



Cloud VR

Scenario White Paper



February 2018



Preface

Cloud VR introduces cloud computing and cloud rendering for VR services. Fast and stable networks allow the implementation of cloud-based VR service content and content rendering where display output and audio output are coded, compressed, and transmitted to user terminals.

Cloud VR represents the most advanced technological development of the VR industry. Cloud VR aggregates VR content and quickly distributes it to common users and vertical industries. Cloud VR enables rendering on the cloud, lowering requirements on VR terminals, and facilitating user acceptance.

This white paper was developed under the guidance of the Chinese Ministry of Industry and Information Technology (MIIT), and released jointly by the China Academy of Information and Communications Technology (CAICT) and Huawei according to the annual work plan of the Virtual Reality Promotion Committee. This white paper focuses on the present context and the potential value of Cloud VR. It also discusses the development path of its scenarios, which are divided into the following three phases: the recently cloudified phase, the mid-term cloudified phase, and the long-term cloudified phase. This white paper defines 17 Cloud VR application scenarios based on the existing industrial context. The value and application direction of each scenario is analyzed based on the service characteristics of Cloud VR, experience and customer feedback from CAICT, Huawei iLab, and Huawei C&SI Business Consulting Dept. This paper summarizes the service formats of Cloud VR, discusses the business models of each service scenario, and analyzes the pace and trend of Cloud VR business development. This white paper can be used to guide the future service development of Cloud VR scenarios.



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Cloud VR Scenario Overview

Cloud VR

Cloud Virtual Reality (Cloud VR) introduces cloud computing and cloud rendering for VR services. Fast and stable networks allow the implementation of cloud-based VR service content and content rendering, where display output and audio output are coded, compressed, and transmitted to user terminals from the cloud.

Cloud VR application scenarios

Cloud VR can be applied to many scenarios, and has a lot of market potential. Its widespread adoption will revolutionize people's lives and production methods. CAICT, Huawei iLab, and Huawei C&SI Business Consulting Dept have divided the 17 Cloud VR scenarios into Cloud VR 2C scenarios and Cloud VR 2B scenarios based on research and industry insights both inside and outside China.

Cloud VR 2C Application Scenarios

- Cloud VR IMAX
- Cloud VR live broadcast
- Cloud VR 360° videos
- Cloud VR gaming
- Cloud VR music
- Cloud VR fitness
- Cloud VR karaoke
- Cloud social VR
- Cloud VR shopping

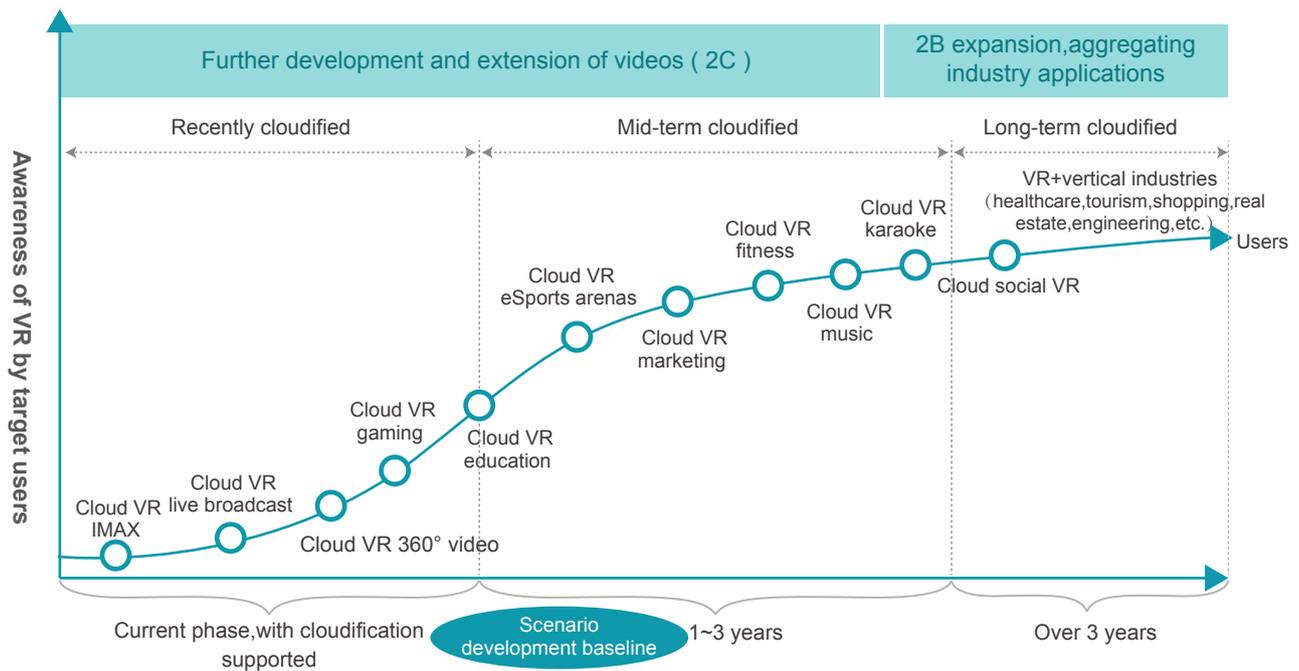
Cloud VR 2B Application Scenarios

- Cloud VR education
- Cloud VR eSports arena
- Cloud VR marketing
- Cloud VR healthcare
- Cloud VR tourism
- Cloud VR real estate
- Cloud VR military
- Cloud VR engineering

02

Three Phases of Cloud VR Scenario Development

The development of everything is a gradual process of progression, and Cloud VR application scenarios are no exceptions (including both indoor and outdoor scenarios). Cloud VR development can be divided into the following three phases based on the user base, usage frequency, content maturity, user experience, cloudification progress, and industry maturity: the recently cloudified, the mid-term cloudified, and the long-term cloudified.



Recently cloudified phase (Current support for cloudification)

Scenarios have already implemented wireless terminals, cloud-based content, and cloud-based real-time rendering and computing. The industry is mature, with frequent usage and a large user base. Various types of terminals are available on the market. Traditional content is provided through a new experience, and new content, such as Cloud VR live broadcast and videos, is also available, providing highly immersive experiences. Scenarios in this phase can be regarded as an extension of video, and cultivate the VR habits of users.

Cloud VR IMAX, Cloud VR live broadcast, Cloud VR 360 ° videos, and Cloud VR gaming are supported on cloud platforms. As long as the cloud service platforms implement these services, they will become widely used by users on a large scale.

Mid-term cloudified phase (1 to 3 years)

Scenarios in this phase have demonstrated a significant trend toward cloudification. The user experience of scenarios is good, they have a high usage frequency, huge market potential, and mostly matured industry technologies. However, there are still some issues hindering an optimal experience. The content is limited, and the terminals are not completely wire-free. In some scenarios, user experience can only be ensured through use of a wired head mounted display (HMD) and an external locator, with content still being rendered locally in real time. The lack of content and the high cost of terminals have restricted the popularization of these scenarios which are frequently applied. Once content and content rendering are implemented on the cloud platform, good content will be efficiently and cyclically used, reducing consumer costs and promoting user consumption.

Cloud VR education, marketing, eSports arenas, fitness, music, karaoke, and healthcare all belong to the mid-term cloudification phase.

Long-term cloudified phase (over 3 years)

There is a broad prospect for scenarios in this phase. Professional knowledge needs to be customized, and requirements on experiences are high. The business models of these scenarios are clear. However, industry technologies are still immature, capital is still being deployed, and the content of these scenarios is relatively scarce. Once the industry chain matures, the scenarios of the long-term cloudified phase can be expanded quickly on cloud platforms.

Cloud VR tourism, social networking, shopping, military, engineering, and real estate all belong to the long-term cloudified phase.





Cloud VR Application Scenarios



Cloud VR IMAX: New Experience for Watching Movies

Definition

VR HMD can be used to watch traditional online videos and experience a large personal IMAX with great visual impact.

Application Scenarios

Home IMAX: With VR HMDs, viewers can experience private IMAX, 3D images, 1080p to 4K resolution, IMAX of 800 to 1000 inches, and flexible screen size adjustment. Previously, viewers had to go to a cinema and buy a ticket for 3D movies. Now with VR IMAX, they can watch 3D movies on their own anywhere at home, without worrying that others may want to watch a different channel.

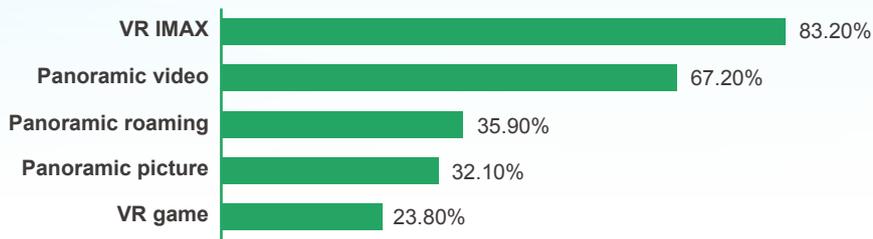
Portable IMAX: With no location restrictions, viewers can enjoy IMAX during trips, in parks, or in rural areas. VR IMAX provides viewers with customized viewing backgrounds, for example, they can watch the Apollo 13 flying across the Atlantic Ocean while sitting on top of a mountain. They can also watch movies in forests, on trains, in the sea, or even amongst flowers.

Industry Situation

- 1.Extensive variety of videos in the Cloud VR IMAX:** The existing IPTV service platform offers many high-quality videos.
- 2.Easy deployment as an extension of the IPTV service platform:** The IPTV system has a large number of subscribers, and the service platform does not need to be optimized or modified.
- 3.Widespread terminal support:** Many terminals support the Cloud VR IMAX, including all-in-one VR machine, PC VR, and mobile phones with VR glasses. For example, Huawei has cooperated with IMAX Corporation on VR2 HMD.
- 4.Highly recognized user experience:** Cloud VR IMAX has a certain number of users and offers a demonstrably good user experience. The China VR industry development report lists the preferred application types of Chinese VR users, as shown in the following figure.



Application Types of China VR Users



Source: China VR User Behavior Research Report

5. Portability and convenience: Terminals allow viewers to enjoy movies anytime from anywhere.

6. Ultra-HD display: The terminal resolution per eye can reach up to 1K to 2K. The dual-eye parallax effect is used to simulate 3D display, offering an imaging principle similar to that of human eyes, enabling viewers to experience the IMAX effect equivalent to a 1,000-inch physical screen. Viewers who are short sighted can also enjoy VR IMAX, which supports adjustment of the degree of sight.

7. Advantages of VR IMAX: VR IMAX can provide content with higher resolution. In traditional TV experiences, viewers cannot distinguish between resolutions once they reach 4K. However, VR IMAX can break through this ceiling. By adjusting the field of view (FOV) and increasing the screen size, 8K can be consciously experienced.

🎯 Business Opportunities

The Cloud VR IMAX can be viewed as an extension of the IPTV video service. With the high bandwidth and low latency of the 4K bearer network, Cloud VR IMAX services can grow fast if the terminal penetration rate is improved.



3.2

Cloud VR Live Broadcast: Easy to Commercialize

📄 Definition

Ball games, sports events, and concerts are broadcast through VR technologies in real time. In the current phase, users can feel immersed, as if they are seeing celebrities in person. Together with VR spatial audio, they can hear the real cheers in the venue. In the future phase, users can both enjoy the visual and audio experience and also interact with others. They can connect with friends remotely to share games, communicate about strategies, or even "high five" virtually.

Application Scenarios

Cloud VR live broadcast can be applied in multiple fields, such as NBA sports events, Olympic Games, concerts, fan meetings, and news conferences.

1.Cloud VR live broadcast has been successfully implemented in multiple sports events.

NextVR obtained authorization for the NBA League, with an estimated market value of US\$800 million. WhaleyVR worked with China Sports Media (CSM) and FlyCat to provide VR live broadcast of the 2017 Chinese Football Association Super League (CSL). The BBC provided an approximate 100 hours of VR live programming for the Rio 2016 Olympic Games. Intel TRUEVR provided VR live broadcast for the NCAA Championship games.

On April 13, 2016, the Lakers were playing against the Jazz. The average ticket price of Kobe Bryant's final game was US\$26,500. NextVR provided 360° panoramic live broadcast for that game. A fan who watched from home through live VR said, "It was just like sitting right at the substitute bench, and I could clearly see every one of Kobe's moves. But, if I had gone to the game, it would have cost me US\$100 to 200 thousand." With VR, a fan only has to spend US\$6.99 to watch the game.

It is the end of Kobe's basketball career, but only the beginning of Cloud VR live broadcast.

2.Cloud VR live concerts bring viewers' favorite singers right in front of them.

NextVR and Coldplay, a British rock band, jointly held a concert live through VR.

Faye's Moment Live 2016, the concert of a famous Chinese singer, was provided as a VR live broadcast at prices as low as CNY30. A total of over 20 million fans immersed themselves in the concert through VR.

The concert provided a 3DoF experience, enabling viewers to feel like Faye was right in front of their eyes. Despite the excellent lighting and choreography, the shortcomings of this experience were also noticeable. The face of the singer was blurry due to low resolution. Faye's concert was broadcast in 4K VR with a bandwidth of about 12 Mbit/s, resulting in a resolution equivalent to 240p. This made the images unclear.

With high bandwidths, concerts will be able to provide the expected standard of Cloud VR live experience. In that case, even if prices rise to CNY100, fans will still find the experience worth the money.

3.Cloud VR live broadcast allows fans to "meet" their idols.

