SYSTEM FOR TESTING THE QUALITY OF SERVICE FACTORS OF INFLUENCE FOR MULTIMEDIA TRAFFIC

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Abstract: *The Quality of Service in communications has different factors of influence. Testing the behavior of applications and data streams in the case of varying Quality of Service conditions is important to study. University students need to understand these aspects and test them during the traffic engineering laboratory. This paper presents the hardware and software setup that can be used in and undergraduate laboratory to present the quality of service factors of influence for multimedia traffic*

1. INTRODUCTION

The network traffic is a dynamic component of a computer network that cannot be designed as it varies in time based on the number of computers that communicate and the type of traffic that is exchanged. There is a direct dependency between the network traffic, Quality of Service (QoS) and system capacity.

When the system capacity is set to a specific value (for example due to the provider limit for a specific location), the Quality of Service (QoS) component is the one that influences the network traffic. The QoS of a specific service is a measurement of the performance of that service [1]. Multiple factors influence the QoS: throughput, packet loss, latency, jitter, etc. In computer networks it is possible to prioritize a specific traffic in order to guarantee a minimum level of performance in the detriment of other types of traffic.

There are multiple types of traffic. Multimedia streaming is often present in the modern networks and constitutes more than 70% of the total network traffic in 2016 [2] and will increase in excess of 80% of traffic by 2021. [3]

This is due to the increase in live internet videos, video surveillance and internet TV streaming services (such as Netflix, YouTube, Hulu and Amazon, in the detriment of classic cable services) that offer on demand of any video titles at global level. This in turn is caused by the spread of the broadband internet in the search of businesses to reach new markets and increase revenue from this market.

Designing good applications that behave as expected in various network conditions needs a reliable testing environment. This means that it is necessary to recreate specific network conditions in the test environment on request. Real network traffic can seldom be used for these tests. Testing the effects of Quality of Service factors can be done using specialized equipment [4-5] or software that can be expensive to acquire and difficult to configure.

Using virtualization, at undergraduate level it is easy to test the influence of the QoS parameters on the network traffic. The information on how these tests were created can be used even later, in production, when it is necessary to develop software that need to be repeatedly tested against the QoS influence factors.

This paper presents the configuration used in the Local computer networks laboratory in order to test the QoS parameters influence on real systems, without the need to make configuration changes to the physical network infrastructure. In order to achieve this, the Linux traffic control application (*tc*) was used in a Virtual Box system. The multimedia stream will be generated using VLC player with both TCP and UDP traffic.

The paper is structured as follows: chapter 2 presents the influence factors for the Quality of

Service and the system data flow, Chapter 3 presents the usage of the *tc* and VLC applications in order to influence the afore mentioned factors and the conclusions section presents the problems encountered and considerations regarding the implementation in an undergraduate laboratory class.

2. TEST SYSTEM ARCHITECTURE

The following factors influence the Quality of Service [6]:

1. Throughput: represents the rate of successful data delivery over the communication channel and can be affected by the line noise, congestion, packet loss and other factors. Some applications have throughput requirements for successful operation.

2. Latency: the average end to end delay that the packets present. The real time traffic is highly sensitive to this value.

3. Jitter: represents the variation in the delay that a communication is experiencing that can be either random or deterministic [11]. The presence of jitter may lead to data loss as some delays can become so large that the packets are dropped. The causes of jitter range from simple congestion to network equipment configuration errors.

4. Packet loss, network errors and out of order delivery of packets: these factors represent a distinct category where sent packets do not arrive at the destination in the same way they were sent or even prevent them from reaching the destination at all. The causes are usually linked to congestion, bad routing or traffic priority rules.

Designing a testing environment for these factors can be performed in different ways:

- A physical implementation with real networking equipment and the configuration that will reliably control the influence factors.
- An alternative is to analyze the influence in dedicated simulation software (such as OpNet IT Guru Academic Edition [7], OMNeT [8] or NS-2 [9]) that either implies cost or a good knowledge of that software usage.
- Finally another solution is to use software networks and virtualization. This is a mixed solution compared with the previous tools as it is possible to combine software and hardware components. There are multiple ways to perform this implementation, for example using software tools that allow the QoS control (tc) or software that simulated networking equipment and allows the connection to real networks (GNS3 [10]).

