Open-source based methodology for creating small-scale commercial traffic for MATSim simulations

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MATSim User Meeting 2023

Generation of Small Scale Commercial Traffic

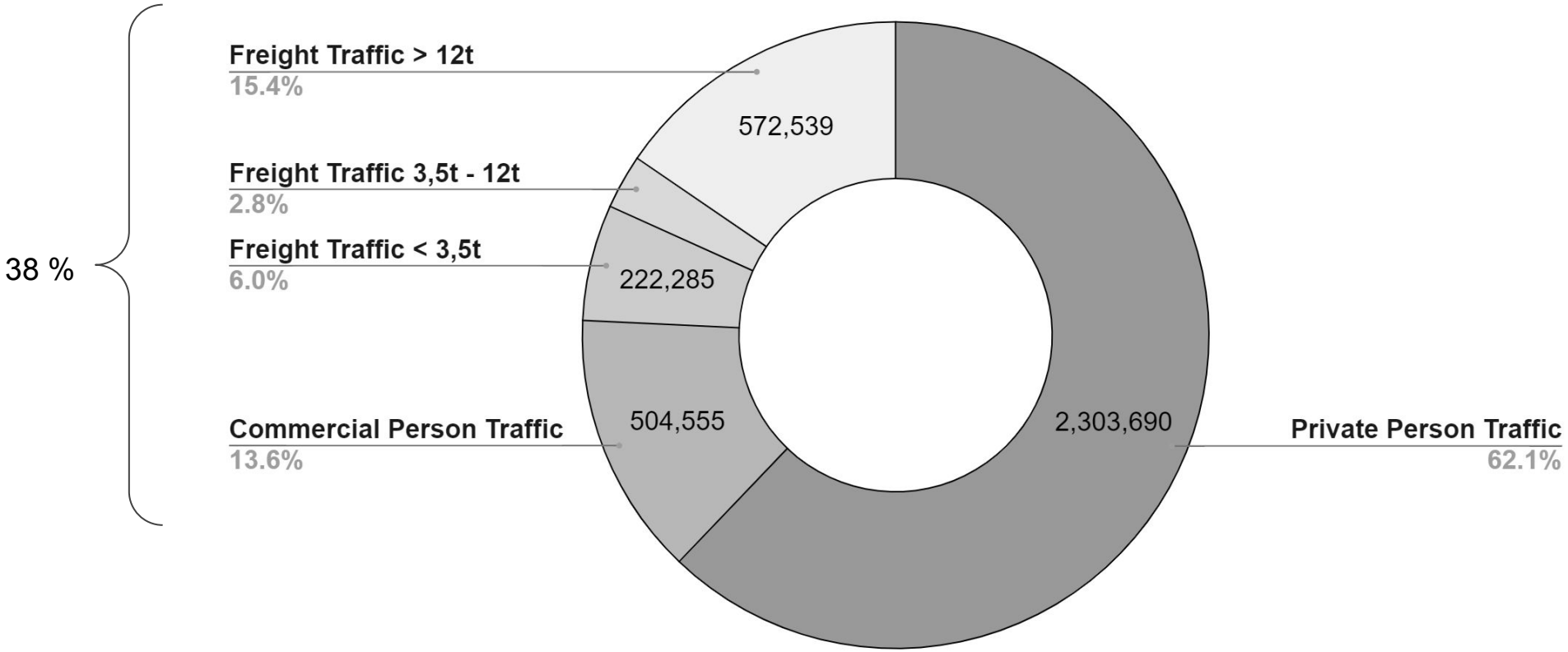


Figure 1: Rough approximation of CO2-emissions by segment in tons per year based on the vehicle-kilometers provided in PTV/TCI [1] for Berlin

