A novel cloud game framework in dual Gigabit Network

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Abstract: With the development of 5G, cloud computing, and artificial intelligence (AI) technology, cloud game has become a hotspot about application and innovation of Gigabit bandwidth. This paper, firstly, analyses the present situation and development of cloud game to clarify the key business and key technology of cloud game, then, proposes an operational framework of cloud game, finally, the feasibility of the proposed framework is discussed and several suggestions about the operation of cloud game are given.

1. Introduction
With the large-scale construction of 5G and optical broadband dual Gigabit networks, cloud computing, AI, and intelligent terminal technologies have brought violently changes and huge growth opportunities for information applications. In the past ten years, cloud game industry has made a lot of technical verification and commercial exploration to break through the limitations of network transmission capacity, terminal computing power and use scenarios, and has become a new industry investment hotspot. At present, the industry's understanding of cloud game business mainly refers to running large-scale games on cloud servers, transmitting the rendered and compressed game screen to user with the rendering capabilities of cloud GPU, and making the interactions between users and cloud server. Users can play large-scale games directly without purchasing expensive hosts and game terminals. In 2009, OnLive officially launched the cloud game platform for the first time and quickly entered a low ebb period because of poor user experience, immature GPU virtualization technology, high operating costs, and content piracy problems etc. Since 2017, some leading enterprises in the industrial chain, e.g. Microsoft, Google, EA, Sony, NVIDIA, Tencent, and some large communication operators etc. have put forward the attractive development plans of cloud game based on their core competence, which strongly promote the development of cloud game industry into a new era.

With the emergence of new technologies and the improvement of industrial chain maturity, network transmission bandwidth and cloud computing capacity have been greatly improved, and all parties have launched active exploration of commercial operation, and the development environment of cloud game has been significantly improved. Specifically, it is mainly manifested in the following aspects. Firstly, the industrial infrastructure is becoming more and more perfect, including the popularization of high-speed broadband, 5G business, and the improvement of cloud platform computing power etc. Secondly, effective technical support, including GPU virtualization technology, audio and video compression technology, edge computing and so on. Thirdly, the improvement and
enhancement of cloud game interaction mode by intelligent wearable terminal, such as VR / AR terminal. Fourth, the construction of new business models, such as cloud game based on audio and video streaming. Fifth, driven by new business and new technology, cloud game industry is in the transition from technical verification to commercial verification. For providing users with better business experience, operators still face many challenges and obstacles in key technologies, system architecture, business models and so on.

2. Key technologies of cloud game

For meeting the needs of cloud game business, the business requirements of cloud game are shown in Figure 1, cloud server realizes the running and rendering of games and the coding of video stream, the transmission network realizes the downlink of audio and video stream and the uplink of control flow, and the terminal realizes the decoding of the video stream to present the game picture and the controlling of the game. To the cloud server, its key technical factors mainly include game rendering delay, game picture rendering quality, audio and video coding efficiency and quality, and control command response delay, etc. The influence of 5G optical fiber transmission network access on cloud game is mainly the network transmission delay. And the impact of terminals mainly includes audio and video decoding delay, audio and video synchronization.

Due to the limitation of network infrastructure, the promotion of cloud game can only be carried out in a few countries or regions with good network facilities. For example, Sony PS NOW service only serves users in North America, and Switch cloud game only provides services for Japanese users. From the perspective of user experience, bandwidth and delay are still the bottlenecks restricting the development of cloud game services.

![Figure 1. The business requirements of cloud game](image)

The technology implementation of cloud game involves cloud service platform, transmission network, and user terminal, its key core technologies include four parts: GPU (Graphics Processing Unit) virtualization technology, Digital audio-video media coding & decoding technique, Network transmission technology, and Edge computing.

2.1 GPU virtualization technology

The development of AI and big data processing technology promotes the improvement of high-density GPU server, which can support 10 billion floating-point computing per second. Virtualization technology can realize the sharing of GPU on multiple virtual machines, which can greatly improve the utilization efficiency and reduce the operation cost. With the virtualization container isolation technology, multiple game processes can run in one operating system at the same time, and the computing power resources are divided into finer granularity and higher utilization rate. Moreover, virtual desktop technology can also be used to realize that each virtual machine run one game, which can provide a low-cost independent running environment, and optimize the server resource configuration and achieve the higher efficiency of resource management. In general, the GPU products of NVIDIA and AMD have better performance. With the support of AMD graphics card, Google launched the cloud game platform stadia in 2019. GPU virtualization technology has been paid more and more attention, and the technology is gradually improved, but there is still much room for improvement.
2.2 Digital audio-video media coding & decoding technique
Cloud game have high requirements on network bandwidth and interaction delay. The higher the compression degree of video stream, the less bandwidth requirement pushed rendered video to users, so high definition (HD) video can be provided to users in small bandwidth. However, with the increase of compression rate, the encoding time also increases. The codec (coding & decoding) technology should be able to achieve the balance of bandwidth and delay. In particular, when the network bandwidth is unstable, the codec frequency of audio and video can be adjusted flexibly to match the current bandwidth. At present, the mainstream video codec formats supported by the industry are H.264 and H.265.

