NETWORK SIMULATORS FOR NEXT GENERATION NETWORKS: AN OVERVIEW

Monika[1], Akhil Kaushik[2] and Mani Shekhar[3]

[1,2]Department of Computer Engineering, The Technological Institute of Textile & Sciences, Bhiwani, Haryana, India
[3]Department of Electronics & Communication Engineering, PSIT, Kanpur, U.P., India

ABSTRACT

In this modern era of technology, the advancement and development specifically associated with network simulators make them a significant tool for enhancing fundamental understanding in the field of next generation wireless network technologies, worldwide. Network simulators provide consent to investigators and developers to test diverse scenarios with an ease that are very tricky, intricate or expensive to simulate in real world. These are proven to be incredibly effective and efficient in developing basic knowledge by analysing distinct layers of the hypothetical as well as real-life objects. It is of the most important to test a newly proposed protocol in a real-world before actual placement. Nowadays, most of the research organizations, universities and viable industries are applying a great sum of effort in the development of new sophisticated network simulators used for next generation wireless networks. In this paper, some of the advanced "widely used" wireless network simulators (commercial and non-commercial such as NS-2; NS-3; OPNET; NetSim; OMNeT++; REAL; J-Sim and QualNet etc.) available in recent years are presented with their characteristics such as types, interface, availability, network impairments and support for network protocol. Most importantly, the documented comparative overview helps the researchers and academicians to choose optimal network simulator as per their interest and requirement.

KEYWORDS

Commercial and Open Source; Interface and Availability; Network Simulators; Network Simulators Features

1. INTRODUCTION

The future next generation wireless networks (FNGWNs) are considered indispensable for sustaining the advancement and growth in services with their escalating requirements. Next generation wireless networks are generally categorized on the basis of their specific uniqueness for example Ad-hoc/Mesh Networks, Sensor Networks (SNs), Cognitive Radio Networks (CRNs), and many more. These are found applications in vast domains, listed as emergency and health-care systems, advertisements, military, gaming, customer-to-customer applications, etc. Nowadays, researchers and scientists are applying their efforts to a greater extent in designing the FNGWNs [1].

There are several conventional techniques that are used to measure the performance of wired and wireless networks such as: analytical methods, computational simulations, and physical measurement [2]. But the problems and complexities associated with mathematical modelling as well as real test-beds encouraged the researchers to go for computer simulations.

DOI : 10.5121/ijmnct.2014.4404

In this modern era, simulation emerges as one of most common approach for developing and testing of new protocol as well as the modified existing protocols. It gains popularity worldwide because of high speed (fast), low economy (very cheap), reproducibility and flexibility in model construction and validation at a wide range of conditions. It evolves as a precious tool in copious areas where the analytical methods aren't pertinent and experimentation isn't viable. In context with FNGWNs, the potential of simulators are exploited for the development, improvement and validation of new algorithms, testing a networks capacity and analysing the performance under specific conditions and many more.

Simulation is a dominant tool, but it has certain potential pitfalls too [1, 3]. To conquer these drawbacks, it is essential to acquaint with the different NSs available in recent times with their pros and cons. The main objective of this research work is to present an overview of available wireless network simulators (WNSs) mainly used for general purpose.

2. Classification of Wireless Network Simulators

Figure 1, illustrates the classification of simulation tools and Table 1 demonstrates the available network simulators (general as well as specific purpose), emulators and testbeds for WNs. These summarizations help those who have limited knowledge in this field and but interested to work with the NSs. For more details regarding emulators and physical testbed, the interested reader can refer to one of the excellent review in [4].

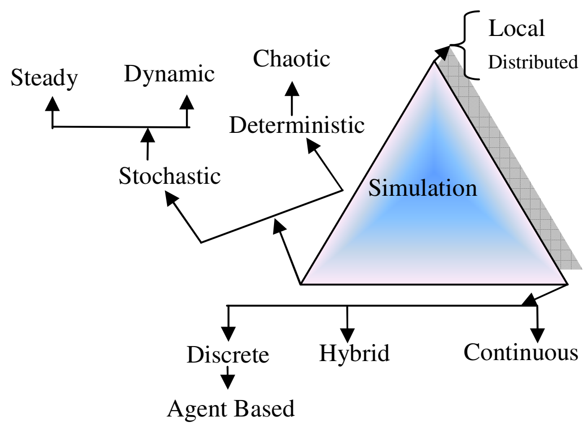


Figure 1. Classification of simulation tools

3. Related Work

There are quite a few surveys, comparisons, and also a number of case studies about NSs available today. These investigations are diverse with one another because of the mixture of NSs, their focus and level of detail provided. From Table 2 one can find the systematic summary (year-wise) of previous literature related to NSs.

