Cloud XR
Medical Platforms
Raise Healthcare Service Levels
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EXECUTIVE SUMMARY

The healthcare industry is facing various challenges, including an aging population, scarce and imbalanced medical resources, and excessive growth in medical expenses. Public demand for healthcare services will continue to grow rapidly well into the future. To meet these challenges, China and many other countries are now making full use of emerging technologies to improve their healthcare service capabilities.

Extended Reality (XR) can be used in medical teaching and training, diagnosis, treatment, and telemedicine. It is quickly becoming one of the key technologies for improving healthcare services, even now in its earliest stages.

According to IDC’s research, the XR medical market will reach US$1.7 billion in 2022, with a compound annual growth rate (CAGR) of 105.6% from 2018 to 2022. In hospital departments where XR systems have been deployed, 30% of doctors have adopted XR technology in their treatments. In daily case handling, XR frequency use is nearing 50%, and steadily rising. XR supported medical care is winning the recognition and affirmation of doctors and patients alike.

Cloud XR represents the future trend. It offloads digital content, computing and rendering functions onto the cloud, letting terminals be just simple displays with motion capturing capabilities. The result is XR terminals that are lightweight, cordless and wearable, which means they can be used in various medical scenarios.
Telecom operators have natural advantages in developing Cloud XR medical care. They already have powerful cloud network resources, which can provide users with the best Cloud XR medical experience. They can also leverage their outstanding operational capabilities and social credibility to provide Cloud XR platform as a hub that integrates various vendors (including equipment suppliers, content producers, channels, integrators and industry users) in the XR medical ecosystem, connects ecosystem breakpoints, pools industrial forces, and pushes forward the development of XR in medical treatment.

Figure 2: XR Medical Technology Evolution Ecosystem Map

Source: IDC, 2019

Telecom operators will use Cloud XR medical platforms to provide education, training, diagnosis, treatment, and services to medical schools and hospitals both in China and worldwide. They will also provide rehabilitation and health management services to rehabilitation institutions, pension institutions and families to improve their healthcare service capabilities. Cloud XR will enrich and fully integrate with connected healthcare, support the “Health China” initiative, and help raise the level of public health all over the world.
CHAPTER I: HEALTHCARE INDUSTRY DEVELOPMENT TRENDS AND DEMAND FOR XR TECHNOLOGY

Demand for healthcare services continues to grow as medical resources remain low.

China's healthcare industry is facing various challenges, including an aging population, scarce and imbalanced medical resources, and excessive growth in medical expenses. Public demand for healthcare services will continue to grow rapidly well into the future, but the medical industry cannot keep pace with this growth with current resource levels. It is not just China, many countries around the world face similar healthcare challenges.

As the economy has developed and living standards have improved, demand for healthcare has increased. An aging population has also led to a substantial rise in demand for medical services. According to data released by the National Bureau of Statistics of China, at the end of 2018, China's elderly population (over 60 years old) reached 249 million, 17.9% of the national population. By 2030, the percentage will increase to 30%. Healthcare services for the elderly will be a major challenge for China's social development.

The World Health Organization estimates that the global shortage of medical workers will exceed 14 million by 2030. There is already a lack of medical workers, medical training technology and equipment in small- and medium-sized cities and rural areas in China. There is and will continue to be long term demand for medical personnel training.

Figure 3 China's Aging Trend and Proportion Forecast

Source: National Bureau of Statistics of China
The Application of New Technology Is Key to Improving the Capacity of Medical Resources and Meeting Growing Demand for Healthcare Services

Today, emerging technologies are developing quickly, particularly in the healthcare industry. New technologies, including XR, robotics and AI, have been applied in the areas of disease prevention, diagnosis, surgery, nursing, and medical education and training. These new technologies have shown great potential in improving healthcare service capabilities.

The Chinese government has long attached great importance to the development of healthcare services and the application of new technologies. In March 2017, the National Health and Family Planning Commission issued the Thirteenth Five-Year National Population and Health Informatization Development Plan to promote the role of informatization in reinventing healthcare. Many hospitals in China are either adopting or planning to adopt cloud computing, XR, AI, robotics, and other technologies to improve the capacity of their healthcare services, raise diagnosis and treatment levels, and promote the development of healthcare in China.

