



**BSc (Hons) Applied Computing (Top-Up)**

# **Researching Technology**

## **Assignment 2**

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# Glossary of Terms and Abbreviations

<b>Term</b>	<b>Definition</b>
3G	Third Generation of connective/network technology
4G	Fourth Generation of connective/network technology
5G	Fifth Generation of connective/network technology
CRAAP	Currency, Relevance, Authority, Accuracy, and Purpose
PC	Personal Computer
QoS	Quality of Service
QoE	Quality of Experience
TV	TeleVision

## Abstract

With cloud gaming slowly becoming more popular then conversations discussing the potential success of this technology have been omnipresent. This sparked the idea of *'Will cloud gaming make traditional gaming obsolete in the near future?'*. To discover an appropriate conclusion then certain methodologies were employed.

Secondary research was conducted to discover all of the relevant information about cloud gaming. This includes research on current uses, benefits, drawbacks, and potential improvements. A mixture of qualitative and quantitative research was gathered to ensure that both statistical and opinion-based information was considered. Data triangulation has been used throughout this research project to ensure that each source was cross-examined. Finally, each source went through the CRAAP framework which improved the validity of the information provided.

Results found that cloud gaming provides huge benefits to consumers as it reduces the barrier of entry by providing a cheaper alternative to traditional gaming. Additionally, the overall accessibility of the technology ensures that more people can access previously platform-locked games. The drawbacks of cloud gaming suggest that the current network infrastructures found throughout the world aren't robust enough yet. A reliable and powerful internet connection is required for cloud gaming, which is currently only available in certain regions. Furthermore, the cost of services like 4G along with energy consumption could deter users from cloud gaming. The technology's future relates to improving network infrastructure, along with making cloud gaming more accessible and advertisable.

Conclusions around this topic relate to how cloud gaming could make traditional gaming obsolete as long as the appropriate improvements are made. The reason for this follows a similar story to the popularity of Netflix and other online streaming services over traditional ways of viewing media.

Future research needs to be conducted around the effects cloud gaming services have on current traditional game companies. If cloud gaming does overtake traditional gaming in popularity then many hardware-based companies will have to adapt or innovate, and the exact way they will do this needs to be discovered. Additionally, more primary research around cloud gaming popularity, interest, and usability needs to be conducted so more statistics can be gathered from a larger sample size.

## Introduction

Research around the topic '*Will cloud gaming make traditional gaming obsolete in the near future?*' will be conducted through this report as there was a clear research gap within provided information around cloud gaming. "Cloud gaming refers to a new way to deliver computer games to users, where computationally complex games are executed on powerful cloud servers." (W.Cai et al,2016). Cloud services have been gaining in popularity over the past couple of years with platforms like Netflix and Sky Glass becoming mainstream. It was only a matter of time before the gaming industry attempted to create a streaming service. Certain gaming services like Playstation Now (2014) adapted into cloud gaming, whilst more recent services like NVIDIA GeForce Now (2020) and Xbox Cloud Gaming (2020) refined the technology before the official launch.

Whilst previous academic research has been conducted around cloud gaming, there is a lack of information about if cloud gaming has the potential to make hardware-based gaming obsolete. To achieve a relevant conclusion then current statistics around cloud gaming will be analysed to discover the current impact of cloud computing and any potential drawbacks. These drawbacks will then be compared against future improvements to the technology which will lead to an appropriate answer to the research question.

## Literature Review

Di Domenico A et al. (2021) explores the current performance of multiple cloud gaming services in a network context. This source suggests that current network infrastructures impede the overall experience of cloud gaming. The information is extremely useful since it covers current issues with cloud gaming. However, there's a clear gap in the information on network infrastructures for cloud gaming and how they will improve.

Wierzbizki,M. (2021) investigates how cloud computing is currently being used by consumers along with exploring the different benefits and drawbacks of the technology. Wierzbizki,M suggests that cloud gaming will become mainstream in the coming years due to its major advantages. The information is useful as it shows the increasing popularity of cloud computing for a casual audience. There is missing information showing the statistics behind how cloud computing currently performs along with if it will become more popular.

W. Cai et al (2016) explores the current QoS and QoE for cloud gaming which provides metrics on topics like energy consumption and usability. The source suggests that as cloud gaming keeps developing then more successful programming paradigms will be created to ensure an increase in the technologies' popularity and usability. The information provided is important as understanding the different technical aspects of cloud gaming will ensure that current weaknesses have been identified. Research relating to understanding the technologies future advancements and discovering if it will become more mainstream over traditional gaming methods was missing.

