Towards an activity-based model for pedestrian facilities

Antonin Danalet
Bilal Farooq
Michel Bierlaire
Transport and Mobility Laboratory (TRANSP-OR)

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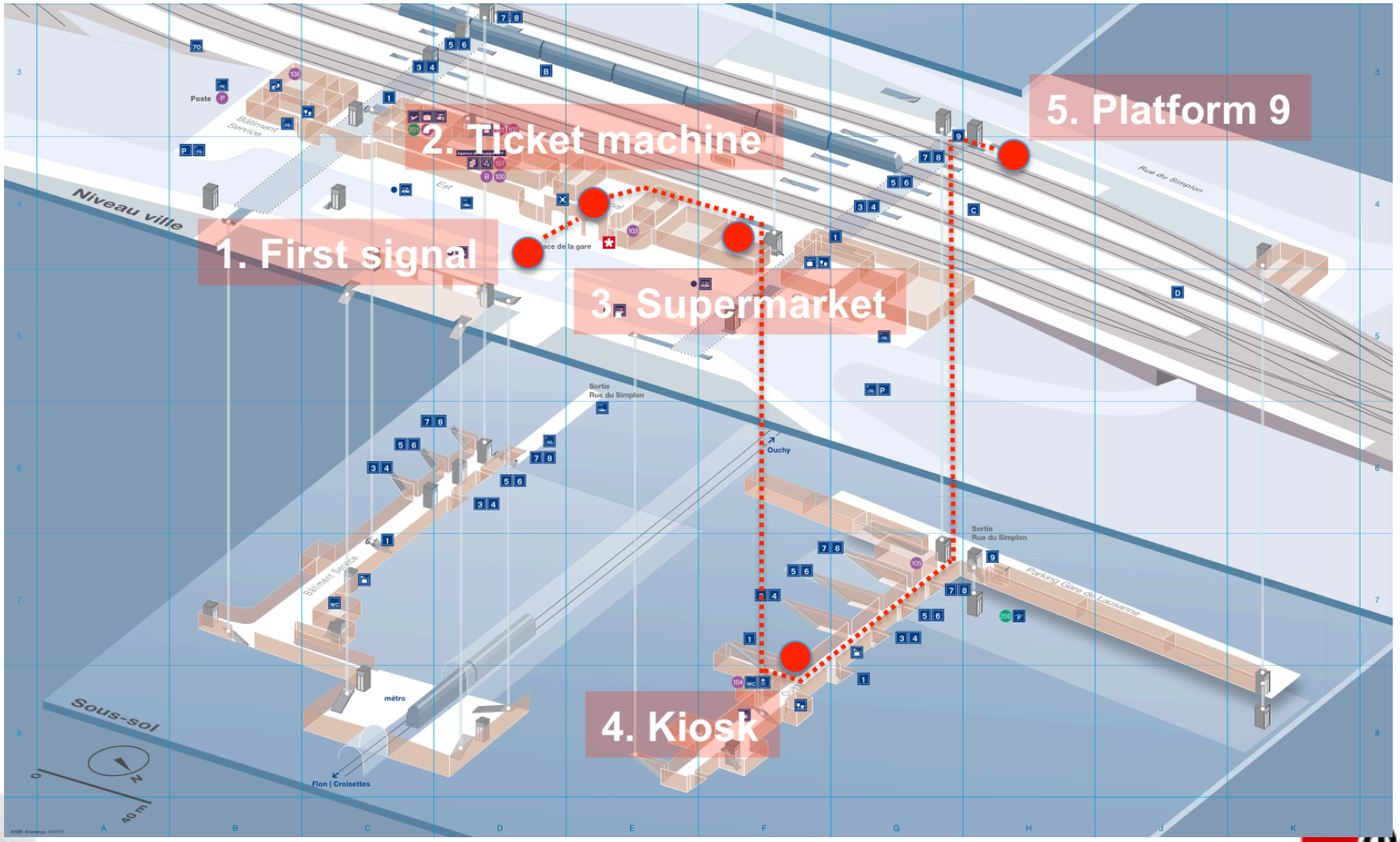
- Motivation
- Data (short)
- A Bayesian estimation to detect destinations
- Model (long)

Why do we care about pedestrians?

- Urban growth ⟹ pressure on infrastructure
  - In particular in **transport hubs**
- Demand modeling for pedestrian facilities needs
  - **data collections** and
  - developments of **modeling approaches**
- Testbed on **campus** with WiFi from access point