The digital transformation of healthcare services driven by new technology applications is in full swing worldwide. According to IDC’s research report (A Way for U.S. Healthcare to Think Digital and Get Digital Done, October 2017), as of 2017, 60.7% of healthcare organizations in the United States began to implement digital transformation in order to improve their medical service capabilities to meet the growing demand for healthcare services.

XR Medical Technology Is Becoming Key to Meeting Healthcare Demand

XR utilizes computer technology to form images, sounds, and other sensations and signals. This enables simulated or enhanced visual, auditory, tactile, and other perceptual feedback. The result is completely immersive or enhanced scenes that enrich the healthcare experience. XR includes virtual reality (VR), augmented reality (AR), mixed reality (MR) and other technologies.

XR technology is an effective tool for improving healthcare services. It can be used to increase the availability of medical and nursing talents, improve the efficiency of diagnosis and treatment, and support the development of telemedicine. It has huge potential for future development.
In the past, medical anatomy training had a limited number of human specimens available and few opportunities for students to do anatomical operations. XR technology overcomes these issues by giving all students the opportunity to carry out practical operations and perform repeated anatomical drills in the virtual space.

In 2016, Sichuan University established a VR Anatomy Laboratory. In November 2018, Taipei Medical University and the DeepQ team at HTC's Healthcare established VR anatomy classrooms to support clinical anatomy training.
Application Scenario 2: Surgical Operation Training

Using visuals, touch, and other feedback systems, XR technology allows doctors to fully immerse themselves in their training, perform surgical operations and drills, and experience realistic clinical surgical processes. It lets doctors carry out repeated operation drills without facing major repercussions from errors while training. It can be used for preoperative planning and intraoperative operation simulation, improving the ability of doctors to diagnose and formulate treatment plans. It also substantially reduces the costs of training, including equipment and specimens.

Both Wu Tianping Urology Center of Peking University Shougang Hospital and the Clinical Skills Center of Beijing Friendship Hospital affiliated to Capital Medical University have installed XR-based surgical simulation training equipment.

Figure 6 Comparison Between Real Body Anatomy and VR-Based Medical Anatomy

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<th>Real Body Anatomy</th>
<th>VR-Based Medical Anatomy</th>
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<tr>
<td>Few operating opportunities for students</td>
<td>Students can perform anatomy</td>
</tr>
<tr>
<td>Limited anatomy teaching opportunities</td>
<td>Students can learn at any time</td>
</tr>
<tr>
<td>Organ observations are not detailed enough</td>
<td>In-depth observation of various organ structures</td>
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Source: IDC, 2019

Figure 7 Comparison Between Simulation Props-Based Surgical Training and VR-Simulated Surgical Training

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<tr>
<th>Simulation Props-Based Surgical Training</th>
<th>VR-Simulated Surgical Training</th>
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<tr>
<td>Surgical props are not real enough</td>
<td>Pictures adopt real surgical scenes</td>
</tr>
<tr>
<td>Can only make hypothetical preoperative planning</td>
<td>Preoperative planning and intraoperative operation can be simulated</td>
</tr>
<tr>
<td>Can only perform surgical simulation on props</td>
<td>Real surgical drills can be done with tactile devices and immersive VR devices</td>
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Source: IDC, 2019
Application Scenario 3: Surgery Training Live Streaming

Live streaming of surgeries using XR technology enables students and doctors to view detailed surgical processes. Observers can take highly detailed snapshots during the surgery, and integrate them into XR scenarios in the same way they would see them in an actual surgery. They can easily see every step in great detail, which allows for tremendous gains in surgical experience. The live stream does not have to be viewed exclusively in hospitals, it can be accessed remotely using mobile apps and VR devices.

Since 2014, Zhongshan Hospital in Shanghai has been using VR technology for live hepatectomy, gastrectomy and other surgical operations. Zhongshan Hospital invites the family members of patients and other patients scheduled for the same procedure to view the live stream. Viewing the live stream allows patients and family members to better understand the procedure, which makes them more understanding and cooperative during treatment, leading to better surgical outcomes.

