CASPT 2015 Rotterdam

Why closing an airport may not matter The impact of the relocation of TXL airport on the bus network of Berlin

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The minibus model

Overview

The demand side asks for direct hassle-free connections (door-to-door)

versus

The supply side asks for profitable lines to operate (hub-and-spoke)

Network design problem

3 – Model application

2 – Model development

1 – Understanding minibuses

Flexible minibus systems

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The evolutionary game approach

Co-evolutionary algorithm of transit line optimization.

Operators compete with each other and evolve by applying the genetic operators of

Mutation

includes changing the line's route profile and its time of operation

Selection

is represented by each individual line's fitness. Operators withdraw vehicles from unprofitable lines and assign them to more profitable ones. If no vehicle is left, the line dies out. — Service frequency

Mutating the route

Time of operation

Reduce to demand

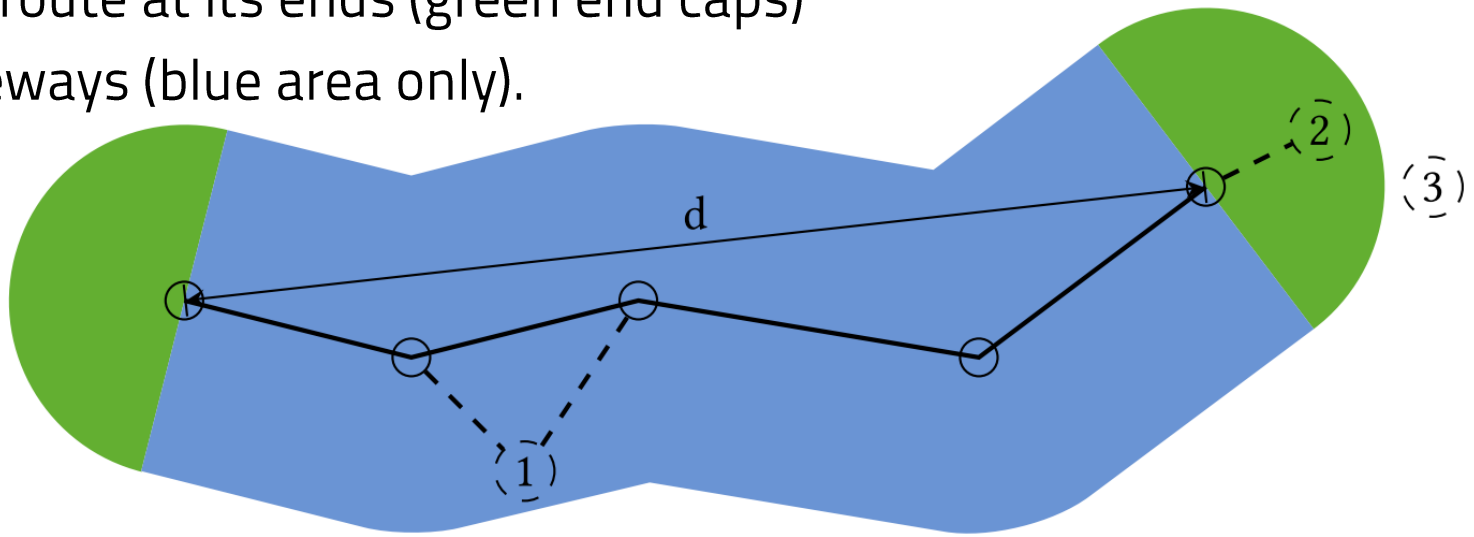
Extend the time of operation

Route profile

Reduce to profitable parts of the route

OR Extend the route at its ends (green end caps)

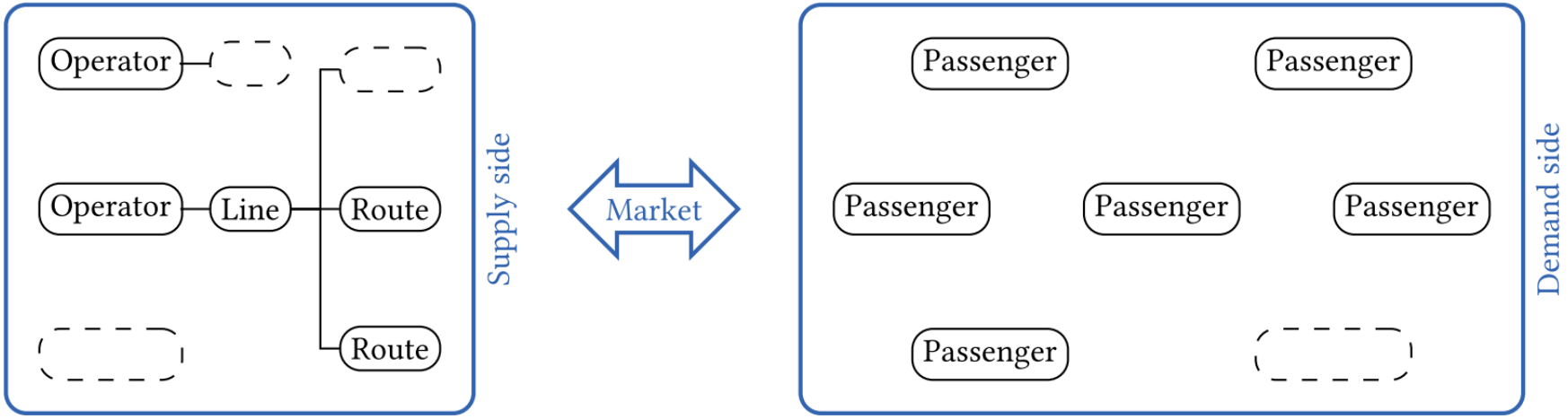
OR Extend sideways (blue area only).



Surviving modifications become eventually candidates for mutation

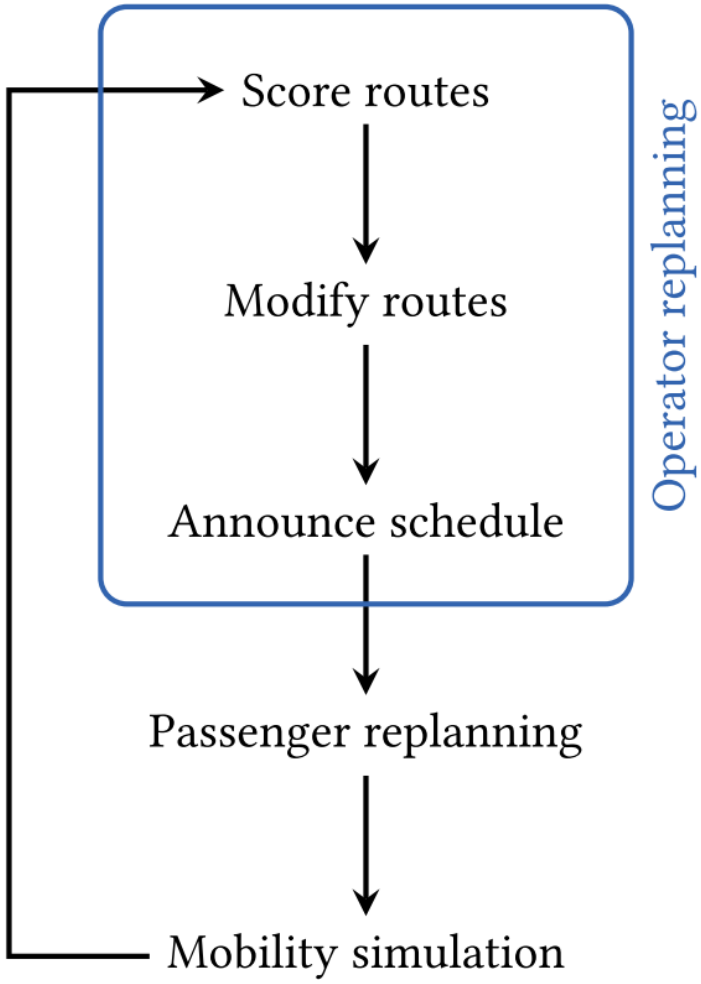
The model's core mechanics I

The model's representation of the supply side and the demand side



The model's core mechanics II

The operator replanning in the context of the passenger replanning and the mobility simulation.



Passengers search individually for new paths considering minibus as well as formal transit services

