Investigate Network Simulation Tools in designing and managing intelligent systems

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Received: 04/Jul/2019 Revised: 24/Oct/2019 Accepted: 08/Dec/2019

Abstract

Network simulation is a technique that models network behavior by performing transaction calculations between different network entities and using mathematical formulas and taking observations of network products. A network simulator is a software program have been applied to analyze the performance of a computer network without the presence of a real network. Hardware equipment, equipment configuration, communication, and routing protocols and network traffic modeled in simulation software and the behavior of the network and its components examined from different dimensions. The user can also customize the simulation software according to their needs. Simulation software has different uses, and the user can use these tools to model their network by recognizing this software. In terms of research, it is difficult to create a network, especially large networks, in a real-time scenario, and it is not easily possible to carry out it in the real world, and it is very costly. So, simulators help network developers to control whether the network can work in real-time or not, or whether it is efficient enough. This reduces the time and cost of network application testing.Today, simulation technology is successfully used to model, design and manage a variety of intelligent systems. Numerous tools have been created in this regard. In this article, we review and compare important network simulators such as CloudSim, GloMoSim, GNS3, NS-2, Opnet, OMNet ++, NetSim, NS-3, AVRORA, Packet Tracer, QualNet, J-Sim, REAL and OptSim and their results. These comparisons express from several perspectives in the tables.

Keywords: Simulation; network simulator; network simulation; Network simulation languages; comparison.

1- Introduction

Today, there are huge industrial and economic activities around the world, and factories, manufacturing, and industrial centers, with the workforce and availability of the raw materials they need, sometimes run around the clock. In the meantime, the most important thing that industry owners and service providers pay particular attention to is to optimize their activities and actions so that they can use the smallest materials and components and the required equipment to give the highest quality products or services to give. In another case, the owners of capital and groups that are in the early stages of entering these types of activities need to have an image of what they want to invest in, as well as the amount of utility (return) of that specific activity and general knowledge of the cycle of their desired activity. The first suggestion for this goal is a small (laboratory) sampling, which, of course, requires first costs for a project that we do not now have a comprehensive understanding of its problems. Network simulation means virtual simulation. The purpose of the simulation is to find problems in existing networks or find unexpected interactions on a network that has not yet been built [1].

By locating or preventing existing failures, reliability improved and costs reduced. Other reasons for using the simulator include the lack of hardware and the consequent lack of hardware reform problems or other problems, such as the complex configuration of real-world equipment [2].

In the field of computer research and network communication, simulation is an important technique, because network behavior modeled by calculating the interconnection between different network components using mathematical formulas. Simulation can also be modeled by real or virtual recording and periodic real-time observation of real-world networks. Once the data is obtained through observations of simulation experiments, the network behavior and supported protocols viewed and analyzed in a series of off-line testing experiments. Also, all types of environmental features modified in a controlled way to test how the network can work under the combination of different parameters or configuration conditions. Comparing simulators and choosing one of them will help organizations and groups achieve the goal of each project.

In [1]: Some of the simulators are dedicated to a wireless network, some of them are dedicated to a wired network or both types of networks. Because of wide variations in operating systems, hardware requirements, programming software requirements, output features, and scalability, it is very difficult to choose a suitable simulator for a specific

job and had one Table for Comparison of 14 simulators based on 7 general information of simulators.

In [28],[30] presented a comprehensive survey on current network simulators and introduced their main features, consider their advantages and disadvantages, but introduced a few simulators (OPNET, NS2, NS3, OMNeT++), therefore it is not a good survey for those who find the Suitable network simulators for their researches.

In [29] introduced the main features of a different network simulator and considered their advantages and disadvantages (NS-2, NS-3, OPNET, OMNeT++, J-Sim, QualNet).

In [31][32]: One method of analyzing systems is the simulation. The basic idea is that if a system modeled, the corresponding results analyzed by changing the characteristics of this model. Because the process of modifying the model is cheaper than actual implementation, a range of situations analyzed at low-cost. thus, introduced the main features of the different network simulator and considered their advantages and disadvantages (NS-2, NS-3, OPNET, OMNeT++, J-Sim, QualNet, PeerSim).

One of the interesting areas in computer networks is to give the ability to evaluate and measure ideas, protocols, architectures and answer various questions, before the physical implementation of the network and its implementation. In terms of research, it is difficult to create a network, especially large networks, in a real-time scenario, and it is not easily possible to carry out it in the real world, and it is very costly. So, simulators help network developers to control whether the network can work in real-time or not, or whether it is efficient enough. This reduces the time and cost of network testing.

For this reason, we came up with a model of a list of widely used network simulators and comparing their properties, one of the ways to optimize the choice and finally speed up network access. Therefore, in this study, many(23) simulators from several different perspectives including accessibility, support, components, simulation, platform, visual/visual, supported protocols, testing, main applications, prominent features and advantages, disadvantages and constraints will compare and we outline the results for a better choice of network developers in the tables [3].

2- What is a Computer Network?

A computer network consists of two or more computers and accessories such as printers, scanners, and the like, which are directly used for the common use of hardware and software, data sources and connected devices. All hardware and software are available in the Source Network. In computer networks, according to the type of computer configuration, each computer can simultaneously use its resources, including tools and data, with other computers at the same time. The reasons for using the network are as follows [4]:

1 - **Common use of resources**: Common use of a source of information or computer equipment, regardless of the geographic location of each resource, refers to the use of common resources.

2. **Reducing costs**: Focusing on resources and sharing them, avoiding their distribution in different units, and the specific use of each user in an organization, will reduce costs. This feature refers to network support providers in the network, This means that we can give various sources of information and systems in the second version of the network and support and if you do not have access to one of the sources of information on the network "due to system failure", use backup copies. Support for servers in the network increases the system's continuous activity and readiness.

4. **Reducing the time**: Another goal of creating computer networks is to set up strong links between remote users, meaning there is no geographical limitation of information exchange to reduce the time of information exchange and the use of their resources.

