MATSim Special session

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Subject: MATSim simulations in the Tel Aviv Metropolitan Area: Direct competition between public transport and cars on the same roadway

Extended Abstract

The Israeli road network is still car-oriented. In the Tel Aviv metropolitan area there are 147 km of dedicated bus lanes. Compared to other metropolitans around the world, we see that Tel Aviv is miles behind (Bocher, 2014). Simulation of the Tel Aviv traffic demands comprehensive processing of the car and public transport (PT) competition on the same roads.

MATSim possesses the ability of simulating concurrent use of the road network by PT and private cars, but this ability remains unexploited. However, vast majority of MATSim simulations ignore competition between private cars and buses for the same network (Horni, Nagel, & Axhausen, 2016). Our application focuses on calibrating MATSim for this purpose. The goal of the this calibration is to apply MATSim for predicting the effects of transportation network changes in relation to the Light Rail (LRT) construction in the Tel Aviv metropolitan area (TLV below) that started in 2014 and will continue until 2021.

Transportation in the Tel Aviv metropolitan area

The investments in the PT network in TLV are far below the necessary level (Figure 1) and bus trips share is major among the modes of TLV PT (Table 1) (Nir et al., 2015).

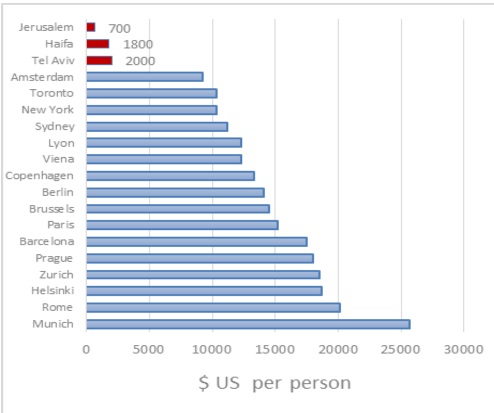


Figure 1. Investment in PT per person (Nir et al., 2015)

Buses and private cars compete for the same road space in TLV. This is possibly the reason that the only two existing MATSim applications in Israel have ignored PT and focused only on private car traffic. Bekhor et al. (2010) created a synthetic TLV population of car users using the generator of the "Tel Aviv activity-based model" (Cambridge Systematics, 2008) and applied it on EMME2-based road network for TLV that is used for metropolitan transportation planning. Dobler & Horni (2014) enriched the application by including a toll road #6 and enabling agents re-planning abilities to include destination choice.

Table 1 – Mode share for daily travelers in TLV (Amir, 2010)

Area	Bus	"Taxi Service"	Train	Total
Inner circle	150,000	25,000	-	175,000
Inside the Tel Aviv Metropolitan	265,000	25,000	30,000	320,000
Outside of the Metropolitan Area	25,000	5,000	30,000	60,000
Total	440,000	55,000	60,000	555,000

Motivations

(1) To extend the TLV MATSim application by including all currently available and projected modes, with an emphasis on bus, train and paratransit.

(2) To validate the TLV MATSim application with the LRT construction examples.

Current State of the TLV MATSim application

The data on the TLV road network are supplied by "Netivey Ayalon" LTD, the agency responsible for the maintenance and updating of the metropolitan model.

The current road network contains 13,109 links and 5,152 junctions. The transit module contains all transit lines operating inside the TLV area. A dozen of operators that are active in the area exploit 1,151 transit lines (1,122 Buses and 29 Trains) that have 6,013 stops. Figure 2 presents the view of entire TLV network at 06:00, while Figure 3 presents the state of the system at 07:00, when many buses are running, and at 7:30, with a moving train.