Supply and demand side interact through the mobility simulation

Model embedded in the multi-agent simulation
http://www.matsim.org

MATSim
Multi-Agent Transport Simulation

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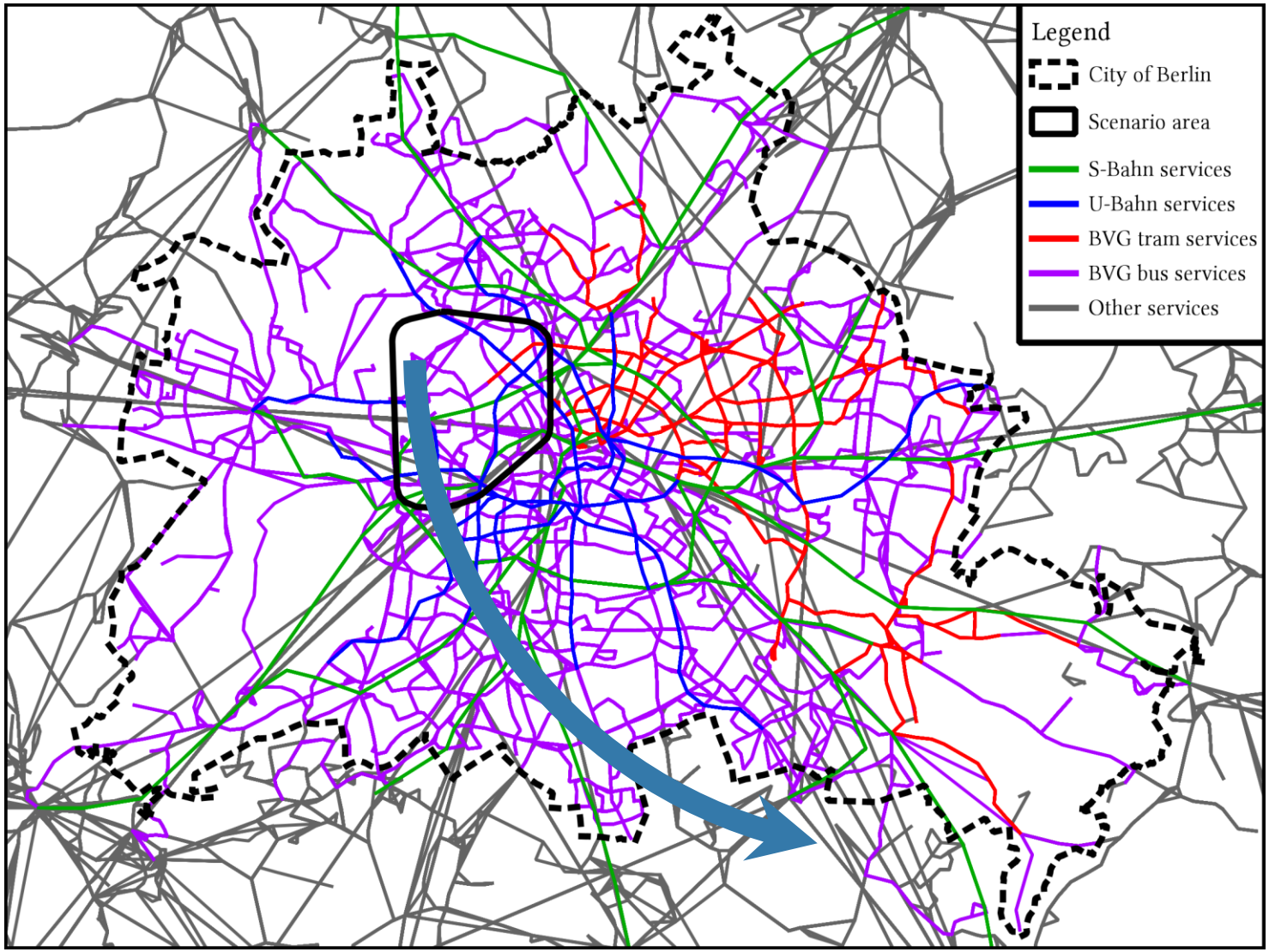
For in-depth reading…

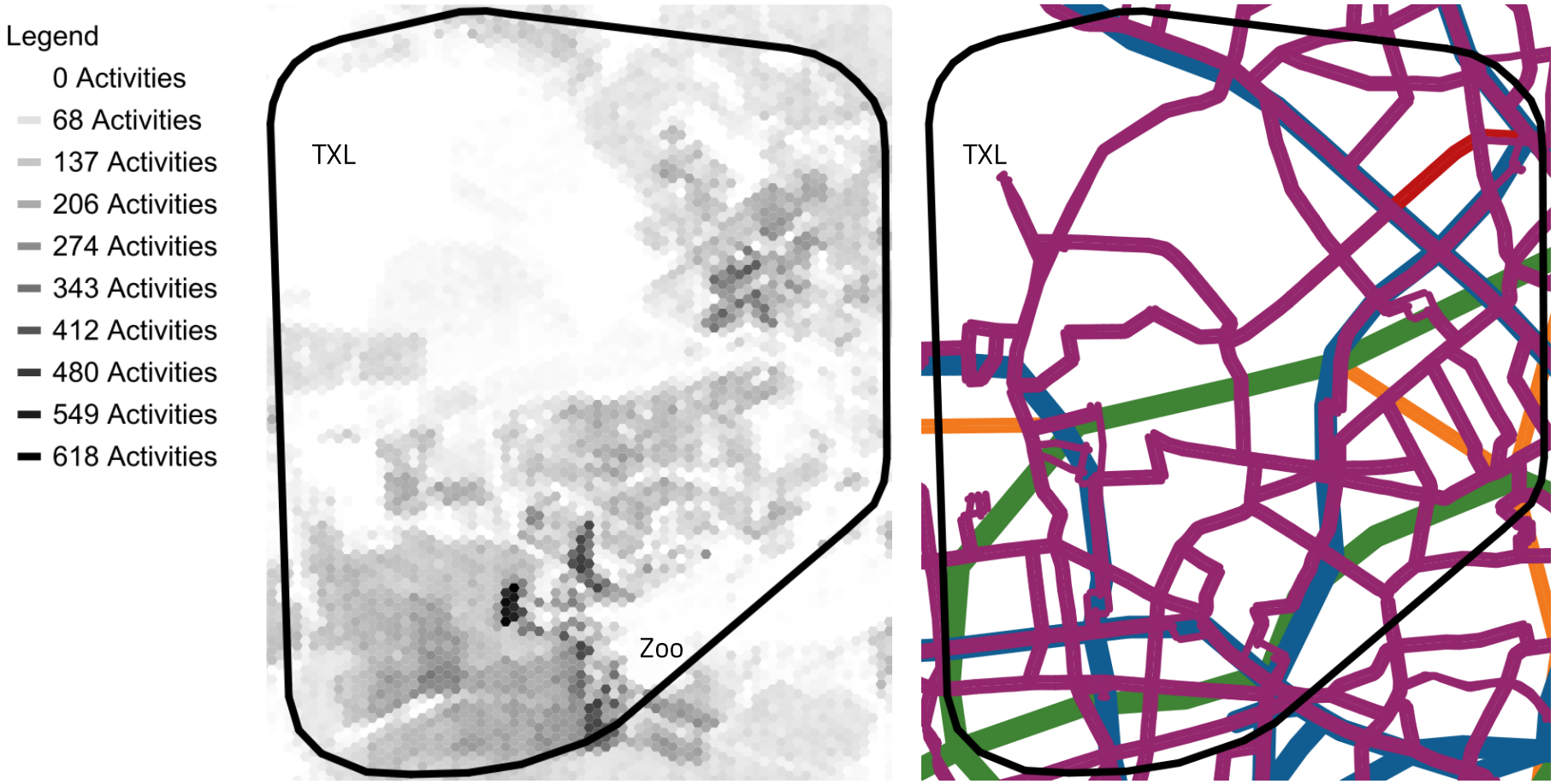
A. Neumann; A paratransit-inspired evolutionary process for public transit network design; PhD thesis, TU Berlin, 2014
http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:kobv:83-opus4-53866

Why closing an airport may not matter

The relocation of the TXL airport



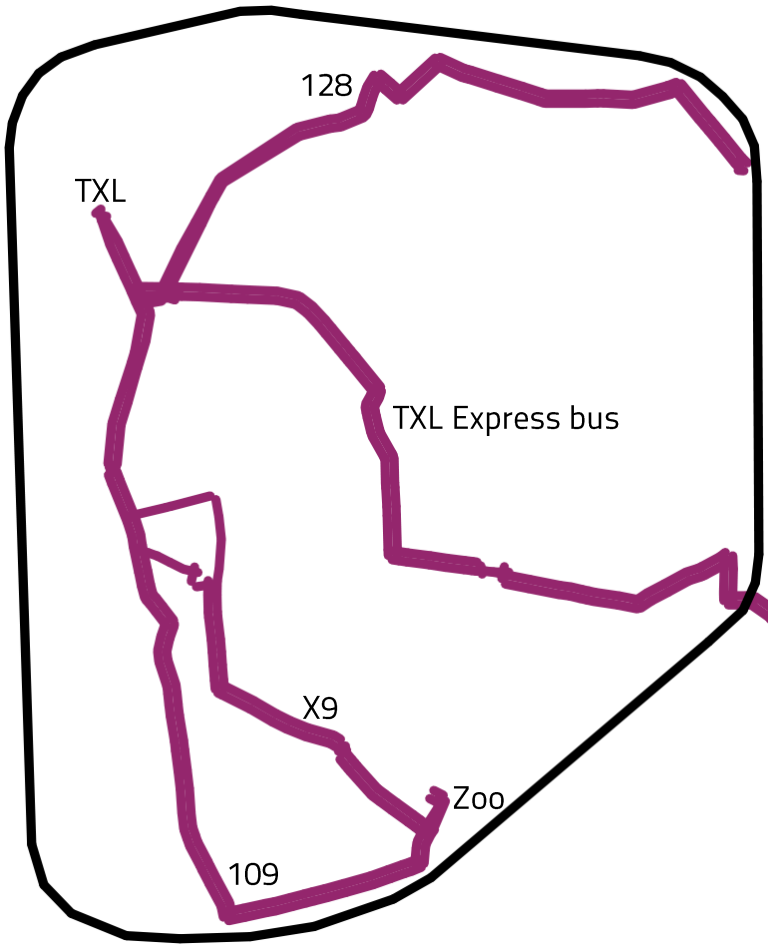
Isolated high-demand area TXL exclusively served by bus



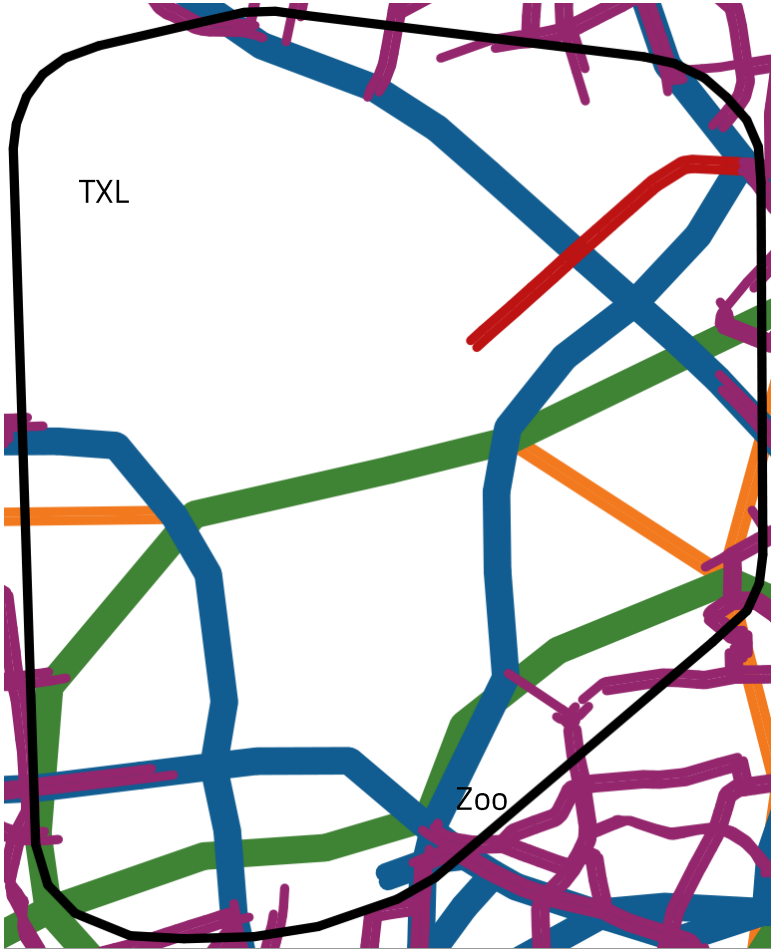
Distribution of activities within the scenario area — BER case. A total of 7,672 activities are relocated from TXL to the new airport BER and are thus not shown.

