CSC 461 Project Report

Researching and Analyzing Different Problem Topics on Twitch

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Introduction

In the ever growing world of multimedia applications, Twitch has become one of the lead live video streaming platforms. The platform has a main focus around video game streaming, but other forms of content exist as well, such as music, art and more. Examples of other popular live streaming services similar to Twitch include: YouTube, Kick and TikTok live.

Twitch's main goal is to provide viewers with virtually real-time broadcasts that allow for users to interact with the stream. Viewers can interact with streams by typing messages in the chat room, donating, or subscribing. As a business model, one of Twitch's primary sources of income is advertisement revenue, where viewers will have their streams replaced by an advertisement for periods of time. Viewers can pay subscriptions to different streams in order to remove these ads. Subscriptions such as Twitch Turbo, that remove all ads on all channels are other alternatives.

In 2022, Twitch had over 2.5 million concurrent viewers [1], but with this high viewership count, in addition to user device and network diversity, issues are bound to arise. The purpose of this report is to find out how and why some problems can occur, and provide some insight on what a potential solution may entail. The problem topics discussed in this report are the following: stuttering of video on mobile devices with a VPN (virtual private network), Twitch's low latency mode causing buffering even with high speed internet, and problems with high refresh rate streaming. These problem topics are important as they all negatively influence Twitch's immersiveness and engagement. Solving these problems will benefit both the viewers and Twitch as a company.

Twitch as a Multimedia System

In order to further understand the problem topics, one must understand the requirements for a multimedia system such as Twitch. There are many requirements that any successful livestream application must withhold. To ensure consistent viewer engagement, playback must be smooth, with virtually no stuttering. In the context of networking, stuttering can occur if the network cannot keep up with the data rate needed to provide smooth playback. This data rate needs to be suitable both on the broadcaster end and on the viewer end. The streamer must have a suitable upload speed in order to stream at a high quality. The viewer must have a suitable download speed in order to receive enough content to playback the video without buffering. In the context of hardware, stuttering can occur if the device is unable to decode at the rate needed to provide smooth playback. In addition to smooth playback, another requirement especially in regards to Twitch is minimizing latency. In order to keep the chat room interactive, the stream must feel as real-time as possible. This can pose a challenge for different users in different network conditions.

In order to fulfill these needs mentioned, the application must have a minimum bandwidth and have an upper bound on end-to-end delay, on both the viewer and broadcaster end. There are many other requirements for successful live streaming applications, but these two will be of larger focus in this report.

Stuttering of Video on Mobile Devices with a VPN

The first problem topic, stuttering of video on mobile devices with a virtual private network (VPN) is an example scenario where users can face issues with niche network combinations. There are two things that need to be analyzed with this problem topic, the mobile data service and the VPN service. One can argue against the need for a VPN when viewing content such as Twitch, as some may not feel the need to secure such data traffic, but some regions actually restrict users from accessing Twitch. The use of a VPN actually becomes a necessity in order to connect to a server in another country that is supported.

VPNs have a couple issues in regards to multimedia applications, especially ones that require minimum latency. VPNs cause the data packets that are being transferred over the network to have a higher overhead, as they need to be encrypted in order to keep data safe, which is one of the main goals of VPNs. An additional problem is the need for packets to travel to a VPN server [2]. The purpose of the VPN server is to transfer data from the server in order to imitate the user's IP address. This causes websites and services interacting with a user to believe that that is the user's true IP address, which provides another layer of confidentiality. This is problematic for multimedia systems such as Twitch as this overhead adds to the delay. When comparing VPN use to just watching the stream without one, the delay added from packets traveling to and from the VPN server is pure additional delay.

The dependency on a VPN server also causes issues to arise. Popular servers may have high server loads which can cause variable latency which leads to stuttering or buffering [3]. Different VPN companies also use different types of servers, which can be more or less suitable

for handling video streaming traffic. Issues with needing to use a VPN in regards to Twitch have recently spiked in relevancy nearing the end of 2023 as Twitch will be discontinuing its services in Korea on February 27th 2024 [4] due to severe networking fees. This will provide the need for Korean viewers to use a VPN in order to watch streams.