Most of the investigations scheduled in Table 2 judge dissimilar NSs or vary in their objective from this document.

4. NETWORK SIMULATORS

This section illustrates some of the most popular NSs used for general purpose with their architecture. We systematically presented the description starting from the commercial NSs followed by the non-commercial one in the subsequent subsections. The architectures of only widely used NSs are shown here.

Table 1. Types of NSs, emulators and physical testbeds.

Simulators		Emulators	Physical Test-beds
General	**Specific**		
NS-2, NS-3	SensorSim	TOSSIM	MoteLab
OMNET++	Nsrlsensorsim	ATEMU	SensorScope
OPNET	Castalia	Avrora	GNOMES
GloMoSim	VisualSense	SENSE	Emulab
QualNet	Viptos	EmStar	SignetLab
JiST/ SWAN	Sidh	VMNet	SENSONET
Ptolemy II	Prowler, JProwler	Freemore	ORBIT
SSFNet	SENS	EXata	
J-SIM		NetPath	
Castalia		IMUNES	
GTnetS		PacketStorm	
Dartmouth SSF		NetDisturb	

Table 2. Summary of available literature (Year-wise).

Year [Reference]	Type of Investigation	Network Simulators	Focus
2002 [5]	Survey	In general simulation study	Credibility, Accuracy
2003 [6]	Case Study	OPNET, NS-2, TESTBED	Accuracy of Results
2005 [7]	Comparison	NS-2, TOSSIM	Models, Visualization, Architecture, Components
2005 [8]	Comparison	OPNET, NS-2	Initialization, Accuracy
2005 [9]	Description	GLOMOSIM, NS-2, IANEMU, GTNETS, J-SIM, JANE, NAB, PDNS, OMNET++, OPNET, QUALNET, SWANS	Overview
2005 [10]	Survey	NS-2, OMNET++, J-SIM, NCTUNS2.0, JIST/ SWANS, GLOMOSIM, SENS, SSFNET, ATEMU, PTOLEMY II, TOSSIM, SNAP	Features & Implementation Issues
2006 [11]	Comparison	OPNET, OMNET++, NS-2, SSFNET, QUALNET, J-SIM, TOTEM	Availability/Credibility of Models, Usability
2006 [12]	Comparison	OPNET, OMNET++, NS-2, QUALNET, J-SIM, SSFNET	For Critical Infrastructure
2006 [13]	Comparison	SSF, SWANS, J-SIM, NCTUNS2.0, NS-2, OMNET++, PTOLEMY, SNAP, ATEMU, EMSTAR,	Models, Type of Visualization

		TOSSIM	
2007 [14]	Description	NS-2, OPNET, SENS, EMSTAR, J-SIM, AVRORA, SENSE, ATEMU, GLOMOSIM, TOS-SIM, SENSORSIM, SIDH, OMNET++	Overview
2008 [15]	Survey	J-SIM, OMNeT++, NS-2, OPNET	Details & Comparison
2008 [16]	Survey	NS-2, GLOMOSIM, OPNET, OMNET++, J-SIM, SENSOR-SIM, SENSE, SIDH, ATEMU, SENS, TOSSIM,	Overview & Analysis
2008 [17]	Comparison	OMNET++, NS-2, OPNET	Performance Comparisons in terms of execution time incurred & memory usage)
2008 [18]	Case Study	J-SIM, OMNET++, NS-2, ShoX	Analyze Pros & Cons with respect to Installation, Implementation issues & Visualization capabilities.
2009 [19]	Comparison	NS-2 & TOSSIM 2.x	Mobility Analysis
2011 [20]	Review	OPNET, QUALNET, NETSIM, SHUNRA VE, NS-2, GLOMOSIM, OMNET++, P2P REALM, GTNETS, AKAROA	Classification, Evaluation Methodologies & Techniques
2011 [21]	Survey	NS-2, TOSSIM, EMSTAR, ATEMU, OMNET++, J-SIM, AVRORA	Overview, Merits and Limitations
2012 [22]	Survey	OPNET, NETSIM, NS-2, NS-3, J-SIM, OMNET++, REAL, QUALNET	Features and their Pros & Cons
2012 [23]	Comparison	QUALNET/GLOMOSIM, OM-NET++, NS-2, OPNET, J-SIM	Overview & Performance Comparison
2012 [24]	Comparison	NS-2, TOSSIM, OMNeT++, J-SIM, ATEMU, AVRORA, OPNET, CASTALIA	Merits and limitations with overview
2012 [25]	Comparison	NS-2, NS-3, OMNeT++, JiST	Performance Analysis
2013 [26]	Comparison	NS-2, NS-3, OMNET++, SWAN, OPNET, JIST, AND GLOMOSIM	Based on CPU utilization, memory usage, scalability, and computational time
2014 [27]	Survey	NS-2, NS-3, GLOMOSIM, OMNET++,	Applications to MANET

.

