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Simulation optimization using SUMO : case of Casablanca

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ABSTRACT

Data exploiting from simulators of road traffic is a well-established field. This paper addresses the development of a tool for data representing for Simulation of Urban MObility (SUMO) software; aiming at first, to (a) optimize of required simulation scenarios inputs (i.e. configuration files), and parse generated data of simulation scenarios such as CO2 emission, noise emission. Secondly, to (b) make generated data more consumable, such as map of emissions activities along the area of study. The evaluation was done with a real-world scenario of Casablanca city, to highlight the performance of the proposed solution.

Keywords: ***Computer simulation; road traffic simulation; SUMO, SAX method.***

I. Introduction

Over the past decades we have witnessed a true explosion of Road Traffic Simulation (RTS). Early work in this field was introduced by [1] in 1935. Moreover, very powerful substantial corpus of RTS models is now available. Traffic simulation systems are artificial reproduction models for imitating road user, traffic supply-demand and even routing technics. Although the vast amount of literature on simulators of road traffic, interfaces for exploiting of generated data from scenarios simulation is a key issue, and few simulators propose this feature. In this article, we investigate data exploiting from SUMO, as it has limited local features, including the ability to present consumable final data quickly to the user. One approach to handle this limitation is to gather generated data from SUMO for a stage of force treatment. This is the motivation for this work. Here we propose a developed tool for data exploiting built in JAVA, which processes output and configuration files of SUMO via Simple API for Xml (SAX) method. Also, this tool is able not only to gives statistics, but also to figure emissions activities of vehicles on the network map, especially, CO2 and noise emissions.

The rest of the article is structured as follows. In the next section, we introduce Computer Simulation and survey its most notable applications. Then, in the Simulation System section, we give a brief introduction on SUMO. Afterward, we highlight the architecture of the developed tool in Simulation section. Finally, we conclude and outline future research.

II. Computer Simulation

A. Simulation models

Progress in mathematical methods and High-Performance Computing (HPC) has made computer simulation a strategic issue for industry and research. Combining mathematical modeling and computer handling, simulation allows better understanding and investigating such phenomenon in evolutionary time and space. It is about reproducing models that meet real-word scenario.

According to [2], simulation is the “Process of designing a model of a real system and conducting experiments, with this model for the purpose of understanding the behavior of the system or of evaluating various strategies for the operation of the system”.

The process of simulation is based on the use of an abstract model, which is in all, a simplified representation of a real system. Simulation models that contain no random variables are classified as deterministic models. With these models, it is possible to predict what could be happen. Whereas, stochastic models are one whose behavior cannot be entirely predicted [3].

A Continuous -Event Simulation (CES) is a model in which the state changes continuously over the time, figure 1. A Discrete-Event Simulation (DES) is a model in which the state changes only when there is a discrete set of points by time, figure 2, [4].

B. Road traffic simulation

Road traffic simulation is much used today. It proves to be an effective tool to analyze a large number of problems that cannot be solved by analytical methods. It is important to note that the first simulation techniques have been developed since the early 50s in transport sector. Nowadays, simulation is considered as a necessary step for people who work on improvement of road projects or on regulation of traffic flow. In general, there are three types of road traffic simulation [5] [6]:

- Macroscopic simulation focuses on the general observable behavior of the system. In case of traffic, the macro-simulation approach involves modeling the general aspects of the system such as density, average speed of vehicles, etc
- Microscopic simulation focuses on the interaction

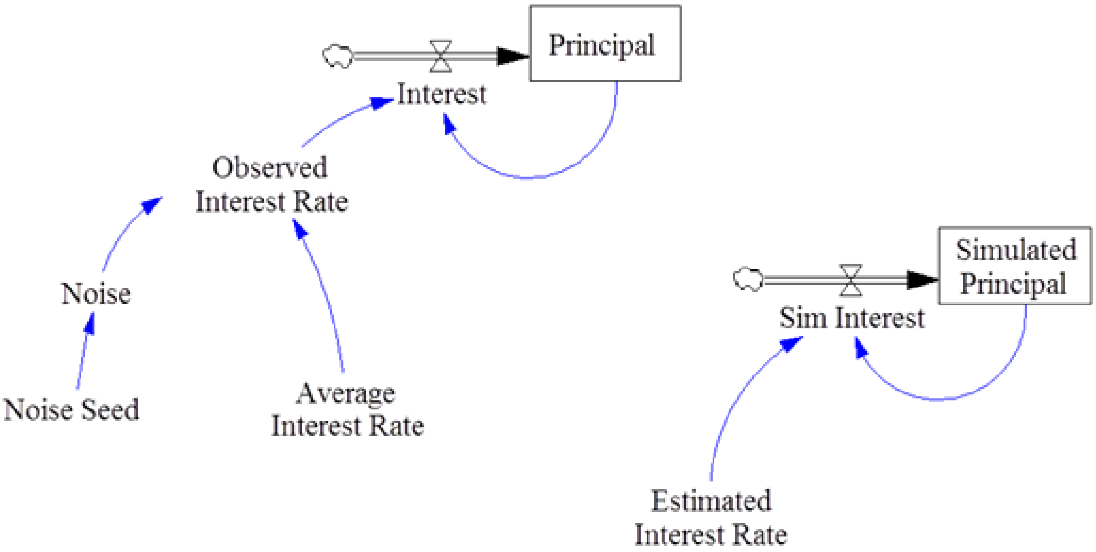

Figure 2. bank account example [7] (left) continuous and stochastic (right) continuous and deterministic

