HUAWEI

iLab

Medical Imaging Cloud

Scenario White Paper

Preface

Medical imaging refers to non-intrusively obtaining internal images of a human body or body part for medical treatment or research.

Medical imaging is arguably the most important clinical diagnosis and differential diagnosis method in modern medicine. It is one of the most important phases in the medical process. Currently, 70% of clinical diagnosis relies on medical imaging, and image data accounts for 80% to 90% of all hospital data.

Medical data is growing rapidly, and hospitals must invest enormously to expand the storage capacity of their data centers every year. In addition, most hospitals still use images within their local area network (LAN). The data volume is large, the transmission speed is low, and the data is not shared. As a result, this important data source is not used effectively and becomes liability rather than asset. How to store, retrieve, and fully apply the massive image data is a challenge facing each medical service organization.

The application of cloud computing in the medical industry will bring it into the data technology (DT) era. Medical data in the cloud can now be shared across regions and medical institutions, allowing more patients to obtain the medical resources they need. After medical images are uploaded to the cloud, cloud computing and cloud storage technologies can provide rapid data retrieving, network data sharing, and application expansion. This not only

provides doctors with more convenient clinical image data services, but also supports big data, Internet of Things (IoT), and artificial intelligence (AI), bringing wider application space and value.

Medical imaging cloud has become an important field of cloud computing. Chinese and international Internet giants including Alibaba, Tencent, Huawei, Amazon, and Microsoft are working with traditional medical equipment and imaging companies including GE, Philips, Siemens, Carestream, and United Imaging to explore and innovate.

This white paper describes recent developments, business opportunities, and network SLA requirements of five application scenarios based on their current development status and national policies. It introduces these sce narios and explores their development background and value, providing analysis and suggestions for future medical imaging cloud services development.

Finally, this white paper serves as a reference for the medical imaging cloud industry and contributes to its development. Huawei iLab is willing to team up with partners in the healthcare ecosystem to promote the development of the medical imaging services.

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01

Medical Imaging Cloud Overview

1.1 Background Information

Driven by factors such as medical requirements, national policies, and the applications and maturity of cloud computing, the medical industry is entering a "cloud era".

Policy drive: The "Healthy China" national strategy is a core driver of the medical imaging cloud market. National medical policies require implementing regional collaboration and hierarchical diagnosis and treatment, including the integration of medical resources, mutual recognition of medical examinations, and medical image sharing. A region's imaging center, ECG center, and pathology center can now collaborate to implement remote image diagnosis, driving the development of medical imaging. China's State Council issued the Opinions of Promoting the Development of "Internet + Healthcare", accelerating the pace of medical cloud development.

Industry trends: Continuing to develop medical imaging cloud technology is inevitable. Some important applications include sharing of medical image data from the hospital level to the regional level, rapid retrieval and sharing of image data, and extended image applications.

Hospital requirements: Medical imaging plays an important role in clinical diagnosis. However, there are many problems in clinical applications; for example, diagnosis results being not mutually recognized, repeated radiography for referral, the lack of historical image data, low efficiency and accuracy of image diagnosis, and difficulty of sharing and using image data.

Patients face the following problems: difficult and expensive medical treatment, excessive number of examinations, repeated radiography for referral, image consultation difficulties, and high misdiagnosis rate.

Doctors face the following problems: heavy workload, low diagnosis efficiency and accuracy, difficult service communication, and insufficient educational materials.

Hospitals face the following problems: difficult image management, low accuracy and efficiency of image diagnosis, poor patient

experience, and many medical disputes. Uneven distribution of medical resources in the medical management department requires that hospitals explore the value of image data and improve the medical level.

Modern hospitals have established a Picture Archiving and Communication System (PACS), Clinical Information System (CIS), Hospital Information System (HIS), and Electronic Medical Record (EMR). In modern hospitals, medical images comprise 80% to 90% of medical data. According to the health observation data of IDC 2017, more than 450 PB of image data is accrued each year worldwide, and the amount of image data stored is expected to double in the next five years. In light of these predictions, traditional single-hospital image storage is not equipped to handle this expansion.

1.2 Solution Overview

Medical imaging cloud integrates various technical concepts such as the Internet, cloud computing, big data, IoT, AI, social networking, medical collaboration, and telemedicine services. Cloud computing and Internet technologies are used to obtain medical image data in real time, promote collaboration between medical institutions, and share medical imaging examination data, supporting patients' health. Hierarchical diagnosis and treatment can be further promoted by sensibly distributing medical resources across regions.

1.3 Solution Benefit

Medical imaging cloud promotes medical industry reform. Imaging cloud applications and medical process optimization facilitate collaboration of medical resources and the development of medical alliance. In the long run, imaging big data can be combined with new technologies such as cloud computing and AI to fully explore the value of this data and improve diagnosis and treatment.

- **For hospitals:** Medical imaging cloud supports image data sharing within and between hospitals, medical and technical data and services management, 3D applications of clinical images, and scientific research. In addition, combining imaging big data with telemedicine, remote diagnosis, and AI can further improve doctors' diagnoses and therefore hospital reputation.
- **For patients:** Medical imaging cloud can assist with consultation, diagnosis, and treatment. In this way, patients can easily get medical treatment, save time and money, and take control of their own health.
- **For doctors:** Medical imaging cloud improves the efficiency and accuracy of diagnoses, promotes effective communication between doctors and patients, reduces medical accidents, and improves patient satisfaction, providing better medical services.
- **For medical management departments:** Medical imaging cloud can be used to build a national electronic health record system, manage patients' health information, improve doctor supervision, promote hierarchical diagnosis in the region, and support scientific medical research.

In summary, medical cloudification allows for efficient utilization of medical resources, reduces costs, and improves efficiency so patients receive better medical services.

1.4 Application Scenario

Based on the development status of the medical industry and the characteristics of medical image services, the main application scenarios of medical imaging cloud can be classified into five types:

- **Cloud image storage:** Massive image data storage and backup on the cloud, cloud image archiving, and remote image disaster recovery (DR).
- **Imaging cloud application:** Cloud image-based applications, such as medical and technical cloud PACS, 3D clinical image applications, mobile image reading, imaging center, ECG center, and pathology center of the region.
- **Cloud-based medical collaboration:** Regional imaging centers and remote imaging consultation centers.
- **Cloud-based medical education:** Online doctor training, surgery live broadcast, doctor examination, multi-hospital morning reading, and image expert pool.
- **Cloud-based health management:** Personal image file, image online consultation, and remote health monitoring.

02 Medical Imaging Cloud Development Trends

Currently, medical imaging systems in China operate mainly at the hospital level. Most image data can only be used in the medical technology department or the hospital. Image data is retrieved based on the local PACS system for storage and management. The following problems occur:

1 Extremely unbalanced development

CHIMA data shows that less than half of graded hospitals have a PACS system. The PACS development stage and usage in secondary and tertiary hospitals differs significantly by region. The rate at the department level is 60% to 70%, at the multi-department or hospital level is 50% to 60%, and at the regional level is 10% to 20%. PACS construction in grassroots medical institutions is incomplete.

2 Outdated storage mode

Most hospitals use local storage. For example, tertiary hospitals typically use clustered NAS systems and tier 3 storage, and secondary hospitals typically use IP-SAN storage. Other hospitals use the unified storage system and depend on the file system of the PACS server, posing a performance bottleneck. Local storage provides low service experience and security, is difficult to scale, and lacks redundancy to back up the data. Hospitals independently maintain their own PACS server (facing talent shortage). The traditional storage architecture cannot meet the requirements of real-time services and imaging technology development.

3 Inconvenient retrieval

Online information is limited and query speed is slow. A large number of historical imaging files need to be stored nearline or offline in the CD-ROM library or tape library, preventing instant retrieval.

The development of medical alliance and independent imaging centers requires data sharing and diagnosis across regions, and the establishment of personal healthcare records. The medical industry requires a way of using the Internet, big data, and cloud computing to transfer medical image data from in-hospital applications to regional applications, and from local storage to cloud storage, to implement remote consultation and remote imaging diagnosis.

Medical imaging cloud developed from private cloud, hybrid cloud, regional medical cloud, and finally to public cloud.

Phase 1: Medical institutions build their private clouds, integrate their internal medical information systems, migrate the registration, consultation, payment systems, and then HIS, CIS, and EMR to the private clouds. Then, they can migrate the PACS to a public cloud. In the early stages of cloud application rollout, doctors are very concerned about medical data security, especially of scientific research data. Doctors are often unwilling to store information on the cloud.

At present, the hospital cloud includes non-medical core systems such as office and medical examination systems. However, hospitals are relatively cautious about storing EMR, HIS, and LIS systems on the cloud.

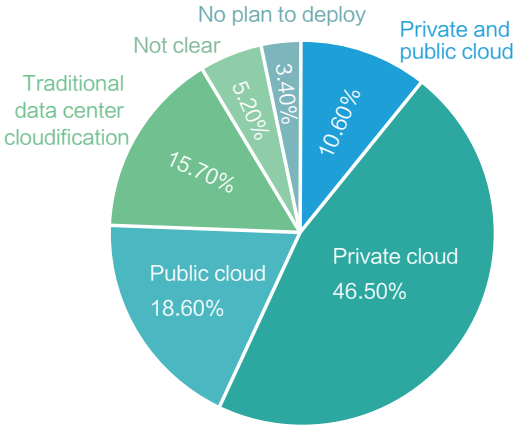


Figure 2-1 Cloud forms primary/secondary hospitals choose

Graded hospitals are more likely to deploy a private cloud, especially a self-built private cloud. Grassroots medical institutions and specialized hospitals are more likely to accept public cloud. In the early stage, private cloud and hybrid cloud are still the most viable solutions for the medical cloud.

Phase 2: The medical cloud begins shifting to hybrid cloud systems, driven by the mature application of cloud computing, medical collaborations such as regional imageimaging centers and telemedicine, and the requirements for sharing. Hospitals will only retain some sensitive medical data, and will migrate other data to the public cloud.

- Core service systems such as HIS/CIS/HRP are deployed on local nodes or the dedicated cloud. Innovative services such as medical big data, AI, and imaging cloud are deployed on the industry cloud.
- Non-core services such as mobile apps, cloud PACS, and OA are deployed on the industry cloud or dedicated cloud.

Phase 3: Out-of-hospital services become major medical application scenarios and are gradually migrated to the regional medical cloud and public cloud. In the future, public cloud will be the mainstream choice.

Over the next few years, medical cloud will continue to grow rapidly, and the core medical service systems will gradually migrate to the cloud.

03 Application Scenarios of Medical Imaging Clouds

3.1 Cloud Image Storage

Scenario Description

Medical image storage backup involves transferring medical images from their existing hospital data center to other campuses or third-party cloud platforms through a network to implement PACS application backup, image data DR, and permanent storage of the massive volume of data in the case of natural disasters, hard disk faults, attacks, and human error.Cloud image storage involves storing, retrieving, and maintaining a massive volume of image data in the cloud, implementing multi-point disaster recovery (DR) for permanent image storage. There are data level and application level DR.

1. **Data-level image DR**

   To ensure availability of the service data, the DR service platform synchronizes data in real time or as scheduled between the production center and the DR center through the data replication tool on the network.

2. **Application-level DR**

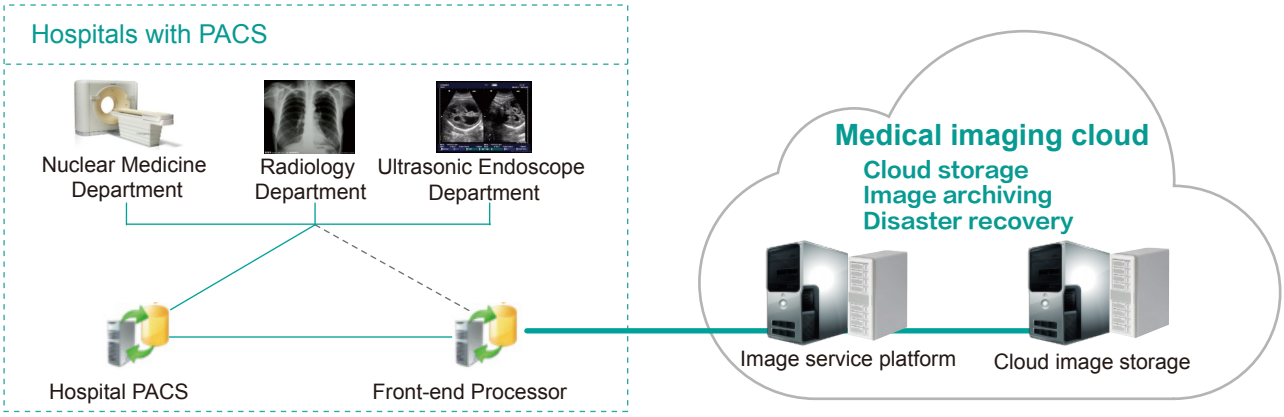
   An application-level DR system is built based on the data-level DR to provide a backup application and network system. If the production environment becomes faulty, the applications in the DR center take over to reduce system downtime and ensure service continuity.

Application Scenario

The HIS, CIS, and PACS of the hospital generate significant outpatient and clinical data every day. Security of clinical treatment and hospital management data is vital, and its loss would significantly impact the hospital.

Cloud image storage includes remote DR, image archive, and application-level backup of PACS, helping hospitals secure their production and operation systems and data.

Figure 3-1 Cloud storage DR and backup architecture for medical images



- **Imaging cloud archiving:** This function can be deployed for hospitals whose PACS system has insufficient storage space. Frequently-accessed data is stored locally, and other data is stored in the clouds of hospitals or third parties. Two or more imaging cloud centers are recommended for high availability.
- **Remote DR of imaging data:** This function can be deployed for hospitals which have deployed a PACS system. The DR system has no impact on the existing PACS system. The data is backed up to the cloud so that it can be recovered in case of local data loss. Remote DR ensures data availability and service continuity.
- **Application-level backup of PACS:** A DR PACS system can back up the primary PACS system to ensure service continuity. The primary data center and the DR data center can work in active/active or active/standby mode.

National Policy

China's National Health Commission (NHC) requires that hospitals implement hierarchical management of information system operation rights according to the Information Graded Security Protection Regulation to protect network and information security, protect patients' privacy, standardize system O&M management, and implement emergency response mechanisms to ensure business continuity.

1. In 2011, the Ministry of Health released the Notice on Information Security Graded Protection in the Health Industry. The notice requires local health administration boards and hospitals to ensure information security. **In principle, the safety protection level of important health information systems should not be lower than level 3, PACS systems in hospitals are level 3, and remote data backup is required for restoration.**

Table 3-1 Hospital system security levels

System Type	Systems	Recommended Security Level
Patient service system	HIS system, outpatient registration system, appointment registration system, and portal website	Level 3
Systems with business value or scientific research value	EMR、PACS、LIS、RIS	Level 3
Doctor and nurse management system	Doctor workstation and nurse workstation	Level 2
Internal management system	OA and email systems	Level 2

Table 3-2 Level 3 information security requirements

Security Type	Level-3 Information Security Requirements
Network security	Structure security, access control, security audit, border integrity check, intrusion prevention, malicious code prevention, behavior monitoring, and pipe security
Host security	Intrusion prevention, security audit, and malicious code prevention
Application security	Identity authentication and security audit
Data security, backup, and restoration	Backup and restoration, hardware redundancy, and remote backup

❷ In December 2013, the NHC released the Regulation on Medical Records Management in Medical Institutions (2013 Edition). According to the regulation, if medical records are kept by medical institutions, the medical institutions must record test or inspection results within 24 hours of obtaining the results. They must also archive the records within the first working day after each diagnosis and treatment activity. The retention period shall be no less than 15 years from the date of the last consultation with the patient, and the retention period of medical records of hospitalized patients shall be no less than 30 years from the patient's last discharge date.

❸ In April 2018, the NHC formulated the National Hospital Informatization Standards and Specifications, which specifies the following data backup and recovery requirements:

Table 3-3 Data backup and recovery standards

Backup Type	Data Backup Mode	Requirements
Data backup	Local data recovery	Two indicators, namely, recovery time objective (RTO) and recovery point objective (RPO), are available for vital systems. • Secondary hospitals: RTO ≤ 30 min, RPO ≤ 15 min • Grade B tertiary hospitals: RTO ≤ 20 min, RPO ≤ 15 min • Grade A tertiary hospitals: RTO ≤ 15 min, RPO ≤ 10 min
	Remote data recovery	RTO and RPO indicators are available for vital service information systems: RTO ≤ 60 min, RPO ≤ 30 min
Application backup	Local application recovery	RTO and RPO indicators are available for vital service information systems. • Secondary hospitals: RTO ≤ 30 min, RPO ≤ 15 min • Grade B tertiary hospitals: RTO ≤ 20 min, RPO ≤ 15 min • Grade A tertiary hospitals: RTO ≤ 15 min, RPO ≤ 10 min
	Remote application recovery	RTO and RPO indicators are available for vital service information systems: RTO ≤ 60 min, RPO ≤ 30 min

Industry Situation

1 Imaging data accounts for more than 80% of all hospital data, and the amount of image storage is expected to double in five years.

Based on IDC's health insights 2017, the amount of image storage is expected to double in the next 5 years, with the medical industry having one of the fastest growth rates. Technological innovation and the rapid increase of medical examination results data are driving explosive growth of medical clinical data, especially imaging data, which accounts for about 80% to 90%. More than 450 PB of imaging data are being generated each year.

According to the statistics of HC3i (China Digital Medical Network), 84% of hospitals in China stored more than 10 TB in 2016. Common medical institutions in China produce 1 to 20 TB of medical data each year, and large medical institutions produce 300 TB to 1 PB of data each year.

2 The long retention period and large amount of storage data are overwhelming hospitals.

Regulations require that electronic medical records be retained for no less than 15 years from the date of the last consultation with the patient.

84% of hospitals spend more than RMB 200,000 in data management. 33% spend RMB half a million to one million, 17% spend RMB 1 to 2 million, and 17% spend more than RMB 2 million.

3 The cost of independently building a data DR center is high, and outsourcing is popular.

Building a data DR center is costly and technically challenging. The investment is huge, including the costs of construction, equipment rooms, IT systems, and communication networks. However, the DR center normally remains idle when no disaster has occurred, resulting in a high total cost of ownership (TCO). Not every hospital is willing or able to build a DR center. In contrast, DR technologies are mature, and laws and regulations regarding DR are being perfected. Therefore, many hospitals are choosing to outsource DR.

Business Opportunity

1 Providing DR for imaging data using cloud computing (cloud DR)

Cloud computing and cloud storage services are easy to access and can reduce customers' required investment. Therefore, cloud DR services will become more popular.

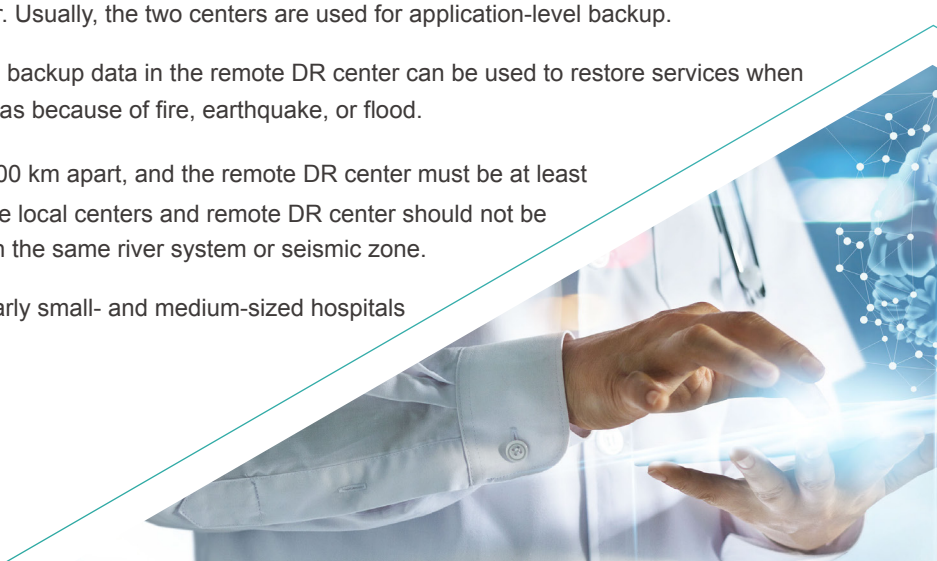
2 Dual local centers and one remote DR center

Two DCs are built in the same city or adjacent cities. Each DC can independently support the operation of vital systems. The two DCs have identical service processing capabilities and synchronize data to each other through high-speed links. They can load balance when both operate normally. If one DC becomes faulty, the other takes over. The fast switchover ensures service continuity in case of a disaster. Usually, the two centers are used for application-level backup.

