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The application of microscopic activity based travel demand modelling in large scale simulations

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Outline

Approach for traffic flow simulation

Approach for travel demand estimation

Results of a case study: Cologne

Results of a brigde blockade scenario

Conclusions

Model traffic systems

Evaluate . . .

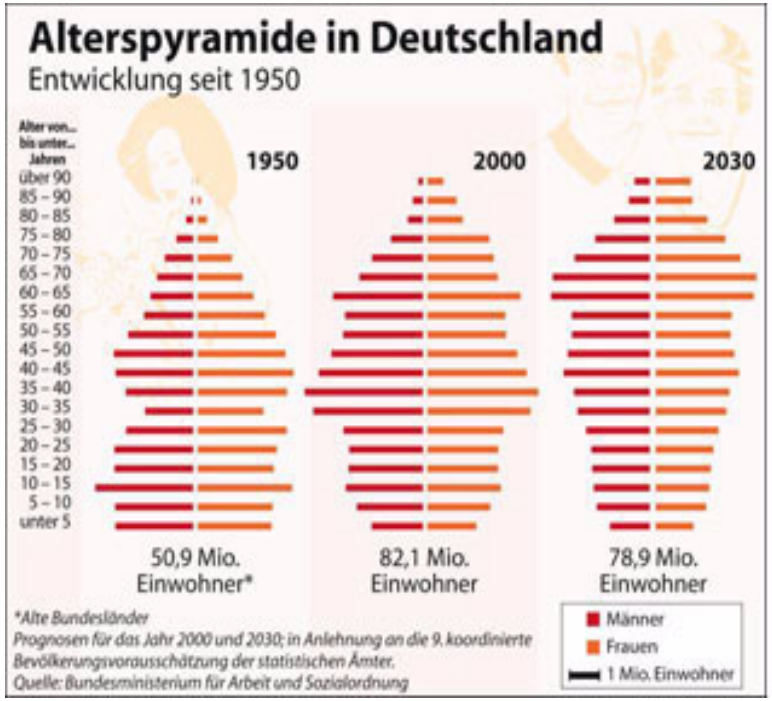
. . . traffic system performance,

. . . infrastructure projects,

. . . travel management measures
(tolls, congestion pricing,
parking restrictions),

. . . changes in society
(life styles, demographic structure).

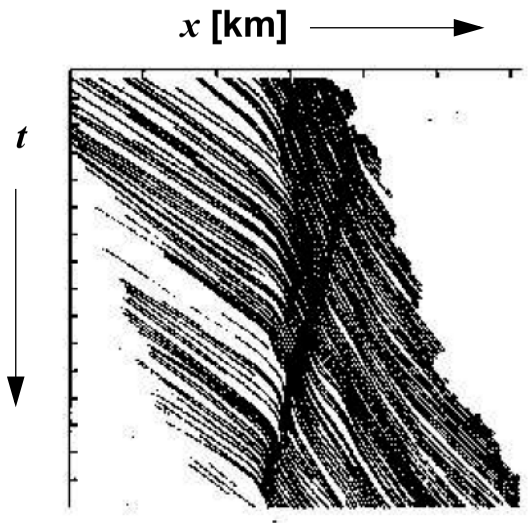
age pyramid (german population)



Background

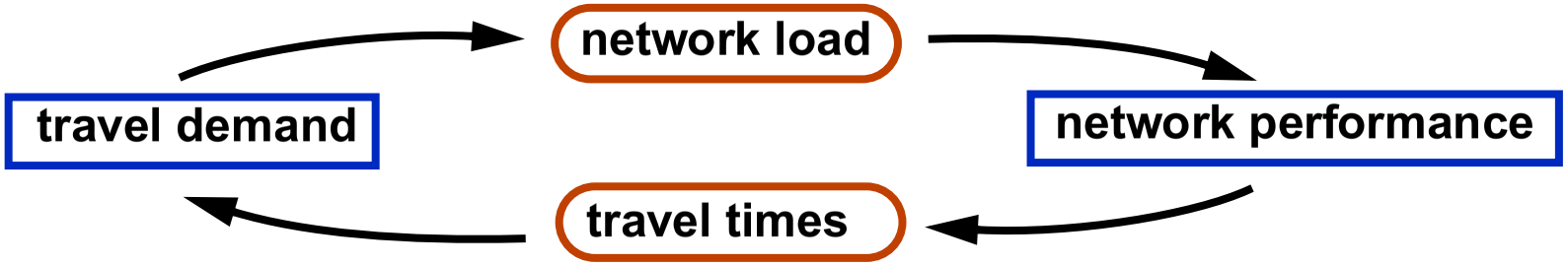
Dynamic features of traffic need to be considered

- **traffic flow itself**
- **Flow depends on the temporal variation of traffic load (*e.g.* spill back, upstream propagation of jams).**
- **Demand varies with time (time of day, day, season, ...).**



Background

Traffic demand depends on the travel times experienced by the travellers. (Close this feedback loop.)



Traffic is caused by the desire of people to perform out-of-home activities (activity-based approach).

Activities are not planned independently from each other.

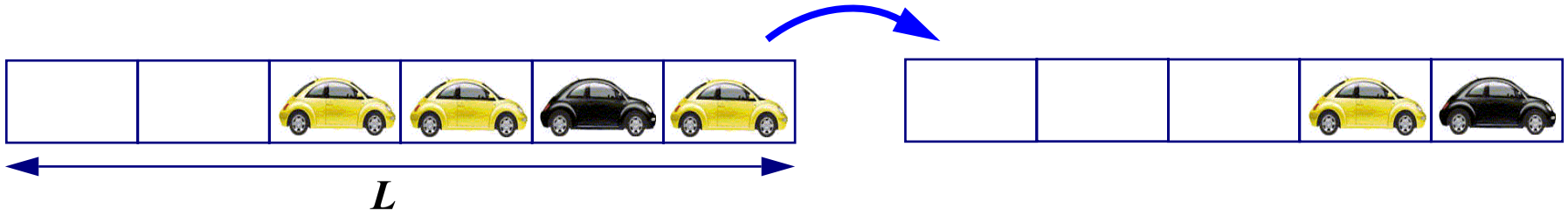
→

- **Microscopic scale**
- **Activity-based travel demand**
- **Efficient procedures**

Traffic flow simulation

Use a (fast) queueing model for traffic flow simulation

- **Each lane of the network is a FIFO queue, with limited storage capacity.**
- **A vehicle has to stay at least $T = L/v$ in the queue.**
- **The time to enter the next queue is given by a minimal (service) time or depends on the traffic states in the queues.**



