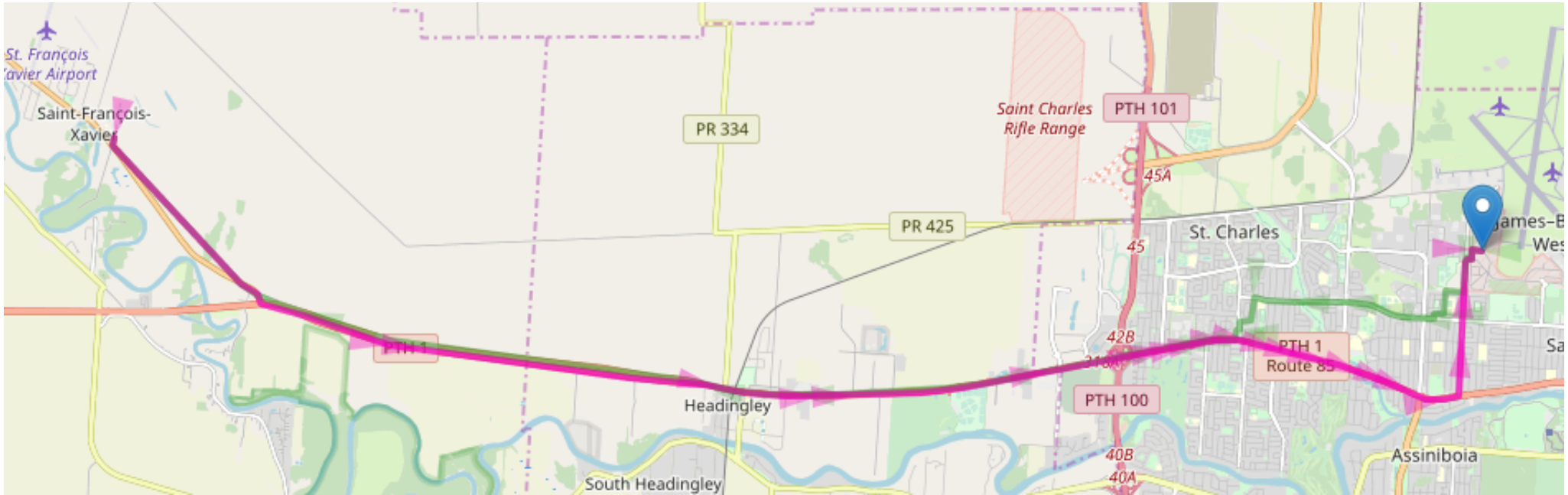
Symulacje systemów transportowych w języku Julia



Dane przestrzenne

- Google Maps
- Open Street Map
- Inne (Bing Maps, MapQuest, Tom Tom, ...)

Open Street Map - https://www.openstreetmap.org

- Otwarty, darmowy projekt
- „Wikipedia dla map”
- Dane cały czas edytowane i poprawiane przez społeczność użytkowników

Niepodległości 162

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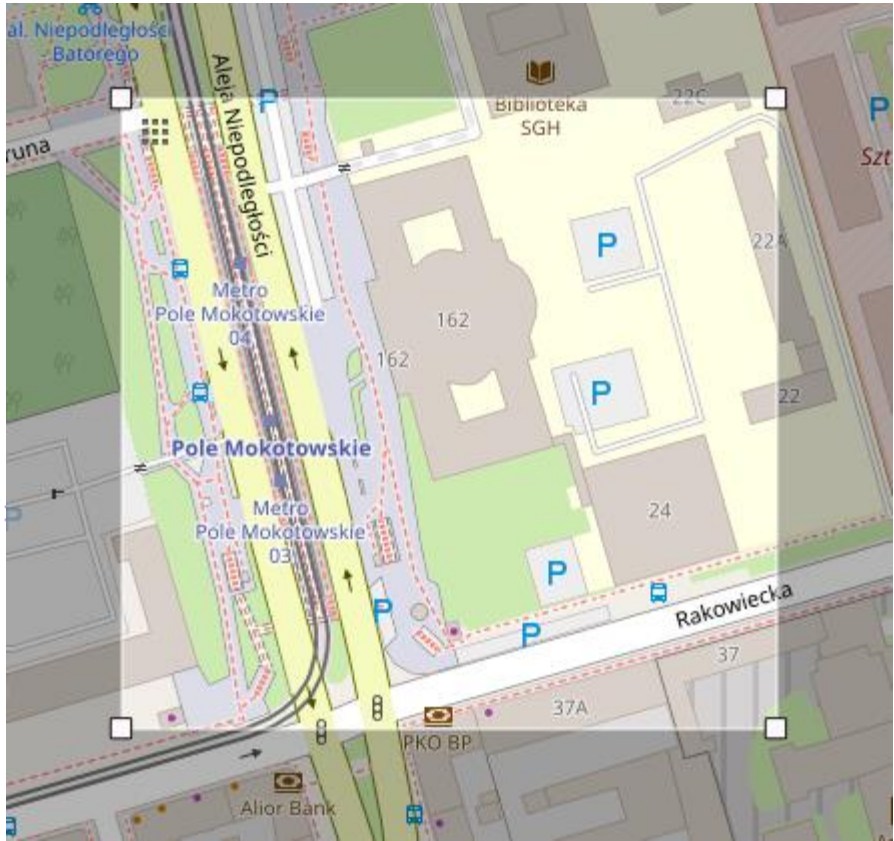

Filtrowanie danych

- Baza OSM zawiera ogromną ilość informacji zbędną w praktycznych analizach (np. historię autorów dokonujących zmiany)
- https://wiki.openstreetmap.org/wiki/Osmfilter

```
osmfilter somemap.osm --keep="highway=motorway
highway=motorway_link highway=trunk
highway=trunk_link     highway=primary
highway=primary_link highway=secondary
highway=secondary_link highway=tertiary
highway=tertiary_link highway=unclassified
highway=residential" --drop-author -o=somemap2.osm
```

Okolice SGH – dane wyfiltrowane

```
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    <tag k="network" v="ZTM Warszawa"/>
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    <tag k="network" v="ZTM Warszawa"/>