A remote DR center is built in another city. The backup data in the remote DR center can be used to restore services when both of the active centers become faulty, such as because of fire, earthquake, or flood.

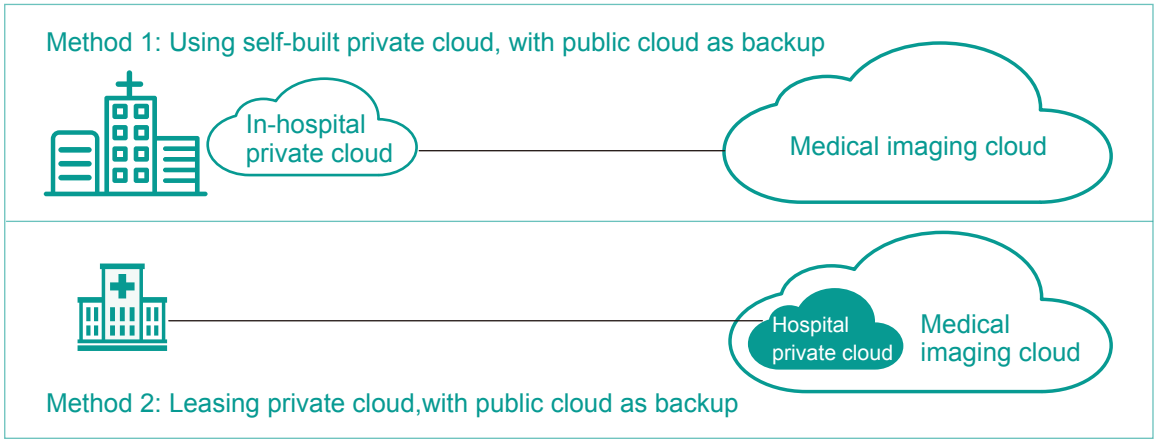
The two local centers can be no further than 100 km apart, and the remote DR center must be at least 300 km away from the nearest local center. The local centers and remote DR center should not be connected to the same power grid or located in the same river system or seismic zone.

This is a huge challenge for hospitals, particularly small- and medium-sized hospitals andgrassroots facilities.



In contrast, the cloud platform architecture of operators can ensure data availability through local or remote DR using private and public clouds, or through private clouds and cloud DR.

Figure 3-2 Cloud DR provided by operators

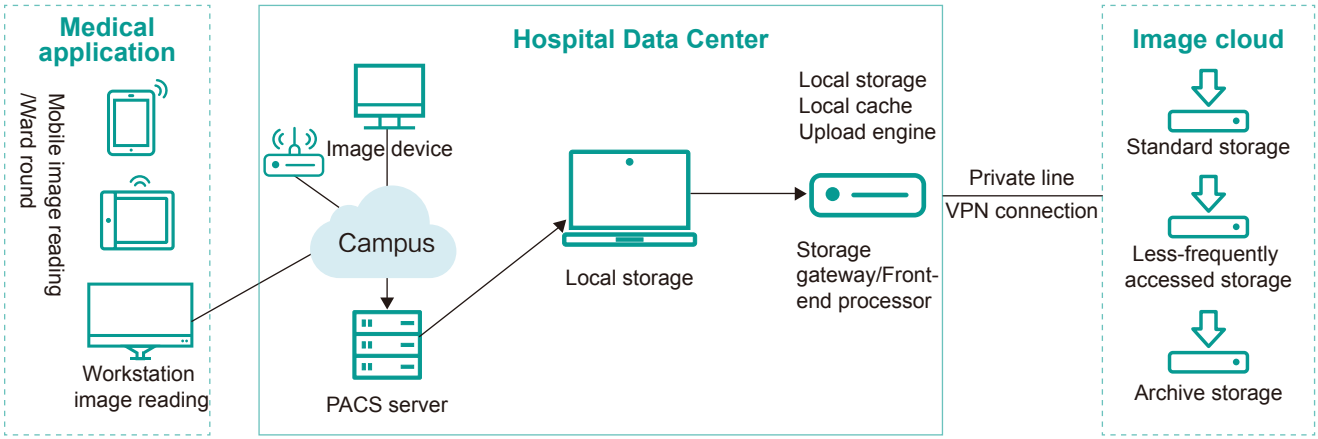


Network SLA

1 DR networking requirements

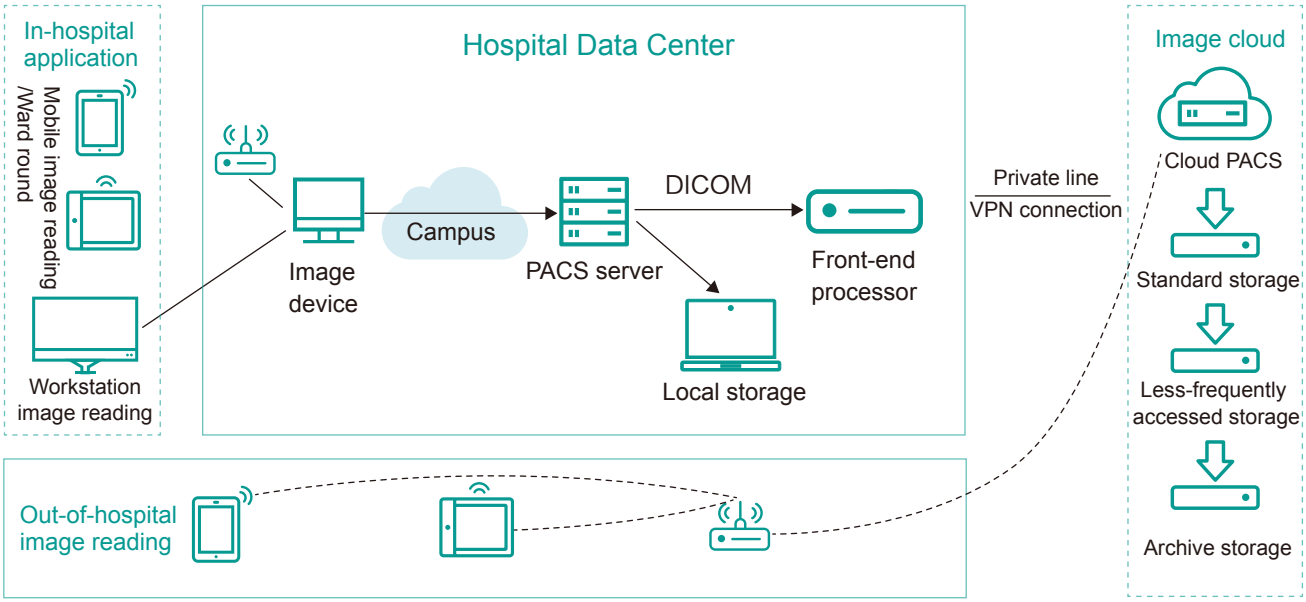
- Deploying data-level DR (remote DR/historical image archiving) does not require changes to the internal networks of hospitals. Hospitals only need to add a storage gateway or front-end processor (FEP) to provide a unified NAS interface to the PACS system. The storage gateway or FEP is mounted through a local file system to transfer data to the cloud. To ensure data is not lost, at least two private lines or VPN connections are required to provide active/standby redundancy. Using private lines of different operators is recommended to ensure high availability. If the primary link becomes faulty, the backup link takes over, ensuring 24 x 7 availability. Meanwhile, the PACS performs lossless compression on medical images to ensure storage efficiency.

Figure 3-3 Remote DR/historical image archiving



- To deploy application-level backup, an FEP needs to be deployed at the egress of the hospital network. The PACS sends the image data to the FEP, which uploads the data to the cloud. The PACS server synchronizes data with the cloud PACS in real time. In addition to active-active DR for the PACS system in the hospital, the imaging cloud can also provide access to external users. Similarly, at least two private lines from different operators should be deployed at the hospital network egress for high availability.

Figure 3-4 PACS application-level backup (active-active)



❷ Private line bandwidth at egress

Image data needs to be uploaded and backed up in real time to meet the safety and reliability requirements. The uplink bandwidth of the private lines needs to be calculated based on the current hospital image statistics and the following general principles: the imaging department works eight hours each day, and the peak traffic volume is twice the average traffic volume. Two private lines from different operators are deployed to ensure availability. The private line bandwidth requirements are listed in the following table.

Hospital Scale	Number of Beds	Annual PACS Storage Volume (Statistics)	Uplink Bandwidth
Grassroots hospital	< 100	< 5 TB	10 Mbps x 2
Secondary hospital	101–500	5–10 TB	20 Mbps x 2
Tertiary hospital	> 501	10–15 TB	30 Mbps x 2
Grade A tertiary hospital	> 800	15–50 TB	100 Mbps x 2
Large grade A tertiary hospital	> 1500	50–80 TB	150 Mbps x 2
Ultra-large grade A tertiary hospital	> 1500	80–120 TB	240 Mbps x 2

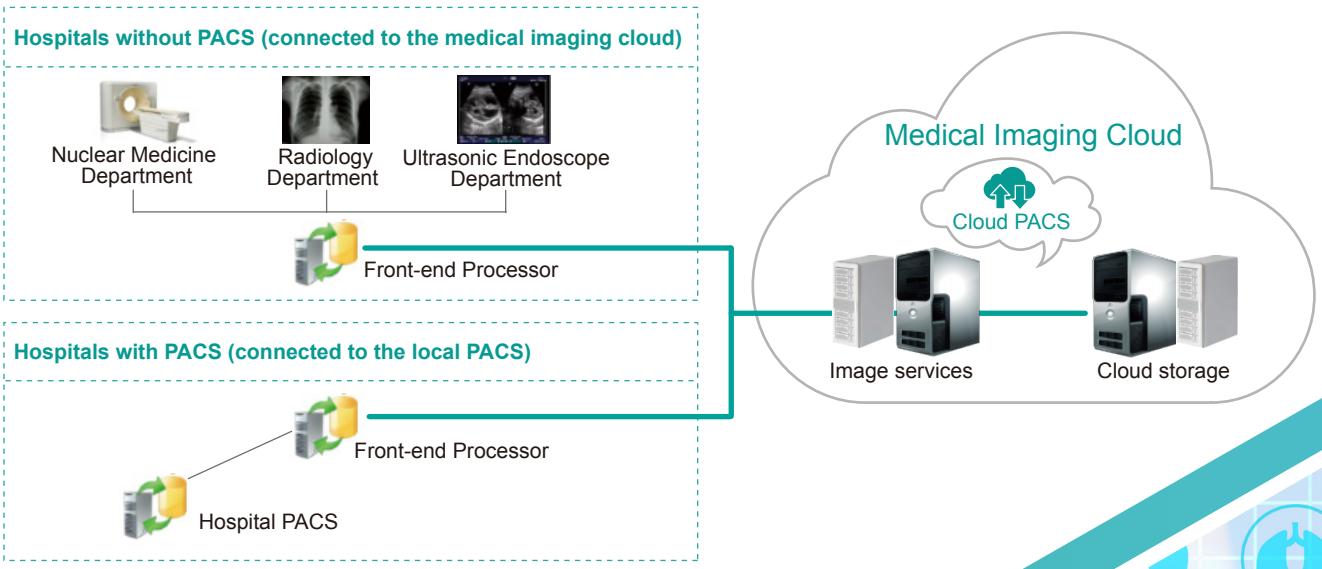
3.2 Imaging Cloud Application

3.2.1 Imaging Cloud PACS: The Eventual Form of PACS

Scenario Description

The cloud PACS application can replace the local PACS system and covers the entire workflow of imaging doctors, providing functions such as appointment registration, image reading for diagnosis, and diagnosis reporting. The solution also supports image post-processing and management. The images in the cloud can be shared to other organizations. Cloud PACS can be deployed if a hospital does not have a PACS system or wants to upgrade its PACS system. This is an opportunity for the development of PACS and one of the most popular medical cloud services.

Figure 3-5 Cloud PACS architecture



Application Scenario

The cloud PACS imaging platform provides SaaS cloud services for tens of thousands of medical institutions and supports regional image sharing to achieve regional medical collaboration, remote imaging diagnosis, and imaging consultation.

- **Providing full-process imaging services**
  Secondary and tertiary hospitals usually spend RMB 5 to 10 million to build their own PACS systems. However, small- and medium-sized hospitals may not be able to afford such PACS systems. Therefore, such hospitals are more likely to use medical imaging clouds, which have the advantages of low cost and pay-as-you-use charging. The PACS solution based on imaging clouds covers the entire workflow of imaging doctors, providing functions such as appointment registration, queuing, imaging, and image reading for diagnosis. The solution also supports image post-processing and management.

- **Building an imaging diagnosis platform for a regional medical alliance**
  Medical imaging diagnosis is an important part medical diagnosis and poses high requirements on doctors. Rural doctors may not have adequate training. As a result, medical institutions at the grassroots level may have imaging devices but no doctors capable of reading the images.

  Therefore, medical alliances are established. Lower-level hospitals upload the images they have taken to the cloud platform so that doctors at upper-level hospitals can examine them and provide diagnoses. In this way, the expertise of doctors at large hospitals can be shared more broadly.

- **Providing full-process cloud PACS services for third-party imaging centers & chain medical organizations**
  The medical imaging platform can be a unified workspace and collaboration platform for third-party imaging centers and chain medical organizations. The service supports pay-as-you-use charging and allows medical organizations to improve operational efficiency, optimize the allocation of doctors, provide innovative medical service models through global service data analysis and monitoring, reduce OPEX, and grow their businesses.

Industry Situation

1 The PACS deployment in China is insufficient, leaving a huge market for cloud PACS.

Hospital-level PACS systems have been implemented in most grade A tertiary hospitals and hospitals in China's larger cities. However, most tertiary hospitals in underdeveloped areas and secondary hospitals have only department-level PACS systems or mini PACS systems.

According to a CHIMA survey, no more than 50% of graded hospitals have PACS systems (60% to 70% of PACS systems are department-level, 50% to 60% are multi-department- or hospital-level, and 10% to 20% are regional-level), not to mention grassroots medical facilities. Meeting this latent demand is a large opportunity for cloud PACS.

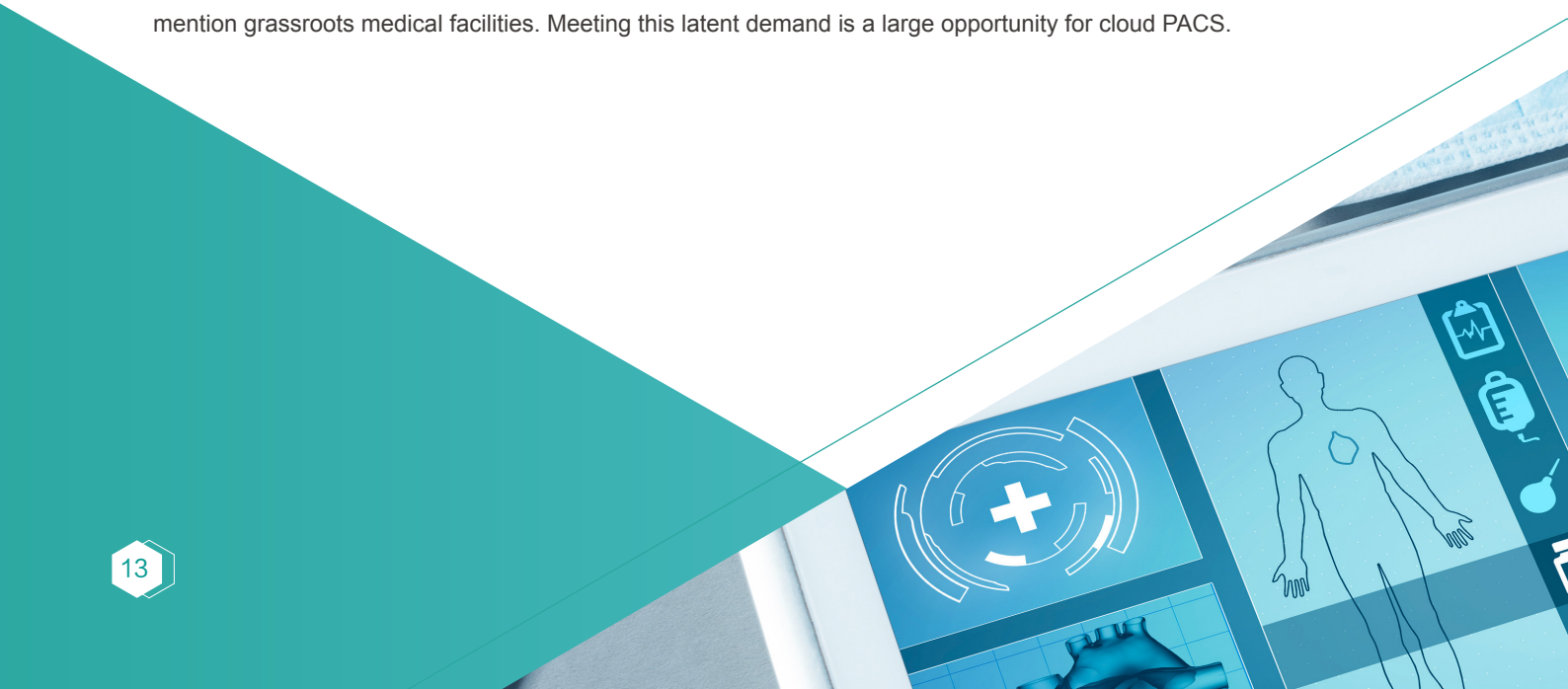
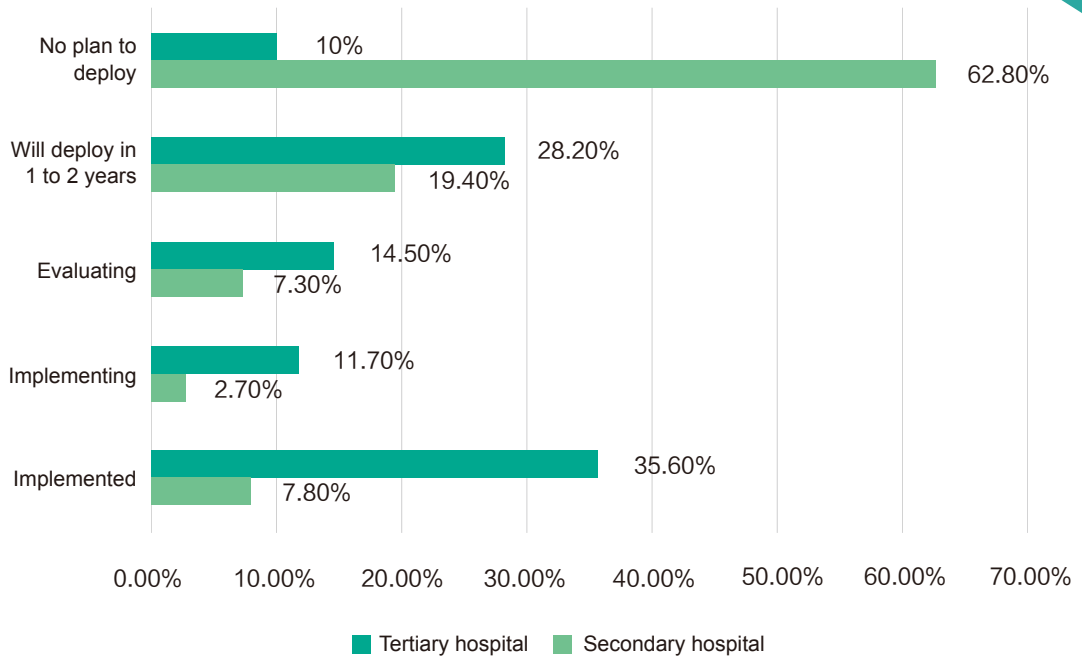


Figure 3-6 PACS deployment in graded hospital (2015–2016, from CHIMA)



❷ **Cloud PACS features low cost, fast access, cloud storage, and comprehensive support for PACS applications.**

Small- and medium-sized medical facilities may not be able to afford to build their own PACS system. Cloud PACS is affordable and supports pay-as-you-use charging. Therefore, grassroots hospitals are a huge potential market for cloud PACS.

Business Opportunity

In terms of profit and cost management, Cloud PACS and cloud storage are good budget choices for grassroots and specialized hospitals.

According to NHC statistics, as of the end of April 2017, there were 930,000 grassroots medical and healthcare facilities nationwide, including 35,000 community health service centers (stations), 37,000 county-level hospitals, 638,000 village clinics, and 205,000 infirmaries. The grassroots medical facilities will be a large market for cloud PACS.

