1 INTRODUCTION

As the size of networks continues to increase, the scalability of the centralized controller becomes increasingly issues in Software Defined Networking. Distributed controllers have been proposed to solve the problem. However, such distributed architecture introduces a new challenge to the load re-balancing of controllers when uneven load distribution among the controllers due to the statically configured mapping between a switch and a controller. Therefore, under variable traffic conditions in real networks, keeping load balance dynamically among the controller clusters is essential for realizing a high performance and scalability control plane.

To address these issues, we proposed a dynamic load balance method based on switch migration mechanism for clustered controllers. The switch migration is a mechanism that two controllers handover their roles for one switch to change the number of connected active switches in order to migrate the switch traffic from one controller to another controller. We implemented a prototype system based on the Open source SDN controller OpenDaylight [1] to evaluated the performance of our design. The result shows that the method enables controllers to relieve the overload via switch migration and can improve throughput and reduce the response time of the OpenFlow control plane.

2 BACKGROUND

OpenFlow [2], is one of the mostly representative protocol for SDN, the message called packet-in is the most fundamental features of it. The massive packet-in message which from data forwarding plane to control plane can make the controller heavily-load. Some work [3] has proposed physically distributed control plane to relieve the packets load. However, the distributed controllers method introduces a new problem that load imbalance among controllers which would result in suboptimal performance. OpenFlow 1.3 version specifies three roles for a controller: MASTER, SLAVE and EQUAL. However, each controller only has one role that means there is only one master controller in one cluster and in this way still can not shift the load among the controllers. Furthermore, how to coordinate the role changing among the multiple controllers is not provided. [4] proposed a mechanism to dynamically migrate switches among multiple controllers using the role-request message of OpenFlow 1.3, however, the seamless migration of a switch case complex communication between controllers. The detail of how to estimate the load of controller and whether support controller failover are also not described in the work.

3 PROPOSED METHOD

The proposed method has three advantages. First, the different controllers can be set master role for individual switch, according to the feature, we can dynamically shift the load across the multiple controllers by switch migration to avoid a particular controller overloading. Second, we use distributed architecture to avoid the single point of failure problem and support the crash-tolerant for controllers in the event of the controller failure. Finally, our method provide a simple management for controllers and switches by grouping the network.

In this framework, shown in Fig.1, the whole network is divided into several groups according to the geographical distance. Each group is set up multiple controllers, which called the local controller cluster. In each group, the switches establish communication with the local controller cluster. The local controller cluster performs load scheduling and according to the load conditions of controllers, to coordinate switch migration which one controller can change the number of connected active switches by
changing its role for a certain switch. All the local cluster make up a big controller cluster, which we called the global controller cluster, to provide the global view of network to the upper controller.

The controller structure is implemented based on an Open source SDN controller OpenDaylight. It contains three modules:

- Load monitoring module collects and calculates controllers load periodically.
- Load scheduling module According to the load conditions of controllers to decides which controller should be elected as master to receive load shifting and when to perform the switch migration.
- Switch migration module is responsible for coordinating actions for switch migration.

4 EVALUATION

We evaluate the performance of the proposed method compared with a switch-controller static mapping model.

4.1 Throughput

From the result as illustrated in Fig. 2, we observe that in static mapping model, the mean throughput of controllers decreases under workload B and sharp decreases under workload C. We also plotted the difference value of two controllers. When the difference value of load is greater than a threshold value, the switch migration is triggered. Controllers dynamically change the number of connected active switches to achieve load balancing.

4.2 Response Time

Figure 3 plotted the response time CDFs of OFC B fixing the load level. The response time increases marginally up under workload B and goes up higher under workload C. In static method, only about 25 percent of ping replies arrived in 5ms, while in the proposed can achieve more than 70 percent. That is because once the packet interval rate exceeded the capacity of the controller, queuing causes response time to shoot up. We also noticed that packet begin to loss due to the overload.

5 CONCLUSION

The load imbalance among controllers results in suboptimal network performance. To address this problem, we propose a scalable and crash-tolerant load balancing based on switch migration for multiple OpenFlow controllers. According to the load conditions of controllers, our proposed method enables the controllers coordinate actions to dynamically shift the load across the multiple controllers through switch migration which also support the controller failover. The result of evaluation showed that compared with the traditional static mapping, our method can improve the resource utilization of controller cluster, and improve the throughput and response time of control plane.

参考文献