Survey of video game streaming solutions

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Abstract

This project work conducts a survey of currently available cloud game streaming solutions on the market in an attempt to further systemize the variety of different technologies available to the users both paid and free. The new type of real-time content being games provides new challenges, such as not only requiring real-time video and sound streaming but also imposing new restrictions on input delay and responsiveness. As described in the first half of this work, there has already been research done in the field of cloud gaming technologies – by measuring various delays along the path from the client device, researchers tried to formalize how different network conditions and game complexity affected user experience. An evolution timeline of cloud gaming services is presented, with the most recent services being picked in this work for analysis. At the end of the work, a small test is carried out that gives some insight into the abilities of each streaming technology.

1. Introduction

In recent years, due to the growth of computing power and more affordable bandwidth, there has been an emergence of various types of cloud services. In the realm of cloud services for entertainment pioneering companies such as Netflix and now also Amazon Prime and Disney+, the latter one launched very recently at the end of 2019. Seeing the demand for online streaming video-on-demand solutions, other companies see an opportunity for them to provide a wider variety of services to their customers particularly in the realm of video games (gaming-as-a-service – GaaS).

This work reviews the history of the video game streaming services not purely as a video streaming solution (such as Twitch, YouTube, etc), but taking the service one step forward by providing users with total control of the game. This in turn poses a major challenge: unlike in typical video streaming, when a certain delay is acceptable and video can be buffered on the client-side, in real-time video game streaming delay must be as low as possible, oftentimes no more than a couple of hundred milliseconds. As will be seen further in the work, not every solution is equal, sometimes varying drastically not only in provided functionality but also in the library of games, which in turn make one service more favorable to one person than the other.

The work consists of two parts. In the first part, the previous works related to cloud gaming research are reviewed. Along with the historical review, the current state of research in the area is presented, showing previous works that attempted to describe the problems of cloud game streaming. After that, the state of the art is presented by listing the most common streaming solutions while comparing them to the general set of criteria.

After presenting the timeline of cloud gaming services and making a list of the most prominent services, the second half of the document a description of currently available services is provided along with the comparison across a set of common criteria. The systematic approach aims to try and compare services as objectively as possible, by referring to a list of generic criteria, such as cost and business model, number of games that can be played, available platforms, input delay, etc. In the end, a small experiment is conducted by comparing and analyzing the traffic of several streaming solutions. This work does not attempt to analyze in-depth the performance (such as resource usage, i.e. CPU, RAM) of given solutions, instead of giving a systematic overview.

The structure of the document is as follows: in chapter 2 an overview of previous works in this field is presented, mainly focusing on the technical side of video game streaming. In chapter 3, the video game streaming solutions development timeline is discussed while in chapter 4 the current state of the art services are discussed, highlighting their strengths and weaknesses. In chapter 5 a small test is carried out, comparing traffic consumption and its patterns for reviewed services. At the end of the document, the conclusion and an outlook on further improvements to this work are presented.

2. Previous works

Previous works on this topic mainly focus on the technical side of things, analyzing the performance game streaming mechanisms, trying to figure out which platforms deliver the best quality of service while also trying to understand which design elements are required for the best cloud gaming experience [Che11]. In their work, authors compare OnLive and StreamMyGame cloud gaming solutions, since at the time of writing cloud gaming just started to get into the hands of the public through the massive campaign OnLive ran at the time. The authors propose a general methodology to measure various latency components that are involved between the user and server system (Fig. 1) and their approach was successfully applied even to the closed systems such as OnLive.

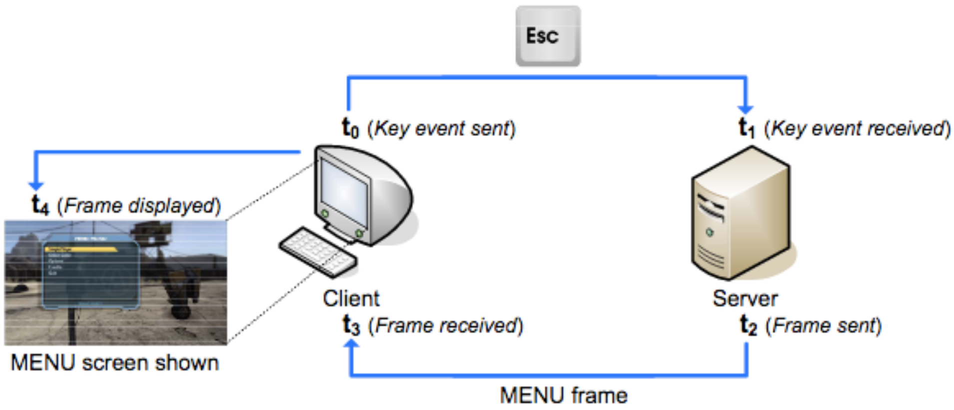
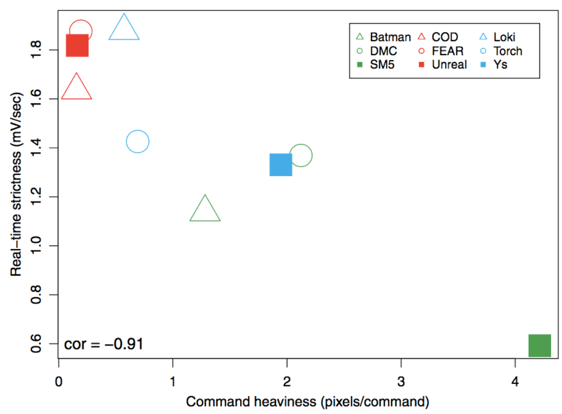


