Towards simulation-based sketch planning: Some results concerning the Alaskan Way viaduct in Seattle WA

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1. Introduction

As part of a research cooperation between TU Berlin and UW, the research software MATSim (see www.matsim.org) was combined with the Urbansim software (see www.urbansim.org).

As part of that integration effort, data from Seattle and from Puget sound were used for test cases.

As part of these test runs, simulations with and without (parts of) the Alaskan Way Viaduct were run.

These runs do not claim to be calibrated and/or validated in any way. It was nevertheless decided to make some of their results available, in order to maybe contribute to a narrative hopefully ultimately leading to a better-informed decision.

2. About MATSim and this case study

MATSim stands for Multi-Agent Transport Simulation. Its goal is to generate a synthetic version of the population in a region of interest, follow the full daily movements of every person of that population throughout a representative day, and have these synthetic travellers adjust to any policy measure that is taken. An important difference to existing large-scale traffic simulation software is that it is fully time-dependent, i.e. traffic jams in front of bottlenecks form, grow longer, and eventually grow shorter again and go away.

This study was, in part, an exercise to concentrate on "fast turnaround" rather than "being very realistic". In consequence, the study concentrates on the following issues:

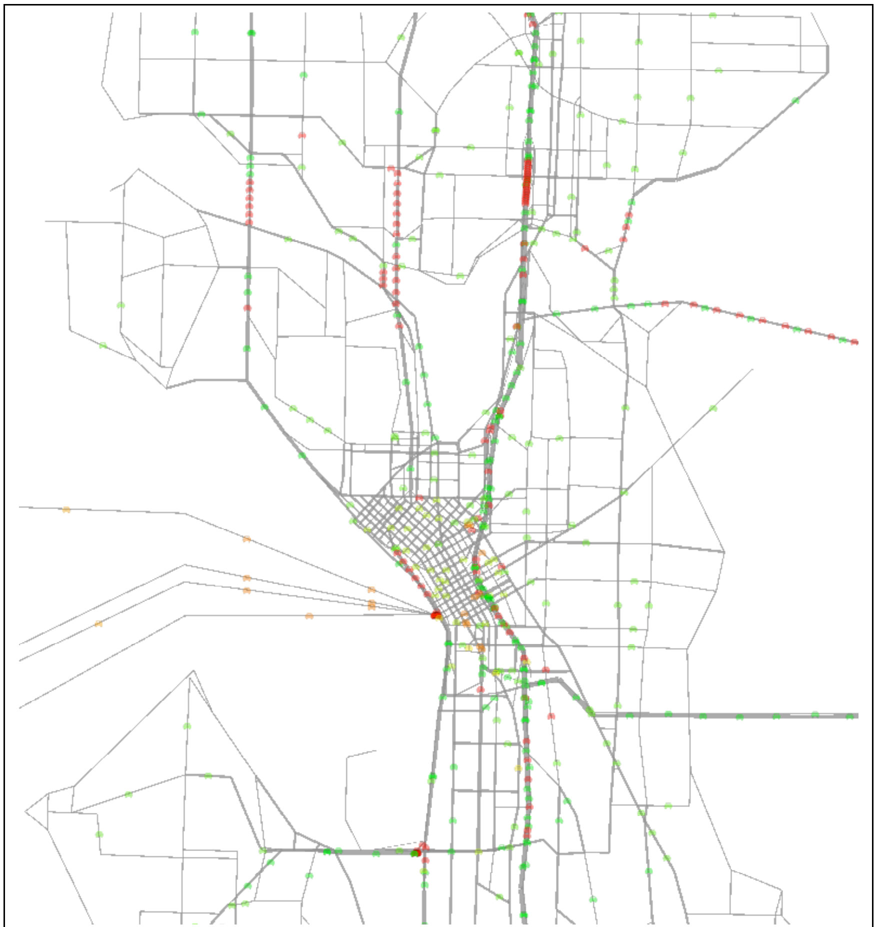
- It only models commuting traffic, and only traffic by car.
- All simulations are run with a "1%" sample of the population. That is, only every hundredth person in the region is represented, and road space/capacity is reduced by a factor of hundred.