5. **Ability to develop**: A local network expanded without changing the structure of the system and become a larger network. Here, the cost of developing a system for the cost of facilities and equipment needed to expand the network considered.

6. **Communications**: Users can exchange their messages through existing innovations such as e-mail or other messaging systems; even file transfers are possible.

3- Simulation

Simulation technology and software are one of the most powerful methods and tools available to managers, industry engineers, system analysts, and so on, which enables them to make systems, in hands, before making any decision about any production system, service, Modeling and simulating them, performing or working them, and making necessary statistical surveys in all its dimensions to make better decisions, with the goal of reducing costs and increasing profit (or efficiency).

Using simulation, a range of dynamic (dynamic) issues analyzed in the areas of manufacturing, support, and services. The simulation allows for modeling the flow of materials and goods, human resources and information in the organization, and analyzing the system by simulating and adjusting different scenarios, 3D animations, and ... It concerned with potential improvements [5].

4- Network Simulator

A network simulator is a piece of software or hardware that predicts the behavior of a computer network without a real network. A network simulator is a software program that imitates the function of a computer network. In simulators, the computer network modeled with devices and traffic, and then its efficiency analyzed and analyzed. Usually, users can customize the simulator to fulfill their own analytical needs. Simulators generally support well-known protocols that used today, such as wireless LAN(WLAN), WiMAX (Worldwide Interoperability for Microwave Access), UDP (User Datagram Protocol), and TCP (Transmission Control Protocol) [6].

Most commercial user interface graphical use simulations. Some network simulators need the comments of scripts and commands (network parameters). The network parameters define the network status (place of nodes, links (and events), data transfer, link failure, etc.). The most important output of the simulators is the tracking file. Tracking files can document any simulation event that analyzed and analyzed. Some simulators have added functions to capture data directly from the environment at different times of day, week, and month to show the average, worst and best modes. Network simulators give other tools for facilitating visual analysis of trends and potential bottlenecks. Simulation of the network is difficult, such as, when there is large congestion, the average occupancy estimate due to high variance is difficult. To estimate the network buffer overflow, the time required to respond increased [7]. Specific techniques, such as variant control, important sampling, etc., which extends the simulation speed.

5- Application of Network Simulators

Network simulators solve a lot of needs, faster and cheaper than the network simulator compared to the cost and timing of launching the test bed for a large project that includes computers and routers and data links. The simulators allow engineers and researchers to simulate scenarios that are difficult and expensive to carry out in real hardware with several ninety and new protocols tested on the network. Network simulators are useful because they allow researchers to test network protocols or change protocols in controlled and renewable environments. A kind of network simulator includes a range of network technologies and can help users build complex networks of simple blocks such as nodes and links, and are hierarchical networks with different types of nodes such as computers, hubs, network bridges, routers, switches, links and mobile units [8].

6- Network Simulation Tools and Soft wares

An important part of the development of each system is evaluation of its performance with regard to delays and delays in different real-life scenarios. In many cases, the performance and applicability evaluation of the network through simulation experiments, which also requires a suitable environment and simulation tools. Several tools and techniques have been created in this regard. For example, an event-driven simulation technique used, which is the basis of many new simulators. In a group of types of simulator software in communication networks classified into three main categories [9]:

1. general Purpose Simulation Language
2. communication Oriented Simulation Language
3. Network simulation software

Understanding the performance of these tools is an important step towards developing an overall method for generating network simulators [10]. Therefore, the following features of the simulators have discussed below.

7- Network Simulation Tools

This group includes full packets that Communication-Oriented Simulator can simulate communication networks without the need for coding and usually through graphical interfaces, presence of simulated elements corresponding to the actual elements (routers, switches, …). In addition to enhancing accuracy, it improves ease and speed in the simulation process and is very suitable for unfamiliar users with programming technology. COMNET III, BoNes PlanNet, NETWORK II and L.NET III are examples. [14]

The group is successful. Altogether, professional users, especially those dealing with specific networks, prefer simulation languages with difficulty working with them, and, in contrast to users who deal with the simulation topic in a cross-sectional fashion, packets like Prefer the instrument. Network simulation tools should have the following five characteristics [15][16]:

1. **Flexibility in modeling**: the user must be able to add new types of common network resources such as nodes, links, and protocols to the emulator's suite.
2. **Ease of Modeling**: the existence of graphical interfaces and the possibility of structured modeling, in the form of complex models based on simple models, as well as the ability to reuse modules are features that accelerate the simulation process.
3. **Fast execution of models**: processing time in large simulations is important for networks with a large number of nodes, which requires proper memory management.
4. **Animation**: graphical display of network elements that are exchanging messages with each other to solve simulation errors and understand how it works. In

some simulation software, the simulator runs simultaneously with the implementation of the simulator and in some others after it performed in the form of Playback.

5. **Ability to Re-run and Repeat Simulation**: The purpose of the simulation is mainly to investigate the effect of one or more parameters (average packet length or buffer capacity) on its efficiency, and the repeatability is a necessary condition for this software.

In general, it should note that the creation of an accurate and valid network simulator requires the use of simulation technology along with network knowledge and protocols. Of course, along with the above features, there will be some capabilities on the value of each simulator, among which are the following [16]:

- ✓ Presence of Built-in Modules corresponding to network elements and protocols.
- ✓ existence of a Random-Number Generator and, in more advanced forms, the ability to create quantities with different random distributions, because most occurrences in a simulation process are of the type of random processes.
- ✓ Support for users with timely upgrades (especially for new protocols) with full documentation.
- ✓ Providing reports on network performance parameters (output rate, efficiency, transmission delay and so on) in the form of figures and curves, together with the possibility of performing statistical operations on the results of other positive features of a simulator [17].

