INSTITUTE OF PRINTING TECHNOLOGY & GOVERNMENT POLYTECHNIC COLLEGE SHORANUR, KERALA

Department of Computer Engineering
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Seminar report on

CLOUD GAMING

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CERTIFICATE

This is to certify that seminar report entitled **CLOUD GAMING** submitted by **NITHIN P.T , Reg.No: 19138122** to the Department of Computer Engineering, **Institute of Printing Technology Government Polytechnic College Shoranur, Kerala,** in partial fulfilment of the requirement for the award of Diploma under the Directorate of Technical Education, Government of Kerala is a bonafide record of the work carried out by him.

Guided By **Head of Department**

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Place:

Date:

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ABSTRACT

Recent advances in cloud technology have turned the idea of Cloud Gaming into a reality. Cloud Gaming, in its simplest form, renders an interactive gaming application remotely in the cloud and streams the scenes as a video sequence back to the player over the Internet. This is an advantage for less powerful computational devices that are otherwise incapable of running high quality games. Such industrial pioneers as Onlive and Gaikai have seen success in the market with large user bases. In this article, we conduct a systematic analysis of state-of-the-art cloud gaming platforms, and highlight the uniqueness of their framework design. We also measure their real world performance with different types of games, for both interaction latency and streaming quality, revealing critical challenges toward the widespread deployment of Cloud Gaming.

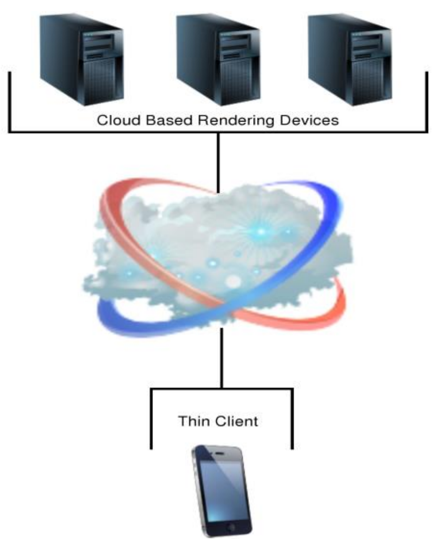
INTRODUCTION

A cloud is a type of a server, which is remote (usually in Data Centers), meaning you access it via the internet. You are renting the server space, rather than owning the server. Thanks to the processing power of the cloud, video games are allowed to run on remote servers, while streaming them directly to a user’s device. This shifts all the heavy lifting of the processing power from their device to the cloud. Like the multimedia content is streamed through the network from the server to the user. Through the utilization of elastic resources and widely deployed data-centers, cloud computing has provided countless new opportunities for both new and existing applications. Existing applications, from file sharing and document synchronization to media streaming, have experienced a great leap forward in terms of system efficiency and usability through leveraging cloud computing platforms. Much of these advances have come from exploring the cloud’s massive resources with computational offloading and reducing user access latencies with strategically placed cloud data-centers. Recently, advances in cloud technology have expanded to allow offloading not only of traditional computations but also of such more complex tasks as high definition 3D rendering, which turns the idea of Cloud Gaming into a reality. Cloud gaming, in its simplest form, renders an interactive gaming application remotely in the cloud and streams the scenes as a video sequence back to the player over the Internet. A cloud gaming player interacts with the application through a thin client, which is responsible for displaying the video from the cloud rendering server as well as collecting the player’s commands and sending the interactions back to the cloud. Figure 1 shows a high level architectural view of such a cloud gaming system with thin clients and cloud-based rendering. Onlive [1] and Gaikai [2] are two industrial pioneers of cloud gaming, both having seen great success with multi million user bases. The recent 380 million dollar purchase of Gaikai by Sony [3], an industrial giant in digital entertainment and consumer electronics, shows that cloud gaming is beginning to move into the mainstream. From the perspective of industry, cloud gaming can bring immense benefits by expanding the user base to the vast number of less-powerful devices that support thin clients only, particularly smartphones and tablets. As an example, the recommended system configuration for Battlefield 3, a highly popular first-person shooter game, is a quad-core CPU, 4 GB RAM, 20 GB storage space, and a graphics card with at least 1GB RAM (e.g., NVIDIA GEFORCE GTX 560 or ATI RADEON 6950), which alone costs more than $500. The newest tablets (e.g., Apple's iPad with Retina display and Google's Nexus 10) cannot even meet the minimum system requirements that need a dual-core CPU over 2.4 GHz, 2 GB RAM, and a graphics card with 512 MB RAM, not to mention smartphones of which the hardware is limited by their smaller size and thermal control. Furthermore, mobile terminals have different hardware/software architecture from PCs, e.g., ARM rather than x86 for CPU, lower memory frequency and bandwidth, power limitations, and distinct operating systems. As such, the traditional console game model is not feasible for such devices, which in turn become targets for Gaikai and Onlive. Cloud gaming also reduces customer support costs since the computational hardware is now under the cloud gaming provider's full control, and offers better Digital Rights Management (DRM) since the codes are not directly executed on a customer's local device. However, cloud gaming remains in its early stage and there remain significant theoretical and practical challenges towards its widespread deployment. In this article, we conduct a systematic analysis of state-of-the-art cloud gaming platforms, both in terms of their design and their performance. We first offer an intuitive description of the unique design considerations and challenges addressed by existing platforms. We highlight their framework design. Using Onlive as a representative, we then measure its real world performance with different types of games, for both interaction latency and streaming quality. Finally, we discuss the future of cloud gaming as well as issues yet to be addressed.

