

Why Implement Distributed Systems in Municipal Music Schools in Colombia?

Leidy D. Ariza¹ & Carlos R. Orjuela¹

¹ Technological faculty, Francisco Jose of Caldas District University, Bogota, Colombia

Correspondence: Leidy D. Ariza, Technological faculty, Francisco Jose of Caldas District University, Bogota, Career 159 # 136 -25, Colombia. Tel: 11-57-313- 3114595. E-mail: leidydi.ariza@gmail.com

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Abstract

In Colombia, since 2003, the public policy "National Plan of Music for citizen Coexistence" has been implemented as a government measure, which provides music courses in each one of the country's municipalities. This plan does not take into account the use of technologies to share the experiences of each one of the schools.

Taking into account the above- mentioned points, this article focuses its attention on the search of technologies that can be used to share multimedia content such as *Content Delivery Network (CDN)*, *Learning Management System (LCMS)* and Distributed Systems in order to indicate which technology is the most appropriate to fulfill this purpose.

In that sense, through the Wireshark tool, network traffic is captured for each one of the tests performed: Upload, display and deletion of videos for each configured technology (CDN, LCMS and Distributed Systems), having as comparison parameters the following aspects: Real-time Traffic, Total Traffic Vs Packet Loss, Communication Exchange and Protocol Hierarchies. After doing that, we proceed to take statistics to be analyzed and obtain the comparative results that are needed for this research.

Finally, one can conclude the comparison of the results of each technology: that it is appropriate that the municipal schools of music use distributed systems because the size of the packets sent is smaller than that one that is sent by CDN and CML technologies. There are no multiple communication jumps. No prior approval is required to publish the content and there is no limitation on the size of the content to be published.

Keywords: content delivery network, communication, distributed system, e-learning, learning content management system, multimedia, package, performance, traffic

1. Introduction

1.1 Introduce the Problem

1) Why is this problem important?

In Colombia, the connection in opportunities with access for the exercise of education and musical practice in conditions of equity and under the criteria that allows broad regional coverage has been limited. The Ministry of Culture through the "National Plan of Music for Coexistence", a public policy for music since 2003, seeks to strengthen and guarantee the population their right to know, practice and enjoy musical creation. In this way, it fosters the training and consolidation of Municipal Schools of Music in all the municipalities of the country, promoting musical education for children, young people and adults.

At present, there are 943 Municipal Music Schools created through an administrative act, corresponding to 73% of national coverage, with an approximate service of 93,000 children, adolescents and young people. Currently, these schools do not have a system to store and share such information, since all multimedia material is handled locally.

2) How does the study relate to previous work in the area? If other aspects of this study have been reported previously, how does this report differ from, and build on, the earlier report?

In order to carry out this article it was necessary to consult on different theses that have been interested in the matter to be addressed in this project. During the search of these theses, it was identified that some theses focused their attention on one of the technologies to share multimedia such as LMS, making comparative charts

that allowed identifying between different platforms which one was the most appropriate for a certain institution. Another study focused its attention on the measurement of parameters to verify that LMS tool will allow adding new components to the platform and that its integration is acceptable.

Analysis of Productivity to Add Components in LMS Tools Applied to the Development of a Module Oriented to the New Management of Epoch Ratings.

This thesis is carried out in Riobamba, Ecuador in 2013. In this research, the authors pretend to select, under the measurement of parameters, the LMS tools that best suit the requirement to add new components. Once the tools have been selected, it will proceed to validate similarities of the characteristics and behavior that each one has, in order to be able to select the tool that best suits to the need. (Villacres & Silva, 2013)

Comparative research of LCMS platforms used by universities at the national level.

This thesis is carried out in Machala in 2016. It shows a comparative study of the LCMS platforms used by ten universities of Ecuador that were selected for this research; it analyzes the functionalities, advantages and disadvantages of each virtual platform. Finally, a performance test of the virtual educational platform is performed, by using a computer tool that measures the behavior of the hardware along with the software, in terms of processing speed. (Armijos, 2016)

State of the Art Construction of Technologies Used in Virtual Education

This project is carried out in Pereira in 2009, this project that is related to the technologies that are used in virtual education, aims at providing all the necessary information for the research group Nyquist of Technological University of Pereira, to build a new platform for virtual education. This research tries to reveal aspects such as: traffic generated, bandwidth used, application capabilities, in order to determine the hardware requirements and the impact that the applications generate in the traffic level of the networks. (Arevalo, 2009)

3) What are the primary and secondary hypotheses and objectives of the study, and what, if any, are the links to theory?

General Objective

To query on the characteristics of the main technologies that allow to share multimedia contents and to establish through a comparative test the performance, speed of each technology and the cost - benefit relation in order to point out which one is suitable for Municipal Schools of Music.

Specific Objectives

To identify the characteristics and benefits of LMS, LCMS, CDN technologies and Distributed Systems.

To carry out the analysis of traffic network and the behavior of each one of the technologies, taking into account the selected comparative parameters.

To determine which one of the researched technologies best suits to the needs of the Municipal Schools of Music according to the results obtained.

1.2 Explore Importance of the Problem

This project analyzes the current situation regarding the local storage of information, the limited internet access in departments with presence of armed conflict actors and the centralized access to the multimedia production of the Municipal Music Schools in Colombia, as well as the lack of a system that allows to carry out the academic follow-up of the students, especially for those who, due to their condition of vulnerable population, are forced to change their physical location and want to continue their musical academic training in another municipal school near their new place of residence.

