Comparative Evaluation of Road Traffic Simulators based on Modeler's Specifications: An Application to Intermodal Mobility Behaviors

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Abstract: Today, large cities and peri-urban areas experience problems in the mobility of their population. Faced with this problem, decision-makers must have reliable tools to help them to build and evaluate their policies of mobility. Computer simulations especially traffic simulation tools are, therefore, the solution to better understand (study) the problem and test different resolution scenarios. Unfortunately, there are numerous simulation tools and the choice can be very difficult for traffic modelers. In this paper, we present, based on a generic method, a comparison of the most popular traffic simulation tools in two steps: 1) a comparison part using a weighted system of evaluation criteria to automatically select the candidate simulators. 2) a deeper study of the candidate simulators according to a simulation scenario corresponding to the study case. Finally, this paper presents an application of this method for the selection of a simulator for the study of intermodal mobility behaviors where *MATSIM* and *SUMO* were studied in deeper.

1 INTRODUCTION

Nowadays, transportation is one of the vital needs of humans in the same way as access to water, health care, and education. In addition, faced with the issues of global warming and expensive living, policymakers are increasingly focused on people's transportation systems to provide both economic and customer-friendly solutions. In order to experiment with their solutions, decision-makers use most often traffic simulation tools(Pursula, 1999).

The initial motivation for this work was the study of the capability to simulate intermodality[1] and to integrate new behaviors into the simulation. There is a need to easily add such behaviors in a multimodal simulation. Fortunately, recent developments in traffic simulation tools allow simulating these kinds of behaviors.

Modern traffic simulation tools are based on different principles and have two main origins: industrial and academic ones. Industrial simulators (e.g., *Vissim*, *Aimsun*), developed for commercial purposes, are generally easier to use and offer user assistance. However, they are less extensible and offer less flexibility and limit the user to predefined cases. The second group of simulators comes from research labs (Lopez et al., 2018; Horni et al., 2016; Mandiau et al., 2008). Developed as part of research work, these solutions are usually less complete and not easy to use for an uninitiated user.

Simulation tools offer different levels of traffic modeling usually classified into three following groups: macroscopic, microscopic, and mesoscopic. In macroscopic models, vehicle flow is assimilated to the runoff of a fluid in a pipe and modeled through the equations of fluid mechanics. In contrast, in microscopic and mesoscopic approaches, each actor of the traffic is respectively considered individually and in small homogeneous groups. These simulations are implemented through a behavioral approach: road traffic is considered as an emergent phenomenon resulting from interactions between road users modeled as autonomous agents (or group) and a realistically modeled infrastructure. Some works have even investigated the integration of these different levels inside a same agent-based simulation (Mathieu et al., 2018).

In light of this diversity of traffic simulation tools,

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[1]Intermodality is usually defined as the capability of using several transportation modes during the same trip.

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the modeler[2] can have some difficulties in choosing the appropriate simulator that meets his/her specifications or the requirements of a project. Therefore, in this paper, we propose a simple method to quickly compare different simulation tools as a first step of a selection process. This comparison is based on fundamental criteria and those relating to the targeted project. As a second step, the two selected solutions *SUMO* and *MATSim* are investigated regarding an intermodal transport scenario.

The remainder of the paper is organized as follows. Section 2 presents the goal of this study and provides an overview of related works on the comparison of traffic simulators. Then, Section 3 describes the approach used to compare and select simulators. Section 4 presents the comparison results of *SUMO* and *MATSim*. Finally, Section 5 concludes the paper.

2 PROBLEM STATEMENT

Comparison studies in literature of traffic simulators can be split into two groups mainly depending on the method used. These two approaches are described in the two following subsections.

2.1 Qualitative Methods of Comparison

Qualitative approaches are based on some comparison criteria in order to see the ability of software to meet these criteria.

