

# A Method of Constructing Virtual Network Based on NFV

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**Abstract**—Relying too much on dedicated hardware equipment, resulting in poor flexibility and extensibility of existing communications network, while the new technology application cycle is long, seriously affect the communication operators' interest in deploying. In order to solve these problems, the new network architecture—Network Function Virtualization (NFV), was proposed. This paper introduces the basic principle and design framework of NFV, proposes a method of constructing virtual network based on NFV, namely achieving routing function in the form of software, deploying it to a virtual operating system, and running in the universal server virtualization software in the form of virtual machine, multiple virtual routers and virtual terminal system interconnection constitutes a virtual network, testing and analyzing the transmission performance of the virtual network, realizing to control the transmission performance of the virtual network, create a virtual network that have the transmission characteristics of real network environment to test new technologies.

**Keywords**—network functions virtualization; software defined networking; virtualization technology; routing function virtualization; virtual network

## I. INTRODUCTION

Traditional communication network is usually based on the special hardware to provide high reliability and high performance guarantee, but its flexibility is low, scalability is limited, the technological innovation is difficult, and the inflexibility of the network infrastructure makes the management and maintenance extremely complicated and inefficient. At the same time, the rigid structure of the network system is seriously hindered the technology innovation and deployment, under the existing network environment, the application of new technology needs to purchase new dedicated hardware devices, so the original equipment may be discarded or idle, resulting in hardware resources waste, server resource utilization rate is low, the investment of network equipment is large, and many other problems. Therefore, the new network architecture *NFV* has been created[1-2].

NFV technology involves the implementation of network function in software based on standard IT virtualization technology, makes the network function get rid of the shackles of special hardware equipment, a variety of virtualization network functions can share hardware resources in the form of virtual machine, and can be moved to, or instantiated in, various locations in the network as required, without the need for installation of new equipment.

In this paper, we realized routing function virtualization based on the principle of NFV technology, using multiple virtual routers to build a virtual network, and using Net Em simulator to control the transmission performance of virtual network, realizing to make virtual network have the transmission characteristics of real network environment, which can be used to test new network protocols and new network equipment.

## II. RELATED WORK

### A. *NFV and SDN Technology*

The cornerstone of NFV technology is the maturity of cloud computing technology[3-4], the core of NFV is using IT virtualization technology to involve the implementation of network function in software that can run on a range of industry standard server hardware, its ultimate purpose is using industry standard high volume servers, storage and switches to replace dedicated hardware device in communication network, implemented in reducing IT costs and improve the flexibility and expansibility of communication network. NFV is applicable to any data packet processing and control plane function in fixed and mobile network infrastructures.

The core idea of Software Defined Networking [5] is to separate the control plane and the data forwarding plane, and realize the programmable control. From top to bottom, SDN is divided into three layers: application layer, control layer, infrastructure layer, its main features include control forwarding separation, logic centralized control for control layer, control layer open API to the application layer.

NFV and SDN are two key technologies in the development of the network in the future, and they are closely related to each other. NFV and SDN are based on the same technology, which are based on universal server, cloud computing technology and virtualization technology. NFV and SDN are highly complementary, but they are not dependent on each other, they are independent, NFV needn't rely on SDN, it can use the traditional network management. SDN aims to generate the abstract of the network, so as to quickly carry out the network innovation, focusing on centralized control and network programming. NFV is a rapid innovation and open system established by communications operator to reduce the CAPEX (capital expenditure) and OPEX (operating expense), focusing on high-performance forwarding hardware and virtualization network functionality software. However, the combination of the two can be more effective to achieve the opening and innovation of the network. The relationship between NFV and SDN can be expressed in Figure 1.

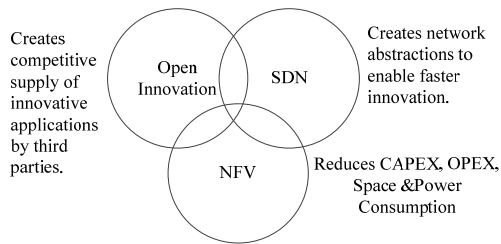


FIGURE I. NETWORKFUNCTIONS VIRTUALISATION RELATIONSHIP WITH SDN

### B. Virtual Network

Virtualization technology can improve server resource utilization and reduce the complexity of management and maintenance. NFV uses virtualization technology to involve the implementation of network function in software, breaking the dependence relation between the network function and the special hardware equipment. The virtual network based on the principle of NFV technology will make the construction of the network test environment simple and efficient.

