IJEW 国际工程期刊 International Journal of Engineering Works انجینرنگ کاموں کا بین الاقوامی جرنل

International Journal of Engineering Works
ISSN-p: 2521-2419
ISSN-e: 2409-2770
Vol. 7, Issue 05, PP. 228-232, May 2020
https://www.ijew.io/
https://doi.org/10.34259/ijew.20.705228232

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Implementation of Mobility Model for V2V Communication on LTE using NS3 and SUMO

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Received: 19 April, Revised: 04 May, Accepted: 11 May

Abstract— Ad hoc network is a type of network in which there is no center node or center entity. So, there are two type of ad hoc network MANET and VANET. MANET (Mobile Ad Hoc Network) is a type of ad hoc network in which the nodes are connecting wirelessly and have some random mobility. But VANET (Vehicular Ad Hoc Network) are different in traditional MANET due to high mobility of nodes but the realistic vehicle can't be traced by using random mobility model and way point mobility model. So, for this purpose SUMO (Simulation of Urban Mobility) tool is used for vehicular mobility models and we successfully implement that model in NS3 and use a device to device feature (proximity sensor) of LTE module in NS3 for connected nodes (Vehicles) directly. And the aim of this project is to reduce the overload on infrastructural network and overhead in vehicular communication to avoid infrastructure and by connecting vehicles directly.

Keywords— Vehicles, Roads, Trafic, LTE, Device-to-device, NS3, SUMO, OpenStreetMap, TraCI.

I. Introduction

Vehicle-to-vehicle (V2V) based on device-to-device (D2D) communication on LTE is seen as a promising technology to fulfill latency, reliability and capacity required by future wireless communication. Vehicular Ad-hoc Network (VANET) is a type of Ad-hoc Network that is used to provide communications between nearby vehicles, and between vehicles and fixed infrastructure on the roadside.

For defining mobility, we have two types of mobility models that is low mobility models and high mobility models. Low mobility models are used for user equipment's like mobile and this mobility is fully random. And on the second side we have high mobility which is used by vehicles on high speed which follows some architectural paths or patterns. There is a lot contribution present in telecommunication networks for low mobility networks, but no work done on high mobility infrastructure control mechanisms.

Deploying and testing these high mobility networks, usually known as Vehicular Ad-hoc Networks (VANETs), involves a high cost in the real world, so simulation is a useful alternative in research. Different simulation tools are available in the market to simulate these networks. But for mobility model implementation we use SUMO (Simulation of Urban Mobility) because of it is an open source tool which give us a good urban mobility model. And NS3 for simulating the network part of simulation are also open sourced tool having module for LTE.

A. *Organization of paper*

This paper follows the traditional paper flow of IEEE papers. There are five sections. First section is introduction in which I explain the various aspect of title and explain why we chose simulation. In the second section of paper I introduce the problem and literature review with various work done on this side with solution of problem in third section. Fourth section have two subsections, first subsection is about SUMO simulation and second subsection is about NS3. Finally, fifth section is a conclusion and future work.

II. PROBLEM STATEMENT

So, our aim to simulate mobility models for VANETS on LTE using SUMO and NS3. That of to provide path to practical demonstration in future.

A. *Problem explanation*

There are many ways to find the mobility of nodes in the network. In this project we will be using SUMO to define the mobility for the nodes in the network. To study different parameters of the LTE standard based network under different mobility models defined by SUMO we will be using NS3. The NS3 by itself cannot define Vehicular mobility for the nodes(it just have some random mobility models) that is why SUMO is used to generate the trace file of mobility for nodes which then will be imported in the context of NS3. *Automated cleaning.*

III. Literature Review

The literature is divided into three sections. In Section one we are going to study VANETs Models, then in section two we study mobility models and finally we study LTE in Vehicular communication [1].

A. VANETs Models

Figure 1. explaining that there are mainly three type of research area in VANETs Vehicles-to-Vehicles(V2V), V-to-RSU (V2I) and RSU-to-RSU(I2I). RSU also known as Road Side Unit and in VANETs it is also called OBU (On-Board Unit).

