



THE ROLE OF CLOUD IN THE EVOLUTION OF GAMING

¹Mayank RAJ, ²Shivam GUPTA, ³Biresh KUMAR, ⁴Pallab BANERJEE

¹B.Tech Scholar, ²B.Tech Scholar, ³Assistant Professor, ⁴Assistant Professor,

¹Computer Science and Engineering

¹Amity University Jharkhand, Ranchi, India

Abstract: Online gaming has become a primary source of entertainment for hundreds of thousands of people globally. The way they impact lives can never go unnoticed. In recent years with the arrival of multiplayer games, the number of players has grown significantly. This rise in the gaming community requires steady and robust servers capable of handling multiple players at once. This requires the gaming servers to be accessible at all times and largely scalable which is not possible with on-premise servers. Therefore, the games are hosted on the cloud for maximum availability. This paper focuses on the timeline and evolutionary changes that this industry went through and how it can shape the future of online multiplayer gaming.

Index Terms - Cloud Computing, Online-Gaming, Gaming-Servers, Survey

1. Introduction:

The dawn of online gaming was seen in the early 1970s with the arrival of packet-based computer networking. The very first online game MUD1 was initially released on the internal network before getting launched on ARPANet in 1980. Later, many online games followed it in the next decade. The first commercial game to hit the market in 1984 was the Island Of Kesmai followed by MSX Links in 1986, Air Warrior in 1987, and there emerged a whole new era of online gaming. [3], [5], [9]

Computers and the internet were gaining popularity during that time and people expected more from it. With launch of such games, new possibilities opened up for people and a large number of people wanted to experience the change. It was only a matter of a few years that these online gaming platforms were flooded with users. This called for dedicated gaming servers that could run every second of 365 days without failure. [15], [19], [54], [91] Many gaming companies were facing issues with on-premise servers due to an exponential increase in the number of players joining day-after-day. With the launch of games like Counter-Strike and Starcraft, the online gaming industry was revolutionized to a huge extent. Gaming no longer was a source of entertainment but it had become a huge industry. Every player was important for a gaming company. But still, global connectivity was a challenge. It was in the year 2000 when cloud computing started popularity and with its introduction, multiple industries saw an opportunity to harness its potential including the gaming industry. [1], [10], [13], [28]

2. Literature Survey:

With the inception of 2000, multiple companies started working on online games with global servers. The first one to gain popularity was World Of Warcraft in 2004. It was a Massive Multiplayer Online (MMO) that remained at the top for most of the decade. Later, it was followed by a different genre of games called Multiplayer Online Battle Arena (MOBA) games like Dota, Heroes of Newerth, League of Legends, and Dota 2. [6], [11], [78]

Cloud was parallelly growing as well. In 2006, Amazon launched its first cloud service called Elastic Compute Cloud (EC2), followed by Google Cloud Platform in 2008 and Microsoft Azure in 2010. [20] The first dedicated gaming cloud was launched in 2010 by OnLive which was later acquired by Sony Entertainment. OnLive was the first to introduce Gaming as a service. By this time an entirely game format has gained popularity called the Battle Royale. After some time, the first groundbreaking game was launched on AWS in 2017 called Player Unknown Battlegrounds which was very soon started to use Microsoft Azure's support as well. It was in the format of Battle Royale. Within a year it gained an enormous amount of users globally. Later PUBG was followed by Fortnite, Apex Legends, and Call of Duty. [34], [51]

Timeline comparison:

Year	Cloud	Online game
1960	Introduced	N/A
1978	N/A	MUD introduced
1980	N/A	Launched to ARPANet
2000	Gained Popularity	Counter Strike, Starcraft etc.
2004	N/A	MMO format introduced
2006	Amazon EC2	MOBA format introduced
2008	Google Cloud Platform	N/A
2010	Microsoft Azure & OnLive introduced	World of Warcraft tops MMO
2015	Sony acquired OnLive	N/A
2017	AWS hosted PUBG	Battle Royal format introduced
2017	Microsoft hosted PUBG	PUBG started to use Azure for support

Table 1: Timeline showing key activities in gaming and cloud development

3. Comparison between Cloud environments:

The details below are some of the performance metrics comparisons between top services of four cloud service providers including Microsoft Azure, Amazon Web Services, Google Cloud Platform, and IBM. The performance metrics included Downlink and Latency. For most parts, IBM proved to be faster and more reliable than its competitors followed by Microsoft Azure, AWS, and Google cloud. To the surprise, Google Cloud Platform was slower than its competitors in terms of its CDN (Content Delivery Network).

