Research on Self-Configuration Technology for Survivability Enhancement Based on SDN

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Abstract. In recent years, SDN has become the network technology which the academic and industry most concerned about following cloud computing. Compared with the traditional network, SDN forwards the network control plane and data plane separation, and implements programming control centralized. At first, based on the brief introduction of SDN basic definitions and concept, this paper described the architecture and key technologies of SDN, and a survivability enhancement self-configuration technology based SDN was proposed, which was implemented by the combination of SDN, network virtualization and cloud computing, finally outlined the challenges encountered in the development process of SDN.

Introduction

In recent years, Internet has become the current generic real-time computer network, and with the popularity of computer networks, various types of mission-critical systems is gradually becoming more networked, to realize the operation of remote and the expansion of the scale of applications. But because of the openness and the complexity of the network, design flaws of hardware and software systems as well as human errors and other factors, which led to mission-critical systems be in danger. In fact, it would have a huge impact on the national economy and people's lives once these systems were destroyed. So it is hoped that the software system can continue providing critical services stably even met with an accident, under attacks or system failures, and only in this way it is possible to improve the system survivability. To meet the requirement of the growth of system survivability, the system needs to implement dynamic allocation in the structure, behavior, properties and other aspects according to the perception of the external environment and the results of the feedback event handler from the self-sensing module during the operation, and to do some micro autonomic regulations. SDN[1] (Software Defined Networking) as a new network architecture, which not only separated the control and forwarding, but also achieved a programmable centralized control. In other word, SDN can take advantage of the associated software platforms which were centralized in the controller layer to achieve using the programmable control the underlying hardware, to lead to the distribution of network resources were flexibly according to need. And SDN turned resources into IT services, which were provided to customers by way of automated processes and software. SDN has become the world's most popular network in the field of current research.

SDN Profile

SDN originated in the Slate Clean project of the United States of America's top universities, which is funded by the United States GENI, whose goal is to improve the existing traditional network architecture. It has attracted more and more attention from the academic and business since the
emergence of this new network architecture, which has a broad development prospects and great research value. SDN is currently one of the most popular technologies. As a new way to realize the network architecture, SDN brings new vitality and challenges to the traditional network.

**The Definition of SDN**

Currently, SDN is divided into two kinds: 1) generalized SDN: refers to those who have an open application interface, and can be implemented by software programming to control the equipment at the bottom of the network architecture; 2) special SDN: refers to those who meet the ONF (open networking foundation) as defined by the organization and based on OpenFlow protocol to realize software defined network.

In simple terms, SDN does not need to rely on the underlying network equipment (switches, routers, firewalls, etc.), which not only shields various differences from many underlying network equipments, but also because of the completely open control, users can define any network routing and transmission rules strategy they want to achieve according to their own ideas and needs, which makes the system can be more flexible and intelligent to meet their needs.

**The Architecture of SDN**

SDN is a kind of new network architecture to separate the data and control power, and can realize the software programming. As shown in Figure 1, SDN is mainly divided into three planes and two interfaces, from bottom to top respectively are:

- **Infrastructure layer**: including a number of network units, and each network unit can provide network traffic. Network equipment which can be either a hardware switch, or a virtual switch, such as OVS, of course, can also be other physical devices, such as routers, firewalls, etc. All of the forwarding tables are stored in the network devices, and the user data packet is processed in this layer forwarding.

- **Southbound interface**: located between the infrastructure layer and the control plane, which is responsible for the data exchangel and interoperations between SDN controller and network unit. OpenFlow is the most famous work in southbound interface of the agreement.

- **Control layer**: this layer is composed of controllers and the network operating system, in which the most important is SDN controller. SDN controller is the core components of the SDN network, which as an important task of traffic control network, and is responsible for handling resources from the data plane, and maintains view of the global network, and collects the information of network devices in the network, and then generates strategies according to the demand and sends strategies in the form of flow tables and then controls the network behavior [3]. Controllers in a SDN network can be one or more, and a plurality of controllers can be a master-slave relationship, or a peer to peer relationship.
One of the controllers can control a number of devices, and of course, a device can also be controlled by multiple controllers. Normally, the controllers are running on a separate server.

Northbound interface: located between the control plane and the application plane. The upper application program accessed the network resources from the lower layer through the northbound interface, and sent data to the lower network through the northbound interface. The most simple and most traditional northbound interface is SNMP, CLI, and the most popular northbound interface is REST API.

Application layer: including a variety of applications, and users can define network control and network services in the form of logic through the open programming interfaces and network views provided by the control layer. Application layer is to provide users with services, including load balancing, security, network operation monitoring, including congestion, delay and other network performance detection and management, topology discovery, and many other services. These services will eventually be presented in the form of software applications. And they can run on the same single server with the controller, and they can also run on other servers, in fact they communicate with controllers through the communication protocols.

