

# Computer Network Simulators for Education Purpose

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**Abstract**— Networking subjects are specialized in many universities. Learning network is very difficult that mix with different applications, routing algorithm through different communication protocols. It is very difficult to establish a network scenario in real time. It also takes a huge amount of network connection time and network development cost. Network simulation tools can help the network developer to test whether the computer network can be work well in real time. In this paper, we describe about network simulation tools that are useful in education area. These simulation tools can not only improve the student's practical skill in networking but also help students to understand network communication mechanism.

**Keywords**— network simulation, education

## I. INTRODUCTION

Teaching networking course is very challenging in real time. Most of the universities delivered networking course to teach students in basic networking concepts. With the help of network, simulation tools, students can not only have to get knowledge about network connection but also have experience in practical includes configuring and managing different network communication scenarios [1].

With the use of networking technology, network system becomes more complex with various different types of network protocols and different network devices such as routers, switch, etc. Networking courses based on networking simulation tools can give the effective and efficient way in cost and time consuming.

Network simulation is very useful in learning networking course and useful methodology to develop various network topologies in real world implementation. In network communication, network simulation tools used in different areas such as research areas, industrial development, education, analyzing different network topologies, design networks, network simulation and measure the performance of different network architectures. Among these areas, we describe different network simulators such as NS2, NS3, OPNET, JSIM, TCP/ IP Network Simulator, Delite and NVLab in education area and its useful features.

The rest of the paper is described in sections as follows: Section 2 presents problems in teaching networking subjects and Section 3 describes different network simulators.

## II. PROBLEMS IN TEACHING NETWORKING SUBJECTS

In teaching networking subjects in universities, there are many challenges of technical complexities in computer network, data transmission processing and protocols [2]. It is needed for students to have comprehensive in learning network communication mechanism and their practical skills with exercises to understand the huge numbers of theoretical

details in network layers, different protocols and network configuration [3]. The traditional learning methods is inadequate to motivate for students in teaching network education [4]. In teaching computer network subjects, the major challenges are difficult to learn the complex network theory and to make visualization various networks protocols and functions that are used in data communication [5]. Students also need to have developed skills in network troubleshooting and determine the cause of problem between computer networks [6].

## III. NETWORK SIMULATION TOOLS

### A. NS2

Network Simulator2 (NS2) is a discrete event driven simulator and an open-source developed by UC Berkeley and designed especially for computer communication networks. It is used to simulate different network topologies with different network protocols. It provides considerable supports to make simulation of TCP, UDP, FTP, CBR, and VBR, HTTPs, router queues handling mechanism such as RED, and CBQ, Drop Tail, routing algorithms, and many more [7]. It can also simulate both wired and wireless networks. It is primary Unix based and use TCL as scripting language. It supports an object-oriented dialect of TCL.

The simulator includes two main programming languages: C++ and Otcl (Object-oriented Tool Command Language). With the backend of the network simulation is defined by C++, Otcl makes the simulation by configuring and collecting the objects as well as scheduling discrete events. The C++ and Otcl are linked and working together using Tcl. The basic architecture of NS2 is shown in fig.1.

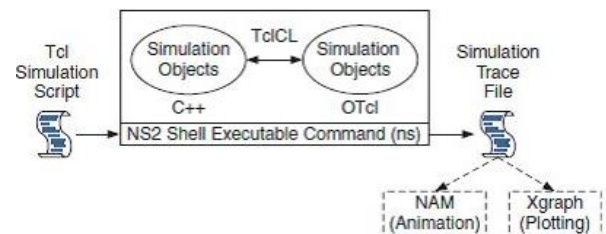


Fig. 1. Basic architecture of NS2

The purpose of NS2 is to support research in networking and education and it is also suitable for creating new protocols, comparing different protocols and traffic evaluations. It is developed as a collaborative environment.