Ejercito et al. (Ejercito et al., 2017) performed a comparison of traffic simulators in order to choose the most reliable and suitable to allow researchers to simulate road traffic in the EDSA (Epifanio de los Santos Avenue) in Manila (Philippines). The simulators studied were *MATSim*, *SUMO*, *AIMSUN*, and *PTV VISSIM*. Several criteria were considered in this work such as nature of software (e.g., free, open-source, commercial), portability operating systems, creation of road traffic networks and associated vehicle models, and graphical simulation and quality of graphical representation. The authors only focus on how the different functionalities in the simulators are defined based on the comparison criteria. Therefore, conclusions drawn by the authors are not precise enough to guide the choice of a given modeler in the selection of a traffic simulator for another specific case.

Saidallah et al. (Saidallah et al., 2016) and Ghariani et al. (Ghariani et al., 2014) start with a presentation of the simulators studied by highlighting their different characteristics. Then, they perform a comparative study (still qualitative) based on a set of selected criteria such as general characteristics (e.g., software category), integration of transit components (e.g., roads, stops), and simulation models (microscopic or macroscopic). The work in (Ghariani et al., 2014) focused on the study of seven simulators (*SUMO*, *TRANSMIS*, *ARCHISIM*, *AIMSUN*, *Paramics*, *VISSIM*, and *CORSIM*) according to their ability to simulate public transport. The study carried out in (Saidallah et al., 2016) focused on four simulators (*MATSim*, *SimTraffic*, *MITSIMLab*, and *TransModeler*) in addition to the seven previously mentioned.

The qualitative comparison framework proposed by these authors (Saidallah et al., 2016; Ghariani et al., 2014) is quite explicit. Through the summary table, one is briefed about the functionalities that simulators can satisfy. However, this information is only limited to the functionalities defined by the authors. Moreover, some features have not been studied such as portability, generation of traffic demand, and software scalability.

The main drawback of the above-mentioned approaches (qualitative) is that they are subjective since the evaluation criteria are too specific in most cases to the project or to the modelers (authors). The results of the study just indicate whether the simulator can meet these criteria or not. Thereby, conclusions of these studies are general and difficult to tailor to a particular modeler's needs. Furthermore, a quantitative evaluation of each simulator (as described in the next section) should be added based on the conclusions drawn from the qualitative comparison.

2.2 Quantitative Approaches of Comparison

The quantitative approaches aim to supplement the qualitative methods by proposing a notation to the simulators studied. To our knowledge, only one study has focused on this type of comparison by using a system of classification to compare *AIMSUN* and *VISSIM*(Xiao et al., 2005). The authors proposed in addition a weighting system to give a mark to each simulator. Unlike the studies above mentioned, the evaluation criteria are both qualitative (e.g., functional capabilities and input/output features) and quantitative (e.g., accuracy of the simulator). This system takes into account the modeler's priority by assigning weights to each evaluation criterion. One of the main limitations of this approach is the qualitative evaluation performed by the authors. The conclusions drawn are not explicit enough as in (Saidallah et al., 2016) and (Ghariani et al., 2014). In addition, some criteria

[2] In the following, we will use the term *modeler* to designate a person who uses a traffic simulation software.

designated by the authors as quantitative such as the accuracy of the simulator and the setting time are difficult to assess without studying the simulators a little more in-depth. Finally, the system of classification is quite difficult to reproduce and extend to other simulators.

In general, the choice of the simulator depends on some criteria (qualitative and/or quantitative) as specified in the works above mentioned. It will be interested to have a classification system that will allow the modeler to perform a quick selection without studying the simulators a little more in-depth. The aim is to save time by avoiding in-depth study of simulators that are not likely to respond to the case study. Considering the limitations of existing studies, it is, therefore, necessary to propose a more intuitive evaluation approach to guide modelers in the choice of their traffic simulation tools.

3 CRITERIA FOR EVALUATING EXISTING PLATFORMS

This section describes the first step of our comparison approach. It consists first in defining the comparison criteria. Then, the most popular simulators are evaluated against their ability to meet the comparison criteria defined by the modeler. At the end of this step, a restricted list of simulators is carried out for a deeper study.

3.1 Definition of Our Criteria

We have grouped the comparison criteria into five categories: 1) **Nature of software**, 2) **Creation of Road Network and Transport Demand**, 3) **Simulation realism**, 4) **Documentation and GUI**, 5) **Modeler's specifications**.

