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Obstetric Imaging Diagnostic Platform Based on Cloud Computing Technology Under the Background of Smart Medical Big Data and Deep Learning

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ABSTRACT The deep learning methods in the field of computer vision and big data are becoming more and more mature. Through the application of big data and deep learning technology, the diagnosis of artificial intelligence medical image can be realized, which provides a new opportunity for the automatic analysis of obstetrics medical image and the assistance of doctors to realize high-precision intelligent diagnosis of diseases. The current medical obstetric image diagnosis platform mainly targets low-resolution medical obstetric image files, and does not consider the data-sharing problem of the distributed file system in different storage nodes, which greatly reduces the efficiency of obstetric image storage and diagnosis. Based on this, this article designs an obstetric image diagnostic platform based on cloud computing technology. First, a medical imaging platform was designed by combining cloud computing technology, caching technology, and a distributed file system. Secondly, the use of contrast-enhanced ultrasound technology provides a more accurate ultrasound image for assessing the structure, size, location, and developmental abnormalities of the placenta. Finally, the effectiveness of the obstetric imaging diagnostic platform proposed in this paper is verified by experiments. The results show that the platform has fast data processing speed and convenient use, which greatly reduces the cost of medical equipment and improves efficiency. The hospital only needs to collect the obstetric image of the patient at the front end, transfer it to the cloud for image processing, and finally diagnose the disease.

INDEX TERMS Smart medicine, big data, cloud computing technology, obstetric imaging, diagnosis.

I. INTRODUCTION

In recent years, medical obstetric imaging technology has achieved rapid development. New technologies and new equipment have emerged to make it easy and convenient to obtain two-dimensional, three-dimensional and even more-dimensional obstetric images in clinical medicine. With the rapid development of computer technology, image processing technology and intelligent control technology have gradually matured and evolved. It has been widely used in today's medical obstetric imaging equipment, and it has developed into the fastest technology [1]–[5]. Today's medical imaging technologies mainly include X-rays, computed

tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI), and so on [6]–[10]. These new technologies and methods continue to introduce new changes to the medical imaging industry, and promote the rapid development of medical imaging technology. It not only improves the quality of medical images and enables doctors to diagnose the condition more accurately, but also breaks through the traditional diagnostic mode and simplifies the complexity of the diagnosis [11], [12]. The emergence and rise of cloud computing technology provides a new and effective way to process massive medical data. In addition to the significant advantages of resource integration, high availability, high performance, and easy expansion, it provides new methods for data storage, retrieval, processing, and analysis. It is very suitable for long-term storage and fast

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and effective access to medical obstetric image data [13]. By making full use of the advantages of the distributed file system and the excellent scalability of the cloud platform, the storage and diagnosis of massive medical obstetric image data is of great research significance and application value [14], [15].

At present, the mainstream medical imaging technologies at home and abroad generally include ultrasound imaging, CT imaging, MRI imaging and X-ray imaging. CT and MRI devices are two commonly used digital medical image imaging devices [16]–[18]. Their imaging principles are different and have their own advantages. CT uses X-ray imaging, while MRI uses magnetic resonance to now image. All of them can display the lesion information of tissues and organs in different parts with different resolutions. After observing this image information, doctors can accurately make diagnosis and formulate treatment plans [19]. Abma *et al.* [20] used the contrast effect of energy Doppler and color Doppler before and after contrast-enhanced ultrasound to study 30 patients with ectopic pregnancy. The results suggest that the contrast agent can significantly help the development of color blood flow and nourishing leaf blood flow in ectopic pregnancy, and it is helpful in the localization of villous tissue in ectopic pregnancy bleeding accessory mass. Shaaban *et al.* [21] performed diagnostic studies on images of 23 patients with gestational trophoblastic disease. This provides a new technical means for the imaging diagnosis of benign and malignant trophoblastic diseases. Wei *et al.* [22] used imaging technology to diagnose the disease by observing the flow of the contrast agent in the uterine cavity and fallopian tubes. The experimental results prove that the diagnosis by fallopian tube patency is more accurate and specific. As a non-invasive and radiation-damaged clinical examination method, magnetic resonance has attracted the attention of obstetricians and is used for examinations in the second and third trimesters of pregnancy. Patel *et al.* [23] used 0.35T magnetic resonance to scan normal fetal brain anatomy. However, its magnetic field strength is too low, and the acquired image is not clear. The applied sequence makes the image acquisition time longer, resulting in more image artifacts. Hirsch *et al.* [24] used semi-Fourier RARE sequences to scan the brain tissues of 25 fetuses in utero at 12–38 weeks of gestational age. The relationship between the volume of the subarachnoid space and gestational age was evaluated. De *et al.* [25] found through research that ultrasound contrast agents can show blood transfer between fetuses in multiple pregnancy in humans, but cannot depict clear blood vessel structure images of the entire placenta.

