

Which network simulation tool is better for simulating Vehicular Ad-hoc network?

Oanh Tran Thi Kim, VanDung Nguyen, and Choong Seon Hong*
 Department of Computer Engineering, Kyung Hee University
 {ttkoanh, ngvandung85, cshong}@khu.ac.kr

Abstract

Simulation methodology has become popular among computer and VANETs researchers. For selecting an right network simulator for a simulation task, it is important to ensure that the results generated by the simulators are valid and reliable. This thing requires researchers have a good understanding of the simulators, along with their advantage and disadvantage. Motivated by this, this paper focus on survey and compare four VANETs popular network simulations, NS-2, NS-3, MATLAB and OMNeT++. Analysis provides guidelines for best choice in network simulation for distinct applications in VANETs. Especially, It is really useful for who newly research about VANET network simulators.

Key word: VANETs network simulator, VANETs simulator, Ns-2, NS-3, MATLAB, OMNeT++.

1. Introduction

In the recent years, the multi-path ad hoc networks have become an attractive topic. Vehicular Ad-hoc Network (VANET), a subclass of MANETs potential are an emerging field of research that will help improve road safety, navigation, and congestion. In VANET basically, there are two types of communication possible, Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V). Each vehicle are installed with On Board Unit (OBU), which is helpful to communicate with other OBUs and Road Side Units (RSU), which are installed on Road Side to help in communication [1].

At research, design and development stages, on-road application of VANETs based services is a difficult task to carry out due to financial limitations and physical constraints in large scale deployments. Therefore, a pre-deployment stage is required in order to evaluate the performance quality provided by the underlying VANETs services. Hence, simulation tools are effective means for evaluating performance of any proposed VANETs communication protocols and on-road vehicular communication scenarios [2].

In VANET, most of researchers implement and evaluate their proposal on simulation because the simulation does not require any equipment, high-cost device and cars. Some of the popular ones include **Network Simulator 2** (NS-2), **Network Simulator 3** (NS-3), **MATrix LABORatory** (MATLAB), **Objective Modular Network Testbed in C++** (OMNeT++), so forth and so on. It is important for network researchers and developers to use a credible simulation tool which is easy to use; more flexible in model development, modification and validation; and incorporates appropriate analysis of simulation output data, pseudo-random number generators, and statistical accuracy of the simulation results. To select a credible simulator for a simulation task, it is also important to have good knowledge of the available simulation tools, along with their relative strengths and weaknesses [3].

In this paper we analysis four popular network simulators; NS-2, NS-3, MATLAB, OMNeT++. Network researchers and developers can use the results of this study in making the right decision to select the most accurate simulator.

The remainder of this paper is organized as follows. The overview of simulation tools are analyzed in Section 2. Section 3 we draw some recommendations based on the results of our survey. Finally, Section 4 highlights the conclusion.

2. overview of simulators for VANET

While various simulators exist for building a lot of network models, in scope of the paper we focus on fours popular network simulators highlighting their strengths and weaknesses.

a) Ns-2

NS-2 [4] has been developed in 1989. It is a discrete event simulator designed for research in communication networks. Ns-2 code is written either in C++ and OTCL and is kept in a separate file that is executed by OTCL interpreter, thus generating an output file for NAM (Network animator). The target of ns-2 is to run on Linux based operating systems but can also be used on Windows platforms through Cygwin emulator.

NS-2 can support wireless networking modules and wired networking modules. For the case of VANETs, it has the capability to provide both facilities for VANETs protocol developers, either as built-in modules or as an extension. Besides that a number of communication protocols, related to transport, network and data-link layers are supported as built-in modules that augments NS-2 capability as a simulator for VANETs. NS-2 also support the physical wireless layer modeling by providing built-in modules of transmitting antenna type, wireless network interface and a number of wireless channel propagation models. NS-2 has an omni-directional antenna module which is usable off the shelf and can be easily integrated in any

developed VANETs scenario [2].

An important disadvantage of ns-2 is not able to be reused for real implementation [5]. Therefore, in the field of vehicular communications is that its high complexity hardens the implementation of vehicular mobility models inside the framework [6].

b) NS-3

NS-3 [7] has been started in mid 2006 but until 2009 the first release was introduced. Similar to NS-2, NS-3 is also discrete event network simulator. However, C++ is used to write the core elements and models in NS3. With C++, NS-3 has become a more scalable and easier network simulator compared to the others.

