



A Comparative Study of the Quality of Experience(QoE) for YouTube, Prime Video, Disney+ Hotstar and Netflix

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Abstract— A service provider must acquire a competitive edge to stay strong whether it is in food industry, hotel or entertainment industries. Post the Covid pandemic, when theatres were shut down and people were forced to stay at home, online streaming services, or OTTs such as Netflix, Prime Video and Disney+ Hotstar gained ground. YouTube has been popular even before the Covid pandemic due to its collection of a wide array of videos ranging from education to entertainment. This paper discusses Quality of Experience (QoE) metrics for the four OTT platforms and performs a comparative analysis of the QoE metric values returned by the platforms. It helps understand the experience provided by the different platforms.

Keywords—Quality of Experience (QoE), Netflix, YouTube, Amazon Prime Video, Disney+ Hotstar, metrics, video, streaming, Computer Networks, Networking, Visual Experience, bandwidth, throughput, latency, encryption.

I. INTRODUCTION

The concept of video streaming is to provide the user to watch video immediately rather than waiting for video to get downloaded completely. A video streaming service is delivered using a dedicated streaming server that sends video frames watched by the user. Most of the streaming servers usually host one kind of video type and all videos should be in the same codec with the same configuration. Streaming servers can also serve video streaming at different bit-rates based on the bandwidth available to the user (E.g. RTSP(Real Time Streaming Protocol) /RTMP(Real Time Messaging Protocol)). A major drawback of the same is the need to maintain dedicated servers or cloud storage and not all devices support these codecs. There are essentially two different types of downloads used in this case. One being Progressive Download (used for FLV and MPEG), this is easier to implement as it can be placed on a web server and point to the URL. Client player starts the video playback once it downloads the sufficient data while downloading the rest of the video simultaneously. A few drawbacks of the same is that it is unable to change the video bit-rate during playback and when the user skips the video or playing bit-rate is changed, the bandwidth is wasted on the unwatched downloaded video. Second being the Adaptive Streaming (HLS, HDS, MPEG DASH). These are

Bandwidth efficient, bit-rate switching while playback, no need for dedicated servers. Video is generally stored in small fragments at different bit-rates which contain a few seconds of video. The player downloads these fragments and combines them into a continuous playable stream. Video Quality of Experience (QoE) is a measure of a client's experience of watching a video. This experience can depend on various factors like Jitter, Network Level information (Throughput, Packet Loss etc), Latency, Video information (encoded bit-rate, duration).

II. BACKGROUND

Different platforms follow different sets of procedure for delivering their content. Thus, the Quality of Experience (QoE) if varies across the platforms.

Netflix sends movies and TV shows to the screen using the internet. The content goes through many points before it reaches the user, such as servers, the internet, and the user's internet provider's network. When the user presses the play button, Netflix sends the video to the user's internet provider using the fastest way possible. When Netflix sends a video, they try to avoid traffic, accidents, and construction along the way to get the video to the user quickly. Shorter paths make the video quality better.

YouTube primarily utilizes the VP9 and H.264/MPEG-4 AVC video codecs, along with the Dynamic Adaptive Streaming over HTTP (DASH) protocol. It also offers MPEG-4 Part 2 streams within 3GP containers for low-bandwidth connections. Starting from January 2019, YouTube began releasing videos in the AV1 format. A 2021 report indicated that the company was considering making AV1 mandatory for streaming devices to reduce bandwidth usage and enhance video quality. Typically, Opus and AAC audio codecs are delivered alongside the videos.[1]

Amazon Prime Video supports streaming up to 4K (UHD) resolution and high-dynamic-range (HDR) content, depending on the device being used. The introduction of UHD/HDR content included their original productions. Some titles allow for 1080p (HD) streaming with 5.1 Dolby Digital or Dolby Digital Plus audio, and Dolby Atmos support for certain titles will be available soon. Additional charges may apply for

HD content that is available for purchase and not included in the customer's Amazon Prime subscription.