4.1. Commercial Network Simulator

QUALNET [28]: It is developed by Scalable Network Technologies; Inc. in 2000-2001, as the descendant of their open source simulator named GloMoSim for their defence projects. It supports for wired, wireless and mixed networks. Figure 2, illustrates the logical architecture of QualNet.

Optimized Network Engineering Tools (OPNET) [29]: This is developed by OPNET technologies; Inc. and since 1987, it becomes a commercial software. It is initially produced at Massachusetts Institute of Technology (MIT). It offers an inclusive development environment that supports the modelling, specification, simulation, performance and behaviour analysis of FNGWNs. Figure 3, illustrates the logical architecture of OPNet.

Network Based Environment for Modelling and Simulation (NETSIM) [30]: It is developed by Tetcos in 1997, in association with Indian Institute of Science and available both commercial and academic versions. It provides support for ATM, TCP, FDDI, IP, Ethernet, WNs types of network protocol. Figure 4, illustrates the logical architecture of NetSim.

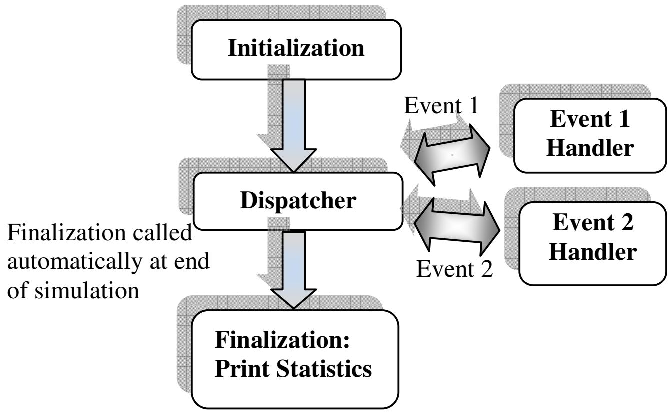


Figure 2. Logical Architecture of QUALNET

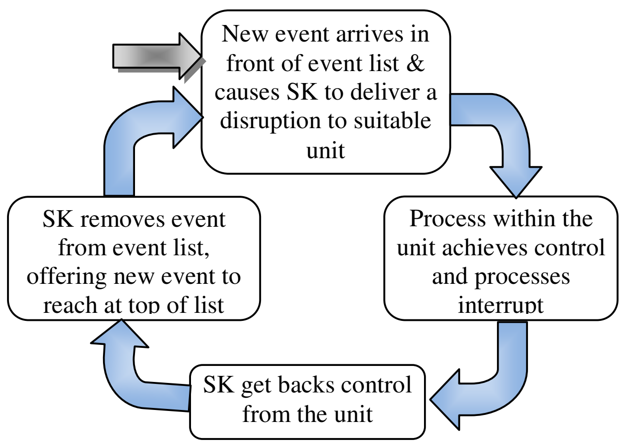


Figure 3. Logical Architecture of OPNET

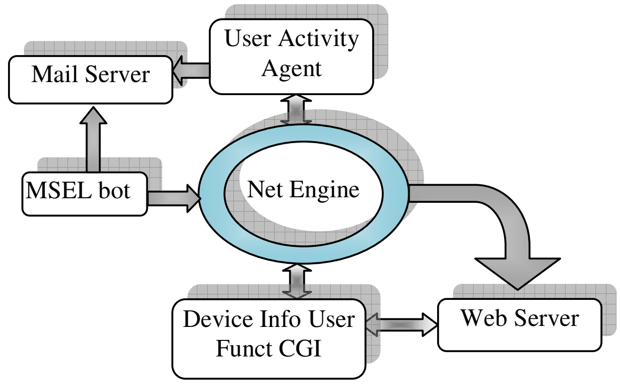


Figure 4. Logical Architecture of NETSIM

Shunra Virtual Enterprise (Shunra VE) 5.0 [31]: It is a hardware-based simulation environment having an advantage of high speed than the software-based simulation [13]. Storm-Cather enables the replay and capture of network activities. Storm-Console used as the interface to Storm Appliance, creates the network model [13].

4.2. Open Source Network Simulator

Network Simulator Version-2 (NS-2) [32]

It is developed under VINT (Virtual Inter Network Testbed) project; in 1995 by a joint venture of people from University of California at Berkeley, University of Southern California's Information Sciences Institute, Lawrence Berkeley National Laboratory and Xerox Palo Alto Research Center. It is supported by Defense Advanced Research Projects Agency and National Science Foundation. A separate application named NAM can be employed to visualize the mobility and packet traces formed during simulation in NS-2. Figure 5, shows a Unix-like environment and command-line interface running on Windows.

