The NCTUNS 1.0 Network Simulator

S.Y. Wang
Department of Computer Science and Information Engineering
National Chiao Tung University, Hsinchu, Taiwan
+886 3 5131550, email: shieyuan@csie.nctu.edu.tw

ABSTRACT

This paper presents the NCTUNS 1.0 network simulator, which is a high-fidelity and extensible network simulator capable of simulating both wired and wireless mobile IP networks. After two years’ developments, the NCTUNS 1.0 now is in a state ready for release to the public and we have set up a web site at http://NSL.csie.nctu.edu.tw/nctuns.html for people to download this software. In this paper, we will present the high level architecture of the NCTUNS 1.0 as well as many of its useful features.

INTRODUCTION

The NCTUNS 1.0 is a high fidelity and extensible network simulator capable of simulating various protocols used in both wired and wireless IP networks. Its core technology is based on the novel methodology invented by S.Y. Wang [1, 2] when he was pursuing his Ph.D. degree at Harvard University. Due to this novel methodology, NCTUNS 1.0 provides many unique advantages that cannot be achieved by traditional network simulators such as ns-2 [3] and OPNET [4].

After obtaining his Ph.D. degree from Harvard University in September 1999, S.Y. Wang returned to Taiwan and became an assistant professor in the department of Computer Science and Information Engineering, National Chiao Tung University (NCTU), Taiwan, where he founded his Network and System Laboratory (NSL). Since that time, Prof. S.Y. Wang has been leading his students in the NSL to design and implement the NCTUNS 1.0 (the NCTU Network Simulator 1.0) for more than two years. Fig.1 shows the starting screen of the NCTUNS 1.0.

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SIMULATOR FEATURES

The NCTU 1.0 is a whole new design and implementation. It has many useful features listed as follows:

- It can simulate both wired networks with fixed nodes and point-to-point links and wireless networks with mobile nodes and IEEE 802.11 (b) wireless network interfaces.
- It can simulate various networking devices such as Ethernet hubs, switches, routers, hosts, IEEE 802.11 wireless access points, etc.
- It can simulate various protocols such as IEEE 802.3 CSMA/CD MAC, IEEE 802.11 CSMA/CA MAC, learning bridge, spanning tree, IP, RIP, OSPF, UDP, TCP, HTTP, FTP, Telnet, etc.
- All real-life existing or to-be-developed UNIX application programs can be run on a simulated network to generate network traffic.
- All real-life existing UNIX network configuration tools (e.g., route, ifconfig, netstat) or performance monitoring tools (e.g., tcpdump, traceroute) can be run on a simulated network to configure or monitor the simulated network.
- It has an integrated and professional GUI
environment for (1) drawing network topologies, (2) configuring the protocol modules used inside a node, (3) specifying the moving paths of mobile nodes, (4) plotting network performance graphs, (5) playing back the animation of a logged packet trace, and more.

- Its simulation engine architecture is an open-system architecture. By using a set of module APIs that are provided by the simulation engine, a protocol module developer can easily implement his or her protocol and integrate it into the simulation engine.

- Its operating architecture is a distributed architecture. The GUI environment and simulation engine are separately implemented and use the client-server paradigm to communicate. Therefore, a remote user using the GUI environment can remotely submit his or her simulation job to a server running the simulation engine. The server will run the submitted simulation job and later return the results back to the remote GUI environment for analyses. This scheme can easily support the server farm model in which multiple simulation jobs can be performed in parallel on different server machines.

**SIMULATOR ARCHITECTURE**

Using a distributed architecture, the NCTUNS 1.0 has five separate components.

1. The first component is the GUI program by which a user can edit a network topology, configure the protocol modules used inside a network node, specify mobile nodes' moving paths, plot performance graphs, play back the animation of packet transfers, etc.

2. The second component is the simulation engine that provides useful simulation services to simulation modules.

3. The third component is various simulation modules that perform specific protocols. (A simulation server is composed of the second and third components. It executes the simulation job submitted by a GUI user.)

4. The fourth component is the simulation job dispatcher that can manage and use multiple simulation servers at the same time to increase simulation throughput.

5. The fifth component is the kernel source patches that need to be made to the kernel of the UNIX machine so that a simulation server can run on it.

**SIMULATOR OPERATING MODES**

Due to its architecture, the NCTUNS 1.0 can be operated and used in two different modes.

1. In the first mode, called the “single machine mode,” the five components of the NCTUNS 1.0 are installed and run on a single machine. A user who has only one PC may prefer this mode.

2. In the second mode, called the “multiple machine mode,” the GUI can be installed and run on multiple machines, the simulation server and the kernel patches can be installed and run on multiple machines, and the dispatcher can be installed and run on a separate machine. A user who has many PCs and wants to run multiple simulations concurrently to increase simulation throughput may prefer this mode. This mode is also suitable for a simulation service center that may have many simulation servers servicing simulation jobs submitted from many remote GUI users.

**SIMULATOR SCREEN SHOTS**

The NCTUNS 1.0 has an integrated and professional GUI environment for various purposes. In the following, we will present some of them.

Fig. 2 shows the topology editor of the NCTUNS 1.0. The topology editor provides a convenient and intuitive way to graphically construct a network topology. A constructed network can be a fixed wired network or a mobile wireless network. Due to a user-friendly design, all GUI operations can be done easily and intuitively.

Fig. 3 shows the performance monitor of the NCTUNS 1.0. The performance monitor can easily and graphically generate and display the plots of
some monitored performance metrics such as a link’s utilization or a TCP connection’s achieved throughput.

Fig. 3. The performance monitor of the NCTUNS 1.0.

Fig. 4 shows the node editor of the NCTUNS 1.0. The node editor provides a convenient environment to flexibly configure the simulation modules used inside a network node. By using this tool, a user can easily add, delete, or replace a module with his/her own module to test the performance of a new protocol.

Fig. 4. The node editor of the NCTUNS 1.0.

Fig. 5 shows the packet animation player of the NCTUNS 1.0. By using the packet animation player, a logged packet transfer trace can be replayed at any speed. Both wired and wireless networks are supported. This capability is very useful because it can help a researcher to visually debug and test the behaviors of a protocol. It is also very useful in education.

Fig. 5. The packet animation player of the NCTUNS 1.0.

CONCLUDING REMARKS

After two years’ developments, the NCTUNS 1.0 now is in a state ready for release to the public. To promote its uses, we have set up a web site at http://NSL.csie.nctu.edu.tw/nctuns.html for people to download this software package. A GUI user manual and a module developer manual are also provided for people to easily operate and use the NCTUNS 1.0. At the NSL, a simulation service center is set up for people to submit and run their simulation jobs at the NSL. More information about these details can be found at the above web site.

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