Courtemanche, V... (2020) discusses how cloud gaming could potentially provide an alternate way to interact with games without hardware limitations, whilst also covering the current technical limitations that reduce the technology from becoming mainstream. The source suggests that a balance between network latency and quality needs to be met to ensure that cloud gaming is viable. The statistics and graphs around latency provide useful information as it allows conclusions around limitations to be addressed. However, there is a gap in where the technology will go along with the likelihood of the technology being on par or surpassing traditional gaming.

Jha G. (2021) investigates the current audience of cloud gaming along with its potential to reach a larger audience. The source suggests that the idea of cloud gaming intrigues all genders and ages but current technical architectural limitations reduce its current reach. This information is useful as it provides clear evidence towards the potential popularity of cloud gaming. However, there is a gap in research around how the technology will address these current issues, along with if improvements will lead to it going mainstream.

The research project aims to fill in the potential gaps identified in the current literature reviewed. Using all of these sources and combining the provided information will ensure that appropriate conclusions around the current issues, future improvements, and overall potential of cloud gaming will be found. Doing so will remove all of the current research gaps and allow the main question to be answered.

## Main Body

Cloud gaming as a concept has been around since around 2010 when it was clear that many services were converting to an always online and accessible approach. The first ever commercially available cloud gaming service was PlayStation Now (2014), which allowed users to download multiple different games for an optional subscription. This service developed the foundation for a cloud gaming platform since the basis of a subscription-based model to access a library of games is required for cloud gaming. The premise of PlayStation Now (2014) was to allow PlayStation users to sign up for a subscription-based service to unlock free digital games every month.

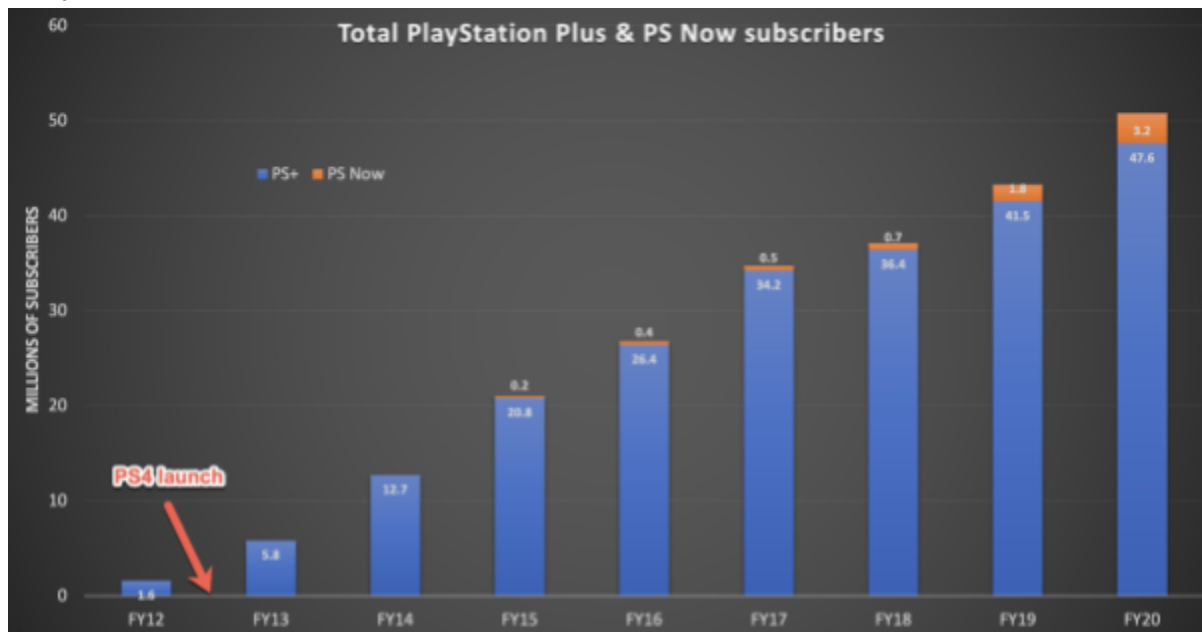


Figure 1, An image showing the total subscribers for Playstation Plus and PS Now (Ahmad D,2021)

Figure 1 shows statistics around Playstation-based subscription models. As you can see, PS Now started in 2014 and slowly started to grow in popularity each year as more people started to see the value in getting several free games every month. In 2015 the subscription count was around 200,000 then in 2020 the number of members grew all the way to 3.2 million. Figure 1 clearly shows a linear increase which further proves that the popularity of subscription-based services is increasing. This technology acted as the foundation for other companies to build upon.