Network Simulator Version-3 (NS-3) [33]

It is developed under NS-3 project in 2006 as a discrete-event NS having licensed under GNU GPLv2 license and particularly utilized for research and educational purpose to build up new models, debug and retain existing ones. Figure 6, illustrates the logical architecture of NS-3. Recently, Tapparello et al. [34] made contributions to the ns-3 energy framework for improving its quality of simulations of energy-aware wireless networks.

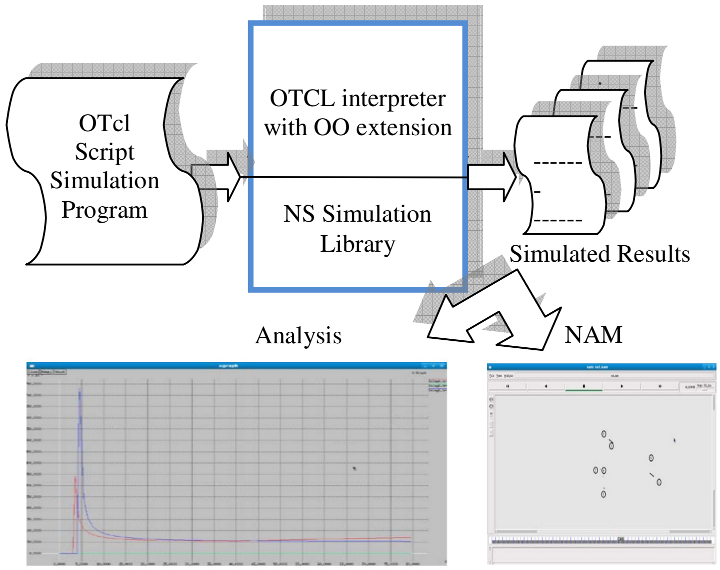


Figure 5. Logical Architecture of NS-2

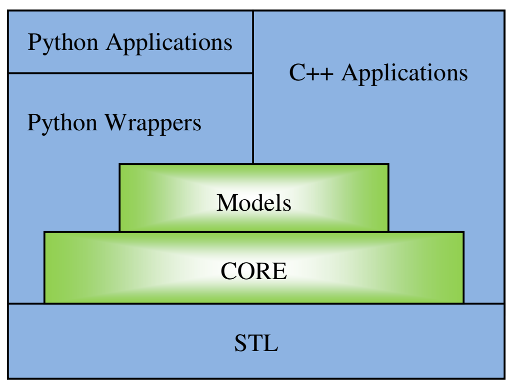


Figure 6. Logical Architecture of NS-3

Global Mobile Information System Simulation Library (GloMoSim) [35]

It is developed in 1998, and its ability of parallel network simulation make them suitable for mobile WNs. It uses an object-oriented approach. Lastly in 2000, it stops releasing updates. Figure 7, illustrates the logical architecture of GloMoSim.

Objective Modular Network Testbed (OMNET++) [36]

The main contribution in developing OMNET++ is from Andras Varga from Technical University of Budapest, with some intermittent contributors having wide applications in the area of WNs. The generic and flexible architecture efficiently widened its area to other complex applications related to IT systems and many more. Figure 8, illustrates the logical architecture of OMNET++.

