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Traffic Statistics Measurement of Video Streaming in Software Defined Network

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Abstract

Video streaming is the dominant internet traffic. It is becoming the most popular content delivery mechanism for media services. Multiple video streams will compete for bandwidth, thus leading to degrading performance and impacting the received quality of experience (QoE). Software Defined Networking (SDN) provides a significant advantage because it is easier to introduce and tune up new functionalities. The logically-centralized control of OpenFlow brings to the operators the flexible and convenient controllability over the underlying networks. In this paper, it gets traffic statistics at each video streaming host and proposes the video streaming framework to enhance user QoE. It uses OpenFlow features to get traffic statistics from network devices. That is showing the end to end average throughput and port statistics of streamed video traffic over Mininet emulated OpenFlow networks. The experimental results of traffic statistics can be beneficially applied in the network when the network congested conditions occurred and it should be carefully interpreted considering between the clients for enhancing video streaming.

Keywords- Video Streaming, SDN, OpenFlow

1. Introduction

Although the internet has been initially designed to transfer text and data, the improvement of technologies introduced new services, such as voice and video. Nowadays, video streaming is the dominant Internet traffic. Report from Cisco Systems shows the Internet video traffic represents 59% of the global internet traffic. It will reach 77% by 2019 [7]. Therefore, it is focused on video traffic in this paper.

ISO standard: Dynamic Adaptive Streaming over HTTP (DASH), also known as MPEG-DASH, was developed by a cooperation of industries and standardized organizations aiming to high-quality video delivery. DASH runs over HTTP due to the support of HTTP by the servers, middle boxes, and client applications. Each video is available on the server with multiple copies and each copy with different encoding. Each copy is divided into chunks with equal duration. The chunk metadata is available in the Media Presentation Description (MPD). The client requests the MPD file then it chooses the most suitable bitrate and starts downloading chunks.

Traditional network architectures are rigid, it is especially hard to add new features to them. In order to overcome these issues, SDN (Software Defined Networking) paradigm has brought flexible controllability and sufficient programmability to the network operators by separating the control and data planes with an open and standardized interface. In this regard, the OpenFlow interface is the first and has become one popular protocol widely accepted. The OpenFlow standard enables the direct communication between SDN controllers and networking devices so that network management becomes easier than the traditional network management [9].

Moreover, streaming video generates the largest portion of Internet traffic, where traffic statistics measurement of video clients plays an important role in adapting to the current network load. In general, knowledge about the available bitrate of the network would benefit many users and operators of network applications and infrastructures. One of the ultimate goals in future multimedia networks is to provide a user-centric fair-share of network resources so that the user Quality of Experience (QoE) is maximized for all users in a network. There is a strong need to ensure QoE fairness across different devices in a network-wide manner [6]. To alleviate the congestions, the logically-centralized control of OpenFlow provides to the operators the flexible and convenient controllability over the underlying networks [11].

In this paper, it is interested in streaming video on the OpenFlow network. Video traffics are the majority of traffic load on the internet. These high traffic loads can potentially lead to network congestions, which are the cause of degraded quality of video at clients and also impact on QoE. The traffic statistics of the testbed are measured to solve the network congestion under the bandwidth competition of multiple clients in video streaming.

The remainder of the paper is organized as follows. Related work in this problem domain is presented in Section II. Then, Section III explains the enhance QoE video streaming framework. In Section IV, the studying experimental results in video streaming are reported. Finally, the conclusion and future work are discussed in Section V.

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2. Related Work

Akhshabi et al [5] proposed traffic shaping at the server side to reduce the player oscillations. When instability in the players is detected, then the server reduces the player bitrate profile or increases it on the other case. However, this technique solves the instability problem by reducing the bitrate profile and that leads to reducing the video quality.

In [7] the authors evaluate the performance of traffic shaping for competing for video flows over a shared bottleneck link using SDN. They show the individual traffic shaping gives better results than the aggregate traffic shaping. However, the authors shape the traffic for each client to the constant value which is impractical because when the number of clients increases, then the available bandwidth will be less than the required bandwidth, which leads to poor performance.

In [2], DASH runs over HTTP which uses TCP as the transport layer, thus leading to the mismatch between the DASH adaptation logic, which runs on the client side and the TCP congestion control which runs on the server side. When two or more DASH clients compete for bandwidth, thus leads to instability of the players, unfairness between the players requested bitrates and network bandwidth under-utilization.