a. Microsoft Azure:



Fig 1: Latency and Downlink speed test for Azure from cloudharmony.com

b. Amazon Web Services:



Fig 1: Latency and Downlink speed test for AWS from cloudharmony.com

c. Google Cloud Platform:



Fig 1: Latency and Downlink speed test for Google from cloudharmony.com

d. IBM:



Fig 1: Latency and Downlink speed test for IBM from cloudharmony.com

4. Comparison between dedicated gaming servers of the Three cloud giants:

- a. **Agones from Google and Ubisoft:** Agones is an open-source server that utilizes the Kubernetes engine for high-performance GaaS (Gaming as a service) delivery. It was jointly created by Google and Ubisoft for high-performance gaming services. It can easily be monitored and supports almost every gaming engine. Because it runs on a Kubernetes cluster, it supports containerized deployments which makes it easy to manage and makes it highly robust. [43], [65]
- b. **Azure Service Fabric from Microsoft:** It is a distributed system that supports containerized deployments and microservices architecture. It runs on a very dense cluster of machines that makes it airtight against failures, It supports stateless and stateful services as well. Its automatic scalability feature makes it robust against the sudden surge of service users. [29], [43]
- c. **GameLift from Amazon:** As a part of Amazon web services, GameLift is extremely lightweight and highly responsive in terms of its latency. It claims to have a global latency of 45 ms with 100 ms matching time which is fast for gamers looking for competitive games. [7], [43], [56]

Company	Service Name	Latency	Matching Speed	Reduced Compute Cost
Amazon	GameLift	45 ms	100 ms	70%
Microsoft	Azure Service Fabric	128-150 ms	>150 ms	Depends on service uptime and algorithm
Google	Agones	100-150 ms	>150 ms	Depends on service uptime and algorithm

Table 1: Comparison between response time of cloud platforms

5. Market capture:

Online games have captured the market with their endless captive and immersive gameplay experience. For instance, the world’s topmost mobile game PUBG Mobile has seen a significant increase in its revenue since the date of release. Similar has been the scenario with Fortnite. These games were of a similar format but had a huge player base giving tough competition to each other. [7], [17]

While PUBG mobile saw a sell-out of Royal Pass worth \$22 million after its release in June 2019. It was 195% more than what it used to earn before. Now, approximately \$650,000 is spent worldwide for a royal pass in recent years. This has boosted the revenue as much as over 350% of what it used to make in its early days. Fortnite also made a fortune worth \$2.4 billion in 2018. Online games are expected to surpass the profits of offline game GTA by Rockstar games which made just over 5 billion dollars. The production cost of GTA was just a fraction of it.

No matter how good a game performs online, it always requires the maintenance of servers, machine uptime costs need to be paid. The table following best differentiates between online and offline games.

Metric	Online games/ Cloud hosted	Offline games
Infrastructure	Dedicated gaming server	User's device
Update Method	Over the air	Not possible
Production cost	Varies game to game	Varies game to game
Maintenance cost	Depends on API requests and requests per 100ms	Almost none
Error handling	Runs on error budget	Crash logs
Progress Tracker	Linked to gaming account	Saved as file system
Multiplayer	Humans	Bots

Table 2: Comparison between online and offline games.

