QUIC over IP Multicast

Degree Thesis submitted to the Faculty of the
Escola Tècnica d'Enginyeria de Telecomunicació de Barcelona
Universitat Politècnica de Catalunya
by

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In partial fulfillment
of the requirements for the degree in
Services and systems of Telecomunications **ENGINEERING**

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Barcelona, Date 2022

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Abbreviations

ETSETB Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona

EU European Union

Abstract

This document analyses the current implementations of QUIC protocol and the HTTP/3 mapping that facilitates the transfer of HTTP resources over multicast QUIC transport as its framing and packetisation layer. It shows the steps to create a radio station over HTTP in order to demostrate that a live-streaming over QUIC multicast is possible at the current moment. The benefits and withdraws of the current existing library (NGHQ[1]) are explained.

[1]HTTP over Multicast QUIC Draft 07 - Sam Hurst, Richard Bradbury

Revision history and approval record

Revision	Date	Purpose
0	05/03/2022	Document creation
1	dd/mm/yyyy	Document revision

DOCUMENT DISTRIBUTION LIST

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1 Introduction

The main purpose of this thesis is to test QUIC protocol over Multicast in a simulated environment in order to analyse the benefits and withdraws of the current way of delivering live-streaming content through networks, which is using unicast and TCP. An HTTP Radio Station will be deployed using NGHQ, the only avalaible open-source QUIC Multicast library. It does not have a stable version, so for future implementations some specifications may be different.

In order to replicate the internet environment, it has been developed a similar sceneario of the IP Multicast Practice from TCGI[2] but developed in VNX[3] instead of SimCTL and using an Ubuntu 18.03 LTS instead of Debian 5.

A unicast simple server using QUIC was also done using the NGTCP2 library, which is stable. It will be used as the reference for nowadays servers using the RFC 9000 QUIC.

Due to the complexity of the technologies involved and the differences of the approach using multicast instead of unicast it was needed to read a lot of documentation such as RFCs. During that time, it has been done the initial tests with the NGHQ library with some examples which are included with it (a simple sender-receiver application). Unluckly, it was found a small problem analysing the packets: wireshark did not detect them as QUIC. In order to be able to analyse those packets, a dissector using Lua have been developed. After the creation of the dissector, the small radio-station was developed and tested.

1.1 Gantt Diagram

Figure 1: Gantt diagram of the project

[2]TCGI : Transport, Control i Gestió d'Internet
[3]VNX : **V**irtual **N**etwork over Linu**x**

2 Live-streaming state of art

Live-streaming content is in its dawn. Although it is possible and it is being done nowadays, real-time content in Internet is still primitive in the way we are delivering it. We are using brute-force to deliver huge amounts of real-time content. It is a matter of fact that the demand for this type of content is growing far faster than the CDN [4] (from now on called servers) are able to supply to the spectactors (from now on called clients).

Even though someone might say it is almost every content via internet, there are still a lot of events that can not transmitted using internet because it cannot be supported[5] due to the heavy load of users that need to managed. As Jake Holland from Akamai wrote on Github: "The capacity of CDNs and others to deliver popular content at scale is not keeping up with demand."

In april of 2020, Akamai achieved the new world record of peak traffic delivery which was 176 tbps. It seems a lot, however it is not. Making some linear and quick easy maths it is easy to see that it is not. Keeping in mind that usually for real-time video we use CBR[6] encoder in order to squeeze the internet resources, for a 1080p video we need a bit-rate of 5 mbps, and for a 4k video, 20 mbps. This means that with the current world-record we can arrive to 35.2 millions of simultaneous users for live-streaming content using a 1080p encoding and 8.8 millions users using 4k. Considering that the world population with internet access is 5200 million people we are really faraway from delivering TV or Radio via Internet using the current methods. What is more, the Fifa World Cup Finals 2018 were seen by 500 million people, 200 million to 300 million people were seeing in India the Cricket World Cup in 2015 (whenever India is playing) and a large etcetera with a lot of content can be done. The brute force does not seem like a good stategy for scaling anymore, maybe only for quick deployments.