Fig. 1: Response delays during different parts of network communication. Source: [Che11]

During that time other research was focused on how well various games are suitable for real-time streaming depending on the genre, required reaction time, and graphical fidelity of the games. In their work [Lee12], authors show that user experience varies depending on the game. To quantify this, they developed a model to predict cloud-gaming friendliness depending on game screen changes and player input frequency requirements (Fig. 2).

Using this approach, it is possible to predict QoE degradation that is perceived by each player depending on their network connection while the game is hosted on the same server. Authors propose a possible application for this approach in the optimization of server operator costs without major players' experience sacrifice.

a) A screenshot of a game with its motion vectors overlaid



b) The relationship between real-time strictness and command heaviness

Fig. 2: Command heaviness graph (b) is calculated from motion vector data (a). Source: [Lee12]

Around the time of more prominent emergence of cloud game streaming, there was also an attempt at the development of a cloud-based open-source game system framework for one of the popular game engines Unity – Uniquitous [Luo15]. The authors' motivation was to make an open system that would be available to both developers and researchers and would provide a higher level of control over game content and cloud system at the same time, fulfilling the role of a testbed. Since Unity provides support for numerous platforms, including smartphones, this makes it possible to use this testbed in limited or generally lower quality network conditions.

There can also be seen a tendency of making technologies more adaptive, both virtualization solutions that aim to make hardware adaptive [Yad17] and software solutions with algorithms gaining an ability to adapt to changing network conditions such as packet loss and bandwidth [Suz16].

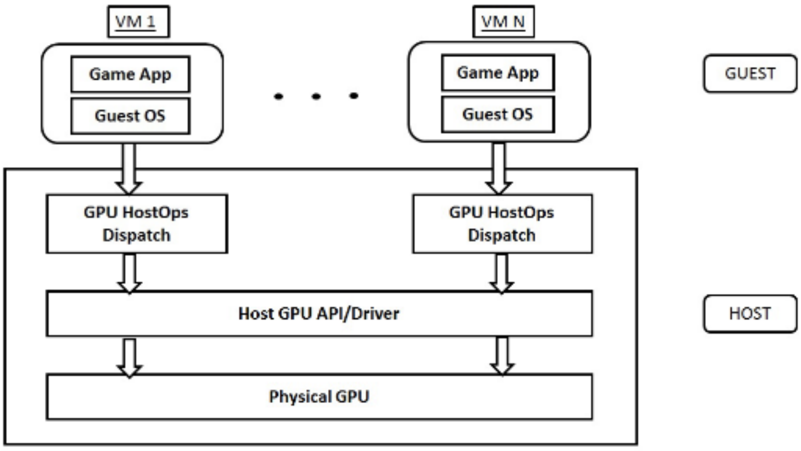


Fig. 3: GPU paravirtualization architecture. Source: [Yad17]

Hardware adaptation is at most importance for service providers since it allows to dynamically assign different loads to available hardware (Fig. 3). In the realm of cloud gaming, an important role plays adaptive GPU resource scheduling in a virtualized environment [Yad17] because it makes it possible to load hardware more fully, which in turn increases the number of clients that can be served at the same time. One example of why resource virtualization is important could be seen in the reason why OnLive did not succeed. At the time when the service launched there were no widely available virtualization technologies specific for gaming – therefore the company had to keep a dedicated machine for each client, which introduced tremendous overhead in periods when there was no active service usage.

Technologies such as NVIDIA virtual GPU [NVI20b] allow to use either one powerful GPU to create multiple less powerful virtualized GPUs similar to CPU and RAM virtualization solutions. Furthermore, this technology also allows to allocate multiple dedicated GPUs to one virtual machine for demanding works such as machine learning. Such advancements in GPU virtualization make it possible to provide cheaper computing power (through dividing dedicated hardware to multiple users) to a larger number of users.

Along with advancements in adaptive GPU scheduling technologies there was research aimed towards learning subjective perception variation depending on different network conditions [Suz16]. In their work, the authors conducted their experiments using NVIDIA GeForce NOW cloud gaming service while it was still under development. Researchers tested how the adaptation of network delay, delay variation, packet loss, and bandwidth shaping affected players' willingness to continue playing (Fig. 4).