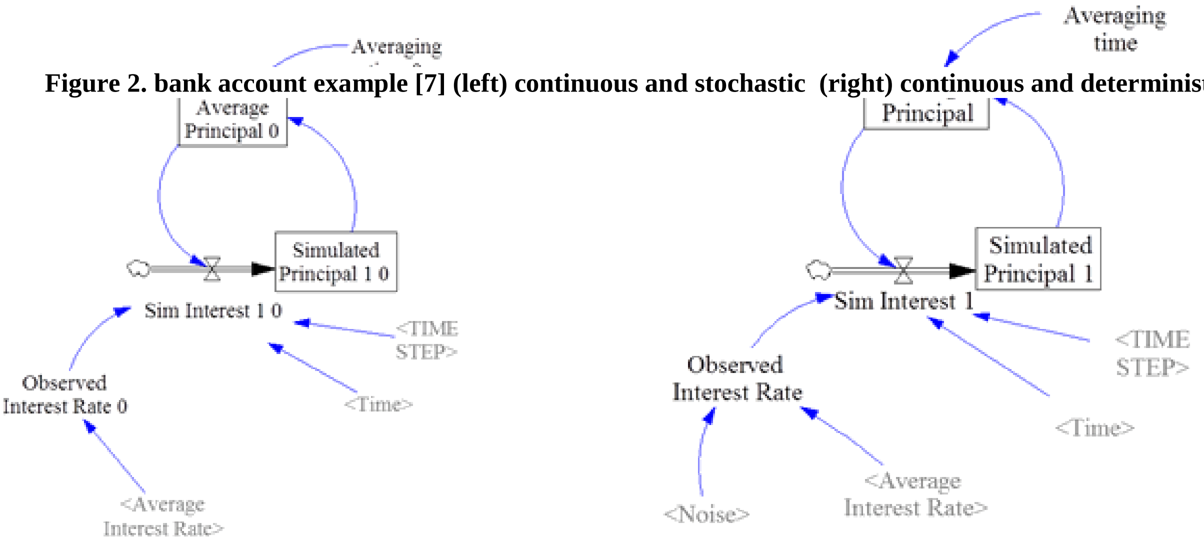

Figure 1. bank account example [7] (left) discrete and deterministic (right) discrete and stochastic

of various locally components system. Microscopic simulation approach for road traffic enables to model each vehicle with specific features such as vehicle width, speed limit, behavior, etc.

- A miso-simulation is an intermediate level between micro and macro simulation. For instance, in case of road traffic, we can consider the overall traffic as a collective behavior of different vehicles.

III. SIMULATION SYSTEM (SUMO)

Simulation of Urban Mobility (SUMO) is a free and open microscopic road traffic simulation package, which has been developed since 2001 by the Institute of Transportation Research in German Aerospace Centre, figure 3 [8]. It allows modeling of multimodal traffic systems, including road vehicles, public transport and pedestrians. SUMO is purely microscopic (vehicles, pedestrians and public transport are modeled in an explicit way) and is implemented in C++ language and uses only portable libraries.

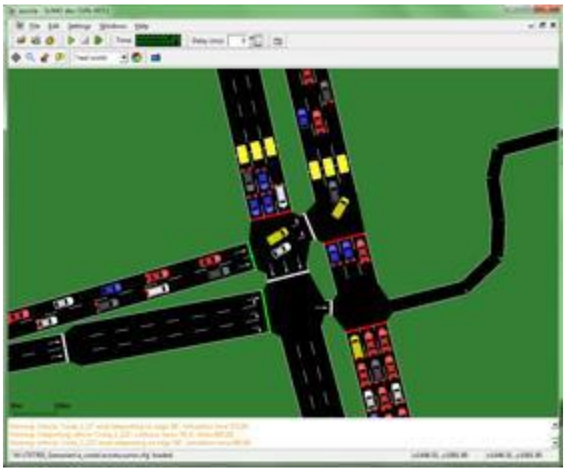

Figure 3. SUMO GUI snapshot

SUMO implements the car following model developed in [9]. Moreover, SUMO has an interface called TraCI (Traffic Control Interface) [10] that makes monitoring of SUMO possible and provides others issues, which are related to the simulation process. SUMO generated data are in XML encoding files, which enable further processing.

IV. CONCEPTION

A. *Use case diagram*

A use case diagram is a graphic depiction of the interactions among the elements of a system. In order to have a comprehensive and clear view of the application, was chosen to model the requirements drawn in the specifications the use case

