

OPTIONS FOR SWITCHING MODES OF TRANSPORT IN VIENNA

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ABSTRACT

In city planning, simulation has often been employed for assessing the impact of regulatory decisions. One of the aspects that widely influence the development of a city is the use of different transport modes (motorized individual transport, public transport, pedestrian or bicyclist traffic). In the model we are going to present, we have looked into a reallocation of commuter traffic as means for building a walkable city. Holding commuters' origins and destinations constant, we built an agent-based simulation model in search for opportunities to switch modes of transport. We utilize real network data together with municipal census data (commuters living and working in Vienna, differentiated by transport modes). Our results show possible ways towards sustainable transport mode usage. Being already feasible today, its implications are interesting well beyond the borders of our chosen area.

Keywords: agent-based modeling, traffic simulation, walkable cities, commuter traffic

1. INTRODUCTION

Commuting is an everyday reality for most people nowadays. The key problem is that sustainable infrastructure (bicycle lanes, public transport) that supports people in their daily travel to and from work is not always available, due to the fact that city planning has long evolved around the private car as primary transportation means. This is a pity, because there are multiple transport modes to choose from. In our model, we show that by using a simple approach of mode change, people can get faster to work (and back again) even if residential and workplace locations are distributed as today. Take, for example, the situation shown in Figure 1: a commuter going by car travels along the node network of a city, which takes a defined time. By evaluating additional choices, here: first the alternative route via foot (no decrease in travel time) and then via public transport followed by egress (decrease in travel time), the commuter can decrease his time spent in traffic and at the same time contribute to form the walkable, decarbonized city.

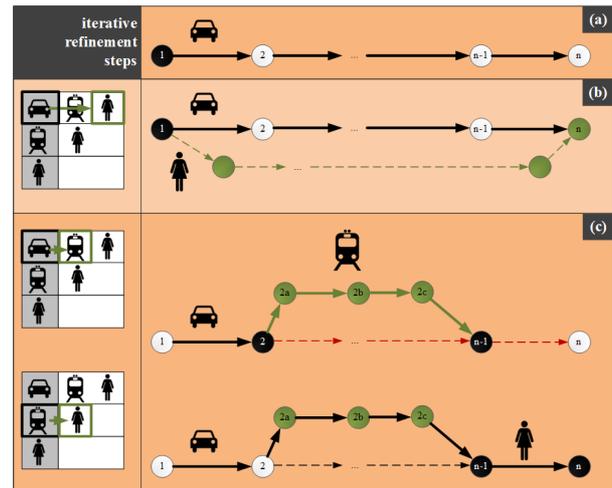


Figure 1: Optimisation of Paths via Mode Switch Evaluation. An initial route by car is first substituted by a pedestrian connection, with no success (increase in travel time). At the next node, a preferable route is found which first uses public transportation before resorting to egress by foot. Note that the choice of subsequent transportation means is done via a look-up-table, as shown left in the graphics.

2. MODEL DESCRIPTION

Our model is based on a directed graph, with allowed modes being attributed to the edges (public transport, motorized individual transport, pedestrian or bicyclist traffic). Furthermore, we attribute maximum speed limits and metric length to each edge. These two characteristics form the weight used during path finding (weight = length / speed).

We have imported this network information into a Netlogo 3D model (Wilensky 1999) extended by a plug-in for shortest path inquiry. Arrival data is loaded from spreadsheets, obtained from municipal census data on commuters from 2009 (Statistics Austria 2009). In more detail, this takes the form of a matrix, in which traffic between each two zones of the city is given as the number of commuters per transport mode. The network itself is imported from GIS-Data, available from the Viennese transport model of the city of Vienna (Magistrat der Stadt Wien 2012).

The progression of our simulation model is as follows: In the first step, commuters are distributed to a random vertex within their residential zone. This vertex

needs to be attached to the circulative network required by the commuter (public transport, motorized individual transport, pedestrian-, or bicycle network). Likewise, a target vertex is selected in the destination zone. Using the described weights on the edges of the network, the commuter now determines his initial shortest path, the duration of which is taken as a baseline. If every commuter acts in this way, we have our first model, the baseline model.