What we plan to do



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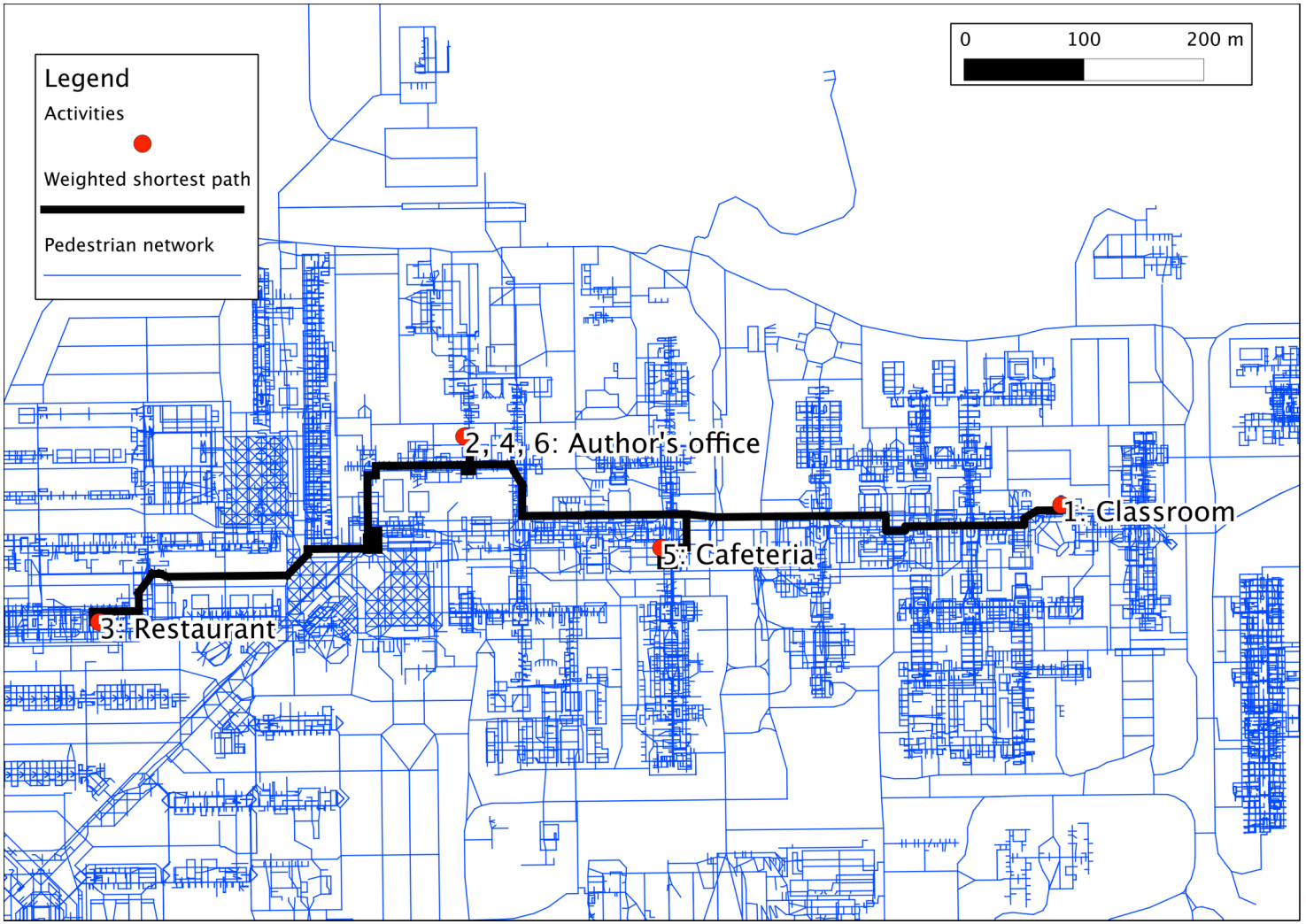
What we are doing



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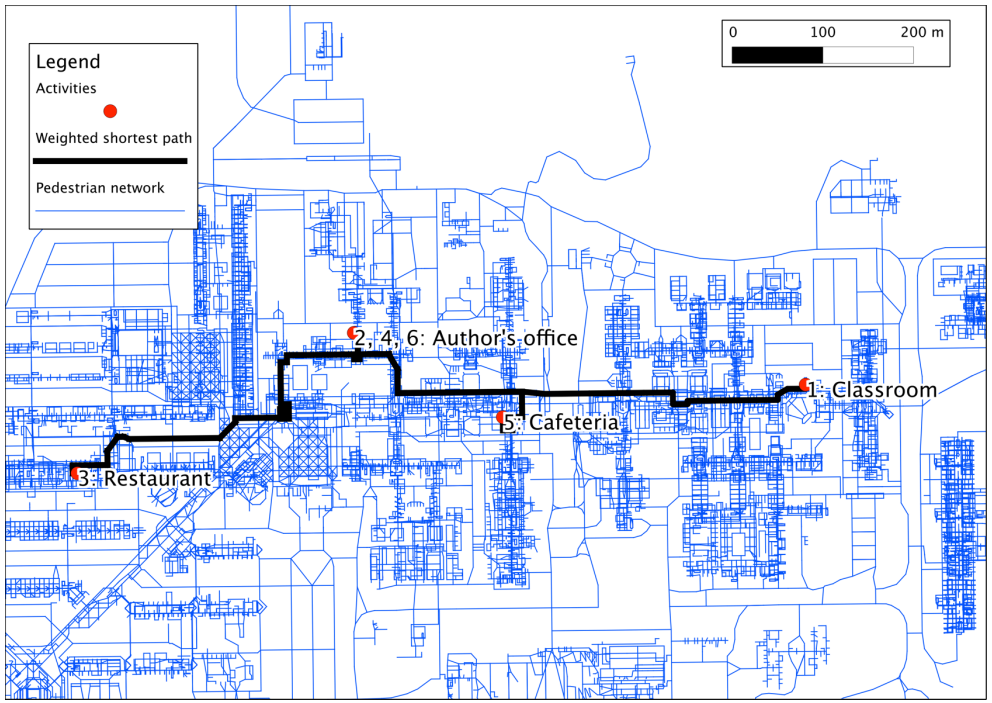
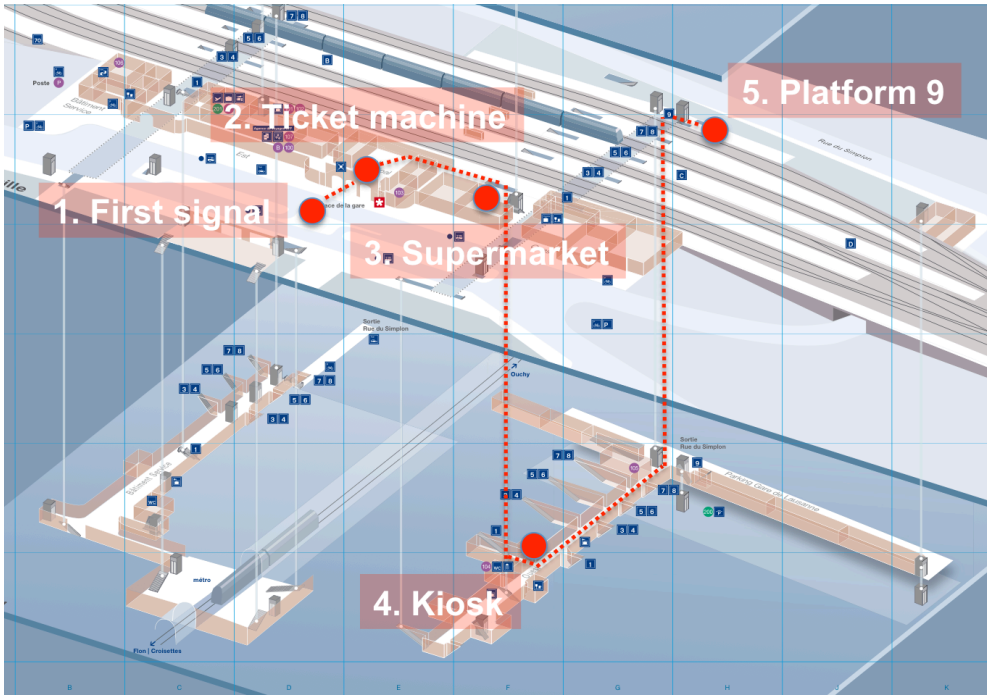
Campus



