Realistic Urban Traffic Simulation as Vehicular Ad-Hoc Network (VANET) via Veins Framework

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Abstract

These days wireless communication has impacted our daily lives. The developments achieved in this field have made our lives amazingly simpler, easier, convenient and comfortable. One of these developments has occurred in Car to Car Communication (C2CC). Communication between cars often referred to vehicular ad hoc networks (VANET) has many advantages such as: reducing cars accidents, minimizing the traffic jam, reducing fuel consumption and emissions and etc. For a closer look on C2CC studies the necessity of simulation is obvious. Network simulators can simulate the Ad-hoc network but they cannot simulate the huge traffic of cities. In order to solve this problem, in this paper we study the Veins framework which is used to run a Traffic (SUMO) and a Network (OMNET++) simulator in parallel and we simulate the realistic traffics of the city of Cologne, Germany, as an ad-hoc network.

Index Terms: VANET, Network simulation, Wireless, 802.11p, Veins, OMNET++, SUMO.

I. INTRODUCTION

Recently increasing the number of cars on city roads has created many problems, such as traffic congestion, the huge number of getting killed in cars accidents, fuel consumption, emissions and etc. For example according to the National Highway Traffic Safety Administration (NHTSA) there are about 43,000 people who are killed in fatal car accidents each year in the United States [1]. In order to solve these problems and make the roads convenient and safe the researcher has worked on many solutions, one of them is communication between cars [2, 3]. Car to Car Communication (C2CC) or Vehicle to Vehicle (V2V) Communication based on Wireless technology designed to help cars to “talk” to each other. The communication method between the cars has various different approaches but the low cost solution is to use existing wireless networks such as 3G, Wi-Fi, WiMAX, etc [4]. In telecommunication C2CC supports the IEEE standardization (IEEE 1609.x – IEEE 802.11p, IEEE 802.11 a/b/g) [5]. Also wireless communication can run as different scenarios. Vehicular Ad-Hoc Network (abbreviated as VANET) is one of them.

A. Vehicular ad-hoc networks

VANET represent a research field that is a particularly challenging class of Mobile Ad Hoc Networks (MANET). The basilar concept of the VANET is straight and simple: create a widel and cheap wireless technology to connect the vehicle to each other and road side units (RSU) for sending and receiving the information. The important features of VANETs includes these items: Cars and RSU are nodes in VANET, The nodes can moving very fast, and The considered network is highly dynamic which means that topology of the network is continuously changing with changing the position of the nodes and density [6-8].

B. Simulation of VANETs

New protocols, scenarios and wireless technology schemes because of complexity and high expenses cannot be accomplished in large testbed [9]. Due to this problem simulation of VANET is essential to find capability of systems and new approaches. VANET simulation requires two types of simulation components: Network and mobility. In most case network and mobility simulator are separate. There are several simulator available that can be used for VANETs simulation. This paper has classified existing VANET simulation software into three different categories: (a) Mobility generators, (b) Network simulators, (c) Software which are integrated (a) and (b) or software can simulate both mobility and network (VANETs simulator). Figure 1 presents the classification of VANET simulators.

Traffic flow simulator generates required realistic vehicular mobility traces to be used in network simulator as an input. The network simulators calculate and create the required components in a wireless network like detailed structure of all nodes (cars), sending and receiving packets roles, data traffic transmission, channels, etc [10].

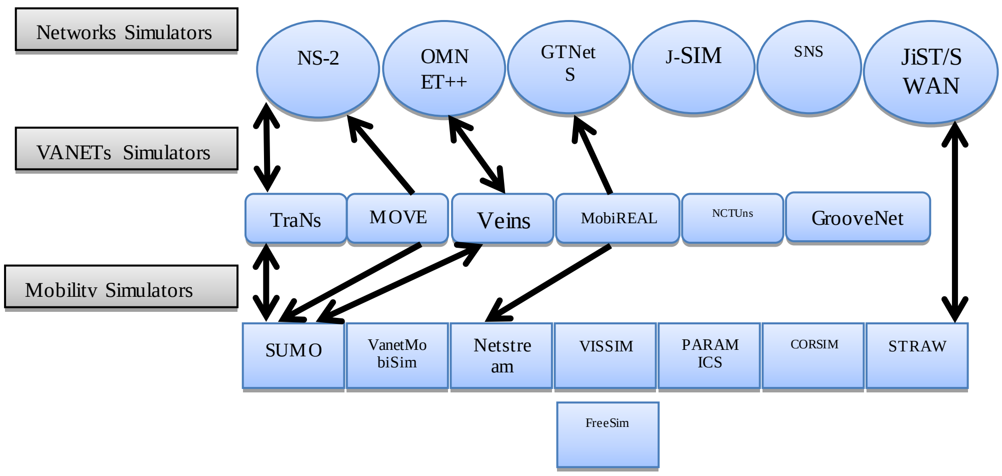


Fig.1. Classification of VANET Simulators

1) Mobility generators:

Vehicular mobility simulations are usually categorized into two main types: microscopic and macroscopic. Macroscopic only focusing on mobility of flow of cars not each car individually. In Macroscopic simulation the generations of vehicular traffic such as traffic density or traffic flows are defined. In the other types of the mobility models, microscopic approach, the movement of each individual vehicle and the vehicle behavior is important [11].

In microscopic model which is used in VANET simulation the required parameters for the mobility generator can be the roads map, scenario of cars traveling and some road and cars parameters like maximum cars speed, roads limitation, arrivals and departures times of each car, etc. Also the output can be the coordinate of each vehicle at every time and their mobility parameters like speed, acceleration, etc. Examples are SUMO [12], VanetMobiSim, CORSIM, CityMob, VISSIM, STRAW, PARAMICS, FreeSim and Netstream.

2) Network Simulator:

Network simulator is usually used for simulation the computer networks. They are used for simulating the VANETs by evaluating the performance of network protocols for mobility of nodes and other required technique. Most currently used network simulators are developed for MANETs and hence require VANET extensions (such as using the vehicular mobility generators) before they can simulate vehicular networks [13]. Examples are OMNET++, NS-2 and NS-3, GloMoSim, J-SIM, SNS, JiST/SWANS, and GTNetS.

3) VANETs simulator:

As mentioned above, VANET simulators provide traffic and network simulation or can combine traffic and network simulator. Examples are Veins, TraNS, MOVE, NCTUns, GrooveNetand, and MobiREAL.

II. VEINS FRAMEWORK

A. Acceptable Simulator

According to the above sections there are several candidates to simulate the VANETs. To select a proper group of network, traffic and VANET simulator, at the first step the network simulator should be considered. Most popular network simulators are NS-2(3), GlomoSim and OMNET++. Due to provided technology and supported standards, NS-2 and OMNET++ are appropriate softwares to simulate the wireless networks [14]. Also according to [15] NS-3, OMNET++ and JiST are able to perform large-scale network simulations in an efficient way. There are several interfaces to couple these network simulators and traffic simulator. But all have drawbacks. For example MOVE could not create a reciprocal communication between network and traffic simulator or in TraNs (with NS-2) there is no analysis in 802.11a/b/p [11]. Also similar researches have been done in this area to select an acceptable interface, for example [16-23]. [16] presents the MOVE software that is based on NS-2 and SUMO. [17] works on TraNS which integrates SUMO and NS-2. VanetMobiSim simulator which is written in Java is studied in [18]. In [19] real maps are used to create mobility traces. The integration of SUMO and NS-2 is done in [20]. Recently a simulation framework with integration between NS-3 and the microscopic traffic simulator DIVERT [22] is presented in [21] and then is extended in [23]. One of The drawbacks of most of integrated simulators is that the network simulator cannot influence the cars behavior in the mobility simulator.

This paper selects Veins framework which coupled the OMNET++ and SUMO due to these most important features: Online re-configuration and re-routing of cars in reaction to network simulator, Fully-detailed models of IEEE 802.11p and IEEE 1609.4 DSRC/WAVE network layers, Supporting the realistic map and realistic traffic. Veins enables running of two simulators in parallel, connected via a TCP socket. Veins framework developed based on MiXiM. OMNeT++ provides a powerful networking simulation tools but it has deficiency in the modelling of wireless communication. In [24] MiXiM, a framework for simulating wireless channels has presented which that provides detailed models of wireless channels, connectivity, mobility and MAC layer protocols for OMNeT++. In Addition SUMO is an open source, microscopic and continuous road traffic simulation package designed to handle large road networks [12].

