City-Scale Traffic Simulation from Digital Footprints

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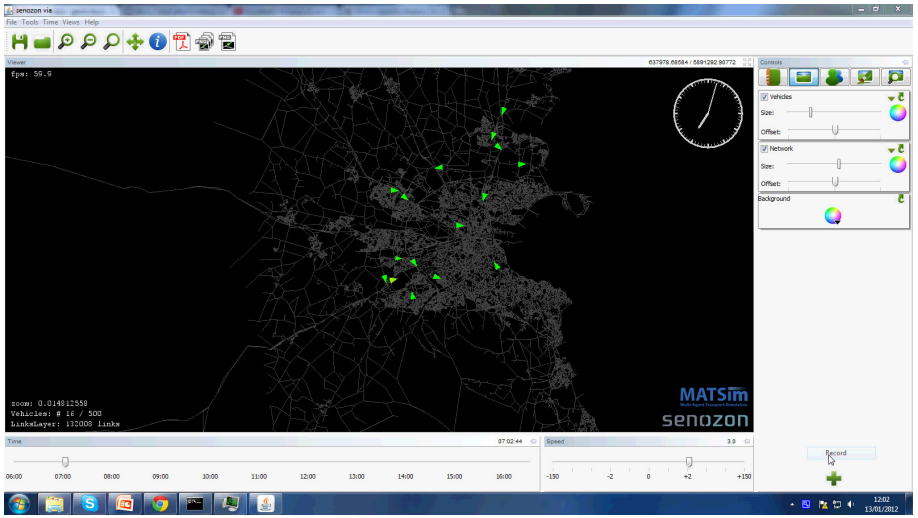
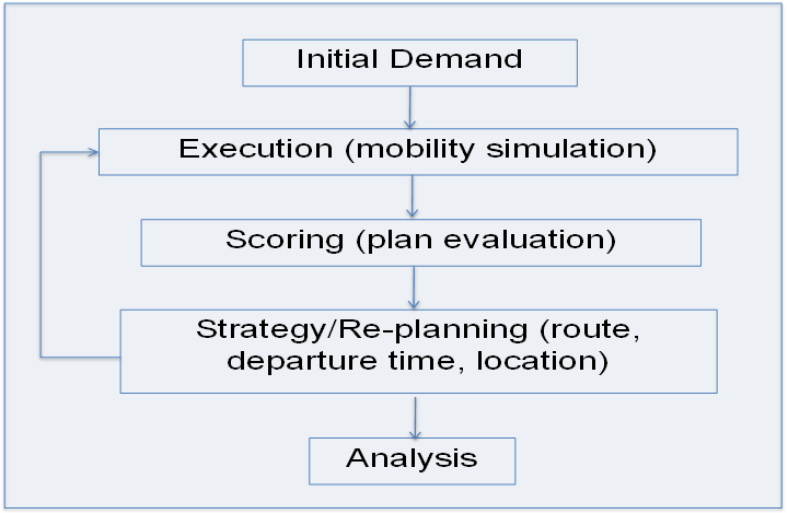
Traffic micro-simulation

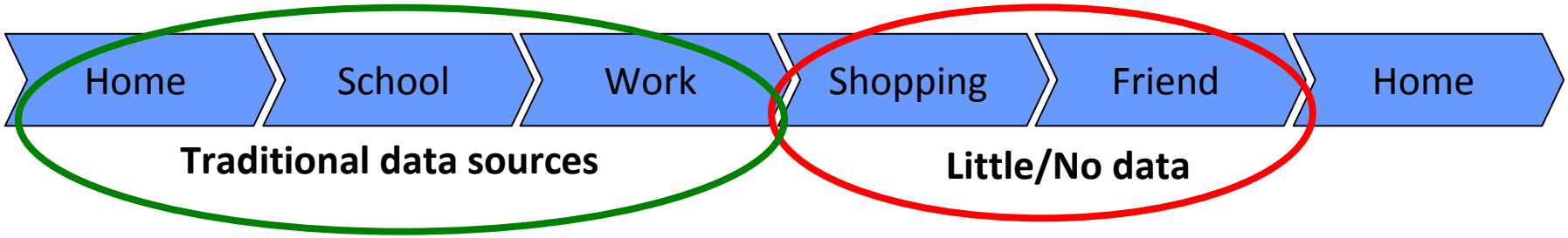
[www.matsim.org]