    <tag k="public_transport" v="stop_position"/>
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<node id="3411278133" lat="52.2102612" lon="21.0073472" version="1">
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</node>
<node id="4027020405" lat="52.2092623" lon="21.0054738" version="2"/>
<node id="4983691477" lat="52.2093294" lon="21.0051656" version="1"/>
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```

OpenStreetMapX.jl

- Biblioteka do przetwarzania danych przestrzennych w formacie Open Street Map
- System drogowy jest reprezentowany w postaci grafu – LightGraphs.jl
- Wsparcie dla wyznaczania dróg w grafie (routing)
- Możliwość robienia rysunków układów drogowych OpenStreetMapXPlot.jl

OpenStreetMapX.jl

- https://github.com/pszufe/OpenStreetMapX.jl
- Instalacja (naciśnij] aby przełączyć się do menedżera pakietów):
  - (v1.0) pkg> add OpenStreetMapX

- Sposób użycia

```
using OpenStreetMapX
m = get_map_data("mapa.osm");
```

OpenStreetMapXPlot.jl

- Zestaw narzędzi do wizualizacji danych
- Instalacja
- (v1.0) pkg> add https://github.com/pszufe/OpenStreetMapXPlot.jl
- Sposób użycia

```
p = OpenStreetMapXPlot.plotmap(m)
plot_nodes!(p,m,[fastest_route1[1],fastest_route1[end]],start_numbering_from=nothing,fontsize=13,color="pink")
