A new method of routing in SDN network to increase the delivery rate of sent packets

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Abstract
The evolution of mobile devices and accessories and server virtualization leading to a review of common architecture of networks. The architecture of many traditional networks is hierarchical which is formed with the use of Ethernet switch nodes in a tree structure. This architecture will be more tangible when the client-server communications are discussed, but such a static architecture is not sufficient for dynamic communications and the needs of companies in the field of data centers and media servers. It is almost impossible to face with the current needs of the market by using common network architectures. Companies of information technology use the manual processing and management tools in the level of machine to deal with issues like recession or budget cuts. Companies which providing telecommunication services are faced with the same challenges because the demand for accessing to broadband of dynamic networks, dramatically is increasing; Also, the profit of these companies will compromise with increasing the costs of central equipment and reducing the income. In our representing method, we are trying to improve and enhance the reliability which is an important factor for SDN networks. In this study, the reliability of SDN networks will increase and the rate of accurate data transmission will significantly improve. The research method of this study is the scientific research. The review and study of target research will be discussed in the first part. In the second part, we examine the basic concepts of the subject and represent an available problem. In the third part, we introduce the proposed approach and offering a theoretical- laboratory case in connection with that. Then in the fourth part of the study, we practically examine and evaluate the proposed method with the represented laboratory example. At this stage, methods of data analysis are simulations and cooperation with previous methods. Also, we presented some graphs with the outputs of simulations which show the enhancement of the reliability of the proposed method and we conclude in the final part.

Key-words:

SDN, delivery rate

1. Introduction

Companies of information technology use the manual processing and management tools in the level of machine to deal with issues like recession or budget cuts. Companies which providing telecommunication services are faced with the same challenges because the demand for accessing to broadband of dynamic networks, dramatically is increasing; Also, the profit of these companies will compromise with increasing the costs of central equipment and reducing the income. The architecture of existing networks are not designed in such a way that can provide the current needs of companies, telecommunications servers and users. In other words, network designers faced with some limitations such as complexity, contradictory policies, lack of scalability, dependence to the seller [1] and the lack of coordination between the needs of market and capabilities of network which leads the IT industry toward the diversion point. To prevent such incidents, IT industry represents the architecture- defined with software or SDN and developed the related standards. Controller placement algorithm, routing and traffic control, seriously have been considered in SDN networks in order to maximize the possibility of traffic control in SDN networks. Only one controller is used in this architecture, so this method cannot be responsible for environments that require more than one controller. In this study, in order to enhance the reliability of communication pathway, we propose a multi-control placement algorithm between the switch and controller. As mentioned, in this study the number and location of controllers in the network will be effective on increasing the reliability [1].

2. The network of SDN and OpenFlow

The structure of control networks in SDN can have several different forms. For example, a controller can only have the stellar structure or be as the hierarchical structure which is formed from a set of controllers connected with each other in a full mesh and have a connection with nods or as dynamic loop distribution from a set of controllers. Regardless of the exact form of structure, layout of controllers is effective on the capability of controllers in response to the demands of the network and that is so important. Thus, the correct positioning of controllers as well as knowing and specifying the number of controllers needed to respond to the performance and tolerance of error in the SDN networks in order to achieve a better performance compared to the traditional networks, has a paramount importance. Therefore, the selection, design

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and placement of controllers is one of the critical issues. Todays, Load balancing or traffic load balancing technology considered as one of the basic factors in exchange of information in the cyberspace, but unfortunately, most of the people are unfamiliar with this technology and in many cases is not considered as a principle in network engineering. To take advantage of all the facilities and benefits of this profitable technology, IT and Network professionals must learn all the basic concepts and details of the mentioned technology.

OpenFlow provides the possibility of direct access and changes in app submitted equipment of the network such as switches and routers both as physical and virtual (hypervisor based) form. The lack of an open interface in data transmission program causes that today's networks equipment be as seamlessly, closed and semi-central processor. Any other standard protocol on the network is not able to perform the functions of OpenFlow and the same protocol is necessary to control the network from outside the network switches and direct to the central logical controller software

At first, Load balancing began its role in the world of information technology as the network-based hardware of traffic load balancing and now, is a critical components of the Application Delivery Controller methods. After the primary application of Load balancing in the network, under-network advanced devices of Load balancer were the second significant use of them that actually played the role of the father of today's ADC methods. Since these devices were able to collaborate independently and outside of the application of programming servers, could properly perform the function of load dividing by using Straightforward techniques of the network. In fact, these devices were displayed the virtual address of the server to the outside world; so, when the user is communicating with the server to write their demand, could intellectual and automatically connect to the server via the best and low-traffic exiting path NAT servers also plays a vital role in this operation [6].

