Scheduling Data Flow between Data Centers Based on Software Defined Network

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Abstract. For intelligent control of network traffic, to solve the problem of low utilization of public network bandwidth, we put forward scheduling data flow between data center based on SDN technology. First, we connect the data center distributed in different locations by wide area network and exchange or share the research data of high performance. Then, the system can sense the utilization and performance of the network bandwidth resources between the data center. Based on the results of perception, we can dynamically adjust and optimize the path of data and maximize the utilization of network link. SDN is a new software based network structure. This paper uses SDN network architecture to schedule the traffic of data center, and constructs a two-layer network suitable for cloud computing and virtualization environment. It realizes the global, dynamic and intelligent data flow.

Keywords. Network traffic; data center; software defined network.

1. Introduction

With the continuous progress and development of information society, the emergence and rise of cloud computing, big data and other services, communication networks are facing unprecedented challenges [1-2]. The traditional traffic control scheme gradually shows some shortcomings, how to realize simple, open source, programmable traffic scheduling is more and more concerned by researchers [3-4]. SDN is a new software based network architecture [5]. SDN separates the tightly coupled control plane from the data plane to realize the centralization of network control and the transparency of the underlying network facilities to the upper application [6].

2. Related Work

This paper studies the traffic scheduling scheme based on SDN technology. The research on SDN began with the clean slate project led by Professor Nick McKeown of Stanford University in 2006, which aims to overcome the shortcomings of the existing network infrastructure [7]. At the beginning of 2012, the backbone network connection of Google data center all adopted SDN architecture, and the network utilization rate increased to 95%. In November 2012, big switch launched a SDN controller suitable for network virtualization, which made a new breakthrough in SDN technology in the field of radio and television [8]. In 2017, Fox TV flexibly dispatched the Super Bowl video stream through SDN technology [9].
Since 2012, domestic research on SDN has become more and more popular. In 2014, Beijing Telecom and Huawei completed the commercial deployment of SDN, the world's first operator, and successfully applied SDN technology to IDC Network [10-11]. In 2018, Liu Jie and others found that the 5G satellite integrated network based on SDN can better avoid network congestion, improve network utilization, and intelligently switch ground satellite routing equipment to deal with various satellite link problems [12]. In 2019, Qiao P A and Ren Z designed a dynamic traffic adjustment strategy for SDN [13].

The innovation of this paper is to use the SDN network architecture to schedule the traffic between data centers, and the network architecture built in this paper is a layer 2 network architecture suitable for cloud computing and virtualization environment, which facilitates the migration of virtual machines across three layers. Intelligent traffic scheduling improves the link utilization of the public network.

3. SDNIDCP Strategy and Analysis

To connect the data centers distributed in different locations by wide area network and exchange or share the research data of high performance, a strategy named SDNIDCP is designed. The design of the whole system is divided into three parts.

3.1. The Architecture For Multiple Data Centers Interconnection

The multi data center interconnection adopts overlay layer technology. Introducing routing function in STP protocol to solve the problem of link utilization and broadcast in STP protocol, and realize multi-path forwarding. However, the configuration of VPN in overlay layer scheme is relatively complex, and its control perspective is single point, and it lacks global centralized control and automatic deployment.

The core technology of SDN network architecture is logical centralized control. The controller can be used for the secondary development of the controller and the development of the network application in the data center of medium and large enterprises with different structures and requirements.

3.2. SDN Network Global Control and Topology Discovery

Traditional network topology discovery uses SNMP protocol. However, the oid (object identifier, OID) number of different manufacturers may be different and private, and the topology format may also be different. The two core points of SDN network architecture are the separation of control and forwarding, but the link discovery of SDN network needs to be completed by the controller.LLDP (Link Layer Discovery Protocol) is an industry standard protocol, which can detect and collect network topology. The process of topology discovery based on LLDP protocol is shown in figure 1.

![LLDP protocol topology discovery process](image-url)
3.3. Quality of Service Based on SDN

The network which is composed of connection oriented technology needs to be managed by their own network management system. The refined traffic management ability provided by SDN equipment and the unified control ability of controller can be used to realize the direct and efficient traffic scheduling solution. The traffic scheduling architecture based on SDN is shown in figure 2.

In the experiment of WAN traffic scheduling in SDN network, the link resources need to be dynamically and flexibly scheduled according to the status of each link in the network, such as bandwidth utilization, load, delay and so on. The design of the whole SDN WAN traffic scheduling system is shown in figure 3.

![Figure 2. Low scheduling block diagram of wide area network based on SDN.](image)

![Figure 3. Relationship of components in flow scheduling process.](image)

4. Validation

The designed SDN network architecture is introduced into Wan for testing. Three L2VPN gateways and three SDN switches are deployed at the gateway exits of three data centers in Beijing, Shanghai and Shandong respectively. The controller is deployed in the Chinese Academy of Sciences to configure and manage the status of the whole network and the trend of user data, so as to realize traffic scheduling. The experimental test is shown in figure 4.

![Figure 4. Using SDN network architecture.](image)
The user data is introduced into the SDN network architecture through the configured excute. The comparison data of the original IPv6 performance of each link and the link utilization and network delay after superimposing SDN network architecture (i.e. adding L2VPN and SDN switch) are shown in table 1.

**Table 1. Wan test performance.**

| Ipv6 Performance | VPN+SDN Performance |
|------------------|---------------------|
| LAN 1 Bandwidth (Mbps) | 691 | 583 | 86.44% | 533 | 77.13% |
| → LAN2 Delay (ms) | 19.514 | 17.214 | 34.545 |
| LAN 1 Bandwidth (Mbps) | 724 | 603 | 83.28% | 518 | 69.79% |
| → LAN3 Delay (ms) | 11.565 | 15.688 | 52.67 |
| LAN 2 Bandwidth (Mbps) | 573 | 498 | 86.91% | 416 | 72.54% |
| → LAN3 Delay (ms) | 19.514 | 16.273 | 40.488 |

From table 1, we can see that the direct short path and the route around the president work normally. After the introduction of SDN switch and L2VPN gateway, the performance of single point-to-point link in SDN network architecture is degraded, but the total bandwidth is more than 150% of the original network bandwidth.

In order to better observe the data comparison of the available bandwidth of the network we are concerned about, we sample the link data in one day. The available bandwidth comparison of the original IPv6 network link and the new SDN network link is shown in figure 5.

![Figure 5. Link available bandwidth comparison.](image_url)

In order to test the traffic scheduling in the new network architecture, we inject test traffic into the original IPv6 network link and the new network link (only from Beijing to Shanghai) between 10:00 and 12:00 to observe the change of the situation.

It can be seen from figure 6 that the packet loss rate in IPv6 network is higher than that in SDN network architecture. The reason can be seen from figure 7 that the low priority traffic injected during congestion period is transmitted through the long path from Beijing to Shandong and then to Shanghai. During this period, the traffic occupation in the originally idle bypass link increases significantly, reducing the pressure on the direct link from Beijing to Shanghai.
5. Conclusion
This paper proposes a traffic scheduling scheme based on SDN technology, which realizes global, dynamic and intelligent traffic scheduling, monitors the data traffic before forwarding, allocates the bandwidth dynamically, and then implements the corresponding traffic forwarding policy. The improved SDN technology can improve the network utilization and greatly improve the transmission efficiency of traffic. The development of network architecture based on SDN will undoubtedly bring changes to the existing network, break through the limitations of the existing network, and promote the progress of information technology and the development of information industry.

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