Multiagent transport model for urban planning of the Brno metropolitan area

Ing. Dmitrii Grishchuk

Ing. Pavel Orlíček

Ing. Hana Fridrichovská

Ing. Martin Všetečka, PhD.

Brno City Chief Architect's Office

Kancelář architekta města Brna

Brno University of Technology

Data sources

- 2021 Mobility survey
- 2011 Census
- 2021 Census (partially)
- CEDA maps – road network
- OpenStreetMap – land-use, POIs
- KORDIS JMK – PT data

CZECH STATISTICAL OFFICE

B R N O

CEDA

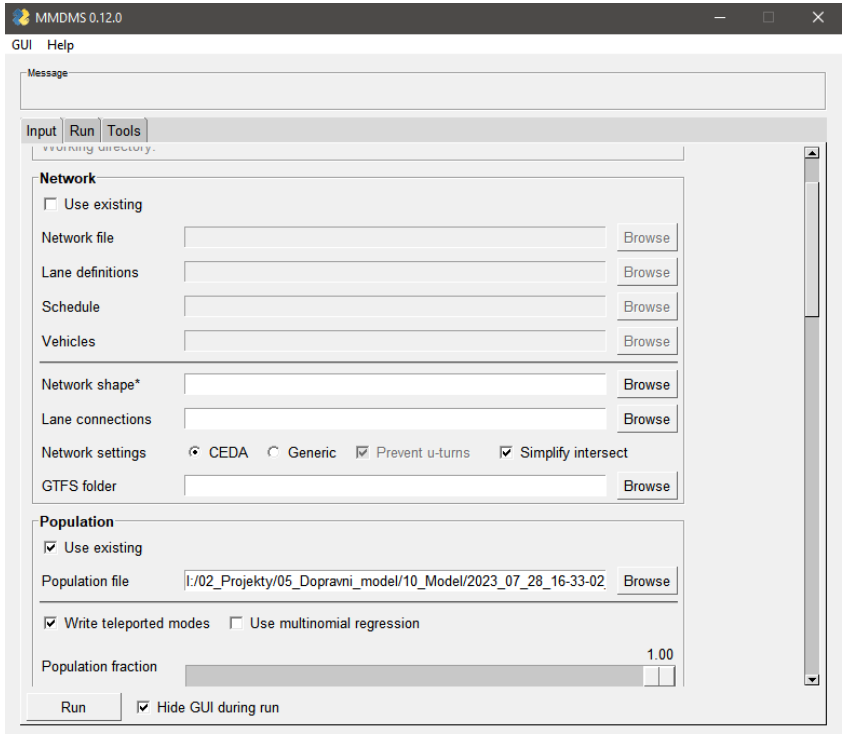
kordis jmk

Software

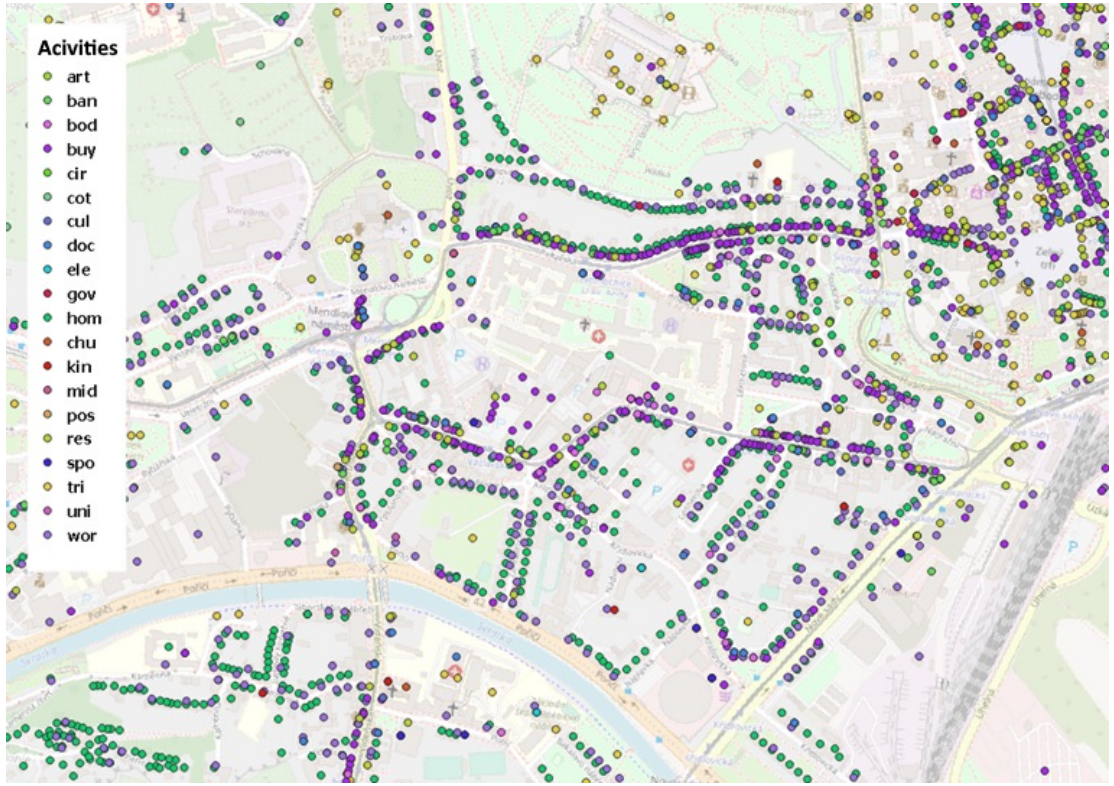
MATSim
Multi-Agent Transport Simulation

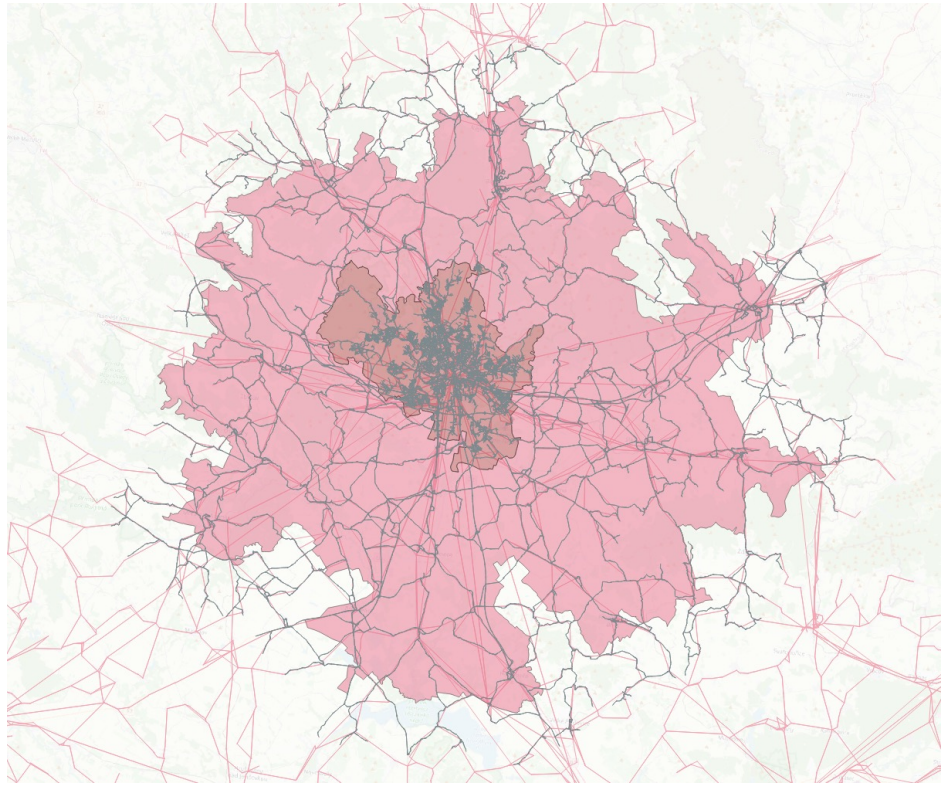
MMDMS

QGIS



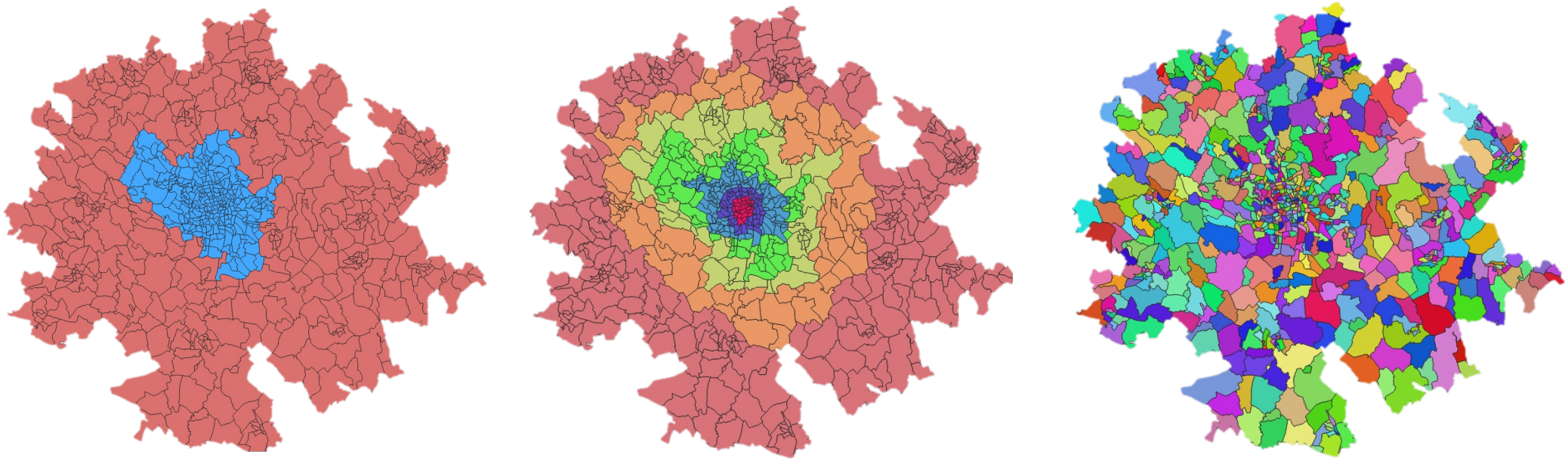
