Comparative Study on Performance of NS2 versus OPNET Network Simulators on Large Scale Network

Ange Honorette Uwuburiza
Student at MSc. IT, Department of Information Technology, University of Lay Adventists of Kigali

Dr. Papias Niyigena
Lecturer, Department of Information Technology, University of Lay Adventists of Kigali

Abstract – Network simulators predict the behavior of a network, it allows the designer to test new networking protocol and change the existing protocol. Diverse works have been conducted and we still struggle to the ability of choosing the best or most performing network simulator to large scale networks. To solve the dilemma, we have to answer the following questions: Which is the most performing network simulator between NS2 and OPNET on large scale networks? Which among the above network simulators has high packet delivery ratio, is less complex, low CPU utilization, excellent user support, and less memory usage while performing simulation task? The experiment on University Teaching Hospital of Kigali network is conducted with 1434 nodes using NS2 and OPNET simulators by comparing their performance on this network; the results indicate that OPNET is most performing vis-à-vis NS2 as its Packet delivery ratio is high, less complexity, and for other metrics OPNET is better than its rival.

Index Terms – NS2, OPNET, Network Simulators, Large Scale Network.

1. INTRODUCTION

The 19th century was the age of the steam engine. During the 20th century, the key technology was information gathering, processing, and distribution. Among other developments, we saw the installation of worldwide telephone networks, the invention of radio and television, the birth and unprecedented growth of the computer industry, the launching of communication satellites, and the Internet (Andrew, S. T. and David, J. W., 2011).

Networking in particular has been a child of the late twentieth century. The Internet has been developed over the past 40 years or so. The integration of wireless, computer and sensor technology has the potential to make possible networks of miniature elements that can acquire sensor data and transmit the data to a human observer (Thomas, G. R., 2011). Due to the rapid development of network technology and expansion of network scale, it is difficult to analyze network. Therefore, various network simulation software is developed to simulate the network behavior and test new algorithms (Xiao, Z. and Hui, T., 2016).

In light of the present study simulation is of vital significance, since it is nearly impossible to reproduce the wireless propagation environment, difficult to use real radio-wave based transmission to test the concept, and non-trivial to use real wireless sensor/devices to present a research idea; Simulators often allow user implementations of protocols for transmission, propagation, reception or other communication aspects to work with their "ether" (Nancy, G., 2015).

Computer simulation is often used to test the planned capacity of networks and to meet customer requirements and selecting the appropriate network simulator is a crucial task for researchers. To help other researchers and network technicians, we are conducting this research with objective to conduct a comparison study on performance of NS-2 and OPNET network simulators on large scale networks by focusing on Packet delivery ratio, Complexity, CPU utilization, User support, and Memory usage during task accomplishment.

The main methods of studying networks are experimental method, analysis method and simulation method. Network simulators are used by people from different areas such as academic researchers, industrial developers, and Quality Assurance (QA) to design, simulate, verify, and analyze the performance of different networks protocols (Gayatry, B., and Gypsy, N., 2014).

2. RELATED WORK

Simulation is a very important modern technology; The simulation in computer can model hypothetical and real-life objects on a computer so that it can be studied (Suraj, G. G. et al., 2013). In computer networks, new, untested protocols cannot be launched on a large scale due to uncertainty of its successful outcome; in simulators, the computer network is typically modelled with devices, links, applications, etc. and the performance is then analyzed. Diverse researchers studied on performance of Open and commercial network simulators especially NS-2 and OPNET on large or small scale networks, some these researchers are as follows:

- Vidhi et al., 2015; Network Simulators: A Comparative Survey

- Rajan, P. and Pariza, K., 2015, Investigation of Network Simulation Tools and Comparison Study: NS3 vs NS2.

2.1 Vidhi et al., 2015; in their research paper entitled, Network Simulators: A Comparative Survey:

They conducted a survey by comparing three network simulators performance, NS2, NS3, OMNET++ with basis on Simulation, Computation time, CPU utilization, Execution, User support, Mobility, Graphical User Interface, Complexity, Memory consumption, Propagation delay, Packet delivery ratio and Throughput attributes. As results of their research, every network simulator has its strong points but from our terms of evaluation, means, Memory usage and Computation time, NS3 and OMNET++ are the most performing simulators in term of the computation time because they use low time to accomplish the time; while in terms of Memory usage, the most performing is simulator is NS3.

If you continue to read their paper, it seems challenging to decide which most accurate network simulators from these three used in that study because each one has its strong point compared to others. That's why we wish to clarify things by making a comparative study of two network simulators one from open resource network simulator and another from commercial network simulators group. By considering performance of the two simulators in terms of Packet delivery ratio, Complexity, CPU utilization, User support, Memory usage and Computation time attributes on large scale network.