2.1 pervious studies

Here are some researches are evaluated on the subject of this study:

In [7], the author investigated the performance of SDN controller by using some existing policies for OpenFlow controller. The aim of this study is providing a better understanding of the performance of controller in SDN architecture for faster routing. This study shows that the performance is not an inherent limitations of SDN network and for proving it, a multi-threading controller called NOX-MT proposed which is the new version of NOX controller and this new design improves the performance of NOX controller for 30 times. NOX controller can set up a very low flow and to delay the startup time of very large flows. NOX-MT controller has been suggested to improve the drawbacks of NOX controller which has improved the response time and throughput of the NOX controller. NOX-MT Controller has use the known methods for improving the NOX controller which these techniques involve IO.Batching to reduce the overhead of I.O and ASIO techniques that simplify the multi-threading operations.

In [8], Floodlight controller which is one of the OpenFlow controllers, has been studied and its purpose is to show that how the lag time between OpenFlow switches and controller, impacts on routing performance. SDN basic concepts on control Plane accomplished through a centralized controller. A centralized controller is a single entity that is responsible for managing of all send devices. Floodlight controller is used in this article. The controller is a centralized controller that may lead to a single break point or scalability limitations. With increasing the Data Plane elements, this controller cannot provide a sufficient management on the network. Researchers are suggesting the development of several controllers for managing the network components.

In [9] a controller placement algorithm and routing traffic control in SDN networks are represented in order to maximize the possibility of traffic control in SDN networks. . Only one controller is employed in this architecture, so this method cannot be responsible for environments that require more than one controller. In this study, in order to enhance the reliability of communication pathway, we propose a multi-control placement algorithm between the switch and controller. As mentioned, in this study the number and location of controllers in the network will be effective on increasing the reliability.

3. The proposed method

To enhance the reliability and reduce the delay in a SDN network, we have presented a method based on controllers that is composed of several parts and are described below.

- Our proposed method is based on the OpenFlow structure.
- The static and distributed controllers are used in this method in a way that each controller, monitores a number of switches and the location of these controllers on the network is constant and static.
- The correctness part is distinct from the data transmission part.

The proposed architecture is that several distributed controllers as well as a central controller exist in the network that the function of central controller is to control the distributed controllers. The proposed architecture is in a way that the switches are clustered and each cluster is monitored by a controller and all these controllers managed and monitored by a central controller. The proposed architecture is shown in Figure 1.

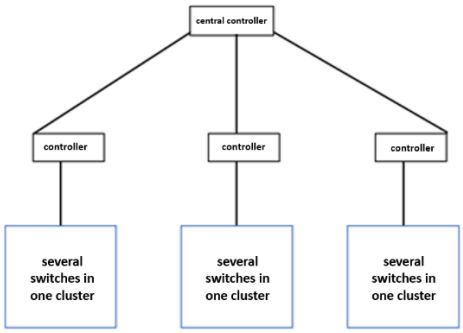

Fig. 1 The proposed architecture

3.1 Reducing the traffic of control

When a packet is going to send between the transmitter and receiver, a brief information of the receiver state and the data packet is placed in the static controller. This information includes the size of the package, the computational overhead state of receiver, etc. After receiving the package, central controller waits for the receiver to note that it has received the package. With this process, we separated the reliability and accuracy of the data from the traffic and data transmission parts that this separation has a considerable effect on reducing the traffic and delay. Our innovation in this part is the separation of communication link for exchanging the controlling data in the network that does not impose the traffic load on the network.

