Representation of local streets in TRANSIMS

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1 Introduction

Micro-simulations for transportation planning, such as TRANSIMS, are based on a microscopic representation of reality. In principle, this means that each object that occurs in reality is represented as an object in the simulation. Dynamical behavior is generated by letting the collection of objects evolve through time, while *interactions* between objects generate the behavior of interest. As an illustrative example, the capacity of a road is not externally prescribed for this type of simulation, but it is intrinsically generated, emerging from the interactions between the vehicles on the road and the geometric and other constraints e.g. given by road layout.

Now, while this microscopic approach is in principle very powerful since there seems to be no *systematic* limit to the representation of reality in the computer, there is certainly a resource limitation: First, there are limits of how well we actually know reality, and second, there are limitations to how much time we want to spend coding all these aspects of reality. Fortunately, however, it seems that in many cases useful results can be obtained from representations that are limited in resolution and fidelity. One topic where this is important for transportation planning simulations is the question to what extent small, or local, streets need to be represented for region-wide simulations. Clearly, in the past planning organizations have usually relied on street network representations that leave out most of the local streets. Two reasons then and now why this makes sense are indeed resource limitations: Collecting all the necessary information is expensive, and running such extensive networks on computers is expensive, too. For that reason, we will perform here a systematic study into to what extent the inclusion of local streets changes the outcomes of typical TRANSIMS questions.

2 Study

As also mentioned above, TRANSIMS in its whole approach is *microscopic*. This means that raw quantities that can be extracted from TRANSIMS should correspond to samples of a similar real world scenario. For example, for any particular car trip the simulation should give the time when the last activity location was left, when the car was entered, how long it was driven, when it was parked and locked, and when the driver arrived at her/his next activity location.

This means that any replacement of local streets by other objects in TRANSIMS needs to be done in a way that quantities such as the above remain correct at least in some statistical sense. This immediately rules out to just move activity locations away from the local streets to the non-local streets since the driving time in the local streets would be neglected. It also suggests some structure of how such a study of the influence of local streets should be performed:

1. **Base case:** Run the whole TRANSIMS scenario using the network containing all streets, including the local ones.

2. **Reduced usim:** Run TRANSIMS modules on the full network, *except* for the micro-simulation, which now is run on some reduced version of the network. The assumption behind such a study is that collecting the data for a local street network may in the near future actually become considerably cheaper, while the computation on it will remain expensive. Also, the data necessary for running the micro-simulation is more expensive than the data necessary for running the other TRANISMS modules.

3. **Reduced usim and route planner:** Run TRANSIMS modules on the full network, *except* for the micro-simulation and the router, which are now both run on some reduced version of the network.

4. **Reduced everything:** ...

3 Quantities of interest

Quantities can be differentiated in *microscopic* ones, and *macroscopic* or *emergent* ones, although the distinction is not completely sharp.

3.1 Microscopic quantities

By microscopic quantities I mean traveller-based quantities. They do, at least in principle, already make sense when there is only a single traveller in the simulation. For such a traveller, one can report the time spent on each individual leg. For the purposes of the present study, we also need:

- Time spent on local part of network.
- Time spent in waiting queues when switching from local to nlocal network.

- How many people use local streets in the "middle" of the trip, i.e. as shortcut?

For analysis, one would probably aggregate these quantities. For example, one could note how much the average time (averaged over the whole population; or sub-populations) changes when one changes the representation of local streets.

3.2 Macroscopic quantities

By those I mean quantities that only emerge if one runs the full scenario. For example, levels of congestion can only be compared if the demand is sufficiently controlled. Quantities of interest include:

- Distribution of links by density, speed.
- Number of gridlocked links.
- Lost vehicles.
- Number of vehicles in simulation as function of time-of-day.

Some of this information can also be extracted from microscopic quantities. For example, congestion levels can be induced from travel times. This is the reason why the distinction between these two categories is not exclusive.

4 Base case

Quantities from the base case should be extracted in view of areas where results whould change if the local strets were removed.

4.1 Microscopic quantities

Here, the focus should be on the question if simulated quantities can be replaced (parametrized) by other quantities. One area of interest are thus the travel times on the local part of the street network. Questions include:

- Can these times be parametrized in terms of any other quantity, such as size of block, size of block group, length of local streets not represented, function of length (such as square root) of local streets not represented, length of the nearest arterial, etc.?
- What other quantities besides travel times should be looked at? Probably at least distance on local streets, speed on local streets, all the other data that can be collected in the current simulation output system.

