Design and Development of Virtual Network Optimization Platform Based on the Teaching of "Mobile Communication Network and Optimization"

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Abstract: In the process of mobile communication network construction, network optimization is the core and key, which can effectively improve the quality of mobile communication network, and will have a direct impact on the operation quality and construction cost of the network. Virtual machine technology can build multiple virtual computers in one computer, which meets the needs of network construction in network courses. For teachers and students who can't skillfully operate virtual machine software, it is time consuming, laborious and difficult to build the required experimental environment every time. This problem can be solved by building a general experimental platform that meets the needs of most online courses. This paper studies a virtual network optimization platform based on the teaching of "Mobile Communication Network and Optimization". Through virtualization technology, the platform can integrate various wireless network optimization software tools, which not only retains the advantages of flexible and convenient use of traditional stand-alone software tools, but also provides the requirements of centralized management, multi-mode remote access, strong scalability, hardware resource allocation as required, and high efficiency and large-scale simulation.

1. Introduction

In traditional teaching, teachers can get the performance information of students' learning behavior through face-to-face communication with students, which can easily understand students' learning situation and teaching effect. However, with the development of modern educational technology, the popularity of online learning methods and the changes of students' learning behavior, online teaching based on virtual environment has gradually penetrated into students' daily learning and become a powerful supplement to traditional learning methods [1-2]. Computer science is one of the important basic sciences in the development of information network in China, and its practicality and applicability are very strong. Therefore, developing quality virtual practice courses is one of the important means to create a real learning environment for students.

Many vocational colleges in China offer the course of "Mobile Communication Network and Optimization", but the traditional teaching method has little effect, and students still need to attend training before they can take up their posts after graduation. Mobile communication network is an important foundation for mobile operators to operate the network. The planning quality of mobile communication network determines the final coverage, revenue, capacity and quality of network operation. The planning work of mobile communication belongs to a very complex working process, which almost runs through the whole process of network construction. Therefore, network optimization is of great significance for the construction and development of mobile communication network.

2. Analysis of optimization characteristics of mobile communication network

2.1. Users' high requirements for operators

In China, more and more users will choose mobile network, and the market competition among industries is fierce. Under this circumstance, users will have higher and higher requirements for operators. In order to achieve long-term development and survival, the majority of operators must

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constantly improve their service level. In view of the above situation, the difficulty of network optimization is also increasing, and it needs to be re-planned and innovated in many aspects such as product quality, business support, contractor, acceptance efficiency and business management [3].

2.2. Multi-network collaborative planning

At present, because of the coexistence of multi-networks and multi-operators, it brings unprecedented challenges to network optimization and construction, and at the same time increases the difficulty of this work. At this stage, operators need to implement network optimization from the perspective of coexistence of multiple networks, and at the same time, they need to focus on the coordination of multiple networks.

2.3. Diversification and intelligent characteristics of terminals

In recent years, the terminal has developed rapidly, and gradually presents the characteristics of diversification and intelligence. At the same time, the terminal is no longer a simple communication tool, and even many people have neglected its communication function and used it in work, entertainment, life and other aspects. The above changes are not only reflected in the terminal, but also have a certain impact on the network.

3. Design of virtual computer network

In the design of virtual computer network platform, we should study and analyze some problems that happened before, and then adopt corresponding design schemes to avoid and solve related problems in the design process, so as to form a perfect design scheme of virtual computer network platform, and at the same time strengthen the feasibility of the scheme. In the process of computer network security architecture, although the internal and external networks are isolated and the private network and the Internet are isolated from each other, the vulnerability of the virtual computer network is eliminated to a certain extent, but it is still traceable [4].

If we can build an intelligent detection system, we can greatly enhance the integrity and security of the whole computer network. Compared with the simple manual labor, computers often make fewer mistakes due to their own reasons.

At present, China lacks a related information security planning organization with the highest management authority to manage related information security affairs. Moreover, in the local cloud computing environment, the internal management is relatively weak, and the monitoring of internal personnel is not in place or even there are no monitoring measures, and many operations are not blocked. As a result, some hackers have an opportunity to steal user information by using management loopholes, resulting in potential information security risks. Even some people take advantage of their positions to steal user information. Therefore, in the construction of virtual computer network, it is necessary to design and implement the authority and firewall.

