



# Defining crucial factors of cloud gaming services and how gamers value them

Maximilian Alfred Höfer

Dissertation written under the supervision of Professor André Pinho

Dissertation submitted in partial fulfilment of requirements for the MSc in Management,  
at the Universidade Católica Portuguesa, 2022.



## **Abstract**

**Title:** Defining the crucial factors for successful cloud gaming and how gamers value them

**Author:** Maximilian Alfred Höfer

In recent years, the gaming market experienced the addition of a new platform for users to play on. Cloud Gaming Services are rivaling PC hardware and console manufacturers. Big players like Google, Microsoft, NVIDIA, and Amazon entered the market and now compete for market share.

This thesis aims to find the most relevant parameters responsible for the success of cloud gaming, and subsequently analyze how gamers value these parameters. Current research about the gaming industry and cloud services in the form of secondary data was used as a foundation to find the most relevant and challenging factors for service providers. In addition, primary data in the form of a consumer survey was collected to analyze the perception of gamers on the topic.

The analysis showed that the most important parameters could be grouped into two categories: performance-related and service structure. Hardcore gamers focus more on performance-related issues compared to casual gamers. The amount consumers are willing to spend is not dependent on income but on the service's offerings.

**Keywords:** Gaming Industry, Cloud Gaming, Gaming as a Service, Disruptive Technology, Global Gaming Market, Cloud Computing

## **Sumario**

Título: Definindo os factores cruciais para o sucesso dos jogos em nuvem e a forma como os jogadores os valorizam

Autor: Maximilian Alfred Höfer

Nos últimos anos, novas plataformas para onde os usuários podem jogar, foram adicionadas ao mercado do gaming. Cloud Gaming Services oferecem concorrência a hardware de PC e a fabricantes de consolas. Grandes empresas como a Google, Microsoft, NVIDIA e Amazon entraram no mercado com capacidade de competir.

Esta tese visa encontrar os parâmetros mais relevantes responsáveis pelo sucesso dos jogos na nuvem, e subsequentemente analisar como os jogadores valorizam estes parâmetros. A investigação actual sobre a indústria de jogos e serviços em nuvem sob a forma de dados secundários foi utilizada como base para encontrar os factores mais relevantes e desafiantes para os prestadores de serviços. Além disso, foram recolhidos dados primários sob a forma de um inquérito aos consumidores para analisar a percepção dos jogadores sobre o tema.

A análise mostrou que os parâmetros mais importantes podiam ser agrupados em duas categorias: relacionados com o desempenho e a estrutura dos serviços. Os jogadores hardcore concentram-se mais em questões relacionadas com o desempenho em comparação com os jogadores casuais. A quantidade que os consumidores estão dispostos a gastar não depende dos rendimentos, mas das ofertas do serviço.

Keywords: Gaming Industry, Cloud Gaming, Gaming as a Service, Disruptive Technology, Global Gaming Market, Cloud Computing

## **Acknowledgement**

First, I would like to thank my supervisor André Pinho for his support and guidance during the time of writing. In times where work was demanding all of my time, André Pinho supported me with finding and fine tuning the topic of my thesis. His patience was invaluable and helped me reach the end of my academic career.

Secondly, I would like to express my gratitude to my parents, sisters and grandparents. I thank my parents, Gerda and Magnus, for always supporting me and not giving up on me. I thank my sisters, Laura and Maya, that helped regain motivation and reach my goals. Lastly, I thank my wonderful grandparents, Chake and Alfred. I am immensely grateful for all the support and love I received from you during this time.

Vienna, 2022

Maximilian Alfred Höfer

# Table of Contents

- ABSTRACT .....3**
- SUMARIO.....4**
- ACKNOWLEDGEMENT .....5**
- 1 INTRODUCTION .....9**
  - 1.1 RESEARCH QUESTIONS .....9
- 2 LITERATURE REVIEW .....11**
  - 2.1 VIDEO GAME INDUSTRY .....11
  - 2.2 CONSOLE VIDEO GAME MARKET .....12
  - 2.3 CASUAL & hardcore GAMERS.....13
    - 2.3.1 *Hardcore Gamers* .....13
    - 2.3.2 *Casual Gamers* .....14
  - 2.4 TYPES OF GAMES.....14
    - 2.4.1 *Casual Games* .....14
    - 2.4.2 *Hardcore Games* .....15
  - 2.5 DIGITAL GAME DISTRIBUTION .....16
  - 2.6 CLOUD COMPUTING.....17
  - 2.7 CLOUD GAMING.....17
    - 2.7.1 *Advantages* .....18
    - 2.7.2 *Challenges*.....20
    - 2.7.3 *Early cloud gaming platforms* .....22
- 3 METHODOLOGY .....23**
  - 3.1 RESEARCH STRUCTURE .....23
  - 3.2 DATA COLLECTION .....23
    - 3.2.1 *Secondary* .....24
    - 3.2.2 *Primary* .....24

<b>4</b>	<b>ANALYSIS .....</b>	<b>25</b>
4.1	CLOUD GAMING PLATFORMS .....	25
4.1.1	<i>Google Stadia</i> .....	25
4.1.2	<i>NVIDIA GeForce NOW</i> .....	29
4.1.3	<i>Boosteroid</i> .....	33
<b>5</b>	<b>HYPOTHESES PREPARATION .....</b>	<b>36</b>
<b>6</b>	<b>FINDINGS .....</b>	<b>38</b>
6.1	QUALITATIVE CUSTOMER SURVEY .....	38
6.1.1	<i>Survey Design</i> .....	38
6.1.2	<i>Sample composition</i> .....	38
6.1.3	<i>General findings</i> .....	38
6.1.4	<i>Perception of Cloud Gaming</i> .....	39
6.1.5	<i>Hypothesis validation</i> .....	39
6.2	BENCHMARK .....	42
6.2.1	<i>Hardcore gamers</i> .....	43
6.2.2	<i>Differences based on income</i> .....	44
6.2.3	<i>Age groups</i> .....	45
6.2.4	<i>Cost of PC</i> .....	46
<b>7</b>	<b>CONCLUSION .....</b>	<b>47</b>
7.1	POTENTIAL FOR FUTURE RESEARCH AND LIMITATIONS.....	48
	<b>REFERENCE LIST .....</b>	<b>49</b>
	<b>APPENDIX: .....</b>	<b>55</b>
	QUESTIONNAIRE: .....	55

**Figure 1 Number of active video gamers worldwide – 2015-2023..... 11**  
**Figure 2 2021 Global Games market per device & segment ..... 12**  
**Figure 3 Cloud gaming architecture..... 18**  
**Figure 4 Command Loop..... 20**



# 1 Introduction

The video game industry has experienced a continuous incline in market size to over \$173.7bn in 2020 and is set to surpass \$300bn by 2026 (Mordor Intelligence, 2020). In addition, it is an industry with over 3.2bn gamers across all platforms (Statista, 2021).

Traditional gaming requires considerable investments in hardware like home consoles or PC components and expensive games. The current chip shortage and inflation further increase prices across the board. With new technology like cloud gaming, firms can mitigate said burdens and offer an enjoyable experience on hardware most people already own. For that matter, companies use a Software as a Service (SaaS) business model.

With some of the biggest tech companies like Microsoft, Google, and NVIDIA offering cloud gaming services, the future of gaming might lay in this technology and business model. However, as gaming is a very complex topic that includes multiple significant factors for the consumer's enjoyment, the various players pursue different business models.

For a cloud gaming service to be successful, the quality of experience must be adequate to the users' expectations. There are a multitude of factors, both on a technical and consumer side, that need to be considered.

This thesis aims first to identify the most important factors for cloud gaming to function, and second, how gamers rank those factors in terms of importance for their experience. Those factors include both technicalities that determine the performance, as well as the offering of the platform for the gamers.

## 1.1 Research questions

RQ1: What are the most critical factors for consumers of cloud gaming services?

RQ2: How do the identified factors rank amongst consumers?

## 1.2 Academic and managerial relevance

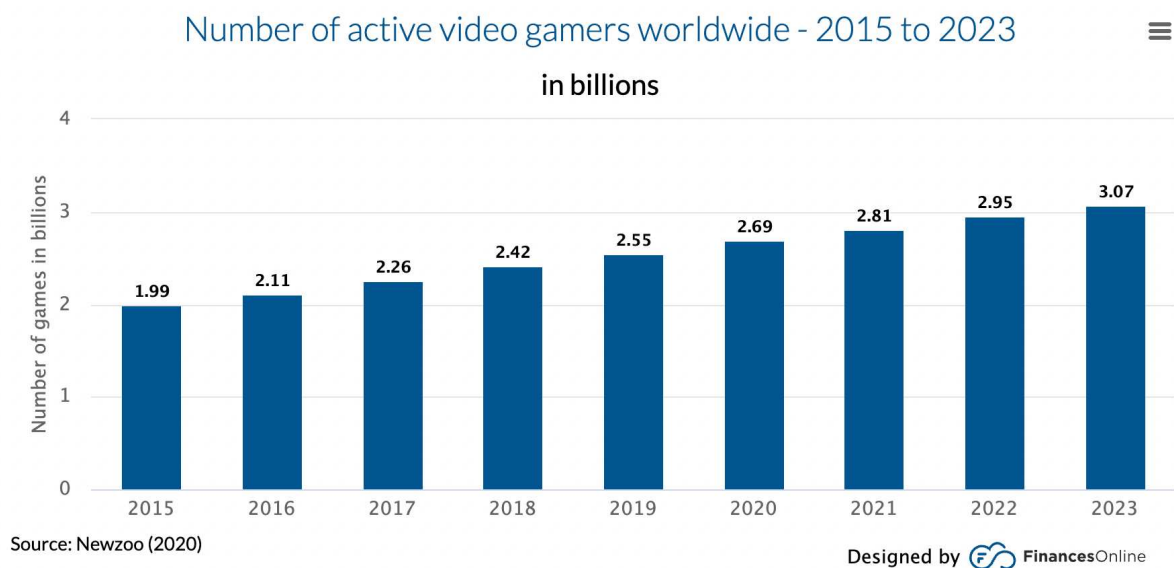
Cloud gaming services have the potential to disrupt the video game industry. A multitude of different factors play a significant role in their success. Assessing the most important factors is an important step in understanding the complexity of cloud gaming, and gaming as

a whole. Academic papers are mostly concerned with technical factors. The consumer side is underrepresented. This thesis provides insights into the consumer's feelings. Knowing how real users rate and value the different characteristics of such services might help craft better business models for cloud gaming providers.

## 2 Literature Review

### 2.1 Video Game Industry

The video game industry has experienced a continuous incline in market size to over \$173.7bn in 2020 and is set to surpass \$300bn by 2026 (Mordor Intelligence, 2020). The segment is expected to grow with a CAGR of 8.94% from 2022-2027 (Mordor Intelligence, 2020). The increasing number of gamers justifies the growth. The COVID-19 pandemic boosted the player count to 2.81 billion in 2021 and is expected to surpass 3 billion active players in 2023 (Finances Online, 2020).



**Figure 1 Number of active video gamers worldwide – 2015-2023**

The industry has become increasingly attractive for large tech corporations. In 2020, Microsoft acquired ZeniMax Media, the parent company of Bethesda, for \$7.5bn (Microsoft, 2020). Bethesda is one of the biggest game publishers owning franchises like “Fallout” and “The Elder Scrolls” (Wikipedia, 2022a). Microsoft further invested in the idea by acquiring Activision Blizzard in an all-cash transaction valued at \$68.7bn in 2022 (Microsoft, 2022).

The video game market is segmented into three categories: (i) PC Gaming, (ii) Console Gaming, and (iii) Mobile Gaming (Newzoo, 2021). The traditional gaming platforms PC and console make up 20% and 28% of the global gaming market, respectively (Newzoo, 2021). The

remaining 52% are generated by mobile gaming, including mobile phones (45%) and tablets (7%) (Newzoo, 2021).

Figure 2 shows that the mobile game segment is the only segment with a positive YoY revenue change of 7.3% in 2021. Despite the release of the 9<sup>th</sup> console generation (Playstation 5 & Xbox Series X/S), the console gaming market lost 6.6% YoY. This might be due to the global chip shortage, as Next-Gen consoles have been sold out since their launch in 2020. The PC market experienced a slight decline of 0.8%.