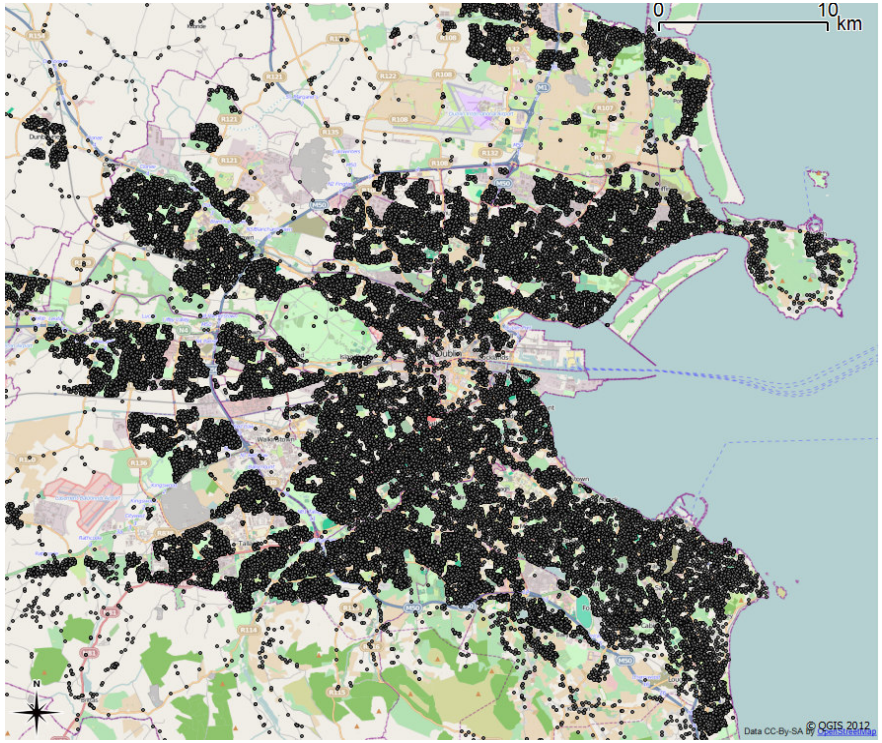


Activity-based transportation micro-simulation

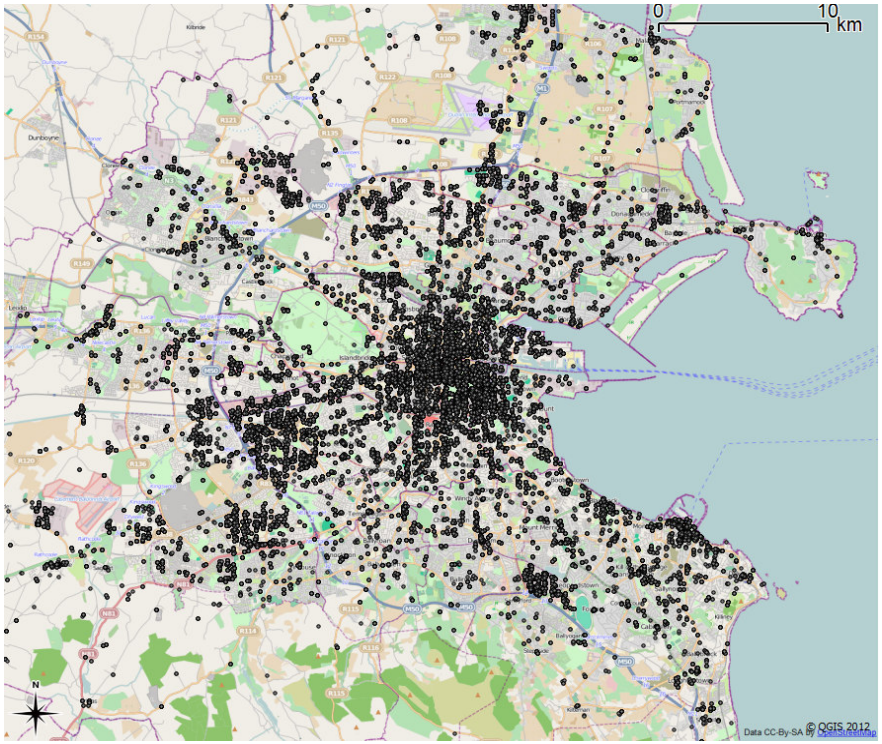
- a population of agents performing a sequence of activities
- large-scale (millions of vehicles), OSM road geometries
- handles interactions between vehicles, junction crossing, congestion, etc.
- adaptation strategies for route selection and departure time



Where do you work?



Home Locations

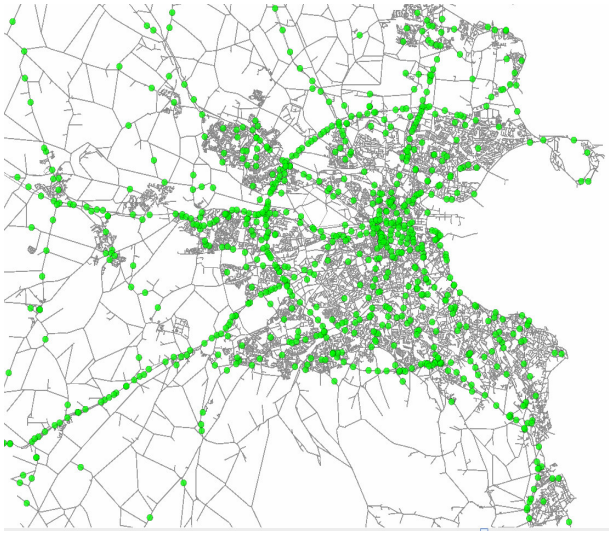


Work Locations

A sub-sample of 50.000 individuals working in Dublin, Ireland, from the census of population, Central Statistics Office (2006-2011).