The network environment constructed by NS2, OPNET and other simulators is poor portability, can't be combined with the real network environment, the authenticity is poor. The virtual network constructed based on NFV has high portability, and real network interconnection, the functions is almost the same as the functions of real network, the higher authenticity, the network size can be changed within the server can bear when needed ,fast and flexible. Therefore, it is very meaningful to construct virtual network based on NFV technology for testing experiment.

In paper [6], the design ideas of Cloud4NFV platform based on cloud computing technology and NFV technology was proposed, analyzed the availability of the platform in the form of theory, in this paper we verify the availability of virtual network that constructed based on NFV technology through the actual experiment.

## III. IMPLEMENTATION SCHEME OF VIRTUAL NETWORK BASED ON NFV

### A. RoutingFunction Virtualization

Router is the core equipment of communication network packet forwarding and routing, demand is very huge, so operators requires not only the purchase of a large number of physical router, but also need enough space to place them, at the same time, a large number of routers running also need to consume large amounts of electricity, large workload of configuration, management and maintenance is extremely complex. Therefore, the routing function virtualization [7], will help the communication operators to solve many problems.

Using the characteristic of Linux system that open for routing function, the Linux operating system can be installed in the virtualization software. Deploy Quagga routing software on each virtual machine, configure related parameters, making these virtual machines become nodes with routing functions. Quagga supports OSPF, RIP, BGP and other routing protocol, this paper uses OSPF protocol to interconnect multiple virtual routers into a large scale network. Through the virtual network

and the physical network bridging mapping, virtual net work can connect with multiple subnets through server's different physical interfaces, the subnets can transport data packet from each other through the virtual network, so as to realize the interconnection between virtual network and real network.

There are many kinds of virtualization software that can be used to deploy virtual machine, such as Xen, KVM[8], VMware, Virtual Box, according to the design principle of NFV and compare the advantages and disadvantages among virtualization software, we make further optimization between the two virtualization software: VMware, KVM which applicable to do NFV technology research, we test the support capabilities for the transmission performance of the virtual network through specific experiment.

### B. Link Simulation

Linux2.6 and above kernel version provides network simulation function module, Net Em. The function module enhanced function of the existing traffic control tool TC of Linux (traffic control), add the simulation of link delay, packet loss, packet duplication and other situations, can be used to simulate the complex behavior of Internet transmission in the good performance of the local area network, such as low bandwidth, transmission delay, packet loss. Therefore, it can be used to control the transmission performance parameters of the virtual network, so as to simulate the real network environment to make related research.

### C. Virtual System Hierarchy

The hardware and software of the virtual system is shown in Figure II, which is composed of the underlying hardware, Linux operating system, virtualization software and virtual machine. Underlying hardware provides the necessary physical resources and title Interface between the virtual environment and the real environment; Linux operating system provides the basic execution environment and KVM Application module; KVM/VMware as part of a virtual engine, to achieve the virtualization of system CPU, memory and I/O, provides public operation environment for virtual machine, and realize the mapping of inter face between physical and virtual; and VM (virtual machine) being routing node for carrying core routing daemon process and basic network protocol.

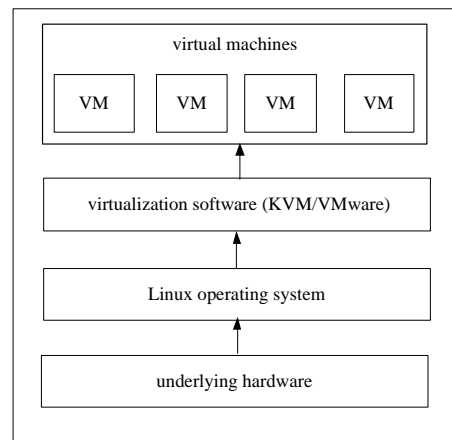


FIGURE II. HIERARCHICAL DIVISION OF VIRTUAL SYSTEM

## IV. SYSTEMS ANALYSIS

### A. Functional Analysis

Using virtual router and virtual terminal system to construct virtual network on the universal server, it can be used as transition network between multiple subnets, for testing experiment, as shown in Figure III, entity router R1, R2 respectively connected with virtual routerr1, r2 through the server's physical interface eth0, eth1, entity switch S1 connected with virtual router r3 through the server's physical interface eth2. Thus, virtual network link Open Flow networks with multiple LAN into large-scale network. By using the virtual reality system, the data transfer between a LAN and the Open Flow network can be tested after the IP network connection.