The biggest innovators for cloud gaming were Xbox Cloud Gaming (2020) and NVIDIA GeForce Now (2020) since they took the subscription model that PS Now (2014) popularised and implemented into a streaming service. The Xbox Game Pass (2017) service was introduced in 2017 and allowed users to pay a monthly subscription to access around 100+ digital games. In 2020, Xbox Cloud Gaming was released and was added to the Ultimate package of Game Pass. This was a huge step for cloud gaming as Game Pass became a mainstream subscription service for both casual and hardcore gamers.



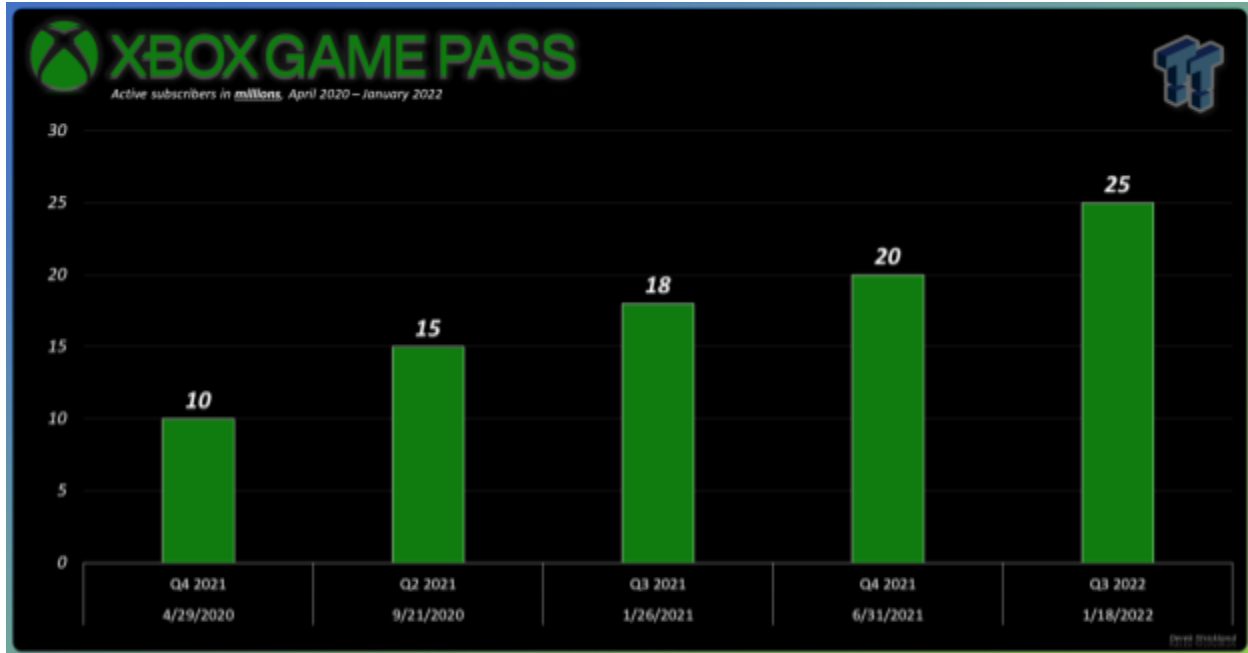


Figure 2, An image showing the active subscribers for Xbox Game Pass (Strickland D,2022)

Figure 2 shows how many people would have been exposed to Xbox Cloud Gaming throughout 2021-2022. As Game Pass grew and became mainstream, so did Cloud Gaming as it was included within the service. The trend of Figure 2 is a linear increase which further proves that the popularity of the technology is increasing. However, this trend is shallower when compared to Figure 1.

Due to the rise in popularity of streaming services (as seen in Figures 1 and 2) it's evident to see that Cloud Gaming is only growing in popularity with both graphs showing a linear increase. Additionally, there were zero drops in both of the graphs presented which further improves the validity of cloud gaming increasing in popularity. Wierzbitzki, M. (2021) also states that:

*“The next few years will need to prove that consumers are willing to see cloud gaming as more than just a value add for their existing gaming platforms.”* (Wierzbitzki, M. 2021)

This quote suggests that for Cloud Gaming to become mainstream then the product must be able to not only provide value for core gamers but also attract casual and non-gamers as well. This means that the service must bring something new for current gamers with owned hardware, whilst simultaneously allowing non-gamers to try the technology for a reasonable price. This is why a subscription model is used since the user has access to hundreds of games for a low price. Streamable services can also be accessed on a wide range of already existing devices, and this will drive all types of people to try Cloud Gaming. This is exactly what Xbox Game Pass has been doing, especially since recently they have collaborated with Samsung to bring the Cloud Gaming service to smart TVs. Not only this but the Xbox mobile app allows users subscribed to the service to play Xbox Game Pass games from their phone.

