HYBRID MESOSCOPIC-MICROSCOPIC TRAFFIC SIMULATION

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Abstract

Traffic simulation models have become an important tool for modelling the operations of dynamic traffic systems. While microscopic simulation models provide a more detailed representation of the traffic process, are macroscopic and mesoscopic models able to capture traffic dynamics of large networks, in lesser detail, but without the problems of application and calibration of microscopic models. In this paper we present a hybrid mesoscopic-microscopic model that is able to apply microscopic simulation to areas of specific interest, while being able to simulate a large surrounding network in lesser detail with a mesoscopic model. We identified which requirements and conditions have to be met for a hybrid model to be consistent and applicable. The requirements vary from network and route-choice consistency to consistency of traffic dynamics at the boundaries of the micro and meso submodels. An integration framework is developed that satisfies the stated requirements, and a prototype hybrid model is constructed using the MITSIMLab microscopic and the newly developed Mezzo mesoscopic models. In a small case study some of the aspects of consistency of traffic dynamics across submodel boundaries are demonstrated.

Keywords: Traffic simulation; Traffic models; Mesoscopic; Microscopic; Hybrid; Integrated
Topic Area: D Transport Modeling

1. Introduction

Traffic simulation models have become very popular for modelling the operations of dynamic traffic systems. Different traffic simulation models can be classified as macroscopic, mesoscopic or microscopic. Macroscopic (macro) models tend to model traffic as a continuous flow, often using formulations that are inspired by gas-kinetic flow or hydrodynamic flow equations. Mesoscopic (meso) models tend to model the individual vehicles, but describe their behaviour in a simplified manner, on an aggregate level. A common way is to describe the vehicles' speed by using a speed/density relation that assigns an average speed based on the density of traffic ahead of the vehicle. Microscopic (micro) models capture the behaviour of vehicles and drivers in much more detail, which makes them appropriate for evaluation of Intelligent Transportation Systems (ITS) systems at the operational level. For instance the modelling of many adaptive traffic control systems depends on such fine-grained modelling of the traffic process, as well as the modelling of drivers response to incidents and the functioning of merging sections. When evaluating more complicated issues such as ITS, which often build on advanced information and control systems,

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micro simulation stands out as the only tool with which such situations may be reliably reproduced.

However, the application of micro simulation has not been without problems. Due to the detailed nature of the models, the input data such as network coding needs to be equally detailed so that even details of the traffic situation are reproduced faithfully. In addition, micro models have proved themselves highly sensitive to errors or variation in input demand data. Finally, partly due to the named sensitivities and due to the complicated structure of most behavioural models incorporated, the parameters of the models are notoriously difficult to calibrate. All of the named problems seem to grow proportionally with the size of the network modelled. On the other hand macro and meso models have fewer parameters to calibrate than micro models and are less sensitive to errors in network coding details or demand variations. However, due to their more aggregate nature, such models are limited in their ability to capture the detailed behaviour needed to study traffic networks with dynamic traffic management capabilities.

The objective of the paper is to present an integrated approach to hybrid meso-micro simulation modelling of traffic flows. The hybrid model has the advantages of both types of simulation models since it combines high fidelity micro simulation in specific areas of particular interest, with meso simulation of a large surrounding area. This enables the study of network effects of local micro phenomena, while increasing the accuracy and validity of micro simulation and reducing the required data collection and model calibration effort.

The remainder of this paper consists of a section introducing an overall integration framework that captures the requirements and conditions that a hybrid micro-meso model needs to satisfy, as well as an integration architecture that specifies how these requirements are met. In the last section we present a small case study with a working prototype hybrid model, where the applicability of the integration framework is demonstrated.

2. Meso-micro integration framework

An important aspect in developing a hybrid meso-micro traffic simulation model is the definition and implementation of conditions for consistent interfaces between the meso and micro simulation components of the simulation model. These conditions range from structural compatibility issues in terms of modelling traffic flows in the two models, to modelling synchronisation and compatibility of route choice.

Previous studies of dynamic hybrid models include Micmac (Magne, L. *et al.* 2000), Hystra (Bourrel, E. & Lesort, J.-B. 2003), (Bourrel, E. 2003), and Micro-Macro link (Helbing, D. *et al.* 2002). These models combine dynamic macro with micro simulation. They focus on compatibility issues between the micro and macro models that arise from combining two models that represent traffic flow in a different way. The macro models represent traffic as continuous flows, while the micro models represent individual vehicles. The proposed approaches address the problem by deriving a micro model from the macro differential (gas-kinetic) equations. However, this may limit the capability of the model since the micro-macro equivalence usually only holds during steady state flows and important aspects such as lane-changing may not be captured. Furthermore the approach may constrain the type of car following models that can be used. In this paper the focus is on the integration of meso with micro models. Since meso models represents flow as individual vehicles the above problem of aggregating/disaggregating the flow is not an issue.