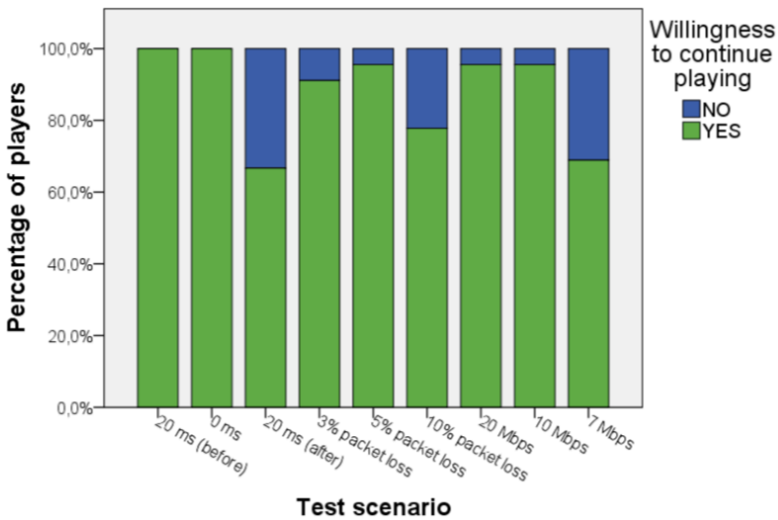


Fig. 4: Willingness to continue playing in various test scenarios. Source: [Suz16]

Name	Class	DoF	MT	CP	ACM	TD	ON	CD	SA	CR
CSGO_P1	3	6	3	3	3	4	3	2	0	0
CSGO_P2	2	6	3	3	2	4	3	2	0	0
Diablo_P1	1	3	2	1	2	3	3	2	1	0
Diablo_P2	1	3	2	1	1	3	3	2	1	0
Dota2_P1	1	3	2	0	0	4	3	2	2	1
Dota2_P2	1	3	2	0	0	4	3	2	2	1

Fig. 5: Game characteristics assigned to source videos. Source: [Zad18]

In their work researches point out that although there has been a number of previous studies that focus on cloud game streaming QoE that all agree that a game genre is a key parameter affecting the quality of experience for the user. However, at the time there were no works that would attempt to classify games objectively.

Subsequently, further research regarding video encoding complexity works such as [Zad18] provide with a classification of video games by linking game characteristics such as camera degrees of freedom (DoF), movement type (**MT**), camera pace (**CP**), amount of camera movement (**ACM**), texture details (**TD**), number of objects in the field of view (**ON**), color diversity (**CD**) and color redundancy (**CR**), and finally static areas (**SA**) such as a head-up display that is very frequently utilized in games (Fig. 5).

After the assignment of the characteristics, authors computed a decision-tree based on characteristic values in order to group games into clusters, therefore formalizing the process of game classification based on their characteristics. Using logistic regression authors were able to create equations for quality prediction for a specific game. This can allow service providers to allocate bandwidth more intelligently by providing minimum bandwidth specifically for the game that is requested, which in turn can optimize costs for the provider.

In the conclusion of this chapter, it is obvious that there is certainly academic interest in the field of cloud game streaming. In their works, researchers focus on subjective attributes of cloud streaming platforms such as response time while also trying to create a formal approach to categorize games and estimate stream performance requirements (such as the number of actions and screen refreshes).

3. Market evolution timeline

In this chapter cloud game streaming solution market is reviewed, trying to pin-point key events in the development of cloud gaming. Cloud gaming was thought about as far as in the middle of 2006, with Crytek doing research related to cloud gaming [Dob091]. However, at the time computing technologies (power and virtualization) might not have been on par with the computation that cloud gaming demanded. Even if computation power would have been enough at the time another major obstacle was the quality of internet connection and available bandwidth in a typical US household (since the company doing research was situated in the US).

Four years later, OnLive was launched while also gaining large social media coverage and investor interest. OnLive proved that it was possible to provide cloud gaming service technically. However, at the time people were not used to cloud services as much and hence the company started to struggle financially since it had to keep many machines running while being idle because it had to have a dedicated machine for each client which was highly inefficient [Hol12]. Finally, in April 2015 OnLive is shut down after being acquired by Sony [Low15], [Hol19]. Sony might have been interested in OnLive technology for its service "PlayStation Now" which was launched in July 2014 and was the first successful commercial cloud gaming service. Around the same time along with OnLive Sony also acquired game streaming company Gaikai that specialized more on lower-level services for service providers.

