Video-on-demand platform using dynamic adaptive streaming over http (dash)—merakiplay

W A González Peinado¹, B M Velasco Burgos¹ and L T Guerrero Prado¹

¹ Grupo de investigación Rotã, Universidad Francisco de Paula Santander, Ocaña, Colombia

E-mail: wilm@ufpso.edu.co, ltguerrero@ufpso.edu.co

Abstract. This paper presents the design of MerakiPlay, a Video-On-Demand application using Dynamic Adaptive Streaming over HTTP (DASH), taking as a reference statistical information on the behavior of online digital video consumers through Video on demand service platforms, based on global studies and especially characterized for the Latin American case. These services generate a high consumption of resources in telecommunication networks, making pertinent to carry out detailed studies that improve the end-user experience.

1. Introduction

Several years ago, "watching television" meant sitting in front of a screen in the living room of your house waiting for a TV program that was normally distributed as standard only by air signal, cable or satellite at a specific time. The widespread growth of the internet has changed the panorama, the connection at any time is easier for users, to view or download the content and enjoy a great customization of it, offering never before seen experiences.

According to Megan Clarken, President of Product Leadership at Nielsen, “Today's media landscape is complex, but the growth of Video On Demand (VOD) programming services can create opportunities for all players in the media ecosystem”.

An online study conducted by Nielsen [1], a global leading information and measurement company, after surveying online more than 30,000 people in 61 countries to measure the overall feeling about VOD, revealed that almost two-thirds of respondents worldwide say that they watch some type of Video On Demand (includes content in short and long format).

For its part, the figures presented for Latin America in the "IMS VIDEO IN LATAM STUDY" developed in 2015 by comScore (comScore, Inc. (NASDAQ: SCOR)), a world leader in measuring the digital world, in association with IMS Internet Media Services, show that 87% of the 138 million desktop Internet users watch videos online; this percentage yields a digital video audience of 119 million with a margin of error of +/-1.1 percentage points (95% confidence level), from which 13.5 million are Colombians with a margin of error of +/-3.0 percentage points.

The same study shows that there is more people watching Video On Demand than Open TV (81% vs 70%) in Latin America, being the Smartphone the preferred device (80% of video viewers use it), 4 out of 5 viewers watch videos on their Smartphone. Likewise, the study shows that 36% of Latin Americans watch digital video outside their homes and 14% of them do it during the daily trip home/work/home.
In the same way, it is possible to appreciate that 56% of the video audience are Millennials, being the Android Operating System the preferred one in the region with 80% of users. In Colombia, the bedroom is the preferred location to watch digital video for Millennials.

It is worth mentioning that this trend of consumption of online digital video and specifically of Video On Demand in Spanish-speaking countries (Colombia, Brazil, Chile, Peru, Argentina and Mexico), has been developed from the appearance of Over The Top (OTT) platforms. The Competitive Intelligence Unit (CIU) defines OTT platforms as those that transmit information to electronic devices connected to the web, such as computers, smartphones, tablets, and Smart TV’s; some examples are Netflix, WhatsApp and Skype.

The OTT concept began to be used in the online video marketing with the appearance of Netflix and Hulu, companies that have left aside large content providers in North America such as Comcast and AT&T. At present, the appearance of services such as WhatsApp has made SMS and MMS message delivery services almost disappear from the operators [2].

Likewise, CIU also states that OTT platforms have special participation in the management of audiovisual content such as films and television series, giving rise to the concept of Video On Demand (VOD or VoD).

At a technical level, the VoD service can be defined as an application that waits for, processes and serves requests from one or several clients. The request contains a command where the client requests the video that he/she wants to receive. Once the server has received the play command, it begins to transmit the video. These data, when arriving at the client application, are temporarily stored to absorb possible cuts in the reproduction due to the latency and the signal variation in time (jitter). In the cases that temporary storage is emptied, blockages (cuts) occur. Another effect are the distortions that occur when some fragments of the data flow sent by the server are lost [3].