2.2 Rajan, P. and Pariza, K., 2015, Investigation of Network Simulation Tools and Comparison Study: NS3 vs NS2.

As indicated by the paper title, two discrete event simulators NS3 and NS2 are compared based on platform, language, architecture, layers, memory, visualization, and simulation time; but inside the paper they went beyond the scope and includes some other network simulators such as OPNET++ and OMNET++. By the result of the study, based on comparative study, it shows that NS3 may better than NS2 in features and, if scalability is the main criteria, NS3 and OMNET++ are smart options.

For completing their research, we are conducting this study focusing only on our content scope for more guidance to the readers, and clearance of what we are reviewing. Only the comparison will be made on two network simulators, NS2 and OPNET simulators. Also, to strengthening my research we will be delimited to large scale network as environment of experiment.

Yeah, diverse works have been conducted and we still struggle to the ability of choosing the best or most performing network simulator to large scale networks. The difference between this study and previously conducted researches is that we are going to compare the performance of NS2 and OPNET network simulators in terms of Packet delivery ratio, Complexity, CPU utilization, User support, Memory usage and Computation time for clarification for the choice of a best simulator to be used once simulating a large scale network.

3. METHODOLOGY

The methodology for conducting this research is closely to the task of gathering information to be used, considering the duration and environment of research. This research is an empirical study, where information used is read from previous works, which means that we followed qualitative approach.

As presented in the literature review section, different researchers discussed the performance of network simulators such as NS2, NS3, OMNET++, OPNET++, GLOMOSIM etc. everyone from those researchers has mentioning on its own, the strength of the network simulator among the used ones in his/her study. Our main objective is to identify which is the most performing network simulator between NS2 and OPNET especially on large scale network.

3. 1 Network simulators

a. NS2

Network Simulator-2 (NS-2), is an open source, discrete event network simulator. It is used for the simulation of network protocols with different network topologies, is the most common and widely used network simulator for research work. It is capable of simulating wired as well as wireless networks (Khan, A. R et al. 2016). NS-2 is based on three languages: TCL writes simulation script, OTCL defines simulation parameter; C++ implements the schedulers (Vinita, M. and Smita, J., 2014). Additionally, different levels of configuration are present in NS-2 due to its open source nature, including the capability of creating custom applications and protocols as well as modifying several parameters at different layers (Gilberto, F. L. et al. 2016).

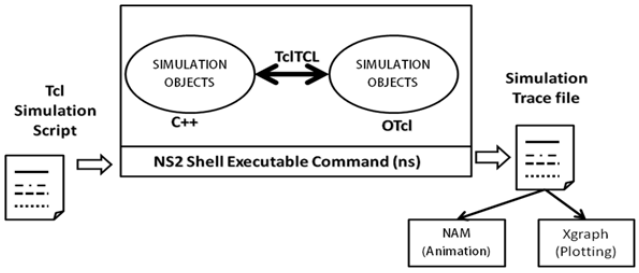

Figure 1 - NS2 Architecture

The user describes a network topology by writing OTcl scripts, and then the main NS program simulates that topology with specified parameters. General format trace files, NAM format trace files, personalized trace files are examples of NS2 output files (Vidhi et al. 2017). NS2 outputs either text-based or animation-based simulation results. To interpret these results

graphically and interactively, tools such as NAM (Network AniMator), XGraph and Gnuplot are used. To analyze a particular behaviour of the network, users can extract a relevant subset of text-based data and transform it to a more flexible presentation (Mohammed, H. K., et al. 2014).

b. OPNET

Optimized Network Engineering Tools (OPNET) is considered as one of the most famous and commercial network simulators because of its wide uses in the industries (Gayatry, B., and Gypsy, N., 2014). It provides a comprehensive development environment supporting the modeling of communication networks and distributed systems. The initial configuration (Topology setup, Parameter setting) is usually achieved using Graphical User Interface (GUI), a set of Extensible Markup Language (XML) files or through C library calls (Saba, S., et al. 2012).

OPNET simulator is very useful when working with complex networks with a big number of devices and traffic flows or in networks where a little change could be critical. OPNET has different tools (NetDoctor, ACE and MVI) that allow administrators to analyze their networks and the future implementations they want to do (Mohammed, H. K., et al. 2014). OPNET claims to be the fastest simulation engine among leading industry solutions. It has a wide variety of niche simulators for the wired/wireless areas. It also has many of wired / wireless protocol and vendor device models with source code, and allows Object-oriented modeling of components (Nancy, G., 2015).