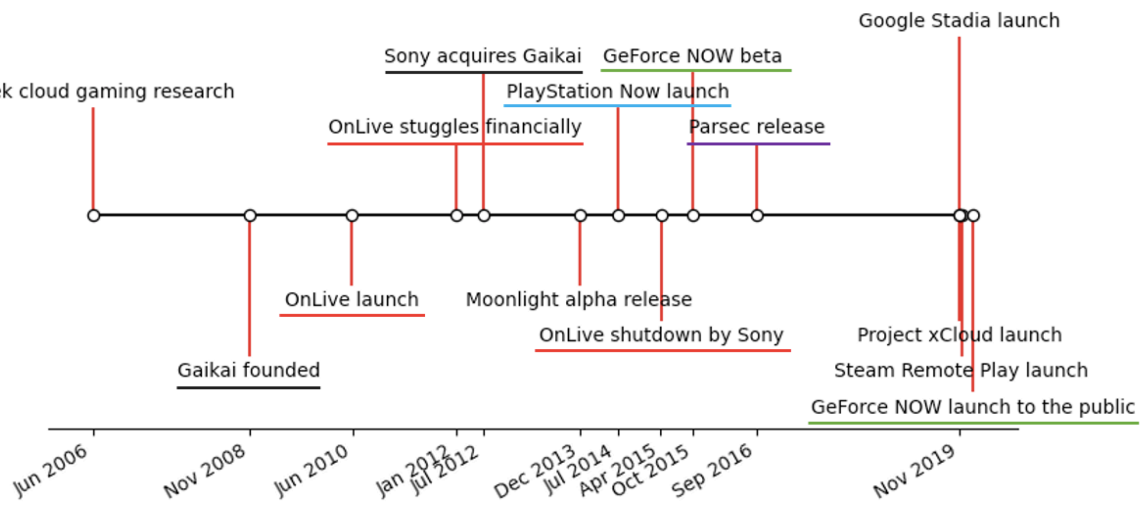


Fig. 6: Cloud gaming technologies timeline

Around 2014 an emergence of cloud streaming solutions started to increase with one noticeable example of such a solution is Moonlight, which was developed during a hackathon by a group of students from Case Western Reserve University [Moo20] with the alpha version being launched in 2013. Moonlight uses NVIDIA shield technology, essentially acting as a software NVIDIA Shield client and server.

With the improvement of adaptive video streaming technologies and protocols Parsec Gaming [Par20] was launched in 2016 that provided remote desktop streaming similar to TeamViewer, however also allowed to stream highly demanding content such as video games.

After taking a three-year break, by the end of 2019 and beginning of 2020 three complete services from big companies were launched: Steam Remote Play [Val20] from Valve, Google Stadia [Goo20], and GeForce NOW [NVI20a] finally coming out of beta in February 2020. The current situation and the launch of so many cloud game streaming services suggests that technology is ready and hopefully market is also, since nowadays people are more used to cloud services and subscription-based payment models, making cloud game streaming not only technically possible but also a suitable venue for profit for big companies.

4. An overview of the current state of the art cloud game streaming solutions

4.1. PlayStation Now

Initially launched at the beginning of 2014 and later extended to other countries over the course 2015 – PlayStation Now [Son20] is a cloud gaming service primarily aimed at PlayStation game consoles since the service provides access to already owned games on the platform over the network connection without the need to install them locally.

Having also a client for the PC, the service has become accessible to a wider range of users. Coupled with backward compatibility – allowing users to play games from the older generation of PlayStation consoles, this makes a compelling to the users who have other devices since the service is also accessible on PC [Son201] and some of the Sony smart TVs. This gives the users an ability to enjoy games exclusive to the PlayStation platform without necessarily having a console.

The business model for the service is subscription-based that costs around 9 USD a month (depends on subscription period) and could be seen as a promotional service for the company's consoles since its main competitive difference is exclusive games that people cannot get on other platforms [Sum17]. Subscription to the service not only grants access to the games but also the hardware to play on, significantly lowering hardware requirements on the user's side.

4.2. Moonlight

Being launched shortly before the launch of PlayStation Now this open-source cloud gaming solution is a result of a hackathon and is made by the enthusiasts in their free time. The service uses Nvidia GeForce Experience software by imitating the Nvidia Shield device. This allows users who have somewhat modern Nvidia GPUs to enjoy a remote play experience similar to Shield without the need to buy extra hardware – by using their smartphone or laptop and streaming from their Windows PC.

Being free software, it relies fully on the user's hardware and ability to configure the software. In cases when network configuration is required for proper connection this can impose difficulties to some users. Furthermore – while being somewhat breakthrough at the time, seven years later it does not hold up to the emerging competitors in the cloud game streaming area, having worse adaptation and encoding algorithms, which in turn provides less than ideal user experience.

4.3. Parsec

Another free game streaming solution comes from a company that develops cutting-edge low-latency streaming technology. The service provided is free for personal use since it does not incur much of the overhead to the company, since all traffic is transferred between user's devices over a secure peer-to-peer connection using datagram transport layer security protocol version 1.2 (DTLSv1.2) that makes it possible to establish a secure connection without sacrificing the performance of a datagram protocol (Fig. 7).

