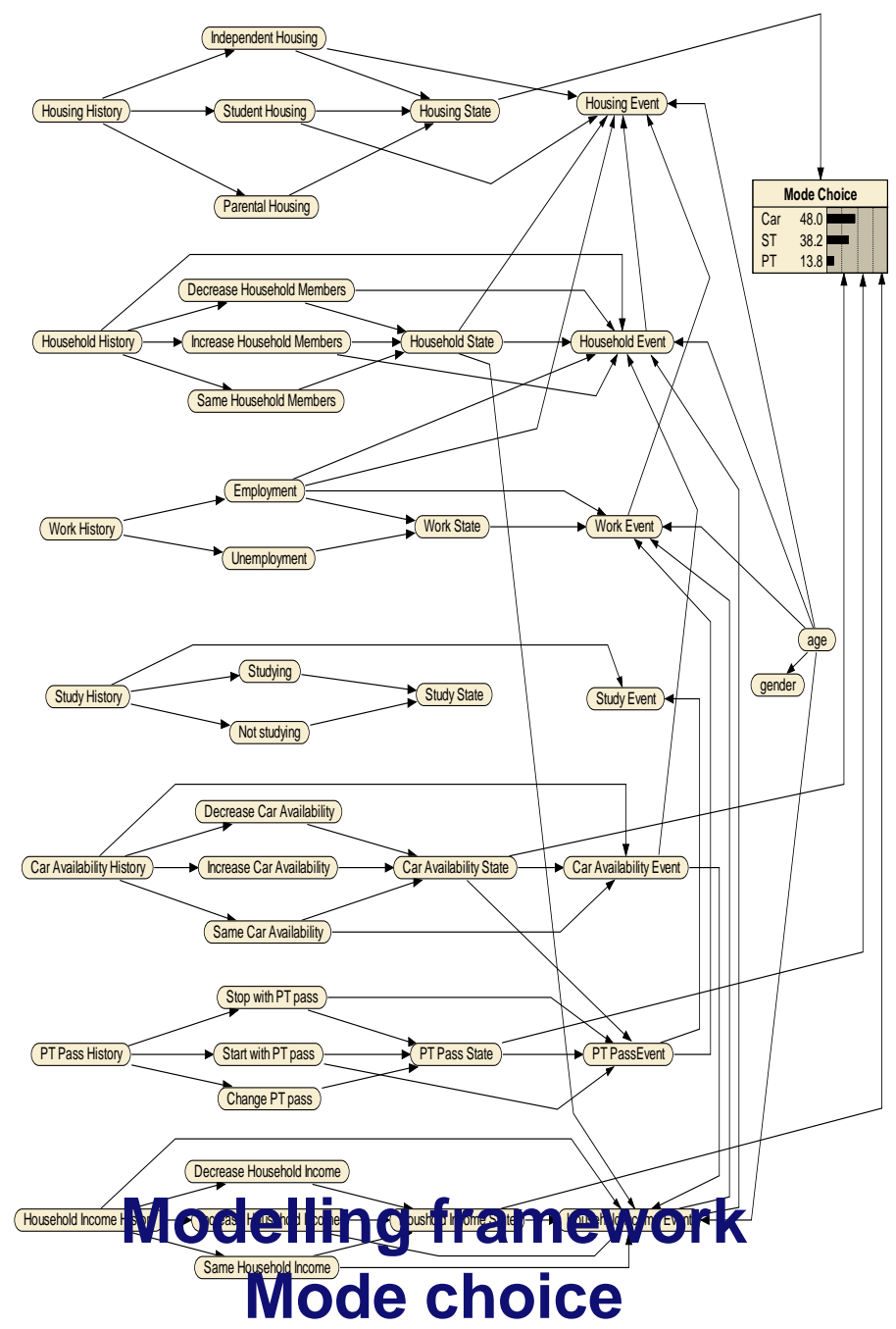