Figure 3 clearly shows that consumers expect a large game selection and reasonable pricing over other factors like performance and accessibility. This is why a subscription-based system like Game Pass is one of the best ways to convince users to try Cloud Gaming.

Another source further complimenting cloud gaming's current growth whilst also providing evidence for the technology's current uses is the article by Jha G. (2021). The research conducted had 77 respondents participate in a questionnaire on the topic of Cloud vs Traditional gaming. Jha G states that:

What are the most important subscription criteria for cloud-gaming platforms?  
(n = 159)

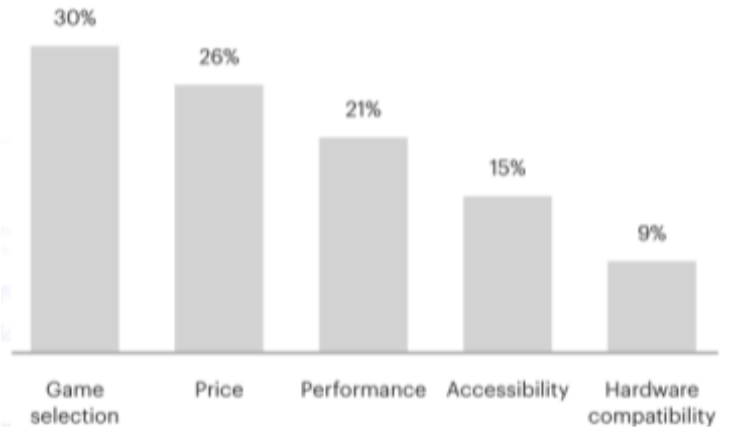


Figure 3, cloud gaming subscription criteria (Wierzbicki, M. 2021)

*“41.6% had no idea about it previously while 20.8% had heard of it but there was no other info available”*

*“59.7% of the people said that they would like to try it out while the rest i.e. 40.3% were not interested” (Jha G. 2021)*

These statistics clearly show that the technology isn't currently mainstream due to the fact that over 60% of the participants didn't exactly know what Cloud Gaming is. The end of the questionnaire also asked if the participants are interested in using the technology, to which just under 60% said yes. These numbers only further prove that the popularity of Cloud Gaming is growing since almost the exact same amount of people that didn't understand the technology also wanted to try it out.

Whilst the increasing popularity of Cloud Gaming has already been covered, there are other positives that the technology brings that need to be discussed. As mentioned before, the main driving factor for Cloud Gaming is how cheap the services are for the amount of content you get. NVIDIA's GeForce Now costs £8.99 a month to access their Cloud Gaming services, which allows users to play their owned games through streaming. Xbox Game Pass on the other hand charges £10.99 a month for their Cloud Gaming Service and additional access to a library containing hundreds of digital games. This adds huge incentives for people to try out the service since users will be able to stream all of the games included in the library.

All of the listed prices are relatively cheap when compared to traditional ways of accessing video games since the user no longer has to buy hardware to access all of the titles they want. This is because Cloud Gaming is a fully digital and streamable service that only requires stable internet access and a compatible device to access. According to Courtemanche V one of the major advantages of cloud gaming is:

*“...it allows people to play higher quality games without spending hundreds or thousands of dollars on an expensive gaming PC that may be obsolete in a few years”.* (Courtemanche V, Desveaux A. 2020)

This quote states that traditional gaming has a massive disadvantage when it comes to the barrier of entry since the user has to spend a lot of money to get access to the platform that the games are located on. Most high-quality games are on platforms like PlayStation, Xbox, and PC. Prior to Cloud Gaming, the only way to access these games was by physically buying one of their consoles and then buying the game. A typical console will set the user back by £450, whilst a gaming PC will cost over £1000 for all of the required hardware and input devices. These are expensive products considering gaming is classified as an entertainment medium. Cloud Gaming not only provides a cheap alternative for current gamers but also allows the more casual audience to access hundreds of games without the hassle of buying and setting up previously required hardware.

Whilst being fully digital and streamable is a benefit in itself, it also provides an additional benefit to Cloud Gaming services as a whole. As previously mentioned, traditional gaming requires the users to be on a specific platform to access specific games. This not only creates an ecosystem that purposely locks communities out from one another but it also turns users away from gaming since choosing a specific platform can be daunting. Cloud Gaming allows users to access platform-specific games on devices that they already own. Services like GeForce Now and Game Pass allow users to access their services on multiple different devices like mobile phones, laptops, and smart TVs. This allows users of all backgrounds to try Cloud Gaming and potentially become casual/core gamers just by streaming their games.