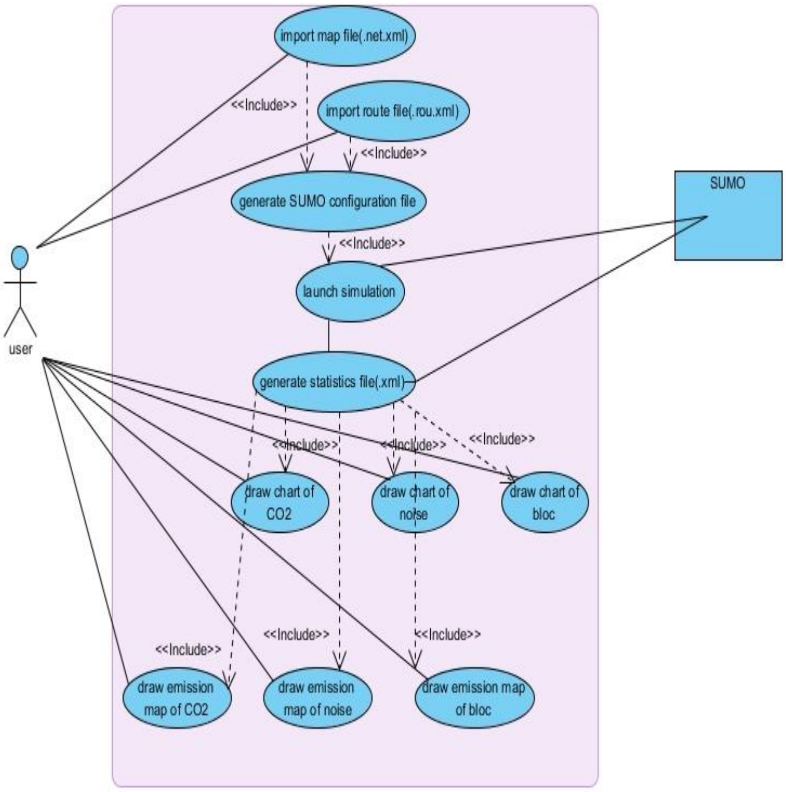

Figure 4. Use case diagram

diagram. The diagram shown in the figure (figure 4) below has the purpose of describing the various interactions between the system and its actors.

Firstly, the user must :

- Import the network file that such extension (.net.xml).
- Import the route file that such extension (.rou.xml).

From these two files the system generates the configuration file that uses SUMO to lunch the simulation and generates the statistics file.

so, the user can view :

- Graphical charter of CO2, fuel and noise.
- Emission map of CO2, fuel and noise.

B. *Sequence diagram*

A Sequence diagram is an interaction diagram that shows how objects operate with one another and in what order. It is a construct of a Message Sequence Chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios see figure 12, 13 and 14.

In the first step, the system asked the user to upload the network and the route file. As soon as the user upload files, the system will check if the files are correct or not.

- If the files are correct then the system goes to the SUMO configuration file to lunch the simulation to the user, as well as the statistical file. After the system may make it possible for the user to view the graphic statistical and the emission map of CO2, noise and fuel.
- Otherwise, the system will ask the user to check the files and try again to uploader of the files.

C. Class diagram

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects.

The figure 15 shows the class diagram we have modeled for the application, it contains eleven classes intervening in the system, the most important is the User class.

V. SIMULATION

A. Experimental settings

The experiments conducted were executed in station work with the following configuration, which constitutes the minimal requirement for simulating for SUMO,

- RAM capacity up to 8GB,
- Processor core at least i5 node with frequency up to 3,80 Ghz.
- To generate statistics file for 1 million vehicles, we need a capacity of HDD up to 500 GBytes.

B. System process

The system process is based on the model building principles in SUMO [11]. Figure 5, gives the general steps for making a scenario simulation. Here, we have investigated the area of Casablanca city. In the first place, the map was gotten from OpenStreetMap and modified by JAVA OpenStreetMap (JOSM), which is a feature included in SUMO. Afterward, the map was converted from ".osm" to SUMO Network File ".net.xml" by using NETCONVERT of SUMO. Then DUAROUTER of SUMO was used to create the simulation scenario and SUMO Configuration File ".sumocfg", figure 6.

At the end of simulation, we get statistics file from SUMO for force handling. Figures 7 and 8 and 9, gives an insight of obtained result under emission activities map form for noise and CO2 emissions respectively. In addition, figures 10 and 11 show the result distribution of CO2 and Noise emissions.

