VanetMobiSim: Generating Realistic Mobility Patterns for VANETs*

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ABSTRACT

In this paper, we present and describe VanetMobiSim, a generator of realistic vehicular movement traces for telecommunication networks simulators. VanetMobiSim mobility description is validated by illustrating how the interaction between featured macro- and micro-mobility is able to reproduce typical phenomena of vehicular traffic.

Categories and Subject Descriptors: I.6.8 [Simulation and Modeling]: Types of Simulation—*Discrete event and visual*; I.6.5 [Simulation and Modeling]: Model Development; I.6.6 [Simulation Output Analysis]

General Terms: Design, Performance

Keywords: Vehicular mobility modeling, validation, vehicular ad hoc networks..

1. INTRODUCTION

Vehicular Ad-hoc Networks (VANETs) represent a rapidly emerging, particularly challenging class of Mobile Ad Hoc Networks (MANETs). VANETs are distributed, self-organizing communication networks built up by moving vehicles, and are thus characterized by very high mobility of nodes and limited degrees of freedom in nodes movement patterns.

A critical aspect, when studying VANETs, is the need for a mobility model which reflects, as close as possible, the real behavior of vehicular traffic. It would be desirable for a trustworthy VANETs simulation that both macro-mobility (road topology, street characterization, car class dependent constraints, traffic signs, etc.) and micro-mobility (car-to-car interactions, car-to-road interactions, acceleration and deceleration, overtaking, etc.) descriptions be jointly considered in modeling vehicular movements.

Nevertheless, many non-specific mobility models employed in VANETs simulations ignore these guidelines, and thus fail to reproduce peculiar aspects of vehicular motion, such as car acceleration and deceleration in presence of nearby vehicles, queuing at road intersections, clustering caused by semaphores, vehicular congestion and traffic jams.

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2. VANETMOBISIM

VanetMobiSim [1] is an extension to CanuMobiSim [2], a generic *user mobility* simulator. CanuMobiSim provides an efficient, easily extensible mobility architecture, but due to its general purpose nature, suffers from a reduced level of detail in specific scenarios. VanetMobiSim is therefore aimed at extending the vehicular mobility support of CanuMobiSim to a higher degree of realism. In the following, for reasons of space, we are only listing the original additions introduced by VanetMobiSim, but it is to note that the complete tool integrates all of the CanuMobiSim features, providing a very wide set of possibilities in simulating vehicular mobility.

2.1 Macro-mobility Features

In VanetMobisim, macro-mobility takes into account the road topology, the road structure (unidirectional or bidirectional, single- or multi-lane), the road characteristics (speed limits, vehicle classes restrictions) and the presence of traffic signs (stop signs, traffic lights, etc.). Moreover, the concept of macro-mobility also includes the effects of the presence of points of interests, which influence movement patterns of vehicles on the road topology.

VanetMobiSim enhances CanuMobiSim allowing to define the road topology in the following novel ways:

- *TIGER map*: the road topology is extracted from a map of the TIGER database [3].
- *Clustered Voronoi graph*: the road topology is randomly generated by creating a Voronoi tessellation on a set of non-uniformly distributed points. This creates fast and configurable random graphs, yet reflecting the non-uniform distribution of obstacles in an urban area.

The concept of vehicular macro-mobility is not limited to motion constraints obtained from graph-based mobility, but also includes all aspects related to the road structure characterization. VanetMobiSim therefore also contains:

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

2.2 Micro-Mobility Features

The concept of vehicular micro-mobility includes all aspects related to an individual car's speed and acceleration modeling.

VanetMobiSim adds two original microscopic mobility models in order to include the management of intersections regulated by traffic signs and of roads with multiple lanes.

