



INDIAN INSTITUTE OF INFORMATION TECHNOLOGY
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Cloud Computing Project Report

Cloud Gaming

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1. ABSTRACT

The gaming industry has been rapidly growing, and the advent of cloud gaming has brought significant changes to how games are played. Cloud gaming enables gamers to access their favorite games from anywhere without the need for expensive hardware. In this research, we explored the use of cloud services for gaming by hosting the popular game Fall Guys on Amazon Web Services (AWS). To host Fall Guys on AWS, we used Elastic Compute Cloud (EC2) instances to set up virtual machines and install the game server. We also used Elastic Load Balancing (ELB) to distribute the incoming game traffic across multiple instances, ensuring smooth gameplay and optimal performance. Our results showed that hosting Fall Guys on AWS was highly reliable and efficient, with minimal latency and downtime. Players were able to enjoy the game without any interruptions, and the game was able to handle high levels of traffic. Furthermore, the use of AWS allowed us to easily scale our resources to accommodate a growing number of players. Our research demonstrated the potential of cloud gaming, and specifically, the use of AWS for hosting games. As the gaming industry continues to evolve, cloud gaming is likely to become more prevalent, and our research provides valuable insights into how it can be implemented successfully.

2. INTRODUCTION

Gaming has been a favorite pastime of many people around the world for decades. With the evolution of technology, gaming has become more immersive and accessible than ever before. The gaming industry has grown rapidly in recent years, with more and more people playing games on various platforms such as consoles, PCs, and mobile devices. However, the increasing popularity of gaming has also created new challenges for the industry, such as the need for powerful hardware and the high costs associated with it. Cloud gaming has emerged as a promising solution to these challenges. Cloud gaming refers to the use of cloud services to play games instead of relying on local hardware. This approach allows gamers to play their favorite games on any device with an internet connection, without the need for expensive hardware upgrades or installations. Cloud gaming services also provide benefits such as low latency, high availability, and scalability. In this research, we explore the use of cloud services for gaming by hosting the popular game Fall Guys on Amazon Web Services (AWS). We chose Fall Guys for our experiment because it is a multiplayer game that requires high-performance servers to deliver a seamless gaming experience to players. Our goal was to assess the feasibility and effectiveness of using AWS for hosting games, as well as to identify the benefits and challenges associated with cloud gaming. The gaming industry has undergone a significant transformation in recent years, with the introduction of new platforms, devices, and technologies. Gaming has become more accessible than ever before, with millions of people playing games on their smartphones, tablets, and PCs. However, the demand for high-quality games has also increased, leading to the need for more powerful hardware.

and more advanced game engines. Cloud gaming has emerged as a promising solution to the challenges of the gaming industry. It enables gamers to play their favorite games on any device with an internet connection, without the need for expensive hardware upgrades. Cloud gaming services use powerful servers and high-speed internet connections to deliver low latency, high availability, and scalability. Cloud gaming has become increasingly popular in recent years, with major companies such as Google, Microsoft, and NVIDIA launching their cloud gaming services. These services offer a range of benefits, such as instant access to games, no downloads or installations required, and the ability to play on any device. AWS is one of the leading cloud computing providers in the world, with a wide range of services designed to meet the needs of various industries, including gaming. AWS offers a suite of services specifically designed for game developers, such as Amazon GameLift and Amazon Game Tech. These services provide game developers with tools and resources to build, deploy, and scale games in the cloud. Fall Guys is a popular multiplayer game developed by Mediatonic and published by Devolver Digital. The game was released in August 2020 and quickly became a sensation, with millions of players around the world. Fall Guys is a game that requires high-performance servers to deliver a seamless gaming experience to players.

3. RELATED WORK

Huang et al. [1] introduced GamingAnywhere, an open-source cloud gaming system that aims to provide a high-quality gaming experience to users. The authors recognized that cloud gaming is a promising solution to the challenges of the gaming industry, such as the need for powerful hardware and the high costs associated with it. However, they also identified several challenges that need to be addressed, such as high latency, limited interactivity, and lack of customization. To address these challenges, the authors developed GamingAnywhere, a cloud gaming system that uses video streaming and remote desktop technologies to deliver games to users. GamingAnywhere is designed to be customizable, flexible, and scalable, making it suitable for different types of games and platforms. Shea et al. [2] discussed the architecture of cloud gaming and the challenges associated with delivering high-quality gaming experiences to users. The authors recognized that traditional gaming requires powerful hardware and software resources that can be expensive for users. They argued that cloud gaming could offer a more cost-effective solution by allowing users to access games from remote servers using thin clients. To provide a high-quality gaming experience, cloud gaming systems must address several challenges, including network latency, bandwidth limitations, and processing power. The authors proposed a cloud gaming architecture that utilizes virtualization technologies to optimize resource allocation and reduce latency. Chen et al. [3] investigated the quality of service (QoS) of cloud gaming systems and proposed a comprehensive framework for evaluating the performance of such systems. The authors recognized that cloud gaming has the potential to offer a high-quality gaming experience to users, but there are several challenges associated with QoS that need to be addressed.