## B. NS3

Network Simulator3 (NS3) is a discrete-event network simulator and open-source for internet systems. NS3 project started in 2006. It is free software, licensed for the GNU that is granted by GPL v2 license. NS3 is developed by C++ and support scripting and visualization by python. While NS2 requires basic manual C++ function, NS3 support all normal C++ functions. The performance of NS3 is better than NS2. In NS3, some modules are ported from NS2 [7].

Because NS3's interface is written in Python and its core is written in C++, some advanced C++ design patterns are also implemented in NS3. Other tools that can be used to analyze traces are generated, such PCAP packet trace files. Additionally, users can use the C++ or Python programming languages to create a network program to develop a simulator. The network protocol elements are made to resemble actual computer networks more closely. Additionally, it encourages the integration of open source networking software and lessens the need to rebuild simulation models.

## C. OPNET

The OPNET simulator is a tool for simulating the performance and behavior of various network types. It runs simulation at the packet level and offers a broad development environment to facilitate the creation of distributed systems and network communication. Systems performance and behavior can be examined using discrete event simulations [8,9]. The main difference between other simulators are powerful and versatility. OPNET is a better platform and it can help to integrate a communication node with a separated access broadband model. To create and test an analytic and practical video, voice and Internet model, OPNET can provide a platform. It can also provide the ability to integrate the model into a different environment. Fig. 2 provides basic structure of OPNET.

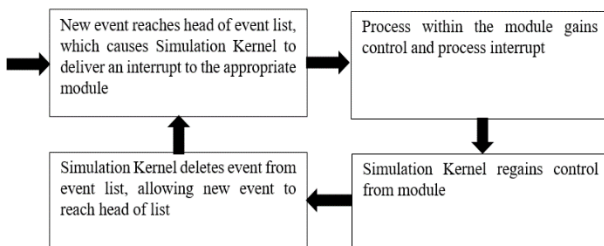


Fig. 2. Basic structure of OPNET

## D. JSIM

It is a module-based coordinated simulation that is based on the Autonomous Component Architecture (ACA). The essentials of ACA are components that are connected with each other in sending and receiving data packet by the use of their ports. The behavior of the components are defined at design phase in contracts including binding actually that will be together linked at system integration time [8].

The architecture of the modules in JSIM allows the user for designing, implementing and testing components individually. The new modules can be extended or exchanged easily instead of existing ones. On top of ACA, Internetworking Simulation Platform (INET), a generalized packet network model is developed. JSIM is implemented by Java programming language and the module-based

architectures makes JSIM a platform independently, reusable and extensible simulation environment. It is developed by a scripting interface that enables using the script of languages such as Python, Perl and Tcl.

Because the components are only loosely connected at integration time, they can handle data handling in independent execution. A component's ability to be reused in different systems with the same context is the main justification. Additionally, a dynamic thread execution framework for creating real-time simulations is provided. It enables online monitoring and auto-configuration for dual-language environments. This has a tight connection to the IC testing and debugging procedure [10].

JSIM includes a library of java classes that can be used to modify the simulator to simulate other types of queuing systems as well. Therefore, it can be used as a starting point to develop larger simulator. It also can help students and educators to explain and understand the basic theory of the system.

## E. TCP/IP Network Simulator

It is a web-based simulation and visualization tool for computer network. Simulator is implemented in Java programming language. The simulator enables process visualization and simulation in computer networks with arbitrary topology. It was supported by the Serbian Ministry of Education and Science (project III44006) [11].

As a component of the computer network education system, the simulator's goal is to assist students in understanding the fundamental operating principles of one TCP/IP computer network. Since users cannot comprehend what occurs in a computer network, data transfers between network devices are complicated and completed in incredibly little time intervals. The simulation process is visualized in this simulator.

The simulator is designed using modular building blocks: the GUI (Graphical User Interface), Control modules, Manager and network elements. These blocks interact with each other as shown in fig. 3.