2.3 Network transmission technology
Network infrastructure is the basic condition for the realization of high bandwidth applications. Through the construction of 5G and optical fiber dual Gigabit network, communication operators ensure the optimal low interaction delay and high stability of cloud game services. Through the updating of metropolitan area network and backbone network, communication operators have built high-speed channels for high bandwidth applications such as cloud game. And with the reasonable layout of network functions, network bandwidth scheduling and quality assurance capabilities for subdivision applications are realized, which provides the possibility for the realization of differentiated applications. On the other hand, in the network terminal side, the home wired or wireless network also needs to provide low delay, low jitter network transmission capability.

2.4 Edge computing
In addition to the real-time rendering capabilities provided by cloud GPU servers, the development of cloud gaming also depends on the improvement of edge computing technology. Based on their cloud platforms, game operators are actively deploying sinking nodes and build high-speed edge clouds, which are closer to users and have faster real-time processing and response. It can significantly improve the user control experience by automatically selecting the nearest cloud node for users and providing AI audit capability for media and content.

3. Core business of cloud game
Different from the existing local games, relying on high-performance cloud server and high-speed transmission network, cloud game bring users a new experience in game content, terminal control, payment mode and so on.

3.1 End to end integrated service quality assurance
Based on the mutual cooperation of cloud platform, communication network and local terminal, cloud game can bring users the ultimate game business experience. If users don't feel the experience advantages of cloud game compared with local games, their acceptance of the new model will be greatly reduced. Therefore, the quality of the game experience is the key to the popularity of cloud game. Such as network experience, image quality experience, game start time, control experience and so on.

3.2 High quality game content
At present, there is still a big gap between the number of mainframe cloud game and market demand, which is not enough to support the needs of large-scale operation. In order to achieve the breakthrough of cloud game in the existing game market and reach the level of large-scale users, 3A level high-quality host game is an important breakthrough.

From the perspective of demand side, game players have obvious preference for high-quality games, but this kind of games have high requirements for host configuration, and the high price is beyond the endurance of many players. It makes this kind of games unable to be widely popularized. From the supply side point of view, developers and operators of high-quality games have a strong
desire to promote the game business, hoping to broaden the market channels and constantly expand the number of users. From the perspective of the competition side, the business operation of other types of large-scale games, such as mobile games, page games and end games, is basically stable. The existing technical solutions can well support the operation of games without changing the architecture. Obviously, only the mainframe games that rely on high-performance hosts need to adjust the game business architecture to achieve user group expansion.

3.3 Cloud game terminal
Most of the existing home network access forms are Set-Top Boxes (STB). Users can access high-speed network signals through STB, which is easier to be accepted by game developers and operators. Specifically, first of all, Virtual Reality (VR) games are suitable for cloud game mode. As a new game mode, VR game is in the initial stage of development and has a broad market prospect. Moreover, VR games can provide high-quality audio-visual and somatosensory experience, and require high terminal computing power. Cloud game mode can reduce the deployment cost of VR terminals and promote the popularity of VR games. In addition, the light console game is a hot spot in the current market. Realizing its cloud deployment and combining with the existing massive home set-top boxes can quickly occupy the market and achieve scale benefits, which is a development method that network operators can give priority to.

3.4 New payment mode for cloud game
With the payment mode of network resource service gradually accepted by users, the subscription system of network service is expected to promote business model innovation. At present, the one-time online game payment model cannot meet the development needs of cloud game. For users, they don't like endless online games with high investment, and are not willing to pay a high price for the right to use the game at one time. At the same time, for game developers or network operators, the one-time sales of online games also has disadvantages, there are risks of being cracked and embezzled.

Therefore, cloud game should adopt subscription payment mode. For example, users pay monthly to buy the right to use the game. Compared with the one-time purchase of the right to use the game, this mode allows users to obtain the same high-quality game experience at a lower cost, and is conducive to the game operators to improve the operation quality and reduce the risk of game piracy and cracking.

At present, key enterprises in the cloud game industry, including large-scale game developers, host game operators and telecom operators, are actively making use of their advantages in content, terminal, network and other aspects, building distribution and operation platform and cloud game content resource library. The operation structure of cloud game is becoming more and more perfect.