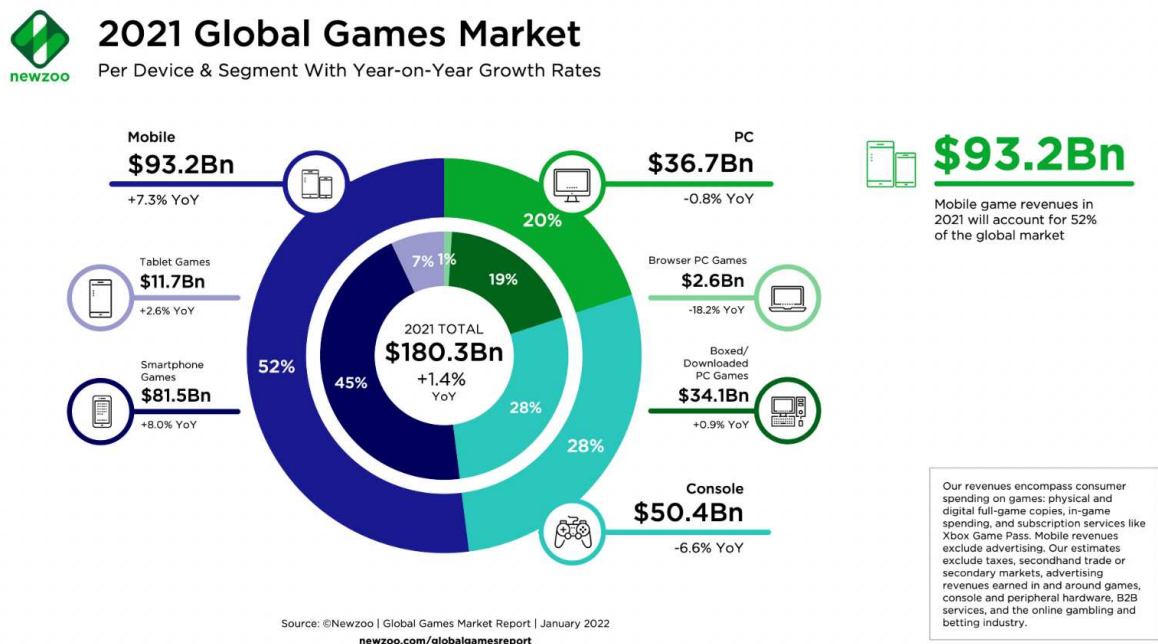


Figure 2 2021 Global Games market per device & segment

Source: Newzoo

## 2.2 Console Video Game Market

The video game console market had its inception in 1972 with the launch of the Magnavox Odyssey, marking the beginning of the 1<sup>st</sup> generation of home consoles (Baer, 2005). Since then, there have been eight subsequent generations, with generation nine being the latest introduced in 2020.

Today, Microsoft (Xbox), Sony (PlayStation), and Nintendo (Switch) are the big players in the console market. Console manufacturers mainly benefit from two main revenue streams:

hardware (consoles and peripherals like controllers and headsets) and selling games (Clayton, 2020).

Each platform is unique in its architecture, so games are not playable across different platforms (Daidj and Isckia, 2009). The resulting lack of interoperability leads to fierce competition amongst market contestants. Console manufacturers see their profit in software sales (Claro Tomaselli Fundação Getulio Vargas *et al.*, 2008). They, therefore, try to generate the most extensive customer base by offering their hardware at a shallow price point, even at a loss (Polygon, 2021).

## **2.3 Casual & Hardcore Gamers**

The segmentation of consumers is heavily dependent on the investigated market. People are generally categorized into casual and hardcore gamers in the games industry. Different parameters define each category, e.g., average playing time over a period, the average length of playing session, attitude, and time invested in game-related activities (Poels *et al.*, 2012). Additionally, the complexity of the game, money spent on consoles and games, the focus on mastering and completing a game, and the competitive aspect are highly valued (Richstad, 2015).

It is difficult to define a precise threshold for the mentioned parameters to categorize players into the correct group accurately. After reviewing other literature, it is observed that the terms hardcore and casual gamers are not used invariably. (Jacobs, 2005; Kuittinen *et al.*, 2007; Poels *et al.*, 2012; Richstad, 2015).

Factors like money spent, skillset, and preferred platform are indicators; however, the unambiguity of hours played per week is easy to use (Richstad, 2015). Three essential dimensions are considered: playing habits, buying habits, gaming knowledge, and attitudes (Jacobs, 2005).

### **2.3.1 Hardcore Gamers**

Hardcore gamers may be described as people that, on average, play more than an hour a day, purchase games, and are engaged with the community (Poels *et al.*, 2012). The type of game is also a strong indicator, as games with high complexity or a strong competitive scene are

preferred by hardcore gamers (Kuittinen *et al.*, 2007). This is because higher complexity leads to increased time investment, closing the circle to time played.

### **2.3.2 Casual Gamers**

The definition “casual gamer” is often an umbrella term and does not entail a specific persona. It refers to a „casual consumer who can pick up and play casual games easily without great effort“ (Kuittinen *et al.*, 2007). The same metrics as for the hardcore gamer can be used to assess the group of casual gamers. With the increased popularity of mobile games, it becomes more difficult to use play time as a parameter. Playing every time while commuting to work might result in an inflated amount of playtime; however, the incentive is more to pass the time and boredom instead of specifically wanting to play a game. Casual gamers, therefore, include new demographics such as “females, non-gamers, thirty/forty-somethings, and ‘lapsed’ gamers” (Eric-Jon Waugh, 2006).

## **2.4 Types of Games**

Video Games can be divided into two categories, just like gamers: casual and hardcore. To classify video games, the following metrics can be used: Genre (Action, FPS, RPG, Strategy, Racing, Puzzle, Adventure, MOBA, MMORPG, Platformer, etc.), complexity, difficulty to master, graphics, handling (controls), competitiveness, platform (PC, console, mobile), and time to completion to name a few.

### **2.4.1 Casual Games**

The idea of casual video games is not a new idea that just recently came up. Games like Solitaire or MineSweeper have been included in PCs for a long time (Cote, 2020). Casual video games serve a broad audience, including people who do not play regularly (Richstad, 2015). Generally, casual games are less intense and belong to genres like Puzzle, Racing, or Platformer. They are intended to be easy to use and enjoyable in short sessions.

A prime example would be Super Mario Bros, a traditional Platformer. Many iterations of Super Mario were released on a multitude of platforms. (Wikipedia, 2022c) Nintendo’s hardware, like the Gameboy or the Nintendo DS, are handheld consoles that were extremely popular amongst many different groups of people, and the Nintendo Wii, with over 100 million units sold. (Wikipedia, 2022b) Those devices were easy to use by almost anybody and could

bring fun for even a brief period of playtime. Super Mario was straightforward to understand, and even young children were able to beat the game.

The introduction of the Nintendo Wii (2006) further increased the appeal of casual games. With Wii Sports being a massive success (over 82 million sold copies)<sup>1</sup>, games with motion control became known to be liked amongst casual gamers. As the Wii is not known for impressive graphics, casual games tend not to feature sophisticated graphics (Richstad, 2015).

Even though handheld consoles like the Gameboy or Nintendo DS have been around for a long time, the rise of Smartphones acted as a catalyst for casual mobile games. Video games on smartphones are mostly straightforward in design, easy to pick up, and do not require a significant time investment at once. Infamous games like Candy Crush flooded the market and grossed hundreds of millions of dollars every year. (Business of Apps, 2022)

#### **2.4.2 Hardcore Games**

On the contrary, hardcore games are more ambitious in their development. Big developers and publishers follow the ideology of bigger and better, aiming to achieve better graphics and higher complexity (Richstad, 2015). Hardcore games require a deeper understanding of the mechanics, more time to complete, or have a competitive aspect. For example, Battlefield is a very successful franchise in the first-person shooter realm. It is known for intense gameplay, long matches, and outstanding graphics.

As a result, such triple-A titles are often developed by a big team of dozens of developers. Furthermore, core games have big budgets at their disposal. Grand Theft Auto V by Rockstar North cost over €200m in development, and over 1000 people were involved.(GameSpot, 2013)

Hardcore games usually involve complex mechanics that require much training to master. The MOBA Dota 2 is one of the most extreme examples. It is said to be one of the most complex games on the market and requires thousands of hours to master. According to the community, at least 1000 hours are necessary to grasp the game's basic mechanics fully. A Reddit user posted an assumption of how long it would take to reach the top 1% of players and concluded that 4845h under ideal conditions (Reddit, 2021). This varies from person to person and is not even achievable for most players due to skill.

---

<sup>1</sup> [https://de.wikipedia.org/wiki/Wii\\_Sports](https://de.wikipedia.org/wiki/Wii_Sports)

## 2.5 Digital Game Distribution

For years, buying games in retail stores was the main way customers acquired game copies. The increase in internet speed and the worldwide shift to a more digitized world led to a steep rise in digital sales (Richstad, 2015). While in 2009, 80% of games were sold in physical form, the share dropped to a mere 17% in 2018 (Statista, 2018). In addition, a digital game store can cut out the retail channel and thus create synergies by not having to produce physical copies (Ammattikorkeakoulu, 2021).

Nowadays, online game stores are the primary way users can buy digital copies. Valve's Steam store is the most prominent, with over 120 million active users and over 62 million daily active users (Finances Online, 2021). Publishers may directly sell their games on the platform, with Steam taking a 30% commission for providing its platform (PCGamer, 2021).

The popularity of steam is not only due to the ability to buy games but rather the platform built around it, organizing interactions between users (Thorhauge and Nielsen, 2021). The platform allows players to have friends lists and seamlessly play with each other, search for and distribute modded content (mods are community-made alternations of games that change the game files and deliver a different experience) (Nieborg and van der Graaf, 2008), manage their game library in one place and have small developers fund their games through Steam's early access program. These aspects, paired with regular sales where games are discounted heavily, create an ecosystem that makes it hard for people to leave.

Steam held a monopoly long before other publishers entered the market (Thorhauge and Nielsen, 2021). Besides Steam, EA's Origin and the Epic Games Store are big stores run by publishers. In these stores, the publishers mainly distribute their own games. Due to the popularity and profit potential, stores try to capitalize on steam's model by taking exclusive deals with other publishers to distribute their games solely in one place.



## 2.6 Cloud Computing

At its core, cloud computing is a collection of networks (Srivastava and Khan, 2018). It provides on-demand availability of various computational solutions and services (Montazerolghaem, Yaghmaee, and Leon-Garcia, 2020). Such services include highly complex computing capabilities and access to large amounts of storage while omitting additional hardware requirements on the client side (Radu, 2017).

By outsourcing computational power and hardware, cloud computing completely changed how companies manage and spend their IT-related resources (Garrison, Kim and Wakefield, 2012). Companies delegate various tasks to the IT service provider, “including hardware and software installation, upgrades, maintenance, backup, data storage, and security“ (Garrison, Kim and Wakefield, 2012).

Three primary services are provided by cloud computing in the form of a hierarchy: (i) Software as a Service (SaaS), (ii) Platform as a Service (PaaS), and (iii) Infrastructure as a Service (IaaS) (Srivastava and Khan, 2018). Infrastructure as a Service serves as the foundation, with Platform as a Service running on top of that and Software as a Service on top. (Tsai, Bai and Huang, 2014).