205	0.157264	109.172.104.29	10.126.55.9	DTLSv1.2	1271	Application Data
206	0.157532	109.172.104.29	10.126.55.9	DTLSv1.2	1271	Application Data
207	0.157538	109.172.104.29	10.126.55.9	DTLSv1.2	1271	Application Data
208	0.164684	109.172.104.29	10.126.55.9	DTLSv1.2	418	Application Data
209	0.164800	10.126.55.9	109.172.104.29	DTLSv1.2	94	Application Data
210	0.169110	109.172.104.29	10.126.55.9	DTLSv1.2	94	Application Data
211	0.171530	109.172.104.29	10.126.55.9	DTLSv1.2	1271	Application Data
212	0.171837	109.172.104.29	10.126.55.9	DTLSv1.2	1271	Application Data

Fig. 7: Direct peer-to-peer connection using DTLSv1.2 protocol

The business model of the company behind this technology is aimed towards business to business (B2B) technology licensing for custom projects while providing their service as a free demonstration.

Users can remotely connect to their PC running Windows 8.1 or higher from the majority of devices and operating systems and stream not only games but also the desktop making it an alternative to TeamViewer for work.

Additionally, the free version of the application includes the ability to play together with other people by connecting to the same device, making local multiplayer possible over the network, or just sharing some of the controls on the PC (i.e. only the mouse). Alongside streaming, the application features the "Arcade" mode that acts as a server list for people to connect to each other and play games together even when those games did not have network multiplayer implemented initially.

4.4. Steam Remote Play

Steam is the largest PC video game store, hosting more than 30,000 games [Min20]. The company behind Steam – Valve corporation is known for such critically acclaimed and world popular titles like Half-Life, Counter-Strike, etc. and are using their resources too try and move the gaming industry forward (for example with the recent triple-A virtual reality title Half-Life: Alyx). To stay competitive on the market they constantly try to improve their game store – Steam, by adding new features and iterating upon already existing ones. With the introduction of Steam Link [Val201] – a device that allows to stream games from PC onto TVs and mobiles around the house, they have been developing a custom game streaming solution as a part of their Steam client software.

A natural evolution from streaming around the house is to stream to other devices remotely through their recently introduced service Steam Remote Play [Val20] that allows streaming any game purchased on Steam from user-owned PC to other devices running Steam such as Mac and Linux computers and mobile devices through Steam Link mobile application.

563…	319.077207	162.254.198.40	10.126.55.9	UDP	1259 27017 → 59717 Len=1217
563…	319.077326	162.254.198.40	10.126.55.9	UDP	345 27017 → 59717 Len=303
563…	319.077516	10.126.55.9	155.133.250.138	UDP	91 59717 → 27019 Len=49
563…	319.077845	162.254.198.40	10.126.55.9	UDP	1259 27017 → 59717 Len=1217
563…	319.077850	162.254.198.40	10.126.55.9	UDP	345 27017 → 59717 Len=303

Fig. 8: Steam Remote Play traffic over the nearest proxy owned by Valve

Providing users with the Steam ecosystem, Steam Remote Play connection is not established directly between user's devices but instead goes over a proxy server owned by Valve (Fig. 8), which potentially helps mitigate problems that otherwise could have occurred due to NAT settings. Other than that, the solution utilizes a generic UDP protocol for streaming.

Because of the usage of a proxy, the connection quality could vary, depending not on just one connection between user's devices, but two connections between these devices and proxy. In general, the quality of the picture for the same setup over a long distance is worse than for Parsec.

Similar to Parsec, Steam gives the ability to play local multiplayer games over the network through Steam Remote Play Together. However, this feature is not supported in all games at the time of writing and is less stable than Parsec.

4.5. Google Stadia

Launched near Steam Remote Play (Fig. 6), Google's cloud service is much more similar to PlayStation Now. It is provided on a subscription basis at 9 USD a month with an option to buy a package that contains Chromecast (a streaming device for TV), a controller, and three months of subscription for 129 USD. Similar to other paid services, Google Stadia provides hardware to play on. It is available through the Google Chrome browser, making it accessible on all major desktop operating systems and even Chromebooks. Alongside desktops, it is also available on selected Android smartphones.

The major downside of Google Stadia is the game library and the way to get them. Users have to buy game specifically for this platform, sometimes having to make the purchase twice, which becomes a strong disadvantage of the platform. This coupled with the small choice of games to play (around 50 games in total at the time of writing) it makes Google Stadia a hard choice for most of the people since they simply do not the games they want to play.

On the technological side – Google Stadia keeps very strong, being able to deliver consistently high-quality picture with small input delay while utilizing a high-bandwidth connection.

4.6. GeForce NOW

Having launched GeForce NOW in beta as far as in 2015, Nvidia finally launched the service to the public in February 2020. The service makes use of RTX-powered GPUs, making it possible to play high-end games with the latest graphical features. Since Nvidia is a GPU manufacturer it might be cheaper for them to get the hardware, making it easier for them to stay competitive on the price.