Facilities and network





- 260k+ facilities
- 6668 km of roads with lane definitions
- 20k+ transit vehicles trips

Spatial units



- 4 levels of spatial precision
- Largest – region (city, suburbs, „outside world“)

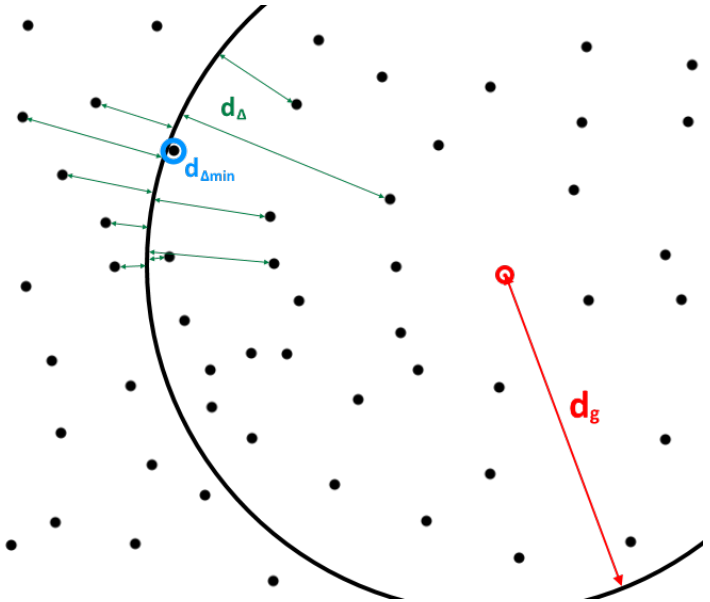
Basic facility search

d_g – distance from Weibull distribution with parameters from the survey;