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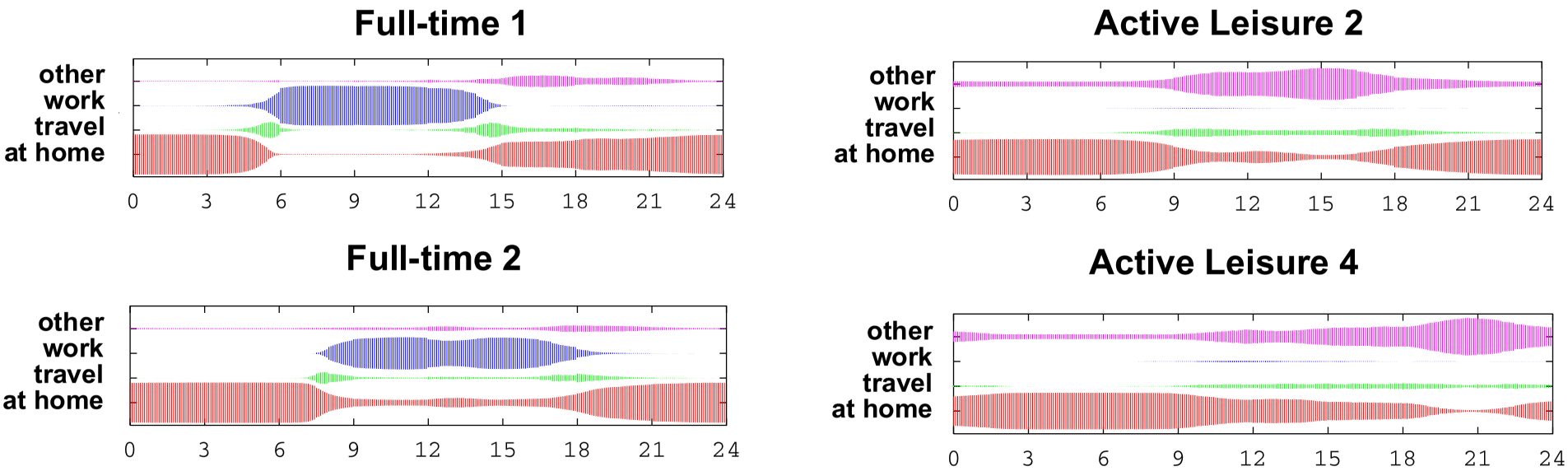
Travel demand

Derive travel demand from observed activity patterns.

- No "behavioural theory of time allocation" included.
- Schedules are consistent.
- Model has to handle temporal shifts due to local conditions compared to original data

Establish classification of activity patterns



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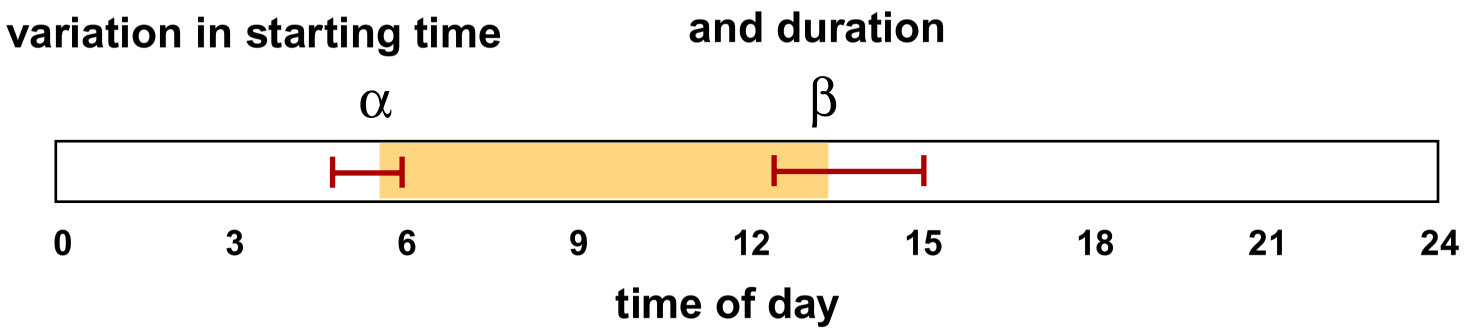
Handle time shifts

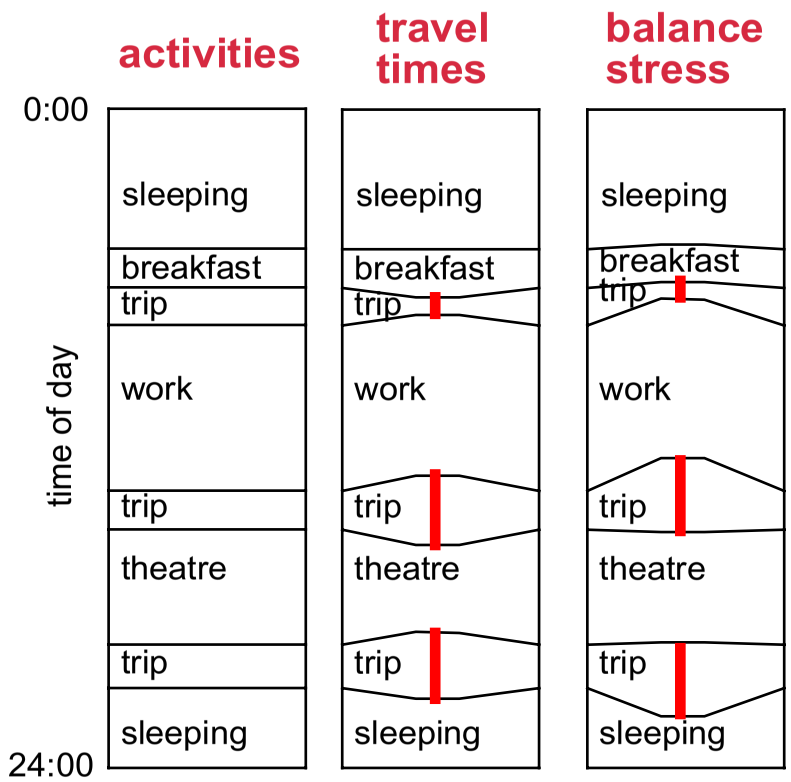
Derive measure for the temporal flexibility of episodes:
determine variation in starting time and duration of similar episodes in the same class of diaries.



Alternative:
Determine flexibility according to activity characteristics, *e.g.* starting time and duration of a film.

Arrive at feasible diaries

- **Equilibrate stress for the schedule as a whole.**
- **Compare total stress to a given threshold value.**
- **Choose new locations and modes if stress is too high.**



stress per episode:

$$s_i = \alpha_i(\Delta t_i)^2 + \beta_i(\Delta d_i)^2$$

Δt_i: difference of starting times (new - original)

Δd_i: difference of duration

α, β: episode specific parameters

minimize total stress:

$$S = \sum_i s_i$$

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Locations and modes

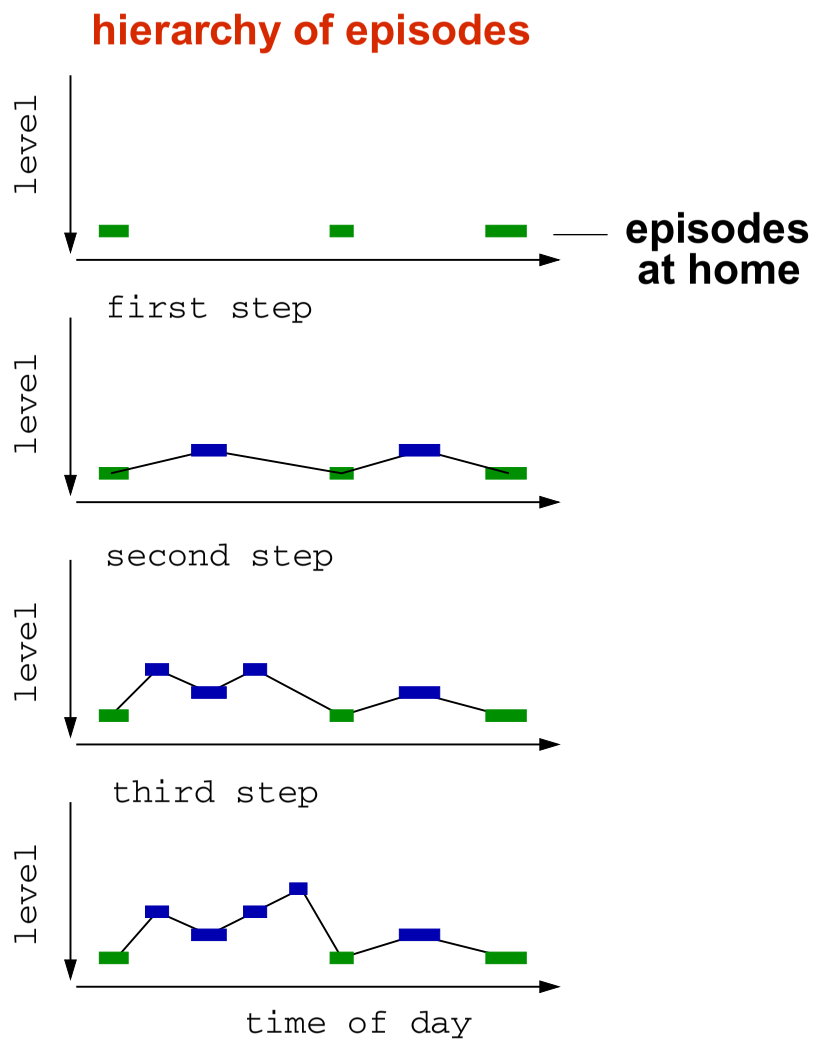
- Establish a hierarchical ordering among the episodes of a tour,
- determine location and mode for the episode on the highest level,
- determine locations and modes for the episodes on the following levels according to locations and modes already set.

Locations:

- Model of intervening opportunities.
- Respect capacities for certain activities (payed work, school)

Modes:

- Decision tree based on empirical data (CHAID-algorithm),
- Check how many cars are still available in the household.



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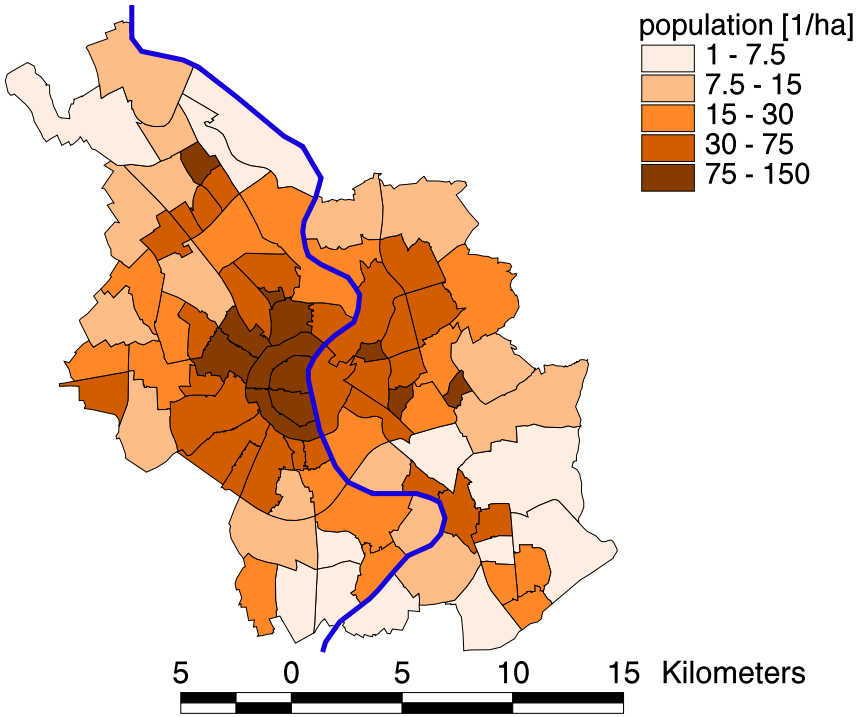
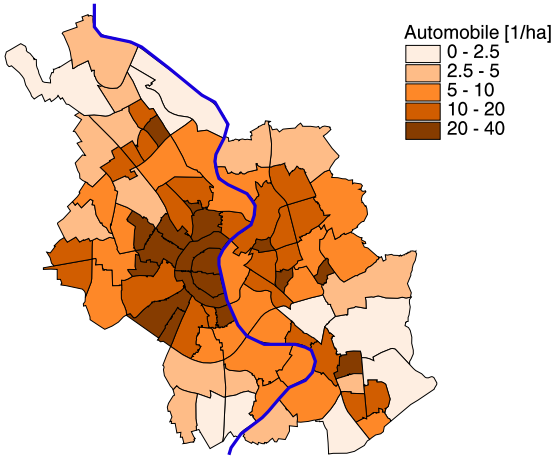
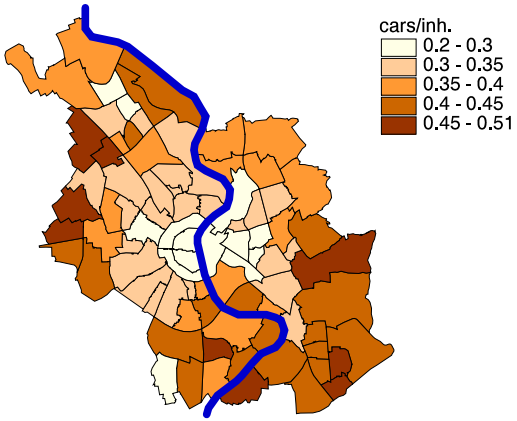
The City of Cologne



population density [1/ha]



car density [1/ha]