CLOUD GAMING: ISSUES AND CHALLENGES

From low latency live video streaming to high performance 3D rendering, cloud gaming must bring together a plethora of bleeding

edge technologies to function We begin our analysis with the important design considerations, which are currently being addressed by cloud gaming providers. A cloud gaming system must collect a player's actions, transmit them to the cloud server, process the action, render the results, encode/compress the resulting changes to the game-world, and stream the video (game scenes) back to the player.



- Fig. 1.Cloud Gaming Overview -

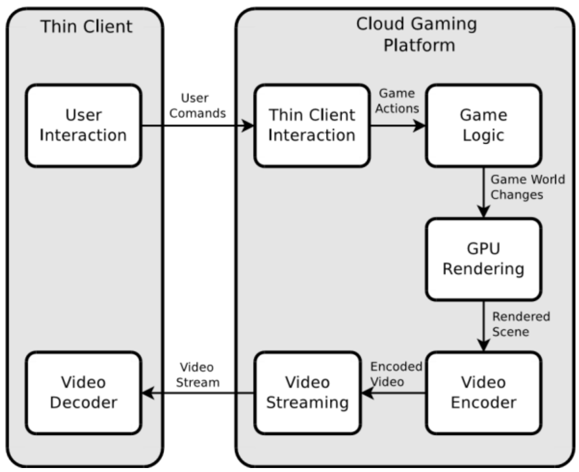
To ensure interactivity, all of these serial operations must happen in the order of milliseconds. Intuitively, this amount of time, which is defined as *interaction delay*, must be kept as short as possible in order to provide a rich experience to the cloud game players. However, there are tradeoffs: the shorter the player's tolerance for interaction delay, the less time the system has to perform such critical operations as scene rendering and video compression. Also, the lower this time threshold is, the more likely a higher network latency can negatively affect a player's experience of interaction. With this is mind, we start our design discussion with delay tolerance.

A. INTERACTION DELAY TOLERANCE

Studies on traditional gaming systems have found that different styles of games have different thresholds for maximum tolerable delay [4]. Table I summarizes the maximum delay that an average player can tolerate before the Quality of Experience (QoE) begins to degrade. As a general rule, games that are played in the first person perspective, such as the shooter game Counter Strike, become noticeably less playable when actions are delayed by as little as 100 ms. This low delay tolerance is because such first person games tend to be action-based, and players with a higher delay tend to have a disadvantage [5]. In particular, the outcome of definitive game changing actions such as who “pulled the trigger” first can be extremely sensitive to the delay in an action-based First Person Shooter (FPS) game. Third person games, such as Role Playing Games (RPG), and many massively multiplayer games, such as World of Warcraft, can often have a higher delay tolerance of up to 500 ms. This is because a player’s commands in such games, e.g., use item, cast spell, or heal character, are generally executed by the player’s avatar; there is often an invocation phase, such as chanting magic words before a spell is cast, and hence the player does not expect the action to be instantaneous.

