Traffic Engineering in DNC with a Ramified Topology

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I. INTRODUCTION

Every year the need for computing power and volumes of information is growing and the task of increasing the efficiency of data center network (DCN) becomes more and more urgent. Modern DCNs are large in size and differ in the variety of equipment connected to them. Because of this, it becomes quite difficult to manage this type of network, namely, traffic orchestration. To solve these problems, use software-defined networking (SDN) technology [1-3]. One of the methods to solve these problems is to use different network topologies. After all, the use of complex topologies (for example, mixed) is not always rational. Since it is much more convenient in small companies to use simple topologies (bus, star, ring, etc.), which are much easier to maintain and orchestrate traffic in them. In large corporations, it is advisable to use more complex network structures to differentiate access, although they are rather difficult to manage and require a large staff of technical staff to maintain them.

The use of a traffic engineering (TE) system [4] can reduce power consumption by about half and increase the maximum utilization of communication channels compared to static TE methods [5].

Centralized formation of multiple paths based on multipath routing in SDN allows to reduce traffic engineering time and improve its quality of service (QoS) [6]; however, the known methods of forming multiple paths have a high time complexity [7]. In this regard, in article [8], a modified method of forming a set of paths is proposed, which is characterized by a lower time complexity in comparison with the known methods of forming a set of paths. In article [9], a modified method of multipath routing is proposed, which, by taking into account the specifics of the SDN organization, in particular, due to the presence of a central controller in the network, reduces the time it takes to form a set of access routes to network resources.

The main disadvantage of these methods is that the routes are formed by each node of the network without taking into account the routes already formed by other nodes. This leads to the re-formation of separate sections of already formed paths.

Rational use of different topologies increases the efficiency of using communication channels and reduces the complexity of traffic orchestration and technical maintenance of the network.

In this regard, we will consider the three main topologies of local networks and develop methods for multipath routing and traffic orchestration in them, taking into account the features and advantages of SDN [10-13].

II. COMPUTER NETWORK TOPOLOGIES

A. *Fat Tree*

In a switched matrix — a network topology that uses switches — the main goal is to connect a large number of endpoints (processors or servers) using switches that have only a limited number of ports. By cleverly connecting switching elements and forming a topology, a network can connect an impressive number of endpoints.

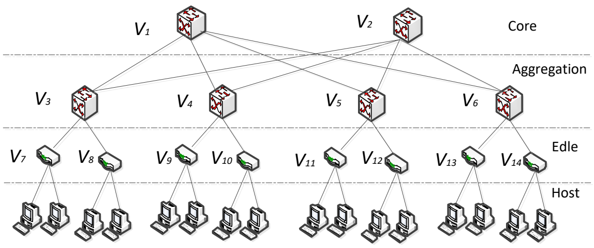

Fig. 1. Topology Fat Tree[13]

Fat-Tree Networks (Fig. 1) were proposed by Charles Leiserson of MIT in 1985. Such a network is a tree, and the processors are connected to the lower layer. A distinctive feature of a thick tree is that for any switch the number of links going down to its descendants is equal to the number of links going to its parent at the top level. Therefore, the links become "thicker" towards the top of the tree, and the radio button at the root of the tree has most links compared to any other radio button below it.

This setup is especially useful for networks on a chip and is cheap and efficient for use in supercomputers. However, for corporate networks connecting servers, standard (off-the-shelf) switches are used, which have a fixed number of ports. Therefore, a design where the number of ports varies from switch to switch is not very user-friendly. Therefore, alternative topologies have been proposed that can leverage existing fixed-port switches.

B. *Double extended star topology*

In star networks, network media connects a central hub to every device on the network. The physical appearance of a star topology resembles radial spokes extending from the center of the wheel. This topology uses central point control, and communication between devices connected to the network occurs via point-to-point links between each device and the center channel or hub. All network traffic in a star topology goes through a hub. First, the data is sent to the hub, and then the hub forwards it to the device according to the address contained in the data.

But if a simple star topology cannot cover the intended area of the network, then it can be extended by using gateways that prevent the attenuation effect from manifesting; the resulting topology is called an extended star topology. In order for a star topology to be effectively used in a large building, it needs to be extended. This cannot be done by lengthening the cables in the horizontal cabling system, as the recommended maximum cable length must not be exceeded. Instead, you can use network devices that prevent signal degradation. In order for the signals to be recognized by receiving devices, repeaters are used that take the weakened signal, clean it, amplify it and send it further along the network. By using repeaters, you can increase the distance that the network can extend. Repeaters work in tandem with network media and therefore belong to the physical layer of the OSI reference model.

