Improving QoE and QoS provided by the OSP (OTT Service Providers)

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Abstract

The delivery of good Quality of Experience (QoE) and Quality of Service (QoS) for multimedia services is more important than ever in the eyes of OTT Service Providers (OSP) due to increased network traffic and consumer expectations at lower costs. With the launch of the fifth-generation of cellular networks, often known as 5G, connectivity and user content consumption will skyrocket. As the first stage in providing cost-effective high-quality services, real-time quality monitoring with a focus on the user has become critical.

Keywords— QoS, QoE, OTT, Over The Top service providers, Internet Service Provider, OTT-ISP collaboration

1 Introduction

With the estimated number of OTT viewers at 3.93B globally, OTT Service Providers and ISPs are keen to enhance their Quality Of Experience (QoE) and Quality of Service (QoS) to provide the best content and service . The OTT platforms have benefited the most, as recurrent lockdowns during the pandemic phase reshaped people's habits to access a range of entertainment content through their devices in a convenient manners sitting right at home. The goal of the OTT Service providers is to maximise the revenue. But subscription prices just can't be increased or else the price savvy consumers will simply switch to other platforms. One of the goals of future multimedia networks is to provide a fair user-centric quality that is consistent among all users in the network. The reason behind this is that selfish services may maximise their own QoE, possibly affecting the QoE of users of other applications.

With such a surge, it is getting difficult for the OTT Platforms to give maximum QoE to the users. Is the ISP of customer is to blame? With cases of streaming services like Netflix, Amazon Prime, Youtube putting a cap on their quality and streaming bitrate to help avert internet gridlock and help mitigate any network congestion as billions of people, confined by the coronavirus outbreak, switch to working from home. help mitigate any network congestion. This widely affected the QoE and QoS of the OSPs.

We'll look into whether better collaboration of OTT Service Provider and Internet Service Providers provide much smoother experience to the viewers in the future.

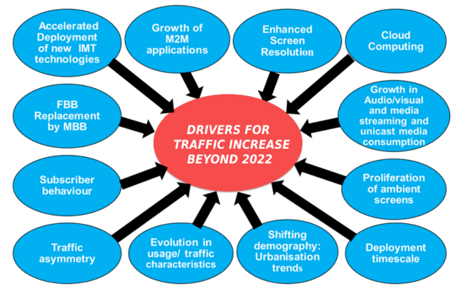

Figure 1: Drivers for Future Traffic Increase

We will also look for solutions for improving QoS in multimedia and complete multimedia communication infrastructure that is needed to support distributed multimedia applications and evaluate the impact of frequency of exchange of information among the OTTs and ISP on the network load as well as on the amount of data and the cost of data storage. OTT streaming services, such as YouTube, Netflix, Hulu, which offer higher requirements for network speed, will work in the mode of ultra-high resolution, 3D and full immersion. Meanwhile, OTT video technology is different from traditional video. Traditional RTP / RTSP video services require a special media server, and since it is transmitted on a UDP basis; the video information carried by the lost packets cannot be recovered. The result is a poor quality, such as mosaic and degraded sound quality. OTT video services based on the HTTP protocol use the TCP protocol at the transport layer. Since TCP uses congestion control and flow control mechanisms to ensure reliable transmission that affects OTT video quality, this means that the problem caused by packet loss and retransmission shows that new developments are needed to ensure the quality of OTT services [5]

We'll aim to achieve highest playback experience at the highest possible bitrate with no stutters and buffering. Traditional RTP / RTSP video services involve the use of a dedicated media server, and is trans-

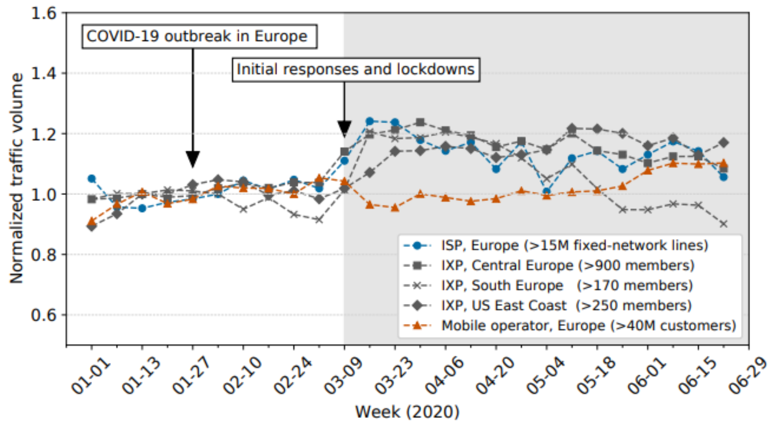

Figure 2: Traffic changes during 2020 at multiple vantage points normalized by the median traffic volume [7]

ferred through UDP, the video data carried by lost packets cannot be recovered. As a result, poor quality is produced, such as mosaic and deteriorated sound quality. At the transport layer, OTT video services based on the HTTP protocol employ the TCP protocol. Since TCP relies on congestion control and flow control mechanisms to maintain reliable transmission, which has an impact on OTT video quality, the problem of packet loss and retransmission indicates that new improvements are required to ensure the quality of OTT services.