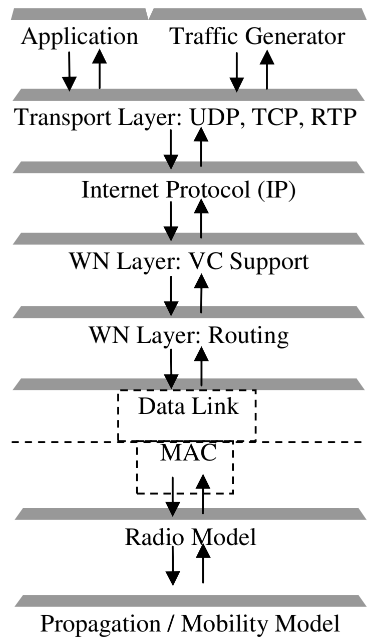


Figure 7. Logical Architecture of GloMoSim

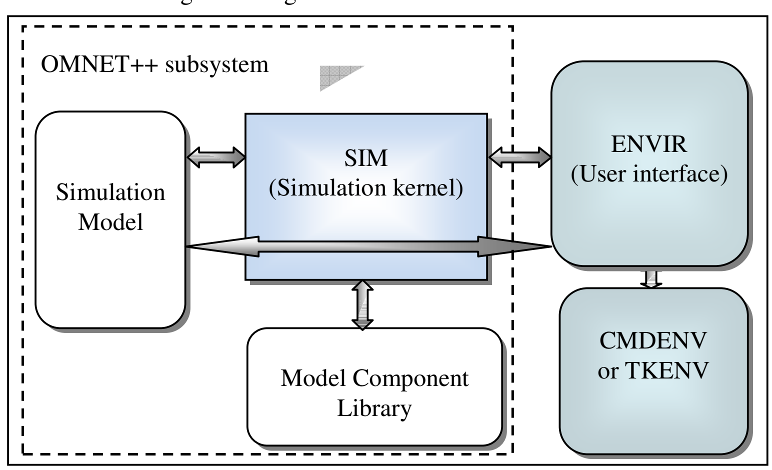


Figure 8. Logical Architecture of OMNET++

REalistic And Large (REAL) [37]: It is developed by Computer Science Department at UC Berkeley in 1988 for analysing the dynamic behaviour of flow and clogging manage schemes in packet switch data networks. Figure 9, illustrates the logical architecture of REAL.

J-Sim (Java-based Simulation) [38]: It is developed as a result of team effort at the Distributed Real-time Computing Laboratory under a project partially supported by (National Science Foundation) NSF, MURIA/AFOSR (Multidisciplinary University Research Initiative Air Force Office of Scientific Research), DARPA/IPTO (Information Technology Office), Ohio State University and the University of Illinois at Urbana-Champaign.

Scalable Wireless Ad-hoc Network Simulator (SWANS) [39]: It is developed as a scalable substitute to NS-2 for simulating WNs. It is built at the top of JiST platform. It is structured as independent software components that can be created to form complete WNs or WSNs configurations.

ShoX: It is an object-oriented NS with architecture that follows OSI seven-layer model written in Java. For details refer to [18].

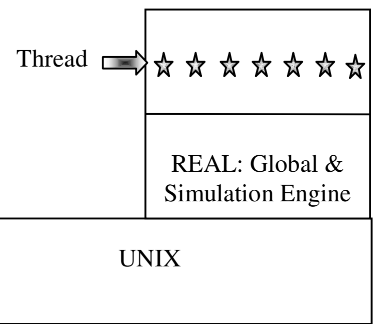


Figure 9. Logical Architecture of REAL

5. INTERFACE AND AVAILABILITY OF NSS

Table 3, shows the interface and availability of available NSs. Column 3 of Table 3 shows URL adders, where one can obtain the setup of software. For more details about, why these languages are used, one can refer to [21].

6. COMPARISON

It is for sure that each NS has its own pros and cons; as a result of that each one is appropriate for some particular application than others. The comparison presented in Table 4 and 5, give an insight, how the features of different NSs vary with one another. Conclusions drawn by the various papers and surveys will affect our decision. This section is divided into two parts, first one of which sums up weaknesses and strengths of the simulators, and second one gives comparative information.

7. DISCUSSION AND SCOPE FOR RESEARCH AHEAD

The objective of this comparative survey is to prepare a solid background for available wireless network simulators used in FNGWNs by highlighting their best and worst features. The intention behind this description is to create awareness among the researchers who are interested in working with network simulators with their strengths and weaknesses, so that they select the best one to their requirement because none of them grant high sustainability for all of those characteristics.

From the survey, it is found that till now none of the author or researcher as per our survey exploits the potential of all the most popular general purpose simulators together for one application so that a common observation will be made about the suitability of the network simulators about that specific application. Some of the investigations [17, 18, and 19], compare the performance of some of the simulators together. Ref. [17] reveals that OMNET++ has superior performance than NS-2 and also has some merits over OPNET like free availability and graphical runtime environment. One of the study reported that J-SIM and NS-2 acquire comparable execution time, but J-SIM takes at least two orders of magnitude lower memory allocation than that of NS-2 to carry out simulation [40]. Furthermore, in Ref. [25] performance comparison of NSs mainly ns-2.35, ns-3.12.1, OMNeT++4.1 and JiST-1.0.6 reveal that ns-3, OMNeT++ and JiST are all capable of carrying out large scale simulation scenarios, whereas ns-2 shows worst overall performance. JiST has best execution speed but worst with respect to memory utilization. Moreover, [26] also found ns-3, OMNET++, and GloMoSiM most suitable for carrying out large scale network simulations. It was reported that despite being quite new and under development ns-3 gives best performance and also fastest simulators in terms of computation time. Therefore, a tradeoff has to be made between computational time and memory usage and often it depends upon the situations and the surrounding environment in which simulation has been carried out. Recent investigations [41, 42] suitably highlighted the importance of smooth handover and mobility management for future networks.