A coefficient is assigned to each category of criteria defining its importance for the modeler. We propose a scale from 1-*not important at all* to 5-*highly mandatory*. Then, a mark ($mark_{cat}$) values each simulator for each category of criteria. This mark assesses the simulator's ability to meet the criteria/functionality in the category. Afterward, the score *ScoreSim* assigned to a simulator is computed as a weighted average (with $mark_{cat}$ value bounded to 10).

$$ScoreSim = \frac{\sum_{cat\in[1..n]} mark_{cat} \times coeff_{cat}}{\sum_{cat\in[1..n]} coeff_{cat}} \quad (1)$$

with $coeff_{cat}$ corresponding to the coefficient assigned to the category of criteria *cat* according to the modeler's specifications and *n* the number of the category of criteria *cat*.

This approach allows the modeler to quickly evaluate several simulation tools using the same formula. Thus, he/she can explore the functionalities of several types of simulators at the same time. Moreover, the modeler can designate a criterion or functionality as "redhibitory". Thus, any simulator that does not satisfy this criterion will be systematically eliminated for the rest of the study. A list of the most popular simulators used in this study is described in the next subsection.

3.2 Studied Traffic Simulators

Several simulation software have been considered to test the comparison approach. They can be organized into two groups defined as follows:

1. **Microscopic Agent-based Road Transport Simulators.** These are specific simulation platforms (intended only) for road traffic. The simulators chosen are: *MATSim* (Multi-Agent Transport Simulation Toolkit) - Version 0.10.1 (Horni et al., 2016), *SUMO* (Simulation of Urban Mobility) - Version 1.0.1 (Lopez et al., 2018), *Aimsun Next* (Advanced Interactive Microscopic Simulator for Urban and Nonurban networks) - Version 8.1.4[3], and *PTV Vissim* (Planung Transport Verkehr AG Verkehr In Städten - SIMulationsmodell) - Version 10 [4].
2. **Generic Multi-Agent System (MAS) Simulators.** Being generic, they can be adapted for modeling several systems including road traffic. Our choice fell on *GAMA* (GIS Agent-based Modeling Architecture) - Version 1.8 (Grignard et al., 2013).

Although the above-mentioned simulation software are not the only ones in the literature, they are those which are the most used in their respective fields.

3.3 Evaluation based on Comparison Criteria

Considering our case study which consists in knowing whether or not there is a suitable traffic simulator to simulate intermodality policies, we have assigned coefficients to each category of criteria as presented in Table 1.

The results of the comparative study of simulation software are presented in Tables 2 to 6 corresponding to each category of criteria.

[3] www.aimsun.com/aimsun-next (Oct. 25th 2018).

[4] vision-traffic.ptvgroup.com/fr/accueil (Oct. 25th 2018).

Table 1: Assigning coefficients to criteria categories based on the modeler's priorities.

Category of criteria	Coefficient
(Cat. 1) Nature of the software	4
(Cat. 2) Creation of road network and transport demand	5
(Cat. 3) Quality of visualization of the simulation	3
(Cat. 4) Documentation and user's interface	4
(Cat. 5) Modeler's specifications	5
Total of coefficient	21

Table 2: Evaluation of simulators according to the nature of the software (Cat. 1).

Simulator	Criterion							Mark
	Open source	Free	Dev. team	Single acqu.	Win.	Linux	Mac OS	
MATSim	✓	✓	✓	✓	✓	✓	✓	10
SUMO	✓	✓	✓	✓	✓	✓	✓	10
Aimsun Next			✓	✓	✓	✓	✓	7
PTV Vissim			✓	✓	✓			4
GAMA	✓	✓	✓	✓	✓	✓	✓	10

Table 3: Evaluation of simulators according to the possibility of creation the road network and transport demand (Cat. 2).

Simulator	Criterion				Mark
	Visual tool integrated[5]	Network from OSM	Transport demand	PT net. and sched.	
MATSim		✓	✓	✓	8
SUMO	✓	✓	✓	✓	10
Aimsun Next	✓	✓	✓	?[6]	8
PTV Vissim	✓	✓	✓	?	8
GAMA		✓	✓		5

Table 4: Evaluation of simulators according to the quality of visualization of the simulation (Cat. 3).