plot_nodes!(p,m,collect(keys(m.nodes)))
plot_nodes!(p,m,collect(keys(m.nodes));start_numbering_from=nothing,color="red")
```

Reprezentacja sieci transportowych w Julia – LightGraphs.jl

Lightgraphs.jl library

- Written in Julia (easy to: modify, introspect, optimize performance)
- Extensible (e.g. SimpleHypergraphs.jl)
- Full array of standard methods for graph analysis
  - Path & traversal
  - Distances
  - Centrality
  - Linear algebra operations
  - Community detection
  - Decomposition
- Built for performance
  - Fast single threaded
  - Small memory footprint for large graphs
  - Many algorithms have parallelized version

Performance

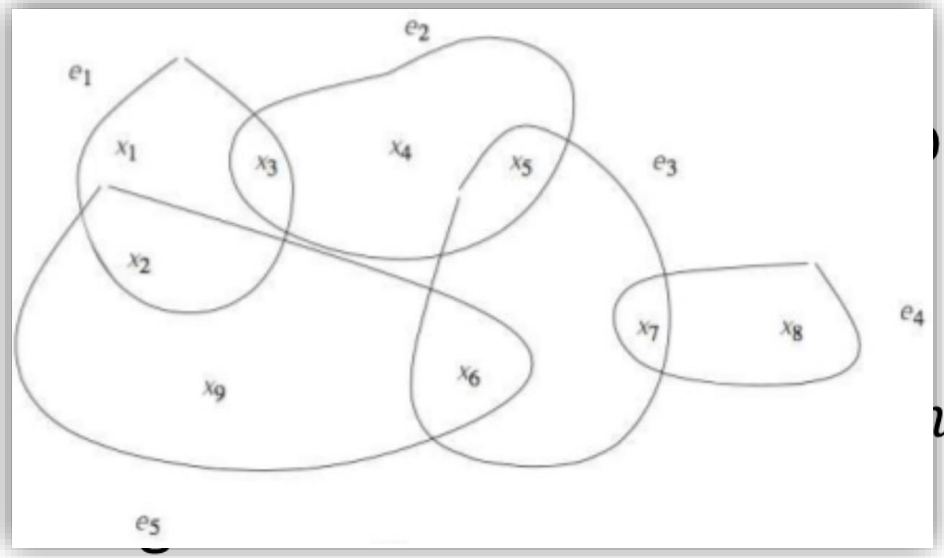
Test	LightGraphs	NetworkX	igraph	graph-tool
G1 = Erdos-Renyi (10k, 0.1) (s)	7.13	19	2.65	19.3
G2 = Barabassi-Albert (10k, 400) (s)	2.89	13.8	3.6	10.1
Betweenness (G2[1:3000]) (s)	4.02	DNF	6.77	3.34
Closeness (G2, s)	35.79	DNF	82	44.2
PageRank (directed G2, ms)	28.20	5 130	75.8	30.2
Local Clustering Coefficient (G2, ms)	255.53	37 400	167	270

Source: James Fairbanks, Seth Bromberger (2017), *Light graphs: Our Network, Our Story*

Extensibility example: SimpleHypergraphs.jl

