Scalability Analysis and Flow Admission Control in Mininet-based SDN Environment

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***Abstract*—In this demo, we provide a Mininet-based Software-Defined Network (SDN) simulation environment that improves the total flow throughput and scalability of the overall network. $Mininet$ is a suitable and manageable tool to implement the proposed SDN based flow admission control module in order to configure the entire topology since it has already built in OpenFlow switches and virtual controllers. This open-source platform is also easily configurable via its drag and drop capabilities. In this Demo, for the Control Plane, $OpenDaylight$ controller is used in order to simulate flow admission control module that fairly admits flows into the OpenFlow switches. $OpenFlow\ version$ 1.3. for communication between separated Data and Control plane and $Linux$ based operating system to build $Mininet$ 2.1.0 are deployed in the simulator environment.**

Keywords*—*Software-Defined Networking, Mininet, Flow Admission Control, Scalability

I. Introduction

The rapid proliferation on global IP data traffic has stressed conventional networks [1]. Because of the limited components in the current physical topology; the performance of a traffic flow in terms of throughput has extremely decreased after certain scalability level. Due to the enhancing overall network throughput without any alteration on the physical topology, dynamic network management has become crucially important for effective network maintenance.

However, in all the current conventional core and access networks, there is no worldwide accepted dynamic network management that admits flows fairly to switches. Moreover, the conventional network does not have global view in order to keep flows in acceptable throughput level as the number of flow increases. Therefore, it cannot serve more flows and users after certain scalability level.

SDN redefines this current problematic network management by separating Data Plane and centralized Controller in Control Plane [2]. Thanks to global view of SDN, requirement and current flow load of each switch could be known. Therefore, newcomer flows could be distributed in a fairer way. This would keep each flow throughput at acceptable levels and also increase network scalability against more flow arrivals.

In the literature, there are many studies that try to examine and improve network management in order to obtain higher flow performance and scalability throughout the overall topology. In [3], an information-theoretic framework is proposed in order to manage network by recovering from non-ergodic link failures by using graph theory network models. In [4], a novel heterogeneous flow admission control is proposed, that minimizes the total flow-blocking rate. In this study, the authors focus on static-state bandwidth load in terms of bandwidth usage by a smaller class of flow than a newcomer flow. In [5], the authors indicate advantages of SDN that overcomes this challenge. They introduces global view and virtualization properties of SDN for network management and configuration methods in terms of four control domains such as time, data usage, authentication status, and traffic flow. However, these aforementioned studies could not handle more flows after certain scalability level, because they do not have global view on topology.

Simulation techniques are commonly used in network management to observe the behavior and the characteristic of a system before its deployment. With this motivation, in this demo, the proposed SDN system is run on a suitable Mininet testbed environment to observe improvement on both flow performance and overall network scalability. $Mininet$ is a freely-available simulation tool for SDN systems that contribute research and education in this area. This tool provides a simulated network environment with network equipment and also enables software implementations on the topology using an SDN controller such as OpenDaylight or Floodlight. [6] describes the SDN components on Mininet simulation tool with Floodlight controller. They assert that performance of the tool is strongly devoted to real environment results. [7] also states the effectiveness of Mininet especially on time and resources according to prototyping, deployment and sharing. Moreover, it is effortless because of easily building topology via drag and drop capability.

Consequently, in this Demo, the following contributions are proposed to enhance flow performance of the overall network:

- Implementation of the Data Plane and Control Plane via Software-defined networking approach.
- Provision of a dynamic flow admission control module that run in Controller side by fairly distributing newcomer flows into OpenFlow switches.
- Usage of Mininet as a testbed environment to maintain a considerable time, effort, budget for SDN simulations and to give real environment results.

II. Proposed System Architecture

In order to control flow admission via global view without any alteration on physical topology, we propose an SDN

