ANALYSIS OF METHODS TO INCREASE QOE PARAMETERS FOR VIDEO STREAMING SERVICES

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ABSTRACT

Video streaming services represent a new generation of television (DTV), which have become an integral part of modern digital culture. With the development of Internet technologies and the spread of broadband access, video streaming has become a popular and convenient way to consume multimedia content. Unlike traditional television, video streaming services provide the user with the ability to choose content, watch it at a convenient time and on different devices, which leads to new challenges and opportunities in improving the quality of user experience (QoE). One of the key elements that determine the quality of a video streaming service is the operator's transmission equipment and platform servers. These components provide content streaming over the Internet and affect such parameters as download speed, data stream stability and playback quality. Efficient management and optimization of the transmission equipment and servers can reduce latency, improve video quality and provide smoother streaming of content to end users. This research project aims to analyze methods for improving QoE parameters for video streaming services to better understand how technologies, algorithms and strategies can be applied to optimise the user experience in this new type of digital content. By considering factors such as video quality, adaptive streaming, traffic management, and many others, we aim to highlight key aspects that contribute to improving QoE and providing a more satisfactory user experience in video streaming services.

KEYWORDS: *Video streaming services, Digital television (DTV), Broadband access, Multimedia content consumption, User experience (QoE), Transmission equipment, Platform servers, Latency reduction, Adaptive streaming, Traffic management*

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Analysing media streaming technologies

The process of live streaming is complex, involving numerous technologies that work in concert to produce the end result that viewers see when watching content. One technological aspect of this process is the delivery of video from the camera to the encoder, to the video host, and finally to the viewers. Professional broadcasters employ two main streaming protocols, MPEG-DASH and HLS, which are types of technology designed to transmit video files over the Internet.

In the past, online video was primarily delivered via the RTMP protocol. RTMP, or Real-Time Messaging Protocol, is a Flash-based video streaming standard that is still employed today to transmit video from an RTMP encoder to an online video platform. However, Flash-based video is no longer a viable option for delivering video to users. The Flash plug-in has lost value, and the number of devices supporting this outdated protocol is declining annually. It is no longer possible to run the Flash player in new versions of most web browsers. The RTMP protocol is gradually being replaced by the HLS protocol. In the last decade, the MPEG-DASH protocol has emerged as a competitor to HLS. It serves the same purpose as HLS, but because it is the newest variant, it is on the rise. This has led to a growing need to understand the difference between MPEG and HLS.

An overview of the comparison of these formats is presented in the table below (Table 1). Despite some advantages and merits neither MSS, HDS nor MPEG-DASH has been able to take as significant and dominant a role in the industry as Apple has done with its HLS.

In any case, the consumption of premium video content via online and mobile platforms has rapidly supplanted traditional television. The Internet has created a need for protocols to be developed to ensure high-quality images, depending on the device type and network congestion. Apple HLS, Microsoft Smooth Streaming and Adobe Flash HDS are adaptive delivery protocols that provide high-quality video consumption over the Internet.

Table 1

Comparison of different protocols

Protocol name	DASH	HLS	MSS	HDS
Type	Open, standards-based	Vendor-controlled	Vendor-controlled	Vendor-controlled
Video codecs	H.264 and other	H.264	H.264, VC-1	H.264, VP6
Audio codecs	AAC and others	AAC, MP3	AAC, WMA	AAC, MP3
Fragment’s format	MP4 и MPEG-2 TS	MPEG-2 TS	MP4	MP4
Files stored on the server	Adjacent or separate files per segment	Separate file per segment	Related	Related
Audio, video, text	Combined or chunked for audio and Video	Combined into one segment	Combined into one segment	Combined into one segment
Segmentation and delivery	Multiple vendors Standard HTTP or Broadcast server	Multiple vendors Standard HTTP or broadcast	MS IIS server (and a few others)	Adobe InteractiveServer
Playback	3GPP-Rel 9 or MPEG clients	Apple iOS, QT X	Silverlight	Flash, Air
Security	Possibility to use third-party solutions	AES-128	PlayReady	Flash Access
Segment length	Varies	10 sec.	2-4 sec.	2-4 sec.