2 Research Key Objective

2.1 Market of OSP,ISP Is Collaboration even necessary?

Globally, consumer Internet video traffic will reach 240.2 EB per month by end of 2022, the equivalent of 60 billion DVDs per month, or 82 million DVDs per hour [2] As a result, Internet Service Providers (ISPs) are forced to improve their network infrastructures and invest in the integration of advanced technologies (e.g., optical fiber, 4G/5G mobile networks) in order to accommodate such a tremendous growth in multimedia traffic. Any collaboration with The OTT Platforms do not directly increase their revenues instead they're fiddling in their market of traditional business i.e voice and messaging services. Although the average ISP profit per user is higher than that of an OTT, OTTs can reach a relatively bigger number of potential customers all over the world. ISPs are the most affected by user churn because, in most cases, user perceived quality is deteriorated owing to bottlenecks in ISP's networks, and users simply choose to switch their Internet connection to another ISP. As a result, an ISP's market share and reputation suffer, affecting their revenue.

As a consequence, ISPs must reconsider their current technological and business strategies, which are linked to Quality of Experience (QoE), or the quality as perceived by the user. Indeed, users who experience a high QoE are more likely to stay with the service and contribute to the ISP's profit. Nevertheless, providing high QoE for each type of service necessitates the ISP adopting unique QoE-aware traffic management methodologies that must be aware of the type of traffic to be managed. On the other hand, emerging multimedia services including High-Definition videos, IRL Streaming, cloud apps, and highly interactive applications, all of which demand more network resources. As a result, OTTs and Content Delivery Networks (CDN) are attempting to embed their platform for service provisioning within ISP networks to acquire better support and the ability to scale up dynamically to offer content to millions of users at the same time.

As a corollary, operating independently, it is difficult for both ISPs and OTTs to provide optimal QoE to their consumers, because QoE is a function of some ISP-controlled characteristics (QoS) as well as some OTT-controlled characteristics. Hence , collaboration between OTTs and ISPs appears to be the inevitable solution for increasing both their revenues and providing better quality to their subscribers.

2.2 Collaboration Approaches

Researches till date in this field has mainly been divided into two paths: on one hand, OTTs use network-aware application management approaches, which aim to adapt application parameters based on the monitored network status. ISPs, on the other hand, use application-aware network management approaches to manage network resources based on the services to be sent across the network.

Main stakeholders engaged in the usual Internet service delivery chain, includes ISPs, OTTs, CDNs, and Internet eXchange Points (IXPs). 3 Approaches has been provided. The first approach tries to maximise their revenues by giving higher-paying clients better quality of experience than others. With such a collaboration, OTTs and ISPs OTTs and ISto offer their services in different Classes of Service(CoS): the higher the price to subscribe to a CoS, the higher the quality of service supplied to that CoS's subscribers. The second aims to maximize the profit by providing better QoE to Most Profitable Customers (MPCs) i.e Customer Lifetime Value Based. Customer Lifetime Value (CLV) is defined as the metric for customer selection because it is defined as "*the total value of direct contributions and indirect contributions to overhead and profit of an individual customer during the entire customer life cycle, from the start of the relationship to its projected ending*" [11] The third aims to maximize QoE and QoE fairness among all customers. According to the general fairness metric defined in [9], which satisfies QoE-relevant properties, a system is defined absolutely QoE fair when all users receive the same QoE value. Therefore, the objective of the proposed collaboration scenario is to maximize the QoE and the QoE fairness of all the N customers in common among the ISP and the OTTs [6]

2.3 Results Findings

According to simulations [6] made to compare the performance of the above described methodologies in terms of quality given to users, quality of experience fairness among users, and total profit earned by providers. The CLV-based and JV approaches, give superior QoE to premium and standard service users, respectively. The QoE-fairness-based method, as expected, delivers a higher level of QoE fairness among users of the same CoS as well as on the network level. In terms of profit, the CLV-based method performs best, followed by the JV approach and the QoE-fairness-based approach.

