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Cloud Gaming: A Survey on Future of Gaming

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Abstract: *Cloud gaming is the new era of gaming as it delivers amazing gaming experiences to gamers irrespective of time and place. In cloud gaming, there are powerful gaming machines in data centres at server side and all the gaming software run on these machines.*

As a response to the input received from users, these machines generate rendered game scenes which are streamed back to the gamers. Gamers use their own devices to interact with the games. Gamer's devices need not to be very powerful to handle hardcore gaming, just strong enough to handle streaming of online videos.

More and more gamers are joining the league of cloud gaming as it is getting popular day by day however, it also faces some challenges.

In this paper, we are going to survey the cloud gaming platform, issues, current commercial services, future research options and get familiar with the recent developments in this area.

Keywords: *Clouds, Data Centres, Rendered Game Scenes.*

I. INTRODUCTION

Cloud gaming completely changes the way we look at gaming today. This is entirely new concept different from the traditional gaming we used to do so far. In cloud gaming, highly computational hardcore games run on the servers and the rendered game scenes are streamed to devices of gamers.

Traditionally, performance of game solely depends on the processor inside the gaming machine. But with cloud gaming, gaming machines with powerful processors are installed at server side, far away from us. We stream games, just like we stream YouTube or Netflix videos.

These videos are generated in response to the inputs provided by gamers. Every time gamers press a key for their characters, an input is generated and sent to a remote server. As a response to this input new video frame is generated and streamed to gamers that shows them the result of their input.

Many startup companies started offering cloud gaming services in the late 2000's, such as OnLive [1], Gaikai [2], G-cluster [3], and Ubintus [4]. Soon some of the world famous companies from gaming field realized the potential of the cloud gaming and started investing in the field of cloud gaming. Regarding to this, Broadmedia Corporation [5] purchased G-cluster in July 2016 while Sony [6] purchased Gaikai at \$380 million [7]. Sony also purchased patents of OnLive on April 2, 2015, and discontinued all its services on April 30, 2015 [8]. A report from Strategy Analytics [9] indicated that the users of cloud gaming increased from 30 million in 2014 to 150 million in 2015. Global Forecast to 2024 regarding Cloud Gaming Market [10] states that the cloud gaming market is expanding at a compound annual growth rate of 59.0% and the its value is estimated to reach USD 3.1 billion by 2024, from USD 306 million in 2019. Launch of the 5G network, continuous growth of gamers on mobile platform and increase in the number of internet users are the main reasons behind the sudden growth of cloud gaming market. Today users of smartphone have dominated any other platform users so it creates a huge opportunity for gaming industries and in such a scenario cloud gaming seems a perfect option to provide high quality games on smartphones.

II. ARCHITECTURE AND FUNCTIONING OF CLOUD GAMING

A. Cloud Gaming Has Two Components On Server Side

- 1) **Game Logic:** It receives the commands from Command Interpreter and converts them into in-game interactions.
- 2) **Scene Renderer:** According to interactions generated by game logic, scene renderer creates the game scenes.

B. Thin Client side of Cloud Gaming also has two Components

- 1) **Command Receiver:** It receives input directly from the users and passes it to the Command Interpreter.
- 2) **Video Decoder:** It decodes the video frames received from the Video Encoder and displays it on screen.