These challenges include network latency, bandwidth limitations, and video quality. To address these challenges, the authors proposed a QoS framework that considers several metrics, including network latency, frame rate, and video quality. The authors conducted several experiments to evaluate the performance of the proposed framework using a cloud gaming system called GamingAnywhere. Cai [4] presented a comprehensive survey on cloud gaming, its current state, and future prospects. The authors recognized that cloud gaming has the potential to revolutionize the gaming industry by providing a cost-effective and scalable solution for delivering high-quality gaming experiences to users. They noted that cloud gaming has been gaining popularity in recent years, but there are still several challenges that need to be addressed, such as network latency, bandwidth limitations, and video quality. To provide a comprehensive survey of cloud gaming, the authors reviewed the literature on cloud gaming, including its history, architecture, and performance. They also discussed the challenges associated with cloud gaming and proposed solutions to address them. K.T., Chang et al. [5] investigated the issue of latency in cloud gaming systems, which is a crucial factor affecting the gaming experience. The authors recognized that cloud gaming has the potential to provide a high-quality gaming experience to users, but latency can significantly affect the user experience. Latency is the time delay between the user's input and the response from the game server, which can result in lag or delay in the game. To address this issue, the authors proposed a latency measurement framework for cloud gaming systems that can accurately measure the end-to-end latency experienced by the user. The framework consists of several components, including a game client, a network emulator, a game server, and a latency measurement module. Manzano et al. [6] conducted an empirical study to evaluate the performance of a cloud gaming system under different network conditions and game scenarios. The authors recognized that cloud gaming has the potential to provide a high-quality gaming experience to users, but there are several challenges associated with it, such as network latency, bandwidth limitations, and video quality. To address these challenges, the authors conducted an empirical study to evaluate the performance of a cloud gaming system called OnLive. The authors conducted several experiments to evaluate the performance of the OnLive system under different network conditions and game scenarios. They measured various performance metrics, such as latency, frame rate, and video quality, and compared the results with a local gaming system. The paper provides a detailed description of the experimental setup and the performance evaluation methodology used by the authors. The authors also discussed the challenges associated with cloud gaming and the potential of the OnLive system to address them. Huang [7] proposed a novel open-source cloud gaming system called GamingAnywhere that can provide users with a high-quality gaming experience over the internet. The authors recognized that cloud gaming has the potential to provide a new way of playing games, but there are several challenges associated with it, such as network latency, bandwidth limitations, and video quality. To address these challenges, the authors proposed a new cloud gaming system that leverages the power of cloud computing and provides users with a high-quality gaming experience. The GamingAnywhere system is based on the client-server architecture, where the game is executed on the server-side and the user interacts with the game through a remote client. The system uses a video codec to compress the game video stream and transmit it over the network to the client. The client decodes the video stream and displays the game on the user's screen. The system also provides mechanisms to

handle network latency and bandwidth limitations to ensure a smooth gaming experience. Ojala et al. [8] investigated the business models of cloud gaming by conducting a case study on a cloud gaming service provider. Cloud gaming is a rapidly growing industry that offers new opportunities for businesses to provide gaming services to consumers. However, the authors note that the business models for cloud gaming are not yet well established, and there is a need for research to understand the business models that can be used by cloud gaming service providers. The authors conducted a case study on a Finnish cloud gaming service provider, analyzing their business model and identifying the key factors that contribute to its success. They identified several factors, such as the need for high-quality infrastructure, flexible pricing models, and strategic partnerships with game developers, that are critical to the success of a cloud gaming service.

4. DESIGN OBJECTIVES

The design objectives for Cloud Gaming include:

4.1 Issues And Challenges

Cloud gaming, like any emerging technology, has its share of issues and challenges. Some of the major challenges and issues associated with cloud gaming are:

4.1.1 Latency

Latency is one of the primary challenges in cloud gaming, as it can significantly affect the quality of the gaming experience. Latency refers to the time delay between a user input (such as a button press or mouse movement) and the corresponding action on the screen. In gaming, even small amounts of latency can make a game feel unresponsive and slow, which can negatively impact the player's experience. In traditional gaming setups, such as console or PC gaming, latency is typically very low because the game is running directly on the user's hardware. However, in cloud gaming, the game is running on remote servers, which can introduce significant latency due to the time it takes for data to travel between the user's device and the server. This latency is caused by a number of factors, including network congestion, server processing time, and the distance between the user and the server.

There are several ways in which latency can affect cloud gaming:

- **Input Lag:** Input lag is the delay between the user's input and the corresponding action on the screen. In cloud gaming, input lag can be higher than in traditional

gaming because of the additional time it takes for the input to travel from the user's device to the server and back.

- **Stuttering:** Stuttering is a term used to describe the uneven or jerky movement of objects on the screen. In cloud gaming, stuttering can occur due to delays in processing data on the server or due to network congestion.
- **Disconnections:** Disconnections can occur in cloud gaming when there is a loss of connectivity between the user's device and the server. This can be caused by a variety of factors, including network issues, server overload, or maintenance downtime.

4.1.2 Bandwidth Saturation

Bandwidth is another significant challenge in cloud gaming as it can affect the quality of the gaming experience. Bandwidth refers to the amount of data that can be transmitted over a network connection in a given period. In gaming, bandwidth is critical because the game constantly sends and receives data between the user's device and the server. In traditional gaming setups, such as console or PC gaming, the game is stored locally on the user's device, which means that only small amounts of data need to be transmitted over the network. However, in cloud gaming, the game is running on remote servers, which requires a high bandwidth connection to transmit large amounts of data between the server and the user's device.

