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LOAD DISTRIBUTION ANALYSIS ON BIPARTITE TOPOLOGY USING FLOODLIGHT CONTROLLER

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ABSTRACT

First-hop redundancy is a technique used in access layer where multiple gateways is deployed in case of a failure, thus increasing availability and reliability of the Internet. Load balancing is often plays a significant role for this technique to properly utilized every gateway in the network. In this paper, we tested the redundancy and load balancing application of Floodlight controller, in a network with bipartite topology simulated by Mininet. The evaluation is done by measuring QoS while sending various traffics through the network such as UDP Flow, Telnet, DNS and VoIP from which show that further optimization is still needed.

Keywords: Network Redundancy, Load Distribution, Floodlight Controller, Bipartite Topology, Software Defined Network

1. INTRODUCTION

In 2008, UC Berkeley and Stanford University developed a concept of a centralized control system to manage devices on a network infrastructure known as Software Defined Network [1]. The basic concept of Software Defined Network is by explicitly separating between a forwarding plane, which remains on the network devices to forward data, and a control plane which is in a separate entity called the controller [2]. The controller allows network administrator to program a network infrastructure without direct configuration on each physical network devices. Software Defined Network has the ability to maximize the utilization of network devices, such as bandwidth optimization, load balancing, traffic engineering, and other programmable stuff [3].

In order for the controller to work optimally, it needs an alternative path/multiple gateways to redirect the traffic in case of a link failure to maintain its performance and availability (network redundancy) [4][5]. Load balancing is also needed to maximize the utilization of each available gateway.

Similar work has been done [5], in which the authors used Pox controller in bipartite topology as shown in Figure 1 with random number of gateways (L1) between 1-4 and also random

number of host-connected switches (L2) between 1-8 despite the limitation of recursive function in the Pox controller. In this paper, we chose a different controller (Floodlight) as an attempt to get rid of limitation, and to see whether the performance of the network will be affected or not. The same topology is used, but the number of L1 and L2 assigned is selected from 2-4 switches. The evaluation is done by measuring Average Delay, Average Jitter, Average Bit Rate, Average Packet Rate and Packet Success Rate while sending various traffics through the network such as UDP Flow, Telnet, DNS, and VoIP.



Figure 1: Bipartite Topology [4][6]

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2. SOFTWARE DEFINED NETWORK

Software Defined Network is a centralized system that separates the control plane and data plane [1]. The basic concept of Software Defined Network is to explicitly separating between a control plane and forwarding plane. The forwarding plane remains on the network devices, while the control plane is in a separate entity called the controller, differs from a traditional network. [2].

3. OPEN FLOW

The first concept of OpenFlow first developed at Stanford University in 2008. OpenFlow is the first standard communication protocol between control plane and forwarding plane/data plane on the SDN network architecture. Version 1.0 of OpenFlow was released in Desember 2009 [7]. OpenFlow is currently managed by Open Networking Foundation (ONF), and user-based organization dedicated to open standards of Software Defined Network [8][9]. OpenFlow network consists of one or more OpenFlow switches and one or more controllers with Secure Channel connection between them [10].

4. NETWORK REDUDANCY AND LOAD BALANCING

Redundancy an alternative path/multiple gateways to redirect the traffic in case of a link failure to maintain its performance and availability [5][11], while load balancing is a technique to distribute traffic on two or more data paths in a balanced way, thus maximize the utility of each gateway [12] [13].

5. FLOODLIGHT CONTROLLER AND MININET

Floodlight controller is an enterprise-class OpenFlow controller that is apache-based and Javabased, supported by Big Switch Networks [14] [15]. Mininet is a Command Line Interface (CLI) emulator that is used to emulate a network topology on Software Defined Network environment [16].

6. RESEARCH METHODOLOGY

In this paper, we tested a built-in load balancer function of Floodlight controller in a network with bipartite topology. The number of gateways and host-connected switches is randomly selected from 2-4 switches, with different bandwidth assigned on each link. Several types of traffic, including UDP Flow, Telnet, DNS, and VoIP is sent through the network while Average Delay, Average Jitter, Average Bit Rate, Average Packet Rate and Packet Success Rate of each traffic is measured. For UDP Flow, a traffic is sent to destination host/protocol with UDP protocol, with constant rate: 1000 packet / s for 15000ms.

For VoIP, a traffic is sent to the host/server using Voice Codec G.711.2, VAD: Si, Frame size: 80, and number of packet / s: 20.