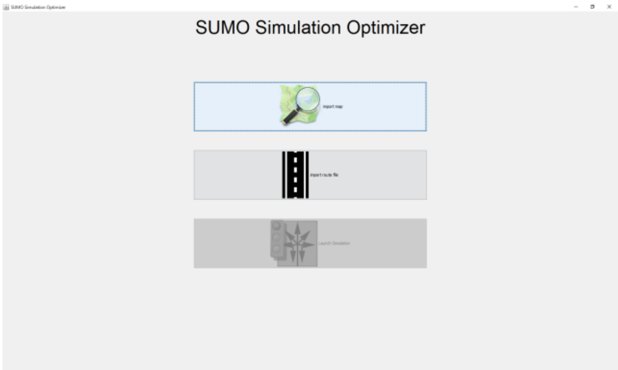

Figure 6. Main GUI

Figure 7. Map of Casablanca city imported into the system

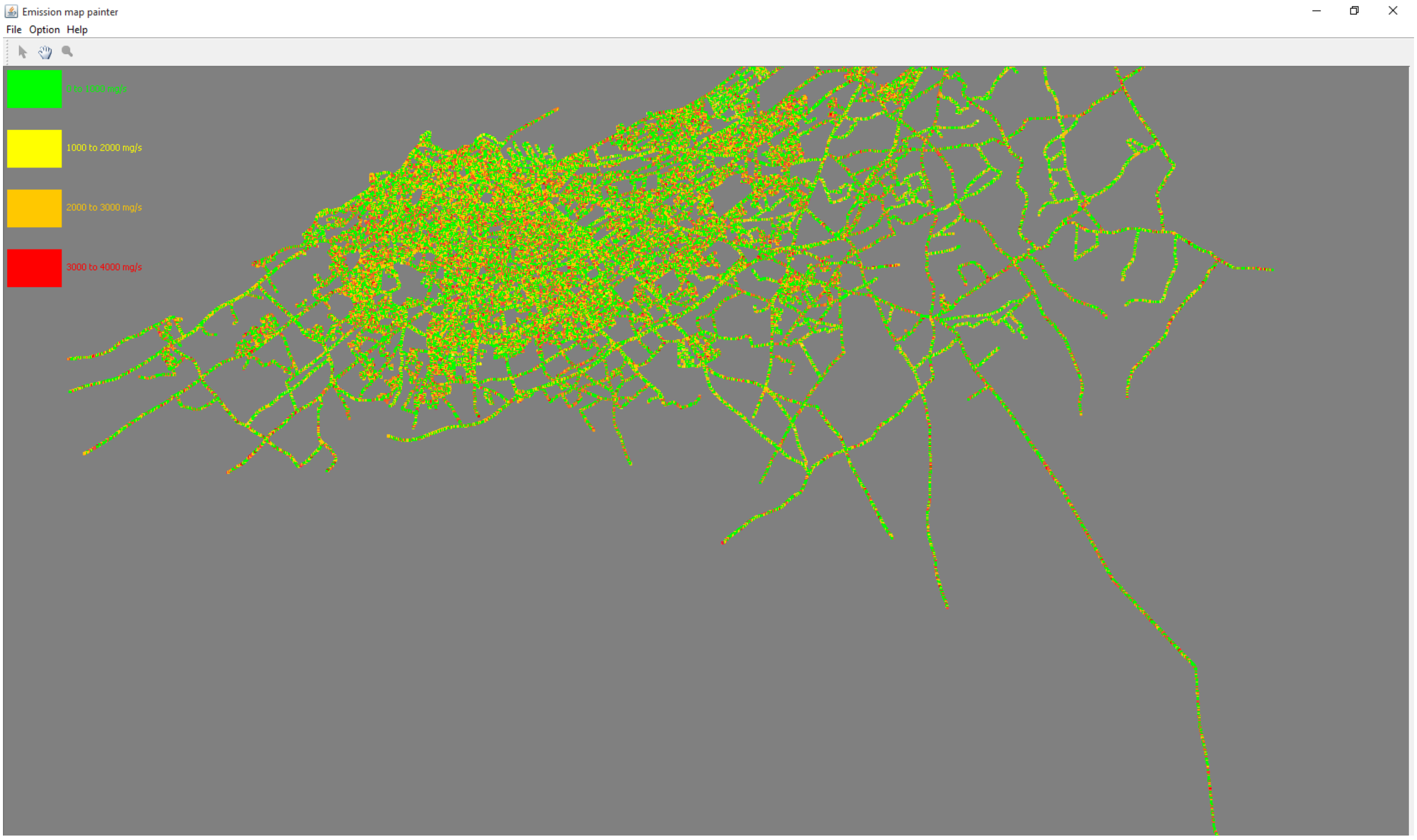

