PERFORMANCE EVALUATION OF MULTIMEDIA CONTENT OVER MPLS E-LEARNING NETWORK

Shahad H. Majid[1], **Emad H. AL-Hemiray**[2]
[1,2]College of Information Engineering, Al-Nahrain University, Baghdad, Iraq
{shahadzwayen[1], emad[2]}@coie-nahrain.edu.iq
Received:30/10/2018, Accepted:20/11/2018

Abstract- **The growth in the use of multimedia in the educational sector is accelerating rapidly. Multimedia contents are very sensitive in terms of link capacity and other parameters affecting its quality. Due to the lack of existing of a network dedicated for testing and evaluating the e-learning network, there is a need to propose and build a testing environment. In this paper, we present a practical implementation of a testing environment that provide multimedia transmission to aid e-learning over a virtualized Multi-Protocol Label Switching (MPLS) network. The designed network combines hardware and software resources where the source is a real-time video streaming using a professional video camera connected to a virtual network of routers to deliver the multimedia content wirelessly to the intended classroom. The network is successfully implemented and evaluated with acceptable quality according to cisco reference for Quality of Service (QoS) Network Design Guide.**

keywords: **Multimedia, e-learning, MPLS virtualization, Streaming.**

I. Introduction

The world is developing rapidly regarding technology, newer tools and ways are being introduced in the educational environment. Multimedia content is a powerful tool for education because it combines video, graphics, text and sound which can benefits the learning process. The video is the most widely used type of multimedia among the other elements. According to Global Mobile Data Traffic Forecast, Cisco announced that by the year 2021 almost 78% of the traffic will be video[1]. Also, Mark Zuckerberg mentioned in one of his recent events that the vast majority of content that people consume online in the future will be video[2]. E-learning as any other new technology is affected by various network conditions and channel states. Thus, such technology requires studying and evaluation in order to develop the e-learning into a higher level. There is lack in the existence of a testing environment for the e-learning network. Building such testingenvironment for e-learning requires many physical equipment such as routers, switches, servers, video streamer, cameras, etc. and some of these devices are often exceed the institutions economical capability. In order to build such networks, virtualization technology could be used. Virtualization technology has been invented and introduced to work with for a long time. Virtualization reduces the need for physical equipment and cost for buying these devices whilst providing high flexibility, reliability and availability[3]. It cuts the need for some software and hardware network resources and enable them to function effectively in a single physical device.

II. Related Work

Gil et al, in 2014 [4], evaluated an optimized resources solution for achieving distance learning and discussed the important of distance learning and the benefits of having student and lecturers working together. The researchers used GNS3 to virtually implement and network topology similar to the real laboratory. Their research was based on students opinion, and it showed positive feedback on the use of virtualized computer network lab environment. Kristianto, in 2014[5], discussed the importance of implementing server virtualization technique in the education section. They explained the difference between virtualization techniques such as full virtualization, paravirtualization and container based OS virtualization. Bukashkin et al, in 2016[6], presented an analytical study for a self- similar multimedia traffic in MPLS networks. The authors used ns2 network simulator to evaluate probability time characteristics for the flows service. Sheshasaayee and Malathi, in 2017 [7], explained the importance of e-learning and how it helps the students to maximize the benefit from learning since it made the learning process faster, easier and cost effective. The authors presented a theoretical study on the impact of big data in the future e-learning technology.

III. Theoretical Background

A. MPLS

MPLS is a high performance forwarding technology that uses labels to forwards the packets from one hop to another. MPLS creates smooth and reliable networking technique with high flexibility to provide a better performance and stability over traditional networks by adding layer 2 switching speed to the flexibilities of layer 3. MPLS enables simpler routing decisions using a simple label content attached to the packet. These labels are advertised among routers to perform label to label mapping by build a labeling table[8] as shown in Fig. 1.