This research also includes a description of the most common alternatives to solve the problems that were previously mentioned such as: CDN technologies, LMS and Distributed Systems including its advantages, disadvantages, performance for both loading and unloading, visualization of files and ease of use for both educators and students.

1.3 Describe Relevant Scholarship

1.3.1 Learning Management System (LMS)

The e-learning platform, virtual campus or Learning Management System (LMS) enables distance learning through a virtual space. LMS facilitates distributed and collaborative learning from activities and content already developed, synchronously or asynchronously, using internet communication services such as mail, forums, videoconferences and chat. (Lopez, 2005)

Within the Educational Software, there are free platforms that allow sharing information. We will mention the following ones:

Learning Content Management System (LCMS)

LCMS is defined as a web-based system that is used to create, approve, publish, manage and store educational resources. This system can be used by the designers who assemble the course, teachers who use the content to prepare their classes and students can also access the platform so as to strengthen their knowledge.

The content is stored within an LCMS as identifiable objects within containers or repositories which can be used independently and are available in an open way, meaning that anyone can access to the information that is needed.

One of the products is ATutor, distributed as a free software and compatible with e-learning standards for the export and import of content with other platforms and also with Learning Object Repositories. (Lopez, 2005)

1.3.2 ATUTOR

ATutor is a Web-based Learning Management System (LMS) created in open source software that is used to develop and deliver online courses. Educators can quickly assemble, package and redistribute Web-based educational content, easily import prepackaged content, and take their courses online.

ATutor's main features are: Accessibility, working groups, forums, create and share documents, store files, share storage space, assign blogs to working groups using mathematical notation in latex templates and multimedia objects when necessary for blog posts, content viewer, and a Concurrent Version System (CVS) to ensure the tracking of the documents worked and the historical archive as well.

1.3.3 ACONTENT

AContent is a learning content management system (LCMS) with an open –source software that is used to create interactive, accessible, and adaptable web-based learning content. It can be used in along with learning management systems to develop, share and store learning materials. AContent has the development of different kind of content, test authentication, and it also offers the opportunity to get the all the interoperability features in terms of content that ATutor has, producing a stand-alone tool that can be used with any system that supports IMS taking into account content interoperability standards.

Table 1. Advantages and Disadvantages of LCMS

Advantages	Disadvantages
Asynchronous and Synchronous Communication	Internet connection is required
Collaborative Groups	The deployment of information depends on speed and browsers
Search of remote database	To publish information, it is necessary to have space on storage server and previous approval by the administrators of the platform for the final publication of the course.
It reduces editing time by reusing templates and learning objects	
Faster content delivery	

1.3.4 Content Delivery Network CDN

It is a network made up of a main server and several alternatives between which the content is kept updated to be delivered to the end users. These types of networks are usually private and corporative; nevertheless, they have recently been opened to the general public by offering content hosting according to the needs of the customers.

Advantages:

High availability of the content to offer, even with the unavailability of one or more of the substitutes.

Low latency and increased response time between substitutes and clients.

Control of content integrity preventing modification or elimination.

Disadvantages:

High maintenance cost per year depending on the type of regional or global coverage.

1.3.5 Distributed Systems (S.D)

A Distributed System is a set of independent computers connected through a network, and with specific software that are shown to users as a single computer. This definition can be taken, taking into account the definitions given by Tanenbaum and Colouris.

Tanenbaum: A distributed system is a collection of independent computers that appear to the users of the system as a single computer. (Tanenbaum, 1996)

Colouris: A distributed system consists of a collection of autonomous computers, linked by a computer network and equipped with specific software. (Colouris, 1999)

Characteristics:

Distributed systems look for goals to achieve, systems to be faster, more efficient, more reliable, more accurate and more adaptable.

To provide greater quality of service and speed by increasing the number of servers.

To ensure operational continuity of the system, in which the most important aspect is not speed but availability.

To look for accuracy or computation ability, taking the background that the system delays in delivering the results. (Menéndez, 2009)

2. Methodology

The methodology will be divided into three sections: loading videos, video viewing and deleting videos, within each one finds the process to obtain the results, which consists in capturing the frames with the program Wireshark from entry to the platform (FTP, HTTPS or NFS), analysis of the traces and generation of comparing graphs.

This methodology will be used in the tests for each of the technologies: CDN, LCMS and distributed systems. The parameters that were chosen to make the comparison of each one of the technologies are: real-time traffic, generation of packets per second identifying the quantity of packets sent (Tx packets), received (Rx packets), original sizes of files and total sizes in the frames, total vs. lost packet traffic ratio, communication exchange capability, and protocol hierarchy.

2.1 Capture and Traffic Analysis

To perform a network traffic analysis, it is required to identify all the necessary data to make the performance comparison of the different technologies that we are going to test. For this test, we will use the tool WIRESHARK

2.2.7 For the traffic capture process, the following steps were followed:

2.1.8 To capture traffic using CDN Technology

A CDN must be configured to allow sending the video or the multimedia content, when uploading videos via FTP (FileZilla Client), the Wireshark program is activated allowing real-time traffic capture. It is important to obtain the .pck file that Wireshark generates in order to get the required data for the traffic analysis, get the display of each one of the videos that were uploaded from the platform.

After following all the previous steps, the corresponding data to the selected parameters were obtained.