Figure 8. CO2 emissions map

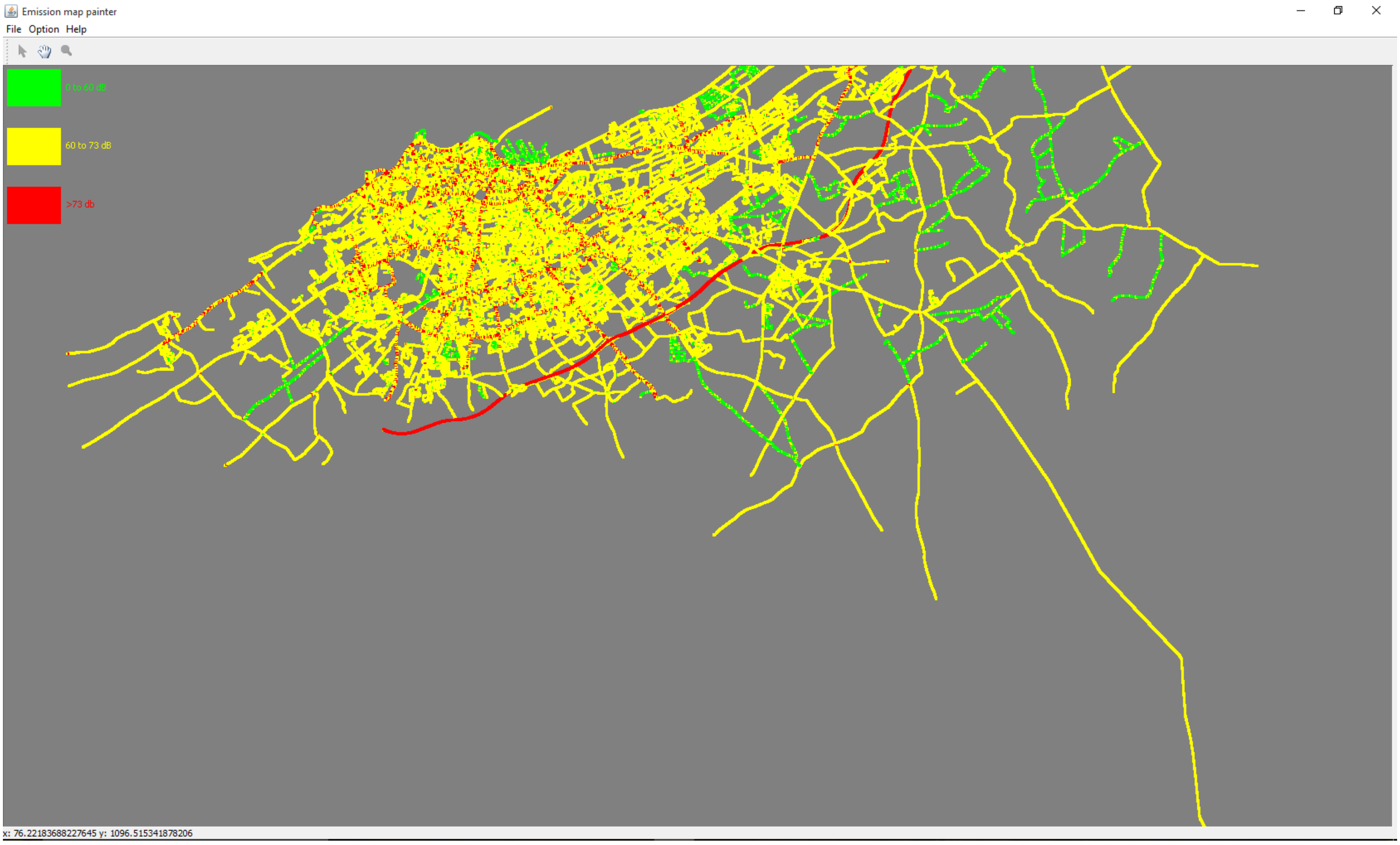

Figure 9. Noise emissions map

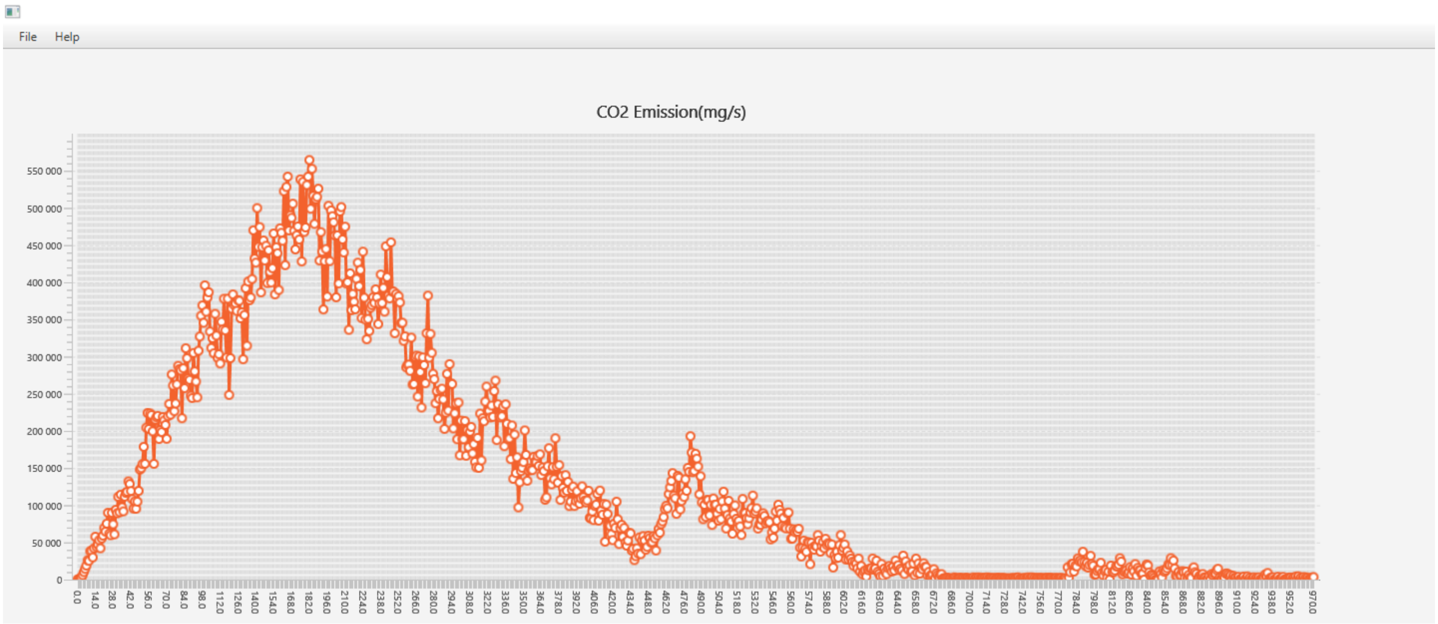

Figure 10. CO2 emissions distribution (mg/s)

