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Design and construction of computer network engineering teaching case

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Abstract: **In view of the lack of real cases in the course teaching of computer network engineering major in Applied Universities and Colleges, this studies and analyzes the content structure and the requirements of the teaching objectives. According to the basic process of the computer network engineering, the basic framework of the teaching case is designed and the different technologies are constructed by using the virtual network environment. Typical network engineering cases are presented and applied in classroom teaching. The teaching practice shows that the basic framework of network engineering teaching case has general characteristics, meanwhile the application of teaching cases enhances the practicality of classroom knowledge, improves the intuition and interactivity of the course content, which is a necessary teaching resource for classroom teaching and students' practice training.**

Keywords: Network engineering; Teaching case; Teaching method; Virtual network environment

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1. Introduction

The main teaching objective of Computer Network Engineering course in Applied Universities and Colleges is to make students initially establish the concepts of computer network engineering, network engineering requirements analysis, network engineering design standards, campus network structure, campus network security and so on. Strengthen the awareness of network design norms, as well as master the needs of analysis technology of campus network, network topology design technology, network equipment and selection technology, network reliability design technology, network security design technology, network QoS design technology and network performance design technology, etc. so as to skillfully grasp the technology of IP address allocation and sub-net partition, routing configuration, VLAN configuration, data flow definition and guidance. It has the ability to design and implement the network plan for small and medium-sized campus[1]. The main problems in the course teaching process are as follows, one aspect is the broad basic concept and basic knowledge. The design technology is abstract, scattered, which is lack of design technology application scene. Another aspect is that the class content is mainly static with picture presentation, lack of dynamic change and interactive operation. It can not show the network system's running situation in real time. The third aspect is the lack of the effective integration and comprehensive application of network engineering's design technology.

On the basis of fully studying and understanding the contents and objectives of the course teaching, this paper uses the virtual network environment to classify the key different teaching cases of network engineering, and applies it to the classroom teaching. It not only makes the presentation of the classroom teaching more vividly, but also provides a variety of design techniques. Combined with the application scenario, with the support of virtual network environment, so as to control network behavior interactively and display of network operation process dynamically.

2. Basic framework of teaching cases

According to the teaching content of Computer Network Engineering course[2] combined with the requirements on the students' professional core ability of network engineering major, with the exploration of the teaching practice, a more effective framework of the case structure of computer network engineering teaching is gradually formed. The framework is composed of six parts: requirement analysis, network design, network configuration description, network operation and function test, network performance test analysis and summary. It covers the main links in the basic process of computer network engineering.

2.1. Network demand analysis

According to the basic content of the general network engineering requirement analysis and the teaching requirements of the computer network engineering course, the contents of the demand analysis in the case are focused on two aspects: the basic situation introduction and the network construction requirements. In order to facilitate the network design in virtual network environment, the requirements of network construction are further refined into four aspects: equipment connection requirements, network service requirements, network usage requirements and network performance requirements.

2.2. Network design

Network design is the key content of the case, covering the main teaching contents and techniques of the computer network engineering course, reflecting the basic design ideas of the case, which can be divided into logical design, equipment selection, simulation design,

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sub-net division, IP address distribution, VLAN division, reliability design, security design, and performance design. And information identification and other contents. Logic design id mainly based on requirement analysis information, and completes the logical representation of network use (business), network service, network performance and network connection, which forms the concept network logic diagram of this case for ordinary users. The equipment selection is mainly based on the concept network logic diagram, network technology, network equipment brand, network equipment performance index, network simulator software and so on, so as to determine the appropriate network equipment to carry on the simulation. The simulation design includes the selection of network simulator, the selection of network modules, the construction of simulation network topology. Information identification mainly emphasizes the appropriate location on the network topology and identifies all kinds of basic information, such as equipment name, model, physical port, IP address, sub-net address, VLAN and other key basic information, so as to facilitate network configuration and testing.

2.3. Network configuration description

Network configuration description is the main content of case, reflecting the basic content, basic method and specific process of network configuration. According to network topology, it can be divided into router configuration, network service configuration, network security configuration, remote security access configuration and so on. Router configuration is configured one by one according to the routing devices in the topology. The main contents include port IP configuration, routing configuration, management routing configuration, DHCP configuration, automatic IP acquisition test Network service configuration mainly refers to the configuration of regular network services (such as DNS, FTP, WEB). The network security configuration mainly gives the specific configuration of the internal network security policy, and the remote security access configuration mainly refers to the joint application configuration of IPSec-VPN and NAT.