Whilst there are a ton of benefits that come with Cloud Gaming, there are also a lot of drawbacks that are hindering the technology's ability to become mainstream. One of the biggest drawbacks relates to network infrastructure and latency issues since streaming anything heavily relies on a constant internet connection. The quote provided by W. Cai et al (2016) explains that:

*“It is observed that some gamers can perceive < 40 ms response delay, and half of the gamers cannot tolerate  $\geq 100$  ms response delay.”* (W. Cai et al 2016)

This quote states that most users require under 100 ms of latency for a game to be considered responsive. Evidence from Figure 3 shows that most users prefer pricing and game library over performance when it comes to cloud gaming, so the performance doesn't need to be flawless for the service to be considered successful. This being said the service must still be able to provide a high-quality viewing experience whilst also ensuring that latency is low.

Figure 4 shows the requirements needed for a cloud gaming service to be perceived as usable. Most users will be satisfied with 720p for their resolution as the overall performance of the service is more important than the quality. Especially when considering that most cloud gaming streaming done through data will be on a mobile device. When considering the previous quote provided by W. Cai et al anything above a bad 3G connection should provide users with an acceptable experience. However, there are several cases throughout the graph where better network infrastructure still provides unfeasible results. This is a

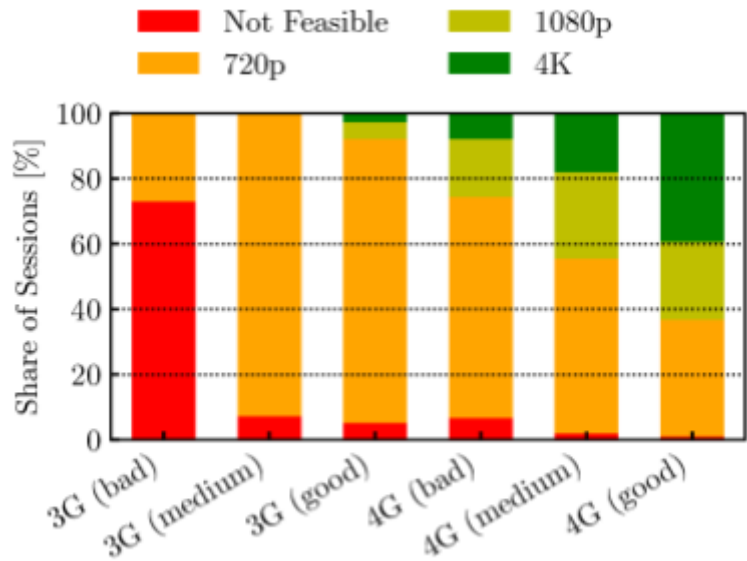


Figure 4. Estimated resolution of Stadia sessions on mobile networks (Di Domenico A et al. 2021)

huge drawback since an unreliable connection will lead to latency and a decrease in overall performance. Factors like this will deter people from using cloud services since if the performance isn't continuous then several users will see it as being intolerable. Cloud services heavily rely on existing network infrastructure, which if not implemented correctly will render the services unusable. Additional factors relate to data cost and how using network infrastructures like 3G/4G requires the user to pay for this service. Cloud gaming requires a high amount of data, so streaming on data will not be viable for some of the users.

Energy consumption is another major drawback that can deter users. Energy consumption relates to the amount of electricity consumed from playing the game on whatever device/service. Cloud gaming works by having a constant connection between the user and the server. This process causes an increase in energy consumption when compared to traditional gaming. According to an online article:

*“using a console for cloud gaming used 156% more energy than local gaming.”*  
(Kypreos, E. 2022)

Cloud gaming can initially be considered a cheap alternative to traditional gaming, however, the user will typically have to pay 50% or more on energy bills. On the other hand, using cloud gaming on mobile devices tends to “save between 12% and 38% of energy use, depending on the types of games and tablets.”(W. Cai et al 2016). This quote does counter the previous findings but it's limited to mobile device battery life. Overall, the energy consumption caused by cloud gaming will increase the user's energy bills which will decrease the appeal of the technology.

Another concern when it comes to cloud gaming relates to an industry-wide issue surrounding digital property. When a user pays for a subscription service, they never actually have ownership of any of the games, which could deter people away from cloud gaming. According to Klaris, E:

*“Accurately and fairly tracking the rights to intellectual property is one of the primary legal challenges of the entertainment media industry in the age of internet streaming services.”* (Klaris, E. 2020)

Since many of the games included in cloud gaming services are owned by other publishers, they have the right to withdraw access to cloud users at any time. A 3rd party publisher will sign a contract with a streaming service to allow their game to be a part of their library. The issue with this system is once that contract is up then the game has to be removed. This results in all of the subscribed players losing access to this title. Losing popular titles from the service will bring outrage, resulting in many people cancelling their subscriptions in retaliation.

