Historical Based Traffic Assignment in Microsmulation for Advanced Traveller Information Systems Assessments

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ABSTRACT

In dynamic models, like microsimulation, dynamic traffic assignment is based on the use of traffic conditions measured during the simulation process in order to keep o sort of equilibrium between demand and supply. Route choices are consequently done by knowing the traffic conditions of the day. This paper suggest another model, more realistic, based on an historical drivers knowledge obtained by an iterative process. This new model, splitting drivers in different knowledge categories, allows more relevant ATIS evaluation.

INTRODUCTION

Traffic simulation is becoming a more and more widely used tool in many transportation researches and studies. At the first times, only marcosimulation tools were available. They were mainly developed for planning purposes and are still used for this type of projects. Nevertheless, with the growth of ITS applications in the past decades, the need for dynamic models has been rapidly emphasized. The development of microsimuation models has consequently been strongly motivated by the necessity of having the use of new tools being able to deal with the dynamic characteristic of ITS applications.

One of the well known differences between both types of simulation tool is based on the traffic representation. In macrosimulators, traffic demand is generally described as flows following behavioural rules based on the mechanic of fluids. On the other hand, microsimulators models provide individual representations of the vehicles driving along the network. Behavioural rules are mainly based on the interaction of the vehicles with each others and with the infrastructure (car-following and lane changing models for example).

Nevertheless, the most important distinction that has to be highlighted is the time dependent characteristic of microsimulators in comparison to the static one of marcosimulators. Indeed, demand is represented as a unique Origin Destination (OD) matrix in the second case while a time varying one is used in dynamic models. This difference has obviously a direct impact on the traffic assignment process.

Static Traffic Assignment (STA) consists of determining network link flows given an OD matrix. Specific assumptions on route choice have consequently to be done to solve this problem. Many researches have been focused on this topic. Reviews of existing models can be found in (1) and (2). Among them, the equilibrium model provided by Wardrop (3) is one the most used: “The journey times on all routes used are equal and less than those which would be experienced by a single vehicle on any unused route”, in other words “The average journey time is minimum”. Concretely, this equilibrium (convergence point) is reached by an iterative process of traffic assignment.

Note that the reverse problem, the static OD matrix estimation, is frequently solved using macroscopic models. In this case, traffic flows coming from field measurements are given and the demand as to be estimated. As the number of measurement points is generally lower than the number of OD pairs, this problem is overdetermined. Thus, to obtain the convergence, other constrains have to be given. For example, an initial OD matrix can be defined (using drivers survey) and the estimated matrix will be the one being as close as possible from the initial one, completing the equilibrium constrain.

In the other hand, Dynamic Traffic Assignment (DTA) is applied in microsimulation models as explained, for example, in (4) and (5). In this case, time is generally discretized and demand is represented by series of OD matrices, each one corresponding to a time period. Routes are assigned to the vehicles entering the network according to the traffic conditions. The latter is represented by dynamic link costs, calculated using a cost function which usually takes link travel time as key parameter. Paths minimising the total cost are then computed for each OD pairs and assigned to the vehicles. In fact, most of the Dynamic Traffic Assignment models tend to use the equilibrium principle, adapted to a dynamic environment. In other words, path assignments are done in order to keep the network in a global equilibrium state, the latter changing from one period to another.

For the assessment of Advanced Traffic Information systems (ATIS), using dynamic models like microsimulators is essential. This type of projects aims generally to estimate the benefits that can be expected from ATIS applications. Comparison between informed vehicles route choice behaviour and non informed ones are usually done. In order to obtain relevant results, route choice models of both drivers categories have to be realistic.

Dynamic traffic assignment models usually applied in microsimualtion tools, even if they are satisfactory in most of the case, aren't as realistic as needed for some ATIS assessment. Next section of this paper will show the limitations of these models and explain why using them can lead to biased results when informed and non informed vehicles are compared.

A different approach is then suggested to avoid this problem. Basic principles are described followed by a concrete application for the specific use of the AISMUN microsimulator, a tool developed by the Polytechnical University of Catalunya in Spain (6). Finally, some comments on further research trends are given.

DYNAMIC TRAFFIC ASSIGNMENT IN MICROSIMULATION AND ITS LIMITATIONS

As explained before, traffic conditions are, in dynamic models, represented by a cost for each link of the network. These costs are mainly calculated on the basis of the average travel time experienced by the vehicles that covered the link in the previous time periods. This allows vehicles to use the shortest path computed by taking into account the current conditions. Consequently, Wadrop's statements can be roughly respected. A sort of dynamic equilibrium is then obtained, even if the words "dynamic" and "equilibrium" seems somewhere in contradiction. Thus, it can be shown as a reactive or adaptive traffic assignment.