The above discussion efficiently laid the foundation for future investigations related to identification of an optimal network simulator based on CPU utilization, memory usage, computational time, and scalability for different routing protocol as per the area of application.

Table 3. Network Simulators and their availability.

NSs	Interface	Availability (URL)
QUALNET	C++	http://web.scalable-networks.com Recent Version: QualNet7.0
OPNET	C, C++	http://opnet-modeler.software.informer.com/16.1/ Recent Version: OpNet modeler 16.1
NETSIM	C / C++, Java	http://www.ssfnet.org/download/licelic.html Recent Version: NetSIMv7
NS-2	C++, Otcl	http://www.isi.edu/nsnam/ns/ns-build.html Recent Version: ns-2.35
NS-3	C++, Python	https://www.nsnam.org/ns-3-dev/download/ Recent Version: ns-3.19
GLOMOSIM	C	http://pcl.cs.ucla.edu/projects/glomosim/academic/license.html
OMNET++	C++	http://www.omnetpp.org/component/docman/cat_view/17-downloads/1-omnet-releases Recent Version: OmNeT++ 4.4
REAL	C	http://www.cs.cornell.edu/skeshav/real/ REAL 5.0, is available as: REAL5.0.tar.gz REAL5.0.tar.Z
J-SIM	Java, Tcl	https://sites.google.com/site/jsimoffijsim/download Recent Version: J-SIMv1.3 + patch4
SWANS	Java	http://jist.ece.cornell.edu/sw.html Recent Version: jist-swans-1.0.6.tar.gz

Table 4. Comparison between Features of NSs.

Features/ Simulators	User Support	Applicability	Learning Time	Mobility	GUI
QUALNET	Excellent	Net./Sys.	Short	Yes	Excellent
OPNET	Excellent	Net./Sys.	Long	Yes	Excellent
NETSIM	Excellent	Net./Sys.	Short	Yes	Excellent
NS-2	Excellent	Net./Sys.	Long	Yes	Limited
NS-3	Excellent	Net./Sys.	Short	Yes	Limited
GLOMO-SIM	Poor	Net./Sys.	Moderate	Yes	Limited
OMNET++	Good	Net./Sys.	Moderate	No	Good
J-SIM	Excellent	Net.	Moderate	Yes	Limited

Table 5. Comparison of Network Impairments and Protocol Support by Different NSs.

Simulators	Scalability	Network Impairments	Support for Network Protocol
QUALNET	Enterprise	Evaluation of various protocols.	Wired and WNs; WANs
OPNET	Enterprise	Link models such as bus and point-to-point(P2P), queuing service such as Last-in-First-Out (LIFO), First-in-First-Out (FIFO), priority non-preemptive queuing, round-robin.	ATM, TCP, FDDI (Fiber distributed data interface), IP, Ethernet, WNs.
NETSIM	Large-scale	Relative positions of stations on the network, realistic modeling of signal propagation, the transmission deferral mechanisms, collision handling and detection process.	Aloha, slotted aloha, Ethernet, Token Ring, Token Bus, W Lan, X.25 Frame Relay, ATM, TCP
SHUNRA VE	Enterprise	Latency, jitter & packet loss, bandwidth congestion & utilization.	Point-to-point, N-Tier, hub and spoke, fully meshed networks.
NS-2	Small-scale	Congestion control, transport protocols, queuing and routing algorithms, and multicast	TCP/IP, Multicast routing, TCP protocols over wired and WNs (local & satellite).
NS-3	Large-scale	Simulation-in-the-loop	IP & non-IP based networks,
GLOMO-SIM	Large-scale	Evaluation of various wirelessnetwork protocols including channel models, transport, and MAC protocols.	Wired and WNs
OMNET++	Small-scale	Latency, jitter, and packet losses.	WNs
J-SIM	Moderate	FIFO, RM, EDF, Stop-and-go, DCTS, VirtualClock, LFVC, SCFQ, PGPS, STFQ, WF2Q, Leave-in-time	RIP (DV), OSPFv2, Multicast shortest path tree Multicast, minimum load tree Multicast Steiner tree DVMRP, MOSPF, CBT
SWANS	Large Scale	hierarchical binning	Wireless network or sensor network configurations

REFERENCES

[1]. S. Mehta, Najnin Sulatan and K.S. Kwak, (2010) "Network and System Simulation Tools for Next Generation Networks: a Case Study," Modelling, Simulation and Identification, Azah Mohamed (Ed.), ISBN: 978-953-307-136-7, InTech, http://www.intechopen.com/books/modelling--simulation-and-identification/network-and-system-simulation-tools-for-wireless-networks-a-case-study

[2]. J. Heidemann, K. Mills, and S. Kumar, (2001) "Expanding Confidence in Network Simulations," *IEEE Network*, Vol. 15, No. 5, pp58-63.