- Data representation of a hypergraph:
  - A collection of hyperedges
- API:
  - seen as a matrix where $A[v, h]$ indicates a weight of vertex v in hyperedge h
- Algorithms:
  - Can use all standard algorithms for graphs via a representation of a hypergraph as a bipartite graph
  - Such a bipartite graph is a view of a hypergraph with zero overhead

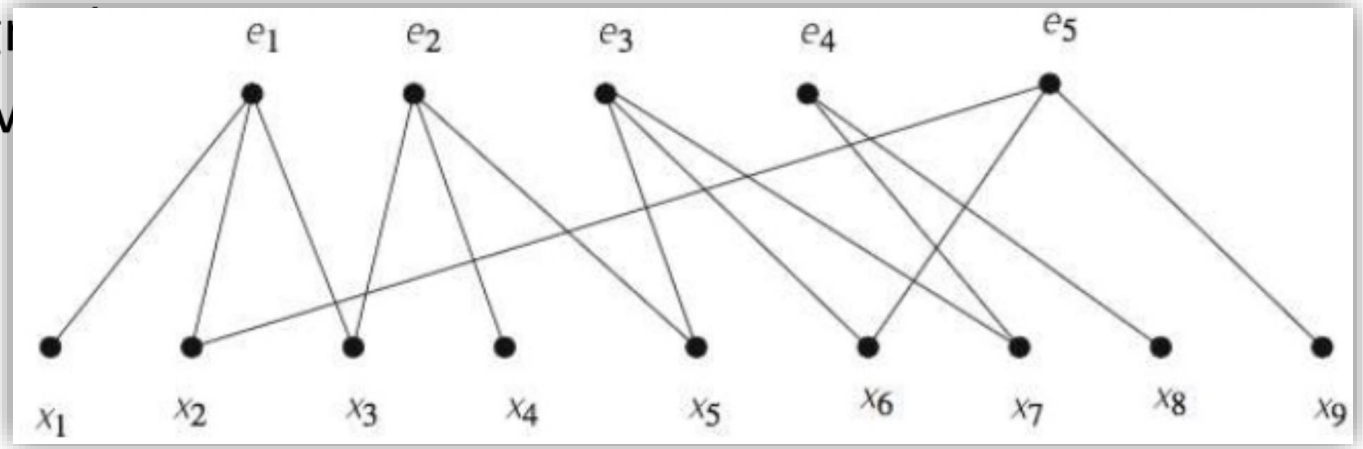
Extensibility example: SimpleHypergraphs.jl



ergraph:

] indicates a weight of vertex v in hyperedge h

- Can use ll standard algorithms for graphs via a representation of a hypergra h as a bipartite gr
- Such a b artite graph is a v



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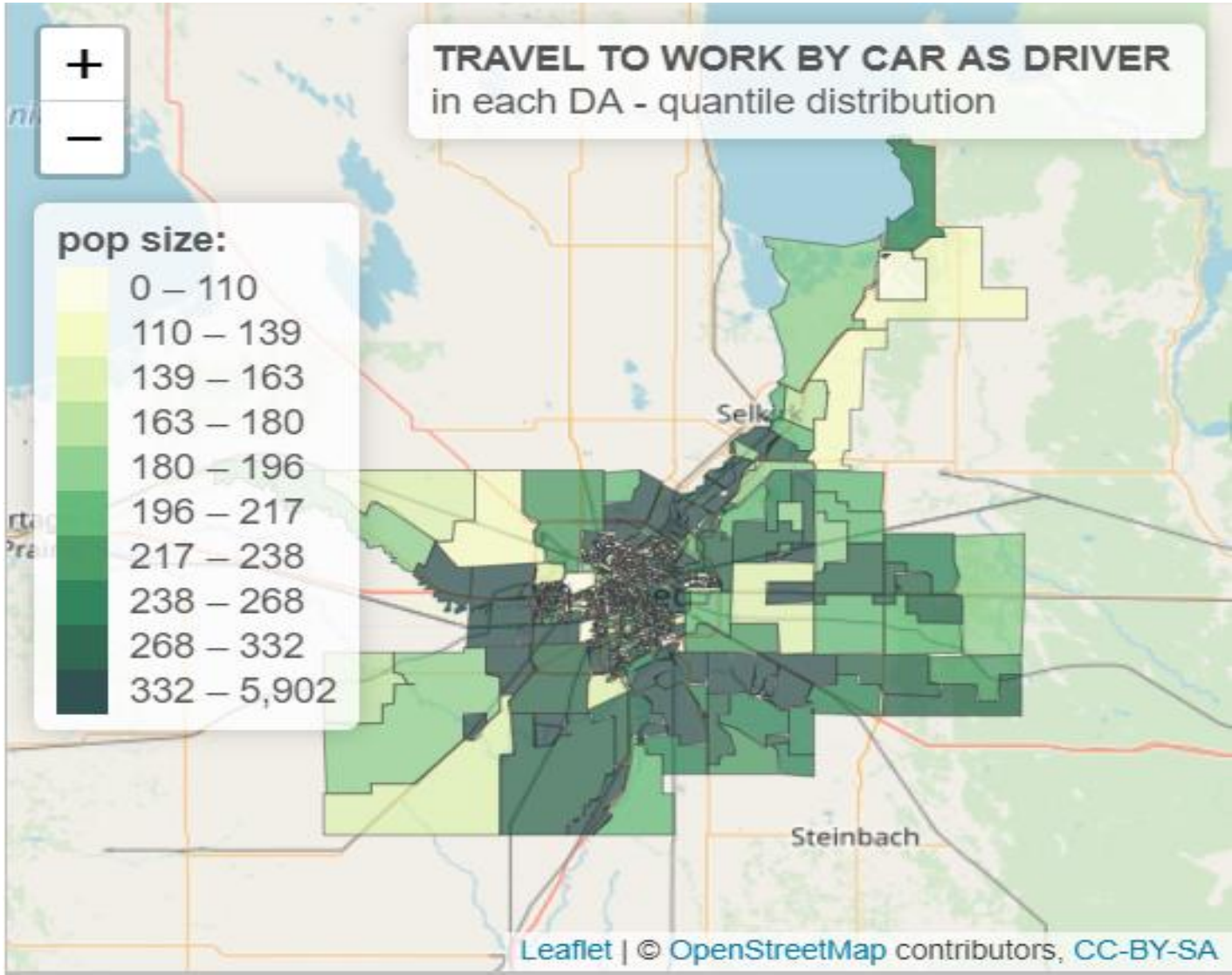
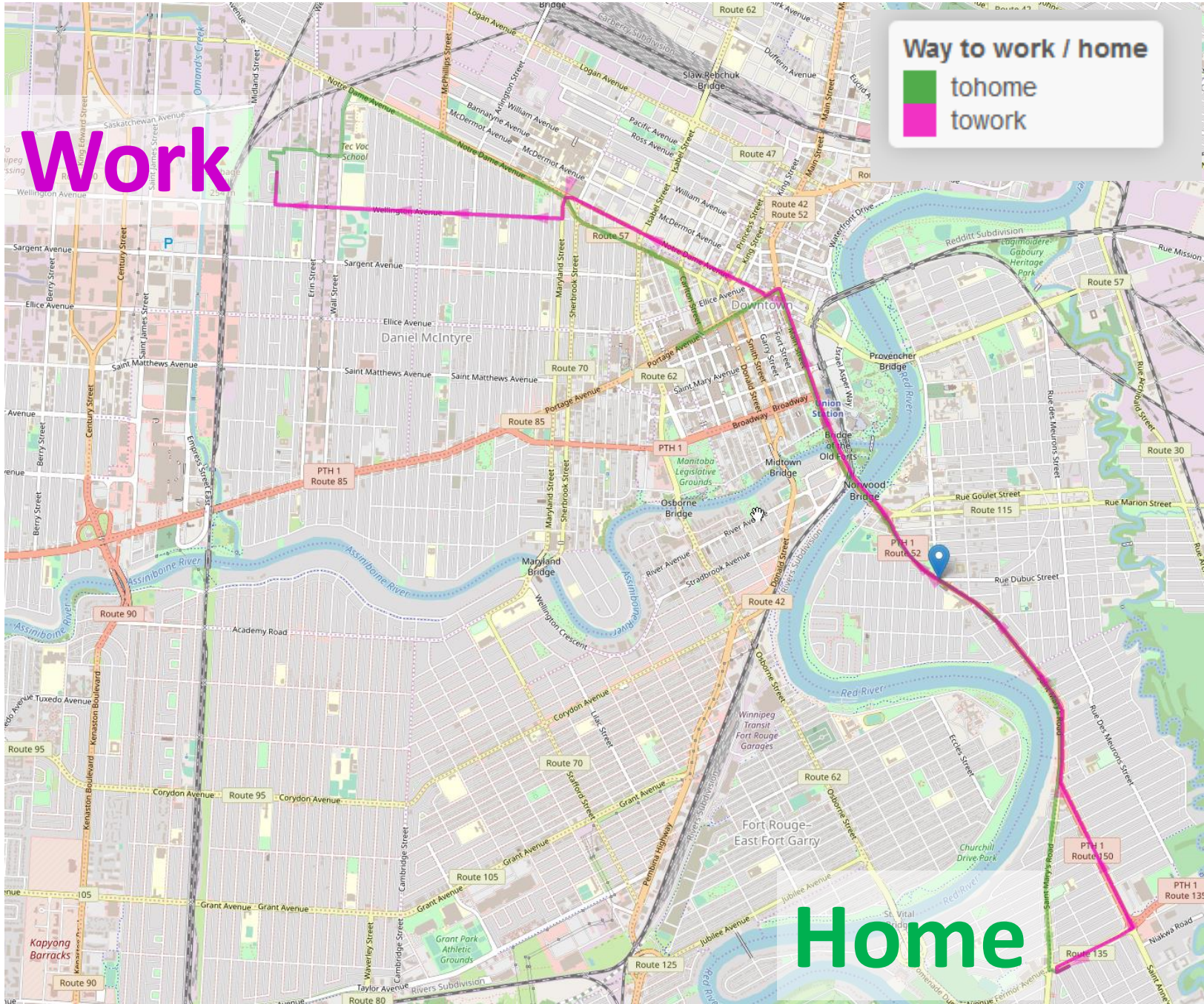
Studium przypadku Winnipeg

The modelled city – available data

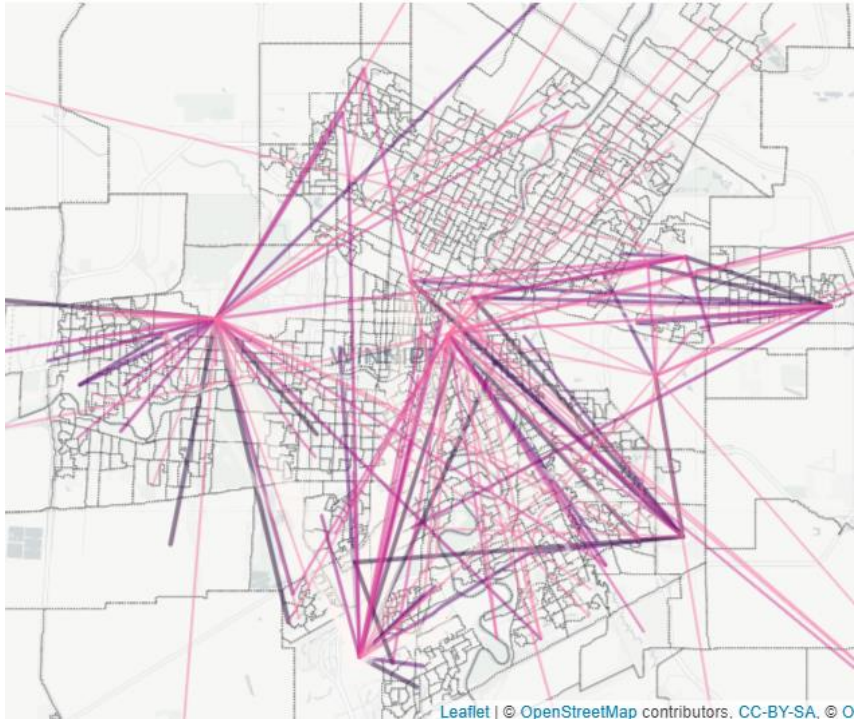
- Winnipeg CMA, Canada
- population ~1’000’000
- 1’200 dissemination areas

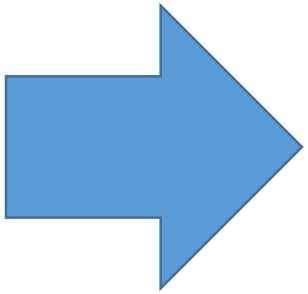


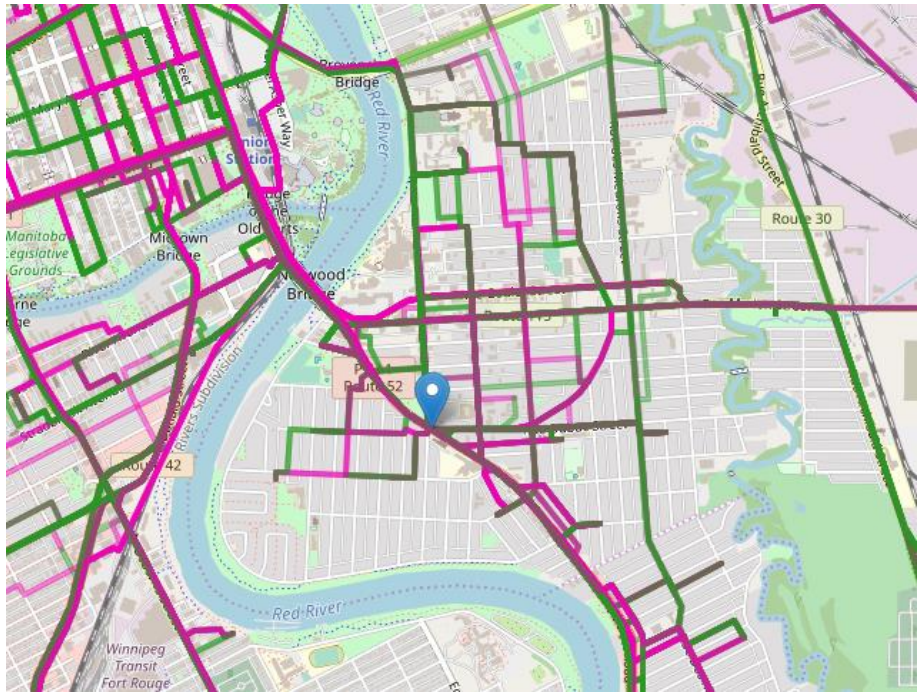
A single simulated commuter's behavior…



Simulation model travel destinations and commuters' behavior



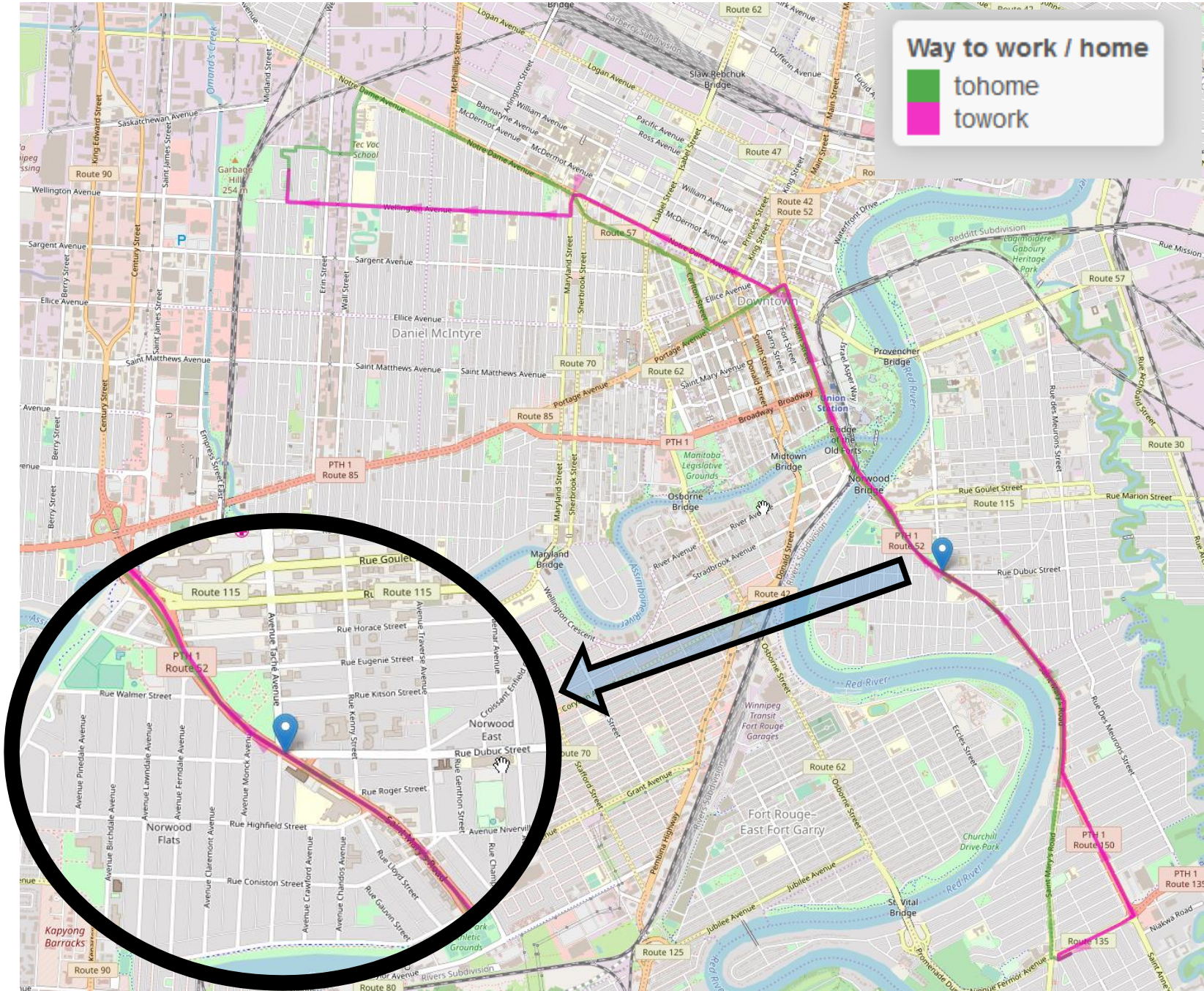


