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Investigation of Network Simulation Tools and Comparison Study: NS3 vs NS2

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Abstract – Establishing and implementation of a whole network in real time scenario is very difficult. It is too much time consuming and costly to deploy a complete test bed component containing multiple networks (computers, routers and data links) to validate and verify a certain network protocol or a specific network algorithm for wired and wireless network. A widespread methodology is used for verifying, testing and analyzing the results of network based on network simulation. A network simulation is a technique where the program models the behavior of a network either by calculating the interaction between the different network entities (hosts, packets, etc.) using mathematical formulas, or actually capturing and playing back observations from a production network. The network simulation is performed by network simulation tool is referred to as network simulator. A network simulator is a piece of software or hardware that predicts the behavior of a network without an actual network being present. During the past years, varieties of network simulation tools have been developed in the field of communication. In this paper, network simulation tools namely NS3, NS2, OMNet++, NetSim, OPNET, REAL, J-Sim, QualNet have been compared and a comparison study between two simulators namely NS3 and NS2 has been conducted.

Index Terms – J-Sim, Network Simulator, NetSim, NS2, NS3, OMNet++, OPNET, QuealNet, REAL, Simulation.

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1. INTRODUCTION

Networking community is largely depending on simulation to evaluate the behaviour and performance of network protocols for various networks [1]. Simulators are good option to negotiation the cost and complexity and gives precise results. The simulator can use for different field of technology like science, engineering, and other application fields for different purposes. It is computer assisted simulation model based on hypothetical and real-life objects or activities on a computer for verifying studied to see how the system working and functioning.

A network simulation is a technique where a program models the behaviour of a network either by calculating the interaction between the different network entities (hardware/software) using mathematical formulas for capturing and playing back observations from a production network [2]. The network simulation is performing by network simulation tool which is referred as network simulator. A network simulator is a part of software or hardware that predicts the behaviour of a network, exclusive of an actual network being present [2]. Network simulators are used by people from different areas for different purposes (design, simulate, verify, and analyze the performance of different networks protocols) [3].

Establishing and implementation of a whole network in real time scenario is very difficult. To deploy a complete test bed which containing multiple networked (computers, routers and data links) to validate and verify a certain modelled network protocol or a specific network algorithm for wired and wireless network is time consuming and costly. With the help of network simulators, the real world networks can try to model. After that the features of the modelled network can be changed and the corresponding results can be analyzed. When a simulation program is used in conjunction with live applications and services in order to observe is referred as network emulation [2].

The rest of paper is organized as follow: the second section is the investigation and classification of various simulation tools, the third section is the comparison study of NS3 and NS2 simulator and finally concluded in last section.

2. SIMULATION TOOLS INVESTIGATION

During the last years, varieties of network simulation tools have been developed in the field of communication engineering. We reviewed the network simulation tools, namely, NS3, NS2, OMNet++, NetSim, OPNET, REAL, J-Sim, QualNet.

2.1. NS3

NS3[4][5] is a discrete event network simulator, primarily focus for research and educational use. NS3 is free software under the GNU GPLv2 license, which is publicly available for use. NS3 encourages the development of simulation models which are sufficiently realistic to allow NS3 to be used as a real-time network emulator which can be interconnect with the real world and which allows many existing real-world protocol implementations to be reused within NS3. The NS3 simulation core supports research on both IP and non-IP network. Majority of its users mainly focus on wireless/IP simulations which involve models for layers 1 and 2 and variety of static or dynamic routing protocols such as OLSR and AODV for IP-based applications.

NS3 also supports a real-time scheduler that facilitates a number of "simulation-in-the-loop" use cases for interacting with actual systems. For instance, users can send and receive NS3 generated packets on real network devices, and NS3 can work as an interconnection framework between virtual machines.

2.2. NS2

NS2[6] is discrete event [7] network simulator which composed of C++ code, which is used to model the behaviour of the simulation nodes, and OTcl scripts that handle the simulation and specify the network topology. This design choice was originally made to avoid unnecessary recompilations if changes are made to the simulation set-up. The frequent recompilation of programs was indeed time-consuming and slowed down the research cycle when the first version (Back in 1996) of NS2 was released.

2.3. OMNet++

OMNeT++ [8] is a discrete event [9] extensible, modular, component-based C++ simulation library and framework. The domain-specific functionality for sensor networks [10], wireless ad-hoc networks, peer-to-peer network, Internet protocols, optical switch and storage area network [11] are supported. OMNeT++ is an eclipse based IDE graphical runtime environment [9]. The extensions are handle real-time simulation, network emulation, alternative programming (Java, C#, C), and database integration.

2.4. NetSim

NetSim[12] is a one more discrete event simulator which was developed by Tetcos. It is mainly used for network lab experimentation. It supports major technologies like wireless (LAN, Wi-Max, MANET, WSN, Wi-Fi), MPLS, QoS, VoIP, TCP, IP, etc. It serves as the interface between user's code and NetSim's protocol libraries and simulation kernel. NetSim protocol libraries are available in open C code for alteration. It also support the debugging ability with breakpoints and checkpoints during simulation through that user can perform single-step, step-in, step over observation [13].