4. A framework of cloud game in dual Gigabit Network
Considering the different types of cloud game terminals, cloud game currently under commercial exploration in the industry are mainly implemented on three types of terminals. The first type is IPTV Set-top box, which has been widely installed with home broadband access, and can be pre-installed or upgraded into cloud game. The second category is 5G mobile terminal, which has developed rapidly in China and has become the mainstream mobile access network mode. Cloud game are downloaded and installed through app application market. The third is VR terminal, which mainly adopts the combination of pre-installation of cooperative terminal and open download.

As network communication operators are the only operators based on the three terminal types to carry out platform network deployment test, this part mainly discusses the development and operation of cloud game for network communication operators.

4.1 Network deployment
The existing IPTV platform and 5G service platform are respectively deployed in their respective private networks. Therefore, the network deployment of cloud game service needs to consider the
consistency of game experience between IPTV and 5G terminals. This consistency is reflected in the following aspects:

- IPTV network and 5G network are interconnected and integrated to ensure the synchronization of user data and the consistency of user experience.
- The cloud game service is deployed as a two-level hierarchical structure in the form of "root node - region sub node", as shown in Figure 2.

In this two-level structure, root node is responsible for game content management, product management, membership system, tariff management, billing and account splitting. Regional sub nodes include cloud game content service platform and regional management platform. Content service platform undertakes the functions of game content calculation, storage and rendering in the form of edge computing, which ensures the high-speed transmission between the edge cloud and the terminal, and provides the ultimate user experience. Regional management platform realizes terminal authentication, user management and other management functions related to regional business.

4.2 The architecture of cloud game service
Cloud game service platform is mainly divided into four layers, namely IaaS (Infrastructure-as-a-Service) layer, PaaS (Platform-as-a-Service) layer, SaaS (Software-as-a-Service) layers, and application layer, shown in Figure 3.
• IaaS layer supports Android virtual machine architecture based on X86 server, Android virtual machine architecture based on ARM server and matrix architecture based on ARM consumer chip.
• PaaS layer supports basic service capabilities, including resource scheduling strategy management, cloud game streaming capabilities (game running, rendering, coding output, etc.), and also supports open development interface to realize the access, development and release of application content.
• SaaS layer supports content management, user management, billing and settlement, terminal information management and other operation management functions.
• Application layer provides management interface and computing interface for all kinds of game services.

4.3 Operation practice
Based on the above dual Gigabit cloud game system architecture, communication operators should focus on the following issues in their attempt to carry out commercial exploration.

4.3.1 Platform development. The development of cloud game is in the stage of commercial exploration. Operators should consider the balance between the investment and income of cloud game, adopt the mode of construction on demand and elastic expansion in platform construction, and invest cautiously.

4.3.2 Content introduction. In the early stage of cloud game operation, operators can concentrate operation resources and marketing resources, give priority to the development of a few high-quality games, avoid decentralized investment and bring pressure to the game operation. In the middle and later stage of game operation, operators can gradually introduce various types of diversified games according to the actual development needs to meet the needs of different levels of users. In addition, the selection of game content and type needs to consider the adaptability of TV screen and mobile screen, content copyright, target user demand, etc.

4.3.3 Charging mode. Cloud game service and network video on demand service have high similarity, cloud game charging mode can also adopt subscription payment scheme. Users choose to buy cloud game packs of different lengths and grades (different types and numbers of cloud game, different number of terminals supported, etc.). For non-paying users, limited time trial of some games is provided to guide them to become paid users.

4.3.4 User promotion. For mobile phone and IPTV large screen, operators should adopt differentiated user promotion strategy. For mobile phone users, the installation files are distributed through the app store, and user registration and authentication are realized through mobile phone binding or other methods. Due to the huge number of IPTV Set-top box users and the variety of access terminal types, IPTV Set-top box should be the target customers that communication operators need to focus on. Due to its particularity in system and control mode, its promotion, installation and certification process also needs to be redesigned, as shown in Figure 4. Generally speaking, users select and install program files according to the recommendation of IPTV page, and then use IPTV account for authentication to quickly log in to cloud game. In addition, in order to promote the application of users, non paying members can try queuing for trial.
5. Conclusion

With the development of 5g, AI and cloud computing, cloud game have been widely concerned by the industry. Many manufacturers have begun to actively explore the layout and become a new investment hotspot. Although the cloud game system based on dual Gigabit of communication operators has entered the stage of commercial promotion, the user habits and industrial scale of cloud game still need a long time to cultivate. In this paper, the development trend and key business technical elements of cloud game system based on double Gigabit are studied, and an operational cloud game system architecture is proposed. In the future, further research and breakthrough are needed in the business model, profit distribution mode, high-quality game content development, fast user experience and cloud game industry standardization.

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