4. Design of virtual network optimization platform

4.1. Overall design of platform

As shown in Figure 1, the virtualization platform uses multiple servers as the underlying hardware environment, and the servers are connected by network. Every server is installed with the underlying operating system of VMware virtualization, so that the resources of multiple servers can be managed uniformly [5]. On top of VMware, it is a variety of virtualization mainstream operating systems, including PC operating system, Linux system and server operating system.

In each virtualized operating system, applications can be installed and deployed, including various wireless network optimization software. Wireless network optimization personnel can access the PC operating system virtual machine deployed in the platform through the network by using the client or browser, so as to remotely call the corresponding stand-alone network optimization software. They can also access the B/S mode system through the browser, which can be accessed through the computer, mobile phone or Pad.

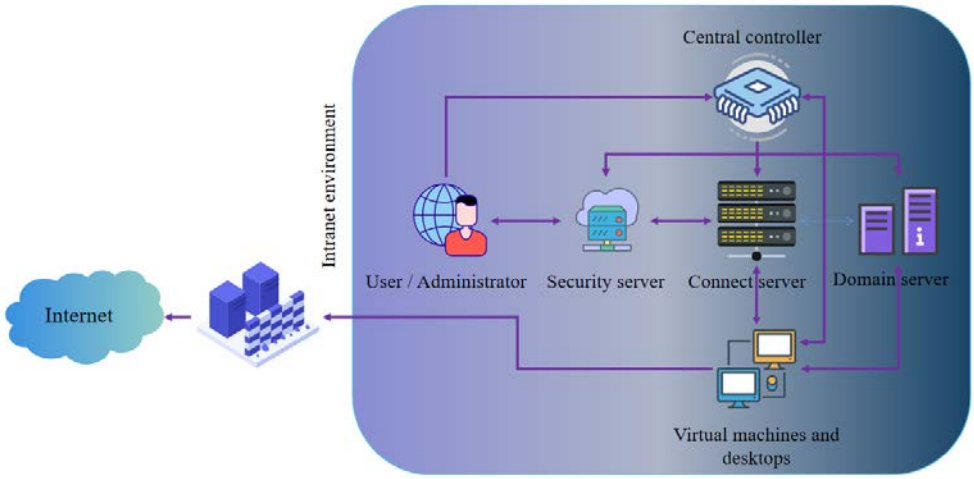

Figure 1 Platform virtualization design

4.2. Resource allocation and isolation

In the virtualization layer, the virtual network optimization platform designs resource mapping algorithm and resource scheduling algorithm respectively. In order to solve the problem of resource mapping when creating experiments, the virtual network optimization platform proposed a hybrid frog leaping algorithm. The algorithm takes the resource mapping scheme as frog individual and the mapping cost as fitness function. The smaller the fitness function value, the better the individual quality [6]. The execution process of the algorithm is similar to frogs jumping to the optimal solution in several subgroups, which can quickly converge to the global optimum. The virtual network optimization platform proposes a scheduling optimization algorithm based on the dynamic change of virtual resources to solve the problem of dynamic change of experimental network requirements. Based on the existing resource mapping results and the updated resource requirements, the algorithm can minimize the resource consumption cost in the scheduling process from a single experiment.

SR-IOV (Single-root I/O Virtualization) provides a standard for efficiently sharing PCI-E network card devices to virtual machines by bypassing the operating system and virtualization layer in hardware [7]. SR-IOV network card supports physical functions and virtual functions. Each virtual function has a separate virtual PCI-E channel, and multiple virtual functions share the PCI-E channel of one physical network card. Virtual machines directly access hardware through the assigned virtual functions, bypassing the virtual machine monitor virtualization layer, and directly completing data I/O processing, which can greatly improve network throughput performance, reduce data transmission delay, and realize high-speed sharing and high scalability of equipment.

VLAN tag technology is used for link isolation in virtual network optimization platform. In each virtual network, by assigning a VLAN tag to the link between any two virtual nodes, one physical link can support multiple virtual links from different networks. Because VLAN tags are different, the data traffic of each virtual link can be isolated from each other.

4.3. Dynamic virtual machine migration modeling

(1)Problem description

From the perspective of dynamic migration, the physical structure of cloud data center can be expressed as a graph structure, which is called cloud data center network structure diagram, in which the vertex of the graph represents physical machines and network devices, while the edge represents the link relationship between physical servers and network devices. The virtual machines in the virtual machine network run on the physical machines, and the virtual machines in the virtual machine network communicate through the actual links of the data center. In addition, different virtual machine requests have different resource consumption due to different applications deployed by users, such as computation-intensive, I/O-intensive and so on. Obviously, deploying a large number of compute-intensive virtual machines on the same physical server will cause a great waste

of other resources.