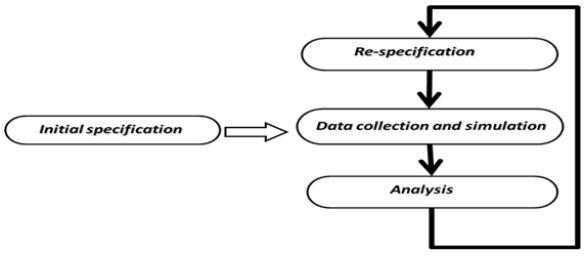

Figure 2 - OPNET Architecture

3. 2 Simulation Performance

While taking a case study of large scale network, the study of these networks relies more and more on an interdisciplinary approach that looks to other areas in the natural and social sciences where experimenting with and analyzing large-scale, complex, and highly interacting.

Under different conditions the attributes of the simulator environment can be modified in a controlled manner to assess how the network would behave. In simulators, the computer network is typically modeled with devices, links, applications, etc. and the performance is then analyzed (Gayatry, B., and Gypsy, N., 2014). From what stated above, we indicated above, we mentioned that our two network simulators, NS2 and OPNET, are evaluated in terms of Packet delivery ratio, Complexity, CPU utilization, User support, and Memory usage. These metrics are defined as follow:

- Packet delivery ratio

It defines the ratio of the number of packets sent by the source node and the number of packets received by the destination node. Simply, it is the ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the sender.

$$PDR = \frac{\sum Npr}{\sum Nps} \qquad (1)$$

Where;

Npr: Number of packets received

Nps: Number of packets sent

- Complexity

Software/tool complexity is a way to describe a specific set of characteristics of your code. These characteristics all focus on how your code interacts with other pieces of code.

- CPU utilization

This the sum of work handled by a Central Processing Unit; It can vary according to the type and amount of computing tasks because some tasks require heavy CPU time while others require less CPU time this is the reason why the CPU utilization is used for estimation of system performance.

$$U = 1 - p^n \qquad (2)$$

Where;

U: CPU utilization

p: Blocked time

n: Number of processes

- User support

User support, especially for software or systems, is generally technical support or breaks / fixes that are delivered for specific software products. In this research work, we look for its availability for our used network simulators.

- Memory usage

The memory usage is the capacity of memory a process running actively or when idle on your computer is occupying on your computer RAM. However, the exact amount of memory the program uses will vary depending on how it is being used.

3. 3 Experiment

During this research, an experiment is conducted using with the case study taken on NYARUGENGE District health institutions that enclose University Teaching Hospital of Kigali (UTHK). The hospital has 3 networks, where Network A has 2 servers, 15 routers with 720 clients that is a total of 737 nodes. Network B has 1 server, 7 routers with 280 clients, which defines a total of 288 nodes; the third network C has 1 server, 8 routers with 400 clients that is a total of 409 nodes. The general total nodes for this experiment are 1434.

Network A is connected to B via standalone routers, B is connected directly to C via single link router. All non-client links have a bandwidth of 2Gb/s and have a propagation delay of 3ms. Clients are connected in a point-to-point fashion with their respective LAN router and have links with 100Mb/s bandwidth and 5ms delay. In order to make a serious comparative study, both network simulators are used with special attention to the characteristics of OPNET's models and the simulation parameters used.

4. RESULTS AND DISCUSSIONS

After conducting the experiment using both network simulators on our network, the results are gathered and presented in a simplified table as following:

Table 1 - Comparison results

METRICS	**TOOLS**	
	NS2	**OPNET**
Packet delivery ratio	Moderate	High
Complexity	More complex	Less Complex
CPU utilization	91%	78%
User Support	Available	Available
Memory usage	234MB	219MB

As results presented in the Table 1, five metrics are used to assess the capacity of our network simulators upon the case study network. From the results, we see that with Packet delivery ratio metric, OPNET is higher than NS2 simulator; on Complexity measurement, the NS2 is more while OPNET is less complex. Regarding the CPU utilization NS2 and OPNET are respectively 91% and 78%; for User support attribute, both tools have this feature, which helps the end users to understand the use of tools at the last we examined the Memory usage for both tools and results show that NS2 is at the high level compare to OPNET with respective values 234MB and 219MB. From the results we can conclude that the OPNET is most performing network simulator vis-à-vis NS2.

5. CONCLUSION

The main objective of this study was to conduct a comparison study on performance of NS-2 and OPNET network simulators on large scale networks by focusing on Packet delivery ratio, Complexity, CPU utilization, User support, and Memory usage during task accomplishment.

An experiment has been conducted to simulate a UTHK network with 1434 nodes and both network simulators were used; the results for all five metrics were presented in Table 1 above. Our results are compatible to the results from (Vidhi et al., 2015) research work, where they indicated that NS2 is more complex and regarding on User support feature is available for both simulators. We are concluding that the OPNET is most performing comparing to the NS2 in large scale network like this UTHK experimented in this research.

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Authors

Ange Honorette UWUBURIZA, Student at MSc. IT, Department of Information Technology, University of Lay Adventists of Kigali (UNILAK),

Dr. Papias NIYIGENA, University of Lay Adventists of Kigali (UNILAK).