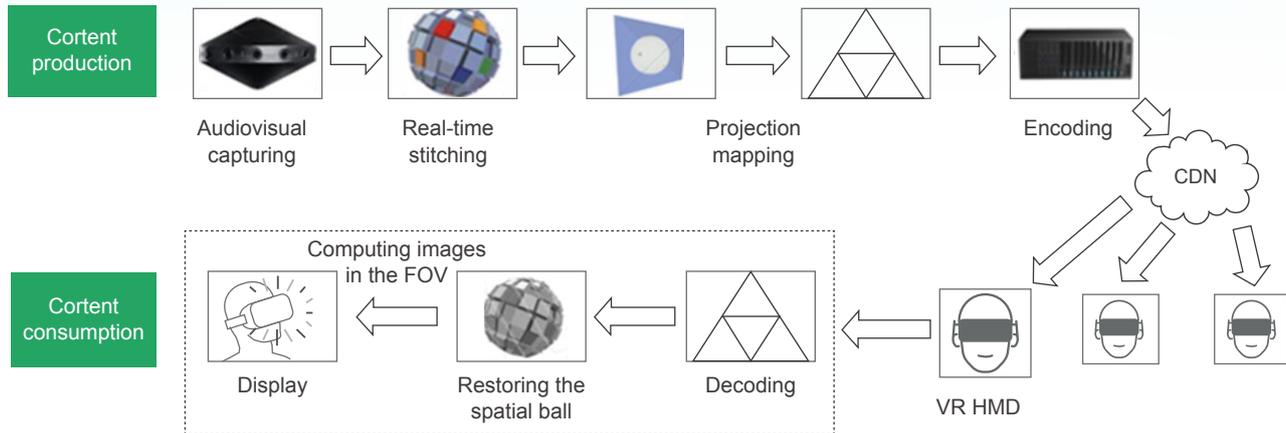
The iResearch *White Paper on Chinese Fandom and Fans' Lifestyle* pointed out that fans spend CNY500 to 2,000 on average per month on their fandom, with the amount even occasionally exceeding ten thousand. Fan meetings and peripheral products comprise a large proportion of these expenses. These types of purchases are made several times each year or month.

Cloud VR live broadcast enables fans to make their dreams of dining with or chatting with their idols face to face a reality. Fans follow every move of their idols on social media, and can make huge efforts to talk to their idols. Now with VR HMDs, fans can easily realize the dream of talking to their idols. In this case, fans will not only be willing to pay for virtual fan meetings, but also to actively spread this new experience to other fans.

Industry Situation

1. Cloud VR live broadcast solutions are already available in the industry.

A VR live broadcast scheme comprises the following three parts: content production, content distribution, and content consumption.



The process of content production for VR live broadcast is as follows:

- **Audiovisual capturing:** The 360° omnidirectional cameras are used to capture panoramic visual information. The professional 360° cameras offer 8K resolution and a 60 fps or higher frame rate.
- **Stitching technology:** Images captured by the 360° camera from all directions are stitched to a space ball.
- **Projection mapping:** The space ball is transformed into a planar media format. Common modes of projection include equiangular projection (cylindrical projection), and polyhedral projection.
- **Encoding technology:** Currently, H.264 is the mainstream encoding standard. H.265 and VP9 are next-generation encoding technologies that are widely accepted in the industry.
- **Network transmission:** In the current phase, bearer networks for 4K videos are possible. For better experience, bandwidth must exceed 100 Mbit/s.

2. The Cloud VR live broadcast experience is limited by bandwidth costs.

Many vendors lower the bit rate of videos to reduce bandwidth costs. As a result, the live broadcast experience cannot be guaranteed, causing unclear images, user sickness, and freezing. Under good network conditions, in the current phase Cloud VR live broadcast experiences are still attractive to users.

3. Cloud VR live broadcast in 4K 180° 3D provides good experiences, and in the future better experiences will rely on 8K.

In the early stages of the development of Cloud VR live broadcast, users are still used to viewing content with a 180° FOV, with the VR user habits being cultivated. In the current phase, the content experience of 4K 180° 3D is good, and the other types of 180° content can be used to implant advertisements.

Business Model

Cloud VR supports a variety of business models. Users can watch VR live broadcasts at home, in VIP suites on-site, or at dedicated viewing locations. VR industry partners provide various types of content for VR live broadcast, and can guarantee several celebrity concerts each year.

	VIP Suites	Dedicated Viewing Locations	Homes
User	<ul style="list-style-type: none"> Bringing suites closer to the stage Providing brand new experiences for high-end users 	<ul style="list-style-type: none"> Attending concerts remotely, reducing travel expenses Enjoying high-quality, strongly immersive VR live broadcasts 	<ul style="list-style-type: none"> Experiencing the live broadcast venue without leaving one's own home Lower ticket prices
Sponsor	<ul style="list-style-type: none"> Raising the attractiveness and value of VIP suites 	<ul style="list-style-type: none"> Raising the attractiveness and value of VIP suites 	<ul style="list-style-type: none"> Wider fan group coverage Higher copyright value
Operator	<ul style="list-style-type: none"> Ensuring high-bandwidth and ultra-low-latency networks with technical advantages for live broadcast Cooperating with IP providers to introduce new content for mutual benefit 	<ul style="list-style-type: none"> Providing quality networks to ensure user experience Cultivating user habits and laying the foundation for the popularization of VR live broadcast at home Connecting with IP providers to introduce content 	<ul style="list-style-type: none"> Exclusive live broadcasts, attracting users and preempting the home broadband market Promoting the popularization of VR live broadcast and facilitating network pipes Launching Gigabit packages with free VR live broadcast privileges to promote user upgrading

Suggestions for the design of Cloud VR live broadcast service packages



1. On-demand charge

Mobile terminals pay per use. For example, a VR live broadcast of a single concert costs only CNY50. The operator shares the ticket revenue with Letin VR, or Letin VR rents the operator's network.



2. Annual subscription

Operators can promote a Gigabit network subscription at CNY1,290, with concerts broadcast live in VR of a singer specified by the user at no additional costs in a year (with free VR glasses).



3. Three-year promotional subscription

Operators can promote a Gigabit network subscriptions at CNY3,600. Users can select three out of ten singers whose concerts in a year will be broadcast live in VR to the user for free.

Source: Letin VR

3.3

Cloud VR 360° Video: Immersion in Videos

Definition

Cloud VR 360° videos, the combination of video on demand (VoD) and VR technology, are divided into two types. The first type allows users to watch videos from a fixed position, and to view any directions. The second type does not have fixed viewing positions, and viewers are able to "walk" freely in the scene or even interact with the scene.

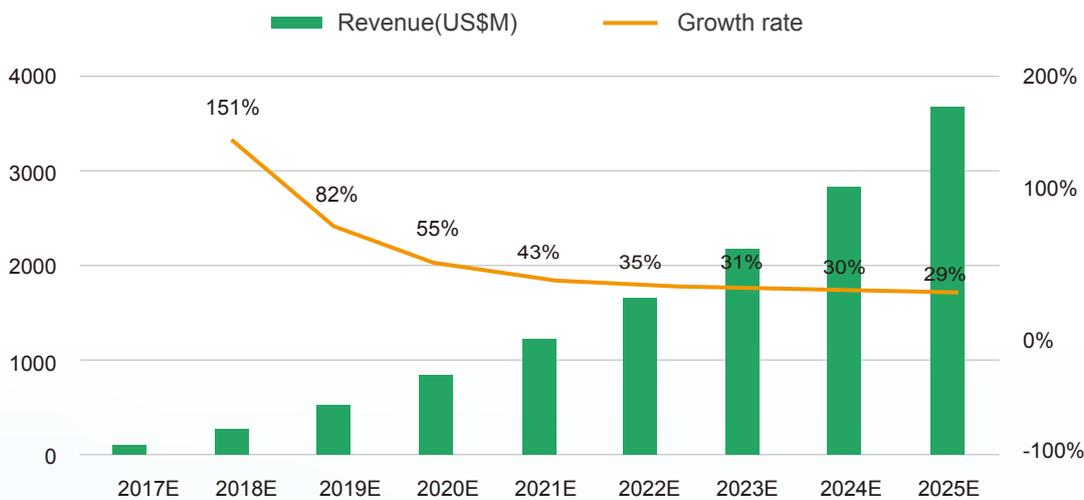
Application Scenarios

The Cloud VR 360° video market has huge potentials.

- As predicted by Goldman Sachs, the number of VR entertainment video users will reach 75 million by 2025, which is approximately the same level as the traditional Netflix user base. Application revenues are estimated to reach US\$3.2 billion, representing huge market potential.



2017-2025 Global VR Video Market Potential



Source: Goldman Sachs Global Investment Research

- Multiple industry giants have seen the potential of and started to deploy VR videos. Operators, such as South Korea's KT, LG U+, and SK Telecom, have deployed IPTV VR videos to cultivate user habits. OTT vendors, such as YouTube, Facebook, Youku, and iQIYI, have launched dedicated VR video columns. Media companies also started their actions. CCTV has launched VR panoramic videos, and Comcast, the largest CATV company in the United States, has invested millions of US dollars in VR content production startups to pilot new video forms.

Cloud VR 360° videos have various application scenarios.

Application scenarios mainly include: sports events, variety shows, celebrity shows, scenery videos, documentaries, movies, and TV series.

1.Sports events: Free AOV switching enables viewers to feel like they are at the event in person.

More sports event sponsors and sports platforms are starting to use VR technologies to shoot events. Currently, the market has multiple VR content vendors, such as Next VR, WhaleyVR, who have entered the VR sports industry. They shoot popular sports games in VR and upload recordings and highlight clips to network platforms for users to watch. With VR videos, users can break through the limitations of space, and switch to any angle of view (AOV), to feel as if they are watching the game at the arena. As the interaction of VR videos improves, users will be able to move around the venue freely, or even to compete with the players.

2.Variety shows/Celebrity shows: The VIP AOV allows users to interact closely with celebrities.

Entertainment videos have always been the focus of video consumption, including concerts, variety shows, and galas. Currently, many media companies around the world are experimenting with VR videos, including multiple CCTV programs, and the American *Saturday Night Live* sketch comedy program. Many celebrity concerts have also been recorded in VR and provided to users. Tickets to these shows



Source: Letin VR

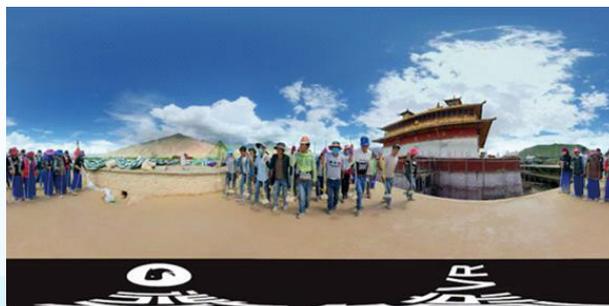
or concerts are hard to get. VR videos bring the best VIP AOV to users, offering them the opportunity to contact their idols. In the future, they will even be able to move around in the videos and interact with their idols. This will be extremely appealing to fans, and means there is a lot of potential in the fandom market.

3.Scenery/Tourism/Documentaries: Users can travel anywhere without leaving their homes.

The attraction of VR for content production in landscape, traveling, and documentaries, is that local customs and practices can be presented comprehensively and authentically to users. This type of video does not usually rely on excellent storytelling skills or involve high costs for intellectual property rights, making it a good choice for many VR content vendors or platforms. These videos are especially helpful for pre-travel decision making as they allow users to preview their destination. Vendors in the tourism industry can also use quality VR videos for marketing purposes. VR documentaries are most frequently used in scenarios such as environmental protection, remote exploration, and anthropology. Now with VR videos, users no longer need to leave their houses to explore the places they want to visit.



Source:3D-BoBo



Source:Whaley VR

4. Movies/TV series: Viewers are becoming more than just viewers.

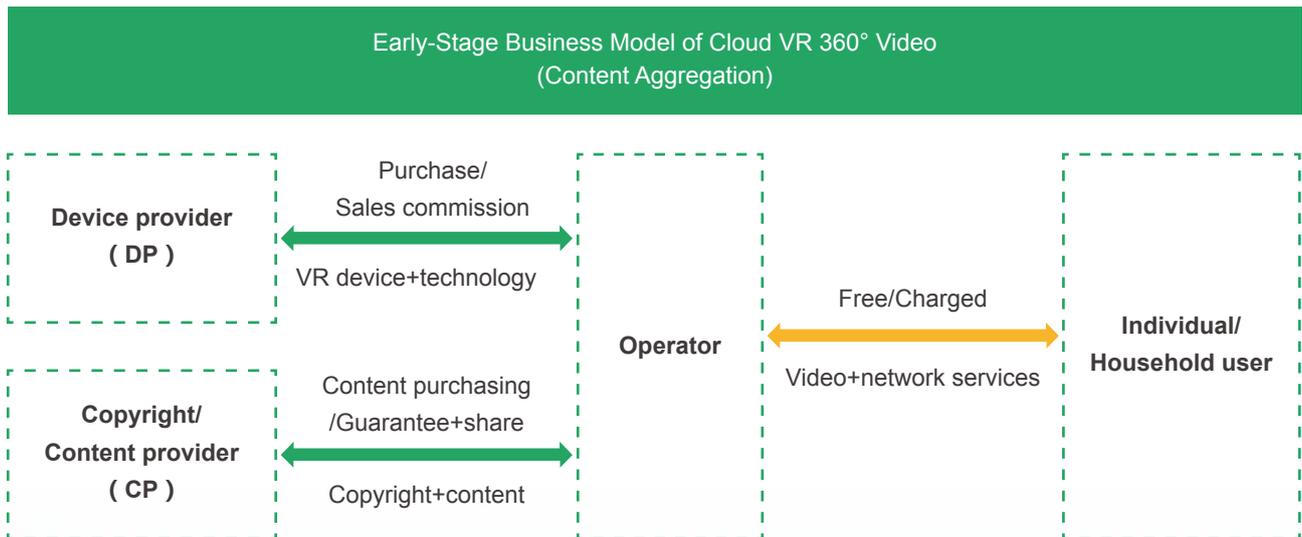
Viewers are usually just observers of traditional movies and TV series. With VR, users cannot only freely select an AOV, but also focus on their favorite roles, or even participate in the roles in videos. For example, in the VR movie Miyubi, a user appears in the video as an advanced robot that can often interact with other roles. Although, currently, these interactions are simple and preset in the video, this is still a brand new experience for viewers. In the future, with the development of VR videos and AI, users will be able to interact more naturally with other roles and scenarios, or even to select the story and change the plot.