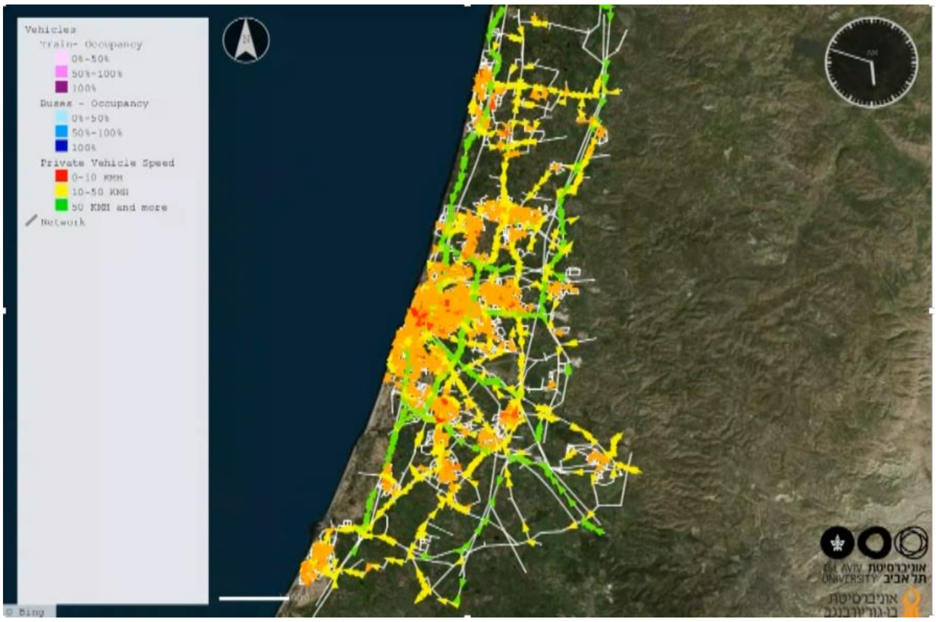
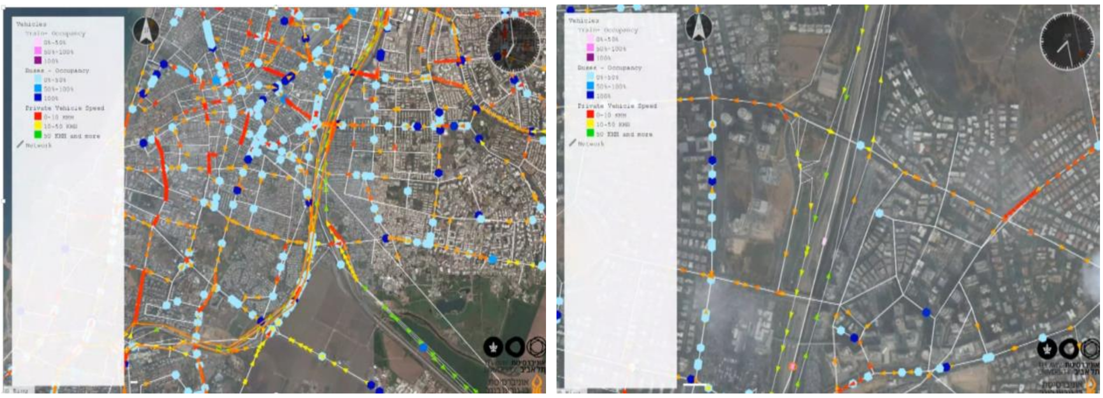


Figure 2. General view of the TLV transportation network, 06:00



a b

Figure 3. (a) TLV transportation system at 07:00 (many buses running) and (b) at 7:30, with a train running.

Problems of public transport scalability

A typical MATSim scenario uses a 10% population sample, and consequently 10% of the original private car fleet. To reflect the system for 100% of users, MATSim modifies several basic parameters of the traffic flow queue model (Rieser et al., 2014), the most important being flow capacity and storage capacity:

$$flow\ capacity = \left(\frac{capacity\ value\ of\ link}{capacity\ period\ of\ network}\right) \times flow\ capacity\ factor$$

$$Storage\ capacity = \left(\frac{length\ of\ link \times\ number\ of\ lanes\ of\ link}{effective\ cell\ size}\right) \times\ storage\ capacity\ factor$$

The above scheme works well either when only private cars are simulated, or when private cars and PT vehicles are simulated on separate networks. However, mixing PT vehicles and private cars in one traffic stream dominated by the latter ones turns out problematic.

Specific issues include:

- The number of the PT vehicles cannot be reduced proportionally to the percentage of travelers participating in the scenario, as conducted with private cars: The use of 10% instead of 100% of buses would reduce the frequency of buses 10-fold.
- As a result, the size of the PT vehicle should be scaled down proportionally to the reduction of the flow/storage capacities. MATSim contains a solution to resolve this issue – the PCE value (Passenger Car Equivalent) that proportionally reduces the size of different vehicle types, but the influence of the PCE on the model output has not been extensively investigated.
- Traffic simulation of a 10% sample exacerbates congestion as traffic flow is not so fine-grained anymore. Because private cars can change their route to avoid congestion, while PT vehicles must follow fixed routes, it is the PT vehicles that are mostly affected by scenario down sampling.

Problems of public transport scalability in the TLV scenario

To investigate the MATSim abilities for the case of the concurrent use of the roads by private cars and PT, we investigated a 10% population scenario and full PT fleet and schedule for morning hours. To scale down the traffic flow model properly, we used the following parameters:
$flow\ capacity\ factor = 0.1$,
$flow\ capacity\ factor = 0.18$
(Nagel, 2016a), $PCE\ CAR = 0.1$ (Nagel, 2016b) (size remains the same, but the amount of cars is reduced 10 times), $PCE\ BUS = 0.3$ (instead of 3.0, which is the original bus PCE; the PT fleet size and PT schedule remain the same). The concurrent use of roads by private and PT vehicles results in essential and unrealistic bus delays in this scenario (Figure 4).