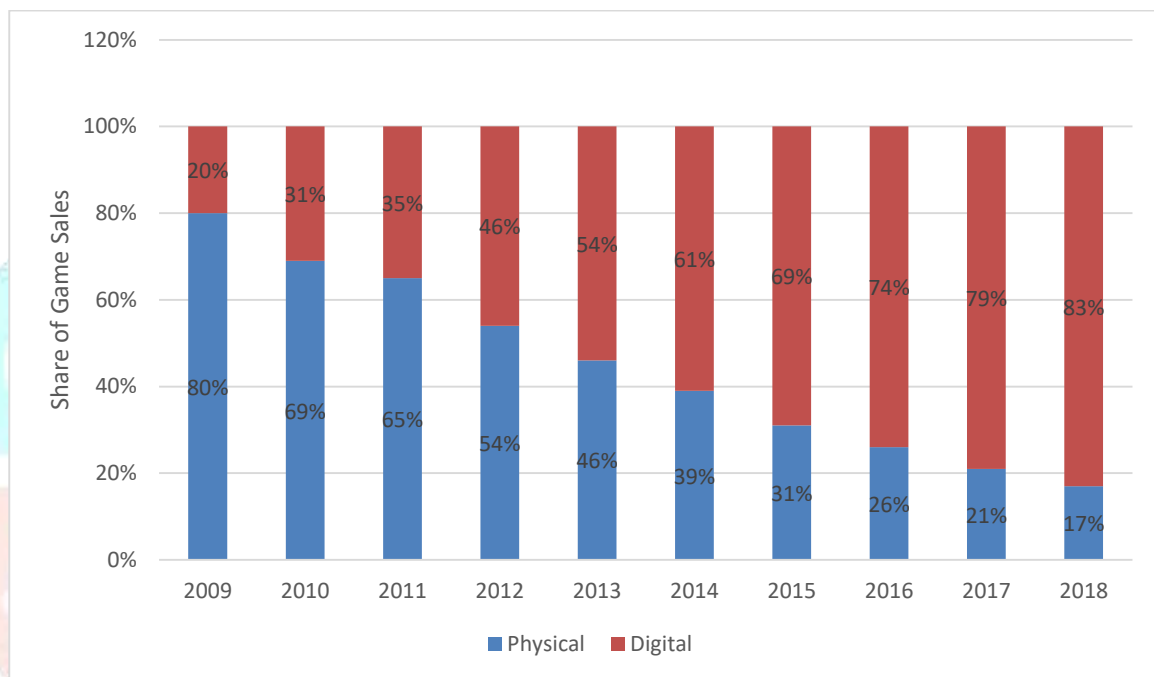


Fig 5: Monetary gain by online and offline games.

6. Quality of Service and Quality of Experience Evaluations:

Quality of service is the measure of performance and ease of availability of a cloud gaming platform.

The better the QoS, the easier it becomes to maintain and deploy updates. There can be multiple dimensions to QoS:

1. **Energy Consumption:** Simulation of gaming environments is a daunting task for physical devices, which is why, the server, needs to be smart enough for the game to run smoothly on a device. The rendering time of surroundings, player interaction with it, and the other players need to be done in a very short period. This requires an adequate amount of energy as well as good network strength which is discussed as the second dimension. It has been observed that physical networks consume 12-38 % more power as compared to games running on the cloud. [89], [93], [94]
2. **Network Speed:** Latency is the term commonly used to identify the strength of the network, lower the latency, faster the render and response time for the player. What is often referred to as texture glitch is a result of render failure due to service unavailability or network's poor strength? Higher latency can also lead to a frame drop. Anti Aliasing in combination with poor latency can add up to irritable gaming experience. Data consumption also depends upon the type of game and its graphics quality the player selects. [49], [60], [97]

However, these two metrics depend on the player and thus experience can vary for them based on their region and choice of Internet Service Provider. The thing that needs to be consistent is the infrastructure of the game hosted on the cloud. The metrics used for this evaluation are:

3. **Cloud Infrastructure:** It can be checked for its efficiency by its Service Level Agreement availability. Usually dedicated gaming cloud servers require 99% availability and it needs smart allocation techniques to output a robust performance. [49], [66], [91]
 - a. **Resource Allocation:** It refers to the number of resources in terms of processing power required to compute gaming requests. For gaming, resource utilization is high and thus the game requires a high amount and availability of

resources. Cloud platforms like that of Google, Microsoft, Amazon, Tencent, and other top providers have high availability and scalability which acts as failsafe even when the number of requests surges dramatically. [88], [86], [97]

- b. **Distributed architecture:** Since a centralized server cannot flex globally, it requires a distributed architecture of the cloud and geographically distinct servers to perform efficiently. The concept of edge processing comes in handy here where the nearest server resolves the request. This makes gaming smoother and requests handling more efficient. The architecture has evolved from monolithic to microservices in recent years. [49], [86], [97]

4. **Communications:** It refers to the request and response between the client and the server. The major drivers of smooth and faster communication are:

- a. **Data Compression:** The data can't be transmitted directly. It needs some sort of compression to be carried by the packet over network. For faster rendering, the payload needs to carry as much information as possible without much delay. Proper compression makes it easier to send high amount of data in less size. Compression in of three types:
 - i. Video (encodes 2D rendered videos)
 - ii. Graphics (encodes 3D textures and 2D graphics)
 - iii. Hybrid (enables both video and graphics compression) [6], [26], [50]

7. Types of dedicated game servers:

- a) **Real-Time Simulations:** They are implemented as endless loop with a goal to complete end it with a short period of time. UDP is followed in such servers.
- b) **Session or Match Based:** It is very common is MOBA format games where players are matched to each other to play simultaneously.
- c) **Massive Multiplayer persistent worlds:** Is preferred server for MMO format games. It follows a complex design to store the state of the world for various players. The changes in the environment of player must not be reflected to another player in other session.
- d) **Request/Response based servers:** This architecture requires high availability of resources for anytime request processing. Typically every game is kind of request response model.