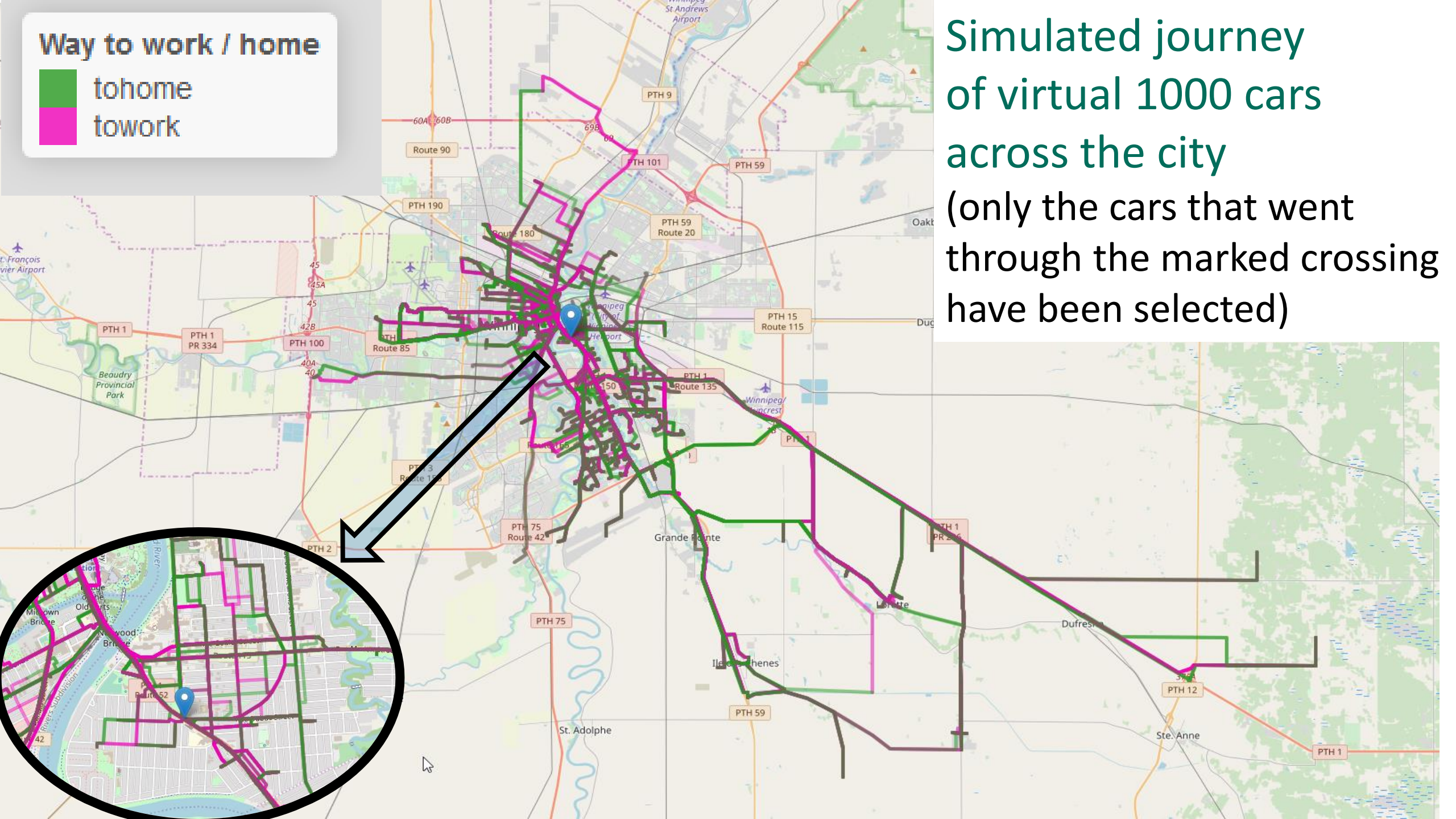


Each agent makes individual travel decisions on the base of her sociodemographic profile

Questions

- How many people went to the given road crossing
- Who are those people? Reach? Poor? Immigrants?
- If a place an advertising billboard – who is going to see it?
- What business makes sense in this area

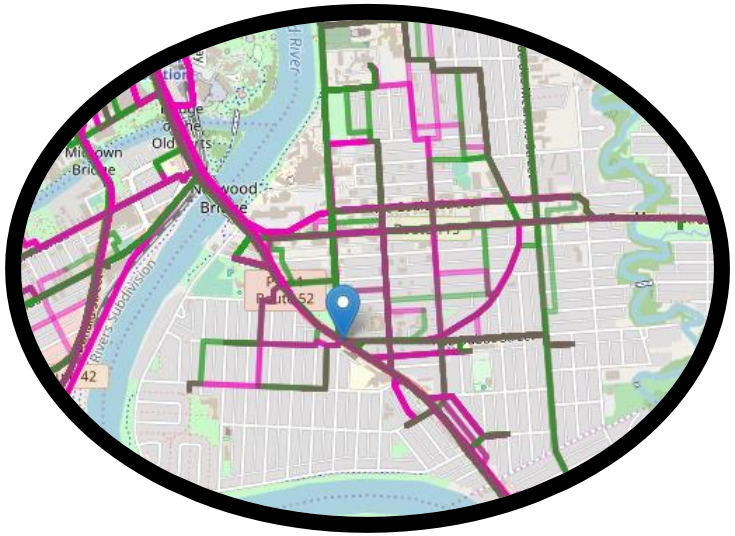


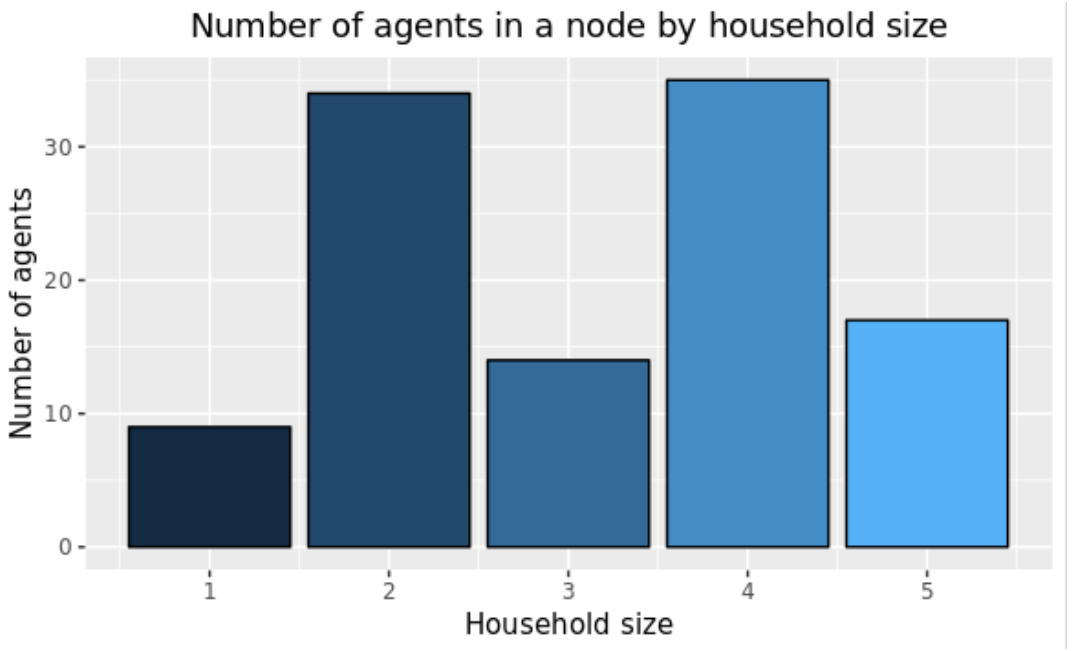

Way to work / home
tohome
towork
Simulated journey
of virtual 1000 cars
across the city
(only the cars that went
through the marked crossing
have been selected)
PTH 9
PTH 101
PTH 59
PTH 190
PTH 59
Route 20
PTH 15
Route 115
PTH 1
PR 334
PTH 100
Route 85
PTH 1
Route 135
PTH 75
Route 42
PTH 2
PTH 75
PTH 59
PTH 12
PTH 1
Route 90
Route 180
Route 150
Beaudry
Provincial
Park
Grande Pointe
St. Adolphe
Ste. Anne

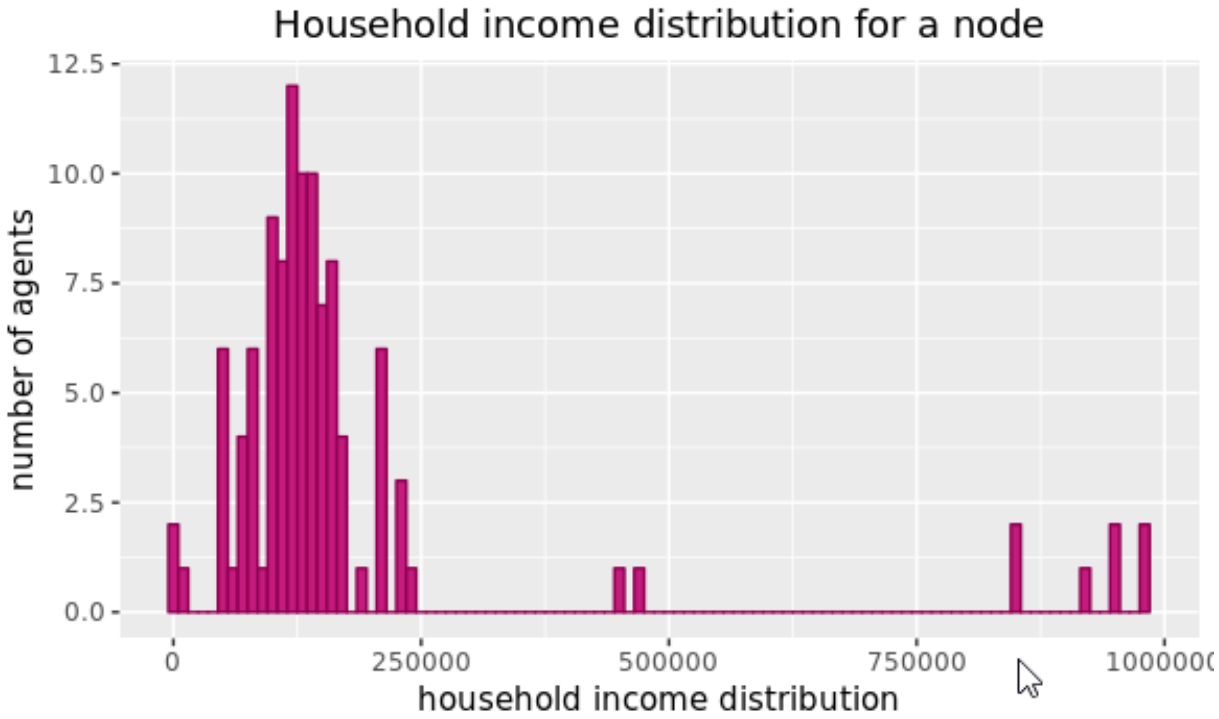
Sample simulation data

NODE_ID	longitude	latitude	DA_home	DA_work	gender	age	marital_st	work_indu	household	household	no_of_chi	children_a	imigrant	imigrant_s	imigrant_	id
369306773	-97.1122	49.90696	46110714	46110684	M	69	true	Retail Trac	89138	2	0	Int64[]	true	Before 20	Eastern Eu	2001000028