Traffic

6 am



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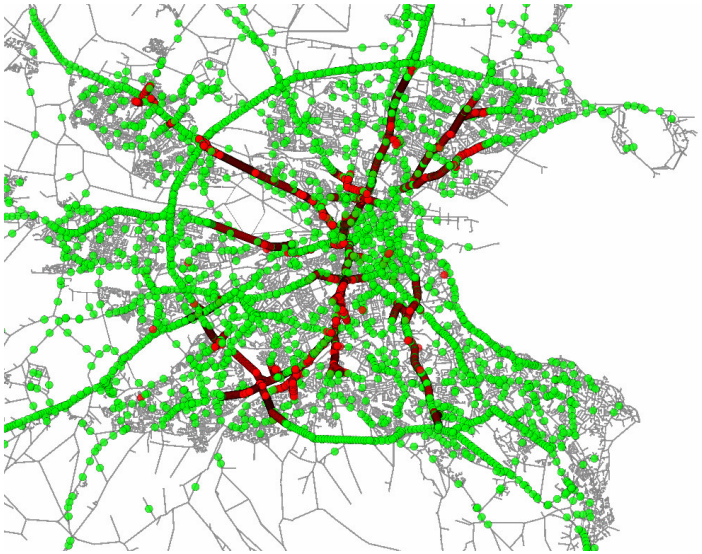
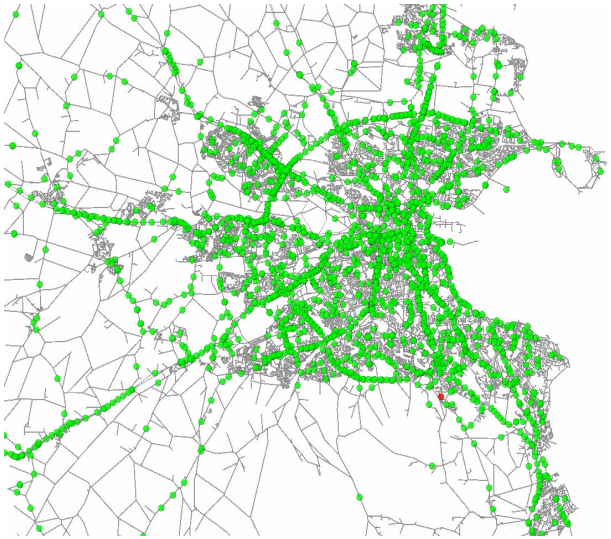


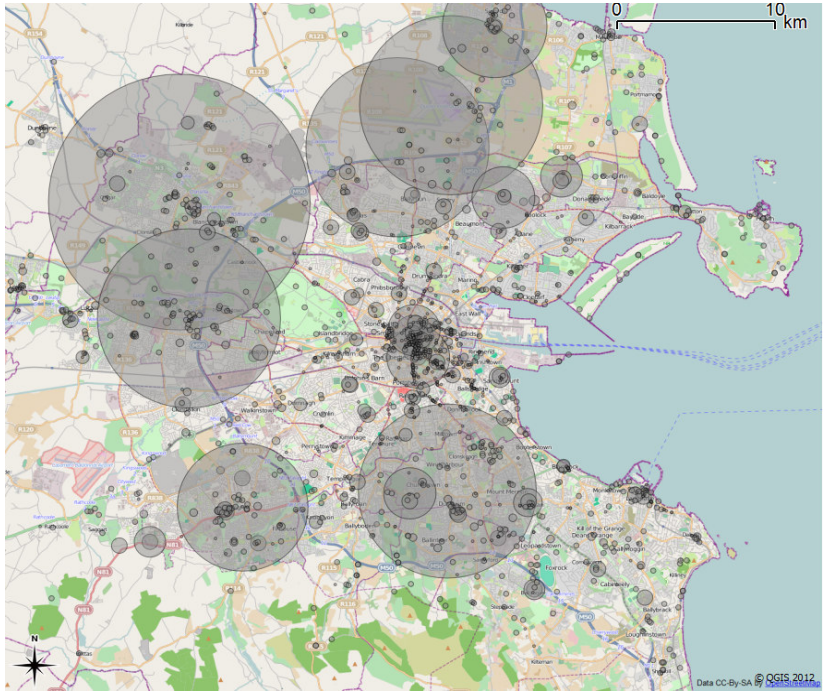
10 am – 5 pm

unknown

8 pm



Where else do you go?



Facilities locations and capacities

National Travel Survey (NTS) includes the following categories:

- **school/education**
- **shopping**

- **personal business**
- **sport/leisure**
- **doctor/medical facility**

- **visiting family/friends**
- **social/entertainment**

NTS also contains statistics on the variability and relative frequencies of activity chains, 16000 people were asked “what did you do today, and when?”

But **where**?