For Telnet, a traffic is sent to destination host/protocol with UDP protocol, with constant rate: 1000 packet / s.

For DNS, a traffic is sent to the destination host/server with UDP protocol, with constant rate : 1000 packets / s.

The tools that has been used to run the proposed scheme in this paper are:

- 1. OS Linux Ubuntu 14.04 LTS
- 2. VirtualBox
- 3. Mininet
- 4. Floodlight Controller
- 5. D-ITG

7. ARCHITECTURE OF SYSTEM

The system is based on Software Defined Network architecture as shown in Figure 2.



Figure 2: Architecture Of System [4][6]

We use programmable switches that support OpenFlow 1.3 as a standard communication protocol with a connected Software Defined Network controller (Floodlight), with Ethernet network facilitate the connection between switches. The IP address of the gateway and other network interfaces outside of the network are stored in the controller, thus each switch does not have IP address on its own.

Hosts on this system can be client computers, servers, and other end-user devices. The IP address is assigned by the Dynamic Host Configuration Protocol (DHCP) that is run by the controller. The assigned IP address is limited to only one subnet in <u>15th March 2018. Vol.96. No 5</u> © 2005 – ongoing JATIT & LLS

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layer 2 (L2) network broadcast multi-access ethernet with the switches act as a relay between the host and the controller in the discover-offerrequest of DHCP process.

Finally we propose a scheme to test the load balancer function in various types of bipartite topology, such as:



Figure 3: Topology L1=2 And L2=2

Figure 3 shows a bipartite topology with 2 gateways and 2 host-connected switches running in Mininet.



Figure 4: Topology L1=2 And L2=3

Figure 4 shows a bipartite topology with 2 gateways and 3 host-connected switches running in Mininet.



Figure 5: Topology L1=2 And L2=4

Figure 5 shows a bipartite topology with 2 gateways and 4 host-connected switches running in Mininet.



Figure 6: Topology L1=3 And L2=2

Figure 6 shows a bipartite topology with 3 gateways and 2 host-connected switches running in Mininet.

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Figure 7: Topology L1=3 And L2=3

Figure 7 shows a bipartite topology with 3 gateways and 3 host-connected switches running in Mininet.



Figure 8: Topology L1=3 And L2=4

Figure 8 shows a bipartite topology with 3 gateways and 4 host-connected switches running in Mininet.



Figure 9: Topology L1=4 And L2=2

Figure 9 shows a bipartite topology with 4 gateways and 2 host-connected switches running in Mininet.



Figure 10: Topology L1=4 And L2=3

Figure 10 shows a bipartite topology with 4 gateways and 3 host-connected switches running in Mininet.



Figure 11: Topology L1=4 And L2=4

Figure 11 shows a bipartite topology with 4 gateways and 4 host-connected switches running in Mininet.

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8. THE RESULT OF EXPERIMENTS

The evaluation is done by measuring Average Delay, Average Jitter, Average Bit Rate, Average Packet Rate and Packet Success Rate in a bipartite topology with different combination of gateways and host-connected switches assigned while sending various types of traffic, such as:

8.1 UDP Flow

For UDP Flow, a traffic is sent to destination host/protocol with UDP protocol, with constant rate: 1000 packet / s for 15000ms.

8.1.1 Average Delay



Figure 12 shows a trend where the number of gateways and host-connected switches are proportionate to the increased delay. However, when L1=3, the delay is oddly decreasing in contrast to the increasing number of gateways assigned.





Figure 13: UDP Average Jitter

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Figure 13 shows a trend where the number of gateways and host-connected switches are proportionate to the increased jitter with an exception of fluctuation shown from L1=3, L2=1 to L1=4, L2=1. The jitter decreased from 0.043 to 0.03, increased to 0.035, and decreased again to 0.031.

8.1.3 Average Bit Rate



Figure 14: UDP Average Bit Rate

Figure 14 shows a trend where the number of gateways and host-connected switches are proportionate to the decreased bitrate, with an exception of increased value to 3148,595089 Kbit / s at L1 = 3 and L2 = 4.



8.1.4 Average Packet Rate

Figure 15: UDP Average Packet Rate

Figure 15 shows a trend where the number of gateways and host-connected switches is proportionate to the decreased packet rate.

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8.1.5 Packet Succes Rate

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Figure 16: UDP Packet Success Rate

Figure 16 shows that all UDP Flow packets are successfully sent in any topology with different combination of L1 and L2.