Although one might expect that DASH is the most balanced and progressive protocol and therefore should be widely used, the reality is that it loses out due to greater complexity of implementation and patent issues. That said, HLS stands out due to its wide representation on a large number of mobile devices from its developer, and its ease of implementation and ability to be used on other companies' devices makes it the most suitable at the moment. The MSS protocol has benefited from the success of the xbox range and well-known security systems. However, it is much more common in Europe than in America. HDS used to benefit from the ubiquity of Flash, but now that this technology is starting to move away, its future is highly debatable. To summarise, HLS is the undisputed market leader, although its competitors are in no hurry to give up so there may be some exciting competition in the future for media streaming technologies.

But it is also important not only to choose a media streaming technology, but also to implement the service itself correctly, because delays, adaptation, competent buffer handling are fundamental factors of quality server operation and user satisfaction, also known as QoE: Quality of Experience.

Comparing services that provide access to media content

As the viewing habits of consumers shift from traditional broadcasting to online streaming, the competitive landscape of online video is becoming increasingly intense. YouTube is now in its second decade on the global web, competing with its Vimeo-like counterparts or with other industry players such as Netflix. In the last five years, there have been some unsuccessful projects, as well as Amazon, the Seattle-based e-commerce giant known for its expansion into new markets, which is rapidly rising up the ranks to compete with industry titans such as Netflix.

A recent Internet usage report from Sandvine indicates that Amazon Video has become the third most popular online video service, trailing behind Netflix and YouTube. The network equipment company's biannual Global Internet Phenomena Report revealed that Amazon's streaming service now accounts for 4.3% of traffic during evening peak viewing hours.

Netflix continues to dominate the streaming video market, accounting for 35.2% of traffic in North America over the past year. Although this represents a slight decline from 37.1 per cent, the report notes that this is likely due to improvements in Netflix's video compression technology. However, measuring downstream Internet activity is not an exact metric, but it does provide insight into the usage of streaming services – a statistic that the services themselves are reluctant to provide.

Netflix was founded in 1997, with a total of approximately 65 million subscribers in 40 countries. In 2015, the company had over 100,000 pieces of content available for streaming. It is reported that 80% of sales come from recommendations. Netflix plays the role of a content ‘aggregator’. However, in order to expand their business and increase their profits, they decided to produce their own content in addition to the usual video rental services [1].

Youtube (Google), founded in 2005, provides video streaming services over the Internet. Youtube is the largest provider of video streaming services, with an estimated 1.3 billion subscribers. In addition to providing video streaming services, Youtube offers video recommendations [2]. Amazon Prime Instant Video is a subscription-based video service, with a cost of $99 per year. Amazon has extended its well-known book recommendation system to video.

It is evident that platforms differ not only in terms of design and subscription price, but also in terms of their underlying architecture. Each platform strives to ensure that the user can consume content in the most comfortable manner possible, as this is directly related to the user's satisfaction with the service. Consequently, the willingness of the user to pay for the service or to view advertisements on it is influenced. This, in turn, provides the owner of the media platform with the opportunity to earn money.

For example, according to the research [3] (Table 2) the average bitrate varies greatly from service to service depending on the codecs used, server settings and many other factors, which in turn has a significant impact on QoE.

Table 2

Average bitrate at different quality of transmitted picture on different multistreaming platforms [3]

Platform	Bitrate 4K	Bitrate 1080p	Bitrate 720p
Apple TV +	26 Mbps	8,84 Mbps	2,56 Mbps
Disney +	16,59 Mbps	7,42 Mbps	4,42 Mbps
Netflix	16,64 Mbps	6,44 Mbps	3,06 Mbps
Video premium	10,02 Mbps	5,12 Mbps	3,18 Mbps
HBO	ND	3,75 Mbps	2,55 Mbps
The movie	ND	4,13 Mbps	2,57 Mbps
FlixOlé	ND	6,66 Mbps	2,68 Mbps
Atresplayer Premium	ND	3,68 Mbps	2,4 Mbps
RTVE Alacarta	ND	ND	2,79 Mbps
Sky	ND	ND	3,26 Mbps
FuboTV	ND	ND	3,2 Mbps