Business Opportunity	Service Scenario	Service Requirement
Cloud PACS + cloud private lines for grassroots hospitals	• Cloud PACS/RIS • Cloud private line • Image hosting service • Desktop cloud for image reading	• Image PACS/RIS system and cloud storage • Image cloud hosting • Image cloud access network
Cloud PACS + cloud private lines for imaging centers of regional medical alliances	• Cloud PACS • Cloud private line • Image hosting service	• Image PACS/RIS system • Cloud platform and cloud storage • Image cloud hosting service • Imaging cloud access network covering all medical institutions of a medical alliance
Third-party imaging institutions and medical groups	• Cloud PACS • Cloud private line • Image hosting service	• Image PACS/RIS system • Imaging cloud platform/cloud storage • Imaging cloud hosting service • Imaging cloud access network
Imaging cloud hosting for hospitals	• Full-process imaging services for medical technology departments • Image big data analytics and AI-aided image analysis • Regional imaging cloud interconnection for medical alliances	• Imaging center access network of medical alliances
Imaging cloud private line	• Private channels that meet the demanding requirements on imaging data safety and application experience	• Safety and reliability • Multiple access methods, high bandwidth, and low latency • Differentiated SLAs

PACS cloud private line bandwidth at egress

Network SLA

1 Cloud PACS networking requirements

If cloud PACS is deployed for a hospital that does not have a local PACS system, an FEP needs to be deployed at the egress of the hospital network. Imaging devices directly send images to the FEP through DICOM ports. The FEP compresses the images and sends them to the cloud. To ensure the safety and reliability of medical data, use two private lines or VPN connections of different major carriers in active/standby redundancy. The FEP is used only for uploading, and image reading traffic does not pass through the FEP.

In the data backup scenario, the PACS performs lossless compression on imaging data. In the cloud PACS scenario, hospitals do not have a local PACS system, and the imaging data is compressed by the FEP using the same algorithm as the PACS. The estimation of imaging data volume is the same as that in the cloud DR scenario.

Figure 3-7 Cloud PACS deployment

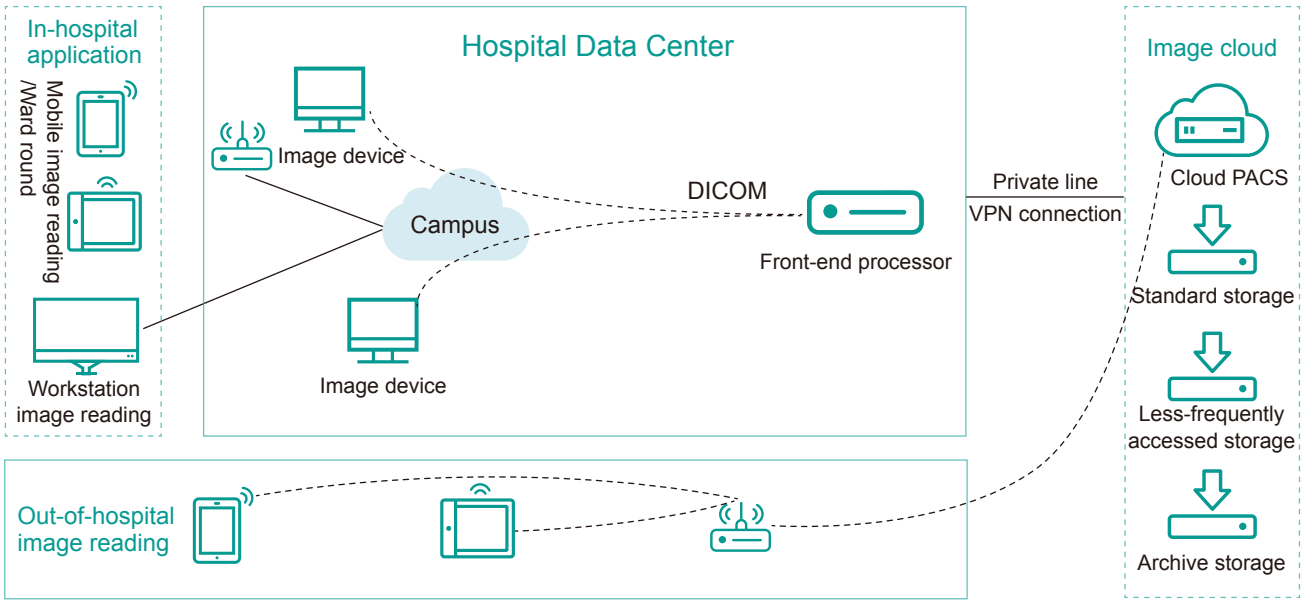


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Image data needs to be uploaded and backed up in real time to meet safety and reliability requirements. The uplink bandwidth of the private lines needs to be calculated based on the current hospital image statistics and the following general principles: the imaging department works eight hours each day, and the peak traffic volume is twice the average traffic volume. Two private lines from different operators are deployed to ensure availability. The private line bandwidth requirements are listed in the following table.

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Secondary hospital	101–500	5–10 TB	20 Mbps
Tertiary hospital	> 501	10–15 TB	30 Mbps
Grade A tertiary hospital	> 800	15–50 TB	100 Mbps
Large grade A tertiary hospital	> 1500	50–80 TB	150 Mbps
Ultra-large grade A tertiary hospital	> 1500	80–120 TB	240 Mbps

3.2.2 Cloud Image Reading: Making Diagnosis More Efficient

Scenario Description

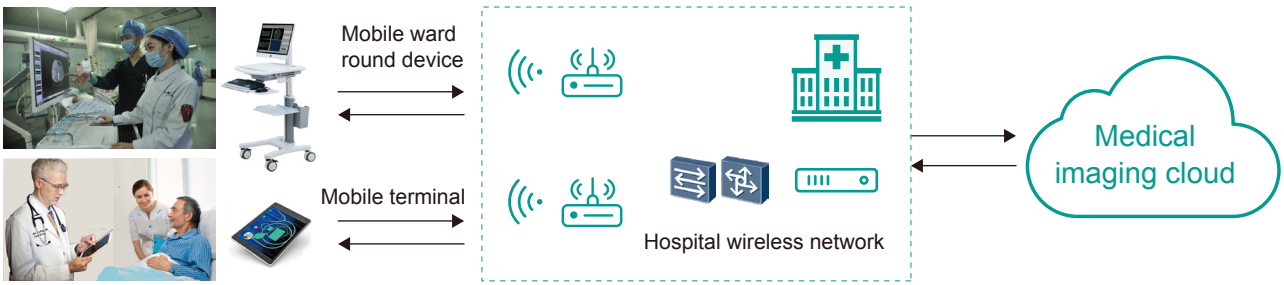
Images are stored in the cloud. Image processing, analysis, and reading (such as image scaling, window position adjustment, marking, and measurement), auxiliary functions (such as image comparison, image fusion display, and 3D reconstruction), and clinical applications (such as intelligent image analysis, maximum intensity projection, one-click bone removal, virtual surgery, 3D printing, and instance teaching) help doctors analyze image data, find trigger points, and provide a diagnosis.

Cloud image reading can analyze images in seconds, and the results can be retrieved from any smart device anywhere at any time. It also facilitates big data analytics of medical images and AI-aided image reading.

Image processing is performed on the cloud. Clients only need to decode and browse the images, thereby lowering the requirements on the hardware specifications of these clients. Clients also only need to receive the data that has been processed, instead of the entire thing, which improves data security. The cloud then only needs to return the image in the display area of the screen, reducing the overall amount of transmitted data.

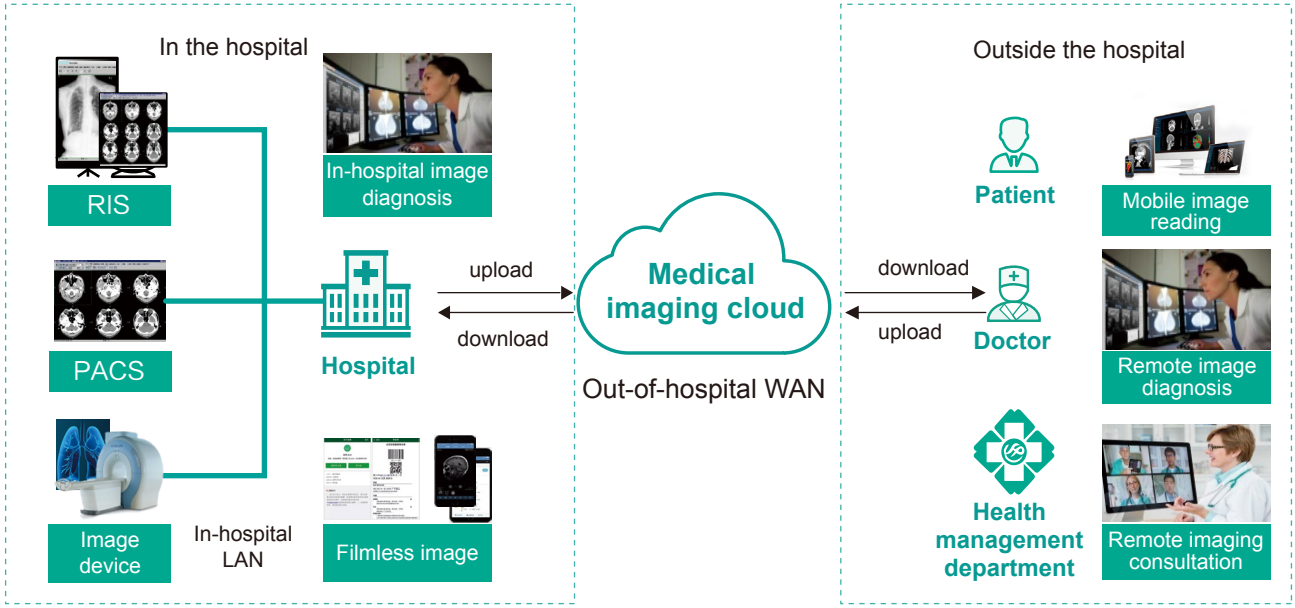
Application Scenario

- **Auxiliary tools on the cloud to improve the efficiency of diagnosis in image reading and review**
  Imaging doctors use the desktop workstation to obtain patients' images, provide image diagnosis reports, and review the reports of other doctors. The doctors use the auxiliary tools on the cloud to improve the accuracy of the image diagnosis reports.



- **Cloud enables filmless imaging**
  The images and diagnosis reports in the cloud are electronic copies, and links to them can be shared with patients through SMS or WeChat QR codes. Doctors can query, archive, and analyze the soft copies of images and diagnosis reports.

  In this way, patients do not need to spend time and money printing and obtaining hard copies and can view and share them anywhere and at any time. The medical facilities also do not need to spend money on printing hardware, and governments can implement their hierarchical system and two-way referral policies.



Industry Situation

1 In the next two years, more than half of all medical institutions will deploy a medical cloud

According to research performed by the Mobile Information Research Center, 21.7% of secondary and higher-level hospitals have already deployed cloud computing, 5.3% are currently in the process of deploying it, 8.6% are evaluating their deployment, 23.4% are considering deployment in the next 1-2 years, and 41% of hospitals are unsure.

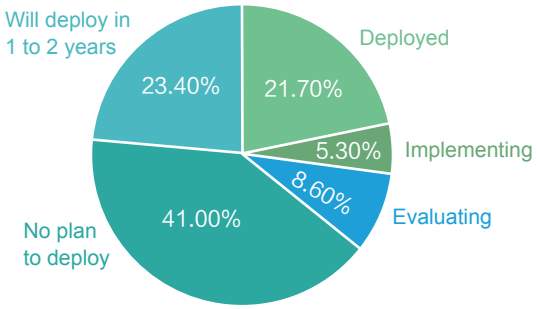


Figure 3–8 Adoption of cloud computing at secondary and higher-level hospitals

2 Image processing on the cloud improves the efficiency and accuracy of diagnoses

Traditional image diagnosis completely depends on doctors and their levels of experience, which can often lead to high misdiagnosis rates.

According to the Chinese Medical Association, about 57 million patients are misdiagnosed each year in China, accounting for 27.8% of all diagnoses. The average misdiagnosis rate is 60% for fetal malpositions, 40% for malignant tumors, such as nasopharynx cancer, leukemia, and pancreatic cancer, and over 40% for extrapulmonary tuberculosis, such as liver tuberculosis and stomach tuberculosis.

The image processing and analysis applications on the cloud can help doctors identify trigger points and improve the efficiency and accuracy of the diagnoses they make. For instance, the accuracy of diagnoses for chest CT imagesis 96%, and 92% for chest DR images.

3 Wide application of imaging requires the support for various terminals

The innovative imaging applications involve multiple types of medical systems (such as PACS and HIS/CIS) and terminals (including mobile inspection vehicles, imaging workstations, laptops, desktop cloud terminals, tablets, and medical PDAs), which pose a challenge to cloud service providers and imaging applications.

National Policy

Various national policies in China promote the development and sharing of medical imaging and big data applications in the medical field.

Time	Policy	Description
July, 2015	Guiding Opinions of the State Council on Vigorously Advancing the "Internet Plus" Action	Support third-party organizations in the construction of shared service platforms for medical information, including medical images, health records, inspection reports, and electronic medical record platforms, and gradually establish a cross-hospital system for sharing and exchanging medical data.
June, 2016	Guiding Opinions of the General Office of the State Council on Promoting and Regulating the Application and Development of Big Data in Health and Medical Care	Promote the sharing of big data resources in the healthcare field; promote big data applications in healthcare governance, clinical and scientific research, and public health; and cultivate new types of operation for big data applications in healthcare.
May, 2017	13th Five-Year Plan for Health and Health Technology Innovation issued by the Ministry of Science and Technology	Implement big data analytics and machine learning in the medical field, achieve personalized diagnoses aided by machine intelligence, and support the development of smart healthcare.

Business Opportunity

Currently, public PACS clouds are more suitable for regional PACS systems, grassroots medical institutions, and specialized hospitals. Private PACS clouds are more suitable for graded hospitals. In the future, with the development of collaboration services such as Internet healthcare and telemedicine, medical clouds will shift from private to hybrid.

Imaging applications on the cloud are based on the storage and analysis of a large amount of imaging data. Consequently, the transmission volume and scope of imaging data are increasing. Therefore, the computing clouds, large-scale networks, and Wi-Fi hotspot coverage of telecom operators have become the essential infrastructure for the transmission of imaging data and have a huge market potential.

1. **Regional imaging cloud services for medical alliances and health commissions require extensive network connections to connect members and branch facilities.**
2. **Imaging cloud hosting services can be provided to hospitals who do not have a PACS system or third-party image hosting service centers.**
3. **Imaging cloud and network connections can be provided to graded and group hospitals and multi-hospital medical institutions.**
4. **The PACS FEP supports the connections between all digital presentation and communication interfaces (DICOM and non-DICOM interfaces) in the hospitals.**

Business Opportunity	Service Scenario	Service Requirement
Desktop network coverage for hospital campus networks	• Imaging workstations and image reading • Hosting services for private imaging clouds	• Image reading and fast downloads at imaging workstations • Safety and reliability
Imaging cloud hosting for hospitals	• Cloud image processing and clinical application services • Big data and AI-aided image analysis • Imaging services for regional medical alliances, group hospitals, third-party imaging centers, imaging hosting centers, and graded hospitals	• The full-process imaging services of medical technology departments include appointment registration, queuing, imaging, and image reading for diagnosis, as well as image management and post-processing. • Imaging center access networks at medical alliances
Imaging cloud private line	• Private channels that meet the high requirements on safety and application experience	• Safety and reliability • Multiple connections, wide coverage, high bandwidth, and low latency • Diversified SLAs
Doctors' desktop cloud for image reading	• Doctors can read images, use diagnosis tools, discuss medical cases, and perform collaborative consultations anytime and anywhere	• Fast image decoding, browsing, collaboration, and sharing
Big data and image analysis	• Cloud computing-based big data image analytics and AI-aided image reading	• Improves the efficiency and accuracy of image diagnosis • Unleash the value of images

Network SLA

As medical images are retrieved frequently, they have to be retrieved in seconds without noticeable delay to meet the requirements for reading images in the cloud.

The required bandwidth for image retrieval must be determined based on the number of image reading terminals, terminal types, and the average size of the images processed by the cloud PACS system.

For example, if a hospital has 200 image reading terminals, the average image download speed is 5 Mbps, and the reserved bandwidth margin is 25%, then the required download bandwidth is 200 x 5 x 1.25% = 1250 Mbps.

Operation Type	Experience Requirements	Network KPIs		
		Bandwidth	Packet Loss	Delay
In-hospital image reading/review	• Meets the transmission requirements for all devices in the imaging department, such as a large number of concurrent users, low latency, and no frame freezing. • Provides differentiated SLAs for departments. • Ensures that images are transmitted within 5 seconds.	Determined based on service requirements (10 Mbps/terminal)	0.05%	≤ 50 ms
Cloud film printing	Calculated based on the following estimation: 10 MB for each image, 10-second download waiting time	10 Mbps/device	-	≤ 200 ms
Image reading on cloud desktops	• Secure and fast loading • 5-second waiting time for image reading	20 Mbps/terminal	≤ 0.2%	≤ 30 ms

3.2.3 Mobile Imaging Cloud: Viewing Images Anytime and Anywhere

Scenario Description

Doctors can view imaging documents or diagnosis reports anytime and anywhere, regardless of whether they are in hospitals (be it in a ward, operating room, or the emergency room), at home, or on the go.

Image mobility is growing in importance and is the basis for both hierarchical diagnosis and treatment and remote consultation.

Application Scenario

- **Mobile image reading, anytime, anywhere, and on any terminal**
  Images are stored on the cloud. Doctors can use mobile phones, computers, tablets, and other terminals to view and process image data anytime and anywhere.

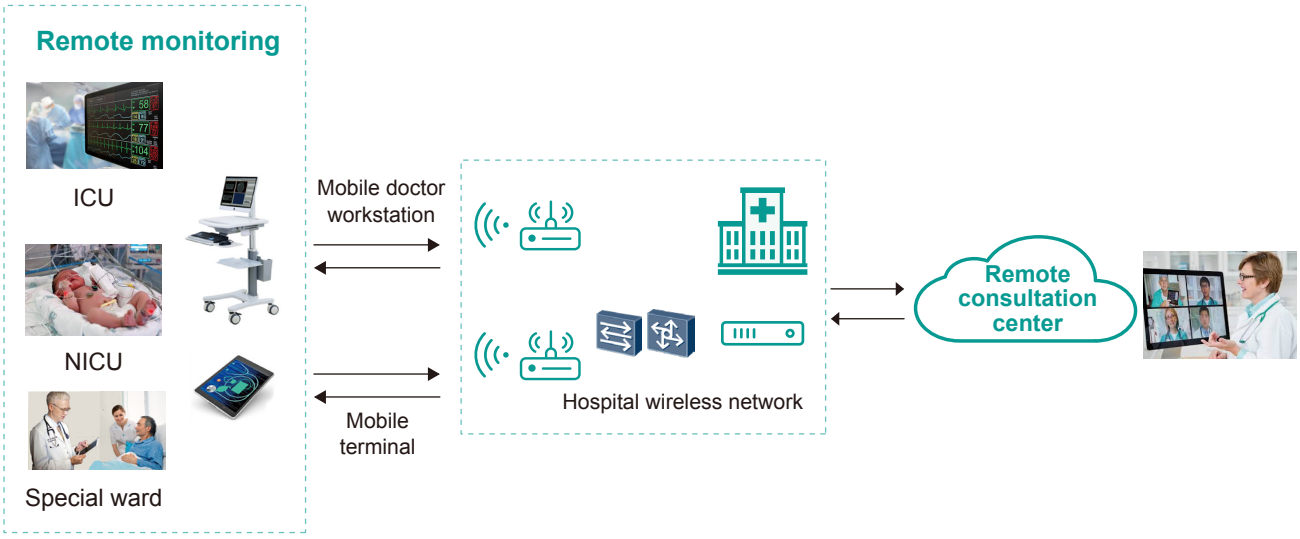
- **Doctors can conduct mobile ward rounds and view patients' imaging information in real time**
  Doctors can view medical documents on mobile workstations, tablets, or PDAs. They can also communicate with patients, analyze and record changes in cases, and provide treatment recommendations whilst on their rounds.

- **Providing or viewing image diagnosis reports on the go**
  Doctors can use mobile terminals to read or reconstruct images, write diagnosis reports, provide diagnosis, and participate in consultations, regardless of whether they are in the hospital or not.

- **Remote first aid guidance and ICU intensive care**
  In emergencies, doctors on duty may need to consult a specialist who is not in the hospital. In this case, the specialist can receive medical images from the wireless network through a handheld device, such as a tablet, and make decisions in a timely manner.