Abuteir et al [4] proposed NAVS (Network Assisted Video Streaming) aims to improve the QoE by reducing player instability, maximize the fairness between clients and increase the video quality. This technique can address the issue at the home network gateway without modifying the client player or the video server. The adaptation logic is the bandwidth estimation based algorithm.

To enhance video content delivery as well as increase the QoE of the end-users, [8] proposed the Server and Network Assisted DASH (SAND) architecture. SAND is a control plane for video delivery that obtains QoE metrics from the users (clients) and returns network-based measurements to help the clients enhance their overall QoE. The third-party measurement server in SAND, known as DANE (DASHassisting network element), provides measurement information to the different parties in the delivery chains including CDNs, ISPs, and content providers.

3. Proposed Effective Video Streaming Framework

The proposed framework is based on Software Defined Network architecture.

3.1. Theory Background

SDN paradigm is one of the best and most attractive solutions for enhancing the Internet with more flexibility and adaptability. It allows a logically centralized software program to control the behavior of an entire network by decoupling the routing decision tier from the forwarding layer.

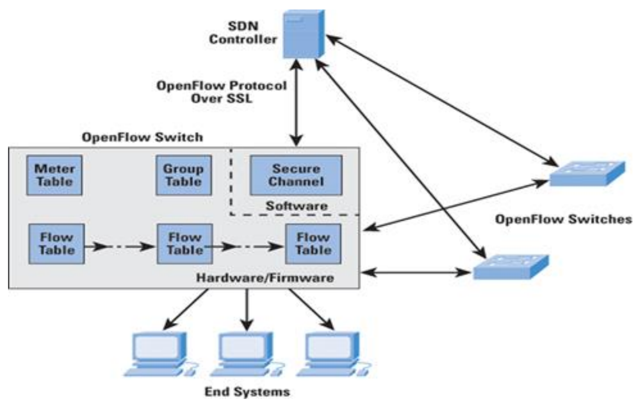

Figure 1. The Components in OpenFlow [9]

OpenFlow shown in Figure 1 enables to communicate between the control plane and data plane. When OpenFlow switch receives the new flow, the applications over control plane manipulate the first packet of this flow.

The switch interconnects with the controller and the controller directs the switch using the OpenFlow protocol. The OpenFlow switch consists of one or more flow tables, group table, and meter table. A single switch can be managed by one or more controllers. Flow tables and group table are used during lookup or a forwarding phase in order to forward the packet to the appropriate port. Meter table is used to perform simple QoS operations like rate-limiting to complex QoS operations like DiffServ. OpenFlow channel is to link to an external controller.

The controller can delete, add or update flow entries in flow tables. It makes this decision based on policies set by the administrator or depending on the conditions of the current network. OpenFlow based controllers will discover and maintain all links in the network and then will create and store all possible paths in the entire network. It can instruct switches and routers to direct the traffic by providing software-based access to flow tables. It can be used to quickly change the network layout and traffic flows as per user requirements.

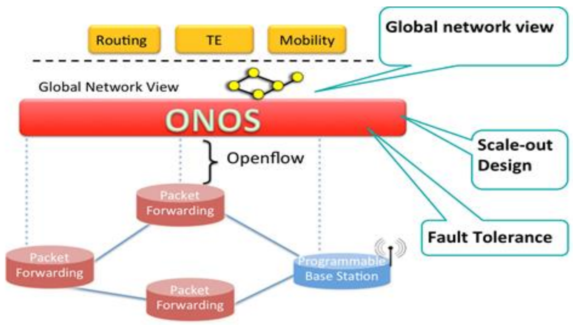

Figure 2. ONOS Controller [3]

Open Network Operating System (ONOS) controller is used in this framework. ONOS adopts a distributed architecture for high performance, availability and scalability requirements of large operator network such as

- High Throughput: up to 1M/ second
- Low Latency: 10 -100 ms event processing
- Global Network State Size: up to 1TB of data
- High Availability: 99.99% service availability

3.2. Effective Video Streaming Framework

In this framework, it is proposed to build an effective video streaming with traffic statistics measurement within the network. The functional building blocks are being brought together to form the framework. Dynamic traffic shaping approach based on the collected network traffic statistics and monitoring of video flows is proposed. It dynamically allocates bandwidth for each video flow in real time to improve performance and user QoE. In addition, it used an abstract model for the controller so its location is less important than its function. The controller consists of three functional modules as shown in Figure 3.