And finally, the results are retained and then compared with the results obtained by the other technologies

2.1.2 To Capture Traffic Using LCMS Technology

For doing that, Docebo platform is selected for this test. registration on the platform is done with a corporate email (in this case, a student mail account from District University). Nevertheless, open emails such as Hotmail, Gmail, Yahoo, etc. are not allowed. Once you enter on the platform, a folder is created to store the multimedia content. The platform allows you to upload 1 video at a time while activating the Wireshark program that allows you to capture network traffic in real time. It's important to obtain the .Pck file that generates Wireshark in order to get the required data for the traffic analysis, get the display of each one of the videos that were uploaded from the platform. After following all the previous steps, the data corresponding to the selected parameters were obtained; the results are retained and then compared with the results obtained by the other technologies.

2.1.3 To Capture Traffic Using Distributed Systems

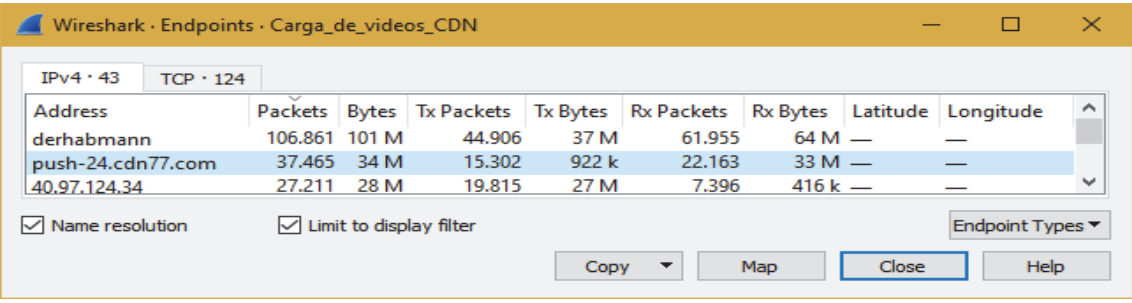
Considerations:

Inner shared folder of the school network with access only to domain users with permissions to write, read and modify content. The Website exposure with Directory browsing permission (in read mode to prevent accidental or incidental deletion or modification of the content) from the server at the external network level through the WIFI of the municipal school or the WIFI network of the Municipal Mayor's Office. For this reason, login processes, advertising banners, and platform load timeout are not present in this analysis. The upload protocol is NFS which allows you to copy content within the same network from one computer to another, copied from an USB device, a pen drive, a video camera, a photo camera or just a mobile phone. Displaying videos from the published intranet site through the WIFI network of the school or the Municipal Mayor's Office. It's mandatory to obtain the .Pck file that generates Wireshark in order to get the required data for the traffic analysis by following all the previous steps, the corresponding data to the selected parameters were obtained and the result were retained and then compared with the results obtained by the other technologies.

2.2 Statistics Collected from Tests with CDN Technology

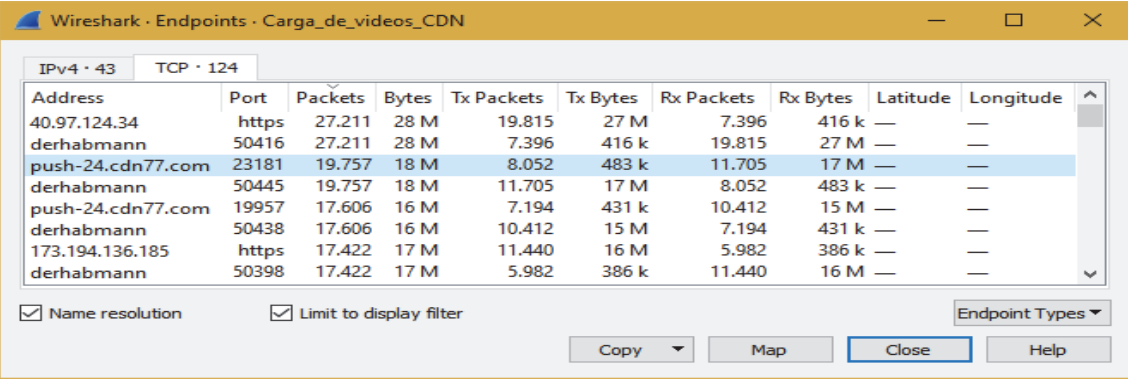
The first thing that done was the loading of videos, and as a result, the following graphs were obtained:

Generation of packages:



Address	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	Latitude	Longitude
derhabmann	106.861	101 M	44.906	37 M	61.955	64 M	—	—
push-24.cdn77.com	37.465	34 M	15.302	922 k	22.163	33 M	—	—
40.97.124.34	27.211	28 M	19.815	27 M	7.396	416 k	—	—

Figure 1. Ipv4



Address	Port	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	Latitude	Longitude
40.97.124.34	https	27.211	28 M	19.815	27 M	7.396	416 k	—	—
derhabmann	50416	27.211	28 M	7.396	416 k	19.815	27 M	—	—
push-24.cdn77.com	23181	19.757	18 M	8.052	483 k	11.705	17 M	—	—
derhabmann	50445	19.757	18 M	11.705	17 M	8.052	483 k	—	—
push-24.cdn77.com	19957	17.606	16 M	7.194	431 k	10.412	15 M	—	—
derhabmann	50438	17.606	16 M	10.412	15 M	7.194	431 k	—	—
173.194.136.185	https	17.422	17 M	11.440	16 M	5.982	386 k	—	—
derhabmann	50398	17.422	17 M	5.982	386 k	11.440	16 M	—	—