2.1. Requirements for integration

Based on these considerations, our approach is to establish universal integration issues and conditions, and to develop a functional prototype hybrid model in which they can be evaluated and tested. In this section we will try to outline the different requirements that need to be met.

2.1.1. Consistency in route choice and network representation

One of the most basic conditions is general consistency of the two models in their representation of the road network, paths, and route choice. The route choice needs to be consistent to ensure that vehicles will make the same decision given the same choice situation, regardless if they are in the micro or the meso model. This means also that the representation of the road network needs to be made consistent throughout the hybrid model, as well as the travel times (link costs). As we will see later on, this is not trivial to achieve.

2.1.2. Consistency of traffic dynamics at meso-micro boundaries

Besides the consistency of network representation, the consistency of traffic dynamics at the boundaries from the meso to the micro submodels and vice versa needs to be ensured. This means that traffic dynamics upstream and downstream of the boundaries need to be consistent. For instance, when a queue is forming downstream of the boundary point, and grows until it reaches and passes the boundary, it should continue in the other submodel, upstream of the boundary, in a similar way as it would if the boundary had not been there.

2.1.3. Consistency in traffic performance for meso and micro submodels.

The two submodels need to be consistent with each other with regard to the results they produce. Ideally, given the same network and demand data, one would like the two submodels to produce the same results (such as travel times, link speed, flow and density). However, the reason for combining the meso and micro models is the fact that each model type has its own strengths and weaknesses, and thus that the models may produce different results given the same network. In addition, the micro model produces results (such as vehicle trajectories) that cannot be produced by the meso model, and thus not compared. We therefore define the following condition on submodel similarity:

For those facilities that can be simulated sufficiently well by both models, the models need to produce (nearly) the same results on the meso level of aggregation.

Meso models produce aggregated results such as link travel times, flows, speeds and densities. Thus, the models should be compatible with respect to these measurements, at least on facilities that do not require the specific detail found in micro models.

2.2. Integration architecture

In this section we discuss different ways to meet the requirements we defined for a consistent hybrid meso-micro model. For a consistent hybrid model, some components should be common for both submodels. The route choice component should be shared by both models, and it should operate on the complete network graph, including both the micro and meso areas. Also, the paths will be defined over this generalized network graph, and the link travel time database needs to be generalized over the whole network.

More specifically, there is a need for a common module, outside the meso and micro models, that contains on the one hand a database with the network graph, the travel time tables and the set of paths, and on the other hand a behavioural component that takes care of the route choice. (See figure 1).

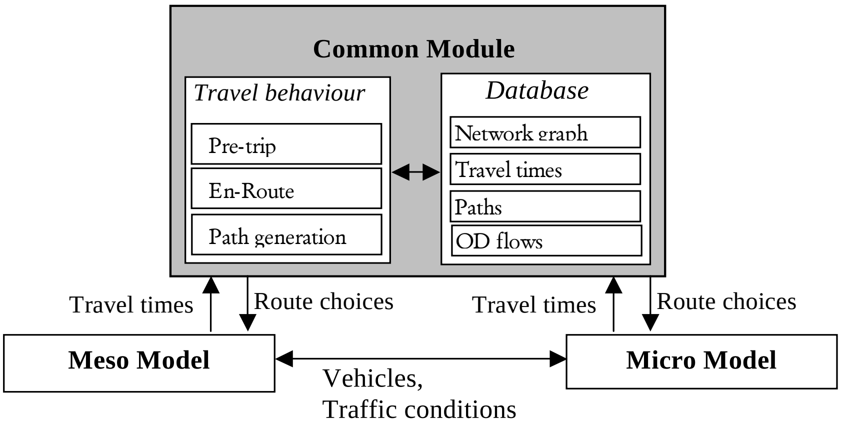


Figure 1. Integration Archtecture

In figure 1 the proposed integration architecture is presented. The common module contains on one hand a behavioural component that contains the path generation and route choice algorithms (en-route and pre-trip). This route choice and path generation module operates using a database that contains the network graph, link travel times and known paths for the entire network. Both the micro and meso models supply descriptions of their subnetworks, from which the network graph is constructed. Each time a vehicle makes a route choice (whether it is in micro or meso), the common module is consulted. For the common route choice module to operate properly, the meso and micro models need to update the travel time database regularly with the link travel times in their subnetwork. The meso and micro models need to communicate with each other to hand over vehicles that cross the boundaries, and inform each other of traffic conditions downstream of the boundaries, so that traffic upstream can react to these. If a hybrid meso-micro model were to be developed from scratch, this architecture would be applicable, but in the case of combining existing models (or in our case one existing with one new model) this architecture would incur large amounts of inter-model communication, and important changes to the model structure.