Industry Situation

Cloud VR 360° video content primarily includes short videos, with plots lacking complexity.

- **Cloud VR 360° videos mainly include short videos, such as sports events, concerts, highlight reels, scenery clips, and documentaries.** This content is useful for attracting users. Post-production of live broadcast content into recorded content is convenient and can be rapidly implemented. However, due to the immature techniques for shooting content and their high production costs, the content in the storytelling category is scarce.
- **Driven by the attractiveness of sports events and the star effect, VR videos about sports events, and variety or celebrity shows can be promoted more easily.** Currently, these videos are mainly in 4K. Attractive sports content and the star effect facilitate popularization. 8K VR video shooting and image stitching technologies have been developed by the industry. As networks improve, 8K VR videos will be popularized among users, supporting a better user experience.

Business Model





3.4

Cloud VR Gaming: Cloud Rendering Lowers Requirements on Terminal Performance and Facilitates User Adoption

Definition

VR technology enables gamers to immerse themselves in a virtual game world, have immersive audiovisual experience, play games through physical movements, and play their dream roles. With the cloud computing technologies, traditional VR games can be stored and rendered on the cloud. This effectively lowers the requirements on terminals to make them more affordable. Users can travel in the virtual world and experience immersive high-quality VR games at low costs.

Cloud VR games are highly interactive and immersive, and are not only typical applications of VR, but also one of the most attractive services. There are 3DoF lightweight casual games and 6DoF hardcore games, corresponding to casual gamers and hardcore gamers.

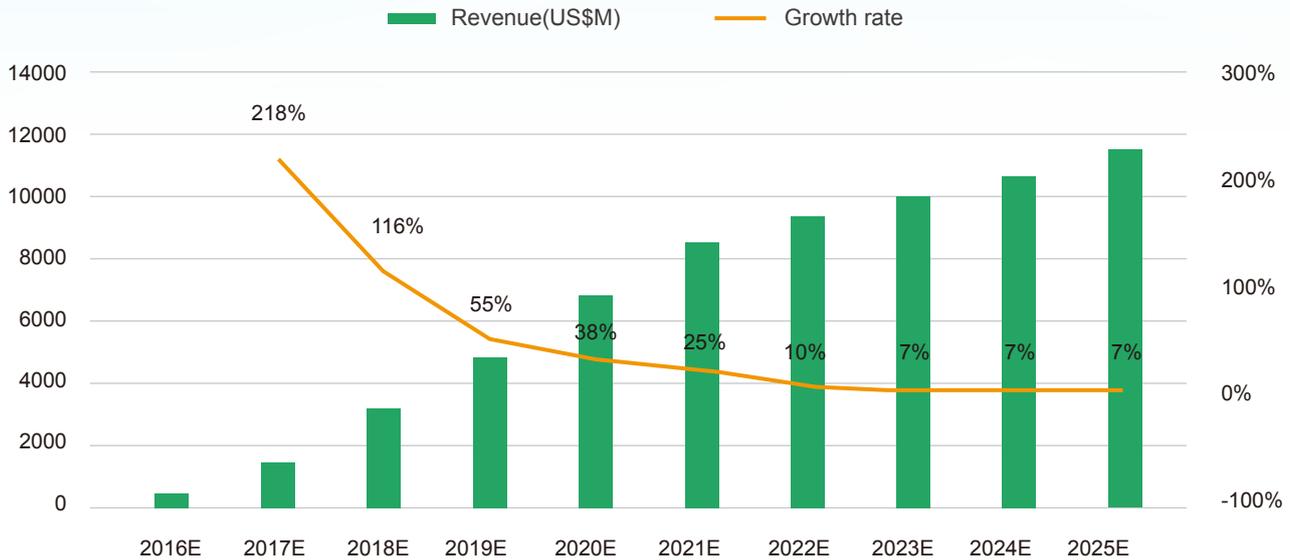
Application Scenarios

Large VR game market

According to the Goldman Sachs report, *Virtual & Augmented Reality: Understanding the Race for the Next Computing Platform*, VR games will be the first VR consumer market to be developed. The VR technology in the game industry is more mature than other industries. Game features are more compatible with VR technologies that offer an immersive experience. VR games on the market are rich, and users can easily pay for good gaming experience.

By 2020, there will be 70 million users of VR/AR games generating \$6.9 billion in software revenue, the report states.

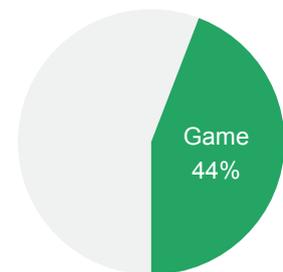
2017-2025 Global VR Game Market Potential



Source: Goldman Sachs Global Investment Research

According to a report jointly released by SuperData and Unity, there is a lot of market potential for VR games, which occupied almost half of the VR software market share as of 2016.

VR Consumer Software Revenue (2016)



Source: SuperData

The Cloud VR game is the best form to promote VR games to families.

VR technologies were hyped in 2016, and then the hypes faded because the cost was too high for the experience users get. In 2016, the first generation of VR devices came out. Users who wanted to experience VR games needed to pay about ¥15,000, equivalent to US \$2,000 with prices differing between regions. Even now, to experience high-quality games, users still need to pay ¥4,000 (US \$400) on an HMD and ¥6,000 (US \$1,000) on a PC.

Cloud VR enables game content and game rendering to be stored on the cloud. The interaction signals from the user end are uploaded to the cloud. The cloud servers complete the complex computing and image rendering of the game and compress them into audio and video streams, which are transmitted to the user VR terminals for decoding and displaying. Cloud VR lowers the cost in high-performance PCs, enabling users to turn from fat clients to thin clients and experience VR games at a lower cost.

In addition, content is managed on the cloud platform, which facilitates copyright protection. The unified platform and development interface enable small-and medium-sized enterprises to invest in VR game development and enrich content.

	Local/Online VR games(rendered locally)	Cloud VR games(content and rendering to the cloud)
Form	<p>Wired HMD, Local rendering PC, Network, Game server</p>	<p>All-in-one VR, ONT, Network, Cloud application and rendering server</p>
User Experience	<ul style="list-style-type: none"> • Inconvenient for movement with a wire • Inconvenient to wear a heavy PC+VR HMD 	<ul style="list-style-type: none"> • Lower requirements on terminals with Cloud rendering • Unwired HMD • More types of terminals accessed
User Cost	Over 10,000 RMB for a PC+VR HMD	<ul style="list-style-type: none"> • Decoded playing by all-in-one VR • Less than 3,000 RMB for terminals
Content Copyright	<ul style="list-style-type: none"> • Difficult offline content management • No copyright protection provided 	<ul style="list-style-type: none"> • Easy content management • Guaranteed copyright

VR games are highly interactive, immersive, and interesting, and are suitable for home entertainment. Cloud VR helps reduce the threshold for VR games and is suitable for bringing VR technology to the home and making it a new family entertainment mode.

Lightweight games and large games go parallel to meet the requirements of different types of users.

Gamers who want to relax and enjoy casual games can connect to the cloud through home Wi-Fi by using cordless all-in-one VR machines or mobile phones with VR glasses. This kind of game uses 3DoF mode, with gamers usually standing or sitting.

Simple games, such as interactive puzzle questions and children's fun games, may be operated through head rotation and sight focus. Some games, such as shooting games, may require the use of the functional buttons on HMDs or touchpads. More complex games may require a joystick connected through Bluetooth to improve user experience through immersive visual and auditory effects. This is a compromise between VR games and traditional games, and is very suitable for a casual play.

Hardcore players will never be bored by games because they can use PC VR devices connected to the converged home gateways, or use cordless 6DoF all-in-one VR machines to connect to the cloud through Wi-Fi to play strongly interactive and immersive 6DoF games. The experience of Cloud VR games is almost the same as that of VR games rendered on local PCs. Gamers can move within a certain range at home, such as squat to bypass bullets, or use both hands to shoot. This full-bodied game mode allows users to feel a strong sense of immersion and is suitable for longer experience and more complex games. Cloud VR games are popular not only for children and family entertainment, but for gamers who are really keen on games, because gamers do not need to pay for local rendering terminals and do not need to update configurations to ensure high performance.

Games can be played anywhere wireless access is available.

With decent Internet access and a portable all-in-one VR machine or mobile phone with VR glasses, gamers can continue to play games even when they are not at home. Due to limited space for movement activity, this scenario is mainly suitable for 3DoF casual games. In places such as waiting rooms and coffee shops, users can wear an HMD and connect to the cloud to play casual games instead of playing with phones.

Industry Situation

- **Mature terminals let gamers focus more on interaction, and the visual effect meets the current experience requirements.**

Excluding the specific HMDs for VR IMAX, the current VR HMDs support 3DoF lightweight games. Most of the 6DoF games are supported by wired HMDs. A few of cordless HMDs that support 6DoF games are in the pre-sale phase. Games require strong interactions, and therefore gamers pay more attention to their interactions with the game environment and are less sensitive to the resolution in gaming than in watching videos.

The resolution of HMDs used for games ranges from 2K to 2.5K for lightweight games, and is about 3K for high-end games. The current terminals are highly mature, but to support an ultimate gaming experience, display effect needs to be improved. According to the *Cloud VR Bearer Networks*, the resolution for user entry-level experience must be 8K in full view, and 1920*1080 for the single eye.

- **Strong interaction requires a high-quality network to ensure user experience, so operators have great advantages.**

To ensure that the experience of the Cloud VR game is the same as that of the locally rendered VR game, high bandwidth and low latency are required for the network. Based on the existing VR content and terminals, the average bandwidth occupied by Cloud VR games is 30 to 40 Mbit/s. To ensure that users can smoothly play games and are not dizzy while playing, the E2E latency must be less than 50 ms. According to the *Cloud VR Bearer Networks*, to meet the entry-level experience of users, the network must ensure that the bandwidth can reach 200 Mbit/s and that the RTT is about 10 ms. This high requirement makes the implementation of OTT Cloud VR games difficult.

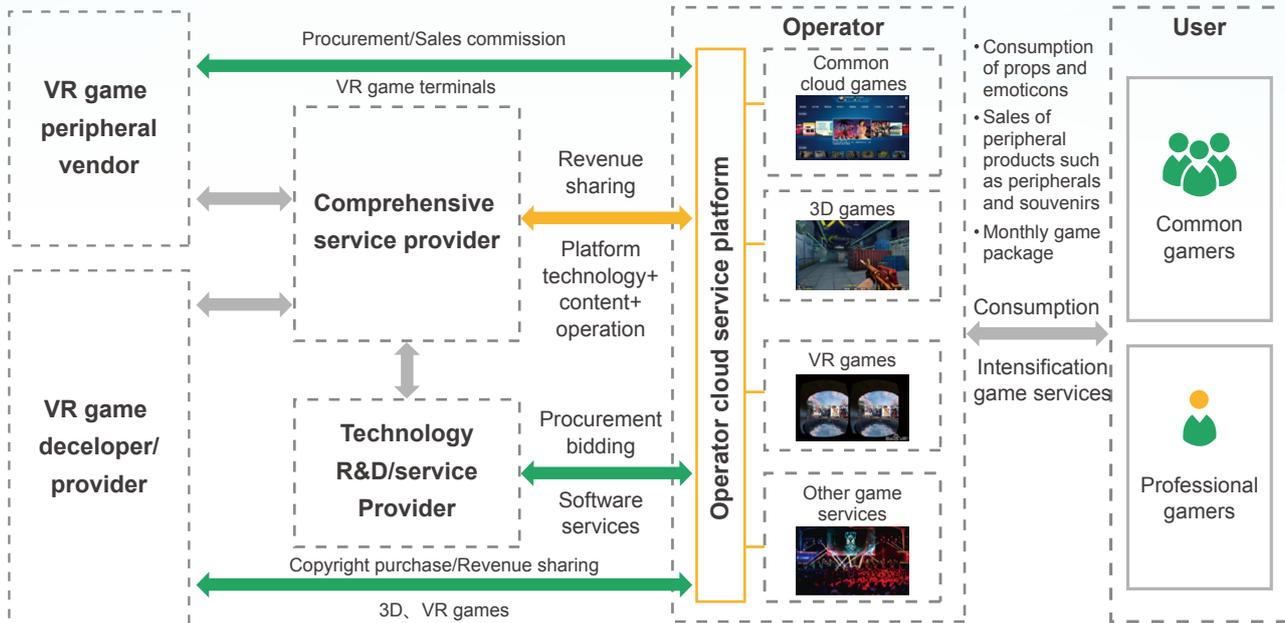
- **A prototype platform has emerged, and the Cloud VR game will be the groundbreaking strong interactive service on the cloud platform.**

Cloud technology is a mature technology. For example, NVIDIA and Sony have invested in the cloud gaming industry, and some cloud gaming platforms are being launched. Although the Cloud VR game is a new business, there are no technological barriers. Huawei iLab has worked with partners to develop E2E prototypes, including the user end and cloud platform.