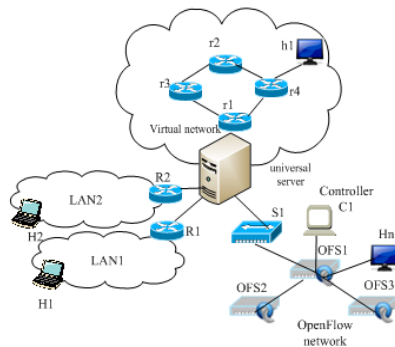


FIGURE III. AN EXAMPLE OF VIRTUAL NETWORK BASED ON NFV

Use the trace route/tracert command to route-tracking, both ends of the system's communication links on each hop route, the TTL value of the data packet is reduced by 1. After many tests, the network topology of the route-tracing results is consistent with the experimental design. In the virtual environment, conducting the network topology is flexible and fast, which can be supplied and changed according to need, so the researchers can construct the corresponding IP network model according to their need.

Virtual machine can save the current operating state through the snapshot technology, if the system crashes or other faults, we can restore it to perform a snapshot in time of the normal state by the snapshot recovery technology, the virtual network can be backed up to other general service through the virtual machine migration technology, so the reliability of data back up is assured. The virtual system can not only bring many benefits to telecom operators, but also for other enterprises to use, for example, it can be used for teachers and students in colleges and universities, they can construct their network model to make relevant research on the universal server according to their need, so we can solve the problem for teachers and students in university that can't intensive study of the problem because of the lack of equipment.

### B. Performance Testing

The transmission performance of the virtual network is influenced by the server memory size, operating system kernel version, and so on. The performance of the server determines the number of virtual nodes, the speed of processing data, the transmission performance of the virtual network, and the

stability of the virtual network. In the real network environment, each node enjoys independent hardware resource. Therefore, the transmission performance and stability are guaranteed, but in the virtual network environment, the resource of each node is distributed by the server according to need, multiple virtual nodes through the middle layer resource allocation and concurrent operation, the process will make its performance affected. The environment of the experiment listed as follows: Xeon E5-2620 processor (2 GHz 15MB 6c) and 32GB of memory, CentOS6.6 64b operating system workstation as a universal server, virtual machine using CentOS6.5 32b operating system and assigned to each virtual machine memory is 1GB. Influenced by the server memory and other performance indicators, the number of virtual nodes to reach 30, the network performance is relatively poor, the main performance: virtual machine start-up is very slow, large delay, low bandwidth. Therefore, the experiment is completed within 30 virtual nodes on a single server. In order to ensure comparability, in addition to the use of virtual software, other conditions are same.

The method of testing the transmission performance of the virtual network [9]: testing the network delay and bandwidth by increasing the link length (link hop count). The transmission control protocol (TCP) is used to transmit data packets. With the increase of the link, the end to end delay is increasing, and the bandwidth of the end to end is decreased, as shown in Figure IV and Figure V. After the link hop count up to 20, the delay gap between the two is significantly increased, and the bandwidth changes tend to be flat, and the gap between them is relatively slow.

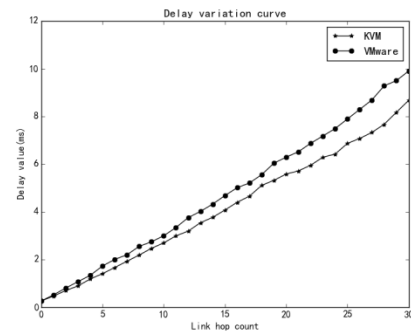


FIGURE IV. DELAY COMPARISON

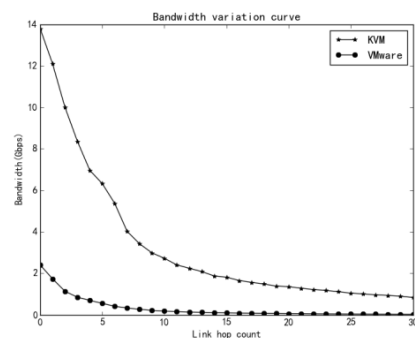


FIGURE V. BANDWIDTH COMPARISON

Combined with the actual network, multiple subnets connected by the virtual network, as shown in Figure VI, mobile host H1 is connected with virtual router  $r_1$  through the universal server's physical interface eth0, entity router reconnected with virtual router  $r_n$  through the universal server's physical interface eth1, test the whole network transmission performance. The methods of testing: the real network to send data packets between each other, gradually increasing the number of routing nodes on the virtual link, test transmission bandwidth. To construct the same virtual network with KVM and VMware, using the same test method, test results as shown in Figure VII, the transmission bandwidth of virtual network that construction KVM relative to higher and increase with the link, bandwidth is reduced amplitude is relatively small.