8- Compare and Evaluate Tools and Languages for Network Simulation

With the growing spread of research and simulation tools, many tools have developed, and since familiarity with single simulators is time-consuming, choosing the right simulator is very important. Therefore, researchers have evaluated and compared the various network simulation tools to help users decide on the usefulness simulator. Since the model correction process is cheaper than real implementation, a range of scenarios analyzed at low-cost. Therefore, several important simulators have investigated and compared in Table 1-1 to Table 1-3.

9- Conclusions

In the network research area, it is very costly to deploy a complete test bed containing multiple networked computers, routers and data links to validate and verify a certain network protocol or a specific network algorithm. The network simulators in these circumstances save a lot of money and time in accomplishing this task. Network simulators are also particularly useful in allowing the network designers to test new networking protocols or to change the existing protocols in a controlled and reproducible manner.

In this paper, we present a comprehensive survey on current network simulators. We introduce their main features, consider their advantages and disadvantages, and discuss the current and future developments. We hope this survey to be a good reference source for those who feel difficult to find the appropriate network simulators for their research or practical requirements.

This article reviews and compares the tools and simulators of the network. The research shows that this kind of simulator is due to network control to decide whether the network is capable of working in real-time or not and has capacity to reduce the time and cost required to test the functionality of the network. In this paper, we tried to compare and compare tabular characteristics and application of the most (23) common simulators. Since the use of a network simulator is effective in the performance of a project and other important issues in laboratory research, depending on the specific characteristics of each simulator, the use of its types can vary depending on the application. Among the most important goals and achievements of research are:

- Network simulation means its virtual simulation. The goal is to simulate problems on existing networks or to find unexpected interactions on a network that has not yet been built. By locating existing problems and preventing them from occurring, it is possible to improve reliability and reduce costs.
- Another reason for using a simulator is the lack of need for hardware and the consequent lack of equipment repair problems or problems such as the complex configuration of real-world equipment.
- Computer simulation is used to study and study most systems such as transportation, hospital, industrial systems, manufacturing, traffic, warehouse, etc. due to its practicality and having its own advantages.
- we have done a comparative study on different network simulators and investigated them from different perspectives, including accessibility, applications, visibility, etc. This research focuses on networking tools and simulators by the features presented in the above tables. Because it seeks to compare tools and simulators that speed up work, reduce errors, increase the level of abstraction and cut complexity. In the table below, these features and parameters are also compared with short.

Table 1-1: Comparison of network simulators based on general characteristics of simulators

Features	NS-2	NS-3	Opnet	OMNET++	Netsim	Glomosim	NCTUns
First version	1996	2008	1986	1997	2002	1998	1999
Use license	open source	open source	Commercial	open source (For students and educational purposes) and commercial (for commercial purposes)(	Dedicated	open source	open source
Language required (components)	OTCL (higher level) and C ++ (lower level)	C ++ (higher level) and Python (lower level)	C C++	C ++ and NED[1] (Model Structure)	C++ Java	ParSEC[2]	C++
General simulator	✓	✓	✓	✓	✓	✓	✓
Availability (accessibility)	Open source software (including source code and tests and examples), Excellent	Open source software (including source code, tests, and examples), Excellent	Commercial software (has no public access), good	Free software only for scientific and nonprofit use, good	Commercial simulator (includes free demo), Excellent	Open source simulator (included below .bin)	good
Easy to use	Hard	Hard	simple	simple	simple	Hard	Hard
Guidance and support	• Have a good guide • Public access to a license or license to use the software • Source code and examples	• Have an excellent guide • Access to shared code page • Access to library documents Access to API documents	• Have an excellent guide • Mailing list (maintenance license required) • Source code and examples	• Have an excellent guide including a programming guide • Has a library of simulation classes	• Simulation engine • Graphical applications • My SQL databases • A laboratory menu includes training, routing protocols	• Ability to expand and add new code • Predefined library components • Public access to the certificate	• continuously supported, maintained and im-proved • New functions and network types are continuously added to NCTUns to enhance its functions, speed and capabilities
Learning time	large	moderate	large	moderate	low	moderate	low
Download and install time	moderate	long time to download and install all the necessary packages and software support	moderate	• Very simple and time consuming. • Easily available	Easily available	Easy to download and install	Esay
Support for nodes mobility	✓	✓	✓	✓	✓	___	✓
Graphical interface support (Visual / Visibility)	• Poor • Lack of graphics output in the original version of the simulator • Added visualizer to eliminate the text-based interface	• Good • View simulation result using NAM animator	• Excellent • Advanced graphic interface	• Good • Graphical user interface for execution • Support for strong graphical interface	Have graphical applications	• Limited • Visual programming for the visual design of the ParSEC program	• easy navigation GUI environment • GUI program contains four main components: - Topology Editor - Node Editor - Performance Monitor - Packet Animation Player Among these four components, the Node Editor is relevant to module developers.
Simulation scale	small	small	large	small	Big enough	large	moderate