Class schedules

Transport hub



Train schedules

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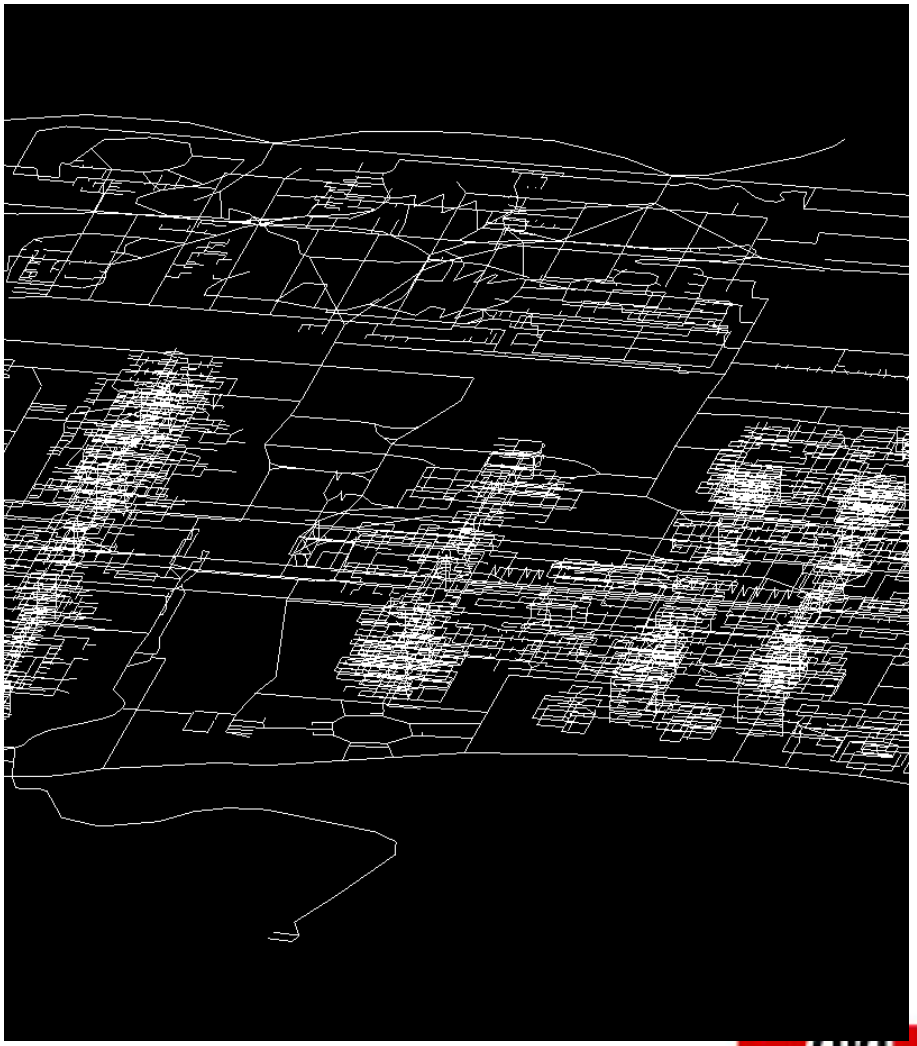
Available data

- Pedestrian network
  - destinations
  - path
- WiFi traces from access points
- Capacity
  - of classes,
  - of restaurants,
  - of platforms,
  - ...