Common Architecture for Gaming server:

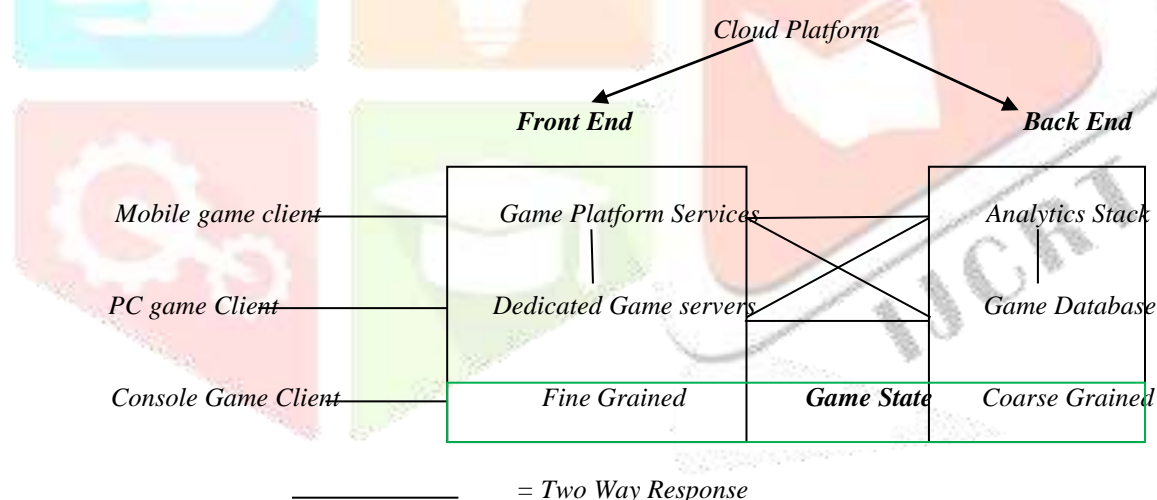


Fig 6: Common architecture of cloud gaming server

8. Database for Online games:

A single relational database server can be used for smaller games but with huge games like PUBG, Fortnite, and several others with millions of users, it can't be altered dynamically which is why there is a different kind of database. [18]

For high-performance gaming, the scalability and schema changes are major challenges, which is why NoSQL databases are considered which offer a more liberal approach to databases used for online games:

1. **Scaling:** They can be scaled horizontally and require zero downtime to be scaled. Sometimes, there can be cases of performance compromise during the scaling because NoSQL databases take some time to reflect all the changes made. Eg. FireBase Firestore.
2. **Schema changes:** It is very difficult for relational databases to change dynamically while in use. NoSQL databases make it easy to make all the necessary changes.
3. **Administration:** IAM or Identity access management make it easy to offer privileges to different levels of users to monitor and maintain various services. [12], [29]

Side by side comparison between relational databases and NoSQL databases:

Metric	Relational DB	NoSQL DB
Schema	Static	Dynamic
Hierarchical data storage	Unsuitable	Suitable
Complex query processing	Easy	No provision for complex queries
Scalability	Vertical	Horizontal
Consistency	Strong	Depends on Flavour
Storage type	Highly available	Commodity type
ACID v/s BASE model	ACID	BASE

Table 3: Comparison between types of game databases based on chosen metrics.

9. Conclusion:

The gaming industry has seen a lot of ups and downs over the years. However, the modern era of gaming has been revolutionized by the cloud. It holds the potential to reform and give an entirely new perspective to the masses. It is much better than offline games because it allows the players to play against real players and also helps them keep track of their performance globally. Also, the creators don't have the burden to create new updates and resell them in case of offline games. It can updates over the air with any downtime. New maps can be added without providing bulky updates. In app-purchases become easy with online games. [93]

There is so much to look forward to when it comes to online gaming. New techniques for faster responses are being researched along with easy to deploy methods. The microservices architecture has proven itself quite efficient and lightweight for designing such complex systems. It can also be optimized for reducing the errors and response failures. This industry has shown promising growth in the past decade and has made e-sports popular among the players worldwide. This can boost the demand for games and more profits can be made through highly responsive architectures. [13], [40]

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