The same input data and configuration is used with two different setups of the scenario called Corridor and Area.

All bus lines serving TXL are removed in the Corridor setup. These lines serve as seeds for the initial minibus operators.



Public transport services in the Area setup. All bus lines operated by BVG within the scenario area are removed.



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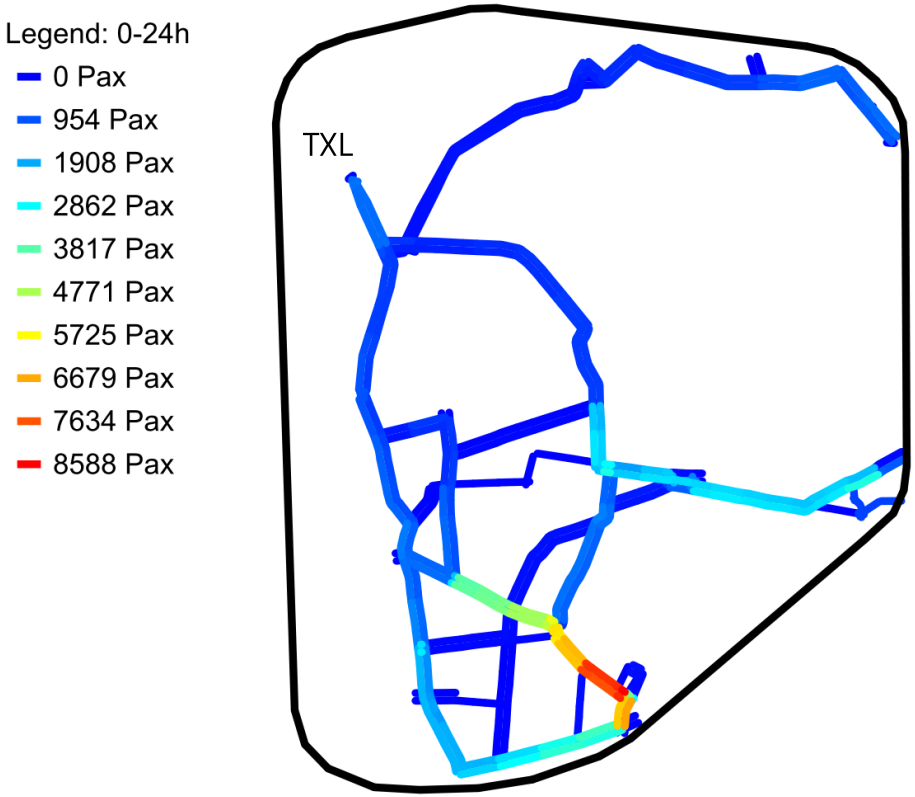
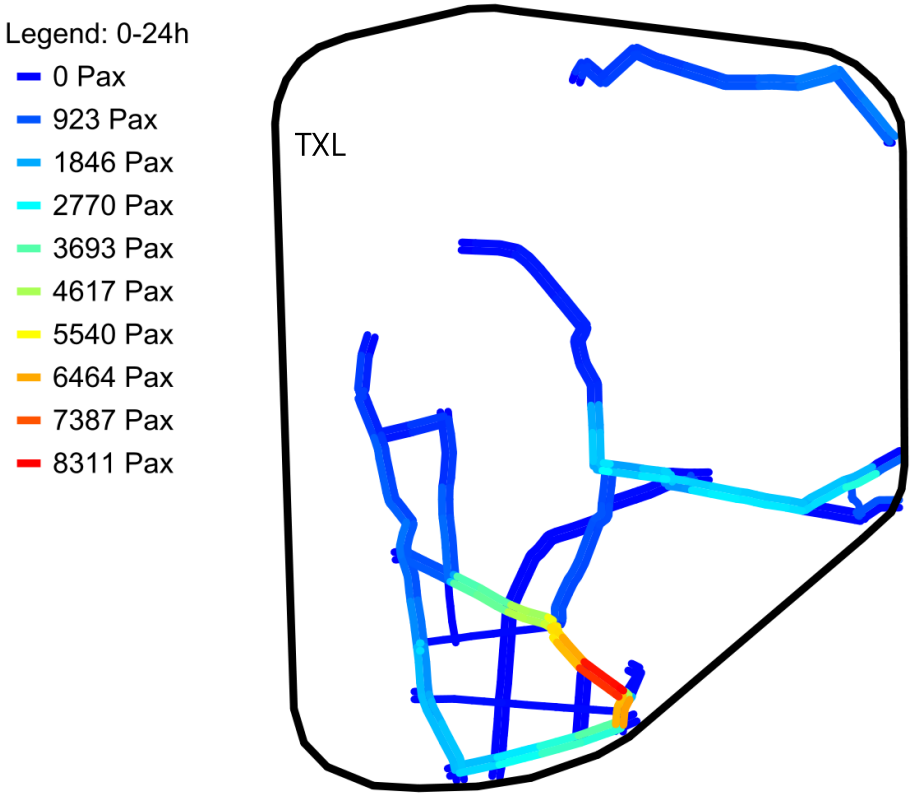
Corridor: Apart from TXL, the rest of the network is unaffected by the closure of the airport.

TXL still open
Resembles current system



TXL closed
Resembles plans by BVG for TXL closure



Surprising additional non-stop connection between which competes with existing bus of BVG

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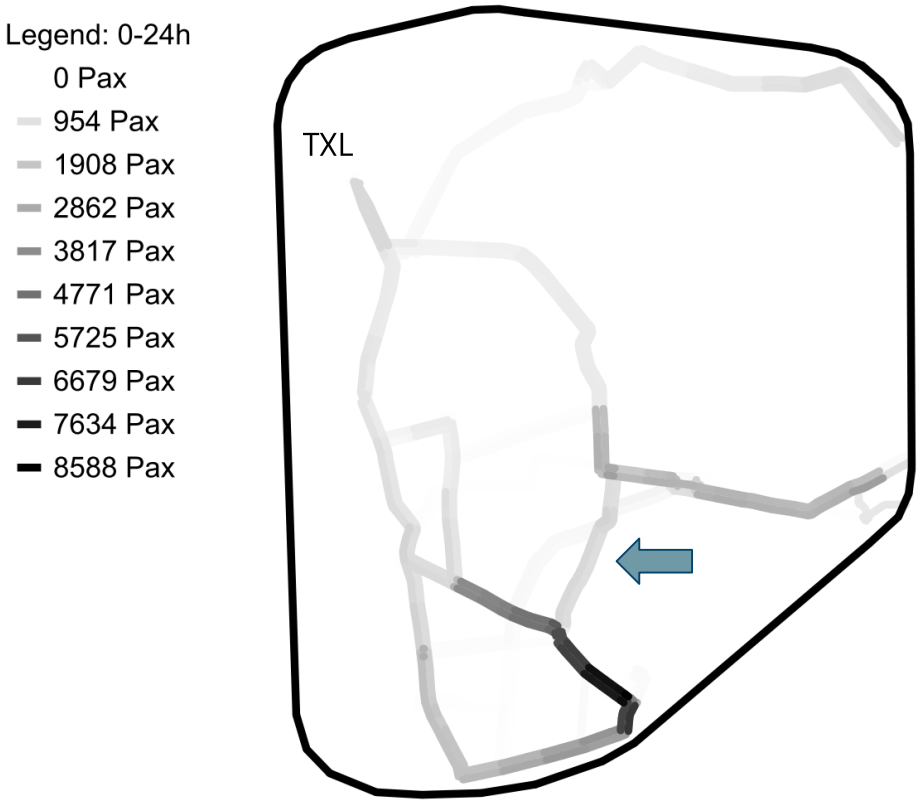