Figure 2. Tcp

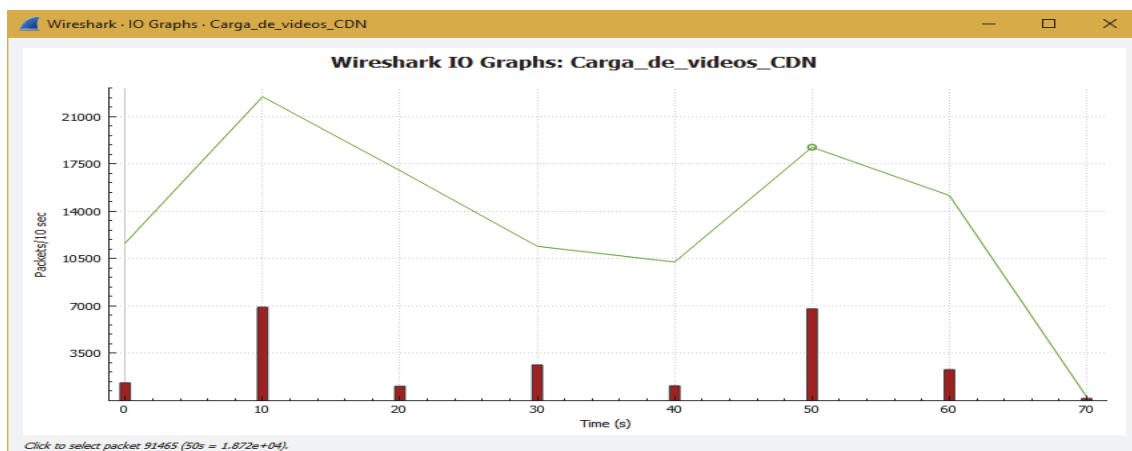


Figure 3. Total Traffic vs. Packet Loss Ratio

Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Abs Start	Duration	Bits/s A → B	Bits/s B → A
push-24.cdn77.com	derhabmann	37.465	34 M	15.302	922 k	22.163	33 M	20:59:18.787732	58.3938	126 k	4545 k
40.97.124.34	derhabmann	27.211	28 M	19.815	27 M	7.396	416 k	20:59:12.055311	69.8496	3189 k	47 k
173.194.136.185	derhabmann	17.422	17 M	11.440	16 M	5.982	386 k	20:59:13.653969	68.4409	1976 k	45 k

Figure 4. Package Exchanges (Conversation) – Ipv4

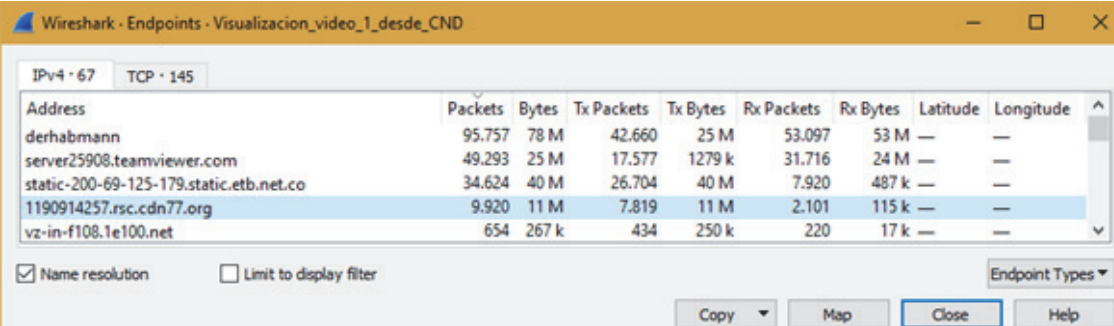
Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Abs Start	Duration	Bits/s A → B	Bits/s B → A
derhabmann	50416	40.97.124.34	https	27.211	28 M	7.396	416 k	19.815	27 M	20:59:12.055311	69.8496	47 k	3189 k
derhabmann	50445	push-24.cdn77.com	23181	19.757	18 M	11.705	17 M	8.052	483 k	20:59:41.028273	35.5725	3949 k	108 k
derhabmann	50438	push-24.cdn77.com	19957	17.606	16 M	10.412	15 M	7.194	431 k	20:59:21.568988	18.6677	6690 k	185 k

Figure 5. Package Exchanges (Conversation) – Tcp

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s
Frame	100.0	106896	100.0	101894978	11 M	0	0	0
Ethernet	100.0	106896	1.5	1496544	170 k	0	0	0
Internet Protocol Version 6	0.0	13	0.0	3464	395	0	0	0
Internet Protocol Version 4	100.0	106876	2.1	2137520	243 k	0	0	0
User Datagram Protocol	1.2	1304	0.0	10432	1190	0	0	0
Teredo IPv6 over UDP tunneling	0.0	4	0.0	340	38	0	0	0
Internet Protocol Version 6	0.0	4	0.0	272	31	0	0	0
Internet Control Message Protocol v6	0.0	4	0.0	112	12	4	112	12
Simple Service Discovery Protocol	0.0	4	0.0	696	79	4	696	79
NetBIOS Name Service	0.0	9	0.0	450	51	9	450	51
Domain Name System	0.0	18	0.0	1371	156	18	1371	156
Data	1.2	1269	0.7	688202	78 k	1269	688202	78 k
Transmission Control Protocol	98.8	105564	95.6	97452809	11 M	79745	64769286	7391 k
Sinec H1 Protocol	0.0	1	0.0	1452	165	0	0	0
Secure Sockets Layer	6.0	6403	40.5	41309909	4714 k	6248	38655568	4411 k
Malformed Packet	0.0	3	0.0	0	0	3	0	0
Hypertext Transfer Protocol	0.0	22	0.2	179268	20 k	15	7362	840
Media Type	0.0	7	0.2	167699	19 k	7	171906	19 k
File Transfer Protocol (FTP)	0.0	49	0.0	3880	442	49	3880	442
Data	18.2	19497	23.3	23721264	2707 k	19497	23721264	2707 k
Internet Control Message Protocol	0.0	8	0.0	64	7	8	64	7
Address Resolution Protocol	0.0	7	0.0	196	22	7	196	22