369306773	-97.1122	49.90696	46110230	46111151	M	28	false	Wholesale	65454	1	0	Int64[]	true	2012 To Pr	Central Ar	2001000030
369306773	-97.1122	49.90696	46110803	46111177	F	22	false	Retail Trac	48281	2	1	[5]	true	2006 To 20	Northern .	2001000035
369306773	-97.1122	49.90696	46110845	46110632	M	52	true	Manufactu	63822	1	0	Int64[]	false			2001000103
369306773	-97.1122	49.90696	46110795	46110162	F	36	true	Transporta	32480	1	0	Int64[]	false			2001000289
369306773	-97.1122	49.90696	46110869	46110100	F	20	false	Finance A	82354	2	0	Int64[]	false			2001000318
369306773	-97.1122	49.90696	46110801	46110117	M	60	false	Arts, Ente	621011	3	0	Int64[]	false			2001000403
369306773	-97.1122	49.90696	46110701	46110669	M	41	false	Public Adr	99562	2	1	[18]	false			2001000525
369306773	-97.1122	49.90696	46110735	46110075	M	41	false	Retail Trac	909754	2	1	[14]	false			2001000529
369306773	-97.1122	49.90696	46110845	46110667	M	51	false	Retail Trac	95722	3	0	Int64[]	false			2001000736
369306773	-97.1122	49.90696	46120046	46110669	M	53	true	Health Car	84334	3	0	Int64[]	false			2001000773
369306773	-97.1122	49.90696	46110802	46110144	M	44	true	Public Adr	42891	4	0	Int64[]	false			2001000948
369306773	-97.1122	49.90696	46111151	46110145	M	37	true	Finance A	118452	1	0	Int64[]	true	2012 To Pr	Southeast	2002000044