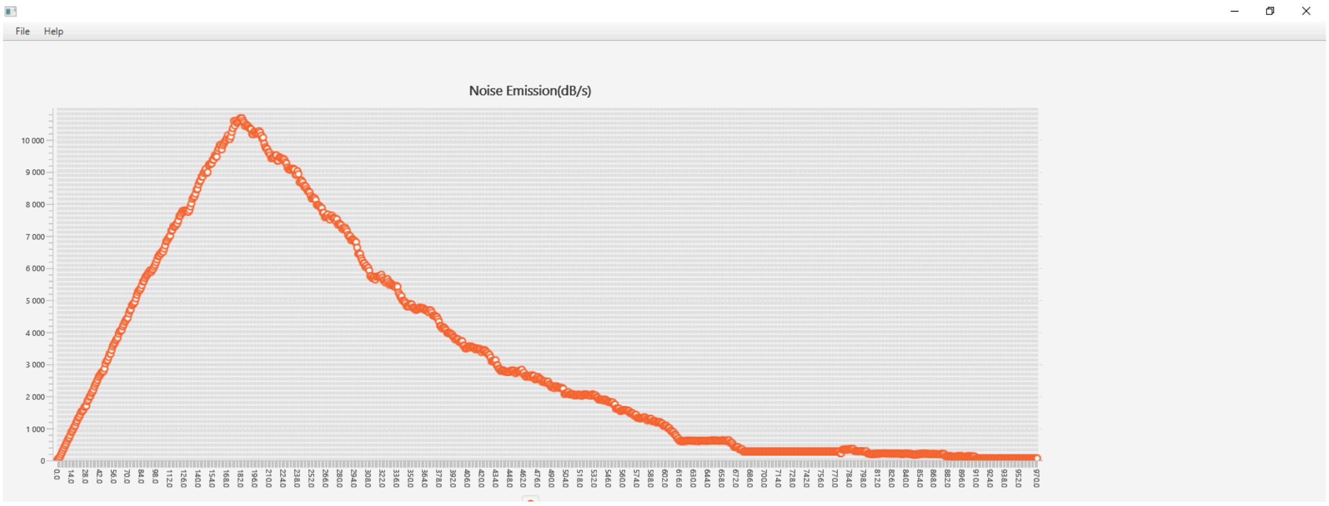

Figure 3. Noise emissions distribution (db/s)

VI. Outlook and Conclusions

As we have mentioned, a significant number of stakeholders worldwide are using road traffic simulators. While only a few simulators provide an interface for data representing, case of SUMO. In this paper, we have focused on optimizing of scenario simulation process and enabling generated data to be consumable. The evaluation has shown that our tool can lead to a better understanding of what has been happen during simulation process for a real-word scenario of Casablanca city. To maintain the aforementioned use cases of the tool, we have incorporated an interactive map, which allows getting better visibility of negative emergent effects (i.e. CO_2, noise). To summarize, the proposed solution constitutes a very useful framework to deal with output files of SUMO and other simulators of road traffic, which have the same files setting. The performed tool presented in this article adds to our perspective, the development of a middleware with numerous application features, making SUMO easier to interact with it.

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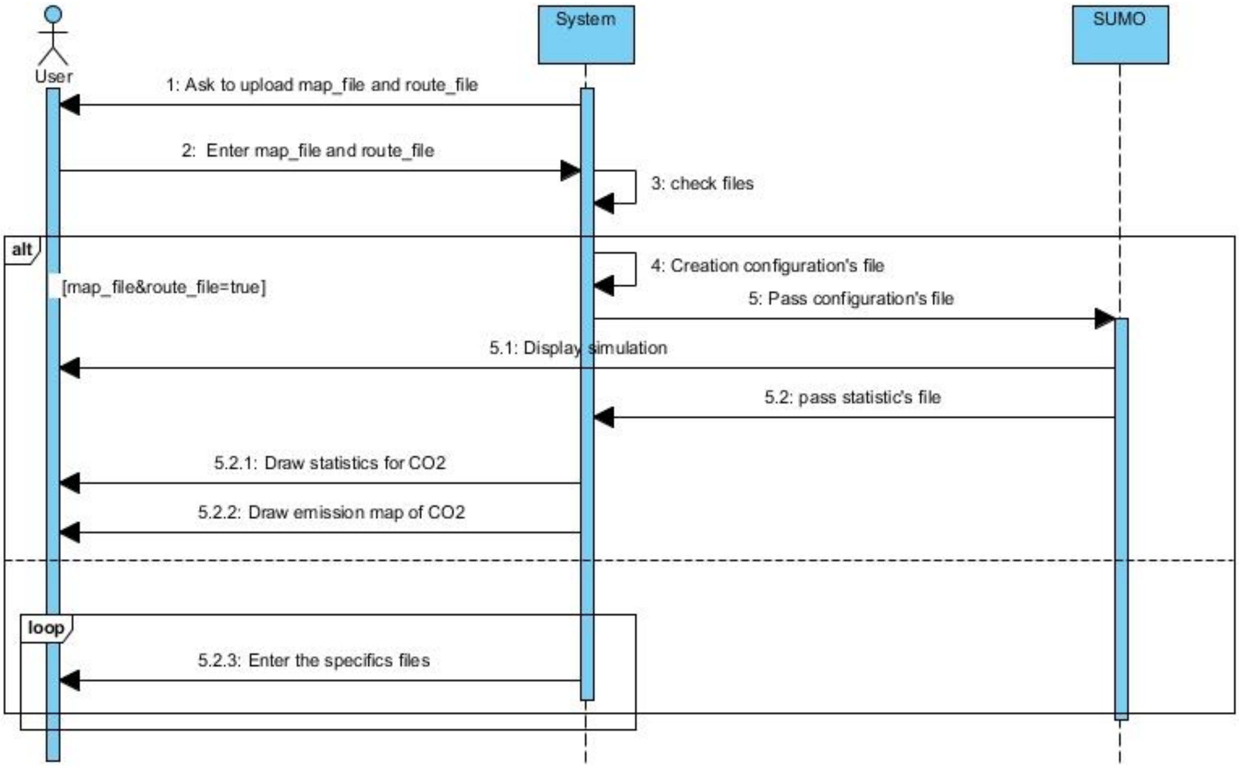