The biggest advantage is the continuous maintenance and rapid growth due to a large development community. It facilitates the creation of ad hoc wireless networks and simulation of radio propagation fading. The visible trend is to implement more features suitable for VANETs, like enhancements in device and channel models or an implementation of vehicular mobility models. We believe that NS-3 is the most flexible and forward-looking tool to be incorporated in VANET simulation platform [8].

NS-3 has known for only a short amount of time, about 5 years, from the first release was introduced in 2009. Thus, there is very limited number of models and contributed codes in NS3 in comparison with NS2. Also, NS-3 is not backwards-compatible with NS2.

c) OMNeT++

OMNeT++ [9] which has been available to the public since September 1997 is an extensible, modular, component-based C++ simulation library and framework, primarily for building network simulators. Simple and compound are two types of modules used in OMNeT++. Simple modules are used to define algorithms and are active components of OMNeT++ in which events occur and the behavior of the model is defined (generation of events, reaction on events). Compound modules are a collection of simple modules interacting with one another.

The main strengths of OMNeT++ include GUI, object inspectors for zooming into component level and to display the state of each component during simulation, modular architecture and abstraction, configurable, and detailed implementation of modules and protocols. However, OMNeT++ is a bit slow due to its long simulation run and high memory consumption. OMNeT++ is also a bit difficult to use.

However, compare with another network simulation that are mentioned above, OMNeT++ is quite easier to learn the way to simulate a realistic scenarios of VANET. Firstly, OMNeT++ has a dedicated simulation framework for VANET, namely Veins - Vehicles in Network Simulation. Secondly, Veins is detailed by

more guide documents, tutorials which are meaningful for researchers who do not more realistic simulation experiments. There are two webpages that can provide enough knowledge to successfully work on Veins, <http://veins.car2x.org/tutorial/> and <http://www.ccs-labs.org/~dressler/projects/veins/>.

d) MATLAB

Initially, MATLAB is a high performance software suit for numerical computing. Recently, It has become a famous network simulation tool. One of reasons has promoted MATLAB becoming popular, MATLAB is an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Due to this, MATLAB is one of network simulations has a significant number of users, including students, researchers, so on so forth.

Considering for VANETs, MATLAB also has gotten a significant portion of the returned records were related to research works at the physical layers of VANETs communication systems, control theory within VANETs and VANETs communication modeling [2].

3. Recommendations

As reviewed in section 2, each network simulation has both benefits and drawbacks. Selecting a network simulation like a tool to evaluate result of new research should base on more factors. This are arrange and target of research, the supporting ability of each network simulation and the programming skills of each researchers. The choosing rights a network simulation for research processes is very important. It can give the researchers more benefits. Saving the time, evaluating exactly efficiency of algorithms, and scalability and developing studies have gained from this right choice.

We make a survey about how many papers were published on international conferences, journals. Based on result of our survey, the researchers who work on VANETs can get right decision selecting the tool to evaluate their studies.

In detail, our survey was done on IEEEExplore digital library by using an advance search query. We survey all papers published from 2010 to 2014. A total of 3897 papers were surveyed. The analysis results are summarized in table 1. Around 53.68% of 3897 papers surveyed have mentioned that researchers in VANET field use NS-2 for their network modeling and simulation tasks. Approximately 34.36% of the total papers surveyed have used MATLAB whereas about 6.11% used OMNeT++. The remaining 5.85% used NS-3. It is obvious that NS-2 and MATLAB are tools which have used popular by VANET researchers.