The multimedia flow is a technique that allows the video to be played while it is being received by the client; it must be encoded before being transmitted, with the aim of minimizing both the space and the bandwidth. The optimal quality of service for the VoD, and by extension for any kind of remote service, is when the user is not able to determine if the video is being retransmitted from a distant point of the network or is stored in his/her own computer [4].

Thus, a VoD platform allows the user to access from any place, from a Computer, Smart TV, Smartphone or any other multimedia device connected to the network, using an interface specifically designed for this purpose, to play, stop, rewind or fast forward any video.

2. Related research

The revolution in Information and Communication Technologies has brought a paradigm shift in the way we have been using the traditional video service; nowadays, the term VoD is more frequent, generating technological and legislative challenges in the implementation process at a global level. For this purpose, the scientific community has been working on aspects such as communication protocols, processing systems, joint engineering, cloud storage, cryptography, streaming, audio and video compression, etc.

There are recently-published studies such as De Melo et al. [5] which presents an-analysis of the system availability and the identification of the components that most affect the streaming service; they carried out a sensitivity analysis to establish the ranking of the most important parameters of the architecture, so they proposed the implementation of a redundant architecture. Bezerra et al. [6] investigated hierarchical modeling techniques to evaluate a non-redundant VoD service; the authors used sensitivity analyzes to identify the bottlenecks in the model, so they proposed improvements. In Wiegand et al. [4], they made a general description of the H.264/AVC video coding standard, concluding an improvement in efficiency and flexibility in relation to the operation of the previous standards; its VCL design is based on conventional hybrid video with motion compensation that provides greater capacity for predicting movement and use of a small block size among others, improving coding methods. On the other hand, Kuang et al. [7] carried out studies in the multimedia flow under the Real-Time Streaming Protocol (RTSP).
This paper presents differences with the related studies, specifically in that none of them take into account adaptive streaming for VoD services with the Apple HLS and Adobe HDS protocols, and Flash-based services that use RTMP.

3. Fundamental concepts
For the development of this paper, concepts of adaptive streaming, video streaming, VoD architecture and streaming protocols are fundamental. Next, these concepts are detailed: Video streaming: It is a technology used in the instant transmission of digital multimedia on the Internet [8]. The streaming allows the data to be delivered to the client and start playing without waiting for the complete file download. The data is stored in a fast buffer of immediate execution. The effectiveness of video streaming is strongly dependent on coding, communication protocols and buffering mechanisms [9].

Within the streaming protocols, we have the following:

- RTSP (real time streaming protocol). Real Networks, creator of Real Player, used RTSP for audio and video streaming in the 90s. Developers also used RTSP to create instant messaging programs, video conferencing software and other types of applications that require real-time interaction. [10].
- RTMP (real time messaging protocol). Adobe, who distributes Flash Player, created RTMP to help low-latency Web servers to stream content on the Web in an efficient way.
- HDS (HTTPS dynamic streaming). Created by Adobe as an alternative to RTMP. HDS allows adaptive transmission over HTTP to any device compatible with Adobe Flash. Because of Flash player has a market penetration of 97%, HDS is a great option for streaming in desktop devices [11].
- HLS (HTTP live streaming). Developed by Apple for its iOS devices, it is currently available for a large number of video players, including HTML5 by default and most native mobile players.
- HSS (HTTP smooth streaming). Microsoft makes an incursion into adaptive HTTP streaming with HSS, which runs on an IIS web server and Silverlight player. The Silverlight player detects the bandwidth and CPU from the local conditions and dynamically changes bitrates to provide an uninterrupted transmission. HSS supports multiple audio and video codecs and is highly customizable [12].
- DASH (dynamic adaptive streaming over HTTP). It is a dynamic protocol that allows VoD streaming. Within its main characteristics is to dynamically adapt to the network conditions, allowing the selection of the bitrate in real time. DASH emerges as an evolution of the proprietary protocols of Apple (HLS) and Adobe (HDS).