Resulting issues are discussed below.

3. Main results

3.1 The base case

The main result of these simulations is that the main bottleneck in Seattle does not seem to be the downtown area, but the ferries and bridges to the west, north, and east directions. Results consistently look like the following (where "red" denotes cars caught in congestion):



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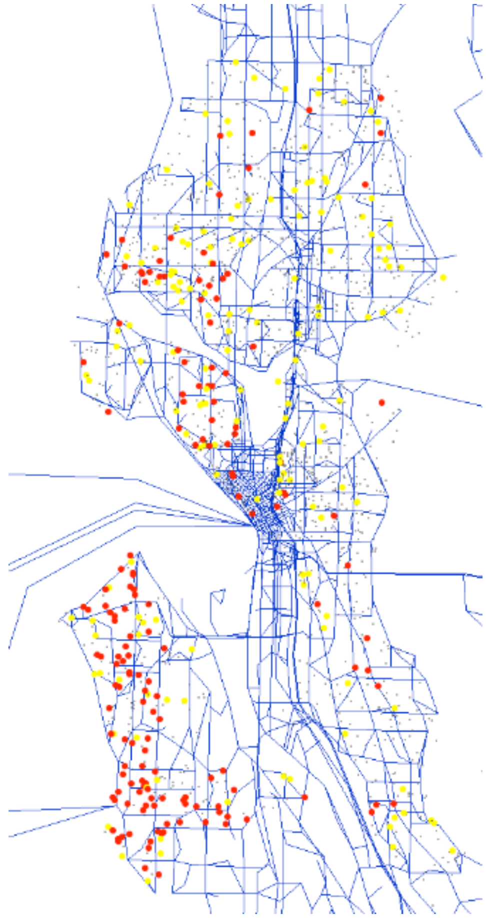
That is, while the model predicts considerable problems getting *onto* the peninsula, the (morning) congestion on the downtown peninsula itself seems to be considerably smaller. The lack of capacity *onto* the peninsula "shields" the downtown area from traffic overload.

3.2 Removing the Alaskan Way Viaduct

Now (some part of) the Alaskan Way Viaduct was removed (technically: its roadspace and capacity were drastically reduced) and the simulation was run again. The simulations include so-called **learning iterations**, that is, the simulation is run multiple times and travellers adapt from one iteration to the next (like the movie "Groundhog Day"). Let us look at those 10% of people who are affected most initially (in what we call the "zeroth" iteration):



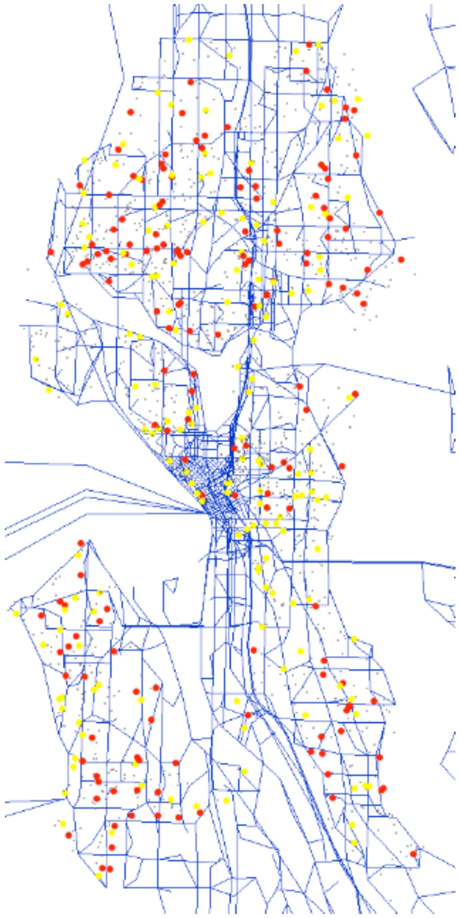
Red: 10% of households that are **initially** most affected after removal of the viaduct. Yellow: The next 10%.