XR Technology Enhances Diagnosis and Treatment

Application Scenario 1: Medical Imaging Analysis and Diagnosis

With the rapid development of 3D medical imaging technology, the combination of VR rendering and 3D imaging technology has provided powerful medical image processing and analysis capabilities. Accuracy of medical image-based diagnosis has greatly increased, and led to much greater efficiency in diagnostic work.

Multiple hospitals have carried out medical image assisted diagnosis combining 3D imaging and VR technology, including the Second Affiliated Hospital of Sun Yat-sen University and Zhangjiakou No.2 Hospital.


With the combined use of tactile, photosensitive and various other sensing technologies in XR, doctors can view detailed images of lesions, blood vessels, nerves, muscles, and other tissues both before and during surgery. They can rotate, flip, stratify and dissect the medical images using touch and gestures, giving them more comprehensive knowledge of the illness, lesions or surgical site. This is extremely helpful for preoperative planning, surgical plan communication, and surgical operation.

With the support of INVISION, Dr. Smile Medical Group began to use XR technology in 2016 for preoperative planning, surgical plan communication and real-time support of varicose veins operations.
Application Scenario 3: Psychiatric Treatment

XR technology can be used to assist the treatment of psychiatric disorders such as phobias, depression and autism. For example, in the assisted treatment of phobias, XR constructs phobia specific situations using vision, hearing and touch. These controlled situations allow for gradual exposure to the phobia event, which allows patient adaptation and eventual phobia elimination.

Shanghai Mental Health Center has also incorporated XR into autism therapies.

Application Scenario 4: Assisted Rehabilitation Training for Patients

XR can generate specific scenes to immerse patients during nerve and body rehabilitation. Using an operating handle or other tactile methods, patients can have targeted exercises for limbs, nerves, and organs to assist in their rehabilitation. The setup can also be used as a way to prevent the onset or further progression of certain conditions like dementia.

The Second Affiliated Hospital of Wenzhou Medical University uses XR to carry out rehabilitation for stroke victims with tremendous results. Beijing Tongren Hospital uses XR to offer amblyopia rehabilitation drills for children.

Application Scenario 5: Doctor-Patient Relationship Management

XR promotes communication between doctors and patients by allowing patients to better understand their condition and participate in the formulation of their own treatment plans. Letting patients participate in their own treatment promotes better treatment results. Hospitals are using XR technology to communicate with patients about their surgical plans, which lets patients better understand their treatment, and avoids potential doctor-patient conflicts. Some hospitals even let patients wear VR devices during surgical operations to help them relax during procedures.
XR Supports Telemedicine with Treatment Results Similar To On-Site Surgeries

Application Scenario 1: Telesurgery and Telesurgery Guidance

XR can vividly replicate the on-site treatment experience using virtual reality, augmented reality, holograms, and other technologies. The technology allows doctors located remotely to “personally” attend operations, carry out remote consultations, and offer medical guidance. Using a combination of tactile gloves, force feedback, telemedicine robots, and other technologies, doctors will also be able to perform telesurgery, which will allow the sharing of high-quality medical resources and personnel in treatment services, and greatly ease the imbalance of medical resources.

Application Scenario 2: Telerehabilitation Guidance and Assistance

XR technology allows patients to perform rehabilitation exercises either in medical institutions or in their own homes. Doctors can use XR to remotely monitor and guide patients during rehabilitation, improving its efficacy.

Application Scenario 3: Remote Ward Inspection and Patrolling

Doctors and nurses can use XR systems to observe patients in their ward from doctors’ offices and nurses’ stations. Medical rounds can also be observed remotely, improving the quality of medical treatment and nursing.

XR Medical Technology Development Prospects and Market Size Forecast

Doctors and patients see the positive benefits associated with using XR medical technology. According to IDC’s survey, 30% of doctors in hospital departments where XR systems are deployed have begun using the XR system. These doctors are utilizing XR systems in 50% or there medical cases, and that casework percentage is still rising. XR systems are now being used in thousands of cases. The technology has shown broad development prospects.

According to IDC’s market research, China’s AR medical systems market is expected to reach US$42 million in 2018, up 204.7% year-over-year. This high growth is expected to continue for at least the next five years, reaching a market size of US$1.29 billion in 2022. In 2018, China’s VR medical systems market reached a size of US$52 million, up 206.8% year-over-year. The market is expected to grow at a CAGR of 66.9% from 2018 to 2022, and will reach US$410 million in 2022. The forecasts for AR and VR medical systems are shown in the following figures.