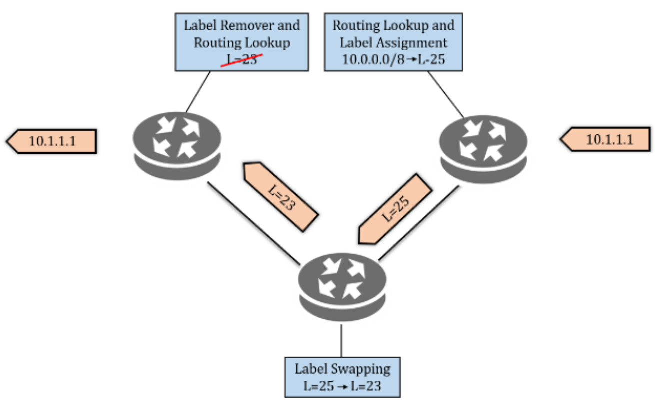

Figure 1: MPLS concept[8]

One MPLS header is 32 bits with a certain structure. The MPLS header stack as shown in Fig. 2, the first 20 bits are the value of the MPLS label. 3 bits for Experimental field, and 1 bit for the bottom of the Stack (BoS). Finally, 8 bits for Time to Live (TTL) field indicating hops number in which this label can live through [9].

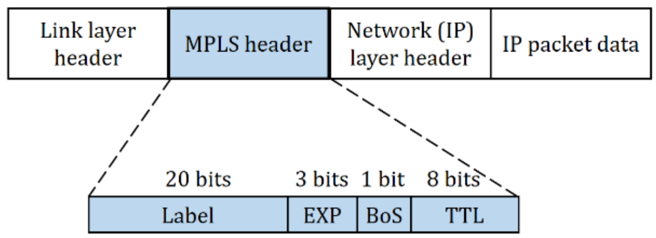

Figure 2: Syntax of MPLS Label[9]

B. Virtualization

Virtualization technology [4]helps in integration of multiple devices into one physical server in an organized way that every virtualized device appears to be a standalone one to the user. Server virtualization has three types: paravirtualization, hardwareemulationand operating system virtualization [10]. In this work, hardware virtualization will be used to virtualize the network inside the physical server. In hardware emulation, a specialized software, which is also known as hypervisor, creates hardware emulation for the operating system in a single server. The hardware emulation allows hosting different types of operating systems in a single physical server.

C. Multimedia Streaming

There are several protocols for communicating between the client and the streaming server. These protocols interact with each other to deliver the multimedia stream. They are classified into three categories according to their functionalities[11]. Network layer protocol, Transport protocols (such as TCP, UDP, RTP and RTCP) and session control protocols (such as RTSP). In this work a RTSP streaming protocol is used with RTP transport protocol to carry the multimedia content over UDP. The video streamed with H.264 video compression. H.264 is one of the most popular of types video compression technologies.H.264 is a video compression standard it is commonly used in distributing video content.H.264 reduces the bandwidth needed to send video files across WAN networks. Bandwidth reduction usage achieved by offering low bitrates. H.264 also decreases the storage space needed storing heavy video files.H.264 enables video from higher resolution cameras in order to be streamed on the Internet.

D. Performance Measures Parameters

In the networking community, QoS refers to the level of the service offered by the network to the user or the application to match the performance needs by means of network QoS parameters including bandwidth, jitter, delay and packet loss, etc. [12]. In order to provide high quality multimedia content, an adequate support for the network is critical in order to reduce the transport delay and the packet loss ratio. For real time video streaming services, there are some performance expectations for the viewer. These include that the start-up delay should be no more than 10 seconds [13]. Packet loss should be no more than 1%, round trip delay should be no more than 300ms and jitter must not increase above 30 ms[14].

IV. Network Model

The proposed testing environment works as follows, a video camera is placed toward the instructor, the camera's HDMI port connects to the encoders HDMI port. The encoder processes the video in real time to perform video compression and convert the video to IP stream to be sent over the network using RTSP streaming protocol. The source and destination can be in the same LAN, in the same Internet Service Provider (ISP) network, or on different ISP networks. It is assumed that the network which the stream passes through consists of many routers forming typical connections between source and destination. The end user then can receive the streamed video played in real time by entering the URL of the RTSP stream in any decoder application software.

V. Network Implementation

The testing environment for e-learning network requires many hardware and software resources. The virtualization technology was needed in implementing the network Fig. 3 shows the conceptual network diagram.

