Gaming in the cloud: one of the future entertainment

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ABSTRACT
Since the rapid growth of the cloud computing, data collection and information sharing are led to a higher level and are replacing the traditional computation. Several technologies using cloud in all areas are developing to adapt the revolution of information technology and one of them is cloud gaming. This paper aims to explain what cloud gaming is, and look at some detail of its overview and general architecture. After that, changes arisen due to the development on cloud gaming are indicated and analysed. In addition, the impacts to society and individuals and QoS of the on-demand gaming will be introduced in the next stage. Finally, the paper concludes that the advancements in cloud computing will turn the future of gaming industry into cloud gaming. However, challenges and negative effects need to be considered during the development to make entire industry move forward smoothly.

Keywords
Cloud gaming, architecture, effect, quality of experience, bandwidth, latency, security

1. INTRODUCTION
The wide-used of the cloud computing has led the gaming industry to a revolution that changes the way human play games. This up-and-coming technology called cloud gaming, also known as gaming on demand, is a concept that involves many of distributed computers connected through a synchronous communication network. The service of documents and file sharing has been altered in gaming industry to adjust the development of cloud gaming.

Cloud gaming is an innovative application that offers new opportunities for both upcoming and existing games based on cloud computing. Under the running mode of cloud gaming, all the games are stored in the operators’ or game company’s server so that direct streaming of video sequence onto electric devices such as computers and consoles over internet are allowed. The thin client in low-end only gives requests to high-end server which deals with these requests and streams game experience back as a response. Games are held and run in remote servers so that no downloading is needed for client side and all updates are completed within these servers. Figure 1 shows the basic idea of cloud gaming.

As a result, cloud gaming liberates users from the need to necessarily update their devices and handles compatibility issues while accessing games from servers. Users do not need to master the functionalities and operation of infrastructure in a cloud or relevant professional knowledge. As an advantage, less powerful computation is required to run a high-quality game and offer great performance. [1] One of other advances is the cost of purchasing a gaming console or a high configuration computer to support a greater computational performance can be reduced. Furthermore, time is saved due to downloading, installing and updating are no more exist onto local host.

Over recent years, events surrounding this emerging technology have been successive occurred all over world; moreover, researches and exploitations are conducting and improving to expand advances in cloud technology to allow processing both traditional and complicated computation in an efficient way.

Figure 1 basic idea for cloud gaming
2. BACKGROUND
Many cloud-based gaming companies such as OnLive and Gaikai recently has started offering services and platforms to allow users to play high-definition video games rendered on remote cloud servers. At the Game Developers Conference in 2009, OnLive and Gaikai announced to release its services in the winter of 2009 and even earlier, few years before that conference, G-cluster has launched the first deployment of cloud gaming in Japan in 2004 just after Phantom Entertainment presented cloud gaming console in 2002. All these events have turned cloud gaming into reality.

3. OVERVIEW
Basically, cloud gaming are implemented using client-server structure where server side is a group of many connected computers. Client side is a thin client acting as an interface that collects commands and requests from gamers and it can be a gaming console, a personal computer or a mobile device. All the data is gathered and transferred to cloud. A TCP is first established to create a UDP link so that cloud responses client side with a UDP communication port number to set up a connection between two sides. In detail, UDP link delivers the client input and commands to cloud while TCP receives response which can either be a video stream or a file stream from servers [4].

After cloud gaming platform gains the user inputs, as shown in Figure 2 [1], servers start analysing incoming data to produce game actions depending on game logics. Similarly to live media streaming, cloud gaming quickly encodes/compresses videos rendered from GPU and allocates them to client sides. However, compared to live media streaming, a command issued by a gamer is transferred to cloud through Internet without capacity to buffer video frames on local host. Finally, once complete frames have been decoded from video stream from TCP connection, a specific server in the cloud then captures and encodes these frames and sends to front end where displays them to players.

4. Architecture
A number of models have been conducted as there is no standard definition for the structure of the cloud gaming currently. Jiang W etc. agree that the architecture model of could game generally consist of two main parts: infrastructure and software computing system [3]. In the general cloud computing structure, as shown in Figure 3, PaaS locates in the middle layer where the upper layer is SaaS and lower layer is IaaS [7].

4.1. Hardware design infrastructure
Hardware design infrastructure, also called infrastructure as a service (IaaS), is the foundation of the whole system and used to define the major structural modules as well as providing an environment for system analysis and computation. First of all, a group of connected servers are needed for cloud computing. In order to maintain the balance of the data loads between servers, computation is divided into pieces and allocated to every member in the cloud evenly. Compared to grid computing, infrastructure in cloud is more centralised and this minimises
the radiation problem. Secondly, for the purpose of meeting the need of constantly increasing information storage, ultra-capacity space plays a key component in cloud to match various memory requirements for both users and systems. Finally, cloud computing is based on the network computational model of Internet which involves frequently saving and exchanging data between numerous server groups and ultra-capacity spaces. Therefore, a high-speed broadband network is used to reduce effects of the latency to clients and improve the efficiency of communication as well as offering better performance [3].