Client-based streaming for progressive loading

In order to apply the principle of streaming to progressive loading, servers, which have been controlling the loading up to this point, are replaced by clients that take over the streaming control and request video data from the servers. Clients only request data if their buffer is below a critical threshold. Once this threshold is exceeded, data is no longer requested. This limits the amount of video data that is wasted if playback is interrupted, and thus the amount of data that is wasted by the servers. This results in more efficient resource utilisation for the video service provider.

Client-based HTTP Adaptive Streaming: in order to be more flexible and avoid the need to evaluate the client's network conditions, the paradigm shift has evolved even further. Nowadays, video files are no longer stored as a whole file for each quality level (i.e. bitrate). Instead, they are stored as multiple files, so-called fragments or segments, each consisting of just a few seconds of playback time. The mapping of files to video segments is defined in a special media description file. This allows for a finer selection of quality (adaptive streaming). In combination with client-based streaming, an advantage arises because the client is directly aware of the current state of the network. This awareness encompasses the client's physical layer for data transmission and also includes the client's awareness of the video streaming capabilities due to the media description file. Consequently, client-based adaptive streaming can adapt seamlessly to changing network conditions by requesting video clips from the server at the appropriate bit rate. This results in the highest possible playback quality and reduced latency, which enhances the user experience [4]. Many proprietary solutions have implemented this new paradigm of client-based adaptive streaming. YouTube has also recently followed the current trend by integrating the standardised adaptive streaming technology MPEG Dynamic Streaming over HTTP (DASH) [5].

The popular Internet service YouTube has adopted Hypertext Markup Language Version 5 (HTML5) by default. This transition has resulted in YouTube adopting Dynamic Adaptive Streaming over HTTP (DASH) as its Adaptive Bit Rate (ABR) video streaming technology. Moreover, rate adaptation in DASH depends solely on the receiver. This problem motivated the authors of the paper [6] to perform an in-depth analysis (Figure 1 and 2) of a specific YouTube implementation of DASH. Firstly, this paper provides an overview of the state of the art in DASH and adaptive streaming technology and works related to the characterisation of YouTube traffic. Secondly, the paper describes a new methodology and testbed for traffic characterisation and performance measurement of

DASH implementation on YouTube. This methodology and testbed do not utilise proxies and are also capable of handling redirections of YouTube traffic.

Finally, a set of experimental results involving a dataset of 310 YouTube videos is presented. The presented results characterise YouTube traffic patterns and discuss the acceptable download bandwidth, the bitrate consumed by YouTube and the video quality. In addition, the results are cross-validated by analysing the HTTP requests made by the YouTube video player. The results of the paper [6] are applicable in the field of quality of service (QoS) and quality of experience (QoE) management. This is valuable information for Internet Service Providers (ISPs), as QoS management based on guaranteed downstream throughput can be used to ensure a targeted end-user quality of experience when using the YouTube service.