d_{ab} – actual distance to a facility

Facility with the smallest d_g gets picked

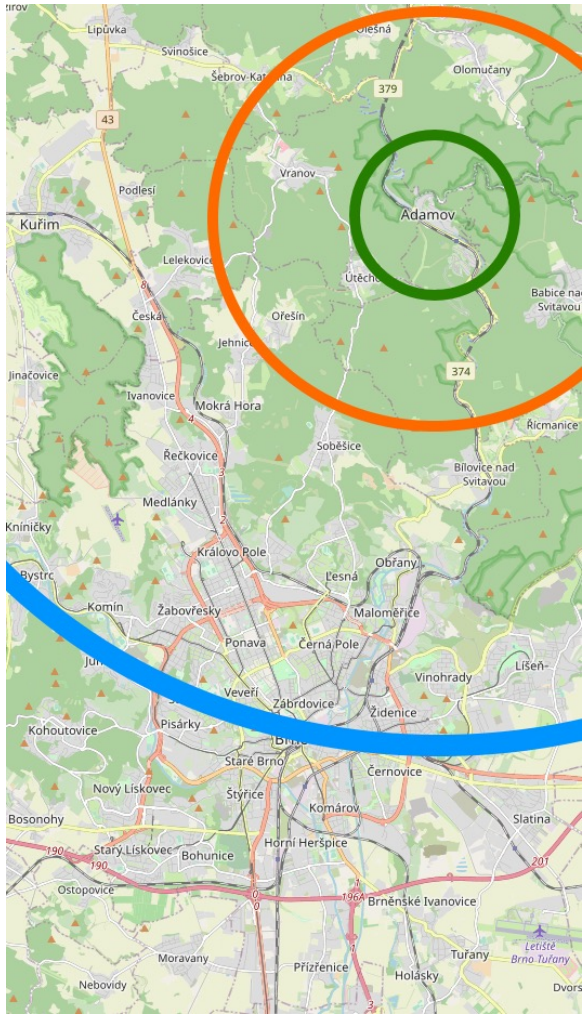
Is it enough?

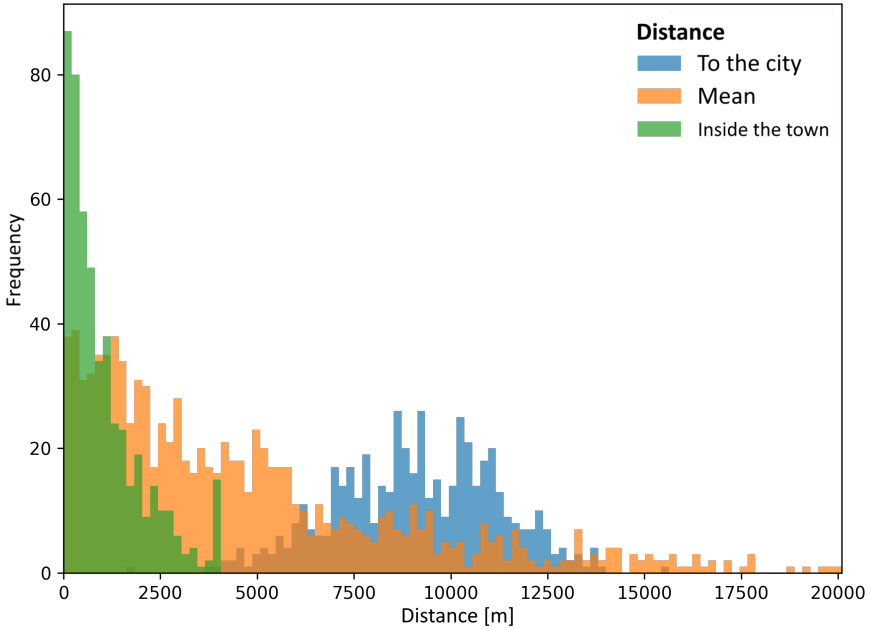


$$d_\Delta = d_{ab} - d_g \text{ [m]}$$

$$d_{\Delta min} = min\{|d_{\Delta 1}|, \dots, |d_{\Delta n}|\}$$

How to improve facility search?