Generation of Small Scale Commercial Traffic

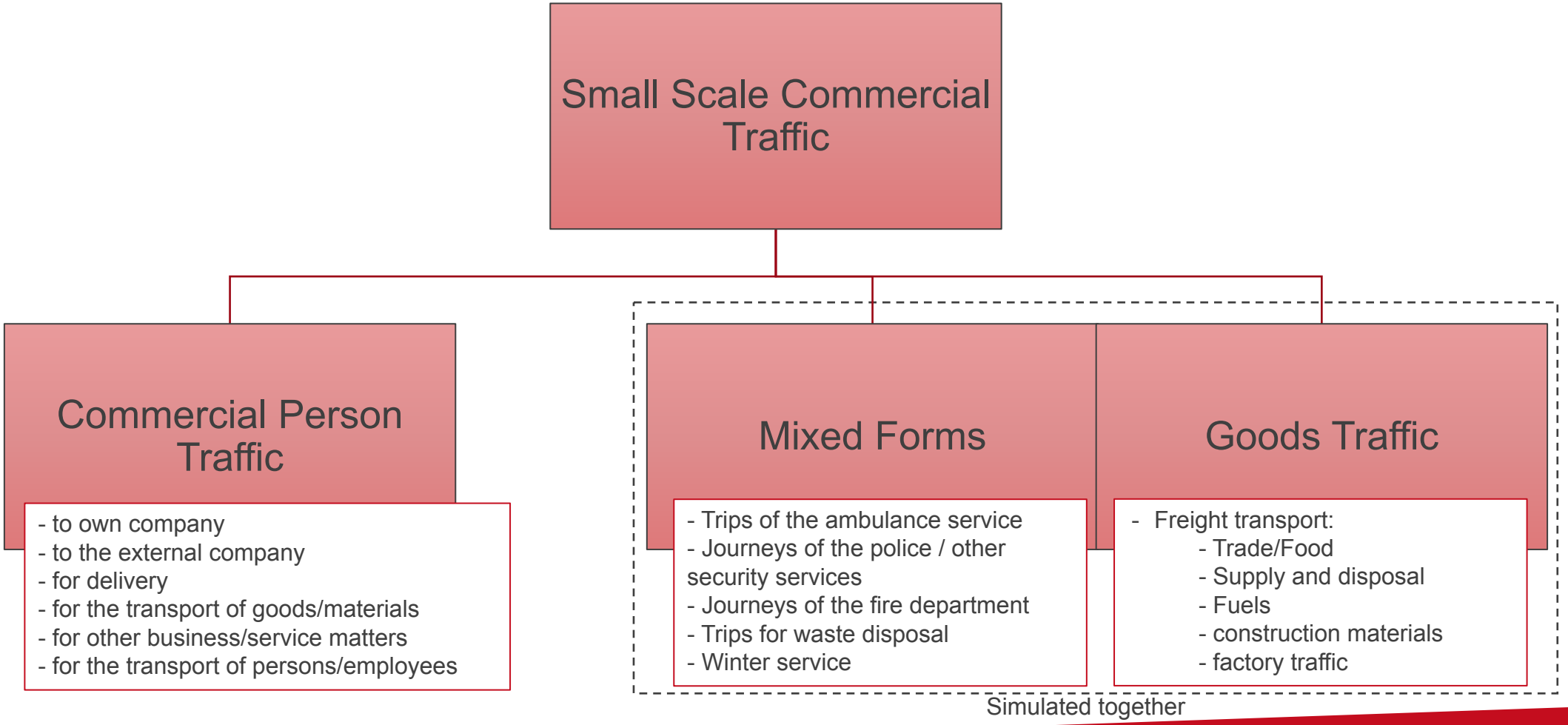
Objective:

- MATSim model of the Small Scale Commercial Traffic to integrate in MATSim scenarios
- Using only open Data

Methodology:

- Demand creation by using the given methodology in IVV 2005 [2]
- Tour planning by using the toolkit Jsprit
- Simulating/Calibrating with MATSim including mode choice
    - Parts of the traffic by bike, pt, walk (not for goodsTransport)

Generation of Small Scale Commercial Traffic



Generation of Small Scale Commercial Traffic - Purpose per trip

			Traffic Type	
Purpose	**Start**	**Stop**	**Commercial Person Traffic**	**Goods Traffic**
1	production	production	Business trips	Delivery
2	production	consumers, trade and transport locations	Business trips	Delivery
3	trade and service locations	consumers, trade and transport locations	Services, visits	Delivery, Services
4	transport locations	consumers and trade locations	Services, visits	Distribution transport
5	construction industry	consumers and construction sites	construction	construction
6	Residential areas	consumers	----------	private collection of goods

Generation of Small Scale Commercial Traffic - Methodology

- Generation rates based on IVV 2005 [2]:

Generation rates “Start”

Verkehrszweck	Strukturmerkmal							
	Einw.	Erw.	Beschäft. Prim.	Beschäft. Bau	Beschäft. Sek. Rest	Beschäft. Handel	Beschäft. Verk./Nachr.	Beschäft. Tert.-Rest
1	0	0,0	0	0	0,059	0	0	0
2	0	0,029	0	0	0,045	0	0	0
3	0	0,021	0	0	0	0,0192	0	0,184
4	0	0,021	0	0	0	0	0,203	0
5	0	0,03	0	0,29	0	0	0	0