Figure 4. Sequence diagram of CO2 emissions

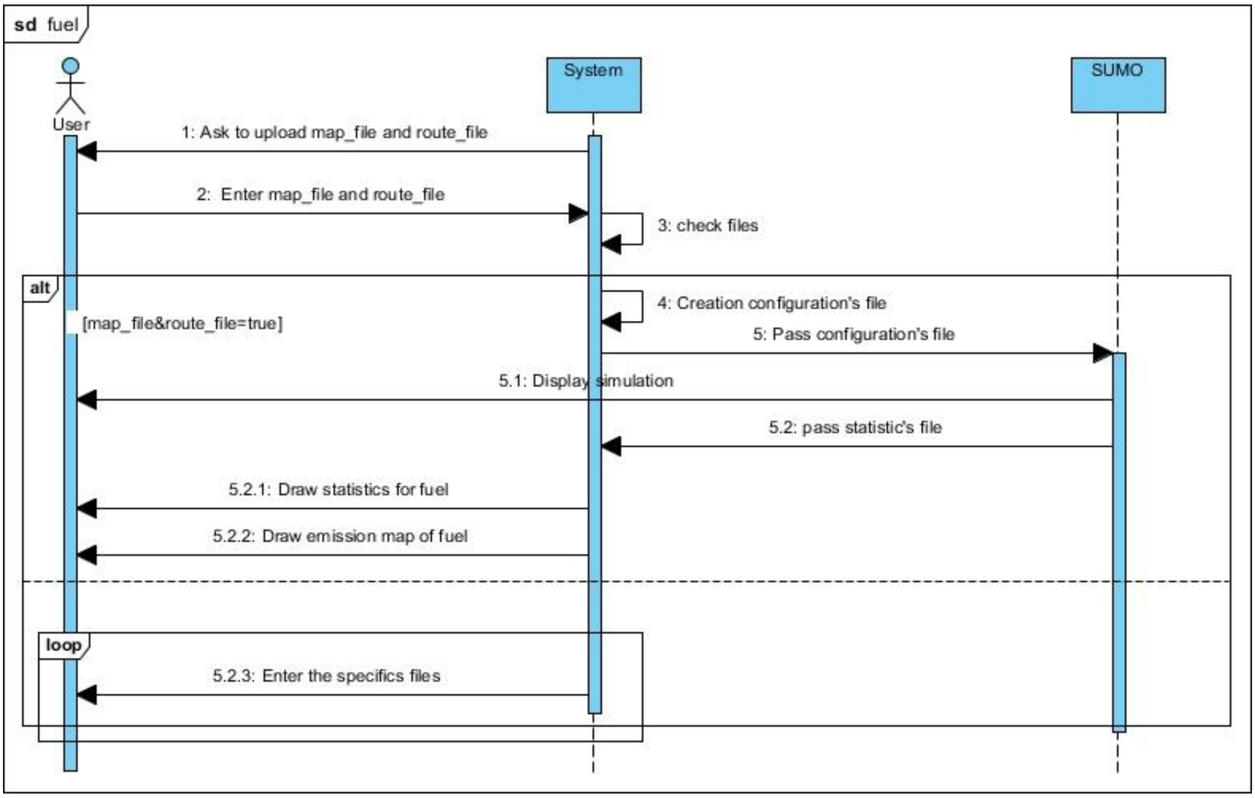

Figure 5. Sequence diagram of fuel