Source: IDC, 2018
CHAPTER II:
CURRENT STATUS AND FUTURE TRENDS OF XR MEDICAL TECHNOLOGY

Deployment and Application of XR Medical Technology

According to IDC’s survey, approximately 8% of hospitals currently use XR technology. Among hospitals that have not deployed XR, the main reason it has not been deployed is because a suitable XR solution has not been found. However, 66.7% of these hospitals plan to deploy XR technology within the next two years.

XR technology is mainly used in surgery, orthopedics, radiology, education and psychiatry. There is broad recognition of the advantages of XR medical technology in medical education and training, but the technology is most mature and widespread in surgical planning, surgical operations and doctor-patient communication. The application of XR in psychiatric treatment and rehabilitation training is still in its exploratory stages.

The application of XR technology has won recognition from hospitals, which state that XR technology plays a large role in improving medical treatment, supporting innovation, and reducing risks. According to IDC’s survey, XR technology can offer enhanced support for diagnosis and treatment in hospitals as shown in the following figure.

**Figure 10** Hospital Plans for Deploying XR Medical Technology

| No specific plan in the next two years | 33.3% |
| Plan to install and deploy in the next two years | 66.7% |

**Figure 11** What Support Has XR Technology Brought for Diagnosis and Treatment at Hospitals?

- Improving/enhancing clinical medical effect: 27.4%
- Conducting innovative diagnostic and therapeutic trials: 19.3%
- Reducing risks associated with clinical skills training: 16.5%
- Helping patients understand diagnosis and treatment more intuitively and better: 12.4%
- Carrying out mental illness and psychotherapy: 12.4%
- Promoting institutional image and attracting groups with demand: 8.3%
- Reducing human and other business costs: 3.7%

Source: IDC, 2018
**Major Problems for the Application of XR Medical Technology**

While XR technology has shown preliminary results and huge application potential in medical treatment, it nevertheless faces challenges. The following are the main challenges:

**XR Medical Technology Needs to Establish Standards and Specifications**

Standards for XR medical technology include general technical standards for XR, and industry standards for medical applications.

Technical standards for XR: In April 2017, General Specification for Virtual Reality Head Mounted Display, China's first independently formulated virtual reality industry standard, was officially released. The release and implementation of the standard by Virtual Reality Industry Alliance member enterprises has promoted the development of XR. However, the platform and application interface standards for XR system development still need to be formulated. XR systems developed on different platforms are not compatible, which negatively impacts the adoption of XR systems.

Industry standards for medical application: To make XR medical treatment conform to the medical standards and specifications, XR medical services need to be completed in collaboration with medical personnel. Currently, the standards for XR medical technology in the medical industry is still in the exploratory stages.

**The XR Medical Application Experience Still Needs to Be Improved**

Using XR systems, requires medical workers to wear terminal devices and operate various software and hardware. The knowledge and experience required for operation means that only the most convenient XR systems can be promoted on a large scale. Currently, the physical comfort of wearable devices and system operation are the main issues with XR from the perspective of the user.

**Figure 12 Comparison Between Local XR Technology and Cloud XR Technology in the Medical Industry**

Source: IDC, 2019
Since 2016, various types of XR headsets have been continuously updated. More cordless and integrated devices have become available, with significantly improved wearable comfort and operational convenience. Cordless and portable XR headsets help alleviate issues associated with comfort and space limitations, but their computing power is often restricted.

Cloud XR transfers the computing and rendering functions to the cloud, which is an effective way to solve the issue of insufficient local computing power. Continued development of network technology will allow even greater cloud support in the future.

Lead Agencies Are Still Needed to Integrate Multiple Resources in the Deployment, Implementation and Promotion of XR Medical Systems

The current method of XR medical system deployment is inefficient, and based on the single point application of individual systems. This makes it difficult to promote XR medical systems to multiple hospitals efficiently. The deployment and promotion of XR systems requires more resources, in addition to lead agencies capable of integrating these various resources.