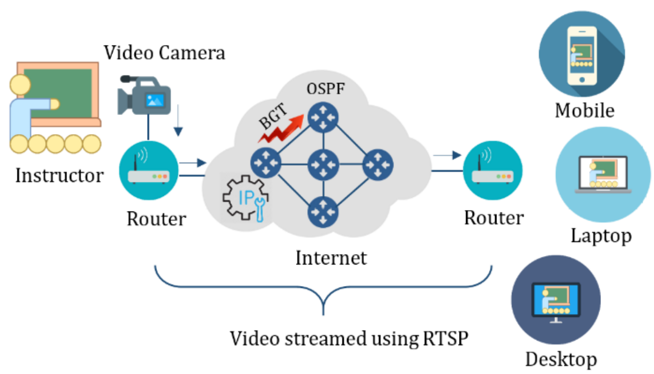

Figure 3: Conceptual network diagram

The network was created and configured inside the server which runs Ubuntu server 14.04 LTS as its operating system with GUI. Other than that, each part of the testing environment consists of real physical devices including: HP ProLiant DL380 G7 server with 24 GB DDR3 with CPU E5620 @ 2.40GHz, 16 cores, FMUSER FBE200 H.264 Video Streaming Encoder, Mikrotik RB2011UAS-ZHND-IN and a professional video camera.

A. *Physical Part of the Testing Environment*

The FMUSER FBE200 [15] encoder was used to stream the video from the camera to the virtual network. The IP address for the encoder is 192.168.1.168 and the IP address for the router interface linked to the encoder was 192.168.1.1 for connecting with the encoder. The encoder was connected to the CE1 router in the network via Ethernet cable, the device that connects the encoder (physical device) to the virtual environment in GNS3 is the cloud, the cloud is configured to be connected to the encoder and the edge router to enter the virtual world.The FMUSER FBE200 encoder has a web based management interface that allow to specify 3 profiles each with specific resolution. Fig. 4 shows the web interface of the encoder with its final configuration.

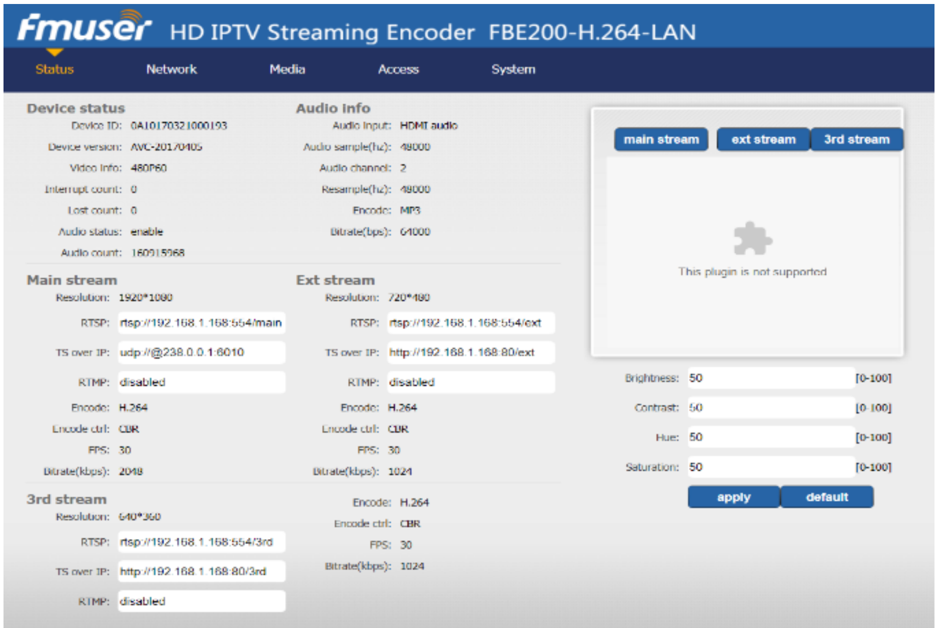

Figure 4: The web interface for the encoder

Mikrotik interface(Ethernet 2) was configured as an AP with dynamic IP lease pool working in the 2.4GHz region with n-mode (multiple antenna mode). The interface is connected to Eth 2 port ofthe server which is connected to the CE2 router of the virtual network through the cloud. The students can connect wirelessly to the network and receive the video being streamed by the instructor.Fig. 5 shows the proposed testing environment.

