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FUTURE OF CLOUD GAME IN MOBILE

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ABSTRACT

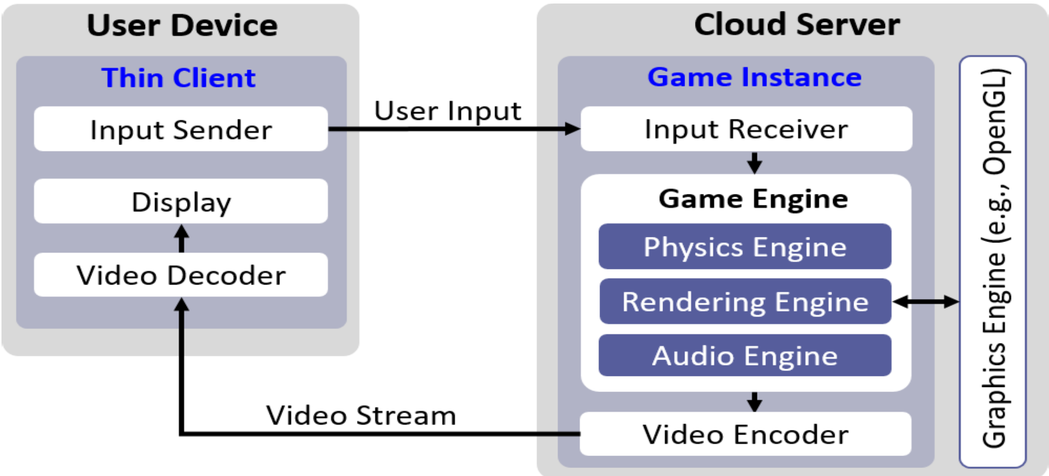
The introduction of mobile cloud gaming has opened up access to video games, but it has also highlighted differences in the gaming experience, especially on lower-end devices. This study looks at the difficulties users of less powerful mobile devices encounter when playing cloud games, particularly those related to graphics performance. This study shows the limitations imposed by these devices when producing high-quality visuals in cloud-based games through a thorough review of user feedback and technological factors.

A workable alternative is put up to overcome this problem and improve the accessibility of cloud gaming: the inclusion of a user-adjustable graphics option within games. This solution gives customers the ability to tailor visual settings based on the capabilities of their device and the network environment, enabling them to enhance their gaming experience.

I. INTRODUCTION

Through the cloud gaming service, customers can play high-quality computer (or mobile) games even on low-end equipment thanks to the rapid advancement of cloud computing and network technologies. The cloud gaming service is advantageous to both game players and game creators. Using a little program known as a "thin client," users can play a variety of fresh, high-caliber games on demand without having to install them or upgrade their hardware. The difficulty of developing and maintaining numerous versions of games for multiple platforms (i.e., hardware and OS) of user devices is eliminated because game developers just need to implement and maintain a single version of games for the cloud platform. Due to these advantages, the global market for cloud gaming services has already surpassed $1 billion in 2021 and is anticipated to expand consistently to $7.24 billion in 2027 [1].

A example software architecture for a cloud gaming service is shown in Figure 1 [2]. The game instance on the cloud server receives user input from the thin client software and processes it. The game instance sends the thin client's user input to the game engine. In the game engine, the physics engine modifies the game state in response to user input, and the rendering engine issues and executes graphics commands by using library functions in the graphics engine to generate updated video frames. These video frames are encoded and transmitted to the thin client where they are decoded and played along with an audio stream produced by the audio engine.



The delay between the creation of user input and the display of updated visual frames by the input [3], [4] is significant in cloud gaming. The most acceptable latency for a game that is very sensitive to latency (e.g., a racing game), we know that it is 100 ms [5]. Another important quality metric for cloud gaming services is video quality, which is determined by the resolution and frame rate of the video stream [2]. For smooth display of gaming scenes, 720p (HD) resolution and 30 frames per second (fps) are considered the minimum requirements. However, in today's local gaming environment, where advanced graphics cards and high-resolution display devices are available, high-end games support 4K (3840 × 2,160) and ≥60 resolutions. fps is common. To satisfy gaming users who are used to such local gaming environments, cloud gaming services are evolving to provide users with high UHD (4K, 60fps) quality gaming environments level [6]. For example, in Google Stadia [7] and Microsoft xCloud [8], users can configure 4K resolution and 60fps cloud gaming environments. However, the current architecture of cloud gaming services struggles to deliver UHD quality gaming services due to the large bandwidth requirements for video streams in the backbone network. Google Stadia requires at least 35 Mbps backbone bandwidth for a UHD quality video stream [7]. Considering the increasing network traffic for various cloud services, including media streaming services, it is difficult for cloud gaming service providers to guarantee the same amount of network bandwidth. such axis for each of their users. Limited network bandwidth reduces the overall quality of cloud gaming services due to increased latency and reduced video stream quality.

In this work, we integrate edge computing with a cloud gaming service architecture and use remote rendering (via graphics streaming [9], [10]) to realizing UHD quality cloud gaming service. We decouple the graphics engine from the cloud game server and localize it to servers located at the edge of the backbone network (i.e. edge servers). Graphics commands issued by the cloud game engine are forwarded to the edge server's graphics engine to display the image. The video images created in the Edge server are then transmitted directly to the client device via a high-bandwidth subscription network (≥35 Mbps), such as 5G mobile networks and FTTH (fiber to the home) networks.). This approach gives us the opportunity to effectively reduce the bandwidth consumption of the backbone network and thus enable a UHD quality cloud gaming service.

Table 1

	CMDs	Bandwidth	Rendering	FPS
Truck town [13]	2,450	**45.3** Mbps	16.5 ms	60
Voxel [14]	618	11.9 Mbps	**20.8** ms	**48**
cf. Legacy Archi.		28 Mbps	$\leq 16.6\ ms$	60

There have been some recent studies looking at a similar "remote rendering" approach, but with a different purpose, i.e. reducing resource contention in cloud game servers [11], [twelfth]. Although they achieved their goal using this approach, they did not address or address two possible side effects, which are bandwidth inflation and latency issues (shown below). below), the solution needed to benefit from this approach to enable UHD quality cloud gaming services. Table 1 shows the average render time per frame and bandwidth consumed to pass graphics commands when we use the simple remote rendering architecture (Edge) for two examples of 4K 3D gameplay at 60 fps in the Godot game engine. For this test, we recorded every graphics command (including hundreds of KB of data) in a cloud game server (Amazon EC2 instance) and transferred each of those commands to its own Edge Server us, where the OpenGL graphics engine is executed. The Truck Town game issued an average of 2,450 commands per frame (148,000 commands per second) and consumed 45.3 Mbps of bandwidth to transmit to the Edge server, which is higher than the bandwidth consumed to stream video (28 Mbps) in old cloud game . - ing architecture (bandwidth inflation problem). In the Voxel game, although it issues much fewer commands than the Truck Town game and thus uses less bandwidth than video streaming, its rendering time (an average of 20.8 milliseconds) exceeds acceptable limits (≤ 1/60 second≈16.6 milliseconds per frame).). 1 to provide a frame rate of 60 fps and thus it only displays a frame rate of 48 fps. Such long rendering times are due to the fact that objects are created dynamically, based on the user's perspective and position, leading to tedious synchronous communication between the game and the Edge server during image rendering.

II. CONCLUSION

In conclusion, this study emphasizes how crucial it is for cloud gaming to support a wide variety of mobile devices. The suggested remedy of including a graphics customization tool not only reduces graphics-related issues but also encourages a more equal and accessible cloud gaming environment, where players may customize their experiences to their particular hardware and network resources.

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