3.2 Reducing the delay

In the proposed method, we clustered the switches and a controller assigned to each cluster which this controller monitored the switches inside its own cluster and distributing the packages in the cluster in a way that does not increase the traffic and delay. The following metrics are used to send packets between the switches:

- Bandwidth
- The traffic
- The closest distance

Of course, one of the most important metric for the selection of the route is the criteria of stability. Before the study of the mentioned metrics, the criteria of link stability will examine and a link that has a high absolute number will not be selected for the connection, except when all stabile links cannot be used. In continuation, at first the criteria of closest path is selected for choosing the path and the next path will be replaced, If the traffic of the path be higher than the defined threshold and so on. For this mechanism, a fully dynamic formula is presented based on three above characteristics. This formula is presented a number between 0 and 1 for each link and the link will have a more chance for selection whatever the number be closer to one (1). The formula is as follows:

$$P=D+B+T$$

In this formula, D is the index of distance, T is the index of traffic and B is the index of bandwidth. As mentioned the metric of distance has more score and its value is a number between 0 to 0.5. Metrics of B and T have a value between 0 to 0.25. Each of these three items is calculated according to the following relations;

Calculation of parameter D

This parameter is related to the distance between the two switches that can be a number between 0 to 0.5. For calculating the minimum distance is considered 0.5 and the maximum distance is considered to be 0. With a coordination, the value of other links also can be obtained.

Calculation of parameter T

As mentioned, this parameter is related to traffic and the traffic state of all links is existing in the controller. This parameter has a value between 0 to 0.25 and the value of minimum traffic on the link, in the whole cluster is about 0.25. Based on this link and with a coordination, can calculate the value of T for other links.

Calculation of parameter B

This parameter represents the bandwidth and the speed of data transmission in a link and its value is a number between 0 to 0.25. As the previous two parameters, the highest bandwidth in the cluster is 0.25 and other links will be scored according to this link.

So, each cluster has a controller that can perfectly manage the path between the switches in the cluster to minimize the delay. The proposed model is described as an example in the following figure. Figure 2 indicates a cluster with a controller.

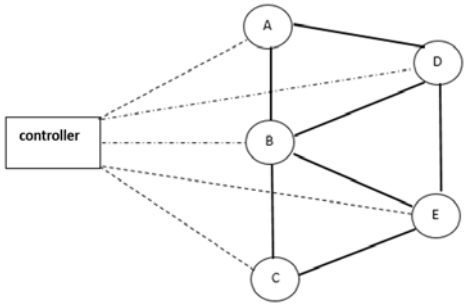

Fig. 2 clustering of switches with a central controller

The specifications of each link is as Table 1:

Table 1: Specifications of a communication link between two adjacent switches

	Distance (D)	Bandwidth (B)	Existing traffic (T)
A-D	25	2	15
A-B	20	3	18
B-D	30	1	22
B-E	30	0.5	14
B-C	20	2	20
C-E	30	1	19
D-E	30	2	14

The primary value of each of the three items for all links specified in the table above and based on these three values the final score (P) is calculated for each link which It can be seen in the table below:

Table 2: calculating the final score of each communication link between two adjacent switches

	D	B	T	P
A-D	0.4	0.16	0.21	0.77
A-B	0.5	0.25	0.19	0.94
B-D	0.33	0.08	0.15	0.56
B-E	0.33	0.04	0.25	0.62
B-C	0.5	0.16	0.17	0.83
C-E	0.33	0.08	0.18	0.59
D-E	0.33	0.16	0.25	0.74

The values of Table 2 obtained as follows:

As an example, for the criterion D in Table 1, the path of B-C has the shortest distance. Therefore, the value of D in Table 2 for this path is 0.5 because it is the closest path. Based on the distance of B-C which is 20, the value will be 0.5 and the coordination of the amount of D for the A-D path with a distance of 25, is equal to 0.4 which is obtained according to the following formula:

$D_{(A-D)}=(0.5*25)/20$

Similarly, the other values are calculated.

In the proposed model assumes that the links are one-way. In this cluster, any data that is going to exchange between the two switches, is managed by the controller and the way of sending is as following algorithm:

- At first, the transmitter and receiver are determined.
- The volume of the data which is going to send is determined.
- Pre-specified all the existing paths between the transmitter and receiver and the score of each path is computed. The score of each path is determined based on the score of links according to the following equation:

$$\boldsymbol{P_{ROUTING}} = \frac{\sum_{i=1}^{N} \boldsymbol{P_i}}{\boldsymbol{N}}$$

  In the above equation, Pi is the score of each link and N is the total number of links.
- The path which gets the highest score is selected and the packet will send from this pathway.
- During the sending, points table of links will update again for the switches which are involved in sending. This update will accomplish according to a specific timetable after the reduction of network traffic. As the SDN networks virtually run, in this part we will not have any worries about the computational overhead and we can minimize the effect of computational overhead on the system by allocating the appropriate memory.
- The algorithm is applied to all packets which are sent in the cluster.