One of the key features of the service is a free one-hour play session that can be used an unlimited number of times. Of course, at the peak times of service usage priority is given to the subscription users, however this gives a perfect opportunity to test the service without the need to provide credit card information. The service boasts around 2,000 games in their library, all available from various PC game stores such as Steam, Uplay, Epic Games Launcher, etc. Unlike Google Stadia, users do not have to buy the games on Nvidia's service – instead, they just need to log in with their store account to launch the game.

The service provides adaptive streaming capabilities, giving users low input response times down to around 20 milliseconds even in more demanding games.

4.7. Project xCloud

Microsoft Project xCloud [Mic20] is the latest announced cloud game streaming service from Microsoft that attempts to move the Xbox gaming experience to the cloud. Since Microsoft not only owns Windows operating system and Xbox console but also publishes games – the motivation of the service could be to drive sales of their own games by giving wider access to their games through cloud gaming. At the time of the writing, the service is still in preview and is to be released in September 2020 [Iva20].

4.8. Conclusion

In the conclusion of this chapter a table is shown below, which compares the beforementioned services regarding the cost, the number of games and their licensing, and also available platforms.

Service	Cost	Hardware provided	Number of games (approx.)	Game licensing	Available platforms
PlayStation Now	Subscription	Yes	800	Games in PS store	PC, PlayStation 4
Moonlight	**Free**	No	Any PC game	**Any game**	PC, Mac, Linux, iOS, Android
Parsec	**Free**	No	Any PC game	**Any game**	PC, Mac, Linux, Web (chrome), Android
Steam Remote Play	**Free**	No	**30,000+**	Steam library	PC, Mac, Linux, mobile
Google Stadia	Subscription	Yes	50	Stadia library	Web (chrome), Android
GeForce NOW	Subscription	Yes	**2,000**	Selected games from various stores	PC, Mac, Android, Shield
Project xCloud	Subscription	Yes	100	Selected games	PC, Xbox, Android

Tab. 1: Cloud game streaming service comparison

5. Test

In this chapter, a small test is carried out to compare the performance of currently available cloud gaming solutions. Service behavior was observed using Wireshark open-source packet analyzer [Wir20] by measuring bandwidth usage and its oscillation over time to correlate it to the subjective experience of the player. Furthermore, it was used to analyze packet destinations to get approximate geographic locations of the servers and round-trip times using server IP-addresses.

Not every beforementioned service was used in the test, namely, PlayStation Now was omitted, since all testing was done on a Mac computer, which is not supported by the service. In total five services were tested using the same game called "Wreckfest". The game was picked because it is a simulation-type racing game that provides enough of feedback for the player to be affected by network delays while at the same time providing enough time to react unlike more real-time games like "Counter-Strike". The game also features fine graphical details that can be used to judge graphical fidelity of the video stream. The exception for the choice of the game is made for Google Stadia, instead testing using another racing game called "Grip", since that is the only racing game available on the platform at the time of the writing.

The client machine was an Apple MacBook Air 2013 connected to a 100 Mbit/s 5GHz Wi-Fi connection. During tests, all applications except for the Wireshark and the game streaming service were closed in order to prevent disruption of the stream.

5.1. General bandwidth usage

The first part of the test was to measure the general bandwidth usage of each of the five services. Wireshark traffic measurements started before active gameplay started, which caused some graphs to be more delayed than others. Because of this, a region during active gameplay in every service was taken (marked with dashed lines). On the diagram shown in Fig. 9, the bandwidth of each service is presented as 10 seconds moving average to remove high-frequency noise in the data.

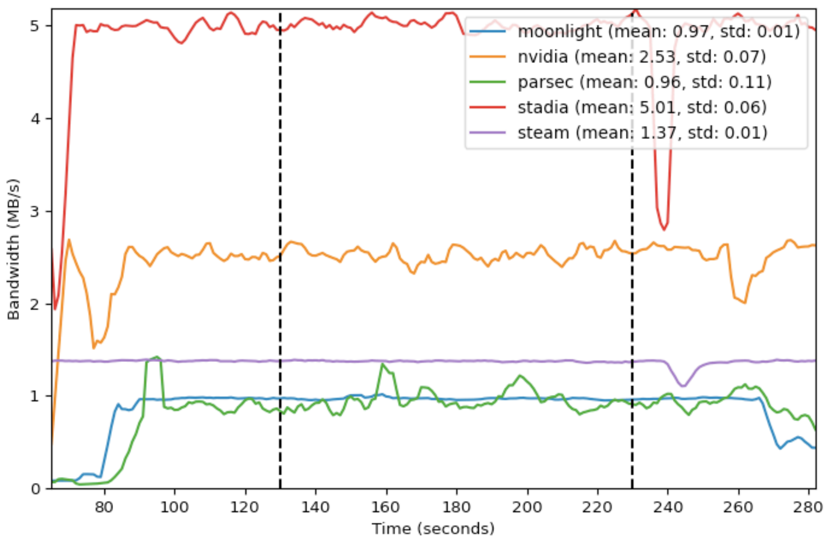


Fig. 9: Bandwidth usage over time (10 seconds moving average)

As can be seen on the diagram, bandwidth usage differs significantly for different services, both those that provide hardware and those hosted on the user's machine. It is worth noting that both Google Stadia and GeForce NOW had the same latency, so the used bandwidth difference is not because of the difference in latency to the server.