Due to the different usage habits of users, the access to virtual machines may show different time periods. Only by collecting and analyzing user behaviors can the virtual machine network in cloud environment be dispatched more reasonably to achieve the goal of saving energy consumption. The scenario description of virtual machine network dynamic migration problem is shown in Figure 2.

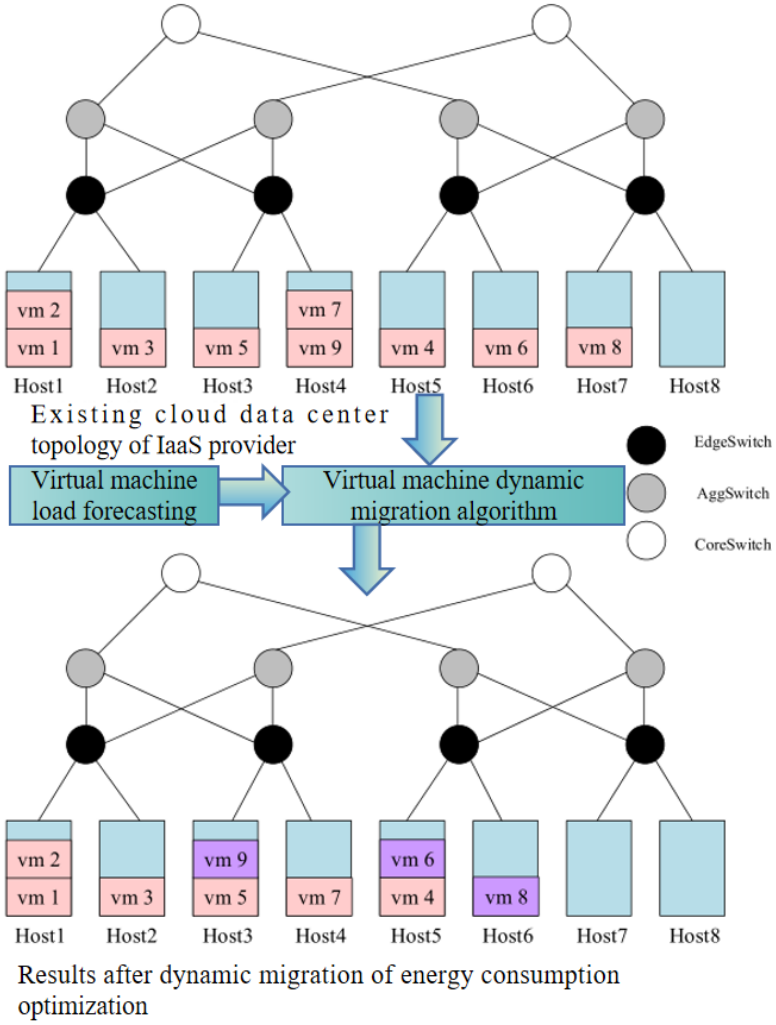

Figure 2 Schematic diagram of virtual machine network dynamic migration

It can be seen from Figure 2 that the problem of dynamic migration of virtual machine network is to trigger the migration operation at the appropriate migration time, and select the appropriate virtual machine to use the virtual machine hot migration technology to dynamically move the virtual machine from host to host. On the premise of meeting the resource requirements of virtual machines, use as few servers and network equipment as possible to reduce the energy consumption of the data center.

(2)Migration modeling

The devices in the network (such as switches) realize forwarding and measure traffic according to the forwarding table they obtain. SDN controller uses standardized protocol OpenFlow to communicate with network devices and collect link state information measured by them. SDN controller is responsible for calculating forwarding tables of all devices. OpenStack, the cloud controller, is responsible for managing all computing and storage resources, and it retains all information about virtual machines and physical hosts.

The brief process of virtual machine migration is as follows: first, the application sends a migration request to the coordinator; Then, according to the data collected from OpenStack and SDN controller, the virtual machine migration model will output a series of virtual machine instances to be migrated and their required bandwidth; At last, after reconfiguring the network to

ensure enough bandwidth, the virtual machine migration is performed by OpenStack.

The goal of this study is to determine the migration sequence and transfer rate of virtual machines under the condition of satisfying the constraints, so as to optimize the migration time. Let M be the memory size of virtual machine, R be the dirty page rate during migration, and B be the bandwidth allocated for migration.