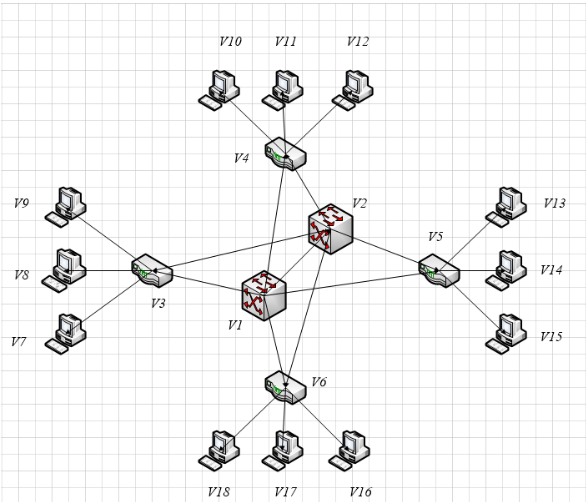

Fig. 2. Double extended star topology

Quite often, to prevent network failures, a second, redundant switch is added, which can take on part of the network load (Fig. 2).

C. Double ring topology

In the ring, unlike other topologies (star, bus), a concurrent method of sending data is not used; a computer on the network receives data from the previous one in the list of addressees and redirects them further if they are not addressed to him. The mailing list is generated by the token generator computer. The network module generates a token signal, which is usually 2-10 bytes to avoid fading, and passes it on to the next system. The next system, having received the signal, does not analyze it, but simply transfers it further. This is the so-called zero cycle.

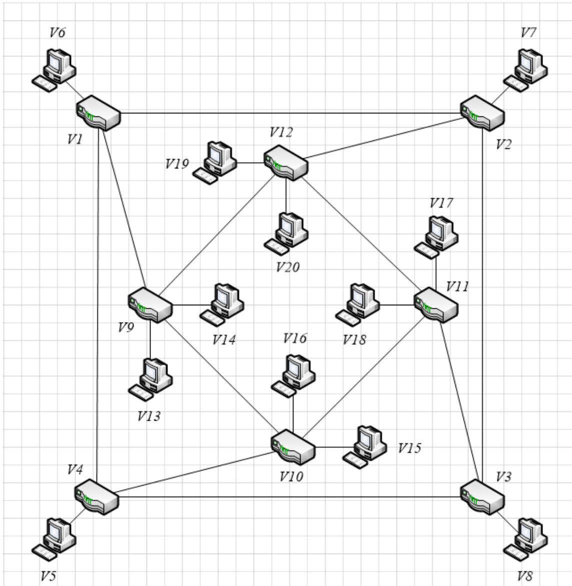

Fig. 3. Double ring topology

Double ring topology (Fig. 3) built on two rings. The first ring is the main path for data transmission. The second is a backup path that duplicates the main one. During normal operation of the first ring, data is transmitted only over it. If it fails, it merges with the second and the network continues to function. In this case, data is transmitted along the first ring in one direction, and along the second in the opposite direction. An example is the FDDI network.

To form routes for packet transmission in the considered topologies, we will use a modified algorithm [13].

D. Examples of forming multipath routing tables.

Let's consider examples of forming routing tables for transmitting information from a node V7 to the node V14 DCN of the above topologies.

In article [13], the sequence of forming route tables for the Fat Tree topology is given. But for this example, we will build route tables for the double extended star and double ring topologies.

TABLE 1. CHANNEL LOAD UP FOR DOUBLE EXTENDED STAR TOPOLOGY

	Links	**Workload**
L1	***V14 V5***	***0.1***
L2	***V5 V2***	***0.2***
L3	***V5 V1***	***0.7***
L4	***V6 V2***	***0.5***
L5	***V6 V1***	***0.6***
L6	***V2 V3***	***0.6***
L7	***V2 V4***	***0.2***
L8	***V2 V6***	***0.4***
L9	***V1 V3***	***0.3***
L10	***V1 V4***	***0.2***
L11	***V1 V6***	***0.4***
L12	***V3 V7***	***0.1***

Sequence of forming route tables

1. A set of nodes is formed W1 ={V5}, adjacent to the node V14.
2. Forming a table of routes for the node V5

TABLE 2. ROUTE TABLE FOR NODE V5

Node table V5			
nodes		*path metric*	*Path load up to V14*
destination	*destination*		
V14	***V14***	***Mi,14***	***0.1***

3. j=1;
4. A set of nodes is formed W2 ={V1,V2}, adjacent to the node V5.
5. Channel load factor L2=(V5, V2) is equal d2=0.2
6. d2> D5 then Di= d2 =0.2
7. Forming a table of routes for the node V2 .