In the current promotion of XR, major improvements have been made. Policy documents on the standardized training of doctors now specifically requires that training institutions equip professional surgical simulation equipment, which lays a foundation for the promotion and application of XR medical technology. The development of Cloud XR medical systems also provides a technical basis for the large-scale promotion and application of XR.
The Technology Ecosystem of XR Medical Systems Needs Further Improvement

The vendor ecosystem of XR medical systems includes equipment suppliers, content producers, channels, integrators, and industry users. To ensure the advancement of XR medical technology, more software companies are needed to produce content for clinical and teaching application scenarios. In regards to computing power and network communication, professional system integrators are needed to build the necessary IT infrastructure.

In the current development and operation of XR medical systems, an XR vendor usually assumes multiple roles described above. Although an XR vendor can provide XR medical systems, it is not specialized in all areas of deployment. In the future vendors in the XR ecosystem need to coordinate and cooperate with each other in order leverage their respective strengths to develop practical XR medical solutions. This coordination and cooperation is needed to realize the full value of XR technology in medical treatment.

Future XR Medical Technology Development and Application Trends

High requirements for data processing and image rendering in the medical industry require strong computing power. As a result, PC- or host-based XR medical systems are mostly commonly used in the market at present. However, progress in computer chips and batteries has made all-in-one machines a new viable option. The all-in-one system has been gaining the attention of industry users because of its light weight and fewer restrictions in regards to physical use and location. Digitization is also a major trend. The contents of XR medical digitization include human anatomy textbooks, medical images, surgical operation images, as well as various situational images related to the treatment of various maladies.

The components of an XR medical system are as shown in the following figure:

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**Figure 14** XR Medical System Composition Schematics

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Components of XR Medical System Development Maturity Analysis Future Development Trend and Path

XR Medical Digital Contents Currently, there are basically digital contents that can be used to make XR medical systems. Clinicians’ cooperation is needed to make these contents into XR systems. There is also a need to collect and edit more contents suitable for XR systems according to their needs, so as to support the development of more functions for XR medical systems.

XR Medical Software There is still a serious shortage of XR medical software. There is a need to find more scenarios in clinical applications, as well as more software development teams to join XR medical software production. There will be more participation of clinicians in XR medical software, and the functions of various XR development platforms will also be perfected. Applicable development standards for the industry will be gradually established, which will speed up the development of XR medical software and enhance its practicability.

XR Medical Display Devices Current display devices can basically realize the display of immersive situations. However, head display devices are inconvenient to wear. For example, heavy equipment, equipment connection cord and so on all affect the practical application effect of XR medical systems. Display devices will become cordless by adopting wireless communication. Through technological improvements, they will also become lighter. These will make it easier to perform various operations with head display devices and other wearables.

XR Medical Operating Equipment Current operating handles can basically achieve immersive scenario operations, but there is a lack of operating devices specially for XR medical systems. In the future development and optimization of operating handles for XR-based medical treatment, it is necessary to attract the participation of clinicians so as to make operating handles, tactile gloves, force feedback gloves and other devices more medically specialized and more in line with the ergonomics of doctors’ operation. This can make medical training more realistic, and enable telemedicine to better achieve the goal of “four ways of diagnosis, namely looking, listening, questioning and feeling the pulse”.

IT Infrastructure for XR Medical Systems Many XR medical systems are now deployed locally, making it difficult to support remote applications. The application effect of XR medical systems is also affected by the deployment and performance of local network communication. In the future, Cloud XR will become the mainstream. The deployment of Cloud XR can effectively guarantee the computing power required by XR software and support multi-point applications and remote applications. The development of next-generation network technology will help XR medical systems to play their effect.

The development trends of the various XR medical system components above will be accelerated by the development and evolution of emerging technologies such as cloud computing, AI, networks, and IoT. In the future, XR medical systems will become more convenient and more comfortable to operate, enabling doctors to improve diagnosis and treatment.

Table1  XR Medical Technology Development and Application Trends

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Source: IDC, 2019
CHAPTER III:
XR MEDICAL INDUSTRY CHAIN
DEVELOPMENT STATUS AND TRENDS

Composition and Operation Mechanisms of the XR Medical Industry Chain

Currently, the XR medical market ecosystem mainly consists of equipment suppliers, content producers, channels, integrators, and industry users. The mainstream business model is represented by direct cooperation between industry users and content producers. Content developers provide standardized or customized services, and offer product maintenance in the latter stages, and users make one-time purchases and one-time payments. For XR-related equipment, users can make hardware procurement by themselves, or choose to adopt total solutions integrating equipment and software.