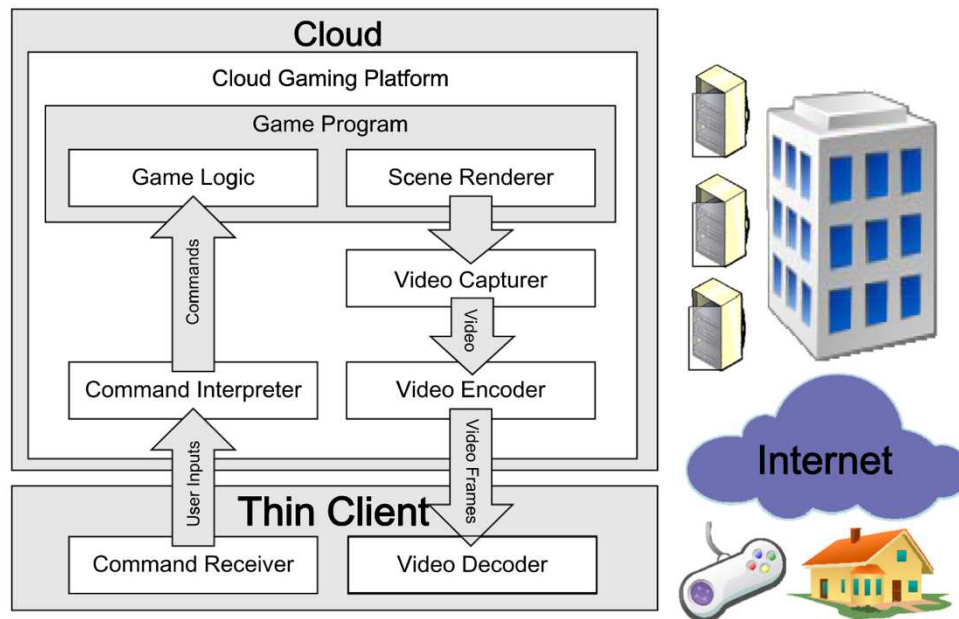
## 2.7 Cloud Gaming

Cloud gaming is a promising concept in the video game industry. It has been around for a long time. However, new technological advances made it reach a market-ready status finally. Revenue for 2021 was \$1.5bn and is expected to grow to \$6.5bn in 2024 (Newzoo, 2021).

The concept of cloud gaming is based on the on-demand offerings of cloud computing. Current computational services based in the cloud turned into an “efficient paradigm to offer computational abilities on a “pay-per-utilize” premise“ (Arunarani, Manjula and Sugumaran, 2019). Tasks required by the user are computed on machines located somewhere in a data center, and results are sent back to the client. Cloud gaming utilizes this idea. Games are executed on an external server which in turn sends the rendered frames over the internet back to the client (Cai *et al.*, 2016).

There are two primary components required to run and display video games: (i) game logic interpreting user inputs and generating in-game scenes and a (ii) scene renderer that is

responsible for converting the inputs into graphical output in the form of individual frames (Cai *et al.*, 2016). Figure 2 shows the different stages necessary for a command to be displayed on the client's display. The commands follow a straight route and start with the user input from the client. The initial command is sent to the cloud and is rendered locally. Rendered game scenes are then captured and decoded before being sent back to the client. Finally, the received video signal is decoded locally on the client's device and displayed on their screen.



**Figure 3 Cloud gaming architecture**

Source: Cai *et al.*

With the cloud gaming platform doing all the complex rendering and heavy processing, the client must no longer fulfill the requirement of owning capable gaming PCs (Laghari *et al.*, 2019). As a result, users can use almost any device with a command receiver and a video decoder, thus the name “thin client”. The only requirement left is a stable and fast enough broadband internet connection. (Cai *et al.*, 2016).

### 2.7.1 Advantages

Cloud gaming offers a multitude of possible advantages for the major stakeholders: (i) gamers, (ii) developers, and (iii) distributors.

As already discussed, the cloud model allows users to omit expensive hardware requirements and upgrading cycles (Cai *et al.*, 2016). Gaming PCs consist of several components - each vital for the gaming experience, including (i) CPU, (ii) GPU, (iii) SSD/HDD (Storage), and (iv) RAM as the most important ones. Due to the global chip shortage and scalpers buying up supplies preventing regular people from buying components, prices rose drastically in the past years. For example, NVIDIA's most capable consumer graphics card, the RTX 3080, launched in 2020 with an MSRP of \$799. Prices reached over \$2,000 just for the GPU (HowMuch.one, 2022). As a result, the required hardware to run recent AAA games became very expensive and out of reach for the average consumer. With cloud gaming only requiring a thin client, the consumer can save much money by using already owned devices. Additionally, with modern games taking up to 200GB of storage, downloading, updating, and storing games evolves to be a bigger problem for gamers (Gamestar, 2021).

Furthermore, consumers can access and play their games from anywhere as long they are connected to a suitable internet connection (Jarschel *et al.*, 2013). Even the requirement of fast internet speed can be decreased by lowering the resolution of the streamed game, as the resolution is directly proportional to data usage (Jarschel *et al.*, 2013).

Another advantage for gamers is the ability to buy or rent certain games on demand (Cai *et al.*, 2016). This option highly depends on the cloud gaming provider because it deals with publishers and licenses.

For publishers and game studios, the advantages lay in focusing on a single platform. Porting and testing costs of games can be significantly reduced as they must only be optimized to run on the cloud data centers (Cai *et al.*, 2016). Furthermore, Gaming as a Service can capitalize on the high potential of economies of scale of SaaS, as cloud computing has little to no upfront cost in infrastructure to deliver on-demand computing power (Yang and Tate, 2012).

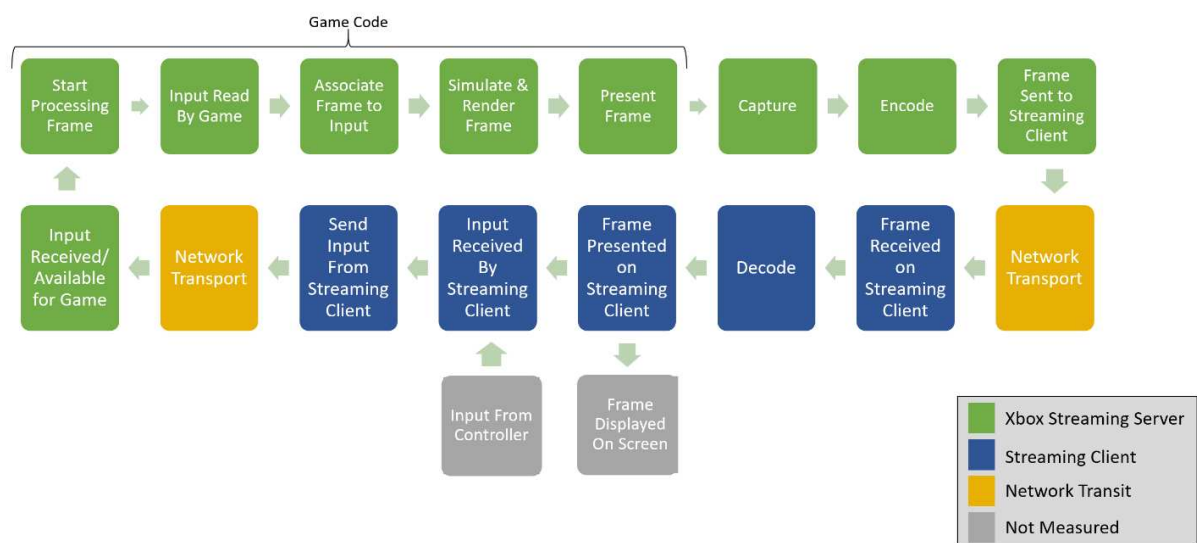
Another aspect directly derived from SaaS business models is cutting out the middleman in digital distribution. There is no need for retailers and the distribution of physical copies, significantly increasing profit margins (Cai *et al.*, 2016). A direct effect of providing games solely in the cloud would be protection from piracy. The contents of the games are not downloaded locally on a storage drive and are, therefore, impossible to distribute illegally (Ojala and Tyrvaenen, 2011).

From the perspective of cloud service providers, advantages lay in adopting new business models and drawing more consumers to already deployed cloud infrastructure (Chen *et al.*, 2017).

### 2.7.2 Challenges

Cloud gaming services face several challenges in delivering a service that meets user expectations. Factors responsible for the Quality of Experience can be categorized into (i) video settings and (ii) network conditions. Video settings include resolution, frame rate, and used codec, while network conditions are described by bandwidth, latency, and packet loss (Ladewig, Lins and Sunyaev, 2019).

Latency measures the time from the moment of user input until they are displayed on the screen (Jarschel *et al.*, 2013). In the case of cloud gaming, information has to go through different stages outside of the client system. Figure 3 shows four different areas where latency is added in the case of Xbox cloud streaming: (i) input from controller and display on screen, (ii) streaming client, (iii) network transit, and (iv) streaming server. Each stage includes different steps resulting in the total delay (Microsoft, 2021).



**Figure 4 Command Loop**

Source: Richstad

Richstad derived the following six different stages where latency is added (Richstad, 2015):

- L1: Local input latency  
User pressing a button
- L2: Connection input delivery latency  
Input from local device to server
- L3: Game latency  
The game itself executes the command
- L4: System latency  
System encodes video for output
- L5: Connection output delivery latency  
Sends the video back to the user
- L6: Local output latency  
Displays the video on screen

The cumulative sum of each step is the total time the system needs to display the player input on the screen. Each step adds a different amount of latency depending on various parameters (Richstad, 2015). With latency directly impacting the user experience, a delay over 100ms should be avoided (Jarschel *et al.*, 2013). L2 and L5 describe latency added by network conditions. Bandwidth and stability of the connection are the crucial parameters on the client side responsible for low latency communication. The server location is also essential as the physical distance information has to travel takes time. As a result, a closely located server reduces latency significantly. A high network speed is required, preferably wired, as it provides a more stable connection than WIFI (Richstad, 2015).

Packet loss occurs when the demand for a particular resource, like bandwidth, exceeds the required capacity (Sanneck and Carle, 2000). This again ties back into network speed and connection type. The problem of lost packets and therefore dropped frames that lead to a stuttering game experience can be combated with faster and more stable connections, as well on the server side, by decreasing data output, e.g., through lower resolutions or lower framerates. A 720p video stream requires 11Mbit/s while a 4K stream quadruples that amount to 44 Mbit/s (di Domenico *et al.*, 2021).

Such low network requirements can only be achieved through compression. A single frame at a resolution of 1080p has an average size of 7.5 megabytes (MB). If a game is streamed at 60 frames per second (fps), one second of video would require 450MB, translating to a required bandwidth of 3200mbit/s. Such high bandwidths are not available in regular households.

Therefore, compressing the video signal is paramount for video streaming (Ladewig, Lins and Sunyaev, 2019). Many streaming services use the H.264 codec, which looks for identical frames and sends back only one (Chen, Huang and Hsu, 2014). This method can reduce network requirements to the rates mentioned above. The downside is that a buffer must be installed for the computation to occur, adding another layer of latency at L4 (Ladewig, Lins and Sunyaev, 2019).

### **2.7.3 Early cloud gaming platforms**

The idea of cloud gaming is not new. It enjoyed popularity before Microsoft and Google entered the market (Truong, 2021). The first cloud gaming services emerged in the late 2000s: OnLive, G-Cluster, and Gaikai (Cai *et al.*, 2016).

In 2005 OnLive was founded and offered the ability to rent games proposing a play-on-demand business model (Truong, 2021). Technology was not as advanced then, and average download speeds were much lower than today's standards; OnLive required too high network demands, raising concerns (Manzano *et al.*, 2014). Despite a large player base, OnLive faced bankruptcy and was bought by Sony (Truong, 2021).

The acquisition of OnLive laid the foundation for Sony's cloud gaming service. In 2012, Sony further expanded by acquiring Gaikai, another cloud gaming service, and combined the technology of both platforms to launch their proprietary service, "PlayStation Now", in 2014 (Truong, 2021).

## **3 Methodology**

### **3.1 Research structure**

This research comprises qualitative primary and secondary data collection. It is organized into two sequential parts: (i) analysis of the current cloud gaming industry landscape in PC gaming and (ii) evaluating survey results.

The first part of the study is about current cloud gaming services on the market and aims to answer the first research question. The literature review was used to gather knowledge and is supplementary to my research on the services. The goal is first to identify the most essential attributes, both from a technical and consumer-oriented point of view, and second, to compare the identified characteristics of each provider.

The second part is based on a survey where gamers were asked about how they value the attributes identified in the literature review and analysis of the service providers. The goal is to answer research question 2 by analyzing how different groups of people rank the identified factors.