Vehicular network is expected to deploy variety of advanced wireless technologies such as Dedicated Short-Range Communication. The DSRC is created to support the data transfer in rapidly changing communication environments. DSRC is effective for short range communication and good for fulfilling the VANETs application for safety that is, Cooperative Collision Avoidance (CCA), Emergency Warning Messages (EWM), Cooperative Intersection Collision Avoidance (CICA), Traffic Managements, Advertisements entertainment and comfort application like Electronic toll collection. But due to low bandwidth DSRC is not applicable for user-based applications like data transmission and video conferencing so therefore we tried to replace it by LTE [2].

B. VANETs Mobility Models

There are two type of mobility models macroscopic and microscopic. Macroscopic models consider constrains at a higher level like road crossing, intersections, streets, roads and traffic lights. While microscopic models take the behavior of individual vehicle with respect to road architecture and other vehicles.

"The development of modern vehicular mobility models may be classified in four different classes: Synthetic Models wrapping all models based on mathematical models, Traffic Simulator-based Models where the vehicular mobility models are extracted from detailed traffic simulator, Survey-based Models extracting mobility patterns from surveys, and finally Traced-based Models which generate mobility patterns from real mobility traces [3]."

"Vehicles follow a trail or certain mobility pattern which is a function of the underlying roads, the traffic lights, the speed limits, traffic condition and driving behaviors of drivers. Because of the particular mobility pattern, evaluation of VANET protocols only makes sense from traces obtained from the pattern [3]."

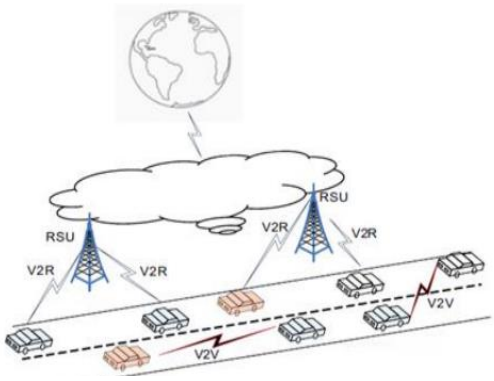

Figure 1. VENATs Model [1]

Different methods of configuration for mobility of Vehicles are advised which are classified as follows:" Entity Mobility Models (that represents mobile nodes whose movements are independent of each other), Group Mobility Models (that represent mobile nodes whose movements are dependent on each other), Urban Mobility Models, City section Mobility models (which are grid based models) and Realistic Mobility Models (that are based on realistic mobility patterns of mobile nodes) [5].

There are different factors which greatly affect the mobility of Vehicles on the roads. The foremost constraint is the presence of streets which restrict vehicular motion to well-defined paths. This makes the areas topology crucial because the same mobility model might lead to drastically different network performance under different topologies. "In short there five main factors which affect the mobility of Vehicles: Layout of Streets, Traffic control mechanisms, Interdependent vehicular motion, Average speed and Block size [5]."

[6] Has compared the performance of VANETs communication under the two mobility models i.e. MOVE and City Mob. According to [6] "Simulation analysis using realistic mobility model for VANET environment show that the performance of the protocol is greatly affected by the mobility model. The performance of an ad hoc network protocol can vary significantly with different mobility models then, the choice of mobility model in simulating VANET is very important. The mobility models for VANET should be most closely matching the expected real-world scenario. In fact, the anticipated real world scenario can aid the development of the ad hoc network protocol significantly.