Now that the benefits and drawbacks of cloud gaming have been discussed, future improvements can be discovered to further improve the technologies likelihood of success. When discussing the main drawbacks of the technology then the main issues are related to network infrastructure and latency issues with current cloud gaming services. According to Srivastava, S:

*“There are still significant irregularity in internet connection, even in developed countries. Cloud Gaming services are very greedy and will need some changes before this service is available and operational everywhere and for everyone.”*  
(Srivastava, S. 2023)

As countries develop their current network infrastructures to better ones like 5G this will allow cloud gaming to become more reliable and accessible. Whilst the appeal of cloud gaming relates to how cheap it compares to traditional hardware initially, the costs of the monthly subscription on top of things like energy bills and data consumption will build up. When network infrastructures become more mainstream and accessible then the overall costs will decrease. Not only this but current cloud gaming infrastructures attempt to adjust to their environment to ensure that the user experience is held to a high standard.

Figure 5 shows this adaptation in practice, as the streamed game would adjust the quality level depending on the current network quality. This means that cloud gaming already currently attempts to maintain a stable connection by adjusting the quality of the game. This will improve the overall user experience since the performance of cloud gaming is more important than the graphics.

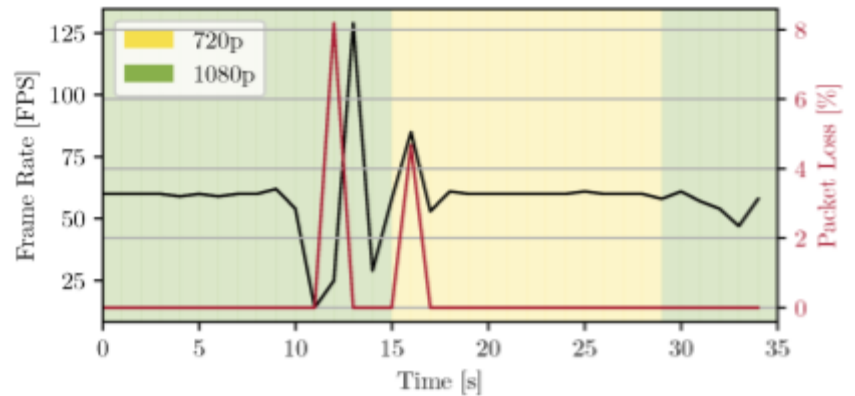


Figure 5, Example of quality-level reduction in Stadia, in terms of frame rate and video resolution subsequent to packet losses (Di Domenico A et al. 2021)

As network infrastructures technology seen in figure 5 improves then this will lead to a more adaptive and dynamic gaming experience through the cloud. Technology like 5G is already getting implemented within more cities and countries which cloud gaming will be able to piggyback off. Figure 6 shows the current 5G coverage map worldwide:

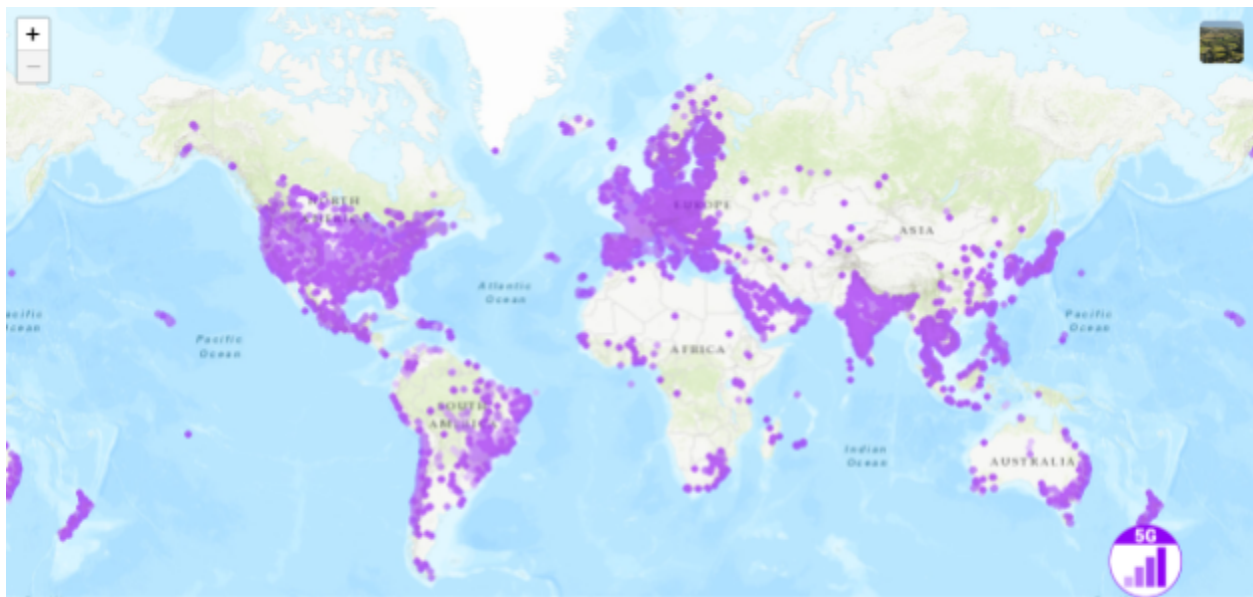


Figure 6, a worldwide map showing all of the current areas covered by a 5G network (nperf. 2023)

The more accessible 5G becomes, the more people can access cloud gaming with a consistent enough internet connection. These future improvements will not only improve the current network infrastructure but will also reduce network issues like latency and packet loss. Additionally, the more accessible a technology becomes the cheaper it gets which will result in reduced data costs.

Another future improvement relates to ensuring cloud gaming is accessible on as many devices as possible. Luckily the technology operates fully through the internet which means that very few hardware resources. Mettavant, E explains that:

*“Cloud gaming lets you play a game through any device with Internet connectivity; it reduces the need for technical hardware, as it’s the server that does all the heavy processing”*(Mettavant, E. 2018)

Cloud gaming isn’t on every device yet because companies are refusing to allow services onto them. It’s currently difficult to distribute these services onto all devices since companies see this as competitors taking advantage of them. For cloud gaming to improve and become more accessible for everyone then companies like NVIDIA, Microsoft, and Sony need to coexist in the same ecosystem. Recent events relating to the \$68.7 billion buyout between Microsoft and Activision Blizzard have led to signed agreements between competitors. A tweet from the vice chair and president of Microsoft states:

*“With today’s agreements with NVIDIA and Nintendo, we will bring Call of Duty to 150 million new devices. That will serve consumers AND advance competition.”*(Smith, B. 2023)

This agreement ensures that all of the games Microsoft has ownership of (including Call of Duty when the buyout goes through) will be accessible on competitors' platforms. The best way to deliver on this promise is by allowing cloud gaming services onto every platform. This future improvement will benefit the consumers as there will be more options on more devices. This creates healthy competition which will lead to further innovation.

Additional future improvements relate to increasing awareness of cloud gaming. Previously discussed secondary research found that over 60% of participants didn’t understand what the technology was or what it had to offer. Having more advertisements on cloud gaming will make more people aware of the technology which will create conversation and drive people to try out the services. The popularity of this technology has already been expected to grow exponentially as can be seen in Figure 7:

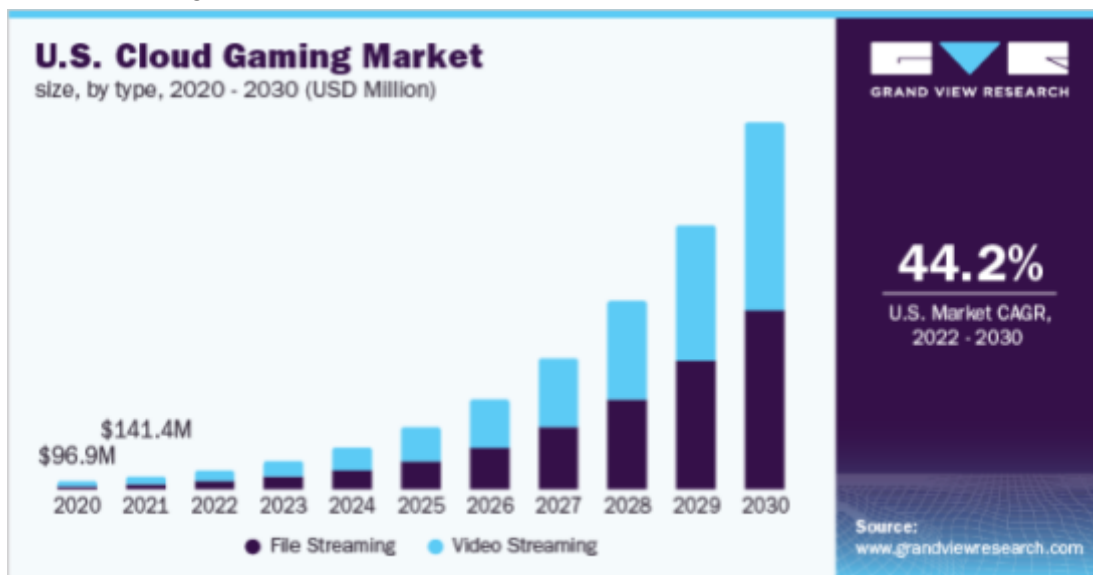


Figure 7, Cloud gaming market trends forecast (grandviewresearch.2020)

Figure 7 shows that the expected forecast for cloud gaming will reach \$20.94 billion by 2030 with an annual growth rate of 45.8% per year. By improving the marketing and awareness of cloud gaming then this forecast will end up becoming a reality since current examples clearly show how impactful cloud gaming can be for consumers and companies.

