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A First Look At The Future Of Gaming-Stadia

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Abstract—Cloud gaming is a new way to deliver high-quality gaming experience to gamers anywhere and anytime. In cloud gaming, sophisticated game software runs on powerfulservers in data centers, rendered game scenes are streamed to gamers over the Internet in real-time, and gamers use light-weight software executed on heterogeneous devices to interact with the games. Due to the proliferation of high-speed networks and cloud computing, cloud gaming has attracted tremendous attentions in both the academia and industry since late 2000's. In this article, we survey the latest cloud gaming research from different aspects, spanning over cloud gaming platforms, optimization techniques, and commercial cloud gaming services. The readers will gain the overview of cloud gaming research and get familiar with the recent developments in thisarea.

Index Terms—Clouds, distributed computing, video coding, quality of service, computer graphics.

I. INTRODUCTION

Cloud gaming refers to a new way to deliver computer games to users, where computationally complex games are executed on powerful cloud servers, the rendered game scenes are streamed over the Internet to gamers with thin clients on heterogeneous devices, and the control events from input devices are sent back to cloud servers for interactions. Figure 1 presents how cloud gaming services work. In the cloud, a cloud gaming platform is hosted on cloud servers in one or multiple data centers. The cloud gaming platform runs computer game programs, which can be roughly divided into
two major components: (i) game logic that is responsible to convert gamer commands into in-game interactions, and (ii) scene renderer that generates game scenes in real-time.

The gamer commands come from the command interpreter, and the game scenes are captured by video capturer into videos, which are then compressed by video encoder. The command interpreter, video capturer, and video encoder are
all implemented as parts of the cloud gaming platform. As shown in this figure, the cloud gaming platform sends the video frames to, and receives user inputs from thin clients used by gamers for playing games. It is a thin client, because only two low-complexity components are required: (i) command receiver, which connects to the game controllers, such as gamepads, joysticks, keyboards, and mouse's, and (ii) video decoder, which can be realized using massively produced (inexpensive) decoder chips. The communications between the cloud game platform and thin clients are over the best-effort Internet, which in turn makes supporting real-time computer games quite challenging.
The tremendous popularity of cloud gaming may be attributed to several potential advantages to gamers, game developers, and service providers. For gamers, cloud gaming enables them to: (i) have access to their games anywhere and anytime, (ii) purchase or rent games on-demand, (iii) avoid regularly upgrading their hardware, and (iv) enjoy unique features such as migrating across client computers during game sessions, observing ongoing tournaments, and sharing game replays with friends. For game developers, cloud gaming allows them to: (i) concentrate on a single platform, which in turn reduces the porting and testing costs, (ii) bypass retailers for higher profit margins, (iii) reach out to more gamers, and (iv) avoid piracy as the game software is never downloaded to client computers. For service providers, cloud gaming: (i) leads to new business models, (ii) creates more demands

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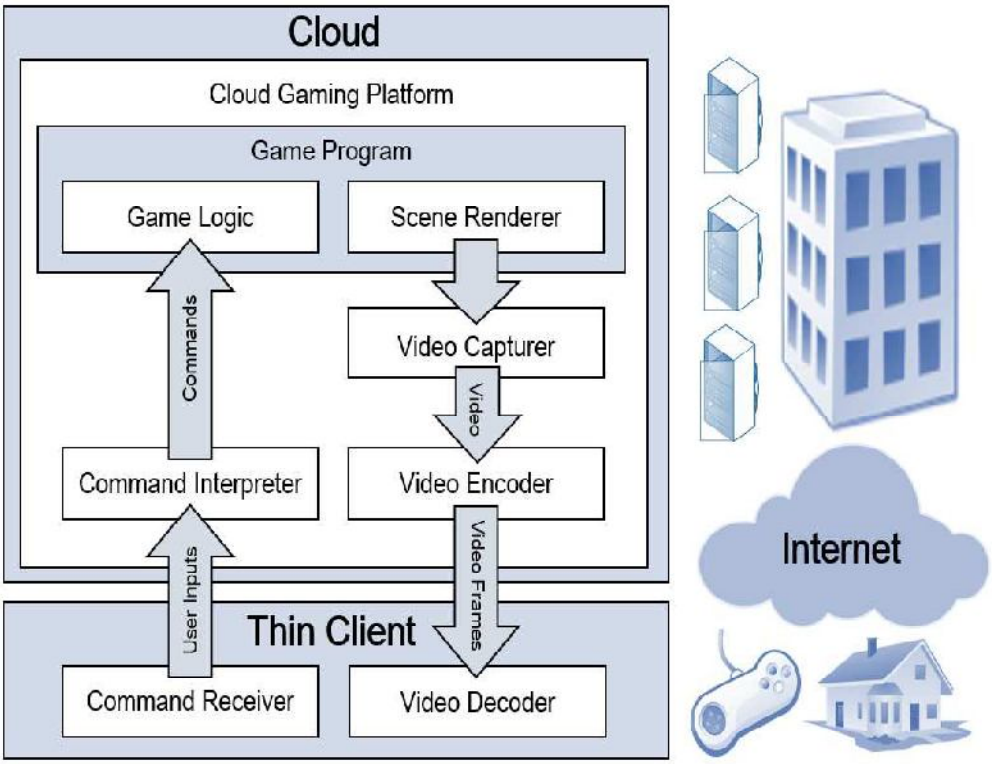
on already-deployed cloud resources, and (iii) demonstrates the potential of other/new remote execution applications, since cloud gaming imposes the strictest constraints on various computing and networking resources. Despite the great opportunities of cloud gaming, several crucial challenges must be addressed by the research