2.5. OPNET

OPNET comes with GUI for the topology design. It allows for practical simulation of networks, with performance data collection and display modules [16]. It is high-fidelity discrete event simulation models for technologies like IPv6, LTE, MPLS, UMTS, 802.16 (WiMax). It facilitate simulation, analysis and design of networks, protocols, devices, and applications (terrain modeling, system-in-the-loop, 3D network visualizer, app transaction xpert models application transactions) [14][15].

2.6. REAL

Mainly, the REAL is intended for studying the dynamic behaviour of flow and congestion control schemes in packet switching network. It provides users with a way of specifying such networks and to observe their behaviour. It has approximate thirty modules which are written in C. It can emulate the several well-known flow control protocols and fives scheduling. The simulator takes as an input of scenario with topology, protocols, and workload and control parameters. It creates as an output statistics like the amount of packets sent by each source, the queuing delay at each queuing point, and the number of dropped and retransmitted packets. The GUI allows users to rapidly build simulation scenarios with drag and draw interfaces [17].

2.7. J-Sim

J-Sim [18] is an object oriented based library for discrete-time process-oriented simulation. The main application area is queuing network simulation. J-Sim is in Java language. It also supports Perl, Tcl, or Python scripting interface for integration [19], [20].

2.8. QuelNet

QualNet [21] is about planning, testing and training tool that imitates the behavior of actual network. It provides a

complete atmosphere for designing protocol, creating and animating network scenario, and analyzing performance. It is a GUI based tool for designing and visualization. In design mode, can set up various connection of network, subnets, define mobility patterns of wireless of network nodes using intuitive, click and drag operation. Use can customize the QualNet's protocol, application layer traffic and services which run for the network. In visualize mode, user can perform in-depth visualization and analysis of a network scenario and can generate dynamic graphs [22].

The above network simulation tools are classified and compared based on different criteria: commercial or free, type of interface (GUI and/or CLI), does it support real time traffic/emulation mode, supporting programming language, supporting platform etc. in Table I.

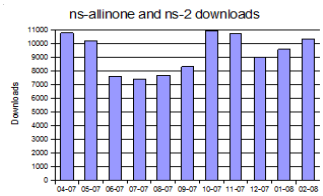
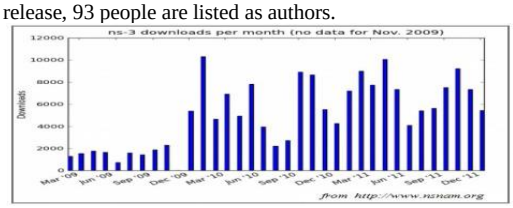
3. NS3 VS NS2

NS3 is built in C++ with library to link statically or dynamically. C++ wrapped by Python scripting language which is optional in NS2. Python script use for simulation and emulation of NS3 modules. C++ is speedy to run but slower to modify for protocol execution. While the OTcl runs much slower but can be changed very speedily and interactively for simulation and configuration of protocol in NS2. Hence NS2 required much resource and lots of tools to make network scenarios. Note that NS2 source codes created on NS2 is not

Table 1 Classification of Simulation Tools

Simulator	Interface			Emul-ation	Open Source	Comm-ercial	Programming Language	Platform (OS)	Latest version	Vendor & Available Site
	GUI	CLI	Analyzer							
NS3	×	√	NetAnim	√	√	×	C++, Python	Windows, Linux, Mac OS, Free BSD	NS3.23 (May 2015)	http://www.nsnam.org/ns-3-13/download/
NS2	×	√	NAM	√	√	×	C++, Otcl	Windows, Linux, Mac OS, Free BSD	NS2.35 (Nov 2011)	http://www.isi.edu/nsnam/ns/ns-build.html
OMNeT++	√	×	√	√	√	×	C++	Windows, Linux, Mac OS	OMNeT++ 4.6 (Feb 2014)	Omnest http://www.omnetpp.org/component/docman/cat_view/17-downloads/1-omnet-releases
NetSim	√	×	√	Net-Patrol	×	√	C,C++, Java	Windows	NetSim 8.3	TETCOS http://tetcos.com/netsim_gen.html
OPNET (Riverbed)	√	×	√	√	×	√	C, C++,	Windows	Version 9.1	OPNET Technologies Inc. http://www.opnet.com/university_program/itguru_academic_edition/
REAL	√	√	-	×	√	×	C (CLI), Java (GUI)	Sun OS, Linux, Windows	Real5.0	S. Keshav Cornell University http://www.cs.cornell.edu/skeshav/real/overview.html
J-Sim	√	√	√	Partial	√	×	Java, TCL	Windows, Linux,	Version 2.15 (Oct. 2014)	https://sites.google.com/site/jsimofficial/downloads
QualNet	√	√	√	√	×	√	C++	Windows, Linux	-	Scalable Network Technologies Inc. http://web.scalable-networks.com/content/qualnet