Disney+ Hotstar relies on AWS (Amazon Web Services)[2] for its backend infrastructure. The EC2 instances serve all the traffic, while the S3 Object store is used as the data storage system. The services employ a combination of on-demand and spot instances to optimize costs. By running machine learning and data analytics algorithms on spot instances, the company significantly reduces expenses.[2]

III. LITERATURE REVIEW

Recent researched propose objective QoE models to estimate views' experience in online streaming in order to avoid time-consuming subjective ratings. The models given by the researchers are proposed via objective quality factor (e.g., the accumulation of physical errors) in a mathematical function which accord with a limited set of subjective data. Without the need for human resources, the whole process of QoE estimation can be completed on one end device by using objective quality model[3]. As a result, in the context of video streaming, objective quality model is the more suitable choice as compared to subjective test.

A. YouTube

A user-centric approach for YouTube performance evaluation, analyzing the Quality of Experience (QoE) as assessed by a group of 33 mobile broadband users in a field trial was adopted by the authors Pedro Casas et. al[4]. Over the course of a 31-day study period, customers who were using their own 3.5G-connected laptops commented on how they felt about browsing their chosen YouTube material while the network circumstances were changing and being intentionally altered using traffic shaping. This method is comprehensive and considers a three-layered evaluation methodology, including user-layer QoE assessment, network and application-layer content monitoring, and control and monitoring of network-layer QoS.

An empirical analysis of the performance of YouTube flows accessed through a national-wide cellular network, considering download throughput as well as end-user Quality of Experience (QoE) metrics is presented by Pedro Casas et al[5]. The study examines the characteristics and effects of the CDN that hosts YouTube and contrasts its actions with those of other well-known HTTP video streaming services used with cellular networks. The QoE study is carried out using end-user device data, which accurately capture the end-users' experiences. This research also demonstrates the possibility of monitoring YouTube performance in cellular networks directly from the users' smartphones, avoiding the traffic visibility loss at the network's core that is brought on by traffic encryption (for example, HTTPS).

In the present environment, there are many internet users, and Google YouTube app is widely used. Particularly intriguing as a possible medium for social communication are online videos. Additionally, video is equipped to capture social interactions. The clients watched noises and videos on YouTube. There are many distinct types of video collections on YouTube. Many people have watched many channels and videos in this regard. A significant portion of YouTube users enjoy watching their favourite channels and videos. In this research article[8], the authors analyse YouTube video views and data using clustering to achieve high-quality clusters.

Today's technology users frequently access YouTube from both online platforms and direct applications. YouTube is a website for sharing videos, and users can use it to watch or distribute films for various purposes. Typically, YouTube videos include three sorts of content: instructional, entertaining, and informative. Users of the YouTube website typically search for

videos with interesting content, such as those in the gaming, music, short film, and other categories. Students commonly search for videos with educational categories on YouTube as a resource and guide to locate additional content for their courses. The authors[9] used data mining technique methods, including classification, association, and clustering to find out the YouTube algorithm for determining which videos can be trending.

At launch in 2005, viewing YouTube videos on a personal computer required the Adobe Flash Player plug-in to be installed in the browser.[30] In January 2010, YouTube launched an experimental version of the site that used the built-in multimedia capabilities of web browsers supporting the HTML5 standard.[31] This allowed videos to be viewed without requiring Adobe Flash Player or any other plug-in to be installed.[32] On January 27, 2015, YouTube announced that HTML5 would be the default playback method on supported browsers.[31] HTML5 video streams use Dynamic Adaptive Streaming over HTTP (MPEG-DASH), an HTTP-based adaptive bit-rate streaming solution optimizes the bitrate and quality for the available network.[33]