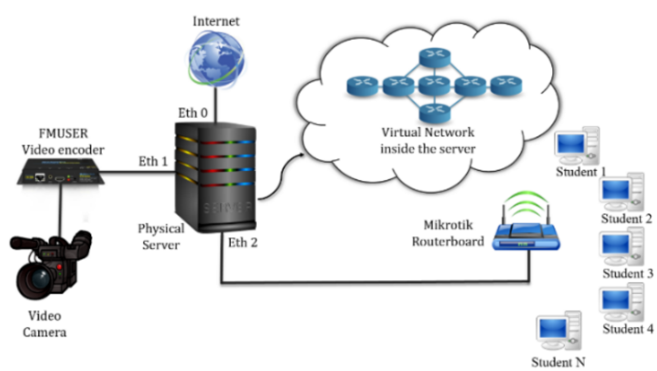

Figure 5: The proposed testing environment

B. Virtual Part of the Testing Environmnt

The virtual part of the testing environment consisted of a virtual network of 9 cisco routers c7200 model configured using GNS3 virtual network creator. Hardware emulation virtualization technique is used to virtualize the network on the physical server. The core of the network was designed as a mesh network topology because it's robust and flexible when adding more devices in the topology.Fig. 6 shows the virtual network design.

VI. Results and Discussion

For testing the e-learning network, the end user needs to connect wirelessly to the Mikrotik AP to obtain IP address dynamically from DHCP pool with IP addresses 192.168.5.0/24. Traceroute is a network management tool used to test student reachability to the video source. Fig. 7 shows the traceroute output from the end user.