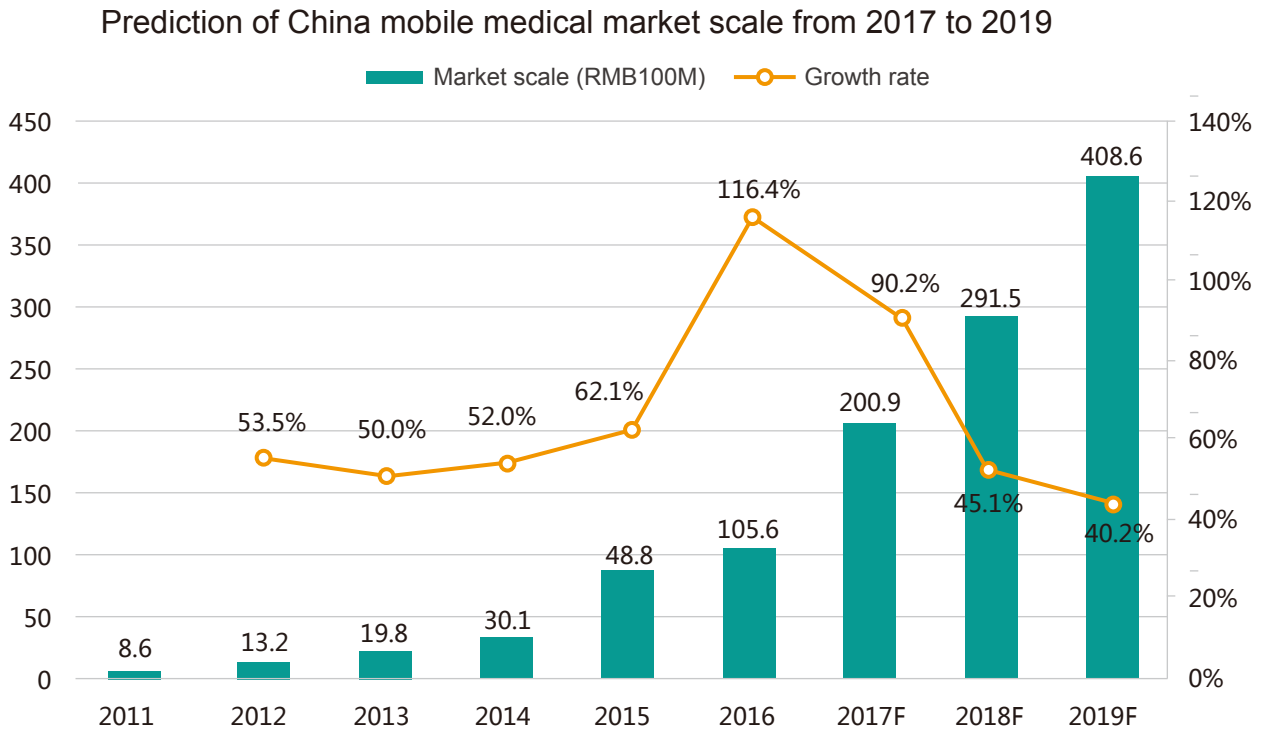
  The collector of data from video devices and medical IoT can collect the physiological data of emergency patients in real time. The ICU experts at a comprehensive hospital can perform remote monitoring in real time and provide emergency guidance for lower-level hospitals through the Internet and cloud platform, reducing the mortality rate.

Figure 3-9 Remote first aid guidance and ICU intensive care



Industry Situation

1 Mobile Internet promotes the development of mobile healthcare. Online consultation is the longest and most active application in the mobile healthcare industry.



Data source: Analysys research report

2 Online consultation optimizes the allocation of medical resources, reconstructs the medical treatment process, and improves patient experience.

Doctors can read images anytime and anywhere, and patients can manage their own medical images and consult other doctors online. Mobile imaging simplifies the image management process at hospitals and improves the efficiency of medical services and patient experience.

3 Mobile healthcare applications and imaging devices are increasing in number.

Imaging equipment companies are also actively developing mobile phone applications and mobile imaging devices to meet the needs of mobile medical care.

National Policy

As shown in the following table, the hierarchical diagnosis and treatment system and various telemedicine policies are driving the development of mobile healthcare.

Time	Policy	Description
August, 2014	Opinions of the National Health Commission Regarding the Promotion of Medical Institution Telemedicine Services	• Actively promote the development of telemedicine services, cancel the approval of telemedicine, and allow the B2C mode. • Allow remote medical cooperation between national and foreign medical institutions.
June, 2015	Guiding Opinions of the General Office of the State Council on Propelling the Building of a Hierarchical Diagnosis and Treatment System	• A hierarchical diagnosis and treatment system is proposed: first diagnosis at the grassroots hospital level, two-way referral, separate diagnosis for urgent and non-urgent cases, and cooperation between upper-level and lower-level hospitals.
August, 2016	Notice on Promoting the Pilot Work of Hierarchical Diagnosis and Treatment issued by the National Health Commission of China	• Four direct-controlled municipalities, including Beijing, and 266 cities are the pilot areas for hierarchical diagnosis and treatment.
January, 2017	Notice of the State Council on the Issuance of Health and Health Planning for the "13th Five-Year Plan "	• Encourage the establishment of regional telemedicine service platforms to promote the vertical development of high-quality medical resources. Ensure that the telemedicine services cover more than 50% of counties, districts, and cities. • Strengthen the demonstration of regional medical data, and promote beneficial services such as remote consultation, remote diagnosis (imaging, pathology, and electrocardiograms), appointment and treatment, and two-way referral. • Actively promote the extension of telemedicine services to poverty-stricken areas.

Business Opportunity

Service Object	Business Opportunity	Service Requirement
Hospital	• Wireless network coverage in wards • Mobile terminals for image reading • Mobile imaging devices	• Stable, reliable, and seamless wireless network, covering all working areas
Doctor	• Mobile terminals for image reading • Image reading, and seamless switchover between cloud desktops and mobile devices	• Fast image decoding, browsing, collaboration, and sharing • Doctors can read images, use diagnosis tools, discuss medical cases, and perform collaborative consultations anytime and anywhere
Doctor	• Cloud computing-based big data analytics of images and AI-aided image reading	• Improves the efficiency and accuracy of image diagnosis • Unleash the value of images

Network SLA

Mobile imaging improves doctors' efficiency and ensures the timeliness and effectiveness of consultations. This requires a stable, reliable, and seamless wireless network, covering all working areas to avoid interruption. Image reading also requires high bandwidth and low latency.

Operation Type	Experience Requirements	Network KPIs		
		Bandwidth	Packet Loss	Delay
Mobile image reading	Assume that the average size of a PACS image is 5 MB. The image loading time must be within 5 seconds.	8 Mbps/terminal	-	≤ 200 ms
Mobile imaging reporting	Assume that the average size of a PACS image is 5 MB. The image loading time must be within 5 seconds. Seamless roaming must be ensured, and there cannot be any frame freezing.	8 Mbps/terminal	-	≤ 200 ms
Mobile ward rounds	Full coverage, seamless roaming, no frame freezing, no interruption, and less than 4 seconds of waiting time in operations.	8 Mbps/terminal	-	≤ 200 ms

3.3 Cloud-based Medical Collaboration

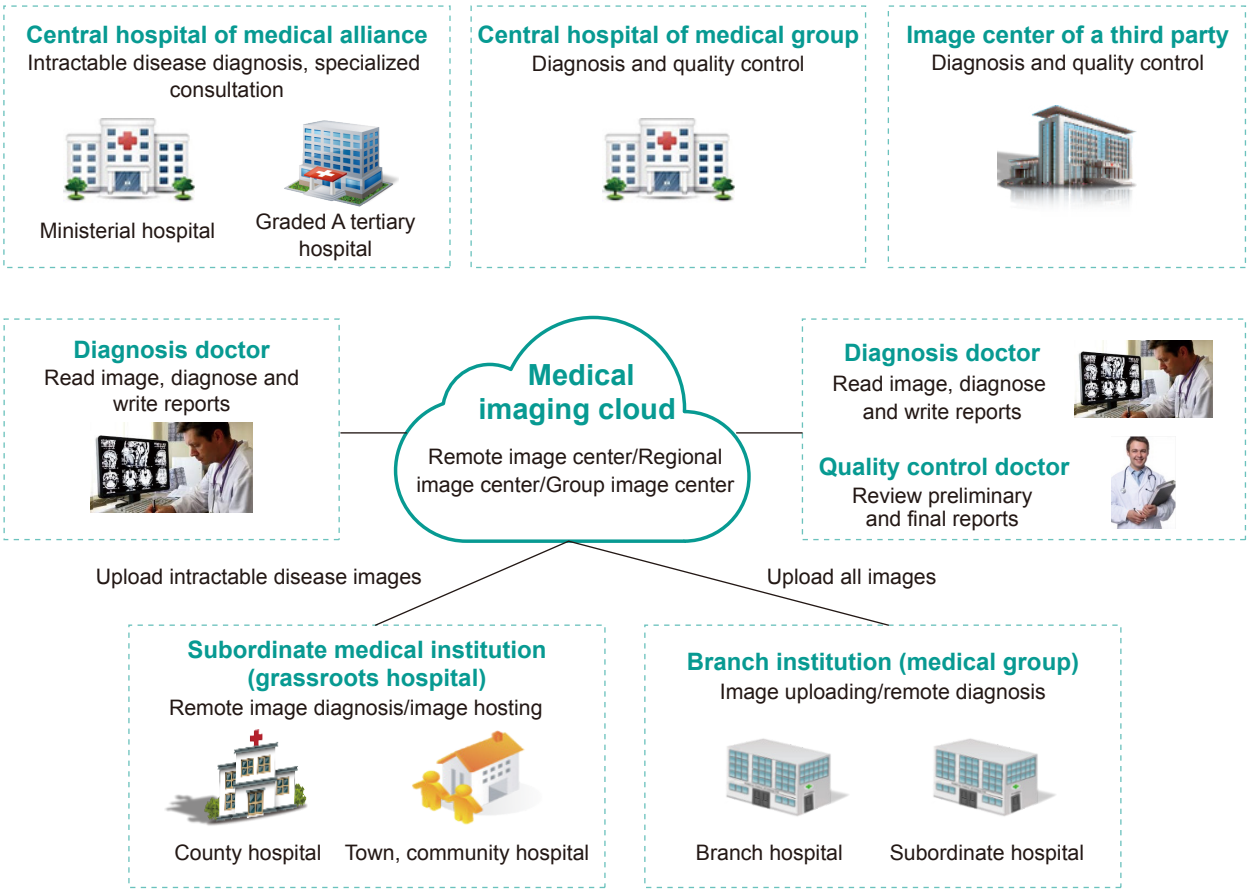
3.3.1 Regional Imaging Centers: Imaging Resource Sharing and Hierarchical Diagnosis and Treatment

Scenario Description

Regional imaging centers are mainly targeted at healthcare regulation boards and medical groups. Based on cloud computing, the regional imaging cloud centers implement centralized image storage, high-performance image processing, big data analytics, and image sharing, supporting fast data retrieval and querying.

Regional imaging centers integrate the imaging information and services of all medical facilities to ensure the sharing and collaboration of imaging devices and experts in the region and to support remote image reading and diagnostic reporting. They also achieve a balance in the allocation of medical resources, improve diagnosis rates at grassroots hospitals, and improve the utilization of imaging devices and the quality and efficiency of medical services.

Figure 3-10 Imaging resource collaboration



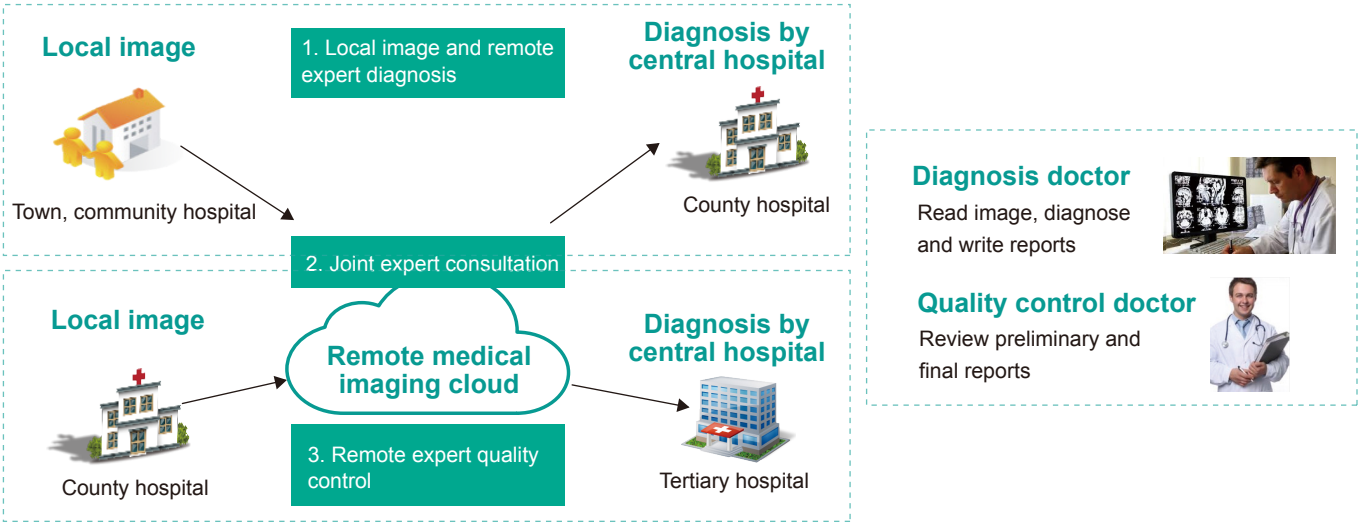
Application Scenario

1 Local imaging for remote diagnosis

The remote imaging center implements image reading and diagnosis, hosting, and reviewing at grassroots hospitals.

In this way, image information can be exchanged and shared between hospitals, and regulators can regulate the management of imaging data.

Figure 3-11 Remote imaging cloud architecture



Two modes are available:

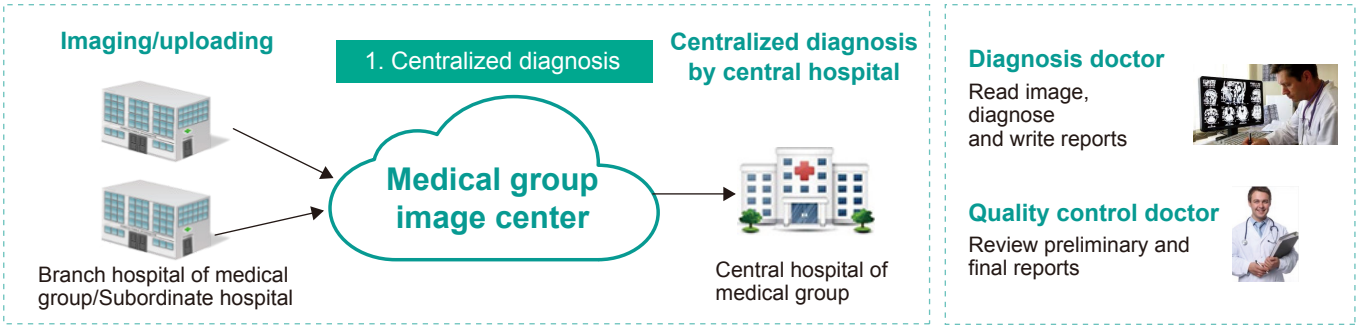
(1) Remote diagnosis of complex case for grassroots hospitals.International medical institutions and experts can participate in the remote diagnosis of complex cases.

(2) Grassroots medical institutions upload image data to the cloud platform so that they can be read at the central hospital through the remote imaging center.

❷ Local imaging and centralized diagnosis for group hospitals

The images of multiple branch institutions can be diagnosed centrally to avoid duplicated costs and improve the utilization of medical resources.

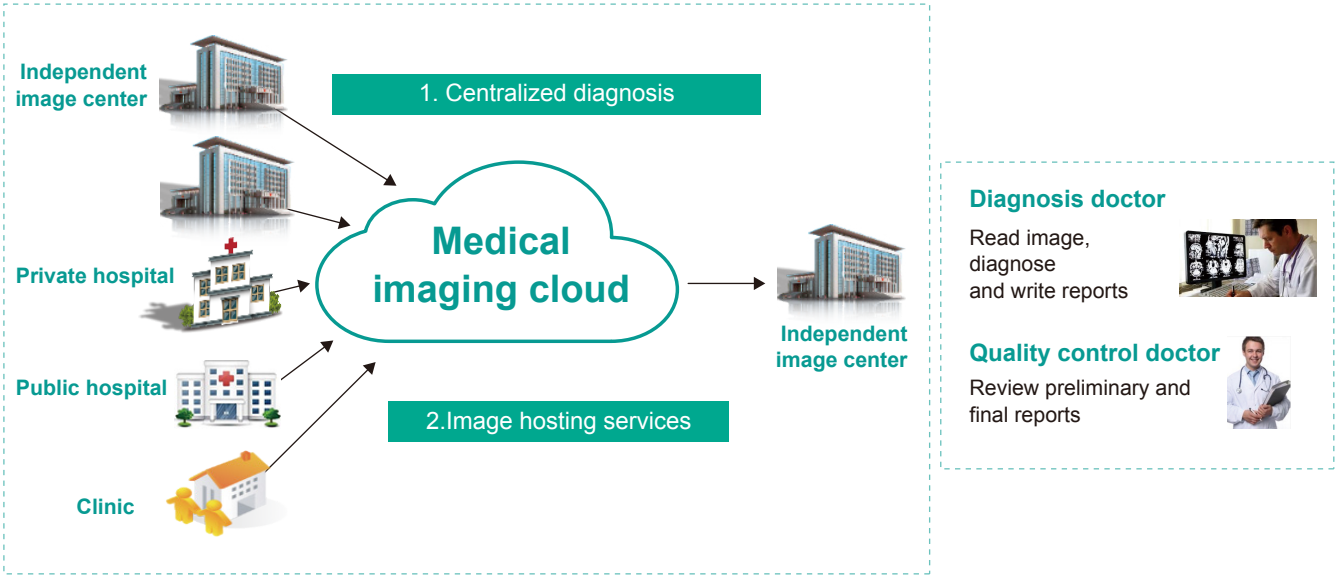
Figure 3-12 Cloud architecture for imaging centers at group hospitals



❸ Third-party imaging centers provide image hosting and online image diagnosis

Third-party imaging centers provide remote image diagnosis for small- and medium-sized hospitals and other medical facilities that may not have enough doctors or resources.

Figure 3-13 Cloud architecture for third-party imaging centers



Industry Situation

1 Traditional treatment models often lead to tertiary hospitals being packed with patients, resulting in poor quality healthcare, poor patient experience, and a waste of medical resources. The regional imaging centers change the treatment model by supporting hierarchical diagnosis and treatment.

According to iResearch's China Healthcare Industry Report 2018, the compound annual growth rate (CAGR) of patients in tertiary hospitals between 2010 and 2016 was 10.7%, and that of medical institutions was 8.3%. However, those numbers were only 1.5% and 0.4% for grassroots hospitals. According to the China Association for Medical Devices Industry, the utilization rate of medical equipment in grassroots Chinese hospitals is lower than 40%, and a large number of medical devices remain unused for long periods of time. The regional imaging centers narrow the regional gaps in terms of medical resources and implement hierarchical diagnosis and treatment.

2 Gaps between urban and grassroots areas in medical resources require the promotion of remote image diagnosis.

Big hospitals in big cities have the best doctors and experts, leaving the grassroots and remote areas lacking, which in turn results in higher misdiagnosis rates. This situation has driven the promotion of remote image diagnosis.

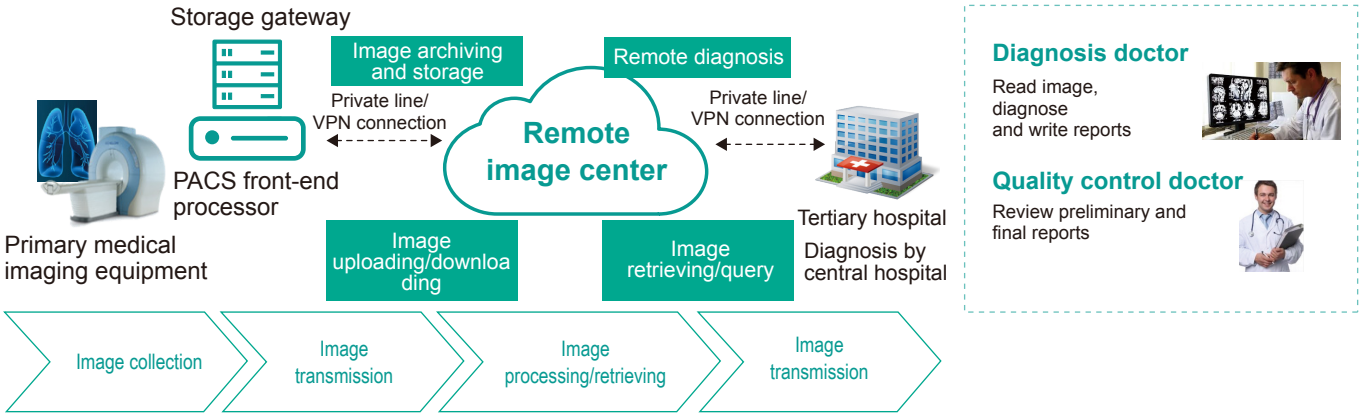
According to a CHIMA survey on the development of information technology in Chinese hospitals between 2015 and 2016, remote image diagnosis systems covered only 13.81% of hospitals. That number was 16.37% for tertiary hospitals and 9.28% for lower-level hospitals. In terms of economic development, the coverage of remote image diagnosis systems was 15.86% in developed areas, 11.18% in moderately developed areas, and 10.53% in underdeveloped areas. The opportunity for remote image diagnosis in China is therefore mature.

