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# Construction and application of multi technology fusion network experimental environment

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***Abstract:*** **Aiming at the problems of single technology and small sets of equipment in network engineering specialty experiment teaching environment, eNSP network simulator, GNS3 network simulator, VirtualBOX virtual machine technology and traditional laboratory network environment which support different network technologies were researched. According to the analysis of interconnection capacity between every part and specific interconnection technology, the construction ideas and methods which supported the multi technology fusion network experimental environment such as Huawei network, Cisco network, Ruijie networks were obtained. These ideas and methods were applied in the practical course teaching of network engineering, and the effect was good.**

***Keywords:*** Network engineering; eNSP simulator; GNS3 similator; Experimental environment; VirtualBOX technology

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## 1. Introduction

In recent years, the professional experiment teaching condition and practice teaching environment of network engineering major has been greatly improved with the improvement of university network engineering specialty schooling ability. Especially the introduction and application of virtual network experiment technology do not only relieve the problem of small sets of network laboratory equipment [1], and also provide the transportable portable network experimental environment for teachers and students [2]. However, real network equipments of laboratory are usually the same brand due to the requirement of equipment management and maintenance, even if the network simulator is used, experimental teaching of network engineering mainly take a single network equipment, resulted in the problem of single experiment technology of network engineering and the solely experimental teaching content due to limitation of the curriculum content. Therefore the heterogeneous network design of multi brand equipment interconnection can't be carried out, and the selected space of different network technology can't be provided to the students.

This paper took the construction of a university network engineering laboratory as an example, a multi technology integration network experimental environment based on a high performance host was proposed. The virtual networks with different technologies were constructed by bridging GNS3 and eNSP through the loopback interface, and the virtual network and real network were connected through the network card and bidirectional routing of host. The heterogeneous OS network service platform was constructed by virtual machine platform, so as to construct a multi technology fusion network experimental environment which fused Huawei, Ruijie and Cisco network technology and included heterogeneous system network service. This network environment could provide practical training conditions for different brands and technology, and the virtual reality network can be connected to each other in it. Therefore, the multi technology integration network experimental environment can effectively solve the comprehensive training problems of computer network curriculum design in network engineering major, so as to provide training platform of different network technology for students and explore a new way for the construction of network engineering professional laboratory.

## 2. Technical content of multi technology fusion network experimental environment

The multi technology fusion network experimental environment was constructed on the basis of original network experimental environment and involved the technical content of network simulator, virtual machine platform and virtual network interface technology. The key of fusion technology was support ability of interconnection and interworking among different network simulator, different OS virtual machine and real network.

### *2.1. eNSP network simulator technology*

ENSP is a network simulator which take Huawei network equipment as the simulation object [3], embedded the system kernel of Huawei network equipment. It mainly includes AR series router, S series switch, wireless network equipment, firewall, various terminal equipments (PC, MCS, Client, Server, STA, Cell-phone) and so on. It integrates VirtualBOX virtual machine [4], Winpcap, Wireshark and other software and provides equipment connection, device configuration and network function simulation ability of Huawei network. Cloud node provides a powerful network connectivity and connect the virtual network, real network, loopback interface, various virtual machines, etc.



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According to the technical information of Huawei Company, each network device of eNSP simulator is realized through cloning VirtualBOX virtual machine. The virtual network of more than 24 equipments in eNSP environment can run smoothly in 4GB memory support, and the resource requirement of a virtual device memory is about 300MB, and thus each additional 1GB memory can provide 3 ~ 4 more virtual network equipment support ability.