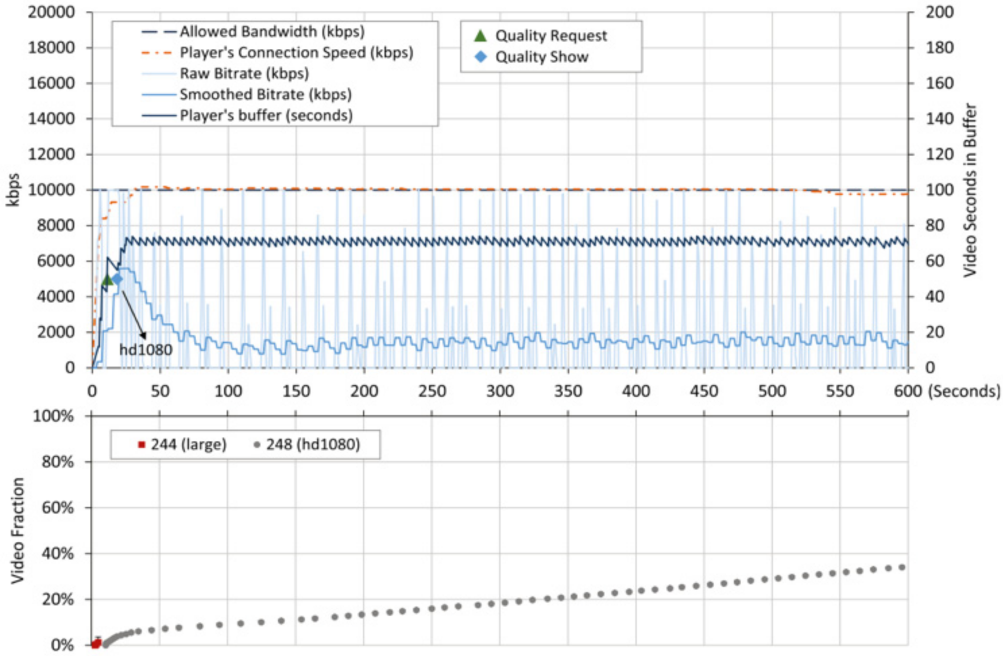

Figure 1. Test showing the bursting phase and throttling phase [6].

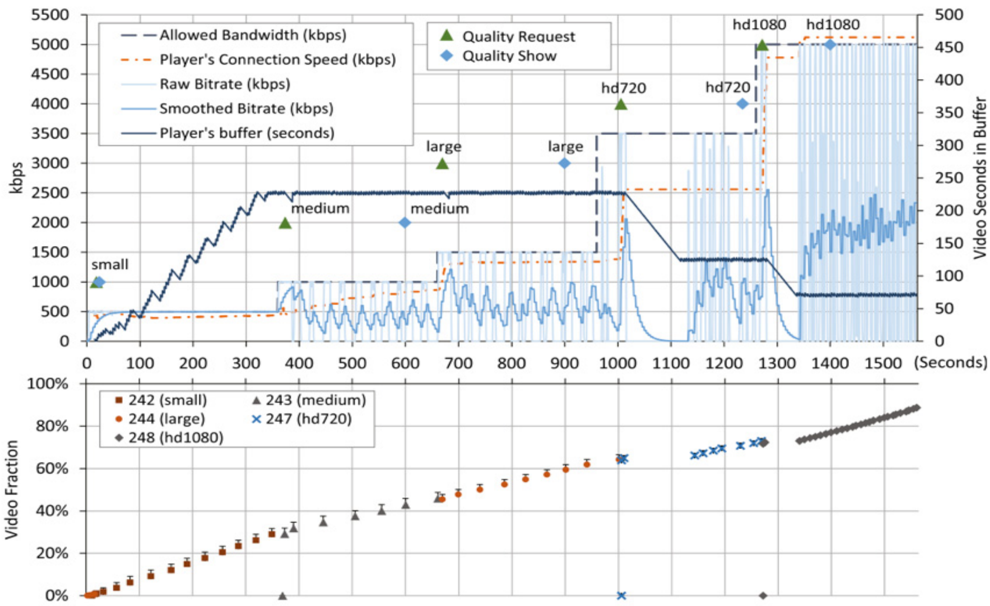

Figure 2. Test monotonically increasing scale of available download bandwidth [6].

As the description of the paper [7] suggests. This paper contributes to the existing literature by characterising the traffic of DASH implementations on YouTube and analysing YouTube's adaptation to dynamic conditions in terms of upload bandwidth fluctuations. In order to contribute, this paper firstly reviews the state of the art in DASH and adaptive streaming, and reviews related work on YouTube traffic analysis.