The study focuses on the PC gaming market for the following reasons: First, console owners already invested in buying the hardware and are therefore invested in the manufacturer's ecosystem. Second, in the console market, the performance of the systems is known, and the availability of games is unlimited. Third, besides Sony's PlayStation Now, there is only Microsoft's Xbox Cloud Gaming, which at the time of this study is still in beta and does, therefore, not represent a market-ready service. As a result, the services examined are (i) Google Stadia, (ii) GeForce Now, and (iii) Boosteroid.

Honorable mentions are Amazon Luna and Shadow PC. Amazon Luna is another cloud gaming service aimed at PC gamers but is currently also in beta testing and will, therefore, not be considered. Another popular service is Shadow PC. However, the premise of the service is to provide access to a complete virtual PC environment and is not focusing on cloud gaming and the infrastructure around it. Technically, cloud gaming is very much possible via Shadow PC; however, it is not comparable due to its infrastructure and premise.

### **3.2 Data Collection**

### **3.2.1 Secondary**

Secondary data was collected based on the findings from the literature review and analysis of the competitors. For that matter, scientific articles and scientific research were used. Market reports, blog articles, and community forums were consulted to collect additional knowledge and trivia. Furthermore, to collect information regarding business models, structure, and offerings of the cloud gaming services in question, the individual websites of the services were examined. The resulting data was used for the first part of the analysis and served as the foundation of the survey.

### **3.2.2 Primary**

Primary data was collected by conducting a survey. The survey aimed to collect data on how gamers value different attributes of their gaming experience. Furthermore, different scenarios were presented asking how much the respondents would pay for a specific service. Based on the literature review and examination of the cloud gaming services, hypotheses were developed that will be presented in the following chapter.



## 4 Analysis

The following analysis complements the findings from the literature review. In chapter 2, scientific articles were reviewed primarily concerned with the technical side of cloud gaming services. Most papers discussed the following metrics: resolution, latency, packet loss, and network speed. However, this is not an exhaustive list of relevant factors that make up the gaming experience. To assess other vital parameters, the websites of each platform were examined.

Firstly, as already established, one of the most significant advantages of cloud gaming is mitigating expensive hardware requirements. The premise is that everything needed for cloud gaming is simply an input device, e.g., a keyboard & mouse or a controller, and a device capable of receiving and displaying the video stream from the cloud. Therefore, compatible devices and the accessibility thereof were analyzed.

Secondly, the games available on each platform were taken into account. The number of offered games, support for AAA titles, and the ability to play already owned games were significant for this section. Additionally, the rate at which games are added to the platform was described.

Thirdly, the feature set and monetization model were examined. The feature set includes the metrics: resolution, HDR support, and performance measured in frames per second. As all services use a subscription model, the different tiers of the services were compared, and the associated features were benchmarked.

### 4.1 Cloud Gaming Platforms

#### 4.1.1 Google Stadia

##### History & Current State

Google Stadia launched in November 2019. It is a promising project as it was developed and operated by Google, one of the biggest companies in the world. With the platform launch, Google introduced the “Stadia Games and Entertainment division. “The idea was to focus on developing Stadia-specific first-party games to complement their games catalog. As described in the literature review, console manufacturers follow a similar strategy with platform-specific games and the acquisition of game studios.

In 2021, Google started to change the course for Stadia and shut down the Games and Entertainment division. The decision was made because Stadia prioritized a more appealing and sophisticated publishing platform for third-party developers. One of Google's general managers, Phil Harrison, stated that he believes this move to be the "best path to building Stadia into a long-term, sustainable business that helps grow the industry." (Kotaku, 2021).

### **Accessibility (Devices)**

Google Stadia is available on a multitude of different devices. This is mainly due to its seamless integration into the Chrome web browser. Devices capable of running the Chrome web browser are therefore qualified to use Stadia. Any computer, whether it is a desktop PC, laptop, Ultrabook, or similar, can install and run Chrome. As a result, the operating system (OS) is irrelevant as all major operating systems (Windows, macOS, Linux) let the user install Chrome. Additionally, any Chromium-based browser (e.g., Microsoft Edge) delivers the same functionality.

With mobile phones becoming more capable and powerful, they present a new opportunity to enjoy games. Stadia allows its services to be used through its mobile application for Android, iOS, and Chrome OS tablets. As phones neither have the graphical processing power of dedicated graphics cards, nor the functionality of emulating games developed for computers, it is the only way of playing more sophisticated games on a mobile device. This, of course, includes tablets and possibly other devices with an app store. Though using a touch screen as an input device and most games not being designed for that particular use case scenario, the experience might be subpar. Additional hardware like gamepads for phones might be necessary to exhaust the potential of a game and make use of all of its mechanics.

Indeed, many people would prefer to play games on their home television. For that matter, Google's proprietary Chromecast Ultra dongle can be bought separately, enabling users to stream the service directly onto their television. Alternatively, televisions running on Android TV offer similar functionality as it basically runs the Android operating system found on phones. Recently, television manufacturers started integrating Stadia into their operating systems. Most prominently, LG markets their new OLED C2 series televisions to feature integrated Stadia support without requiring additional hardware like the mentioned Google Chromecast ultra.

Google sells a “Premiere Edition” hardware bundle priced at €79.99, including the Chromecast ultra and the Stadia controller. The bundle offers everything needed to stream and play games on any device and is most suitable for people not previously owning any input devices.

### **Games library and the problem with triple-A titles**

Currently, Stadia supports 286 titles on its platform. Many genres are available, including first-person shooters, adventure games, role-playing games, platformers, and indie titles.

Most of Stadia’s games library are indie titles or games catered to a more casual audience. In general, most games are lesser-known titles that appear to be fillers to inflate the number of games offered. This sentiment can be observed in internet forums where fans of the service complain about the absence of recent AAA titles (Reddit, 2022). Google did promise to release 100 games in 2022 onto their platform. However, as of May, only 24 games found their way into the Stadia store. Of those newly added games, only three can be considered triple A (Rainbow Six: Extraction, Life is strange, and World War Z). However, “Life is strange” is a game from 2015, “Rainbow Six: Extraction”, while being published in 2022, is a spin-off of “Rainbow Six: Siege” which was released in 2015. It becomes imminent that Stadia struggles to release more recent titles, which upsets hardcore gamers who demand to play new and more sophisticated titles.

Despite the absence of recent titles, Stadia still provides numerous prestigious titles released several years ago. The “Doom” IP (Intellectual Property) is a long-going franchise in the FPS realm. “Doom Eternal” is the latest entry and was a big success at its release. “Doom 64”, published in 1997, is a legendary game by developer Bethesda and marked the beginning of competitive speed running in the video game industry due to its proprietary in-game timer.

Furthermore, Google has a deal with the game publisher Ubisoft and offers most of their games on Stadia. These entail the “Assassin’s Creed” games, including most titles ranging from the very first to the latest “Assassin’s Creed Valhalla” released in 2020 with the new console generation to mark the beginning of next-generation games. The “Far Cry” series is also playable, with “Far Cry 6” being the most recent release from 2021. These are graphically intense titles that do not run on any PC effortlessly and thus are perfect candidates to use Stadia’s proprietary hardware.

Some honorable mentions include “Shadow of the Tomb Raider”, which until today is a popular game used for hardware benchmarks in video performance, the Action RPG “Darksiders I-3” and the football simulation “FIFA 22”.

### **Cost & Gaming Capability**

The primary monetization strategy of Google Stadia is its game store. Customers must buy a license from the Stadia store to stream it through their hardware. As discussed in the previous segment, the store only includes games curated by Google, as opposed to the traditional game market where virtually every PC game is available to buy physically or download from the web.

Stadia offers two different tiers for consumers: Basic and “Pro”.

The basic tier is free for everybody and only requires the user to buy the games they want to play. Purchased games can subsequently be played at 1080p at 60fps. According to the latest Steam Hard-& Software survey from April 2022, over 67% of users use a monitor with a resolution of 1080p (Steam, 2022). Hence, the Basic tier provides an on-par experience for most gamers, with a stable 60fps on top.

Stadia’s plan to let players gravitate towards their “Pro” subscription comes in two ways. First, they include selected games from their store in the subscription. Games, therefore, do not have to be bought as long as the customer is an active subscriber. Moreover, players can “claim” a few selected games permanently to their pro library each month. It is an incentive to remain subscribed, as those games can only be claimed during that specific month. After the offer expires, the monthly specific games change, and the old ones need to be bought from the store.

Second, the pro tier allows users to stream games at 4K resolution and in High Dynamic Range (HDR) at up to 60fps. For people with a capable monitor, it is a big jump in the quality of experience. The subscription costs €9.99/month.

### **Limitations**

Games bought in the Stadia store can only be played exclusively via Stadia. There is no possibility to play the game offline on a console or PC, nor after departing from the platform. In the latter case, a new license must be bought on a different platform for the user to play the

game on anything but Stadia. This may seem ordinary initially, but it introduces new limitations to players.

Game licenses are sold platform-specific, e.g., for PlayStation, Xbox, or PC. Streaming services are an addition to the available platforms. The requirement to be connected to the service via the internet leads to players being unable to play their bought games in case of no connection. This is a severe limitation for people traveling a lot or with poor internet connections.

#### **4.1.2 NVIDIA GeForce NOW**

##### **History & Current State**

“GeForce NOW” is NVIDIA’s cloud gaming service. The service launched in beta in October 2015 for NVIDIA Shield devices (NVIDIA Shield is a living room entertainment device connected to a TV and allows users to stream TV shows, movies, or games in high quality at home). Interested players were able to sign up on a waiting list to get invited to use the platform eventually. In the early stage of the service, subscribers could play every game in the library without acquiring individual licenses.

In 2017, GeForce NOW introduced clients for Windows and macOS machines. At the time, the service was not a dedicated cloud gaming service but a remote desktop environment where customers could install their already owned games from various digital distribution platforms on a virtual machine.

In February 2020, it was released to the general public as a full release. Since then, the GeForce NOW launcher has acted as a dedicated game streaming platform where all available games of the service are displayed and can be directly launched.

##### **Accessibility (Devices)**

GeForce NOW can be used on a broad offering of platforms. The native launcher works on Windows, macOS, and ChromeOS for Chromebooks. The launcher can be downloaded from NVIDIA’s website and is run as a typical application on the computer. The

Additionally, the service runs natively on NVIDIA’s Shield TV. The Shield TV acts as an entertainment hub where users can navigate between different apps like, for example, Netflix. The GeForce NOW service is directly integrated into the system and can be accessed remotely.

According to NVIDIA, most USB keyboards and mice can be connected to the hardware and should function flawlessly. Moreover, NVIDIA sells its Gamepad for the Shield and recommends using it. Though, most other Gamepads as Microsoft Xbox controllers or Sony's DualSense 4 and 5 controllers, are listed as compatible input devices.

In addition, various browsers are supported. Similar to Google Stadia, Chrome is a viable choice that enables most computers eligible to run the service. Support for Microsoft Edge is currently in beta.

Currently, GeForce NOW has a dedicated application for Android devices. It behaves similarly to the desktop application and is supported by most Android phones. No dedicated app exists for iPhone and iPad, running on iOS and iPadOS, respectively. The current solution involves accessing the games via Apple's Safari browser.

LG's recent Smart TVs from 2021 onwards support GeForce NOW natively in their WebOS. It is a convenient solution and eliminates the need for additional hardware requirements. Samsung recently confirmed that integration would come to their 2022 line-up (9to5Google, 2022).

### **Games library**

NVIDIA pursues a "Bring your own games" model. It means that users can use the computing power of the cloud to play already owned games. A free-to-play game can be accessed entirely for free, while a regular paid game must be bought on a different platform.

Unlike Stadia, players are not forced into investing in the platform and are allowed to choose freely where to build their game collection. As a result, leaving the cloud gaming environment comes at no cost.

GeForce NOW lets users connect their accounts from three different game platforms: Steam, Epic Games Store, and Ubisoft Connect. Every game purchasable on one of these platforms, which GFN simultaneously supports, can be accessed.

For gamers, this model brings several advantages compared to Stadia. While Stadia offers occasional discounts, most games (even older ones) still retail for the full launch price. With Steam having regular sales offering generous discounts and third-party sellers like G2A.com

generally offering low prices, the monetary benefit for consumers is drastic. Moreover, people selling their used physical copies of games usually charge low prices for them.