369306773	-97.1122	49.90696	46110851	46111177	M	55	false	Health Car	62681	3	0	Int64[]	false			2002000060
369306773	-97.1122	49.90696	46110453	46110683	F	34	true	Real Estat	29972	5	0	Int64[]	false			2002000172
369306773	-97.1122	49.90696	46110875	46110145	F	32	true	Retail Trac	50486	3	1	[46]	false			2002000265
369306773	-97.1122	49.90696	46110853	46110631	F	25	false	Public Adr	52526	1	0	Int64[]	false			2002000318
369306773	-97.1122	49.90696	46120053	46110669	F	38	true	Manufactu	119023	2	0	Int64[]	false			2002000336

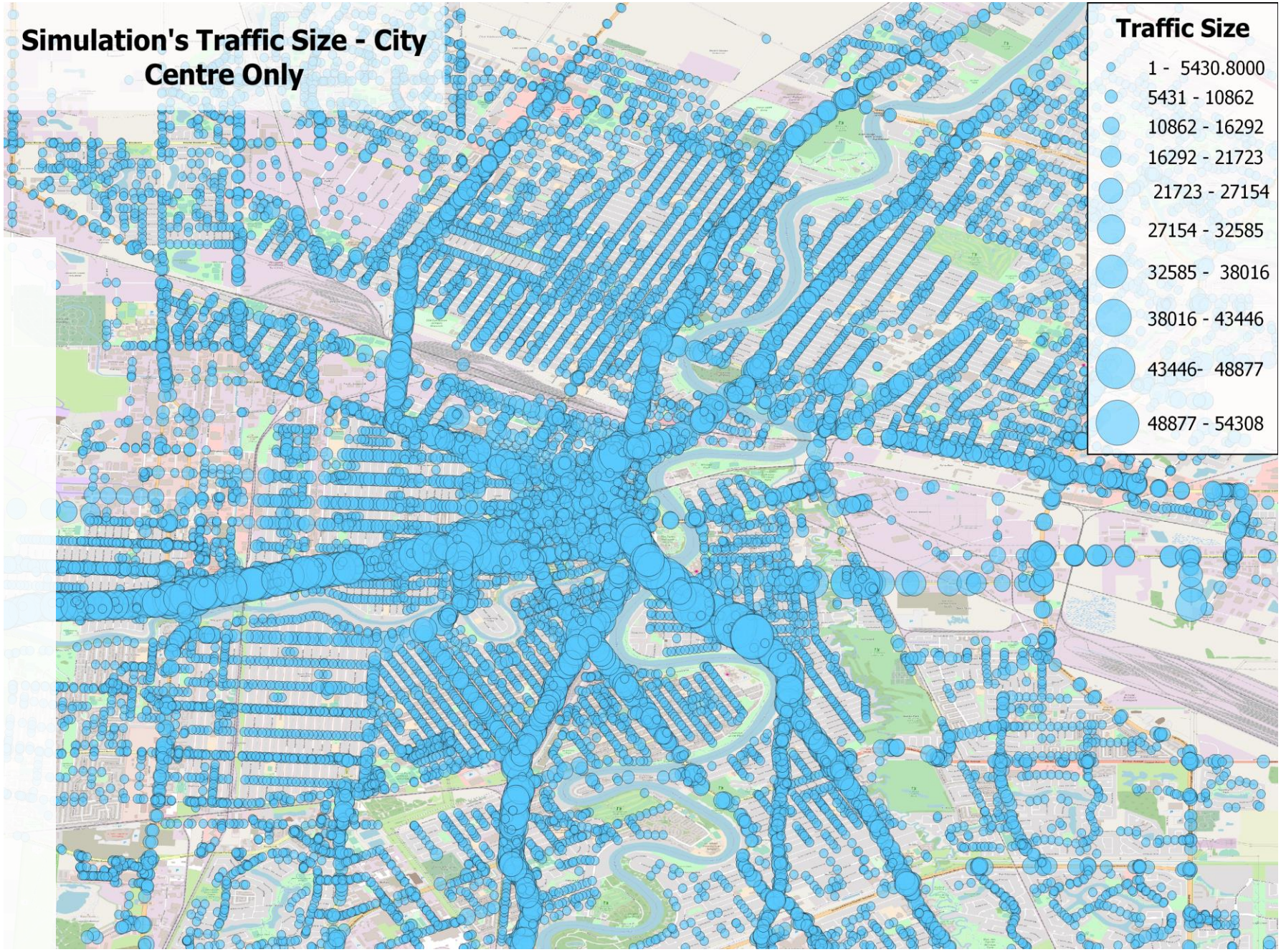
Outcome: Sociodemographic profiles available for each intersection within the city



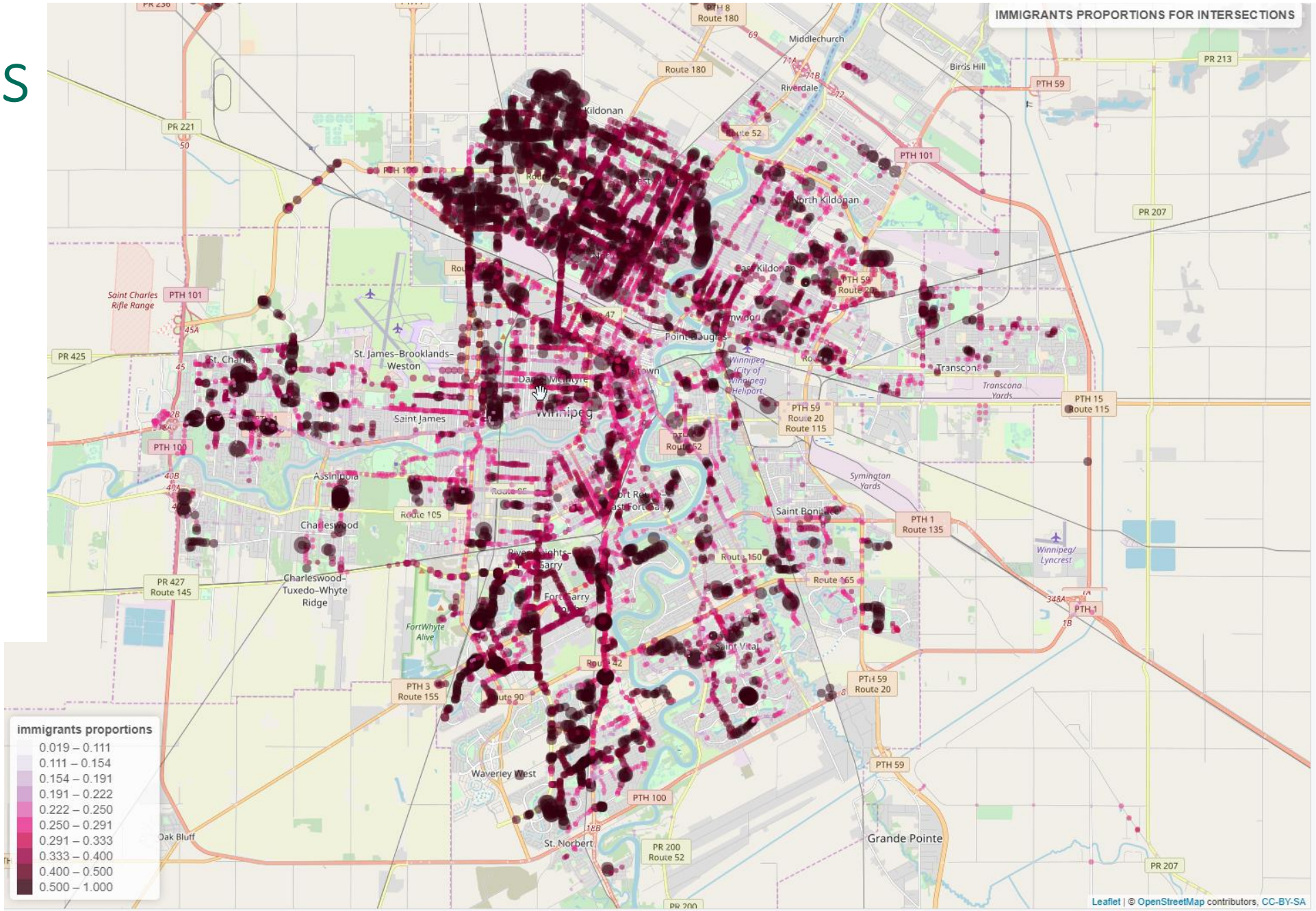




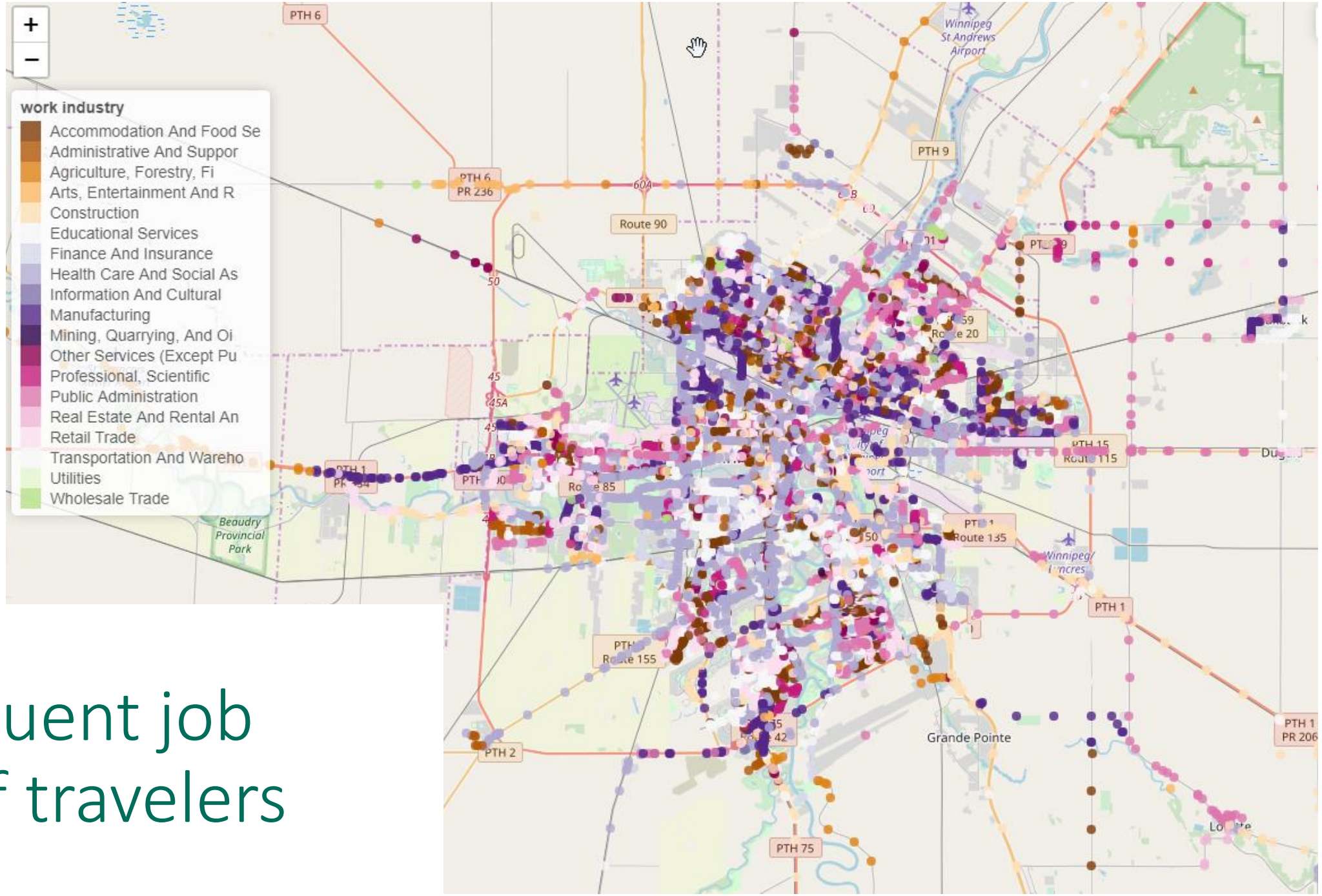
Simulated aggregated traffic on street crossing in the city center

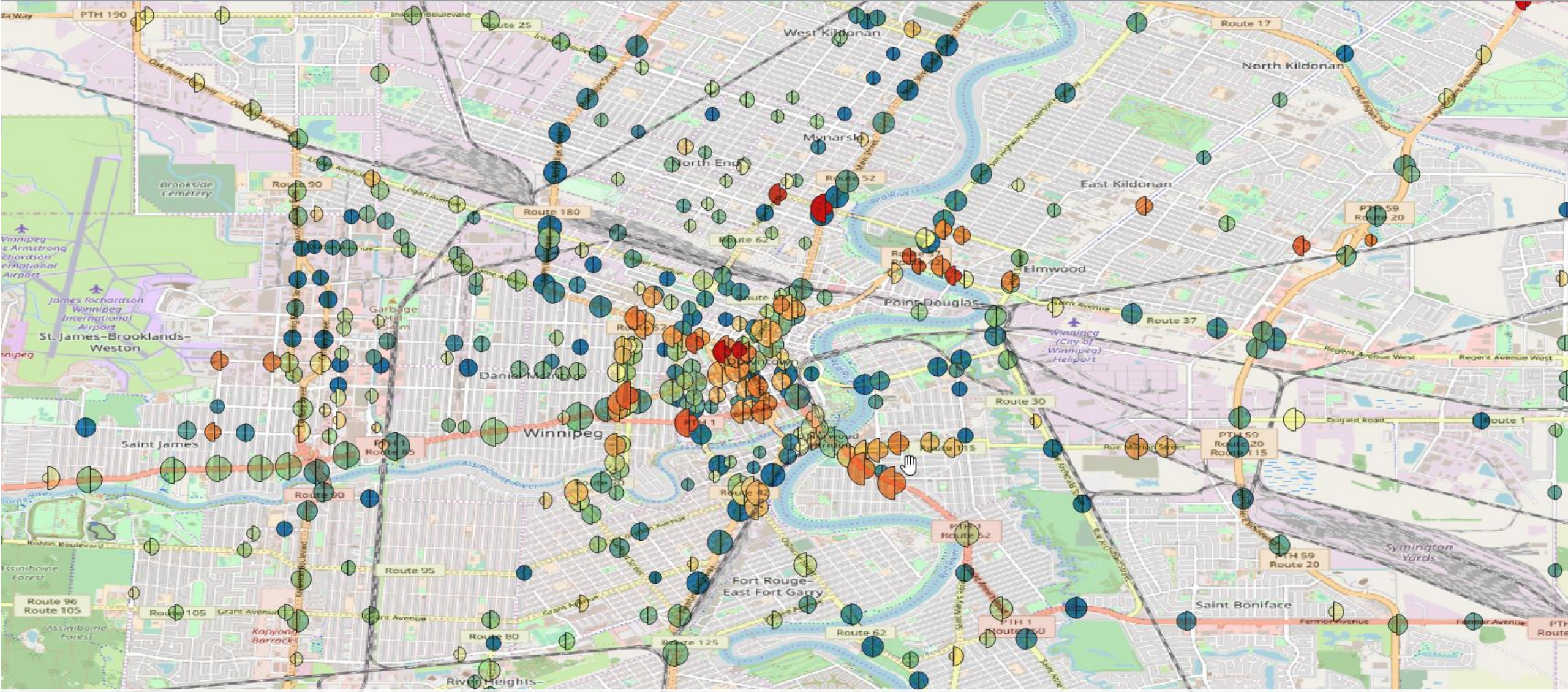


Percentage of immigrants passing through each intersection within the city



Most frequent job profiles of travelers





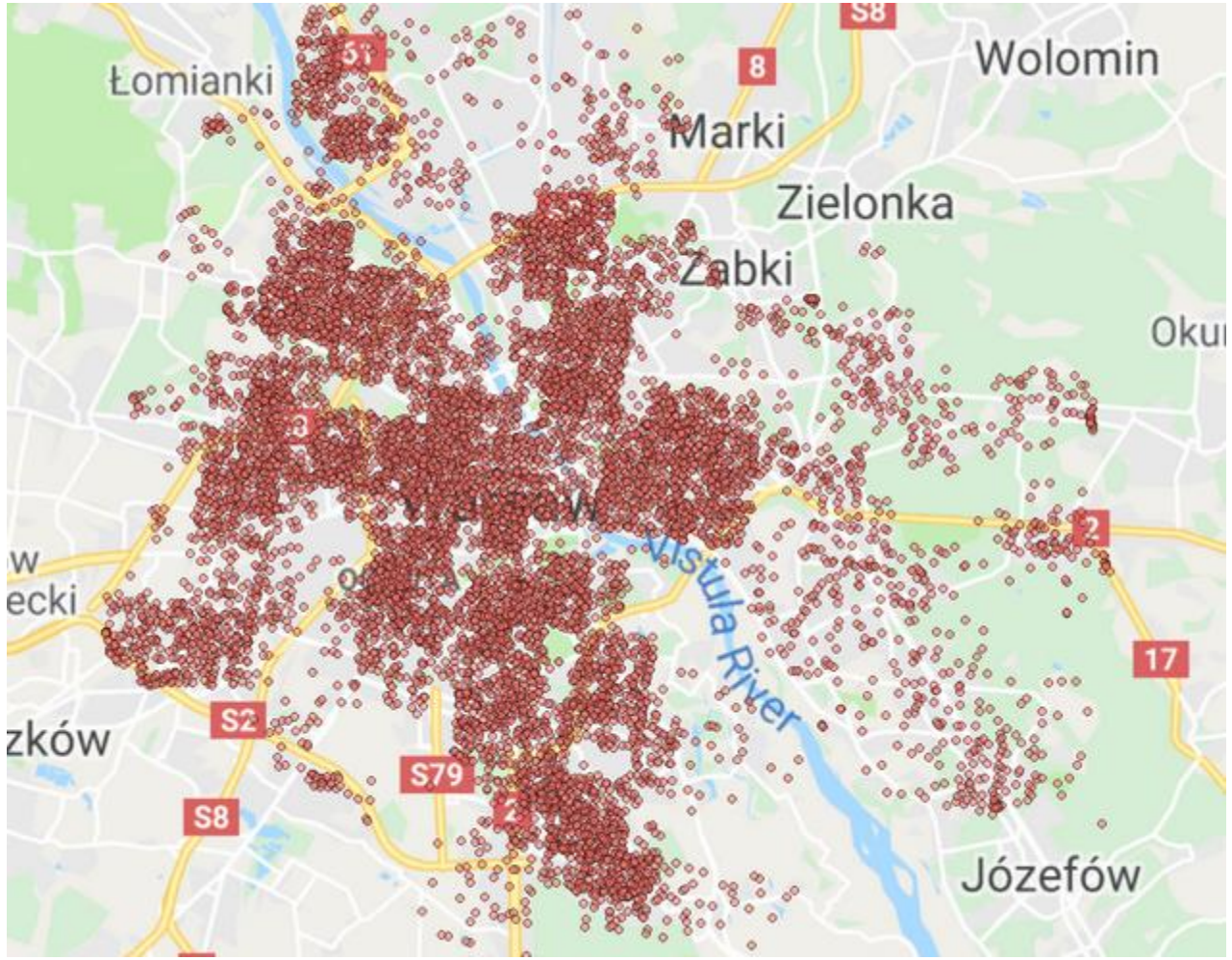
Model validation

(comparing with the actual workday traffic data)

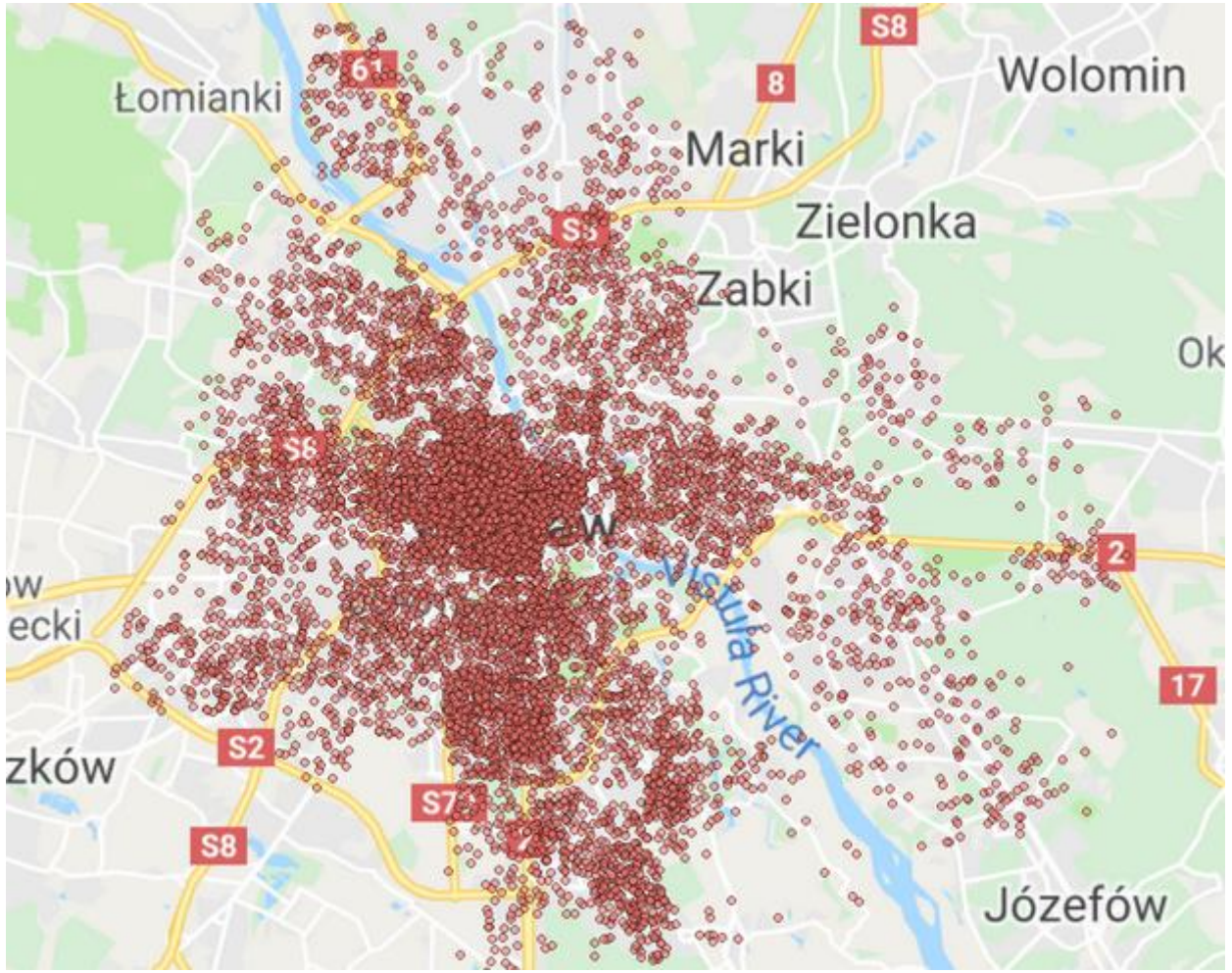
Praca magisterska na SGH...