3 The development of remote imaging centers is hampered by factors such as poor network coverage, slow network speed, and poor imaging devices at the grassroots level.

Remote image diagnosis involves image collection devices in grassroots hospitals, network transmission (upload and download), image processing on the cloud, image retrieval, and image diagnosis. The terminals involved include image collection devices, electronic scanners, digital cameras, microphones, speakers, and image reading terminals.

The quality of remote image diagnosis depends on the image collection and network transmission. Unstable transmission may lead to medical information being leaked, misdiagnoses, and missed diagnoses in telemedicine.

Figure 3-14 Image data flow in telemedicine



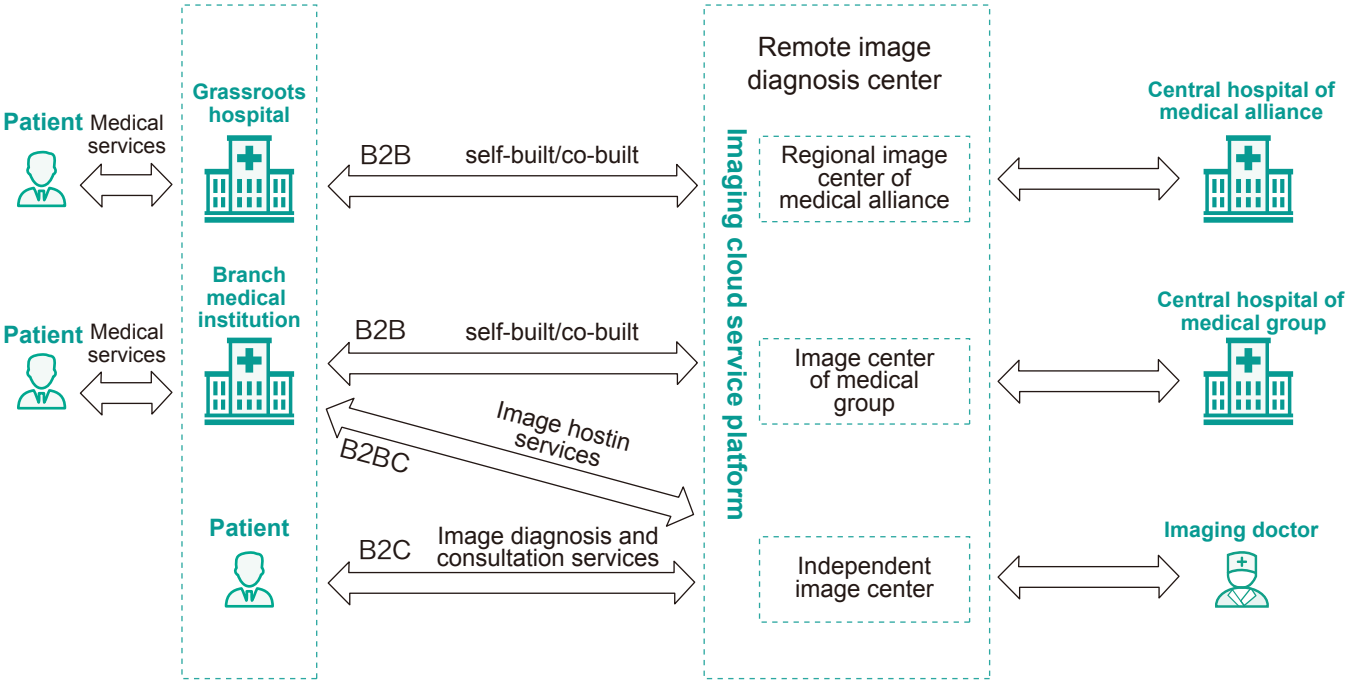
National Policy

1. In 2015, the National Health Commission of China proposed the establishment by 2020 of a comprehensive hierarchical diagnosis and treatment system, including the establishment of regional imaging centers. This would allow grassroots hospitals to examine patients and upper-level hospitals to diagnose them.
2. Medical policies require that regional imaging centers develop remote healthcare and image diagnosis for grassroots hospitals and hospitals in remote and underdeveloped areas.
3. Third-party organizations are supported in the construction of shared medical information service platforms, such as medical images, health records, examination reports, and medical record platforms.
4. According to the opinions of China's State Council on the development of "Internet + Healthcare", the most important thing is to provide high-speed broadband networks to cover urban and grassroots medical institutions, and establish Internet private lines to meet the requirements of telemedicine. Therefore, building extensive, high-performance, highly reliable, and highly secure telemedicine transmission networks will be an opportunity for operators.

Time	Policy	Description
October, 2013	Several Opinions of the State Council on Promoting the Development of Health Services	• Promote third-party services, imaging centers, and remote image diagnosis for grassroots, remote, and underdeveloped areas to develop telemedicine.
September, 2014	Opinions of the National Health Commission Regarding the Promotion of Medical Institution Telemedicine Services	• Telemedicine services include remote pathological diagnosis, remote medical image diagnosis (including imaging, ultrasounds, nuclear medicine, electrocardiograms, electromyography, and electroencephalography), remote monitoring, remote consultation, remote outpatient service, and remote case discussions. • Telemedicine services in B2C mode are allowed. • National and international medical institutions can cooperate in telemedicine services.
July, 2015	Guiding Opinions of the State Council on Vigorously Advancing the "Internet Plus" Action	• Support third-party organizations in the construction of shared medical information service platforms, such as medical images, health records, inspection reports, and electronic medical record platforms, and to gradually establish a cross-hospital system for sharing medical data.
November, 2015	Circular on Issuing Several Opinions on Control of the Unreasonable Growth of Public Hospital Medical Expenses	• **Build a hierarchical diagnosis and treatment system.** Formulate relevant patient-centered regulations to achieve diagnosis at grassroots hospitals first, two-way referrals, separate diagnosis for urgent and non-urgent cases, and cooperation between upper- and lower-level hospitals. Under the same quality standard, institutions at the same level must recognize each other's medical examination and inspection results.
March, 2015	Circular of the General Office of the State Council on Issuing the Outlines of the National Medical Health Service System Plan (2015-2020)	• Establish regional medical imaging centers to promote the service model of "examination at grassroots medical facilities and diagnosis at hospitals".
January, 2017	Guidance of the National Health Commission on Carrying Out the Pilot Work to Build a Medical Association	• **Strengthen regional ICT development.** Build an integrated information system within each medical alliance based on the health information platforms at provincial, municipal, and county levels, thereby helping to share information. • **Share regional resources.** Build a medical imaging center in each medical alliance to provide integrated services for all institutions in the alliance, and push the institutions to recognize each other's examination and inspection results.
April, 2018	Opinion of the General Office of the State Council on Promoting the Development of "Internet+healthcare"	• Build telemedicine centers to provide remote consultation, imaging, ultrasounds, electrocardiograms, ward rounds, monitoring, and training to members of the alliances. • The upper-level institutions in the alliances need to perform remote diagnosis for grassroots facilities. • Operators can build premium Internet private lines and VPN connections to ensure the quality of transmission in telemedicine.

Business Opportunity

Figure 3-15 Business models of remote image diagnosis



1. The core hospitals or medical institutions in a medical alliance build the regional imaging center together. They also share data with and provide medical hardware and software products and cloud services to other hospitals, government agencies, and social security agencies, and charge fees for them. This is a major business model in China. Provincial and municipal imaging centers can use SDH, MSTP, or MPLS VPN connections. District and county-level centers can connect to municipal centers over the Internet.
2. One new business model involves building a joint imaging center with medical institutions or building a hosting center to provide services for small- and medium-sized institutions. B2B models are common. Internet + medical imaging and Internet + medical services are helping to provide online image diagnosis services for small- and medium-sized hospitals and other medical facilities.
3. A medical group builds and runs a private cloud in a central hospital which serves as the imaging cloud center, and branch institutions connect to the center through Gigabit or even 10-Gigabit connections.
4. A third-party imaging center can provide remote B2B and B2C medical image diagnosis through efficient connections to patients, grassroots hospitals, other imaging centers, imaging experts, and equipment vendors, providing innovative imaging services and platforms.

Service Scenario	Business Opportunity	Service Requirement
Imaging center for a regional medical alliance	• Private lines between the alliance members • Private lines from the National Health Commission to the imaging center • Connection between a branch and the group center hospital • Connections between grassroots medical institutions and the main hospitals of the alliance • Private or hosted clouds of regional imaging centers	• Regional private or hosted medical clouds • High-bandwidth and low-latency packet private lines are required.
Regional image archiving, storage, and sharing	• Connections between medical institutions and regional imaging cloud centers • Connections between medical institutions and remote imaging cloud centers	• Imaging cloud private lines
Imaging centers of medical groups	• Connections between branches and the group center hospitals • Connections between branches and the group imaging centers (imaging clouds and private lines) • Internet access at the imaging centers	• Group private and hybrid clouds • Packet E-line
Cloud private lines for third-party imaging centers	• Private or public clouds • Cloud private lines for the branches of third-party imaging centers • Cloud private line for image hosting institutions	• Private or public medical clouds

Network SLA

Application Scenario	Experience Requirements	Network KPIs		
		Bandwidth	Packet Loss	Delay
Connections between regional imaging centers and medical alliances	Connections between grassroots medical institutions and regional imaging cloud centers	≥ 20 Mbps	-	50 ms
Third-party medical centers	Connections between medical institutions and third-party imaging centers	≥ 20 Mbps	-	50 ms

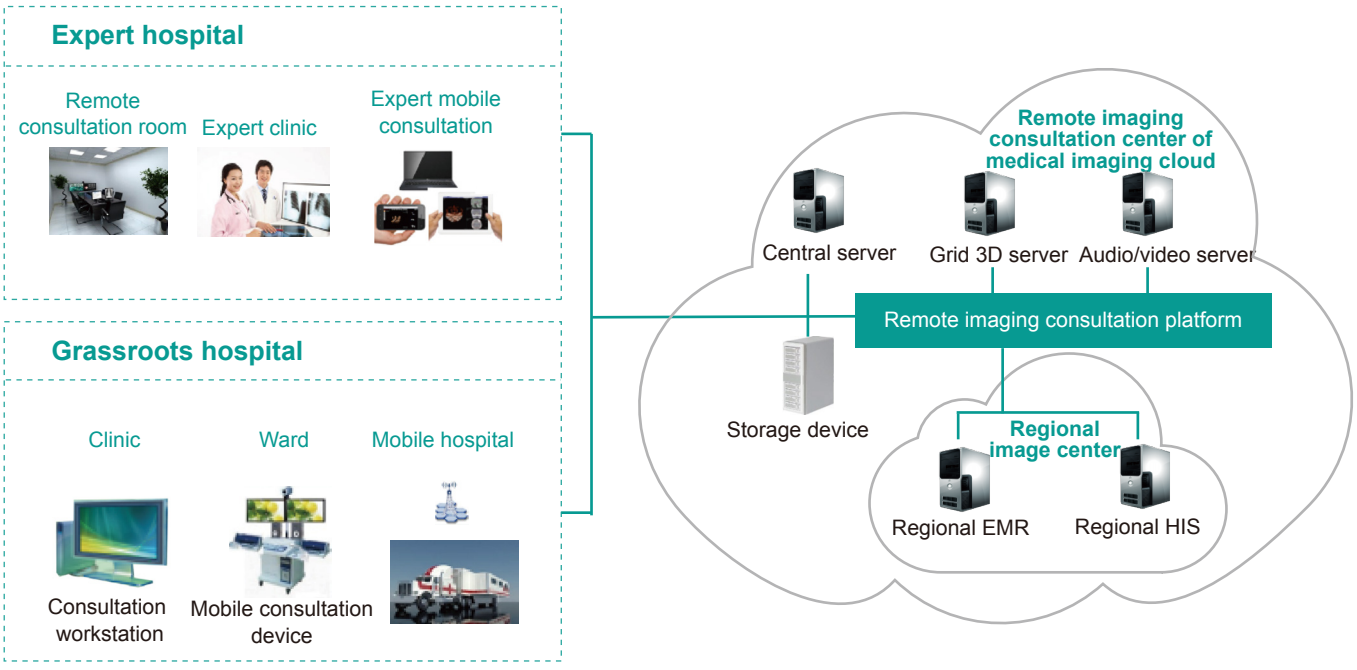
3.3.2 Remote Imaging Consultation Center: Optimizing Connections and Improving Medical Quality

Scenario Description

Remote imaging consultation refers to long-distance ICT-driven "face-to-face" consultation among experts, patients, and medical personnel. It uses medical devices and multimedia technologies to collect, store, transmit, analyze, process, query, and display image, audio, and video data of patients.

A remote imaging consultation center can provide cross-regional healthcare collaboration and remote expert consultation, improving diagnosis quality in grassroots hospitals. Remote imaging consultation is the most widely applied to telemedicine, and has been widely used in joint consultation services with hospitals and medical unions.

Figure 3-16 Architecture of a remote imaging consultation center



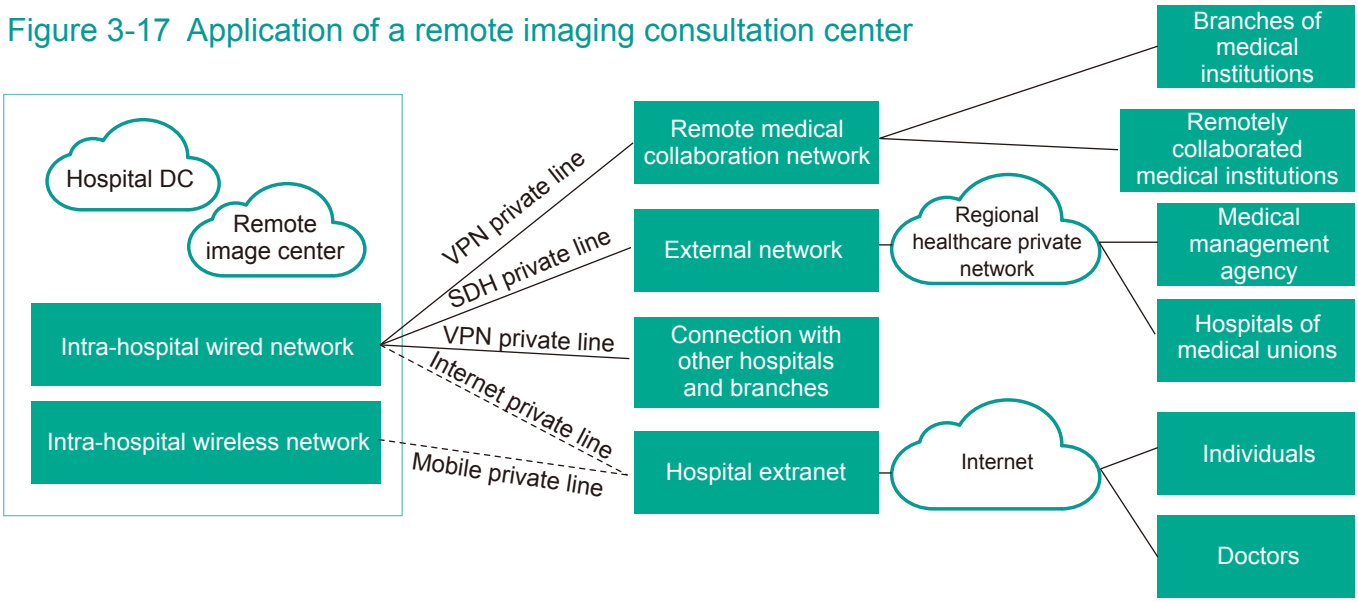
Application Scenarios

Doctors use the imaging cloud platform to read and review reports. The platform allows for remote image diagnosis and consultation services for grassroots hospitals.

1 B2B: Remote consultation center for a medical union, improving connections within the union and improving the quality of medical services

In the remote imaging center, the medical union leads hospitals to help grassroots medical institutions with complicated diagnoses and provide remote guidance. This improves medical practice and allows grassroots hospital inspection. Grassroots citizens can enjoy telemedicine services provided by municipal hospital experts, provincial and national experts, and even foreign experts.

Figure 3-17 Application of a remote imaging consultation center



2 B2B: Third-party independent imaging center, providing remote imaging service outsourcing for medical institutions

For medical institutions that have imaging devices but do not have image doctors or have undertrained doctors, image reports can be reviewed using the imaging outsourcing service, improving the quality of integrated medical services, reducing medical accidents, improving hospital brand, and increasing hospital revenues.

The service is mainly provided to grassroots medical institutions, private hospitals, and public hospitals. Independent third-party medical institutions provide remote medical service platforms and image expert resources to implement remote imaging consultation services for these clients.

3 B2B: Remote imaging consultation across multiple districts, homogenizing medical services across the districts served by one hospital

A tertiary hospital can implement remote medical technologies such as remote video consultation and emergency consultation, remote service communication and training, and remote surgery demonstrations between multiple districts. This improves the work efficiency of hospital experts and improves the overall medical expertise of the hospital. Moreover, medical services for patients are homogenized across hospital districts regardless of whether each hospital has a sufficient number of experts.

4 MDT: A clinic's multidisciplinary treatment (MDT) consultation service, which provides patient-centric multidisciplinary medical collaboration

MDT is a process of discussing and developing personalized diagnosis and treatments for patients by multidisciplinary senior experts. It is especially suitable for diagnosis and treatment of complicated diseases such as tumors, kidney failures, and heart failure. Using MDT, patient information is included in image data. Before treatment, experts from related departments perform comprehensive evaluation through the imaging cloud platform to jointly develop reasonable scientific treatment solutions.

Industry Situation

1 Chinese national healthcare policies promote the development of telemedicine.

Currently, most provinces in China actively carry out telemedicine. Telemedicine centers have been set up in almost all medical institutions, including grade A tertiary hospitals and village healthcare rooms, to carry out remote consultation, remote monitoring, and remote diagnosis.

According to statistics from the National Health Commission of China,by February 2018, provincial telemedicine platforms had been established in 22 provinces across the country, covering 13,000 medical institutions and more than 1,800 counties, including all counties classified as poor at the national level. More than 60 million remote consultations and remote pathology, image, and electrocardiogram diagnoses were provided in 2017 alone.

❷ **Most grassroots medical institutions struggle to perform remote consultation. Cloud computing helps improve the quality of remote consultation.**

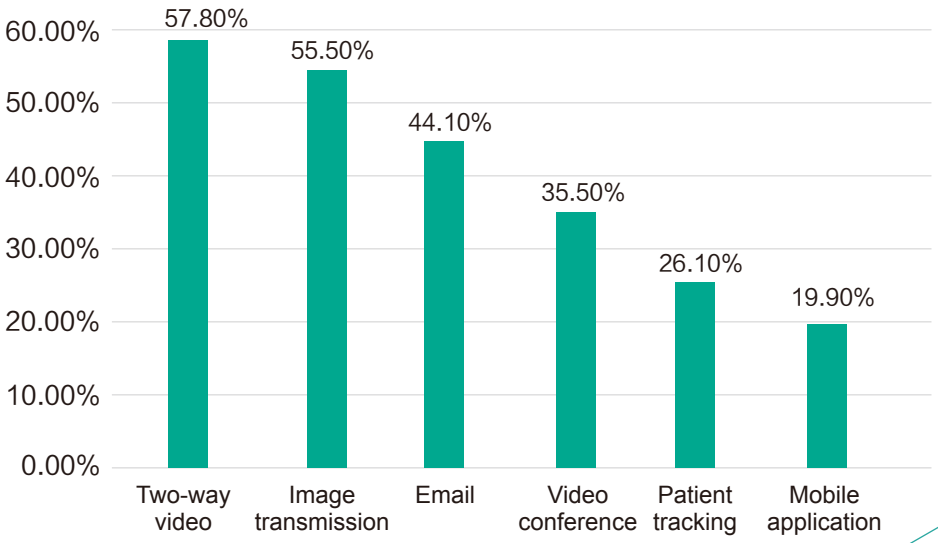
Currently, remote consultation is mainly based on traditional video conferencing technologies. Restricted by the digital imaging devices and PACS systems of grassroots hospitals, the image and clinical treatment information required for remote consultation cannot be provided. Therefore, performing remote consultation for most grassroots medical institutions is difficult. Even when it can be performed, ensuring consultation quality remains a challenge.

