The Simulation Tool of Vehicular Ad-hoc Networks

Dr.Gaurav Kumar Jain, Associate Professor, Deepshikha Kala Sansthan, Jaipur
Shritosh Kumar, Assistant Professor, JECRC UDML, Jaipur
Neelam Gupta, Assistant Professor, JECRC UDML, Jaipur
Dipesh Bhardwaj, RCERT, Jaipur

Abstract – ***Recently, Vehicular ad hoc network (VANET) can offer various services and benefits to VANET users and thus deserves deployment effort. Intelligent Transportation Systems (ITS) are aimed at addressing critical issues like passenger safety and traffic congestion, by integrating information and communication technologies into transportation infrastructure and vehicles. They are built on top of self organizing networks, known as a Vehicular Ad hoc Networks (VANET), Vehicular communication systems facilitate communication devices for exchange of information among vehicles and between vehicles and roadside equipment. Working in tandem with the fielded Intelligent Transportation Systems (ITS) infrastructure, VANET is expected to enhance the awareness of the traveling public by aggregating, propagating and disseminating up-to -the minute information about existing or impending traffic-related events. In support of their mission, VANET communications, employing a combination of Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) wireless communication are expected to integrate the driving experience into a ubiquitous and pervasive network that will enable novel traffic monitoring and incident detection paradigms. In this paper, we consider that every study should chose the appropriate simulator based on its requirements.***

Keywords - Simulation VANET, Mobility model, JiST/SWANS, iTetris, VanetMobiSim, SUMO, VEINS, TraNS, MOVE.

I. INTRODUCTION

Vehicular networks are very likely to be deployed in the coming years and thus become the most relevant form of mobile ad hoc networks. In recent years, the number of motorists has been increasing drastically due to rapid urbanization. The number of automobiles has been increased on the road in the past few years. Due to high density of vehicles, the potential threats and road accident is increasing. Wireless technology is aiming to equip technology in vehicles to reduce these factors by sending messages to each other. Critical traffic problems such as accidents and traffic congestion require the development of new transportation systems [1]. Intelligent Transportation Systems (ITS) that is poised to bring about a revolutionary leap by making roadways and streets safer and the driving experience more enjoyable. VANET communications, employing a combination of Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) wireless communication are expected to integrate the driving experience into a ubiquitous and pervasive network that will enable novel traffic monitoring and incident detection paradigms [2]. It is widely known that, due to high-speed mobility, V2V and V2I communication links tend to be short lived. Thus, it is important to propagate traffic-related information toward a certain region of interest instead of sending to a particular vehicle; moreover, one of the best ways of propagating traffic-related advisories towards a particular region is some form of (controlled) broadcast transmission. A major setback in applying MANET protocols to VANETS is the ability to adapt to conditions such as frequent topological changes. The vehicular safety application should be thoroughly tested before it is deployed in a real world to use. Simulator tool has been preferred over outdoor experiment because it simple, easy and cheap. VANET requires that a traffic and network simulator should be used together to perform this test. Many tools exist for this purpose but most of them have the problem with the proper interaction. The evaluation of VANET protocols and applications could be made through real outdoor experiments, which are time-costly and claim for a large number of resources in order to obtain significant results. Instead, simulation is a much cheaper and easier to use method. Obviously, this leads network and application developers to use simulation in order to evaluate different simple or complicated and innovative solutions before implementing them. In turn, this stimulated the interest for the development of simulators that easily integrate the models and respond to the requirements of VANET applications. Simulators have become indispensable tools at least in the initial phases of the VANET application engineering process [22]. Under these conditions, computer simulation has become the main tool in VANET research. However, despite the attention the field has received in the last decade, there is currently no standard simulator for vehicular communications. In this paper, we present the main solutions available for VANET simulation, along with their strengths and weaknesses.