As one would intuitively expect, the people who are most affected are inhabitants of West Seattle, Queen Anne, and Ballard.

Note that not *all* people living there are affected. In general, the people who are affected (in this study) are those from these neighborhoods who also work downdown or "on the other side of downtown" (seen from their residence).

3.3 After a year …

The simulation system then starts adapting, i.e. the same day is run over and over again. In this set-up, people may shift their routes, and they may shift their departure times. The optimize in how far they are affected, where "affected" is measured by a combination of necessary travel time and so-called "schedule delay" (how much they adjust their schedule in order to avoid congestion). After this simulated year, the locations of the 10% most affected households are now as follows:



Red: 10% most affected households a year later. Yellow: The next 10%.

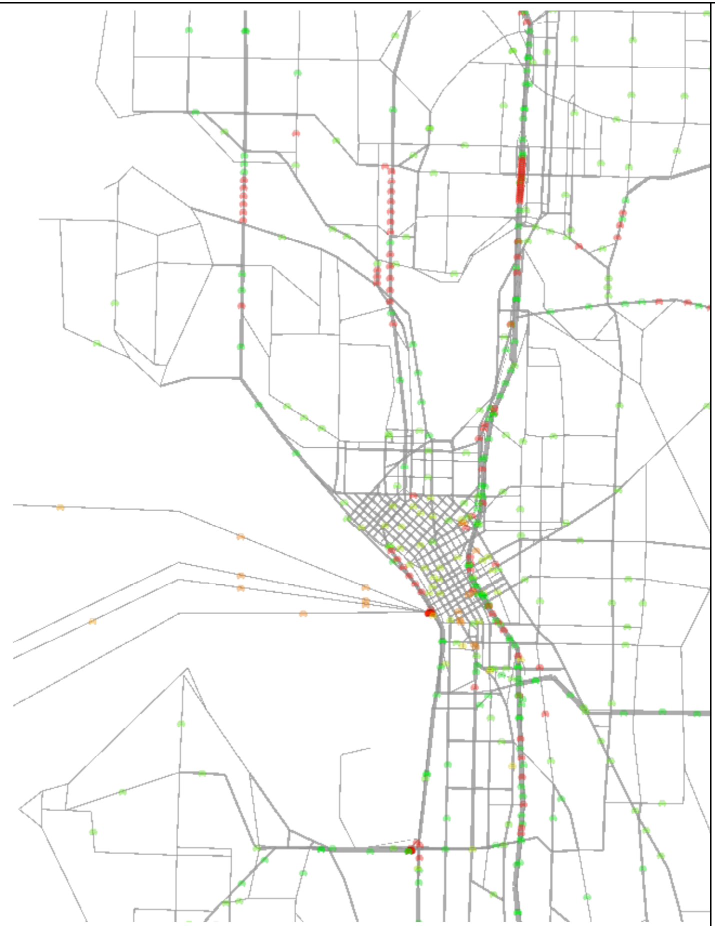
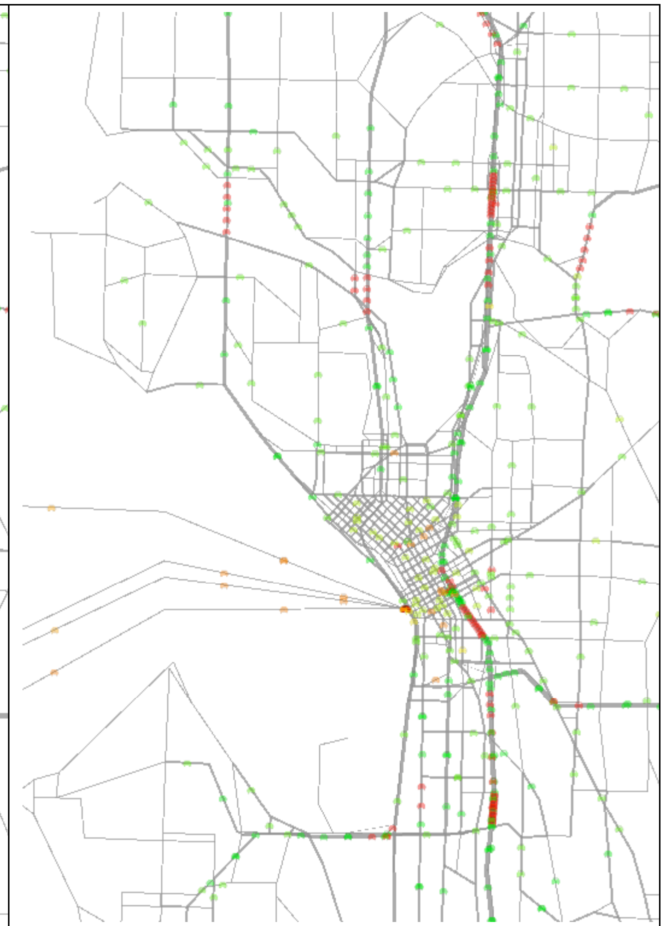
The locations of the most affected households has spread out through the region. That is, those people who used the viaduct moved to other routes or time slots, triggering other people to adjust, who triggered again other people to adjust, etc.

