

Construction of Cisco Virtual Lab Platform*

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Abstract

In experiment of network engineering and network construction, students are required to configure Cisco network equipment. Due to limit of lab environment, amount of equipment is not enough and some experiments require much more expensive and higher level equipment that are not practical to purchase and maintain. It is meaningful to use network equipment simulator on PCs. The proposed platform utilizes Dynamips simulator to simulate routers and switches of Cisco product series. Dynamips supports directly loading Cisco IOS images and provides configuration interface as true equipment's. It has very good teaching effect in experiment of network engineering. And success of the proposed platform shows it can be used in other network related courses.

Index Terms: Cisco network equipment; virtual lab; Dynamips; Cisco IOS

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1. Introduction

Cisco System is an internetwork solution provider whose equipment and software products are mainly for construction of computer network. Equipment of Cisco System has large market share and the related design, configure skill and software usage become main stream of current network technology [1][2]. Towards this trend, we add Cisco network equipment configuration and network design to Network Engineering Integrated Experiments and Computer Network Construction Experiments of our department. In these experiments, students are required to connect and configure Cisco network equipment to achieve some preset tasks. Through these tasks, students can learn commands on Cisco routers and switches and principles of network design which help improve students' network technology level greatly.

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Due to limit of lab environment, there exist some problems:

1.1 Equipment in lab fails to fully support all main stream network experiments

In normal lab environment, it is difficult to set up full Cisco network equipment series since it is expensive. Often we have some basic routers and switches in laboratory such as routers of 1600/1700/2600 series and switches of 1900/2900 series respectively. Such equipment is able to support some basic experiments while others require higher level equipment. For example, MPLS requires 6500 series switch or 7000 series router and the third layer switching requires 4000 series switch. Higher level means much higher price and more maintain effort that is not practical in lab environment. Moreover, amount of hardware interfaces is too limited to support experiments of large topology [4][5].

1.2 Due to limit of equipment amount, it is difficult to support a whole class to have experiment at a time

In normal case, experiments are often organized as a whole class of grouped students. There are often 3-4 students in a group and different groups have the same experiment respectively. We assume there are 50 students in a class, so there are about 13 groups. For BGP, OSPF experiments, at least 4 routers and 1 switch are required. But in lab environment it is not practical to provide all equipment simultaneously. If cross-group equipment share is considered, design of such experiments would be very difficult and would lead to some students do not have chance to do configuration.

1.3 There is of great damage in lab equipment with frequent use

In each experiment, topology would be different from previous one. Students in each experiment have to move equipment and reconnect cables which lead to serious equipment damage. Especially for serial cable V.35 between routers, too many times reconnection would completely damage serial interfaces.

For the reasons above, we state that in lab environment experiments on Cisco network equipment are not practical to launch on real ones. So we propose to use virtual equipment to construct experiment platform.

Currently there are many network equipment simulators. Some certification organization distributes Cisco lab simulators, such as Cisco Network Academy lab simulator flash version, Boson netsim, Routersim for CCNA and CCNP, Boson Router Simulator, Sybex CCNA Lab, Cisco Interactive Mentor (CIM). These simulators can be divided into two categories. The first category is application based simulator. It features of hard coding experiment setting into simulator and a UI for user to use the simulator. This kind of simulators can't support customized network topology. The simulated network environment just looks like real ones and in such environment only preset experiments can be launched [5]. Another category is flash based simulator that is simpler than the first one since it put everything in a single flash file. It is more suitable for presentation and teaching in class than for experiments [7].

Dynamips is a simulator based on virtualization technology whose original name is Cisco 7200 Simulator, originated from one of Christophe Fillot's project started in August, 2005. Dynamips aims at simulating Cisco 7200 series routers on PCs. Now it supports simulation of Cisco 3600, 3700, 2600 and 7200 series routers [3].