2.2.1. Consistent network representation

An important step in the consistent route choice is the formation of a consistent network representation from the meso and micro subnetworks. Problems arise from the level of detail in which micro and meso subnetworks are coded. Networks for micro simulation include usually (almost) all roads in the area of study. On the other hand, meso networks are usually much larger and include only a subset of the roads in the study area. When these networks are combined into a general network graph there are two problems.

First there is a problem in connectivity (See figure 2). Each road that crosses the boundary between the meso and micro area, needs to be present in both (sub)network representations. How should one connect the many small roads in the micro area to the few large roads that are in the meso area?

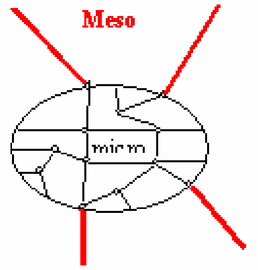


Figure 2. Problem connecting many micro to a few meso links

A practical solution to this problem may be to increase the level of detail in the meso subnetwork where it connects to the micro subnetwork, and maybe decrease the level of detail in the micro subnetwork, near the boundaries with the meso one.

The second problem in consistent network representation is that of the representation of capacity that is inherent in the detail of network representation. In the meso network representation, *only* the larger roads are present, whereas the micro network – when applied to the same area – would include *both* the larger and the minor roads (See figure 3). This means that the capacity that is represented by both networks is different. In a hybrid model, when we replace a certain area in a large meso network with a micro representation (which will include an additional set of minor roads), we effectively increase the capacity of this area, relative to the remaining meso network. In terms of assignment, this will mean that the number of routes through the area that is now micro will increase compared to the all-meso case. This, in turn, will *increase* the amount of traffic that is assigned on routes through the micro-area, and *decrease* the amount of traffic assigned to routes that go outside of this area.

So in general, adding more detail to only a certain part of the network will result in a skewed traffic assignment.[1]

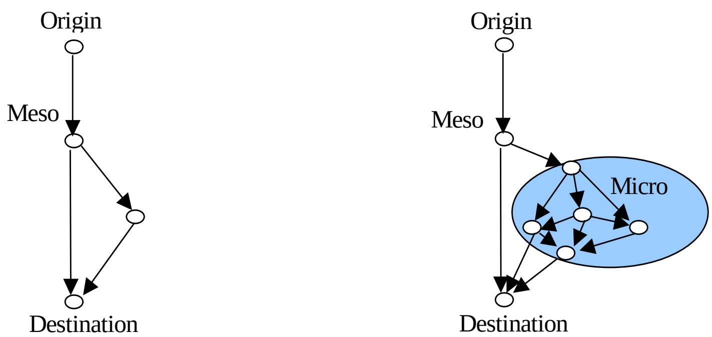
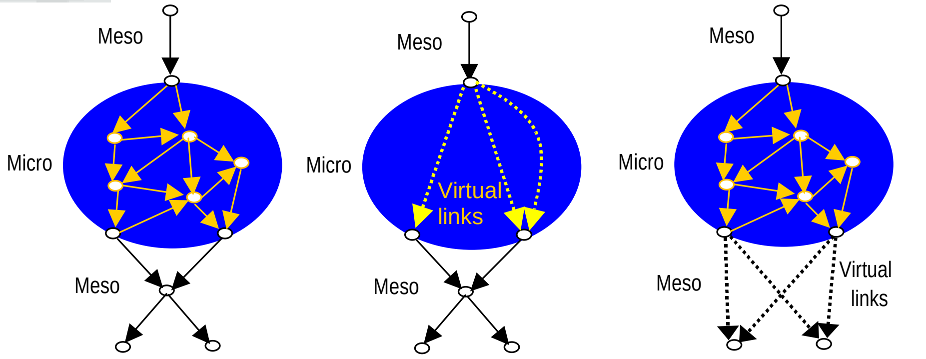


Figure 3. Level of detail in network representation. Left: meso only. Right: meso with micro sub-area.