Figure 6. Protocol Hierarchy

Below is the capture of network traffic at the time of display video 1 in CDN



Wireshark · Endpoints · Visualizacion_video_1_desde_CND

IPv4 · 67 TCP · 145

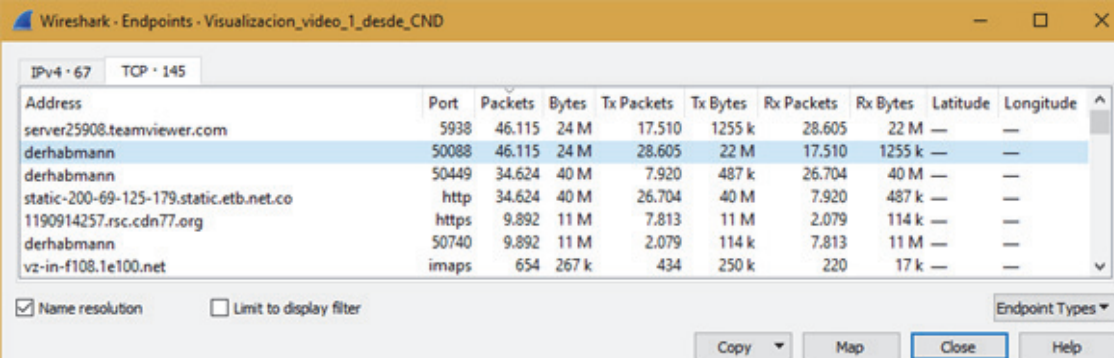
Address	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	Latitude	Longitude
derhabmann	95.757	78 M	42.660	25 M	53.097	53 M	—	—
server25908.teamviewer.com	49.293	25 M	17.577	1279 k	31.716	24 M	—	—
static-200-69-125-179.static.etb.net.co	34.624	40 M	26.704	40 M	7.920	487 k	—	—
1190914257.rsc.cdn77.org	9.920	11 M	7.819	11 M	2.101	115 k	—	—
vz-in-f108.1e100.net	654	267 k	434	250 k	220	17 k	—	—

☒ Name resolution ☐ Limit to display filter

Endpoint Types ▾

Copy ▾ Map Close Help

Figure 7. Network Traffic Ipv4



Wireshark · Endpoints · Visualizacion_video_1_desde_CND

IPv4 · 67 TCP · 145

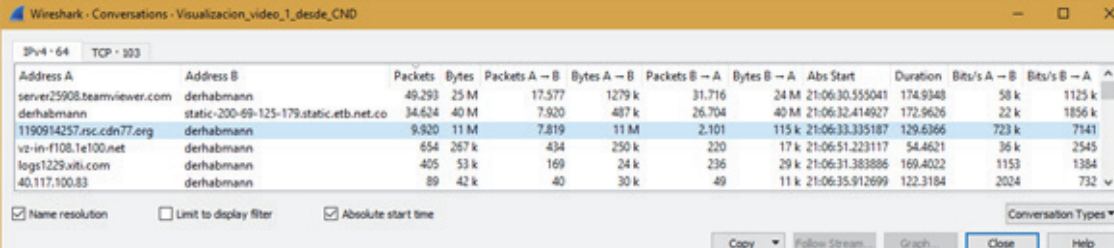
Address	Port	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	Latitude	Longitude
server25908.teamviewer.com	5938	46.115	24 M	17.510	1255 k	28.605	22 M	—	—
derhabmann	50088	46.115	24 M	28.605	22 M	17.510	1255 k	—	—
derhabmann	50449	34.624	40 M	7.920	487 k	26.704	40 M	—	—
static-200-69-125-179.static.etb.net.co	http	34.624	40 M	26.704	40 M	7.920	487 k	—	—
1190914257.rsc.cdn77.org	https	9.892	11 M	7.813	11 M	2.079	114 k	—	—
derhabmann	50740	9.892	11 M	2.079	114 k	7.813	11 M	—	—
vz-in-f108.1e100.net	imaps	654	267 k	434	250 k	220	17 k	—	—