The major difference between this model and real route choice behaviour is that drivers usually have a more or less rough idea of traffic conditions evolution during a typical day (usually named historical profile) but, without information, they cannot know the exact conditions of a particular day as it is the case with the classical DTA. It is particularly the case when traffic conditions are widely varying from one day to another which is mostly the case in complex urban networks. Hence, route choice capabilities of non informed vehicles can be considered as "too good" in a classical DTA model.

This problem isn't critical in many applications of the microsimulation. Nevertheless, when this type of tools is used for ATIS assessment, it becomes significant. Indeed, when the benefit (in time saving) of informed vehicles is measured by comparing their travel time with non informed vehicles one, results can be underestimated due to a non-sufficiently realistic route choice behaviour implied by the classical DTA model. This is particularly the case for dynamic route guidance systems evaluation. This type of applications provides users with dynamic link travel time measured in previous time period which is very similar to what classical DTA does.

In the case of a non recurrent traffic disturbance like an accident or a special event modifying the usual capacities of the network, the difference between DTA model and real behaviour becomes bigger. Even though route choice based on current traffic conditions can be liken to a sort of historical knowledge in recurrent disturbances, this approach cannot be justified in non recurrent ones. As it is well known that ATIS applications are particularly performing in non recurrent situation, this finding lead definitely to search for alternative models.

In addition, other difficulties may appear when large networks are used. In this case, the difference between the information used to assign a route to a vehicle at its entrance time and the ones it will experience arriving at a sensible point situated faraway (in time) from the entrance can lead to a situation far from the equilibrium statements. To put this problem right, microsimulators usually provide the possibility of rerouting the cars after a certain period in order to take into account new traffic conditions. Once more, this feature (even being clearly justified) leads to an underestimation of the benefits that can provide the use of ATIS.

Even if not only related to dynamic models, the driver's network knowledge is also a topic that has to be highlighted in the context of ATIS assessment. In fact, in many models it is assumed that the level of roads network knowledge is the same for every drivers and that each link belonging to the model network representation is known by the users. Obviously, this statement is not realistic, particularly if the model isn't only limited to the representation of main roads. Solutions have consequently to be found.

HISTORICAL PROFILE BASED ROUTE CHOICE MODEL

Based on the DTA limitations described above, this research suggests an alternative approach that can be applied in the use of microsimuation tools. It is based on some observation of real drivers behaviour (obtained by surveys) and on the own experience of the authors. At this point, it must be emphasized that very few literature exist on the drivers knowledge of the network and of usual traffic conditions, even if a lot of route choice models have already been suggested.

To match more with real route choice behaviour it seems, firstly, necessary to define different type of drivers and, consequently, of behaviours:

The "tourist"

Drivers belonging to this category have a limited knowledge of the network and no idea about the traffic conditions. They choose their path by looking to a map or to the direction signs. Major roads are, in priority, chosen. In the model, a link cost function has to be specifically defined for this category. Cost is mainly based on free flow travel time values and important penalties have to be set for links that do not belong to the major roads network. Thus, local streets are only used at the beginning or at the end of their journey (from origin to main roads and from main roads to destination) but not for transit purposes.

The "expert"

For this type of drivers, a perfect knowledge of the network is considered. In addition, they know exactly what the usual traffic conditions are. The "expert" cost function use consequently the common road hierarchy level weighting. About link travel time, the exact values extracted from the historical profile (described latter) are used for calculating costs. Note that in the case of non recurrent disturbances, the intuitive knowledge (that expert drivers can have in reality) of how traffic conditions would change from the usual ones isn't taken into account.

The "regular"

The regulars represent the majority of the drivers. They have a variable level of knowledge of the road network and of the typical traffic conditions. A level close to the expert one is generally assumed when they drive along usual routes (commuters) while they can be considered as tourist one for non usual routes. Nevertheless, link cost functions cannot reproduce the latter behaviour. Indeed, cost values are not able to take into account route choice made by drivers as the latter is dependent from costs itself. It's a vicious circle. Consequently, to simulate their rough knowledge, its variability will be spread homogenously through the whole network by using random factors (between 0.8 and 1.2 for example) multiplying the true values of the historical profile.

By splitting the drivers in different categories, a hybrid model is then obtained matching better with real life behaviours. Note that this new model only relies on historical data and not on the specific traffic conditions of the day which avoids "too good" route choice behaviour and implies a more relevant ATIS assessment.

However, this approach needs the creation of an historical data base that can be used by drivers during the simulation. This remains a difficult and not effortless operation as described below.