More research is needed to determine the influence of the frequency with which OTTs and ISPs share information on network load, as well as the amount of data and the cost of data storage involved.

2.4 Key Factors affecting QoS

Once we determine the key factors assessing QoS, we can create suitable algorithms and models to improve user experience and network efficiency, numerous solutions and optimizations, including as traffic classification, bandwidth control, and switching algorithms, which are applied based on the QoS value.

Two factors directly affect QoS: factors related to the user

2.4.1 Factors related to the Level of Service

One of the reasons for the deterioration in video quality is the retransmission of packets to fill the buffer, which arrives too late. OTT video is based on HTTP and uses the TCP protocol in the transport layer. As a result, the application layer's QoS parameters are the initial buffering time, as well as the time and frequency of re-buffering. Different service providers using different solutions to confirm the transfer of their services may result in different user ratings. For example, when requesting a new segment, the Netflix video server will establish two TCP connections simultaneously (for audio and for video) and periodically send HTTP requests, while, as a YouTube player,it simply establishes one TCP connection. [5]

In the case of streaming ,when the TCP connection speed is slower than the video transmission rate, the data in the buffer will drop. Until the buffer is filled, the video will not play. The initial buffering time, the re-buffering delay, and the rebuffering frequency are all included in the factors of Application Layer. Video transmission speed, resolution, colour,synchronization skew, content, and playback mode (VOD or Live) are also some factors. It is sensitive to delay and delay jitter or the packet delay variations between consecutive packets.

2.4.2 Factors related to the User

Although the sensory perception of the user does not directly effect the QoS but it can't be simply neglected. In fact, the user's expectations for the video, as well as his or her current mood, have an impact on the user's experience. When watching a video, a user's actions can reflect their expectations and moods.

2.5 5G

5G is expected to change user's interaction with digital content. In India, 5G estimately will speed up OTT services by a factor of ten and reduces latency by almost half. This is a fantastic achievement that will allow smooth and continous content delivery with faster data transfer speed at a lower cost.

Hence, It's more important than ever for the OSP to enhance their Service so that the users can enjoy watching their favourite movies and shows without any hassle.

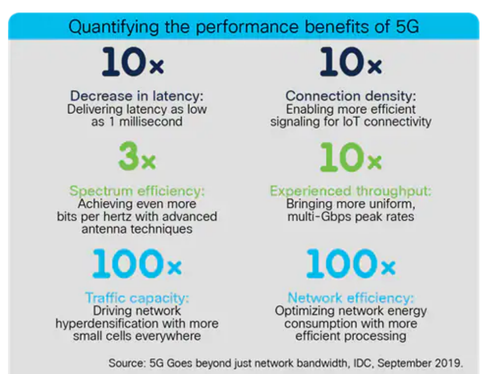

Figure 3: Expected Benefits of Fifth-Generation. [1]

2.6 Improving QoS

2.6.1 QoS Aware Resource Management Architecture

To achieve end-to-end quality of service for distributed multimedia applications along the multimedia communications channel, we need to provide end-point and network services and protocols that comprehend what quality of service is and how to map that quality into the required resource allocation. To provide QoS, each of the shared resources at the end-points must be modelled dynamically enough to provide its own QoS control while also adapting to non-deterministic system changes/overruns on general-purpose systems. The client-server model governs access to a shared resource.

Such guarantees have the following characteristics:

- System-wide resources management and admission control to ensure desired QoS level.
- Dynamic management - It means that QoS is dynamically adjusted rather than statistically maintained though out the lifetime of the connection [10].
- Quantitative specification (Packet Loss Probability, Delay Jitter) rather then qualitative description as in the Internet Transmission Control Protocol/Internet Protocol (TCP/IP). This gives the flexibility to accommodate a wide range of allocations with diverse QoS requirements [3].

The purpose of system wide resource management is to create end-to-end QoS by the coordination of system components. It should be capable of negotiating, controlling, and managing user service contracts and according to the negotiated values, reserve, allocate, manage, adopt, and release system resources.