- **spatial choice models**
- **geography of social networks**

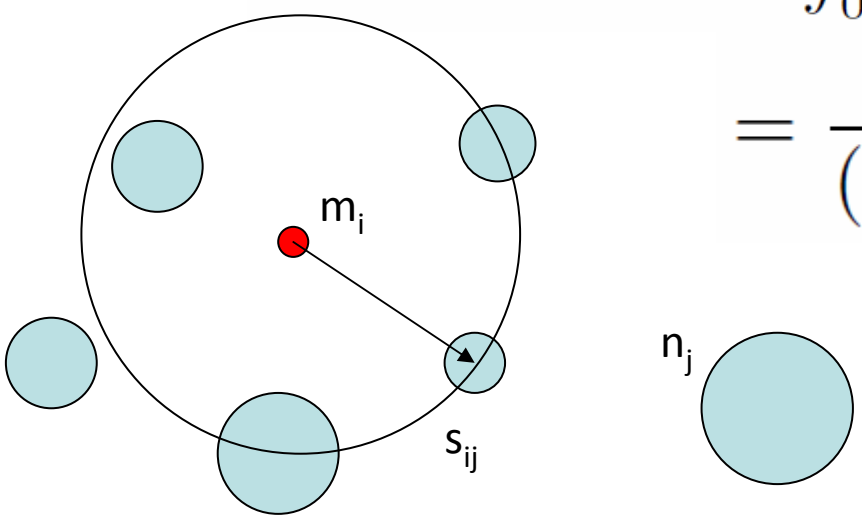
Spatial choice models

We introduced a variation of the radiation model for individual spatial choice

- Theory of intervening opportunities
- Distance decay is replaced with rank-based decay
- Capacities of opportunities matter
- "Individual demand" distribution can be integrated out

$$P(1|m_i, n_j, s_{ij}) = \int_0^\infty dz P_{m_i}(z) P_{s_{ij}}(<z) P_{n_j}(>z)$$

$$= \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}$$

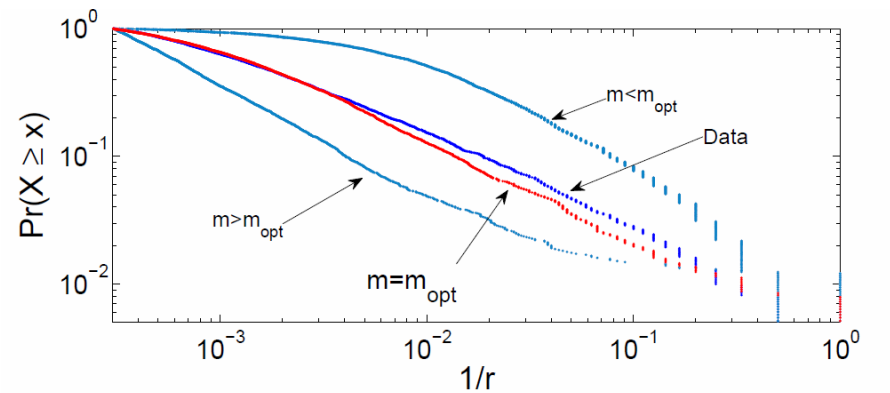


[Simini et al., 2012]

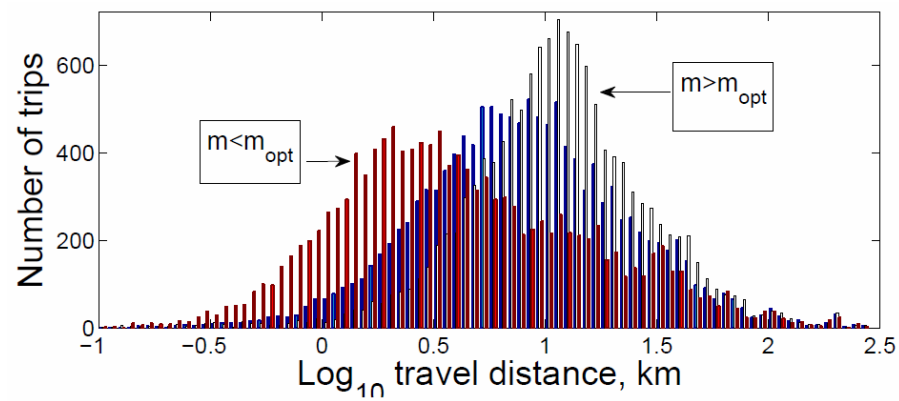
Spatial choice models

m_i – i^{th} individual's demand threshold to undertake a trip
n_j – capacity of a destination j, abilities to satisfy that demand
s_{ij} – sum of intervening capacities

$$P(1|m_i, n_j, s_{ij}) = \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}$$