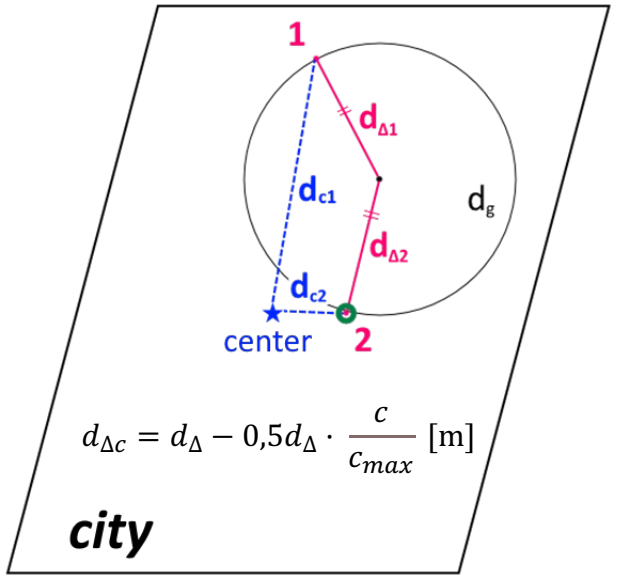




- Improve target zone precision
- Prefer more important facilities
- Prefer bigger facilities
- Prefer facilities close to centers
- Prefer facilities in clusters
- Eliminate cumulating on the fringes

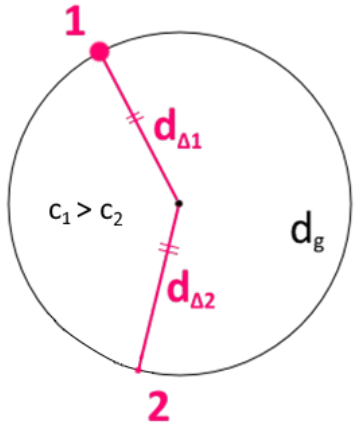
Advanced facility search

distance from center



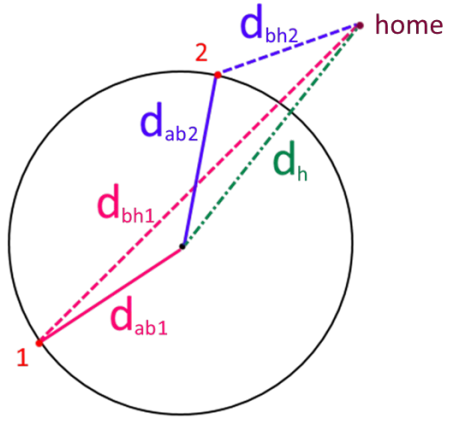
$$d_{\Delta c} = d_\Delta - 0{,}5 d_\Delta \cdot \frac{c}{c_{max}} \text{ [m]}$$

capacity



$$d_{\Delta cd} = d_\Delta + d_\Delta \cdot \frac{d_{cdmin}}{d_{cdmax}} \text{ [m]}$$

distance to home



$$d_{\Delta ah} = d_{ab} + d_{bh} - d_h \text{ [m]}$$

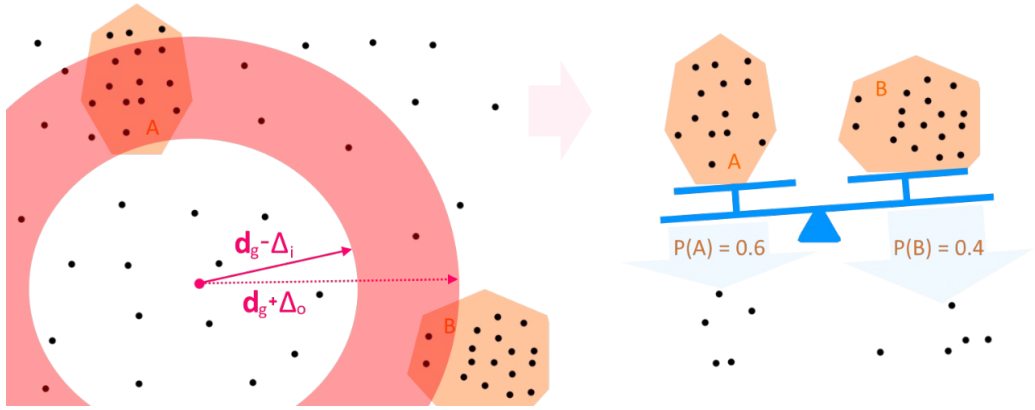
$$d_{\Delta h} = d_\Delta + d_\Delta \cdot \frac{d_{\Delta ah}}{d_{\Delta ahmax}} \text{ [m]}$$