cars per capita

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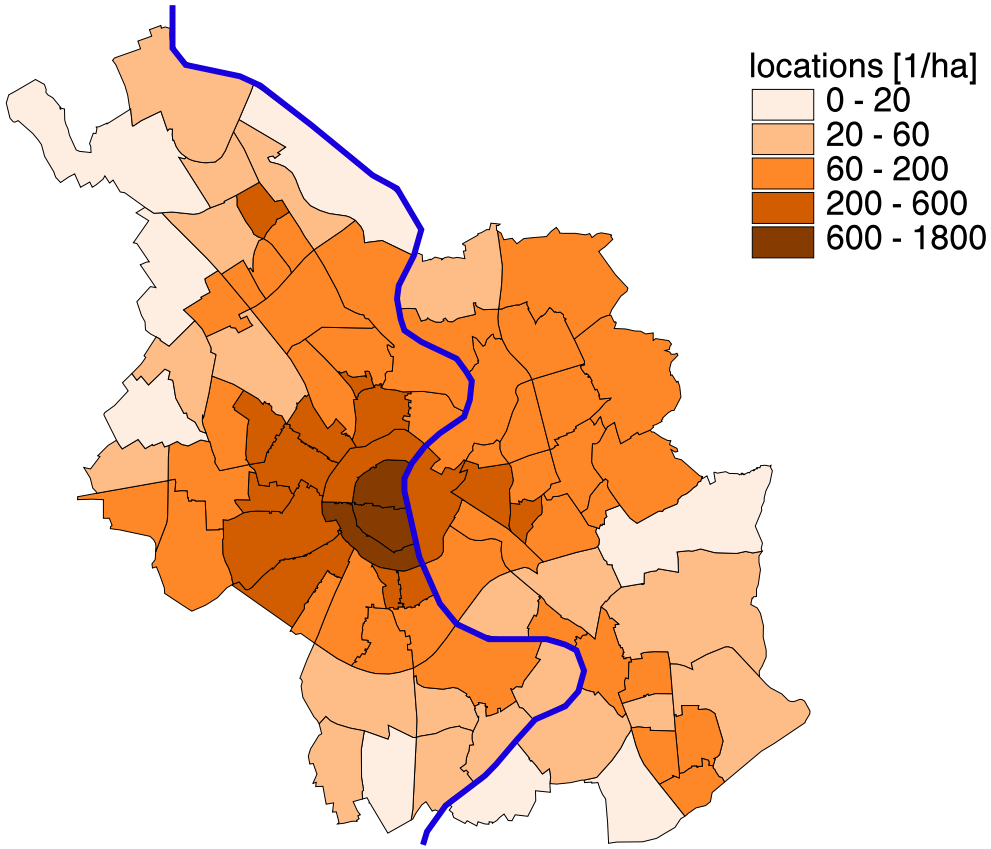
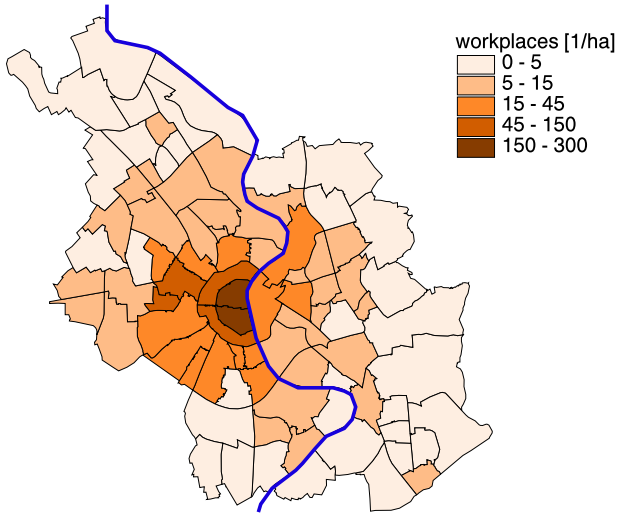
City of Cologne: Locations

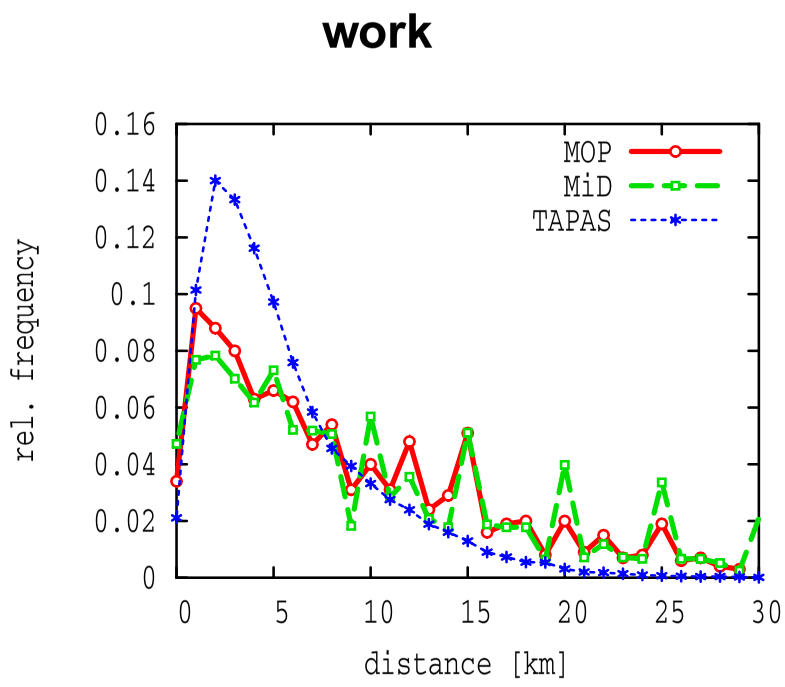


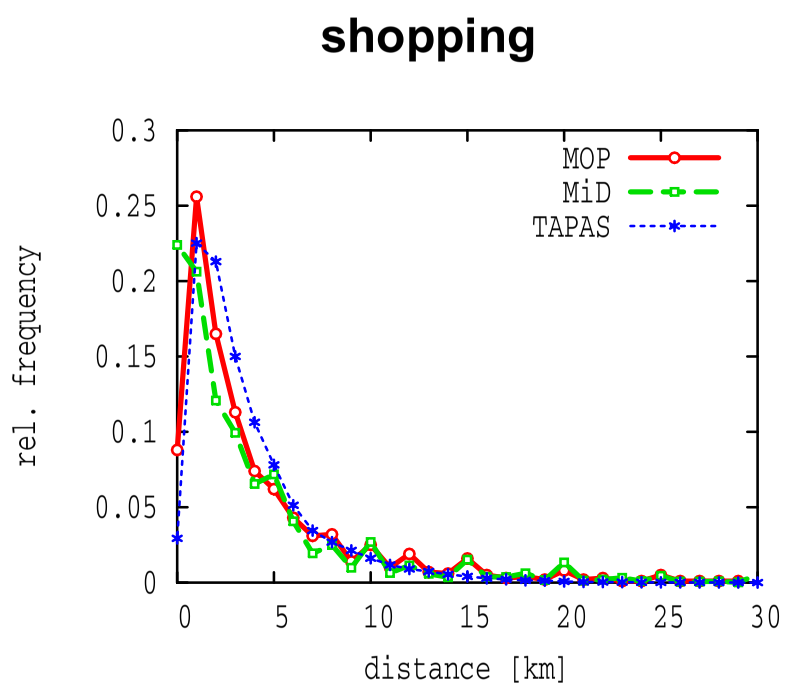
density of locations [1/ha]



density of work places [1/ha]