With the popularization of information technology and Internet technology, people have entered the era of big data [26]. Big data means that the volume and dimensions of the data are large, and the data forms are rich and diverse. The introduction of information technology in the medical industry is also accompanied by a continuous increase in the information and automation of the medical industry, and medical data has increased at the terabyte or even petabyte

level [27]. How to properly manage and store these massive medical data and tedious data types has brought tremendous pressure to the medical industry. With the development of the medical Internet, the number of times cloud computing has been mentioned has gradually increased [28]. Various industries are conducting a lot of research and practice on cloud computing, and cloud-computing technology is slowly changing the service model of traditional industries. Similarly, cloud computing has had a huge impact on the medical imaging diagnostics industry [29]. In recent years, with the development of cloud computing, research on medical information technology based on cloud computing has also gradually developed and achieved certain results [30]–[33]. Harvard Medical School is one of the earliest medical institutions to deploy and use cloud-computing platforms. The private medical cloud it has established has become an integral part of its daily medical and research work [34]. Antai Insurance Company in the medical insurance industry has developed a set of cloud-based medical collaboration systems through cooperation with IBM [35]. The system can provide doctors and hospitals with real-time patient data. E-Health-Trust established the world's first large-scale health records bank (HRB) in Arizona. Users can store and control their own health records information [36]. In the “Shenzhen Only Medical Cloud Service Platform Construction” published by Shenzhen Medical Information Center, Shenzhen was taken as an example to build a “medical resource cloud management platform”, hoping to integrate various medical resources [37]. Palanisamy and Thirunavukarasu [38] researched and conceived the construction of medical big data platforms, and used cloud-computing technology to meet the needs of medical big data collection, processing, storage, retrieval, and application development. Ali-health is Alibaba's platform in the medical and health field. The platform's current main businesses are drug retail, medical services, product traceability, and health insurance. A telemedicine platform is provided in the medical service. Through this platform, the physicians admitted to the hospital can conduct video consultation through the patient's imaging materials [39].

Medical image cloud is widely used and easy to use. The hospital only needs to collect patient data information in the front end and transfer it to the cloud for image processing, which greatly reduces the cost of the hospital and improves efficiency. However, the current medical obstetric imaging diagnostic platform is mainly aimed at small files of medical obstetric imaging. It does not use a distributed file system to achieve data sharing between different storage nodes, which greatly reduces the efficiency of obstetric imaging diagnosis. At the same time, for the impact of server I/O efficiency and network access issues, it is necessary to consider the data sharing of the distributed file system among different storage nodes, and provide multiple access nodes to improve performance, so as to achieve an efficient, obstetric imaging diagnostic platform with strong scalability, high data security, and low cost.

Based on the above analysis, this article designs an obstetric image diagnosis platform based on cloud computing technology. First, a medical imaging platform was designed by combining cloud computing technology, caching technology, and a distributed file system. Secondly, by using contrast-enhanced ultrasound technology, more accurate ultrasound images are provided for assessing the structure, size, location, and presence of developmental abnormalities in the placenta. Finally, the effectiveness of the obstetric imaging diagnostic platform proposed in this paper is verified by experiments.

Specifically, the technical contributions of our paper can be concluded as follows:

The platform data presented in this paper is fast and easy to use. The platform can use digital image processing software technology to process audiograms, which is conducive to improving the quality of audiograms. On this basis, the image post-processing function provides doctors with clear and reliable images, which are easy to identify and understand. At the same time, a sufficient reference information database is provided to improve the accuracy and reliability of the diagnosis.

The rest of our paper was organized as follows. Related work was introduced in Section II. Section III described the obstetric diagnosis platform based on cloud platform technology. Experimental results and analysis were discussed in detail in Section IV. Finally, Section V concluded the whole paper.

II. CLOUD COMPUTING AND DISTRIBUTED STORAGE TECHNOLOGY

Cloud computing is a hot technology today. The prevalence of big data research is also mainly based on the mature development of cloud computing technology. Because of its low cost and high availability, the outstanding advantages quickly attracted people's attention. Therefore, the following focuses on the introduction of computing and distributed storage technology related concepts and methods.

A. CLOUD COMPUTING TECHNOLOGY

Cloud computing is an Internet-based supercomputing model. In remote data centers, tens or even tens of millions of computers and servers are connected into one piece [40]. Therefore, cloud computing can even allow you to experience almost omnipotent supercomputing and storage capabilities. Users only need to access the data center through the web terminal. Then, they are stored and calculated according to their respective needs. Cloud computing is considered an important milestone in the development of technology.

"Cloud" is essentially a resource allocation strategy, which is to form a network group by using computers of a certain size. Then jointly deploy resources in the group. It combines cluster, network, and distributed preservation technologies. Compared with other systems, the "cloud" environment has the advantages of low cost, good performance, stability, and easy expansion [41]–[43].

Cloud computing technology has changed the traditional personal-centric computing model, and creatively proposes a network-centric and real-time application service model. Cloud computing has the following characteristics:

1) LOW COST

In cloud computing, data maintenance, storage, and computing are all in the cloud. The maintenance of software and hardware facilities is also in the cloud, and server and storage-computing resources are efficiently used. For users, they only need to spend a small amount of money to lease related services according to their own needs. Users do not need to purchase expensive servers and maintain them to get powerful processing power and unlimited storage capabilities.

2) HIGH RELIABILITY

Various resources used by customers in their operations are in the cloud platform. In addition, the data storage of the cloud platform adopts a multi-copy, high-fault-tolerant mechanism. There is no data loss caused by a single point of failure, which greatly protects the security of the data. Therefore, a more reliable service can be provided.

3) HIGH SCALABILITY

The high scalability of cloud computing is reflected in the allocation of resources to users. When the scale of users increases, the computing and storage requirements of servers also increase. By adding physical servers to the cluster, the overall service capabilities of cloud computing can be enhanced.

B. CLOUD COMPUTING ARCHITECTURE

The cloud computing architecture is divided according to service types and levels, and can be divided into the following three levels of services: software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) [44]. As shown in Figure 1.

IaaS is the integration of services at the hardware level. With virtualization technology, automation technology, server cluster and other technologies, IT, server, storage, network and other IT infrastructure is provided as a service to client terminals.

SaaS refers to software-level services. Through the Internet and other technologies to provide specific applications to clients, customers do not need to purchase software, hardware, or maintenance and upgrades, and can access and apply various software through the Internet.