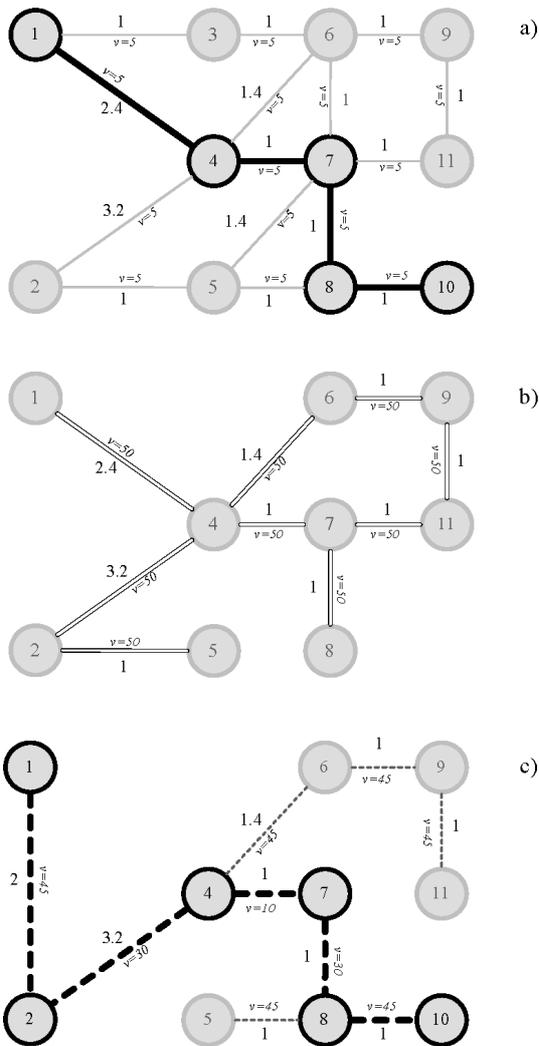


Figure 2: Sample Transport Network Graph for a) pedestrian circulation b) public transport c) motorized individual transport. Highlighted in black: shortest path between nodes 1 and 10.

An example is given in Figure 2: Let us assume that a commuter is to travel from node 1 to node 10. Then, we can look at the graph corresponding to the initial mode choice – pedestrian transport (Figure 2a), public transport (Figure 2b) or motorized individual transport (Figure 2c). Note that we have left out bicycle traffic, as this is largely identical to pedestrian transport except the higher velocities at the edges. For pedestrian and individual transport, there is a suitable route,

whereas there is none for the case of public transport. Thus, we can see that the latter is an intermediate choice, which cannot always be properly reflected if we consider a fixed model only, without the use of mode change. A solution to this problem would be to define catchment areas, which we have implemented as straightforward solution. However, we are more interested in the true reallocation of commuters, which we show in due course.

In our reallocation model, we seek to optimize the initial travel time by examining the alternative transport options at each node of the so-far selected path. Starting with the initial node, we subsequently try alternative means of transport as given by the mode of transport switching in Table 1:

- For each mode, there are allowed next modes to try
- A route is optimized by an agent situated at a current node. This agent examines if there are alternative routes with the allowed next modes, in the following manner: if an alternative path from the current node exists that meets the so-far planned route again, the agent switches his transport mode and takes the new route. In case that the last current node is not the destination node of the route, the agent iterates this process: he examines the mode of transport switch table and takes one of the allowed next transportation means in order to arrive at his final node.
- Once the agent is at his destination node, the travel costs of the alternative route are compared to the initial ones. In case there is a benefit, we accept this as new solution. In all other cases, the agent back-tracks to the node at which the fork was conducted. He then continues to the next node along the hitherto existing route and tries again.

Table 1: Mode of Transport Switch Opportunities: an agent entering in a current mode may choose the allowed next modes in the order defined when optimizing his path.

Current Mode	Allowed Next Mode
individual transport	public transport, pedestrian
public transport	pedestrian
pedestrian	pedestrian

The example in Figure 1 shows exactly this case: A given route by car is first optimized by finding an alternative public transport connection, then, a pedestrian path is searched. As there is no public transport available at that node, the agent goes on to determine a pedestrian route, but fails (no benefits), thus, he has to backtrack and advance to the next node. At this node, there is the opportunity of public transport. The agent (now in public transport mode) takes it and arrives at an intermediate node, which is not his final

destination. Thus, he consults his mode of transport switch table again and finds that there is the possibility to switch to pedestrian mode for reaching the final goal. The total path taken turns out to be of lower cost than the initial one and is accepted as the optimized solution. Figure 3 gives a merged view of all three networks presented in Figure 2, in which the optimized path is shown. The initial route by car went from node 1 over nodes 2, 4, 7, 8 to 10. The optimized route consists of a switch to public transport for travelling the nodes 1, 4, 7, 8 and after that, to pedestrian transport for reaching the final node 10.