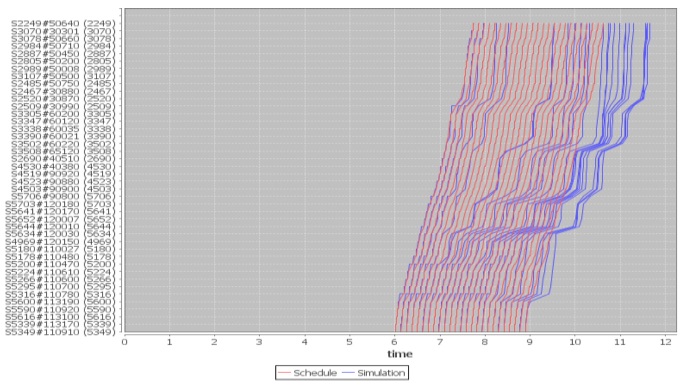


Figure 4. TLV 10% scenario, route-time diagram: The unrealistic 2-hour delay for Dan line #63 in the model (blue) relative to the transit schedule (red)

To explain the delay, Figure 5 presents a MATSim snapshot of link 2822 consisting of 51.6 vehicles/hour capacity that is simultaneously used by cars and several bus lines. As one can see, when buses of several lines entered this link after the private car (shortly before 06:19), the flow capacity of a link is overused and the buses cannot leave it for long.

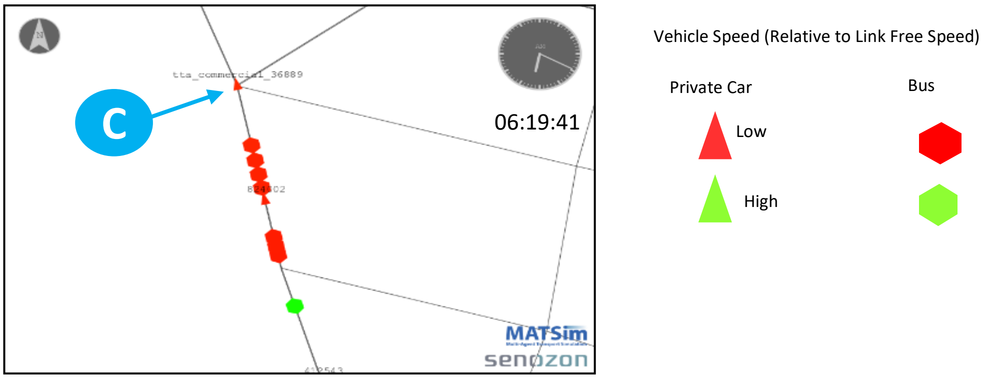


Figure 5. Private car C (corresponding to 10 real cars) leaves the link at 16:19:41. Until then, 7 buses that entered the link between 06:16:32 - 16:19:41 are bunched and cannot leave it.

Possible solution of public transport scalability in the TLV scenario

To resolve the problem of unrealistic bus delays, we modified the queueing model of the mobility simulator (QSim), by allowing the buses to ignore the link flow capacity restriction[1]. Only private cars (in contrast to buses) are kept on the link until its flow capacity accumulator recovers. As a result, when the private car leaves the link, the buses directly behind it can immediately move over the intersection (provided that there is enough space for them on the next link). Figure 6 illustrates this solution for the traffic situation on same link 2822.

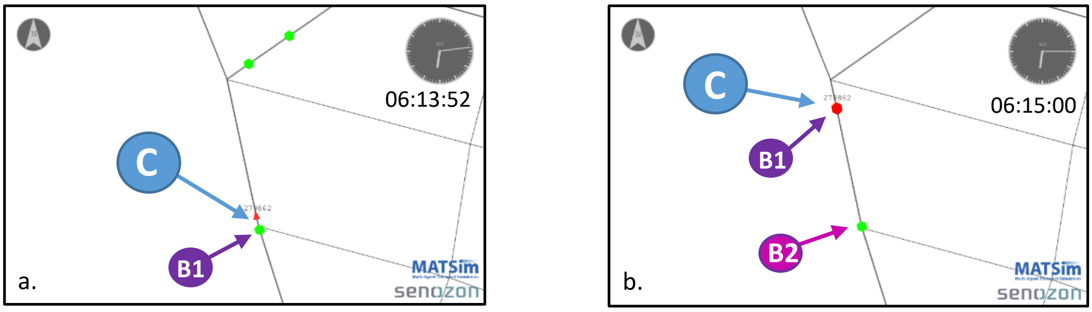
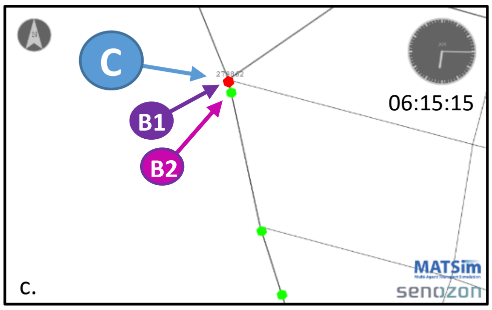


Figure 6. Traffic on the link 2822 for the modified QSim, 10% scenario: (a) Private car C enters the link at 06:13:52, bus B1 is about to enter the link a moment after; (b) Bus B2, enters the link at 06:15:00, B1 caught up C (that is obscured by B1); (c) private car C is about to leave the link at 06:15:15 and this will immediately release B1 and then, very soon, B2.



[1] The corresponding changes to the MATSim's QSim code can be viewed here: https://github.com/matsim-org/matsim/pull/55

We are currently investigating the consequences of this solution and its effectiveness. The results will be presented in the paper.

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