Games are one of the most popular entertainment. As a type of services that attract users and increase user loyalty, the Cloud VR game will be the first type of interactive services aggregated on the cloud platform. In addition, the cloud platform can attract content providers to continue to invest. Phenomenal games can attract gamers and promote platform development.



Business Model



3.5

Cloud VR Education: The New Direction of Education Innovation Facilitates the Systematic Development of VR Education

Definition

VR technology is used to build a virtual learning environment, such as the virtual lab, object movement in the universe, and microscopic world in biology. The abstract and unintelligible knowledge is presented vividly and intuitively. Users can enter the virtual classroom for an immersive learning experience through VR devices, instead of memorizing information in textbooks.

Application Scenarios

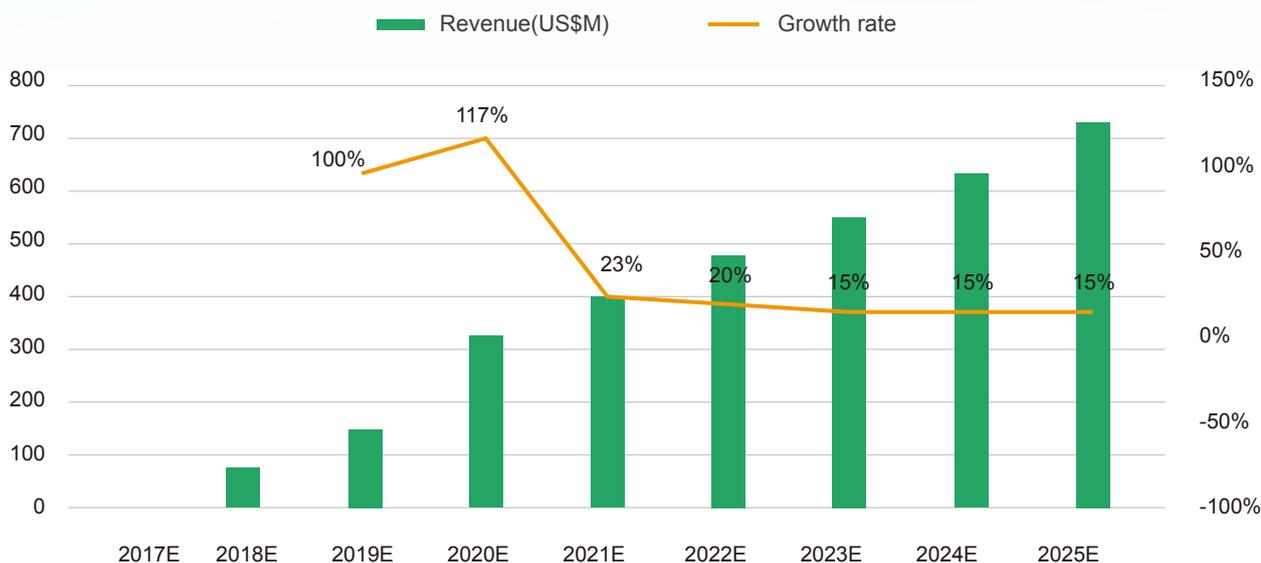
Education comprises a large share of business and consumer markets, and the spending power of users is also strong. Emerging information technology is converging with the traditional education industry, and VR education is a new offshoot of this convergence. The education content on the Cloud VR platform can make VR education systematic, courseware development easy, content updates and maintenance centralized, and learning cost lower. The embarrassing situation of selling hardware in the name of education can be changed.



VR education is the blue ocean of education innovation.

Globally, the education market is vast. According to the report from Goldman Sachs, the value of VR education market will reach \$300,000,000 in 2020 and \$700,000,000 in 2025, and VR will become a basic education tool.

2017-2025 Global VR Education Market Potential



Source: Goldman Sachs Global Investment Research

Google has launched the Google Expedition platform to provide Cardboard products for schools free of charge. By using mobile a phone with VR glasses, students can enjoy a virtual learning journey. This platform has more than 100 education contents.

Cloud VR will help VR education get out of trouble.

The main problem in the VR education market is inadequate quantity and quality for forming a system. In order to sell products, content production companies and education institutions tend to develop unilateral content or gather content and sell them together with hardware. This phenomenon leads to the difficulty in monetizing education content, expanding the market, and low ecological efficiency.

Cloud VR provides a content cloud platform and unified development standards for VR education. Content providers can focus on content production without adapting to different types of terminals or searching for buyers. The cloud platform also facilitates copyright management, protects the enthusiasm of content providers from pirated content, and improves the prosperity of the entire ecosystem.

For users, the content of the Cloud VR education can be updated in time. The content provider maintains the content in a unified manner. No matter whether the user is an individual or an educational institution, the user does not need to update the content periodically. Students can directly access the cloud platform using VR HMDs and conveniently browse content in real time.

There are many types of education market segments. Cloud VR education application scenarios can be classified into the following types:

2C: Consumer education content

This scenario is applicable to individual users. Users connect their PC VR or all-in-one VR machines to the cloud through the home gateway or Wi-Fi, and user experience is ensured by home bandwidth.

The content mainly includes rich science knowledge, skill training, language learning and so on, and most of the applications are self-contained and interesting. For example, the spacewalk application allows users to experience how astronauts live and work in a space station. The micro-world application allows users to penetrate into the microscopic world in their kitchens and observe bacteria and microorganisms that previously can be seen only through microscopes. The English learning application allows users to pretend to be customers or waiters in a simulated coffee shop, and practice English communications. Cloud VR education turns the home into a classroom.

2B: K12 education for schools

This scenario is oriented towards the basic education of primary and middle school students. Students can connect to the campus network through all-in-one VR machines to watch and experience the content arranged by the teacher. The teacher's control end is connected to the same network to control the students' learning content in a unified manner and to explain the content quickly.

K12's Cloud VR education is mainly based on simple contents across types and disciplines. The aim is to help students learn hard-to-understand knowledge in an immersive experience in a short time, and strengthen their memory ability. In addition, the content needs to be systematized based on the syllabus. For example, in the existing VR experiment courseware for junior middle school chemistry, students can conduct experiments on their own. If reagent is added incorrectly, simulated explosion may occur, allowing students to learn the lessons without being exposed to any danger. There is also courseware about the movement of celestial bodies and human blood components to help students experience knowledge in person. Cloud VR education is not only for science, but also for many liberal arts. For example, if the courseware presents a poem about Mount Lushan, VR education allows students to visit Mount Lushan, look at the local customs, and even see the appearance of Mount Lushan in ancient times. Cloud VR education can stimulate students' interest, so that students are more willing to study and learn.

2B: Professional training for enterprises

For enterprises, content customization is more important than diversity. The trainees can use cordless all-in-one VR machines to connect to the cloud through the network. They may also wear a more customized action capture device for multi-person collaboration training in a dedicated space.

Cloud VR education can provide high-quality simulation of training scenarios that would have been both dangerous and expensive without VR, for example, flying, driving, and device operation training. For fire escape drills and emergency response drills, it is impractical to create real fires to ensure security. However, in the virtual world, a real disaster scene can be created for trainees to experience the risks and urgency without real danger. Cloud VR education is a low-cost and highly secure training solution for enterprises.

Industry Situation

Terminals are mature and the content is insufficient. Content needs to be enriched.

The Cloud VR education experience improves along with that of the Cloud VR video and game. Existing terminals are mature and have met the preliminary experience requirements. However, VR education content is relatively fragmented. Consumer-oriented education applications are insufficient, and most companies or studios are just scratching the surface. The contents of K12 cannot cover the syllabus of primary school and middle school students. The training of the enterprise has not been widely implemented.

The cause of this situation is that the ecosystem has not been established and content providers cannot focus on content production. VR education requires a cloud-based platform to improve content distribution efficiency and to ensure the rights and interests of content providers.

2B services require bandwidth guarantees, and operators' private lines can solve the problem.

For 2C services, user experience can be guaranteed if the network environment is similar to that of Cloud VR videos and Cloud VR games. However, for 2B services, regardless whether for schools or enterprises, many people are learning and training at the same time. Operators' private lines can ensure that each student in multiple classrooms can have a good user experience.

Education is a rigid demand. VR education is widely recognized and is most suitable for the first aggregated industry application.

Content companies, terminal companies, education institutions, and schools recognize the value of VR education. Companies such as Google and Microsoft are moving into the education market. Terminal and content companies in China are also cooperating to make VR education accessible to hundreds of primary and middle schools. Education is regarded as a rigid demand. As one of the Cloud VR industry applications, education is most likely to be the first industry applications aggregated on the cloud platform, and the business market promotes the prosperity of the consumer market.



3.6

Cloud VR Marketing: New Retail Marketing Mode

Definition

VR technologies enable consumers to visit stores and interact with products. Consumers can actively choose their favorite products and AOV, and experience the advantages of the products. These experiences can make consumers more willing to purchase the products, which is the marketing purpose of the vendors.

Application Scenarios

There are many forms of VR marketing, including 360 ° panoramic advertisements, built-in advertisements in apps, VR live advertisements, and brand experience activities. These can be classified into dedicated VR promotion content and advertorials embedded in other VR content.

VR marketing stimulates the senses and drives demand.

The selling point of VR marketing lies in the stimulation of users' senses. Users may not be able to directly experience the products

at home, but VR marketing enables them to comprehensively understand the products and even use them virtually. For example, a car can be virtually restored by modeling, so that users can see each detail of the vehicle and test drive it at home. For the marketing of milk, users can see the source and processing of each drop of milk through VR videos. For the marketing of hotels, hotel rooms can be copied into the virtual world for users to experience. As long as a proper point of penetration is found, VR marketing can be applied to almost any type of commodities or physical stores.

Built-in advertorials in VR content implement instant purchases without searching.

As Cloud VR services develop, users will interact with various VR content, including pictures, videos, live broadcast, and games. A large number of advertorials can be implanted into immersive experiences. For example, eye tracking or focus identification can be used in a video or live broadcast to identify a user's interest in a piece of clothes. Detailed information about the product can then be listed in real time, and even an instant purchasing can be supported. Some objects in games can also become customized by the sponsor as peripherals. In the main lobby of social networking, a virtual exhibition rack full of various commodities can be displayed for users to select.

Industry Situation

Some fields have piloted VR marketing, and Cloud VR marketing will develop together with cloud platforms to achieve mutually beneficial situations.

The development of services will bring the 2C and 2B platforms of Cloud VR a larger user base. VR marketing can then be deployed on a large scale. As platforms develop, marketing will gradually develop as well. Marketing content will be added to various types of content. Good marketing content will drive users to make purchases of various types of content. This virtuous cycle will build a virtuous ecosystem, allowing cloud platforms and the content on the platforms to grow together.





3.7

Cloud VR eSports Arenas: Multiplayer Video Game Competitions in Vast Environments

Definition

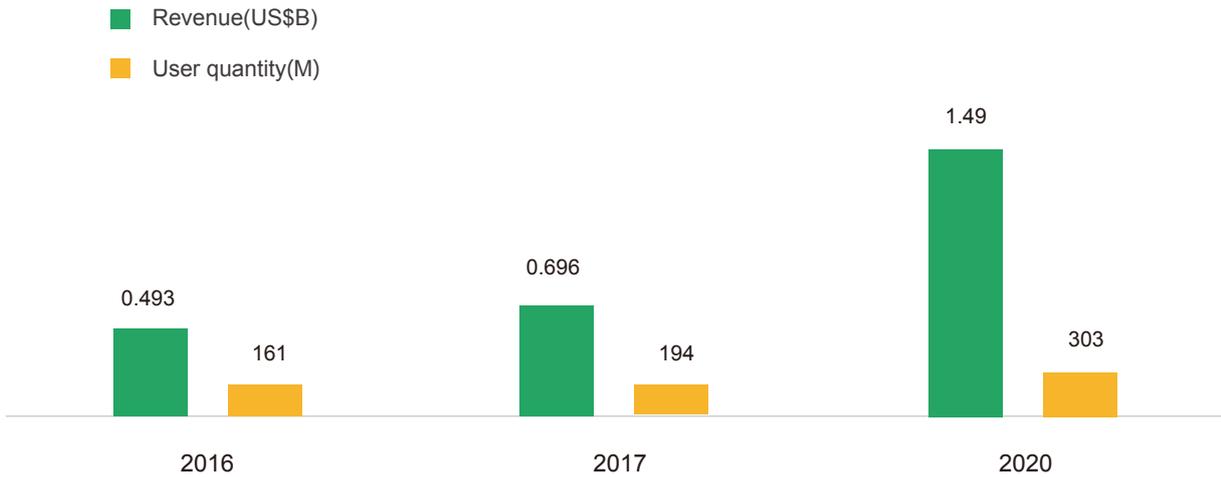
In this scenario, VR technologies are applied to eSports. Players can play any virtual role in a game using systems capable of optical motion capture in a large capture volume, accurate multi-camera synchronization management and computing systems, and special kinetic devices. They can compete with other players in a new way. The game content is stored and rendered on the cloud, improving user experience because heavy backpacks and devices are no longer needed and multiplayer cooperation and confrontation is possible.

Application Scenarios

The e-Space industry is growing, but innovation is needed.

The current eSports market scale is expanding and eSports are sweeping the world. According to the *Global Esports Market Report* published by Newzoo, by 2020, the global eSports market value will reach the US\$1.5 billion mark and the number of spectators will reach 300 million.