Methods do not necessarily apply to all activities' facilities

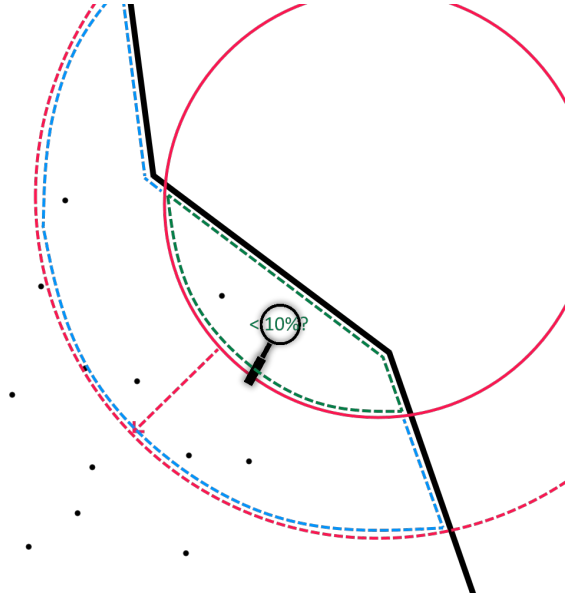
Distance to home only triggers, if next facility is home, and the previous one is not

Advanced facility search

cluster preference

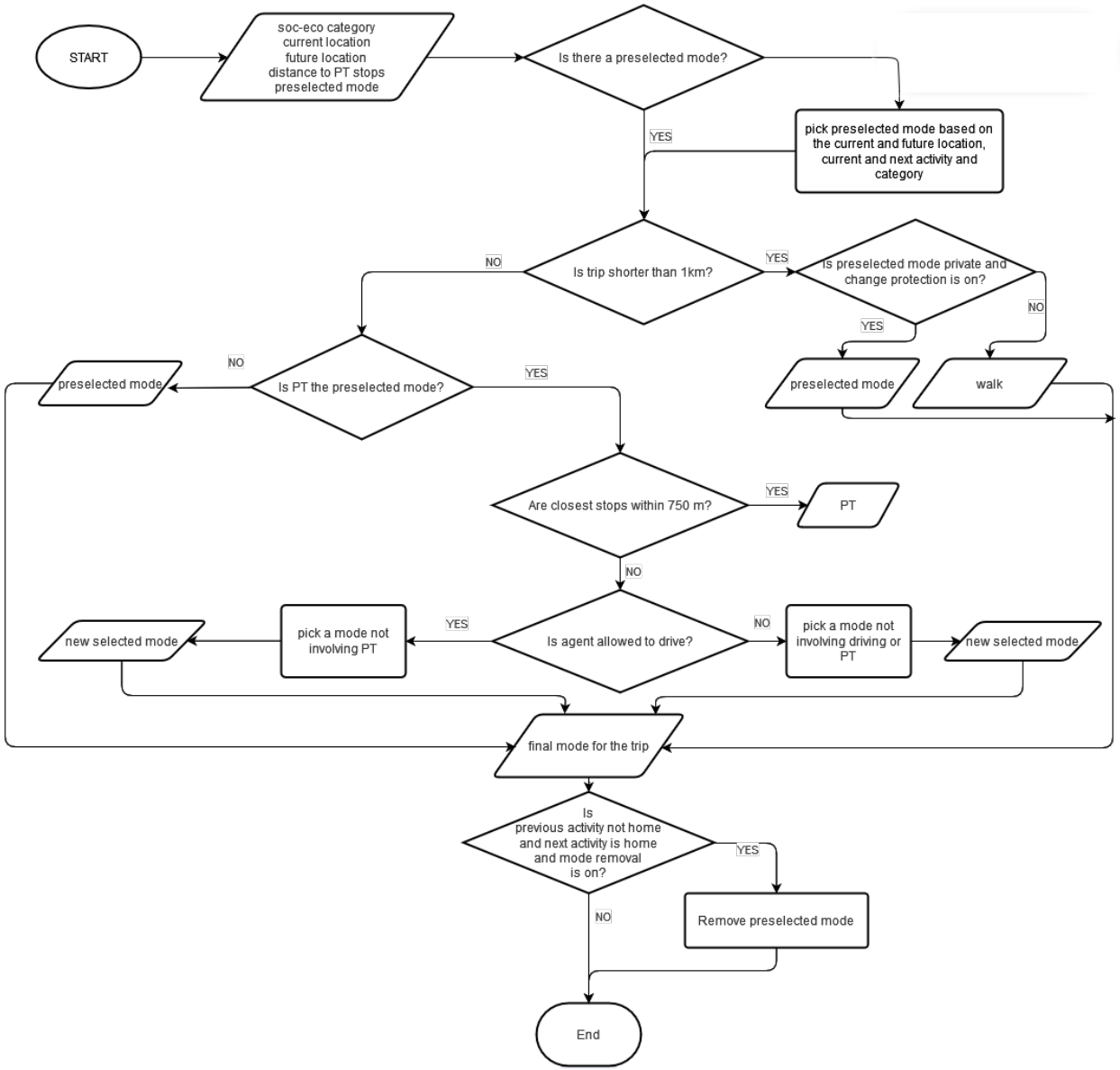


reach extension



Mode choice

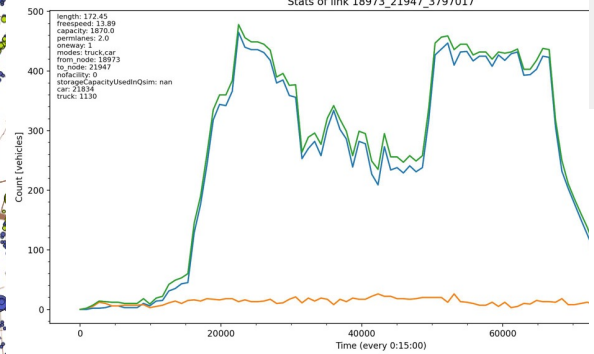
- If PT stops are farther than 750m, agent doesn't pick PT;
- If the trip is shorter than 1000m, agent always walks, unless mode protection is on (keeps cars and bikes from being abandoned mid-day);
- If mode removal is on, preselected mode gets removed as agent reaches home (it will be regenerated after he leaves again);