There are several ways in which bandwidth can affect cloud gaming:

- **Video Quality:** The quality of the video stream can be negatively affected by low bandwidth. The game's graphics and audio data must be transmitted to the user's device in real-time, and if the connection is not fast enough, the video stream may become choppy or distorted.
- **Latency:** As discussed earlier, latency can be affected by network congestion, which can be caused by a lack of available bandwidth. When the network is congested, it can take longer for data to travel between the user's device and the server, which can increase latency and negatively affect the gaming experience.
- **Connection Drops:** When there is insufficient bandwidth, the connection may drop, causing the game to pause or freeze. This can be especially frustrating during critical moments in the game, such as boss fights or multiplayer matches.

4.1.3 Cost

Cost is one of the significant challenges of cloud gaming, as it can make the service inaccessible to some users or lead to higher overall costs for gamers. There are several cost-related issues that can affect cloud gaming:

- **Subscription Fees:** Many cloud gaming services require users to pay a subscription fee to access their games. These fees can vary widely depending on the service, but they can be a significant expense for frequent gamers.
- **Data Usage:** Cloud gaming requires a high-speed internet connection with a large data cap, as the game's video and audio data is streamed over the internet. Gamers who do not have unlimited data plans may incur additional charges from their internet service provider, which can increase the overall cost of cloud gaming.
- **Hardware Requirements:** Cloud gaming requires a device capable of streaming high-quality video and audio content. This means that users may need to invest in new hardware, such as a high-end computer or a gaming console, to access cloud gaming services. This can be a significant expense for users who do not already own compatible hardware.
- **Game Purchases:** Some cloud gaming services require users to purchase games in addition to paying a subscription fee. This can be a significant expense for gamers who want to access a large library of games.

4.1.4 Security Risks

Cloud gaming, like any other online service, has several security risks that users must be aware of. Some of the most common security risks associated with cloud gaming are:

- **Account Hacking:** Cloud gaming services require users to create an account and log in to access their games. If a user's account is compromised, the hacker may gain access to their personal information, game purchases, and in-game progress.
- **Malware and Viruses:** Malware and viruses can infect a user's device and compromise their security. These can be introduced through malicious websites or downloads, and can steal personal information, log keystrokes, and compromise the user's security.
- **Payment Fraud:** Cloud gaming services require users to enter payment information, such as credit card details, to pay for subscriptions or game purchases. If the payment information is compromised, the hacker may be able to make fraudulent charges.

- **Server Vulnerabilities:** Cloud gaming services run on remote servers, which can be vulnerable to cyber attacks. If the server is hacked, the hacker may be able to access user data or even shut down the service entirely.

4.1.5 Quality and Consistency Problems

Quality and consistency are critical factors in ensuring a smooth and enjoyable gaming experience, and they can be affected by several problems related to cloud gaming. Some of the most common quality and consistency issues in cloud gaming include:

- **Video Quality:** The quality of the video stream can be affected by several factors, such as network congestion, server load, and hardware limitations. Low video quality can result in a pixelated or distorted image, which can negatively impact the gaming experience.
- **Latency:** As mentioned earlier, latency can be a significant problem in cloud gaming, as it can cause delays between the user's input and the game's response. High latency can result in a laggy and unresponsive game, which can be frustrating for gamers.
- **Connection Drops:** Cloud gaming requires a stable and high-speed internet connection, and any disruptions to the connection can result in dropped frames or even disconnects from the game. This can be particularly frustrating during critical moments in the game.
- **Inconsistency Across Devices:** Different devices may have different hardware specifications or internet connection speeds, which can result in inconsistencies in the gaming experience across devices. This can be particularly problematic for gamers who want to switch between devices, as they may notice differences in the game's performance.

4.1.6 Lack of Ownership

Cloud gaming raises the issue of lack of ownership, as users do not own the games they play on cloud gaming platforms in the same way as they would with physical copies or downloaded games. This lack of ownership can be a concern for gamers who want more control over their gaming experience and the games they play. Some of the key aspects of the lack of ownership issue with cloud gaming include:

- **Access to Games:** Cloud gaming services require users to pay for access to games, but users do not own the games they play. Instead, they are essentially renting access to the game for a limited time. This means that users cannot play the game if the service is down, if the game is removed from the service, or if they no longer have a subscription.

- **Limited Control:** Users have limited control over the games they play on cloud gaming platforms. They cannot modify the game files, use mods, or make other changes to the game in the same way they could with a physical or downloaded copy.
- **Privacy Concerns:** Cloud gaming services may collect data on users, such as their gameplay habits and personal information. Users may be concerned about the privacy implications of this data collection, especially if they do not own the game and have no control over how their data is used.
- **Dependency on Service Providers:** Users are dependent on the cloud gaming service providers to access the games they want to play. If the service is down or unavailable, users cannot play their games.