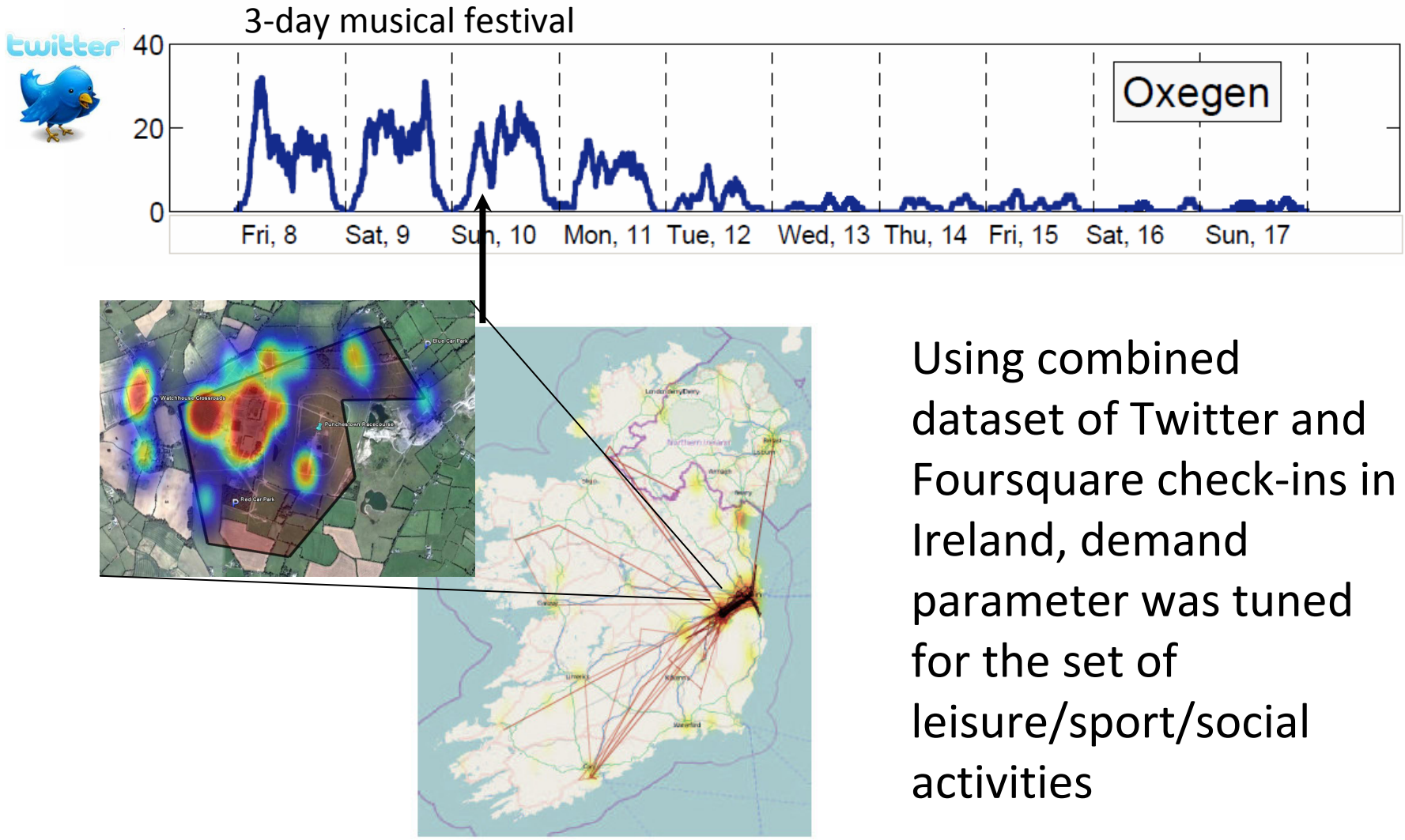
Fitting the m parameter in the inverse rank cumulative probability plot, log-log scale.



Impact of m parameter on the trip length histogram. X-axis is in log_{10} scale, km.

Demand parameter can be tuned for each facility/activity type: schools, shopping, medical facilities...