In this paper we present the use of *tc* Linux software for QoS control in a virtual machine.

Virtualization allows the creation of software versions of hardware devices that perform the same functions but are running as hosts in a guest environment (called hypervisor). Virtualization takes advantage of the processing power in modern computer systems and allows running different virtual system in parallel on the same hardware with minimal performance loss when compared to the real system they intend to replace. Networking virtualization specifically targets the behavior of networking equipment and the networking connectivity.

In this paper VirtualBox software will be used in order to run a Linux OS host inside a guest OS, with the host's network interfaces running in Bridge Networking mode.

The testing system architecture is presented in Fig.1. The virtual machine, running Linux, is the guest operating system and the Windows machine is the host for the test setup (a Linux host can also be used).

The guest machine will be configured as a router with two network interfaces in order to be able to intermediate all the traffic between internet and the host machine. The gateway for the host machine will be the guest network interface. In this way all the rules applied to the interfaces of the guest machine will be able to affect the traffic on the host system.

3. USING TC FOR THE CONTROL OF QUALITY OF SERVICE INFLUENCE FACTORS

The traffic control application [12] is included in the Linux OS. To be able to check if there are any queuing disciplines applied the command to be used is:

```
# tc qdisc show
```

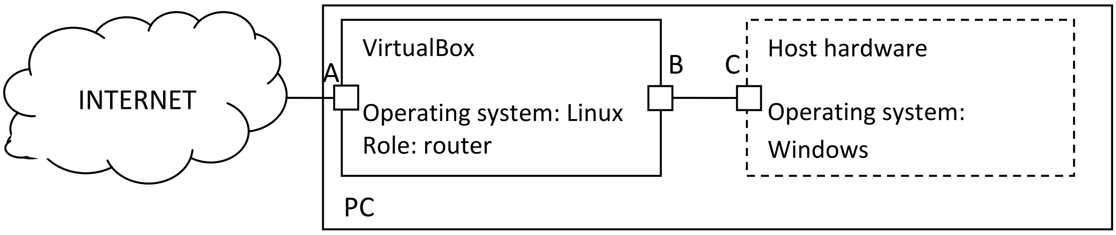


Fig. 1. The test system architecture consists of a single machine running Windows operating system (the host) and a virtual machine running Linux (the guest). A and B are the network interfaces of the guest and C is the interface of the host

If there are no rules applied the default pfifo_fast queuing discipline should be visible. If any disciplines are applied, they can be deleted (and replaced with the default discipline) with:

```
# tc qdisc del dev eth0 root
```

For the first rule configured, the parameter: add will be used and for the following rules the: *change* parameter should be used.

The first factor to be tested is the throughput. In this example in order to limit the download rate, the Token Bucket queuing discipline will be used for shaping the traffic. The discipline ensures that the configured rate is not exceeded. The following line will limit the speed (to approximately 1.5MB/s) where *latency* specifies the maximum amount of time a packet can stay in the TBF queue (packet is dropped when value is exceeded) and *burst* specifies the size of the bucket:

```
# tc qdisc add dev eth0 root tbf
rate 0.025mbit burst 10kb latency 1ms
```

The second factor to be tested will be latency where a delay will be applied to each packet:

```
#tc qdisc add dev eth0 root netem
delay 200ms
```

The third factor to be tested will be jitter with a base delay of 100ms and variation of +/- 10ms:

```
#tc qdisc change dev eth0 root
netem delay 100ms 10ms
```

Finally the last factor to be tested is packet loss with a 5% drop rate:

```
#tc qdisc change dev eth0 root
netem loss 5%
```

Other error types can also be configured with this tool, such as packet reordering, duplication or packet corruption.