Available data: Pedestrian network

- Source: map.epfl.ch
- 56’655 edges
- 4 different levels of path
  - Major (« highway »)
  - Inter-building
  - Intra-building
  - Access to offices
- Weighted shortest path
- All offices, restaurants, classrooms and other points of interest are coded



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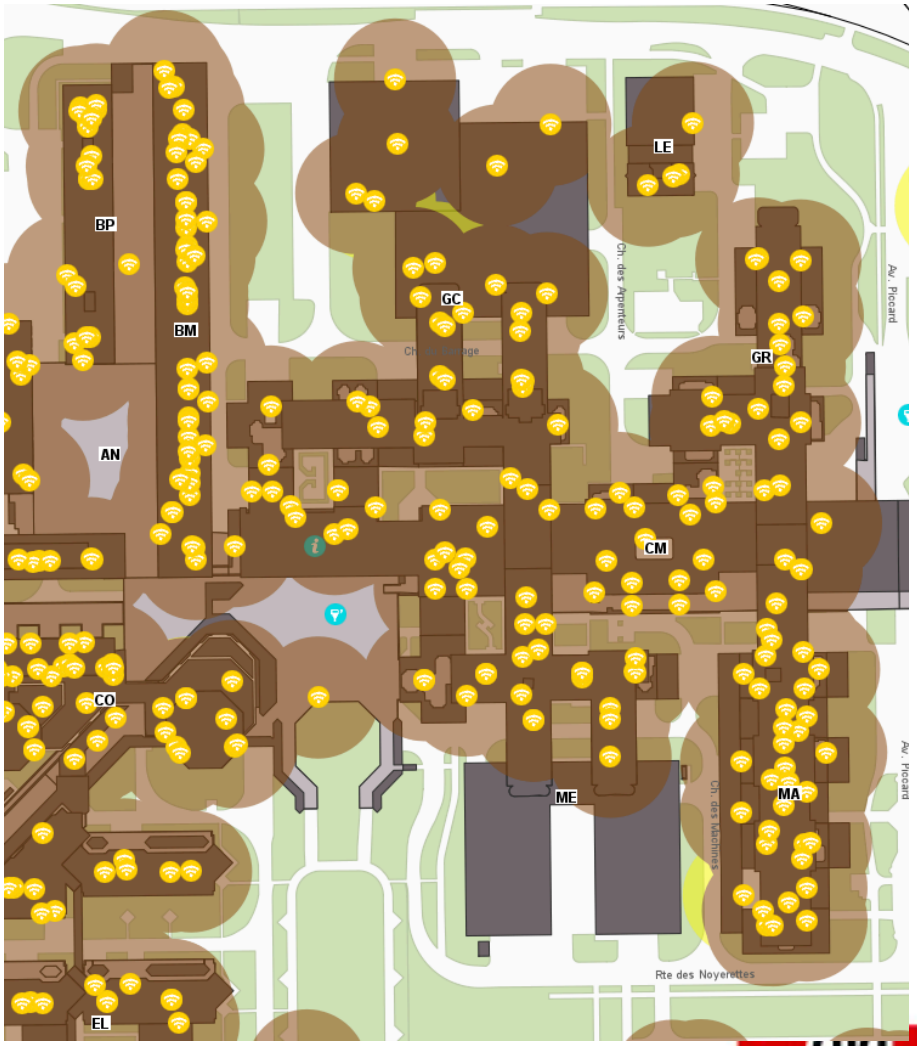
Available data: WiFi traces

- Triangulation data from the 789 access points on campus
- Low precision (187m)
- 200 students from 6 different classes + 300 employees
  - Randomly chosen
  - Anonymous (but class is known)



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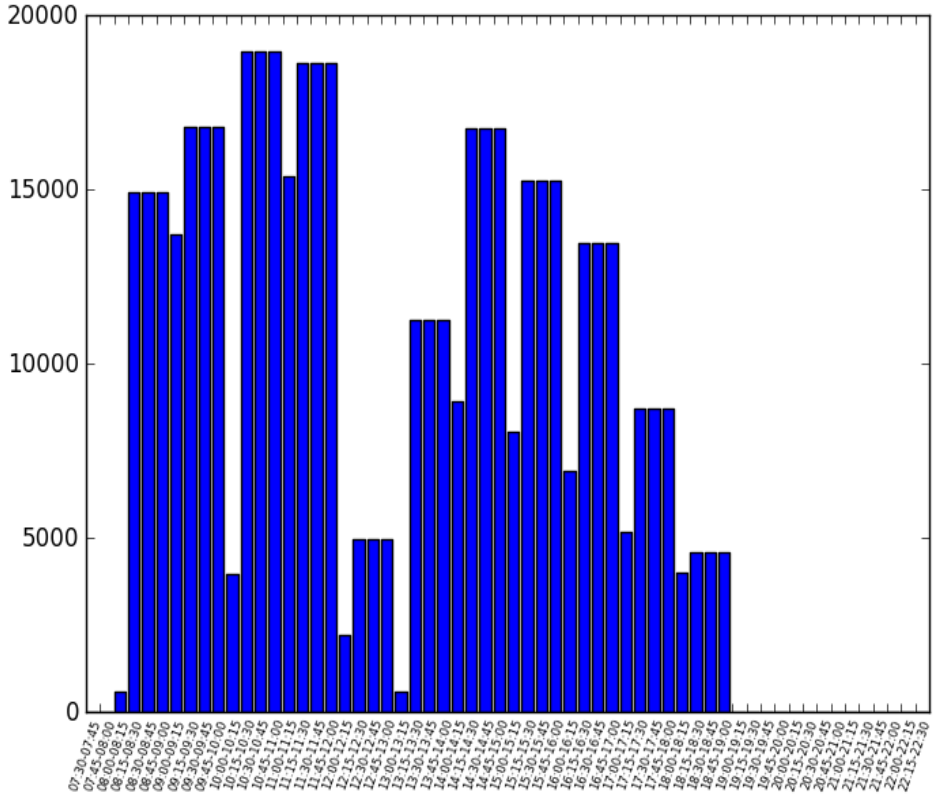
Available data: Capacity