8.2 VoIP

For VoIP, a traffic is sent to the host/server with Voice Codec G.711.2, VAD: Si, Frame size: 80, number of packet / s: 20.

8.2.1 Average Delay



Figure 17: VoIP Average Delay

Figure 17 shows a trend where the number of gateways and host-connected switches are proportionate to the increased delay.

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8.2.2 Average Jitter



Figure 18: VoIP Average Jitter

Figure 18 shows a trend where the number of gateways and host-connected switches are proportionate to the increased jitter.

8.2.3 Average Bit Rate



Figure 19: VoIP Average Bit Rate

Figure 19 shows shows a trend where the number of gateways and host-connected switches are proportionate to the decreased bit rate.

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8.2.4 Average Packet Rate



Figure 20: VoIP Average Packet Rate

Figure 20 shows a trend where the number of gateways and host-connected switches is proportionate to the decreased packet rate.



8.2.5 Packet Success Rate

Figure 21: VoIP Packet Success Rate

Figure 21 shows that all VoIP packets are successfully sent in any topology with different combination of L1 and L2.

8.3 Telnet

For Telnet, a traffic is sent to destination host/protocol with UDP protocol, with constant rate: 1000 packet / s.

8.3.1 Average Delay

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Figure 22 : Telnet Average Delay

Figure 22 shows a trend where the number of gateways and host-connected switches are proportionate to the increased delay, with an exception of decreasing value from 0.121 ms (L1=3, L2=2) to 0.119 ms (L1=3, L2=3)

8.3.2 Average Jitter



Figure 23: Telnet Average Jitter

Figure 23 shows a trend where the number of gateways and host-connected switches are proportionate to the increased jitter.

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8.3.3 Average Bit Rate



Figure 24 : Telnet Average Bit Rate

Figure 24 shows a trend where the number of gateways and host-connected switches are proportionate to the decreased bit rate.





Figure 25 : Telnet Average Packet Rate

Figure 25 shows a trend where the number of gateways and host-connected switches is proportionate to the decreased packet rate.

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8.3.5 Packet Success Rate



Figure 26 : Telnet Packet Success Rate

Figure 26 shows that all Telnet packets are successfully sent in any topology with different combination of L1 and L2.

8.4 DNS

For DNS, a traffic is sent to the destination host / server with UDP protocol, with constant rate: 1000 packets / s.

8.4.1 Average Delay



Figure 27 : DNS Average Delay

Figure 27 shows a trend where the number of gateways and host-connected switches are proportionate to the increased delay.

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8.4.2 Average Jitter



Figure 28 : DNS Average Jitter

Figure 28 shows a trend where the number of gateways and host-connected switches are proportionate to the increased jitter.



8.4.3 Average Bit Rate

Figure 29 : DNS Average Bit Rate

Figure 29 shows a trend where the number of gateways and host-connected switches are proportionate to the decreased bit rate.

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8.4.4 Average Packet Rate



Figure 30 : DNS Average Packet Rate

Figure 30 shows a trend where the number of gateways and host-connected switches are proportionate to the decreased packet rate, with an exception of oddly increased packet rate at L1=3 and L2=4.



8.4.5 Packet Success Rate

Figure 31 : DNS Packet Success Rate

Figure 31 shows that all DNS packets are successfully sent in any topology with different combination of L1 and L2.

From sending various types of traffic in various bipartite topology with different combination of gateways and host-connected switches assigned, we can see that the value of delay and jitter are most likely to have an increasing trend proportionate to the increasing number of gateways and host-connected switches, whereas the value of bit rate and packet rate are decreasing [4]. Some inconsistency shown in the graph above can be induced by running mininet and controller on the same device (AMD A8-7410, 8 GB RAM computer), or because of the limitation of load balancer application and the Floodlight controller itself.

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9. CONCLUSION

The increased number of gateways and hostconnected switches are proportionate to the increased value of delay and jitter and to the decreased value of bitrate and packet rate.

Minimum value of delay recorded is at 0.058 ms from UDP flow traffic, while the maximum delay recorded is at 2.474 ms from DNS traffic.

Running mininet and the controller on the same device (AMD A8-7410, 8 GB RAM computer), and the limitation of load balancer application and the Floodlight controller itself are most likely to contribute to an inconsistency in the experiment results.

The built-in load balancer application of Floodlight controller still needs an optimization in order to eliminate the inconsistency of the experiment results in bipartite topology.

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