2.2.2. Consistent Route Choice

In order to provide the entire model with consistent route choice behaviour, we need to generalize the route-choice to the level of the meso network. This means that we need to find proper abstractions of the paths in the micro area and represent them in the general network graph. We decided to represent each *(sub)path that is used* in the micro subnetwork by a *virtual link* in the meso network description (See figure 4 a, b).

[1] This is also true for single-model traffic simulations when the area of interest is coded in more detail than the surrounding (buffer)network



(a) The Entire network.(b) Meso Virtual Links (c) Micro Virtual Links
Figure 4. Virtual Links in Meso and Micro

This solution guarantees that each relevant path through the micro model is represented correctly in the meso route choice. The meso model can also collect travel times for the virtual link, and use them in the route choice like any other link in the network. Since each relevant subpath in the micro area needs to be enumerated (as virtual link in the meso network), these paths need to be determined prior to the simulation. When these subpaths are found, the micro pre-trip route choice will be disabled, since each vehicle that enters the micro area now already has a subpath that corresponds to the virtual link in meso.

While the pre-trip route choice in the micro model can be eliminated using the virtual links in meso, the en-route route choice cannot be done entirely by meso, since it has no knowledge of the exact micro network topology. Different approaches can be taken to include proper en-route route choice over the entire hybrid model. One way is to extend the notion of virtual links by adding *micro virtual links* to the micro subnetwork (see figure 4c). Each path from an exit point in the micro network to a destination in the meso network is represented by a virtual link in the micro model. This is important since a change of route for a vehicle in the micro sub-network can effectively mean a different exit point into the meso network.

This way there is at the more abstract meso level a complete description of the network, with virtual links in meso representing the subpaths in the micro area. On the other hand, since each path is predetermined, the pre-trip route choice in the micro model can be eliminated. On the other hand, the virtual links in micro provide the possibility of en-route diversions in the micro-area.

This allows us to simplify the Integration Architecture considerably. (See figure 5)

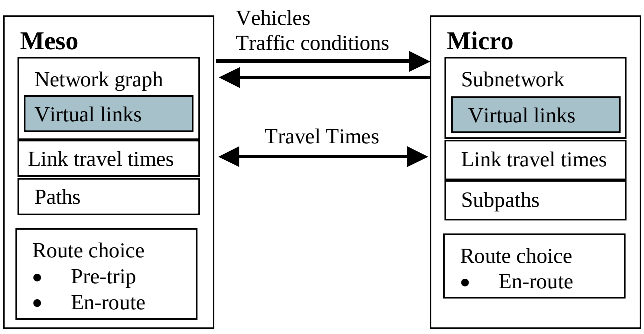


Figure 5. Simplified Integration Architecture

Due to the simplification that the virtual links allow, we can now have all the common components such as route choice and the database with the network graph, link travel times and paths *inside* the meso model. This simplified architecture has a number of practical advantages compared to the initial one. While the initial architecture would be preferable in case a new meso-micro model were developed from scratch, it would require large amounts of communication overhead when combining two existing models. Because in the simplified architecture the meso model takes care of the (pre-trip) route choice, and the subpaths in the micro model are predetermined, a large portion of the communication overhead is removed. Only vehicles and traffic conditions need to be communicated by the models. In the case of small micro areas, where changes of subpath and exit node are not realistic, the virtual links in micro and en-route choice module in micro can be eliminated as well, further reducing the communication needs. Since the complete network representation, paths and route choice are within the meso, it makes sense to have even the demand matrix (OD matrix) within meso. In this case all origins and destinations need to be within the meso area. This means that if there is a need for an origin or destination *inside* the micro area, this should be represented by a boundary node, which functions as an origin or destination in meso.

2.2.3. Consistency of traffic dynamics at meso-micro boundaries

The aspect that has received the most attention in limited literature available on hybrid simulation models is the way the two submodels are interfaced. In most cases the discussion focussed on aggregation / disaggregation issues between the macro and micro representations of traffic (Helbing, D. *et al.* 2002),(Magne, L. *et al.* 2000),(Bourrel, E. & Lesort, J.-B. 2003),(Kates, R. & Poschinger, A. 2000). In our case these issues are avoided by integrating two models that both have a vehicle-representation of traffic flow. However, other issues concerning the interfaces between the models remain. We will discuss first those issues concerning the interface from meso to micro, followed by the micro to meso boundary issues.