Dynamips does not belong to any categories mentioned above. It loads Cisco router IOS image directly to turn a single PC to one or more Cisco routers. It supports interconnection between virtual equipment on different PCs. So we regard it as the best choice of constructing virtual experiment environment based on PCs in lab.

This paper is organized as following: In section II we introduce construction of Cisco virtual lab platform by using Dynamips. In section III application of the proposed platform in real experiment course is presented and effect is analyzed and discussed. In section IV we conclude the paper.

2. Dynamips based cisco virtual lab

PC is one of the most common resources in lab. It would be a good choice to setup virtual lab platform on PCs. Dynamips loads Cisco IOS images directly to simulate routers. It supports to simulate more virtual routers in a single PC with larger memory. It is suitable to simulate 3 routers in a PC in laboratory for limit of memory size. The simulated routers in each PC form a flexible framework of network construction through LAN in lab and with the support of communication between virtual equipment. Fig.1 shows relationship between virtual equipment and PCs.

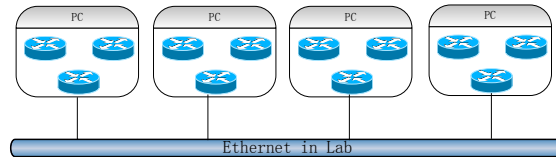


Fig 1. Interconnection between Dynamips simulated equipment and PC

In each PC, three different virtual routers are simulated by loading different Cisco IOS image files. Fig.2 shows architecture of virtual lab platform.

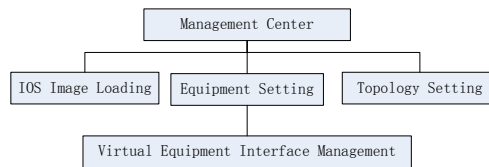


Fig 2. Structure of Virtual Lab Platform

Virtual lab platform is pre-installed in all PCs and all supported Cisco IOS image files are stored in local hard-disk. When launching experiments on the platform, students can load different IOS images to simulate different equipment according to the requirement of experiment. TABLE I shows all supported type of IOS images. Here we only briefly list some supported IOS images.

Table 1 IOS image supported by platform

Equipment Name	IOS Image Name
7200	c7200-adventerprisek9-mz.124-11.T.bin
3745	c3745-adventerprisek9-mz.124-12.bin
3725	c3725-adventerprisek9-mz.123-8.T3.bin
3660	c3660-ik9o3s-mz.124-6.T.bin
3640	c3640-i-mz.124-12.bin
3620	c3620-i-mz.122-37.bin
2691	c2691-adventerprisek9-mz.124-5a.bin
2600	c2600-adventerprisek9-mz.124-10a.bin
Pix	pix722.bin
2950	c2950-i6q412-mz.121-22.EA1.bin
c2900	c2900XL-c3h2s-mz-120.5-XU.bin
c2820	cat2820EN.9.00.00.bin

Virtual lab platform supports interconnection between virtual equipment located in different PCs that makes it possible to set up complex network topology. It is a key feature to support complex topology since in a single PC not much virtual equipment can be simulated with limited memory size.

Dynagen is installed in PC served as frontend of virtual platform to configure the running topology. Often we configure Dynagen on a server and Dynamips virtual service on other PCs [8]. Dynagen controls all virtual routers through .net setting file. The benefit of using Dynagen is that we only need to put IOS image file on server and configuration file (.net file) on every PC. Moreover, each PC can be a server to control all virtual equipment in the environment. Fig.3 shows an example of distributed interconnection.

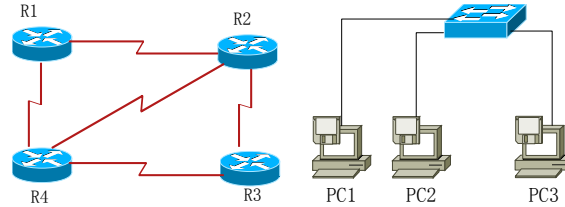


Fig 3. Distributed Interconnection through Dynamips

Fig.3 shows that PC1, PC2 and PC3 are 3 PCs in lab LAN. PC1 is configured to simulated router R1 and R2, and PC2, PC3, for R3 and R4 respectively. Dynagen is installed on PC1 to turn it to server. IOS image files are stored in PC1's hard-disk while Dynamips virtual service is running on PC2 and PC3. Topology configuration files generated by Dynagen are stored in PC2 and PC3.