☒ Name resolution ☐ Limit to display filter

Endpoint Types ▾

Copy ▾ Map Close Help

Figure 8. Network Traffic TCP



Wireshark · Conversations · Visualizacion_video_1_desde_CND

IPv4 · 64 TCP · 303

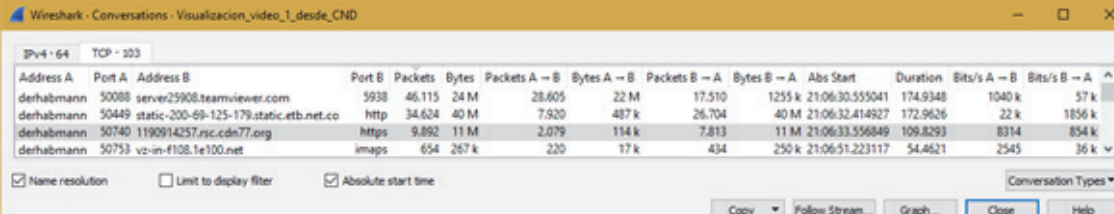
Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Abs Start	Duration	Bits/s A → B	Bits/s B → A
server25908.teamviewer.com	derhabmann	49.293	25 M	17.577	1279 k	31.716	24 M	21:06:30.555041	174.9348	58 k	1125 k
derhabmann	static-200-69-125-179.static.etb.net.co	34.624	40 M	7.920	487 k	26.704	40 M	21:06:32.414927	172.9626	22 k	1856 k
1190914257.rsc.cdn77.org	derhabmann	9.920	11 M	7.819	11 M	2.101	115 k	21:06:33.335187	129.6366	723 k	7141
vz-in-f108.1e100.net	derhabmann	654	267 k	434	250 k	220	17 k	21:06:51.223117	54.4621	36 k	2545
logs1229.xiti.com	derhabmann	405	53 k	169	24 k	236	29 k	21:06:31.383886	169.4022	1153	1384
40.117.100.83	derhabmann	89	42 k	40	30 k	49	11 k	21:06:35.912699	122.3184	2024	732

☒ Name resolution ☐ Limit to display filter ☒ Absolute start time

Conversation Types ▾

Copy ▾ Follow Stream... Graph... Close Help

Figure 9. Package Exchanges (Conversation) – Ipv4



Wireshark · Conversations · Visualizacion_video_1_desde_CND

IPv4 · 64 TCP · 303

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Abs Start	Duration	Bits/s A → B	Bits/s B → A
derhabmann	50088	server25908.teamviewer.com	5938	46.115	24 M	28.605	22 M	17.510	1255 k	21:06:30.555041	174.9348	1040 k	57 k
derhabmann	50449	static-200-69-125-179.static.etb.net.co	http	34.624	40 M	7.920	487 k	26.704	40 M	21:06:32.414927	172.9626	22 k	1856 k
derhabmann	50740	1190914257.rsc.cdn77.org	https	9.892	11 M	7.813	11 M	2.101	115 k	21:06:33.335187	129.6366	8314	854 k
derhabmann	50733	vz-in-f108.1e100.net	imaps	654	267 k	434	250 k	220	17 k	21:06:51.223117	54.4621	2545	36 k

☒ Name resolution ☐ Limit to display filter ☒ Absolute start time

Conversation Types ▾

Copy ▾ Follow Stream... Graph... Close Help

Figure 10. Package Exchanges (Conversation) – TCP

Below is the capture of network traffic at the time of display video 2 in LMS

Wireshark - Conversations - Visualizacion_video_2_desde_LMS

Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Abs Start	Duration	Bits/s A → B	Bits/s B → A
104.44.195.161	derhabmann	93,536	58 M	32,590	16 M	60,946	42 M	19:06:45.455123	166.5764	769 k	2053 k
server-54-192-82-106.mia50r.cloudfront.net	derhabmann	225,586	196 M	126,750	190 M	98,836	5455 k	19:06:45.452397	136.6625	11 M	319 k
derhabmann	www.google.com.co	600	366 k	282	33 k	318	333 k	19:07:15.199212	110.0027	2434	24 k
derhabmann	a1872.g.akamai.net	382	296 k	166	17 k	216	278 k	19:07:13.868265	109.2472	1269	20 k

Figure 11. Network Traffic Ipv4

Wireshark - Conversations - Visualizacion_video_2_desde_LMS

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Abs Start	Duration	Bits/s A → B	Bits/s B → A
derhabmann	53673	server-54-192-82-106.mia50r.cloudfront.net	https	225,574	196 M	98,830	5455 k	126,744	190 M	19:06:45.452397	112.7457	387 k	13 M
derhabmann	53742	va-in-f108.1e100.net	imaps	1,368	544 k	524	42 k	844	501 k	19:06:23.893107	65.5097	5241	61 k
derhabmann	53693	13.107.21.200	https	446	424 k	136	54 k	310	369 k	19:07:13.803416	76.8769	5683	38 k

Figure 12. Network Traffic TCP

Wireshark - Conversations - Visualizacion_video_2_desde_LMS

Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
40.122.162.208	192.168.0.3	23	8026	12	6144	11	1882	41.290166	108.5154	452	138
ec2-52-27-234-183.us-west-2.compute.amazonaws.com	192.168.0.14	6	2299	6	2299	0	0	0.651861	156.7508	117	0
ec2-52-212-68-117.eu-west-1.compute.amazonaws.com	192.168.0.3	21	1610	7	602	14	1008	2.006582	151.1733	31	53
server-54-192-82-106.mia50r.cloudfront.net	192.168.0.3	112,793	98 M	63,375	95 M	49,418	2727 k	0.000000	136.6625	5586 k	159 k
ec2-54-194-15-114.eu-west-1.compute.amazonaws.com	192.168.0.3	145	63 k	72	26 k	73	36 k	2.905489	160.4683	1317	1843
64.4.23.173	192.168.0.3	2	140	1	62	1	78	61.020246	0.1974	2512	3161
msnbot-65-52-108-209.search.msn.com	192.168.0.3	12	1412	4	768	8	644	21.712977	135.2731	45	38
65.55.223.14	192.168.0.3	3	212	1	62	2	150	33.740509	2.1915	226	547
65.55.223.22	192.168.0.3	52	5581	26	2023	26	3558	15.237251	134.2082	120	232