4.2. Software computing system
The software computing system provides services that can be described as two categories: software as a service and platform as a service [5]. Figure 4 indicates various layers that group the software computing system.

![Figure 4. Various layers](image)

4.2.1. Service as a service
Software as a service (SaaS), also referred to on-demand software, is a software distribution model that applications and data are hosted in cloud centrally by a service provider to make available to users over a network which is typically the Internet. As novel technologies offering support to web services and traditional/new developments, SaaS has various benefits to handle commercial and technical services and has become an increasingly popular delivery model. Users perform and store their work online by simply accessing software or applications without installing or maintaining them but over Internet with remote management on a SaaS server that provides ensure the security, availability and performance. SaaS helps users to reduce the cost of purchasing hardware or software as well as saving the time on downloading, maintenance or updating applications. [2]

4.2.2. Platform as a service
Platform as a service (PaaS) is generally a web-based platform that supports application developments by providing end-to-end or partial environments to deal with deployment, maintenance and management [6]. Typically, PaaS is derived from the rapid development process of SaaS and therefore it is an application of SaaS model and accelerates the progress of SaaS especially on developing application. The reason of the production of PaaS is that it supplies a middleware platform for customised research and development and simultaneously covers database and application servers to increase the use of resources on web services such as applying Data-as-a-Service (DaaS) on remote objects. In addition, PaaS manages the way in which the application infrastructure operates [6].

5. CHALLENGES
Despite gaming industry is on an irreversible and unstoppable move into the cloud just like music and films, challenges are existed to slow down the growth of spreading on-demand gaming around the world today. Three main challenges will be discussed in detail: latency, security and packet loss.

5.1. Latency
One of the most vexing challenges might be latency that influences the quality of gamers’ experience. Quicker, more consistence and more stable connection is the ideal state considered by cloud developers because it translates to a great performance. However, latency is not a recent emergence comes along with cloud gaming but always a consideration since the appearance of online games [9]. Although game experiences are affected differently by latency among games, players’ interest of game-play might be greatly reduced so that they cannot experience full pleasure of a game. Cloud gaming system Latency is analysed into three components which are network delay, processing delay and play-out delay but network delay may contribute most of the latency in most cases [10]. There are potential solutions in balancing latency such as reducing game resolution or coding custom logic into game control. One of the fundamental solutions is providing high speed network connection with large amount of bandwidth to cloud to help quicken and better support the communication between front end and back end. Bandwidth usage increases dramatically when multiple players’ games using cloud services rather than on local machines and it can cause serious issues if bandwidth reaches the limit of Internet.
5.2. Security
Security is a potential challenge in cloud gaming especially data protection and location. In-house gaming allows players to establish a personal computing environment and to locate the data storage in detail as well as well handling while gaming in cloud hardly supports finding specific information as all data is stored redundantly in several physical locations without producing detailed location information [11]. Due to the difficulty of capturing data efficiently, sufficient safeguards are troublesome to be ensured whether they are in place and if legal provisions are met. Data protection and privacy are often indicated as primary risks in cloud in where personal information is stored and located [12]. There are many location based services exist that use the location of the user to services. Although these services offer convenient to communities, user information disclosure may result in the loss of user benefits. In some cases, personal data can be embezzled and shifted to commit a crime such as filching virtual currency and defrauding other players. In addition, security management is made to analyse and control the risks raised by virtualisation in order to mitigate the risks appropriately. Table 1 gives a table containing critical risk areas in virtualisation and cloud computing [13].

Table 1. Critical risk areas [13]

<table>
<thead>
<tr>
<th>Risk area</th>
<th>Critical</th>
<th>Some-what Important</th>
<th>Not so Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information security</td>
<td>91.7%</td>
<td>6.3%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Operations management</td>
<td>41.7%</td>
<td>58.3%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Change management</td>
<td>41.7%</td>
<td>60.9%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Disaster recovery/</td>
<td>66.7%</td>
<td>33.3%</td>
<td>0.0%</td>
</tr>
<tr>
<td>business continuity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third-party/</td>
<td>41.7%</td>
<td>41.7%</td>
<td>16.7%</td>
</tr>
<tr>
<td>service level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>management</td>
<td>8.3%</td>
<td>50.0%</td>
<td>41.7%</td>
</tr>
<tr>
<td>Interface management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulations and</td>
<td>33.3%</td>
<td>41.7%</td>
<td>25.0%</td>
</tr>
<tr>
<td>legislation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3. Packet loss
By looking at gaming experience developers need to consider game fluency when a gamer is taking part in cloud services. A simple and unconsidered distribution method may apply significant impacts on the network traffic between components, for example, congestion or packet loss in the worst case. Packet loss greatly influences the motivation of enjoying a cloud game. This could range from user command loss during the delivery to the server so that no action can be made as a response to client side. In order to figure out the impact of the percentage of packet loss, Clincy V and Wilgor B has set up an experiment to subject the players to high latency and packet loss in a real-world, cloud-based First-Person Shooter in 2013. [15] An OnLive set-top box is used to provide a platform to run the test as well as a network control software is applied to subject gamers to different round-trip times and packet loss. The result indicates that a game offers hardly any experience to users at 200ms RTT with 1% loss. Reduction of packet loss becomes necessary to prevent players’ non-confidence of cloud gaming. Compared to Clincy V and Wilgor B, Jarschel M et al. have launched an experiment on the impact of packet loss and latency on various cloud-based games rather than only FPS is examined. They concluded that a game with delay of less than 200ms is tolerable and still playable and they also agreed that 1% packet loss will significantly degrade a player’s patience to experience a game. [8]