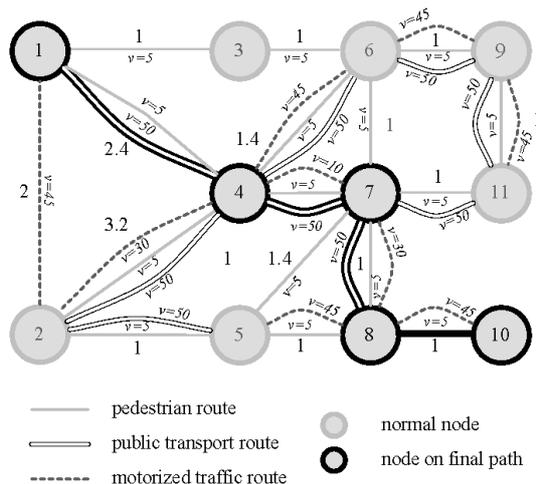


Figure 3: Optimization of paths by switching mode of transport. The highlighted black edges display the optimized path from nodes 1 to 10.

3. DISCUSSION

Average speed values (e.g. pedestrians' speed is 5 km/h, car speed varies according to traffic and congestion) together with segment lengths are used to obtain travel time estimations for found routes. Clearly, this is a snapshot of a situation that corresponds to "interesting" time spans. We could easily make this model more dynamic by importing time series instead of static speed values; however the availability of such data is really the key issue here (future work).

Also, we employ catchment areas for determining when an agent can cross over into another form of transportation. These are of different size (public transport catchment areas are necessarily far greater than for example pedestrian network access radii). However, the radii can also change within one network, which we have still not taken into account.

4. PRELIMINARY RESULTS

We have implemented our approach as a Netlogo 3D simulation in order to test its feasibility on real data (transport networks of Vienna). The results are two-fold: First, we can show that route finding does not simply behave as shortest path problem when looked at from the viewpoint of time and speed (see upper part of Figure 4). Second, we can graph the transport network utilization in each zone for both the baseline model and

the reallocation model, in order to be able to visually compare the predicted commuter volumes. Work on the latter has, however, just started (see lower part of Figure 4).

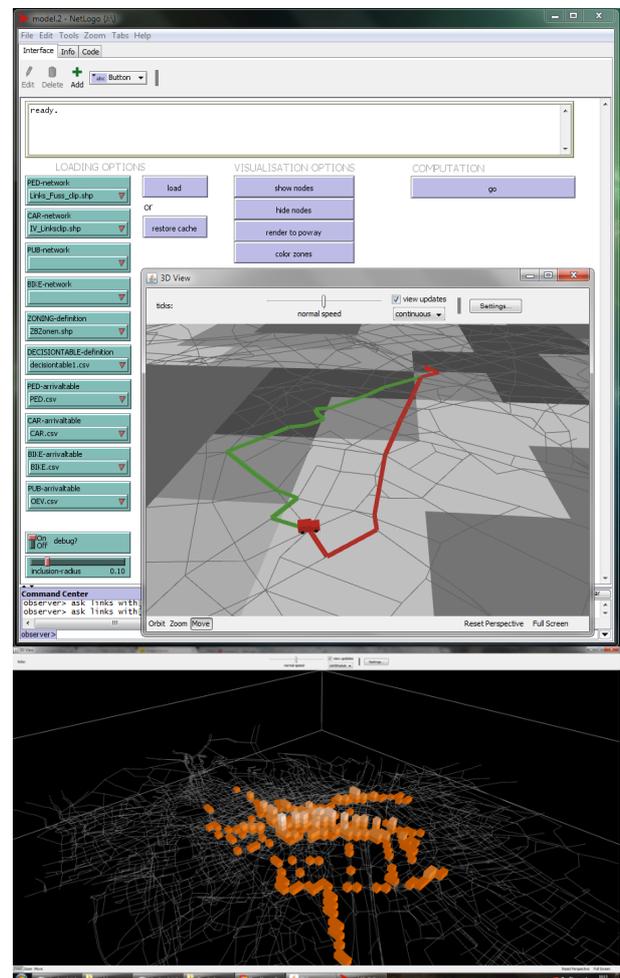


Figure 4: Preliminary implementation. Upper part: Route optimization of an agent traveling by car (red) into a pedestrian route (green). Lower part: Intermediate stage of the simulation, showing utilization of transport in zones.

5. REFERENCES

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