In addition to specific single medical scenarios, suppliers also provide a set of multiple XR medical applications for pan-educational applications such as medical training, including applications from different departments and scenarios. Equipment usually accounts for less than 25% of the total solution procurement costs, with the remaining part mainly coming from software application-related costs.

Figure16  THE XR MEDICAL MARKET AND INDUSTRY CHAIN

Source: IDC, 2019
Major Participants in the Current XR Medical Industry Chain

Equipment Suppliers

Hardware suppliers mainly include head display manufacturers, and manufacturers of handles, sensors, body models of lesions and other equipment.

As industry users’ demand for XR equipment is rather scattered, individual departments of medical institutions usually buy two or three units at present, and only a few orders can reach the scale of twenty or thirty units. Therefore, equipment suppliers mainly enter the user market through channels and integrators. At the same time, buyers can make one-time small purchases directly from the offline stores and official malls of manufacturers. Despite this, because of the existence of chain institutions and hospitals, there is still a huge potential demand for XR equipment in the whole medical market. Therefore, there is a greater need for integrators with platform users to integrate resources.

According to IDC’s survey, when considering purchasing XR medical equipment, users are most concerned, in addition to equipment performance, about the penetration rate of the equipment in the industry. Therefore, equipment suppliers need to rely on integrators’ platform services for promotions and operations so as to attract more end users. In addition, less than 20% of users will pay attention to equipment price. So, XR equipment suppliers should pay more attention to improving the use experience of their equipment, display definition, positioning accuracy, wearing comfort and so on.

Content Producers

The development of medical VR applications in China is mostly concentrated in the training and education field. The number of content producers of preoperative planning, intraoperative assistance and live surgery streaming fields remains relatively small. Meanwhile, because of the medical industry’s high threshold, developers are usually supported by teams with professional academic backgrounds, or they choose to cooperate with hospitals and medical laboratories. In the development process, they tend to focus on specific medical scenarios, such as orthopedics and ophthalmology.

Because there are few platform vendors that can integrate the medical market’s resources, content producers need to attract their own users, which incurs additional costs. While providing software services to industry users, content producers also provide total solutions with hardware packages. They usually choose existing products on the market for head-mounted display devices, and make customized development of data gloves and other supporting devices according to user needs.
Channels and Integrators

Channels and integrators are mostly service providers who provide head-mounted display devices, supplemented by software support, and providers of total solutions integrating equipment and software. For the former, the equipment brands that they serve as agents are particularly important for their market expansion. At the same time, the more customer orders and existing cases a supplier has, the more willing users will be to make purchases from them. For the latter, the market is dominated by total solution providers who provide supporting surgical simulators for head display equipment. They usually cover more application scenarios and can meet the specific needs of different medical institutions for specific applications.

For industry users who lack application development resources and capabilities, channels and integrators can provide total solutions for hardware devices and medical software. Because of the barriers in the medical industry, it is difficult for independent content producers to communicate directly with the dispersed industry users. Therefore, they need to coordinate their demand with channels and integrators that have centralized resources.

Industry Users

Industry users include hospitals, medical schools and their affiliated hospitals, rehabilitation centers and other medical institutions, of which medical schools account for more than 80%. Driven by technological development and policy support, the number of medical institutions that use XR-related technologies and equipment is growing rapidly.

The main ways for users to access XR medical technology are offline promotions, industry meetings, peer referrals and Internet channels. According to IDC’s survey, offline promotions are the main way for institutions that have adopted XR medical technology to learn about related technologies and equipment; meanwhile, industry meetings and peer referrals are the main ways for institutions that have not yet adopted XR medical technology to get information on related technologies and equipment. However, the information obtained through these two channels is relatively shallow and insufficient, which leads to industry users having an overly simplistic and incomplete understanding of XR medical technology. Therefore, the market needs to establish platforms that can provide centralized information integration and equipment services.
The XR medical industry is in a rapid development stage, and the numbers of participants in the upstream and downstream of the industrial chain are growing. However, according to IDC’s survey, the following ecosystem breakpoints persist in the industry chain, and it is necessary to establish aggregation platforms to effectively allocate resources:

**Breakpoint between equipment and content developers and industry users:** There are not enough system integrators in the market that can integrate equipment content resources and industry user resources. The high communication cost between users and equipment and content developers is problematic, and there is a lack of transparency regarding market information.