- Find out if the speed is just the free driving speed time? If not, why not? Is it mostly time spent waiting in queues to enter the arterials (which could be simulated via parking accessories), or is there significant congestion inside the local streets areas?
- Resolve all of this by mode. E.g.: Local walking vs. local driving.

4.2 Macroscopic quantities

Macroscopic data I can currently think of needs to be extracted so it can be compared to the other cases. For that reason, I will treat it there. Other macroscopic quantities, that only show up if one really micro-simulates the local streets:

- How much congestion do we have in the local streets? Remember, congestion needs the usim for a correct dynamic representation. If there is congestion, would we assume that this is realistic?

5 Reduced usim only

Here, we assume that the planner operates on the full network, but the usim operates on a reduced network. There should be at least two tests: (i) run the usim on the same planset as before (which would need to be translated to the new network). (ii) run the routes iteration again, or, alternatively, start iterations from the planset of (i). It could potentially also cause differences for feedback into the activities, but first I don't think so, and second I don't think we understand the activities feedback process well enough in general to obtain useful results here.

One possible problem here is that trips could go through the local network also "in the middle" of legs. The router could in principle (via language constraint) be forced to avoid this, but this would have to be tested.

5.1 Microscopic quantities

One of the advantages of this approach would be that it would be easy to obtain estimates for time spent in the local network, assuming that no severe congestion happens there (see above). Nevertheless, it should be compared again

- how the microscopic quantities change for the same traveller between the approaches.

  Assuming that the local streets only generate free speed travel times, then the results from (i) should be close to the results from the base case.

  It is, however, not automatically true that (ii) generates the same results as (i). For example, feedback using realistic local streets usim could tend to avoid congestion in local streets, whereas without local streets in the usim this is no longer true.

5.2 Macroscopic quantities

The information here should be consistent with the information contained in the micro quantities. If local travel times can reasonably well be extracted from the planner, and the average difference between planned and simulted local ttimes (in the base case) was not too big, then there should be not much difference with congestion levels. Nevertheless, the quantities (see "Quantities" section0 should be monitored.

5.3 Usim computing times

Computing times of this version of the usim should be compared to two other times:

- usim run on full local network (see above)
- usim run on e2 network. Reason for this is that the "thinned out" allstr network will probably have many more nodes than the e2 network, and the question is how much influence this has on computing. If this number cannot be obtained: it is roughly 10 times faster than real time on 8 CPUs of gershwin.
- Also, in principle there should be a study that throws out nodes of degree two and see how much this changes quantities.

6 usim and router run on nonlocal network

Here, one now has to entirely rely on the aggregated quantities which result from the study of the base case. To be clean, one should run this on a case that hasn't studies before, i.e. on a different network. Otherwise, it is clear that the aggregates, whichever one is selected, will be reasonably good.

One of the problems to be solved here is where to put the households. On the "surviving" links closest to their original location? Or do we add virtual "centroid" links, this time from the household to the middle of each adjoining link? The latter has the advantage that at least some geographical information will survive – for example in situations where the bus is really close to some households but far away from others. (**) So there are at least two cases:

- Parametrize time etc. spent on local streets in the router.
- Do not do this (i.e. pretend the "non-local streets" household positions are the true household positions).

6.1 Microscopic quantities

Again, it needs to be checked how on an individual basis (RMS) the travel times change, how they change when separated by mode, by time in local/nlocal network. If they change significantly, use any statistical method to find out where.

Do trips in the average become longer? This could for example happen if households were just pulled to the next arterial, and more than half of the households end up farther away from their destinations. This is a result that could be obtained without running the usim.

Does mode choice change? (Example ($**$) above) Is this noise, or significant?

6.2 Macro quantities

How much does density in the simulation area go up as a result of this; how much does speed go down? (If trips are longer, vehicles spend more time on the road network, clogging it up more than before.) usim is needed for this.

7 No local streets at all

The additional problem one gets here is that one doesn't even know the locations inside the blocks any more – locations would sit on the non-local streets only. If this makes a difference depends on how household locations are chosen on the local streets. Are households distributed for example uniformely across area, or uniformely along existing links? In the latter case, where would be more households in areas with many local links – meaning that the household distribution changes when local links are removed.