The above adaptive streaming technologies have been released by providers that have limited support from company-independent streaming servers and streaming clients. Since a provider-dependent situation is not desired, standardization bodies initiated a harmonization process, which resulted in the ratification of MPEG-DASH in 2012. In [13], they feature: Reduction of start delays and buffering stops during the video, continuous adaptation to the client's bandwidth situation, transmit logic based on the client achieving greater scalability and flexibility, use of existing and profitable HTTP-based caches, proxies and CDNs, and efficient omission of NAT and Firewalls through the use of HTTP.

4. Application design
The Video-On-Demand Platform using Dynamic Adaptive Streaming over HTTP (DASH) - MerakiPlay (www.merakiplay.com), takes its name from the words Meraki (from the Greek, adjective used to describe something in which much effort, creativity or love is put into, whatever it is. It is one of the few words that has no translation or synonym in any other language) and Play (key that, in a
video, cassette, CD device, etc., serves to reproduce what it is on a tape or on a disk). In this way, MerakiPlay is defined as a VoD Service Platform.

The minimum requirements for server installation are a VPS Cloud (an image of Linux-based Ubuntu 14.0 OS), Nginx, FFmpeg, MySQL Database, PHP>=5.6.4 with their corresponding extensions of PDO, Mbstring and XML.

The used technologies are the Bootstrap multiplatform library, Nginx as a high-performance server, Google Cloud Messaging for notifications, YouTube Player and JW Player as players, the Angular and Laravel Framework, the REDIS memory database engine and BitBucket version control system.

4.1. Server

Its core is made up of the Linux-based Ubuntu 14 operating system and NGINX as a streaming server and is designed to offer low memory use and high concurrency.

NGINX creates new processes for each web request, uses an asynchronous approach based on events where requests are handled in a single thread.

NGINX is widely used to deliver MP4 and FLV video content providing adaptive streaming for VOD services using Dynamic Adaptive Streaming over HTTP. This feature allows the server to individually control the bandwidth in the multimedia flows, avoiding that the client-side download accelerators use unnecessary resources, and allowing the video player to select the most appropriate bitrate in real time.

4.2. Streaming delivery

The streaming delivery process is initially done with video consumption through mp4 files stored on disk; then, the transcoding is done on the server to finish with the delivery of VoD over HTTP on multiple devices (TV, Computer, Tablet and Mobile).

The NGINX server provides support for the HTTP Live Streaming (HLS) protocol by using the HLS/VOD module for the delivery of VoD encoded in the H.264 / AAC format. With the implementation of this module, the process of repackaging the existing MP4 content at the time of sending the adaptive transmission to users is ignored: in this way, the content is "transformed" or "transmultiplexed" on the fly from the origin from MP4 files on disk to HLS stream without recoding content [14].

Adaptive Streaming with Adobe HTTP Dynamic Streaming (HDS) provides an alternative method to deliver adaptive streaming media to its users. The video is firstly prepared with the Adobe f4packager tool, which generates Flash Media Manifest (filename extension .f4m), fragment (.f4f) and index (.f4x). These files are published on the web server and delivered by the NGINX f4f handler [14].

4.3. Client

The application follows the Client/Server model.

4.3.1. End user application. Once the user enters to the application through the URL http://www.merakiplay.com, or through the App on mobile devices, he/she must enter credentials for registration, by filling a form out (email/password) or by social login (Facebook/Google).

4.3.2. Administrator user application. MerakiPlay has a dashboard that allows the application administrator user to manage the content and configure the environment. To enter this section in a web browser, the URL http://admin.merakiplay.com must be entered.

5. Conclusions

The widespread growth of the Internet and the proliferation of smart mobile devices have made that the younger public (Generation Z and Millennials) prefer to watch movies and TV series through other screens not as conventional as those of cinema and television.
The use of VoD applications is becoming more frequent, and commercial platforms such as Netflix lead the market thanks to their extensive catalog. Nearly two-thirds of respondents globally say that they watch some type of video on demand according to a study from Nielsen company.