**Breakpoint between suppliers and industry users:** Because of the special nature of the medical industry, suppliers who maintain long-term cooperation with medical institutions are mature in resource control but relatively dispersed. They have high barriers for new entrants, but the development of the whole market lacks efficiency.

**Breakpoint between overseas equipment and the domestic market:** There are insufficient channels in China to promote imported equipment from abroad. There are few developers to follow up with development and application, resulting in even fewer applications in practice.

**Breakpoint between equipment platforms and content developers:** XR equipment platforms of different hardware manufacturers remain relatively dispersed. Cross-platform applications face bottlenecks such as rising costs and technical adjustments, which are not conducive to the promotion and popularization of high-quality content.

**Breakpoint between content resources and industry users:** Because of the lack of content aggregation platforms, industry users need to design and develop customized applications with content developers, which leads to low resource use efficiency. For content providers, user expansion also has issues with high costs and low efficiency.

Medical projects often need customization. This requires content producers to maintain continuous communication with users and provide users with offline or localized doorstep services. In the absence of unified management by integrators, producers also face high costs.
XR Medical Industry Chain Evolution Trend

After entering the XR medical industry ecosystem, telecom operators will play a pivotal role in connecting suppliers and end-users. By establishing service platforms, they can integrate the products and services from content developers and equipment manufacturers, and provide support to industry users in the form of total solutions. The decentralized business model of direct connection between content and equipment providers and end-users will gradually weaken, the service integration role of the platforms will become increasingly important, and the efficiency of industry cooperation and resource operation will improve.

In its research report (IDC US44484018, IDC FutureScape: Worldwide Health Industry 2019 Predictions, December 2018), IDC states that as user expectations continue to rise, 60% of medical service providers will make improving the digital medical experience one of their three strategic priorities by 2020. In the process, digital support technologies represented by cloud services and XR technology will become a focal point for providing more transparent, easy-to-understand and better services for patients.

Figure 20 OPERATORS AS INTEGRATORS AND SERVICE PROVIDERS IN THE XR MEDICAL INDUSTRY
CHAPTER IV:  
THE FUTURE XR MEDICAL INDUSTRY ECOSYSTEM

Leveraging Their Strengths in Cloud Computing and Network Technology, Telecom Operators Can Become XR Medical Solutions’ Best Integrators and Service Providers

Unlike traditional XR solutions, Cloud XR platforms can aggregate the medical industry's XR contents and quickly distribute them to the terminal systems of industry users such as hospitals, medical colleges and other medical institutions. Cloud XR also allows the cloud to perform computing and rendering, which reduces the high hardware configuration requirements for XR terminals and is more convenient for users. In this process, it is necessary to use high-speed and stable networks to promptly transfer the contents processed in the cloud to user terminal devices and bring XR medical services to the cloud.

Telecom operators have outstanding strengths in cloud computing and network infrastructure, and are in an advantageous position in the process of developing Cloud XR medical platforms, integrating medical resources into the cloud, and gathering industry partners and users.

Low efficiency of the current ecosystem

- There are too many platforms and a lot of repeated development; Content is scattered and not easily accessible; It is costly and difficult for content providers to develop the user market by themselves;
- The XR medical system involves a high investment, requiring a powerful computing capacity; There are limited channels of promotion, with a low penetration rate;
- Due to current network conditions, the XR system does not offer a good user experience in terms of resolution and smoothness;
- Industry users are scattered;
- There is a lack of industry standards and norms;

Cloud XR platform provided by carriers

- Unified platform and specification, suitable for promotion; Accelerate medical content aggregation, increase distribution efficiency;
- Cloud-based computing and rendering reduce the cost of the XR medical system, facilitate the equipment’s penetration;
- Provide high-quality network support (5G, dedicated line, ultra-wideband, Wi-Fi, etc.) to ensure a high-level XR medical experience;
- Facilitate centralized management of industry user needs; Involve a large number of family users;
- Promote the formation of industry standards and well-guided market operations;
Vendors on the XR Medical Industry Chain Will Collaborate to Build Powerful XR Medical Solutions Around the XR Medical Cloud Platforms Built by Telecom Operators

All relevant technology vendors on the XR medical industry chain ecosystem can leverage operators’ E-Platform services to remove the business restrictions from user expansion and market promotion, harness their advantages in application development, and cooperate with platforms to provide more diversified service support. This can enable them to make the most of their respective values while promoting the maximization of the whole industry’s value.