[1] Network Description
[2] Parallel Simulation Environment for Complex Systems

Features	NS-2	NS-3	Opnet	OMNET++	Netsim	Glomosim	NCTUns
Number of nodes supporters	Up to 3000	-	210 to 290 in all topologies	-	-	up to 10000	Up to 4096 nodes
Parallelism	-	-	✓	MPI/PVM	-	) (SMP/Beowulf	-
Supported platforms (platform)	Windows (CYGWIN), Linux MINT/UBUNTU / FEDORA / MINT / UNIX	Windows (CYGWIN), Linux MINT/UBUNTU /Free BSD X86/ FEDORA / MAC OS	Hewlett-Packard, Sun-4 SPARCVarious, Solaris 2.6, 7 8Microsoft Windows NT 4.0/Windows 2000Required System Patches-	Windows, Unix-based, Mac OS X 10.6 and 10.7	Windows (7, Vista) , windows XP	Windows, Linux, Sun SPARC Solaris	FreeBSD, Fedora, Red hat, Ubuntu, and Debian
Analysis tool	✓	✓	✓	✓	✓	___	✓
Support for network visualization	✓	✓	✓	✓	✓	poor	poor
Possibility to define and change the scenario	✓	✓	✓	✓	✓	poor	✓
Create a Trace File	✓	✓	✓	✓	✓	✓	✓
Support for design and implementation protocols (both simulated with wire and wireless)	✓	✓	✓	✓	✓	✓	✓
protocols supported (OSI[1] protocols)	• TCP/ UDP • FTP / Telnet and other web protocols in fixed and variable bit rate users • 802.11 and TDMA2 MAC layer protocols • Routing and multiprocessing protocols and, in general, all layers	• Routing protocols • Management Protocol • MAC layer routing protocols • TCP / UDP / Wimax	• TCP / IP /ATM • Frame relay • Protocol 802.11 • Wireless protocols	• UDP / IP and ICMP • Transfer Protocol and MAC protocols • Stop and wait protocol • Some local protocols for wireless sensor networks	• Aloha/ Slotted Aloha / Ethernet • CSMA/CD • Fast Ethernet/Gigabit Ethernet • Token Ring/Token bus in WLan • ATM ,TCP/ RIP • OSPF, BGP, MPLS, ZigBee 802.15.4 • Wimax / Wireless Sensor Networks	• Provide a protocol stack that includes models for channel, radio, MAC, network, transmission, and higher layers. • Simultaneous protocols and wireless networks	• IEEE 802.3 CSMA/CD MAC • IEEE 802.11 (b) CSMA/CA MAC • IEEE 802.11(e) QoS MAC • IEEE 802.11(b) wireless mesh network routing protocol • DVB-RCS satellite MAC and PHY • spanning tree protocol, IP Mobile IP, Diffserv (QoS), RIP, OSPF, UDP, TCP, RTP/RTCP/SDP, HTTP, FTP, Telnet, Bit Torrent, etc.
Ability to interact with the actual system	✓	✓	✓	✓	✓	✓	✓
Ability to communicate with other components	✓	✓	✓	✓	✓	poor	✓
Fast simulation	moderate	moderate	Excellent	moderate	good	moderate	poor

[1] Open Systems Interconnection
2 Time Division Multiple Access

Features	NS-2	NS-3	Opnet	OMNET++	Netsim	Glomosim	NCTUns
Event type simulation (Simulation Mode)	• Discrete event • Sync, single-threaded, queue-based off-the-shelf event, absolutely definitive, version Available Distributed and Parallel	Discrete event (Separate event)	• Discrete event • Synchronized, single-threaded, queue-based, and fast-ended, absolutely definitive • Multi-threaded, queuing-based event, distributed simulation and HLA1 • Simultaneous 32-bit and 64-bit simulation core	• Discrete event (Separate event) • Object-oriented and component-based modules	• Random discrete event • Multi-threaded with Net Engine simulation core	• Discrete event • Simulate a separate parallel event • Use of synchronous and asynchronous algorithms • Multi-threaded	Kernel Inspection Method
Network Type (Available Module)	• Wired / wireless / wireless sensor / ADHOC / MANET / Wired cum Wireless / SDN / VANET / Security /Vertical Handover	• Wired / wireless / wireless sensor / ADHOC / MANET / Wired cum Wireless / SDN / VANET / Device to Device Communication	• Wired / wireless / wireless sensor / ADHOC / MANET / Wired cum Wireless / SDN / VANET / Radio Network •	• Wired / wireless / wireless sensor / ADHOC / MANET / Wired cum Wireless / SDN / VANET / WBAN / Under water sensor network / Social sensor network	• Wired and Wireless Sensor Network (Wireless LAN, WiMAX)	• Wired, Wireless, AdHoc networks but currently have wireless support	• Wired, Wireless, Adhoc and Wireless Sensor Networks •
purpose of the test (Ease of testing a computer program)	• Testing the main platform of this simulator (VINT project) • Apply daily validation tests to NS2 and send to NSNAM	A unit test to inform the user of the correct simulator functionality (in parallel with the help of WAF)	• Testing technology design in real scenarios • Test user scenarios for the correct functioning of the new network to join the central network	Test and debug simulation of users by a strong graphical user interface	Test quick connectivity in K-NetSim (Test connections between network equipment and protocols.)	Test routing algorithms	• Test and use as an emulator (very useful as function and the performance of real-world devices can be tested under various simulated network).
purpose of creating the simulator (Main application cases)	• Especially designed for network simulation and research protocols • General simulator • Use in network research and simulation of IP networks • Uses for scalable wireless and wired network simulation	• The main goal is to use research, training and its sustainability. • Use in research and education issues in wireless and wired networks	• The GUI provides flexibility to make complex scenarios easier • Design, deployment and management of infrastructure, equipment and network applications • Use in the design and study of communication networks, equipment, protocols and applications and wireless environments	• Comprehensive analysis and component and powerful simulation of the discrete event at the university provide research • General simulator • Wired and wireless communication networks, protocols and queues in the network • Modeling distributed hardware systems • Validation of hardware architecture • Assessing the performance aspects of complex software systems Modeling and simulating event systems - distinct	• This is a leading simulation software for modeling and simulating protocols, which allows us to analyze computer networks with great depth, power and flexibility. • Use in experiments and research in network labs • Development in order to study security technology and support for cyberspace exercises	• It provides modular simulation for the protocol column and free for scientific research, but is not updated regularly. • Uses in wireless and wired mobile networks, and in particular the simulation of parallel wireless networking	• Integrated protocol module and can be used for both simulations MANET and VANET. • supports remote and concurrent simulations • use any real-life UNIX network configuration and monitoring tools.
features and benefits	• Easy to add new protocols • A large number of available protocols available to the public • Ability to add new protocols and public access to them	• NS3 is not a NS2 extension, a new simulator. • open source • Virtualization support • Ability to add new protocols	• Opnet communicates with other simulators • Motorcycle engine simulator discrete event • Simulated rechargeable wireless support • Integration, debugging and	• Powerful GUI (easier tracking and debugging) • Power consumption calculations • Has a compiler for the NED topology description language • Network graphic editor • Command line interface to run	• Simple and understandable user interface • Learning concepts and not engaging users by choosing unnecessary devices • Implement password recovery • Implement Telnet between	• Quick integration of models developed in different layers • Use in a parallel development environment • Ability to develop • Run by a large set of synchronization protocols	• easy navigation GUI environment. • Realistic network traffic can be generated by realis-tic life applications to generate more realistic simu-lation results • evaluated easily the

