Study on Construction of a Virtualization based Software Defined Network

Wen-Xin Qiao[1, a], Yu Lu[1]，Chang-Sheng Wang[2]

[1]Department of Information Engineering, Ordnance Engineering College, Shijiazhuang 050003,China

[2]Information Management Center, Ordnance Engineering College, Shijiazhuang 050003,China

[a]qiaowenxin1992@foxmail.com

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Abstract. Information network technologies have been rapidly developing with the rapid growth of demand for information-based society. However, the traditional TCP/IP network architecture could not satisfy the demand of network development, so as to military network. A virtualization based SDN network for military use was designed, through the design of control strategy of this network, it can gain the flexible control and high security features, which could satisfy the controllability and security demand of military network in complex environment.

1 Introduction

With the rapid development of information network technology, and the continuously extension of the network scale, the traditional TCP/IP network architecture could not satisfy the demand of further development. Low utilization ratio of compute and storage resources, complex management measures and network structure, insufficient security measures and so on, all of these issues turn out to be the barriers which limit the internet development. Military network is the internet applied in the military field, so it faces the same troubles with internet. What's more, due to the special application environment of military network, it is important for military network to focus on the controllability and security issues.

Firstly, the device type of military network is diversified, and the heterogeneous level of hardware equipment is high. And the network nodes of military network not only include the common personal computer, mobile terminal, router, server and others, but also contain specific facilities such as radar, radio, sensor and satellite;

Secondly, in terms of data transmission and communication, military network is carrying the most significant functions that transmit the confidential data command, which has highest level requirements in secure communication. Physically, military network is isolated and deny all type of connections with internet, and protect communication secure by using signal interference, electromagnetic jamming and other security measures. Logically, it adopt different encryption means and access control strategies since that different department has different security level in military network;

Thirdly, lacking of a systemic top-level design and management, the current military network doesn't have a unified data standards and interfaces. Most of the departments have their own independent systems and custom software, which caused the low utilization ratio of information and data resources, low efficiency of network management and control measures, and lack of effective integration of resources.

In order to get out of the predicament, researchers begin to study on changing the network architecture to solve the problem. And among the studies, the virtualization technology and SDN (Software Defined Network) are quite superior in improving network management mode and enhancing controllability and security of network.

2 Basic Theory

Virtualization technology was proposed in 1950s, and the early target is to make full use of computer resources, and to solve the problem of limited resources. The essential of network virtualization [1] is abstracting physical entity resources to reform a virtual layer, and using the shared physical resources to create multiple virtual subnets, which are independent and isolated from each other, and could perform operations independently. The network virtualization makes the management and control progress easier and more efficient.

SDN is one of the periodic achievements of the "revolutionary" research. It originated from an open protocol standard named OpenFlow [3]-[5], which was proposed by the research group called Clean-slate [6] organized by the Stanford University in the United States. Its main idea is to separate the control logic which is determining forwarding from the network equipment (switches and routers, etc.), to realize that hardware controls data forwarding rules through software programming, and ultimately achieve the free control of the flow. As a way to implement SDN prototype, OpenFlow has been regarded as the standard SDN communication protocol, because of its good flexibility and standardization features [7]. The SDN network architecture is divided into three parts: application layer, control layer and infrastructure layer, of which the control layer is the core. In this way, SDN control layer handles the global network state, and has the ability to highly control the data flows, with the programmable feature of control layer, which makes the network controllability highly improved and the complexity of the management greatly reduced.

As an emerging programmable network architecture, SDN is one of the most important directions of the next generation Internet technology research. While based on the theory of network virtualization, combining the SDN architecture with virtualization, the control and data forwarding functions could be abstracted into the virtual network, by which the hardware facilities and deployments of current network could avoid from totally reconstructed during the transformation of SDN. Meanwhile, the features that the centralized control, programmable and complete control of data flows, are also quite helpful for virtual network to optimize the network structure, security strategies employment and other aspects.

Therefore, a virtualization based SDN network for military use was designed, and it was composed of application layer, control layer and infrastructure layer. Through the design of control strategy of this network, it can gain the flexible control and high security features, which could satisfy the controllability and security demand of military network in complex environment.