Global Esports Market Report



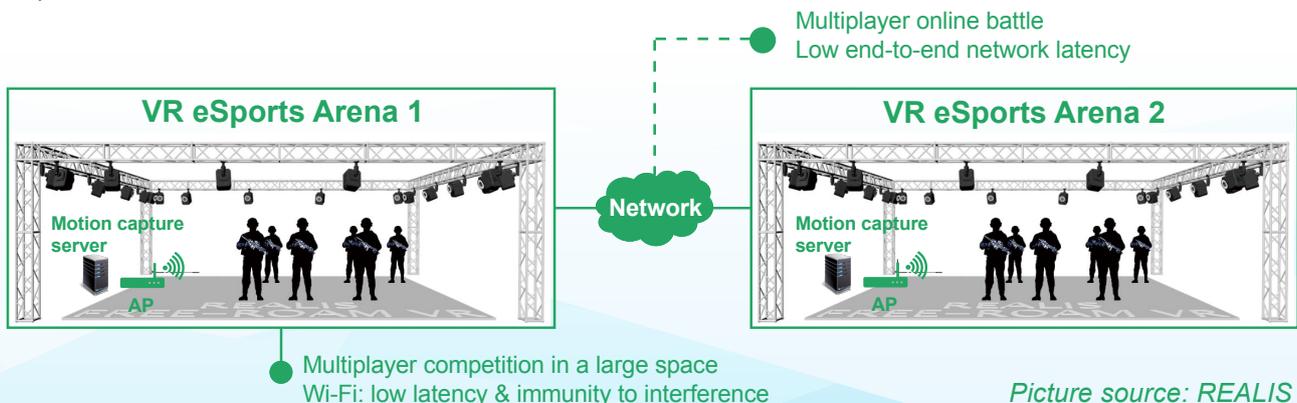
Source: Newzoo Global Esports Market Report

The demand for eSports is growing. However, most eSports are online games for PCs or mobile phones. This has not been changed or innovated for years. VR technologies may present new opportunities.

Cloud VR eSports arenas will create a new way of gaming and bring ultimate immersive experience.

Large VR eSports arenas put more emphasis on individual physical movement than traditional eSports. Therefore, the devices worn by players must be as light as possible to prevent hampering the movement or operations of players. With cloud rendering technologies, players wear only lightweight all-in-one VR machines. Players have more convenience and the cost of devices is lower.

eSports are all about cooperation and confrontation, which is even more true with VR eSports. Players of the same team can play in the same physical space, requiring better cooperation than when using their own computers in different places. This virtual game world, combined with physical body movement of players, creates a new immersive eSports experience.



Picture source: REALIS



Cloud VR eSports arenas are specialized offline venues equipped with motion capture devices, offering an experience that players cannot get at home. Players can go to their local Cloud VR eSports arenas and compete with each other over the Internet. Players need to wear motion capture devices (markers), all-in-one VR machines, and game peripherals (such as guns and swords, depending on the game). The game content is stored and rendered on the cloud. Players only need to connect to the wireless networks at the arenas.

Players can have fun in cooperation or confrontation.

The spacious arenas allow players to play games in cooperation or confrontation mode.

In competitive games, players are grouped into two competing team. For example, in a snowball fight, the two teams can build their defenses and then throw snowballs at each other, enjoying a snowball fight even in the summer. They can even play shooting games in outer space or under the sea, which is more exciting than outdoor laser tag.

They can also have fun in cooperation games. In an escape room adventure, players can be put into a creepy old house and work closely to find clues and solve puzzles and riddles to escape from the room. VR escape room games overcome the limitations of physical escape room games, such as limited space, arrangement difficulties, and infrequent updates. VR escape room games allow users to play in any made-up environment in an immersive way. Players can also cooperate in dungeon RPGs and battle bosses, which is popular with teenagers.

Industry Situation

Video game genres have been widely recognized, and cloud platforms make them more popular and make VR arenas the next-generation amusement parks and game rooms.

Cloud VR arenas are more suitable for physical arenas. Originally, all escape room games were video games. When they got popular, physical escape room games emerged, which have attracted many people. Similarly, the game content and genres have been widely recognized and have hardcore players. It is just that physical arenas are not yet very popular. Cloud platforms allow players in different places to play together and facilitate efficient content distribution and popularity of game genres. The cloudification of VR and the establishment of cloud platforms will make Cloud VR eSports arenas the next-generation amusement parks and game rooms.

Wi-Fi networks must be immune to interference and the network latency must be low to ensure good gaming experience.

Cloud VR eSports arenas have higher requirements on networks than Cloud VR games because players of the same team are playing in the same place, each player needs a channel for audio and video streaming, and the motion data captured by sensors needs to be uploaded to the servers. If the signals of different players interfere with each other, frame loss, distortion, and loss of location may occur, severely impacting the gaming experience. Therefore, improving the Wi-Fi immunity to interference is the key to good experience in Cloud VR eSports arenas.

3.8

Cloud VR Fitness: Interactive and Fun Exercises

Definition

Traditional fitness methods and fitness equipment are combined with VR and wireless sensor technologies. Users can switch between virtual fitness scenarios at any time or compete with remote friends in the virtual world, achieving fitness, entertainment, and social integration.

Application Scenarios

Fitness has become a national routine. VR fitness can enhance the fitness experience and has a potential for development.

Fitness has become a common demand for people, especially for many professionals, fitness is a high quality social activity. The progress of science and technology makes fitness activities more intelligent and fashionable. New gymnasiums often create virtual interaction and online competition scenarios for users to interact with each other while exercising. This approach makes exercising more interesting and is popular among users, which is in line with the advantages of Cloud VR fitness.

Similar to traditional fitness methods, VR fitness is applicable to both the consumer and business markets, including home fitness and gymnasium.

1.Home fitness: A good fitness partner

VR has the potential to become a good partner for fitness activities in virtual sports scenarios. At home, a user can join other remote friends to exercise, facilitating both an enjoyable exercise experience and social interaction. Multi-person remote exercise requires high real-time performance and low-latency network assurance.

2.Gymnasium: Enhanced services to attract users

Cloud VR fitness brings the following benefits: Improves the fitness experience and increases people's enthusiasm and interest in sports and fitness. Helps personal trainers to teach fitness to clients through better interaction and improved training efficiency. Increases value-added services and scope for creativity. Attracts new members, retains existing members, and facilitates market expansion.

Industry Situation

High level of interest, suitable for entry into the installed base fitness market

VR fitness content is extremely interesting. Wireless sensors can be used to adapt to various fitness equipment, which is suitable for the existing home and installed base fitness market. Currently, VR fitness is mainly based on VR HMD with PC host, which is cumbersome. The connected cables restrict user movements and freedom, limiting the range of motion and space. In addition, cables are a trip hazard. During strenuous workouts, users wearing an HMD for prolonged periods may experience discomfort due to sweating. Therefore, a more user-friendly design and cordless helmets are in urgent need.



3.9

Cloud VR Music: Audio-Visual Dual Immersion

Definition

By pairing the VR video visual immersion and the spatial audio auditory immersion, a new and engaging music experience can be provided to users. Cloud VR music is unique in spatial audio, including sound reverberation, orientation, attenuation, space, and multi-angle effects.

Application Scenarios

VR music can be used wherever music is available, bringing huge business potential.

- **The capital market is optimistic about VR music.**
Melody VR, the world's largest VR music platform, has completed many large-scale financing rounds, and has cooperated with Warner Music, Global Music, and Sony Music to create and release VR content for them.
- **A growing number of musicians are favoring VR music,** which helps to activate fan economy. Many stars and bands have released VR music MVs or held VR concerts.

The unique feature of VR music is spatial audio, which is combined with real-scene and computer generated (CG) rendering VR videos, and has various application scenarios.

(1)When the spatial audio and the real-scene VR video are combined, the onsite sound effect can be restored and an immersive feeling can be created. VR music requires precise cooperation between VR videos and spatial audio, focuses on both visual and auditory immersion, and has high requirements on video resolution. The main application scenarios include MV, concert, music festival, and music listening.

(2)The combination of spatial audio and CG rendering VR video enables music to be more than auditory enjoyment, bringing users an experience that exceeds traditional music. The video of this type of VR music is



mainly used to better present a spatial audio, and guide users to experience the spatial audio characteristics. The current mainstream resolution is 4K, which provides a good user experience. The main application scenarios include music listening and animated music.

- **MV: spatial sound, subverting traditional MV**

Traditional MV is a combination of flat video and non-spatial audio, and the viewable content and sound position of a user are fixed. The focus of an MV is determined by the director rather than the user. In the VR MV, users can choose the viewing angle and hear different voices from different perspectives. User therefore feel more like the protagonist in MV scenarios. Huawei has released the VR MV with 8K VR 3D sound field, which is a leading VR application that marks the beginning of high-quality VR music.



Source: Huawei UCD Center, 2012 Laboratories

- **Concert: The sound changes with different viewing angles of a user, and the audiovisual effect is highly restored.**

When VR music meets concerts, users can experience the sound effects closest to the site, leading to the on-site interpretation of musicians. In addition, VR music presents the onsite visual environment by using VR videos, and works with

spatial audio to restore voice signals in different locations. This enables users to clearly identify the changes of onsite voices. Due to the mutual influence of audio and video, the visual immersion is enhanced and the immersive experience is improved. In this way, users can enjoy the optimal audiovisual experience.

- **Music Listening: Immersive experience helps understand music**

VR music helps users focus more on music, especially for music professionals and ardent fans. For example, when listening to lyrical classical music, users can cooperate with related scenes or CGs to produce videos. In the association between music and stories, users' emotions are triggered, which enables users to understand music more deeply. When enjoying 3D surround music, VR animation, such as flying birds, can be used to mark the locations of sound sources and guide users to experience music from a more accurate perspective.

Industry Situation

The current real-scene VR music is still based on 4K resolution and needs to be improved to 8K or higher.

Real-time VR music requires precise cooperation between spatial audio and HD VR videos. VR videos require 8K or higher resolution to ensure visual immersion. The resolution of current mainstream VR music MVs is 4K. The industry has 8K VR music technology and auxiliary terminals. With the improvement of encoding and decoding technologies and network transmission capabilities, high-quality VR music will gradually enter users' life.





3.10

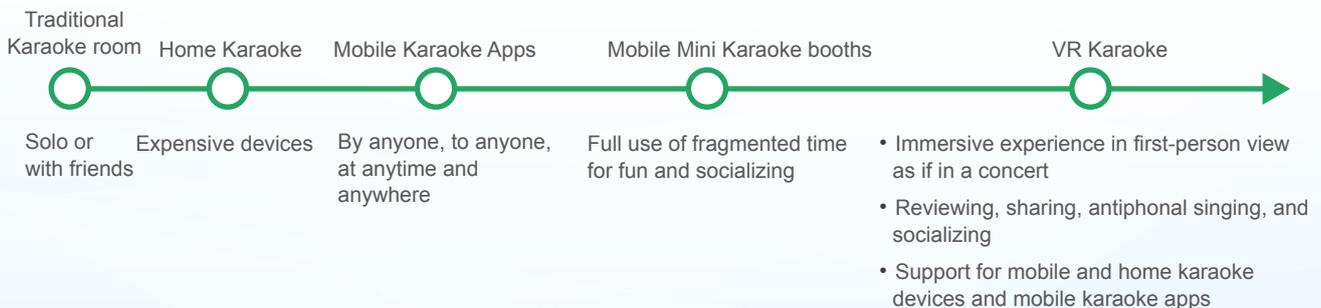
Cloud VR Karaoke: Karaoke in Immersive First-Person View

Definition

Traditional karaoke is combined with VR technologies, which create a virtual stage and allow singers to instantly become superstars, as if they are holding their own concerts. Through a cloud platform, users can sing with their friends, and the audience can interact with the singers and give virtual flowers. Users can also record their songs like a pro and share them with people around the world.

Application Scenarios

Popular, Socialized, and in First-Person View



Immersive karaoke with massive amount of content is available at home.

Cloud VR Karaoke brings a completely new experience to traditional family Karaoke. Instead of singing in front of the TV, they can now sing together in a virtual world. The scene could be a concert of a pop star where they can sing with the pop star, a grassland under the stars where they can sing and dance, or an imaginary world where they can sing with cartoon figures. The immersive experience brought by VR allows users to escape reality, blend in with the virtual environment, and sing to their heart's content.

Cloud platforms free content from the limitations of VR terminals. Copyright is protected by the platforms to encourage content providers to ensure the quality and quantity of contents.

VR karaoke can be anywhere, such as in a shopping mall, an Internet cafe, or an arcade.

In the business market, Cloud VR karaoke will upgrade the experience of existing mini karaoke booths. The confined space of traditional mini karaoke booths makes people uncomfortable. In contrast, VR enables users to forget the real environment and be set free in the virtual world. Moreover, Cloud VR karaoke allows users in different places to sing on the same virtual stage.

Industry Situation

Content development is promoted through popular entertainment methods and hot topics.

Existing karaoke establishments are mainly karaoke bars or clubs and karaoke booths in shopping malls. Going to karaoke is an important way of socializing and having fun, just like shopping and going to the cinema. Therefore, Cloud VR aggregates karaoke scenarios and can grow fast by creating hot topics among the huge user base. With the increase in users, content providers will be more enthusiastic about producing content. When more amazing VR music videos appear on the platform, more people will be attracted. This will be a virtuous cycle.