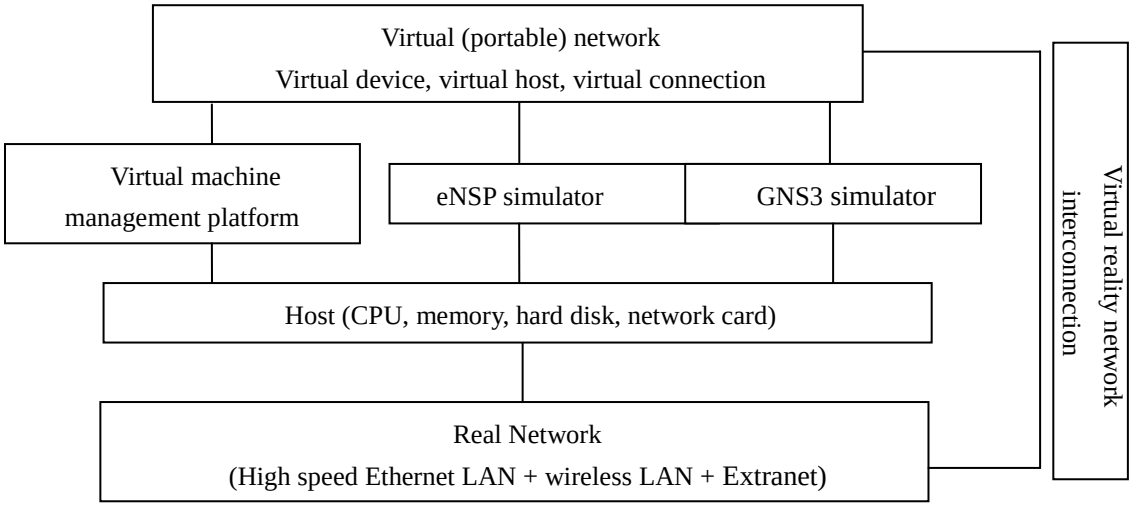


**Figure 1. Schematic diagram of logical structure of integrated network experimental environment.**

### *2.2. GNS3 network simulator technology*

GNS3 is a network simulator which takes Cisco network equipment as the simulation object [5], and it integrates Winpcap, VPCS, Dynamips, Qemu virtual machine [6], VirtualBOX virtual machine, Wireshark and other software. GNS3 can not only load with a different series of Cisco router IOS, and it can also load with PIX firewall, ASA firewall, Juniper router and IOS of IDS and IPS, providing equipment configuration and function simulation ability to Cisco network technology. Especially to cloud node type, GNS3 possesses six different types of network connections, and it can connect VPCS virtual machine, Qemu virtual machine, VirtualBOX virtual machine, VMware virtual machine and host running GNS3, resulting in providing a connectivity with virtual network and real network.

According to the system design of GNS3, within 10 virtual networks consisted of simple network device in GNS3 environment can run smoothly in 4GB memory support. The IOS memory resource of ordinary Cisco router requires 128MB to 256MB, and each additional 1GB of memory can provide 4 ~ 5 more virtual network equipment support ability. Complex devices require more memory resources.

### *2.3. Virtual machine and its network connection technology*

Virtual machine technology is introduced in the network experiment environment, and it can not only construct complex network application service in network simulation, but it can also provide web services for real network under heterogeneous network hosts and heterogeneous platform. This greatly enhances the comprehensive and authentic of network experiment. Whether it is eNSP or GNS3 network simulator, it supports the connection with the virtual machine, which commonly used Oracle VM VirtualBOX and VMware Workstation.

VirtualBox is a free virtual machine platform released by Oracle Company, which can virtualize each series of virtual machine of 32/64 bit, and it has simple and easy to use features. From the networking capability, VirtualBOX virtual machine can provide six different networking modes [7]. NAT mode is the simplest mode which can realize the connection between virtual machine and real network provided by VirtualBOX virtual machine platform, and it can access the Internet without special configuration. It can provide surfing Web page, downloading files and checking e-mail and so on. Bridged Adapter mode can virtual an independent network card and configurate independent IP address possessed the same subnet with the host, resulting in forming the virtual machine which has the same network status with the host. This seems that a virtual machine directly connected to the physical network through the cable, and it can be used as a web server and access each other, resulting in realizing transfer and sharing file. This means that routing can be set between the virtual machine and the network. When this mode is enabled, the connection between VirtualBox virtual machine and the physical network card of host is established, and the network data packet is directly forwarded through the filtering of VirtualBOX bridge driver. Internal model is a kind of network simulated by software, and the virtual machine can be networked with each other, but the virtual machine can't network with the outside or the real host, and this mode seems that an independent Local Area Network is erected between the virtual



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machines. This mode is more suitable for the connection of virtual network constructed by eNSP and GNS3. Host-only Adapter mode can be used to create a network which can connect real host and a set of virtual machines, and the mode needn't use the physical network interface of real host, but set up a virtual network interface in a real host, resulting in a network connection between the virtual host and real host. Universal drive mode achieves the interconnection capacity between two virtual machines in different host through the "UDPTunnel".

## 3. Construction of multi technology fusion network experimental environment

As shown in Figure 1, the multi technology fusion network experimental environment is composed of real network, host, virtual machine platform, network simulator, virtual network. The host provides the ability to run support of virtual machine, network simulator and the virtual network installation environment. Virtual network and real network realize interconnection through different connection types. To facilitate the transfer and operation of virtual network, we must formulate the parameter specifications of the virtual machine configuration and network simulator operating environment to make personal PC of students and teachers establish the same virtual network environment with laboratory host, thus providing support for the migration and operation between virtual network laboratory, students' PC and teachers' PC.