PaaS focuses on the application of the system platform. Using distributed file storage, distributed computing, distributed database and other technologies to meet customers' own application needs of the platform. In addition, provided to the client as a service. Users can develop their own software through the platform provided by cloud service providers. Moreover, it can be published on the Internet through a cloud server.

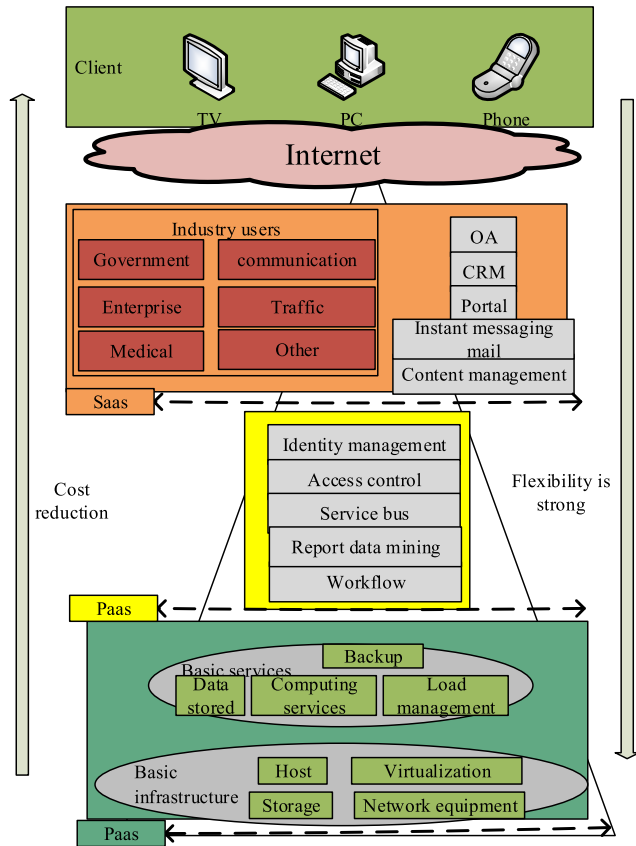


FIGURE 1. Hierarchical diagram of cloud computing service architecture.

According to the analysis of the above three levels of services, it can be known that the main function of cloud computing is to provide a convenient, fast, rapid deployment, and highly scalable network architecture to provide personalized solutions for enterprises and institutions.

C. COMMON STORAGE ARCHITECTURE

1) DIRECT ATTACHED STORAGE (DAS)

DAS is completely server-centric architecture. The client connects directly to the server. When in this mode, the corresponding speed of the system decreases as the I/O traffic increases. In addition, the performance bottleneck of the entire system is directly affected by the performance of the server. Due to the limitations of server performance and storage capacity, storage systems based DAS are not suitable for building systems that require high performance, high scalability, and massive data storage [45].

2) NETWORK ATTACHED STORAGE (NAS)

NAS is a kind of data-centric dedicated data storage server [46]. In order to reduce bandwidth pressure, improve system performance, and reduce total cost of ownership, it centrally manages data and completely separates storage devices from servers. However, NAS has its shortcomings in practical applications. The first is in file access speed. Because file I/O is used, the file transfer process will bring a

lot of network bandwidth overhead, which is not suitable for applications with high access speed requirements. The second aspect is data backup, which requires bandwidth and wastes network resources.

3) STORAGE AREA NETWORK (SAN)

A SAN is a high-speed storage network with a centralized management centered on a fiber-optic network. The data exchange method between the SAN and the storage device is Block I/O.

The earliest distributed file system was the Network File System (NFS) [47]. It uses a client/server model and works on both LAN and WLAN. This file system is used in all current UNIX systems. NFS supports heterogeneous systems, and files can be shared between computers with different operating systems.

However, this type of network file system has great shortcomings in the parallel processing of massive data, mainly including:

- (1) Depending on the central server, system performance bottlenecks and single point server failures are prone to occur.
- (2) Poor scalability and difficult to apply to cluster systems.
- (3) Server maintenance is inconvenient.

Distributed file system refers to the connection of many nodes through a computer network. Moreover, a system for communication and data transmission. In addition, each node can be distributed in different locations. Users of distributed file systems do not need to care about how the data is stored. Just manage and store your data as if you would with a local file system.

D. DISTRIBUTED STORAGE

The cloud storage method based on the distributed file system is adopted to solve the problem that the medical imaging platform cannot handle the file system with increasing data volume. Files in the “cloud” are distributed and stored in different storage nodes. Therefore, it is necessary to uniformly manage them through the network through a distributed file system, manage system resources in a global manner, and arbitrarily schedule storage resources in the network. Moreover, the scheduling process is “transparent”. It also provides users with an access interface of file system, which solves the limitations of the local file system on file size, number of files, and number of open files [48]. When using a distributed file system, users do not need to care about which node the data is stored on or from which node. Just manage and store the data in the file system just as if you would with a local file system. The infrastructure of the distributed file system is shown in Figure 2.

The more common distributed file system architectures currently include clients, master servers, and data servers. The three parts are connected together through a network. The client can be multiple and various types of application servers, or it can be an end user, which belongs to the access layer server. In a distributed file system environment, client nodes do not directly access the underlying block storage media.

Instead, use network protocols for file operation interactions. Therefore, the distributed file system is the sharing of stored data. Instead of storing the sharing of physical resources.

The distributed file system has the following characteristics [49]:

1) HIGH AVAILABILITY

The distributed file system must have high fault tolerance, that is, no matter the client or server fails, it will not affect the function of the entire system.

2) RESOURCE TRANSPARENCY

Access transparency means that the file system must enable users to access local and remote files in the same way. Performance transparency means that the file system must enable users to operate files efficiently and reliably under various load environments.