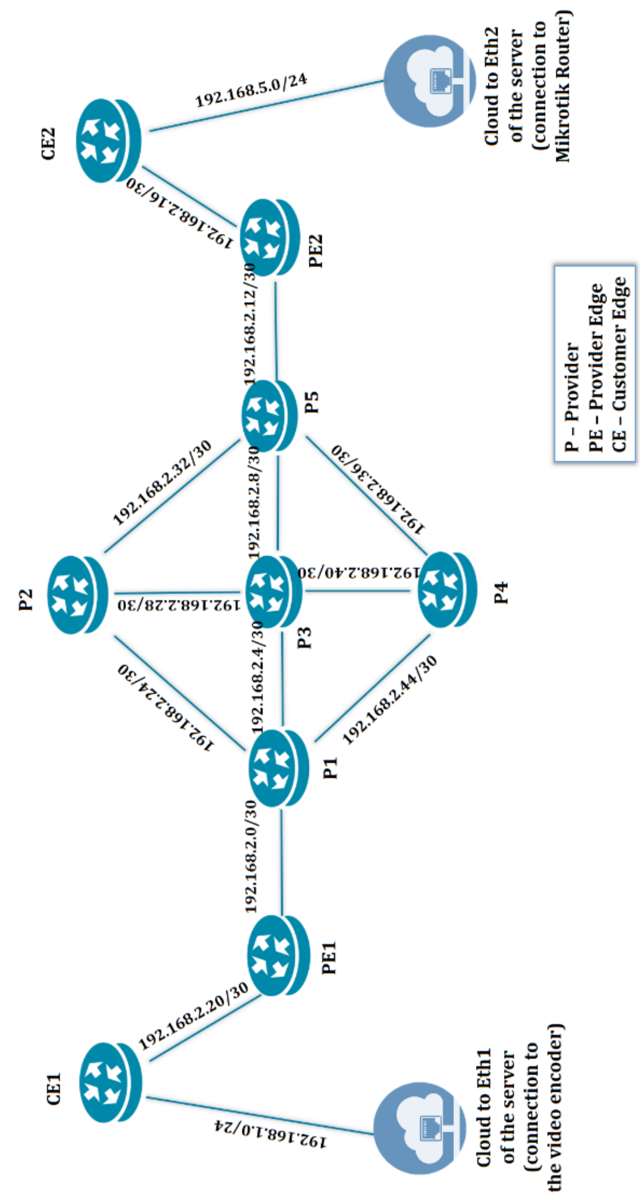

Figure 6: Virtual network design

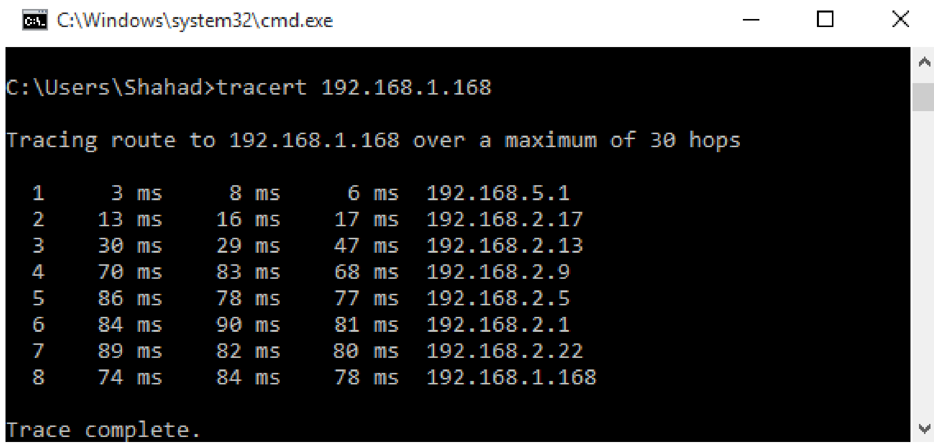

Figure 7: Traceroute output of the end user

To receive the video stream, the student types the URL of the video profile given in the video encoder web page. The video is streamed in real-time from the camera to the end user passing through the virtual network in the server. Fig. 8 shows the received signal of the main video profile. While Fig. 9 shows a real video packet captured using Wireshark packet sniffer. The network was successfully run and tested, the Start-up delay for the video scored is 1.95 seconds which is within the acceptable range for one-way video requirements, the source-to-destination delay scored is 0.605 second. The MPLS network jitter was 9.295 ms and round trip delay was 96 ms with 0% packet loss of the multimedia packets. On the other hand, the same test was repeated for IP-based network in the same infrastructure to compare the difference between MPLS and IP networks. The experiment shows an average of 105 ms RTD and 9.548 ms average network jitter with 0% packet loss. All results values are within the acceptable range according to cisco QoS network design requirements.