(Also, the amount of how much people are affected has decreased very much between these two pictures.)

3.4 Traffic patterns

The snapshot of the congestion with the viaduct removed confirms this:

With viaduct (as before):	Viaduct **removed**: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We observe:

- To the north of the downtown area, relatively little changes in the congestion patterns. If anything, the Aurora corridor gets less congested – as is to be expected since people detour to I-5.
  The reason, presumably, is that the real bottlenecks are the bridges across Lake Union etc. The capacity reduction caused by the removal of the viaduct does not reduce the capacity in the downtown area enough in order to show strong congestion effects.
- To the south of the downtown area, the effects are more pronounced: There is now more congestion on I-5.

4. Sources of errors

Simulations can have many sources of errors. We will name a few:

The code could be wrong

We make many efforts to avoid this (see www.matsim.org/developer), but there is no guarantee.

The input data could be wrong

There are two pieces of input data: the road network and the so-called origin-destination matrix.

Road network: This was taken as I (KN) found it, “as is”, without any further checking. Besides always possible coding errors, the most serious flaw are possibly the reversible lanes on I-5 that I have not put in. It would be possible to put them in, but require additional work.
In addition, this study removed only the downtown sections of the viaduct. The results may be different when more of it is removed.

Origin-destination matrix: The Urbansim project, which hosted me during this study, generates the origin-destination matrix. I took it without verification.

The behavioral model could be too simple

The simulations assume people that simply go from home to work and back. Such an approach seriously under-estimates any traffic after the morning rush.

Certain types of traffic are missing

Types of traffic that are missing from the model include: commercial traffic, long-distance through traffic. In our experience, these types of traffic avoid the morning rush, but play an important role during the remainder of the day.

What about travel times?

This model, as it stands, says something about congestion patterns in the morning. Travel times will certainly get longer if the viaduct is replaced by a signalized surface street. What this model predicts that there will be no major congestion on top of this.

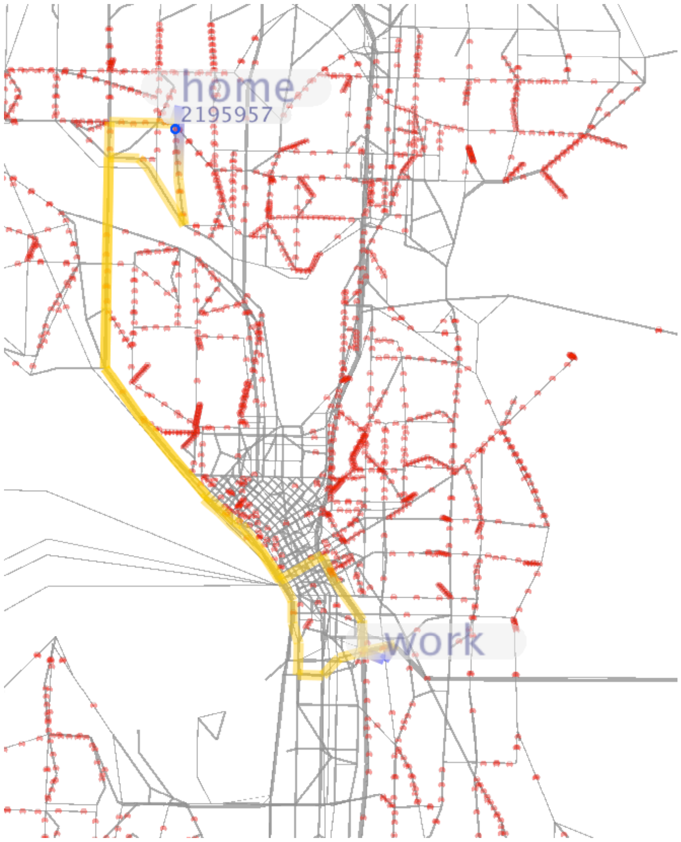
Is this approach useful?