C. Server And Thin Client Communicate With Each Other Via Internet

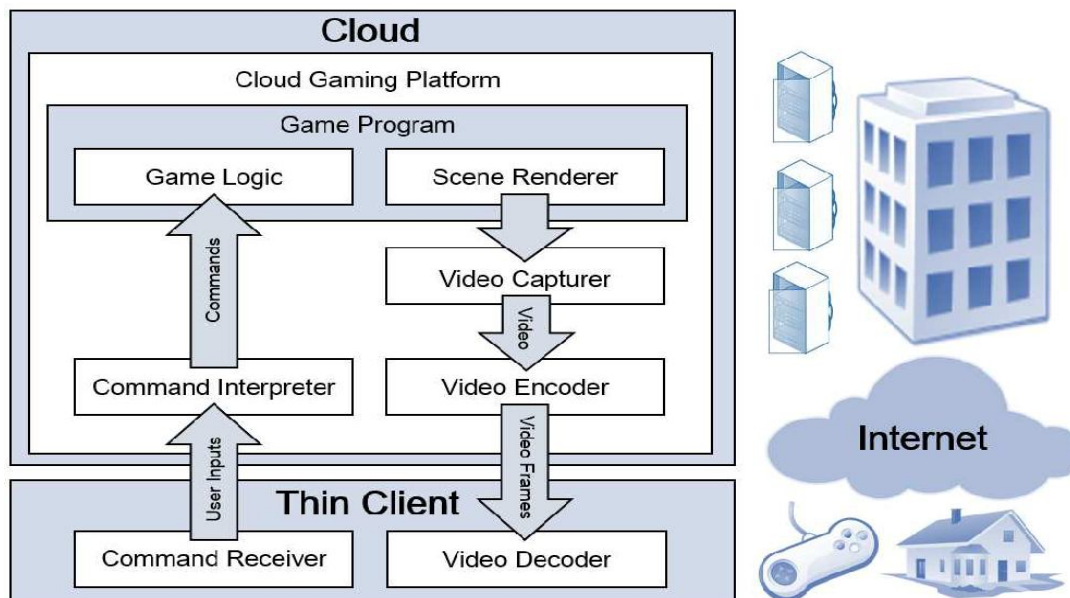


Figure 1: Cloud Gaming Architecture

Following are the steps that occur repeatedly during a game session:-

- 1) **STEP 1:** The user uses keyboard, mouse or controller to provide inputs while playing games. Command Receiver receives these inputs and send them to Command Interpreter present at server side.
- 2) **STEP 2:** Command Interpreter interprets user inputs into commands and transfers them to the game logic which further converts them into in-game interactions.
- 3) **STEP 3:** Interactions generated by game logic are sent to the Scene Renderer, which creates game scenes accordingly.
- 4) **STEP 4:** The Video Capturer captures the game scenes generated by Scene Renderer and sends the video to the Video Encoder which further generates the video frames.
- 5) **STEP 5:** Now these video frames are streamed back to thin client via internet.
- 6) **STEP 6:** The Video Decoder present at the thin client, decodes these video frames and displays them to the gamers.

III. ADVANTAGES OF CLOUD GAMING

The cloud gaming provides several advantages to gamers, game developers, and service providers.

A. *Advantage to Gamers*

- 1) Ability to access the games irrespective of time and place
- 2) Rent or purchase games whenever needed
- 3) Need not to regularly upgrade their hardware
- 4) Some new unique features introduced such as freedom to change gaming device anytime during game sessions, and sharing recorded game sessions among friends.

B. *Advantage to Game Developers*

- 1) Allows them to work on a single platform, which will reduce the testing and porting costs
- 2) No need of retailers in between developers and gamers, which further leads to higher profit margins
- 3) Cloud gaming has increased developer's reach to more gamers
- 4) In cloud gaming gamers don't need to download games on their systems, this avoids piracy of games

C. *Advantage to Service Providers*

- 1) Cloud gaming has created entirely new market for service providers
- 2) Increase in demand of cloud resources
- 3) Scope for some new creative tools for remote execution of cloud applications

IV. CHALLENGES

There are also some challenges that cloud gaming has to overcome with time. Some of the issues are as follows:-

- 1) *Latency*: Latency is the delay in overall process which can occur in following situations:-
 - a) When user sends commands to the server.
 - b) When game scene is generated and encoded.
 - c) When the game scene is streamed back.
- 2) *Internet Connection*: Cloud gaming requires a fast internet connection for its proper functioning, which may not be available to every user. A poor internet connection can cause delay in game scenes.
- 3) *Encoding-Decoding Algorithms*: The encoder encodes video and generates video frames, which is further decoded by video decoder and finally game scenes are displayed to gamers. If encoding-decoding algorithms are not efficient then low-quality game scenes may be created.
- 4) *Security and Privacy*: Online services require lots of data to be stored at cloud such as user's credential record, their games and progresses. This huge amount of data must be protected from malware and hackers, otherwise users will lose all the data.
- 5) *Lack of Resources*: Cloud gaming lacks proper resources currently as it is the starting phase of cloud gaming but soon this problem will be vanished due to involvement of more investors and skilled workers.

Over time these challenges can be overcome with more research and development in the field of cloud gaming.

V. VARIOUS QOS (QUALITY OF SERVICE) PARAMETERS

Quality of Service parameters can be further improved in future with new research and developments in field of gaming technology. This will help in providing great experience to gamers, while playing games.