The solution that is being discussed in this Final Degree Project proposes to use multicast instead of unicast in order to avoid this scalability limitation, due to the fact that using this technology for distribute the same content to everyone is more efficient in terms of computation in the servers and of resources in general.

2.1 Technologies used at the moment

TCP is at the moment the main protocol over Internet. Almost every service at the moment uses it and HTTP is not an exception. When doing a HTTP request or response (versions 1.0, 1.1 and 2), TCP is being used. Even though, it is almost 50 years old and the internet has evolved and has grown significantly, it is still the main protocol. However, it is reaching its full capacity in two particular scenarios: websites with small pageload and real-time content such as TV and Radio. Although, the main goal of this project is to focus on the real-time content delivery, the small pageload problem will also be explained briefly because is what QUIC tries to solve as originally planned.

[4] CDN: Content Delivery Network
[5] https://github.com/GrumpyOldTroll/wicg-multicast-receiver-api/blob/master/explainer.md
[6] Constant Bit-Rate

Most of the is requested via a navigator like Firefox or Google Chrome, which use the HTTP protocol as the main communication protocol which the use of TCP. It is clear and obvious that for large content which is not in real-time that can be stored like films, TCP is not a big bottleneck. However, in the last several years, with the raising of important services (like e-commerce) and cyberattacks, specially spoofing, the use of TLS[7] has also became a standard. Websites that deliver real-time video like Youtube or Twitch are not an exception either. This also adds some complexity and workload delivering the website to the client.

When someone connects to a internet using a web-browser at least it need 3 packets for for stablishing the TCP connection, 3 for stablishing the TLS connection over TCP and 2 HTTP packets (request and response). It is being received the first byte of content after the 7th packet! This handshake, although being the most being used, it is not optimal. When a really small website is being delivered (imagine an html "Hello World!"), a load of resources and packets are being used for a deliver a small packet. More control stuff than content. It gets even worse, if it is the case that have already stablished a connection earlier and after a while there is a new request; all this handshake has to be done again because TCP and TLS are a connection oriented protocols, but HTTP is not. QUIC aims to solve this type of problems.

2.2 The new standard: QUIC

It is clear and obvious that for large content that can be stored in a small buffer and does not need to be real-time we can use a really known protocol that have been around for years which is TCP. It is the main protocol for most of the services in the internet and has been even implemented in the kernel of most of the devices. Many of the devices that rule internet like firewalls or load-balancers were designed bearing in mind that the protocol that had to be used was TCP. During many years it was not a priority to use other transport layer protocols except in rare case.

Nowadays, might be surprising that we use that procotol that is end-to-end to deliver the same real-time content to a large amount of spectactors (for now on they will be called clients)[8]. It is easy to see that this approach although having many withdrawals it has some benefits.

The solution that is being discussed in this Final Degree Project proposes to use multicast instead of unicast in order to avoid this scalability limitation, due to the fact that using this technology for distribute the same content to everyone is more efficient in terms of computation in the servers and of resources in general.

2.3 Benefits of using TCP for live-streaming

The main benefit with this approach for real-time content is the easiness on the programming and mounting at first time. All devices (or almost all) can bypass internet elements

[7] TLS : Transport Security Layer

[8] In the Annexe I there is a larger explanation and details on how to test this with famous websites at the moment

when they talk TCP.

At the current moment, it is the standard which means less complexity, more tools and easier to implement. For young services that are not expected to growth a lot TCP is more than enought for most cases.

At the same time, there

2.4 UDP

Nevertheless, in the last decade it has been a growing interest in other procotols that are end-to-end and allow to expand functionalities in upper layers: UDP[9]. It is a really simple protocol with almost 0 functionalities aside from passing the content to the upper layer. It has been around since the creation of the internet. That means, like with TCP, is implemented in the kernel. Changing the kernel of all the devices in the internet it is imposible

2.5 Topic

Here you have a couple of references about LaTeX [1] and electrodynamics [2].