### *3.1. Real network specification and host upgrade*

The real network is a typical fast dual access network composed of high speed Ethernet LAN and Wireless LAN, and the network bandwidth of the switchboard to the desktop is 100/1000Mbps adaptive. It is composed of 15 groups of network devices and it is connected by the aggregation switchboard and campus network. Each set of equipment including two Ruijie routers, a Ruijie two-layer switchboard, a Ruijie three-layer switchboard and four Lenovo host. In order to achieve the purpose of multi technology fusion, at first the structure, wiring and connection identification of the real network need to be standardized so that the students quickly build a new network topology in the experiment to complete the network connection. Secondly, the overall performance of the host is replaced or upgraded, mainly CPU speed and memory capacity, in order to provide a better virtual network support capabilities. Referring to the requirements of the memory resources of the virtual network devices in different network simulators and combining with the basic requirements of the small and medium-sized network design, the host memory is proposed to extend to 8 ~ 16 GB to ensure the smooth operation of the virtual network.

### *3.2 Construction of standardized virtual network environment*

As shown in Figure 1, the virtual network environment mainly includes the configuration parameters of the eNSP and GNS3 network simulators, and table 1 shows the main configuration parameters of GNS3 network simulator. Specification of these parameters is the key whether GNS3 virtual network can copy, migrate, edit and run. If students, teachers and laboratory all use the same parameter configuration, the virtual network can smoothly transfer and run among them [8].

**Table 1. Recommended configuration of GNS3 operating environment parameters**

| Operating parameters | Recommended configuration |
|---|---|
| GNS3 install directory | C:\Program Files\GNS3\gns3.exe |
| OS Image Directory | C:\Program Files\GNS3\IOS-Images |
| Project Directory | D:\GNS3\Project |
| working directory for dynamips<br>working directory for Capture files<br>Qemuwrapper working directory<br>vboxwrapper working directory | D:\GNS3\temp |

Compared with the operating environment of the GNS3 simulator, the running environment of eNSP is relatively simple. It only needs to specify the location of the virtual network (topology file), and the others can use the default configuration.

### *3.3. Establishment of the virtual machine with standard configuration*

Virtual machines provide the testing and simulation capabilities of virtual network connectivity, network client and network application services, and it can be used to construct simple virtual machine, low configuration virtual machine and high configuration virtual machine according to the different requirement. Simple virtual machine only completes network connectivity testing and it works in the network layer. VPCS acts as Simple virtual machine in GNS3 and CLIENT device in eNSP. Both low and high configuration virtual machines need to create and configure through VirtualBOX virtual machine manager and unified installation in the students, teachers and laboratory host environment. To facilitate the migration operation of experiment teaching and virtual network, the corresponding parameters must be regulated when establishing and configuring the virtual machine. The students, teachers, laboratory managers must create the virtual machine according to the teaching requirements and identify the virtual machine



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and name the virtual machine file strictly according to the prescribed parameters. The standardization of virtual machine configuration creates condition for "carrying" and migrating virtual network.

## 4. Teaching application of multi technology fusion network experimental environment

Based on the experimental environment shown in Figure 1, we can use Ruijie network equipment and technology to build Ruijie networks through real network environment, resulting in training Ruijie network technology personnel. A virtual Cisco network can be built by the Cisco network equipment and technology through the GNS3 network simulator, so as to realize experiment and training of Cisco network technology. A virtual Huawei network can be built by the Huawei network equipment and technology through the eNSP network simulator, so as to realize experiment and training of Huawei network technology. More importantly, the experimental environment can integrate multi brand network technology, to achieve multi technology network interconnection. According to the above technological analysis, the interconnection of the virtual machine and "Ruijie network" can be realized through "Bridged Adapter mode"; the interconnection of eNSP and GNS3 virtual network and the real network can be realized through sharing links to Internet host network card in Microsoft ICS; a virtual interface is created by adding "Microsoft Loopback Adapter" in the host, and "cloud" equipments were added in eNSP and GNS3 network simulator, respectively, and cloud equipment was connected with the created virtual interface, thus to realize the interconnection of "Huawei network" and "Cisco network" after configuration parameters.

## 5. Concluding remarks

The multi technology fusion network experimental environment proposed in this paper is virtual network experiment environment which takes the virtual machine, eNSP network simulator, GNS3 network simulator as the subject in high-performance host. It is integrated with the traditional network laboratory teaching environment, and provides the experiment training platform of several mainstream network configuration technology for such as Huawei, Cisco, Ruijie, etc. It effectively solves the problem of single technology of network engineering experiment environment, and it also provides technology choice to adapt to the needs of different enterprises for students. The experimental teaching application results showed that the experimental environment is conducive to the various experiments of enterprise network design in network engineering professional teaching, and be also beneficial to the design and test of the heterogeneous network. Therefore, the experimental environment greatly increases the students' practical training opportunities and stimulates the students' interest to find the problem and solve the problem. These would improve the teaching quality of network engineering major, and it have important value in training network engineering professionals adapting to the needs of enterprise.

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