3) ELASTIC STORAGE

The number of nodes and capacity of the file system should be able to be dynamically expanded without affecting system operation and user experience. You can flexibly increase or reduce data storage and increase or delete resources in the storage pool according to business needs, without the need for terminal system operation.

4) PROTOCOLS AND INTERFACES

The distributed file system provides a variety of interfaces to client applications.

5) CONCURRENT ACCESS

In a distributed file system, multiple users share file resources. Therefore, the problem of concurrent access occurs, that is, different users or processes access the same file at the same time.

This article will choose an open source lightweight distributed file system, which is Fast Distributed File System (FastDFS). The main function is for file operations, such as file storage, file access, file synchronization, and so on. By solving problems such as large-scale file storage and high concurrent access, load balancing of file storage and online expansion of storage services are supported [50]. FastDFS is more suitable for Internet applications. It does not store files in blocks. Instead, the data is stored on the child nodes as a single file. In other words, the file uploaded by the client corresponds to the file stored in the cluster system.

The server of FastDFS includes two roles: tracker server and storage server. The tracker server is the central node responsible for load balancing and scheduling. Storage server is also called trunk server or data server. It is responsible for directly using the file system of the OS to store file data. It is also responsible for file management, such as storing files, synchronizing files, and providing access interfaces [51]. The system architecture of FastDFS is shown in Figure 3.

Tracker sever records the status and grouping of the storage server in memory. The tracker server according to the file

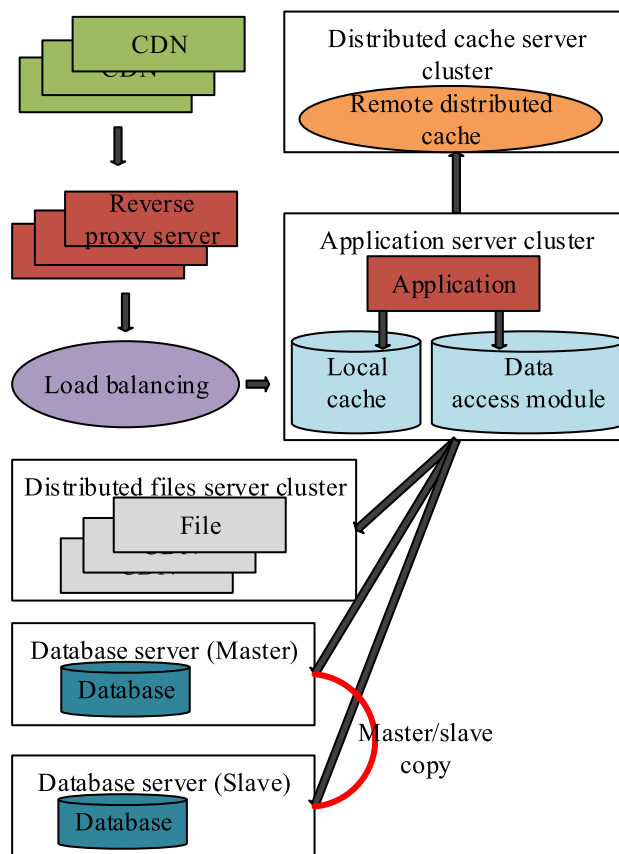


FIGURE 2. The infrastructure of a distributed file system.

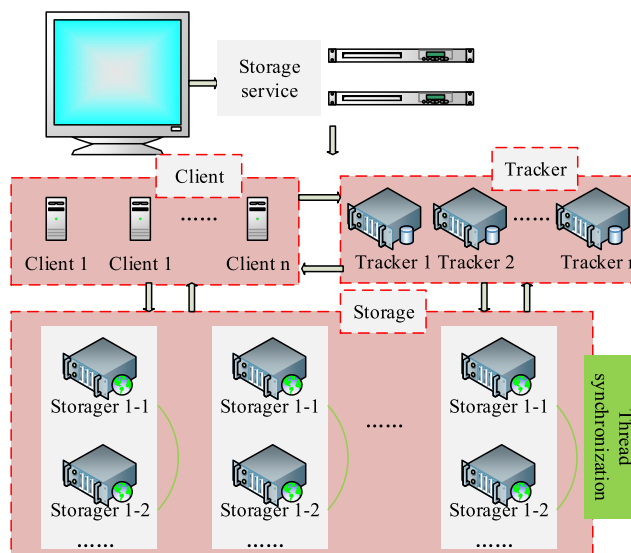


FIGURE 3. System architecture of FastDFS.

name and file name defines the newly saved file name or ID. There is no indexing mechanism, so it takes up very little memory. When the client or storage server actively accesses the tracker server, the tracker server scans the packet and storage server information and gives a response. It can be seen that the tracker server will not become a system bottleneck of

the system, reflecting the lightweight characteristics of the system.

After the file is stored on the storage server. It periodically starts a connection to one or more tracking servers to report statistics, and the number of files successfully downloaded. The data includes the total number of uploaded files, the number of successfully uploaded files, and the total number of downloaded files. To support large capacity, FastDFS uses a packet storage method. A cluster consists of one or more groups. The total storage capacity in the cluster is the sum of the storage capacities of all the groups in the cluster. The relationship between groups is independent of each other. A group is composed of one or more servers. The files in the storage servers in the same group are consistent, which plays a role of redundant backup and load balancing.

The advantages of using group storage are flexibility and controllability. For example, when uploading a file, the client can directly specify the group to upload. When the storage pressure of a grouped storage server is high, you can add storage servers to the group to expand the service capacity. When the system capacity is insufficient, you can add groups to expand the storage capacity. With such a group storage method, you can use FastDFS to manage files, and use mainstream web servers, such as Nginx, to download files. Although the Tracker Server is the control center, the number can also be multiple, and there is a peer relationship between the multiple. The master in the traditional master-slave structure is a single point, and the write operation is only for the master. If the master fails, the slave needs to be promoted to master, and the implementation logic will be more complicated. Therefore, compared with the master-slave model, each node of FastDFS can be the master, and there is no single point problem whether it is a tracker server or a storage server.