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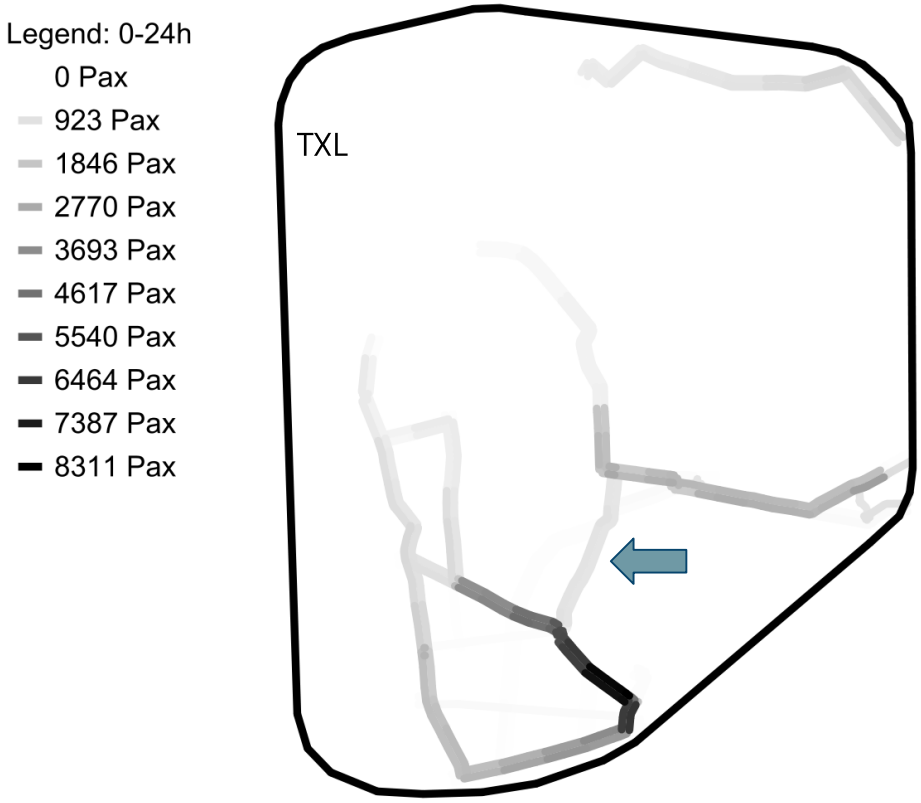
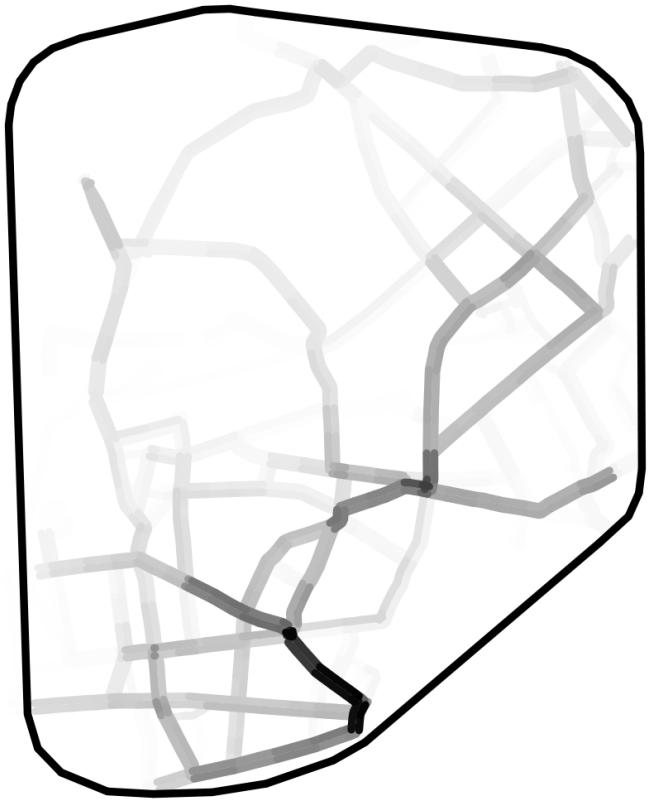


Surprising additional non-stop connection between which competes with existing bus of BVG

Area: The impact of TXL is locally confined

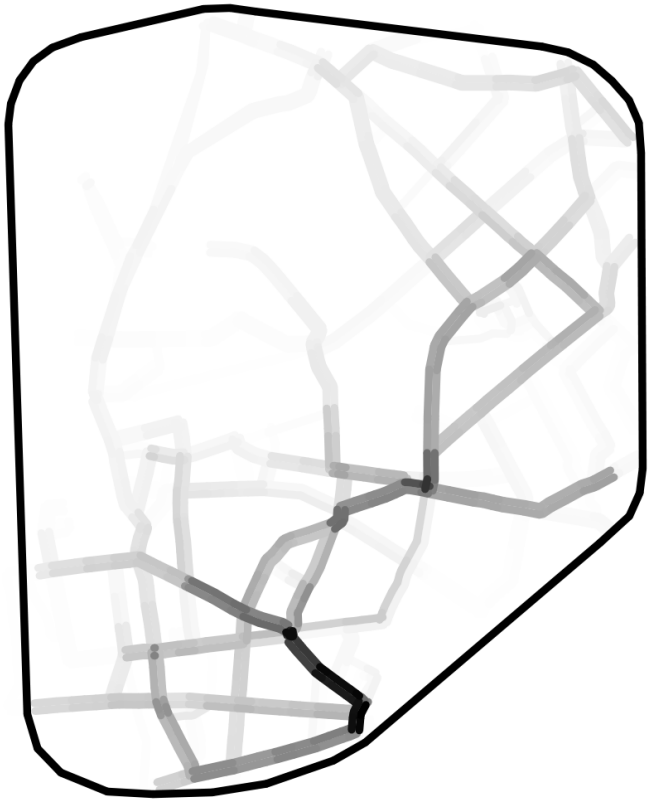
TXL still open

Legend: 0-24h
- 0 Pax
- 908 Pax
- 1817 Pax
- 2726 Pax
- 3634 Pax
- 4543 Pax
- 5452 Pax
- 6361 Pax
- 7269 Pax
- 8178 Pax



TXL closed

Legend: 0-24h
- 0 Pax
- 901 Pax
- 1802 Pax
- 2703 Pax
- 3604 Pax
- 4505 Pax
- 5406 Pax
- 6307 Pax
- 7208 Pax
- 8109 Pax



Even such a strong demand reduction as the TXL removal causes surprisingly local consequences to the transit system.

Going small – Towards a large-scale application

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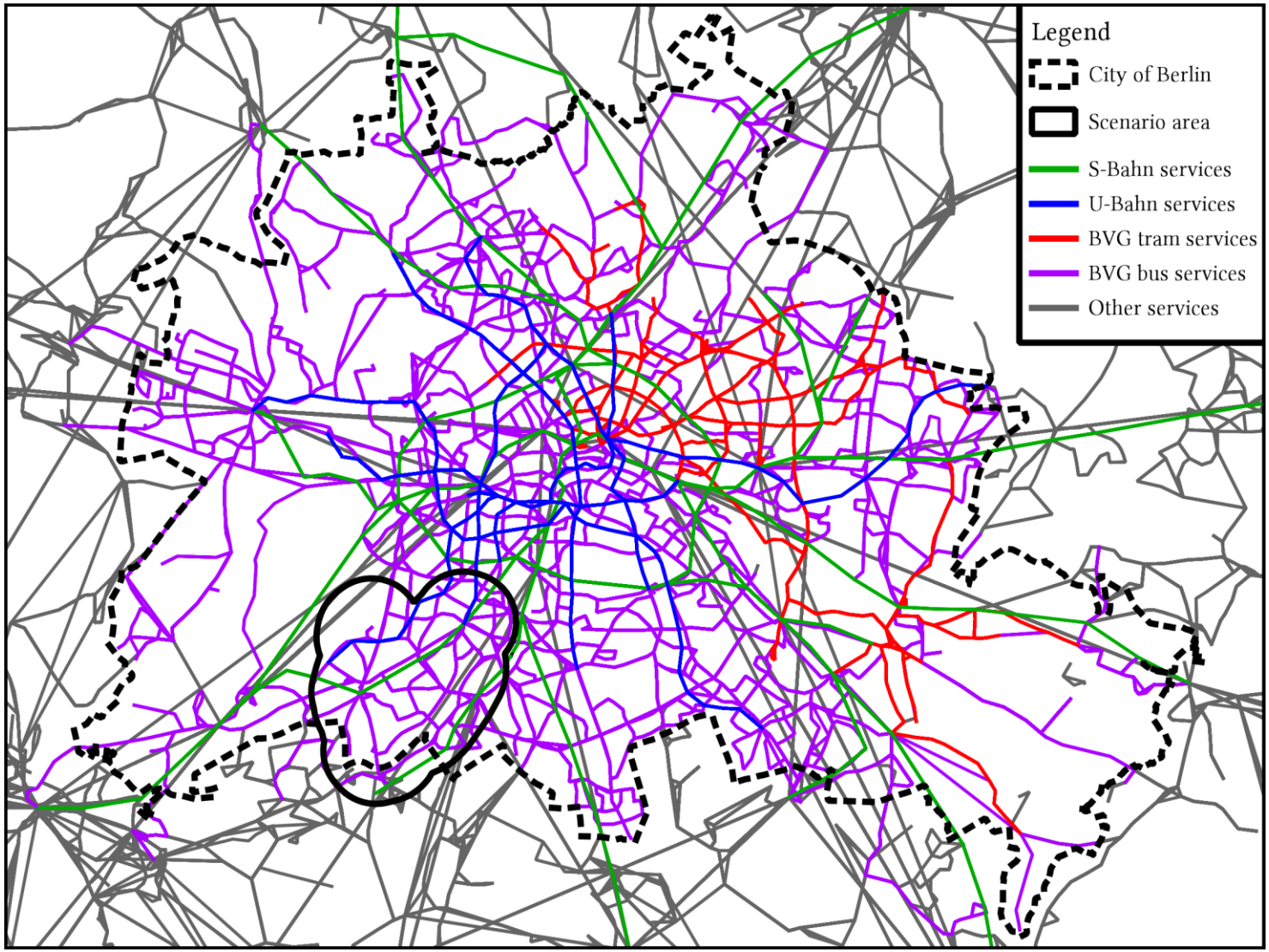
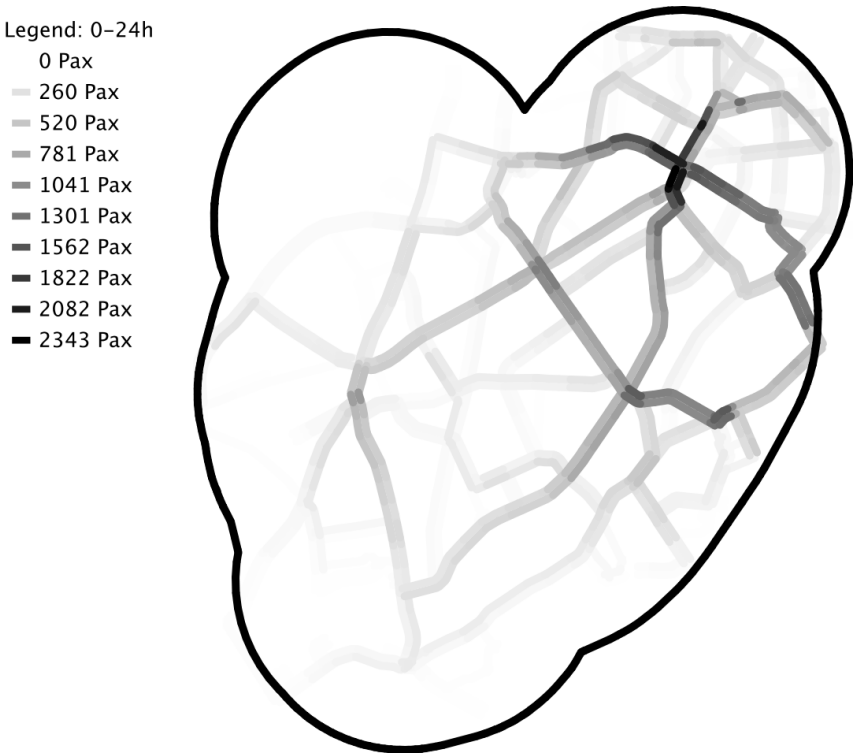