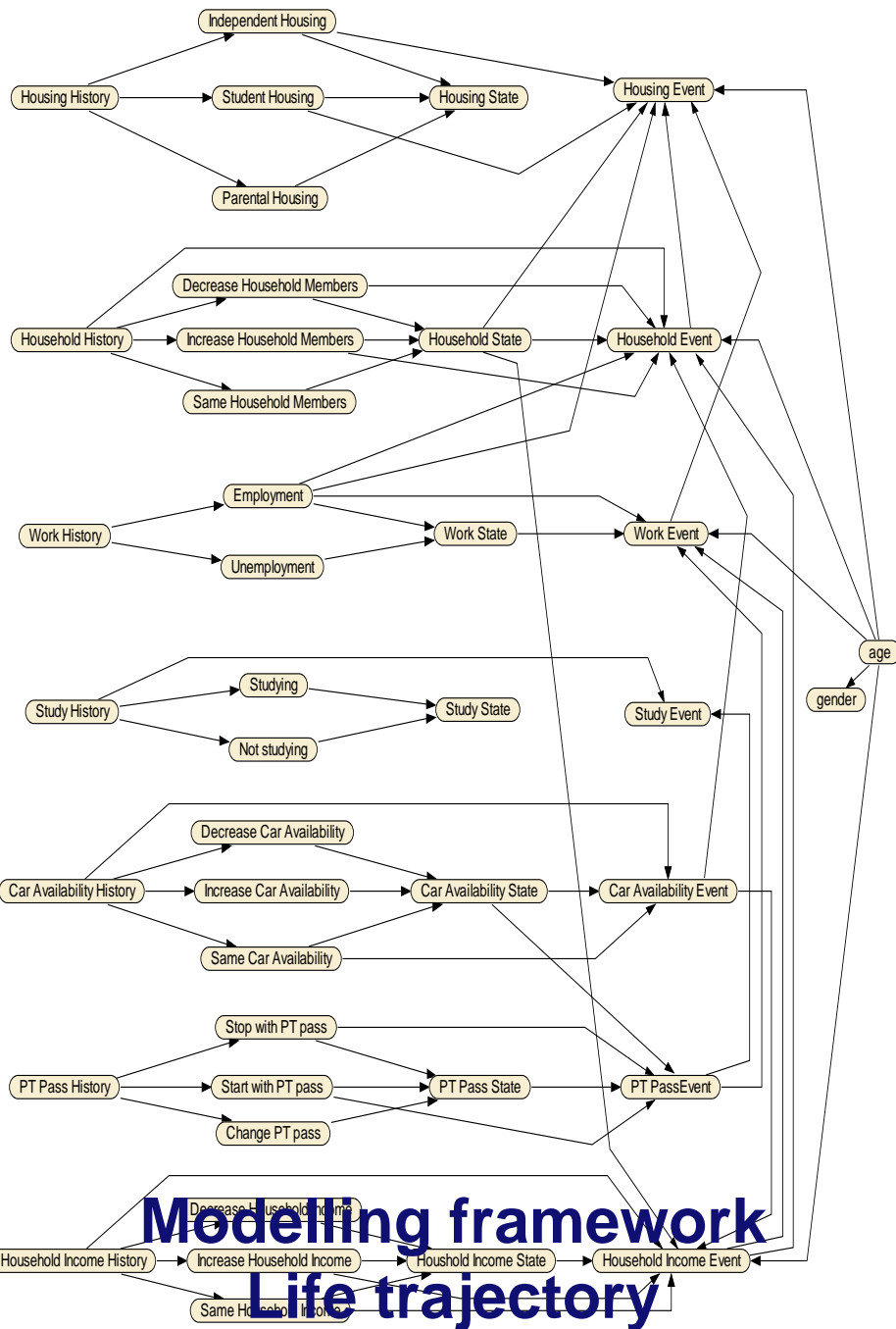