II. BACKGROUND

Vehicular networks share a number of similarities with MANETs in terms of self-organization, self-management, and low bandwidth. However unlike in MANETs, the network topology in vehicular networks is highly dynamic due to fast movement of vehicles and the topology is often constrained by the road structure. Furthermore, vehicles are likely to encounter a lot of obstacles such as traffic lights, buildings, or trees, resulting in poor channel quality and connectivity. Therefore, protocols developed for traditional MANETs fail to provide reliable, high throughput, and low latency performance in VANETs. Thus, there is a pressing need for effective protocols that take the specific characteristics of vehicular networks into account. VANET simulation is a challenging task, since it involves network simulation and traffic simulation [23]. A number of network simulators are currently available, with ns-2 being the most prominent. However, ns-2 also brings performance issues regarding the nodes behavior as real vehicles. Simulating a VANET involves two different aspects. First, there are issues related to the communication among vehicles. Network simulators, like The Network Simulator—ns-2 (2008) and Jist/SWANS (2008) cope with communication issues and focus on network protocol characteristics. The second very important aspect is related to the mobility of the VANET nodes. Traffic simulators take into account the traffic model, not necessarily in conjunction with VANETs. For example, TRANS—Traffic Network Simulator (Katz, 1963) was used to optimize the timing of traffic lights in the absence of inter-vehicular communication. Choffnes and Bustamante (2005) showed that the vehicular mobility (traffic) model is very important, and its integration with the wireless network model could produce more significant results. The authors present an integrated simulator that uses an original vehicular traffic model called Street Random Waypoint (STRAW) implemented on top of JiST/SWANS (2008). The authors have used the simulator to show that studying routing protocols for a vehicular network without an accurate vehicular traffic model is a wrong approach. In this respect, they compared their own results with those obtained with the Random Way point model (Broch, 1998), which is a very inaccurate representation of a vehicular network. The mobility model implemented in some simulators is not a sufficiently accurate representation of actual vehicle mobility. For example, in the model of Saha and Johnson (2004), each vehicle moves completely independent of other vehicles, with a constant speed randomly chosen. Multi-lane roads or traffic control systems are not taken into consideration. Other authors (Mangharam et al., 2005) make similar simplifying assumptions and do not consider multi-lane roads or car following models. The mobility model of Choffnes and Bustamante (2005) is more complex: the motion of a vehicle is influenced by the preceding vehicle, and traffic control systems are considered. However, multi-lane roads are not taken into consideration. VNSim (Gorgorin, 2006), which includes a complex model for vehicles mobility, a wireless network simulator, and an interface for the emulation of vehicular applications. The simulator can be used to analyze networks of several thousands of nodes in complex city scenarios as well as in highway scenarios. The simulator allows the evaluation of a large range of vehicular computing applications, which cannot be studied by using other simulators, and can be used to improve both car-to-car communication protocols and traffic control applications (Gradinescu, 2007; Diaconescu, 2007).

III. SIMULATION TOOL FOR DEVELOPING VANET

Construction of a simulation therefore seems inevitable for VANET. There are two aspects of simulating VANET: one is the traffic simulation and other is network simulation. The traffic simulation aids in creating traces of urban mobility model; this information is fed into the network simulation. The network simulation builds topologies between the nodes and vice versa [17]. Several approaches can be distinguished among the simulation frameworks used for VANET research. The first one is to feed real vehicular traces to a network simulator [11]. This solution has the advantage that it only needs a very simple mobility model. No computation is involved and the network simulator only needs to read from a file the geographical position of the vehicle. However, there are also some important negative aspects about real traces. First of all, such data is very rare. While some highway operators regularly gather this type of information, there are very few dedicated campaigns at the level of a city or region. A second aspect is the fact that the movement of the vehicles is pre-established and it cannot be modified by information received through vehicular communications. This makes real traces unusable for a series of scenarios, like traffic management.

A number of simulations exist for VANET but none of them have been up to the mark and none of them can provide a completion solution set for simulating VANET. From the traffic simulator perspective, the traces generated once seem useless after a certain time as the dynamics of traffic change abruptly. Another problem that remains difficult to solve is the inter communication issue between the two simulators i.e. traffic and network simulator. Without a solid solution to this problem, the inter communication between the two still remains a matter of discussion.

IV. COMPARISON OF SIMULATORS

This section will explore the strengths and weaknesses of each simulator. There are various types of VANET simulator are categories in basically three different types.

1. **Network Simulator**

A. NS2/NS3

NS began as a variant of the REAL network simulator in 1989 and has evolved substantially over the past few years. In 1995 ns development was supported by DARPA through the VINT project at LBL, Xerox PARC, UCB, and USC/ISI. Currently ns development is support through DARPA with SAMAN and through NSF with CONSER, both in collaboration with other researchers including ACIRI. It is packaged with a bundle of rich libraries for simulating wireless networks. All the mobile nodes in NS-2 quickly assume that they are the part of Ad-hoc network and the simulation mobile nodes connected with infrastructure networks are not really possible. For simulating a wireless node the physical layer, the link layer and MAC (media access control) protocol are all included at the same time. But despite this NS-2 is unable to simulate multiple radio interfaces [29] . Moreover NS-2 has unrealistic models for wireless channel, which results in a biased radio propagation [17].