Currently, GFN lists 1315 games on its platform. Like Stadia, the GeForce NOW catalog entails a large number of lesser-known indie games or niche games by smaller publishers. GFN is also struggling to attract recent triple-A games to its platform. Franchises like “Assassins Creed”, “Far Cry” or “Hitman” can be played. Games like “Cyberpunk 2077” from 2020 or “The Witcher 3” from 2015, as well as a selection of games by Electronic Arts like “Battlefield” or “Battlefront” are highlights on the platform.

At launch, NVIDIA had several disputes with developers on the terms of their service. Initially, NVIDIA continued to allow people to play any game they own on Steam or similar on their machines. When they switched from the free beta to a paid service, many publishers were upset as they did not permit to do so. The consequences were drastic, as some of the biggest publishers, like Activision Blizzard and Bethesda, pulled their entire catalogs from the service (The Verge, 2020).

GeForce NOW also offers some free-to-play titles. “Apex Legends” and “Fortnite” are two of the biggest games in the Battle Royale Genre. Additionally, “Dota 2” and “League of Legends” are top-rated games in the MOBA market and can also be accessed via GFN. With NVIDIA’s free tier, those games can be played entirely free of charge.

NVIDIA’s offering is constantly evolving by adding several games every week on “GFN Thursday” as they call it. Most of the time, the games added are no triple-A titles. The problem with this is not only about interest from players but lies within NVIDIA’s marketing of the service. Their main selling point is the availability of their own powerful RTX 3080 GPU. With most games on the platform not needing the extra performance, the higher tier becomes obsolete and offers no significant advantage.

### **Cost & Gaming Capability**

GeForce NOW offers three different tiers. “Free”, “Priority” and “3080”. The membership option differs in performance, available play time, and access to available servers.

#### **Free**

The Free membership of GFN offers the user a “basic rig” which includes a GPU equivalent to a GTX 1060, a dated low-spec graphics card from 2016. With this option, the gaming experience becomes a balancing act between high resolution and high fps. The GTX 1060 cannot run graphically intense games reliably at 60fps at 1080p at even medium graphics settings.

Members of the free tier do not receive instant access to available game servers. Players are placed in a queue and must wait until there is capacity. From my testing, waiting times usually range from 5-10 minutes.

Additionally, NVIDIA poses a time limit for each session. Players are eligible to play 1 hour at a time. After that, the game closes, and the user is required to relaunch the game and possibly wait in the queue again. In online games where pausing is generally not possible, this poses a severe limitation and involves planning the game session in advance. In titles like Dota 2, a single game can often last over 1 hour. Hence, the free tier might not be suitable for people primarily playing games of the like.

### **Priority**

The Priority membership offers several upgrades to the free tier. Subscribers receive access to RTX 2080 GPUs which are high-end graphics cards and were the flagship product before the RTX 30’ series was introduced. This GPU can run most games at 1080p at 60fps.

Additionally, all RTX graphics cards are capable of using active ray tracing. A technology that renders lighting effects in real-time and can reproduce dynamic reflections in mirrors, windows, or water. This feature is a big part of NVIDIA’s branding of their GPUs.

Furthermore, members are prioritized when launching a game. While testing the Priority tier, no waiting times were experienced, entirely omitting this limitation.

Session duration is significantly increased. A player can play 6 hours at a time before restarting the game. This amount of play time should be enough for most people. If not, interrupting the session once might only be a small caveat for most players.

The service costs €9.99/month, being the direct competitor to Stadia’s Pro subscription. The service can either be purchased monthly or at a biannual rate. When choosing the six-month subscription, NVIDIA offers a discount and charges €49.99 instead of €59,94.



## **3080**

In 2022, NVIDIA launched a third tier called “3080”. It allows customers to use the full processing power of the RTX 3080 GPU. As discussed earlier, graphics cards are difficult to buy currently and only at drastically inflated prices. The opportunity to use this card through GFN appears to be a compelling alternative. However, as stated in the Games library section, there is only a hand full of games in need of the full performance capabilities of the RTX 3080.

As with the other tiers, NVIDIA promises even more exclusivity for dedicated RTX 3080 server access. Moreover, players are now eligible to play 8 hours at a time before requiring to restart.

The tier's most significant advantage and selling point is the ability to play games in up to 4k resolution at 120fps. Additionally, NVIDIA unlocks HDR gaming for supported games. Until Mai 2022, these features were exclusive to owners of NVIDIA Shield TV; however, with the most recent software update, Windows and Mac users can now enjoy the same experience on their preferred system.

The 3080 membership costs €19.99/month for single-month subscriptions and €99.99/6 months when choosing the bi-annual subscription.

### **4.1.3 Boosteroid**

#### **History & Current State**

Boosteroid is a Cloud Gaming Service that debuted in 2019. The service started in Europe with servers located in Romania, Ukraine, Italy, Slovakia, France, Spain, the UK, Sweden, and Serbia. (Boosteroid, 2022c) In 2022, Boosteroid launched its Servers in the US.

The service joined forces with Intel and ASUS, some of the world's biggest tech companies. Intel and ASUS work together with Boosteroid to develop their global solution. (Intel, 2020) The collaboration makes Boosteroid a good service for the future and allows them to rival other tech giants like NVIDIA and Google.

In March 2022, Boosteroid announced on their Twitter page that they engaged in a collaboration with Philipps.(Boosteroid, 2022a) The collaboration lets customers use Boosteroid on a Philipps TV via a pre-installed app.

## **Accessibility (Devices)**

Boosteroid is accessible via an internet browser like Chrome, Opera, or Safari. The games are directly launched through the website. The browser application then launches an integrated launcher that gives access to the game interface and lets players control the action.

This design makes the service usable on laptops or desktop PCs and allows consumers to access the service through their Android phone or iPhone.(Boosteroid, 2022b) Subsequently, tablets running Android or iPadOS are also eligible to use the service. However, there are some caveats regarding mobile use: The game needs gamepad support, and mouse and keyboard control is not supported. This feature is currently under testing. (Boosteroid, 2022b)

Furthermore, Boosteroid pursues the same approach as NVIDIA by allowing players to access their games through Steam or the Epic Games Store. There are no investments in the platform needed besides the subscription fee.

## **Games Library**

Boosteroid currently has over 200 games on its platform. Most notably, there are a lot of Triple-A titles featured as opposed to the other services discussed.

The library offers many of the most popular Free to Play titles on the market. Big titles like Fortnite, Dota 2, League of Legends, Genshin Impact, Apex Legends, Call of Duty Warzone, and the newly released Multiversus are all playable on Boosteroid.

For AAA games, Boosteroid is the only service that allows players to enjoy titles like Elden Ring, the prospect to be game of the year 2022, Red Dead Redemption 2, GTA 5, FIFA 22, and Borderlands 3. Those games were big hits when they were released, and some were released recently. Compared to GeForce NOW or Stadia, the library is smaller but includes more high-quality titles.

## **Cost & Gaming Capability**

Boosteroid offers two different subscriptions: “Start” and “Ultimate”. Both subscriptions enable the user to start and play any supported game on the platform. The difference between the subscriptions is in price and pay cycle. The “Start” tier is a monthly model for €9.89. On the other hand, the “Ultimate” tier is billed annually and costs €89.89, which equals €7.49 per

month. The goal is to bind users to their platform for longer and receive money in advance. In terms of gaming quality, both tiers offer the same functionality. Customers can stream their games with a resolution of 1080p at 60fps.

With an active subscription, users can connect their game store accounts and play games they own, and Boosteroid supports them. A subscription is also necessary to play Free to play titles.

## 5 Hypotheses Preparation

As discussed in the literature review, games greatly vary in difficulty and level of attention. Fast-paced First-Person-Shooters are played mainly by competitive players with a prominent urge to win and perform well. Hence, lost frames or high latency are a severe concern. On the other hand, people playing casual platformers or strategy games are not as exposed to performance issues. Therefore, gamers indicated that playing FPS games were considered hardcore gamers, whereas people playing casual games are considered casual gamers. As a result, the following hypothesis was derived:

### **H1: Hardcore and casual gamers value performance-related issues differently.**

Powerful PC components are expensive, especially during the global chip shortage. Gamers are forced to pay a premium to acquire a desired GPU or CPU. The comfort of Cloud Gaming Services removing the said barrier raises the question whether the willingness to pay increases with higher performance.

### **H2: Higher graphical capability increases people's willingness to spend more money on cloud gaming services.**

With more and more services being offered as a SaaS model, subscriptions quickly became a normality in many people's everyday life. It is still interesting to evaluate how much people are willing to spend on Cloud Gaming and if gamers with higher disposable income tend to spend more.

### **H3: People with higher monthly incomes are willing to spend more on cloud gaming services.**

The decision on which games to license next heavily depends on the preferences of the Cloud Gaming Platform's audience. Players from older generations could prefer playing casual platformers like the original Super Mario games, whereas younger people prefer more challenging and complex games. Hence, the relationship between age and preferred genre needs to be evaluated.

### **H4: Gamers above 25 years of age tend to be casual gamers.**

As mentioned in the analysis of Google Stadia, one crucial difference is the game distribution model. Stadia requires customers to buy games from their own store to play them.

It seriously limits a player's flexibility and might lead to multiple future purchases of the same game. Consequently, including a mandatory storefront might decrease the willingness to pay for a Cloud Gaming service.

**H5: Having to buy games on a proprietary store of a streaming service lowers the amount people are willing to pay for a cloud gaming service.**

Presumably, players that spend more money on expensive gaming systems do so to achieve the maximum performance possible. Sourcing out the hardware to a server in a cloud is factually worse due to factors like latency and compression, as explained in the literature review. It is interesting to test whether users with High-End PCs rate the cloud experience worse than others. The following hypothesis was derived:

**H6: People with more powerful PCs rate the cloud gaming experience worse than those with lower-spec machines.**

## **6 Findings**

### **6.1 Qualitative customer survey**

#### **6.1.1 Survey Design**

The survey was posted online on March 31<sup>st</sup>, with answers being collected until April 4<sup>th</sup>. With the topic of the thesis being mainly concerned with gaming affine people, the survey was posted on various forums on Reddit.com. Reddit has a heavily invested gaming community and dedicated Cloud Gaming forums. The decision was based on a test run with family members and friends. Most of them did not know any of the parameters of interest and therefore were forced to guess on many occasions. Furthermore, most of the terminology used was unknown to most.

The survey was structured in three parts. First, general demographic information and their preferred gaming platform were gathered. Second, participants were questioned about the genres of games they played. Additionally, players who own Windows machines were asked about the cost of the system. Only Windows users were asked about the cost of their machine, as they are highly modular, and the price has a direct relationship to performance. Macs, on the other hand, are not catered to gamers and are very expensive in relation to their gaming performance. This shortcoming makes Mac users a valid target demographic for Cloud Gaming Services. Third, participants were asked about their experience with cloud gaming, what they value most, and their fears of using such services.

#### **6.1.2 Sample composition**

In total, 148 responses were recorded. Of those 148 participants, 88.5% were male, and 11.5% were female. 76% of respondents were between 18 and 34 years old, 7.4% were under 18, 15.5% were between 34 and 55, and one user was over 55.

The participants were asked whether they had heard about cloud gaming before the survey. Of the 143 responses, 87.4% (125 people) had already heard about cloud gaming. 11.2% (16 votes) had no prior exposure to cloud gaming, and two respondents were unsure.

#### **6.1.3 General findings**

The participants were asked about their weekly gaming habits in hours. 38.5% indicated that they play between 7-14 hours per week, while roughly 21% play less than that. The remaining

40.5% play more than 14 hours per week, 18.24% play between 15 to 21 hours, 10.8% between 22 and 28 hours, and 11.89% more than 28 hours per week.

Furthermore, respondents were asked about their monthly income. This metric assessed whether income increases the willingness to spend for Cloud Gaming Services. 23.6% earn less than 1000\$ per month. Most of them are under the age of 18. 46.6% earn up to 3000\$ per month, 18.24% up to 4500\$, and the remaining 11.5% over 4500\$ per month.

It was also found that most participants do not spend much money per month on gaming-related goods or services. 34.4% spend between 30\$-60\$, corresponding to the retail price of a regular triple A title. Less than 15% spent more on new games, gear, or in-game microtransactions.