HISTORICAL PROFIL CREATION

The following description is specifically based on the AIMSUN software whose features give users plenty of possibilities to change and test new models. Nevertheless, the general approach is independent from a specific tool and can be applied in any case.

As explained before, the new route choice model is mainly based on historical data base values. Nevertheless, the latter have to reflect the route choice habits of the user over multiple days. Thus, a mutual dependency between them is clearly established. Consistency has then to be assured.

Consequently, the only way to obtain an historical profile in harmony with route choices is to engage an iterative process. The latter aims to obtain a convergence between the traffic conditions followed from the use of the new road model and the ones contained in the historical data base.

Concretely speaking, this means that after a certain number of iterations the global difference between link costs stored in the data based (input values) and the link costs measured during the simulation (ouputs values) has to be stabilized. In reality, as microsimulation is a stochastic process, not only one simulation run per iteration has to be made, but 5, 10 or 20 (number of iteration to obtain relevant results is another research topic which will note be tackled in this article). Cost averages (made over the different runs) are then used as output values. If no convergence is found at the end of an iteration step, simulation outputs are then used as input for the following iteration step as described in Figure 1

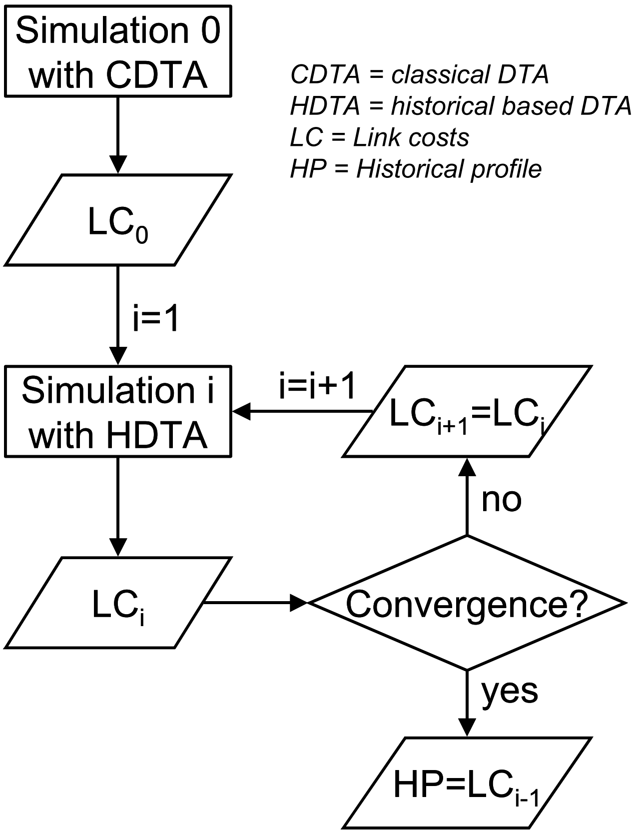

Figure 1: Iteration process to reach the convergence point leading to the determination of the historical profile

Note that the difference (calculated using mean square error, for example) between outputs and inputs will never converge to zero but to a value representing the traffic conditions variability between different days (concretely said, simulation runs). Thus, the convergence criteria can be expressed as following:

$$\Delta(LC_i, LC_{i+1}) = \Delta(LC_{i+1}, LC_{i+2}) \tag{1}$$

With:

$$\Delta(LC_i, LC_{i+1}) = \sqrt{\frac{\sum_{j=1}^{J}\sum_{t=1}^{T}\left(C_{j,t,i} - C_{j,t,i+1}\right)^2}{J \cdot T}} \tag{2}$$

$C_{j,t,i}$ being the cost of link j at the time period t of the i^{th} iteration.