The official ns-2 release contains two mobility models that could be useful in VANET simulation: a freeway model and the Manhattan model, which is basically a grid model. However, in these models, the nodes move independently and the spatial superposition of two or more vehicles is possible [8].

NS-2 has certain limitations when it comes to including more than one wireless interfaces per node and the field of vehicular communications is that its high complexity hardens the implementation of vehicular mobility models inside the framework. Moreover, its memory and CPU consumption do not allow scenarios with more than a few hundred nodes [8].

B. OMNET++

OMNeT++ is an open-source object-oriented modular discrete event network simulation framework. It has a generic architecture [29]. It can be used to model computer networks or just as well for queueing network simulations. OMNeT++ only provides the necessary framework for developing a certain simulation module, but these models are developed independently of OMNeT++, and follow their own release cycles. This means that several frameworks can be modeled in the same research area [8] . OMNeT++ itself is not a simulator of anything concrete, but rather provides infrastructure and tools for writing simulations. One of the fundamental ingredients of this infrastructure is a component architecture for simulation models. Models are assembled from reusable components termed modules. OMNeT++ simulations can be run under various user interfaces. Graphical, animating user interfaces are highly useful for demonstration and debugging purposes, and command-line user interfaces are best for batch execution.

C. QualNet

QualNet is a state-of-the-art simulator for large, heterogeneous networks and the distributed applications that execute on such networks. QualNet support Robust set of wired and wireless network protocol and device models, useful for simulating diverse types of networks, optimized for speed and scalability on one processor, QualNet executes equivalent scenarios 5-10x times faster than commercial alternatives. It is designed from the ground-up as a parallel simulator, QualNet executes your simulation multiples faster as you add processors. QualNet has been used to simulate high-fidelity models of wireless networks with as many as 50,000 mobile nodes [28].

D. JiST/SWANS

JiST is efficient, out-performing existing highly optimized simulation runtimes. As a case study, the JiST framework by applying it on the construction of SWANS [26], JiST is a high-performance discrete event simulation engine that runs over a standard Java virtual machine. It is a prototype of a new general-purpose approach to building discrete event simulators, called virtual machine-based simulation that unifies the traditional systems and language-based simulator designs. Extension of the JIST system to support optimistic execution should also not require any modification of existing application, modulo the rollback methods that are discussed shortly. It will, however, require the implementation of the tricky machinery for logging and recovery within the runtime, including both undo propagation and message cancellation [25]. SWANS are a scalable wireless network simulator built atop the JiST platform. It was created primarily because existing network simulation tools are not sufficient for current research needs, and its performance serves as a validation of the virtual machine-based approach to simulator construction. SWANS are organized as independent software components that can be composed to form complete wireless network or sensor network configurations. The SWANS prototype will be implemented as a plain Java application and will serve as a validation of the JIST idea. In reality, the implementation of SWANS will overlap with and drive the implementation of JIST. SWANS will contain code for physical layer radio propagation, node movement and mobility models, 802.11b, both DSR and ZRP routing protocol, and a CBR traffic-generating application [25].

2. **Traffic Simulator**

A. VISSIM

VisSim is a visual environment for model-based development and dynamic simulation of complex systems. It combines an intuitive graphical interface with a powerful simulation engine to accurately represent linear and nonlinear systems, and simulate their behavior in continuous time, sampled time, or a combination of both. VISSIM is the global leader on the market of commercial traffic simulators. VisSim's visual interface offers a simple method for constructing and simulating large-scale complex dynamic systems; its math engine provides fast, accurate solutions for linear, nonlinear, continuous time, discrete time and time varying and hybrid system designs. The framework includes a very powerful graphical user interface which allows the user to define his own maps and scenarios. The traffic model is a car-following model that considers psychological characteristics of the drivers. A pedestrian mobility model is also included, which could be very interesting for some urban environment scenarios.

VISSIM is only available for Microsoft Windows operating systems [8].

B. Simulation of Urban MObility (SUMO)

Simulation of Urban MObility (SUMO) [36]: It is an open source microscopic simulator, mainly developed by employees of the Institute of Transportation Systems at the German Aerospace Center. It can be used on most operating systems and the community around this project proposes many interesting extensions, like the possibility to generate real-time GPS traces from dump output. The driver model in SUMO is more simplistic than the one in VISSIM and this translates in a higher simulation speed but in fewer details in the mobility model, because of its high portability and its GNU General Public License, SUMO has become the most used traffic simulator for vehicular communications.