- Class schedules with
  - Number of students
  - Name of the classroom
- Number of employees per office
  - Name of the office
  - Sum of percent of work (e.g, 3 full times = 300%)
- Number of seats in restaurants
  - Localization
  - Opening hours
- Number of seats in library



Bayesian estimation of destinations

- Activity probability

Measurement likelihood

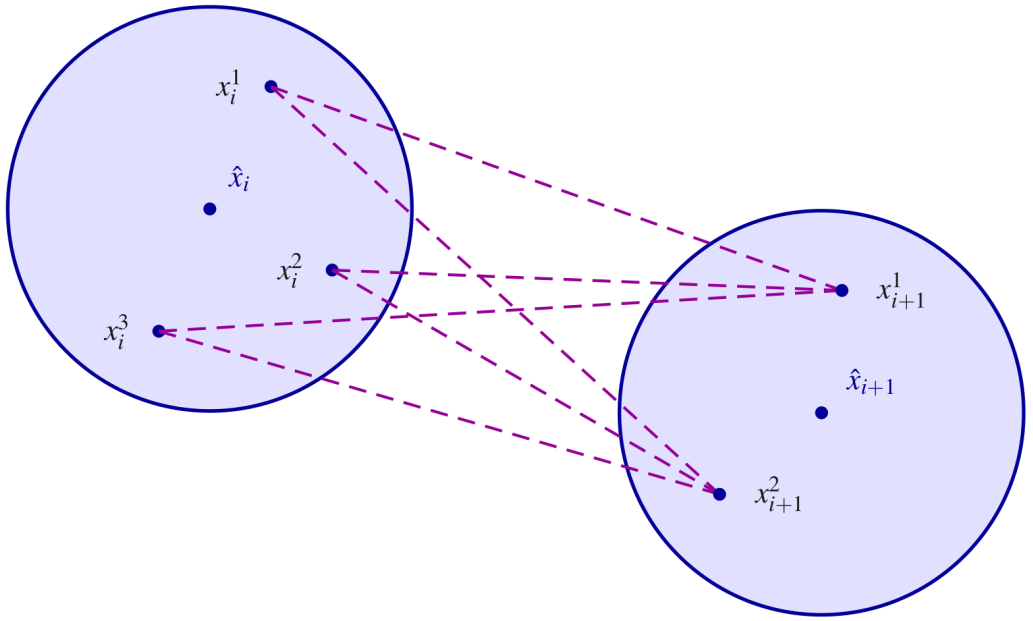
Prior knowledge

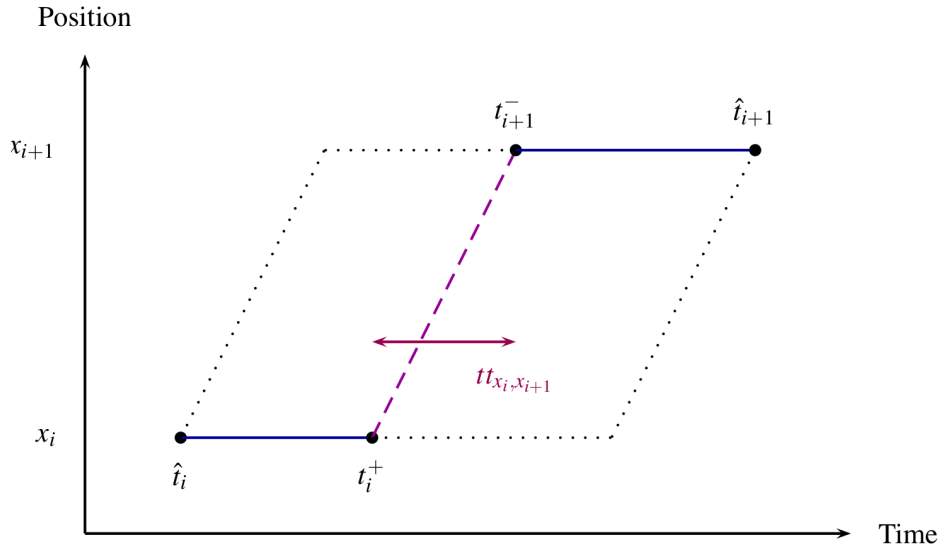
$$P(dest.|signals) \propto P(signals|dest.) \cdot P(dest.)$$

Activity probability

Bayesian estimation of destinations

- Candidate generation
  - Space
  - Time





Bayesian estimation of destinations: Results

- Flat prior

Model				Truth			Δx
Arrival time	*Departure time*	*Floor*	*Location*	*Time spent*	*Floor*	*Location*	*(in m.)*
8:35-8:35	10:38-10:38	1	Printer	8.32am-10.30am	1	Classroom	61
10:40-10:40	11:51-11:51	3	Office	Until 11.47am	3	Author's office	7
12:09-12:10	12:47-12:53	1	Office	From 11.55 am	1	Restaurant	77
12:52-12:58	13:03-13:44	3	Office	Around 1pm	3	Author's office	7
13:06-13:47	13:53-14:02	2	Cafeteria	Around 2pm	2	Cafeteria	0
13:55-14:04	19:45-19:45	3	Office	Until around 7.45pm	3	Author's office	7
19:47-19:47	19:52-19:52	0	Classroom	-	3	Metro stop	277