3 Design Principles

The network designed in this paper, aiming at constructing virtual network using the core idea where control is detached from forwarding based on SDN network architecture. The specific method is to discard the traditional data forwarding ways, instead using the way that send flow table by OpenFlow, to centralize the network control in the control layer where the SDN controller is, and perform fine-grained control of data forwarding process through the SDN switch and controller. The design principles concentrated in the network controllability, security and modularization.

(1)Controllability is the control requirement in network structure, data forwarding, network resource etc. There are a lot of limitations in the existing network architecture. The function and control ability of each network element equipments is seriously limited by hardware. Therefore, the existing network architecture does not have flexible control characteristic. While the SDN network control plane and data plane is separated by its characteristic, and the control function of each network element equipment is abstracted and centralized by the SDN control layer. The controllability of the overall network system is enhanced according to the control and adjustment to current state of the network in real time.

(2)Security is the requirement of network security features and preventive measures, where the isolation is an important factor. High isolation performance between different virtual networks in the non-physical isolated network environment could achieve logic isolation, which means local network

being attacked or failures does not affect the overall situation of the whole network, so as to improve the security and reliability of the whole network.

(3)Modularization design is conducive to the improvement of network reconfiguration and providing customized services and applications. The feature that network and its equipment are not programmable is one of the main causes of the current network rigidity. The programmable feature of SDN control plane with modularization design thought, which makes it convenient to improve the reconstruction ability of network and further evolution. The network virtualization technology with modularization design makes the system more flexible for different demands to provide network service supports, which are meeting the demand of users in heterogeneous networks and complex application environment.

4 Design of general structure

The general structure of virtualized SDN network in this paper is designed as follows:

(1) Infrastructure layer:

Composed of SDN switches. Compared with the conventional switching devices, SDN switches are only responsible for executing the rules of flow table given by the upper controller, and forwarding and processing of the underlying data. Through the multi-level flow table processing rules based on OpenFlow protocol, specific data forwarding and traffic redirection service is finished.

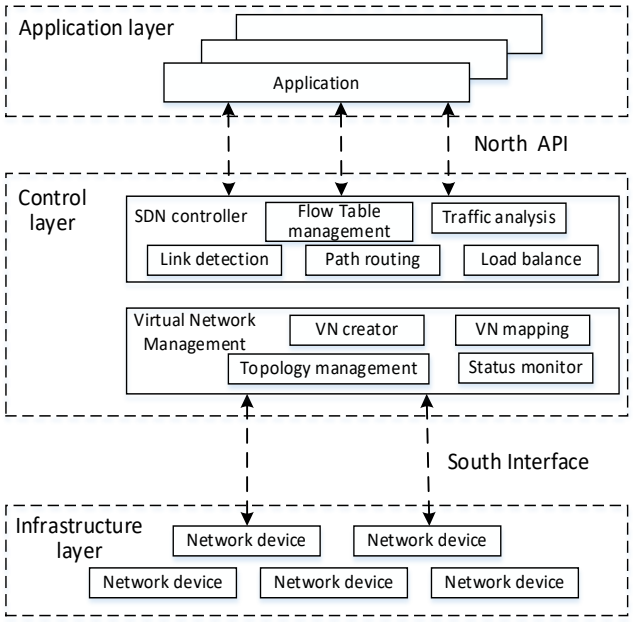

Figure 1 general structure of virtualized SDN network

(2) Control layer:

Composed of SDN controller and the control module. Provides centralized management control functions, such as routing, link discovery, address resolution etc. The controller sends the flow table and packet processing rules to switch, then the switch executes the specific forwarding and redirection task.

The control layer includes SDN controller (at least one) and a number of control components, and the SDN controller is not only the core of this layer, but also the domination of the whole virtual network control. The function of this layer can be divided into basic function and expansion function. The basic function is necessary that guarantee the controller realize the network control, including network state information acquisition, network traffic analysis, path routing, flow table management etc. At the same time, virtual network management module includes virtual network creation, virtual network control and security control, which are responsible for the virtual network creation,

management and security strategy. The network management is composed of virtual network mapping, topology manage, network status monitor and other functions.