The proposed methodology and testbed included in this work allow us to characterise the structure of YouTube traffic without the use of proxy servers. In addition, the methodology and testbed address the problem of YouTube redirections, which has been pointed out in other papers [8]. A large dataset of 310 videos was used for the presented tests. In these tests, network parameters, internal YouTube player parameters and HTTP requests of the YouTube player were correlated. Moreover, a number of experimental results were obtained showing interesting results. The average YouTube download bitrate was obtained, capturing the requested quality, but it was shown that it was not useful for making bandwidth provisioning decisions. Instead, information was provided on the required available bandwidth to obtain a certain requested quality automatically with an estimated probability. It is also observed that the video bitrate requirements on the quality level of YouTube videos have increased compared to the results obtained in [9] in 2015.

Optimising video streaming parameters to improve user satisfaction

Video quality and resolution:

Investigating the impact of video resolution on user satisfaction is a key aspect in QoE optimisation. The optimal resolution depends on many factors, such as the type of content and the device on which it is viewed. For example, for static content such as films or TV series, a high resolution may be preferred to provide a more immersive content experience. However, for dynamic content, such as video games or sports broadcasts, a lower resolution with a higher frame rate may be preferred to reduce latency and provide smooth playback.

Adaptive streaming:

Adaptive streaming is a technique that optimises playback quality depending on the available bandwidth and the characteristics of the user's device. Adaptive streaming algorithms automatically select the optimal video resolution and bitrate for each particular moment in time, based on the current network and user device conditions. This allows for the best possible playback quality to be provided to the user while minimising latency and interruptions [10].

Latency and buffering:

Latency and buffering can have a significant impact on QoE, as they can cause playback interruptions and degrade the overall user experience when viewing content. Intermittent stops or long delays in video loading can cause annoyance and degrade user satisfaction [11].

Exploring methods to reduce latency and optimise buffering plays an important role in improving QoE. One approach could be the use of data preloading algorithms or buffering optimisation combined with adaptive streaming. This can reduce latency and provide smoother content playback, which ultimately contributes to increased user satisfaction.

Traffic management and network protocols:

Studying the impact of network protocols such as HTTP, UDP on streaming video quality and the possibility of optimising them represents a significant research area. Different protocols have different transmission characteristics that can significantly affect QoE. For example, HTTP is often used for video transmission over the Internet, but can cause delays and quality degradation in case of unstable connection. Investigating the performance of different network protocols and developing methods to optimise them will help improve video streaming quality and overall user satisfaction.

Audio Quality:

Conducting research on the impact of audio quality on overall user satisfaction and how it can be improved is an important aspect of optimising QoE in video streaming services. While attention is often focused on video quality, audio quality is also important to the user experience. Exploring methods to improve audio quality, such as audio compression technologies or the use of high-quality audio codecs, can help create a more enjoyable and engaging user experience.

Personalised content:

Exploring methods of delivering personalised content and its impact on QoE is an important aspect of the development of video streaming services. Personalising content allows users' individual preferences and interests to be taken into account, which can significantly improve their satisfaction and time spent on the platform. Exploring methods of audience segmentation, user behaviour analysis and recommendation systems will help to develop effective strategies to deliver personalised content and optimise QoE for each user.

QoE evaluation metrics:

Developing or analysing metrics to evaluate QoE is a key aspect in video streaming. Effective metrics should consider various aspects of the user experience, including video and audio quality, playback latency, and interface usability and content availability. Conducting a study to develop such metrics will help improve the ability to conduct service quality assessments and identify areas for improvement.

Impact of devices and platforms:

Examining the differences in QoE across devices and platforms is an important aspect of the study. Users may use different devices, such as computers, smartphones or smart TVs, with different operating systems such as iOS, Android or Windows. Each of these platforms may present unique technical and user characteristics that affect QoE. Exploring these differences will help to develop optimisation strategies for different platforms and devices to ensure consistent playback quality for all users.

Cloud Computing and Distributed Systems:

Exploring the potential of cloud computing and distributed systems in the context of improving QoE in video streaming represents an important research direction. Cloud computing can provide scalability and flexibility for processing and storing multimedia data and for delivering content to end users. Distributed systems can improve the availability and reliability of video streaming services by providing data backup and query processing closer to end users. Research into these technologies can lead to the development of more efficient and reliable video streaming services [12].