2.6 Topic

[9]UDP: User Datagram Protocol

3 Section 3

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3.1 Subsection

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Algorithm 1 Temperature-Distributed algorithm

procedure TEMP-SPREAD($GN_i, HN_j, temperatures$) ▷ Lowest temperature priority
 $temperature\_list \leftarrow short(temperatures)$
 $max_temperature \leftarrow max(temperature_list)$
 $ThresHold \leftarrow 0.5$
 $temperature\_impact \leftarrow 0.2$
 for GN_i in $i = 1, 8$ **do** ▷ Iterate every hardware node on the given GN
  $it\_temperature \leftarrow temperature\_list(GN_i)$
  $temp\_weight \leftarrow \frac{max\_temperature - it\_temperature}{max\_temperature} * temperature\_impact$
  $\omega(Master - GN_i) \leftarrow ThresHold * temp\_weight$
  for HN_j in $j = 1, n$ **do**
   if $available\_accel_{i,j} > busy\_accel_{i,j}$ **then**
    $policy_\omega = \frac{AvailableHW}{TotalHW} * ThresHold$
    $\omega(GN_i - HN_{i,j}) \leftarrow ThresHold + policy_\omega$
   else
    $\omega(GN_i - HN_{i,j}) \leftarrow 1$
 $node \leftarrow find\_djistra\_shortest\_path(Master\_Node, aux\_node)$
 $returnnode\ b$ ▷ The gcd is b

4 Section 4

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4.1 Subsection 4.1

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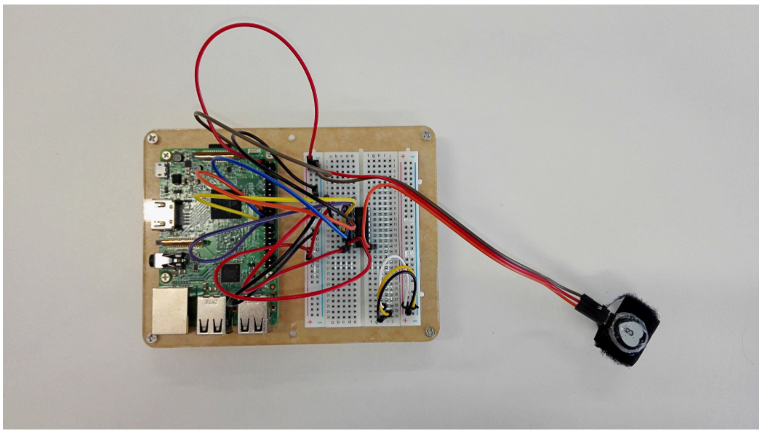

Figure 2: Prototype setup.

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4.2 Subsection 4.2

Table 1: This is the other caption. Since the trial size of the experiments showed is one second, the number of *Target* and *Impostor* data corresponds to number of trials or seconds

Dataset	**Label**	**Train**	**Validation**	**Develop**	**Test**
First	Target	135	45	30	30
	Impostor	5,220	1,740	1,890	2,880
	#Subjects		31		12
Second	Target	144	80	48	48
	Impostor	2,014	1,119	1,343	1,545
	#Subjects		15		5

5 Section 5

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5.1 Overview

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6 Experiments and results

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7 Budget

Depending on the thesis scope this document should include:

8 Environment Impact (Optional)

Whether the tasks that have led to the realization of this thesis, as if its results have identifiable environmental impact, describe it in this section.

9 Conclusions

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10 Future Work

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[1] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Addison-Wesley, Reading, Massachusetts, 1993.

[2] Albert Einstein. Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921, 1905.

[3] Donald Knuth. Knuth: Computers and typesetting.

Appendices

Appendices may be included in your thesis but it is not a requirement.