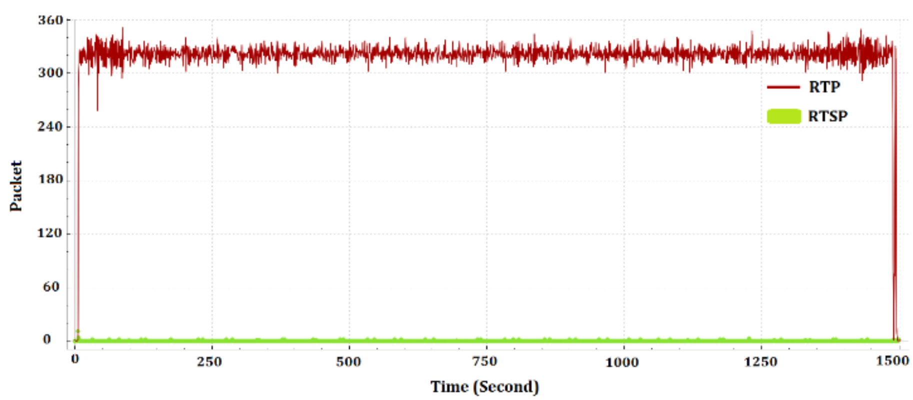

Figure 8: Real video signal received

```
› Frame 150498: 1060 bytes on wire (8480 bits), 1060 bytes captured (8480 bits) on interface 0
› Ethernet II, Src: ca:03:0b:74:00:08 (ca:03:0b:74:00:08), Dst: ca:04:26:c0:00:08 (ca:04:26:c0:00:08)
˅ MultiProtocol Label Switching Header, Label: 220, Exp: 0, S: 1, TTL: 62
   0000 0000 0000 1101 1100 .... .... .... = MPLS Label: 220
   .... .... .... .... .... 000. .... .... = MPLS Experimental Bits: 0
   .... .... .... .... .... ...1 .... .... = MPLS Bottom Of Label Stack: 1
   .... .... .... .... .... .... 0011 1110 = MPLS TTL: 62
› Internet Protocol Version 4, Src: 192.168.1.168, Dst: 192.168.5.6
› User Datagram Protocol, Src Port: 60000, Dst Port: 65126
˅ Real-Time Transport Protocol
  › [Stream setup by RTSP (frame 16)]
   10.. .... = Version: RFC 1889 Version (2)
   ..0. .... = Padding: False
   ...0 .... = Extension: False
   .... 0000 = Contributing source identifiers count: 0
   0... .... = Marker: False
   Payload type: DynamicRTP-Type-96 (96)
```

Figure 9: Real packet received

VII. Discussion

In IP networks, media transmission is done by routing packets from the source to the destination. Each hop takes its time to process the information then forwards the packet to the next hop. MPLS switch packets in a faster way based on labels. These labels are considered as a 2.5 layer because the label is injected between data link layer and network layer. MPLS minimize the forwarding processing time due to label switching technique. Within the network, packets are forwarded based on the simple label attached to the packet. This minimize the delay experienced by the traditional IP networks which performs the standard routing that's why it's a better solution for delay sensitive traffic (ex., video).

VIII. Conclusions

This paper presents a practical implementation of a cost effective virtual testing environment for testing the e-learning network. The created virtual testing environment can be added as testing laboratory for postgraduate students in their research course. The virtual testing environment is flexible. Any device can be connected to the network in order to test it without affecting network parameters or configuration. Also, the network can easily be expanded without affecting the overall network. Which means, it can easily be used in testing other network devices and evaluate the performance of network conditions.

References

[1] Cisco Visual Networking Index, "Global Mobile Data Traffic Forecast Update, 2016- 2021" white paper, 2017.
[2] P. Mohan, The Majority of Content We Consume Will Be Video, http://www.fastcompany.com/3057024/mark- zuckerberg- soon- the-majority- of-content- weconsume- will- be- video, 2016 (Accessed 4th of Aug. 2017).
[3] D.Menace, "Virtualization: Concepts, Applications and Performance Modeling", in Int. CMG Conference, 2005, pp. 407- 414.
[4] P. Gil, G. Garcia, A. Delgado, R. Medina, A. Calderon and P. Marti, "Computer networks virtualization with GNS3: Evaluating a solution to optimize resources and achieve a distance learning", IEEE, in Frontiers in Education Conference (FIE), 2014, pp. 1- 4
[5] E. Kristianto, "The performance of e-learning Website on open source virtualization", IEEE, in Advanced Informatics: Concept, Theory and Application (ICAICTA) International Conference, 2014, pp. 109- 112.
[6] S. Bukashkin M. Buranova and A. Saprykin, "An analysis of multimedia traffic in the MPLS network in ns2 simulator", in Problems of Infocommunications Science and Technology , Third International Scientific- Practical Conference, 2016, pp. 185- 188.

[7] A. Sheshasaayee and S. Malathi, 2017, February, "Impact and consequences of BIG DATA in e-learning.", IEEE, In Innovative Mechanisms for Industry Applications (ICIMIA) International Conference, 2017, pp. 726- 729.
[8] Cisco System, inc., implementing cisco mpls, volume 1, 2004.
[9] L. Ghein, MPLS fundamentals, Cisco Press, 2016.
[10] Wing, "Types of Virtualization Technology Advantages vs. Disadvantages", 2014, "https://securitywing.com/types-virtualization- technology/" (Accessed 12th of Sep. 2017)
[11] J. Hwang, "Multimedia networking: from theory to practice", Cambridge University Press, 2009.
[12] B. Forouzan, "TCP/IP protocol suite", 2002.
[13] Z. Sheng, J. Fan, J., C. Liu, V. Leung, X. Liu and K. Leung, "Energy-efficient relay selection for cooperative relaying in wireless multimedia networks", IEEE 2015, pp. 1156- 1170.
[14] C. Headquarters, Enterprise QoS Solution Reference Network Design Guide, 2005.
[15] FMUSER user manual, "H.264/H.265 High Definition HD IPTV streaming encoder", (Last updated 29th December 2016).