Simulator	Conference	Journal & Magazine	Early Access Articles	Total Publication
NS-2	1697	371	24	2092
MATLAB	869	430	40	1339
OMNeT++	199	32	7	238
NS-3	190	35	3	228

Table. 1 Simulators used in the selected IEEE journal and conference papers published from 2010 to 2014 (<http://ieeexplore.ieee.org>. Accessed 30 October 2014)

From the brief analysis above, it can determine that NS-2 and MATLAB which are one of simulators is better for simulating VANETs. However, in particular each simulator suits for specific application. With lots of different field research in VANETs, selecting network simulation should base on the simulator's dedicated ability. In the scope of this paper, we focus on network simulation which should choose to simulate routing protocol, MAC protocol and algorithms for physical layer. To get an insight into the simulation tools for specific applications, in the paper, we also make a review that is relative to between four simulations mentioned and the specific application using it. the achieved statistical results is given in Fig. 1, Fig. 2, and Fig. 3. These bar graphs represent significant usage different among the simulators for the separate applications in VANETs research published in IEEE conferences and journals & magazines from 2010 to 2014, respectively.

Fig. 1 Approximate usage of network simulators to simulate routing protocol

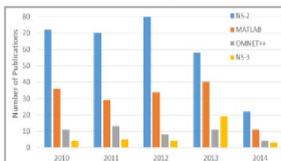


Fig. 2 Approximate usage of network simulators to simulate MAC protocol

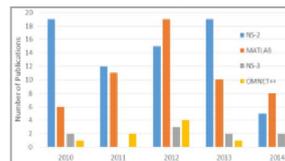
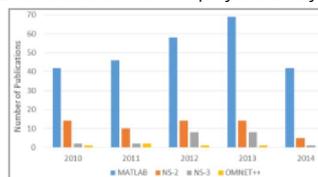


Fig. 3 Approximate usage of network simulators in VANETs researches for physical layer



It is obvious that the most researchers have decided to use NS-2 or MATLAB for their studies.

4. Conclusion

This paper reviewed simulation of VANETs. We first analyze in detail four popular VANETs network simulators. These their strengths and weaknesses were considered. Finally, the survey was done to

highlight these recommendations that is extremely meaningful selecting approximate network simulation for the studies of VANETs. As mentioned in previous section, we can emphasized that the researchers should choose NS-2 for these studies focused on routing protocol or MATLAB protocol, however when they work on physical layer should use MATLAB to evaluate their researches.

5. Acknowledgement

This research was supported by the MSIP(Ministry of Science, ICT&Future Planning), Korea, under the ITRC(Information Technology Research Center) support program supervised by the NIPA(National IT Industry Promotion Agency)" (NIPA-2014-(H0301-14-1003). Dr. CS Hong is the corresponding author

6. Reference

- [1] Ravi Patel, Khushbu Shah, "GLANCE over VANET, ATTACKS over VANET and their IDS approaches", *International journal of innovative research in technology*, vol. 1, pp. 6-11, 2014.
- [2] Osama M. Hussain Rehman, Hadj Bourdoucen, Mohamed Ould-Khaoua, "Impact of NS-2 as FOSS Simulation Tool for Research in Vehicular Ad-hoc Networks", *Free and open source software conference*, pp. 34-38, 18-19 February 2013.
- [3] Nurul I. Sarkar, Syafnidar A. Halim, "A Review of Simulation of Telecommunication Networks: Simulators, Classification, Comparison, Methodologies, and Recommendations", *Cyber Journals: Multidisciplinary Journals in Science and Technology, Journal of Selected Areas in Telecommunications (JSAT)*, pp. 10-17, 2011.
- [4] The Network Simulator - ns-2. <http://www.isi.edu/nsnam/ns/>. <<http://www.nsnam.org/>>.
- [5] P. Rajankumar, P. Nimisha, P. Kamboj, "A comparative study and simulation of AODV MANET routing protocol in NS2 & NS3," *Computing for Sustainable Global Development (INDIACom)*, pp.889,894, 5-7 March 2014.
- [6] Razvan Stanica, Emmanuel Chaput, Andre-Luc Beylot, "Simulation of vehicular ad-hoc networks: Challenges, review of tools and recommendations", *Computer Networks*, vol. 55, pp. 3179-3188, 2011.
- [7] The Network Simulator - ns-3. <http://www.nsnam.org/>.
- [8] A. Grzybek, M. Seredynski, G. Danoy, P. Bouvry, "Aspects and trends in realistic VANET simulations", *World of Wireless, Mobile and Multimedia Networks (WoWMoM)*, pp. 1-6, 25-28 June 2012.
- [9] <http://www.omnetpp.org>