Machine Learning and Data Analytics:

The application of machine learning and data analytics to optimise QoE parameters is a promising area of research. Machine learning can be used to predict user preferences, identify anomalies in the data stream, and automatically adjust playback parameters for each user. Data analysis can help identify patterns and trends in user behaviour, which can help optimise video quality, traffic management and other aspects of video streaming services [13-14].

Summary and Conclusion:

In this chapter, various aspects of optimising QoE parameters for video streaming services have been discussed. The study has shown that video quality and resolution play a key role in user satisfaction and the optimal parameters may vary depending on the type of content and user devices.

Adaptive streaming allows dynamic adaptation of playback quality based on network and device conditions, which significantly improves the viewing experience and user satisfaction.

Latency and buffering have a direct impact on QoE, and optimising these parameters can significantly improve user satisfaction and reduce the likelihood of churn.

Traffic management and choice of network protocols are also important to ensure stable and high-quality video content playback.

Audio quality and personalised content are additional aspects that can significantly improve user experience and satisfaction.

Thus, to ensure a high level of QoE in video streaming services, it is necessary to take a comprehensive approach that takes into account all of these aspects and optimises each of them based on user needs and preferences.

Optimising operator transmission equipment to improve QoE

Operator transmission equipment plays a key role in delivering content from the provider to the end user. Optimising this equipment can significantly improve user satisfaction and quality of user experience (QoE). Below are some ways that can help in improving QoE through optimising the operator's transmission equipment:

1. Increase network bandwidth: Ensuring sufficient network bandwidth allows video content to be transmitted at higher resolution and quality. This can be achieved through upgrading network equipment, increasing link bandwidth and optimising traffic routing.

2. Deployment of caching servers: Placing caching servers closer to end users reduces latency and content download time. This improves user experience, especially for streaming services with high traffic volumes.

3 Using CDN technology: Content delivery networks (CDNs) allow content to be distributed to different nodes in the network, reducing the distance and time it takes to deliver content to the end user. This reduces network load and improves QoE by increasing download speeds and reducing playback latency.

4. Monitoring and Quality of Service (QoS) Management: Implementing QoS monitoring and management systems allows operators to monitor network performance and respond to potential problems before they occur. This helps prevent playback interruptions and ensures stable, high-quality content playback.

5. Optimised data encoding and compression: Using advanced data encoding and compression techniques, content can be delivered with higher quality at lower bandwidths. This reduces network resource utilisation and improves QoE for users with limited access to broadband.

These techniques can help operators optimise transmission equipment and improve QoE for users of video streaming services. By investing in state-of-the-art equipment, utilising advanced technologies and network management, operators can ensure stable and high-quality content playback, leading to higher user satisfaction and increasing the competitiveness of their services in the market.

Conclusion

In today's world, video streaming services have become an integral part of our lives, providing access to a variety of media content anytime and anywhere. In this study, we have examined several key aspects of media streaming technologies and optimising parameters to improve user satisfaction (QoE).

Analysing media streaming technologies allowed us to familiarise ourselves with the main methods of delivering content to end-users and to understand which technologies are the most effective in terms of user satisfaction.

We looked at comparing different services that provide access to media content, which allowed us to understand their strengths and weaknesses.

Optimising video streaming parameters to improve user satisfaction was the central theme of our research. We looked at the impact of video resolution, adaptive streaming, latency and buffering, traffic management and network protocols, audio quality, personalised content, QoE evaluation metrics, device and platform impact, cloud computing and distributed systems, machine learning and data analytics on overall user satisfaction.

We concluded the study by highlighting the importance of optimising an operator's transmission equipment to improve QoE. This means that operators should invest in state-of-the-art equipment, utilise advanced technologies and manage the network in a way that ensures stable and high quality content playback for their users.

Thus, our research allowed us to cover a wide range of topics related to video streaming services and identify the key factors that affect user satisfaction. The implementation of the proposed recommendations will help operators and providers to achieve a high level of QoE and strengthen their positions in the media streaming market.

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