[1] High Level Architecture

	• Object design and the ability to create protocols and use them • Features in sensor networks including sensor channels, battery models, low-power protocols • Perform simulations at the closed level, resulting in more precise results	• The software core written in C ++ and the Script interface in the Python language • Attention to realism and the approach of design to real systems • Software integration • Customize the output without rebuilding the network core	GUI-based analysis • Hierarchical Modeling Environment • The fastest discrete event simulator engine among upcoming industrial solutions • A complete library of Opnet models • Grid grid computing support for distributed simulation • Integration, debugging, graphical user interface and analysis	the simulation • Simulation management facilitating tools • Creating an Infrastructure for writing various simulations •	devices • Simple display of routing table • Build and upgrade the lab by the builders • Simulate network traffic using virtual packet technology	• Run in two types of shared or distributed memory systems	performance of any real-life application under various simulated network conditions.
Disadvantages and Limitations	• supports only two MAC wireless protocols, 802.11 and one TDMA protocol • You do not need to get to know writing programming language • Supports two wireless MAC protocols: 802.11 and TDMA • Lack of user-friendly package due to text-based interface • Need advanced skills to do the right simulation • Unavailable customization • Lacks a functional model	• The Python link does not work in Cygwin. • Only IPv4 is supported • Lack of available models • Lacks a graphical interface for creating topology • Has a laboratory-level visibility capability	• A commercial product • Memory consumption models • Minor training • Limit the accuracy of the results to the sampling resolution • Inefficient in the absence of the event for a long time • Missing laboratory guides	• The number of protocols is not large enough. • Compatibility problem (not portable) • OMNeT ++ is a bit slow due to the implementation of long simulation and high memory consumption • Lack of sufficient number of available protocols	• Supports 47 different Cisco devices • Supports 200 devices on network topology	• Limited to IP network due to low level design assumptions • No support for adding new protocols • Limited to package formats and energy models • It provides the Random Waypoint mobility model, which may not be suitable for all types of simula-tions	• Connection through dispatcher with simulation server is not much stable. • The programming is not supported by the NCTUns. So, the parameters are needed to set via GUI. • The manipulation of every node has to be done node by node or all nodes in the same time.

Table 1-2: Comparison of network simulators based on general characteristics of simulators

Features	QualNet	CloudSim	Tossim	J-Sim	REAL	Avrora	Packet tracer
First version	2000	2009	2003	2002	2008	2007	2006
Use license	Commercial (Separate license for academics and others)	open source for Cloud Computing	open source	open source	open source	open source cycle-accurate simulator	open source
Language required (components)	C++	Java	Python, C++, NesC	Java	Scenario (and C) Modulated Structure .NET) Java	Java	Cisco Input / Output Instructions Javascript/CSS
General simulator	✓	for Cloud Computing	Special for WSN	✓	✓	Only for WSN	✓
Availability (accessibility)	Commercial version of the GloMoSim simulator, Excellent	Open source simulator (includes package, class, and example)	Good	Open source software (with available code and examples), moderate	Open source simulator	Open source simulator (online access to documents)	Free and open source software
Easy to use	moderate	hard	very simple	simple	simple	moderate	moderate

Features	QualNet	CloudSim	Tossim	J-Sim	REAL	Avrora	Packet tracer
Guidance and support	• Excellent • Documentation and Standards Library • Certificate of Product Extensibility • Annual support and maintenance contract Access to new releases and software certification	• Have an excellent guide • Access to API1 documents • Source code and examples • Certification access Access to .jar NS-3 NetSim files	• online documents • provides images instead of text commands • compiles TinyOS code directly	• Have a good guide • Public access to the certificate • Source code and examples	• Ability to use new modules • Accessibility from the main server • Excellent guide • Online documents	• Access archive to previous projects • Lacks active support • Access a large amount of information through the help option • Online documents	• In-service tutorials • Public access to the certificate
Learning time	Very simple	simple	very simple	moderate	simple	moderate	moderate
Download and install time	short time	free or open source, available for public download.	Esay	Easy to download and install	Easy as Available Site	Esay	Esay
Support for nodes mobility	✓	-	✓	✓	• Graphical interface written in Java to create faster simulation scenarios	• has a control flow graph for graphical representation of program instructions to understand the structure and understand how the code is compiled.	• Graphical interface with multi-language support, has two logical topologies and physics along with improved multi-user environments
Graphical interface support (Visual / Visibility)	• Excellent • Graphical design of a network model using libraries by the QualNet animator	• itself do not have a graphical user interface, extensions such as CloudReports offer a GUI for CloudSim simulations • Graphical interface for reading network topologies • Have Limited graphical tools (Via CloudAnalyst)	✓	• Good • 2 user graphical interfaces and use Console	✓	No graphical interface	• a built-in GUI interface is supported, with a possibility to trace and store all events. • Different languages supported for the GUI. • User-Friendly Interface
Simulation scale	large	small	small	small	large	Very large	large
Number of nodes supporters	500 to 20000	small	thousands of nodes	Maximum 1000 for a tree	Up to 30000	thousands of nodes up to 10,000 nodes	1000 to 3000
Parallelism	(SMP/Beowulf) ✓	not consider parallel experiments	-	Based on RMI	✓	✓	✓
Supported platforms (platform)	MAC os, Unix, Windows,Linux, Solaris, DOS	LINUX (ubunt), Windows 7	Linux Operating Systems or on Cygwin on Windows	Windows XP, Vista & 7, MAC OS X, Linux Matlab	Unix ,BSD 4.3 ,Solaris ,Ultrix , Free BSD ,Sun OS ,IRIX	Mica2 and Mica Z independent operating systems	Windows) XP، Vista،7 ,(Linux)ubuntu ،fedora(
Analysis tool	✓	✓	✓	✓	✓	✓	Linux ,Windows
Support for network visualization	✓	✓	✓	✓	✓	✓	✓
Possibility to define and change the scenario	✓	✓	difficult	✓	✓	allow users to create a new simulation type and choose the type of simulation to perform, depending on the number and orientation of the nodes	✓
Features	**QualNet**	**CloudSim**	**Tossim**	**J-Sim**	**REAL**	**Avrora**	**Packet tracer**