Due to the advantages of low cost and high availability of cloud computing and distributed storage, this paper designs a diagnosis platform of obstetrical imaging based on cloud computing technology. Next, the paper focuses on the specific design of the obstetrical imaging diagnosis platform.

III. OBSTETRIC IMAGE DIAGNOSIS PLATFORM BASED ON CLOUD COMPUTING TECHNOLOGY

The traditional obstetric image storage system mainly uses the high-performance local server centralized storage to store. Although its data storage and transmission performance is relatively strong, its expansion performance is poor. As the amount of data increases, server capacity expansion is inconvenient. Cloud computing-based distributed storage systems have strong scalability and are suitable for storing massive amounts of data. Nevertheless, it is not suitable for the storage of a large number of small files, which will reduce its storage performance. Therefore, this paper first uses the distributed file system FastDFS to change the storage format of medical images. Then, by combining with traditional storage systems, design a hybrid storage architecture that combines distributed storage with centralized storage. Finally, contrast

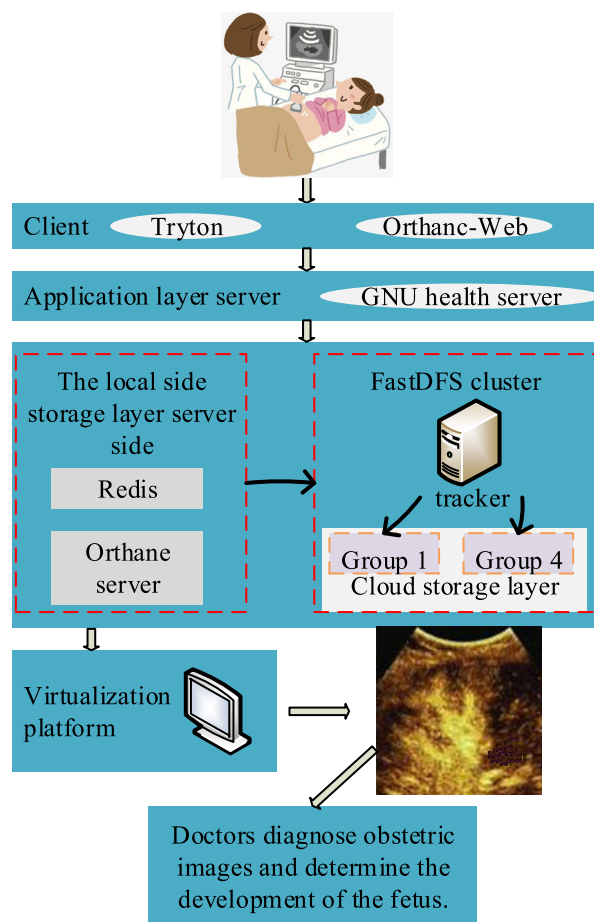


FIGURE 4. Storage architecture design of medical obstetrics image based on cloud platform.

ultrasound was used to compare the subtle changes in the two-dimensional image of the placenta before and after the contrast agent contrast, to provide a more accurate ultrasound image for assessing the structure, size, location, and presence of abnormal development of the placenta.

A. STORAGE OF OBSTETRIC IMAGES

Based on long-term research and actual inspection, and combined with the status of the use of domestic medical imaging systems, the design of the medical obstetric image storage architecture based on the cloud platform is shown in Figure 4.

According to the traditional domestic model for managing various information data of hospitals, this architecture consists of an application layer, a storage layer, and a platform layer. The application layer is composed of the client of the HIS system and the PACS system, and is responsible for providing the user with the operation interface, information management, obstetric image viewing, and obstetric image diagnostics. The storage layer is a two-tier storage model on the local side and in the cloud. The local end consists of a HIS server and a PACS server. It can be built on the local server and is responsible for storing and managing the hospital's structured information data and recent obstetric imaging data. A FastDFS large-scale distributed cluster constructs the

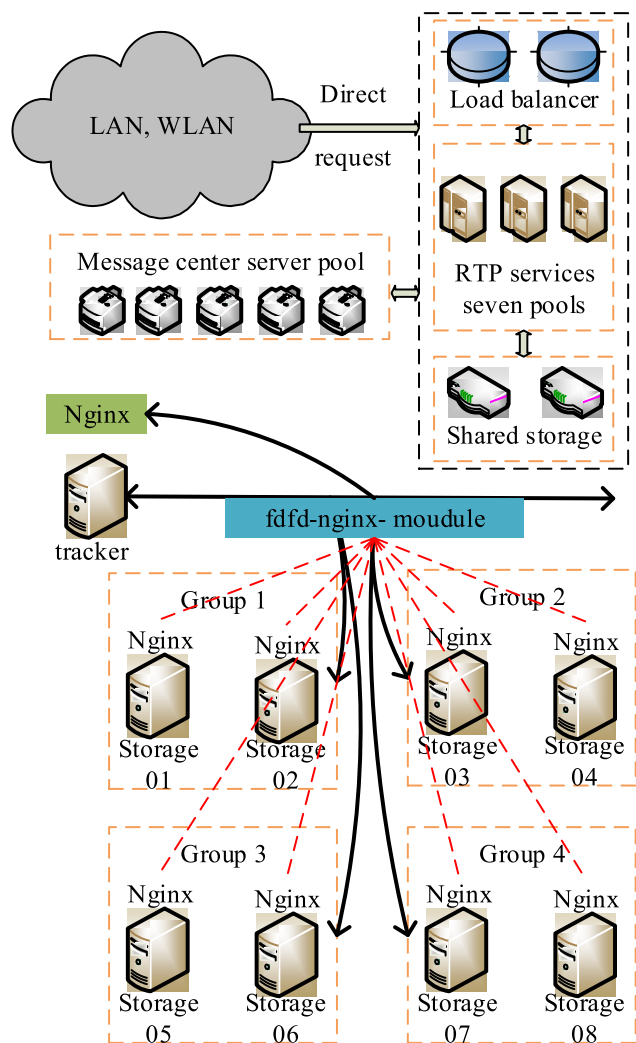


FIGURE 5. Cluster design.