From meso to micro

On the boundary from the meso to the micro submodels, a number of conditions need to be met. Information is flowing in both directions: from meso to micro information about vehicles (with a certain speed and at certain time intervals) needs to be communicated; from micro to meso information about blocking of boundaries and downstream density needs to be communicated. If the entry to the micro link (downstream of the boundary point) is blocked, for instance because a queue has backed up to the boundary, the meso needs to stop vehicles from exiting the upstream meso link. The micro model informs also when the blockage is removed and vehicles can start flowing (over that specific boundary) from meso to micro again. When a blockage is removed (for instance when the queue front has reached the boundary), the density in the vicinity of the boundary is communicated to meso, where it is used to calculate the propagation speed of the shockwave that continues in the meso. A more complicated issue is the generation of information that is needed in the micro representation of traffic, but missing in the meso one. While vehicles are represented individually by the meso model, they do not have the detailed characteristics needed in the micro model. Therefore these characteristics need to be created at the meso to micro boundaries. The micro characteristics that need to be generated at the entry to the micro model can be divided into vehicle/driver *attributes* and *model variables*. Attributes such as desired speed and the critical gaps for lane-changing can be generated independently from the traffic situation upstream and downstream of the boundaries. However, model variables, such as the vehicle’s speed, acceleration and time headway to the vehicle in front need to be *in accordance with the traffic situation upstream and downstream of the boundary*.

The variables that need to be assigned values at the entry of a vehicle from the meso into the micro models are usually: lane, time-headway to the vehicle in front, speed and acceleration. From the meso model the time-headway is determined, but not the speed, acceleration or lane. Based on the type of vehicle and the continuation of the vehicle's route, a set of candidate lanes is constructed, where all lanes that are disallowed for the vehicle (E.g. bus-lanes) or not connected to the continued path (so that an immediate lane change would be required), are taken out. From the candidate lanes the lane with the largest headway (space) is selected. At this point the time headway and lane are known, but not the speed and acceleration. In (Burghout, W. *et al.* 2004) the subject of speed generation is discussed in detail and a new model for speed generation is proposed.

The speed of a vehicle is determined according to the following regimes:

- Regime 1 (bound traffic): $0.5 < t_h <= 2.5$ seconds
  - o $V = V_{front}$
- Regime 2 (partially bound traffic): $2.5 < t_h <= 7.5$ seconds
  - o $a = (t_h-2.5)/(7.5-2.5)$
  - o $V = a*V_{desired} + (1-a)*V_{front}$
- Regime 3 (unbound traffic): $t_h > 7.5$ seconds
  - o $V = V_{desired}$

Where t_h = time headway (s)
V = speed (km/h)
V_{front} = speed of vehicle in front (km/h)
$V_{desired}$ = desired speed (km/h)

This 3-regime algorithm was also compared to measurements of speeds and timeheadways on an urban freeway in Stockholm. The measurements show high correlation of speeds between consecutive vehicles on the same lane, in the case of small headways. This correlation decreases with increased time headways, and beyond 7.5 seconds remains at a constant low level. This supports the relevance of the method, and suggested the break-off points of 2.5 and 7.5 seconds between the three regimes.

In almost all micro models, an initial acceleration rate of 0 m/s^2 is assigned to the vehicles that enter the network. While it may be possible to assign different values, it is difficult to obtain experimental data with standard equipment (as opposed to time headways and speeds). In the future this kind of data may be available (as point-data, together with the time headways and speeds), and equivalent an algorithm may be developed that assigns non-zero accelerations based on the time headway and speed of the vehicle in front. At this moment, with a sufficiently good algorithm to assign initial speeds, the assignment of zero acceleration seems to suffice for our purposes.

From micro to meso

In the interface from the micro to the meso model, the same kind of conditions need to be met as mentioned in the meso to micro case. In the first instance the meso needs to inform the micro each time the downstream meso link becomes blocked or unblocked, so that the micro model can stop / start sending vehicles at the right moments. In addition to the blocking, the vehicles in micro that move towards the exit to meso, need to react to the downstream traffic conditions, as they would if the downstream link were micro as well. In that case, the vehicles would react to vehicles in front, using their car-following logic, and those vehicles would react to vehicles in front of them, etc. In the meso model, however, the position and detailed behaviour of vehicles is not usually modelled. But it is known when the latest arrival of a vehicle was, and the (average) speed it was assigned. Using this information a *virtual vehicle* is projected in the continuation of the micro link, and vehicles in micro that are near the exit *react to the virtual vehicle*, as if it were a normal vehicle in front of them (See figure 6). This idea can also be found (in a slightly different form) in ((Bourrel, E. & Lesort, J.-B. 2003)and (Magne, L. *et al.* 2000)). An obvious refinement would be to have each lane have its own virtual vehicle.