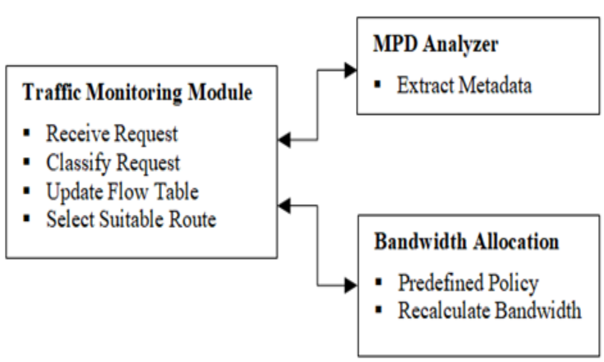

Figure 3. Functional Block Diagram of System

Multiple clients are connected to the video server for video streaming in the network. The server allows the Video-on-Demand (VoD) streaming service depends on the current network situation.

When the controller receives a request from any client, it classifies the request type, whether the video streams or not. If it is a video streaming request, the controller passes the MPD file of the client request to the MPD analyzer to start the extraction of metadata and store it in the Active Video Flow Info table. The metadata contains the video length, the number of chunks, the available bitrates and the chunks URLs. When the video flow removed from Active Video Flows Info table, the active video flow info table belonging to it is also removed. When the flow becomes inactive for a certain time that means the flow has stopped and it will be updated by removing from the active video flows table.

The bottlenecks in the network could be due to limited bandwidth in the access. When multiple video flows compete for bandwidth, a poor performance could be resulted and impact the user QoE. To improve QoE and resolve traffic congestion, it must be the bandwidth that assigned to all video flows is less than the overall bandwidth and any two video flows should get the same bandwidth. If a new video flow start or a video flow is stopped, the value of the allocated bandwidth for each client is recalculated.

4. Preliminary Experimental Results and Testbed

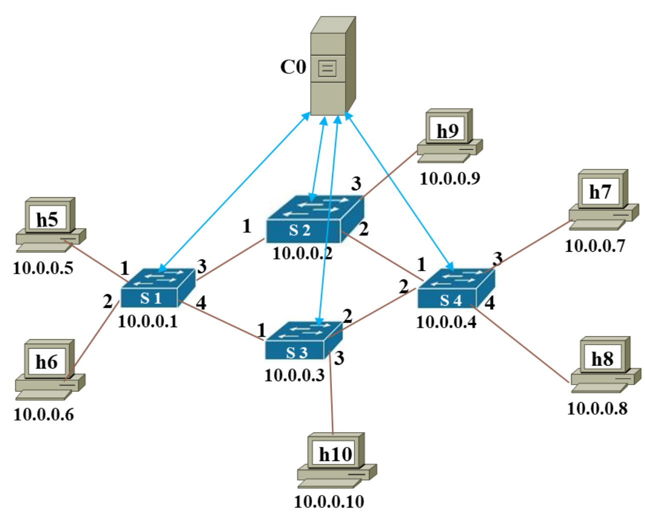

Figure 4. Testbed Topology for Emulation

In order to make an effective video streaming, the preliminary experiment on the current testbed is performed and the traffic statistics of each host are measured in this paper. To test the functionality of SDN-enabled network controls, many researchers rely on Mininet as an experimental platform. Mininet is the network emulator which can create hosts, OpenFlow switches, network links and SDN controllers virtually within a single computer. Fast prototyping can thus be achieved over Mininet platforms.

The topology of the OpenFlow network in this work is presented in Figure 4. The network consists of a video server (h5), five video clients (h6, h7, h8, h9, and h10), and four OpenFlow switches (s1, s2, s3, and s4). In addition, an SDN coordinator is equipped with an SDN controller for monitoring the video server and streaming clients. The SDN controller is based on the ONOS controller and the OpenFlow switches are based on Open vSwitch.

For the video streaming flow, on the server side, the VLC media player is used as a video streaming server. On the client side, it is also used the VLC media player as a client to receive the network video stream. On the server side of streams video, a simple HTTP (Hypertext Transfer Protocol) server bound to port 8080. There is the recommended downloading bitrate which represents the amount of bitrate required to play the selected resolution without any viewing interference. For example, YouTube requires 2.5 Mb/s for 720p and 725 Kb/s for 360p.

An animation video, Big Buck Bunny, with the two resolutions of 480x360p, 40.4 MB size and 1280x720p, 89.4MB size, and its duration of 9.56 minutes have been used for streaming over the Mininet. The video codec is H.264 with encoding bitrate. VLC media player has been configured to stream out the video packets by using TCP (Transmission Control Protocol) mode. All packets have been captured by Wireshark for all end-to-end video flows at clients.