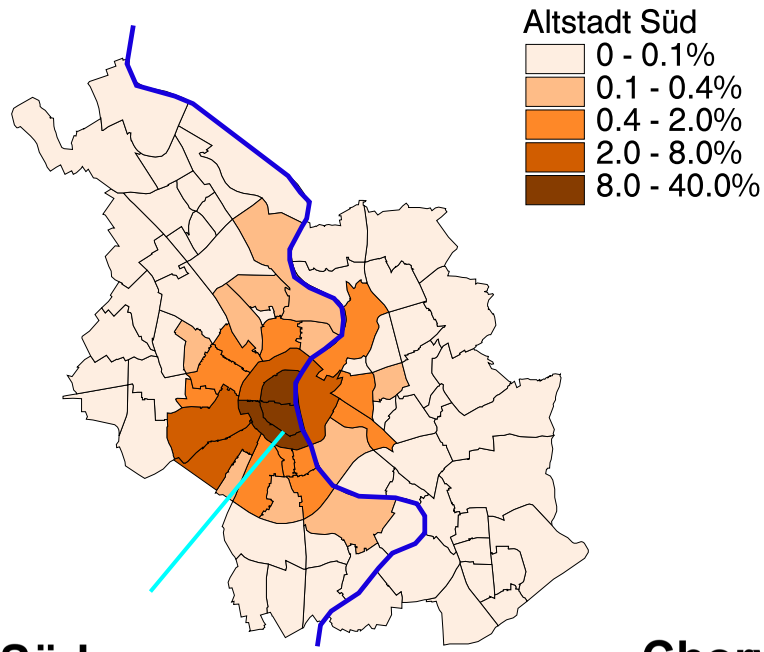
Trip length distribution



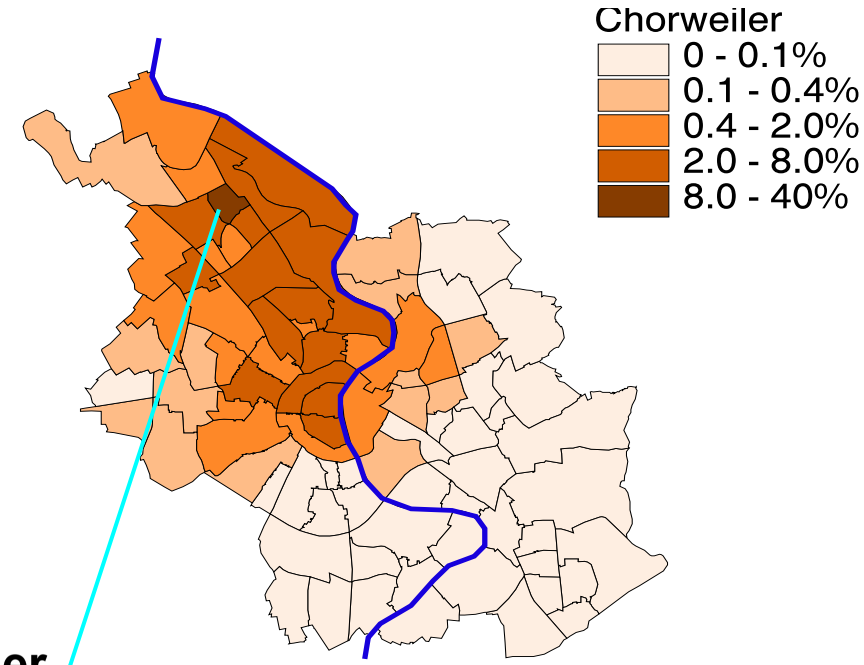


ZBE: Time budget survey
MiD: Mobility in Germany 2002
TAPAS: Simulation

Destinations by quarters



Altstadt-Süd (35% internal)



Chorweiler (17% internal)

Destination of trips for different home locations: share by quarters

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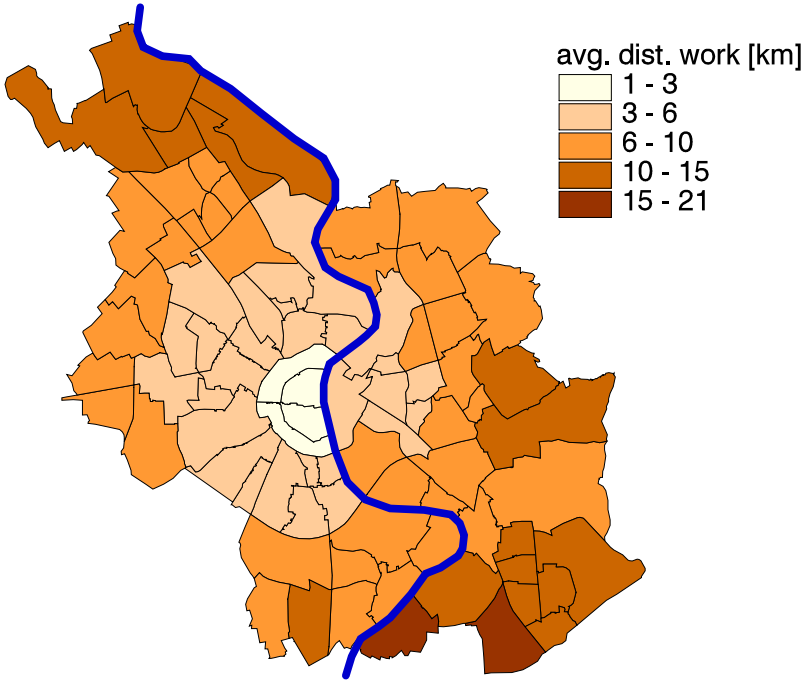
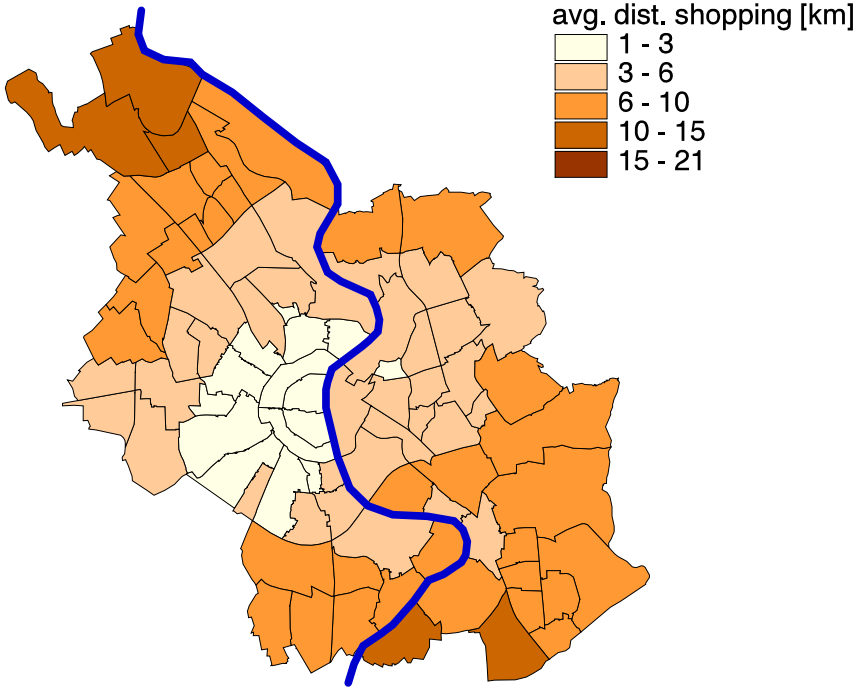
Average distance per trip