[3]. S. Mehta, Mst. H. Kabir, Md. N. Sultana, N. Ullah, and K.S. Kwak, (2009) " A Case Study of Networks Simulation Tools for Wireless Networrks," in procceding of AMS'09, Indonesia, pp661-666.

[4]. M. Imran, A.M. Said, H. Hasbullah. (2010) "A Survey of Simulators, Emulators and Testbeds for Wireless Sensor Networks," *IEEE*, pp897-902.

[5]. K. Pawlikowski, H.D. Jeong, and J.S. Lee, (2002) "On credibility of simulation studies of telecommunication networks," *IEEE Communications*, Vol. 40, No. 1, pp132–139.

[6]. G.F. Lucio, M. Paredes-Farrera, E. Jammeh, M. Fleury, and M.J. Reed, (2003) "Opnet modeler and ns-2 - comparing the accuracy of network simulators for packet-level analysis using a network testbed," *WSEAS Transactions on Computers*, Vol. 2, No. 3, pp700–707.

[7]. M. Karl, (2005) "A comparison of the architecture of network simulators ns-2 and tossim," In Proceedings of Performance Simulation of Algorithms and Protocols Seminar. Institut fr Parallele und Verteilte Systeme, Abteilung Verteilte Systeme, Universit Stuttgart, 2005.

[8]. B. Schilling, (2005) "Qualitative comparison of network simulation tools," Technical report, Institute of Parallel and Distributed Systems (IPVS), University of Stuttgart, January 2005.

[9]. L. Hogie, P. Bouvry, and F. Guinand, (2005) "An overview of manets simulation," In Electronic Notes in Theoretical Computer Science, Proc. of 1st International Workshop on Methods and Tools for Coordinating Concurrent, Distributed and Mobile Systems (MTCoord 2005), LNCS, pages 81–101, Namur, Belgium, April 2005. *Elsevier*.

[10]. E. Egea-Lopez, J. Vales-Alonso, A. Martinez-Sala, P. Pavon-Mari, and J. Garcia-Haro, (2005) "Simulation Tools for Wireless Sensor Networks," Summer Simulation Multiconference - SPECTS 2005, pp 2-9.

[11]. L. Begg,W. Liu, K. Pawlikowski, S. Perera, and H. Sirisena, (2006) "Surveyof simulators of next generation networks for studying service availability and resilience," Technical Report TRCOSC 05/06, Department of Computer Science & Software Engineering, University of Canterbury, Christchurch, New Zealand, February 2006.

[12]. S. Duflos, G.L. Grand, A.A. Diallo, C. Chaudet, A. Hecker, C. Balducelli, F. Flentge, C. Schwaegerl, and O. Seifert, (2006) "Deliverabled 1.3.2: List of available and suitable simulation components," Technical report, Ecole Nationale Supieure des Tommunications (ENST), September 2006.

[13]. E. Egea-Lopez, J. Vales-Alonso, A. Martinez-Sala, P. Pavon-Mari, and J. Garcia-Haro, (2006) "Simulation scalability issues in wireless sensor networks," *IEEE Communications Magazine*, Vol. 44, No. 7, pp64–73.

[14]. D. Curren, (2007) "A survey of simulation in sensor networks," Student project, 2007. www.cs.binghamton.edu/˜kang/ teaching/cs580s/david.pdf

[15]. M.M. Koksal, (2008) "A Survey of Network Simulators Supporting Wireless Networks," pp1-11.

[16]. C.P. Singh, O.P. Vyas, and M.K. Tiwari, (2008) "A Survey of Simulation in Sensor Networks," *IEEE*, pp867-872.

[17]. X. Xian, W. Shi, and H. Huang, (2008) "Comparison of OMNET++ and Other Simulator for WSN Simulation," *IEEE*, pp.1439-1443.

[18]. J. Lessmann, P. Janacik, L. Lachev, D. Orfanus, (2008) "Comparative Study of Wireless Network Simulators," Seventh International Conference on Networking, IEEE Computer Society, 2008, pp517-523. DOI 10.1109/ICN.2008.97

[19]. C. Stevens, C. Lyons, R. Hendrych, R.S. Carbajo, M. Huggard, C. Mc Goldrick, (2009) "Simulating Mobility in WSNs: Bridging the gap between ns-2 and TOSSIM 2.x," 13th IEEE/ACM Int. Symposium on Distributed Simulation and Real Time Applications, IEEE, pp247-250.

[20]. N.I. Sarkar, and S.A. Halim, (2011) "A Review of Simulation of Telecommunication Networks: Simulators, Classification, Comparison, Methodologies, and Recommendations," *Journal of Selected Areas in Telecommunications (JSAT)*, pp10-17.