The VideoLAN Client media player (VLC) application is free open source software that allows both playing and streaming of multimedia data and supports a multitude of file formats and compression methods. VLC media player (if missing) can be installed in Linux with the command:

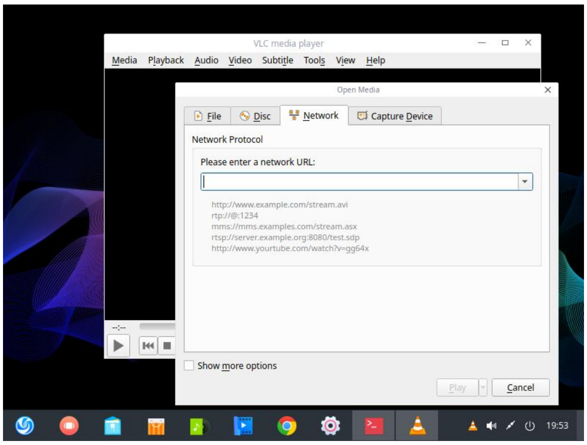
```
#apt-get install vlc
```

For this paper VLC was be used to stream a multimedia file though the network to the client (that is another VLC application). In the presented architecture the server will be on the Windows machine and the client in the Linux guest. For the sever application, VLC can be configured to stream TCP or UDP traffic. In the tests HTTP was chosen: Media → Stream → Destination (HTTP), with H.264+MP3 encoding profile. For the client application interface (seen in Fig. 2) the stream was opened using the menu: Media → Open Network Stream.

In order to make the tests, the traffic control discipline was applied on an interface in Linux, then the server was started, finally the client was connected and the multimedia stream received. TCP connections only stream traffic if the client is connected, while UDP servers scream the traffic regardless of the presence of clients. After the observations were made for that influence factor, the discipline was changed and the streaming resumed.

The only problems encountered were related to the fact that with the default configuration, the VLC would not stream the video signal, while the audio was playing correctly. The solution was to change the Video Settings Output type to “X11 video output (XCB)”. After the modification, the video played correctly as seen in Fig. 3. Several Linux distributions were tested for this fix, including Knoppix, DeepIn and Ubuntu.

Beside the effects on the multimedia traffic, the presence of the latency, jitter and packet loss disciplines can be easily tested using ping while the throughout TBF discipline effect can be tested by downloading from the internet a large file (in order for the student to have enough time to observe the rate limiter).



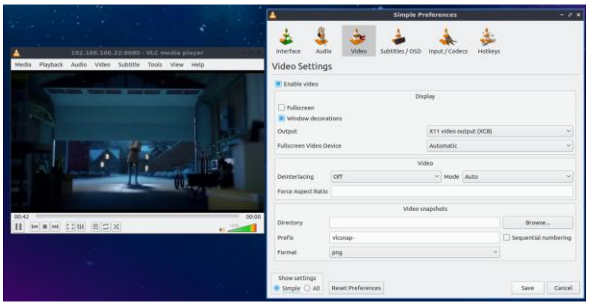
Network Protocol

Please enter a network URL:

http://www.example.com/stream.avi
rtp://@:1234
mms://mms.examples.com/stream.asx
rtsp://server.example.org:8080/test.sdp
http://www.yourtube.com/watch?v=gg64x

□ Show more options

Fig. 2 VLC client interface in DeepIn Linux



Video Settings

☑ Enable video

Display

□ Fullscreen
☑ Window decorations
Output: X11 video output (XCB)
Fullscreen Video Device: Automatic

Video

Deinterlacing: Off Mode: Auto
Force Aspect Ratio:

Video snapshots

Directory:
Prefix: vlcsnap- □ Sequential numbering
Format: png

Show settings ● Simple ○ All

Fig. 3 VLC client video configuration needed for the correct playback in Ubuntu Linux

4. CONCLUSIONS

This paper presented aspects related to the setup and implementation of a testing system, for the QoS influence factors, that can be used in undergraduate university classes.

The setup uses minimal hardware (a single PC) along with virtualization in order to be able to reliably modify the influence factors for a multimedia stream. The configuration can test throughput, latency, jitter and different types of errors. The installation and configuration of the system takes very little time (under 30 minutes) and the tests can be performed in less than one hour, leaving enough time to propose more complex scenarios for the traffic shaping disciplines and to target different communication types.

Several problems were encountered and were fixed such as the need to update the distribution packages or the errors in video playback for the default VLC configuration.

In the future different the effect of more complex queuing disciplines will be observed and the effect of a more complex software network configuration that could introduce minimum latency configuration restrictions.

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