Generation rates “Stop”

Verkehrszweck	Strukturmerkmal							
	Einw.	Erw.	Beschäft. Prim.	Beschäft. Bau	Beschäft. Sek. Rest	Beschäft. Handel	Beschäft. Verk./Nachr.	Beschäft. Tert.-Rest
1	0	0	0	0	0,020	0	0	0
2	0,002	0	0,029	0,029	0,009	0,029	0,039	0,029
3	0,025	0	0,0168	0,168	0,0168	0,0168	0,097	0,168
4	0,002	0	0,025	0,025	0,025	0,025	0,075	0,025
5	0,004	0	0,015	0,002	0,015	0,015	0,020	0,015

- needed data: structure data for each traffic cell

Generation of Small Scale Commercial Traffic

- Data connection:
  - Production: Employees in the secondary sector excluding construction
  - Consumers: Inhabitants and all employees
  - Trade: Employees in the trade sector
  - Transport locations: Employees in the transport and communications sector
  - Construction: Employees in the construction sector

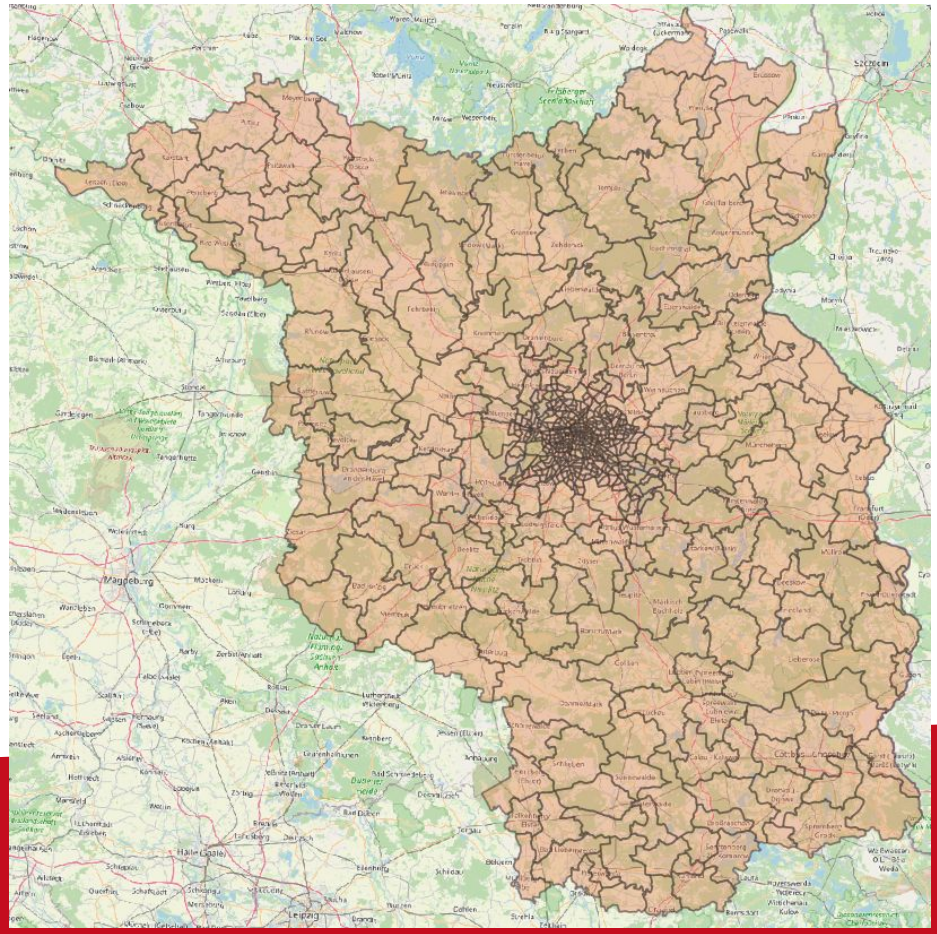
Generation of Small Scale Commercial Traffic

- Input statistics for each region

Area	Inhabitants	Employee	Employee Primary Sector	Employee Construction	Employee Secondary Sector Rest	Employee Retail	Employee Traffic/Parcels	Employee Tertiary Sector Rest
Berlin	3645000	2067600	900	90200	131100	215200	85300	1544900
Brandenburg	2531492	1120100	27400	96500	149900	136300	80900	629100