[1] application programming interface

Features	QualNet	CloudSim	Tossim	J-Sim	REAL	Avrora	Packet tracer
Create a Trace File	✓	✓	configuration difficult to construct	✓	✓	✓	✓
Support for design and implementation protocols (both simulated with wire and wireless)	✓	✓	✓	✓	✓	✓	✓
protocols supported (OSI[1] protocols)	• Has a protocol stack • Routing protocols • Messege protocol and wireless, wired and widespread networks	Open flow	• includes two different models: Radio models for all kinds of transmission aspects and ADC models	• Routing protocols such as RPSG2 and AODV3 • Protocols used in wireless lines and single networks	• Flow control protocols (TCP and…) • Transition layer protocols	• MAC layer protocols in wireless networks	• BGP, EIGRP, EIGRPv6, OSPF, OSPFv6, RIP, RIPng, • DHCP, DHCPv6, FTP, HTTP, HTTPS, RADIUS, POP3, SMTP, SNMP, SSH, Telnet, TACACS. • SCCP, TCP, UDP. • ARP, CAPWAP, HSRP, HSRPv6, ICMP, ICMPv6, IP, IPv6, NDP. • Bluetooth, CDP, CTP, H.323, LACP, LLDP, PAgP, STP, USB, VTP.
Ability to interact with the actual system	✓	✓	configuration difficult to construct	✓	✓	✓	Emulate real network interface
Ability to communicate with other components	✓	✓	capture a wide range of network interactions	✓	✓	✓	✓
Fast simulation	Excellent	Fast (seconds)	good	Poor	good	Very fast performs as much as 20 times faster than most other simulators with equivalent accuracy	Fast
Event type simulation (Simulation Mode)	• Discrete event • Distributed and parallel simulation	Discrete event (Separate event)	Discrete bit-level event	• Varied numerical method • Sync, single-threaded, fully-definite, multi-threaded, based on processes with Real-time, non-deterministic, component-oriented architecture	threading directly and intolerably	Discrete event (Separate event)	• Use the time-out model • Discrete-event
Network Type (Available Module)	Wired / wireless / wireless sensor / ADHOC / MANET / Wired cum Wireless / SDN / VANET	Cloud Computing	Simulation of a TinyOS -based Wireless Sensor Network	Wired and Wireless Sensor Networks	Wired and Wireless Sensor Networks	sensor network simulation communicate via the radio using the software stack provided in TinyOS	.Packet level
purpose of the test (Ease of testing a computer program)	• Network communication testing • Test network connectivity features by users • Design protocols • Creating and mobilizing network scenarios • performance evaluation	• Testing cloud networks due to limited test bed scales • Service testing of user generated networks in a controlled environment • Use of test methods and faults to fix defects Has a library package test • Modeling and simulating infrastructures and cloud computing	• simple and powerful testing for Wire-less Sensor Network • observes interaction difficult to live-capture	• Design, create and test the unit of each component in this simulator • Modeling systems to apply distinct changes in objects • Provide all Java language features • Use in wireless and sensor environments	• Testing scenarios in non-stress conditions • Output scenario testing of this simulator in a large amount of workload	• Test the program before placing on the hardware by the user • Use GDB debugging for development and testing	• Test in the Activity Wizard section of this simulator • Test in the Activity Wizard section of this simulator

[1] Open Systems Interconnection
[2] Greedy Perimeter Stateless Routing
[3] Ad-hoc On-demand Distance Vector

purpose of creating the simulator (Main application cases)	A unique platform for designing new protocols and their performance analysis	• well known simulator for cloud computing • can extended easily but currently it does not consider parallel experiments or lifecycles of VMs.	Provides a simple and powerful simulator for wireless sensor networks	Especially for the components of the public network	Use to study dynamic behavior of flow control and congestion in networks	• Use in wireless sensor networks • can support thousands of nodes simulation • can save much more execution time • Enable validation of time-dependent properties of large-scale networks	• Use CCNA and CCNP training courses to create an unlimited number of network equipment and debug these networks without the use of real switches and routers
features and benefits	• Powerful GUI • It shows great scalability, it's time to simulate logically. • Can support real-time speed to enable loop-free software, network simulation and hard-ware in loop modeling • Designing a new prototype and optimizing the old model • Network Performance Analysis • Features speed, expandability, reliability, portability, expandability • Remove the implementation limit of just one protocol at a time	• Supports modeling and simulation of large-scale cloud computing data centers, energy-conscious computing resources, federal clouds • Support for dynamic insertion, stop and resume simulation • Supports user-defined systems Optimizing the cost of • access to resources focusing on improving profit	• very simple but powerful emulator for WSN • support thousands of nodes simulation (very good feature: because it can more accurately simulate the real-world situation) • Besides network, it can emulate radio models and code executions. This emulator may be provided more precise simulation result at component levels because of compiling directly to native codes	• Supports energy modeling, with the exception of radio power consumption, • Support for mobile wireless networks and sensor networks. • Customer-referenced architecture • Supports energy modeling with the exception of radio power consumption • scalable • Simplified equipment models	• ability to add different modules • Ability to test and configure the simulator as needed • Custom design and production • Uses for analyzing TCP, FIFO, and ... protocols.	• Managing networks with 10,000 nodes (at speeds of around 20 times the speed of other simulators and precision with accuracy) • Validation of independent network time features • A scalable and accurate simulator for hardware platforms in sensor programs • Implementation of sensor network along with precise timing • Ability to connect programs with radio • help flexibility and portability	• Powerful simulation • Interoperability, writing and simulation evaluation • A combination of real simulation and configuration experience • Supports HSRP1
Disadvantages and Limitations	• A commercial product • Hard Install in Linux • Reduce personalization due to some tools	• Limit testing to the test bed scale • Reproduce the problem of results	• Only for applications of TinyOS • not good for the performance metrics of other new protocols. • every node has to run on NesC code, a programming language that is event-driven, component-based and implemented on TinyOS • only for type of homogeneous applications • motes-like nodes are the only thing that TOSSIM can simulate	• Low simulation performance. • Only MAC protocols for 802.11 wireless networks are provided. • Extra cost at runtime • Low performance • Supports a MAC wireless protocol: 802.11 • Unnecessary overhead at runtime	• The limitation of simulation time to cases such as protocols	• Failure to model the Clock output change • Inability to model mobility • is 50% slower than TOSSIM.	• Inappropriate for modeling production networks • Has technical limitations other than Cisco3 • not support modeling