C. VanetMobiSim

VanetMobiSim [24] is an extension to CanuMobiSim , a generic user mobility simulator. CanuMobiSim provides 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. 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, 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. VanetMobiSim are necessary to reach a level of realism sufficient to confidently simulate VANETs mobility.

D. VERGILIUS

VERGILIUS [32] is a macroscopic-level vehicle motion generator. The output of this framework is then fed to a microscopic traffic simulator (currently SUMO or CORSIM), automating the process of map extraction and mobility trace creation. The user only needs to provide the total input flow rate and VERGILIUS builds a set of paths on top of the road topology. VERGILIUS enables more general and more reliable simulation studies for VANETs. VERGILIUS provides two innovative tools: a finely tunable mobility Scenario Generator to systematically explore the design space of protocols for VANETs and a Trace Analyzer to analyze and characterize urban mobility traces.

3. **Interlink Simulator**

A. MOVE

MObility model generator for VEhicular networks (MOVE) [37]: This tool is build on top of SUMO and it produces trace files that can be directly used in several network simulators. It facilitates the utilization of SUMO by the means of a very user-friendly, but complete, interface. MOVE allows the creation of a user-generated map and it also proposes some pre-defined topologies (grid, spider, random networks). TIGER maps are also supported and the mobility pattern can be generated automatically or manually through a Vehicle Movement Editor. MOVE (MObility model generator for VEhicular networks) to facilitate users to rapidly generate realistic mobility models for VANET simulations. MOVE is built on top of an open source micro-traffic simulator SUMO [7]. The output of MOVE is a mobility trace files which contains the information of vehicle movement, which can be immediately used by simulation tools such as ns-2 or QualNet.

B. TraNS

Traffic and Network Simulation Environment (TraNS) links two open-source simulators: a traffic simulator, SUMO, and a network simulator, ns2. Thus, the network simulator can use realistic mobility models and influence the behavior of the traffic simulator based on the communication between vehicles. TraNS is the first *open-source* project that attempts to realize this highly pursued coupling for application-centric VANET evaluation. The goal of TraNS is to avoid having simulation results that diver significantly from those obtained by real-world experiments, as observed for existing implementations of mobile ad hoc networks [34]. TraNS combines ns-2 and SUMO and can operate in two modes. The first mode, termed network-centric, simply feeds ns-2 with vehicular traces from SUMO. The application centric mode can be used to test applications that have an influence on the mobility. In this second mode, SUMO and ns-2 have to be synchronized and commands from the network simulator are transmitted in SUMO through a specific interface. TraNS is not a high-performance framework, but it has the merit of proving the concept of coupled simulators. It has no longer been maintained since 2008 and it does not support recent versions of SUMO.

C. iTetris

The Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions (iTetris) is an European Union Framework Program 7 funded project. It integrates SUMO and ns-3 through a central control block named iTetris Control System (iCS) and it is seen as the successor of TraNS The iTetris project has set out to satisfy this need through the development of an open, ETSI standard, compliant, and flexible simulation platform that will create close collaboration between engineering companies, road authorities, and communications experts. iTetris integrates wireless communications and road traffic simulation platforms in an environment that is easily tailored to specific situations allowing performance analysis of cooperative ITS at city level. The accuracy and scale of the simulations leveraged by iTetris will clearly reveal the impact of traffic engineering on city road traffic efficiency, operational strategy, and communications interoperability.

D. Vehicles in Network Simulation(VEINS)

Veins incorporate all the benefits from state-of-the-art simulation techniques of both the network simulation and the road traffic micro simulation domains. A vehicle in Network Simulation (Veins) [35] couples SUMO and the INET framework from OMNeT++ through a TCP connection. In Veins, the network simulator is directly extended and it is therefore able to send commands to vehicles from the network simulator, influencing their speed or path. its advantages and the need for bi-directionally coupled simulation based on the evaluation of two protocols for incident warning over VANETs.

E. VISSIM

Inter-linked VISSIM and ns-2 by the means of a Matlab/Simulink module. The synchronization between the two simulators is provided by an extension of ns-2. An interesting fact about this project comes from the fact that VISSIM only functions on a Microsoft Windows operating system, while ns-2 can only be used on a Posix- like platform. Therefore, cross operating system communication was needed [37, 39].