Simulator	Criterion				Mark
	2D	3D	Realism[7]	Few memory [8]	
MATSim	![9]			✓	3
SUMO	✓			✓	5
Aimsun Next	✓	✓	✓	✓	10
PTV Vissim	✓	✓	✓	✓	10
GAMA	✓	✓		✓	8

Table 5: Evaluation of the simulators according to the quality of the documentation and the GUI (Cat. 4).

Simulator	Criterion							Mark
	On line	PDF	Forum	Conference	Community	Training	GUI	
MATSim	✓	✓	✓	✓	✓	✓	✓	10
SUMO	✓		✓	✓	✓		✓	7
Aimsun Next			✓		✓	✓	✓	6
PTV Vissim		✓	✓	✓	✓	✓	✓	9
GAMA	✓	✓	✓		✓	✓	✓	9

3.4 Short Listing of the Solutions

Table 7 proposes an overview through the five categories. It makes it clear that no simulator is *ideal* to meet all the needs and requirements of the modeler.

The simulators dedicated to traffic, outperform our test with a score of up to 7.4. The delimitation between commercial and OpenSource software is also clear. Commercial software are well integrated into the GIS solution to build and set up simulation and provide qualitative GUI and simulation view. However, those solutions remain obscure considering the possibility to enter into the simulation source code and provide customized behaviors and simulation.

The simulators chosen to be more deeply investigated by implementing intermodality scenarios are *MATSim* and *SUMO*. For this work, we were interested in the intermodal routing module in particular in the cost function of the modal choice (intermodal) implemented by these two simulators.

4 FOCUSING ON INTERMODAL ROUTING PROBLEM FOR *MATSim* vs *SUMO*

This second step of comparison consists in studying more deeply the selected simulators on a road traffic scenario. To compare the two simulation tools with respect to the intermodal routing problem, the emphasis will put on the four aspects: 1) creation of a complete multimodal transportation network, 2) definition of the availability of transportation modes, 3)

[5] Some simulators do not allow the creation of the road network directly. In this case, one needs to use other software for creating road traffic (details in Section 4).

[6] Commercial software evaluation versions did not allow us to test this functionality.

[7] The criterion of realism strongly depends on the expectations of the modeler. It can be decomposed at the macroscopic and microscopic levels. At the macroscopic level, realism relates to the physical quantities observed: density, flow, average speed, etc. At the microscopic level, the realism relates to the observable behavior of users (car driver, pedestrian) and the way they move (walking, car steering).

[8] It is assumed that a need of less than 16 GB of RAM is sufficient for a 3D display and realistic effects.

[9] *MATSim* does not allow the visualize simulation results. Another tool such *Simunto VIA (see https://www.simunto.com/via/)* is used for this.

Table 6: Evaluation of simulators according to the modeler's specifications (Cat. 5).

Simulator	Criterion									Mark
	Model micro./meso.	Scaling	User and mode characteristics	Statistics output	Intermodality	Calibration	Dynamic behaviors	API	Source code access	
MATSim	✓	✓	✓	✓	✓	✓			✓	8
SUMO	✓	✓	✓	✓	✓	✓		✓	✓	9
Aimsun Next	✓	✓	✓	✓	✓	✓		?		7
PTV Vissim	✓	✓	✓	✓	✓	✓		?		7
GAMA	✓	✓	✓						✓	4

Table 7: Comparison of simulators according to chosen criteria (first step).

Simulator	Category of criteria					*ScoreSim*
	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	
SUMO	10	10	5	7	9	8.48
MATSim	10	8	3	10	8	8.05
Aimsun Next	7	8	10	6	7	7.48
PTV Vissim	4	8	10	9	7	7.48
GAMA	10	5	8	9	4	6.90

intermodal routing algorithm (the cost function of the modal choice), 4) degree of difficulty in the definition of new intermodal behaviors.

After a description of traffic simulation scenario generation in *MATSim* and *SUMO* in the first subsection, the two other subsections detail these different points for each simulator.

4.1 Traffic Simulation Scenario Generation Framework

The use of both *SUMO* and *MATsim* relies on several tools to generate simulation configurations from classical data format. Figures 1 and 2 present a global framework of the generation of a traffic scenario from *OpenStreetMap (OSM)*[10] and mobility data (usually the Households Travel Survey (HTS) and/or the Census of the population) in *SUMO* and *MATSim* respectively.

