UNIVERSIDAD DE MÁLAGA

# Executive Overview

**Title:** D1.3.1-VanetMobiSim: The vehicular mobility model generator tool for CARLINK

**Summary:** This report presents the different ways of defining realistic mobility models for achieving VANETs (Vehicular Ad-hoc NETworks) simulations as closely as posible to the real world, for using them in CARLINK. Afterwards VanetMobiSim is proposed as the traffic simulator for the project.

**Goals:**

1. Establishing the necessity of defining realistic mobility models for VANETs simulations.
2. Featuring macroscopic description of mobility models.
3. Featuring microscopic description of mobility models.
4. Presentation of VanetMobiSim as the traffic simulator proposed for generating mobility models.

**Conclusions:**

1. For a trustworthy VANETs simulation in CARLINK project, both macro-mobility and micro-mobility descriptions need to be jointly considered in modeling vehicular movements.
2. VanetMobiSim mobility generator tool will be proposed to define the mobility models in CARLINK project.

# D1.3.1-VanetMobiSim: The vehicular mobility model generator tool for CARLINK

CARLINK::UMA

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## 1 Introduction

Vehicular Ad-hoc Networks (VANETs) have been seen as a particular case of Mobile Ad-hoc Networks (MANETs) because they are distributed, self-organizing communication networks and characterized by the mobility of the nodes that make them up.

Notwithstanding, VANETs have some special characteristics, the principals are that the nodes in VANETs have higher mobility and limited degree of freedom in their mobility than the nodes in MANETs, because the VANTEs' nodes should move according to the real behavior of vehicular traffic.

The nature of this kind of networks makes useless the protocols and applications utilized in another type of networks. Therefore, a large number of new applications and protocols are appearing. The evaluation and testing of these ones are being done by using network simulation tools [2].

One of the decisive aspects using VANETs simulation tools is the employment of realistic mobility models that reflects as closely as possible the characteristic behavior of the nodes as vehicles through road traffic.

Generally, the vehicular mobility models are classified into two main categories:

- The **macro-mobility models** focuses on the macroscopic point of view, i.e. motion constraints such as roads, streets, crossroads and traffic lights; the generation of traffic such as traffic density, traffic flows and initial vehicle distribution.
- The **micro-mobility models** focuses on the microscopic descriptions, i.e. the behavior of each driver individually when interacting with other drivers or with the road infrastructure.

The next sections aim at presenting more deeply the main aspects of the macro-mobility and micro-mobility motion aspects that should be taken into account for simulating VANETs to obtain results close to real world. The remainder of this report is organized as follows: Section 2 and Section 3 describe the main features and explain the macro-mobility and micro-mobility models respectively. Section 4 presents **VanetMobiSim** tool for generating realistic mobility models. Finaly, in Section 5 presents some conclusions of the whole analysis.

## 2 Macro-mobility features

Macro-mobility describes all the macroscopic aspects which define vehicular traffic: the road topology, cars movement constraints, the road characterization defining: speed limits, number of lanes, overtaking and safety rules over each street of the aforementioned topology, or the traffic signs description establishing the intersections crossing rules.

The macro-mobility characteristics that mainly may be defined for the simulation of the behavior of vehicles are showed below:

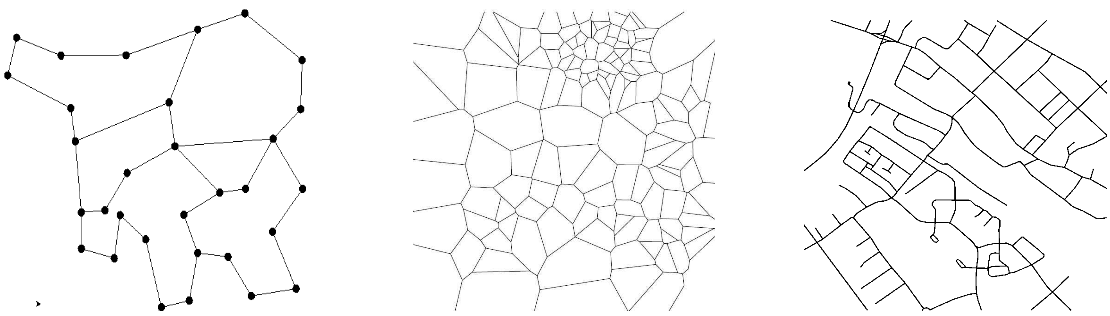
- Road topology: The macro-motion is restricted to move on a graph.
- The initial and destination points.
- The trip through the different points of the road.
- The path selection between the points.
- The velocity of the vehicles through different roads.