Kiryl Varanovich

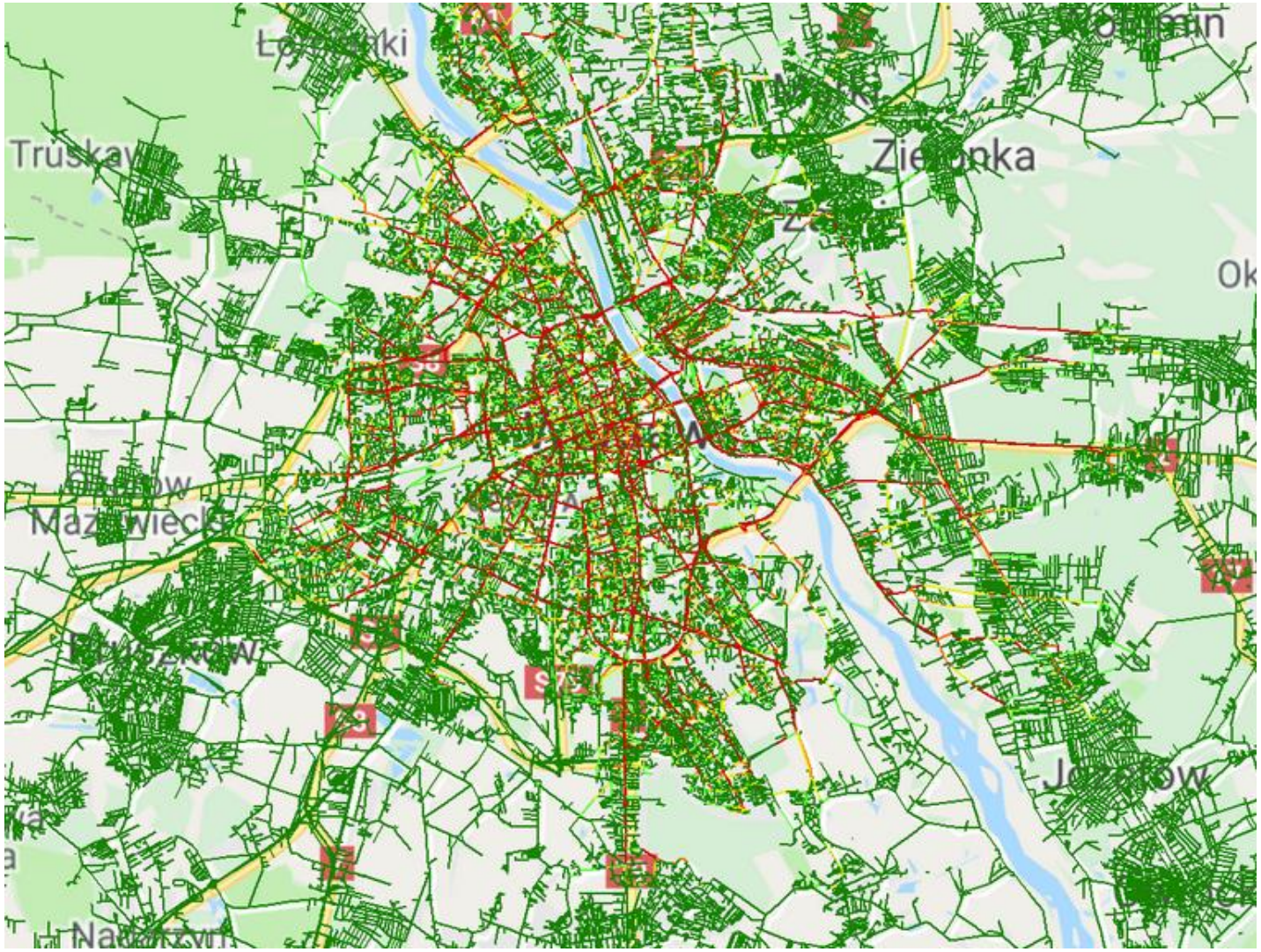
Population density



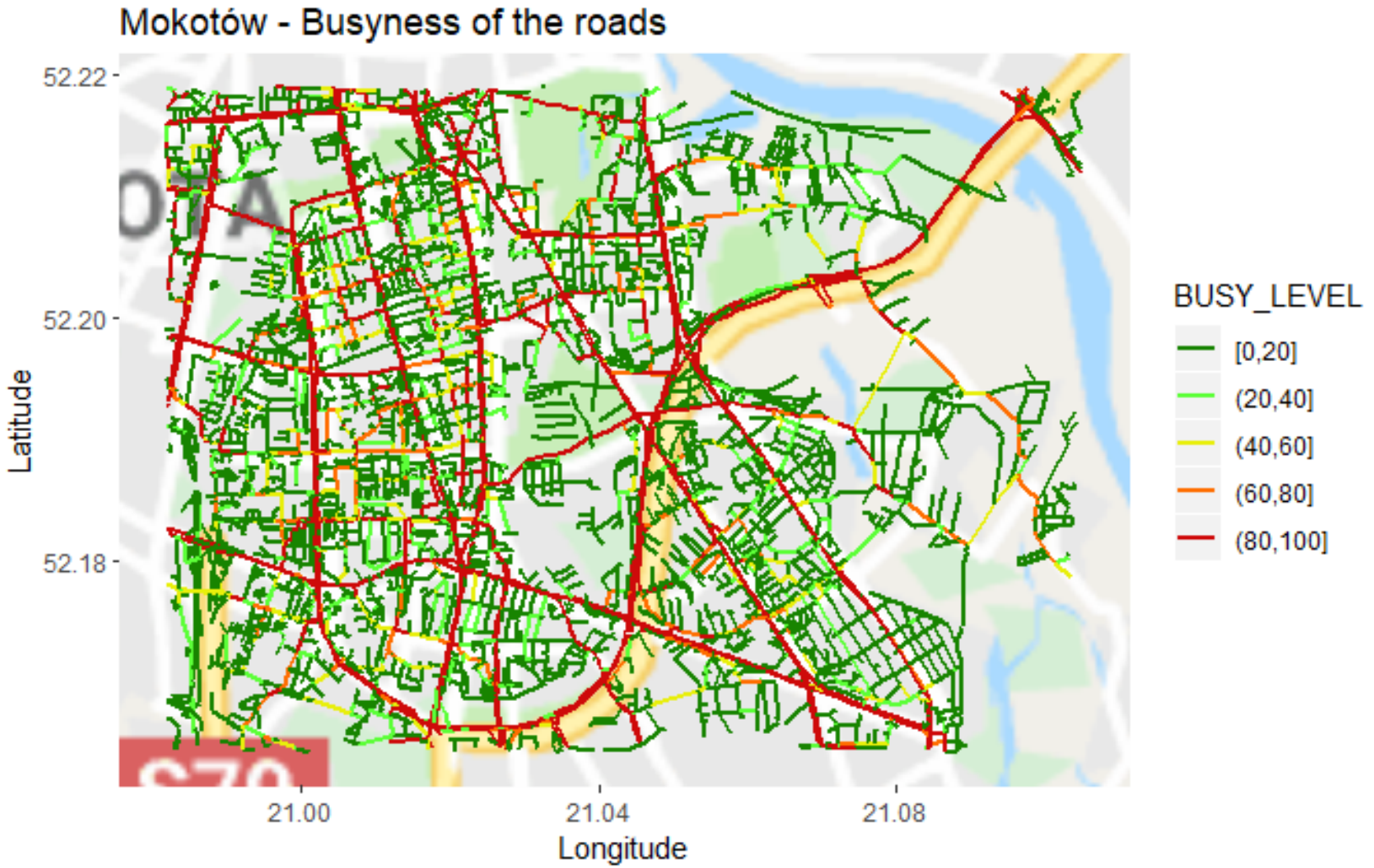
Business location density



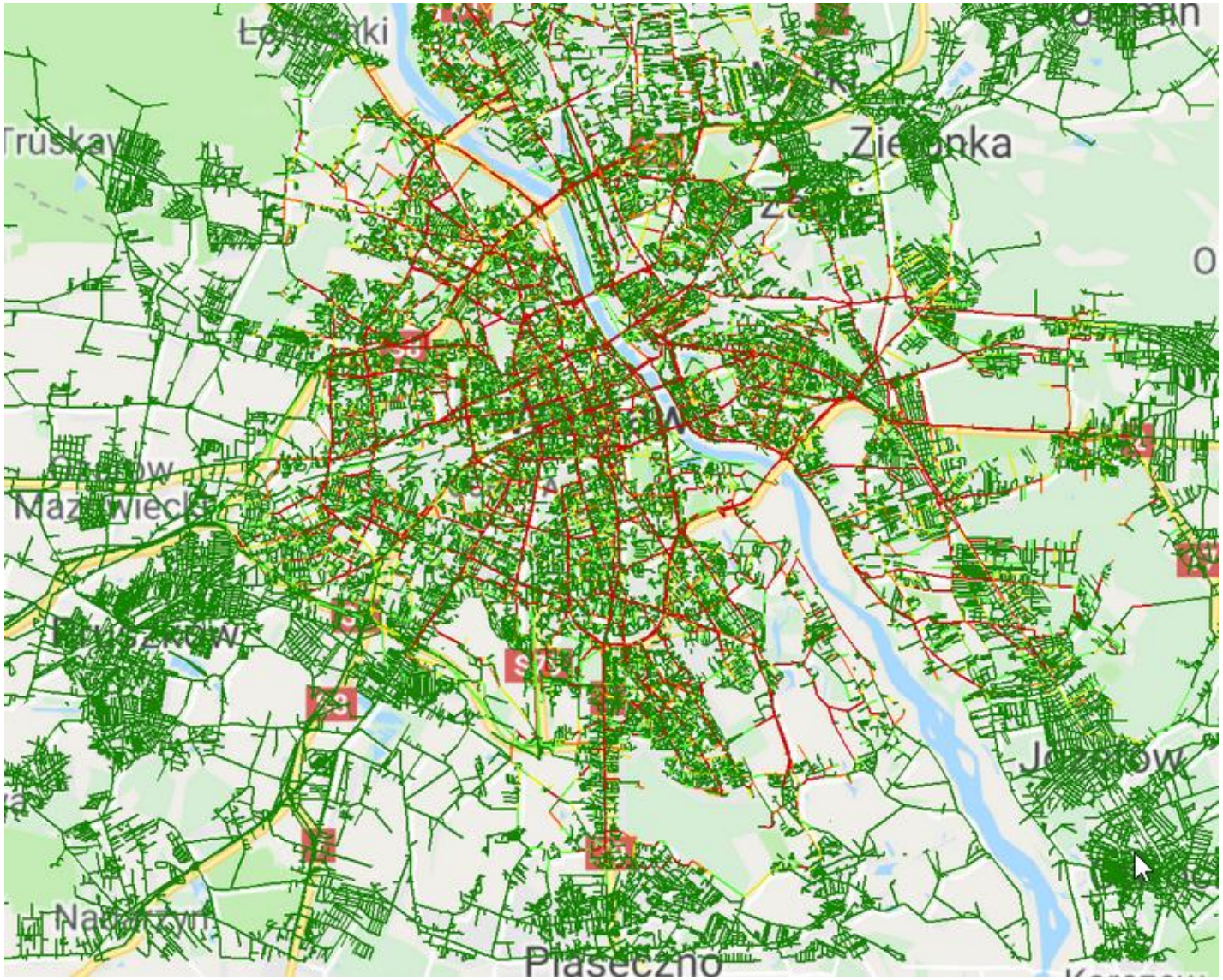
Simulated road traffic load in Warsaw



Mokotow district simulated traffic load



Traffic load for uniformly distributed business locations



Traffic load in Mokotow district (uniform businesss distribution)