The mobile data service was the other aspect of the topic that could cause issues. An article by Putri, Anahr et al. shows that Twitch is one of the best live streaming platforms when measured using TIPHON standards on LTE networks [5]. This article compares Twitch to other popular live streaming platforms such as YouTube and Vidio. Twitch received the best index score out of all the platforms, showing that the Twitch platform does a good job at optimizing LTE performance. One thing that does need to be mentioned however is that Twitch received a very high index score in the throughput category on this study. Throughput was measured based on a higher is better scale. Although this is useful, a high throughput does not necessarily mean that the throughput is being used efficiently. A lower throughput, with similar or equal quality video using appropriate compression algorithms may be more appealing to those with limited data plans. Nonetheless, Twitch receives high index scores in the study showing its exceptional performance in other categories such as minimizing jitter and packet loss.

In short, due to the additional overhead that VPNs need in order to keep data secure, this adds more points of potential failure within the VPN's framework that can cause issues with video streaming. Problems include VPN server loads and an overall higher end-to-end delay in regards to network travel. In regards to mobile networks, such as LTE, Twitch received a very high performance score in the study mentioned, which leads to believe that the issue lies within

the VPN. Final thing to point out in regards to this problem topic is the potential compatibility issues with specific VPN and LTE combinations that could cause this stuttering to occur.

Low Latency Mode Issues

The next problem topic is Twitch's low latency mode causing buffering even with high speed internet. Twitch's low latency mode is delivering the live streamed video with the lowest possible delay from broadcast to arrival. This allows for viewers to experience the stream in almost real-time, which as mentioned previously, is really important for features such as the interactive chat and donations. This mode can cause an increase in buffering if the user's internet connection is unstable, as the mode will load the stream with a predicted delay, but then the network will become unstable and the data arrives slower than initially expected. This causes the need to buffer and pause the stream, in order for the data stream to catch up to the user. Typically problems with low latency mode occur with a poor connection but sometimes buffering like this can still occur even with a consistent connection.

If buffering still occurs, even with a good connection, the problem may stem from the content delivery aspect and how Twitch distributes streams across the internet. Unlike services such as Netflix where there is a database of content, Twitch allows for anyone with a suitable connection and a compatible device to stream. In order to optimally distribute content, streams must be dynamically hosted. Twitch distributes streams to servers depending on popularity. A study by J. Deng et al shows that this popularity oriented distribution is really efficient for the majority of viewers [6]. This is important as streams not as popular may take longer to load as there are physically less servers containing the data. Less servers containing the data also means

fewer optimal routes that the user can receive the data from, so this could increase latency. The article also discovers that, especially in Asia servers, there was a "poor local interconnectivity with Twitch's Autonomous System" [6] which led to users being redirected to North American servers rarely. This could prove to be a problem for low latency streams as occasionally being redirected to a farther server can cause variance in delay. This issue with a combination of some packet loss could lead to occasional buffering even with a good internet connection.

Thus, for users that experience buffering even with a high speed connection, the problem could be with lack of hosts available to receive content from, as less popular streams are hosted less. If there are problems with a popular stream, the problem may be a regional problem similar to Asia servers where users will be redirected to North American servers occasionally which can cause variance in the network. Twitch would need to have a content distribution framework change in order to fix the problem due to the nature of Twitch Autonomous System. It is unlikely though that this problem will be fixed as typically eastern countries around Asia contribute to significantly less traffic when compared to regions such as North America or Europe [8]. Based on Twitch's decision to terminate services to Korea, it seems unlikely that the company will allocate more resources to regions that have less data traffic, as for them it is less profitable.