[21]. F. Yu, and R. Jain, (2011) "A Survey of Wireless Sensor Network Simulation Tools,". http://www1.cse.wustl.edu/~jain/cse567-11/ftp/sensor/index.html

[22]. S. Siraj, A.K. Gupta, and R. Badgujar, (2012) "Network Simulation Tools Survey," *Int. J. Advan. Resear. Comp. Communi. Engg.* Vol. 1, No. 4, pp201-210.

[23]. A. Kumar, S.K. Kaushik, R. Sharma, and P. Raj, (2012) "Simulators for Wireless Networks: A Comparative Study," *Int. Conf. Comp. Sci.*, pp338-342.

[24]. A.K. Patil, and P.M. Hadalgi, (2012) "Evaluation of Evaluation of Discrete Event Discrete Event Wireless Sensor Network Simulators," *Int. J. Comp. Sci. & Net. (IJCSN)*, Vol. 1, No. 5.

[25]. D. Pal, (2012) "A Comparative Analysis of Modern Day Network Simulators," D.C. Wyld et al. (Eds.): Advances in Computer Science, Eng. & Appl., AISC 167, pp489–498

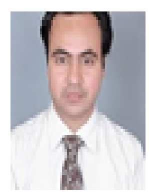
[26]. A.R. Khana, S.M. Bilalb, and M. Othmana, (2013) "A Performance Comparison of Network Simulators for Wireless Networks," Computer Science, Networking and Internet Architecture, arXiv.org > cs > arXiv:1307.4129.

[27]. A.O.A. Salem, and H. Awwad, (2014) "Mobile Ad-hoc Network Simulators, A Survey and Comparisons," *Int. J. P2P Net. Trends Tech. (IJPTT),* Vol. 9, pp12-17.
[28]. QUALNET: http://www.qualnet.com
[29]. OPNET: http://www.opnet.com
[30]. NETSIM: http://www.tetcos.com/
[31]. Shunra VE: http://www.shunra.com/about-shunra
[32]. NS-2: http://www.isi.edu/nsnam/ns
[33]. NS-3: https://www.nsnam.org/
[34]. C. Tapparello, H. Ayatollahi, and W. Heinzelman, (2014) "Extending the Energy Framework for Network Simulator 3 (ns-3)," http://arxiv.org/abs/1406.6265v1.
[35]. GloMoSim: http://pcl.cs.ucla.edu/projects/glomosim
[36]. OMNeT++: http://www.omnetpp.org/
[37]. REAL: http://www.cs.cornell.edu/skeshav/real/index.html
[38]. J-SIM: http://www.j-sim.org
[39]. SWANS: http://jist.ece.cornell.edu/
[40]. A. Sobeih, W.P. Chen, J.C. Hou, L.C. Kung, N. Li, H. Lim, H.Y. Tyan, and H. Zhang, (2006) "J-Sim: A Simulation and Emulation Environment for Wireless Sensor Networks," *Wireless Communications*, IEEE, Vol. 13, No. 4, pp104–119.
[41]. H.A. Bhute, P.P. Karde, V.M. Thakare, (2014) "A vertical handover decision approaches in next generation wireless networks: a survey" International Journal of Mobile Network Communications & Telematics (IJMNCT) Vol. 4, No.2, pp33-43.
[42]. Monika, M. Kumar, M. Shekhar, (2014) "Mobility Management in Distributed Computing System using QualNet," 2014 International Conference on Reliability, Optimization and Information Technology (ICROIT-2014), India, Feb 6-8 2014, 978-1-4 799-2995-5/14/$31.00©20 14 IEEE.

Authors

Monika Sharma has received B. Tech. in Computer Science Engineering from M.D.U. Univ ersity in 2012 and pursuing M. Tech. from TIT&S, Bhiwani, Haryana, India. She has published a number of papers in international/national conferences. His research interest includes Networking, Image and Video Processing.

Akhil Kaushik has received the Master degree in Information Technology from Centr al Queensland University, Melbourne, Australia. Currently he is working as an Assistant Professor in "Technological Institute of Textile & Sciences", Bhiwani, Haryana, India. He has his research contribution, four at International level in various proceeding like IEEE, ICNIT, ICFN, IJARCS and three at National level. His research interest includes network security, cryptography and Artificial Intelligence.



Mani Shekhar was born in Kanpur, India in 1987. He obtains his M-Tech. in Communication systems and networks from NIT Hamirpur, in 2011. He is with Department of Electronics & Communication Engineering, Pranveer Singh institute of technology, Kanpur, India. His research is concern the Seamless and Secure Mobility Management for Next Generation Networks.