F. Intelligent Traveler Assistant (ITA)

Intelligent Traveler Assistant (ITA) is a simulation platform that couples VISSIM and SWANS and it is developed at the University of Illinois at Chicago. As in other similar approaches, an external coordinator applications maintains a single simulation time step between the two environments [38].

V. CONCLUSION

VANET simulation requires that a traffic and network simulator should be jointly used with a powerful feedback between them to render the simulation results as accurate as real life. We first presented features of important traffic and network simulators and also certain VANET simulators. Vehicular communications are a major component of a future intelligent transportation system. Designed mainly for safety-related reasons, a vehicular network can also be used by applications with a different profile, like traffic management or passenger entertainment. The complexity of analytical models and the financial cost of tests with real hardware have imposed computer simulations as the leading solution for V2X communications research. Software based simulations are designed to provide an alternative to obtain the required results. VANET hits the protocol's strength due to its highly dynamic features, thus in testing a protocol suitable for VANET implementation the use of realistic mobility model should be considered. This paper tries to facilitate the first stage of a study on vehicular communications by providing researchers with meaningful information concerning the multitude of existing VANET simulators.

VI. REFERENCES

[1] V. Srivastava, M. Motani, Cross-layer design: a survey and the road ahead, IEEE Communications Magazine 43 (12) (2005) 112–119.

[2] O. Riva, T. Nadeem, C. Borcea, and L. Iftode, ―Context-Aware Migratory Services in Ad-Hoc Networks,‖ *IEEE Transactions on Mobile Computing*, vol. 6, no. 12, pp. 1313–1328, Dec. 2007.

[3] E. Lieberman, A. Rathi, Traffic simulation, United States Transportation Research Board Revised Monograph on Traffic Flow Theory (2005) 1–23

[4] Vishal Kumar & Narottam Chand, ―Data Scheduling in VANETs : A Review‖, International Journal of Computer Science & CommunicationVol. 1, No. 2, July-December 2010, pp. 399-403

[5] Ghassan M. T. Abdalla, Mosa Ali AbuRgheff and Sidi Mohammed Senouci, ―Current Trends in Vehicular Ad Hoc Networks‖.

[6] Maxim Raya and Jean-Pierre Hubaux, ―Securing vehicular ad hoc networks‖, Journal of Computer Security 15 (2007) 39–68, IOS Publication.

[7] P. Papadimitratos, A. de la Fortelle, K. Evenssen, R. Brignolo, S. Cosenza, Vehicular communication systems: enabling technologies, applications, and future outlook on intelligent transportation, IEEE Communications Magazine 47 (11) (2009) 84–95.

[8] Razvan Stanica ⇑, Emmanuel Chaput, André-Luc Beylot, ―Simulation of vehicular ad-hoc networks: Challenges, review of toolsand recommendations‖ Computer Networks, journal homepage: www.elsevier.com/ locate/comnet2011

[9] H. Stubing, M. Bechler, D. Heussner, T. May, I. Radusch, H. Rechner, P. Vogel, simTD: a car-to-X system architecture for field operational tests, IEEE Communications Magazine 48 (5) (2010) 148–154

[10] Susan A. Shaheen , Project Work ―Dynamics in Behavioral Adaptation to a Transportation Innovation: A Case Study of Carlink–A Smart Carsharing System‖

[11] T. Camp, J. Boleng, V. Davies, A survey of mobility models for ad hoc network research, Wireless Communications & Mobile Computing. Special issue on Mobile Ad Hoc Networking: Research, Trends and Applications 2 (5) (2002) 483–502.

[12] Christoph Sommer, Zheng Yao, Reinhard German and Falko Dressler, ―On the Need for Bidirectional Coupling of Road Traffic Microsimulation and Network Simulation‖.

[13] Josiane Nzouonta, Neeraj Rajgure, Guiling (Grace) Wang, *Member, IEEE*, and Cristian Borcea, *Member, IEEE, "*VANET Routing on City Roads Using Real-Time Vehicular Traffic Information*",* IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 58, NO. 7, SEPTEMBER 2009.

[14] E. Lieberman, A. Rathi, Traffic simulation, United States Transportation Research Board Revised Monograph on Traffic Flow Theory (2005) 1–23 (Chapter 10).

[15] U.S. Census Bureau – Topologically Integrated Geographic Encoding and Referencing System. <http://www.census.gov/geo/www/tiger/>.

[16] A. Mahajan, N. Potnis, K. Gopalan, A. Wang, Evaluation of mobility models for vehicular ad-hoc.