Bus-oriented area with a single CBD and low-demand residental areas

Using only a 10% sample of the full population

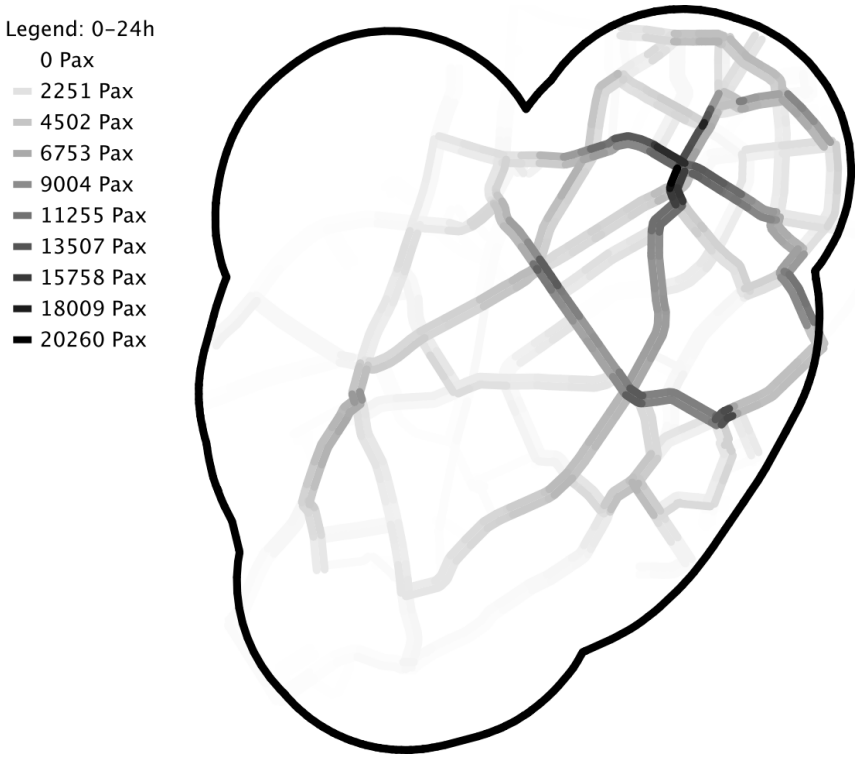
Reference system with 100% sample and minibuses

10% sample of the population

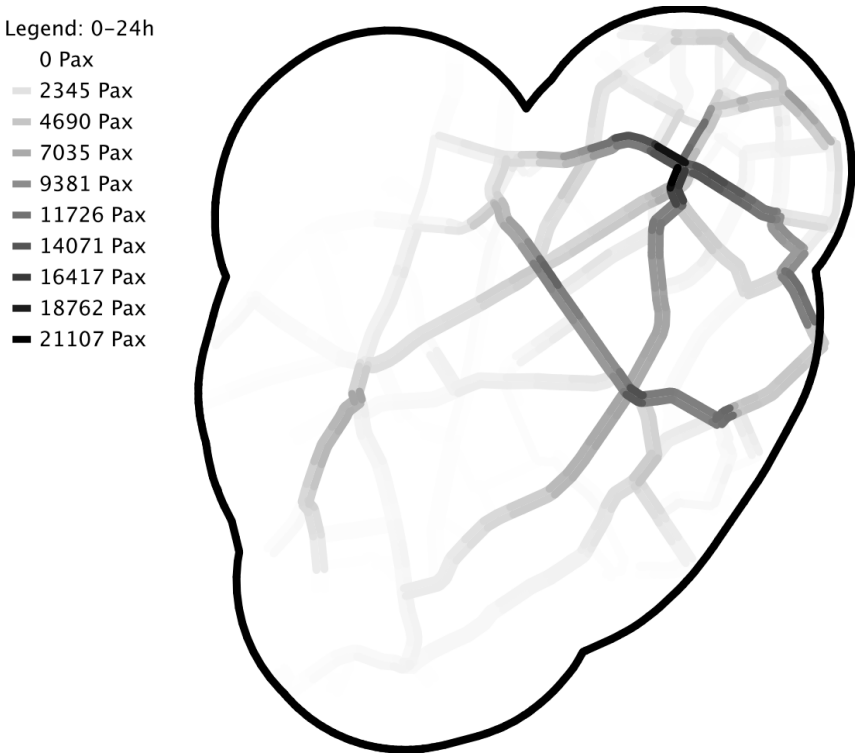


Using standard buses instead of minibuses

Reference system with 100% sample and minibuses

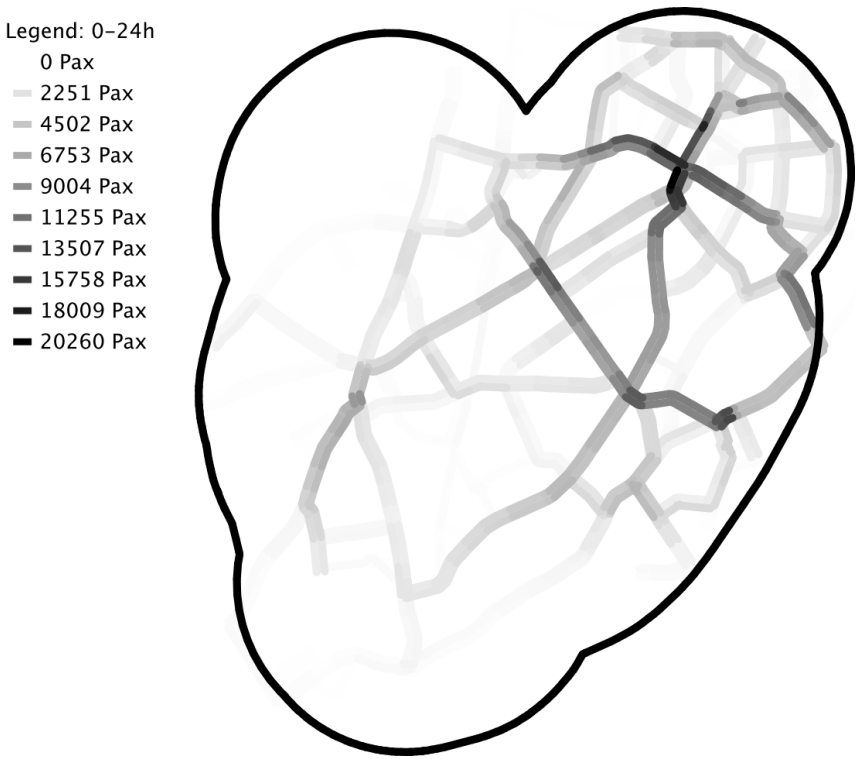


Standard buses

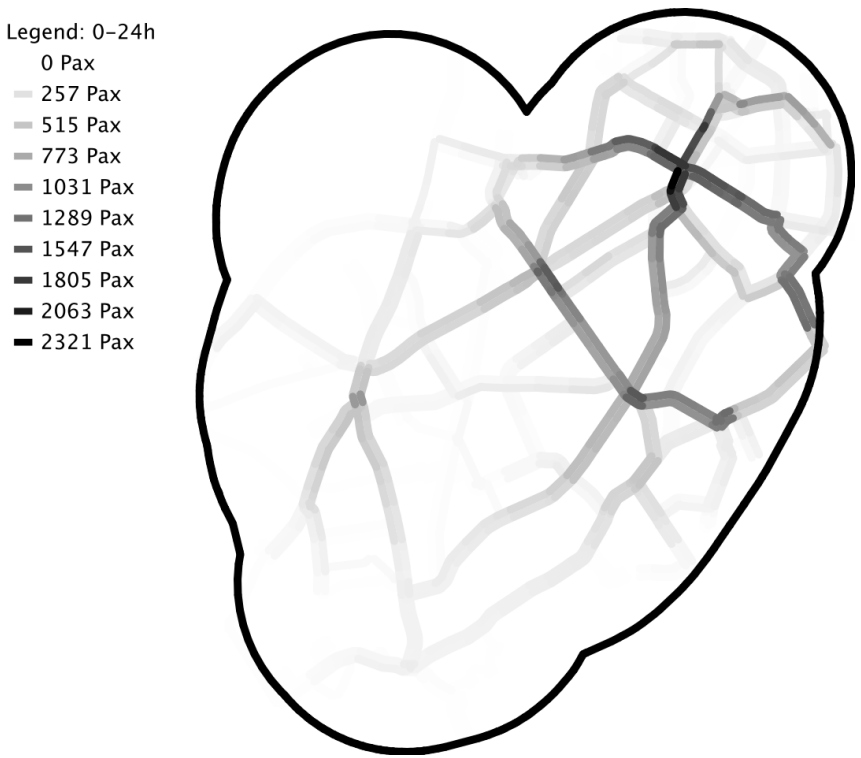


Combining both: Standard bus and 10% sample

Reference system with 100% sample and minibuses



10% sample of the population with standard buses



In-depth analysis reveals

With larger vehicles

Operators are forced to concentrate their services on corridors
→ Service coverage in low-demand areas decreases slightly

Passengers have to walk longer distances to access the transit system

Overall, passengers gain from a shorter total travel time and a more reliable service, e.g. waiting time at the stop decreases.