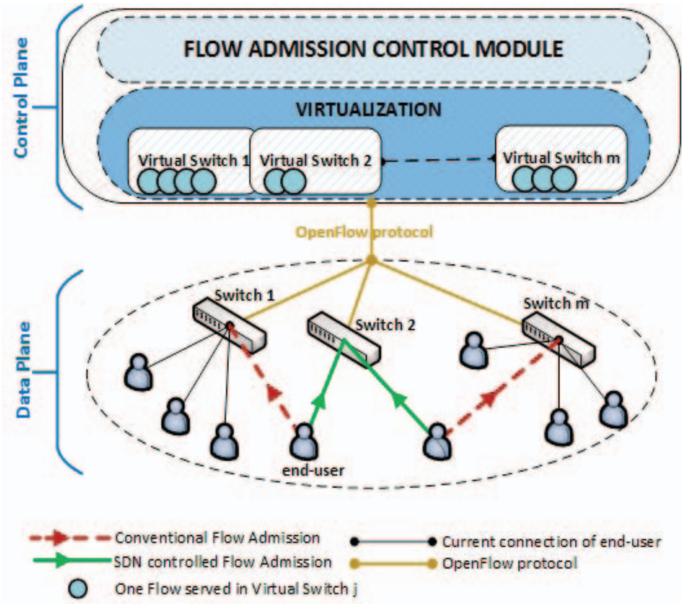

Fig. 1. Proposed Software-Defined Network (SDN) Architecture

system as seen in Fig.1. The system model has two main components named as $Data\ Plane$ and $Control\ Plane$. In Data Plane, there exists m OpenFlow switches corresponding end-users which have wired connection (each end-user has wired connection to each OpenFlow switch). These dummy OpenFlow switches has only forwarding capability that serve end-users by forwarding their traffic flows. In Control Plane, there are two main sublayers named as $Virtualization$ and $Flow\ Admission\ Control\ Module$. In Virtualization sublayer, there are m virtual representaters of physical switches. These are implemented by using $Mininet$ test-bed environment as details given in Section III. the Flow Admission Control Module runs embedded algorithm that considers flow throughput according to predefined threshold. Newcomer flows are admitted to switches according to flow load of OpenFlow switches. Therefore, both scalability of system would increase and performance of each flow can be kept over acceptable levels via SDN controlled dynamic flow admission approach.

In this demo, the difference between conventional and SDN controlled fair flow admission approach is emphasized clearly as exemplified in Fig.1. The conventional one is performed by static admission without considering flow load of switches as given dashed-lines. On the contrary, in SDN controlled method, $Flow\ Admission\ Control\ Module$ admits flow of end-users according to expected throughput and load of switch as given solid-lines. Therefore, traffic flows from end-users could be fairly distributed overall network topology.

III. Demo Description

As shown in Fig. 2, an example topology scenario has drawn and run on $Mininet$ 2.1.0 over $Linux$ operating system environment to simulate proposed SDN based flow admission control system. We have one Controller that has global view over physical topology. $OpenDaylight - Helium$ version is used for the controller. There are 6 OpenFlow switches that

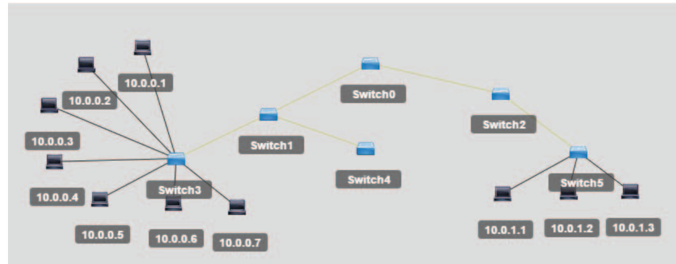

Fig. 2. An Example Scenario Screenshot taken from Mininet Simulator

have wired connection with Controller. There are 10 end-users (called host in Mininet) that have wired connection to each OpenFlow switches. At the initial topology; for Switch 3, there are 7 end-users and for Switch 5, there exists 3 end-users that are currently admitted, and Switch 4 has no host. After the SDN based fair flow admission control approach is run, all flows are fairly admitted to these OpenFlow switches. In order to provide communication between Controller and OpenFlow switches, we use $OpenFlow$ 1.3. protocol as secure-channel.

As the number of flow is increased one by one by initially starting mentioned example topology seen in Fig.2, the alteration on flow throughput is examined in both conventional and SDN controlled flow admission approaches. In the conventional approach, flow load of OpenFlow switches is not considered while arriving new flows to networks. Therefore, the load of switch becomes high levels and this brings about lower throughput per flow in OpenFlow switches. We observe that both throughput per flow and scalability of topology are under acceptable level with conventional approach. On the contrary, in proposed SDN approach, the newcomer flows are admitted to another switches that has low load. Therefore, the proposed system keeps flow throughput at acceptable level and scalability of topology can reach higher levels.

References

[1] "Visual Networking Index Report: Forecast and Methodology, 2014–2019," Cisco, Tech. Rep., 2015.

[2] A. Lara, A. Kolasani, and B. Ramamurthy, "Network Innovation using OpenFlow: A Survey," *IEEE Communications Surveys Tutorials*, vol. 16, no. 1, pp. 493–512, First 2014.

[3] T. Ho, M. Medard, and R. Koetter, "An information-theoretic view of network management," *IEEE Transactions on Information Theory*, vol. 51, no. 4, pp. 1295–1312, April 2005.

[4] M. Kawano, S. Miyata, and K. Yamaoka, "A Basic Study of Heterogeneous Flow Admission Control Based on Equality of Flow Classes," in *2010 7th IEEE Consumer Communications and Networking Conference (CCNC)*, Jan 2010, pp. 1–3.

[5] H. Kim and N. Feamster, "Improving network management with software defined networking," *IEEE Communications Magazine*, vol. 51, no. 2, pp. 114–119, February 2013.

[6] R. de Oliveira, A. Shinoda, C. Schweitzer, and L. Rodrigues Prete, "Using Mininet for emulation and prototyping Software-Defined Networks," in *2014 IEEE Colombian Conference on Communications and Computing (COLCOM)*, June 2014, pp. 1–6.

[7] B. Lantz, B. Heller, and N. McKeown, "A network in a laptop: Rapid prototyping for software-defined networks," in *Proceedings of the 9th ACM SIGCOMM Workshop on Hot Topics in Networks*, ser. Hotnets-IX. New York, NY, USA: ACM, 2010, pp. 19:1–19:6. [Online]. Available: http://doi.acm.org/10.1145/1868447.1868466