For example, in Figure 1, A is going to send the data packet for switch E. The score of all pathways are shown in the following table according to table 2.

Table 3: the score of pathway between A and E

pathway	the score of pathway
A-D-E	0.75
A-B-E	0.78
A-D-B-E	0.65
A-B-C-E	0.78
A-D-B-C-E	0.68

In this table, calculating the score of pathway between A and E is equal to the average score of all links in the path.

3.3 Choosing the optimal pathway between two controllers

We use the central controller to choose the best pathway between two distributed controllers. The central controller determines which of the distributed controllers should be select in order to move the packages by their switches. To

reach this goal, should perform according to the following algorithm:

- There are several controllers, each consist of a number of switches
- A graph is formed in central controller
- Distributed controllers are the vertices of the graph
- If there is a connection between the switches of two controllers, a mane would form between the two vertices.
- Each mane has a numerical metric which is calculated based on three characteristics of bandwidth, traffic and the distance and indicating that how much time is required to move each package between the two vertices. This metric is calculated by the distributed controllers. The way of calculating this metric is described below.
- In central controller, a mane which has the most efficient state is selected between two nodes.
- If a cluster has a high rate of traffic delay, the controller will suspend and by this reaction sends an alarm to the central controller that is not able to receive the new package. So, prevents accepting more packages which cause delay.

According to mentioned topics, package always fairly distributed in the network and the algorithm acts in a way that always chooses the best and low-latency path.

3.3.1 How to calculate the score of the link between two controllers

As mentioned earlier, stability is one of the important factors for choosing the path and to choose the path, at first, stable links will examine and links with low stability do not enter to the selection process. Calculation the score of each link according to three criteria: distance, bandwidth and traffic is based on the following relation:

E=D+B+T

In this relation, D is the distance, B is the bandwidth and T is the traffic. The amount of these three variables is as follows: the metric of D is a number between 0 and 0.5 and the value of B and T is any number between 0 and 0.25. So, the value of E is a number between 0 and 1. The link will have a more chance for selection whatever the number be closer to one (1). Each controller (whether distributed or central) is cognizant of the conditions of the links which attached to the controller. Each of the three factors is calculated by the following equation, as similarly and completely dynamic.

Calculation of distance D

In this factor, the standard minimum distance in the graph is 0.5 and according to this link, the value of other links is calculated based on the following equation:

D(x-y)=(d*0.5/Di)

In this equation, Di is the distance between two switches of X and Y and d is the shortest distance in the graph.

Calculation of Traffic (T)

The minimum value of the traffic in a link is 0.25 and according to it, the value of other links is calculated based on the following equation:

T(x-y)=(t*0.25/Ti)

In this equation, Ti is the traffic between two switches of X and Y and t is the lowest traffic in the graph.

Calculation of bandwidth B:

The highest existing bandwidth is 0.25 and according to this link, the score of bandwidth in other links, is calculated based on the following equation:

B(x-y)=(b*0.25/Bi)

In this equation, Bi is the bandwidth between two switches of X and Y and b is the maximum bandwidth in the graph.

3.4 choosing the path

After the scoring of all links and determining the transmitter and receiver, all pathways in the network between the transmitter and receiver will check based on the scoring and the pathway with the highest score will be selected for data transmission. For calculating the score of pathway, total score of all links in the path divided by the number of links, according to the following formula:

$$P_{ROUTING} = \frac{\sum_{i=1}^{N} P_i}{N}$$

In the above equation, Pi is the score of each link and N is the total number of links. If we have several paths with the same score, the packages will divide between the paths with the same score.

4. Evaluation

Certainly one of the most important parts of research is simulation and comparison of methods. In this part of assessment, the proposed method simulated by using MATLAB software. The proposed method is evaluated by a number of important factors with method [11]. In the paper [11], two items of distance and traffic has been used for load distribution which according to the distance between the source and destination and the traffic,

calculate the duration of arriving the package in the different pathways and also, place the package in the pathway that has the least time. The fair distribution of the load is the advantage of this method but has a high computational overhead which leads to delaying. The conditions of stimulation are as follows:

- The number of variable switches ranging from 20 to 100
- The distance switches minimum 10 and maximum 40 m
- Power of switch is unlimited
- The bandwidth from 2m to 10m which is specified
- The topology of network is as Mesh
- The number of controller is variable

In all cases, the stimulation is variable and the simulation was run for several times and the average of the results is compared with each other.