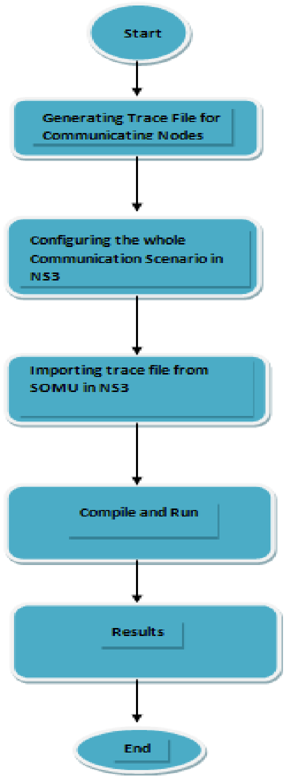

Figure 2. Block Diagram

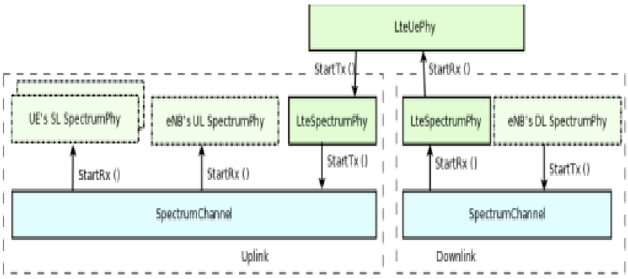

Figure 3: New PHY and Channel Model Architecture for the UE

IV. METHODOLOGY

As the main purpose of this project is to study the throughput for V2V for different mobility models using SUMO and NS3.Therefor we are going to use two major simulation tools to look for the desired results. The figure 2 shows the whole process of execution of this project.

For the movable communicating nodes first, it needs to be configured under specific communication standard protocol-in this case it is LTE. The second important parameter it must be provided with certain mobility pattern either to follow probabilistic pattern or deterministic pattern of motion. Figure 2 is flow chart we first study how we got the trace file out of SUMO. Export that trace file into ns3 adding LTE configuration.

A. Generating mobility model using SUMO

Before going into the steps we have taken for generating mobility in SUMO, we must mention that here we are using Ubuntu as an operating system platform for both NS3 and SUMO, also it is worth mentioning that SUMO could also be used in windows. And SUMO uses XML language for generating mobility scenario.

The following steps were taken to generate mobility in SUMO.

1. Generating Physical infrastructure: In this step we are going to generate physical infrastructure for mobility model that is roads and side buildings. For roads we have nodes (point where change in parameters of road occur) and links (connection between nodes). And also we used Open Street Map (OSM) for cloning maps for this purpose. After mentioning all parameter than we have to compile it by using SUMO pre define script that is "netconvert" which give us one file which contain full architecture and its attribute defined.

2. Dynamic of Traffic: Now we need to define number of vehicles its attribute and its mobility. Here we defined traffic and linked it with physical infrastructure. And for defining traffic we used both approach that define vehicles its sources and sink and its full path and time to start and end or we also used probabilistic approach which only need time to start and number of vehicles.

3. Then we converted that mobility to NS3 compatible trace file by using SUMO python script name "traceExport.py".

B. Putting all togather in NS3..

Now the trace file is created. It's time to configure the network of the communicating nodes in NS3. The whole process is divided into the following steps:

1. We created the lteHelper as an LTE object. Which includes our whole scenario. Then in the second and third line, we are going to create a core network, called PointToPointEpcHelper in the form of an object called epcHelper.

2. Now we configure the LTE scenario which consists of configuring eNbRrc in the transmission mode =2. As part of configuration, we create communication nodes, UE and eNB. we configure our scenario as default that is uplink bandwidth and download bandwidth is 50mbps default transmission mode of EnbRrc as 2. Their transmission and receiving power is 23dB and 46dB respectively.

3. Now attach the trace file generated by SUMO to the UEs. After this, we install the communication devices on UEs and eNbs. We attach the SUMO generated trace file named "examplemobility.tcl" as a mobility file of our scenario (SUMO generates NS2 support trace file which is also supported by NS3 using "ns2-mobility-helper.h" and install it to our scenario. The main limitation in NS3 in mobility models is that you can't specify the exact nodes for mobility. Because SUMO mobility should be installed to all nodes. So, making enb and epc static we do some changes that defining the position of those nodes in trace file at the last and make epc and enb nodes after UE nodes.
4. UEs are configured with side links with the default configuration. Now install internet devices on each UE and eNb and assigning IPs by epc (core network). We configured sidelink at Radio Resource Code level as preconfigure mode in this mode the UE's uses its configuration stored as a default in UE's this mode is used in out of coverage areas or we used here in V2V scenario. (that carrier frequency of sidelink is 23330Hz of the bandwidth of 50Mhz we make one pool of nodes that is every node are in the same network. And after that, we configure the parameter of the pool.) And after that we are going to install that default configuration to ueDevs(vehicles.)

5. Finally, we install application on the devices and run the simulation for particular duration. And enabled all traces of LTE. And enable animation interface on named "anim.xml." after all of that run simulator and end.