Some of these parameters are following: -

- 1) *Traffic Characteristics*: Bandwidth usage and packet rate in a gaming session are referred as traffic characteristics. Bandwidth usage should be less while packet rate should be very high.
- 2) *Latency*: Latency matters a lot for better performance of cloud gaming Services. Latency is the delay in overall process. Latency shows how responsive a system is. Lower is the latency value, better is the performance.
- 3) *Graphics Quality*: Graphics quality plays very important role in providing a better quality experience to gamers. Graphics quality is determined by the quality of the content streamed back to gaming devices. It is also depended on the changes in quality over varying network conditions. Streaming quality is generally measured in frame rate (FPS), while Graphics Quality is measured in Peak Signal to Noise Ratio or Structural Similarity Index Method metric.
- 4) *Network Delay (ND)*: It is the delay in user's input to reach the server and video output streamed back to the user. This delay can cause lag in the gameplay.
- 5) *Processing Delay (PD)*: It is the delay in time taken by the server to receive and process the user's command. It also includes time to encode and packetize the current frame for the client.
- 6) *Game Delay (GD)*: It is the delay in processing the user's command and then generating the corresponding game frame by the game software.

VI. COMMERCIAL CLOUD GAMING SERVICES

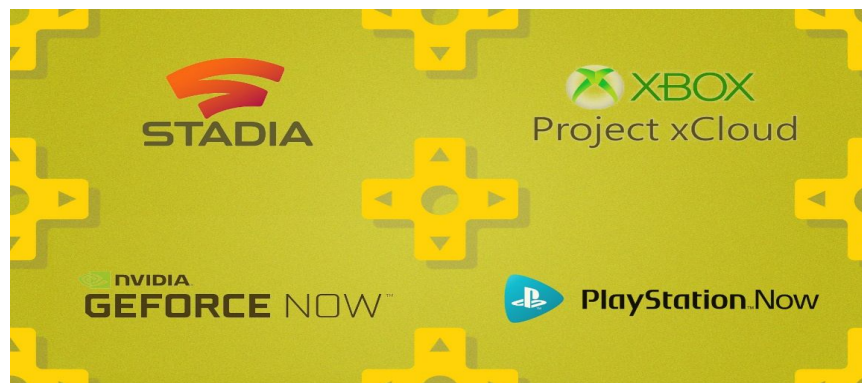


Figure 2: Commercial Cloud Gaming Service Providers

	Google Stadia	Microsoft Project xCloud	NVidia GeForce Now	Sony PlayStation Now
Price	\$10 per month	In Development	\$5 per month	\$5-10 per month
Games	30+	50+ in beta	1,500+	650+
Platforms	Chrome cast Ultra, browser, smartphone	Smartphone and tablet in beta	NVidia Shield TV, browser, smartphone	PS4, Windows PC

Table 1: Comparison of Major Commercial Cloud Gaming Services

A. Google Stadia

- 1) *Working:* Google Stadia [11] provides service for streaming cloud games to users on their TVs, computers and smartphones. Players can purchase games from online stores, which can be directly accessed from Google cloud servers without downloading on their systems. Gamers can use any controller, but currently the compatibility with wireless controllers is not working properly, its performance depends on the systems.
- 2) *Price:* Access to Google Stadia games requires a Google Stadia Pro subscription at a cost of \$10 monthly. Currently \$120 Stadia Premiere Edition is the only method to get this. This also offers us a pleasing experience by providing access to 4K resolution. Although, Stadia offers a free 1080p resolution streaming, but users still need to buy games from online store, which may cost around \$20 to \$60.
- 3) *Advantage and Disadvantage:* One of the major advantage of Stadia is that it is totally platform independent. We can use it on a TV, computer or smartphone etc. We can simply save our games on one device, then pick them up on another device within minutes. If we can provide a proper internet connection that is up to 15 Mbps, Stadia can perform pretty decent. Along with these pros, it also has some cons such as PC and smartphone platforms compatibility is still an issue to resolve, as it lacks wireless controller and full-UHD resolutions support. It also lacks parental control, which is a necessary need from parent's point of views. Graphics quality is still not very stable and smooth during streaming of the games.
- 4) *Verdict:* Stadia can be a decent choice for those who have stable and fast internet connections but they lack dedicated gaming system in their homes.

B. Microsoft Project xCloud

- 1) *Working:* Microsoft's xCloud [12] project is a service offered under cloud gaming, which allows us to stream Xbox games on a mobile phone or tablet. This project is still under development, so it is too early to say anything about its proper functioning. The beta version is already rolled out for user's testing, but this version can't represent the full strength of the final product. So we have to still wait a few more months to test its final stable performance.
- 2) *Price:* Actual pricing details are not disclosed yet by Microsoft. Its beta version is free to test but Microsoft will definitely charge for its final version service. Currently Microsoft charges \$10 for a month to use Xbox gaming service. It will really be a good news for gamers, if Microsoft charges somewhere around this price point for xCloud services too.
- 3) *Advantage and Disadvantage:* Since xCloud is still in its development phase, currently it is hard to point out any advantage or disadvantage of xCloud service. While other companies has already launched their final versions in the market, Microsoft is still in its beta phase, it may be the biggest con of it.
- 4) *Verdict:* Project xCloud can be the strongest of all cloud-gaming services with help of various potential Microsoft technologies.