B. Amazon Prime Video

For video service providers like Amazon Prime Video, maintaining a positive consumer Quality of Experience (QoE) is crucial. Network issues must be found, identified, and rectified because they reduce quality of experience (QoE). This is challenging, though, because each segment of the end-to-end path is the responsibility of a different autonomous system (AS), which is typically controlled by a different organisation. Examples of such organisations are the video streaming provider, the internet service provider (ISP), and the client's local network operator. Although the client typically holds the video service provider (VSP) accountable when there is subpar QoE, the VSP lacks access to various areas of the network to pinpoint the problem. In this paper, the authors [6] demonstrate that the VSP can localise the network failure using only QoE data and AI without having access to the faulty component. They gathered data from a real-world testbed for video streaming, where several videos are transmitted from a video server to a client network over a condensed ISP network. The ISP and client networks both produced actual failures. They employed the multi-layer perceptron (MLP) and long-short-term memory (LSTM) deep learning algorithms to detect and localise the issue with an accuracy of 93-97%, depending on the circumstance, using just the QoE metrics measured from the client side.

Streaming video can suffer from defects introduced during recording, encoding, packaging, or transmission, so most subscription video services — such as Amazon Prime Video — continually assess the quality of the content they stream[7]. The Video Quality Analysis (VQA) team at Prime Video began utilising machine learning three years ago in order to identify defects in footage that had been collected from gadgets like game consoles, TVs, and set-top boxes to verify new application releases or offline changes to encoding profiles. They have been using the same techniques in recent years to tackle issues like at-scale content analysis of new catalogue releases and real-time quality monitoring of our thousands of channels and live events.

Examining subscriber preference and content consumption behaviour towards the OTT platform is the aim of the paper[10]. This report also looks into how popular OTT platforms are with Indian audiences. Three significant OTT services' subscribers—Amazon Prime, Netflix Video, and Disney+Hotstar—have provided data. The lexicon-based technique was used to analyse 1860 reviews that were scraped as text. Using sentiment analysis, the polarity of the opinions expressed in the reviews of various platforms was examined. Furthermore, natural language programming (NLP) was used to

perform topic modelling on the reviews. The results of sentiment research revealed that, when compared to Amazon Prime Video, Netflix and Disney+Disney+Hotstar had a significant amount of positive comments from viewers. Finally, the article expressed dissatisfaction with Amazon Prime Video in regards to shows, ads popping up, interface problems, streaming material, etc. Our research assists OTT platforms in identifying the reasons that are causing this significant change in viewing behaviour so that more effective subscriber acquisition and retention strategies can be created.

In order to improve the video feed, sports field registration entails mapping video images onto a topographical model of the field. It is the technology that enables broadcasts of American football games to feature virtual first-down lines or swimming broadcasts to feature virtual world-record lines. Sports field registration typically calls for on-site cameras that are sensor-equipped and calibrated to certain spots on the field. Field registration is produced with great accuracy by fusing the sensor output and the video from the cameras. Amazon Prime Video[11] address the problem of sports field registration in the absence of instrumentation, using video from a single camera capable of pan, tilt, and zoom (PTZ) motion. This would make it possible to add cutting-edge graphics to broadcasts of amateur or minor-league sporting events, broadcasts of less well-liked sports, or even video signals from unequipped secondary cameras at significant sporting events.

C. Netflix

One of the most popular multimedia platforms in the world today is Netflix. Netflix offers its users a variety of entertainment, including films and TV episodes. The type of content that can be watched varies from country to country. The study[12] intends to explore the various viewing interests of Asian nations and to show the kinds of content that are watched in five South-East Asian nations. With the aid of Excel and Weka Machine, the usefulness of the pivot table is assessed. The nations to which the application was applied include Indonesia, Malaysia, Philippines, Singapore, and Thailand.

Netflix settlement freely peers with Internet service providers (ISPs) directly and at common Internet exchange points. In June 2012, a custom content delivery network, Open

Flow Tuples	bytes_in_mean	bytes_out_mean	active_bytes_in_time	active_bytes_out_time
11309	35830.37	74.750000	9.2	0.6
28235	161661.60	0.000000	10.0	0.0
19280	47619.54	88.142857	9.8	0.3
17475	13496.85	35.382716	9.7	0.3
9637	77832.00	0.000000	10.0	0.0

Connect, was announced.[13] For larger ISPs with over 100,000 subscribers, Netflix offers free Netflix Open Connect Computer appliances that cache their content within the ISPs' data centers or networks to further reduce Internet transit costs.[14][15] By August 2016, Netflix closed its last physical data center, but continued to develop its Open Connect technology.[16] A 2016 study at the University of London detected 233 individual Open Connect locations on over six continents, with the largest amount of traffic in the US, followed by Mexico.[17][18] As of July 2017, Netflix series and movies accounted for more than a third of all prime-time download Internet traffic in North America[19].

