UNIVERSIDAD POLITÉCNICA DE MADRID

ESCUELA TÉCNICA SUPERIOR
DE INGENIEROS DE TELECOMUNICACIÓN

MÁSTER UNIVERSITARIO EN INGENIERÍA DE TELECOMUNICACIÓN

TRABAJO FIN DE MÁSTER

DESIGN AND IMPLEMENTATION OF AN ABR VIDEO STREAMING SIMULATION MODULE FOR NS-3. ANALYSIS AND COMPARISON OF ABR VIDEO STREAMING ALGORITHMS OVER VARIOUS MOBILE NETWORK SCENARIOS.

XINXIN LIU
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ERICSSON

TRABAJO DE FIN DE MÁSTER

Título:	Diseño e implementación de un módulo de ABR video streaming para NS-3. Análisis y comparación de algoritmos de ABR video streaming sobre varios escenarios de redes móviles.
Título (inglés):	Design and implementation of an ABR video streaming simulation module for NS-3. Analysis and comparison of ABR video streaming algorithms over various mobile network scenarios.
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Resumen

El streaming de vídeo con tasa de bits adaptativa se está convirtiendo en la técnica más utilizada para las plataformas de vídeo en línea. Con la pandemia mundial *COVID-19*, el streaming de vídeo se ha convertido en una de las principales fuentes de entretenimiento durante los confinamientos. De hecho, más de la mitad de la cuota de tráfico de la red se utiliza hoy en día para streaming de vídeo [3].

El objetivo de este Trabajo Fín de Máster es construir un framework en *ns-3*, implementado en *C++*, para probar algoritmos de adaptación de vídeo y comparar algunas implementaciones sobre diferentes escenarios de red. El primer paso es estudiar *ns-3*, familiarizarse con algunos módulos de *ns-3* y construir varios escenarios de red *LTE*. El segundo paso es construir un módulo que pueda simular servidores y clientes de vídeo *ABR*, estudiar algunos enfoques de los algoritmos de adaptación de la tasa de bits de vídeo e implementar dichos algoritmos, incluyendo soluciones basadas en el ancho de banda, en el buffer y algoritmos híbridos. Por último, podemos comparar y evaluar el rendimiento de diferentes algoritmos *ABR* en escenarios con condiciones variables con diferentes métricas objetivas de *QoE*.

//// Resultados

Este proyecto se ha llevado a cabo con la cátedra Ericsson-UPM en software y sistemas.

Palabras clave: DASH, ABR, ns-3, streaming de video por HTTP, simulación, QoE

Abstract

Adaptive bitrate video streaming is becoming the most used technique for online video platforms. With the *COVID-19* worldwide pandemic, video streaming has become one of the primary sources of entertainment during the shutdown. In fact, more than half of the network traffic share today is used by video streaming [3].

The objective of this Master's Thesis is to build a framework in *ns-3*, implemented in *C++*, for testing video adaptation algorithms and to compare some implementations over different network scenarios. The first step is to study *ns-3*, familiarize with some *ns-3* modules, and build various LTE network scenarios. The second step is to build a module that can simulate *ABR* video servers and clients, study some approaches of video bitrate adaptation algorithms and implement those algorithms, including throughput based, buffer based and hybrid solutions. Finally we can compare and evaluate the performance of different *ABR* algorithms on scenarios with varying conditions with different objective *QoE* metrics.

//// Resultados

This project has been carried out with the Ericsson-UPM scholarship in software and systems.

Keywords: DASH, ABR, ns-3, HTTP video streaming, simulation, QoE

Acknowledgements

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Glossary

IP - Internet Protocol

ABR - Adaptive BitRate

HTTP - HyperText Transfer Protocol

CPU - Central Processing Unit

DASH - Dynamic Adaptive Streaming over HTTP

MPEG - Moving Picture Experts Group

ISO - International Organization for Standarization

IEC - International Electrotechnical Commision

MPD - Media Presentation Description

URL - Universal Resource Locators

QoE - Quality of Experience

HLS - HTTP Live Streaming

ns-3 - network simulator 3

LENA - LTE-EPC Network simulAtor

Chapter 1 | Introduction

1.1 Context

There is no doubt about the importance of online video streaming. According to Sandvine [3], in 2020, 57% of the global internet traffic was used by video streaming. Moreover, one of the key predictions made by Cisco in 2018 [4] stated that by year 2022, video traffic will make up 82% of all *IP* traffic.

Consequently, numerous challenges arise. Due to the growth of the number and diversity of video capable connected devices and every time more available bandwidth and better quality contents, the client and the server need to adapt the video content to the network and the devices. The technique of taking account the varying network conditions and computing resources of the user device to choose the adequate quality level is denominated as *Adaptive BitRate (ABR)*. Adaptation may be performed monitoring different paramaters such as estimated bandwidth, client's buffer level, CPU load or screen size.

The *Dynamic Adaptive Streaming over HTTP (DASH)* is one of the standards that implements Adaptive BitRate video streaming and was developed by the *Moving Picture Experts Group (MPEG)* [8]. *MPEG-DASH* enables provisioning and delivering media using existing *HTTP*-delivery networks supports dynamic adaptation with seamless switching.