B. VIDEO STREAMING AND ENCODING

We next examine the video streaming and encoding needs of a cloud gaming system. Cloud gaming's video streaming



- Fig. 2.Framework of a cloud gaming platform –

requirements are quite similar to another classical application, namely, live media streaming. Both cloud gaming and live media streaming must quickly encode/compress incoming video and distribute it to end users. In both, we are only concerned with a small set of the most recent video frames and do not have access to future frames before they are produced, implying encoding must be done with respect to very few frames.

CLOUD GAMING FRAMEWORK

Based on the design considerations we have been discussing, we now outline a generic framework for a cloud gaming system. Figure 2 shows the various functions and modules required by a cloud gaming system. As can be observed, a player's commands must be sent over the Internet from its thin client to the cloud gaming platform. Once the commands reach the cloud gaming platform they are converted into appropriate in-game actions, which are interpreted by the game logic into changes in the game world. The game world changes are then processed by the cloud system's graphical processing unit (GPU) into a rendered scene. The rendered scene must be compressed by the video encoder, and then sent to a video streaming module, which delivers the video stream back to the thin client. Finally, the thin client decodes the video and displays the video frames to the player.

To confirm the representability of this generic framework, we have conducted a traffic measurement and analysis from the edge of four networks which are located in the United States, Canada, China and Japan. We recorded the packet flow of both Gaikai and Onlive. After that, we used Wireshark to extract packet-level details, which reveal the existence of thin clients and their interactions with remote cloud servers. We also discover that Gaikai is implemented using two public clouds, namely Amazon EC2 and Limelight. When a player selects a game on Gaikai, an EC2 virtual machine will first deliver the Gaikai game client to the player. After that, it forwards the IP addresses of game proxies that are ready to run the selected games to the players. The player will then select one game proxy to run the game. For multiplayer online games, these game proxies will also forward the players' operations to game servers and send the related information/reactions back to the players. Onlive's workflow is quite similar, but is implemented with a private cloud environment. Using public clouds enables lower implementation costs and higher scalability; yet a private cloud may offer better performance and customization that fully unleash the potentials of cloud for gaming. Hence, we use Onlive in the following measurement and analysis.

REAL WORLD PERFORMANCE:ONLIVE

Despite some recent financial issues, Onlive was one of the first to enter into the North American market and offers one of the most advanced implementations of cloud gaming available for analysis. A recent official announcement from Onlive put the number of subscribers at roughly 2.5 million, with an active user base of approximately 1.5 million.