4.1.7 Device Compatibility

Device compatibility is a critical factor in ensuring a smooth and enjoyable cloud gaming experience. Cloud gaming services typically require users to have specific hardware and software specifications to access and play games. Some of the key device compatibility issues with cloud gaming include:

- **Hardware Requirements:** Cloud gaming services require users to have specific hardware specifications to access and play games. This may include a high-speed internet connection, a compatible device, and a compatible game controller. Users may need to upgrade their hardware to meet these requirements, which can be expensive.
- **Software Requirements:** Cloud gaming services may require users to have specific software installed on their devices, such as the cloud gaming platform's application or a specific operating system version. Users may need to update their software to meet these requirements, which can be time-consuming.
- **Device Compatibility:** Cloud gaming services may only be compatible with certain devices, such as specific gaming consoles, smartphones, or computers. Users may need to purchase a compatible device to access the cloud gaming service, which can be costly.
- **Performance Issues:** Even if a user's device meets the hardware and software requirements for a cloud gaming service, performance issues may still arise. This may be due to network congestion, server load, or other factors. Users may experience lag or other performance issues, which can negatively impact the gaming experience.

4.2 Cloud Gaming Framework

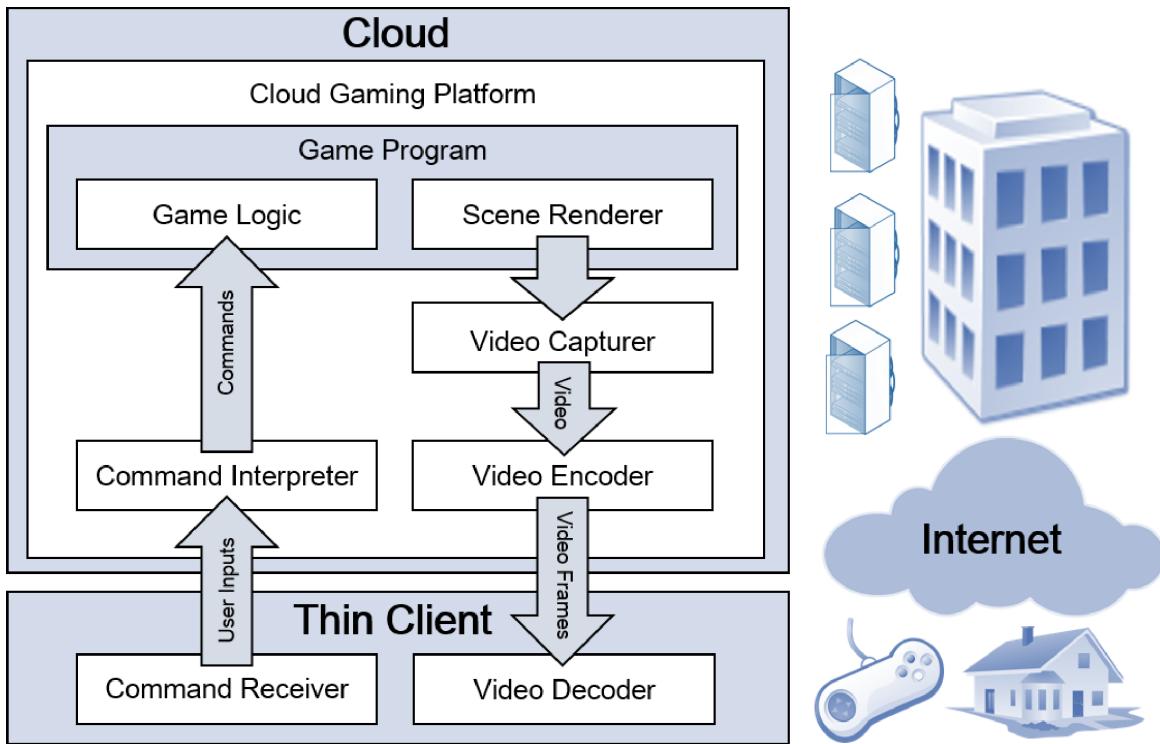


Fig 1. Typical Cloud Gaming Service [2]

Cloud gaming is a complex system that involves multiple layers and components working together to deliver a seamless gaming experience. The following is a general framework of cloud gaming:

- **User Devices:** The user devices are the devices used by the gamer to access the cloud gaming service, such as a computer, smartphone, or gaming console. The devices must have a compatible web browser or application that can connect to the cloud gaming platform.
- **Cloud Gaming Platform:** The cloud gaming platform is the backbone of the cloud gaming system. It consists of a server infrastructure that hosts the games and streams them to the user devices. The platform includes multiple components such as the game library, streaming servers, game servers, database servers, and content delivery networks (CDN).
- **Game Library:** The game library is a collection of games that are available to the users through the cloud gaming platform. The library may include a variety of games from different publishers and developers.
- **Streaming Servers:** The streaming servers are responsible for streaming the game content to the user devices. These servers are equipped with powerful GPUs that are

capable of rendering the game graphics in real-time. The streaming servers use various compression and encoding techniques to reduce the latency and improve the streaming quality.

