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Cloud Gaming: A Green Future

[1] Moulavi Shadaab [2] Rajput Rashmi [3] Sarode Shrikant [4] PatilPallavi [5] Ms. BarkadeVaishali M
[1][2][3][4][5] Department of Computer Engineering
JSPM's Rajesh Shahu Collage of Engineering (RSCOE) Tathawade, Pune.
Savitribai Phule Pune University, India.
[1] Pimple Gurav, Pune [2] Moshi Pradhikaran, Pune-39 [3] Someshwar Hostel, Tathawade [4] JSPM Girls Hostel
[1] shadaabmoulavi@gmail.com [2] contact.rashmi94@gmail.com [3] sarodeshree07@gmail.com
[4] patilspallavi@gmail.com [5] vaishalimbarkade@gmail.com

***Abstract*- Today the gaming industry is at its peak, with advanced video games which requires high computations. These computations are achieved with powerful hardware that provides realistic scenes and smooth actions. Playing these high quality video games requires expensive graphics processors. On the counterpart cloud gaming utilizes cloud computing for gaming and offers a green solution to bring high quality games to thin and mobile clients. Cloud gaming has become increasingly more popular in the industry. Many cloud gaming services have subscribed thousands of subscribers showing the initial success of cloud gaming. In this project we will be implementing cloud gaming services that reduce latency within a certain network bandwidth. We will be achieving this by enhancing and optimizing the cloud resources, with the inclusion of the NVIDIA GRID GPU. In the upcoming future cloud gaming can provide multiple clients and concurrency in multiplayer games.**

***Keywords*-Cloud Gaming; Low latency; NVIDIA GRID GPU; Multiuser Gaming.**

I. INTRODUCTION

Video gaming is one of the fastest growing businesses in the multimedia and gaming industry. Today video games are provided on desktops, laptops and mobile phones. High end video games require advanced computational power to render realistic and interactive games[1].To fuel such games one needs a gaming system which hosts gaming hardware i.e. graphics card etc. machines with basic configuration are not capable enough to run these games.

Ex: Assassin's creed requires 6GB RAM, core i5-2500k 3.3GHz 50HDD and 2GD Graphics card[6].

On the contrary cloud gaming has a better way to deliver high quality gaming experience; it provides a better gaming platform to the games and opens a new business opportunity to the games service providers[2]. In cloud gaming system the game software is hosted on the cloud server. The user control commands at the clients are transferred to the cloud server. The game is executed at the server and the game images are rendered and streamed back to the client[5]. As all the computation is shifted to the cloud high end games can be played on the devices with the less computational power[3].Cloud gaming can prevent software piracy, since game is serviced on demand after authorization, instead of as a packaged software product[8]. Virtualization technology is making a significant impact on how resources are used and managed in a cloud data center[9]. Several virtualization solutions (VMware products, Xen, VirtualBox) are getting more and more mature in constructing a huge cloud computing center[9]

Cloud gaming provides advantages in the following aspects:

A. Hardware Management

Video games today demands high capability hardware. Whenever a new gameis to be installed the hardware needs to be upgraded to fulfill the game requirements[3]. Hardware may be abandoned because it cannot meet the requirements of a new game even though they function fine, resulting into unnecessary electronic waste being produced[6]. Recent report[6] revealed that in the United States alone, E-waste disposal tops 372.2 million units. In cloud gaming user do not required to upgrade and maintain powerful hardware. Since high quality games are processed at the cloud server. Also video games require large storage space for installation and enforcing the user to upgrade their storage disks.

B. Software Management

Installing a game on individual local machine requires regular updates for patches and fixes. Significant efforts need to be taken to achieve compatibility between operating systems and platforms. When a new version is launched, supports for older versions are often terminated gradually[6]. Cloud gaming provides an advantage of making new software releases available to the client immediately. The game vendors only need to maintain the game software at the cloud server reducing the software management cost[3].

C. Deployment Cost

Traditionally, computer games were delivered either in boxes or via internet download. Cloud gaming eliminates this cost of game distribution by delivering games directly to the players. Beside pay-per-service saves client from the large upfront cost of owning hardware and software in which they are likely to lose interest sometime later[4]. In summery cloud gaming offers a given solution in terms of managing game software, storage, equipment wastage due to hardware incompatibility and cost effective deployment[6].

II. CLOUD GAMING PLATFORM

Currently several commercial services and research works are working on cloud gaming platforms. Commercial services include Stream My Game, On Live Game system and GaiKai's streaming service. On Live Game system provides games to various devices, including PC's, tablets, smart phones, TV, set-top-box and other devices. In 2012 Sony has acquired GaiKai. GaiKai's system can be embedded into websites and devices so users are not required to install any software[1]. With cloud gaming, players just pay for the time of playing multiple games and do not need to worry about minimum hardware requirements of each game. The mobile players can also demand high-quality video games on their handsets on the way. Today, the network bandwidth is capable to support cloud gaming online, but the latency is still a critical concern on the QoS in cloud gaming industry[8].