3. Platform application in lab

We test the proposed platform in Network Engineering Experiment of our department. Every time a whole normal class of about 50 students take lab course. Five experiments are taken on the proposed virtual platform: RIPv2, CIDR, OSPF, VLAN and routing between VLAN, BGP and campus network construction experiment. Experiment is taken in a lab with 40 PCs and students are grouped by 3. Dynamips and Dynagen are installed on every PC and all IOS images are copied to every PC's hard-disk. The reason is every group should set up a server and may change the server in experiment [9].

Take BGP for example. Fig.4 shows topology of BGP experiment.

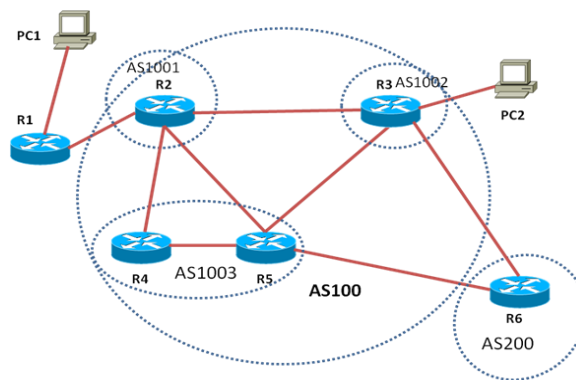


Fig 4. BGP topology

There are 3 students in a group and 2 PCs for a group. As mentioned above, each PC simulates 3 routers. In BGP experiment setting, two 700 series routers and four 3640 series routers are used in the experiment topology. PCs in Fig.3 are simulated by loopback interface configured on corresponding routers. Connection between routers is defined by .net files generated from Dynagen. In this experiment, BGP is configured running between AS and OSPF is running in a single AS as IGP. There are so many configuration points to configure in the BGP experiment that 3 students form a group makes the experiment possible. Two PCs for a group can be served as console for both Console and Ethernet interface configuration which is directly supported on virtual routers.

The only one problem occurs in experiment is all PCs in a lab is in the same LAN thus they can "see" all other PCs' message because Ethernet is a broadcast media. All virtual routers would receive all servers' messages that would cause virtual equipment fails to find corresponding configuration files. This problem can be solved by VLAN configuration on real switches in the lab [8].

Experiments on virtual lab platform are organized better than on real equipment and of almost the same effect. It is effective to use the proposed virtual platform in lab environment.

4. Conclusion

Configure of Cisco network equipment and network construction is an important part of college network engineering course and experiment. While in lab environment, type and amount of equipment is hard to meet the requirement of experiment of whole class. In this paper, we propose the construction of Cisco virtual lab platform by Dynamips simulator that simulates almost all types of Cisco routers and switches in a united platform. Dynamips simulates network equipment by directly loading real Cisco IOS image and provides the same environment as real equipment. Moreover, virtual equipment simulated by Dynamips can communicate with each other just as real ones, and even communicate with real equipment. Such feature leads to the feasibility of exchange information between real and virtual equipment and the possibility of distributed network experiments.

We test the proposed virtual lab platform in Network Engineering Integrated Experiment of our department. The proposed platform is installed and configured in PCs. Five experiments are launched by grouping students on the virtual platform and the effect is better than on real ones. The virtual lab platform provides the same environment as real ones while makes better organization of experiments. It is easy and clear for students to record and analyze output during experiments. Virtual lab platform provides logical links between equipment and it is more stable than physical links which leads to less troubleshooting time and high successful rate.

In future work, we will focus on writing some configuration scripts of traditional experiments and building a web-base management interface for better user experience.

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