SDN Technology

The core technology of SDN is OpenFlow. OpenFlow was suggested firstly by Professor Nick McKeown at Stanford University. It was used to overcome difficulties in innovating the network, which cannot be implemented simply and convenient in the real network. SDN has the same and consistent goal, therefore, it has received the widespread attention. OpenFlow itself is a kind of network equipment specification, which includes functional requirements and its basic components of the network forwarding equipment OpenFlow switches, which as SDN infrastructure layer, and the OpenFlow protocols which is responsible for remote control of OpenFlow controllers or an OpenFlow controller cluster to the switch in OpenFlow network.

Self-Configuration Based on SDN

In order to meet the requirements of system survivability enhancement, this paper use the idea of self-configuration, so that the system has the ability of self-configuration, so the system can be operated under the conditions of no intervention or less human intervention. In this paper, we put forward a survivability enhancement self-configuration technology based on SDN. And there are two key research directions: network virtualization and system self-configuration technology.

SDN and Network Virtualization

Network virtualization technology puts the network resources form the underlying physical layer into a pool of resources, which allows multiple virtual networks accessing to network resources, network control equipments, network management traffic dynamically, and makes them can be used by multiple virtual networks[4]. In the architecture of SDN, the state of switches, the information of links and network topology information can be obtained by a centralized controller, which supports the abstraction of network resources in network virtualization technology development. Network virtualization technology can shield the differences between underlying physical heterogeneous devices, which can make several virtual networks coexist on the same physical network. In this way, virtual networks can use their own protocol architecture, and do not affect each other, which can improve the utilization rate of resources effectively.

Traditional network virtualization solutions are to add multiple virtual nodes and virtual links to complete the construction of the virtual network topology on the physical network. In this scheme, the network management layer needs to manage every network nodes, which makes the network management become more and more complicated. SDN virtualization technology obtains the information of the whole network and state mainly through the centralized controllers, and then abstract network resources according to these information, so that the resources can be divided and separated, and then uses the unique programmability of SDN, and uses the virtual network resources
according to the definition of a good control logic. Because of the good programmability in SDN network, network managers and researchers can easily control network equipment, deploy new network protocols, which making the network become more intelligent and flexible.

**SDN and Cloud Computing**

Cloud service network deployment is a system engineering, and the administrator can contract with the cloud service management platform directly, which is also known as cloud computing platform, such as OpenStack[5] and CloudStack or private platforms designed by cloud service providers. The cloud computing platform is responsible for the management of a variety of resources, including computing resources, storage resources, network resources, etc.

As a cloud computing resource management platform, OpenStack is used in the application layer of SDN system structure. Managers and users can call directly the northbound interface API, which is provided by SDN controllers, by adding SDN management plug-ins in the network resource management components, and then drive SDN controllers directly to call to the underlying physical resources according to the actual needs of the applications, which can easily call the network capability to open to the outside world of SDN controllers. Figure 2 is a typical architecture of SDN resource management platforms.

![Figure 2. A Typical Architecture of SDN Resource Management Platform.](image-url)

**The Challenge for SDN**

At present, the development of the SDN industry is still in the initial stage, there are still many problems in the process of its development which need to be solved.

1. **Difficulties on computing**
   
   In order to achieve the function of SDN, the current system is facing a severe test. What is a major challenge facing the current SDN is how to compromise the complexity of the software and the efficiency of computing capabilities.

2. **The interfaces of controllers have not been fully standardized**
   
   The ONF only defined the southbound interfaces between the control layer and data layer, but did not define the interfaces between controllers and interfaces between the control layer and the application layer. This affected the process of commercialization of SDN to a certain degree.

3. **Security risks of centralized control of network**
The centralized control of logic is one of the main characteristics of SDN network, and the "single point failure", which belongs to the inherent limitation of centralized control, will certainly affect the development of SDN.

Conclusions

With the current rapid development of network technology and the continuous expansion of the network, the computer network has been widely used in many areas of government, military, education, scientific research, commerce, etc., which there are security risks of all kinds of application systems. The traditional network architecture can not meet the current security needs and survivability requirements of the system, and SDN appears just to meet the needs of users to adapt to the current development of computer networks, which makes the current network devices simplify and optimizes the network structure, which making the network more and more flexibility, and improving the speed of response. These advantages based on SDN attracted more and more attention, making SDN are developing rapidly. But SDN is still in the early stages of development, there have been many challenges in its development process, so it has been restricted to the development of SDN to a certain extent. The current study on SDN must have a profound impact on the development of the computer network.

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References