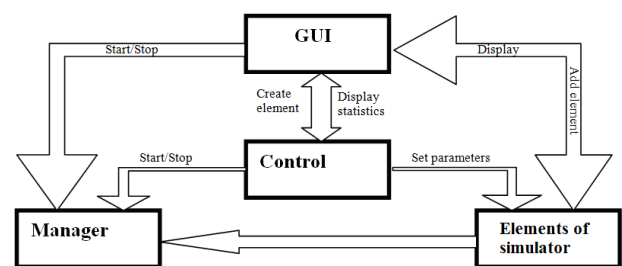


Fig. 3. Modular building blocks

The simulator enables to edit computer network arbitrary topology and process tracking in network in real time.

Operation in computer network education environment can be divided into three parts:

- Modifying computer network using available components.
- Specifying basic parameters to get desired processes such as naming, defining IP addresses, router configuration.

- Processing tracking in simulation within visual presentation of frame motion through network facilities and transmission paths.

#### F. Delite

Delite tool [12] is a wide area network (WAN) design tool that are useful for education and practical works. It can develop computer network design with limited size and use network design algorithms that are embedded in a set. In network design, the data are needed to read from formatted files. This tool delivers visual displays that represents network nodes and their links for analyzing data that may be delay analysis and a reliability analysis for special windows. The file used as input may contains the data for designing network such as node coordinates, traffic parameters and link parameters as equipment specifications and cost.

The simulation tool provides network learner with user-friendly interface and uses 1000x1000-unit window for displaying the network model in a square on the screen. It has a unique type of window called “Delite Monitor” in receiving user responses and to analyze the network model output. The tool is very useful in research area and network designer to implement network design process and to develop network algorithm. The simulation tools and the use of designing network model are very important for processing the network design, deployment, testing and an evaluation of network communication. Tools are integrated in parts to cover planning network design. Network learners can analyze the output used by these tools, compare with different network design and select the greatest design depends on the predefined criteria.

#### G. NVLab

The virtualized environment NVLab [13] is a web-based environment that provides tools to construct small-scale computer network designs, create networks that are begun by one VM for each router and PC, and configure the many VMs with connections to the machines hosting them. NV structure is shown in fig.4.

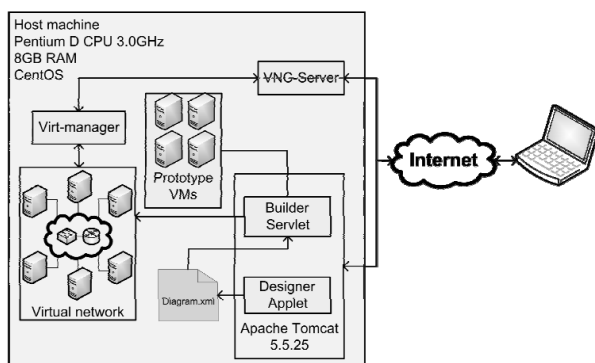


Fig. 4. NVLab structure

Virtualization and VNC are the main technologies employed in the construction of NVLab. Multiple virtual machines (VMs) can be created on a single server thanks to virtualization, and VNC defines remote access to the server for setting up and testing virtual machines. Two new learning resources, such as Designer and Builder, are introduced in the lab. To create a network drawing and transfer data as an XML document to be saved on the server side, use Designer. They will next invoke the Builder, which is in charge of producing

Virtual Machines that correspond to those found in the XML document. Next, students launch virt-manager, a program that allows them to operate the virtual machines, configure their networks, and test them using VNC, which is installed on the host computer.

In response to a request, a group of students with varying degrees of networking experience attempted a sample exercise to learn about IP subnetting, connectivity testing, and fundamental routing from a distance.

All participants in this simulation system successfully finish the exercise and receive feedback on their work designs. According to the feedback, notes on the laboratory interface will be taken into account for use in future iterations of the laboratory system.

#### IV. CONCLUSION

In teaching networking course, it is very difficult to establish network visualization in real time. Students also has many challenges to understand network communication. In this paper, we describe different network simulators that are suitable in education including NS2, NS3, OPNET, JSIM, TCP/IP Network Simulator, Delite and NVLab. All simulators allow for the modification of network situations and provide network visualization tools. Even though, our study will useful in teaching networking courses to understand network communications.

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