Operators can coordinate and integrate effective resources in the industry, attract more industry organizations to join the XR medical industry chain, and combine the R&D technologies of content producers with the diagnosis and treatment methods of traditional medical institutions, which will help promote the XR medical industry’s sustainable development. Operators can modularize the operation of XR medical services; hierarchically manage industry users by region, specialty, type and other characteristics; and synchronously update applications through back-stage services.

Content producers can leverage the service platforms provided by operators to collect and analyze the needs of industry users, conduct special research and development targeting market pain points, and improve and upgrade existing XR medical applications.

XR device vendors can connect the different types of XR equipment from different manufacturers to the cloud platforms through standard data interfaces. In addition, traditional medical device manufacturers are gradually becoming important members of the XR medical ecosystem. For example, Medtronic and Johnson & Johnson have launched their own VR products.

Through cooperation with XR technology developers, industry users (such as medical institutions, and medical education and training institutions) will expand existing XR medical scenarios and establish an ecosystem closed-loop from industry users to content producers to industry users.
CHAPTER V:
FUTURE PROSPECTS

Telecom Operators Push Forward the Development of XR Medical Platforms and Support More Medical Application Scenarios

Telecom operators are actively establishing Cloud XR medical platforms. For example, China Mobile Fujian Company, in collaboration with Huawei; Cyber Cloud; LETINVR; and other vendors in the XR ecosystem, built a cloud VR platform in July 2018 to support education, entertainment and other businesses. It is also developing XR applications for the medical industry.

With the improvement and expansion of the XR medical ecosystem, the cooperation among equipment suppliers, content producers, channels and integrators, industry users and traditional medical device manufacturers will increase, promoting the incubation and implementation of more XR medical scenarios such as education and training, disease diagnosis and treatment, telemedicine, rehabilitation and health management, harnessing the value of XR in medical treatment and helping medical institutions provide better healthcare services to patients and household users.

Next-Generation Networks Promotes the development of Cloud XR in Medical Treatment and Boosts Fully Connected Medical Services

According to IDC’s survey, 30% of the hospitals that have preliminarily used XR medical systems report that there was insufficient network bandwidth in their application of XR systems, and 20% of hospitals say that there was low fluency and big delays in their XR systems.

Next-generation networks (such as 5G, UBB) can provide stable content transmission with large bandwidth and low latency, which is ideal for supporting Cloud XR medical services. Cross-regional, multi-branch collaborative remote surgeries, remote guidance and other scenarios are sensitive to time delays, and they have very strict requirements for reliability and security, which needs high-quality, dedicated support.
According to Huawei iLab’s White Paper on Cloud VR Solutions, Cloud VR requires a bandwidth of more than 1 Gbps in the ideal experience stage.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Fair-experience Phase</th>
<th>Comfortable-experience Phase</th>
<th>Ideal-experience Phase</th>
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<td>Bandwidth requirements</td>
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<td>Full perspective:</td>
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<td>≥140Mbps</td>
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<td>FOV:≥75Mbps</td>
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<td></td>
<td>RTT requirements</td>
<td>≤20ms</td>
<td>≤20ms</td>
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<td></td>
<td>Packet loss requirements</td>
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<td>1.7E-5</td>
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<tr>
<td><strong>Cloud VR strong interactive service</strong></td>
<td>Bandwidth requirements</td>
<td>≥80Mbps</td>
<td>≥260Mbps</td>
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Huawei iLab is the Ultra Broadband networks innovation lab, which is dedicated to studies on scenarios, experience, ecosystems, and friendly networks. Huawei iLab is willing to work with industry partners to facilitate business and technical innovation, industry development, and development of an open industry ecosystem for a better connected world.

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About iLab

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