3.11

Cloud VR Healthcare: Highly-Promising VR Application in Medical Training and Treatment

Definition

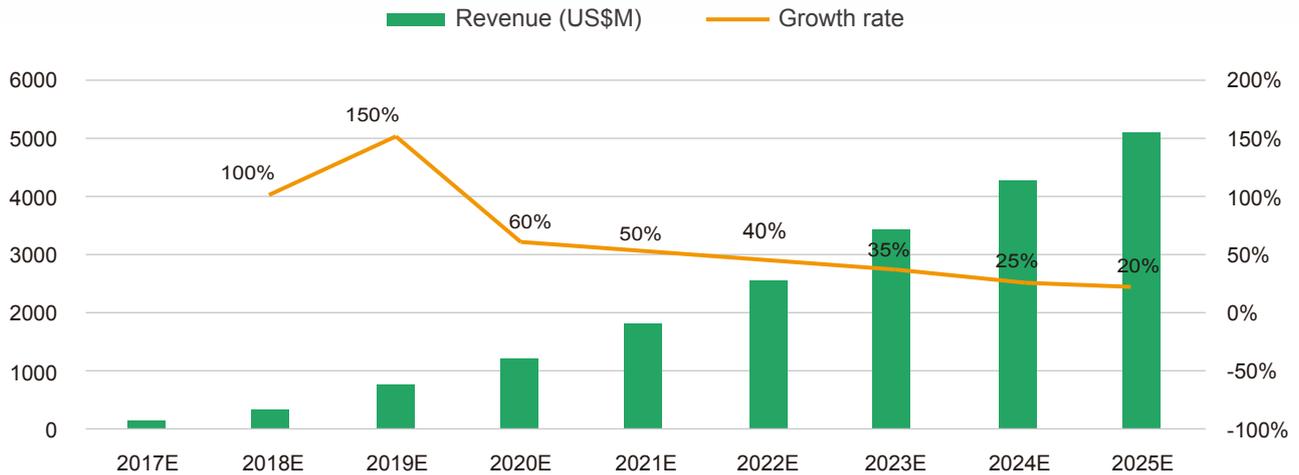
VR technologies can be combined with traditional means of medical education, training, and treatment, as well as surgery simulation and psychological therapy. VR technologies, coupled with computerized tomography (CT) and computer modeling technologies, can clearly reveal the physical conditions of patients and live broadcast or record the surgery process.



Application Scenarios

Goldman Sachs believes, based on the standard expected pattern, VR medical revenue will reach US\$1.2 billion by 2020 and US\$5.1 billion by 2025. VR is one of the most promising industry applications.

2017-2025 Global VR Healthcare Market Potential



Source: Goldman Sachs Global Investment Research

Training of medical students: virtual material for repetitive practice, saving costs

The life of a patient on the operating table lies in the hands of the doctors. Therefore, the fact that the 'surgeon tryouts' of Japan's Kurashiki Central Hospital include making a five-millimeter origami crane is no exaggeration. However, it takes a lot of money to train a capable doctor because the materials (such as Guinea pig specimens) cannot be reused in repetitive practices. Human anatomy is even more scarce. VR technologies can help medical students to practice repeatedly on virtual operating tables without using real materials. Although VR operating tables cannot replace real operating tables, they can help students familiarize themselves before getting hands on one-off practice with physical materials.

VR healthcare broadcast: live surgery with remote guidance

The experience of senior experts and professors in the medical field is precious. However, without VR, they can only pass on their experience to a limited number of students. If their surgery operations are recorded using VR technologies, their knowledge can be shared with more people. Students can repeatedly view the immersive recordings. Unlike 2D video recordings, VR recordings allow the students to observe more details from multiple perspectives. Some highly difficult surgical procedures can be broadcast live to experts using VR to obtain their guidance, fully leveraging expert resources.

VR psychological therapy: effective assistance in psychological treatment

VR technologies can also be applied in psychological treatment, for example, virtual environments can be created to treat acrophobia (extreme fear of heights). VR can also be applied in drug rehabilitation. Zhejiang Drug Rehabilitation Center uses VR technologies in the treatment of drug addicts, and up to 75% of those who have received the VR treatment have weaker desire for drugs.

Industry Situation

Contents are developed by specialists and aggregated on the cloud.

Although VR can be used in a wide variety of scenarios in healthcare, the content needs to be developed and refined by the specialists because they are matters of life and death. As an industry application, VR healthcare is ecologically inefficient, and the content distribution and monetizing process are slow. The cloud platforms aggregate contents to motivate content providers to produce more contents and facilitate the cooperation between institutions of higher education, hospitals, and specialized institutes, accelerating the development of the Cloud VR healthcare ecosystem. Cloud VR healthcare will be an important service on the industry cloud platform and benefit all parties involved.

3.12

Cloud VR Tourism: New Way to Travel and Promote

Definition

Virtual 3D scenic spots can be created using VR technologies to free travelers from constraints of time and space and allow them to have an immersive travel experience or preview their destinations while planning their trip.

Application Scenarios

VR tourism industry has just started, offering a new way to travel.

According to the 2017 Tourism Development Report of China National Tourism Administration, China's domestic, inbound, and outbound tourists reached 4.7 billion in 2016, spending a total of 5.5 trillion Chinese Renminbi, indicating that tourism has become a necessity.

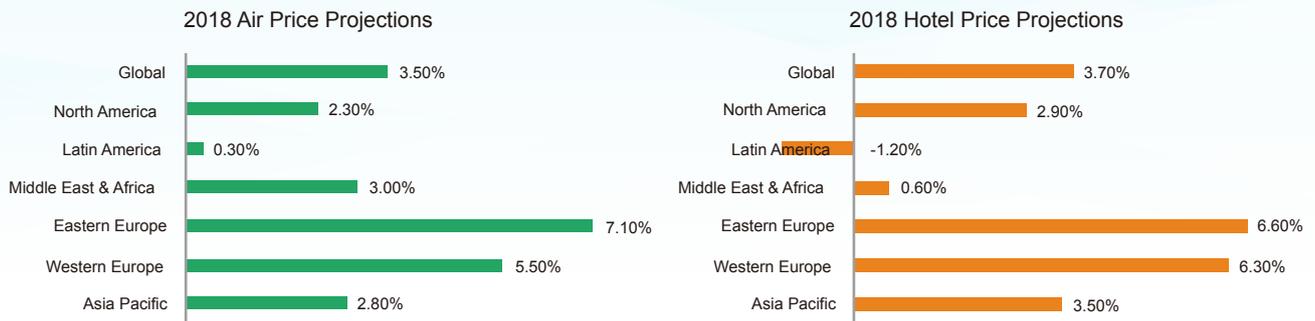
The Radar 2017 Report of Sabre, a Global technology provider in the tourism industry, listed VR as one of the nine trends and technologies that have impacted the tourism industry due to its ability to inspire real world travel and upsell premium experiences. According to *2018 CES Trend Report*, 63% of consumers are willing to use VR to explore holiday destinations or shopping malls to help make a decision.

The analysis of SuperData shows that the revenue of VR tourism software is expected to reach US\$240M in 2018, and that the market will gradually open up.

Users can enjoy exclusive tours without high costs, crowds, or waiting for perfect weather or season.

The Global Business Travel Association's 2018 travel trend report predicts that the global travel costs will continue to rise in 2018.





Source: Global Business Travel Association

A holiday, especially a holiday abroad, costs a fortune for ordinary people. Although traveling and accommodation are part of the fun, it is the destination that matters most for the largest number of people. VR tourism saves time and money in traveling, providing a cost-effective way of sightseeing. Virtual sightseeing tickets generate extra revenue for the scenic spots.

Well-known tourist destinations are always crowded. Sometimes the tours are not as good as expected, not because of the views themselves, but because there are too many people. For destinations that are best viewed in a particular period of time or season, it may take a long time to wait for the best time. In contrast, VR allows users to view and take pictures of the scenes in their best seasons or different seasons at the comfort of home anytime they want.

VR can promote brand awareness.

VR tourism benefits not only consumers, but also businesses. VR tourism allows users to enjoy beautiful scenes without actually being there, but will not replace the luxury of being truly present. VR tourism can make people more eager to physically go there. Scenic spots, hotels, parks, and amusement parks can make VR promo videos to provide consumers with an immersive experience of their best parts, capturing the hearts of consumers in the virtual world before they are physically present. Therefore, VR tourism can improve the brand awareness of scenic spots and attract more people to physically go there.

VR allows more visitors to see the exhibits.

Museums and exhibition halls can also use VR to record and promote their exhibits. Many museums and exhibition halls have restrictions on the number of visitors and opening times. Visitors must reserve tickets far in advance, and they are not allowed to touch the exhibits. In contrast, in a VR environment, users can visit a virtual museum or exhibition hall anytime and even 'play' with the exhibits, even cultural relics. VR allows more visitors to see the exhibits while completely eliminating the possibility of damaging them.

Industry Situation

Tourism is a necessity, different players are tapping into VR tourism, and cloud platforms can accelerate content aggregation and the prosperity of the industry ecosystem.

Although tourism is a necessity, VR tourism contents are rare because many scenic spots and amusement parks worry that there are no channels to push the VR contents to target users and they need to cooperate with VR terminal vendors. A cloud platform for this industry offers a good opportunity for scenic spots, hotels, and amusement parks to distribute VR contents to a large number of consumers, benefiting everyone involved.

3.13

Cloud VR Real Estate: Enhanced Visual Presentation for Real Estate

Definition

VR technologies can be used in different stages of real estate, including planning, design, construction, and sales. The most common scenario is property viewings. VR allows users to view their properties of interest or show homes and gardens in a virtual environment to view the detailed design from different angles. In addition, VR can be used in the design of building structures, surrounding environment, and interior decoration.

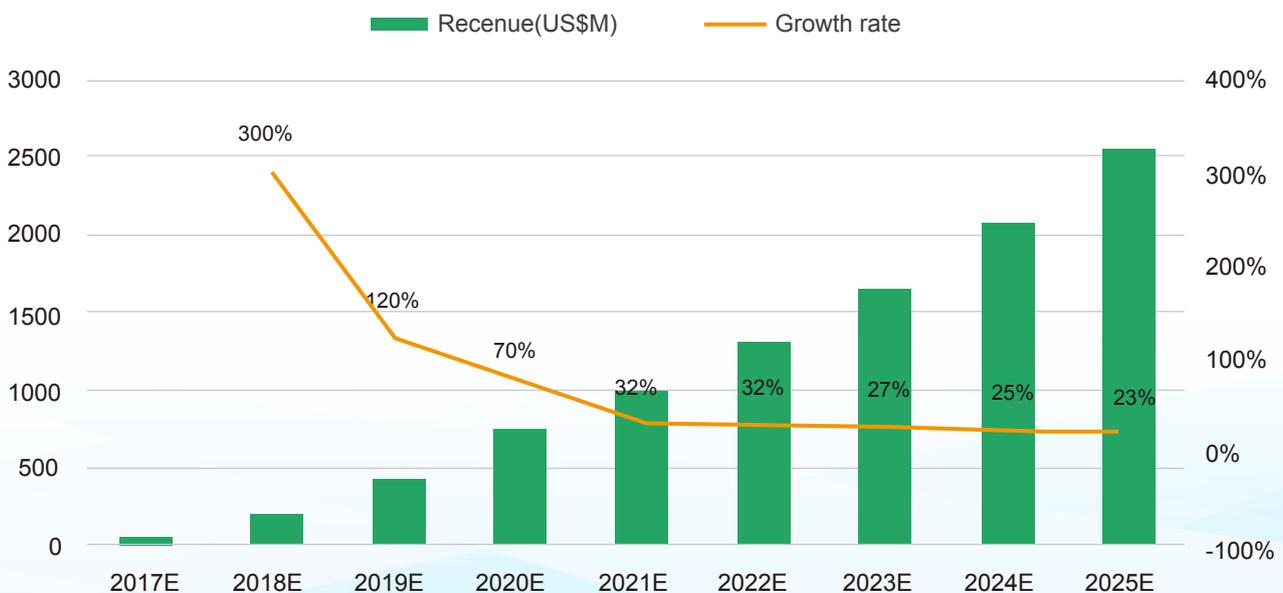
Application Scenarios

VR real estate: a typical and promising VR application in vertical industries

Goldman Sachs predicts that the revenue of VR real estate applications will reach US\$750M by 2020 and US\$2.6B by 2025, and that VR technologies will promote the sales of real estate. Currently, a lot of real estate developers have produced VR contents.



2017-2025 Global VR Real Estate Market Potential



Source: Goldman Sachs Global Investment Research



VR can be used in different stages of real estate, including planning and design, construction, and marketing.

Typical VR application scenarios in the real estate industry include real estate marketing, decoration design, planning, and construction.

1.Real estate marketing: enhanced property viewing experience, a new way of property marketing, and improved marketing efficiency

Potential property buyers can use VR to view their developments of interest, show homes, and gardens. They can remotely view properties of any layout on any floor and choose furniture of any style that fits their properties of interest, saving a lot of time and effort. Real estate developers can produce VR content for potential buyers and sell properties off-plan, improving the cash flow and competitive advantages of developers. VR provides better portability and efficiency than traditional viewing modes, because people can view properties simultaneously and remotely.

2.Decoration design: efficient and customized

Compared with common graphic design, VR can display decoration designs in a more intuitive, real, and natural way, helping designers better communicate with customers, collecting feedback regarding the personalized needs of customers, and adjust the design accordingly.

3.Construction planning: more intuitive presentation for design adjustment

Designers can instantly see the effect of the structures and surrounding environment they design as if there were present, allowing them to make adjustments and display to customers in an intuitive way.

4.Construction: construction process preview to optimize the construction plan

VR allows construction workers to understand the structures and components and their positions, predict the possible quality and security risks during processes like modeling and concrete pouring, and take preventive measures or optimize the construction plan.

Industry Situation

Cloud-based VR application in the real estate industry adds a marketing channel, and the channel is mobile.

VR frees real estate marketing from the constraints of time and space, allowing potential buyers to view properties remotely and simultaneously using portable VR terminals. When VR contents are produced for a growing number of property developments, because VR terminals may not have the required capacity, the contents need to be stored on the cloud instead of VR terminals. This also makes it easier for developers to centrally manage contents.