- Perfect prior 1:3

Model				Truth			Δx
Arrival time	*Departure time*	*Floor*	*Location*	*Time spent*	*Floor*	*Location*	*(in m.)*
8:35-8:35	10:38-10:38	1	Classroom	8.32am-10.30am	1	Classroom	0
10:40-10:40	11:51-11:51	3	Office	Until 11.47am	3	Author's office	0
11:54-11:54	12:47-12:53	1	Restaurant	From 11.55 am	1	Restaurant	0
12:51-12:58	13:03-13:44	3	Office	Around 1pm	3	Author's office	0
13:06-13:47	13:53-14:02	2	Cafeteria	Around 2pm	2	Cafeteria	0
13:55-14:04	19:45-19:45	3	Office	Until around 7.45pm	3	Author's office	0
19:47-19:47	19:52-19:52	3	Classroom	-	3	Metro stop	278

Bayesian estimation of destinations: Results

- Campus prior

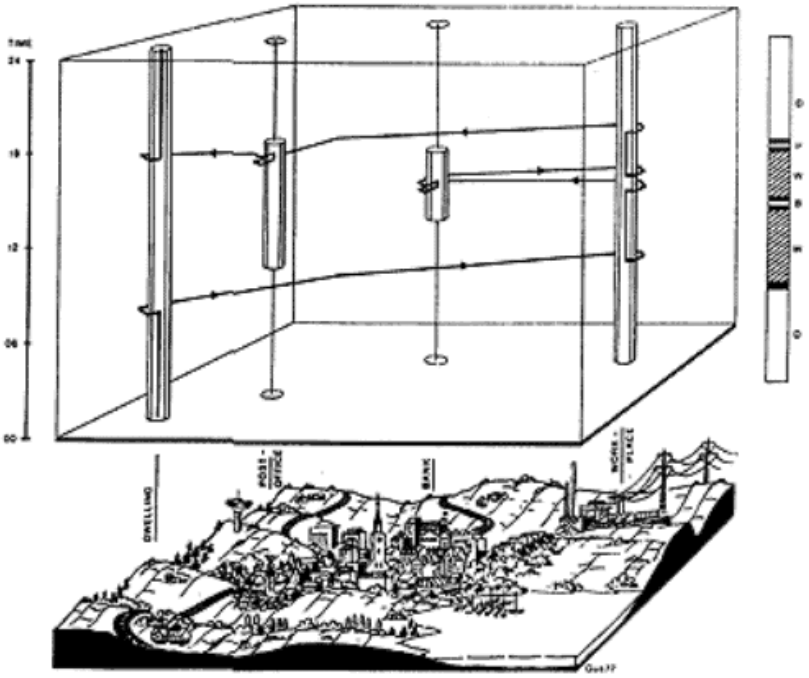
Model				Truth			Δx
Arrival time	*Departure time*	*Floor*	*Location*	*Time spent*	*Floor*	*Location*	*(in m.)*
8:35-8:35	10:38-10:38	1	Classroom	8.32am-10.30am	1	Classroom	96
10:40-10:40	11:51-11:51	3	Classroom	Until 11.47am	3	Author's office	71
11:54-11:54	12:47-12:53	1	Restaurant	From 11.55 am	1	Restaurant	0
12:51-12:58	13:03-13:44	3	Office	Around 1pm	3	Author's office	7
13:06-13:47	13:53-14:02	2	Cafeteria	Around 2pm	2	Cafeteria	0
13:55-14:04	19:40-19:44	3	Classroom	Until around 7.45pm	3	Author's office	37
19:47-19:47	19:52-19:52	3	Workshop	-	3	Metro stop	366

- Class prior

Model				Truth			Δx
Arrival time	*Departure time*	*Floor*	*Location*	*Time spent*	*Floor*	*Location*	*(in m.)*
8:33-8:33	10:38-10:38	1	Classroom	8.32am-10.30am	1	Classroom	0
10:40-10:40	11:51-11:51	3	Office	Until 11.47am	3	Author's office	7
11:54-11:54	12:47-12:53	1	Restaurant	From 11.55 am	1	Restaurant	0
12:51-12:58	13:03-13:44	3	Office	Around 1pm	3	Author's office	7
13:06-13:47	13:53-14:02	2	Cafeteria	Around 2pm	2	Cafeteria	0
13:55-14:04	19:45-19:45	3	Office	Until around 7.45pm	3	Author's office	7
19:47-19:47	19:52-19:52	3	Workshop	-	3	Metro stop	366

Activity-based model for pedestrians?

- **Goal**: adapt the concept to pedestrian facilities
- **Hägerstrand**
  - Capability constraints: *lunch*
  - Coupling constraints: *timetables*
- Pedestrians have **planned** and **unplanned** activities
- Sensitivity to changes in:
  - Pedestrian network
  - Possible destinations
  - Schedules



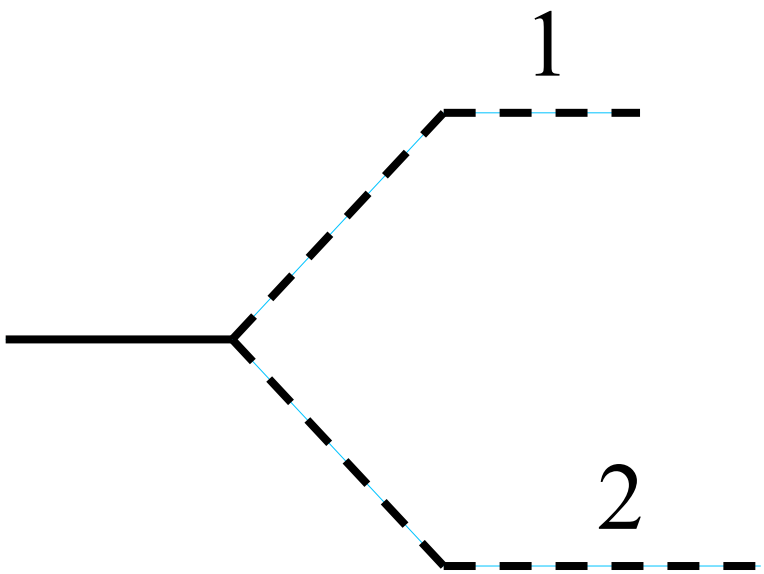
Carlstein, T. (1978)