Figure 13. Package Exchanges (Conversation) – Ipv4

Wireshark - Conversations - Visualizacion_video_2_desde_LMS

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
192.168.0.3	53673	server-54-192-82-106.mia50r.cloudfront.net	https	443	112,787	98 M	49,415	2727 k	63,372	95 M	0.000000	112.7457	193 k
192.168.0.3	53566	ec2-52-212-68-117.eu-west-1.compute.amazonaws.com	https	33380	21	1610	14	1008	7	602	2.006582	151.1733	53
192.168.0.3	53675	103.10.4.40	https	21	3	198	3	198	0	0	2.812428	9.0009	175
192.168.0.3	53664	ec2-54-194-15-114.eu-west-1.compute.amazonaws.com	https	443	139	63 k	69	36 k	70	26 k	2.905489	160.4683	1830
192.168.0.3	53672	69.41.46.41	https	80	1	66	1	66	0	0	3.639709	0.0000	---
192.168.0.3	53656	134.179.111.154	https	80	1	60	0	0	1	60	8.780832	0.0000	---
192.168.0.3	53676	69.41.46.41	https	443	3	198	3	198	0	0	8.965109	9.0033	175
192.168.0.3	53677	play.google.com	https	443	36	17 k	15	1782	21	16 k	11.018094	154.0113	92

Figure 14. Package Exchanges (Conversation) – TCP

Below is the capture of network traffic at the time of display video 1 in Distributed system

Wireshark - Conversations - Visualizacion_video_1_desde_SD

Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
static-186-31-119-144.static.etb.net.co	derhabmann	40,330	40 M	26,631	39 M	13,699	896 k	0.178719	204.0709	1559 k	35 k
cable-181-131-32-51.une.net.co	derhabmann	32,942	18 M	3,077	562 k	29,865	17 M	0.000000	207.3879	21 k	677 k
192.168.0.4	192.168.0.11	14,475	11 M	7,118	432 k	7,357	11 M	6.563911	92.7744	37 k	958 k
derhabmann	255.255.255.255	104	13 k	104	13 k	0	0	0.887217	206.2896	540	0
192.168.0.1	derhabmann	99	10 k	49	6591	50	4109	1.030608	201.0008	262	163

Figure 15. Network Traffic Ipv4

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
derhabmann	63660	static-186-31-119-144.static.etb.net.co	https	40	330	13	699	896	26	631	39 M	0.178719	204.0709
192.168.0.4	53827	192.168.0.11	https	14	451	11	M	7	103	431 k	7.348	11 M	6.589186
derhabmann	63410	bog02s05-in-f206.1e100.net	https	84	14 k	39	10 k	45	3877	4.143589	187.0533	442	165
derhabmann	63744	a-0011.a-msedge.net	https	48	27 k	22	11 k	26	15 k	156.455060	1.4996	62 k	83 k
derhabmann	63739	a-0001.a-msedge.net	https	32	14 k	14	5651	18	9096	103.099592	69.7396	648	1043

Figure 16. Network Traffic TCP

Wireshark - Conversations - Visualizacion_video_1_desde_50

Ethernet II, 12IPv4, 45IPv6, 7TCP, 31UDP, 161

Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
192.168.0.3	224.0.0.253	1	82	1	82	0	0	75.961637	0.0000	—	—
192.168.0.3	224.0.0.251	1	83	1	83	0	0	123.712538	0.0000	—	—
192.168.0.3	mia07s26-in-f4.1e100.net	7	378	7	378	0	0	124.680997	18.9015	159	0
192.168.0.3	a-0011.a-msedge.net	48	27 k	22	11 k	26	15 k	156.455060	1.4996	62 k	83 k
192.168.0.4	239.255.255.250	20	13 k	20	13 k	0	0	1.417922	161.5123	691	0
192.168.0.4	192.168.0.11	14	475	11	M	7	118	6.563911	92.7744	37 k	958 k
192.168.0.4	192.168.0.255	2	442	2	442	0	0	170.693223	1.5021	2354	0
192.168.0.11	192.168.0.255	1	243	1	243	0	0	65.441040	0.0000	—	—
192.168.0.13	bog02s05-in-f206.1e100.net	1	66	0	0	1	66	201.538248	0.0000	—	—
192.168.0.13	mia07s26-in-f4.1e100.net	1	66	0	0	1	66	201.538248	0.0000	—	—

☒ Name resolution☐ Limit to display filter☐ Absolute start time

CopyFollow StreamGraphCloseHelp

Conversation Types

Figure 17. Package Exchanges (Conversation) – Ipv4

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
192.168.0.3	58466	91.190.216.54	12350	3	173	2	113	1	60	205.508507	0.2487	3635	1930
192.168.0.4	53826	192.168.0.11	443	8	1847	5	506	3	1341	6.563911	0.0226	179 k	474 k
192.168.0.4	53827	192.168.0.11	443	14	451	11	M	7	103	431 k	7.348	11 M	6.589186
192.168.0.4	53828	192.168.0.11	443	8	1847	5	506	3	1341	7.527225	0.0936	43 k	114 k
192.168.0.4	53830	192.168.0.11	443	8	1847	5	506	3	1341	8.691133	0.0194	208 k	552 k
192.168.0.13	35214	13.107.3.128	443	1	60	0	0	1	60	32.161301	0.0000	—	—
192.168.0.13	33325	bog02s05-in-f206.1e100.net	443	1	66	0	0	1	66	201.538248	0.0000	—	—
192.168.0.13	46874	mia07s26-in-f4.1e100.net	443	1	66	0	0	1	66	201.619388	0.0000	—	—

Figure 18. Package Exchanges (Conversation) – TCP

3. Results and Discussion

It is important to keep this table in mind for comparing technologies

Table 2. Names of the Videos

File	Name
Video 1	Playing_with_the_names.mp4
Video 2	Musical Initiation Class.mp4

Table 3. Load of videos referring to each one of the technologies selected for this research.