Leisure and social activities on Twitter

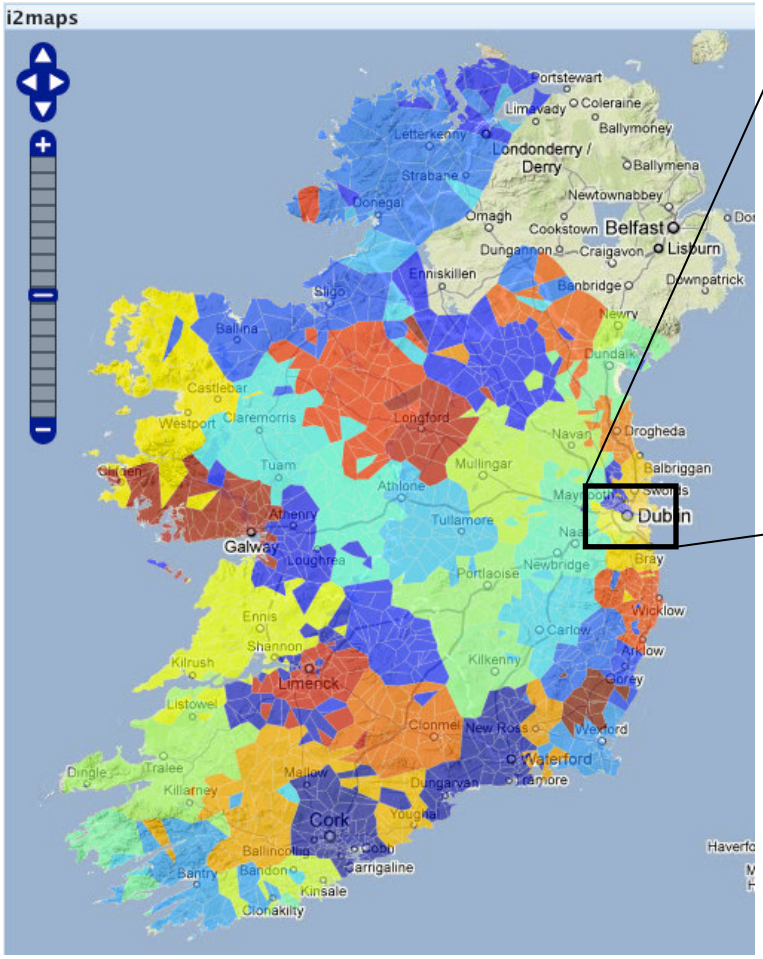


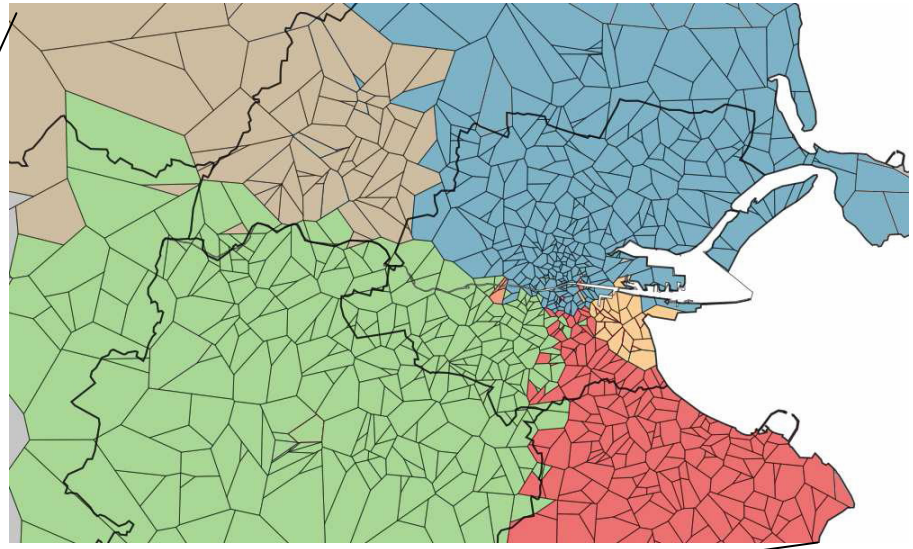
Using combined dataset of Twitter and Foursquare check-ins in Ireland, demand parameter was tuned for the set of leisure/sport/social activities

[Pozdnoukhov&Kaiser 2011]

Geography of social networks

Community structure of social network in Ireland from mobile phone data analysis, >10^6 users





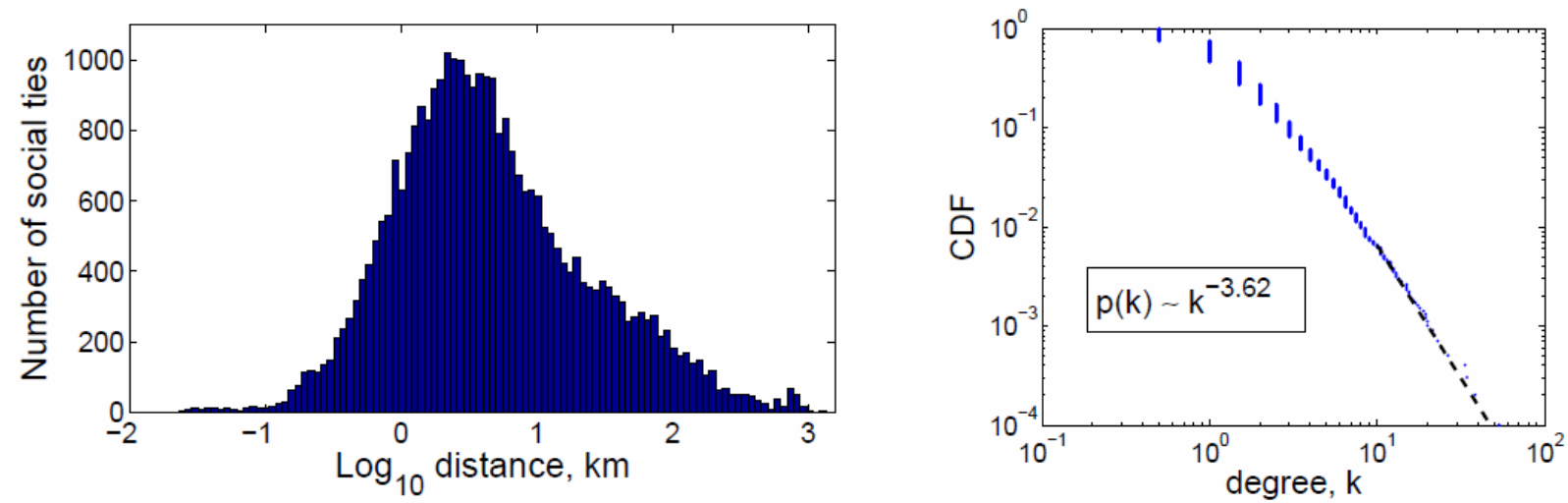
Probability of friendship decays with distance/rank

Communities are spatially structured into enclosed contiguous regions

[Walsh&Pozdnoukhov 2011]