Moonlight was the service that used the least amount of bandwidth. During the gameplay, it was not able to provide frame rate higher than 30 frames per second, which is less than ideal. As can be seen on the graph, Parsec used the same amount of bandwidth while having much greater changes in bandwidth usage over the course of play – this might suggest that the algorithm used in Parsec is more complex than in Moonlight.

Both GeForce NOW and Google Stadia also were actively varying bandwidth usage, similar to Parsec, while Steam Remote Play was similar to Moonlight in behavior, albeit having higher bandwidth usage at around 1,4 MB/s.

Out of free services, Parsec subjectively performed the best, providing the lowest input delay during gameplay while also having the highest quality of the picture. Exploring the behavior of these three services further, in Fig. 10 it can be seen that even on a smaller scale the traffic usage stays essentially the same, which in turn could be the cause of worse performance than Parsec, while Parsec was changing bandwidth slightly with high frequency.

At 2,5 MB/s GeForce NOW provided slightly worse picture quality than Google Stadia, which used twice as much bandwidth. However, it has been observed that GeForce NOW adaptation algorithm makes the best effort to provide the lowest possible input delay, sometimes at the sacrifice of picture quality.

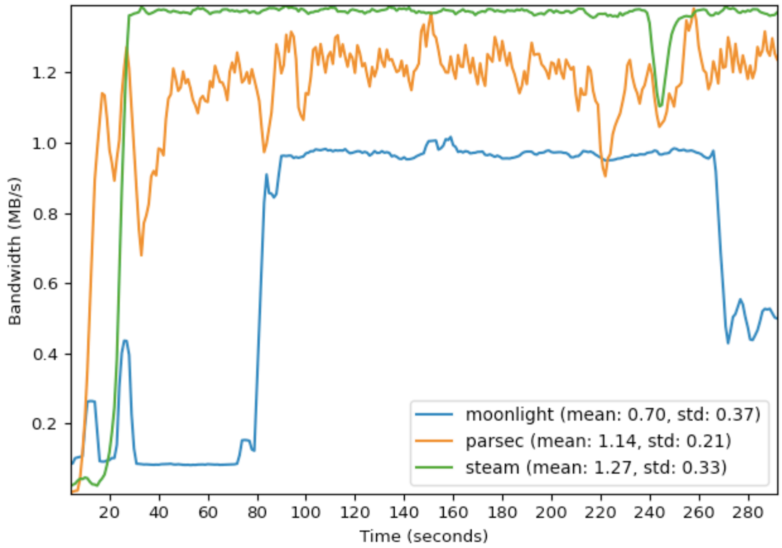


Fig. 10: Moonlight, Parsec, and Steam adaptation patterns (5 seconds moving average)

Out of the two services, one of which is free and the other one is paid, Parsec and GeForce NOW were chosen as the most performant and feature-rich. Between the two, GeForce NOW had a lower frequency of bandwidth change over time compared to Parsec (Fig. 11) while using twice as much bandwidth.

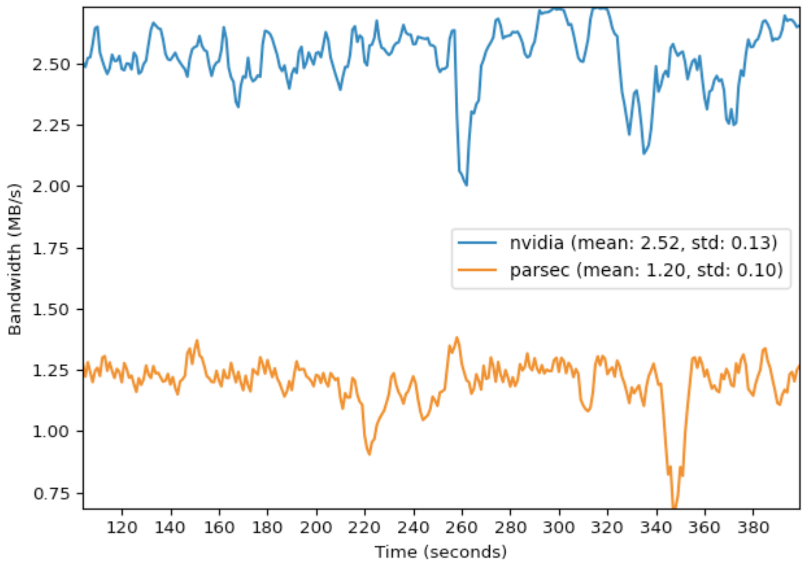


Fig. 11: GeForce NOW and Parsec adaptation patterns (5 seconds moving average)

Using captured traffic, IP-addresses of services' servers were acquired and were used to get network latency and geographic location of the servers (Tab. 2). The latency and the distance were calculated relative to Osnabrück.