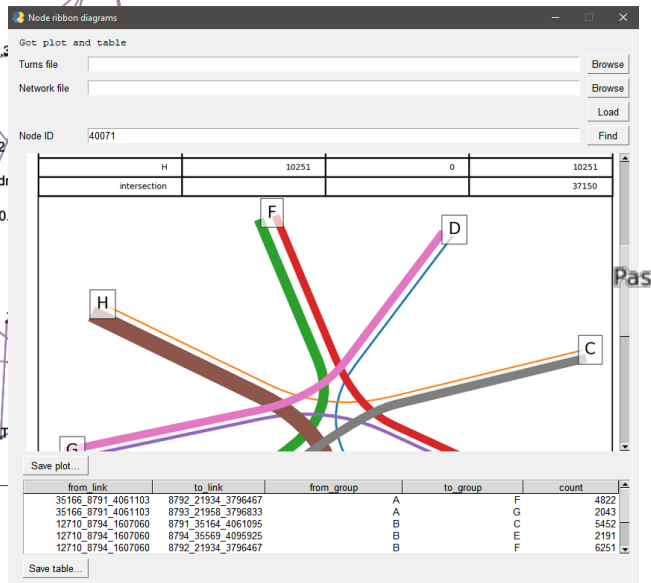


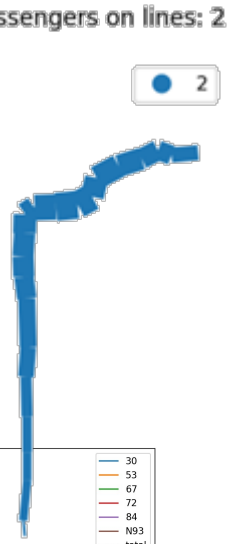
MATSim configuration

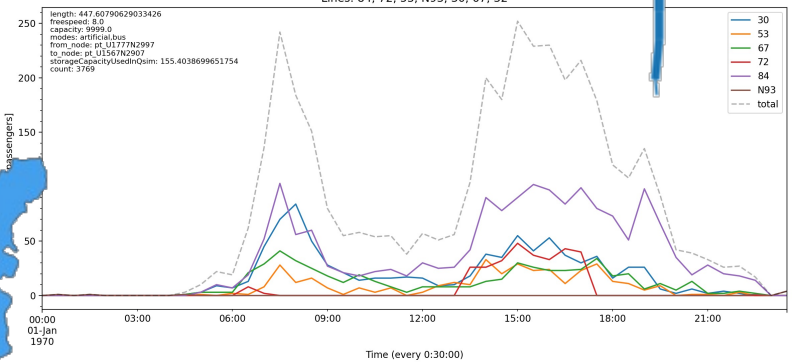
- Regular (mutable) and transit (mostly immutable) population
- Lanes and lane definitions are used (restricted turns)
- Recalculated disutility parameters for modes
- Possible time mutation – up to 5 minutes per iteration
- SubtourModeChoice (car/pt/walk) – 10%, ReRoute – 10%, SelectExpBeta – 50%, TimeAllocationMutator – 20%
- Innovations are off after 90% of iterations

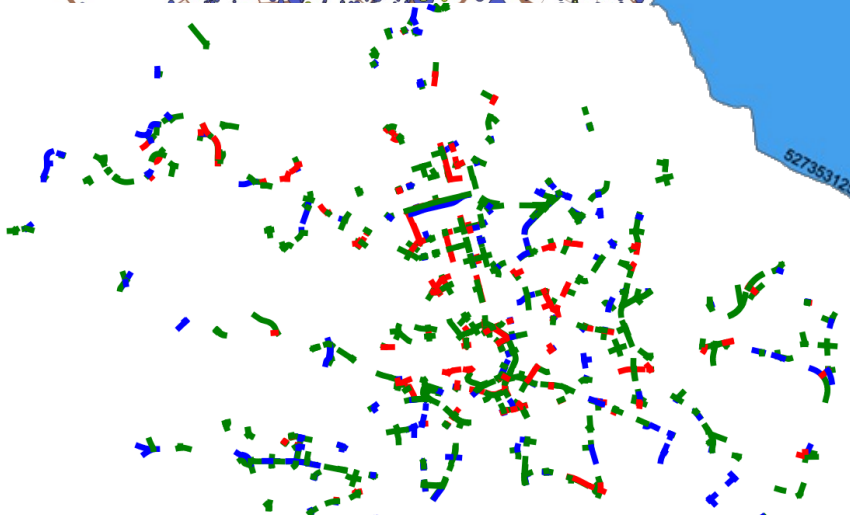
Results











100 iterations are usually enough
to reach equilibrium

Discussion

- The data preparation system is flexible and may be adjusted for less detailed data;
- Agents are not enforced to visit certain facilities, but can prefer the ones we make to seem “attractive”;
- May be useful for future time scenarios (with facilities that do not exist today, new timetables and roads);
- Usage of main roads is not enforced; thus, such roads may be less popular – capacity and speed ratio or routing algorithm in question

Thank you for your attention

Ing. Dmitrii Grishchuk
grishchuk.dmitrii@kambrno.cz

Multiagent transport model for urban planning of the Brno metropolitan area

Ing. Dmitrii Grishchuk
Ing. Pavel Orlíček
Ing. Hana Fridrichovská
Ing. Martin Všetečka, PhD.

Brno City Chief Architect's Office

Kancelář architekta města Brna

Brno University of Technology