C. NVidia GeForce Now

- 1) *Working:* GeForce Now [13] is a cloud gaming service offered by NVidia that streams our games on laptop, computer, tablets and smartphones etc. Gamers don't need to buy games in GeForce Now unlike other cloud service providers instead, they can link their GeForce Now account with their existing libraries such as Steam, UPlay and Epic. Now they can start playing with their previously saved progress of games.
- 2) *Price:* Currently it is free to play games on GeForce Now, but the limitation is that all of the sessions are just for one hour and users also may have to wait in a queue with other players for next session. If anyone wants to play more than one hour they can buy Foundation tier which will cost around \$5 for a month. This provides them game session of six hours. Another benefit of payment is that the player gets the priority over other players in the queue.

- 3) *Advantage and Disadvantage:* If gamers already own a lot of games on Steam and similar platforms, they can get incredible game selection on GeForce Now. Even if NVidia stops the service of GeForce Now in a few years, gamers won't lose any of their games. Performance is amazing and smooth, if there is a stable internet connection with 10 Mbps speed or more. It can easily run on either a computer or a smartphone. There are also some disadvantages related to GeForce Now such as one hour sessions for nonpaying subscribers does not seem fair enough for heavy gamers, and even paid subscribers are getting just 6 hour sessions which does not seem like a justice to paid users. Also to play games on TV, users must have an expensive NVidia Shield streaming player at their home.
- 4) *Verdict:* GeForce Now has the potential to be the best cloud game service provider if NVidia can overcome cons mentioned above.

D. Sony PlayStation Now

- 1) *Working:* Among all service providers, Sony PlayStation Now [14] is the oldest and is available only on PC and PlayStation4. Even it has the most number of games available among all service providers, which is currently around 600 games. Players can stream their games directly from Sony's servers. They can even download these games to a PS4. By paying some monthly charge, users get chance to access as many as games as they want. Currently smartphones are not supported, and controller compatibility is also limited.
- 2) *Price:* PlayStation Now provides 3 subscription plans. First one charges a fee of \$60 per year, second plan charges \$25 as subscription fee per three months while third plan charges \$10 as subscription fee per month. The first plan seems quite reasonable choice as we can save a lot by paying in advance. Once users stop paying, their collection of games disappears as all the games they play, are on cloud and can be accessed only by paying some money to service providers.
- 3) *Advantage and Disadvantage:* The biggest advantage with PS Now is that it has largest library of games currently available in market. Since, a lot of publishers has published their games for PS4, so there are plenty of contents for all age group fans, and casual as well as hardcore gaming fans. It only charges \$60 as subscription fee per year which is quite cheaper than most of its competitors. The streaming also works pretty well, if the users have a stable and fast internet connection. The main problem with PS Now is that it mainly supports PS4 game console, which is pretty expensive. Consoles provide far better gaming experience in comparison to any other platforms. This way Sony is making sure that its PlayStation does not get out of the market. Surely these games can be played on a PC with PS3 or PS4 controller, but the experience is not good as compared to PS4. Also in near future there doesn't seem any plans for smartphone or browser compatibility.
- 4) *Verdict:* PS Now is very popular among the fans of PlayStation, as it provides awesome experience on PlayStation platform. But since it is available on fewer platforms only so it seems, it may not be a fair choice for smartphones and TV users. Sony urgently needs to take care of TV and smartphones users in order to capture the gaming market else it will end up far behind than its competitors.

VII. CONCLUSION

Cloud gaming is getting popular day by day as it is providing a gaming experience to the players that they have never experienced before. However, lots of improvement are still required to be done for providing a far better experience to gamers. In this paper, we have discussed the cloud gaming architecture and it's functioning, issues related to cloud gaming and we also have compared some of the giant commercial cloud gaming service providers. We have seen some of the quality of service parameters also in cloud gaming which can be implemented to further improve the overall experience. Today cloud gaming has extended itself to many platforms thus making itself available to a very large number of users. This creates a huge opportunity for cloud gaming market. There are lots of scope for new and creative ideas in this field which can change the way games are played these days and further improve the overall gaming experience.

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