Upload Technology comparative table									
Technology	File	File (MB)	Size	Total (MB)	files	Size	Protocol	Total Size traffic after upload (MB)	Total files Size 1 & 2 (MB)
CDN	Video 1	10,4	20,5	20,5	2	20,9	FTP	18	34
	Video 2	10,1					FTP	16	
LMS	Video 1	10,4	20,5	20,5	2	20,9	HTTPS	11	22
	Video 2	10,1					HTTPS	11	
S.D.	Video 1	10,4	20,5	20,5	2	20,9	NFS	10,4	20,5
	Video 2	10,1					NFS	10,1	

As a result of the first table there is an increase in the size of the traffic-level file on the CDN and LMS platforms, compared to the original size, except for the Distributed System (DS) in which as it is a local copy of the file to a repository (in this case to a folder of an exposed website with browsing permission in read- only mode) there is not any increase.

Table 4. Visualization Technology comparative table

Technology	File	File (MB)	Size (MB)	Total files Size (MB)	Protocol	Total Size incoming traffic (MB)	Total files Size 1 & 2 (MB)
CDN	Video 1	10,4	20,5		HTTPS / 2	11	25
	Video 2	10,1			HTTPS /2	14	
LMS	Video 1	10,4	20,5		HTTPS	11	24
	Video 2	10,1			HTTPS	13	
S.D.	Video 1	10,4	20,5		HTTPS	11	22
	Video 2	10,1			HTTPS	11	

On the other hand, as a result of the second table, there is an increase in the size of the file at the traffic level in each one of the platforms, showing a marked growth in both CDN and LMS. In the case of CDN, it is due to jumps in the communication between hosts until arriving at the nearest server (Brazil) with respect to the place where the measurement has been made (Colombia). For the case of LMS, it makes a jump between different hosts (login site, Amazon CDN and Finally Google video services). In the case of DS, the communication is at the local level of the network since the URL [https://croserver/Media /](https://croserver/Media/) is exposed from the Web server in whose Media folder the videos are located and which can also be entered without authentication, avoiding jumps in the communication between the client device (Laptop, Smartphone, Tablet, etc.).

Table 5. Costs / Details Technology comparative table

Technology	Plans	Capacity GB	Cost Per month (US\$)	Maximum Files	Maximum active users
CDN	Min	6000	230	According to capacity	unrestricted
	Max	100000	1890		unrestricted
LMS	Min	Unrestricted	230	Unlimited	50
	Max	Unrestricted	350		600
S.D.	Min	1000	~100	According to capacity	50
	Max	7000	~200		480

As a result of the third table, we have that at cost / benefit level both CDN and LMS have high costs associated with the availability of content storage capacity and the number of simultaneous users (concurrency). On the contrary, the D.S is characterized by sharing the resources of the server, workstation or desktop computer selected for this service.

For each one of the technologies, it was chosen the one that is best adapted, taking into account different aspects such as the ease of use both for the administrator by the municipal school and for the end user, including ease of publication; visualization, access to each one of the sites, both for the CDN and the LMS for being high availability services. Test time was taken into account for free in order to test the functionalities, in this case a maximum period of 14 days.

In the case of the CDN, CDN77 was selected which offered the file upload service both for web and for FTP. In this case, FTP was used because it is required fewer steps for connection, creation of folders and the corresponding upload of the video files.

For the LMS case, it was selected Docebo for ease of use against Atutor which required complete publication of the material for reviewing and prior approval by the platform administrators for their final publication, to allow uploading any type of file without restriction of a specific size (for free account maximum 50 GB of storage), compared to one of the platforms that is most often used at the educational level (Moodle) which does not allow loading of multimedia files and has a maximum restriction of 10 MB per file.

For the Distributed System, it was selected a virtualized server with a virtual PC that has the following characteristics: Windows 2012 r2 with 8GB RAM, 80GB disk storage with 2-core processor AMD FX 8350 to

4GHZ, private network connection shared with the hosts equipment with IIS 8.5 with the internal TESTSD website to a folder called MEDIA where videos are hosted, posted with security HTTPS and whose address was (<https://croserver/Media/>) and private IP address 192.168.0.11, static from the internet connection modem.

The website has directory browsing permission in read mode that allows viewing and / or downloading the videos but not delete or modify them. In respect of the estimated prices, it was made on the quote of a workstation (Hewlett Packard Z800) with 2 TB of storage and 3 years guarantee.

For the cases of test for the display of the videos in the Distributed System, it was used a Smartphone and an additional laptop of the hosting equipment, thus confirming the operability and facility of access to the information which is a premise of any distributed system.

The choice of a local Distributed System was made based on the 3 tables that were mentioned in the results and additionally taking into account that the municipal school budget is largely focused on the acquisition and maintenance of musical instruments. Moreover, the facility of publication of multimedia content once the website is created and the inner side of the school, the Media folder can be presented as a shared resource with permissions of writing to a group of authorized users to upload or delete the published videos doing even easier maintenance of the website without the intervention of technical staff for that purpose.

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