❸ Remote imaging and remote pathology are two widely used telemedicine services. According to World Health Organization statistics, in 2010, 62% and 42% of surveyed countries/regions had implemented remote imaging and remote pathology, respectively.

❹ **Network transmission quality has become one of the primary determinants of telemedicine quality.**

Chinese premier Li Keqiang learned from the remote consultation center of Huashan Hospital of Shanghai's Fudan University that the slow network speed remains a major problem affecting the actual use of telemedicine.

Multiple information transmission services are required between medical doctors, between doctors and patients, and between hospitals. According to the Healthcare Information and Management Systems Society (HIMSS), the main applications of telemedicine are as follows:



Online real-time audio and video communication and high-quality medical image data transmission are the main measures of remote consultation. B2B telemedicine has high requirements on the definition, transmission speed, and accuracy of image and video information. Poor video quality and image quality may prevent doctors from identifying diseases, and could cause misdiagnosis.

Currently, remote consultation requires more than 1080p resolution at 30 frames per second (FPS) real-time video transmission. Many factors are extremely important, including the speed of online audio and video interaction; HD image transmission, storage, and loading; massive image data access and retrieval; and HD video transmission performance. Currently, most hospitals use public networks for remote consultation, which cannot meet the requirements of diagnosis information transmission. To meet these requirements, high bandwidth, low latency, and highly reliable private line networks are essential.

National Policy

1. National healthcare policies encourage the development of regional telemedicine service platforms, promote the development of telemedicine services, and allow B2B and B2C models.
2. The construction of telemedicine private networks is promoted nationally in China. By 2020, telemedicine services will cover all medical unions and county-level hospitals in the country, and will gradually extend to community health service institutions, township health institutions, and village health rooms. The medical union leads hospitals to establish telemedicine centers.

Table 3-4 List of related national policies

Time	Policy	Policy
August, 2014	Opinions of the National Health Commission (NHC) Regarding the Promotion of Medical Institution Telemedicine Services	• Actively promote the development of telemedicine services, remove the approval requirement for telemedicine, and allow B2C telemedicine. • Promote remote medical cooperation between national medical institutions and overseas medical institutions.
January, 2017	Notice of the State Council on the Issuance of Health and Health Planning for the "13th Five-Year Plan"	• Encourage the establishment of regional telemedicine service platforms to promote the vertical development of high-quality medical resources. Ensure that more than half of countries, districts, and cities receive telemedicine services. • Strengthen the demonstration of regional clinical medical health data, and promote beneficial services such as remote consultation, remote diagnosis (imaging, pathology, and electrocardiogram), appointment and treatment, and two-way referral. • Actively promote the provision of telemedicine services in poverty-stricken areas.
April, 2018	Opinion of the General Office of the State Council on Promoting the Development of "Internet+healthcare"	• Promote telemedicine to cover all medical unions and county-level hospitals throughout the country, and promote high-quality medical resources in eastern China to meet the requirements of inland regions. • Enable high-speed broadband networks to cover urban and grassroots medical institutions, and establish Internet private lines to meet telemedicine requirements.

July, 2018	Notice on the Further Development of "Internet+healthcare"	• Promote the construction of telemedicine private networks nationally. Ensure that telemedicine services cover all medical unions and county-level hospitals by 2020, and gradually extend telemedicine services to community health service institutions, township health institutions, and village health rooms. The medical union leads hospitals to establish telemedicine centers. • Promote the mode of grassroots-hospital inspection and superior-hospital diagnosis. Expand use of functions such as medical imaging, remote ECG, and lab inspection in grassroots health information systems to improve the capabilities and efficiency of grassroots medical services.

Business Opportunities

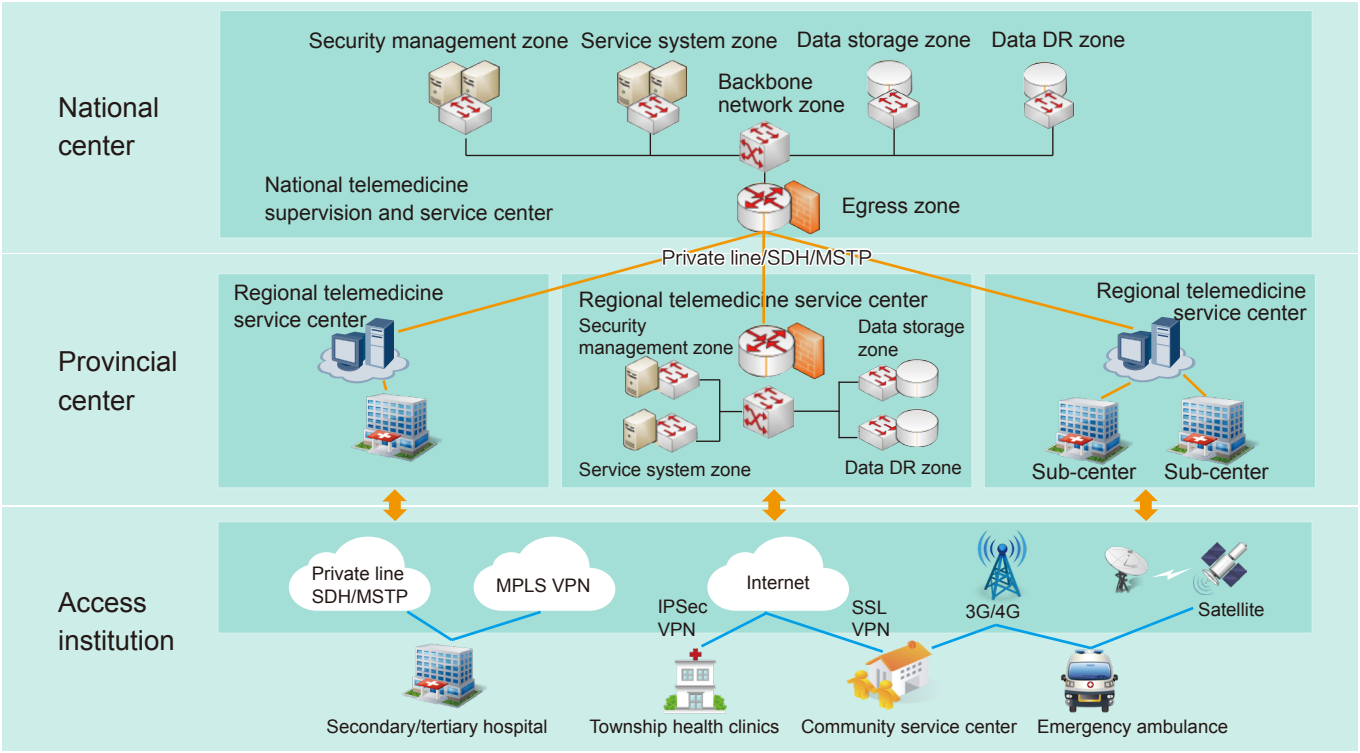
Currently, most telemedicine services in China operate in B2B mode between medical institutions. They are constructed by hospitals led by local governments or medical unions. In B2B2C mode, independent telemedicine centers participate in constructing and operating imaging service hosting centers to service small- and medium-sized medical institutions. Restricted by policies prohibiting online diagnosis and treatment, there are only a few B2C telemedicine applications. In these applications, online hospitals provide medical accessibility and convenience for patients. This mode of services focuses on remote consultation, especially for high-end international medical services. Traditional hospitals seldom participate in such services.

Service Object	Business Opportunities	Service Requirements
Governments and hospitals of medical unions	• Healthcare cloud platforms for national and provincial governments and telemedicine centers • Multi-branch interconnection private lines	• Hospitals build a private cloud, which connects to the medical institutions of medical unions through private lines. • Hybrid cloud: Carriers provide public cloud services as remote imaging centers and connect medical institutions using networks. • Ecosystem partners build imaging cloud platforms to provide cloud image cloud storage, auxiliary diagnosis, audio and video systems, and interconnection with hospitals' PACS/HIS systems. • Cloud platforms of national and provincial healthcare centers • Interconnection between national and provincial healthcare centers • Access private lines for secondary and tertiary hospitals, township hospitals, community healthcare service centers, and ambulances
Hospitals of medical unions, group hospitals, private hospitals, and independent third-party medical institutions	• Remote healthcare cloud platform • Multi-hospital interconnection private line • Private lines for interconnection between medical institutions • Connection from branches to group center hospitals • Connection from remote medical institutions to remote imaging centers	• Method 1: Carriers and ecosystem partners co-construct and host telemedicine services. • Method 2: Third-party medical institutions provide telemedicine services. Carriers provide public cloud services, and ecosystem partners provide telemedicine platforms. • Private lines must connect each image-hosting medical institution to the cloud. • Networks need to cover grassroots medical institutions. • High-bandwidth and low-latency packet private lines are required.

Network SLA

According to the requirements of the Technical Guidelines for Telemedicine Information System Construction and Telemedicine Information System Technical Specifications, the telemedicine network architecture should consist of three layers: national center, provincial center, and medical access institutions. Provincial telemedicine service centers are connected to access units such as secondary and tertiary hospitals, township hospitals, community healthcare service centers, and ambulances through digital private lines, MPLS VPNs, the Internet, 3G/4G, and satellites.

Figure 3-18 Telemedicine network architecture



In April 2016, China's NHC issued the Guide to the Medical Service Capabilities of Tertiary Integrated Hospitals. The Guide specified that audio and video interaction systems of telemedicine services should support simultaneous interaction at multiple points and online interactive services on at least 30 points simultaneously. Moreover, the Guide suggests that video definition be no less than 1080p. Based on these requirements, telemedicine network SLAs should be as follows:

Application Scenario	Experience Requirements	Network KPIs		
		Bandwidth	Packet Loss Rate	Latency
National remote consultation center	• Smooth video playback should be ensured. • Digital private lines, such as SDH, are recommended for connecting national centers to provincial centers.	≥ 100 Mbit/s	≤ 0.05%	≤ 50 ms
Provincial remote imaging consultation center	• Provincial tertiary hospitals need to be connected to provincial centers.	≥ 100 Mbit/s	≤ 0.05%	≤ 50 ms
Connection between municipal hospitals and centers	• Connected through digital private lines or MPLS VPNs	≥ 200 Mbit/s	-	-
Connection between county hospitals and centers	• Connected through digital private lines or MPLS VPNs	≥ 20 Mbit/s	≤ 0.05%	≤ 50 ms
Access of township and community service centers	• Connected to county-level imaging centers through Internet+VPN. (if campus networks are deployed, IPSec VPN is recommended. Otherwise, SSL VPN is used.)	≥ 4 Mbit/s	≤ 0.05%	≤ 50 ms

Application Scenario	Experience Requirements	Network KPIs		
		Bandwidth	Packet Loss Rate	Latency
Hospital campus network	• Interconnection between departments in a campus • Cross-campus interconnection	Campus network of each branch: ≥ 1000 Mbit/s	-	< 50 ms
Regular remote consultation room	• Audio and video quality should not be affected with a packet loss rate of 0.05%. • 1080p@30FPS • 1080p@60FPS • 2-screen display in standard configuration	• Minimum bandwidth of 5 to 10 Mbit/s per screen • 20 Mbit/s recommended for two screens • 30 concurrent channels: 30 x 20 Mbit/s = 600 Mbit/s	≤ 0.05%	< 150 ms
High-end remote consultation room	• 1080p@30FPS • 1080p@60FPS • 3-screen display in standard configuration	• Minimum bandwidth of 5 to 10 Mbit/s per screen • 30 Mbit/s recommended for three screens • 30 concurrent channels: 30 x 30 Mbit/s = 900 Mbit/s	≤ 0.05%	≤ 150 ms
Connection between medical institutions and grassroots hospitals	• Recommended: 1080p@30FPS (but no less than 720p) • Single-screen display in standard configuration	720p: • Minimum: 2.1 to 8.7 Mbit/s; • Recommended: no less than 4 Mbit/s 1080p: • Minimum: 5 to 10 Mbit/s • Recommended: 10 Mbit/s It is recommended that digital private lines and upper-level hospitals that set up remote consultation and collaboration centers use the same operator network.	≤ 5%	≤ 150 ms
	1080p video transmission	Recommended: ≥ 5 Mbit/s per screen	≤ 5%	≤ 50 ms

3.4 Cloud-based Medical Education

3.4.1 Imaging Cloud Teaching: Most Widespread Medical Applications

Scenario Description

Based on the medical imaging data platform, provide doctors, nurses, medical students, and medical image processing professionals with live and recorded remote teaching online, and large-scale medical conference broadcast, to provide medical courses, special lectures, academic exchanges, surgery observation, and simulations. This fosters sharing of medical education resources, reducing the cost of national medical education and improving medical skills nationwide.

Application Scenario

1 Online imaging teaching

Use the imaging cloud to teach remotely using audio, video, and courseware resources, and perform imaging education in classrooms. For example, provide imaging teaching in medical colleges, hospitals, on Internet education platforms and using social media. Teachers and doctors log in to the teaching system to view images, edit courseware, assign jobs, and manage learning progress. In addition, they can log in to the imaging cloud teaching system through classroom terminals to obtain teaching courseware. Students can log in to the imaging cloud from their mobile phones, computers, and tablets outside classrooms. This is the most widely used scenario.

2 Online imaging exam

Medical colleges, hospitals, and Internet medical education platforms provide teachers with functions such as question library selection, exam paper editing, exam notification, exam arrangement, and grade management. Medical college students and doctors can log in to the system to take practice tests and actual examinations, and check the analysis of test questions.

3 Live teaching

Live surgery and remote teaching can be provided between hospitals and medical colleges, senior hospitals and grassroots hospitals, hospitals and patients, hospitals and Internet users, and experts and Internet users.

Live surgery and remote teaching use panoramic views of operating rooms, feeds from surgical field cameras, medical data from operating room equipment (such as MRI, cavity mirror, endoscope, X-ray machine, and CT scanner), patients' DICOM audio and video data, and operating room videos. Voice interaction is allowed during live surgery. At the same time, the recorded videos are stored for future observation and learning. Live playback terminals include mobile phones, computers, multimedia teaching terminals, and VR/AR headsets.

Live broadcast in the medical education industry improves doctor-patient relationships, medical care transparency, and consultation efficiency.

Figure 3-19 Scenario of live surgery and teaching

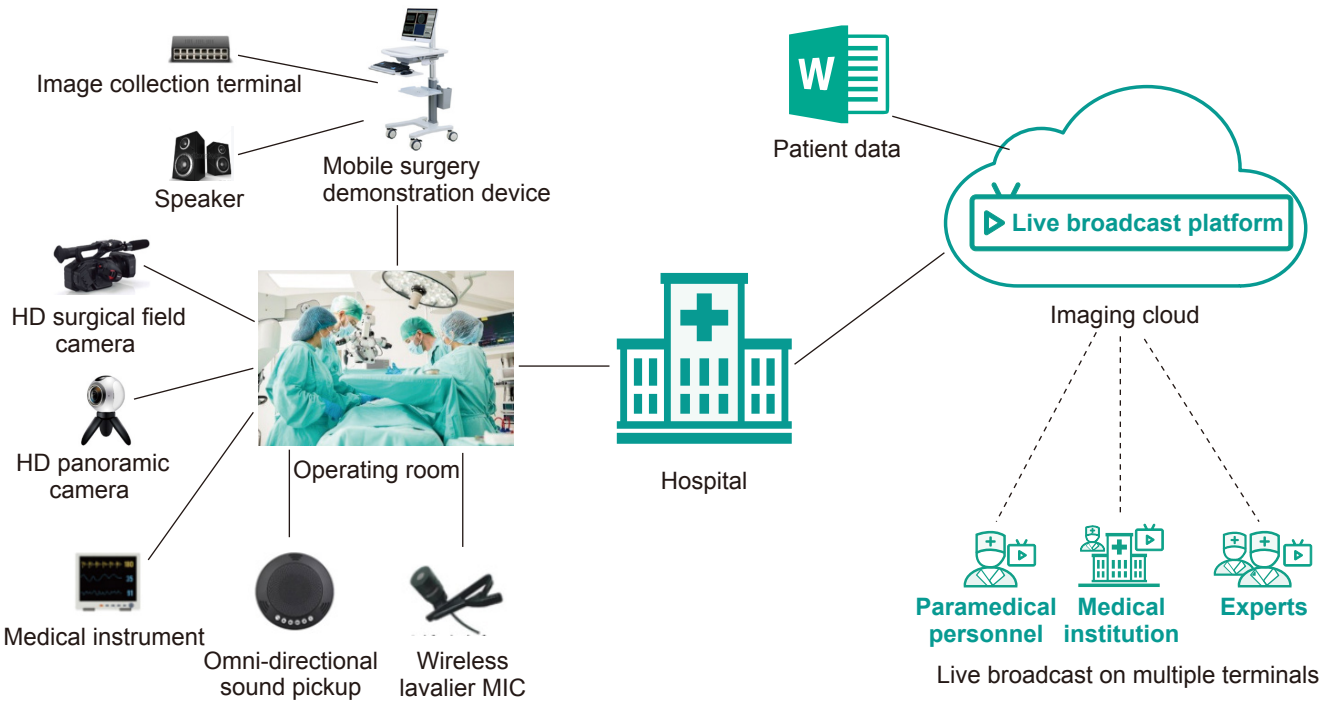
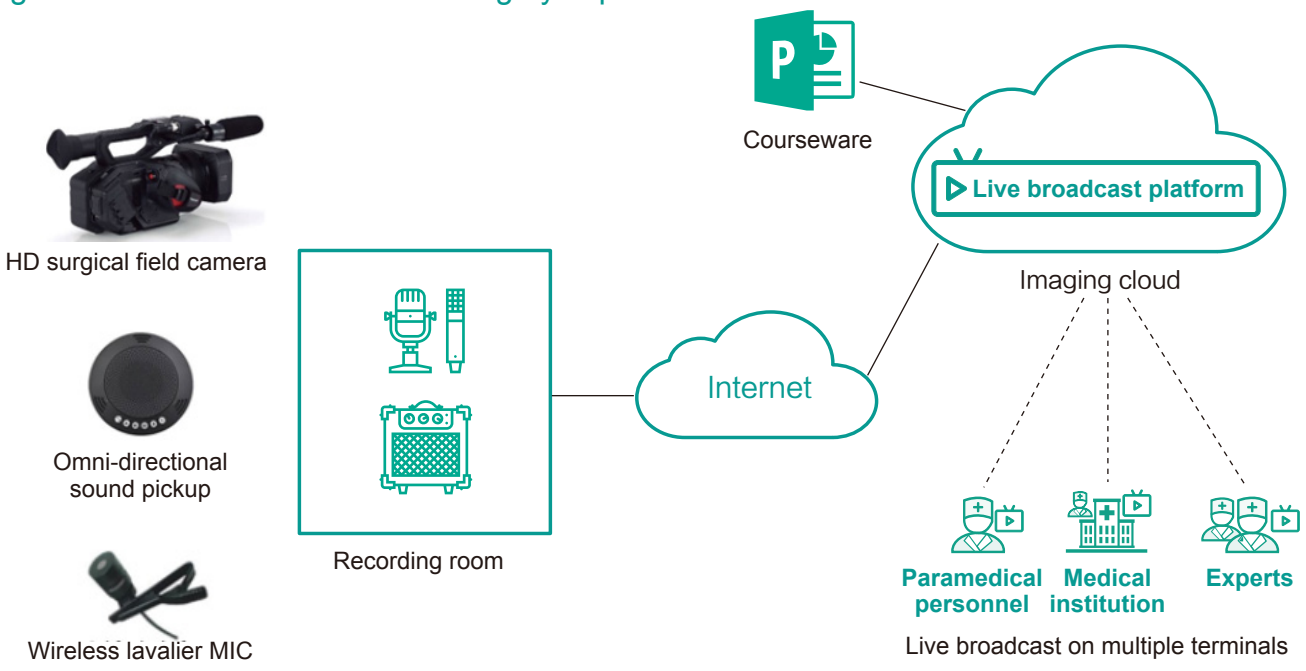


Figure 3-20 Scenario of live teaching by experts



4 Teaching using virtual imaging technology

Medical colleges use the VR, AR, and MR technologies to virtually teach surgery, anatomy, and acupuncture based on the imaging cloud. The original data, such as ultrasonic, CT, and MRI data, extracted from the medical imaging cloud is then reconstructed using algorithms, and 3D images are generated by using virtual imaging technology before being presented to medical students. At the same time, interactive operations including splitting, combining, scaling, rotating, and changing transparency are performed on the 3D images. This scenario is suitable for various applications such as medical education, new doctor training, skill testing, technical study, and surgery planning.