community before it reaches its full potentials to attract more gamers, game developers, and service providers. We summarize the most important aspect as follows. First, cloud gaming platforms must be built up for comprehensive performance evaluations. The evaluations include measurements on Quality of Service (QOS) metrics, such as energy consumption
and network metrics, and Quality of Experience (QOE) metrics, such as gamer perceived experience. Building platforms and test-beds, designing the test scenarios, and carrying out the evaluations, require significant efforts, while analyzing the complex interplay between QOS and QOE metrics is even more difficult.

Second, the resulting platforms and evaluation procedures allow the research community to optimize various components, such as cloud servers and communication channels. More specifically, optimization techniques for: (i) better resource allocation and distributed architecture are possible at cloud servers, and (ii) optimal content coding and adaptive transmissions are possible in communication channels.

Third, computer games are of various game genres [19].These genres can be categorized on the basis of two elements: *viewpoint* and *theme. Viewpoint* is how a gamer observe the game scene. It determines the variability of rendered video on the screen. Most commonly seen viewpoints include first-person, second-person, third-person, and omnipresent. First-person games adopt graphical perspectives rendered from the viewpoint of the in-game characters, such as in Counter-Strike. Second-person games are rendered from the back of the in-game characters, so that gamers can see the characters on the screen, like in Grand Theft Auto. Third-person games fix the gamers' views on 3D scenes, projected onto 2D spaces. Modern third-person games usually adopts the sky view, also known as God view. Classic third-person games include Diablo, Command & Conquer, Free-Style, and etc. Last, omnipresent enables gamers to fully control views on the region of interest (ROI) from different angels and distances. Many recent war games, e.g., Age of Empires 3, Stronghold 2, and War-Craft III, fall into this category. Game *theme* determines how gamers interact with game content.

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Common themes include shooting, fighting, sports, turn-based role-playing (RPG), action role-playing (ARPG), turn-based strategy, real-time strategy (RTS), and management simulation. Although the *viewpoint* may be restricted by game *theme*, but generally a game genre can be describe by a pair of *viewpoint*and *theme*, such as first-person shooting, third-person ARPG, omnipresent RTS, and etc. Among them, fast-paced first-person shooting games impose the highest scene complexity, which are the most challenging games for cloud gaming service providers. In contrast, third-person turn-based RPG games are least sensitive to delays and thus more suitable for cloud gaming.

II. GOOGLE STADIA

The ambition of Google's vision for Stadia is rooted in the fundamental components of gaming, whether it is a ball game millennia ago or the most advanced video games of today: players, watchers, and developers. These three aspects of gaming have been essential since the earliest sporting events and have become even more pertinent as the barriers to playing, watching, and developing a game have all but vanished with the dawn of the internet.