This research project aimed to discover if “Cloud gaming will make traditional gaming obsolete in the near future?”. The evidence collected leads to a possibility of this being the case, especially when viewing the evidence found in Figure 7. Cloud gaming has an estimated annual growth rate of 45.8% per year which only proves how popular this technology will become. When comparing this forecast with current active subscribers to cloud gaming platforms (as seen in Figures 1 and 2), then the common relationship between them all is the overall increase in popularity as the years go on.

The reason why cloud gaming has such potential relates to the key benefits that were found throughout this research project. Cloud gaming offers users a unique gaming experience that is affordable and fully digital without the need for additional hardware. Since most cloud gaming services are monthly subscriptions that are less than £10 then this is easier to justify when comparing against the £400-1000 required in current hardware. Cloud gaming is also fully digital which means that no downloads are required for games. Additionally, performance and quality are also improved from the lack of hardware. Finally, another huge benefit relates to how cloud computing is already accessible on multiple different devices such as mobile phones, tablets, laptops, and smart TVs.

For cloud gaming to reach the predicted market value seen in Figure 7 then current drawbacks need to be addressed. The biggest issue relates to the current network infrastructure and the problems that are associated with it. Cloud gaming is fully digitally streamed which requires a stable internet connection to function properly. For the performance and quality of the service to be acceptable then a good 4G or above connection is required. This means some areas in the world don't have access to cloud gaming based on the lack of suitable network infrastructure. Additionally, latency and data costs are directly related to network infrastructure which directly affects people with the needed requirements. High energy consumption on certain devices along with certain legal issues around digital property also provide a hindrance to the technology's success. Efforts are already being made to improve and address certain issues. For example, network infrastructure around the world is improving to provide 5G in more areas. This will not only improve the overall performance of cloud gaming but will also reduce data costs and latency issues. Further improvements in energy consumption and digital property need to be addressed before the technology reaches its true potential.

With the research concluded then it's safe to assume that cloud gaming will be a popular way to access the gaming entertainment medium. Additionally, the potential for the technology to render traditional gaming obsolete will be highly likely as long as the drawbacks are appropriately addressed. The benefits that cloud gaming introduces already improve the issues found in traditional gaming, and with improvements already being made to the network infrastructure then most of the drawbacks will be negated or reduced.



## Summary

This research paper aimed to discover if “Cloud gaming will make traditional gaming obsolete in the near future?”. To achieve this then current information about the benefits and drawbacks of technology needed to be gathered.

The main benefits of cloud gaming relate to affordability and accessibility. This is because it's monthly subscription-based and is typically accessed on already-owned devices. The games are directly streamed to the user's device over the internet which reduces the need for powerful hardware. The streaming side of cloud gaming is also its main drawback as poor network infrastructure heavily reduces the technologies performance. Additional issues like energy consumption and digital property legal were also discovered. For cloud gaming to reach its full potential then these drawbacks need to be addressed. Current improvements around network infrastructure will heavily reduce issues like latency and data costs. More solutions around energy consumption and legality in digital property also need to be addressed though. If all these issues are addressed then cloud gaming has the potential to render traditional gaming obsolete. Especially since the current benefits are already a huge incentive for a user to completely switch.

A weakness of this report relates to how no primary research was conducted. This was due to the lack of technology to appropriately test certain elements like latency and network infrastructure that link to cloud gaming. More time would have also needed to be allocated to compensate for the additional research required, which would have prolonged the deadline further. Additional research around certain secondary sources also provides weakness. Some of the quantitative research provided only used a small sample size of around 77 respondents to discover statistics on cloud gaming's current popularity. This small sample size doesn't provide enough evidence to sufficiently build a conclusion.

Further research needs to be conducted on cloud gaming from the public's perception. This research will need a large sample size to ensure that enough data is collected from as many unique people as possible. Doing so will provide factual statistics around topics like popularity, interest, and usability. More information around latency, power consumption, and legal issues would also improve future research so appropriate improvements can be identified for these current drawbacks of cloud gaming.

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