## Road topology

The selection of this feature is an important factor for achieving realistic simulations of vehicular movements. This feature affects directly some important measures, either the allowed speed or the traffic density through a road.

The road topology are defined by graphs categorized by the following criteria [5]:

- *User-defined*: The road topology is defined as a list of vertex interconnected by edges (see Figure 1 a).
- *Random*: A random graph is generated using different algorithms (see Figure 1 b).
- *Extracted from real maps*: The road topology information is obtained from real maps and represented using different topological standards, such as either GDF[1] or TIGER[2] (see Figure 1 c).



a) User-defined topology b) Randomly defined topology c) GDF map topology

Figure 1: Different road topologies definition

## Initial and destination points

The initial and destination points may be defined using a set of attraction and repulsion points. These are sources or destination points that have a potential attractive or repulsive measure. Moreover, this points may be defined as random or random restricted, as well.

## Trip generation

The trips are the different sequence of points that the vehicles visit during the simulation. These points may be defined by either activity sequences, which are a set of points of interest, or randomly.

[1]http://www.ertico.com/en/links/links/gdf_-_geographic_data_files.htm
[2]http://www.census.gov/geo/www/tiger/

### Path selection

Independently from the trip generation method employed, different algorithms may be used to generate the sequence of edges to reach the selected next destination point. To achieve that, different aspects may be considered, e.g. the shortest path, the traffic congestion, etc.

### Velocity estimation

The velocity of the vehicles during the simulation may be limited by the road characteristics; these velocities may be uniform through all the roads, smooth accelerations or road-dependant.

## 3 Micro-mobility features

The concept of micro-mobility models includes all aspects related to the individual behavior of the vehicles, e.g. speed and acceleration. This behavior is linked to the driver's personal aspects as the gender, the age or even the mood.

The micro-mobility description plays an important role in the definition of realistic vehicular models, mainly because it is responsible for effects such as smooth speed variation, cars queues, traffic jams and overtakings. [4].

The main aspects that may be featured using micro-mobility definition are:

- *Human Mobility Patterns*: The cars internal motion and its interactions with other cars may be inspired from human motions described by mathematical models such as Car Following, or not.
- *Lane Changing*: Describes the kind of overtaking model implemented by the model, if any.
- *Intersections*: Describes the kind of intersection management implemented by the model, if any.

Three broad classes of micro-mobility models, featuring an increasing degree of detail, can be identified depending on whether the individual movement of vehicles is obtained:

- in a deterministic way
- as a function of nearby vehicles behavior in a single lane scenario
- as a function of nearby vehicles behavior in a multi-flow interaction scenario.

Several mathematical models exist to represent the different possible behaviors of the nodes in the road traffic. These models are explained in detail in [3].

## 4 Mobility models using VanetMobiSim

VanetMobiSim [6] is an open source vehicular mobility generator tool based on CanuMobiSim[3] which has been extended to achieve realistic simulations of vehicular mobility. This software is coded in Java, so it is platform independent.

The input of VanetMobiSim is an XML file where the user specifies the different mobility configurations to define the scenario to simulate.

The output of VanetMobiSim is a trace file which specifies the mobility of the vehicles that have been simulated, this simulation may be showed in a window during the execution (see Figure 2). The trace files may have different formats depending on the network simulator that will used these traces, in the CARLINK project Ns-2[4] is used.