Information about gaming habits was also collected, like the preferred genre of games played. Adventure games like Assassins Creed and Multiplayer FPS games ranked the highest with 85 and 83 votes, respectively.

#### **6.1.4 Perception of Cloud Gaming**

In the survey, respondents who had already heard of cloud gaming were asked further questions about their experience. Of those, 62.24% (89) already used a Cloud Gaming Service. Subsequently, people with experience with Cloud Gaming Services were asked to rate their experience on a scale from 1 to 10. The response was generally positive, with a mean score of 7.65. The lowest score given was a 4, and three people rated their experience as excellent with a score of 10.

#### **6.1.5 Hypothesis validation**

**H1:** To evaluate the first hypothesis, the respondents must be categorized into casual and hardcore gamers. To do so, the chosen genres were considered. With Multiplayer FPS games being fast, competitive, and challenging, people invested in such titles were classified as hardcore gamers. As a result, the resulting groups had a relationship of 60:40.

In Q13, participants were given eight characteristics of the general cloud gaming experience, which they were asked to rank regarding their importance. To evaluate H1, the characteristics representing performance the most were inspected: Low Latency, High frames per second, and Stable Performance.

To compare the two groups, a simple t-test was carried out. As we expected a specific result, a one-sided test was *conducted* to test the hypothesis. The confidence level was chosen to be 95%.

For Low Latency, when looking at the means, it can be observed that it is more critical to hardcore gamers than casual gamers. The P-Value is 0.02, which means that the null hypothesis can be rejected, indicating the type of gamer does have an impact on the score. The same is true for high frames per second. Again, hardcore gamers seem to value a high framerate more than hardcore gamers. The p-value is 0.02 and, therefore, statistically significant.

When it comes to stable performance, however, casual gamers perceive it to be more critical than casual gamers. The p-value is significant, and the null hypothesis can be rejected.

In conclusion, hardcore gamers tend to rate specified factors higher, while casual gamers prefer stable performance without worrying about what this means explicitly.

**H2:** In Q17 and Q18, people were given a description of different Cloud Gaming Services. In Q17, a service with the capability to play previously owned games in 1080p resolution at 60fps, and how much they are willing to spend on it per month. In Q18, a service with the ability to play in 4K at 60fps.

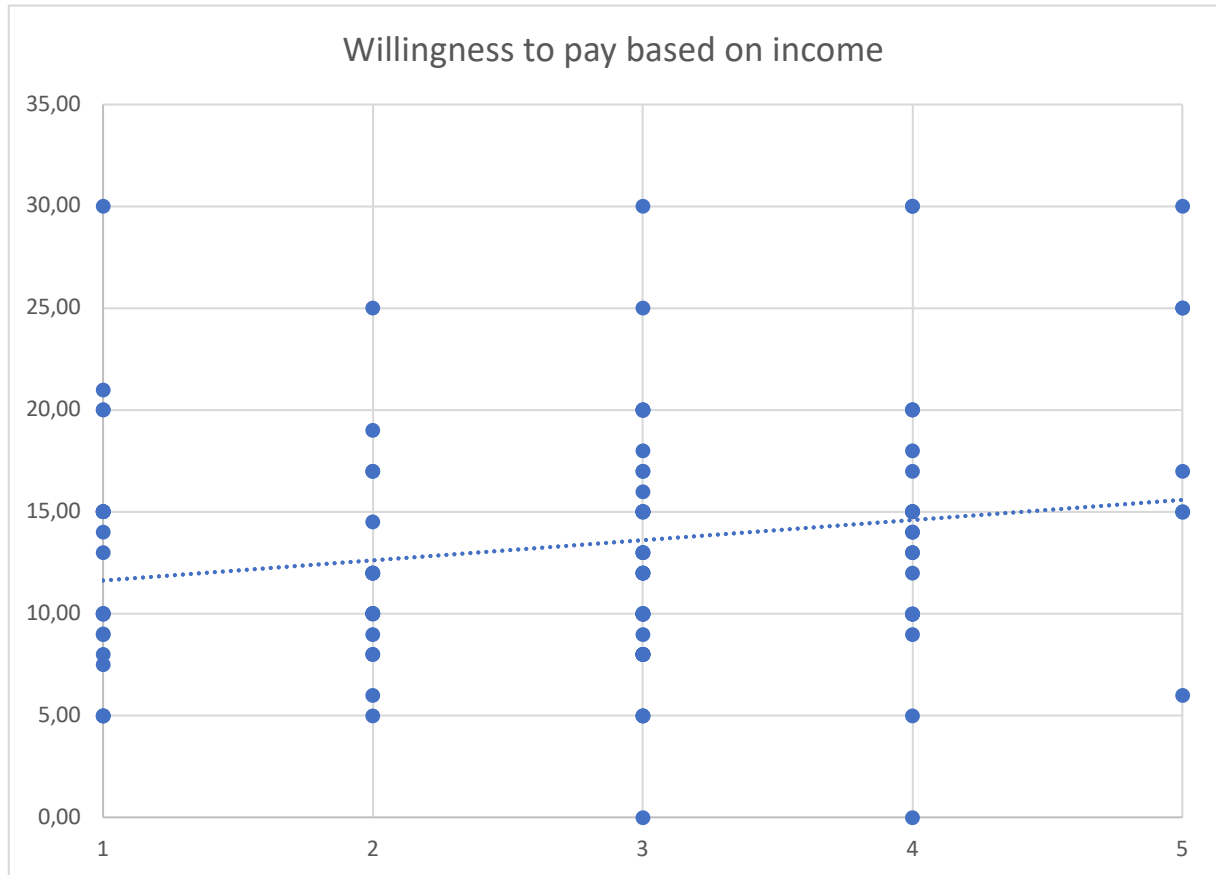
When studying the results, it became clear that higher graphics performance incentivizes consumers to pay more for a Cloud Gaming Service. The mean for money spent on the first scenario is €13.38 and €18.7 for the second scenario. The t-test yielded a very low p-value under 0.05, which allows the null hypothesis to be rejected. It can be concluded that people are willing to spend more on a service with higher graphical performance.

**H3:** To validate H3, the willingness to pay was paired with the monthly income. The graph below clearly shows the income group on the x-axis (1 being low income and 5 being high income) and the amount each respondent is willing to spend on the y-axis. A trend can be observed that more money is spent with higher pay.

To validate this observation, an ANOVA was carried out. The p-value is 0.7 and, therefore, higher than the alpha. Additionally, the F-statistic is lower than the critical f-value, leading to



the null hypothesis's acceptance. As a result, the mean differences are not statistically significant despite the graph's trend.

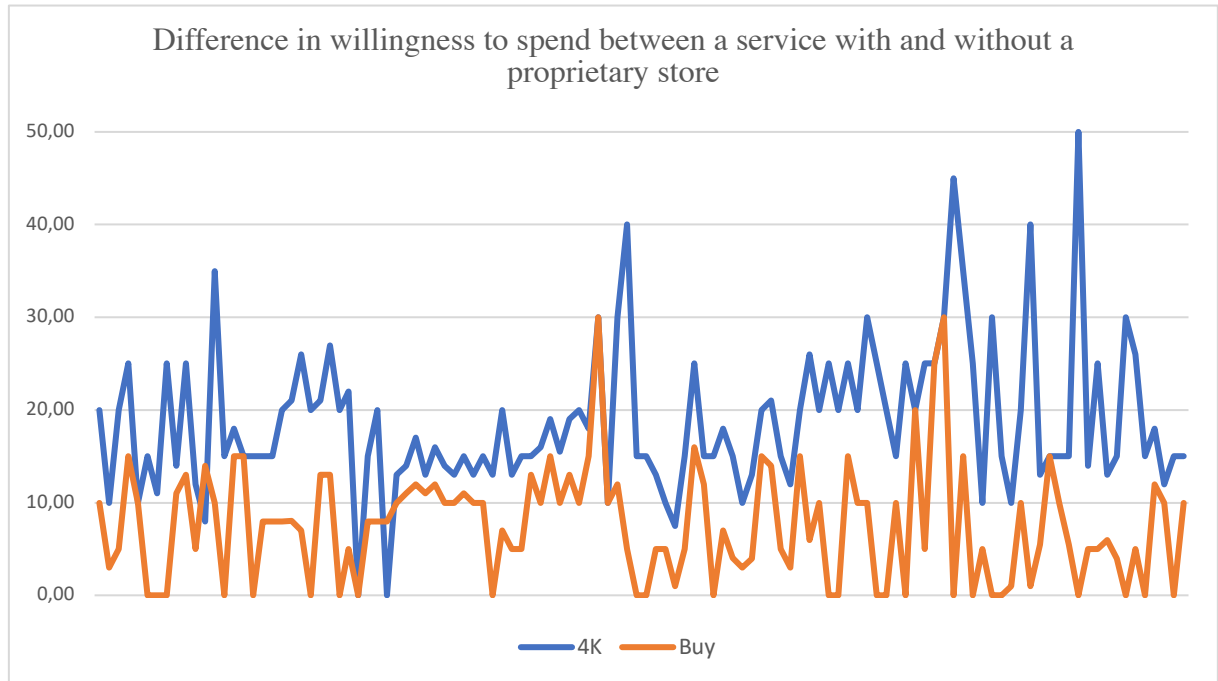


**H4:** Similarly, to H1, Multiplayer FPS games were chosen as an indicator for hardcore gamers. There are 67 respondents under 25 and 81 older than that. The variances are equal, and a t-test was conducted. The p-value is 0.01, which allows *rejecting* the null hypothesis. As a result, there is a statistical difference between age groups, meaning older people tend to be casual gamers.

**H5:** In Question 18, people were asked how much they would spend on a cloud gaming service with 4K 60fps performance. Question 19 asked about the same service. However, people need to buy the games from the services store. Of the 115 respondents, almost all are less inclined to pay for a service where they must *purchase* games in a proprietary store.

When comparing the means, it becomes evident that the need to buy games on a new platform significantly lowers *the* willingness to pay. For the service without an extra store, the

average spending was €19.4, while the other service came down to €8.4. The p-value is near zero, so the null hypothesis can be rejected.



**H6:** Only participants in the survey that already used a cloud gaming service were asked this question to ensure representative data. When comparing the average rating of the overall cloud gaming experience between gamers with high-end machines versus gamers with low-end ones, no statistical differences were found.

A t-test was carried out to compare the means. The p-value 0.29 which leads to the acceptance of the null hypothesis.

On a scale from 1 (bad) to 10 (perfect), owners of high-end systems gave the overall experience on average 7.5 points. Gamers with low-spec machines on the other hand gave an average score of 7.3.

## 6.2 Benchmark

The survey's findings are used to answer the second research question. For this, the initial ranking by the respondents from question 13 is used as a benchmark. Where fitting, a direct comparison between specific demographics was conducted. Furthermore, the hypotheses

revealed significant differences in the perception of the identified factors, depending on the demographic they belong to. To evaluate how the evaluation changed, demographic-specific rankings were analyzed.

**RQ2: How do the identified factors rank amongst gamers?**

The answers to question 13 of the survey yield the base ranking of the factors for the whole sample population:

Rank	Base case
1	Stable Performance
2	Low Latency (Under 100ms)
3	Ability to play already owned games
4	Low monthly cost
5	High resolution (Over 1080p)
6	High fps (steady > 60fps)
7	Support of latest AAA titles
8	Support on many different devices

**6.2.1 Hardcore gamers**

In H1, it was discovered that hardcore gamers value performance-related issues more and therefore rate them higher than others. To explore how the ranking of hardcore gamers deviates from the base case, the answers of hardcore gamers were benchmarked against the whole population.

The following ranking can be deducted from the responses by hardcore gamers:

Rank	Hardcore gamers	Base case
1	Low Latency (Under 100ms)	Stable Performance
2	Stable Performance	Low Latency (Under 100ms)
3	High resolution (Over 1080p)	Ability to play already owned games
4	Ability to play already owned games	Low monthly cost
5	High fps (steady > 60fps)	High resolution (Over 1080p)
6	Low monthly cost	High fps (steady > 60fps)
7	Support of latest AAA titles	Support of latest AAA titles
8	Support on many different devices	Support on many different devices

It can be observed that, as expected, performance indicators like low latency and high resolution do rank higher than the general population. As a result, the monthly cost decreased in significance, as well as the ability to play already owned games.