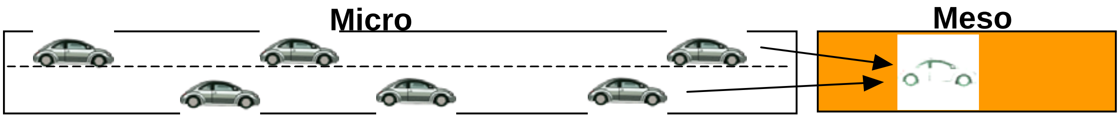


Figure 6. Exiting vehicles in micro follow virtual vehicle

3. Case study

We will demonstrate the various issues and conditions addressed in the previous section with a small case study. The focus of the case study is to look in more detail at the traffic flow representation consistency. For this case study two simulation models are integrated: MITSIMLab (Mitsim) and Mezzo. MITSIMLab is a high fidelity micro model, which has been applied in a number of studies, and has been calibrated and validated in both USA and Sweden ((Ben-Akiva, M. *et al.* 1997; Yang, Q. 1997; Toledo, T. *et al.* 2003))[2] The meso model that has been used had to be developed from scratch, since none of the existing meso models were deemed suitable, for reasons of access to source code, or internal structure that was not suited for hybridisation.

Mezzo is a new event-based mesoscopic model (Burghout, W. 2004). Mezzo has a fairly simple but complete structure. A network in Mezzo consists of nodes and links. The links are characterised by the number of lanes and length. Each link has a speed/density function associated with it, that determines the traversal speed of vehicles entering the link, given the density at the time of entry. At the nodes, one stochastic queue-server for each turning movement regulates the transfer of vehicles from one link to another. The queue at the downstream end of the link consists of vehicles that are ready to exit (given their entry time and traversal speed), and occupies space. The space on the link that is *not* occupied by the queue is called the *running part* and the density in that part is used in the calculation of the traversal speeds. Queues blocking back from one turning movement can block access to the other turning movements, if they grow beyond a specified size. This way, the propagation of queue-tails is modelled properly, and the propagation of the queue-front in case of dissipation is modelled using shockwave theory ((Lighthill, M.H. & Whitham, G.B. 1955),(Richards, P.I. 1956)) by using the upstream and downstream densities and flows. When a link exit has been blocked (e.g. when a queue backs up from a downstream link), and becomes unblocked (when the queue front reaches the current link), the speed of the recovery shockwave is calculated using the densities and flows downstream and upstream of the link exit node. Using the shockwave speed, the exit times of the vehicles in the queue are updated by calculating when the shockwave reaches them, and how long it will take them to drive the remaining distance to the link exit (given the speed corresponding to the downstream density).

[2] The authors would like to thank the ITS lab of MIT for making available the MITSIMLab program source code.

The two submodels communicate via a Parallel Virtual Machine (Alexandrov, V. & Dongarra, J. 1998), which can include multiple physical computers. This makes it possible (but not necessary) to run Mezzo and Mitsim on different computers. The submodels pass messages to each other containing the following information:

1. vehicles that are passing the boundaries between the models
2. link blocking/unblocking information
3. density on micro segments
4. Information for virtual vehicles (speed and entry time of vehicle that last crossed the border)

Since Mezzo is event-based, the message passing is also used for synchronising with the micro time-steps. Each Mitsim time-step (0.1 sec) a message with the relevant information for Mezzo is sent, and upon receipt, Mezzo sends back a message with the relevant information for Mitsim. These messages from Mitsim are therefore treated as external events, and are processed just like any other event.

3.1. Scenarios

We looked specifically at the way queue build-up and dissipation propagates across the boundary, both in the meso-to-micro and micro-to-meso direction. We will present the results of the cumulative flows on the links, which show both the temporal and spatial traffic dynamics.
The network we used consists of a single two-lane road that is 5 km long, divided into 10 segments of 500 meter (see figure 7). The first five segments are within Mezzo, followed by two segments in Mitsim, and finally three Mezzo segments.

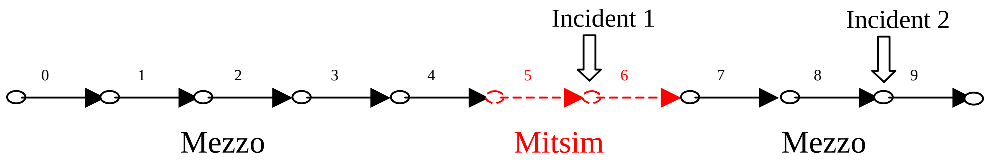


Figure 7. Test network

The free flow speed is 100 km/h and the speed limit is 90 km/h. A constant demand of 3000 veh/h is applied for a simulation time of 1 hour (3600 seconds). Using this network we will test two incident scenarios, which will test the queue propagation and dissipation across boundaries. The incidents will appear after 20 minutes (1200 seconds) and completely block the link for 5 minutes (300 seconds). The first scenario has the incident on the boundary between micro segments 5 and 6 and the second scenario has the incidents on the boundary between segments 8 and 9 in Mezzo.