Differences urban / pedestrian facilities

- Focus on pedestrian facilities
  - Space: Train stations, music festivals, supermarkets, airports, stadiums, campuses, city centers
  - Time: Covering the journey in the facility
- **No home** ⇒ no tour
- Mode is already known
- No monetary cost (but distance)

Model structure

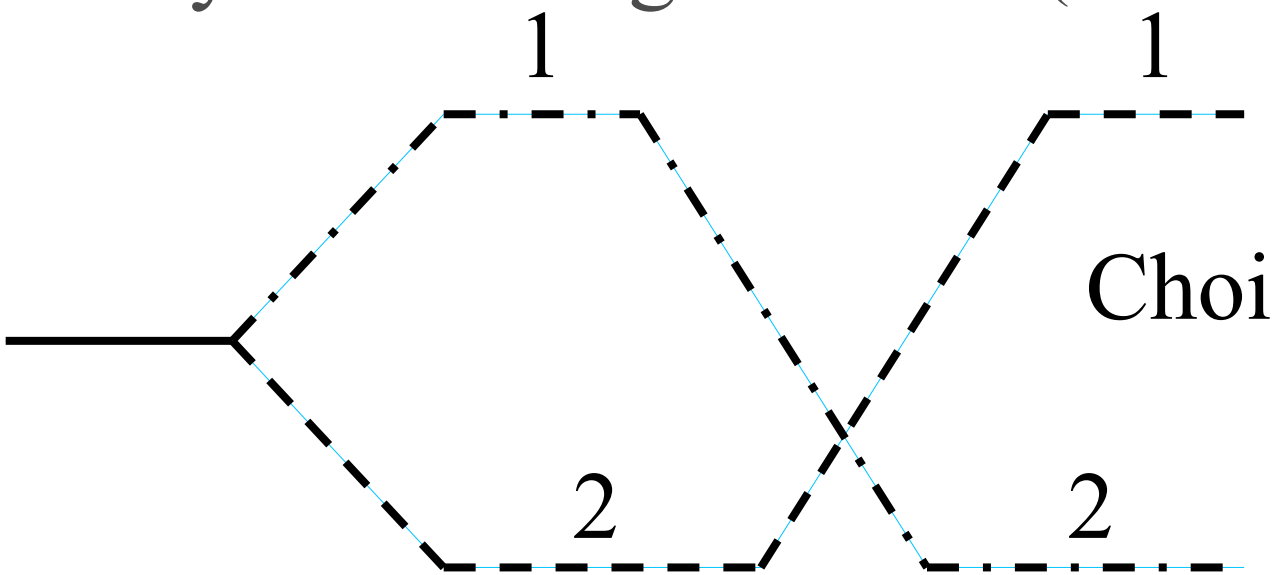
- One modeling approach:
  sequential destination choice
  (hybrid simulation: Ettema, Borgers and Timmermans 1993; Ettema et al. 1995)



Choice set: 1,2

Model structure

- One modeling approach:
  sequential destination choice
- Existence of schedules in pedestrian facilities,
  activity scheduling decision (Bowman 1998)