B. Beaconing

The C2CC concept relies on continuous broadcast of information by all the cars, which allows each car to find out all neighboring cars in real time. These information are broadcasted as periodic messages, which are also known as beacons. The beacons are generated and broadcasted consecutively to tell the neighbors about the car profile. Beacons can include these information about cars: speed, coordinate, next coordinate, acceleration, etc. As mentioned earlier the IEEE 802.11p protocol is used for communications in the VANET. IEEE 802.11p uses a Media Access Control (MAC) protocol that is based on a Carrier Sense Multiple Access protocol with Collision Avoidance (CSM+-A/CA) [25]. Beacons are sent on a fixed interval in VANETs. Most vehicular application used 10Hz for generation rate; also a beacon is about 400 bytes long (including security fields) [25-27].

III. SIMULATION SCENARIO AND RESULT

The main goal of this section is describing the steps of realistic traffic simulation of a city as VANET. As mentioned before, this paper uses SUMO, OMNET++ and Veins to simulate the scenario.

A. Realistic Map and Realistic Traffic

Scenarios in SUMO simulator consist of two parts: Road Network (maps) including roads, streets, traffic light, junctions and etc. and Traffic demand, which mean details of the cars traveling like cars speed, some physical properties for each car, direction, departure and destination time and positions and etc. SUMO's road network can generated by an application named "netgen" that provided with SUMO package, or generate by importing a digital road map. The traffic demand can be define with different sources. For large-scale scenarios usually O/D matrices (origin/destination matrices) are used. O/D matrices describe the movement between traffic assignment zones in vehicle number per time [28].

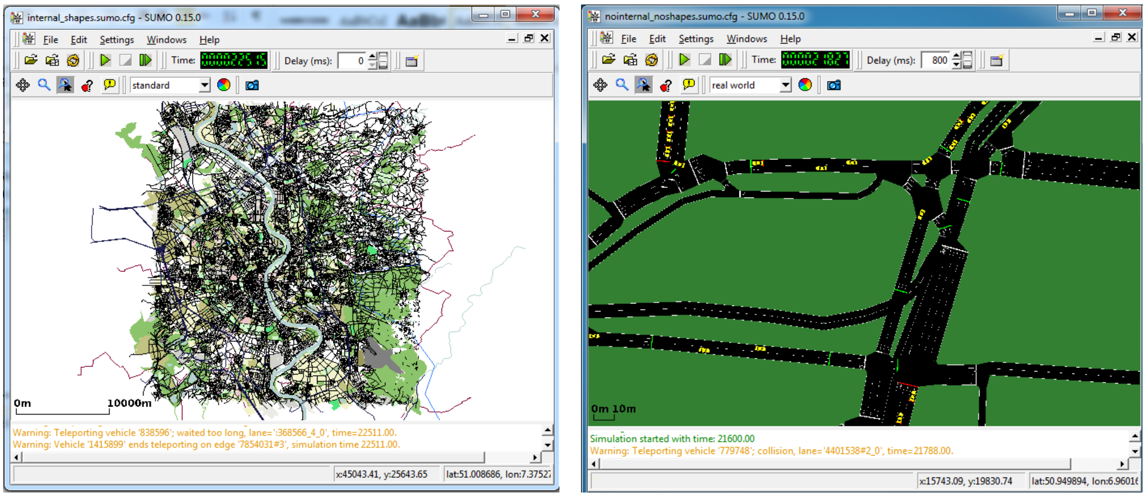
This paper uses the data of [29] for road network and traffic demand. In [29] the realistic traffic demand for city of Cologne, in Germany with realistic map for this city has presented. The cars traveling dataset is mainly based on the data made by the TAPAS-Cologne project. TAPASCologne, provided by the Institute of Transportation Systems at the German Aerospace Center (ITS-DLR), determines realistic car traffic in the city of Cologne. Also street network of the city are imported from the OpenStreetMap (OSM) database [30]. This map covers an area of approximately 400 km^2 around Cologne. These two dataset exported to SUMO. Fig. 2(a) shows the Cologne map in SUMO and Fig.2 (b) shows the traffic in details.

B. Network Simulator configuration

Previous section prepares the realistic traffic and map in SUMO. Next step is configuring the network simulator to run the VANET simulation. Veins framework implements the 802.11p in OMNET++ with all default parameters. The main parameters that used in this study for the network simulation are summarized in Table I.