3.1.1. Calibration of Mezzo capacity and speed/density functions

In order to ensure that the modelled traffic performance in Mezzo is comparable to that of Mitsim, we need to calibrate the server capacity of the turning-movements at the nodes, and the parameters of the speed/density function in Mezzo to the performance of Mitsim.

In our network, there is only one turning movement type, which is a straight movement. We measured the flow over time in Mitsim, given demands increasing from 3000 to 5000 veh/h (1500-2500 veh/h/lane). Since it is a stochastic simulation, the results may vary from one simulation run to another. We therefore repeated the simulation an (arbitrary) number of 10 times (see (Toledo, T. *et al.* 2003) for a good way to determine the required number of replications in stochastic simulation). By identifying the 15 minute period with maximum (output) flow, and taking the mean and standard deviation over the 10 simulation runs, we could set the capacity of the turning movement servers in Mezzo. The values we used were a mean time headway of 1.44 seconds / lane and a standard deviation of 0.1 seconds. This corresponds to a mean capacity of 2500 veh/h/lane and a standard deviation of 360 veh/h/lane.

We then need to calculate the parameters of the Mezzo speed/density function so that it matches the speed/density measurements from the micro model. Again 10 replications are made, but to obtain speed/density values for high densities, a bottleneck is created at the downstream end of the second link in the network. The function parameters were fitted manually to the data obtained from Mitsim obtained. In figure 8 the match with the resulting speed/density function is shown, along with the fit of data from Mezzo simulation runs to the speed/density data obtained from Mitsim.

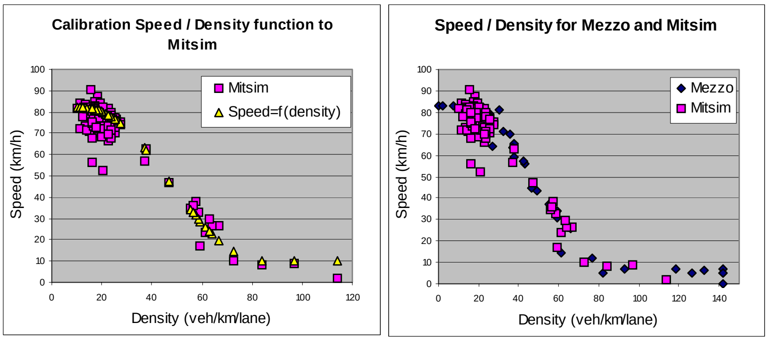


Figure 8 Calibration (left) of Mezzo speed-density function from Mitsim data, and results (right) from Mitsim and Mezzo

3.1.2. Results scenario 1

In Figure 9 a plot is shown of the cumulative outflow (veh/lane) for segments 0 to 5. The cumulative outflow for a segment can be seen as the number of vehicles that have left that segment, over time. Each line shows one segment, and the distance between two segments shows the density over time.

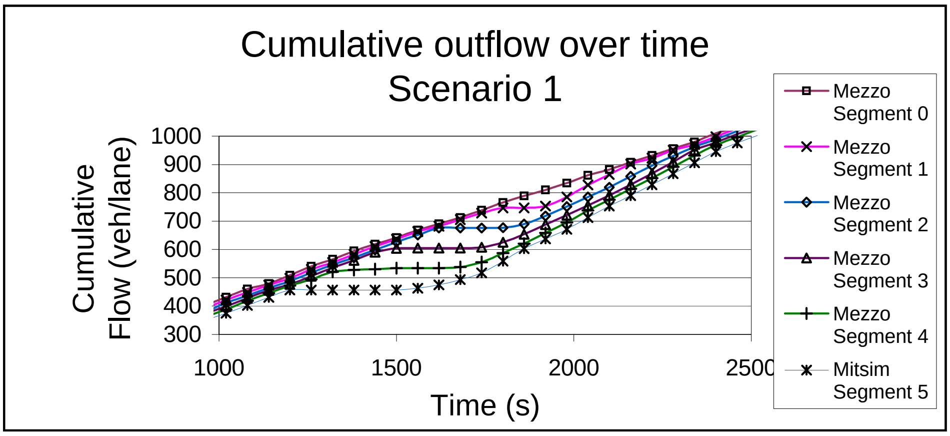


Figure 9. Cumulative flow plot of incident scenario 1.