2.4. Network operation and testing

Network operation and testing are the testing methods, testing procedures and results of the verification content in the case, reflecting the network function and performance. Network operation mainly emphasizes the "card" problem of simulation network under different operating conditions, under the simulation environment, through all operation, part operation, key link operation and other methods. The function test is mainly tested for various application service function. The performance test is mainly simulated by Huawei NQA or CISCO's SLA on designing network and network service delay, delay jitter, packet loss rate, throughput and so on.

3. Introduction of virtual network environment

The construction and operation of the teaching case of computer network engineering needs the support of the virtual network environment, including the virtual technology tools such as the network simulator, the virtual machine system, Wireshark and the SocketTool auxiliary software.

3.1. Network Simulator

Different network simulators can be selected for different network technologies. Enterprise Network Simulation Platform (ENSP) is a network simulator with Huawei network device as an simulation object[3], embedded with Huawei AR series routers, Huawei S series switches, Huawei wireless devices, Huawei firewalls and all kinds of terminal devices. It provides equipment connection and device configuration of Huawei network. And the ability of network function simulation. GNS3 is a network simulator[4], which can use Cisco network devices as simulation objects. It can load IOS with different series of Cisco routing devices. It also provides the virtual reality of Qemu client, ASA firewall, IDS and IPS kernel by integrating Qemu virtual technology[5], with configuring the corresponding OS images, providing the network technology (routing). The device configuration and function simulation capabilities of switch, network link, network security, etc. In recent years, there has been a EVE-NG network simulator[6]. It can support the simulation of multi vendor equipment, which has a more reasonable system architecture, more stable simulation operation, and the system is not easy to collapse.

3.2. Virtual Machine System

VirtualBox is a free virtual machine platform issued by Oracle, which can virtualize32/64 - bit series of virtual machines, such as windows7/8/10 client, windows server, Linux client/server, Mac OS X client/server. VirtualBox virtual machine plays three main roles in virtual network environment. First, it provides the running environment of virtual network devices, the second one is to provide the operating environment of complex network application services, and the third one is to simulate the real network client. From the perspective of networking capability, VirtualBOX virtual machine provides six different networking modes[7], which can realize multiple connections with GNS3 network simulator and real network.

VPCS is a virtual machine technology embedded in GNS3 network simulator. It is divided into two types: Multi-Host and independent VPCS. Multi-Host is a "conjoined" host, which opens the console through the Tools menu of GNS3, which can provide 9 virtual hosts in a continuous way to test the connectivity of the virtual network.

The use of virtual host technology can effectively solve the problem of simultaneous installation and use of multiple operating systems at the same time. It is easy

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to display the functions of various network hosts in the network system, which can also visualize the configuration and operation process of the main network services.

3.3. Auxiliary Tool Software

Wireshark is a network packet that can capture and analysis software, which calls WinPCAP component, obtains the network data packets directly from the network card or virtual network link, it can realize the visual detection and analysis of the network data packet flow and types by visual graphics[8]. Through Wireshark, the type of packet (filter condition) to capture can be defined directly. According to the network hierarchy model, different data packet structure can be displayed in layers. It is convenient for students to understand the network hierarchy structure, network protocol, data Baotou structure and network protocol execution process.

SocketTool is a network transmission layer communication debugging tool, which can simulate and test the functions of TCP server/client, UDP broadcast and multicast, and support multi Socket parallel testing. By using SocketTool tool, we can visualize TCP connection, TCP port, UDP port and service state in the network, cooperated with the Wireshark protocol analysis. It can greatly enhance the visual display capability of the transmission layer protocol, especially the establishment of TCP connection, the sliding window mechanism and the release connection process, which can improve the movement of the course information. The state of state is intuitionistic.

4. Construction of typical teaching cases

Based on the framework of teaching case structure, in view of the needs of classroom teaching and practice training in the course of computer network engineering, starting from the teaching contents and objectives of the course, taking the interconnected network of the park as the object, according to the different technical emphasis, a case of general park network is constructed (case 1), and campus network with outstanding reliability design is highlight (case 2), the case of campus network with outstanding security design (case 3) and the case of campus network with outstanding network performance control (case 4). These four types of different typical cases in the course of teaching, according to the different needs of the course teaching contents can choose different network cases flexibly.

