The advantages of combining traffic simulation models for transportation analysis and ITS systems assessment

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1. Introduction

In the field of transport engineering, simulation software have been, for many years now, helpful tools on which specialists rely for analyzing and assessing transportation networks. However, during the last decade, the diversity of these tools has been seen grooving. Indeed, the classical planning (macro) software packages, generally based on static paradigms, were no more the only type of application available to face transport engineering challenges. Due, among other reasons, to the permanent computation power progresses, more disaggregated and dynamic models appeared on the field. This is the case of the microscopic, the nowadays most used model for operational studies, and the mesoscopic which, even if the concepts exist for many years, only recently started to be seen as an interesting compromise between macro and micro.

With the presence on the market of these three types of traffic simulation approach, too many people have an unfortunate tendency to compare them in order to find the “models contest” winner. One have to understand that each application has specific advantages and disadvantages and the selection of the adequate tool is mainly depending one the objectives of the study, the data available and the temporal window. Let’s go even further by admitting that transportation studies are more and more multi objectives ones and that the models should then be complementary instead of antagonist. Consequently, the question to be raised is: How to communicate and put the three approaches to work together in an efficient way?

2. Combined use of the models

When the modeling approaches have been developed independently, implemented in independent software packages the exchange of information between the three levels based on file exchange is the only but not the most efficient way, and requires a complex overhead when also time dependent paths of vehicles traveling across the network from origins to destinations must be taken into account as in the case of hybridizing meso an micro approaches. An efficient answer to these questions must be based

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Figure 1: The three modeling approaches interaction  
Figure 2: An integrated platform applying the three model approach to the same network
in a flexible combination of computer modeling and transport modeling, which is an implementation of transport models supported by advanced software architecture. This is definitively the current trend on the simulation market where the systems are conceived as a integrated environments enabling the direct exchange of information among various transport analysis tools.

3. The fully integrated approach

Ideally, the key component is an extensible object model common to all applications that share a unique Model Database. Transport Planning, mesoscopic simulator and microscopic simulator, among other applications exchange the information directly in this way, each one using the information that needs and modifying the stored information accordingly, all the data have a common storage and the type of network representation depends only on which subset of data is used. The object model for the Macro level contains attributes exclusive of the macro network representation and attributes which are shared with the Meso level, and similarly, Micro level shares some of the attributes with meso and macro, but has other exclusive of the micro level. However, all these attributes are stored in a unique model database.

![Image](image.png)

Figure 3: Windowing operation in macro model for dynamic operation analysis with meso or micro approach

Figure 2 depicts the case in which on the left window has been executed the user equilibrium assignment, link colors visualize the expect level of service after the assignment, the central window visualizes similar results for a given time interval from a mesoscopic simulation, and on the right window is being executed a microscopic simulation and the corresponding animated view visualizes the individual vehicles, queues at intersections, etc.

Macro, meso and micro approaches to traffic modeling although sharing some common concepts are based on different types of network representations. All them share in common the demand model in terms of an Origin-Destination Matrix whose entries represent the number of trips from the selected origin to the chosen destination, for a given time period and trip purpose; origins and destinations being represented in the model in terms of artificial nodes, or centroids, where traffic flows are generated and sunk. The differences in demand representation lay in that, for macro approaches usually based on static user equilibrium, the demand matrix is unique for all the time horizon considered, while in the meso and micro approaches the demand matrix is usually split in a set of matrices for smaller time period spanning the whole temporal horizon, to approximate better the time varying traffic demand.

Macro and meso approaches are based respectively on link node and extended link node network representations, with nodes modeling intersections and links modeling the transportation infrastructure, while microscopic modeling to traffic networks requires an explicit and detailed modeling of the road sections, intersections, roundabouts and so on. Road sections at macro and meso levels, are therefore represented in terms of abstract oriented arcs, whose characteristics are defined in terms of numerical attributes, i.e. capacity, number of lanes, associated volume-delay function, or speed density relationship in the extended link node, etc; while at microscopic level lanes must have a width, and other additional numerical attributes are necessary, as for example the speed limits on the section, although macro and meso, or meso and micro, can share some of the numerical attributes. At macro level nodes representing intersections include a detailed definition of the allowed turnings, but no information on signal setting at signalized intersections, or specific give way or stop rules at unsignalized intersections as far as they do not account for signal control, while meso and micro approaches need all the information concerning phasing schemes and time settings at controlled intersections as they deal explicitly with signal control, as well as information on give ways and stops at unsignalized intersections to model traffic behavior in a suitable way in these cases.

That means, usually, that when moving form the upper aggregated level of network representation of macro approaches to the lower level of meso and micro there is missing information that should be additionally provided to ensure the model consistency at the corresponding lower level, and when moving in the opposite direction, from the fully disaggregated lower microscopic to the upper aggregated levels meso or macro, the appropriate aggregation rules must be defined to ensure a unique way and keep the models consistent. The ideal situation is that depicted in Figure 3, where starting at the macro level with a very large model of a region or a metropolitan area the analyst, after conducting a transport planning analysis windows into a large sub
area (possibly the whole area spanned by the model) to get a deeper insight accounting for the dynamic effects of time dependencies of traffic phenomena through the meso level. The dynamic analysis may then reveal potential conflicts in smaller sub areas requiring a further detailed analysis, namely when one should account for ITS applications, like adaptive control strategies, for which microscopic simulation is the suitable model.

The models integration trend for simulation packages being definitively launched, the next step is without doubts to “educate” users to deal with this multi-level potential for their transportation studies in order to get the best from this new designed tools offer.

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References