4.1 The criteria of delay

The criteria of delay is one of the most important criteria for evaluating the proposed method. In this case, the number of controllers in the network and also, the number of sent packets is invariant but the number of switches is variable. In this approach, switches are placed randomly on the net then clustering is performed and a transmitter and receiver randomly will be selected for each package. With finishing the number of packages, the delay is calculated on the entire network. The result of simulation is shown in Figure 4.

As the chart shows, the proposed method has the less delay.

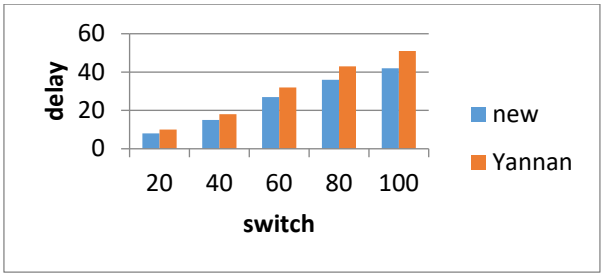

Fig. 4 calculation of delay with variable number of switch

4.2 Rate of transmission

Another criteria of evaluation is the calculation of the correct rate of sending. It is so important to know that how percentage of the sent packets would properly arrive to the destination. To calculate this factor, the scenario of simulations is as below:

- The number of switches is variable
- The number of controllers is fixed
- The number of sent package is fixed
- The transmitter and receiver are selected randomly

After selecting the transmitter and receiver, specified number of packets will be sent at each period. After completing this process, the correct rate of sending and receiving will calculate. The result is visible in Figure 5.

As the result of simulation shows in Figure 5, the proposed method consists of the higher rate because in each step of transmission, the best possible option is selected and this will cause that the packets arrive at their destination with greater reliability.

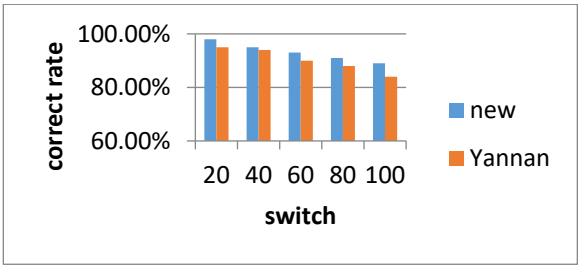

Fig. 5 the correct rate of sending with a variable number of switch

4.3 The equitable distribution of load

The next criteria for evaluating the proposed method is the load distribution and the traffic of network on the links. Whatever the traffic is fairly distributed, the network would have a better performance. For this factor, the scenario of simulations is as below:

- The number of switch is variable
- The number of controllers is fixed
- The number of sent package is fixed
- The transmitter and receiver are selected randomly

The average of the load distribution in links is shown in Figure 6. To calculate the load distribution, the difference between the highest and lowest load is indicated. Simulation shows that the proposed approach has a better distribution because at each step, acts in a way that cause the traffic distributes fairly.

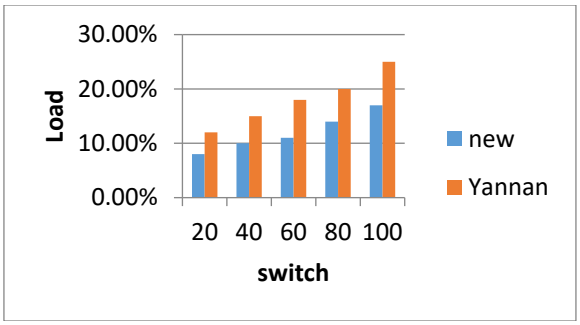

Fig. 6 The rate of load distribution with a variable number of switch

5. Conclusion

In this paper, we presented a novel method of routing in order to increase the efficiency of the SDN network which based on the clustering of switches by controllers. In this method, each controller includes a number of switches in its own cluster and to choose the pathway, we used some metrics such as stability, traffic, distance and bandwidth. By studying these factors, always the best pathway between the transmitter and the recipient will be selected. The results of simulation and comparison show that the proposed method has an acceptable performance.

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