In 2008 NVIDIA introduced cloud gaming technology which makes video games transmitted over the web in the form of streams. It also provides an NVIDIA GRID Toolkit; a complete development kit to perform efficient image capture and remote processing for NVIDIA GPU[5]. The GRID SDK provides two ways for GPU rendering namely NvFBC and NvIFR. NvFBC (NVIDIA frame buffer capture) API captures and compresses the entire windows desktop or full screen applications on a supported OS. It provides dedicated hardware compression and delivers frame data to system memory faster than any other display output. NvIFR does not include any window manager decoration rather it is ideally suited for application capture[5].

In this paper we propose a cloud gaming platform based on NVIDIA GRID GPU in the section Related work, finally the concluding remark are presented in section conclusion.

III. RELATED WORK

A major attraction of cloud gaming is that it frees players from the need to frequently upgrading their computers as they can play games remotely with a thin client[7]. The game is executed on one VM assign to each player. Although this model can be scaled up or scaled down when the number of online players increases or decreases, one VM is heavily loaded with data-intensive tasks while other VMs could be idle. Therefore, we need load balancing among the provisioned VMs[8]. NVIDIA GRIP GPU provides full advantages of GPU processing power to provide GPU accelerated games and applications through the network to the user. The GRID SDK provides a mechanism to capture, compress, and render game video. NvIFR uses an on-chip hardware video encoder that encodes videos to H.264 video stream and copies it to the system memory at host[5].

We proposed to establish:

1. Cloud gaming system using NVIDIA GRID GPU.
2. Add a local cloud to provide resources and client session management.

A client 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 an architectural view of our cloud gaming system with thin clients and cloud-based rendering. When the user posts the game play request in the application a virtual machine is booted up for the player at cloud server. The public cloud is where the NVIDIA Grid GPU resides and it sends a GPU instance to the local cloud on demand from the virtual machine. The local cloud which acts as a cache,provide resources and client session management. This processed graphics is then streamed to the user's machine where decoding and rendering takes place. At the same time the game commands are captured and send back to the server.

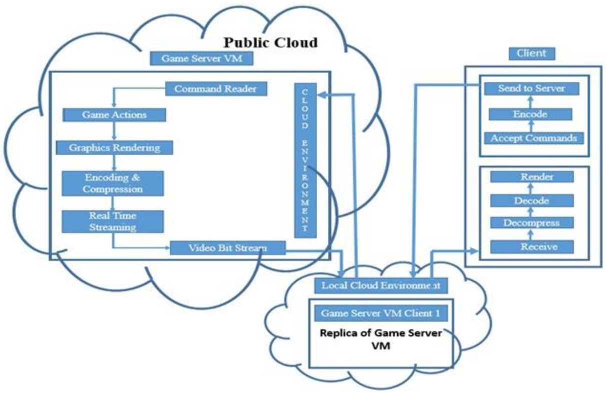

Fig 1: System Architecture

The local cloud will be acting as a cache between the public cloud and the client. Here virtual machine will be setup and the resources i.e. CPU and RAM will be allocated as per the game specification. The local cloud will be used as session manager to start and stop the session for clients being connected to the server. It will setup VMs as per the game requested from the clients, except the graphics processing part of the game, the computations will be done at the local cloud.

IV. MODULES

Basically system architecture divided into five types modules, they are as follows:

A. *Personalized Game Environment Setup*

In cloud gaming system the game processing takes place at the cloud server. In this module, the user will request for the game he/she wants to play. Then a virtual machine is created for that client.The required drivers and OS get loaded to the virtual machine in response to the requested game. Then the instance of the virtual machine is created.

B. *Graphics Capturing*

The frames are captured of the running games and passed on to the video encoder.

C. *Video Encoding and Streaming*

The captured frames are then encoded and compressed using the H.264 standard and are then streamed to the client.

D. *Video Decoding*

At the client end the encoded frames are received. These frames are then decoded and rendered on the client.

E. *Client Command Capturing*

This module captures the various inputs given by the client. These input commands are send back to the cloud server.

V. H.264 VIDEO ENCODING STANDARD

A video consists of a sequence of pictures or frames. When these frames are displayed rapidly in succession and provided the frame rate is high enough (typically 20-25 frames per second), viewers have the illusion that motion is occurring. To be able to store and transmit large video sequences, they need to be compressed or encoded.H.264 is a *block-based* coder/decoder (codec), meaning that each frame is divided into small square blocks called macro blocks (MBs). The coding tools/ kernels are applied to MBs rather than to whole frames, thereby reducing the computational complexity and improving the accuracy of motion prediction. An **encoder** converts video into a compressed format and a **decoder** converts a compressed video back into an uncompressed format.