The road network is generally produced from the OSM data of the study area extracted from *OpenStreetMap*. Moreover, it is possible to include GTFS[11] data, allowing a better description for the public transport supply in *MATSim* context. Details on the network generation tools are presented in the subsections dedicated to each simulator.

[10]OpenStreetMap is an open data platform that provides map information of roads, trails, etc.: https:/https://www.openstreetmap.org/about

[11]General Transit Feed Specification (GTFS) is a standard for transit schedules and geographic information: https://gtfs.org/

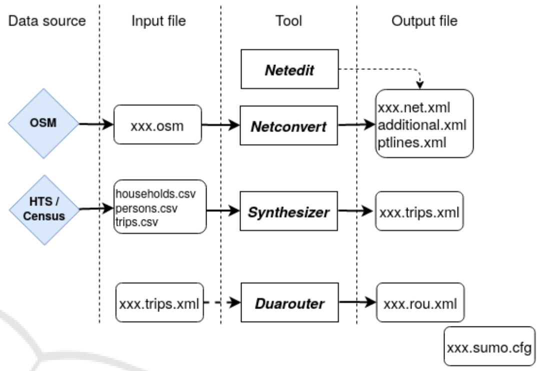

Figure 1: General process to create traffic scenarios from OSM and mobility data (HTS/Census) in *SUMO*.

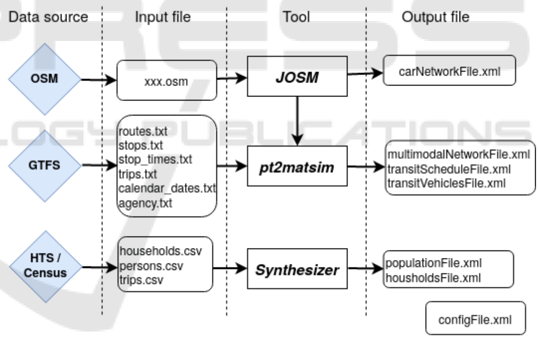

Figure 2: General process to create traffic scenarios from OSM and mobility data (HTS/Census) in *MATSim*.

The initial transport demand is generally created from a synthetic agent population synthesizer. This population reflects the mobility data, for example from household travel surveys (HTS) and/or census data. It should be noted here that this population is not necessarily specific to the format of the simulator. Therefore, from the mobility information of the population generated, it is possible to create a traffic demand in the simulator format (xxx.trips.xml in *SUMO* and populationFile.xml in *MATSim* for example). This demand can then be directly simulated without defining travel routes. On the other hand, it takes a long time with regard to the routing time. Thus, the tool *Duarouter* allows creating a traffic demand (xxx.rou.xml) with cleaned routes which can be easily simulated by *SUMO*.

4.2 Intermodal Routing in *SUMO*

To perform intermodal routing, we need a multimodal network, the availability of several transportation modes to combine them, and the definition of a cost function of the modal choice. These different steps will be studied for each of the two simulators.

4.2.1 Creation of a Complete Multimodal Transportation Network

The multimodal network is well modeled in *SUMO*. *Netconvert* creates the road network for *SUMO* from *OpenStreetMap* data. *Netedit* allows corrections on the network created because some information may be incorrect from the *OpenStreetMap* site, such as the use of a traffic light instead of priority stop at an intersection. Each specific lane to a category of transportation mode can be modeled. *SUMO* also allows the cohabitation of several transportation modes in the same lane such as cars, buses, and motorcycles. Interactions between pedestrians and motorists are also possible at zebra crossing at intersections. Traffic control systems like traffic lights are also taken into account in *SUMO*.

The public transport network is generated from OSM data. Thus, the network only includes the stops and lines listed on *OpenStreetMap*. Information on transit schedule and the types of vehicles assigned to each line are not taken into account. However, the tool *Netedit* aims to complete and to modify the road network generated from OSM data. This allows to create a model of the network close to reality and to add news elements of the road infrastructure to it.