3.14

Cloud Social VR: Next-Generation Social Network Platform

Definition

The VR technology is used to overcome the limitations of space imposed on traditional online social networking, and deepen the experience through more refined forms of expression, such as avatars and facial expression recognition, to truly integrate VR and reality.

Application Scenarios

Social VR has a primary user base.

- According to *Virtual Reality Industry Report: Fall 2016* released by Greenlight Insights, 67% of VR users were interested in social VR.
- Mark Zuckerberg, CEO of Facebook, once indicated that VR will become the most sociable platform in the future. In January 2018, Spaces, Facebook's Social VR application, had more than 2 million users. VR Chat, a popular social VR application, had over 10,000 active users daily.

Social VR scenarios are diversified, focusing on enhancing the online social interaction experience.

Currently, there are three types of mainstream social VR applications suited to different virtual scenario content: comprehensive experience applications, social tool applications, and user creation and sharing applications. They are all used to improve users' online social networking experience through VR.



	Comprehensive Experience	Social Tool	User Creation and Sharing
Feature	Daily social activities, such as conferencing, gaming, and meeting, are integrated into VR, to transplant the real life into VR.	Simple VR social networking scenarios that focus on the chatting experience.	By focusing on the visual experience, users are able to create virtual scenario content themselves and share the experience
Typical applications	Facebook Space, Altspace VR, Bean VR, etc.	vTime, Rec Room, etc.	Sansar, High Fidelity, VR Chat, etc.

Of the three types, the comprehensive experience applications are the most commonly used in social VR. They integrate daily social activities into VR and integrate various basic applications, such as videos and games. The activity scenarios are most closely related to reality. The application scenarios include social gatherings, remote conferences, virtual launch events, and video calls.

• **Social gatherings: reuniting with friends at home, and overcoming the limitations of texting, voice, and video**

Users can create avatars like in cosplay and enter the virtual social space created by themselves or others, such as bars, board game cafes, karaoke bars, and suburban areas. They can also interact with the avatars of their friends or strangers in the virtual space, such as by chatting, shaking hands, singing, and gaming. VR makes online social networking more vivid and attractive, and is welcomed by young people.

• **Remote conferences: more vividness and enhanced communication, improving the conference efficiency**

Remotely located users overcome limitations of space and enter the same virtual space for conferences. As avatars and virtual scenarios become more realistic, the participants feel like they are communicating with each other face to face, making the conference more real and improving the communication as well as the conference efficiency. In addition, users can conveniently browse web pages, implement 3D drawings, share screens, and have discussions in the virtual scenario.

• **Virtual launch events: innovative forms of product release, facilitating marketing**

VR virtual launch events use the real-time object clipping technology to combine the presenter with the event scenario. In this way, users can enjoy a VIP viewing experience from the comfort of their homes, and can communicate and interact with other people on site or in the virtual space. For publishers, virtual launch events are not restricted by the actual venue, attracting more attendees and improving the marketing effect and brand awareness of the product.

Future social VR is expected to become the next-generation social networking platform and the portal of applications.

Next-generation social VR is expected to become a social networking platform like WeChat. As avatars and virtual scenarios of social VR become more realistic, experiences will be improved continuously. For example, in a remote conference, participants will feel like they are communicating in a real conference room. High-quality social VR can build a good user base. With the development of applications such as VR videos, games, and shopping, they can be aggregated into the social networking platform, so that it is not only a platform for people's social communication, but also an entry point for applications. Network platform-based social VR is expected to become the ultimate application of VR development.

Avatar Realness Evolution Path in VR Social Networking			
Avatar realness	Low	Medium	High
Visual display	Cartoons	CG avatars	Real-person videos
Audio sense	No distance or direction	No direction	Spatial audio
Facial expression	None	Simple facial expression tracking	Real-person facial expressions
Body positions	Only head poses	Head and hands	Entire body
Flexibility	3D OF	Discrete 6D OF	Continuous 6D OF

Industry Situation

Cloudification of social VR is the key to becoming the next-generation social networking platform.

Currently, social VR content is on the cloud but is rendered locally. With the increase of virtual avatars and scenarios, a large amount of content loading and rendering will pose great challenges on local terminals. Cloud-based rendering is urgently needed, which enables VR terminals to become lighter and easier to carry. Once 5G mobile networks are put into commercial use, social VR will then truly become a ubiquitous social platform.



Cloud VR Shopping: the Third Screen in the Era of 'New Retail' Enhances Consumer Experience

Definition

Computerized 3D modeling can be used to create 3D models of the items on sale in a virtual shopping mall or experience shop for consumers to check and select in an immersive way. Consumers can visit any shop and 'try' any item.

Application Scenarios

Goldman Sachs forecasts that the market value of VR retail software will reach US\$1.5B by 2025. According to the *2016 Future of Retail Study* of Walker Sands, one third of respondents prefer to go to shops that offer VR shopping. VR makes consumers more willing to buy.

eBay and Myer, an Australian retailer, have jointly launched the world's first VR department store. The eBay VR Department Store app is available to both iOS and Android users, giving them access to thousands of items from Myer from the comfort of their home.

Tmall Buy+ VR shopping attracted eight million early adopters in just ten days, and 70% of them are millennials. Jingdong has set up a VR lab and the first VR/AR alliance in the e-commerce industry to change shopping experience through its 'Tiangong' VR shopping plan.

Item displays change from 2D to 3D.

The biggest advantage of VR shopping is having 3D models of the items on sale, instead of textual descriptions and images. Consumers can view the items from different angles using VR HMDs. They can even 'dismantle' some complex products to view the internal structure. The 3D models, combined with the detailed description, minimizes the likelihood of dramatic differences between what buyers see and the actual product.

With VR, online shopping can offer the same experience as real shopping.

Online shopping is efficient and convenient, but not as fun as real shopping in a mall or on a high street. VR combines the advantages of both offline and online shopping to allow consumers to enjoy the convenience of online shopping without sacrificing the fun of real shopping. If combined with the social networking function, consumers can interact with

each other, further improving the online shopping experience.

In summary, **VR shopping will be mainly used in existing e-commerce platforms** to allow consumers to shop and pay in a virtual environment and receive the items they have bought through logistics in the real world.

Industry Situation

3D modeling involves a huge workload. In addition, new technology will help standardization.

The key to VR shopping is 3D modeling, which can be done using computers. However, the cost is high. Currently, 3D modeling is used only for a small number of high-value items on an experimental basis. As Big Data processing and artificial intelligence (AI) technologies develop, automated and standardized modeling methods and tools will become available, and 3D modeling of millions of items will become practical.

The industry development requires the cooperation between multiple parties, and the role of operators is critical.

VR shopping requires the cooperation between e-commerce, logistics, devices, and content providers. Cloud VR shopping means that the 3D modeling data of a large number of items needs to be uploaded to the cloud so that consumers can load the data in real time. The massive amount of traffic generated by VR shopping requires operators to provide a network and platform with adequate performance to ensure consumers can buy what they want at peak hours, such as during the Singles' Day on November 11 (China's version of Black Friday).

3.16

Cloud VR Military: Immersive Military Simulation to Improve Training Efficiency

Definition

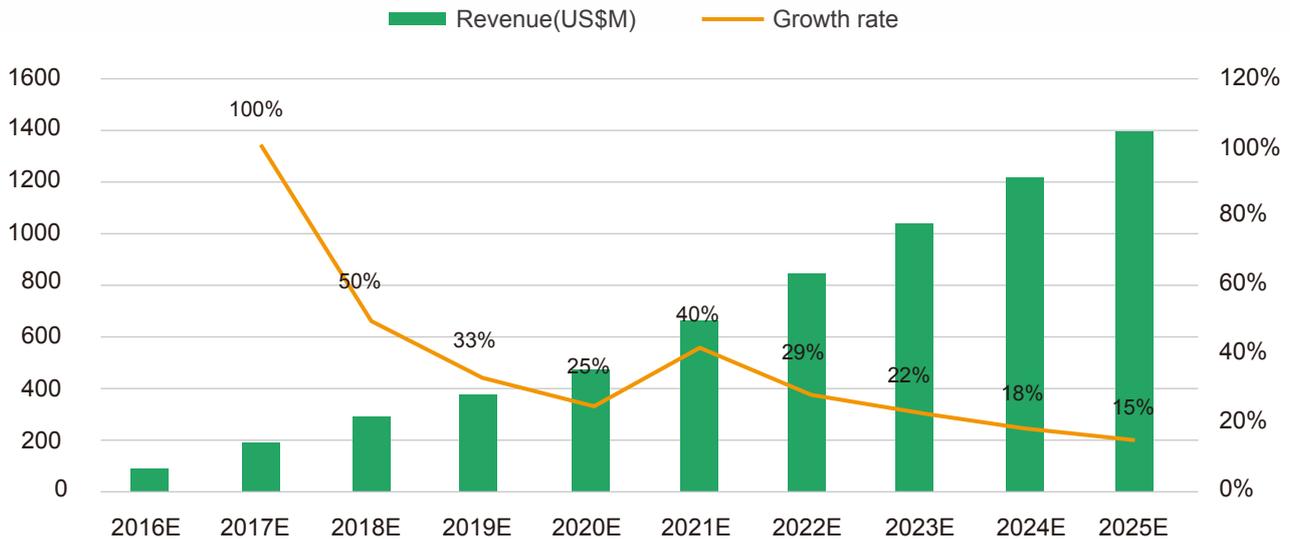
VR can create realistic virtual environments and 1:1 models of equipment, which, coupled with visual, auditory, and tactile effects, allow soldiers to experience the battlefield and confrontational situations in realistic but more safe and cost-effective way.



Application Scenarios

Goldman Sachs predicts that the VR military application market will be worth US\$1.4B by 2025, and that 15% of military simulation and training budget will be replaced by VR.

2016-2025 Global VR Military Market Potential



Source: Goldman Sachs Global Investment Research

Military simulation and training have always been a rigid demand of the military. VR, which is highly immersive, can be used to simulate many military training scenarios, including battlefield environments, joint exercises, high-tech weapon experiments, and rescue operations.

1. Simulation of realistic battlefield environments

Safe and low-cost simulation helps soldiers to get familiar with the war zone and exercise their tactical maneuvers, improving the combat skills, responsiveness, and psychological quality of soldiers, as well as and the quality of military training.

2. Simulation of joint exercises

Simulated joint exercises can evaluate the performance of weapon systems, improve the efficiency of operational level military training, and inspire new military philosophy.

3. Development of and experiments on high-tech weapons

VR simulation can be used during the development of and experiments on high-tech weapons, including weaponry and equipment design and manufacturing, remote weapons control, operations and usage of weapon platforms, and weapon damage display to evaluate and analyze the operational effectiveness of the weapons, shorten the R&D period, and ensure that the weapon performance meets real-world battlefield requirements.

4. Simulation of rescue operations

VR can also be used to simulate rescue operations in natural disasters, such as mudflows, floods, and earthquakes. Soldiers can practice how to stop bleeding, apply medicine, and dress wounds in realistic and intense battlefield scenarios, improving rescue skills and psychological quality.



3.17

Cloud VR Engineering: Upgrade Industrial Manufacturing

Definition

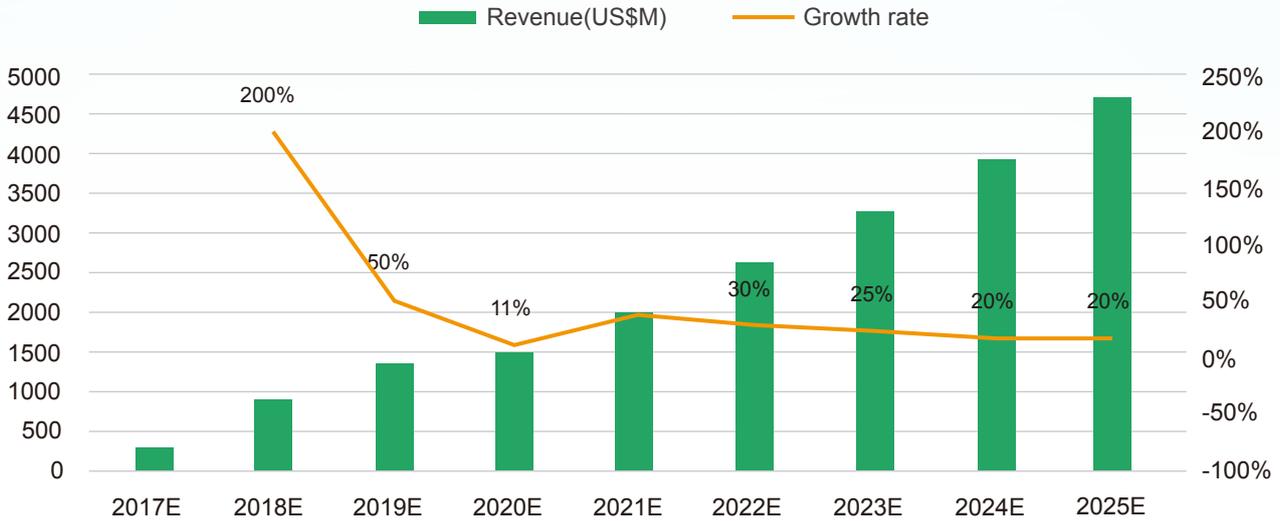
VR technologies can be used in engineering management, design, and manufacturing. The advantages of VR in visual presentation and interaction improve engineering efficiency.

Application Scenarios

VR engineering has huge market potential.

Goldman Sachs predicts that the VR engineering application market will be worth US\$4.74B by 2025. Engineering is a promising vertical industry for VR application.