cloud, which is responsible for the permanent storage of long-term files. The data in the storage layer is uploaded by the user and will be periodically uploaded from the local end to the cloud. The cluster design is shown in Figure 5. The platform layer is a virtual platform built on the infrastructure implemented by virtualization technology, and it is convenient to provide cloud services by using server resources reasonably and effectively.

The cluster consists of nine nodes, of which only one Tracker Server is selected as the coordinating node of the other eight Storage Servers. Each two storage nodes are used as a group of four groups and each group is backed up to effectively improve the data disaster tolerance problem. Whenever there is an operation to store data, the startup status and storage status of each group will be reported to the Tracker Server node, and data will be transmitted according to the capacity of each group, but the data will only be transmitted to a source data server in the group. After the upload is completed, perform intra-group synchronization, but this synchronization takes time. Once there is access to the storage server node that has not been synchronized,

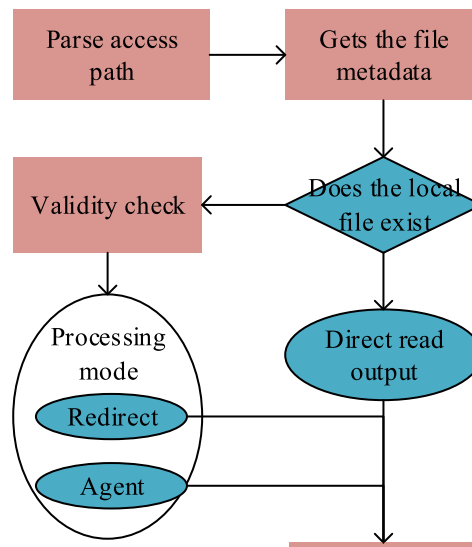


FIGURE 6. FastDFS download process.

data cannot be obtained. In order to avoid this problem, this article the mainstream web server is built on the nodes, named Nginx.

Nginx, as an anti-proxy server, solves the synchronization delay problem of storage. Nginx and the FastDFS extension module FDFS-Nginx-module are deployed on each storage server. When the storage node cannot find the file, it will initiate a redirect or proxy action to the source storage server. This avoids the problems of replication delay between storage. The download process after building Nginx is shown in Figure 6.

Cache technology is used in dynamic applications to reduce the database load. By caching data and objects in memory, the number of database reads is reduced and the access speed is improved. Applications can store frequently accessed data and data that requires significant processing time to create in memory, thereby improving performance [52].

This article uses a memory-based cache system, Redis, as a memory-based key-value database system. Due to its rich data structure, multi-language API, and memory-based and persistent properties, it has a wealth of applications scene [53]. Traditional obstetric cache systems cache systems of image picture tend to cache the obstetric image pictures obtained by users in local memory or disk. When the user requests the same picture again, it returns directly from the local memory or disk, thereby reducing the access pressure of the storage node of background object. This article will combine the distributed file system FastDFS and the cache database Redis to improve the quality of multi-user concurrent query service in the medical obstetric imaging diagnostic system.

Redis provides a rich data structure, as shown in Figure 7. It includes simple dynamic strings, double-ended linked lists, dictionaries, compressed lists, integer collections, and more. However, Redis does not directly use these data structures

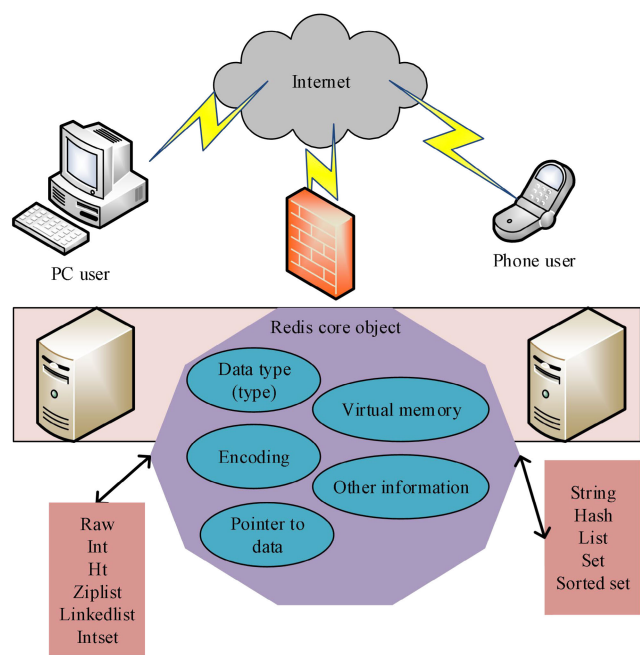


FIGURE 7. Implementations of different Redis data types.

to implement a key-value pair database. Instead, it creates an object system based on these data structures. This system includes string objects, list objects, hash objects, collection objects, and ordered collection objects. Five types of objects. The advantage of using objects is that this article can set a variety of different data structure implementations for objects for different use scenarios, thereby optimizing the use efficiency of objects in different scenarios.