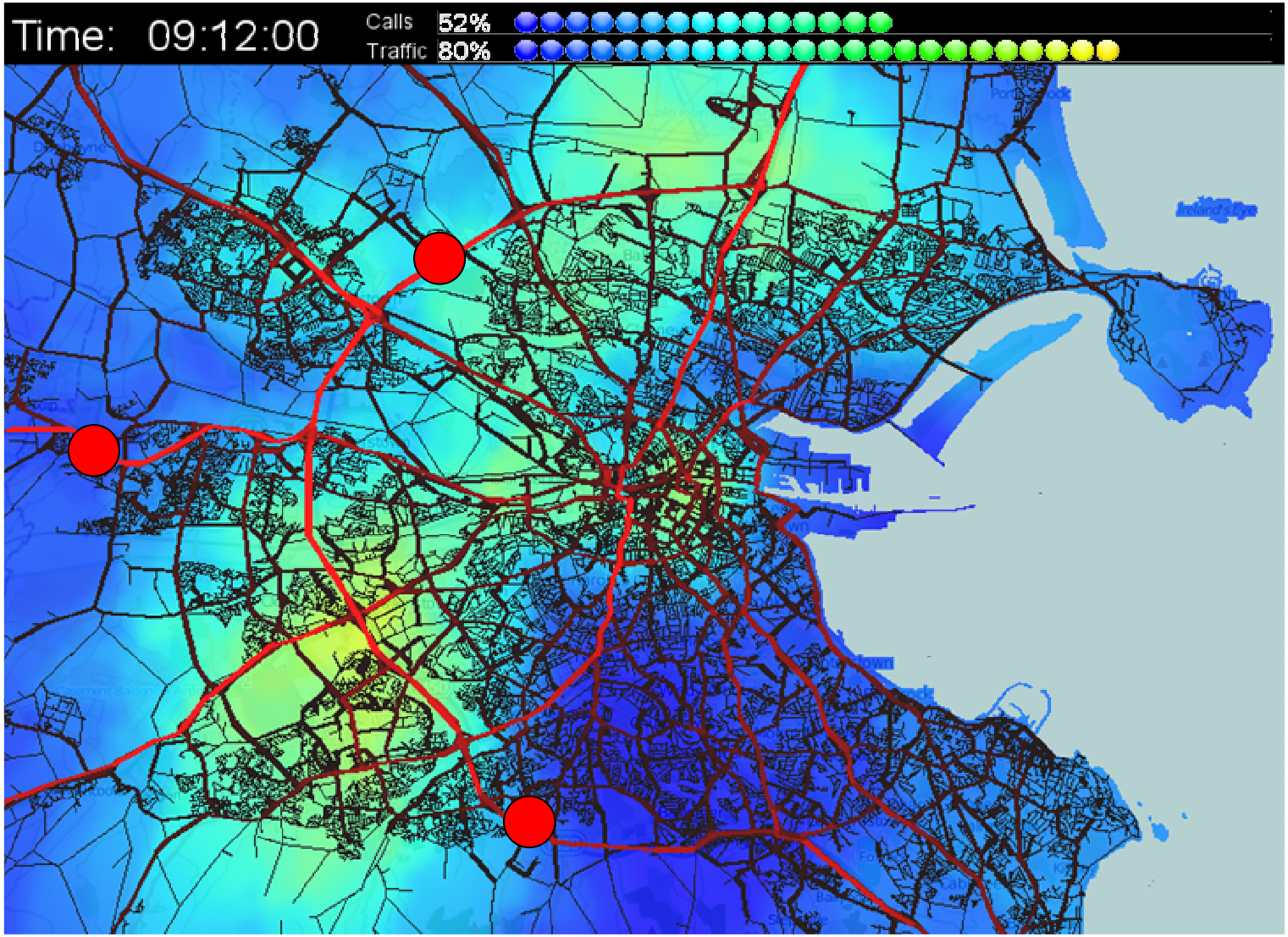
Geography of social networks

A social network for the population of agents was generated that reproduces the geographical alignment of community structure, node degree and social tie length distributions of a real social network of 1M people derived from cell phone data.