4.2.2 Availability of Transportation Modes

The definition of the transportation modes available or accessible by the traveler is essential to properly model an intermodal transport supply. For example, it would not be possible to use a bicycle or a car and then take the train if the traveler does not know these modes.

SUMO takes into account the transportation modes available in an intermodal trip through the *modes* attribute in the *personTrip* module, which will contain the name of these modes. For example, *modes="car public"* means that the agent can use the car, or public transport or a combination of both. Walking is assumed to be available to all agents while the other modes need to be supplied explicitly.

4.2.3 Cost Function of the Modal Choice

After defining the available transportation modes, the modal choice cost function is used to determine the mode(s) of transport to use to perform the trip. The choice of one mode or the combination of modes is generally based on several characteristics such as the cost, the travel time, and some user's socio-demographic attributes such as age and social professional categories.

Currently, *SUMO* only takes into account the travel time of the transportation modes. Thus, the mode(s) chosen is/are determined by the one/those which has/have the shortest travel time according to the route calculated by *Duarouter*. To calculate the travel time, *Duarouter* uses a shortest-path routing algorithm such as *Djikstra* or A^*. The modeler can choose the routing algorithm that suits him/her best. The travel time of an edge is generally calculated in the free-flow traffic according to the maximum speed of the mode (car, bike, walking) and the speed limit of the edge. Travel times by public transport are calculated from the time of departure, the waiting time, and the difference in intermediate times between successive stops.

4.2.4 Difficulty for New Intermodal Behaviors

In *SUMO*, a person can be in three states during his/her trip: riding, walking, or stopping. The *riding* state, through the attribute *modes* of the *personTrip* module, allows the use of multiple transportation modes to perform a trip. Therefore, it is possible to define intermodal mobility behavior between the origin and destination points (edges) by defining the transportation modes available for an agent. However, the availability of transportation modes is not the only factor influencing the modal choice. The human dimension and the transport supply should be taken into account. Such modifications cannot be carried out by simply customizing the attributes of agents and the transportation modes. Therefore, some adjustments or additions to the source code may be necessary to consider new intermodal mobility behaviors. However, the complexity of the *SUMO* source code makes this operation very tedious.

4.3 Intermodal Routing in *MATSim*

This subsection presents the steps required to perform intermodal routing in *MATSim* as presented above.

Table 8: Main characteristics of agent, network and modal choice in *SUMO* and *MATSim*.

Simulator	Agent's behaviors					Network			Modal choice				
	riding	walking	stopping	in activity	crossing interaction	multimodal	transit schedule	control system	utility function	multi-criteria	trip-based	tour-based	shortest-path
SUMO	✓	✓	✓		✓	✓		✓			✓		✓
MATSim	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓

4.3.1 Creation of a Complete Multimodal Transportation Network

The multimodal network for *MATSim* is generated with the *pt2matsim* module (Poletti et al., 2017). Therefore, cars and buses can interact in the same link. However, there is no dedicated lane for pedestrians and therefore no interactions between drivers and pedestrians. To do this, pedestrians are *teleported* between the origin and destination points at a certain time duration normally corresponding to their walking times. Some traffic control systems like traffic lights are not modeled in *MATSim*. Adjustments such as the definition of free speed and the removing/adding link are possible via the tool *JOSM*[12] through an additional plugin (Neumann and Zilske, 2018). It should be noted that this plugin allows to create a unimodal transportation network for private cars.

4.3.2 Availability of Transportation Modes

MATSim takes into account the availability of transportation modes when an agent performs a trip. Walking is still possible (teleportation in this case). The modes must be defined either globally (parameter *mainMode* in the *QSim* module) or individually for each agent (*mode* attribute of the *leg* parameter in the plan of a person). If a mode is not defined in *QSim*, the agent using this mode will be teleported.

4.3.3 Cost function of the Modal Choice

To understand the modal choice cost function, it is necessary to have an overview on the overall functioning of *MATSim*. Figure 3 presents the general *MATSim* simulation cycle.

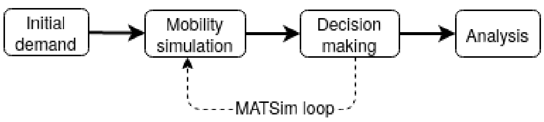

Figure 3: *MATSim* simulation cycle (ref. (Horni et al., 2016)).