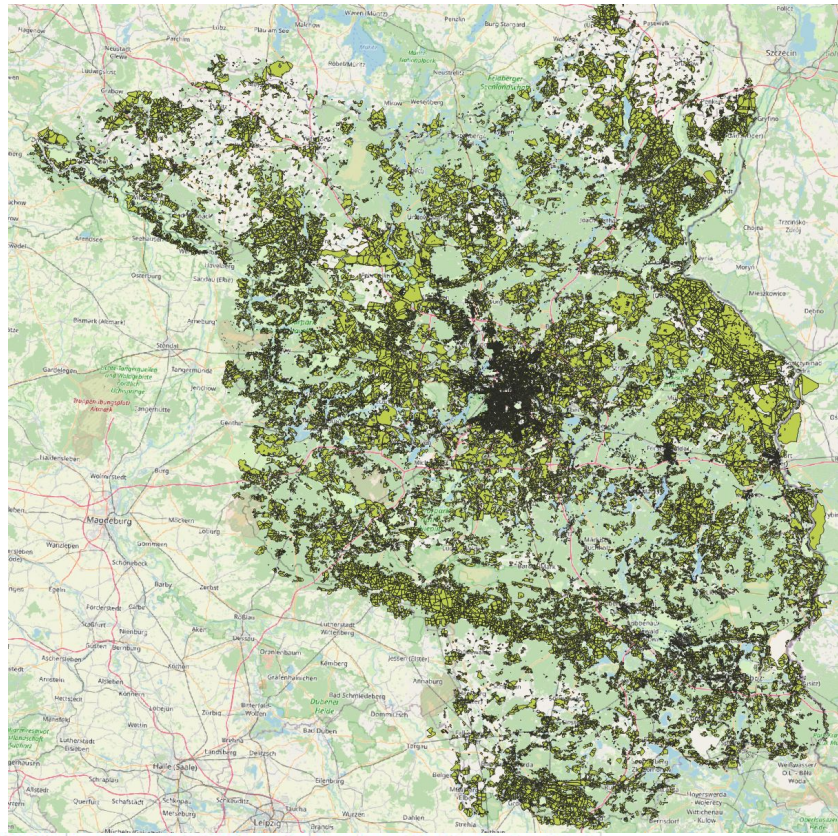
- For generation:
  - data for smaller areas (e.g. traffic cells or districts) needed

  → Shape Landuse + Buildings (incl. Levels)



Generation of Small Scale Commercial Traffic

- OSM data contains:
  - Land-use
  - Buildings (incl. number of levels)
  - Quality of the data is very different
- Calculating the share of the used square meters per sector (based on the given employee data)