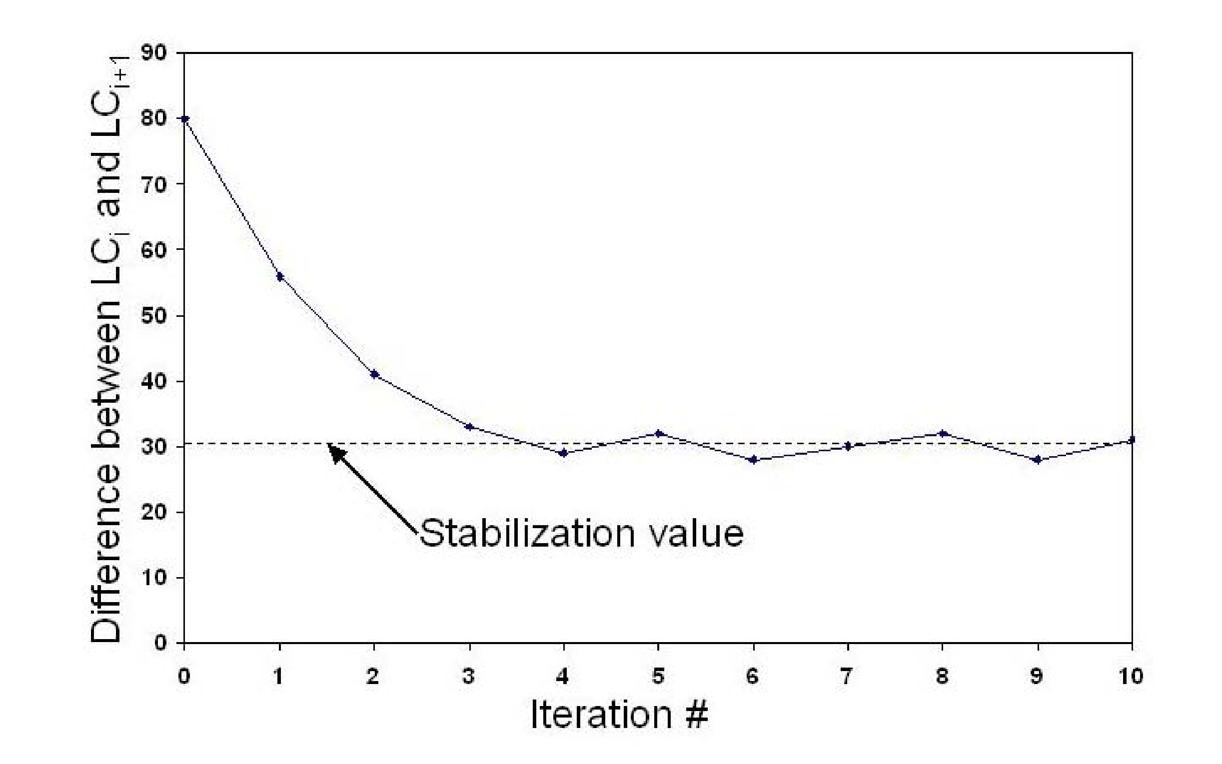

Figure 2: Stabilization process after several iteration steps

When stabilization is obtained, as shown in Figure 2, the link costs matrix (whose size is J·T) used as input for the last iteration can be considered as the historical profile to use in the new assignment model.

FURTHER RESEARCHES

The method described allows obtaining encouraging results. Nevertheless, more research has to be done to improve its efficiency and particularity it capacity of approximating satisfactorily real life behaviours.

Indeed, some parameters used in the model have to be chosen without any information coming from other researches. For example, the drivers splitting in different categories, as explained above, has to be done instinctively, no percentage values being available in the literature. In addition, it must be emphasized that these percentages can vary from one network to another and that a local approach will have to be done in each case.

Random factors, used to simulate the knowledge variability of the regular drivers, are also values that can be only chosen by experience as no research has already be done on this particular field. Consequently, more studies to define the real behaviour have to be done, mainly on the drivers knowledge variability.

By using different simulation runs to obtain link costs averages, variability between different days is taken into account. Nevertheless, this variability is only provided by the stochastic character of the simulator and its magnitude can be smaller than expected. Indeed, in some networks, traffic conditions variability between different days can be important. To solve this problem, different OD matrices could be used, each of them having a different traffic structure and volume. If N matrices are used and M replications are simulated per matrix, link cost averages would then be calculated over the N x M runs.

A study based on a real case will be done to demonstrate the advantages of using the historical based traffic assignment. It will mainly aim to emphasize the difference in the results obtained for an ATIS application assessment. Why this new method is closer to real route choice behaviour than a classical DTA will clearly be shown.

CONCLUSIONS

This article has explained why only dynamic simulation models can be used for ATIS evaluations. Nevertheless, classical dynamic traffic assignment used in microsimulation have limitation for this type of studies as route choice behaviour is mainly based on the availability of dynamic link travel times which isn't realistic. This method is used to simulated the historical knowledge of the users to keep the network conditions on a sort of equilibrium without having to use iterative process.

Consequently, drivers knowledge can be considered as "too good" in comparison to real life, particularly in non recurrent events. Thus, a new assignment method is suggested where drivers, divided in different knowledge categories, use historical profile link costs. The later is obtained by applying an iterative process which aims to obtain a convergence between the costs obtained by simulation and the ones used as input. The historical profile is the last matrix used as simulation input when convergence is reached.

Even if this new method is promising, a lot of research is still to be done. Indeed, literature giving information about the knowledge level of network users is very limited. Lacks in this research field leads to choose some important parameters only on the experience base and not on a methodical one. Therefore, more studies will be done, mainly based on surveys, to be able to catch the real drivers route choice behaviour.

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