- **Game Servers:** The game servers are responsible for handling the gameplay logic and communication between the players. These servers are typically located in data centers and are optimized for low-latency and high-performance gaming.
- **Database Servers:** The database servers store the user profiles, game progress, and other relevant data. These servers are critical for providing a personalized gaming experience to the users.
- **Content Delivery Networks (CDN):** The CDN is a distributed network of servers that are used to deliver the game content to the users. The CDN servers are located closer to the users' geographic location, reducing the latency and improving the streaming quality.
- **User Input:** The user input is the actions taken by the user while playing the game. The user input is transmitted to the game servers through the cloud gaming platform, and the game servers process the input to update the game state and provide a real-time response to the user.
- **Game Output:** The game output is the visual and audio feedback provided to the user while playing the game. The output is rendered on the streaming servers and transmitted to the user devices through the cloud gaming platform.
- **Latency Optimization:** Latency is a critical factor in cloud gaming, as it can significantly affect the gaming experience. The cloud gaming platform uses various techniques to optimize the latency, such as data compression, network optimization, and server-side prediction.
- **Business Model:** The business model of cloud gaming can vary depending on the cloud gaming platform. Some platforms charge a subscription fee, while others use a pay-per-play model or a combination of both. The revenue is typically shared between the platform and the game publishers.

4.3 Real World Performance : OnLive

OnLive was one of the first cloud gaming services to gain significant attention in the gaming industry. Launched in 2010, the service promised to revolutionize the way gamers played their favorite titles by allowing them to play high-end games on any device, including low-spec PCs, tablets, and even smart TVs, without the need for expensive hardware. The real-world performance of OnLive was a mixed bag. While the service offered some unique benefits, such as the ability to play high-end games on low-spec

hardware and the convenience of being able to play on any device with an internet connection, it also faced several issues and challenges that prevented it from becoming a mainstream success.

- Latency: One of the biggest challenges facing OnLive was latency. Due to the nature of cloud gaming, where the game content is streamed over the internet, there is always a delay between the user input and the game response. While OnLive attempted to minimize latency through various techniques such as server-side prediction and compression, the delay was still noticeable, especially for fast-paced games.
- Bandwidth: Another issue with OnLive was the high bandwidth requirements. To stream high-quality game content, users needed a stable and fast internet connection, which was not always available in many parts of the world. The high bandwidth requirements also made it challenging for OnLive to scale its service to a global audience.
- Quality and Consistency: The quality and consistency of the gameplay experience on OnLive varied significantly depending on the user's internet connection and the quality of the streaming servers. Many users complained of stuttering, freezing, and other issues that disrupted the gameplay experience.
- Cost: The cost of OnLive was also a significant factor that prevented it from gaining widespread adoption. The service required users to pay a monthly subscription fee, in addition to the cost of individual game titles. This pricing model was not appealing to many gamers, who preferred to own their games outright rather than pay for a subscription.

Despite these challenges, OnLive did have some notable successes in the gaming industry. The service was praised for its ability to run high-end games on low-spec hardware, making gaming accessible to a wider audience. The convenience of being able to play games on any device with an internet connection was also a significant selling point for many users. Additionally, OnLive partnered with several game publishers to offer exclusive game titles, such as the critically acclaimed "Deus Ex: Human Revolution" and "Saints Row: The Third." These partnerships helped to establish OnLive as a serious player in the gaming industry and generated significant buzz among gamers. OnLive also made several significant technical advancements during its time in the gaming industry. The service was the first to introduce cloud-based gaming on a large scale, paving the way for other cloud gaming services such as PlayStation Now, Google Stadia, and Microsoft xCloud. OnLive also pioneered the use of server-side prediction, a technique that predicts the user's input based on the previous game state to reduce latency. However, despite these successes, OnLive struggled to compete with traditional gaming platforms such as consoles and PCs. The latency and bandwidth issues, as well as the high cost, prevented it from gaining widespread adoption among gamers. The service ultimately shut down in 2015, with its assets and patents being acquired by Sony Interactive Entertainment.

5. IMPLEMENTATION

5.1 Setting up the Server

We'll begin by following the Parsec AWS guide.

- If you haven't already, create a Parsec Account and download the Parsec Client
- If you haven't already, create an AWS Account.
- Login to the AWS Console using your root account.
- Go to Services > EC2.
- Choose a region closest to you (from the top right).
- Click Launch Instance.
- Give name or tag.
- Select Windows Server 2019 Base.
- From the next screen, choose the g4dn.xlarge instance type.
- Now click *Review and Launch* and click *Launch*. You'll be asked to create a key pair. Click *Create a new key pair* and give the key a name.
- *Download* the key and keep it somewhere safe. I strongly recommend you create a folder on your system to keep all documents related to your gaming rig. From now on, I'll refer to this as *That Folder*.
- Set 256 Gib gp3 storage.
- Finally, click *Launch Instances*. Now, you'll get a message that your instance was launched successfully.
- Now we'll connect to the instance. With your instance selected, click *Connect*, then switch to the *RDP client* tab, click *Download Remote Desktop File* and add it to *That Folder*. Next, click *Get Password*. If you get a warning about the password not being available yet, close the window and click *Connect* again after a few minutes. Browse to the location of your key file (it should be in *That Folder*). This will display the key contents in the window.
- Click *Decrypt Password*. You will be shown the username (*Administrator*) and your password. Save these somewhere safe, I suggest in *That Folder* at first, but eventually move these to a proper password manager.

5.2 Installing Parsec

We'll now install Parsec via their awesome script, which will also install other stuff to make our life easier, as well as update the GPU drivers.

- Double-click on the RDP file you downloaded earlier, this will open a connection in Microsoft RDP Client, with the username already filled in. Simply paste the password and click *Connect*. You will connect to the desktop of the instance.