It is our experience that this type of approach gives useful intuition for the morning rush period. The over-arching statement here remains that the bridges across Lake Union restrict flow in north-south direction so much that, with the viaduct, there is spare capacity in the downtown area during the morning rush.

The model, as it stands, does not really say anything useful about the evening rush.

5. Spiders

The simulation allows to look at individual persons over a day:



Example of one daily plan (home-work-home) including its routing. The use of the Ballard instead of the Fremont bridge is probably caused by congestion avoidance.

You can now mark a link and look lay the trajectories of all synthetic travelers who use that link on top of each other. This is color-coded as turning increasingly red. (You need a high-contrast, high-gamma monitor setting.)

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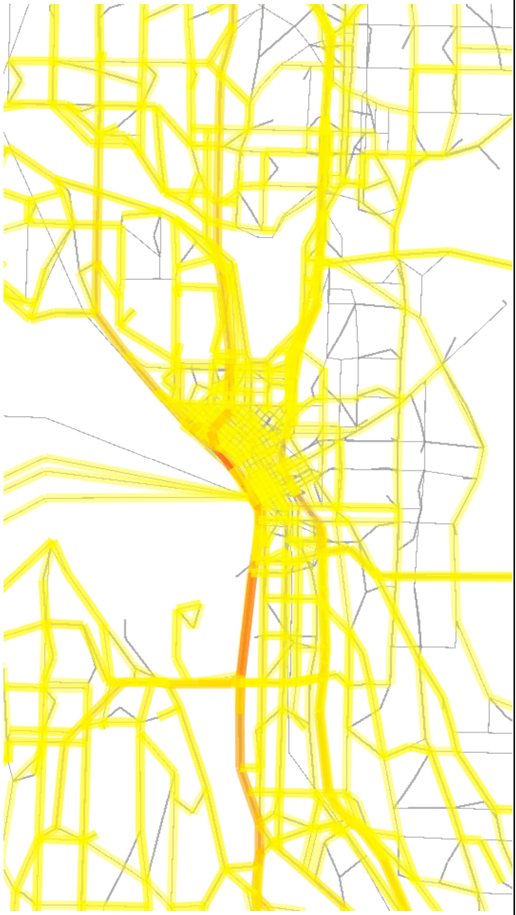
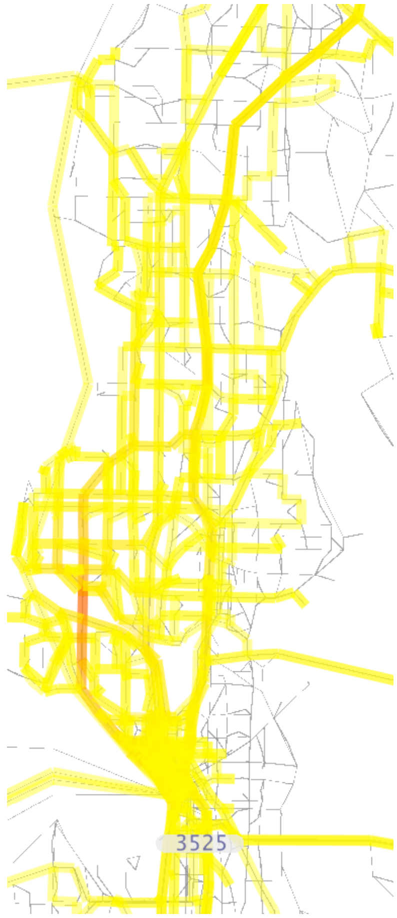
<td></td>
<td>
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<td>Spider analysis for the Alaskan Way Viaduct. One clearly sees that (for our synthetic travellers) it has a strong “southern” reach, but in contrast the “northern” reach is rather diluted.</td>