Table 1-3: Comparison of network simulators based on general characteristics of simulators

Features	DRMsim	SSFnet	GrooveNet	Trans	GNS3	JiST	OptSim
First version	2003	2004	2001	2002	2006	2004	2005
Use license	open source	open source	open source	open source	open source	open source	open source
Features	**DRMsim**	**SSFnet**	**GrooveNet**	**Trans**	**GNS3**	**JiST**	**OptSim**
Language required (components)	Java	Java/C++	C++	Java/C++	Dynamics	C/ C++/python/Java	C++ /C

[1] Hot Stand by Routing Protocol

General simulator	Only for WSN	✓	✓	Only for WSN	✓	✓	✓
Availability (accessibility)	good	good	medium	Poor	Open and free simulator	Very good	Business simulator up to 1998 (now free in academic cases)
Easy to use	moderate	Hard	simple	moderate	simple	easy to use	moderate
Guidance and support	• made to compromise on the quality of the code written so that extensibility and reusability are maximized • document availability moderate	• simulate Core Internet protocol models (IP, BGP4, OSPF, TCP, UDP), Sockets and various workload-generating client-server application models and Protocol validation tests using SSFNet.	• a hybrid simulator for geographic routing that address the need for a robust, easy-to-use realistic network and traffic simulation. • is an opportunistic broadcast protocol with minimal hand-shaking between sending and receiving parties with little or no shared state information among neighboring vehicles	document availability poor	• Have an excellent guide • Limited Certification	JiST simulations are written in Java, compiled using a regular Java compiler, and run over a standard, unmodified virtual machine.	• A wide library of models, standard components and parameters accurate
Learning time	good	large	good	low	low	good	low
Support for nodes mobility	✓	✓	✓	✓	-	✓	
Graphical interface support (Visual / Visibility)	• Topology Generators like Brite, Inet, GLP etc. • Import external topologies. E.g. CAIDA maps	• facilitates topological network component addressing and automated IP address allocation (CIDR compliant)	• codedin C++ and Matlab provides GUI for drawing structures and graph. • a cross- platform GUI in Qt	• open source GUI simulation tool • integrates traffic and network simulators (SUMO and ns2) to generate realistic simulations of Vehicular Ad-hoc networks (VANETs)	• Simple and general graphical interface (includes)everything	limited Graphical interface	• Visual simulation of communication systems • Interface with 3D tools, Liekki design software, visual vector analysis • Inner visual connections
Backup the graphical interface	✓	✓	✓	✓	Excellent	✓	provides feedback for efficient simulations.
Simulation scale	large	Very large	large	large	small	Excellent	small
Number of nodes supporters	Up to 10000 nodes	Up to 100000 nodes	-	Up to 3000 nodes	Up to 1000 nodes	large	Up to 1000 nodes
Parallelism	-	✓	✓	-	✓	Java, win, Mac, Linux, Unix	-
Supported platforms (platform)	UNIX,Linux, Mac OS	• Parallel execution under Linux, Solaris, and Windows NT using JDK1.2 and higher. • Other platforms may support parallelism as well.	• Linux Operating Systems with kernel version 2.6 (Ubuntu-12.4 tested and SUSE). • requires Qt 3.x graphic library.	• Linux, Windows (trace-generation mode)	• Router platforms for Cisco and Linux, Windows and Mac	• Linux, Android 4.1+, iOS 8+ and Microsoft Windows.	• Windows ,Unix ,Linux
Analysis tool	✓	✓	✓	✓	✓	✓	✓
Support for network visualization	✓	✓	✓	✓	✓	✓	✓
Features	**DRMsim**	**SSFnet**	**GrooveNet**	**Trans**	**GNS3**	**JiST**	**OptSim**
Possibility to define and change the scenario	✓	✓	✓	✓	✓	✓	✓