2017-2025 Global VR Engineering Market Potential



Source: Goldman Sachs Global Investment Research

VR can upgrade the experience in multiple engineering processes and scenarios.

Typical VR engineering application scenarios include engineering management and industrial design.

1. Engineering management: visualized engineering simulation, planning, and control

VR and data visualization technologies can be combined for engineering simulation, planning, and control, covering progress control, engineering implementation planning, material consumption, investment, and personnel allocation, efficiently simulating changes in engineering spatial data.

2. Industrial design: improved design quality and efficiency

Compared with the traditional graphic design or engineering drawing, VR enables 3D presentation of industrial products. Designers can examine the interior and exterior details of an engineering project from different angles to accurately simulate and evaluate the design effect and adjust the design accordingly. This feature improves design quality and efficiency.

Industry Situation

Cloud-based VR engineering facilitates collaboration and industrial product IPR protection.

- Complex industrial design usually requires collaboration of multiple engineers. Cloud platforms help engineers collaborate in a unified space in real time, quickly adjust the design, minimize communications during subsequent interworking, and allow team leaders to view the engineering progress.
- The IPRs of industrial products are key assets of enterprises. Cloud platforms allow centralized management of industrial designs to ensure information security.

3.18

Cloud VR Scenario Summary

- The four cloudified scenarios, Cloud VR live broadcast, Cloud VR 360° video, Cloud VR IMAX, and Cloud VR gaming, provide a good experience in the current phase. They can be developed as an extension of IPTV videos, and can be used to cultivate VR user habits as the basic services for further video service development. The Cloud VR gaming market has huge potential. Currently, VR games have an abundance of content, which is what users are most willing to pay for. It can be used as a value-added service (VAS) to increase user loyalty.
- Cloud VR application scenarios have much promise in the 2C and 2B domains. In 2C scenarios, Cloud VR videos are developed first as the extension of IPTV services, and then other content, such as games, is aggregated. In 2B scenarios, education and healthcare may be developed first because their business models and user groups are clear. By building a cloud platform, content can be effectively distributed even with strong customization, breaking into the 2B market.
- Good user experience in Cloud VR scenarios depends on good networks with high bandwidths and low latency. Operators have network infrastructure to assure the bandwidth and therefore have more advantages in deploying Cloud VR services. Not only can the network pipes be facilitated, but the VR field can also be deployed in advance.



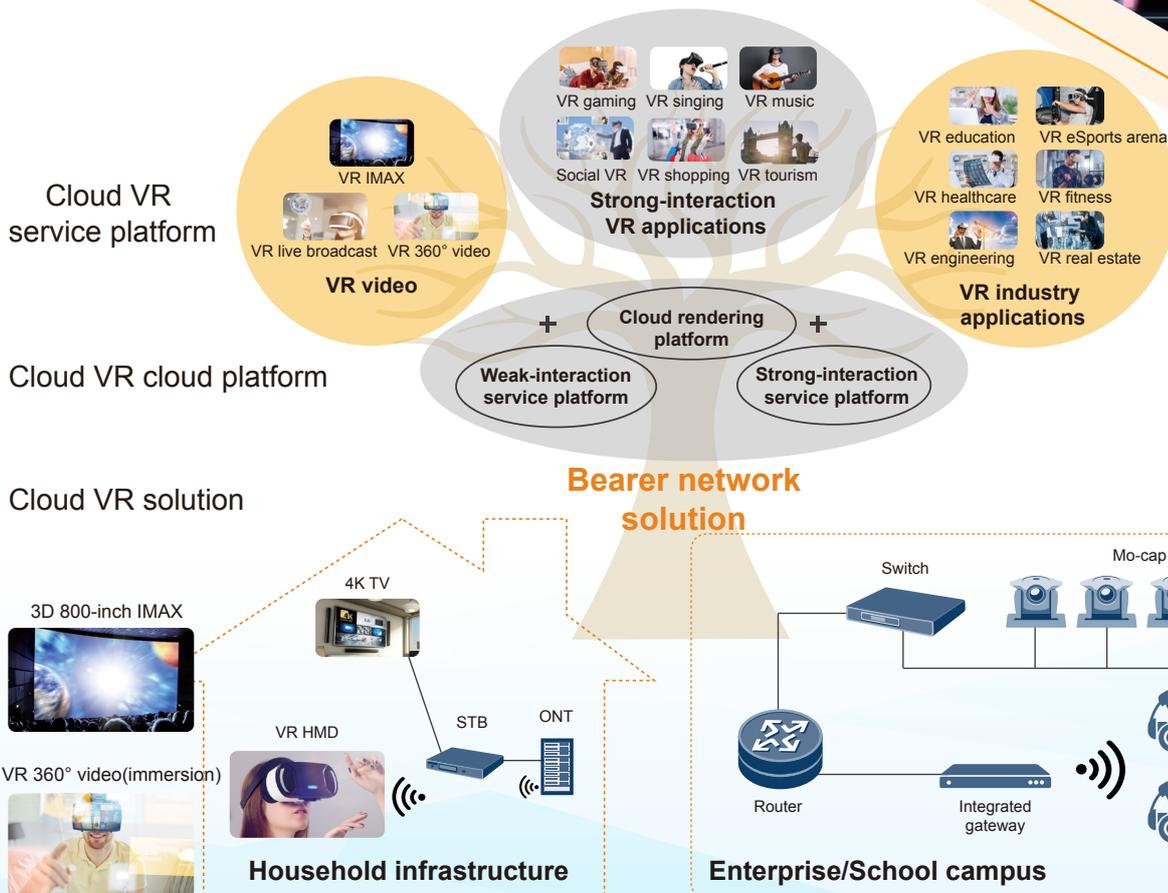
04

Prospects of Operators Deploying Cloud VR Services

4.1

Operators Are Capable of Driving the Development of the Entire VR Industry Ecosystem

Operators have a service platform, a large number of users, a resource pool infrastructure close to users, strong network quality, and abundant access network fiber resources. These are necessary for the large-scale development of Cloud VR services. If these advantages can be leveraged, operators will be capable of driving the development of the entire VR industry ecosystem.



Overall solution

Operators fully leverage their advantages of large pipes, platforms, user bases, and access fiber resources to attract high-quality VR service providers, VR terminal vendors, and VR content providers. Computing processes, such as rendering, is implemented on the cloud. The powerful network ensures high bandwidth and low latency between the cloud and user terminals, reducing VR terminal costs, and enabling more users to consume VR services.

Platform basics

E2E service process is already mature, covering the IPTV service platform, standard interfaces, and flexible interconnection. Cloud VR live broadcast, Cloud VR 360 ° video, and Cloud VR IMAX are compatible with the existing platforms. Therefore, the existing video coding and streaming media transmission technologies can be used. Cooperation with VR partners can then be implemented to build a real-time rendering cloud computing platform and introduce more Cloud VR scenarios, increasing user loyalty.

Content aggregation

Content is the key competitiveness of Cloud VR. It can be mixed by VR content providers to construct the Cloud VR product system, which is then bundled and sold by operators.

Cloud VR services have high requirements on experience, but operators' advantages lie in network solutions.

Experience is an advantage of Cloud VR, which also poses high requirements on networks. If the bit rate is reduced due to bandwidth costs, experience will greatly deteriorate. Operators' network infrastructure can solve the problem of bandwidth with the foundation of FTTH and the assurance of bandwidth. For operators who are weak in optical networks and have insufficient infrastructure bandwidth, network infrastructure reconstruction is needed.

Operators have a large user base.

Operators have a wide range of users in the home and enterprise fields. They have the foundation of developing VR user habits and guiding users' VR consumption.

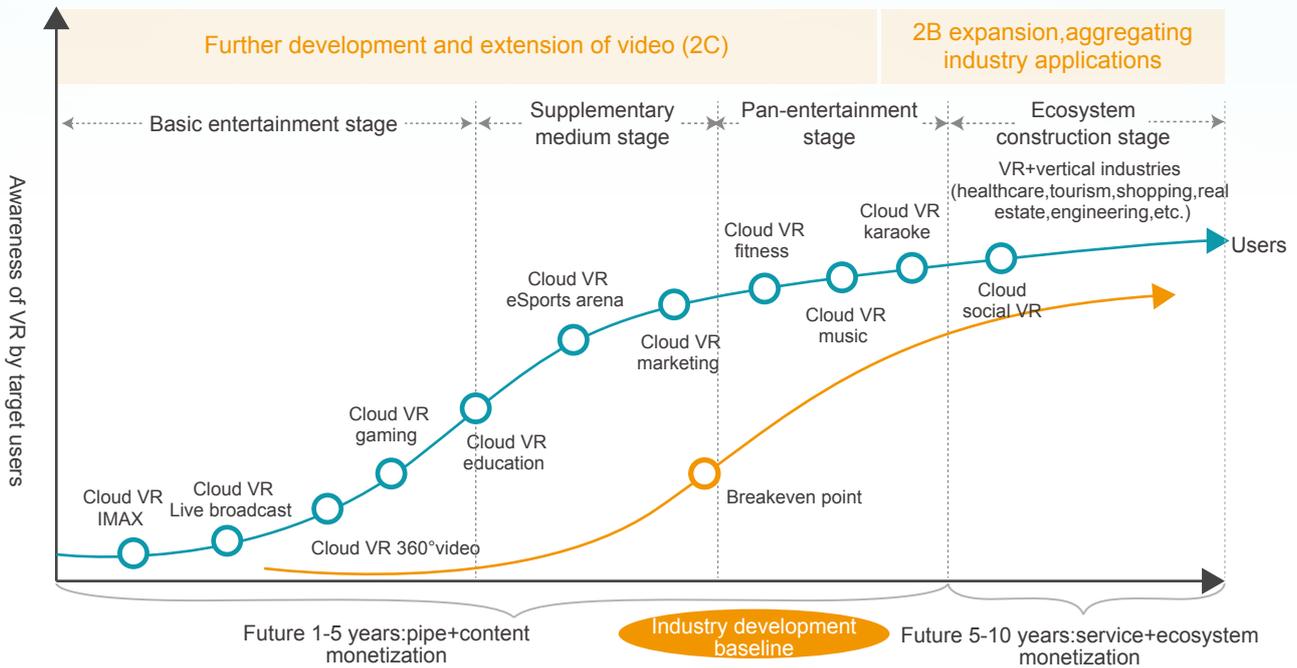
4.2

Pace Hypothesis of Cloud VR Service Deployment

- In the basic services phase of Cloud VR, scenarios that already support cloudification, such as Cloud VR video and Cloud VR gaming, are developed first to seize market leadership, establish the service norms, and cultivate user habits.
- In the supplementary medium phase, operators have accumulated the user base and have gained experience in content aggregation and business models. Once industrial technologies mature in the mid-term cloudified scenario, services can be deployed rapidly.

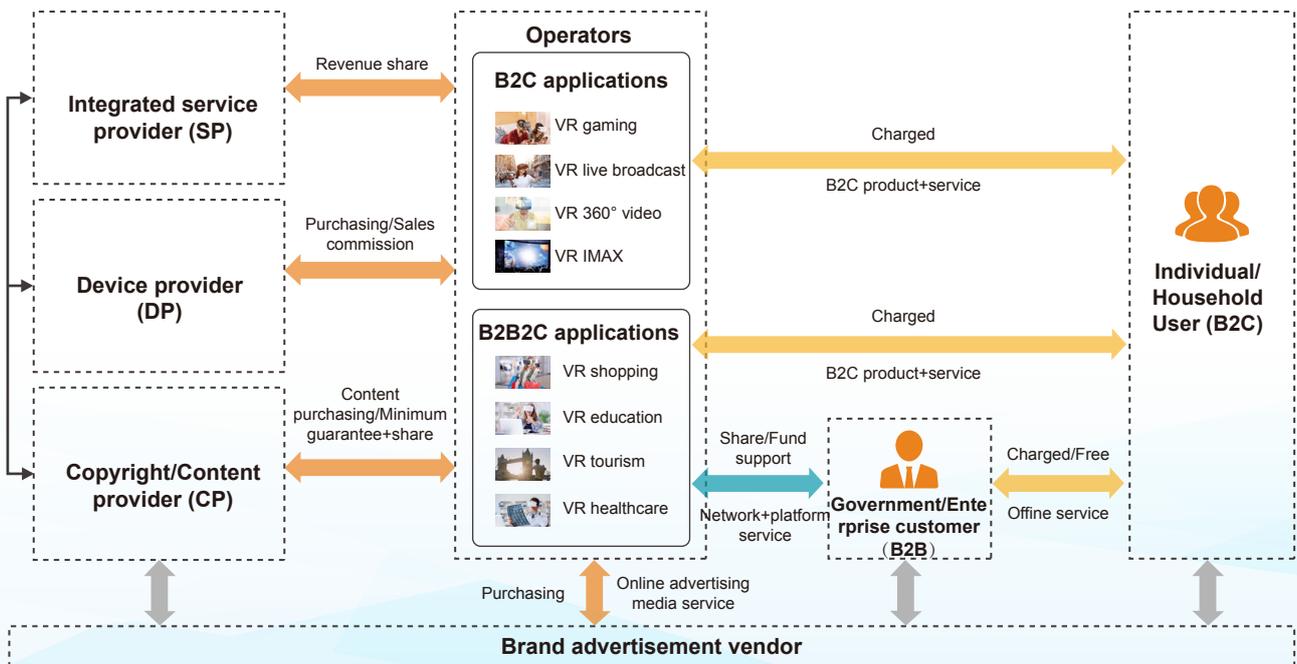


- After 2C users are developed, services can expand to the 2B field to aggregate more industry applications and build the Cloud VR service ecosystem.



4.3

Cloud VR Business Model Hypothesis



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