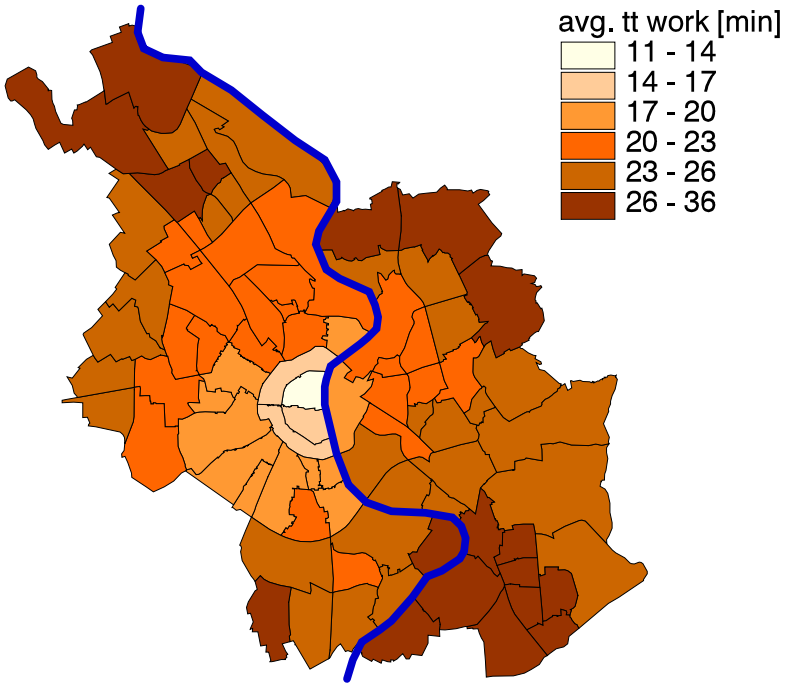


work

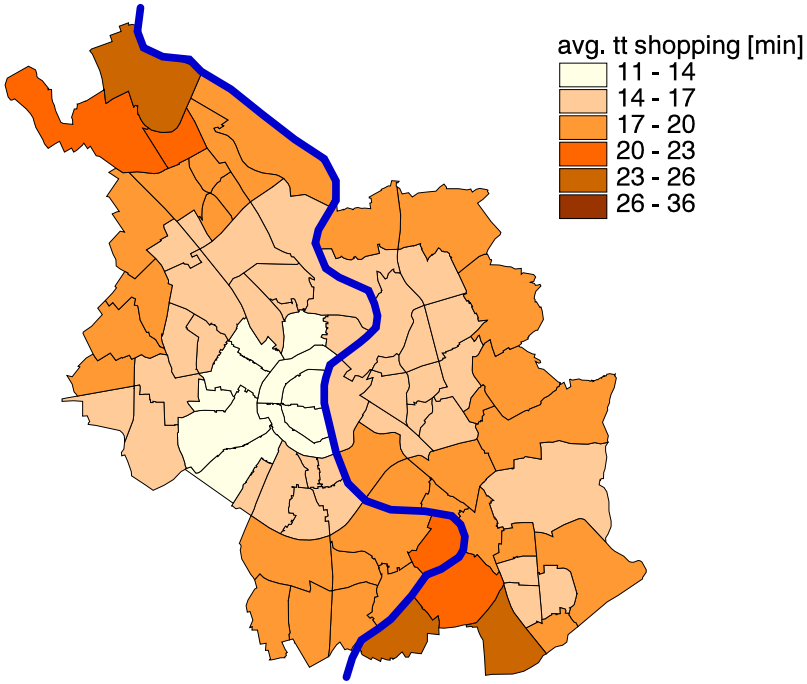


shopping

Average travel time per trip



work



shopping

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Compare the situation on the different sides of River Rhine

home left

trips per person	3.84	3.80
share of car trips (driver)	35%	38%
distance per person and day	15.5 km	16.9 km
travel time per person and day	65 min	66 min
avg. trip length (car)	5.3 km	5.8 km

without city centre

home right

trips per person	3.73	3.72
share of car trips (driver)	40%	40%
distance per person and day	20.5 km	21.0 km
travel time per person and day	70 min	70 min
avg. trip length (car)	6.9 km	7.0 km

without city centre

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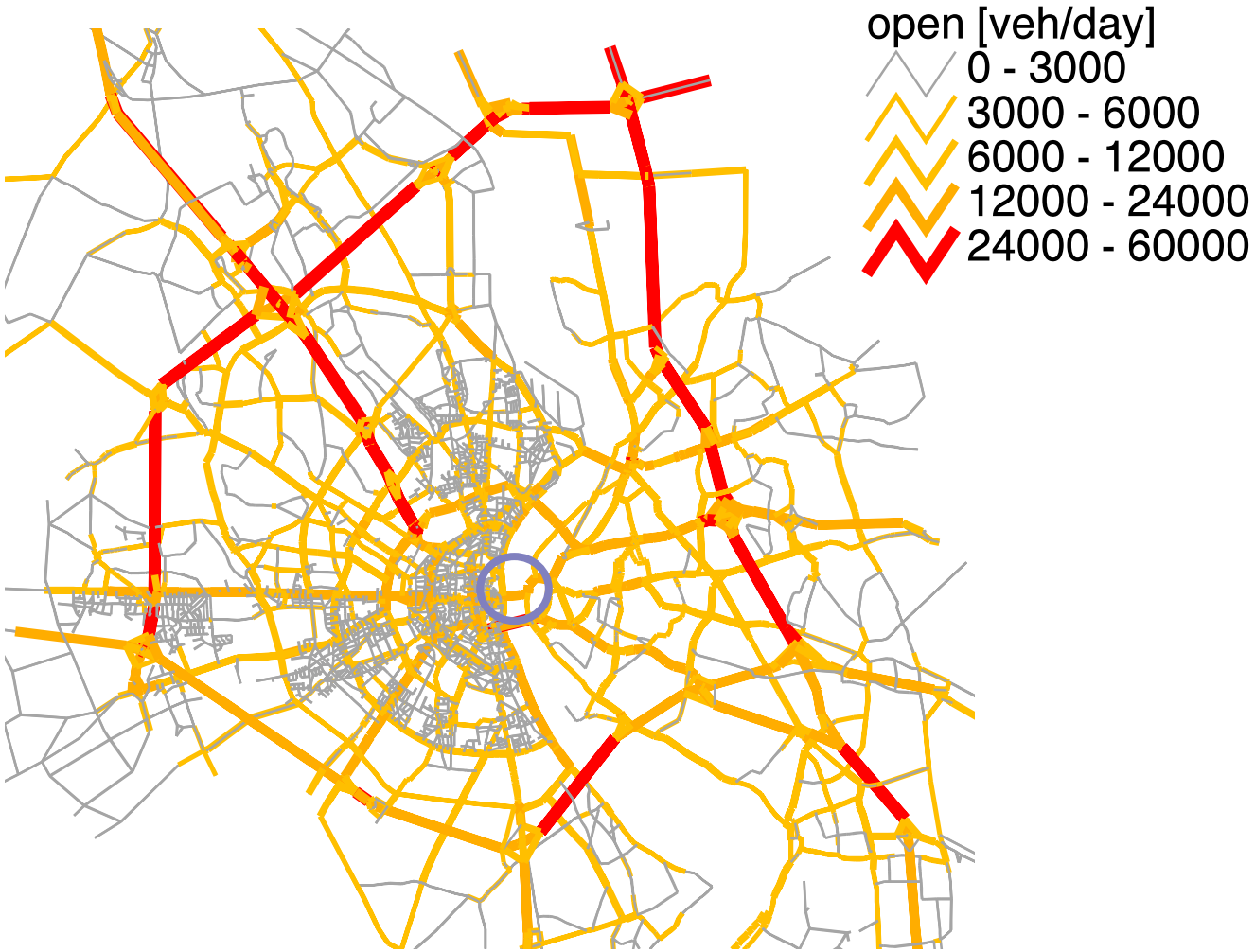
Scenario: “Deutzer Brücke” open/blocked