Create a Trace File	• compromise on the quality of the code written so that extensibil-ity and reusability are maximized.	✓	✓	• Mobility trace generation for ns2 from TIGER and Shape file maps (using the net convert tool from SUMO).	✓	✓	✓
protocols supported (OSI[1] protocols)	• Network and Data Link Layer • RIP, BGP and NSR • Supports high end routing protocols like BGP, DSDV up to 16000 nodes.	• with various highly scalable Internet protocols like IP, TCP, UDP, BGP, OSPF etc. and large network elements like Routers, Switches, Links, LAN's etc	• support three types of simulated nodes: - vehicles which are capable of multi-hopping data over one or more DSRC channels - fixed infrastructure nodes - mobile gateways capable of vehicle-to-vehicle and vehicle-to-infrastructure communication.	• Physical, Network and Data link Layer Support	OSPF[2], Ethernet and STP[3] protocols	used to implement IEEE 802.15.4 MAC-layer protocol	• Random or fixed access protocols • Reservation protocols • High-speed communication protocols • MAC protocol TCP / IP (most of the transmission and network protocol protocols
Ability to interact with the actual system	✓	✓	✓	✓	✓	✓	✓
Ability to communicate with other components	✓	●SSFNet models provide components for simulating networks at IP level and above and include models for hosts, router, links and a framework for modeling protocols.	✓	✓	✓	✓	✓
Fast simulation	Fast	good	moderate	good	Fast	moderate	Fast
Event type simulation (Simulation Mode	Discrete event	Discrete event	Hybrid simulator	Discrete event	Discrete event	discrete event	Separating the domain time and frequency range
Available module	Simulate dynamic path model	Modeling and simulating Internet and network protocols	Realistic simulation	Vehicle Adhoc Networks (VANETs)	• a discrete-event network simulator for Internet systems • targeted primarily for research • educational use	discrete event simulators, called virtual machine-based simulation	especially designed to be used in Monte Carlo simulation and Project Portfolio applications.
purpose of the test (Ease of testing a computer program)	• careful analysis of the data structures in the network model • as well as on the granularity and time management of the simulation model	• simulated Protocol validation tests using SSFNet.	• support multiple network interfaces for real vehicle-to-vehicle and vehicle-to-infrastructure communication:5.9GHz DSRC, IEEE 802.11a/b/g, 1xRTT and EVDO cellular interfaces. • Communication over TCP or UDP sockets. • All real vehicles communicate with DSRC or 802.11 with each other • mobile gateways communicate with infrastructure nodes over the cellular interface	• has two distinct modes of operation: - network centric - application centric	• Virtual network testing • functions exactly similar to the Cisco packet Tracer software.	• 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.	• Laboratory testing of equipment such as agile Test component features such as L-I curves for laser models and so on

[1] Open Systems Interconnection
[2] Open Shortest Path First
[3] Spanning Tree Protocol

purpose of creating the simulator (Main application cases)	• Quick simulation of routing schemes in a wide dynamic network • study focusing on dynamic compact routi • evaluate the main performance metrics of routing schemes especially, the metrics related to the scalability and dynamic properties of these schemes (main goal)	• Unique to increase scalability of modeling, traffic patterns, bandwidth and so on • basically, designed for simulating various network scenarios like network topology, protocols and traffic and also enables simulation of Wide Area Network like Internet.	• Unique for its capacity to analyze performance and scalability of communication protocols between vehicles • capable of communication between simulated vehicles, real vehicles and between real and simulated vehicles. • Supports communication between real and simulated vehicles such that vehicles in the vicinity of each other are able to exchange packets	• Provides the TraCI interface for generating range by connecting SUMO and ns2 with Google Earth • Realistic Joint Traffic and Network Simulator for • VANETs	• A tool for configuring and checking the network to participate in Cisco Exams • a discrete-event network simulator for Internet systems • targeted primarily for research • educational use	• The JiST approach is inherently flexible, capable of transparently performing important cross-cutting program transformations and optimizations. • This transparency is a key benefit: simulation code that runs on JiST need not be written in a domain-specific language invented specifically for writing simulations, nor need it be littered with special-purpose system calls and call-backs to support runtime simulation functionality	Visual simulation of communication systems at the signal emission level
features and benefits	• DRMsim is dedicated for a routing model simulation. • efficient graph structures and algorithms. • capability to import external topologies (e.g., CAIDA maps). • "100% pure Java" application which makes it executable on most platforms. • free of cost for research purposes.	• Scalable high-performance Java simulation platform • simple, standardized syntax for high-level model description DML. • Allow Management of global traffic patterns • Support high performance network simulation • free or available at nominal cost for research purposes.	• able to support hybrid simulation. • Support multiple vehicles, trip and mobility models over a variety of network link and physical layer models. • provide well-defined model interfaces that make easy to add different network models. • implement multiple rebroadcast policies to investigate the broadcast storm problem. • The well-defined graphical user interface makes it easy to auto-generate simulations	• facilitate automated generation of random vehicle routes. • Map cropping and speed rescaling (only for TIGER maps) • Google Earth visualization of simulations (only for TIGER maps) • Provide TraCI interface for mobility trace generation by coupling SUMO and ns2.	• An excellent complementary tool for networking • High-quality design of complex network topologies • Real-time simulated virtual network communication Receive packets using the wireshark protocol	• The JiST approach is inherently flexible, capable of transparently performing important cross-cutting program transformations and optimizations.	• Has a virtual lab with over 600 components and fiber • Quick learning curve • Has several implementation engines including both time domain and frequency separation cases • Has MATLAB interfaces, functional programming and ... Luna Optical Vector Analyzer
Disadvantages and Limitations	• only the routing protocol can be simulated • does not make use of parallel/distributed discrete-event simulation techniques. It optionally relies on distribution for the parallel execution of simulation batches. • packaged to be used on a machine must have at least 4G of memory. If memory isinsufficient, the performance of the software may decrease or may corrupt the simulation process	• convergence may occur in presence of long-range correlated traffic. • Understanding of scaling conditions: some emergent phenomena can be seen in sufficiently large networks, with sufficiently many traffic flows. • Need to understand relations between different abstraction levels. • Need to predict internet behavior under alternative-futures scenarios.	• As GrooveNet is Open Source, every online document and online support is not available all the time	• The development of TraNS is suspended. Hence, TraNS does not support the latest version of both Sumo and ns2. • Although free version of this type is available, no proper documentation is available for TraNs simulator.	• Requires Cisco Input / Output images Change the required CPU resources dynamically • not support various protocols such as Border gateway protocol and Multi-Protocol Label Switching (MPLS)	• not simulate all services and functions like tunneling •	• Limit on the Demo of this simulator, such as the failure to modify Schematic simulations, the failure to create individual simulator schematics, the lack of storage of graphical objects, the absence of user-defined models or model details

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