The *MPEG-DASH* standard was published in 2012 and revised in 2019 by the *International Organization for Standarization (ISO) / International Electrotechnical Commision (IEC)* as *MPEG-DASH ISO/IEC 23009-1:2019* [7].

DASH divides the media file into small chunks or segments. *MPEG-DASH* defines the *Media Presentation Description (MPD)*, which is an XML-structured manifest file that contains the *Universal Resource Locators (URL)* of the segments. Different qualities are defined as representations, the *MPD* file contains information for each representation such as the codec, bandwidth, the resolution of the video or framerate.

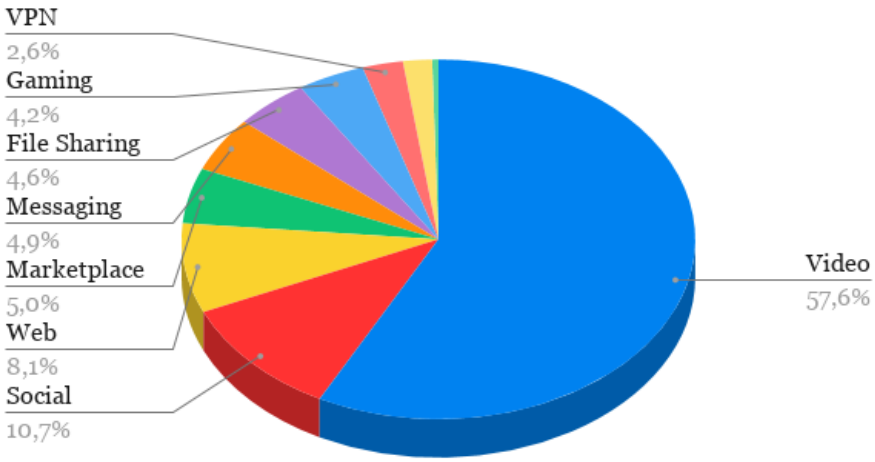

Figure 1.1: *Global application category total traffic share during COVID-19 lockdown. Source: Sandvine [3]*

However, the DASH Standard [7] only defines the data formats for the media reproduction and do not provide the adaptation algorithm. The *DASH Industry Forum* [5] provides a open source *MPEG-DASH* player implented in *JavaScript* with different adapation algorithms. Similarly, *hls.js* is a implementation of an *HTTP Live Streaming*[1] client.

The adaptation algorithms needs to be tested in different scenarios (real or simulated) and tweaked to provide the maximum perceived quality by the users. Also, there are algorithms that perform better in some specific scenarios and worse in others. The adaptation algorithm is the responsible of avoid problems that have a negative impact on the *Quality of Experience (QoE)*. Firstly, the algorithm can overestimate the bandwidth and it would cause a pause in the reproduction because all the segments in the buffer is emptied. The algorithm can also underestimate the bandwidth, the video player requests media segments with inferior quality than the quality at which the bandwidth available of the network can allow. Lastly, the algorithm should avoid constant bitrate switches result of bandwidth fructuations, and provide a smooth and seamless video watching experience.

The *ns-3* simulator is a open-source and extensible discrete-event network simulator. The extensible nature of this tool allows us to develop a new module for *ns-3* mimicking the behaviour of *ABR* clients and servers. With this new module, *ns-3* will be able to simulate extreme network scenarios and test the performance of various adaptation algorithms.

[1]HTTP Live Streaming is an HTTP-based adaptive bitrate streaming protocol developed by Apple Inc. [1]

1.2 Objectives

The objectives of this thesis is to build a framework for testing *ABR* adaptation algorithms, and implement some adaptation algorithms and compare them in various mobile network scenarios with different objective *QoE* metrics. In order to achieve the proposed objectives, the following steps will be proposed:

1. Study and understand *ns-3* and basic modules such as the core module, the internet module, applications module, *LENA* module among others. Build basic *LTE* scenarios tweak radio paramaters, and output results.
2. Design a new module in ns-3 that simulates behaviours of *ABR* clients and servers. Study and implement existing adaptation algorithms.
3. Define and implement objective *QoE* metrics. Build new *LTE* scenarios and compare the perfomances of the implemented adaptation algorithms.

1.3 Structure of the thesis

Chapter 1. Presents the context, the motivations and the objectives of this thesis.

Chapter 2. The State of the Art. BBBBBBB

Chapter 3. dddd

Chapter 4. dddd

Chapter 5. dddd

Chapter 2 | State of the art

In this chapter we ....

2.1 Adaptive Video Streaming

2.1.1 History

The first commercial video streaming was introduced in 1995 and is growing at an incredible rate.

2.2 Network Simulator 3

Chapter 3 | Conclusions And Future Work

Bibliography

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Chapter A | Impact

A.1 Social Impact

A.2 Economic Impact

A.3 Ambiental Impact

A.4 Ethic Impact

Chapter B | Budget