Learned networks

Modelling framework

Mode choice





Validation

Validation life trajectory network

- Goodness-of-fit
- Predicted life trajectories were compared with observed life trajectories based on four criteria:
 - Number of occurrences
 - Interval times between occurrences of events
 - Simultaneous occurrences of events
 - Sequence of occurrences of events

Validation mode choide network

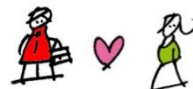
- Goodness-of-fit
- predicted modal split compared with the observed modal split in 2004.



Validation

Validation life trajectory network (1)

- **Goodness-of-fit:** Rho-Squares all seven events are above 0.20. This indicates, based on generally accepted norms, that the models perform well.
- **Analysis, count:** slight **under** prediction of the number of occurrences **household event** and **over** prediction **PT pass event**.
In general: life trajectory network reproduced the number of occurrences in the life trajectories quite well.



Validation

Validation life trajectory network (2)

- **Analysis, interval times:** the network predicted more or less the same interval times for the events, except for the PT pass event.
- **Analysis, synchronic events:** the network was less successful in predicting correctly the observed synchronic events.
- **Analysis, sequence of occurrences:** the analyse illustrate that the network predicts the sequence of the occurrences in the life trajectories relatively good.

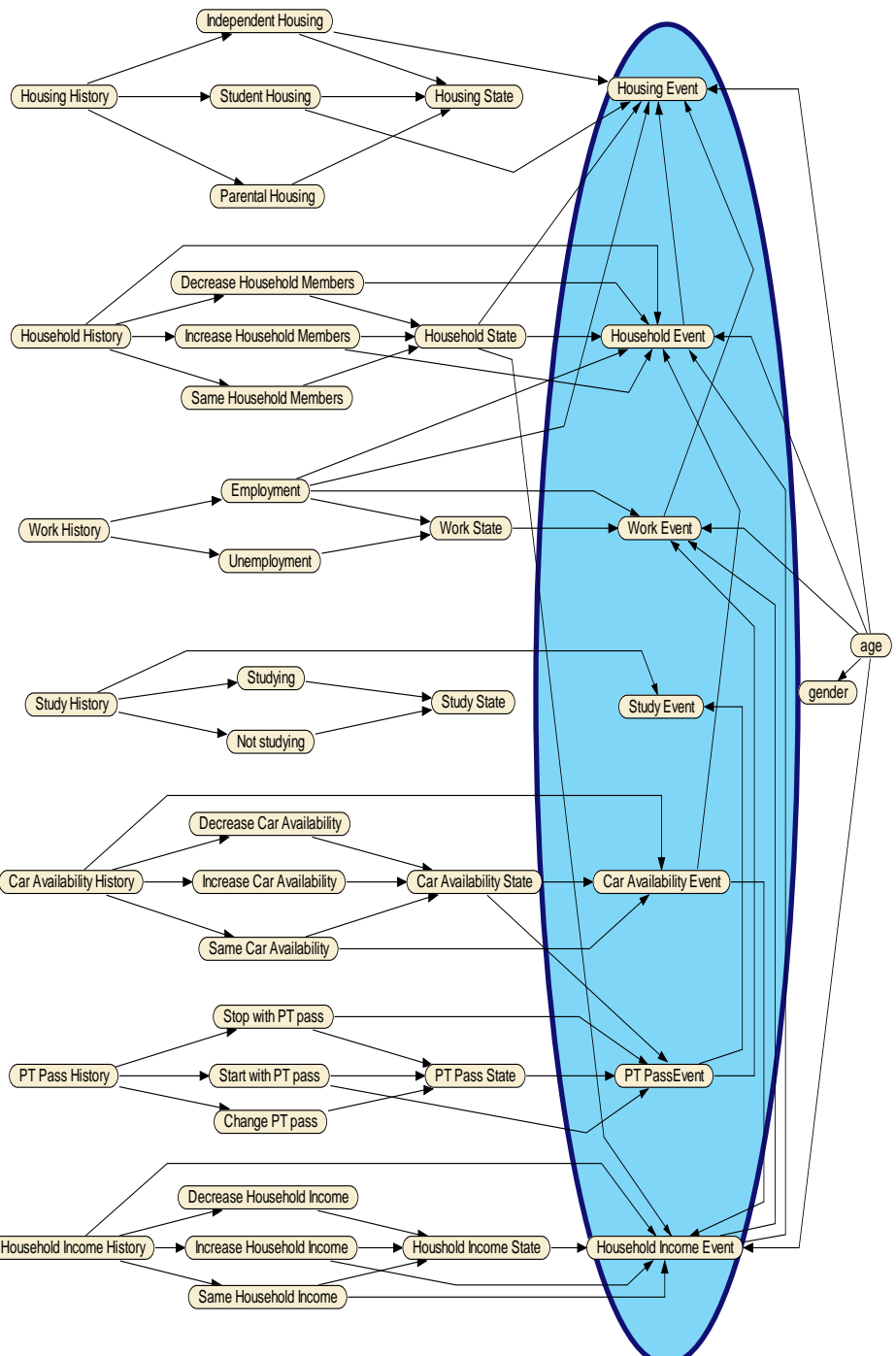


Validation

Validation mode choide network

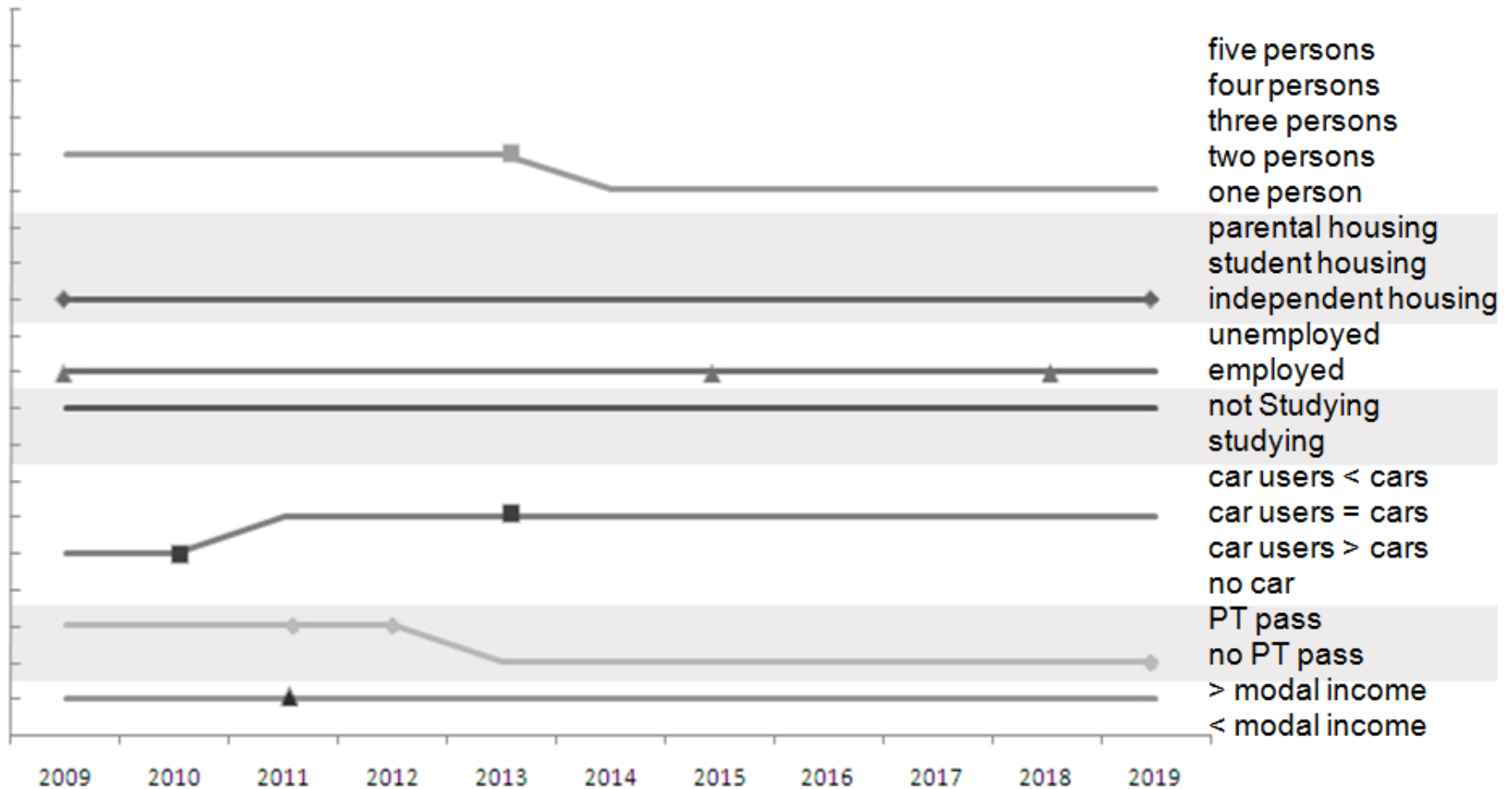
- **Goodness-of-fit:** Rho-Square values are above 0.36, which indicate that the network performs relatively well.
- **Comparison modal split in 2004:** small **over** prediction of **public transport** and **under** prediction of **car** and **slow transport**