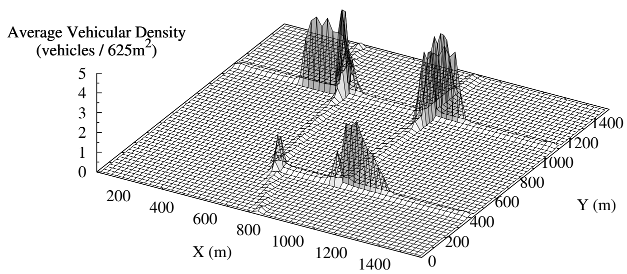

Figure 1: Vehicular density: IDM-IM with stop signs

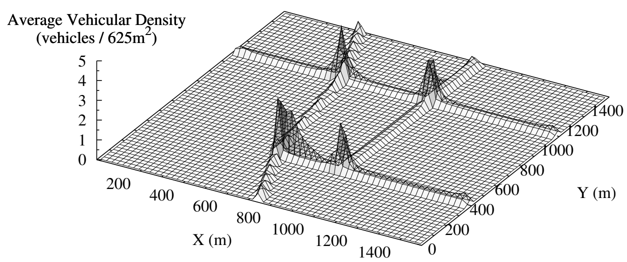

Figure 2: Vehicular density: IDM-IM with traffic lights

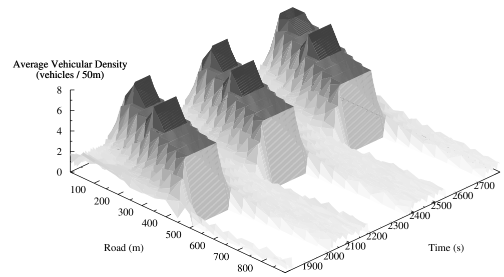

Figure 3: Vehicular density shock waves

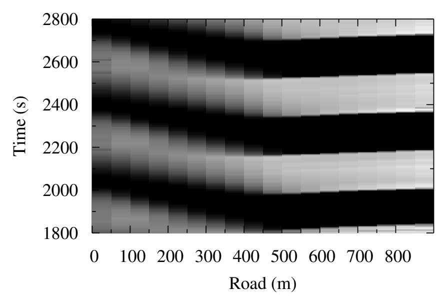

Figure 4: Vehicular speed shock waves

- *Intelligent Driver Model with Intersection Management* (IDM-IM) adds intersection handling capabilities to the behavior of vehicles driven by the IDM [4]. In particular, IDM-IM models two different intersection scenarios: a crossroad regulated by stop signs, or a road junction ruled by traffic lights.
- *Intelligent Driver Model with Lane Changes* (IDM-LC) extends the IDM-IM model with the possibility for vehicles to change lane and overtake each others.

3. VANETMOBISIM VALIDATION

Several tests were run on the vehicular movement traces produced by CanuMobiSim and VanetMobiSim, comparing outputs obtained with the different microscopic mobility models implemented by these tools. Due to space limitations, we are only presenting results for IDM-IM and IDM-LC. For a more complete description of the simulation settings, results and comparisons, please refer to [1].

The IDM-IM model has been tested on a user-defined graph representing a square city section of 1500 m side. The road topology is deliberately simple, so that the analysis of the mobility model is easier and not biased by the complexity of the macroscopic description. Vehicles travel between entry/exit points at borders, crossing the city section according to the shortest path to their destination. We present results in the case that intersections are regulated by stop signs or traffic lights.

As shown in Fig. 1, the stop-ruled intersections case leads to slow crossing of crowded intersections, and, consequently, to long queues of vehicles in their neighborhoods. This also proves how the presence of a mobility model accounting for the car-to-infrastructure interaction (i.e., intersection management) can noticeably affect the outcome of the simulation. Indeed, if such aspect is ignored, the distribution of vehicles is uniform all over the road topology. In Fig. 2 it can be noticed that, when traffic lights with a period of 90 s are used to regulate traffic at intersections, vehicular mobility is improved with respect to the stop sign case, especially in dense scenarios.

Another validation test was performed by recreating a typical effect of vehicular traffic. In Fig. 3, the shock waves produced on vehicular density by a periodic perturbation are shown. This result has been obtained with IDM-LC on a 1 km long, double lane, straight road, with cars moving towards positive abscissae, and using a traffic light, located halfway and with a period of 360 s, as the perturbation source.

It is possible to see that the high density shock wave propagates in the opposite direction with respect to movement of cars as time goes on. The speed dynamics recorded during the same experiment are depicted in Fig. 4, where the lower is the speed, the darker is the plot. We can observe even better the queue perturbation, represented by the dark, zero-speed area, propagating against the traffic flow direction in time.

4. CONCLUSIONS

In this paper we presented VanetMobiSim, an extension to CanuMobiSim, capable of producing realistic vehicular mobility traces for several network simulators. We detailed the extensions brought by VanetMobiSim in both macro- and micro mobility, and discussed simulation results illustrating the distribution and density of vehicles. Our conclusion is that all the features introduced by VanetMobiSim are necessary to reach a level of realism sufficient to confidently simulate VANETs mobility.

5. REFERENCES

[1] VanetMobiSim Project, `http://vanet.eurecom.fr`.

[2] CANU Project, `http://canu.informatik.uni-stuttgart.de`.

[3] U.S. Census Bureau - Topologically Integrated Geographic Encoding and Referencing (TIGER) system, `http://www.census.gov/geo/www/tiger`.

[4] M. Trieber, *et al.*, "Congested traffic states in empirical observations and microscopic simulations", Phys. Rev. E 62, Issue 2, August 2000.