With a smaller sample size of the population

The impact of each traveler increases (veh cap = 1pax)
→ Operators offer more direct (taxi-like) services

Combination

forces operators again to find a solution that suits several requests

10% sample of the full population – No single CBD

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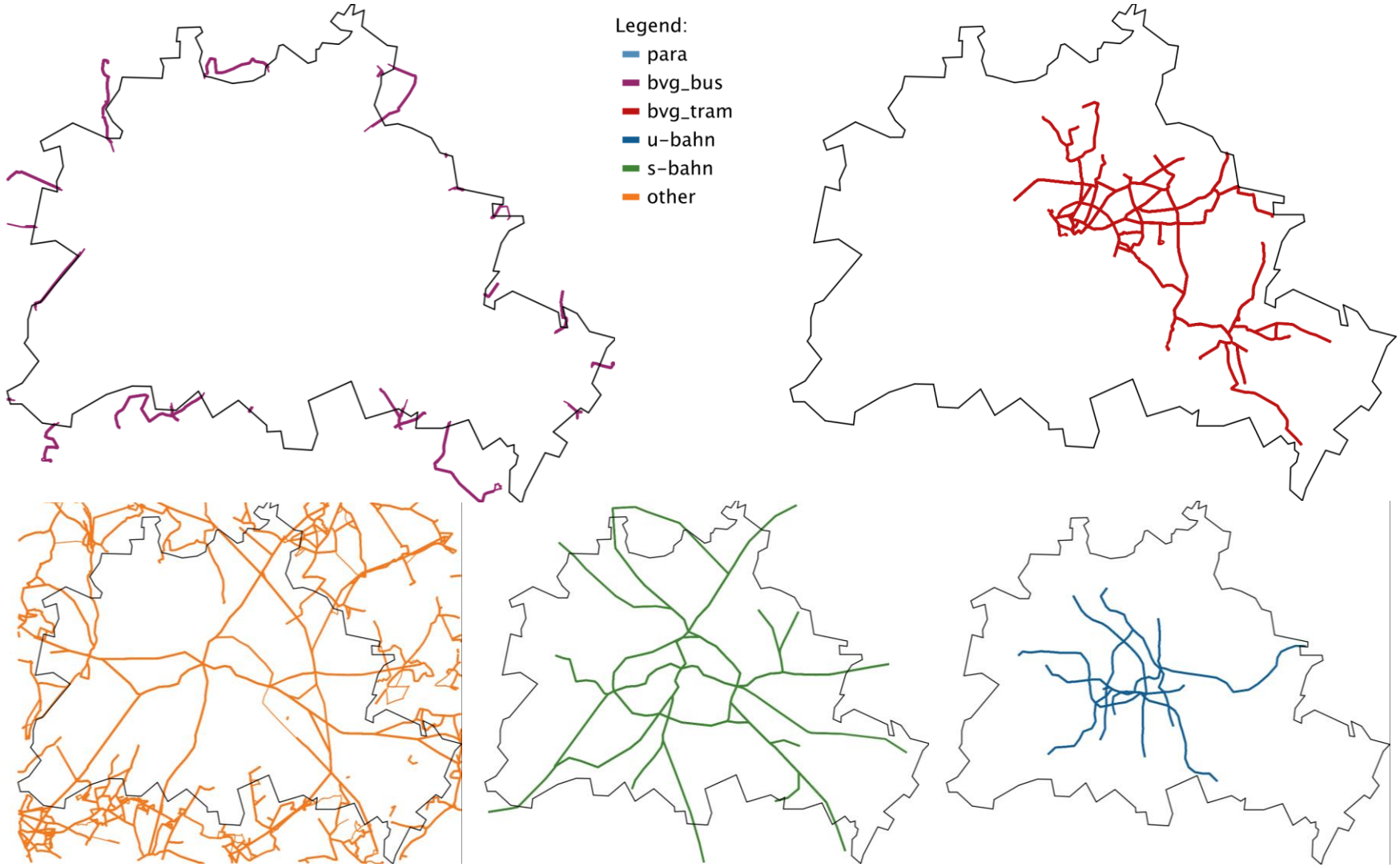
Transit supply differs within the city



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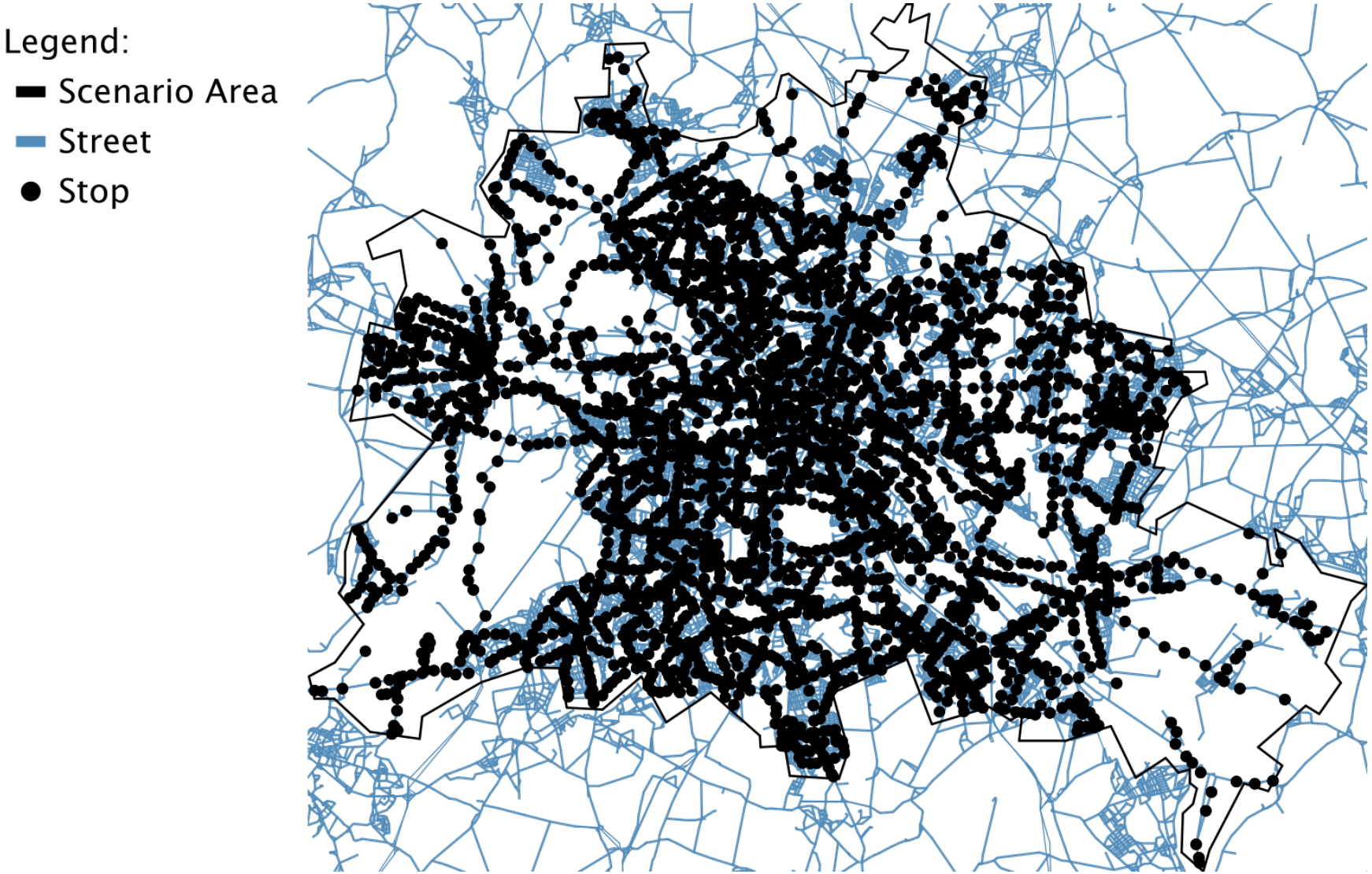
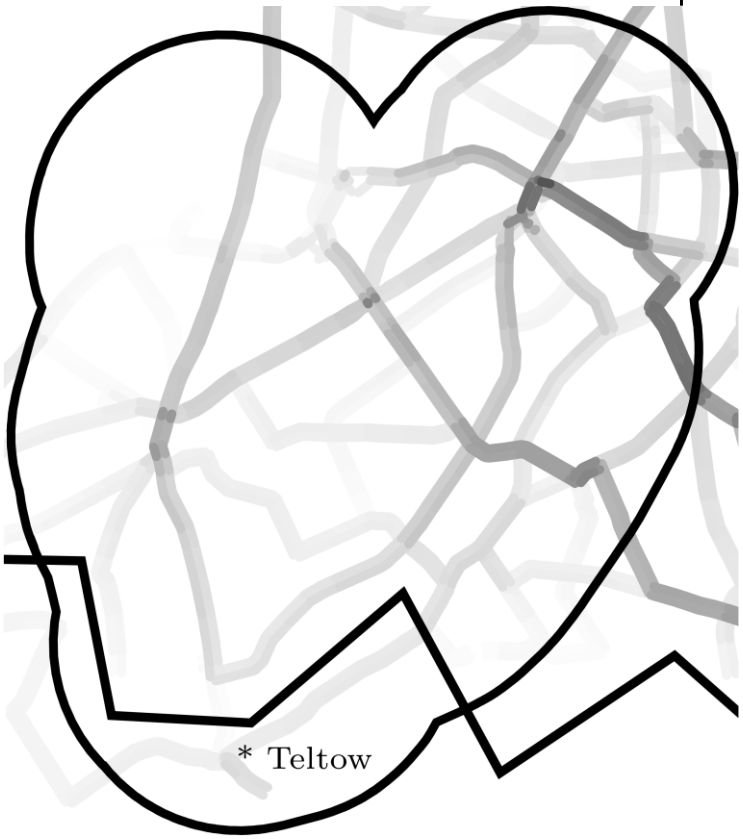
Minibus stops are equally distributed within the city