The choice of transportation mode is performed in the *Decision making* phase. This phase assigns a score to all plans of an agent in each simulation cycle (iteration) based on a utility function. The score of a plan depends on the utility of the activities carried out and the utility for traveling (typically negative) to those activities based on the transportation mode used. To improve the score of a plan, several replanning strategies are possible: changing the route, changing the transportation mode or changing the starting time of the activity. These strategies are configurable by the modeler who can choose the percentage of agents that will change plans between two iterations. In this case study, we are interested in changing the transportation mode. Currently, the utility function of the transportation mode is based on a single factor, the travel time which is calculated at each end of the cycle. *MATSim* is also based on shortest-path routing algorithms such as *Dijkstra* to estimate travel times during the simulation.

4.3.4 Difficulty in the Definition of New Intermodal Behaviors

MATSim allows to simulate the daily movements of a given population including commutes, leisure trip, etc. Each agent is modeled taking into account his/her capacity (e.g., age and possession of a driving license) to use a given transportation mode. The modal choice is based on a utility function that takes into account the human dimension. Thus, by customizing some attributes/parameters of utility function such as *marginal utility of money* and *marginal utility of travel time*, it is possible to reproduce certain basic intermodality behaviors. On the other hand, to define new behaviors it is necessary to modify some functionalities in the source code. Fortunately, these functionalities are modularly designed and *MATSim* offers a lot of flexibility in the modification of its modules.

4.4 Discussion

Table 8 summarizes our analysis (agents, network and modal choice). The multimodal network of *SUMO* is better modeled than in *MATSim*. It should be noted at this level the difficulty of correcting the *SUMO* multimodal network for larger study areas. This can take a long time to work without being sure of the final result. Li et al. (Li et al., 2018) showed, for example, flow problems at intersections where vehicles could

[12]https://josm.openstreetmap.de/

get stuck without entering the roundabout, thus causing unrealistic congestions. Taking GTFS data into account, *MATSim* multimodal network offers a more realistic public transport supply. Integration of GTFS data into *SUMO* are still in progress.

MATSim, thanks to its activity and agent-based approach, allows better modeling intermodal mobility behaviors by taking into account, for example, the trip purpose, the chains of daily activities, and some attributes of the user such as car availability. The modal choice is also based on a utility function that can consider several criteria such as travel time and cost. This choice can be performed upstream of the simulation through a pairing with a discrete choice model (Hörl et al., 2019). However, due to a high abstraction level, *MATSim* does not simulate microscopic interaction as the pedestrian crossing. *SUMO* takes advantage if the studies focus on a specific multimodal area such as a town square with a train station, buses, bikes, car parking plot. In addition, through the *MATSim* loop, it is possible to better assess the travel behavior of agents who, thanks to replanning, can modify their habits. This is quite interesting because one can imagine new users learning to define the routes as they discover the road network and the state of the traffic. *SUMO* also has an iteration module (*dua-iterate*), but it only relies on travel times to make the choice of transportation mode.

5 CONCLUSION

In this paper we evaluated different simulation platforms with the aim of choosing the most suitable to simulate intermodality policies. The paper first presented a state of the art of traffic simulators comparison. These works can be divided into two groups depending on the evaluation method used: qualitative or quantitative. Based on these works, we proposed a new comparison approach that is both qualitative and quantitative and which takes into account criteria specific to the modeler. It consists first in evaluating the simulators on their ability to meet the evaluation criteria. From this step, a shortlist is retained for a deeper study. Finally, the paper presented a case of study where we evaluated five simulators: four specific to traffic and one generic. We retained *SUMO* and *MATSim* and compared their capabilities to simulate the intermodal mobility behaviors of a given population. *MATSim* was selected as the most appropriate simulation tool to reproduce intermodal mobility behaviors on large scale.

As future works, we plan to focus our studies on *MATSim*, working on embedding an intermodal mode choice module. The aim will be to estimate the parameters of this model from actual mobility data such as HTS and then to implement it inside *MATSim*.

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