2.6.2 Multimedia Communication, Internet Protocols and CABB

The Internet has grown rapidly into a significant network infrastructure for communication. It provides the Internet protocol (IP) with best effort delivery and has a large user base. Asynchronous transfer mode (ATM) is rapidly becoming available on the market. It provides on-demand bandwidth and guaranteed QoS and is expected to be the best candidate for high-quality media delivery. The Internet Engineering Task Force (IETF) has addressed the issues in developing a QoS support infrastructure for Internet deployment over IP. Several working groups have put forward viable alternatives. However, given the Internet's size and increasing heterogeneity, a single solution remains elusive. Integrated Services, Differentiated Services (diffserv), and Multi Protocol Label Switching are the most prominent proposals (MPLS).[8]

Paper [8] talks about how diffserv classifies network traffic and assigns network resources to flows in accordance with a management policy. Service classes with varying QoS guarantees are created, and flows are assigned to these classes. Service Level Agreements (SLA) are established between neighbouring diffserv domains. The SLA defines the traffic profile to be maintained by independently managed domains and establishes policy criteria.

The CABB presented in [8] uses the bandwidth broker architecture. This architecture's key components include the User Interface, Inter-domain Interactions, Intra-domain Interactions, Routing Table, Database, and Policy Services. They can tolerate resource scarcity (within certain limits) by lowering performance, and they can use additional resources to boost performance. The CABB prevents congestion by effectively ordering flows to conform to the traffic profile agreed upon in the SLA. Because CABB is content aware and understands the flexibility of the applications, it considers it when allocating flow rate. CABB improves flow throughput by detecting and controlling rogue flows. Furthermore, CABB eliminates the need for applications to interact directly with the diffserv router in order to obtain resources. CABB tunes bandwidth requirements (avoiding overallocation), while application level adaptive QoS fine-tunes applications in response to network changes.

2.6.3 Software-Defined Networks (SDNs) and Network Function Virtualization (NFV)

For network monitoring and administration, Software Defined Networks (SDN) and Network Function Virtualization (NFV) can be considered crucial future technologies. They allows more dynamic programming of systems which results in regular updates, more scalability, and reduced maintenance costs. SDN is focused on optimizing data transport, and programming tools are used to centrally manage traffic flows, to separate networks, and also to provide QoS at the application level. On the other hand, NFV focuses on implementing network functions in software, to support multiple versions and multi-tenancy, to deploy support and network management functions, and to virtualize and optimize the deployment of network functions. The SDN allows the programmability of the NFV infrastructure to support the development and deployment of network functions, while the NFV allows separation of network bandwidth and functionality so that network functions can be dynamically created and deployed.[5]

2.7 Improving QoE

Quality of Experience (QoE) has a wider meaning than Quality of Service (QoS) even though viewers have a worse time if either are impacted. The International Telecommunications Union (ITU) defines QoE as *"the overall acceptability of an application or service, as perceived subjectively by the end-user. It includes the complete end-to-end system effects (client, terminal, network, services infrastructure, etc.) and maybe influenced by user expectations and context."* Good QoE ensures that the viewer can put their trust in each of their 'clicks,' and know what will happen and won't have to wait.

Parameter	Treatment	Client Behaviour	Possible QoS decisions	QoS delivery
DELAY	↑	Transmission rate ↓	1.Allocate more bandwidth 2.Change video server 3.Change video codec	1.Change video codec 2. Change video server 3. Allocate more bandwidth
	↓	Transmission rate ↑	Not considered	1. Increase client buffer 2.Increase server buffer
JITTER	↑	Video Smoothness ↓	1.Increase server buffer 2.Increase client buffer	2.Increase server buffer
	↓	Video Smoothness ↑	Not considered	
PACKET LOSS	↑	Image/audio quality ↓	1.Change protocol UDP→TCP 2.Change codec	1.Change codec 2.Change UDP→TCP
	↓	Image/audio quality ↑	Not considered	
CACHING	↑	Rebuffering time ↓	Not considered	
	↓	Rebuffering time ↑	1.Allocate more bandwidth 2.Increase client buffer 3.Change video codec	1. Increase client buffer 2. Change video codec 3. Allocate more bandwidth

Figure 4: Changing network QoS parameters and appropriate QoS decisions

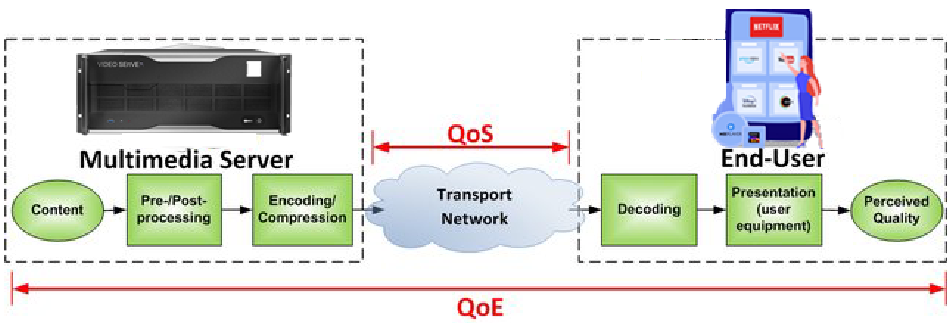

Figure 5: QoS vs QoE

According to research, It has been found that if there is any buffering or problems with the audio or video, customers will actively sought a different service. Providing an exceptional QoE on every device, however, is a difficult task. The OTT environment is far more complex than the linear broadcast environment.