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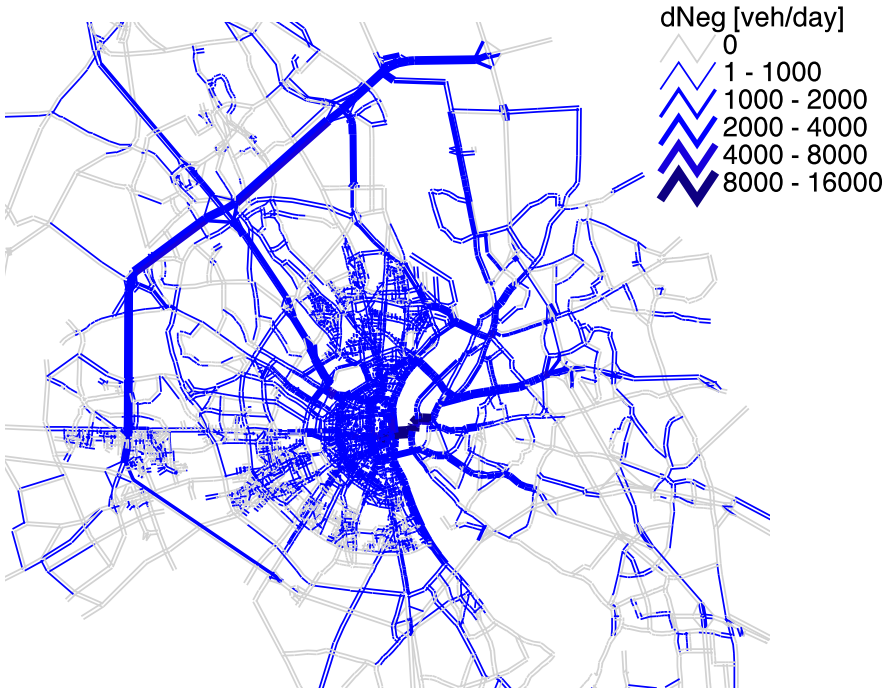
Differences in simulated traffic flow

less flow



more flow

Number of trips crossing the Rhine

bridge open

home left

direction	trips [10^3]	share [%]
left side	1987	94.6
left to right →	54	2.6
right to left ←	53	2.5
right side	6	0.3

home right

direction	trips [10^3]	share [%]
left side	37	3.2
left to right →	151	13.0
right to left ←	153	13.2
right side	818	70.6

bridge blocked

direction	trips [10^3]	share [%]
left side	1941	94.9
left to right →	50	2.4
right to left ←	48	2.3
right side	6	0.3

direction	trips [10^3]	share [%]
left side	29	2.5
left to right →	126	11.2
right to left ←	127	11.3
right side	853	75.1

Conclusions

Travel demand can be estimated from consistent activity patterns in an efficient way.

→ dynamic travel demand for a working day

Simulation results are sensitive to local traffic conditions.

Travel demand characteristics vary on a small spatial scale.

Outlook

Better empirical data of tour formation and changes in activity patterns under various (spatial) conditions needed.

Include surrounding districts for incoming/outgoing traffic.

Thank you!

Diary data

Time use survey of the Federal Statistical Office in Germany (1991/1992):

Sample: 7,200 households with a German head of the household. Each member was asked to fill in two diaries for consecutive days.

Time interval: 5 minutes.

Activity catalogue: free description, coded with a set of 231 activity types.

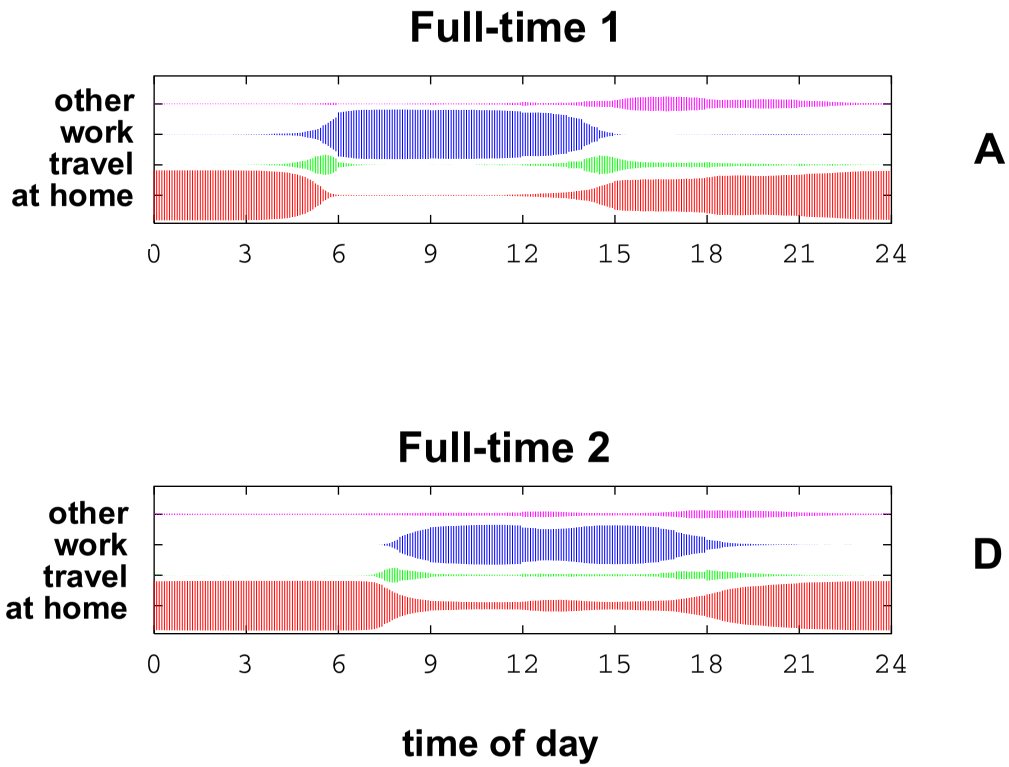
Data element (diary): sequence of 288 activity codes

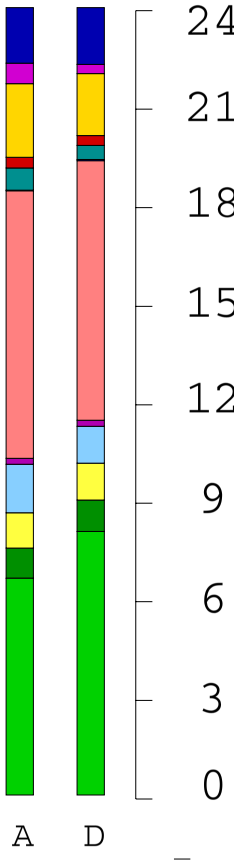
Additional variables: location, parallel activities, presence of other persons, socio-demographic variables of the individuals, regional data.