(3) Application layer:

The layer is the top level of this system, composed of multiple application modules. It acquires web information through the standard API provided by control layer, and realizes functions of varies web services and applications through interaction. The virtual networks are modularized that can provides customized services according to the specific requirements. The development of new applications and services is more flexible because of the unified programming interface provided by control layer, and has excellent compatibility and reusability.

5 Design of Control Strategy

Based on the SDN network architecture, the SDN control layer abstracts and centralizes the control function of the whole network so as to realize the real-time control of the whole network. This can be embodied in resource level and data level.

5.1 Resource Management and Control

(1) SDN control layer collects and records the computation, storage resources and current network status of entire network, forecasts and calculates the computation and storage resources to form a virtual subnet according to the specific needs, then controls the corresponding physical equipment to establish a corresponding virtual subnet.

(2) Different virtual subnets need control layer carries out corresponding deployment and configuration according to the different demands, such as the use of communication protocol, networking, security strategy and providing network services, etc. The modularization thought of this paper make the virtual subnet configuration faster and more flexible.

(3) SDN control layer monitors the running status of the whole network in real time, and optimizes network resources in the global perspective at the same time.

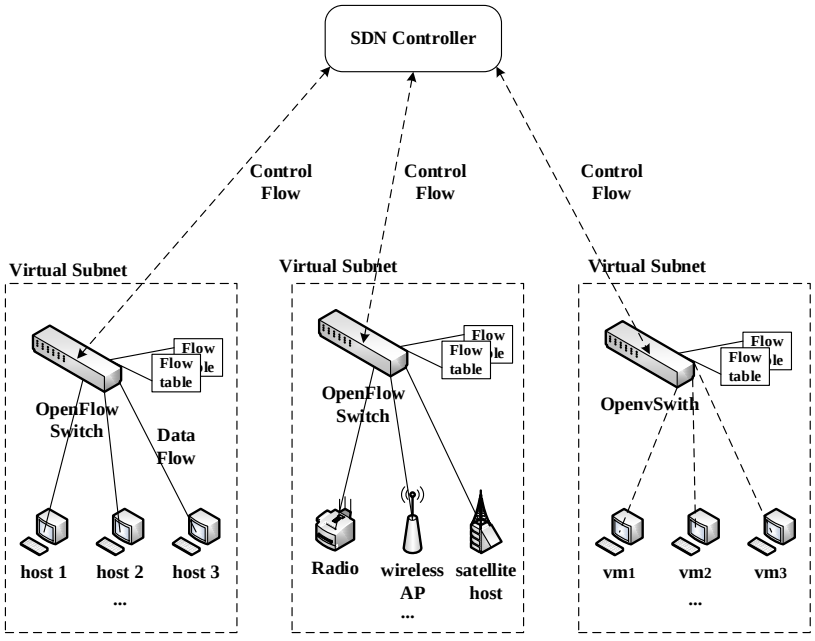

Figure 2 control strategy of the virtualized SDN network

5.2 Data Flow Management and Control

(1) According to the match—action thought based on the flow of OpenFlow [3]-[5] protocol, the control to the data plane is mainly reflected in the control process of the forwarding strategy of data flow. Firstly, it divided the flow into a number of matching domains according to the OpenFlow protocol format, such as IP address, MAC address, port number and protocol, etc. Then the control layer set the corresponding data processing rules according to demands and send flow tables to the switches of virtual subnets.

(2) Each virtual subnet contains a SDN switch, whose function is interact with the SDN controller for control command transaction, and collects network status and reports to the SDN control layer. When the control layer send the flow table to the virtual subnet, the switch will receive the flow table and update the data processing rules. After that, the new packets arrived will execute by matching new rules of the flow table inside the switch. The matched packets will execute corresponding operation, otherwise, they will be discarded or addressed by the SDN control layer.

6 Conclusions

This paper designed a virtualized SDN network for military environment use. Through the design and analyze of general structure and control strategies of this network, it will achieve the controllability, security and modularization goal of the design principles. In the next step, the key function of this network will be studied, and will constructed by using experiment platform.

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