VanetMobiSim supports both macro-mobility and micro-mobility descriptions for scenarios definition. These features are described below.

[3]http://canu.informatik.uni-stuttgart.de/mobisim/
[4]http://www.isi.edu/nsnam/ns/

## 4.1 Macro-mobility features using VanetMobiSim

The macro-mobility features that may be defined using VanetMobiSim are showed in the following subsections.

### Road topology

The road topology may be defined by the user, with GDF or TIGER files or randomly generated by creating a *Voronoi tessellation*[10] on a set of non-uniformly distributed points.

Also the following characteristics may be defined:

- Physical separation of opposite traffic flows on each road.
- Roads with multiple lanes in each direction.
- Speed constraints on each road segment.
- Implementation of traffic signs at each road intersection.

### Trip generation

The trip may be defined using activity sequences to define vehicles that move from a predefined point to another predefined point or randomly for vehicles that have not any specific trip.

### Path selection

The path may be randomly selected and using the Dijkstra algorithm to compute the shortest path. The costs between the different points may be defined as distances between, traffic congestion levels or speed limits.

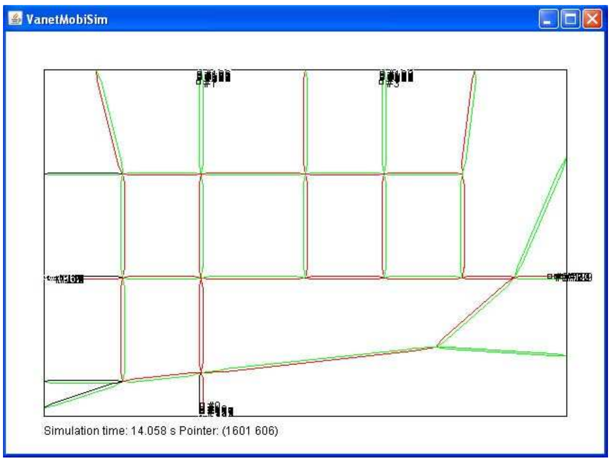



Figure 2: Example of VanetMobiSim simulation output

## 4.2 Micro-mobility features using VanetMobiSim

The micro-mobility features that will be defined using VanetMobiSim to simulate the behaviour of the drivers are showed below.

Computation of the individual speed of vehicles in a deterministic way:

- *Graph-Based Mobility Model* (GBMM)[8]
- *Constant Speed Motion* (CSM)
- *Smooth Motion Model* (SMM)[1]

Computation of the speed of vehicles as a function of nearby vehicles behaviour in a single lane scenario:

- *Fluid Traffic Model* (FTM)[7]
- *Intelligent Driver Model* (IDM)[9]

Intersection management:

- *Intelligent Driver Model with Intersection Management* (IDM-IM)[4]

Lane change and overtake:

- *Intelligent Driver Model with Lane Changes* (IDM-LC)[4]

These models are explained deeply in [3].

# 5 Conclusions

The VANETs are a networking field with growing for the interest from both research and industry communities. The interest from both research and industry communities for VANETs is growing, and nowadays some new protocols and applications are appearing. The main characteristics of this kind of networks are a higher mobility and limited degree of freedom in the mobility patterns of its nodes. These particular characteristics determine that standard protocols inefficient or unusable in this kind of networks.

In the CARLINK project applications and protocols are being developed. These have to be analyzed and tested to observe its behavior. The nature of this kind of systems makes difficult the real tests and analysis. For this reason, simulation tools are needed.

For a trustworthy VANETs simulation both macro-mobility and micro-mobility descriptions need to be jointly considered in modeling vehicular movements.

Indeed, the use of non-specific mobility models employed in VANETs simulations may provide bad results, because they ignore the special behavior of the nodes through this kind of network.

Finally, VanetMobiSim has been proposed as the mobility generator tool for the definition of mobility models inside CARLINK project. The mobility models generated with this tool will be used jointly with NS2 to simulate the different CARLINK scenarios.

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