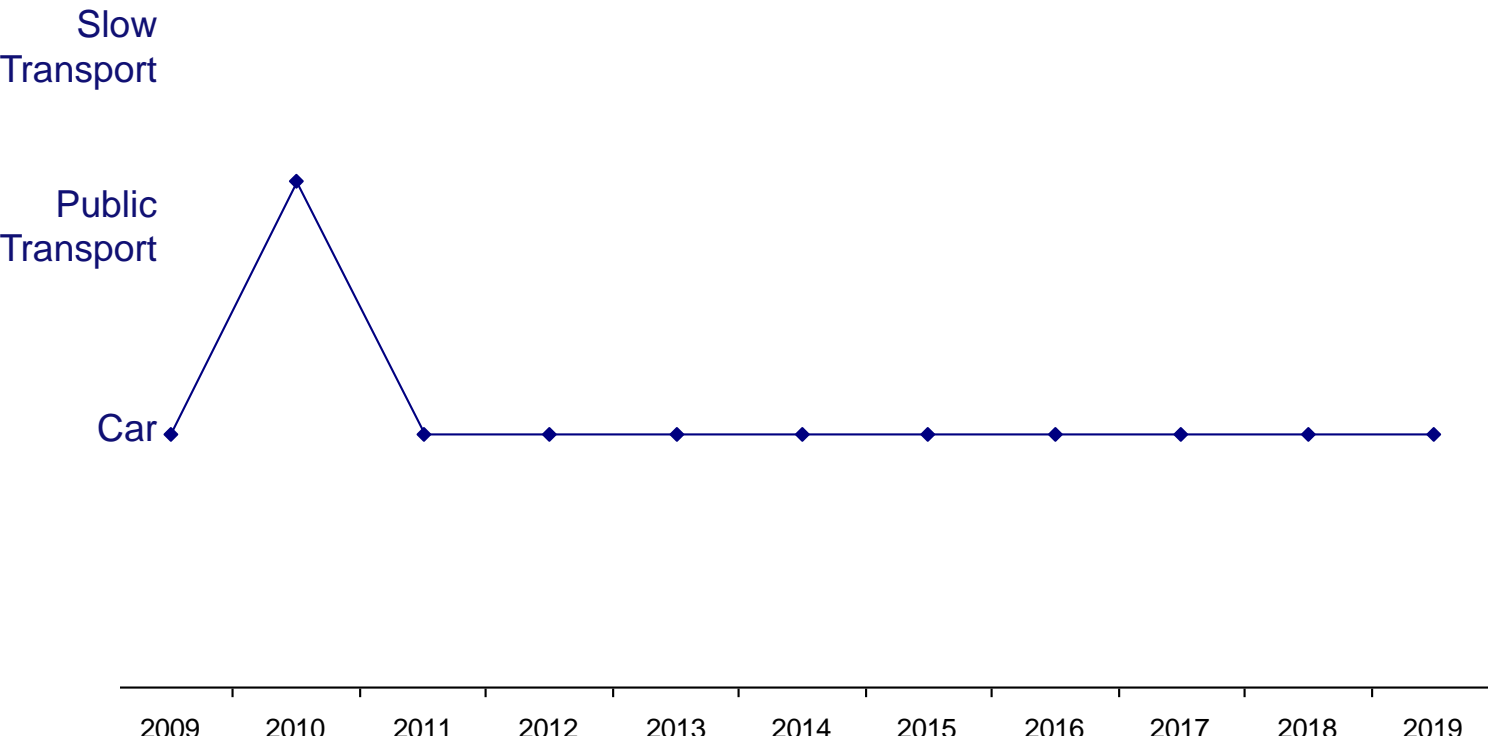


Modelling framework Life trajectory

Illustration



Illustration



Discussion and conclusion

- BBNs are a potentially powerful approach for modelling direct and indirect influences between variables
- **Future research:** investigate the sensitivity of predictions for the choice of time resolution
- Limitations of retrospective surveys administered through Internet. The way in which memory is triggered
- **Future research:** survey with interactive time to stimulate recollection of occurrences