Table 2 NS3 vs NS2

	NS2	**NS3**
Started	1995	2006
First release	1996	2008
Type	Freeware & Open source	Freeware & Open source
Funded by	DARPA VINT,SAMAN & NSF CONSER	NSF CISE & INRIA
Based on	NS1 & REAL simulator	NS2, GTNets, YANS
Current support	Volunteers, USC ISI & Sourceforge	NSF, INRIA, GT, WashU & volunteers
Architecture	OTcl & C++	C++ & optional Phyton scripting
Scripting	OTcl which Introduced overhead with large simulations.	Python
Visualization	NAM	ns3-viz, pyviz, NetAnim,
Memory management	NS2 requires basic manual C++ memory management functions	Because NS3 is implemented in C++, all normal C++ memory management functions such as new, delete, malloc, and free are still available.
Simulation time	Total simulation time is large in NS2	The total computation time required to run a simulation scales better in NS3 than NS2.
Compatible	Partially NS2 is compatible with NS3 i.e. C++ code may use in NS3	NS 3 is not backwards-compatible with NS2
Scalability	Sequential simulations	MPI for distributed simulations
Packets	A packet consists of 2 distinct regions; one for headers, and the second stores payload data.	A packet consists of a single buffer of bytes, and optionally a collection of small tags containing meta-data.
contributed models and codes	A lot of different organizations contributed to the models and components of NS2,	There is very limited number of models and contributed codes in NS3 in comparison with NS2
Application	Ping, vat, telnet, FTP, multicast, probabilistic and trace-driven traffic gen., webcache	Sockets-like API, P2P, traffic generator, Ping, Echo, Packet sink, Topology Input Readers
Transport	TCP, UDP, SCTP, XCP, TFRC, RAP, RTP, Multicast: PGM, SRM, RLM, PLM	TCP stack emulation (Linux, BSD), DDCP, additional high speed TCP variants, UDP
Network	Unicast: IP, MIP, DV, LS, IPinIP, SR, Multicast: SRM, MANET: AODV, DSR, DSDV, TORA, IMEP, Queuing: DiffServ, RED, WFQ, DropTail	full IPv4 & IPv6 support, NAT, BGP, OSPF, RIP, IS-IS, PIM-SM, IGMP/MLD, static (Dijkstra) unicast, static multicast, DSDV, Global(link state), Nix-vector, DSR, VANET, Click, MANET: OLSR, AODV,
Link & Mac	ARP, HDLC, GAF, MPLS, LDP MAC: CSMA, 802.11b, 802.15.4, satellite Aloha, Queuing: Drop Tail, RED, RIO, SRR, WFQ, REM	new 802.11 model, Wifi 802.11 links, Mesh 802.11s, 802.11 variants (mesh, QoS), WiMAX 802.16, TDMA, CDMA, GPRS, CSMA, Bridge (802.1D Learning), PPP, Zigbee, MPLS
Physical	Two-Way, shadowing, Omni Antennas, Energy model Satellite repeater	IEEE 802 physical layers, Rayleigh and Rician fading channels, GSM, Jakes composite loss model, Friis, log-distance
Mobility	Many including bonn-motion tool	Hierarchical, Random direction, RWP, RW, ns-2 Scen-Gen
Support & Utility	Random number generator, tracing, monitor, mathematical support, test suit, animation, error model	Random number generator, tracing, unit test, logging, callback, animation, error model, Queuing
Emulation mode	Integration with real networks	Integration with real networks
Downloaded	Over 8000 downloads/month ns-2 plus ns-allinone  http://nsnam.org	In 2009, ns-3 releases were downloaded around 14,000 times. In 2011, ns-3 releases were downloaded 86,014 times. As of ns-3.13 release, 93 people are listed as authors.  Statistics: SourceForge project site (http://sourceforge.net/projects/nsnam/)
Supporting Platform	Windows, Linux, Mac OS, Free BSD	Windows, Linux, Mac OS, Free BSD
Latest version	NS 3.35	NS 3.23
Available site	http://www.isi.edu/nsnam/ns/	http://www.nsnam.org/

capable to be reused for actual execution while the NS3 allows the users to work on source code for implementation and can reuse in real execution [23].

Two discrete event simulators NS3 and NS2 are compared based on platform, language, architecture, layers, memory, visualization, simulation time etc. The main comparisons between NS3 and NS2 are demonstrated in Table II [24].

4. CONCLUSION

Many network simulators are presented in the field of communication. Among them NS2, NS3 and OMNeT++ are frequently used for simulation. As the rich set of models for NS2, still needs to be ported from NS2 to NS3. OMNeT++ can be considered as viable alternative. Furthermore, OMNeT++ provides a rich GUI interface and an abstract modeling language. NS2 and NS3 are also abstract modeling language and CLI based source code for the development of the whole simulation. As compare to OPENet++, the NS2 and NS3 have greater contributors and community even if these simulators are not supporting the GUI mode. However, based on comparative study, it shows that NS3 may better than NS2 in features.

In conclusion, the issue of which simulator to use is a difficult and the answer is mainly dependent on the exact use-case. However, if scalability is the main criteria, NS3 and OMNeT++ are smart options. Hope this review shows to be a good reference source for community who feel difficult to choose the suitable network simulators for their work.

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