B. OBSTETRIC IMAGES USING ULTRASOUND CONTRAST AGENTS

1) RESEARCH OBJECT

From May 2018 to August 2018, 20 pregnant women requiring labor induction were randomly selected to participate in the trial, and all participants volunteered and signed informed consent. Among them, 16 pregnant women needed medical induction due to abnormal fetal organ development or fetal chromosomal abnormalities, 1 pregnant woman induced severe thyroid dysfunction due to her own complications, and the remaining three pregnant women needed induction due to social factors.

2) THE PROCESS OF ACQUIRING IMAGES

An experienced ultrasound physician trained in standardized inspection techniques, two clinicians, and a nurse performed the trial. The ultrasonic diagnostic instrument used is the IU-22 diagnostic instrument produced by Royal Philips Electronics of the Netherlands. The C_{s-1} abdominal convex frame probe configured with the diagnostic instrument is used.

Before starting the test, set the ultrasound diagnostic probe frequency to 3.5-5.0MHz and the control mechanical index to 1.2. First, a routine ultrasound scan of the subject was performed, and a two-dimensional ultrasound scan of

the placenta was acquired to determine the position and size of the placenta. Then scan all parts of the fetus and myometrium. Moreover, collect images through this platform. Then, the nurse established a venous channel for the test subject, placed an indwelling needle, and the clinician took 5 ml of physiological saline and injected it into a bottle of samovar, shaking vigorously. The microbubbles and physiological saline were thoroughly mixed, and 2.4ml of the microbubbles that were shaken was drawn with an empty needle for later use. The nurse injected contrast. Compare and analyze the collected images before and after the contrast to determine whether the use of contrast agent can make the structure of the placenta clearer, and whether it helps to improve the accuracy of the diagnosis of placental disease.

The image acquisition starts from the observation that the contrast agent develops at the placenta and continues until the contrast agent completely subsides. Throughout the experiment, the ultrasound doctor has always placed the probe on the abdomen of the mother and constantly changed the direction and position of the probe. Nevertheless, without changing the frequency of the probe, carefully observe the contrast and diffusion of the contrast agent in the myometrium, placenta, and fetus. At the same time, observe whether pregnant women have adverse reactions to the contrast agent during the imaging process.

C. DENOISING OF OBSTETRIC IMAGES

In the process of digitally transmitting obstetric images, interference with peripheral equipment, software platforms, and human operations often causes the images to be blurry or distorted at the edges. Most of the images collected by the probe contain noise. In order to facilitate the human eye to observe and analyze the image and reduce noise interference, it is important to provide image quality, which requires denoising processing on the image.

Various noises in the image not only reduce the quality of the image, but also cause the image to be blurred, failing to highlight important details and features, which will cause confusion in the analysis of the image, affect the doctor's observation of the diagnosis result, and cause the diagnosis result to be inaccurate. In order to eliminate the mixed noise in the image, filter technology is used to improve the image quality and enhance the image details. Since the filtering method only needs to post-process the image through the image-processing algorithm, without changing the hardware facilities, it is a very effective denoising algorithm. This article chooses the mean filtering method.

Mean filtering is a linear filtering, which can effectively eliminate Gaussian noise. The basic principle is to take the average value of the neighborhood pixel of a certain point in the image or sequence and use it to replace the pixel value of each point in the original image. For example, select some pixels around the current pending pixel point (x, y) , and the mean grayscale value of some pixels is the grayscale value of the current pixel point (x, y) . The mean filtering formula is

shown in formula (1).

$$g(x, y) = \frac{1}{m} \sum f(x, y) \tag{1}$$

where m is the number of all pixels in the neighborhood.

In terms of eliminating noise, the mean filtering method is simple and easy to understand, and the calculation is fast, but this method will blur the image. The larger the selection range of adjacent areas, the higher the image blurring degree. The threshold neighborhood method can effectively solve this problem. The method uses a fixed height and width window to slide the image and sequentially calculate the neighborhood gray average between the pixels to be processed in the window. The gray value of the pixel to be processed is subtracted from the average value. If the difference exceeds a predetermined threshold value, the average value is used as the gray value of the pixel at the processing point; otherwise, the gray value of the pixel is kept unchanged. The arithmetic expression of this method is shown in formula (2).

$$g(x, y) = \begin{cases} \frac{1}{M} \sum f(x - m, y - n) & |f(x, y) - \frac{1}{M} \sum f(x - m, y - n)| > T \\ f(x, y) & |f(x, y) - \frac{1}{M} \sum f(x - m, y - n)| \leq T \end{cases} \tag{2}$$

T is a predetermined threshold, and the selection of the threshold needs to be determined according to the actual situation.

To sum up, the obstetrical imaging diagnosis platform based on cloud computing technology has been designed. Next, we verify the validity of the proposed platform through subjective and objective experimental results.

IV. EXPERIMENTS AND RESULTS

A. ANALYSIS OF OBSTETRIC IMAGING DIAGNOSIS RESULTS

This article compares the results of the images after the injection of contrast agents with the ordinary images, thereby verifying that this article can diagnose the obstetric imaging images obtained by injection of contrast agents, which can help doctors improve the accuracy of diagnosis.