On October 1, 2008, Netflix offered access to its service via a public application programming interface (API).[19] It allowed access to data for all Netflix titles, and allows users to manage their movie queues. The API was free and allowed commercial use.[20] In June 2012, Netflix began to restrict the availability of its public API.[21] Netflix instead focused on a small number of known partners using private interfaces, since most traffic came from those private

interfaces.[22] In June 2014, Netflix announced it would be retiring the public API; it became effective November 14, 2014.[23] Netflix then partnered with the developers of eight services deemed the most valuable, including Instant Watcher, Fanhattan, Yidio and Nextguide.[24]

D. Disney+ Hotstar

Depending on their package, Hotstar customers can stream videos on up to four devices at once, and certain content can be downloaded for offline viewing. The majority of content may be streamed in resolutions as high as 1080p. In April 2020, Hotstar started rolling out Dolby Digital sound on Android TV, Apple TV, Amazon Fire TV, Fire HD, and Roku,[25] and later 4K with HDR in August 2020, initially for Apple TV and Android TV devices.[26]

The service had previously been available in India with "VIP" and "Premium" subscription tiers, which could be distinguished by their content libraries (the Premium tier had more expensive foreign series and films). In September 2021, Hotstar introduced a new plan structure based on device support and concurrent streams (more akin to that of Netflix), with "Mobile" allowing a single stream on a mobile device only, "Super" allowing streams on up to two devices simultaneously, and "Premium" allowing streaming on up to four devices simultaneously, and with 4K support[27]. Under the new plan structure, the same content library became available to all Disney+ Hotstar subscribers regardless of tier.[28][29]

With the introduction of 4K HDR, Disney+ Hotstar keeps up its effort to advance technologically and keep up with the times. However, it's still extremely constrained, which is an issue. Beyond Disney+ exclusive content, surround sound support is still limited, and one can expect that this will also be the case for 4K HDR support. More crucially, Disney+ Hotstar still only supports surround sound on TV, which is disappointing given that services like Netflix also support it on desktops. On laptops and mobile devices, Netflix also provides HDR, so maybe Disney+ Hotstar will make an effort to do the same.[26]

IV. COMPARATIVE ANALYSIS

For each of the Video category apps, some portion of flows were predicted as content. Looking at IO charts, they do appear to be content flows as they do not have typical streaming behaviour with buffer chunks and idle gaps. All of these data have been collected and fettet using Wireshark. The table 1 provides QoE metrics values for YouTube.

Table 1: A few QoE metric values for YouTube

The graphs below from figure 1 to figure 3 shows client bytes sent and servers bytes received for different time intervals.