V. RESULTS AND DISCUSSION

As we have been using simulation tools in this entire project, therefore the results are presented in the form of the snapshots from the interfaces of these simulating tools. The simulating tools are SUMO and NS3 which had been discussed in great detail in the previous Section of methods.

We can see in figure 4a where the vehicles start to be generated by SUMO at the lower left corner and moving toward the right. In this topology of roads, there are three lanes defined in each segment of the road. Every vehicle follows its corresponding lane on which it is generated by the simulator.

In figure 4b Vehicles also generated from the second segment (the second left side vertex) also we can see that vehicles from the lower left side are taking turns in the intersection. This decision of taking turns is totally probabilistic, every vehicle takes a turn on the intersection they encounter is probable by a certain level of probability defined to the vehicles.

In figure 4c the vehicles are finally approaching for their defined destination. This locomotion of vehicles from start to their destination is logged by the simulator in the form of a trace file which is then exported to the Network nodes in the simulator, here in this project in NS3.

Now we are going to show the same movement of nodes in the network simulator, NS3. Where these vehicles will look like simple dots moving on the defined grid. The full scenario is expressed through the following figures. The sequence of the figures shows the progression in the motion of nodes toward the defined destination.

Figure 5a is the start of mobility and figure 5b is random clicks of scenarios in movements. In these figures, we only install the mobility of SUMO on nodes to validate the SUMO mobility in NS3. In NS3 comparing NS3 mobility to SUMO mobility animation file, we get that in NS3 origin of the plane is up-left while in SUMO it is down left.

Now after this we have installed the communication devices on each node so that they could communicate with each other. The next figure that is figure 6a and figure 6b is going to show how these moving nodes (vehicles) transmit message packets to each other on the shared medium.

The direction of arrows toward nodes shows the direction of communication. Also, the radius of the circles shows the transmission range of the individual node. So, from here we clearly see that every nod is communicating with each other.

VANETs and LTE protocol to have the maximum throughput. We didn't get to our goal during this short period of time as compared to the level of this project. Therefore, we only validated the D2D or ProSe functionality in LTE for VANETS.

As most part of this project has been completed, therefore the future of this project will be the achievement of the goal, to have the best-case scenario for the maximum throughput, for which this project had been started.

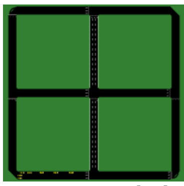

Figure 4a: Vehicles Start Moving

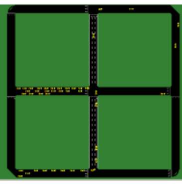

Figure 4b Vehicles Turns take on Intersection

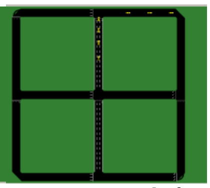

Figure 4c: End of Simulaion

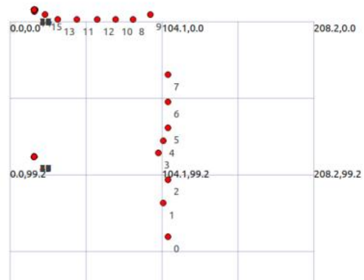

Figure 5a: Random click of NS3 Simulation

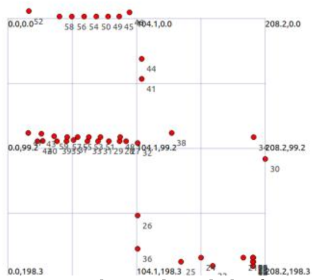

Figure 5b: Random click of NS3 Simulation

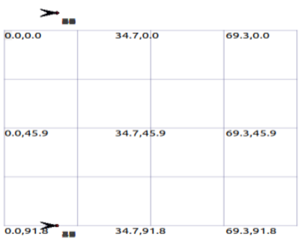

Figure 6a: communication between nodes

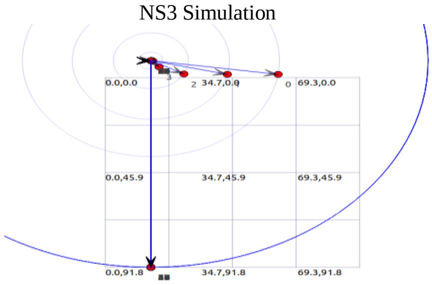

Figure 6b: communication between nodes

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