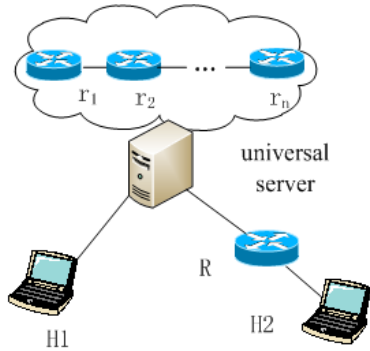


FIGURE VI. VIRTUAL REALITY NETWORK INTERCONNECTION

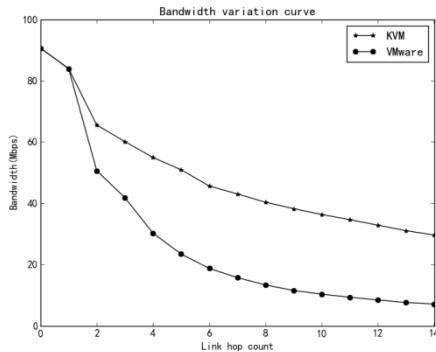


FIGURE VII. BANDWIDTH COMPARISON OF THE NETWORK THAT VIRTUAL NETWORK CONNECTED WITH REAL NETWORK

Using Net Em link simulator to simulate the Internet transmission performance, simulation results are shown in Table I, Table II and Table III. From the data shown in the three tables, we can see that using KVM and VMware to construct the same virtual network environment, using Net Em to simulate Internet transmission performance, the simulation results are very close to each other. Therefore, there is no difference at this point. Analysis the data shown in table, can be obtained, the fidelity of NetEm simulation is very high. Similarity can reach more than 90%. Therefore, using this way for studying the feasibility of the new scheme is desirable, and can be used to simulate extreme conditions, for example, will be a link packet loss rate is set to 100%, so that the link in a break state.

TABLE I. DELAY COMPARISON

Set delay value (ms)	Measured value (ms) (VMware)	Measured value (ms) (KVM)
10	10.7	10.5
20	20.7	20.6
30	30.6	30.5
40	40.7	40.6
50	50.8	50.7
60	60.8	60.6

TABLE II. BANDWIDTH COMPARISON

Set bandwidth value (bps)	Measured value (bps) (VMware)	Measured value (bps) (KVM)
64K	61K	61 K
128K	122K	122 K
512K	488K	489 K
16 M	15.2M	15.2 M
32 M	30.5 M	30.6 M
64 M	61 M	61 M

TABLE III. PACKET LOSS RATE COMPARISON

Set packet loss rate value	Measured value (VMware)	Measured value (KVM)
10%	9%	9%
20%	19%	20%
30%	28%	27%
40%	38%	37%
50%	47%	51%
60%	60%	61%
100%	100%	100%

Analyzing the result of the performance testing, it can be concluded that in the same hardware conditions, the transmission performance of KVM virtual network construction is better, especially in the aspects of network bandwidth, but they also have limitations as well as good points, therefore, what kind of virtualization software is more suitable for the research of NFV technology, should be decided by the actual situation, if only a small virtual experiment temporarily, we can choose to use VMware, if we want to have a long-term study of NFV technology, and virtual large-scale network, relatively speaking, KVM is more appropriate, but, with the development of virtualization technology, virtualization software that more suitable for the research of NFV technology will be developed.

### C. Examples of Application Scenarios

Using multiple virtual routers to construct virtual network that the topological structure is complex as the core network, edge linking multiple subnets, used to simulate multiple subnets linked each other by large-scale IP network, and then test the data transmission.

Virtual routing function deployed on the Linux operating system, so we can use Net Em link simulator that provided by the kernel, to set the value of link bandwidth, delay and packet loss rate of the networks, the higher similarity Net Em

simulation, and can be modified at any time, based on this advantage, we can use virtual network to simulate satellite networks, wireless networks, and other special network. For example, according to the characteristics of the satellite communication network, we can make follow settings: the communication bandwidth is about 10Mbps, and the communication delay is about 500ms, then the virtual network can be used to simulate satellite net work to carry out related research.

## V. CONCLUSIONS

NFV as a kind of new network architecture, has very important significance for the development of the future network, get rid of the shackles of the specialized hardware devices, scalability and flexibility have been improved, so it can effectively promote the network's innovation. Based on the NFV technology, this paper proposes a method to construct the virtual network by using the virtual routing function, which can construct arbitrary network topology, configuration flexibility and easy backup. However, not all users are familiar with the principle and operation of the virtual system, so it is difficult to be extended, in order to solve this problem, in the future work, the integrated use of programming, Web, Database and Socket communication technology will realize the long-distance control of the virtual system. Users will be able to complete the basic configuration operations through the visual interface. For example, users can choose virtual routers they needed, and set the link delay, bandwidth, and other transmission performance parameter values in the visual inter face according to the network topology they had designed, and related tasks on the universal server will be accomplished by professionals.

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