6. EFFECTS
As being believed to be the future of gaming industry, cloud gaming has brought a plenty of benefits to society along with impacts on social or personal aspects. Players can simply pay online and access the cloud to experience a specific game without having heavy deployment on hardware or a game console, which means no further downloading or upgrading is needed as all required applications and data are stored in the cloud and players only need a high-speed network with large-amount bandwidth. Therefore service providers collect payment on network and offer the ability to access games by giving permission such as an access code to the payer without purchasing any mediums carrying game installation. Moreover, the numbers of game stores may be reduced as less production are required to be made and sold [14]. Using services in cloud involves various cloud service provides with many service allocation, data management and payment collections and this makes an impact on price settings. The traditional standard of game pricing may change depending on how service providers divide the price among numbers of entities [8]. Thanks to advancements in both hardware and software, entertainments can apply on not only computer or game console but mobile devices or tablets. This frees gamers from playing high-performance games indoor with the need of bulky devices and makes outdoor activities more diverse.

7. QUALITY OF EXPERIENCE
These days, compared to traditional services with few requirements established in the cloud, users are able to use a
large numbers of apps and services remotely which derivatives rapidly growth of requirements on quality of service (QoS) as gamers want to have a higher standard experience. Unlike the online gaming as only multiplayer games use the network to control the status updates and message communication where few data exchange is involved, cloud gaming have to stream the entire gaming experience from data centre to players through Internet [8].

Various surveys and researches have been conducted to cover this concept recently to discover challenges, benefits and effects. An instance of a research on latency measurement on several platforms (OnLive and StreamMyGame) and games is made to show their performance for comparison with traditional online gaming and stand-alone gaming even other cloud gaming on different platforms [10]. As a result, OnLive offers shorter latency for real-time gaming than StreamMyGame under similar configurations on hardware and network connection environment. Another research focused on delay and packet loss is conducted by Jarschel M et al. by testing several scenarios on three classes of games: real-time strategy games, role-play games and fist-person shooters. As shown in Table 2, parameters are defined and weighted to investigate the outcome of the QoE perception [8]. From the research, a conclusion is analysed from the evaluations that QoE is influenced by parameters and user experience needs to be considered into context with the content.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Packet Loss</td>
<td>1.0</td>
</tr>
<tr>
<td>Downstream Delay</td>
<td>0.583</td>
</tr>
<tr>
<td>Upstream Packet Loss</td>
<td>0.370</td>
</tr>
<tr>
<td>Upstream Delay</td>
<td>0.212</td>
</tr>
<tr>
<td>Type of Game</td>
<td>0.067</td>
</tr>
<tr>
<td>Player Skill</td>
<td>0.006</td>
</tr>
<tr>
<td>Player Attitude Towards Game</td>
<td>0.006</td>
</tr>
<tr>
<td>Player Age</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 2. Parameters

8. CONCLUSION

In cloud gaming implementation, client-server structure is used to create a communication between front end and back end. User inputs are collected and delivered to cloud by UDP link and then data centre starts analysing incoming inputs and gives responses that can be either file stream or a video stream. In the next step, TCP connection receives packets and allocates them to each client. During the communication, required data is encoded into streams and decoded into frames in TCP connection so that video is shown to clients.

The architecture of cloud gaming basically includes application services, platform services and infrastructure services. These layers can be divided into sub-layers depending on the service properties. Software as a service (SaaS) is introduced to provide applications stored in the cloud so that users are able to use these apps remotely without installing them. As a middle layer in the structure, platform as a service (PaaS) offers a middle-ware platform to develop applications online and manages the use of resources on web services on remote object. Finally, infrastructure as a service (IaaS) is a lower layer that gives physical environment support for cloud computing containing a group of connected computers and ultra-capacity storages as well as a data centre to compute every possible algorithm and data.

While the rapid growth of cloud gaming, challenges especially security risk, latency and bandwidth as well as packet loss are gradually arisen to impede technology developments. Benefits and impacts follow the appearance of cloud gaming and change the way players experience games traditionally. No heavy deployment on hardware or further downloading or updating is required and therefore less production such as disc will be made by vendors.

Because of gamers might expect higher standard experience is met, quality of experience (QoS) is proposed to deal with explosively increased requirements to enhance the performance of gaming. Two research covered on different topics are given to analyse the factors that influence the QoS.

9. REFERENCES