The port data rate at video server and each video client are measured in this preliminary experiment. In Figure 5, video streaming with 360p resolution data transmission rate at every host is shown and the high definition (HD) resolution 720p video streaming testing is depicted in the next Figure 6. Host 5 transmission bit rate is the highest because of the server host.

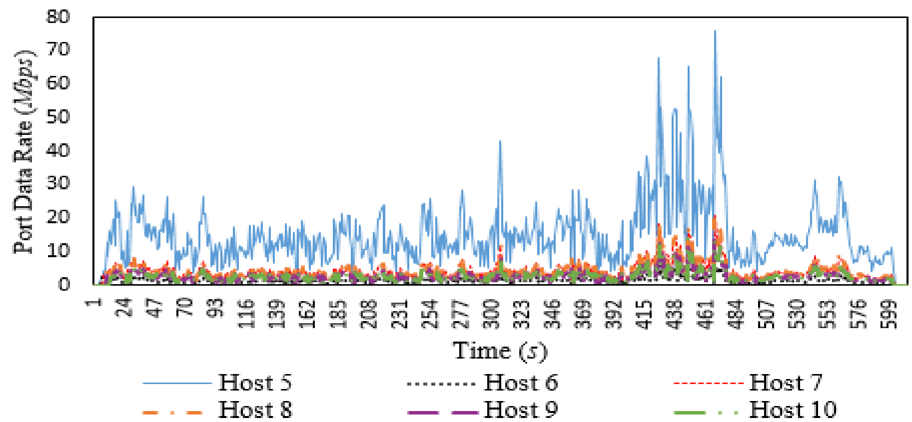

Figure 5. Data Rate Measurement for 360p Video Transmission

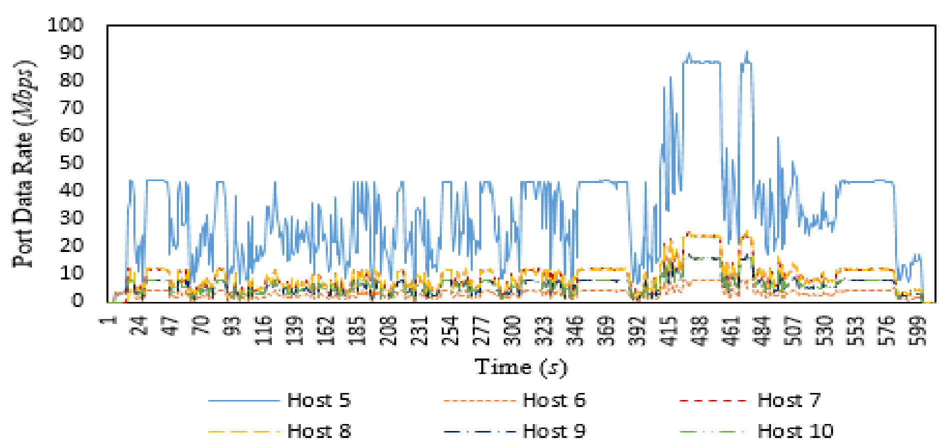

Figure 6. Data Rate Measurement for 720p Video Transmission

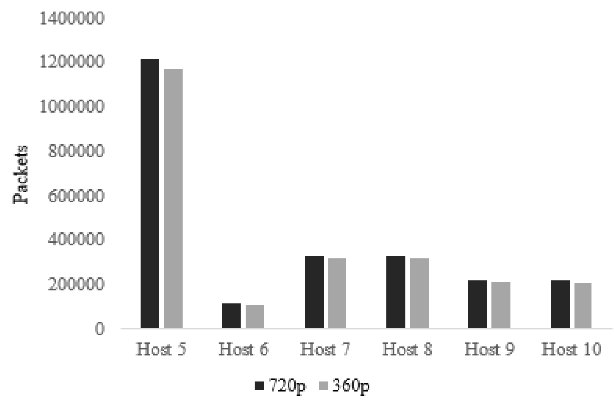

Figure 7. Video Packet Transmission with Two Resolutions

In this testbed, the HTTP video server, Host 5 transmits the video packets to all clients by using TCP mode. The number of video streaming packets from HTTP video server to all clients in TCP transmission is shown in Figure 7. Host 6 is connected to the same switch to the video server Host 5, its number of packets are lowest in the graph. The two clients Host 7 and Host 8 are attached to the same switch S4 and traversed three intermediate switches from the video server to each client, their packet amount is an approximately equal to each other and higher than the other video clients. Then, the two other hosts, Host 9 and Host 10 are streaming videos from via the next switches of server switch, so the number of packets is close to each other and medium range as their switches are located.

