

분산 SDN 컨트롤 계층의 스위치 마이그레이션 기반 부하 분산 기법 분석

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Switch-migration based Load Adaptation Mechanisms in Distributed SDN control plane

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Abstract

The software defined Networking (SDN) paradigm separates the control plane and data plane and manages the operations of switches in its domain. Techniques such as Switch-migration (SM) and dynamic assignments between switch and controller are used in order to balance the load over distributed SDN controllers. This paper reviews the SM based load adaptation mechanisms and highlight the necessary things to consider in existing control plane load monitoring and load adaptation processes.

I. Introduction

The growth of data traffic and ever-increasing use of mobile devices in modern internet basically challenge the conventional internet architecture. Traditional networking infrastructure requires manual configuration changes to adjust the particular networking policy. Such manual modification impacts the required level of the Quality of Service (QoS) or Quality of Experience (QoE) in today expanding networks.

On the other hand, recent Software Defined Networking (SDN) paradigm offers programmability to network by separating the control logic from networking devices and facilitates the automatic and adaptive control approach. An SDN network is composed of set of switches and centralized controllers. Switches in the data plane stores flow rules (e.g. forwarding state) and delivers packets according to the rules. The request, PACKET_IN message, is sent from switches to controller to install the rules when new flows arrive.

Since network traffic varies with time and space, distributed controllers with static configuration limits the capability of controller load adaptation in dynamic environment. Moreover, if the switch to controller mapping is static, a controller may become overloaded when the switches mapped to this controller suddenly observe many flows, while other controllers remain underutilized. Over provisioning controllers is one way to solve this issue. However, it is a costly solution and not a feasible one to address the issue. Another alternative is migrating switches from overloaded

controller to underloaded controllers, but well-defined design is needed in migration process in order to fully utilize the available resources.

Despite load balancing, SM based mechanisms raises many challenges including cascaded load imbalance and sub-optimal load balancing issue if there is no well-designed solution. In this paper, we first review the previous SM techniques along with their load imbalance detection and adaptation decision process and then we discuss the monitoring and load adaptation phases of SMs and highlight the issues that we need to consider to construct robust SM mechanism.

II. Related Works

In the literature, Jie et. al [1] addressed the issue of static configuration of switch-controller mapping based on the response time delay of controller PACKET_IN message processing latency. The proposed solution can provide balanced load in the control plane, but the delay of response time is directly proportional to the link state and network condition. Cheng et. al [2] randomly select a switch from overloaded controller when uneven load distribution occurs. PACKET_IN event on the controller is considered as the load of controller in their approach. With random selection of switch in load adaptation phase, their proposed scheme might lead to new load imbalance after migration. Wang et. al. [3] pursued multiple controller load balancing with migration efficiency model, however, it has sub-optimal load balancing performance because of long load-balancing time by comparing every switch from

overloaded controller to new one to maximize the migration efficiency, which might cause new load imbalance. Zhou et al. [4] proposed switch group migration decision for load balancing. In which, switch group are selected whose load is nearest to the overloaded controller minus network average in order to maximize the network utilization. However, it increases the migration cost because of extra unnecessary migration of switches.

III. Discussion

The recent version of OpenFlow protocol [5] proposed that each switch can be controlled by multi-controllers with three different roles: master, equal, and slave. Nevertheless, there is no suggestion for specific mechanism of SM or controller role changes in the protocol. Therefore, existing SM techniques construct their own designs with different considerations for load imbalance detection and SM process.

In general, SM based control plane load balancing techniques can be identified with two main phases: (i) monitoring the load imbalance status of control plane, and (ii) performing load adaptation with dynamic switch-controller mapping. In the monitoring phase, most of the existing solutions [1-4] collect the PACKET_IN frequency to measure the controller load. Since the controller plane is physically distributed, communication between controllers via East/West bound APIs is performed to guarantee the strong consistency of global controller view. These loads may vary with SM happening in the today's dynamic network. Therefore, SM techniques need to monitor more types of loads in the control plane load detection.

Furthermore, monitoring data stored in SDN controller should be fresh to obtain the valuable insights for load adaptation decision making process in timely manner. Previous SM mechanisms used the monitor data from default controller storage. For example, Floodlight controller provides snapshots statistics by default, which does not guarantee the freshness of data. Moreover, OpenDayLight (ODL) controller provides distributed datastore architecture which store the data into shards and cluster member maintains a subset of shard. Therefore, SM techniques used with ODL controller must access the global network view of control plane with many intra-controller traffic in the cluster. One way to guarantee the freshness of data is directly access the data via the OpenFlow counters. Since OpenFlow [5] provides several counters to access the information of data plane, we can take the advantage of the counters in data acquisition process. However, frequent collection of data might impact the southbound network traffic between the control and data plane. As a result, comprehensive controller load measurement with fine-grained monitoring is necessary in building efficient SM techniques.

The load adaptation phase of SM techniques starts with deciding which switches should be migrated to which controllers. Most of the existing SM techniques

select the heavy switch from overloaded controller and directly migrate the switch to underloaded one. It is necessary to care about this situation because cascaded load imbalance might occur after migrating heavy switches by just shifting them to the underloaded controller.

Before migration, we can consider the more types of moves, but this can lead to long load balancing time. Instead of directly shifting the switch to underloaded controller, swapping the switches between controllers can also avoid the problem of cascaded load imbalance. Therefore, optimal switch-controller mapping is also important in designing robust SM based load adaptation technique.

As a result, careful consideration of monitoring data and migration mechanism is needed in the design of efficient SM. In this paper, we presented the SM mechanisms with different identifications of load imbalance detection and adaptation decision. Our study focus on the two main phases of existing SM based load balancing in the control plane. We make thorough discussion for these two phases in order to get useful insight in SM. With these considerations in mind, we intend to explore efficient SM based dynamic load adaptation technique as part of future work.

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References

- [1] J. Cui, Q. Lu, H. Zhong, M. Tian and L. Liu, "A Load-Balancing Mechanism for Distributed SDN Control Plane Using Response Time," in *IEEE Transactions on Network and Service Management*, vol. 15, no. 4, pp. 1197-1206, Dec. 2018, doi: 10.1109/TNSM.2018.2876369.
- [2] G. Cheng, H. Chen, Z. Wang, and S. Chen, "DHA: Distributed decisions on the switch migration toward a scalable SDN control plane," in *Proc. IFIP Netw. Conf. (IFIP Netw.)*, May 2015, pp. 1- 9.
- [3] C. Wang, B. Hu, S. Chen, D. Li, and B. Liu, "A switch migration-based decision-making scheme for balancing load in SDN," *IEEE Access*, vol. 5, pp. 4537- 4544, 2017.
- [4] Y. Zhou, Y. Wang, J. Yu, J. Ba, and S. Zhang, "Load balancing for multiple controllers in SDN based on switches group," in *Proc. 19th Asia-Pac. Netw. Oper. Manag. Symp. (APNOMS)*, Sep. 2017, pp. 227- 230.
- [5] OpenFlow Protocol version 1.4.0. [Online] Available:<https://www.opennetworking.org/images/stories/downloads/sdn-resources/onfspecifications/openflow/openflow-spec-v1.4.0.pdf>