The main objective has been the design of an application that provides VoD services, improving the quality of service by using the Dynamic Adaptive Streaming over HTTP (DASH) standard.

During the development of the MerakiPlay application, several standards and technologies for the consumption and delivery of video on demand have been analyzed, as well as the compatibility with currently-available browsers and operating systems (desktop and mobile).

Under an academic context, the application can be used as a platform for virtual academic communities, allowing the generation and sharing of educational content that broaden the base of knowledge and the planning of future works regarding the use of the DASH transmission protocol.

Finally, the research generates a new scenario for content providers that want to expand their service offerings on their networks, making a determined incursion into the new Over the Top trend.

References
[1] The Nielsen Company 2016 *Video on demand how worldwide viewing habits are changing in the evolving media landscape* consulted on: https://www.nielsen.com/content/dam/nielsenglobal/latam/docs/reports/2016/EstudioGlobal_VideoOnDemand_ES.pdf

[2] Lucena Cabello M 2015 *Desarrollo de un sistema de medicion, monitorizacion y gestion de servicios OTT* (Madrid: Universidad Autonoma de Madrid)

[3] Campo W Y, Arciniegas J L, García R and Melendi D 2010 Análisis de tráfico para un servicio de video bajo demanda sobre redes HFC usando el protocolo RTMP *Información Tecnológica* 21 37

[4] Melendi D, Pañeda X, García V, García R and Neira A 2003 Métricas para el Análisis de Calidad en Servicios de Video–Bajo-Demanda Reales III Cong. Iberoamericano de Telemática

[5] De Melo R M, Bezerra M C, Dantas J, Matos R, De Melo Filho I J and Maciel P 2014 Redundant VoD streaming service in a private cloud: availability modeling and sensitivity analysis *Mathematical Problems in Engineering* 2014 764010

[6] Bezerra M C, Melo R, Dantas J, Maciel P and Vieira F 2014 Availability modeling and analysis of a VoD service for eucalyptus platform 2014 *IEEE International Conference on Systems, Man, and Cybernetics (SMC)* (IEEE) pp 3779–3784

[7] Kuang T and Williamson C 2002 *A measurement study od RealMedia streaming traffic* consulted on: https://pages.cspe.ucalgary.ca/~carey/papers/2002/itcom02.pdf

[8] Diaz Delghado G, Carrascal Frias V and Aguilar Igartua M 2006 Video streaming transmission with QoS over cross layered Ad hoc Networks *International Conference on Software in Telecommunications and Computer Networks Split* 102-106

[9] Diaz-Sanchez D, Almenarez F, Marin A, Prosperi D and Cabarcos P A 2011 Media cloud: an open cloud computing middleware for content management *IEEE Transactions on Consumer Electronics* 57 970-978

[10] Dantas J, Matos R, Araujo J and Maciel P 2012 An availability model for eucalyptus platform: An analysis of warm-standy replication mechanism 2012 *IEEE International Conference on Systems, Man, and Cybernetics (SMC)* (IEEE) pp 1664–9

[11] Zhu W, Luo C, Wang J and Li S 2011 Multimedia Cloud Computing *IEEE Signal Processing Magazine*. 28 59–69

[12] Chen I R and Bastani F B 1994 Warm standby in hierarchically structured process-control programs *IEEE Transactions on Software Engineering* 20 658–63

[13] Mueller C 2015 *MPEG-DASH (Dynamic Adaptive Streaming over HTTP, ISO/IEC 23009-1)* consulted on: https://bitmovin.com/dynamic-adaptive-streaming-http-mpeg-dash/

[14] NGINX Inc, *Entregar de forma escalable medios de transmisión con NGINX Plus* consulted on: https://www.nginx.com/products/nginx/streaming-media/