High Refresh Rate Streaming

The last topic covered in this report is problems related to high refresh rate streaming on Twitch. As computer games continue to grow with popularity, more and more people are buying high refresh rate monitors, such as 120Hz, 144hz and more. To many people, a high refresh rate is very important, as it provides a more immersive experience. Having the ability to see more frames per second is essential especially in fast paced first person shooters such as CS:GO and Valorant where milliseconds can influence decisions [9]. As these people buy more high refresh rate monitors, it is reasonable to assume that some may want to watch others play at this high refresh rate. This is why the ability to stream at a high refresh rate would be ideal for viewers.

Twitch officially only supports streaming of up to 1920x1080 at 60FPS (Frames per second) with 6000 KB/S being the maximum bitrate for streams [7]. If a streamer tries to stream at a higher bitrate, the stream will become unresponsive, just a black screen. In contrast to this, if one tries to stream at a higher FPS, with 6000 KB/s bitrate, the stream will actually work. Twitch does not officially support high FPS streaming, but FPS counts such as 120 seem to work perfectly fine, which allows for viewers with high refresh displays to put them to use.

Streaming at a higher FPS does cause some issues to arise. There is overall more work on the user end as there are more frames than traditional 60FPS streaming. There is a need for more work from the decoder end. Those with worse hardware, or no dedicated GPU may experience stuttering issues loading high frame rate streams. There is also a bitrate upper bound. This causes per frame quality to be slightly worse as there are double the frames being represented by the

same amount of bits. Depending on how the broadcaster encodes the stream, it is still of relatively high quality but there can be a very slight decrease in image quality.

The issues highlighted with high FPS streaming can cause viewers to not want to watch a streamer's livestream. It is important for streamers to grow in order to build a community and gain revenue. Losing part of one's viewer base to strengthen another's already enjoyable viewing experience may not be worth it. Vast majority of the video consumed over the internet is of 60FPS or lower, so the lack of a high FPS streams would not be too detrimental. Ultimately, it is likely not worth it for the streamer to stream at a higher FPS as making your content inaccessible could falter growth.

Conclusions and Potential Solutions

This section of the report will discuss potential solutions to the previously mentioned problem topics. It will also mention briefly where further research would be ideal in order to solve problems regarding the topics.

A potential solution to stuttering of video on mobile devices with a VPN would be using VPN services that have a high performance VPN server with good load balancing, ensuring that all users have a consistent and reliable connection. A VPN with IKEv2/IPsec encryption protocol would also be ideal as it performs better than SSL [3]. Further research into optimizing VPNs interaction with services such as Twitch would be greatly beneficial, especially with regions now having discontinued Twitch services such as Korea.

There are a few things that need to be implemented in order to fix Twitch's low latency mode buffering even with high internet speed. Twitch would need to allocate more resources to Asia servers in order to avoid clients being redirected to North American servers. This is crucial to minimize variance in latency. The model that Twitch distributes streams to different server hosts also needs to be altered, but more research needs to be done in order to optimally do this. The current model favors streams with high popularity, which does satisfy the majority, so as a business model this may be sufficient for them.

As for solutions regarding high refresh rate streaming, it is a little more complex. To most users, the difference between 60 FPS and 120 FPS goes unnoticed as many devices and monitors only support up to 60Hz. With the potential issues previously mentioned, it is currently not worth it for streamers to livestream at a higher FPS as it may cause the stream to be inaccessible to some. Overtime, as more efficient hardware becomes cheaper, it is likely that high frame rate streaming will become more popular, as fewer people will have hardware issues. In order to fix the individual frame quality, Twitch could simply increase the allowable bitrate, but this would put a higher strain on streamers, as they would need a higher upload speed.

In conclusion Twitch does a very good job at optimizing performance for the majority of its users. In order to solve the problems mentioned in the report, further studies should look into plausible resource allocation adjustments for content hosting and watch out for technological advances. Solving all of these problem topics will have benefits to both the consumer and Twitch, so hopefully future studies will explore these topics more.

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