- Now click *Start* and type *PowerShell*, click on *Windows PowerShell*. Now we need to get the Parsec setup script. Head on over to the Parsec Cloud Preparation Tool GitHub and run the following commands on powershell:

1. `[Net.ServicePointManager]::SecurityProtocol = "tls12, tls11, tls"`
2. `$ScriptWebArchive = "https://github.com/parsec-cloud/Parsec-Cloud-Preparation-Tool/archive/master.zip"`
3. `$LocalArchivePath = "$ENV:UserProfile\Downloads\Parsec-Cloud-Preparation-Tool"`
4. `(New-Object System.Net.WebClient).DownloadFile($ScriptWebArchive, "$LocalArchivePath.zip")`
5. `Expand-Archive "$LocalArchivePath.zip" -DestinationPath $LocalArchivePath -Force`
6. `CD $LocalArchivePath\Parsec-Cloud-Preparation-Tool-master\ | powershell.exe .\Loader.ps1`

- You will be asked whether to configure automatic Windows login. Type *Y* to accept this. You will be asked for your username and password, which you placed earlier in *That Folder*.
- The script will now install a bunch of stuff, including DirectX 11, Chrome, Parsec and 7zip.
- When Parsec is installed, you'll see the Parsec client - go ahead and login. The login won't work at first, but you'll receive an e-mail asking you to confirm your location. Click on *Approve your new location* once you get the email, then login to Parsec on your gaming server.
- The Parsec script will now continue with the GPU updater tool. You'll be prompted to provide an Access Key and Secret. To do this, copy the link that is shown in the prompt, and paste it in your browser.
- Now click on *Access keys (access ID and secret access key)* and click *Create New Access Key*. Click *Download Key File* and add this to *That Folder*. Then click *Show Access Key* - this will show the access key and secret access key. Copy the first one and paste it in the PowerShell window, pressing *Enter*. Then copy the secret key and also paste it in PowerShell, followed by *Enter*. You'll be asked whether to save the access key - type *y*. Answer the next two questions with *y*.
- When the driver is installed, you'll be advised whether or not you need to reboot.
- If you rebooted, use the steps outlined in step 1 to re-connect to your system via RDP.
- Download Xbox controller for remote controller on server from the given link: <https://www.techspot.com/drivers/driver/file/information/11300/>
- At this point you should configure Parsec (double-click the Parsec icon on your desktop).

- At this point, the Parsec client on your system should show the server as available.

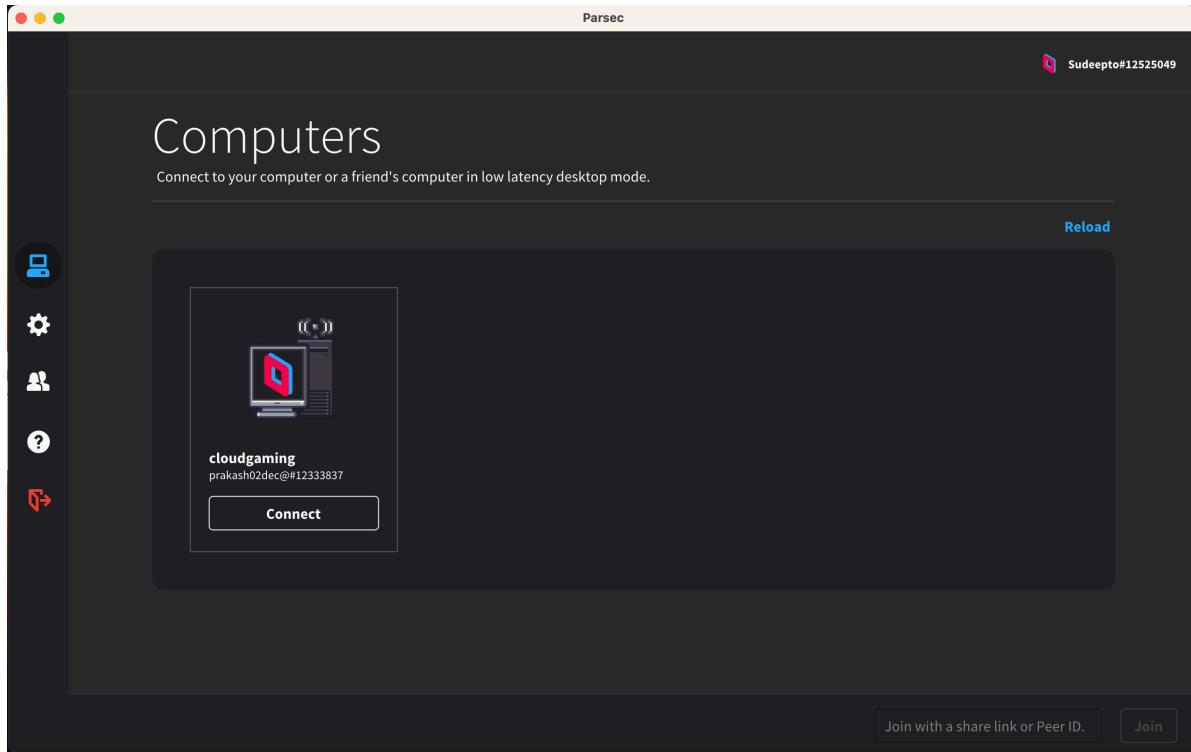


Fig 2. Parsec client application

- Optionally, double-click on the *Setup Auto Shutdown* icon on your desktop. This will shutdown your system after a number of minutes if its idle, just in case you forget to do it yourself. When prompted, I set it to 45 minutes.
- Now, disconnect from your server (i.e. close the RDP window), and connect to the server via Parsec instead. You're now ready to game! If you're not interested in the automation stuff, you can now skip to the Gaming section.
- Now download your favorite video game digital distribution service. We have installed steam and then downloaded the Fall Guys to play on cloud server.