At t=1200s an incident blocks the exit of segment 5, which is in Mitsim. We can see from figure 9 how the cumulative flow line that belongs to Mitsim is horizontal from t=1200s, until the clearance of the incident at t=1500s. This means no vehicles exit the segment during that period. Around 150 seconds later we observe the same behaviour for the upstream Mezzo segment 4. This means it took 150 seconds for the queue to reach the exit of segment 4, and it takes another 150 seconds to reach segment 3, etc. When the incident clears, it takes around 130 seconds before the queue front has reached the exit of segment 4 and traffic starts to flow there. From segment 4 to segment 3 it takes 110 seconds and we see how it propagates backward until the queue front meets the queue back in segment 1 at t=1920s, after which a small forward shockwave forms, which disappears in segment 2. This shows that the queue propagation and dissipation propagates properly over the Mezzo-Mitsim boundary, thereby showing the correctness of propagation of traffic conditions over the micro-to-meso boundary.

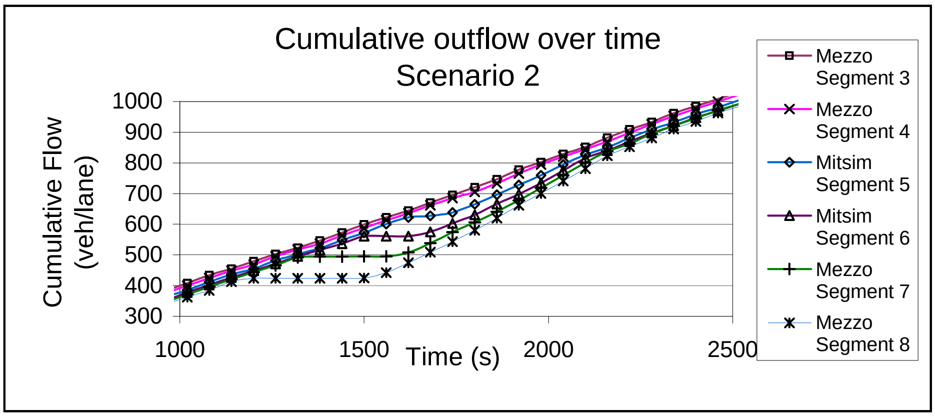


Figure 10 Cumulative flow plot of incident scenario 2

3.1.3. Results scenario 2

In the second scenario the same incident was introduced, but now on the exit of segment 8 in Mezzo, which is downstream of the micro segments in Mitsim. We observe in figure 10 the same behaviour of queue propagation starting at segment 8 around t=1200s propagating via segment 7 (in Mezzo) to segments 6 and 5 (Mitsim) and on the Mezzo segment 4 the queue front meets the queue tail and the queue disappears. One difference that can be observed in the results of the two scenarios is the steep increase of the outflow from (Mezzo) segment 8 in scenario 2 at the end of the incident, whereas the increase in flow on (Mitsim) segment 5 is more smooth and slower. This can be explained by the fact that shockwave theory, which is used for modelling the queue dissipation in Mezzo, assumes immediate changes in speed, while the vehicles in Mitsim are bound to their acceleration limits (and reaction times).

4. Conclusion

Micro and meso traffic simulations have different strengths and weaknesses. While micro models provide a more detailed representation of the traffic process, are meso models able to capture traffic dynamics of large networks, in lesser detail, but without the problems of application and calibration that a micro model would have. In this paper we have investigated the possibility of a hybrid meso-micro model that would be able to apply micro simulations to areas of specific interest, while being able to simulate a large surrounding network in lesser detail with the meso model. We identified which requirements and conditions have to be met for a hybrid model to be consistent and applicable. The requirements vary from network and route-choice consistency to consistency of traffic dynamics at the boundaries of the micro and meso submodels. An integration framework was developed that can satisfy the stated requirements, and a prototype hybrid model was made out of the MITSIMLab micro and the newly developed Mezzo meso models. In a small case study some of the aspects of consistency of traffic dynamics across submodel boundaries were demonstrated. The results are promising, but more involved case studies will investigate other aspects of the integration framework, such as consistency of route choice across both models, both pre-trip and en-route. At the same time the Mezzo model will be further developed and validated. Finally the integrated hybrid model will be validated in real-life case studies.

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