These fundamentals, paired with the platforms supported by Google, have created near-perfect conditions for the creation of a complete gaming experience. Google already supports live streaming of games through YouTube, but there is inherent friction for the viewers. A user may be watching someone play a game, but they themselves cannot join in the fun. Even if they purchased the game, it would require that the viewer download and install the game before participating in the fun. The goal of Google's Stadia is to remove this friction and allow anyone, anywhere to start playing a game in seconds: no installation, no downloads, no third-party software. Just immediately playing a game.

This vision is made possible by integrating YouTube and Stadia, with YouTube providing the platform for watchers to experience a game through live streaming and Stadia providing the platform for players to take part in a game and developers to create new games.

The core of Stadia is cloud-computing. In much the same way that cloud-computing establishes an environment in which programmers can create applications without limits—programmers see a nearly unlimited pool of resources to work with, regardless of the physical topology or orchestration behind the scenes—Stadia utilizes the Google Data Center to create a cloud-based gaming experience. This approach means that instead of purchasing a game—either physically or digitally—installing the game, and then having the game available natively on a system, the game is instead executed on a compute node (or set of compute nodes) and streamed to the player's device.

III.CONCEPT OF STADIA

Although video streaming (such as Netflix or Hulu) is nothing new, game streaming is a different beast entirely. Generally, video streaming data is unidirectional, with the stream provider (i.e., Netflix) providing video data to a client device. In game streaming, data is bidirectional, with inputs flowing from the player and the provider streaming audiovisual (AV) data that *results* from these inputs. This causal relationship between player input and AV data means that AV data cannot be pre-computed or pre-compressed. Instead, the provider must compute AV data in real-time *after* receiving the input from a player.

Theoretically, given a fast enough connection between the player and Stadia network and swift enough computing in the Stadia network, input from a player can be sent to the Stadia network and used to compute AV changes to the game without any issue. The generated AV data reflects these changes, which are then sent from the Stadia network back to the player's device:

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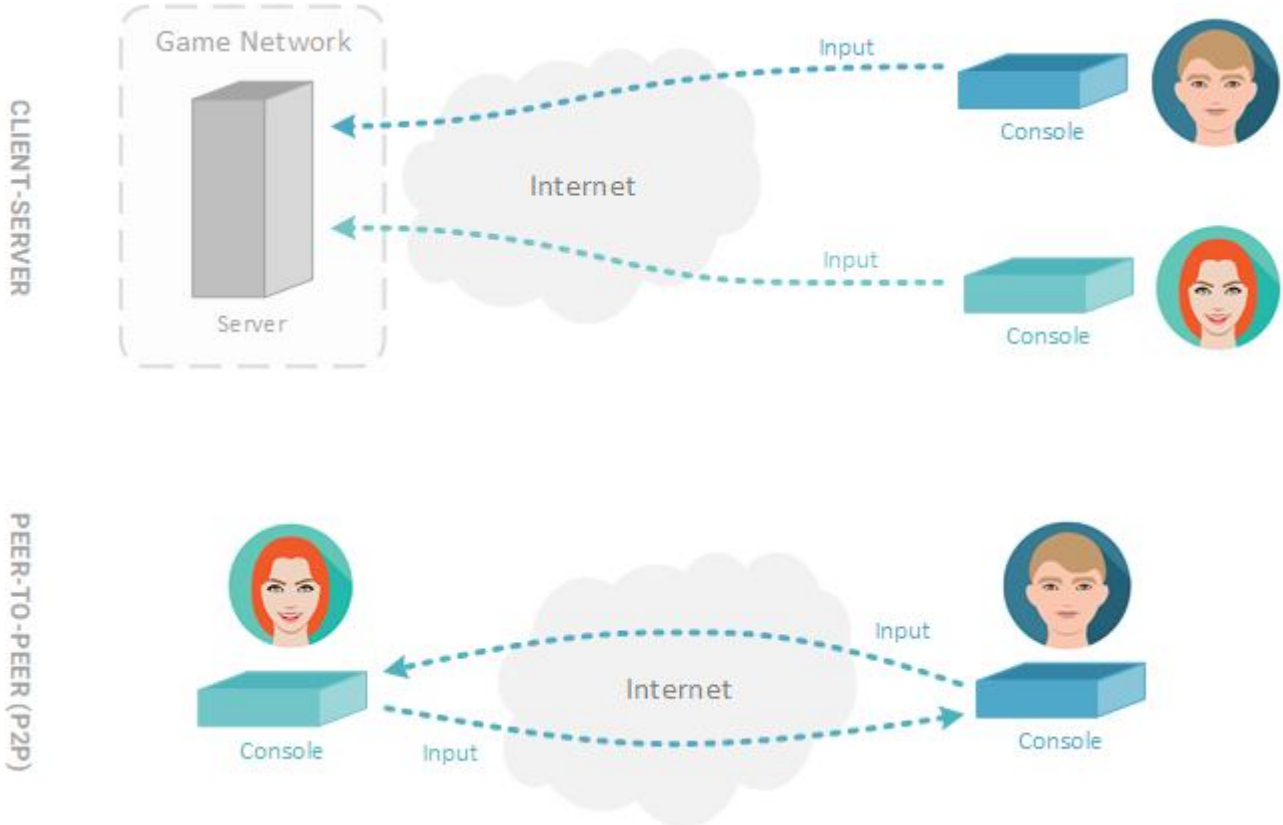
In the interconnected gaming world of today, with a large portion of the most popular games being Massive Multiplayer Online (MMO) games (such as *Fortnite* or *Apex: Legends*), this has many advantages. Currently, gamers purchase an individual game console and this console connects to either a server or other consoles and data flows through the internet to create an interconnected network of consoles. For example, in a multiplayer scenario, one player may move his character, and this data is either sent to a server or directly to other players to reflect his or her change in position on the other player's console:



Stadia completely changes this topology, drawing in the console portion of the scheme into a single, localized network. This means that one console—called a Stadia instance—can communicate with another instance without sending data over the public internet. Instead, each Stadia instance communicates with other instances directly within the same network:

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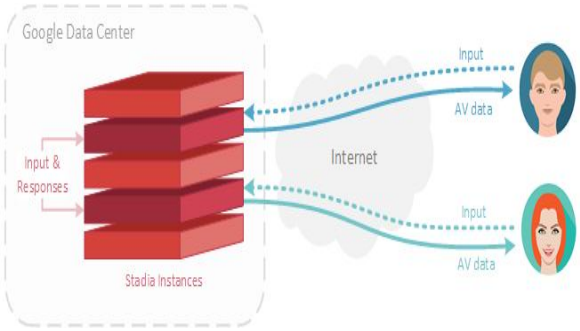

In games that require it, the client and server portions of a game are co-located within the same network. This means that the client has direct access to the server. According to Google, this can lead to multiplayer games growing from a hundred players—as it typical with battle-Royale MMOs—to tens of thousands of concurrent players.

IV.ACCESSIBILITY

To facilitate its accessibility to everyone, Google has ensured that Stadia is genuinely cross-platform. According to Harrison, developers will be able to create a single codebase that is playable on:

1. Desktops
2. Laptops
3. TVs
4. Tablets
5. Phones

This cross-compatibility is made possible by the streaming nature of Stadia. Instead of downloading code and executing it natively on a device, as is done with consoles, Stadia streams the game to any device that can accept the stream and provide player input.

V.CONCLUSION

In this article, we grouped the Future of Gaming into categories of (i) Introduction (ii) Google stadia (iii) Concept of stadia and its (iv) Accessibility.

Cloud gaming is not a panacea and incurs non-trivial costs to service providers. Minimizing the cost on cloud and networking resources while achieving high gamer experience requires careful optimization. Without these optimizations, service provider cannot consolidate enough cloud gaming users to each physical machine. This in turn leads to much lower profits, and may drive the service provider out of business.

Most current cloud gaming platforms work as a ”black box” simply wrapping a traditionally programmed game in a support system to enable cloud gaming. Although, the original black box model of cloud gaming has led to many practical real world implementations a more integrated approach may be necessary.

Google Stadia is Conceptually a massive leap toward the future of gaming. No longer is a game developer required to create and support multiple versions of a single game on different consoles. Instead, a developer can now create a single game and gamers and play it on a wide variety of devices.

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In summary, Although I may appear sour on the outlook of Stadia, I find the technology very impressive; but there is a still a long way to go beyond computer science before Stadia can establish itself as a big player in the gaming community. Only further announcements from Google will bring its vision closer to reality, but in the meantime, the introduction of Stadia by Google has brought some much-needed outsider competition into a market that has been hyper-focused on reinvention, rather than innovation, for a long time.

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