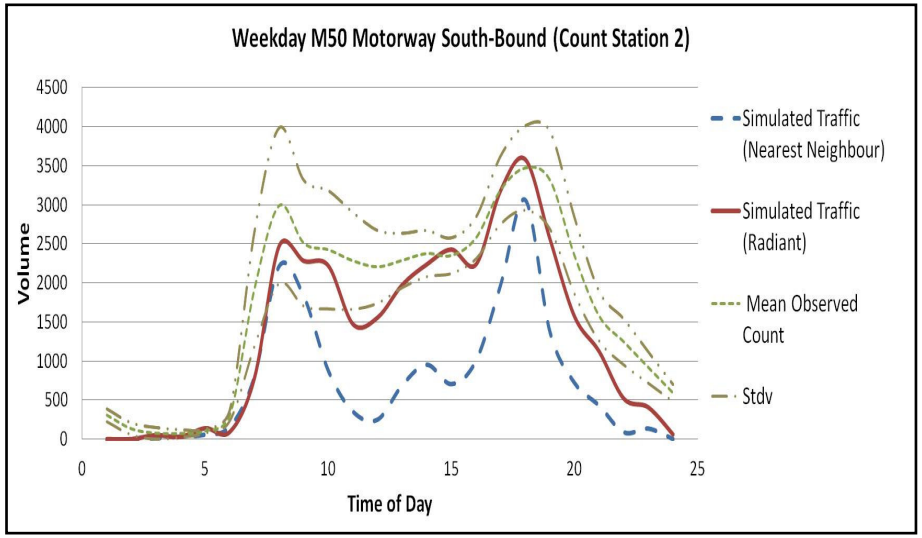


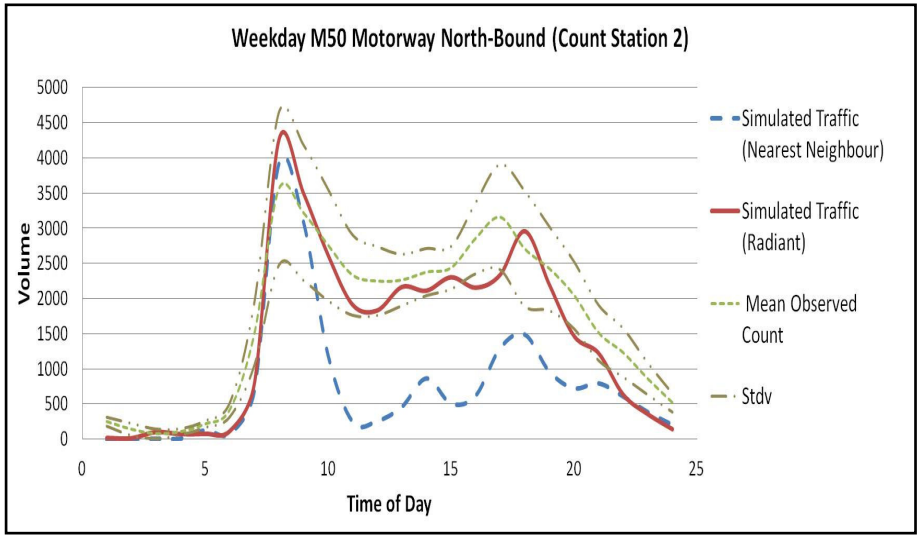
A histogram of a social tie length (left) and node degree (right) of the simulated social network.

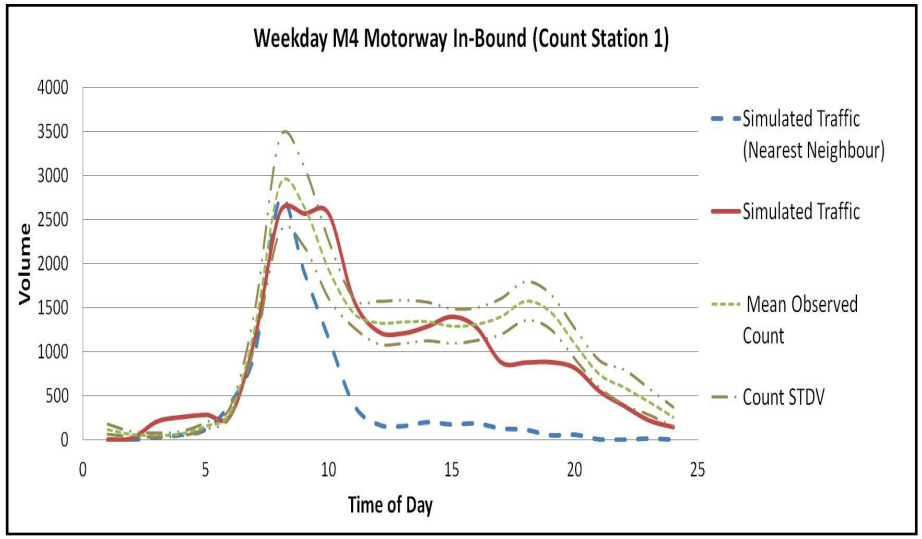
Traffic volumes

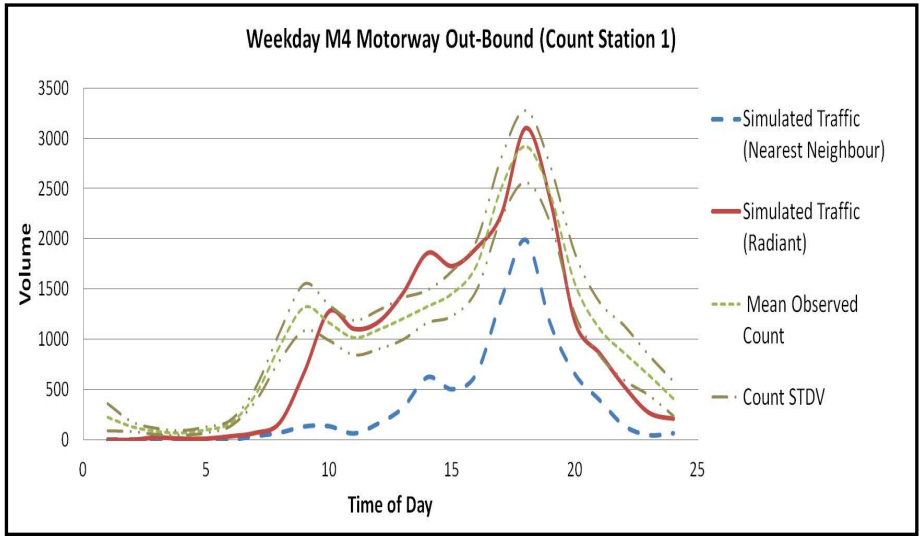


Traffic volumes validation









500 more SCATS counters available in the city…

Conclusions

Realistic large-scale traffic micro-simulation accounting for social and leisure trips and validated on road counts.

Mid-day activities are rarely covered by traditional data sources, and we applied:

- social network model from cell phone logs for geography of friendship and destinations of social visits;

- social media to calibrate a radiation-type destination choice model for leisure/shopping journeys.

Now: currently running experiments with > 500.000 agents, inter-city journeys, more realistic volumes, influence of traffic jams on destination location choice, “what-if” scenarios, etc.

Future: Interplay between social ties and mobility is complex, better models needed for that. What about weekends?

Thanks!

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