6. RESULTS AND DISCUSSION

Our results demonstrate the potential of cloud gaming for providing a high-quality and seamless gaming experience. However, it is important to consider the potential drawbacks and limitations, particularly in terms of internet connectivity and cost.

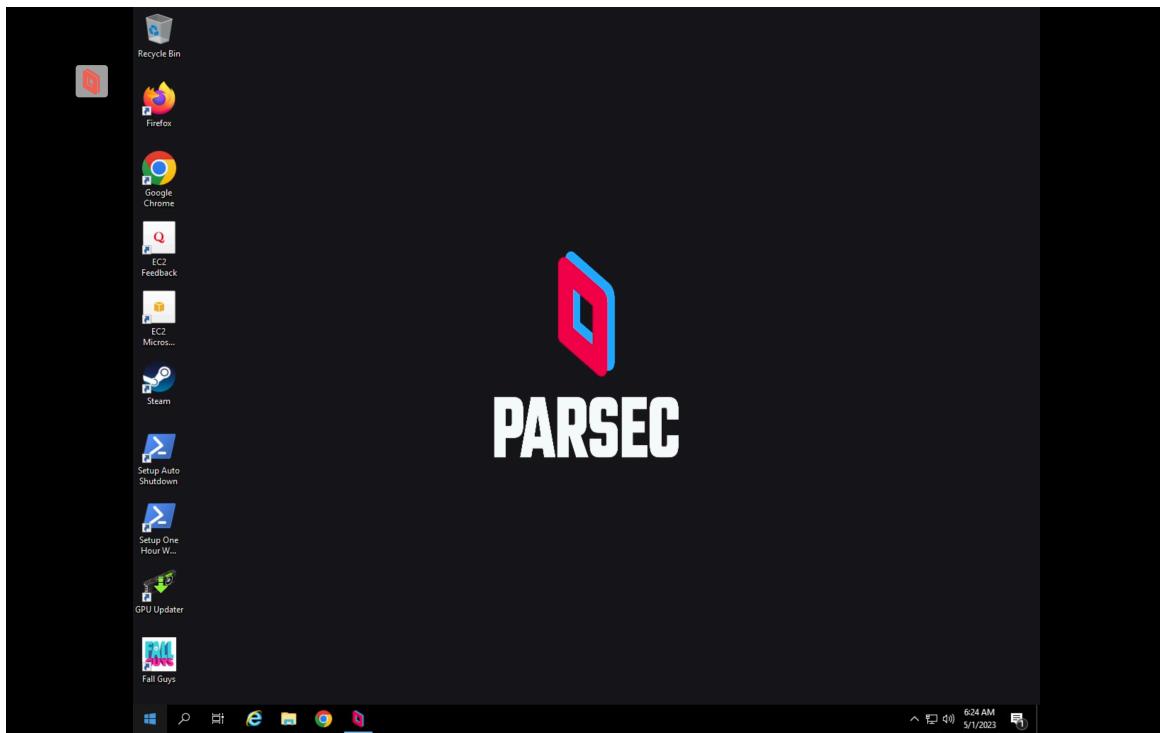


Fig 3. Windows server 2019

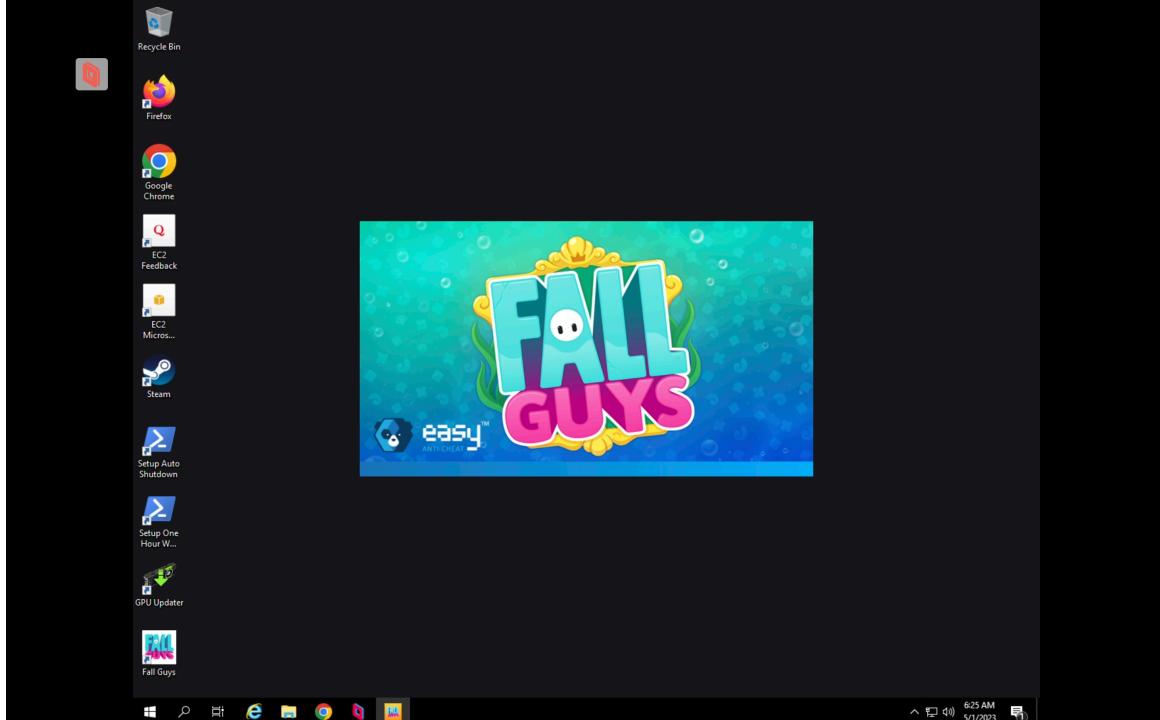


Fig 4. Fall Guys game starting on Parsec service



Fig 5. Fall Guys game running on Parsec service

7. CONCLUSION AND FUTURE WORK

Cloud gaming is an emerging technology that has the potential to revolutionize the gaming industry. The ability to stream games from the cloud eliminates the need for powerful hardware, enabling gamers to play high-end games on low-end devices. Additionally, cloud gaming provides gamers with the ability to play games on multiple devices without the need to purchase multiple copies of the game. Our study focused on hosting Fall Guys game on AWS, and the results showed that AWS is a viable option for cloud gaming. The latency was low, and the game ran smoothly without any major issues. However, there were some minor issues, such as occasional lag and reduced graphics quality, which could be addressed through further optimization and tuning of the cloud infrastructure. Cloud gaming has the potential to provide gamers with a more convenient and accessible gaming experience. However, there are still some challenges that need to be addressed, such as latency, network bandwidth, and optimization of cloud infrastructure. Additionally, there are concerns about data privacy and security, as cloud gaming requires transmitting sensitive data over the internet. As cloud gaming continues to evolve, there are many research opportunities and areas for further development. For example, there is a need for better tools and techniques for measuring and optimizing latency in cloud gaming systems. Additionally, there is a need for better data privacy and security measures to protect gamers' personal information.

As a future work we are planning to integrate cloud gaming with metaverse. Integrating cloud gaming technology with the metaverse is a logical step forward for the gaming industry. Metaverse is a virtual world that allows users to experience a completely immersive environment with their digital avatars. The metaverse concept is not new; it has been around since the early days of video gaming. However, with the advancements in technology and the increasing demand for immersive experiences, the metaverse is gaining more attention from the gaming industry. One of the key advantages of integrating cloud gaming technology with the metaverse is that it will provide users with a seamless experience. With cloud gaming, the games can be streamed to the users' devices without requiring them to download any software or install any hardware. This means that users can access the games from anywhere and at any time. This is particularly important