C. Simulation Result

Veins connects SUMO and OMNET++. At First the cars are generated in SUMO and then exported to the network simulator. OMNET++ considers all cars as nodes and simulates the scenario. If any change occurs in the network, Veins can change the cars scenario in SUMO. Fig.3 depicts how Veins works in more details.



(a) Fig.2. Cologne map and traffic during the simulation in SUMO (b)

TABLE I
NETWORK SIMULATION PARAMETERS

Parameters	Value
beaconing rate	10 Hz
beacon size	256 bytes
maximum transmission power	20 mW
minimum signal attenuation threshold	-89dBm
channel bitrate	11Mbits^{-1}

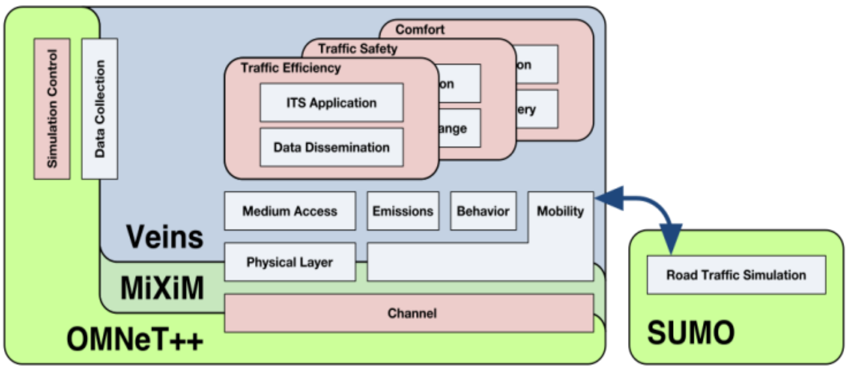


Fig.3. integration of SUMO and OMNET++ by Veins Framework [31]

Simulation scenario is done using the configuration, dataset and parameters defined in the previous section. This scenario runs the simulation 12 times starting from zero. Each time 30 seconds has been added to the simulation time up to 360 seconds. In this scenario, each car sends 10 beacons per second and all neighbors can received the beacons. Output of the simulation contains several statistics for each car such as sent packets, received broadcasted packets, lost packets, speed, position and etc.

In order to analyze the results several sample cars are selected arbitrarily. This paper calculates the Probability of Beacon Delivery for each sample car by using the output statistics. Fig.4 shows the result for two cars in different area versus number of all neighbor cars during the simulation. The result shows that the Probability of Beacon Delivery is different for each car. That can be change due to density of cars or number of received beacons in each period.

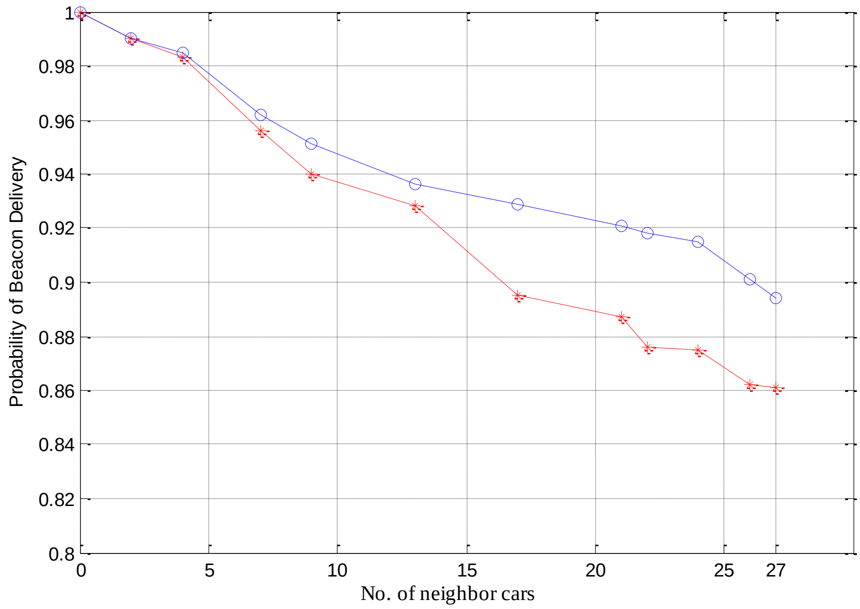


Fig.4. Probability of Beacon Delivery

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