Table 1. Comparison of Average Bitrate

Video Streaming Hosts	**360p Video Average Bitrate (*Mbps*)**	**720p Video Average Bitrate (*Mbps*)**
Host 5	12.6322	32.5490
Host 6	1.3592	3.0058
Host 7	4.0603	8.8721
Host 8	4.0483	8.8432
Host 9	2.6989	5.9129
Host 10	2.6865	5.9149

The average transmission bitrate at each host is compared in Table 1. Their rates are different as their packet transmission amount. The nearest client needs the least rate, the video clients attached to the next hop switch of server switch are medium bitrates and the last client hosts with the highest bitrate. A link defined as a bottleneck if it provides lower data rate than the required bitrate of current streaming flow, which may cause the buffering experience at client-side. To enhance video streaming, the throughput for a client with different clients in competition for the same video stream should be fair in any situation. By maintaining the fair throughput in changing conditions, the more effective video streaming is led to enhance user experience.

5. Conclusion

In this paper, it is reported the traffic statistics of the current testbed such as the data transmission rate, number of packets and average bitrate at each host in video streaming with two different resolutions. This preliminary results can assist to implement the proposed video streaming framework used ONOS SDN. The proposed framework tends to allocate bandwidth for different video streams based on the predefined policy, the number of video flows, available video bitrates, and bottleneck bandwidth. If a new video flow starts or existing video flow is stopped, the policy is easily modified and the value of the allocated bandwidth for each client will be recalculated. The maximize bitrate received by each client can be reduced the bottleneck network traffic even busy hour duration with higher resolution. The current testbed topology in emulation consists of only one video server for simplicity of preliminary test. This is not covered in the real world. The implementations of the proposed framework by adding more video servers is in future work.

6. References

[1] CISCO, “Visual networking index: Global IP traffic forecast 2014 - 2019”, May 2015.

[2] V. Anthony and S. Iraj, “The mpeg-dash standard for multimedia streaming over the internet,” *IEEE Multimedia*, No. 4, 2011, pp. 62-67.

[3] P. Berde, M. Gerola, J. Hart, Y. Higuchi, M. Kobayashi, T. Koide, B. Lantz, B. O. Connor, P. Radoslavov, W. Snow and G. Parulkar, “ ONOS, Towards an Open, Distributed SDN OS”, *Proceedings of the third workshop on Hot topics in software defined networking*, Chicago, USA, August 22, 2014, pp. 1-6.

[4] R. M. Abuteir, A. Fladenmuller, and O. Fourmanx, “SDN based architecture to improve streaming in home network”, *IEEE 30th International Conference on Advanced Information Networking and Applications*, 2016, pp. 220-226.

[5] S. Akhshabi, L. Anantakrishnan, C. Dovrolis, and A. C. Begen, “Server-based traffic shaping for stabilizing oscillating adaptive streaming players,” in *Proceeding of the 23rd ACM Workshop on Network and Operating Systems Support for Digital Audio and Video*, ACM, 2013, pp. 19-24.

[6] P. Georgopoulos, Y. Elkhatib, M. Broadbent, M. Mu, and N. Race, “Towards network-wide QoE fairness using openflow-assisted adaptive video streaming,” in *Proceedings of the 2013 ACM SIGCOMM workshop on Future human-centric multimedia networking*, ACM, 2013, pp. 15-20.

[7] J. J. Quinlan, A. H. Zahran, K. Ramakrishnan, and C. J. Sreenan, “Delivery of adaptive bit rate video: balancing fairness, efficiency and quality,” in *Local and Metropolitan Area Networks (LANMAN), 2015 IEEE International Workshop* on IEEE, 2015, pp. 1-6.

[8] *ISO/IEC JTC1/SC29/WG11 (MPEG) Report, Technical report*, ISO, November 2013.

[9] W. Stallings, “Software-Defined Networks and OpenFlow”, *The Internet Protocol Journal*, Volume 16, No.1, http://www.cisco.com/.

[10] M. M. Rahman, “Introduction to SDN”, ppt, November 2013, moin@1asia-ah1.com, http://slideshare.net.

[11] P. Panwaree, J. W. Kim and C. Aswakul, “Packet Delay and Loss Performance of Streaming Video over Emulated and Real OpenFlow Networks”, *29th International Technical Conference on Circuit/Systems, Computers and Communications (ITC-CSCC)*, Phuket, Thailand, July 1-4, 2014, pp. 777- 779.