for the metaverse as users can access the virtual world from different devices, including smartphones, tablets, and laptops. This will make the metaverse more accessible and attractive to a wider audience. Another advantage of integrating cloud gaming technology with the metaverse is that it will provide users with a better gaming experience. The metaverse is all about immersion, and cloud gaming can enhance this experience by providing high-quality graphics and fast response times. With cloud gaming, users can play games with high-resolution graphics and fast frame rates, which will make the games feel more realistic and immersive. Integrating cloud gaming technology with the metaverse will also create new opportunities for game developers. With the metaverse, game developers can create games that are specifically designed for the virtual world. This will require a different approach to game development as the games will need to be designed for a virtual world, where players can interact with each other and the environment. With cloud gaming, game developers can leverage the power of the cloud to create games that are scalable, flexible, and accessible to a global audience. In addition, integrating cloud gaming technology with the metaverse will open up new revenue streams for the gaming industry. With cloud gaming, users can subscribe to different gaming services and access a wide range of games. This will provide the gaming industry with a recurring revenue stream, which can be used to fund the development of new games and technologies. However, there are also some challenges associated with integrating cloud gaming technology with the metaverse. One of the main challenges is ensuring that the games are optimized for the virtual world. The metaverse is a complex environment, and game developers will need to ensure that the games are optimized for the virtual world to provide users with a seamless experience. Another challenge is ensuring that the games are secure. With cloud gaming, the games are streamed to the users' devices, which means that the games are vulnerable to hacking and other security threats. Game developers will need to ensure that the games are secure to protect the users' data and prevent unauthorized access. In conclusion, integrating cloud gaming technology with the metaverse is an exciting development for the gaming industry. It will provide users with a seamless and immersive gaming experience and create new opportunities for game developers and the gaming industry as a whole. However, game developers and the gaming industry will need to overcome some challenges to ensure that the games are optimized for the virtual world and are secure. With the right approach and investment, integrating cloud gaming technology with the metaverse has the potential to transform the gaming industry and provide users with a new level of gaming experience.

8. REFERENCES

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