Assume that the virtual machine migration needs to be performed for n rounds, and the amount of data transmitted in each round is V_i. In the first round, all memory pages are copied to the target host, then $V_0 = M$. Then in the next round, the pages modified in the previous round are copied to the target host. The amount of data transmitted is $V_i = RT_{i-1}$. therefore, the time of each round can be expressed as:

$$T_i = \frac{MR_i}{B_{i+1}} \quad (1)$$

Let $\lambda = R/B$, then the total virtual machine migration time can be expressed as:

$$T = (M/B)((1-\lambda_{n+1})/(1-\lambda)) \quad (2)$$

The network is represented by graph $G = (V,L)$, where V is a node set and L is a link set. c_l is the remaining bandwidth of link l. $k \in K$ is an instance of virtual machine migration. s_k represents the source node where the virtual machine migrates, d_k represents the destination node where the virtual machine migrates, m_k represents the memory size of the virtual machine, r_k represents the dirty page rate, and b_k is the bandwidth allocated to the migration instance k. P_k represents the set of paths from s_k to d_k. The university network optimization model based on virtual machine migration has the form of formula (3):

$$\begin{aligned} &maxmize \sum_{k=1}^{K} (b_k - P_k r_k) \\ &subject\ to \sum_{p \in P_k} x_p = b_k \\ &\sum_{p \in P_k} x_p \le c_l, P_k \in \{0,1\}, x_p \ge 0 \end{aligned} \quad (3)$$

The goal of optimization problem is to maximize the network transmission bandwidth. The first constraint is bandwidth constraint: since a virtual machine can migrate using multiple paths, the sum of the bandwidths transmitted on multiple paths should be equal to the bandwidth allocated to the migration instance. The second constraint condition is the link capacity constraint, that is, the data allowed to be transmitted on each link cannot exceed the capacity of the link. The third and fourth constraints are the domain of variables.

5. Optimization design and test of virtual machine network

Set up a test environment, download and install the tool software iPerf 3.1.3 of Windows version and Linux version from IPERF official website in two virtual machines, and test the network I/O throughput. To facilitate the performance comparison of network cards, add a Virto virtual network card to two virtual machines (turn off kernel acceleration). Between two virtual machines, carry out the network throughput pressurization test between two SR-IOV network cards and two Virtio network cards respectively. In order to ensure the accuracy of the test data, each test is carried out 6

times and the average value is taken. The network I/O forwarding performance test results are shown in Figure 3.

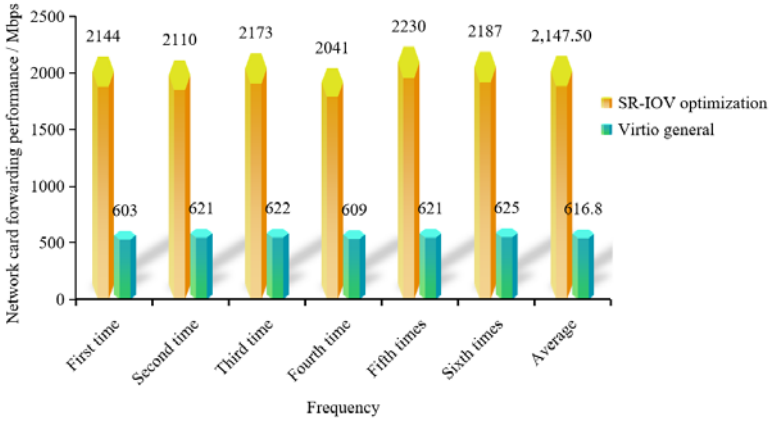

Figure 3 Throughput performance comparison

The forwarding performance (I/O throughput) of the optimized SR-IOV network card is much higher than that of the ordinary Virtio network card.

6. Conclusions

"Mobile Communication Network and Optimization" is a directional course for communication engineering majors. It explains the architecture, working mechanism, key algorithms and high-level signaling of communication systems, and explains the optimization and optimization process and methods of mobile communication networks. With the rapid development of cloud computing technology, more users are provided with applications and services, which requires higher and higher network I/O performance of virtual machines. Optimizing network I/O of virtual machines from software level and hardware level can improve the network performance of virtual machines in cloud computing environment. Because of the strong scalability of virtualization technology, the platform can continuously develop with the progress of wireless network optimization technology, and continuously integrate more advanced tools and software to provide powerful IT support for wireless network optimization.

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