5 Multi-hospital morning reading

Based on the imaging cloud, hospitals can organize unified examination of images, and select some typical medical records for joint examination, creating a learning atmosphere and improving doctors' skills.

6 Imaging expert library

The imaging cloud establishes an expert diagnosis and analysis case library and shares the cases (free or charged) with young doctors. For example, if a doctor searches for "X-ray cases", many analysis reports will be returned, including case analysis, theoretical reports, and discussions. The case library is a platform for hospitals, doctors, experts, and patients to actively participate.

7 Online workshops on image diagnosis

The Hospital and Medical Imaging Association broadcasts and rebroadcasts large medical conferences to provide face-to-face sharing and communication opportunities for hospitals, doctors, nurses, medical students, and medical colleges.

Industry Situation

1 Current teaching is based on networks and PACS systems, but imaging cloud teaching can promote resource unification and sharing between colleges and hospitals.

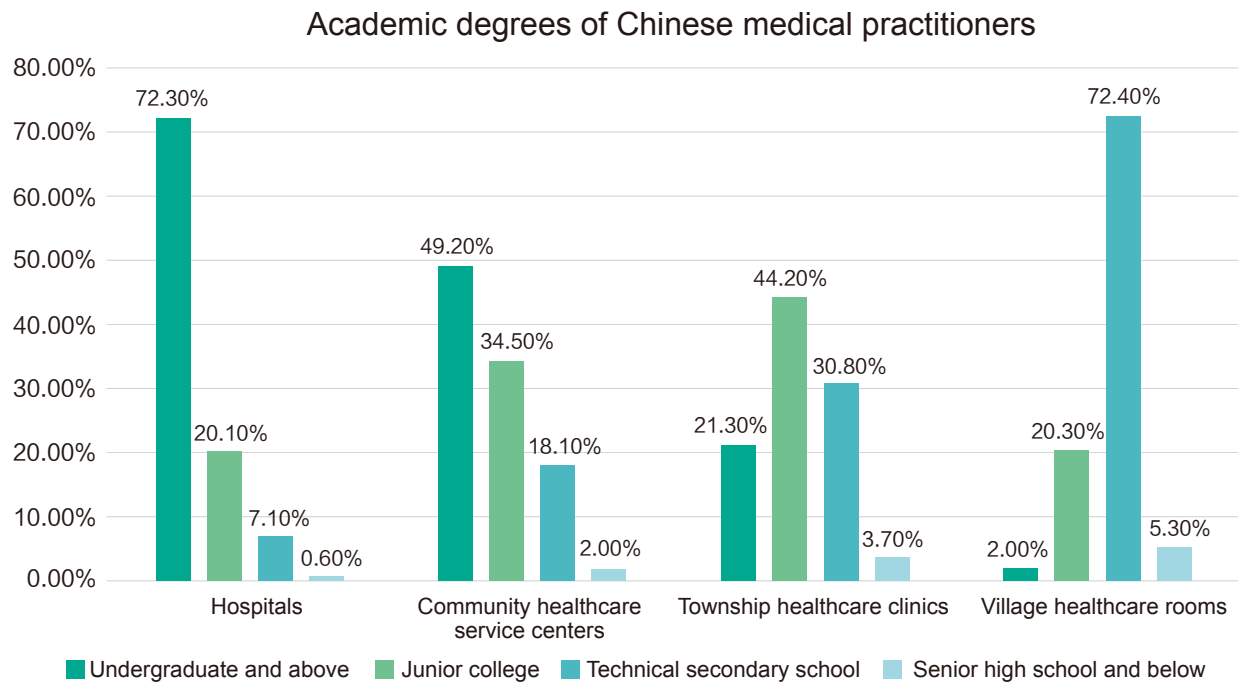
At present, colleges are shifting from traditional slideshow-based teaching to online courses, PACS system teaching, and convergence of multiple modes, and are establishing digital simulation centers for medical imaging. Online examination has been added to the PACS system of colleges. Some colleges have connected their PACS system to the medical imaging teaching system of hospitals so that the college students can experience hospital work environments.

The hardware and software facilities for imaging teaching in most colleges do not follow the rapid development of imaging and information technologies, and the PACS software is still being developed. Therefore, applying PACS in imaging teaching still has some limitations in terms of data consistency, update speed, and collaboration with hospitals.

Gansu University of Chinese Medicine has constructed an imaging teaching cloud platform that shares imaging teaching materials and medical data from two affiliated hospitals and eight provincial and municipal hospitals. This implements real-time online teaching and clinical applications and ensures data consistency, diversity, and novelty. In addition, medical students, teachers, and hospitals can communicate with each other smoothly, and even surgeries can be broadcast with low latency, which can improve leaming efficiency.

2 Doctors in grassroots hospitals urgently need to improve their capabilities. Remote imaging teaching breaks the geographical limitations of education.

Ideally, diagnosis and treatment of minor illnesses can be performed in township hospitals, and that of serious illnesses can be performed in county hospitals. However, only a minority of grassroots doctors has a bachelor's degree or above, in stark contrast with the proportion in hospitals. Therefore, it is necessary to improve capabilities of grassroots doctors so that patients can be examined locally and obtain accurate diagnoses. Due to the limitations of geography, time, and cost, remote learning is the best choice to improve the capabilities of grassroots doctors.



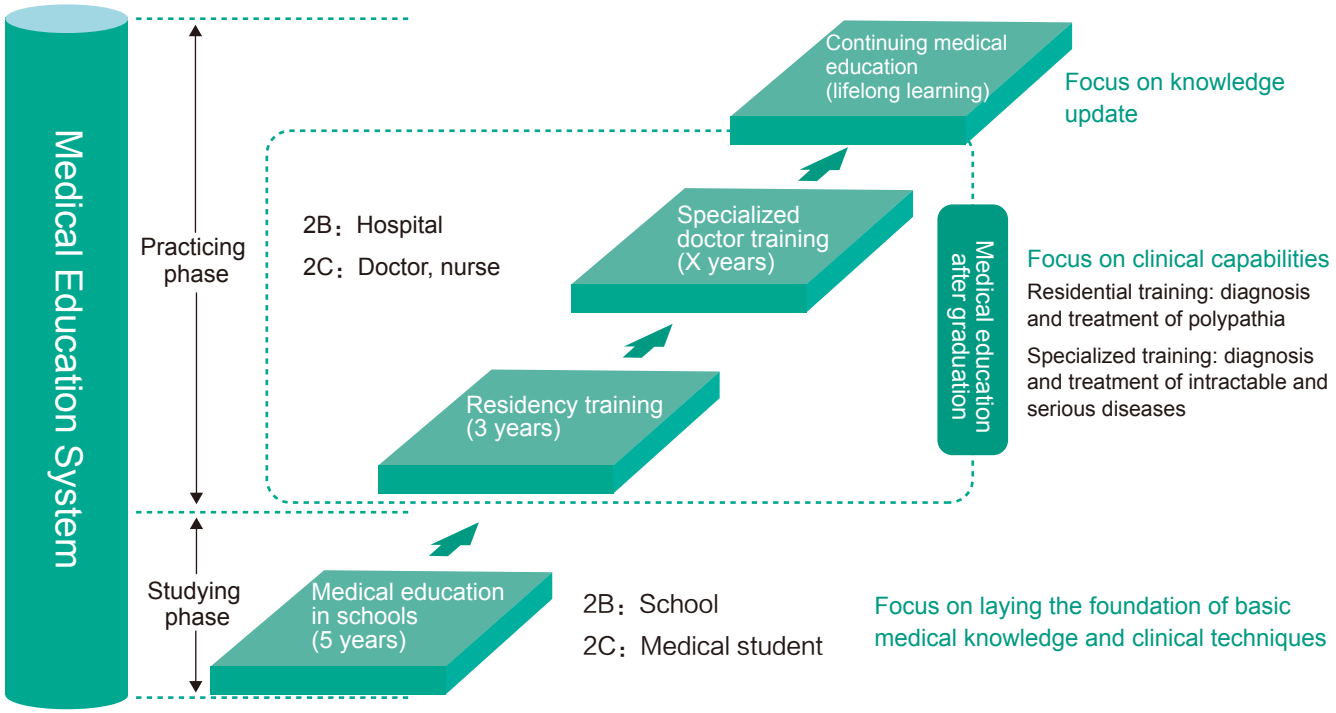
Source: Educational Background of 2.6 Million Practical Physicians in China

According to statistics contained in government procurement documents of the recent year, Jining, Shanxi, Tangshan, Beijing, Dongguan, Tianjin, Baotou, Gansu, Henan, and Zhejiang have developed remote imaging teaching and remote imaging guidance solutions for grassroots hospitals centered at tertiary hospitals through the imaging cloud.

③ Doctors demand education, and Internet + Healthcare + Education is becoming a hot spot.

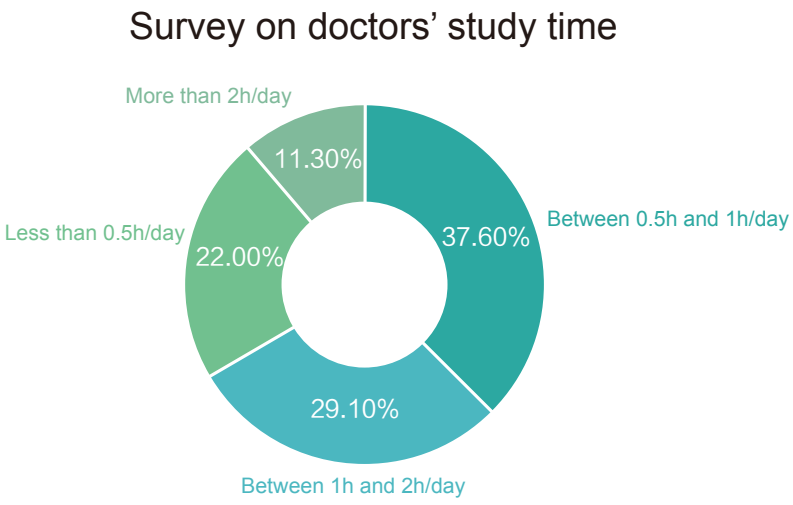
According to the Guidelines on Establishing a Standardized Training System for Residents released by the NHC, a complete lifelong medical education course of five-year medical school, three-year medical residency, specialist training, and lifelong learning will be established.

Figure 3-21 Architecture of the medical education system



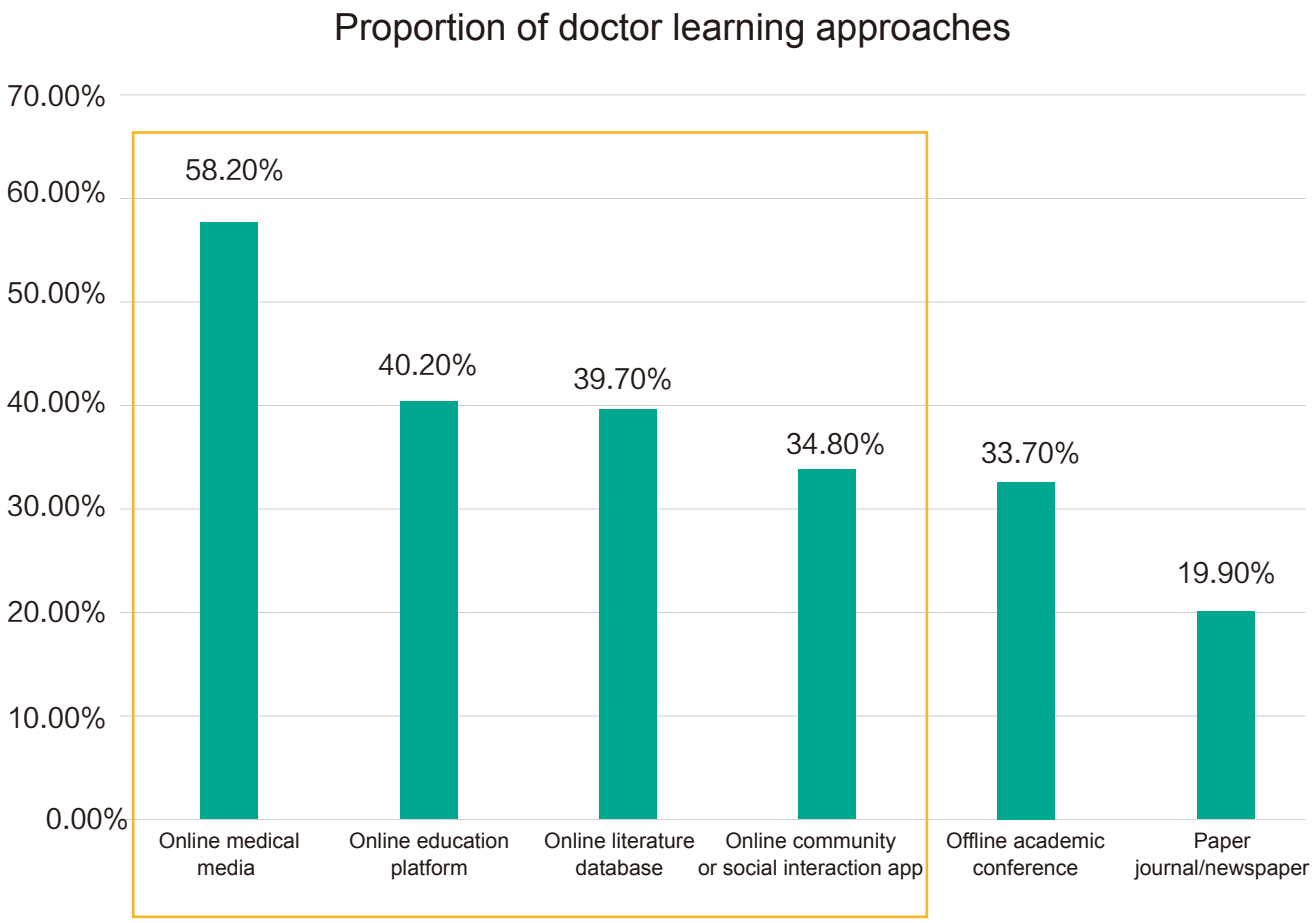
Source: Market Status Analysis and Investment Prospect Forecast of Chinese Medical Education Industry in 2017-2023

According to the Survey on the Present Situation of Chinese Doctors in 2017, doctors use little of their free time for study. Over 37% of doctors said that they devote only 30 minutes to 1 hour a day to study.



Source: Survey on the Present Situation of Chinese Doctors in 2017

In the recent 79th National Pharmaceutical Conference, Beijing Zest Bridge Media Technology and iResearch Consulting Group released the Research Report on Medical Communication Audience. The Report found that the Internet has become a major learning platform for doctors, and that online medical specialty media, education platforms, literature databases, and communities or social networks have become the major learning resources, being used by 58.2%, 40.2%, 39.7%, and 34.8% of doctors, respectively.



Source: Research Report on Medical Communication Audience

On the Internet, network live broadcast and seminars are the most influential new channels for doctors (the influence focuses on doctors' work efficiency, prescription behavior, and rational use of drugs). (Source: Chinese Doctors/Patients' Digital Life in 2017)

4 Live broadcast+healthcare builds a new ecosystem in the medical industry and ultra-HD video experience,and increases network bandwidth and storage requirements.

Live broadcast+healthcare has become a new ecosystem in the medical education industry. In 2016, the Red Hat team made a live broadcast of a myopia correction surgery for the Aier Eye Hospital, attracting more than 400,000 viewers. In March 2017, eleven hospitals held a live network healthcare broadcast in Hunan Provincial People's Hospital to promote education and capability improvement of the hepatic gallbladder surgery medical team. In April 2017, the People's Daily Online joined hands with the Health Times to invite experts to join the live broadcast of the "People's Good Doctor" program, answering questions about ultrasound therapy online.

Remote demonstration and live broadcast require more than 1080P@30fps HD dual-stream (surgical panorama and medical data) real-time videos. Future 4K UHD resolution technology will be widely used for surgery live broadcast. Recently, live VR

surgery education has become popular in the fields of ophthalmology, orthopedics, plastic surgery, liver transplant, and tumor resection, increasing demand for network bandwidth.

In addition, video data from live broadcasts and teaching is precious and needs to be stored for subsequent on-demand teaching, viewing, and editing. Therefore, significant server storage capacity is required.

5 VR/AR/MR technology is in the exploratory test phase, and medical teaching needs to take place first.

According to Grand View Research (GVR), the VR/AR medical market will exceed $5 billion by 2025. VR medical teaching is the main application field and has advantages in medical training, human body research, rehabilitation, psychological training, and preoperative guidance. VR/AR/MR in the medical industry has gradually moved from theory to practice. More than 150 grade A tertiary hospitals and 200 experts in China have experienced MR and some have started the procurement process.

However, there are still many problems to overcome, such as resolution, refresh rate, and transmission bandwidth bottlenecks. and lack of content innovation in medical and educational training. Therefore, clinical applications of VR+medical products are far from ready. According to the financing statistics of 2018 H1, VR+medical products are seen as a promising future market. (Source: VR/AR Financing Analysis in 2018)

The development and application of VR technology in the medical field inevitably increase network requirements. According to the IPTV VR Technical Industry White Paper, the three phases of VR development, immersive experience, interactive experience, and convergent experience, will pose increasingly high requirements on networks. Currently, the minimum bandwidth and maximum latency required for 8K VR immersive experience is 100 Mbit/s and less than 20 ms, respectively.

VR Experience	Immersive Experience		Interactive Experience	Convergent Experience
Technology Feature	8K 8bits 30fps	16K~32K 10~12bits 60~120fps	6DoF Real-time interaction	Opeical field, holography
Bit Rate	80 Mbps	500~2500 Mbps	1~10 Gbps	10~100 Gbps
Transmission Rate	80 Mbps (Common mode)	100~500 Mbps (FOV mode)	500 M~1Gbps	1~10 Gbps
Bandwidth Requirement	100 Mbps	100~1000 Mbps	1000 Mbps	10 Gbps
Network Latency Requirement	20 ms	10 ms	5 ms	1 ms

Source: IPTV VR Technical Industry White Paper

National Policy

1 Build an integrated "Internet+education" platform and actively promote the development of "Internet+education".

According to the Education Informatization 2.0 Action Plan issued by China's Ministry of Education, an integrated "Internet + Education" platform will be built. A "Platform + Education" service model will also be introduced, and various public service platforms and support systems in the field of educational resources will be integrated at all levels. This will help realize the interworking, connection, and openness of resource and management platforms, and build a national public service system for digital education resources.

2 "Internet+healthcare" facilitates remote medical education.

According to an Opinion of the General Office of the State Council on promoting the development of "Internet+healthcare" issued on April 25, 2018, efforts should be made to strengthen Internet+healthcare education and the popularization of science. This will help encourage the establishment of a cloud platform for medical training and health education purposes, implement the policy of "continuing education + suitable technology promotion", focus on healthcare and poverty alleviation, and promote the popularization of practical and suitable technologies through remote education, mainly in grassroots and poverty-stricken areas.

3 The government supports remote medical education and surgical demonstration.

The Technical Guideline for Telemedicine Information System Construction issued by the NHC in November 2014 stipulates the scenarios, functions, and technical parameters of the surgical demonstration system.

On December 13, 2016, the NHC issued a list of specifications for the basic functions of the telemedicine information system, defining the functions of both remote medical education and remote surgical demonstration. Remote medical education is applicable to hospitals and experts providing trainings, lessons, discussions of medical cases, and technical support for grassroots doctors through audio, video, and courseware resources. For remote surgical demonstration, video and remote consultation technologies are used to record and transmit in real time all images involved in clinical diagnosis or surgical demonstration, so that they can be used in remote surgical lessons.