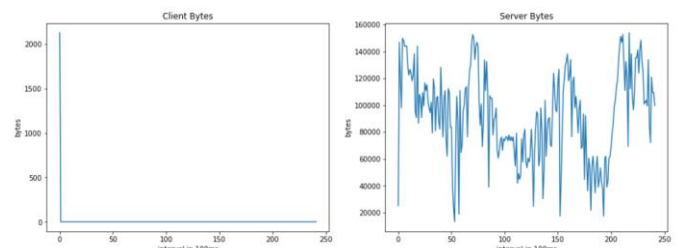


Figure 1: Graphs for client bytes and server bytes for first time interval

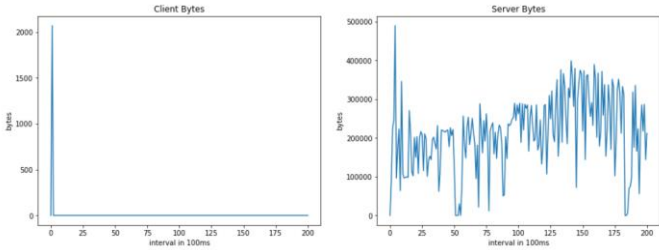


Figure 2: Graphs for client bytes and server bytes for second time interval

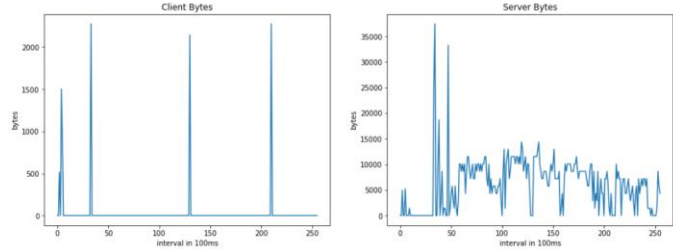


Figure 3: Graphs for client bytes and server bytes for third time interval

The table 2 provides QoE metrics values for Netflix.

Table 2: A few QoE metric values for Netflix

Flow Tuples	bytes_in_mean	bytes_out_mean	active_bytes_in_time	active_bytes_out_time
20863	88071.580000	46.800000	9.1	0.8
35430	37593.840000	33.852632	9.4	0.6
13062	38504.554455	33.414894	9.2	0.6
17603	34286.400000	0.000000	9.9	0.0
29666	25790.400000	38.785714	10.0	0.7

The graphs below from figure 4 to figure 6 shows client bytes sent and servers bytes received for different time intervals.

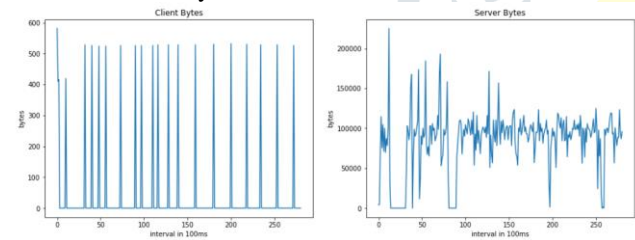


Figure 4: Graphs for client bytes and server bytes for first time interval

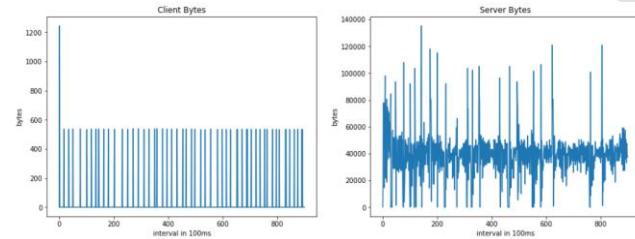


Figure 5: Graphs for client bytes and server bytes for second time interval

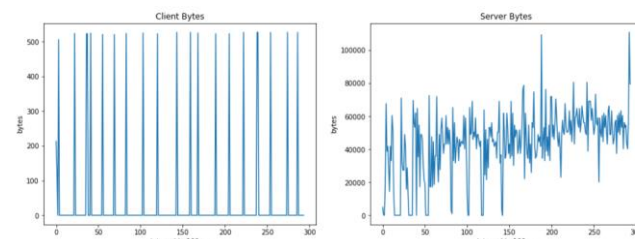


Figure 6: Graphs for client bytes and server bytes for third time interval

The table 3 provides QoE metrics values for Amazon Prime Video.

Table 3: A few QoE metric values for Amazon Prime Videos

Flow Tuples	bytes_in_mean	bytes_out_mean	active_bytes_in_time	active_bytes_out_time
21757	108244.168317	7.422680	9.9	0.3
34765	23504.800000	16.930233	9.6	0.2
11239	14408.390000	43.300000	9.2	0.9
29553	32448.850000	15.904762	9.9	0.3
24114	26930.990099	11.214286	10.0	0.3

The graphs below from figure 7 to figure 9 shows client bytes sent and servers bytes received for different time intervals.