Service	**IP address**	**Location**	**Latency**	**Distance to server**
Steam *(to proxy)*	162.254.198.40	Stockholm (SE)	32,8 ms	1,200 km
Steam *(from proxy)*	109.172.104.29	Tver (RU)	27,5 ms	1,200 km
Parsec	109.172.104.29	Tver (RU)	64,1 ms	2,300 km
Moonlight				
GeForce NOW	185.136.69.229	Frankfurt a.M. (DE)	17,5 ms	280 km
Google Stadia	136.115.69.234	Amstelveen (NL)	19,7 ms	250 km

Tab. 2: Server locations and network latency to them (relative to Osnabrück)

Fig. 12 shows latencies between various services relative to the client machine in Osnabrück connected over 5GHz Wi-Fi connection. As can be seen, paid services that provide hardware have much lower latency since the servers are located much closer to the client machine. In practice, this affects input delay, because input delay physically cannot be lower than network latency. Even though numerically input delay is three times more, subjectively it is perceived as being less and acceptable, even though it feels lower in comparison to paid services.

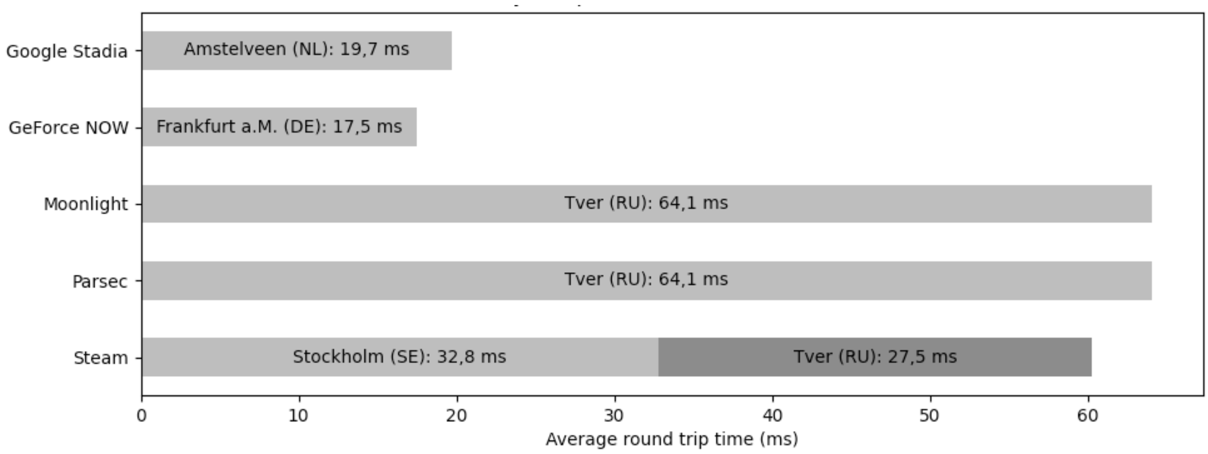


Fig. 12: Latency comparison (relative to Osnabrück)

6. Summary and outlook

In this work, a survey of currently available cloud gaming solutions is conducted, through the review of service evolution history over the last ten years and describing the main strengths and weaknesses of major cloud gaming services. Additionally – in the first part of this work – an overview of previous works in the field was done to bring to light the main problems researchers encounter during the period of cloud game streaming technology development. Compared to previously done research, this work attempts to systemize currently available services by specifying a set of criteria to compare them objectively by the features they provide to the users (Tab. 1). To test the adaptive capabilities of technologies their traffic was captured with a traffic analyzer software, which gave insights into the complexity of algorithms of each game streaming solution.

In the future, this work could be extended by providing a more sophisticated testing methodology that could use bandwidth limiting and more in-depth perception description, potentially creating a formalized way to describe observed stream quality degradation and input delay effect on user experience.

As for the future of cloud gaming technologies – as can already be seen, higher centralization becomes a new norm. By blurring the line between platforms, game publishers allow more people to enjoy games in new ways, best suitable for different kinds of people. Cloud gaming brings an opportunity for people to enjoy high-quality games without the need for buying and maintaining sometimes costly devices.

On the business side of things, a possible evolution of subscription-based models can find their continuation in so-called "pay for what you use" models similar to cloud hosting business models that already exist, such as Amazon AWS and others.

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