### 6.2.2 Differences based on income

Previously in H3, it was discovered that income does not significantly impact gamers' willingness to pay. Nonetheless, people with different incomes and presumably lifestyles might value the factors differently.

For that matter, the respondents were split into two groups: High- and low-income individuals. From \$1500 and up, respondents were classified as high income.

Rank	High-income individuals:	Low-income individuals:
1	Stable Performance	Stable Performance
2	Low Latency (Under 100ms)	Low Latency (Under 100ms)
3	Ability to play already owned games	Low monthly cost
4	High resolution (Over 1080p)	High <i>fps</i> (steady > 60fps)
5	Low monthly cost	Support of latest AAA titles
6	Support of latest AAA titles	Ability to play already owned games
7	High <i>fps</i> (steady > 60fps)	High resolution (Over 1080p)
8	Support on many different devices	Support on many different devices

It immediately stands out that despite the indicated prices people from these groups are willing to pay do not differ significantly, low-income individuals do value low monthly costs higher.

Furthermore, high resolution is ranked a lot lower by low-income individuals. Unsurprisingly, low latency and stable performance perform well in both groups. No matter the income, the quality of a paid service should always fulfill the consumer's expectations.

### 6.2.3 Age groups

Hypothesis 4 revealed that younger players tend to be hardcore gamers. Earlier, it was discovered that hardcore gamers rank performance-related indicators higher. Therefore, the ranking of the respondents under 25 years of age should be similar.

The data gave the following ranking:

Rank	Under 25 years old	Hardcore gamers
1	Stable Performance	Low Latency (Under 100ms)
2	High resolution (Over 1080p)	Stable Performance
3	Low Latency (Under 100ms)	High resolution (Over 1080p)
4	High fps (steady > 60fps)	Ability to play already owned games
5	Ability to play already owned games	High fps (steady > 60fps)
6	Low monthly cost	Low monthly cost
7	Support of latest AAA titles	Support of latest AAA titles
8	Support on many different devices	Support on many different devices

When comparing the ranks, the finding that performance indicators are more critical does hold for the younger demographic. Younger people even rate high frames per second above the ability to play already owned games, which further strengthens the connection to hardcore gamers, as frames per second are also a performance indicator.

#### 6.2.4 Cost of PC

Hypothesis 6 was concerned with the impact of high-end systems on evaluating the overall cloud gaming experience. The result suggested that there is no statistically significant difference in the ratings. The rankings of the two groups are as follows:

Rank	High-spec machines	Low-spec machines
1	Stable Performance	Stable Performance
2	Low Latency (Under 100ms)	Low monthly cost
3	High resolution (Over 1080p)	Low Latency (Under 100ms)
4	Ability to play already owned games	Support of latest AAA titles
5	High FPS (steady > 60fps)	Ability to play already owned games
6	Support of latest AAA titles	High FPS (steady > 60fps)
7	Low monthly cost	High resolution (Over 1080p)
8	Support on many different devices	Support on many different devices

Even though the experience ratings were equal, the respective rankings differed. Amongst people with cheaper PCs, low monthly cost ranks drastically higher than gamers with higher-spec systems. On the other hand, resolution and high framerates lose significance for low-spec owners. Stable performance remains the most important factor for both groups.

## 7 Conclusion

This thesis deals with cloud gaming technology and the perception of gamers regarding its most important parameters.

The first research question was about identifying the most critical factors for the cloud gaming experience. The interplay of technical difficulties and elements responsible for the quality of experience represent the challenge of cloud gaming providers. It was found that gaming is a very complex topic. Despite any technical features, gamers show different behaviors and cannot be easily classified.

From academic literature on the topic, as well as the analysis of commonalities between the different services, eight crucial factors were identified: (i) stable performance, (ii) low latency, (iii) high resolution, (iv) high framerate, (v) ability to play already owned games, (vi) availability of AAA titles, (vii) ability to play on different devices and (viii) low monthly cost.

The survey's statistical analysis showed significant differences in how different gamer demographics value each factor. Additionally, the respective rankings for those demographics were further investigated to assess the impact of those differences. The results showed that stable performance is the most critical factor for most groups. Solely, hardcore gamers rate low latency the highest. This is congruent with the finding that hardcore gamers value performance-related characteristics higher than the total population, as seen in chapter 6.2.1.

Furthermore, it can be observed that the offering of triple-A titles does not concern gamers all too much. This was surprising as the available games are the sole reason to use such a service.

The thesis further revealed that the willingness to pay does not differ too much between groups. The average monthly amount gamers are willing to pay is rather consistent throughout the whole sample population.

Even though one of the main selling points of cloud gaming services is the omission of further hardware needs and, therefore, the ability to play on any device, gamers seem not to value this feature much. Amongst all investigated groups, accessibility ranked the lowest each time.

The achieved results are an exciting indicator for companies on how to prioritize the features they offer with their cloud gaming service. Depending on the target demographic, specific needs ought to be satisfied first.

## **7.1 Potential for future research and limitations**

Analyzing the different service providers gave insight into how they are structured and allows for further analysis of the business models. The derived rankings could be used to evaluate the different services based on the categories used in the analysis and crown the superior provider and its offering. For that matter, more profound insights into user data of the services are required.

Additionally, the results of the survey extensively showed that there are, in fact, significant differences between groups. Future research might be concerned with why those differences exist and how to manipulate them.

Certain limitations need to be regarded concerning the results of the thesis.

The survey's sample size was relatively small, with roughly 150 respondents. Even though the participants were targeted directly in gaming-related environments, a bigger population might produce different results. As described, infrastructure in terms of network quality and server location does play a significant role in the quality of experience. The study did not focus on geographical influences, which would be an interesting topic for future research.



## Reference List

9to5Google (2022) *Samsung TVs will support Stadia and GeForce Now in 2022*. Available at: <https://9to5google.com/2022/04/04/samsung-tv-2022-google-stadia-geforce-now/> (Accessed: 29 May 2022).

Ammattikorkeakoulu, V. (2021) *Video Game Industry Market Analysis*.

Arunarani, A.R., Manjula, D. and Sugumaran, V. (2019) 'Task scheduling techniques in cloud computing: A literature survey', *Future Generation Computer Systems*, 91, pp. 407–415. Available at: <https://doi.org/10.1016/j.future.2018.09.014>.

Baer, R.H. (2005) *Videogames: In The Beginning*. Rolenta Press.

Boosteroid (2022a) *Boosteroid on Twitter, Twitter*. Available at: [https://twitter.com/boosteroid\\_main/status/1498692381746548745](https://twitter.com/boosteroid_main/status/1498692381746548745) (Accessed: 3 September 2022).

Boosteroid (2022b) *Can I play on mobile devices?* Available at: <https://help.boosteroid.com/en/content/can-i-play-on-mobile-devices-i17Td-G74PY> (Accessed: 3 September 2022).

Boosteroid (2022c) *Where is service available?* Available at: <https://help.boosteroid.com/en/content/where-is-service-available> (Accessed: 3 September 2022).

Business of Apps (2022) *Candy Crush Revenue and Usage Statistics (2022)*. Available at: <https://www.businessofapps.com/data/candy-crush-statistics/> (Accessed: 3 September 2022).

Cai, W. *et al.* (2016) 'A survey on cloud gaming: Future of computer games', *IEEE Access*. Institute of Electrical and Electronics Engineers Inc., pp. 7605–7620. Available at: <https://doi.org/10.1109/ACCESS.2016.2590500>.

Chen, K.-T. *et al.* (2017) 'Cloud gaming', *Frontiers of Multimedia Research*, pp. 287–314. Available at: <https://doi.org/10.1145/3122865.3122877>.

Chen, K.T., Huang, C.Y. and Hsu, C.H. (2014) 'Cloud gaming onward: Research opportunities and outlook', in *2014 IEEE International Conference on Multimedia and Expo Workshops, ICMEW 2014*. Institute of Electrical and Electronics Engineers Inc. Available at: <https://doi.org/10.1109/ICMEW.2014.6890683>.

Claro Tomaselli Fundação Getulio Vargas, F. *et al.* (2008) *Value Chain Management and Competitive Strategy in the Home Video Game Industry*. Available at: <https://www.researchgate.net/publication/265245119>.

Clayton, A. (2020) 'Game Over? How Video Game Console Makers are Speeding Toward an Antitrust Violation', *BUS. ENTREPRENEURSHIP & TAX L. REV.*, 4(1). Available at: <https://scholarship.law.missouri.edu/betrhttps://scholarship.law.missouri.edu/betr/vol4/iss1/46>.

Cote, A.C. (2020) 'Casual resistance: A longitudinal case study of video gaming's gendered construction and related audience perceptions', *Journal of Communication*, 70(6), pp. 819–841. Available at: <https://doi.org/10.1093/JOC/JQAA028>.

Daidj, N. and Isckia, T. (2009) 'Entering the Economic Models of Game Console Manufacturers', *Communications & Strategies*, 73.

di Domenico, A. *et al.* (2021) 'A Network Analysis on Cloud Gaming: Stadia, GeForce Now and PSNow', *Network*, 1(3), pp. 247–260. Available at: <https://doi.org/10.3390/network1030015>.

Eric-Jon Waugh (2006) *GDC: Casual Games Summit 2006: An Introduction to Casual Games*, *Gamedeveloper.com*.

Finances Online (2020) *Number of Gamers Worldwide 2022/2023: Demographics, Statistics, and Predictions - Financesonline.com*. Available at: <https://financesonline.com/number-of-gamers-worldwide/> (Accessed: 22 March 2022).

Finances Online (2021) *96 Steam Statistics You Must Know: 2022 Market Share Analysis & Data*. Available at: <https://financesonline.com/steam-statistics/> (Accessed: 30 March 2022).

GameSpot (2013) *Rockstar: More than 1,000 people made GTAV*. Available at: <https://www.gamespot.com/articles/rockstar-more-than-1000-people-made-gtav/1100-6415330/> (Accessed: 3 September 2022).

Gamestar (2021) *COD Game Size*.

Garrison, G., Kim, S. and Wakefield, R.L. (2012) 'Success factors for deploying cloud computing', *Communications of the ACM*, 55(9), pp. 62–68. Available at: <https://doi.org/10.1145/2330667.2330685>.

HowMuch.one (2022) *RTX 3080 Price history*. Available at: <https://howmuch.one/product/average-nvidia-geforce-rtx-3080-ti-12gb/price-history> (Accessed: 28 March 2022).

Intel (2020) *Boosteroid Supports Millions of Online Gamers*. Available at: <https://www.intel.com/content/www/us/en/customer-spotlight/stories/boosteroid-customer-story.html?wapkw=boosteroid> (Accessed: 3 September 2022).

Jacobs, G. (2005) 'Ip-Jacobs2005\_Article\_SegmentationOfTheGamesMarketUs', 13, pp. 275–287.

Jarschel, M. *et al.* (2013) 'Gaming in the clouds: QoE and the users' perspective', *Mathematical and Computer Modelling*, 57(11–12), pp. 2883–2894. Available at: <https://doi.org/10.1016/j.mcm.2011.12.014>.

Kotaku (2021) *Google Stadia Shuts Down Internal Studios, Changing Business Focus*. Available at: <https://kotaku.com/google-stadia-shuts-down-internal-studios-changing-bus-1846146761> (Accessed: 2 April 2022).

Kuittinen, J. *et al.* (2007) 'Casual games discussion', *Proceedings of the 2007 Conference on Future Play, Future Play '07*, (May 2015), pp. 105–112. Available at: <https://doi.org/10.1145/1328202.1328221>.

Ladewig, S., Lins, S. and Sunyaev, A. (2019) 'Are we ready to play in the cloud? Developing new quality certifications to tackle challenges of cloud gaming services', in *Proceedings - 21st IEEE Conference on Business Informatics, CBI 2019*. Institute of Electrical and Electronics Engineers Inc., pp. 231–240. Available at: <https://doi.org/10.1109/CBI.2019.00033>.