Repetition: 2001/2002

Restriction to (Tuesday, Wednesday, Thursday), elimination of incosistent patterns: 14 000 patterns

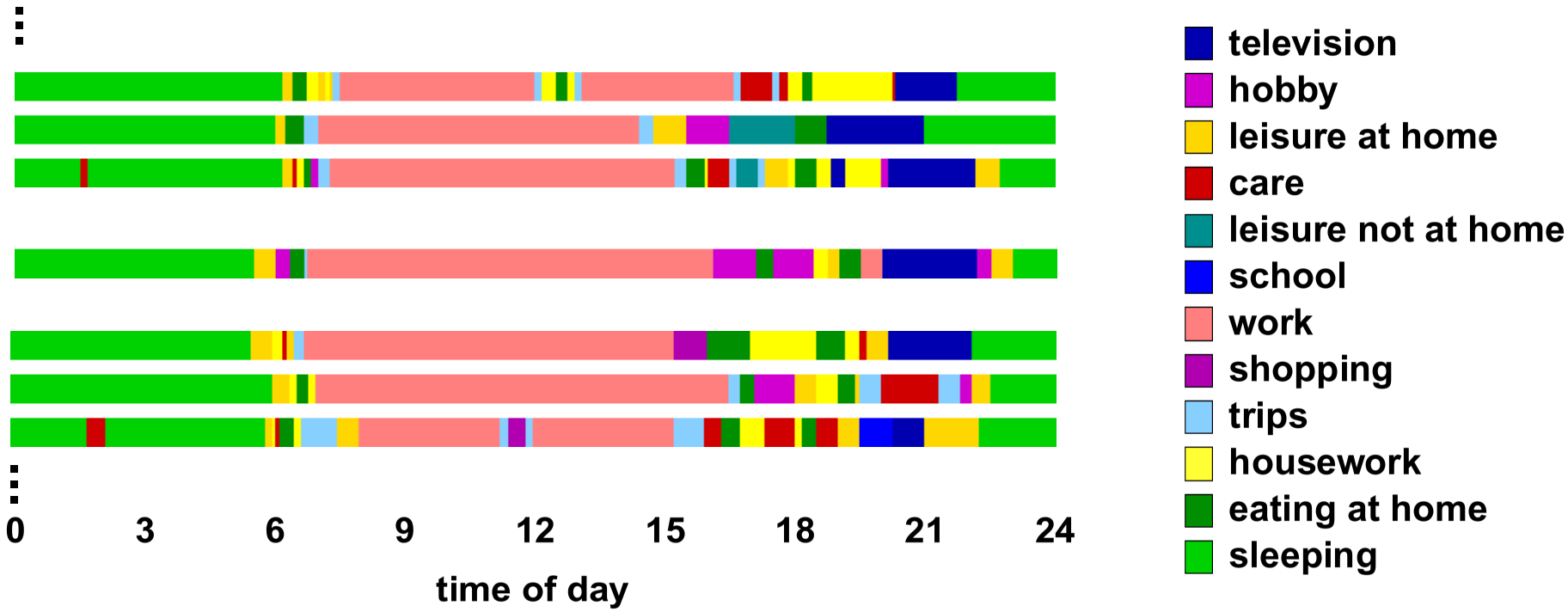
Activity sequencing in the diary classes





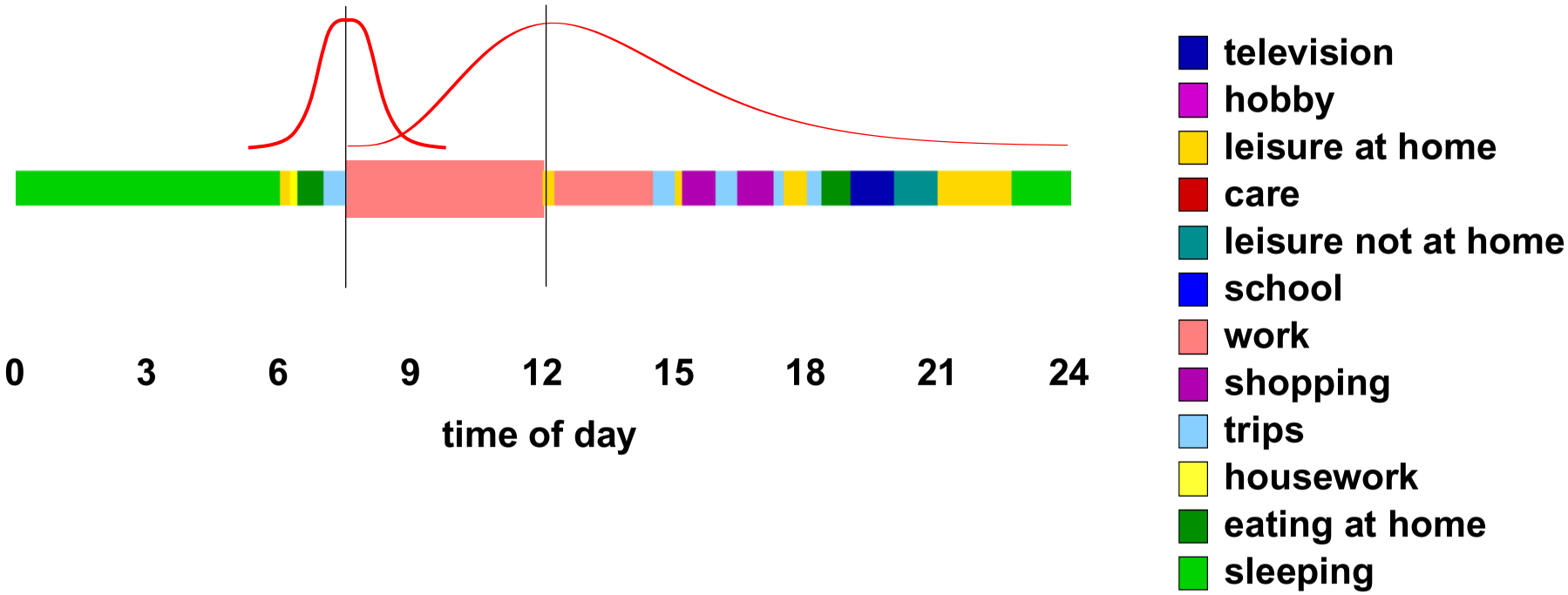
Determine the rigidity of starting times

- Classify diaries according to their structure (hierachical clustering algorithm).
- Compare episodes to corresponding episodes of diaries in the same class. The paramters



Comparison of episodes

Weighting functions dependent on differences in the starting time and duration.



Evaluation of the schedules

Set the duration of trips according to time dependent travel times.

Adjust starting times: minimize costs for the whole schedule:

costs per episode:

$$u(x_1, x_2) = \alpha_1 (x_1 - s_1)^2 + \beta_1 (x_2 - x_1 - d_1)^2$$

Time shifts propagate in both directions.

Compare the total costs with some threshold value and eventually reject the schedule.

Location choice (intervening opportunities)

The set of alternatives is ordered by travel times (requires preliminary mode choice).

A location is selected according to

$$f(k,q) = q^{k-1}(1-q); \; F(i,q) = P(k \le i, q) = \sum_{k=1}^{i} f(k,q) = 1 - q^{i}$$

$$q = q(A, a, s)$$

activity (activity catalogue) — **age** — **gender**

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Conclusions

Diary data offer the opportunity to estimate travel demand for status quo scenarios in a reliable and efficient way.

Restrictions: People react by using known time use patterns.

The model can be coupled with synthetic pattern modelling and help to discern the effect of each modelling step.

Moderate computing time facilitates the integration in feed back loops (e.g. traffic flow modelling).

Consistent patterns are required: Some effort is needed for consistency checks or modifications.

The adaptation to the local situation is a crucial step:
A quadratic cost function was proposed.

Further validation and investigation of the interplay of parameters is planned.