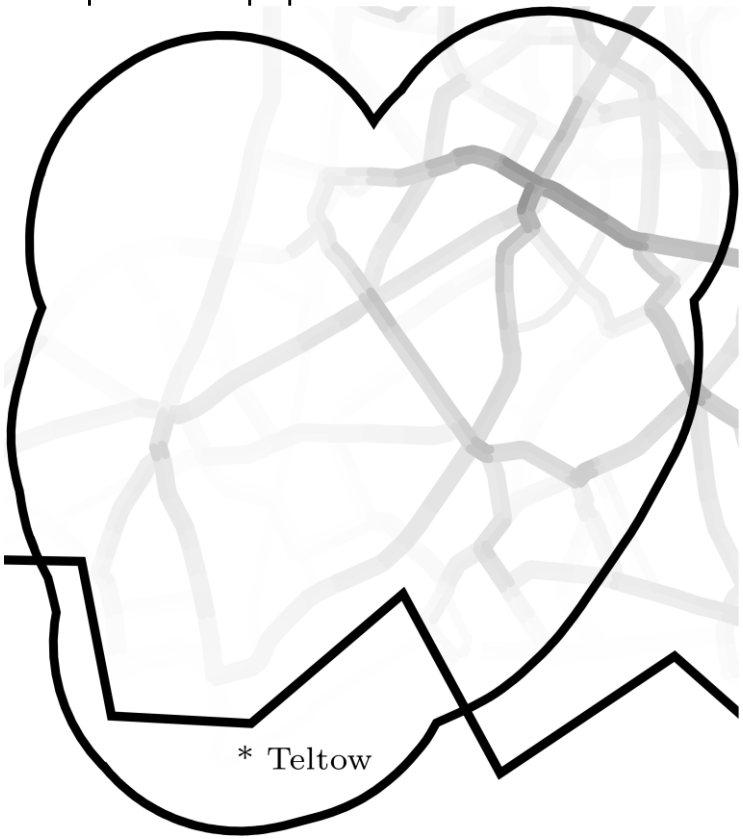
Combining both: Standard bus and 10% sample

Similar networks and served demand. Difference in greyscale derives from – Note that Teltow cannot be served due to the setup. The difference in the maximum value and thus in the gray-scale derives from the direct competition between the transit modes in areas not shown in this figure.

BVG bus services as reference with 100% sample



10% sample of the population with standard buses



Note: Actual figures and results for other parts of the city can not be disclosed.

Summary

The minibus model
- can be applied to large metropolitan areas
- creates similar networks independent of the size of the scenario area.

Increasing the scenario area allows the model to propose transit services that link different districts of the city.

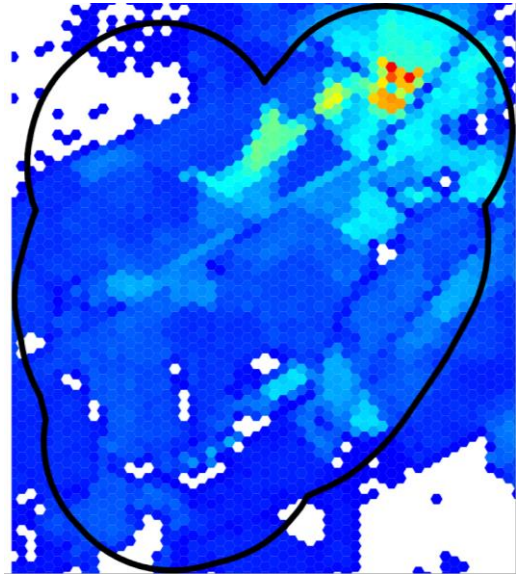
Thus passenger flows between different parts of the city
- become apparent and
- can be incorporated into the transit network planning process.

Summary

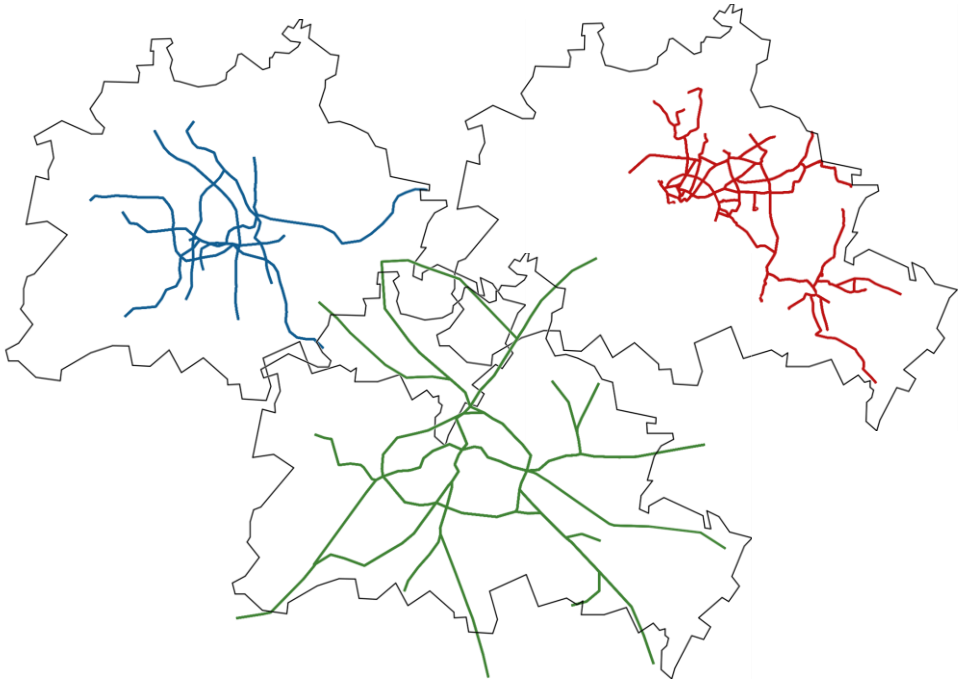
Requirements

Infrastructure

Demand



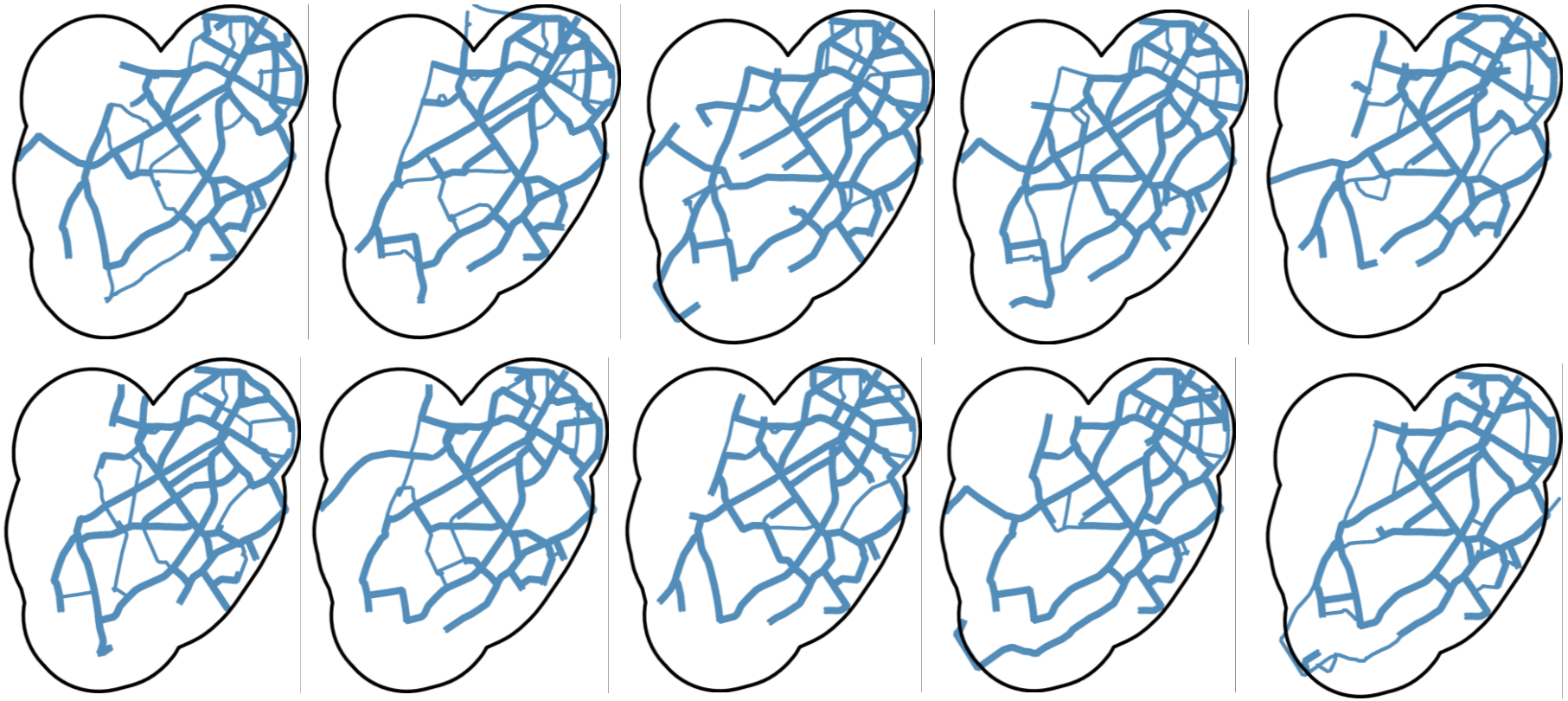
Transit supply (optional)



Results

Analyze individual proposed transit networks

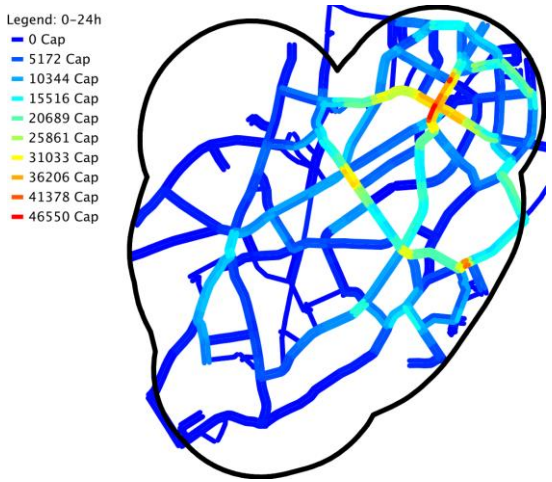
Variants differ in operating times, routes, and frequencies.