2.7.1 Adaptive Bitrate Streaming (ABR)

Adaptive bitrate streaming (ABR or ABS) is a technology that allows files to be streamed more efficiently over HTTP networks. Multiple files of the same content, in various sizes, are proffered to a user's video player, and the viewer choose the best available video segment to play based on the available bitrate and device capability. Paper [12] proposed a Dynamic Bitrate Adaptive Algorithm and tried to improve average QoE via MPEG-DASH. The ecosystem toward DASH utilizes HTTP/TCP as its transporting protocols. [12]

This allows for a large deployment in existing network infrastructure. DASH video segments are stored at various bitrates and playback lengths. It was found that video quality quickly improves when the network profile changes to a better bandwidth and kept moving a average approach and gradually increased or decreased to the next downloadable bitrate and provided a smooth playback. User QoE can be guaranteed by delivering appropriate bitrate segments.

2.7.2 Per-tile/per-chunk encoding

The concept of per-title encoding is based on the fact that different types of video content necessitate different bitrates and encoding settings in order to achieve a certain level of quality. It has the potential to significantly reduce storage, transmission savings on CDN delivery costs. OSP can provide the best quality at a given bitrate for every scene of content using this evolved approach to offline encoding. This is best suited for for VOD asset encoding. Doing the same for live is an intriguing challenge that will necessitate the use of additional tools such as machine learning in order to achieve it within a reasonable CPU processing envelope.

2.7.3 Application of AI/ML

Broadcasters and service providers can use AI/ML-based Quality Control technologies to ensure that the experience they provide is of the highest quality while also keeping processing time to a minimum.

AI/ML technologies, in conjunction with computer vision, are becoming increasingly important in enabling OSP to generate metadata for content classification.

The most recent AI/ML models, designed for use by broadcasters and media companies, accelerate the detection of errors across multiple content formats. Broadcasters can gain unique insights into viewing psychology and improve QoE by using automation and AI models for data analytics.

2.7.4 Application of Neural Network

In addition to AI/ML auto QC solutions leveraging image processing, this technology and deep neural networks can aid in quick, precise identification of lip sync issues and facial recognition, optimizing the quality of experience for viewers. This is critical, as lip sync issues have long been one of the most noticeable and irritating errors for consumers, and can lead to churn.

The neural network approach in paper [4] was able to mimic network behaviour and predict an optimised Mean Opinion Score (MOS), allowing the approach to optimise the caching system and required prefetching to adequately improve QoE on wireless networks. This method improved the Analytic Hierarchy Process (AHP)'s best cases when faced with latency, jitter, and packet loss, and it also fixed the issues discovered when using the AHP on low bandwidth scenarios by matching the best QoE found with and without prefetch.

2.8 Conclusion

In the OTT world, competition is fierce. There are numerous OTT platforms to choose from, and today's consumers stream more content than ever before. Expectations for the viewing experience have transitioned, and delivering lower quality on devices is no longer acceptable.

QoE and QoS goes hand in hand. We found many ways to improve QoE and QoS by Congestion Control and reducing waiting time, Quality Control Adaptive Bit-Rate (ABR) technology and MultiProtocol Layer Switching (MPLS) among others. More solutions for improving QoS in multimedia must be developed, as well as a comprehensive multimedia communication infrastructure should be built. that is required to support distributed multimedia applications. Applications should be more user friendly and interactive.Higher performance processors and hardware, network bandwidth and data compression ratios are required. Digital transformation technologies such as Cloud, Internet-of-Things (IoT), Blockchain, Artificial Intelligence, and Machine Learning and Big Data Analtyics constitute a bulk of the of what is being adopted by organizations as part of their transformation effort and can detect and resolve video streaming issues in real time, as well as gain deeper insights into what is going on in media workflows.

While standard OTT services lack many of the tools required to provide the best QoE, they must use similar video optimization techniques , newer codecs such as HEVC and AV1, traffic prioritisation, client acceleration, and network monitoring. Keeping all this in mind, it is also extremely important that the service/subscription should be commercially viable but easy on the subscriber's pocket!.

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