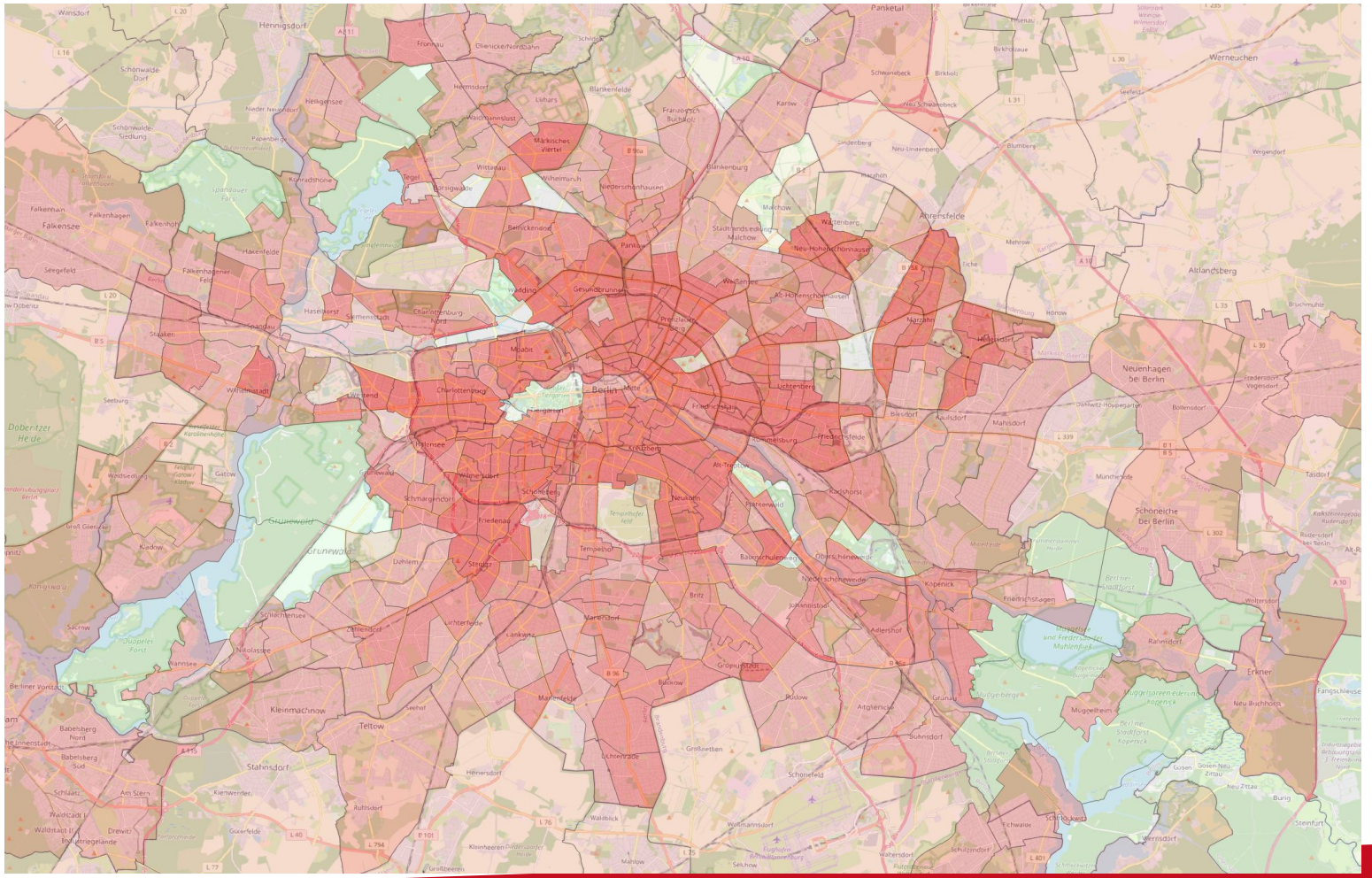


- Resulting data distribution per cell

areaID	areaName	Inhabitants	Employee	Employee Primary Sector	Employee Construction	Employee Secondary Sector Rest	Employee Retail	Employee Traffic/Parcels	Employee Tertiary Sector Rest
Brandenburg_1206514400	Hohen Neuendorf	20323	2094	2	900	39	718	44	392
Brandenburg_1206222400	Herzberg (Elster)	9828	3902	123	0	68	170	388	3153
Brandenburg_1207224000	Ludwigsfelde	20581	24078	34	1855	6392	2402	2010	11386
Brandenburg_1206509600	Glienicke/Nordbahn	7621	686	0	12	0	164	53	456
Brandenburg_1206924900	Groß Kreutz (Havel)	11475	5231	191	222	431	678	414	3296
Brandenburg_1206700006	Odervorland	10435	5654	225	0	59	67	616	4687

Generation of Small Scale Commercial Traffic

- Population density; example Berlin



Generation of Small Scale Commercial Traffic

- Calculating the traffic volume per cell, purpose and trafficType

$$Q_{VZ,Vk} = \sum_{Stm}^{8} \left(X_{Vz,Stm} * ER_{Q(Vk,Stm} \right) \quad (1)$$

$$Z_{VZ,Vk} = \sum_{Stm}^{8} \left(X_{Vz,Stm} * ER_{Z(Vk,Stm} \right) \quad (2)$$

Q = traffic volume (start)
Z = traffic volume (stop)
Vz = cell
Vk = purpose
Stm = structure data type
X_{Vz} = volume of structure data type in this cell

⇒ traffic volume for each cell

Generation of Small Scale Commercial Traffic

- Creation OD-Matrix:
  - General approach for the gravity model

$$F_{ij\,(Vk)} = k * Q_{i\,(Vk)} * Z_{j\,(Vk)} * e^{-\beta w_{ij}} \quad (3)$$

  - resistanceValue:

$e^{(-\beta * w(ij))}$ w(ij)…*transportCosts*

β…*resistance factor*

  - At the moment:
    - source fixed gravity model

⇒ OD-Matrix with trips between every area for every purpose and every traffic type

Generation of Small Scale Commercial Traffic

- Using Jsprit [3] for tour generation:
  - Toolkit for solving vehicle routing problems (VRP)