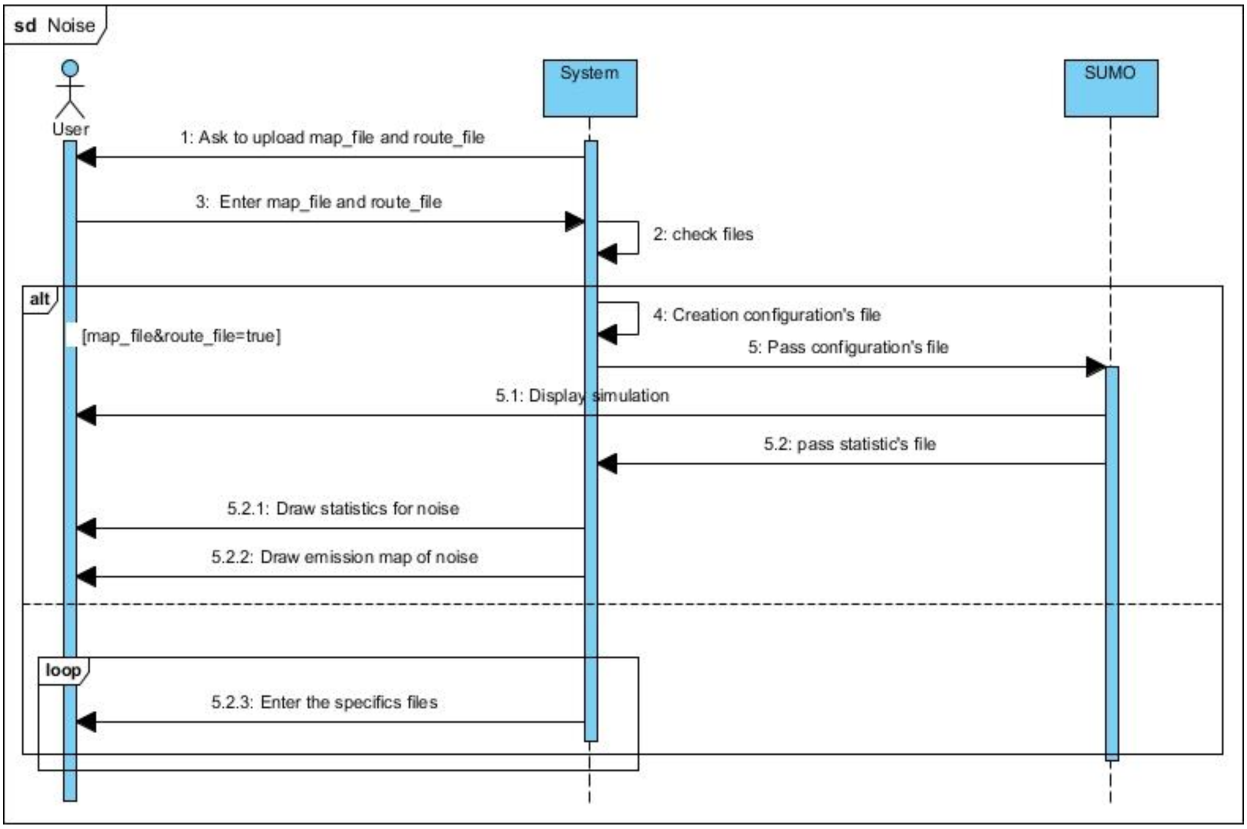

Figure 6. Sequence diagram of noise

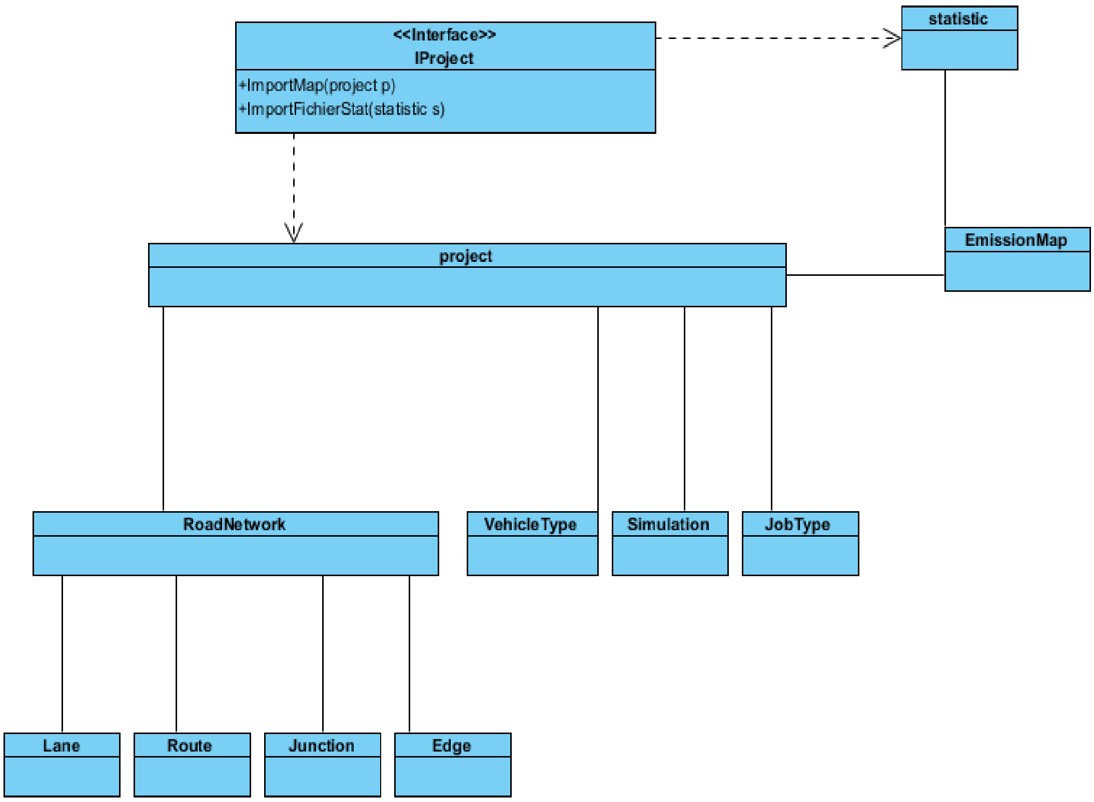

Figure 7. Class diagram