<td>Travellers who use Ballard bridge are somewhat likely to use SR-99 into the downdown area, but not beyond. In contrast, there is a slightly increased probability that they use I-5 further north, indicating that they would not be much worse off using I-5 in the downtown area. [You see this only on a display with high contrast and large gamma value.]</td>
<td>In contrast, the Aurora Corridor has increased correlations beyond the downtown area. However, also here many synthetic travellers use I-5 further north, indicating that they could use I-5 in the downtown area as an alternative.</td>
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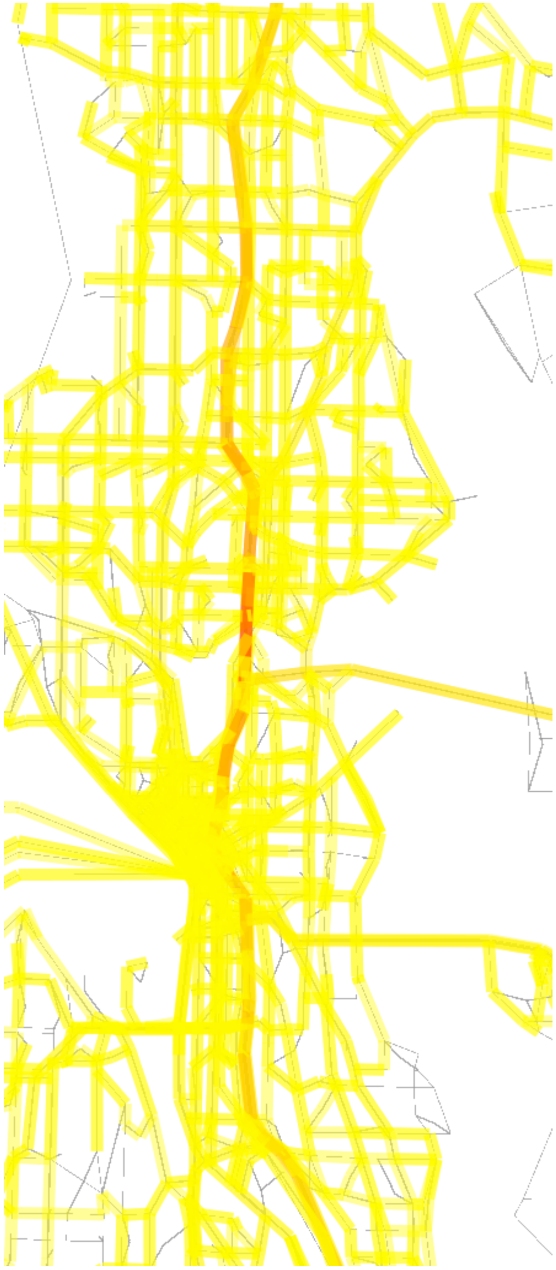

At the I-5 bridge, one observes a much more long-distance reach.

The attempt of some conclusions:

- The is little traffic connecting the “far north” with the “far south” that uses the viaduct.
- Relatively little of the traffic that uses the Ballard/Aurora bridges goes beyond downtown or comes from beyond downtown.
- *In contrast*, a large share of traffic using SR-99 south of downtown goes through downtown.

That is, typical users of the viaduct seem to be:

- People who live in West Seattle.
- People who work at Boeing.

In contrast, people living in Queen Anne, Ballard, Fremont are *not* typical users of the viaduct: most of their travel is not beyond the downtown area. Although they will probably like the option to go south if they have to (e.g. airport access).