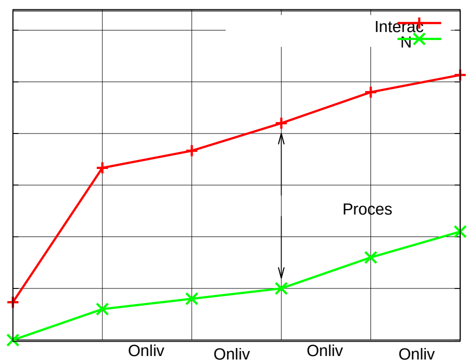


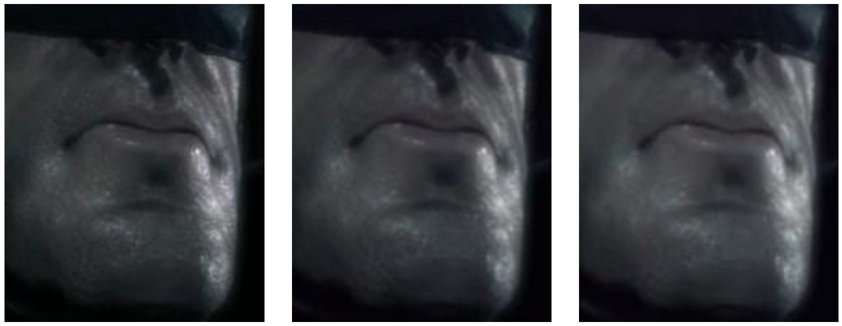
Fig. 3.Interaction Delay in Onlive

We evaluate the critically acclaimed game Batman Arkham Asylum on Onlive and compare its performance to a copy of the game running locally. In our analysis, we look at two important metrics, namely, the interaction delay (response time) and image quality. Our hardware remains consistent for all experiments. We run Batman through an Onlive thin client as well as locally on our local test system. The test system contains an AMD 7750 dual core processor, 4 GB of ram, a 1-terabyte 7200 RPM hard drive, and an AMD Radeon 3850 GPU. The network access is provided through a wired connection to a residential cable modem with a maximum connection speed of 25 Mb/s for download and 3 Mb/s for upload. Our system specifications and network connections exceed the recommended standards both for Onlive and the local copy of the game, which ensures the bottleneck that we will see is solely due to the intervention of cloud.

COMPARISON

As discussed previously in section II-A, minimizing interaction delay is a fundamental design challenge for cloud gaming developers and is thus a critical metric to measure. To accurately measure interaction delay for Onlive and our local game, we use the following technique. First, we install and configure our test system with a video card tuning software, *MSI afterburner*. It allows users to control many aspects of the system's GPU, even the fan speed. Our locally rendered copy has an average interaction delay of approximately 37 ms, whereas our Onlive baseline takes approximately four times longer at 167 ms to register the same game action. As is expected, when we simulate higher network latencies, the interaction delay increases. Impressively, the Onlive system manages to keep its interaction delay below 200 ms in many of our tests. This indicates that for many styles of games Onlive could provide acceptable interaction delays. However, when the network latency exceeds 50 ms, the interaction delays may begin to hinder the users' experience. Also, even with our baseline latency of only 30 ms, the system could not provide an interaction delay of less than 100 ms, the expected threshold for first person shooters.

137 ms. Finally, we calculate the cloud overhead, which we define to be the delay not



(a) Master Image(b) Local Capture (PSNR:33.85 (c) Onlive: 10 Mb/s Connection

dB, SSIM:0.97) (PSNR:26.58 dB, SSIM:0.94)

(d) Onlive: 6 Mb/s (e) Onlive: 3.0 Mb/s Connection Connection(PSNR:26.53 (PSNR: 26.03 dB, SSIM:0.89) dB, SSIM:0.92)

Fig. 5.Image Quality Comparison

caused by the core game logic or network latency. It includes the amount of delay caused by the video encoder and streaming system used in Onlive. To calculate this number, we subtract the local render processing time of 37 ms from our Onlive experiment processing time. Table II gives the interaction processing and cloud overhead measured in our experiments. As can be seen, the cloud processing adds about 100-120 ms of interaction delay to the Onlive system. This finding indicates that the cloud processing overhead alone is over 100 ms, meaning that any attempt to reach this optimal interaction delay threshold will require more efficient designs in terms of video encoders and streaming software.

CONCLUSION AND FURTHER DISCUSSION

This article has closely examined the framework design of state-of-the-art cloud gaming platforms. We have also measured the performance of Onlive, one of the most representative and successful cloud gaming platforms to date. The results, particularly on interaction latency and streaming quality under diverse game, computer, and network configurations, have revealed the potentials of cloud gaming as well as the critical challenges toward its widespread deployment. For a future work we would like to further investigate the effect other network conditions such as packet loss and jitter have on the end users cloud gaming experience.

Cloud gaming is a rapidly evolving technology, with many exciting possibilities. One frequently mentioned is to bring advanced 3D content to relatively weaker devices such as smart phones and tablets. This observation is made even more relevant by the fact that both Gaikai and Onlive are actively working on Android apps to bring their services to these mobile platforms. However, recent large scale research indicates that it is not uncommon to find cellular network connections that have network latencies in excess of 200 ms [7], which alone may already cause the interaction delay to become too high for many games. Seamless integration between cellular data connection and the lower latency WiFi connection is expected, and the switching to LTE may help alleviate the problem. Other potential advancements involve intelligent thin clients that can perform a portion of the game rendering and logic locally to hide some of the issues associated with interaction delay, or distributed game execution across multiple specialized virtual machines [8]. This will likely require creating games specifically optimized for cloud platforms.

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