4 The government is accelerating the development of the VR industry.

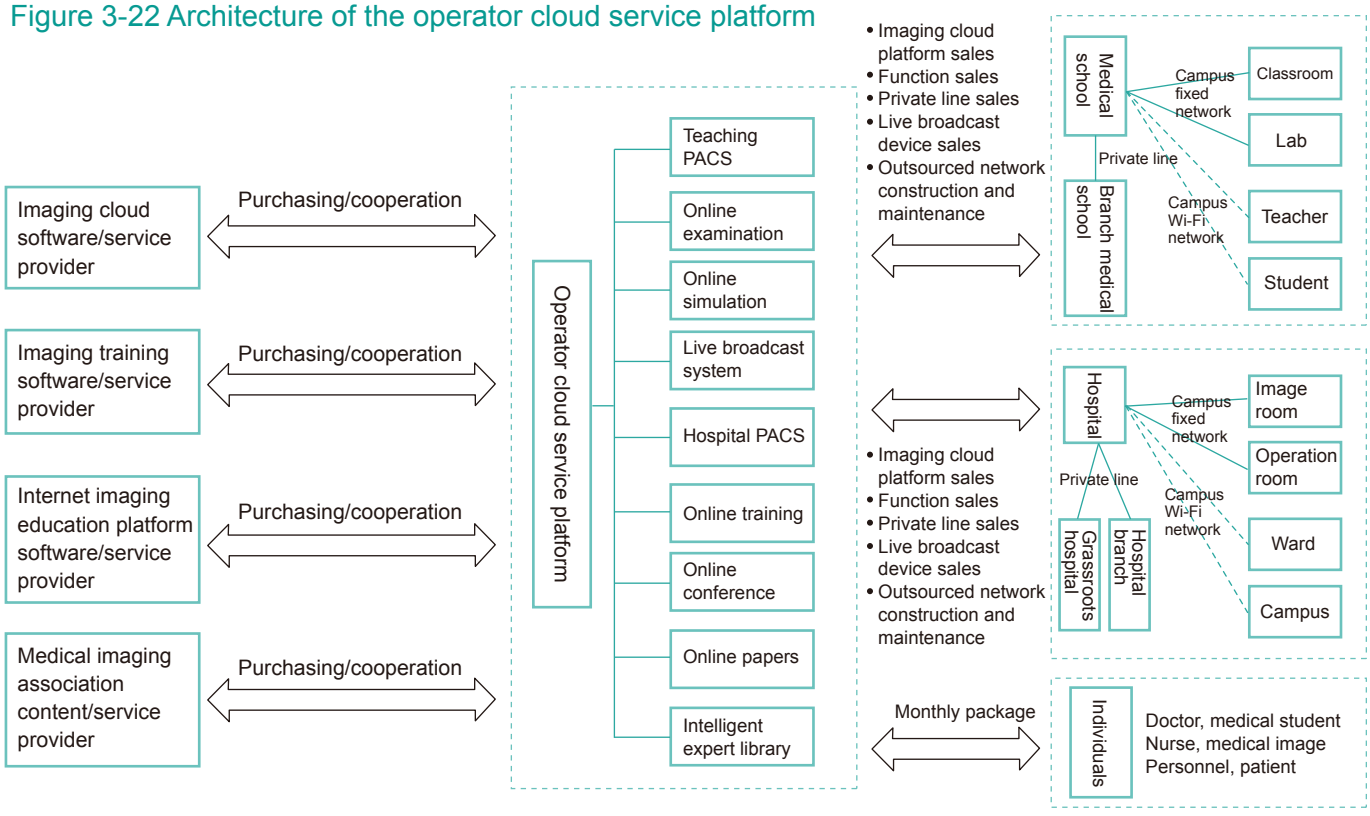
In 2016, the Ministry of Industry and Information Technology (MIIT) and the National Development and Reform Commission (NDRC) formulated the Smart Hardware Industry Innovation and Development Initiative 2016-2018 to accelerate the R&D and industrialization of VR devices. In January 2017, MIIT and NDRC issued the Guidelines for the Development of the Information Industry, which highlights that the R&D and industrialization of VR products will be the focus of development.

On May 21, 2018, Wu Sheng Wu, deputy director of the Electronic Information Division at MIIT, announced that MIIT would organize the formulation of the Opinion on Accelerating the Development of the Virtual Reality Industry. This will help support the R&D of core VR technologies and products, strengthen collaboration in production, learning, research, and application, promote research on basic theories, common technologies, and application technologies, and accelerate the R&D and industrialization of integrated VR equipment and interactive perception equipment.

Business Opportunity

1. **B2B: The imaging cloud is based on operators' cloud platforms and provides medical colleges with cloud-based PACS lessons, distance teaching, live platforms, online surgery simulation, and online examination systems that have the same image resources as hospitals. It also provides medical colleges with private lines and campus networks.**
2. **B2B: The imaging cloud is based on operators' cloud platforms and provides hospitals with online training, distance and continuing education, and live operation broadcasting, as well as the private lines and campus networks that these functions depend on.**
3. **B2B2C: Cloud platforms and storage functions are provided for medical education platforms on the Internet and image associations.**

Figure 3-22 Architecture of the operator cloud service platform



Network SLA

Application Scenario	Experience Standards	Network KPIs		
		Bandwidth	Packet Loss Rate	Latency
Online lessons	• System start time ≤ 3 seconds • Interaction latency ≤ 500 ms	-	-	-
Online exams	• System start time ≤ 3 seconds • Exam content download time ≤ 500 ms • Interaction latency ≤ 500 ms	-	-	-
Live broadcasts of surgery / remote demonstrations	• System start time ≤ 3 seconds • No sound distortion or frame freezing • No frame freezing or frame skipping • Interaction latency ≤ 500 ms	2 Mbit/s	-	Watching: ≤ 500 ms Interaction: ≤ 1 second
Live VR broadcasts of surgery (4K)	-	12 Mbit/s	-	20 ms
Virtual surgery lessons (8K immersive experience)	Interaction latency ≤ 500 ms	100 Mbit/s	-	20 ms
Virtual anatomy lessons (8K immersive experience)	Interaction latency ≤ 500 ms	100 Mbit/s	-	20 ms
Virtual acupuncture lessons (8K immersive experience)	Interaction latency ≤ 500 ms	100 Mbit/s	-	20 ms
Live network broadcasts (healthcare) (4K)	• System start time ≤ 3 seconds • No sound distortion or frame freezing • No frame freezing or frame skipping	-	0.05%	10 ms
Online conferences (healthcare) (1080p)	• System start time ≤ 3 seconds • No sound distortion or frame freezing • No frame freezing or frame skipping	4-8 Mbit/s	1%	20 ms

Note: For more information, see AccuRad's image reading data.

3.5 Cloud-based Health Management

Scenario Description

Users can use smartphones, apps, and wearable devices to record their own physiological data. Based on the healthcare cloud, individuals can communicate and consult with doctors through the network and manage and improve their health with the doctors' assistance.

Data for chronic diseases, medical images, and medical tests can be managed on the cloud through cloud computing, providing health consultations, scheduled referrals, follow-ups, and extended prescriptions online.

Application Scenario

- **Personal/family image files, used for managing family health in a centralized manner, facilitating secondary diagnosis and consultation**

  Personal or family image files can be created based on the imaging cloud to store all historical image records, serving as a reference for doctors during secondary diagnosis and consultation.

- **Online image consultation and personal image consultation services**

  Patients can use web pages or mobile phones to upload image information and communicate with online experts through text, voice, and video to get second opinions. For image consultation, patients can also contact experts in medical institutions offline (C2B) and online (C2C).

- **Remote health monitoring, chronic disease detection online, and health guidance**

  Patients with chronic diseases such as diabetes, hypertension, and heart disease can upload data collected by intelligent terminals at home to the cloud through wireless networks. Doctors can monitor and analyze the data in a timely manner and promptly intervene when data fluctuates, providing patients with a valuable medical service.

Industry Situation

1 The policy in non-medical institutions of prohibiting medical treatment but allowing health consultation affects the development of 2C medical services.

The NHC released the opinions on promoting the telemedicine service of medical institutions and pointed out that non-medical institutions should not carry out telemedicine services. Third-party organizations on the other hand can provide platforms for telemedicine services but cannot provide services directly.

2 The "Internet+healthcare" policy clarifies the 2C service model.

According to the policy, Internet medical services can cover pre-consultation services such as guidance and registration, and post-consultation services such as further consultations online and patient management. Medical institutions are allowed to develop Internet hospitals so that they can perform consultations and prescriptions online for some common and chronic diseases.

Artificial intelligence and smart healthcare devices can be used to monitor and evaluate your health in real time, warn against diseases, screen for chronic diseases, and intervene where necessary.

2C Service Model of "Internet+Healthcare"	
Item	**Service Model**
Internet hospital	Doctors and patients are connected through the Internet, where further consultation, the sharing of electronic medical records, and advice and prescriptions are all carried out.
Chronic disease management	The Internet is used in the management of chronic diseases.
Family doctor	A hierarchical consultation and treatment service platform is established based on family doctor services.

3 The direct-to-consumer (DTC) telemedicine service is promoted, and the policy of "My Health, My Choice" gives patients more say in health matters.

Currently, 31% of users have considered using wearable devices to monitor their vital signs. In contrast, only 10% doctors can use this data fully during consultation and treatment. Less than 20% of free practitioners have or are about to provide remote consultation services to patients.

National Policy

1. Telemedicine services defined by the NHC include remote pathological diagnosis, remote medical image diagnosis (including imaging, ultrasounds, nuclear medicine, electrocardiograms, electromyography, and electroencephalography), remote monitoring, remote consultation, remote outpatient service, and remote case discussion. Telemedicine services in B2C mode are allowed.
2. Third-party independent imaging centers can provide patients with cloud-based image reading services.
3. The "Internet+healthcare" policy specifies that Internet healthcare is used for the management of chronic diseases and online consultations. Medical institutions are allowed to develop Internet hospitals so that they can perform these consultations as well as prescriptions for some common and chronic diseases.
4. Internet+public health services promote the online querying and standard use of residents' electronic health records. The online management of chronic diseases has been strengthened, especially that of hypertension and diabetes. Wearable devices are also being used to obtain data on people's vital signs, helping to monitor the health of pregnant women.

Time	Policy	Description
October, 2013	Several Opinions on Promoting the Development of Health Services, issued by the State Council	• Promote third-party services, imaging centers, and remote image diagnosis for rural, remote, and underdeveloped areas to develop telemedicine.
September, 2014	Opinions of the National Health Commission Regarding the Promotion of Medical Institution Telemedicine Services	• Telemedicine services include remote pathological diagnosis, remote medical image diagnosis (including imaging, ultrasounds, nuclear medicine, electrocardiograms, electromyography, and electroencephalography), remote monitoring, remote consultation, remote outpatient service, and remote case discussion. • Telemedicine services in B2C mode are allowed. • National and international medical institutions can cooperate in providing these services.
April, 2018	Opinions of the General Office of the State Council on Promoting the Development of Internet+Health-care	• Internet medical services can cover pre-consultation services such as guidance and registration, and post-consultation services such as further consultations online and patient management. • Medical institutions are allowed to develop Internet hospitals so that they can perform these consultations as well as prescriptions for some common and chronic diseases.

Business Opportunity

1. Develop Internet hospitals and conduct 2C remote imaging diagnosis and related services.
2. Based on the varied application of wireless networks and wearable devices, online health guidance should be provided based on personal healthcare data such as ECG and blood pressure.

Service Object	Business Opportunity	Service Requirement
Individuals	• Intelligent wearable devices	Health management cloud provides guidance based on analysis of medical data such as your ECG, blood pressure, and blood sugar levels.
Individuals	• Internet+telemedicine • Network and cloud hospitals • Healthcare cloud services	Third-party medical institutions provide online consultation, remote monitoring, and telemedicine for nursing homes.

04 Summary of Medical Imaging Cloud Scenarios

- **The medical imaging cloud is mainly used in business applications in China, including in hospitals at all levels, medical groups, medical institutions, government hospitals, and third-party independent imaging centers.** Due to the influence of national healthcare policies, the development of customer applications is difficult. Therefore, the related medical policies need to be relaxed and the related technologies need to be promoted.
- **Five typical application scenarios of the medical imaging cloud are as follows: Cloud image storage, image cloud application, Cloud-based medical collaboration, Cloud-based medical education, and Cloud-based health management.**

Scenario Category	Application Scenario
Cloud image storage	• Cloud image storage • Cloud image archiving • Cloud image backup
Imaging cloud application	• Full medical and technical imaging cloud PACS • Cloud image reading • Mobile image cloud
Cloud-based medical collaboration	• Regional imaging center • Remote imaging center • Remote image diagnosis • Remote image consultation • MDT clinical multi-disciplinary collaboration
Cloud-based medical education	• Doctor training • Surgery live broadcast • Doctor examination • Multi-hospital morning reading
Cloud-based health management	• Personal image file • Online image consultation • Remote health monitoring

- **The medical imaging cloud provides applications such as big data storage, elastic expansion, and flexible sharing, all of which require a good transmission network. This places a new requirement on networks.**

  ①The sensitivity of medical data requires networks to guarantee the security and reliability of cloud services. Data centers need to support multi-point disaster recovery, remote backup, high availability data storage, and data security protection mechanisms.

  ②As there are a large number of grassroots medical institutions and community hospitals, and as they are scattered around the country and use different access modes, the transmission network must support multiple access modes and offer wide coverage and full mesh.

- **The typical service types of the medical imaging cloud are as follows:**

  ①The medical cloud services based on IaaS are mainly provided by public cloud vendors and telecom operators. They provide data center equipment rooms for the cloud, as well as racks, cloud storage, cloud backup, and leasing services for the cloud computing server. They also provide equipment room hosting services for medical institutions and cloud service providers in the medical field. The representative services include Alibaba Cloud, Tencent Cloud, Huawei Cloud, China Telecom Cloud, and China Unicom Cloud.

  ②The medical cloud services based on IaaS focus on Internet+healthcare cloud services and regional imaging cloud services. They provide medical software services on clouds for medical institutions. Typical medical cloud service applications include Kyee Medical Cloud, Winning Healthcare Cloud Hospital, Lianzhong eimage-global platform , uCloud, AccuRad Yizhen Cloud, cloud HIS, cloud PACS, and cloud EMR. Medical SaaS is still in its early stages, leaving it plenty of room to develop in the future.

- **With their rich network resources, localized data centers, localized O&M support capabilities, and the credibility of state-owned enterprises, operators can build an overall imaging cloud solution with many ecosystem partners, improving medical collaboration efficiency and quality to better serve doctors, patients, medical institutions, and the entire society and accelerating medical services to clouds and expanding the market space of the medical industry. The following table lists the business opportunities that exist for operators.**

Service Type	Business Opportunity
Medical cloud application	• Provide cloud PACS, cloud HIS, cloud EMR, and mobile imaging cloud services for basic medical institutions and regional healthcare imaging centers. • Provide medical collaboration services for regional medical unions and remote imaging centers, including regional medical private networks + regional imaging clouds, and remote image consultation services. • Provide big data analysis for medical institutions.
Medical cloud data center and cloud platform services	• Provide IaaS-based medical cloud services for medical institutions and medical service providers, for example, hosting services for data center equipment rooms or equipment room devices. • Provide basic medical services such as collaborative cloud-and-network private lines, cloud image storage, and image backup and redundancy services for hospitals, regional imaging centers, and third-party imaging centers. • Provide hybrid cloud, regional medical cloud, public cloud, and cloud private lines for medical institutions and medical service providers.
Medical private line	• Provide differentiated private services for hospitals, medical unions, medical management organizations, regional imaging centers, and telemedicine centers.

05 Medical Imaging Cloud Requirements for Networks

Service Scenario	Sub-scenario	Experience Criteria	Cloud & Network Requirements
Cloud image storage	Cloud storage	• Meet the level-3 requirements for ensuring information security in the healthcare industry. • Meet official Chinese requirements on healthcare organizations for online storage, geographic redundancy, backup, and recovery of data. • Meet requirements for real-time upload, backup, and restoration of image data.	• Clouds and networks provide level-3 information security. • Clouds meet requirements for same-city dual-center and remote image data DR. • Operators' networks connect to clouds through two lines, ensuring high network availability. For details, see "Network SLA" in section 3.1 Cloud Image Storage.
	Cloud archiving		
	Cloud backup		
Imaging cloud application	Cloud PACS	• Meet the level-3 requirements for ensuring information security in the healthcare industry. • Meet official Chinese requirements on healthcare organizations for online storage, geographic redundancy, backup, and recovery of data. • Meet requirements for real-time upload, backup, and restoration of image data.	• Provide medical imaging cloud and cloud hosting services. • Operators' networks connect to clouds through two lines, ensuring high network availability. • Support various access modes, offer wide coverage, multiple connections, high bandwidth, and low latency, and provide differentiated SLAs. For details, see "Network SLA" in section 3.2.1 Imaging Cloud PACS: the Eventual Form of PACS.
	Cloud image reading	• Review and retrieval of images from all departments in seconds • No obvious delay in processing	• Support access to all departments, and meet the requirements of large concurrency, low latency, and no frame freezing. • Provide differentiated SLAs for medical departments. For details, see "Network SLA" in section 3.2.2 Cloud Image Reading: Making Diagnosis More Efficient.
	Mobile imaging cloud	• No interruption during roaming, smooth browsing, no frame freezing, and zero wait time	• The wireless network covers all areas, is stable and reliable, and features zero roaming and no disconnection. • Support transmission with high bandwidth and low latency. For details, see "Network SLA" in section 3.2.3 Mobile Imaging Cloud: Viewing Images Anytime and Anywhere.

Service Scenario	Sub-scenario	Experience Criteria	Cloud & Network Requirements
Cloud-based medical collaboration	Regional imaging center	• Meet requirements for centralized regional image storage, high performance processing, big data analytics of regional images, and image sharing and collaboration.	• Provide regional medical cloud and cloud hosting services. • Provide private cloud hosting, public cloud, and hybrid cloud services. • Provide private lines to connect hospitals in medical unions and to cloudify medical institutions in the medical unions. • Networks must provide wide coverage and high bandwidth, and support on-demand provisioning. For details, see "Network SLA" in section 3.3.1 Regional Imaging Centers: Imaging Resource Sharing and Hierarchical Diagnosis and Treatment.
	Remote imaging center	• Simultaneous interaction at multiple points • Clear and smooth audio/video playback on intranet and extranet • Secure, reliable, and complete transmission of telemedicine information	• Implement cloud-network synergy based on networks, and support the real-time transmission of images across regions. • Provide wired, wireless, and other access modes. For details, see "Network SLA" in section 3.3.2 Remote Imaging Consultation Center: Optimizing Connections and Improving Medical Quality.
Cloud-based medical education	Medical training	• Smooth audio and video, no frame freezing, and no distortion	• Implement cloud-network synergy based on networks, and support the real-time transmission of images across regions. • Provide wired, wireless, and other access modes. For details, see "Network SLA" in section 3.4 Medical Education.
	Live surgery broadcast Medical examination		
	Multi-hospital morning reading		
Cloud-based health management	Personal image file	• Smooth audio and video, no frame freezing, and no distortion • Numerous connections for various wearable medical terminals	• Provide wireless networks with high bandwidth and low latency. • Support numerous connections of various wearable medical terminals.
	Online imaging consultation		
	Remote health monitoring		

06 Appendix

Acronyms and Abbreviations

Acronym and Abbreviation	Full Spelling
HIT	Hospital information technology
DT	Data technology
AI	Artificial intelligence
PACS	Picture archiving and communication systems
DICOM	Digital Imaging and Communications in Medicine
HIS	Hospital Information System
CIS	Clinical information system
RIS	Radiology information system
LIS	Laboratory information system
HRP	Hospital resource planning
EMRS	Electronic medical records
EHR	Electronic health record
HIMSS	Healthcare Information and Management Systems Society
CHIMA	China Hospital Information Management Association
CFDA	China Food and Drug Administration
MITA	Medical Imaging Technology Alliance
GMIS	Globe medical information service
DTC	Direct-to-consumer
MDT	Multidisciplinary treatment

Acronym and Abbreviation	Full Spelling
IaaS	Infrastructure as a service
SaaS	Software as a service

Medical Imaging Cloud Ecosystems

Category	Major Vendors
Telecom operators + cloud + PACS	China Telecom + AccuRad (China Telecom Medical Cloud), China Unicom + AccuRad (WoYizhen Cloud), China Mobile + Hinacom
Internet vendors + PACS ecosystem	Amazon, Microsoft, Alibaba Cloud, Tencent Cloud, and Huawei Cloud
Cloud system (SaaS)	Yizhen Cloud, Wanli Cloud, Sino-Vision, HOKAI, RayPlus, and Mediinfo
Traditional imaging equipment vendors + PACS	Philips, GE, Siemens, United Imaging, and Carestream
Traditional PACS vendors + cloud	Neusoft, Hwatech, Zhongdi Medical, EBM, ANKE Medical, Wingspan, Hinacom, Lianzhong Medical, Ruida image
Startup company (Internet+healthcare)	AccuRad, Ai Wen Yi Lian, Hui Yi Hui Ying, Yingda Media, Weiyun Imaging, DICOM Imaging, Imaging Union
Independent imaging organizations	Health 100, RIMAG, Best uniMed, Sequoia Medical, Universal Medical Imaging, EPiC Healthcare, QED Technique, DICOM Imaging, Infervision, 12 SIGMA technologies

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