- General assumptions:
  - One carrier per start zone
  - tour duration distribution from KiD
  - service times distribution from KiD
  - tour start distribution from KiD
  - Services between 0:00 and 24:00
  - Different vehicle Types for different purposes

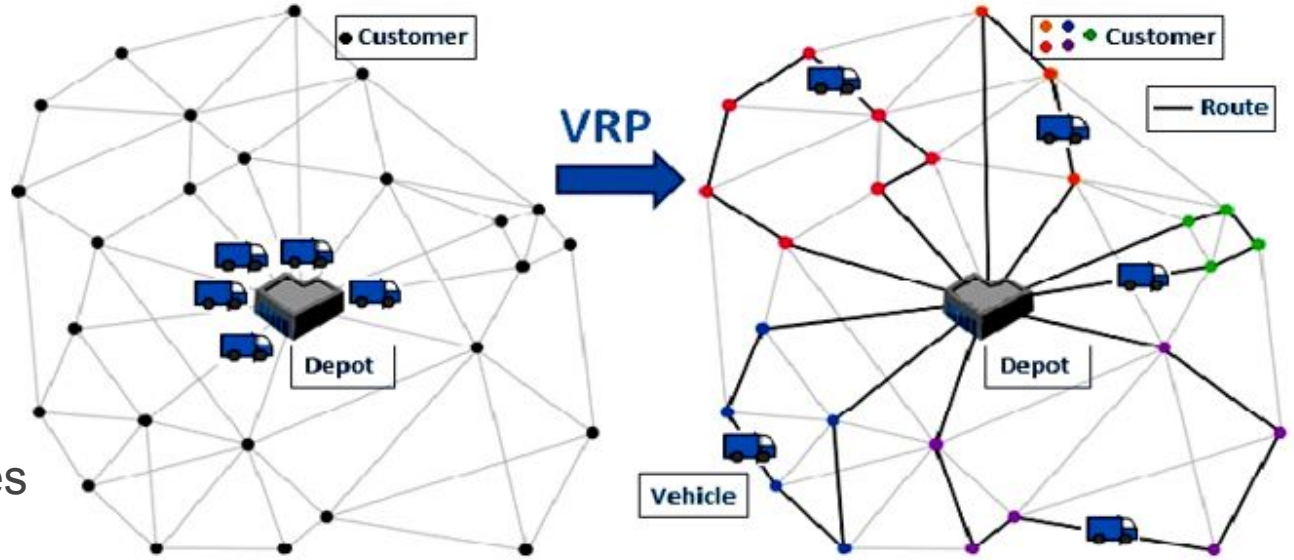


Figure: Vehicle Routing Problem [4]

Generation of Small Scale Commercial Traffic

- Key facts:
  - needed data:
    - structure data for regions
    - extracted OSM Data
  - created model:
    - freight model with realistic tours
    - MATSim modell including different sectors and vehicle types
  - limits:
    - no tours for detailed for a certain sector (e.g. care services)
    - no goods transport per volume
    - overlap of private and commercial personal traffic
  - code:
    - MATSim-lips -> Application contrib
    - contains function to include existing commercial models

Generation of Small Scale Commercial Traffic

- next steps:
  - publishing the methodology in a paper
  - publishing a new version of the Open Berlin Scenario [5] including commercial traffic
  - publishing paper with first cases in the direction of decarbonization of small-scale freight traffic (e.g. taxes)

References

[1] PTV/TCI, 2009. Gesamtverkehrsprognose 2025 für die Länder Berlin und Brandenburg. URL: https://www.brandenburg.de/media_ fast/4055/GVP2025_Ergebnisbericht_2009-11-23.pdf.

[2] IVV. Kleinräumige Wirtschaftsverkehrsmodelle, FE-Nr. 70.0689/2002/, (2005).

[3] jsprit. 23. Juni 2021. [Online]. Verfügbar unter: https://github.com/graphhopper/jsprit

[4] A. Gupta und S. Saini. (2017), An Enhanced Ant Colony Optimization Algorithm for Vehicle Routing Problem with Time Windows, in *2017 Ninth International Conference on Advanced Computing (ICoAC)*, Chennai: IEEE, S. 267–274. doi: 10.1109/ICoAC.2017.8441175

[5] Ziemke, D., Kaddoura, I., Nagel, K., 2019.The MATSim Open Berlin Scenario: A multimodal agent-based transport simulation scenario based on synthetic demand modeling and open data. Procedia Computer Science 151, 870–877. doi:10.1016/j.procs.2019.04.120.

Thanks for your attention

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