4.1. Brief case introduction of general park network

This kind of case is basis on basic network equipment, including hub, two layer switch, router, three layer switch, firewall, VPCS simple virtual machine. Complex virtual machine can run client program and network service, so as to build a shared LAN, exchange LAN, and connect through router or three layer switch. The corresponding LAN forms a typical Campus Internet architecture. The standard network services such as DNS, FTP and Web are built by VirtualBox virtual machine, and the interconnection of the park network is realized by logical network design, sub-net division, IP address allocation, port IP address configuration, routing configuration. In order to clearly simulate and display the scope of network application, work processes and the principle of IP address automatic allocation of DHCP protocol, this case specializes in configuring DHCP-Server on router R2-3745 provides dynamic IP address allocation capability for hosts in each sub-net in the case. In order to find the DHCP-Server in the campus network, the default gateway interface of each sub-net is configured to be DHCP-Agent so that the host can forward the Discover packet to DHCP-Server or the next DHCP-Agent in a timely manner. The host is looking for DHCP-Server. On this basis, through the firewall or border router, connected to the ISP network, it mainly simulates the network entrance, the firewall protection, the DMZ network, the teaching network, the experimental network, the student dormitory network in the typical campus network.

4.2. Campus network case with outstanding reliability design

This kind of network case, based on general network technology, using of reliability design techniques such as link redundancy, routing redundancy, redundancy of equipment, redundancy of services, and other reliability design techniques to form a network case with outstanding reliability design. For example, using the equipment and link redundancy technology, the original single core router is replaced by a dual core router, shorted for "dual center". The lower router has one link to the dual center router, and it is backup each other. It uses VRRP protocol to design the routing redundancy. It uses multi server and DNS load balancing technology, imitating load balancing capability and service reliability of the same network service under real multi server conditions.

4.3. Campus network case with outstanding safety design

This kind of network case is mainly oriented to the headquarters branch type enterprise or the school of main school and branch school. It uses IPSec-VPN technology to transform the network entrance, the original network part is the headquarters network, the public Internet is simulated with one cloud, the branch network and the headquarters network are connected through the cloud, and the headquarters and the branch network are set up separately. VPN gateway is set up and IPSec-VPN is configured to realize encrypted transmission of the specified data stream and avoid the security risk in the transmission process of Internet, thus it can make the same unit of the heterogeneous network with the same security as the park network.

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4.4. Campus network case with outstanding network performance

On the basis of general network technology, this kind of network case increases network multicast service. In the enterprise park network, it is mainly used in professional training, staff entertainment and so on. In the campus network, it is mainly used in network teaching. The prominent feature of network multicast service is to use multicast flow instead of point to point data flow to reduce the consumption of network bandwidth resources. However, with the increasing of the number of network multicast business sources, it will also greatly "encroach" the bandwidth of the original network flow. It will affect the transmission of the original normal traffic. Therefore, on the basis of increasing network multicast service, this kind of network case also sets QoS control strategy in the main part of the network, which can divide the network bandwidth into a strategy to ensure that the multicast data flow and the original normal business flow that can not affect each other. At the same time, different IP SLA job can be configured on the source - end device to test performance[9], and the target device can be configured as "Responder". Running the network can also complete the test simulation of the specified performance (such as the round-trip delay RTT of different network protocols).

5. Conclusion

The standardized case framework can be formed, it can not only ensure the effectiveness and generality of case design and construction, but also can provide network engineering application scene for the course teaching content. The construction of these four kinds of different cases basically covers the main design technology content of the computer network engineering course. During the course of teaching, based on different contents of courses, we can select different cases or different parts of different cases to make the specific explanation. The display results especially can try the different possibilities of network connection and access at any time, produce different access control results, combined with the rational use of mind mapping courseware, so as to make the classroom teaching content display from "Static" change to "dynamic". Classroom teaching process can be from "one-way explanation" to "two-way interaction". Practice training courses can also have "case", so as to be found to reduce the blindness of students' independent training. Teaching cases have become the necessary teaching resources of Computer Network and Computer Network Engineering as well as the corresponding professional skills training courses.

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