Discussion and conclusion

- Mode choice only registered in 2004, not in retrospect. Solution offered with temporal influence parameter (α)
- **Future research:** explore options for collecting transport mode careers, or to collect data to estimate the temporal influence parameter

- Only transport mode choice was considered
- **Future research:** expansion of network with other facets used in activity-travel models, like location choice, duration



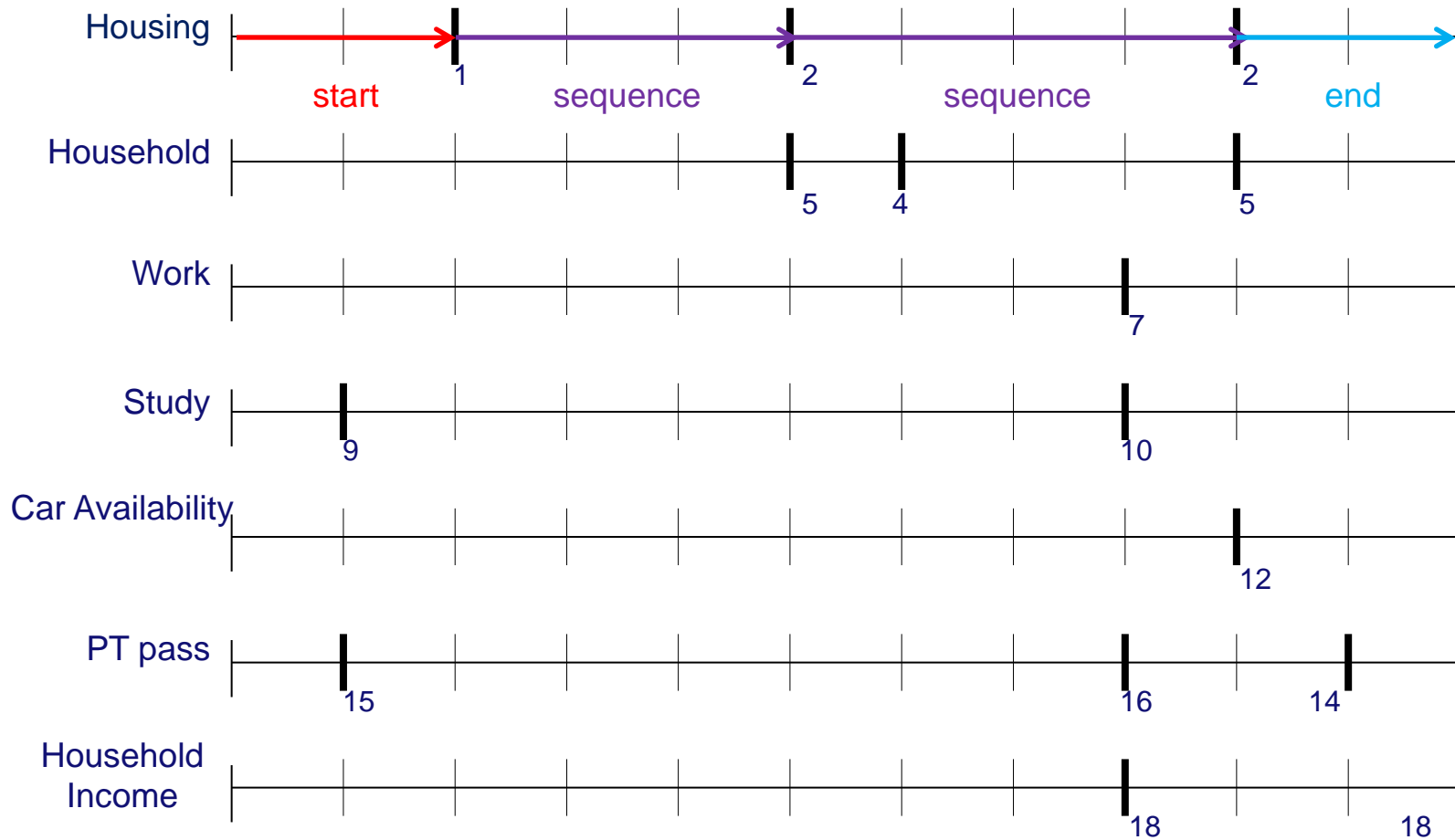
Discussion and conclusion

Extension of the networks to include:

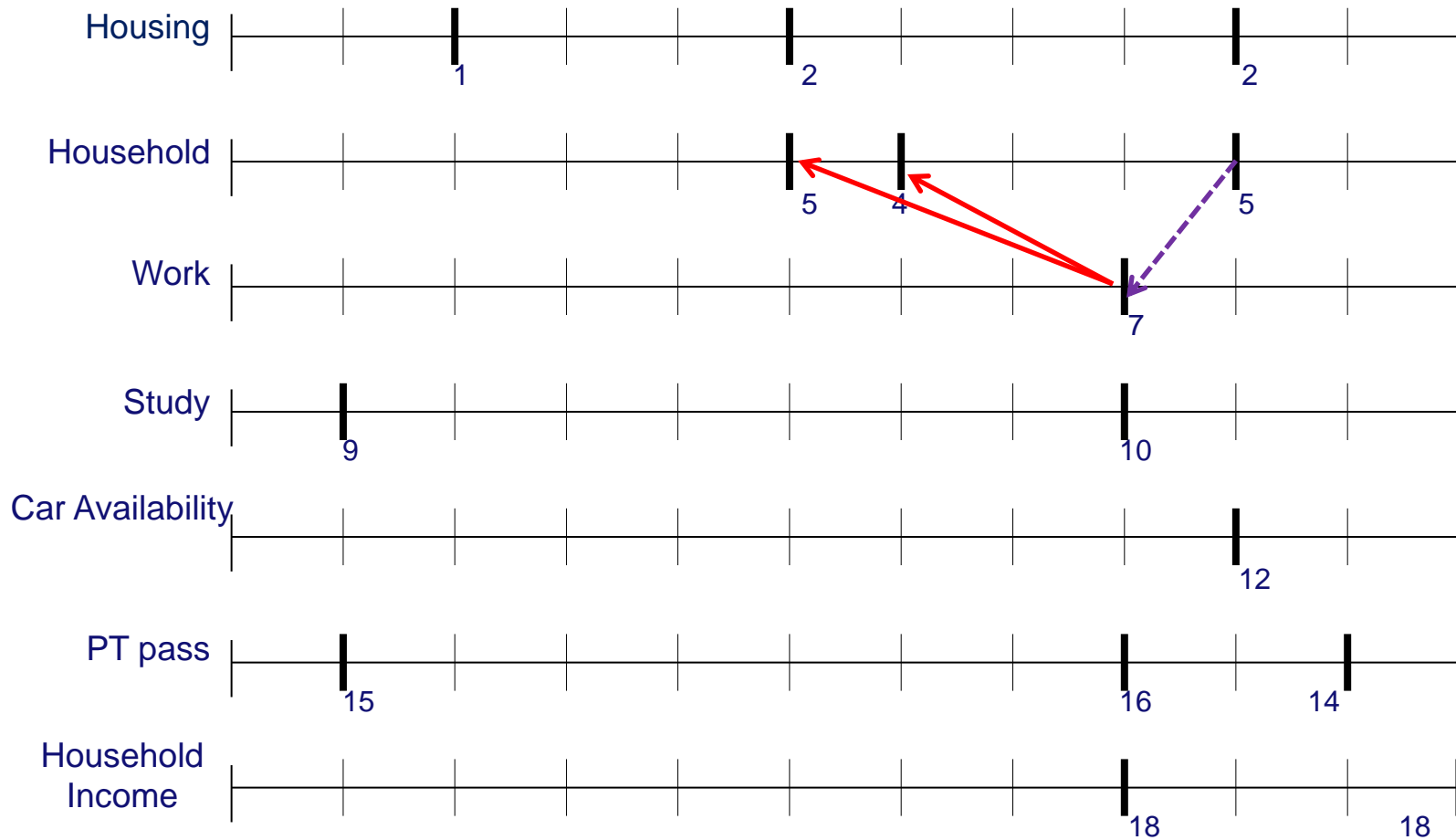
- reaction of individuals to changes in the transportation system, spatial or economical context
- other household characteristics and the past experiences of household occurrences
- the link between social networks and life trajectories of people



Validation: interval times within an event



Validation: interval times between events



Validation: simultaneous occurrences