VI. OVERVIEW OF H.264

A) *Frames Types*

H.264 defines three main types of frames: *I*-, *P*-, and *B-frames*. An I-frame uses intra-prediction and is independent of other frames. In intra-prediction, each MB is predicted based on adjacent blocks from the same frame. A P-frame (Predicted frame) uses motion estimation as well as intra-prediction and depends on one or more previous frames, which can be either I-, P- or B-frames. Motion estimation is used to exploit temporal correlation between frames. Finally, B-frames (Bidirectional predicted frames) use bidirectional motion estimation and can depend on previous frames as well as future frames.

B) *Entropy Coding*

H.264 includes two different entropy coding techniques. The first one is *Context Adaptive Variable Length Coding* (CAVLC), which is an adaptive variant of Huffman coding and targeted at applications that require a slightly simpler entropy decoder. The second one is *Context Adaptive Binary Arithmetic Coding* (CABAC),which is based on arithmetic coding techniques. Arithmetic coding differs from Huffman coding in that it does not encode each symbol separately, but encodes anentire message in a single number between 0.0 and 1.0.

C) *Transform*

The Discrete Cosine Transform (DCT) is a mathematical transform that convertsinput data (e.g. residual data) into a different domain (called the frequency domain).The main purpose of this conversion is to separate the input data into independent components and concentrate most of the information on a few coefficients. H.264 transform is an integer approximation of the DCT allowing implementations with integer arithmetic for decoders and encoders. The main transform is applied to 4×4 blocks and is useful for reducing ringing artifacts (negative codingeffects that appear as bands near the edges of objects in an image).The H.264High Profile (described later) allows another transform for 8×8 blocks which is useful in HD video for the preservation of fine details and textures. The encoderis allowed to select between the 4×4 and 8×8 transforms on a macroblockby macroblock basis.In the decoder, an Inverse Discrete Cosine Transform (IDCT) isapplied to the transformed coefficients in order to reconstruct the original residual data.

D) Quantization

The encoder quantizes the transformed coefficients by dividing them by valuesgreater than 1, so the quantized coefficients can be coded using fewer bits. The decoder has to perform the inverse operation, i.e., multiply the quantized coefficients with the same values. Quantization is the main reason why video coding is *lossy*, meaning that some information is lost due to rounding errors. The loss of information is, however, usually too small for humans to notice.

E) Inter-Prediction

The H.264 standard allows variable block sizes ranging from 16×16 down to 4×4, andeach block has its own motion vector(s).The motion vector is quarter sample accurate, meaning that motion vectors can also point to positions between pixels andthe best matching block is obtained using interpolation. Multiple reference frames can be used in a weighted fashion. Using multiple reference frames significantly improves coding *occlusion areas*, where an accurate prediction can only be madefrom a frame further in the past.

F) Intra-Prediction

H.264 supports three types of intra coding, denoted by Intra 4x4,Intra 8x8, and Intra 16x16. Intra 4x4 is well suited for coding parts of a picture with significant spatial detail.The 16×16-pixel MB is divided into sixteen 4×4 sub-blocks and intra-prediction is applied to each sub-block. Samples are predicted using previously decoded samples from the blocks to the north, north-east, and west. The High Profile defines intra-prediction for 8×8 blocks. The prediction modes are basically the same as in 4×4 intra-prediction with the addition of low-pass filtering to improve prediction performance.Intra 16x16 predicts a whole MB and is well suited for coding frame areas withsmooth variations of tone and color. Four different prediction modes are available for this type of prediction: vertical, horizontal, DC-, and plane-prediction. The firstthree ones are very similar to the modes available for 4×4 blocks. Plane-prediction employs a linear function between neighboring samples.

G) Deblocking Filter

Processing a frame in MBs can produce artifacts at the block edges, generally considered the most visible artifact in standards prior to H.264. These *blocking artifacts*can be reduced so that they are no longer visible by applying a deblocking filter to the pixels around the block edges, which basically smooths the block transitions. The filter strength is adaptable through several syntax elements. The deblocking filter is applied before theframe is used as a reference frame, which improves the efficacy of motion compensation.

VII. CONCLUSION

The proposed cloud gaming system will be providing a green solution over the traditional cloud gaming systems. In addition to bringing high-quality games to thin devices, cloud gaming promises better efficiency in hardware utilization and software maintenance by using the NVIDIA GRID GPU. We opt to use the Grid GPU that will be hosted on the Amazon public cloud. With the Grid GPU included in the server the processing delay (i.e. game processing delay, play out delay and the network delay) will reduce drastically. The bandwidth required to stream the game to the client will also reduce.

We propose to add a local cloud environment in the network. The local cloud will be acting as a cache. The resources on the Amazon cloud will be replicated on to the local cloud. Virtual machines will be set up for each client running multiple games. As the clients do not require much of the gaming hardware on their systems and the cloud will be hosting virtual machines, hence we achieve a green solution.

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