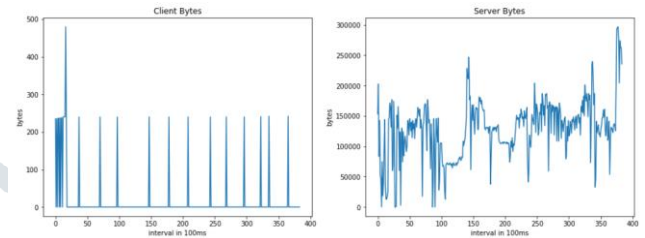


Figure 7: Graphs for client bytes and server bytes for first time interval

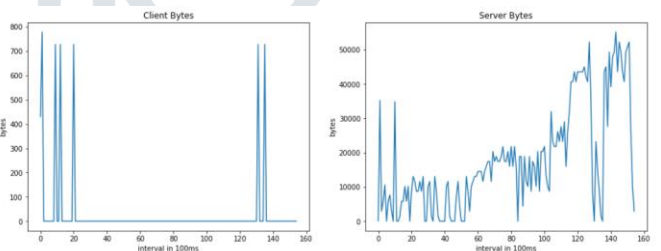


Figure 8: Graphs for client bytes and server bytes for second time interval

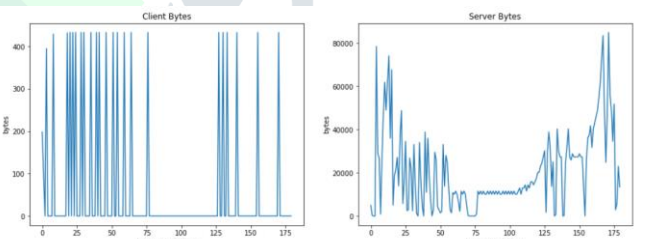


Figure 9: Graphs for client bytes and server bytes for third time interval

The table 4 provides QoE metrics values for Disney+ Hotstar.

Table 4: A few QoE metric values for Disney+ Hotstar

Flow Tuples	bytes_in_mean	bytes_out_mean	active_bytes_in_time	active_bytes_out_time
33079	499227.14	214.59375	9.9	0.3

The graphs below from figure 10 shows client bytes sent and servers bytes received for one time interval.

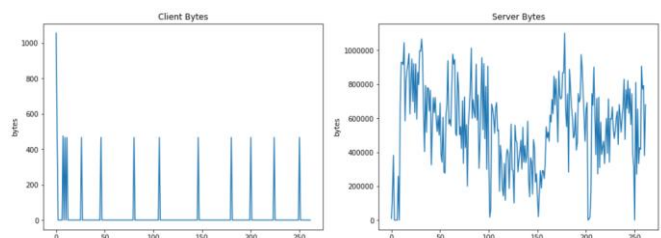


Figure 7: Graphs for client bytes and server bytes for a particular time interval

V. CONCLUSION

The lesser the number of flow tuples, the more efficient is the video streaming service. From tables 1, 2, 3 and 4 for YouTube, Netflix, Amazon Prime Video and Disney+ Hotstar, it can be observed that flow tuples are the least for YouTube and most for Disney+ Hotstar. Hence, it can be concluded that YouTube is the most efficient video streaming service and Disney+ Hotstar is the least efficient. The flow tuples recorded uses User Datagram Protocol(UDP) as we are analysis video streaming.

YouTube supports Full HD(1080p), Ultra HD(1440p and 2160p), and 4K(2160p) video quality through its video streaming infrastructure and adaptive bitrate technology. Similarly, Netflix, Amazon Prime Video and Disney+ Hotstar also support Full HD, Ultra HD and 4K video quality through its streaming infrastructure and advanced video encoding techniques. For all video streaming services, the bandwidth consumption ranges from 4K consuming the largest bandwidth, followed by Ultra HD, Full HD, 1080p, normal HD and finally SD consuming the lowest bandwidth.

VI. FUTURE SCOPE

The behavior of video streaming apps such as YouTube, Amazon Prime, Disney+ Hotstar and Netflix can be predicted based on their throughput and latency. If this information is made available to the Internet Service Providers(ISPs), then the traffic can be shaped accordingly such that more bandwidth is available for video streaming and other such applications.

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