Laghari, A.A. *et al.* (2019) 'Quality of experience (QoE) in cloud gaming models: A review', *Multiagent and Grid Systems*, 15(3), pp. 289–304. Available at: <https://doi.org/10.3233/mgs-190313>.

Manzano, M. *et al.* (2014) 'Dissecting the protocol and network traffic of the OnLive cloud gaming platform', *Multimedia Systems*, 20(5), pp. 451–470. Available at: <https://doi.org/10.1007/s00530-014-0370-4>.

Microsoft (2020) *Microsoft to acquire ZeniMax Media and its game publisher, Bethesda Softworks, for \$7.5 billion - Stories*. Available at: <https://news.microsoft.com/features/microsoft-to-acquire-zenimax-media-and-its-game-publisher-bethesda-softworks-for-7-5-billion/> (Accessed: 22 March 2022).

Microsoft (2021) *Game streaming latency measurement - Microsoft Game Development Kit | Microsoft Docs*. Available at: [https://docs.microsoft.com/en-us/gaming/gdk/\\_content/gc/system/overviews/game-streaming/game-streaming-latency-measurement](https://docs.microsoft.com/en-us/gaming/gdk/_content/gc/system/overviews/game-streaming/game-streaming-latency-measurement) (Accessed: 28 March 2022).

Microsoft (2022) *Microsoft to acquire Activision Blizzard to bring the joy and community of gaming to everyone, across every device - Stories*. Available at: <https://news.microsoft.com/2022/01/18/microsoft-to-acquire-activision-blizzard-to-bring-the-joy-and-community-of-gaming-to-everyone-across-every-device/> (Accessed: 22 March 2022).

Montazerolghaem, A., Yaghmaee, M.H. and Leon-Garcia, A. (2020) 'Green Cloud Multimedia Networking: NFV/SDN Based Energy-Efficient Resource Allocation', *IEEE Transactions on Green Communications and Networking*, 4(3), pp. 873–889. Available at: <https://doi.org/10.1109/TGCN.2020.2982821>.

Mordor Intelligence (2020) *GAMING MARKET - GROWTH, TRENDS, COVID-19 IMPACT, AND FORECASTS (2021 - 2026)*, Mordor Intelligence. Available at: <https://www.mordorintelligence.com/industry-reports/global-gaming-market>.

Newzoo (2021) *The Games Market and Beyond in 2021: The Year in Numbers | Newzoo*. Available at: <https://newzoo.com/insights/articles/the-games-market-in-2021-the-year-in-numbers-esports-cloud-gaming/> (Accessed: 22 March 2022).

Nieborg, D.B. and van der Graaf, S. (2008) 'The mod industries? The industrial logic of non-market game production', *European Journal of Cultural Studies*, 11(2), pp. 177–195. Available at: <https://doi.org/10.1177/1367549407088331>.

Ojala, A. and Tyrvaenen, P. (2011) 'Developing cloud business models: A case study on cloud gaming', *IEEE Software*, 28(4), pp. 42–47. Available at: <https://doi.org/10.1109/MS.2011.51>.

PCGamer (2021) *Most game devs don't think Steam earns its 30% revenue cut | PC Gamer*. Available at: <https://www.pcgamer.com/most-game-devs-dont-think-steam-earns-its-30-revenue-cut/> (Accessed: 30 March 2022).

Poels, Y. *et al.* (2012) 'Are you a gamer? A qualitative study on the parameters for categorizing casual and hardcore gamers', *ladis International Journal on www/internet*, Vol. 10(1), pp. 1–16.

Polygon (2021) *Sony is selling the PS5 at a loss, investors told*. Available at: <https://www.polygon.com/2021/2/3/22264242/playstation-5-sales-loss-manufacturing-costs-msrp-sony> (Accessed: 23 March 2022).

Radu, L.D. (2017) 'Green cloud computing: A literature survey', *Symmetry*. MDPI AG. Available at: <https://doi.org/10.3390/sym9120295>.

Reddit (2021) *How many hour it takes to become immortal?* Available at: [https://www.reddit.com/r/DotA2/comments/n9fu8o/how\\_many\\_hour\\_it\\_takes\\_to\\_become\\_immortal/](https://www.reddit.com/r/DotA2/comments/n9fu8o/how_many_hour_it_takes_to_become_immortal/).

Reddit (2022) *Will we see any AAA games on Stadia again?*, *Reddit*. Available at: [https://www.reddit.com/r/Stadia/comments/u41os6/will\\_we\\_see\\_any\\_aaa\\_games\\_on\\_stadia\\_again/](https://www.reddit.com/r/Stadia/comments/u41os6/will_we_see_any_aaa_games_on_stadia_again/) (Accessed: 13 May 2022).

Richstad, O.K.B. (2015) 'User Preferences for Video Game Delivery - A Case Study of Cloud Gaming', *Norwegian University of Science and Technology Department of Computer and Information Science* [Preprint], (June). Available at: [https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2353599/10389\\_FULLTEXT.pdf?sequence=1](https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2353599/10389_FULLTEXT.pdf?sequence=1).

Sanneck, H. and Carle, G. (2000) *A Framework Model for Packet Loss Metrics Based on Loss Runlengths*.

Srivastava, P. and Khan, R. (2018) 'A Review Paper on Cloud Computing', *International Journal of Advanced Research in Computer Science and Software Engineering*, 8(6), p. 17. Available at: <https://doi.org/10.23956/ijarcse.v8i6.711>.

Statista (2018) • *U.S. computer and video game sales - digital vs. physical 2018*. Available at: <https://www.statista.com/statistics/190225/digital-and-physical-game-sales-in-the-us-since-2009/> (Accessed: 30 March 2022).

Statista (2021) *Number of gamers worldwide by region 2021*, *Statista*. Available at: <https://www.statista.com/statistics/293304/number-video-gamers/> (Accessed: 12 September 2022).

Steam (2022) *Steam-Hard- & Softwareumfrage*. Available at: <https://store.steampowered.com/hwsurvey/Steam-Hardware-Software-Survey-Welcome-to-Steam> (Accessed: 28 May 2022).

The Verge (2020) *Why Nvidia's GeForce Now has become so controversial with game developers*. Available at: <https://www.theverge.com/2020/3/2/21161469/nvidia-geforce-now-cloud-gaming-service-developers-controversy-licensing> (Accessed: 29 May 2022).

Thorhaug, A.M. and Nielsen, R.K.L. (2021) 'Epic, Steam, and the role of skin-betting in game (platform) economies', *Journal of Consumer Culture*, 21(1), pp. 52–67. Available at: <https://doi.org/10.1177/1469540521993929>.

Truong, A. (2021) *Evaluating Cloud-Based Gaming Solutions Item Type Thesis*. Available at: <http://hdl.handle.net/20.500.12648/1782>.

Tsai, W.T., Bai, X.Y. and Huang, Y. (2014) 'Software-as-a-service (SaaS): Perspectives and challenges', *Science China Information Sciences*, 57(5), pp. 1–15. Available at: <https://doi.org/10.1007/s11432-013-5050-z>.

Wikipedia (2022a) *Bethesda Softworks - Wikipedia*. Available at: [https://en.wikipedia.org/wiki/Bethesda\\_Softworks#Games\\_published](https://en.wikipedia.org/wiki/Bethesda_Softworks#Games_published) (Accessed: 22 March 2022).

Wikipedia (2022b) *Home video game console*. Available at: [https://en.wikipedia.org/wiki/Home\\_video\\_game\\_console](https://en.wikipedia.org/wiki/Home_video_game_console) (Accessed: 3 September 2022).

Wikipedia (2022c) *Super Mario, Wikipedia*. Available at: [https://de.wikipedia.org/wiki/Super\\_Mario#New\\_Super\\_Mario\\_Bros.\\_U\\_Deluxe\\_\(2019\)](https://de.wikipedia.org/wiki/Super_Mario#New_Super_Mario_Bros._U_Deluxe_(2019)) (Accessed: 3 September 2022).

Yang, H. and Tate, M. (2012) 'A descriptive literature review and classification of cloud computing research', *Communications of the Association for Information Systems*, 31(1), pp. 35–60. Available at: <https://doi.org/10.17705/1cais.03102>.

## Appendix:

### Questionnaire:

Q#	Question	Possible answers
Q 1	<b>How old are you?</b>	Under 18 18-24 25-34 35-45 46-55 55+
Q 2	<b>What is your gender?</b>	Male Female
Q 3	<b>How many hours per week do you play video games?</b>	0-6 7-14 15-21 22-28 More than 28
Q 4	<b>What is your monthly income?</b>	Over \$4500 \$3000-\$4500 \$1500-\$3000 \$1000-\$1500 Under \$1000
Q 5	<b>How much money do you spend on gaming per month? (Including microtransactions, new games, subscriptions, etc.)</b>	\$0-\$30 \$31-\$60 \$61-\$80 \$81-\$100 \$100+

Q 6	<b>On what platforms do you play video games? Multiple selections possible.</b>	Windows PC Windows Laptop PlayStation Xbox Nintendo Switch MacOS Linux Mobile (Phone/Tablet) Other
Q 7	<b>How much did your current gaming Windows PC/Laptop cost?</b>	Under \$1000 \$1000-\$1500 \$1500-\$2500 \$2500+
Q 8	<b>What genre of games do you play?</b>	Multiplayer FPS Racing Adventure (e.g. Assassins Creed) Role Play Games (RPG, MMORPG) Platformer Indie Games Simulation Strategy MOBA (e.g. DOTA 2) Other
Q 9	<b>Prior to this survey, have you heard of Cloud Gaming?</b>	Yes No I do not know
Q 10	<b>Have you used a Cloud Gaming service in the past?</b>	Yes No
Q 11	<b>How would you rate your general cloud gaming experience?</b>	1 (bad) to 10 (perfect)



Q 12	<b>Are you actively using a cloud gaming service?</b>	<p>Google Stadia</p> <p>Xbox Game Cloud</p> <p>Geforce NOW</p> <p>Boosteroid</p> <p>Amazon Luna</p> <p>I currently do not use a Cloud Gaming service</p> <p>Other</p>
Q 13	<b>What aspects are most important for you in cloud gaming services? Please rank the following statements from most important (1) to least important (8)</b>	<p>Stable Performance (Constant connection and no dropped frames)</p> <p>Low latency (Under 100ms)</p> <p>Ability to play already owned games</p> <p>Low monthly cost</p> <p>High resolution (Over 1080p)</p> <p>High FPS (steady &gt;60fps)</p> <p>Support of latest AAA titles</p> <p>Support on many different devices (e.g. Laptop, PC, Tablet, Smartphone)</p>
Q 14	<b>What other factors would be important to you, if any?</b>	Open Question
Q 15	<b>What are your biggest concerns on cloud gaming? Please rank them from most concerning (1) to least concerning (6)</b>	<p>Only having the ability to play the game online</p> <p>Not being able to play already owned games (e.g. Games bought on Steam or Origin)</p> <p>Lag/Stutter/Frame Drops</p> <p>No trust in cloud gaming services yet</p> <p>My Network speed is not high/stable enough</p> <p>Needing multiple subscriptions to cover all games I want to play (Similar to Netflix and Disney+ for example)</p>
Q 16	<b>What other concerns do you have, if any?</b>	Open Question

Q 17	<p><b>Imagine a service where you can play all your already owned games (e.g. on Steam or Origin) on 1080p 60fps on any device via the internet. You only have to pay for the cloud server that runs your games. How much would you pay every month for that service? (In USD, no ranges! Use the form of: XX.XX)</b></p>	Open Question
Q 18	<p><b>Now imagine the same service but capable of streaming your games in 4K 60fps (Performance equal to a RTX 3080). What monthly rate would you be willing to pay? (In USD, no ranges! Use the form of: XX.XX)</b></p>	Open Question
Q 19	<p><b>Some Cloud Gaming platforms require you to buy the game from their proprietary store. If you had to buy the games from their store, how much would you pay per month to use the service? (In USD, no ranges! Use the form of: XX.XX)</b></p>	Open Question
Q 20	<p><b>If you have any other thoughts on cloud gaming like wishes, fears or general</b></p>	Open Question

	<b>thoughts, please indicate them here.</b>	
--	---	--