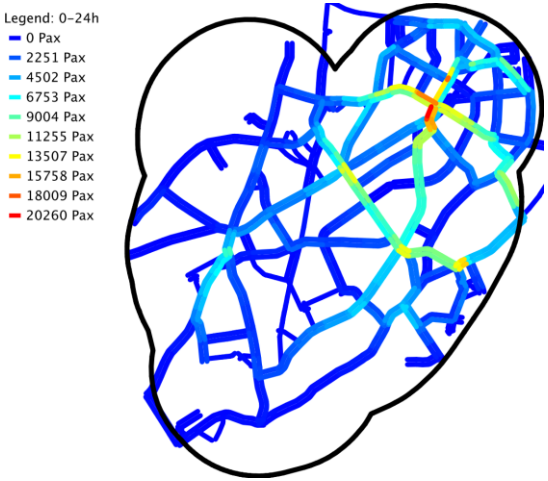


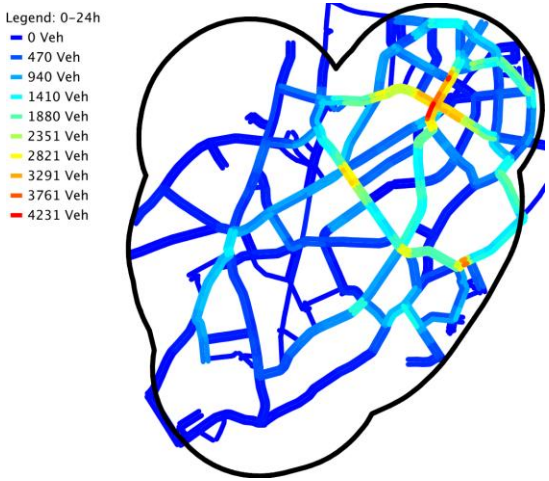
Results

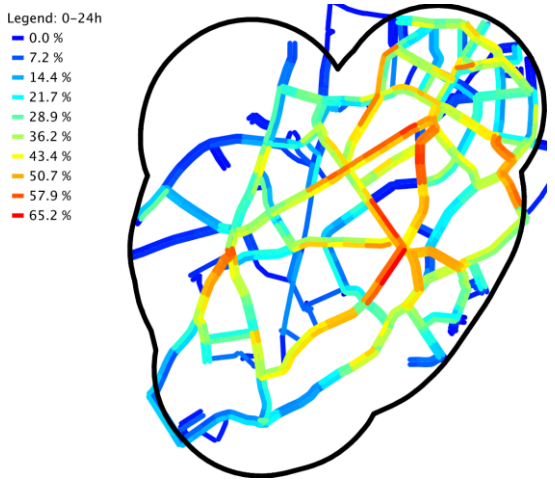
Decide which services are important

Averages of served passengers,
provided capacity,
vehicle load, and
departures per street section.









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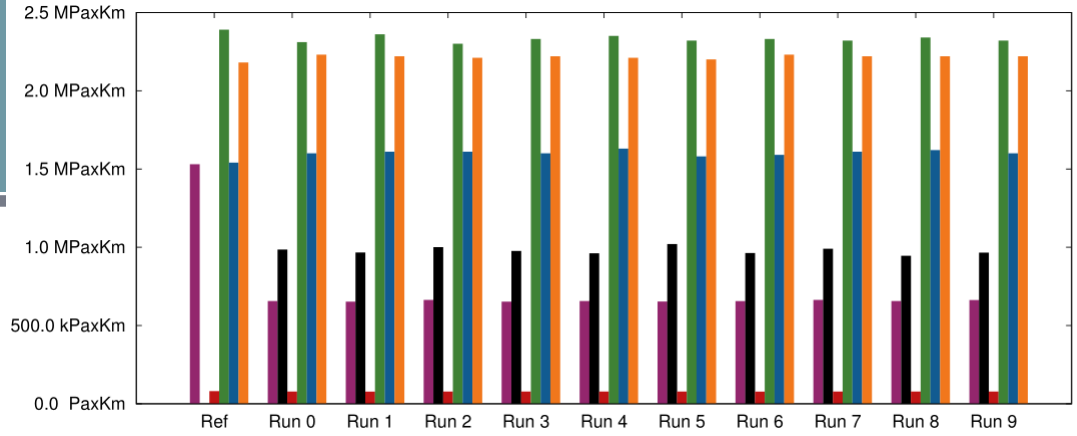
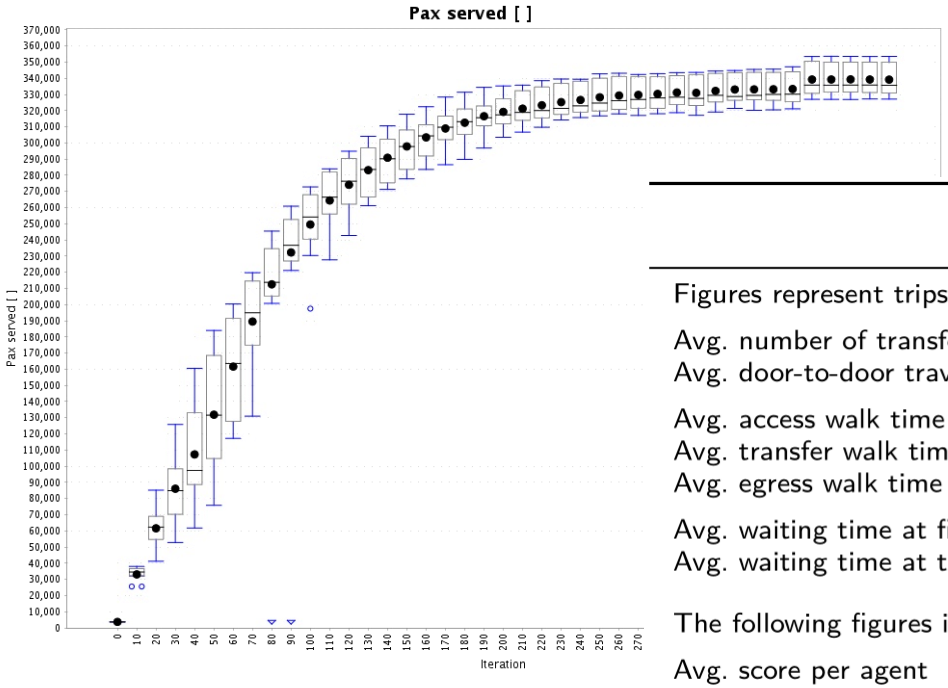
Results

Compare different scenarios

Aggregated metrics





	Reference setup	Minibus model Mean	SD σ	Minimum	Maximum
Figures represent trips starting and ending within the scenario area only					
Avg. number of transfers	0.198	0.475	0.018	0.427	0.506
Avg. door-to-door travel time	28.3 min	26.8 min	2.3 min	23.5 min	32.3 min
Avg. access walk time	8.3 min	5.5 min	0.1 min	5.4 min	5.6 min
Avg. transfer walk time	0.1 min	0.0 min	0.0 min	0.0 min	0.1 min
Avg. egress walk time	7.0 min	5.4 min	0.1 min	5.3 min	5.6 min
Avg. waiting time at first stop	3.1 min	7.1 min	1.6 min	4.4 min	10.7 min
Avg. waiting time at transfers	4.6 min	6.2 min	1.5 min	4.6 min	9.8 min
The following figures include all trips of the population					
Avg. score per agent	115.810	113.163	0.798	112.076	114.154
Avg. score per non-stuck agent[1]	116.069	114.844	0.270	114.371	115.274
Avg. number of agents stuck	151.000	2408.300	852.022	1289.000	3672.000
Percentage of stuck agents	0.02 %	0.41 %	0.14 %	0.22 %	0.62 %
Circuity[2] of transit trips	1.333	1.354	0.003	1.349	1.359

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Summary of the underlying model

Minibus model automatically adapts supply to demand.

Creates transit networks from scratch
both for minibus and formal transit systems.

Suggests incremental improvements to existing transit systems.

Ongoing development and application of the model by

Berlin Transit Authority (BVG) as a strategic planning tool
http://www.bvg.de/

German research foundation (DFG), Technische Universität Berlin
http://www.vsp.tu-berlin.de/projects/laufende_projekte/transit_optimization/

ERA-NET-Project "Smart Adaptive Public Transport"
https://smart-pt.tau.ac.il/.

Thank you for your attention

A. Neumann; Why closing an airport may not matter – The impact of the relocation of TXL airport on the bus network of Berlin; Procedia Computer Science 52C:896–901, DOI 10.1016/j.procs.2015.05.160