Choice set: {1,2},
{2,1}

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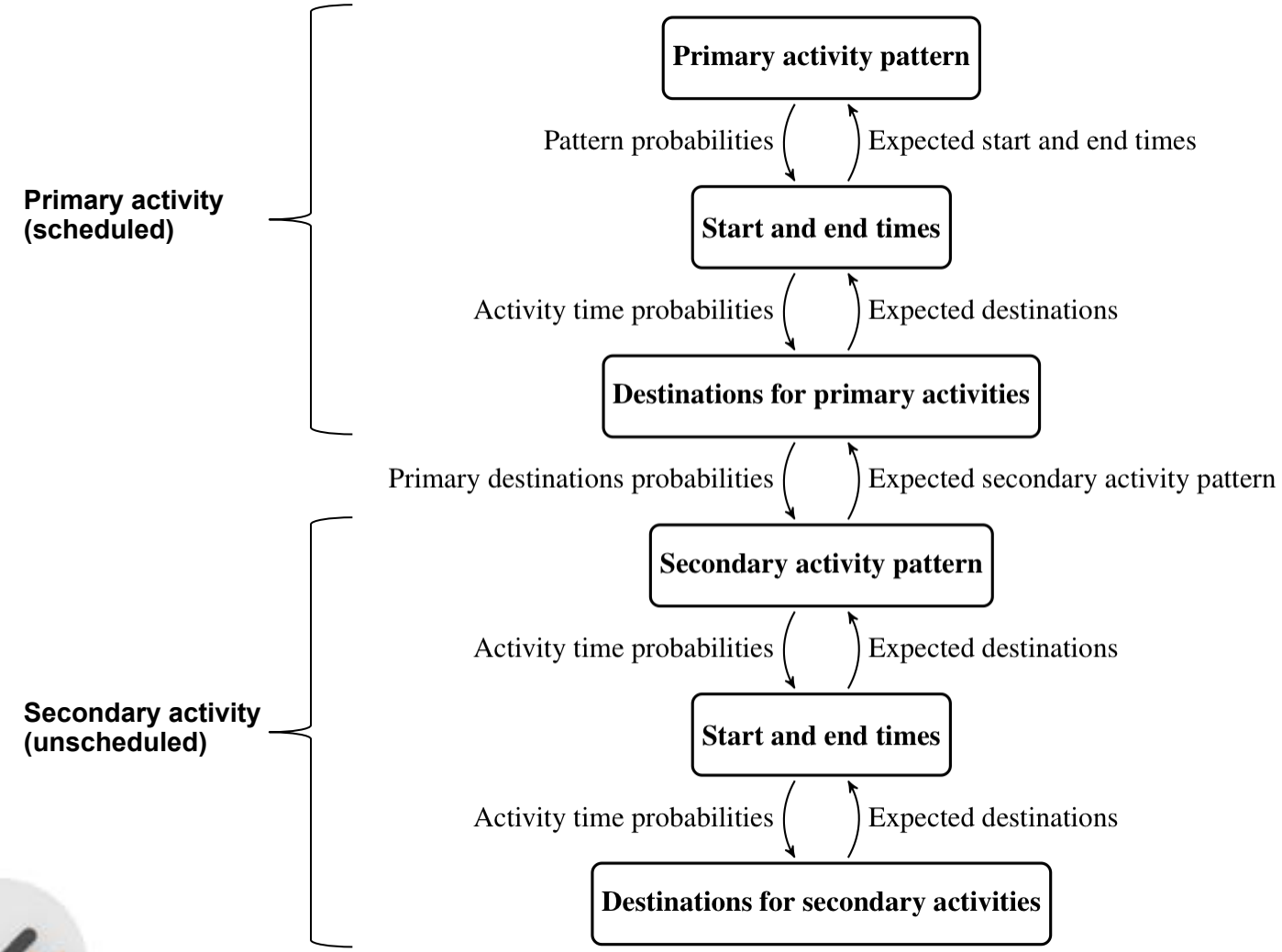
Model structure



Model structure: example (campus)

Model				Truth			Δx
Arrival time	*Departure time*	*Floor*	*Location*	*Time spent*	*Floor*	*Location*	*(in m.)*
8:33-8:33	10:38-10:38	1	Classroom	8.32am-10.30am	1	Classroom	0
10:40-10:40	11:51-11:51	3	Office	Until 11.47am	3	Author's office	7
11:54-11:54	12:47-12:53	1	Restaurant	From 11.55 am	1	Restaurant	0
12:51-12:58	13:03-13:44	3	Office	Around 1pm	3	Author's office	7
13:06-13:47	13:53-14:02	2	Cafeteria	Around 2pm	2	Cafeteria	0
13:55-14:04	19:45-19:45	3	Office	Until around 7.45pm	3	Author's office	7
19:47-19:47	19:52-19:52	3	Workshop	-	3	Metro stop	366

- **Primary pattern (scheduled):**

Primary activity	Free time	Primary activity	Free time
Classroom		Restaurant	
8:33-10:38		11:54-12:47/12:53	
CE 1 105		Ornithorynque	

Model structure: example (campus)

Model				Truth			Δx
Arrival time	*Departure time*	*Floor*	*Location*	*Time spent*	*Floor*	*Location*	*(in m.)*
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19:47-19:47	19:52-19:52	3	Workshop	-	3	Metro stop	366

- **Secondary pattern (unscheduled):**

Primary activity	Sec. activ.	Primary activity	Secondary activities
Classroom	Office	Restaurant	Office / Cafeteria / Office
8:33-10:38	10:40-11:51	11:54-12:47/12:53	12:51/12:58-13:03/13:44… -19:45
CE 1 105	GC B3 445	Ornithorynque	GC B3 445 / Satellite / GC B3 445

Model structure: example (station)

- **Primary pattern (scheduled)**

Primary activity	Free time	Primary activity
Ticket machine		Train
7:30-7:34		7:40-7:50
North east machine		Platform 8

- **Secondary pattern (unscheduled):**

Primary activity	Secondary activity	Primary activity
Ticket machine	Buying a croissant and a newspaper	Train
7:30-7:34	7:36-7:40	7:40-7:50
North east machine	Newspaper kiosk	Platform 8

Primary activity pattern: choice set

- Free time (21)
- myClassroom, freeTime (2)
- freeTime, myClassroom (2)
- freeTime, myClassroom, freeTime (2)
- myClassroom, freeTime, restaurant, freeTime (1)
- freeTime, myClassroom, freeTime, myClassroom, freeTime, myClassroom, myClassroom (1)
- freeTime, restaurant, restaurant, freeTime, myClassroom, myClassroom (1)
- …

Primary activity pattern: attributes

- Socioeconomic:
  - class
- Alternative-specific:
  - nb of courses in total,
  - nb of courses followed,
  - going to restaurant for lunch or not

What's next

- Application with data for 10 days
  - Test panel effect
  - Test different attributes:
    - distance
    - rain
    - cost of meals
    - evaluation of restaurants
    - evaluation of courses
    - …
  - Latent class model with measurement equation
- Destination category (observed) ≠ activity (unobs.)
  - Destination category is an indicator of a latent activity

Conclusion

- Transport hubs face an increasing demand
  - Detect, model and forecast at a large scale and from innovative and available data
- Schedules are common:
  - Campuses (classes)
  - Stations (trains)
  - Music festivals (concerts)
- Stations are small cities (SBB/CFF: “Rail cities”) with various activities