TABLE 3. ROUTE TABLE FOR NODE V2

Node table V2			
nodes		*path metric*	*Path load up to V5*
destination	*adjacent*		
V14	***V5***	***Mi,14***	***0.2***

8. Channel load factor L3=(V5, V1) is equal d3=0.7
9. d3> Di then Di= d3 =0.7
10. Forming a table of routes for the node V1

TABLE 4. ROUTE TABLE FOR NODE V1

Node table V1			
nodes		*path metric*	*Path load up to V9*
destination	*adjacent*		
V14	***V9***	***Mi,14***	***0.2***

11. j=2;
12. A set of nodes is formed W3 ={V3, V4, V5}, adjacent to the node V2.

Similarly, having formed routes to other nodes, as a result, we will get a route table for the node V3 through which we will gain access to the node V7.

TABLE 5. ROUTE TABLE FOR NODE V3

Node table V3			
nodes		*path metric*	*Path load up to V1*
destination	*adjacent*		
V14	***V1***	***Mi,14***	***0.3***
V14	***V2***	***Mi,14***	***0.6***

Based on the above routing tables, information is transmitted from the node V7 to the node V14 with minimum value D1 =0.3 in the following sequence V7 $\rightarrow$ V3 $\rightarrow$ V1$\rightarrow$ V4$\rightarrow$ V2$\rightarrow$ V5$\rightarrow$ V14.

TABLE 6. CHANNEL LOAD UP FOR DOUBLE RING TOPOLOGY

	Links	**Workload**
L1	***V14 V9***	***0.1***
L2	***V9 V10***	***0.2***
L3	***V9 V1***	***0.7***
L4	***V10 V4***	***0.3***
L5	***V6 V1***	***0.6***
L6	***V11 V3***	***0.5***
L7	***V11 V12***	***0.5***
L8	***V12 V2***	***0.5***
L9	***V3 V4***	***0.6***
L10	***V4 V1***	***0.2***
L11	***V1 V2***	***0.4***
L12	***V2 V7***	***0.1***

Sequence of forming route tables

1. A set of nodes is formed W1 ={V9}, adjacent to the node V14.
2. Forming a table of routes for the node V9

TABLE 7. ROUTE TABLE FOR NODE V9

Node table V9			
nodes		*path metric*	*Path load up to V14*
destination	*adjacent*		
V14	***V14***	***Mi,14***	***0.1***

3. j=1;
4. A set of nodes is formed W2 ={V1,V10}, adjacent to the node V9.
5. Channel load factor L2=(V9, V10) is equal d2=0.2
6. d2> D9 then Di= d2 =0.2
7. Forming a table of routes for the node V10.

TABLE 8. ROUTE TABLE FOR NODE V10

Node table V10			
nodes		*path metric*	*Path load up to V5*
destination	*adjacent*		
V14	***V5***	***Mi,14***	***0.7***

8. Channel load factor L3=(V9, V1) is equal d3=0.7
9. d3> Di then Di= d3 =0.7
10. Forming a table of routes for the node V4

TABLE 9. ROUTE TABLE FOR NODE V4

Node table V4			
nodes		*path metric*	*Path load up to V6*
destination	*adjacent*		
V14	***V10***	***Mi,14***	***0.3***

11. j=2;

12. A set of nodes is formed W3 ={V4, V11}, adjacent to the node V10.

Similarly, having formed routes to other nodes, as a result, we will get a route table for the node V2 through which we will gain access to the node V7.

TABLE 10. ROUTE TABLE FOR NODE V2

Node table V2			
nodes		***path metric***	***Path load up to V1***
destination	***adjacent***		
V14	***V1***	***Mi,14***	***0.4***
V14	***V12***	***Mi,14***	***0.5***

Based on the above routing tables, information is transmitted from the node V7 to the node V14 with minimum value D1 =0.4 in the following sequence V7 $\rightarrow$ V2 $\rightarrow$ V1$\rightarrow$ V4$\rightarrow$ V10$\rightarrow$ V9$\rightarrow$ V14 .

If the load on the link of the selected route increases, its routing table changes. This leads to a reconfiguration of the given path.

The traffic engineering procedure is described in more detail in article [13]. Using it, you can fairly easily orchestrate traffic for different network topologies.

III. CONCLUSIONS

In this work, two network topologies are implemented and the method of traffic orchestration in DCN is used, which, by taking into account the peculiarities of the SDN organization, allows to reduce the time of forming a set of access routes to network resources and to simplify the rerouting procedure.

Topology data using this method [13] makes it possible to practically eliminate the delay or loss of packets in the process of traffic rerouting. At the same time, the more paths are formed in topologies, the less the probability of delay or packet loss will be.

These topologies are well suited for small and medium-sized offices. For use in large enterprises, these topologies must be expanded and branched.

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