As shown in Figure 8, obstetric image images of the placenta and fetal part injected with a contrast agent and without a projection agent, respectively. It can be seen from Figure 8 that the placenta of the ordinary two-dimensional image obtained through the obstetric imaging platform of cloud computing technology presents a relatively heterogeneous echo area. The echo intensity of the entire placental tissue is relatively consistent, there is no obvious echo difference, and the fine structure of the placenta cannot be distinguished. In the normal scan images, the changes of the uterine muscular layer and the placental echo intensity are similar. There is no obvious contrast. The decidua plate shows a high echogenic band, and the image effect is poor. After the contrast agent is pushed in, the contrast image obtained

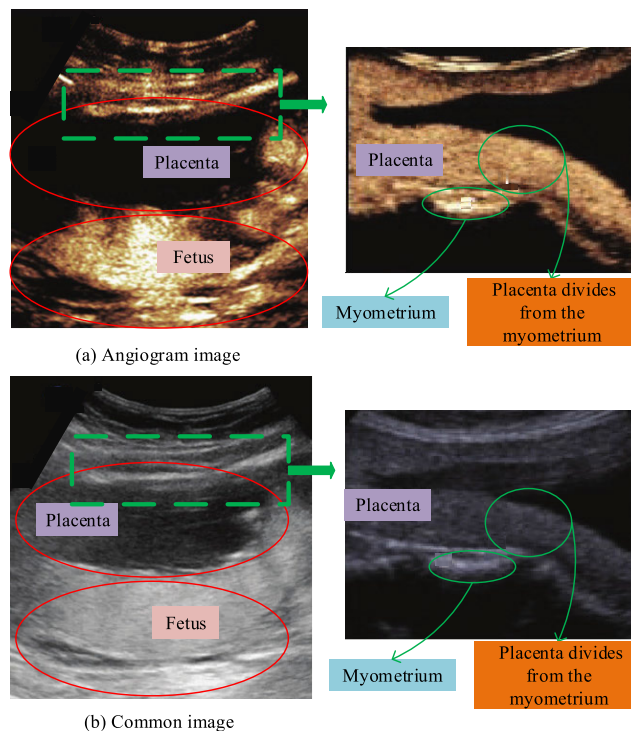


FIGURE 8. Obstetric image comparison of placenta with and without contrast injection (15 weeks gestational age).

through the obstetric imaging platform of cloud computing technology clearly shows that the placenta has a high echo, and a relatively clear image can be obtained. Therefore, based on the clear images obtained by the platform, the relationship between the placenta and the muscular is attachment site can be judged, and there are no abnormal diseases such as placental adhesion and placental implantation.

Further, in order to verify the results of obstetric imaging diagnosis, the fetal development at 28 months of gestation was observed. Results are as shown in Figure 9, from the observation that the contrast agent is developed in the myometrium, placental tissue and other parts to complete regression; the entire fetal part of the normal image shows low echo or even no echo. However, the contrast image of the fetal umbilical wheel shows contrast agent development in the skin, and a hyperechoic area similar to that of the placenta is displayed, which can provide doctors with clearer obstetric images.

Therefore, the cloud computing-based obstetric imaging diagnostic platform proposed in this article can provide doctors with clearer obstetric images, thereby diagnosing better fetal development and further improving the accuracy of doctors in determining fetal development.

B. IMPACT OF CACHE ON READ AND WRITE PERFORMANCE OF OBSTETRIC IMAGES UNDER SINGLE-THREADED LOAD

This article first simulates a doctor's visit to a maternal image file in a single thread. A series of patient examinations often produces multiple images. Therefore, there are often multiple

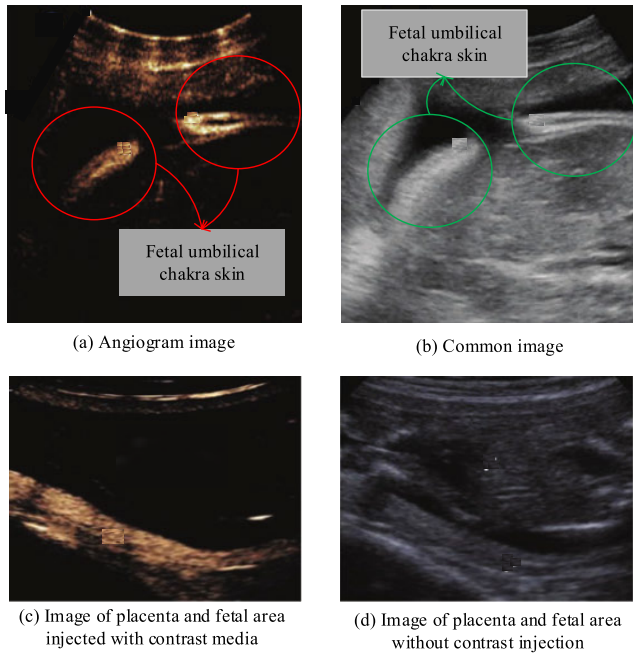


FIGURE 9. Obstetric image comparison of placenta and fetal area with contrast agent injected and without projection agent (gestational age 28 weeks).

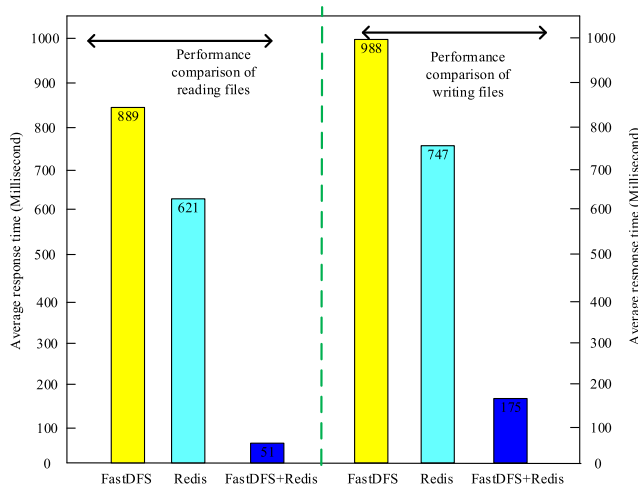
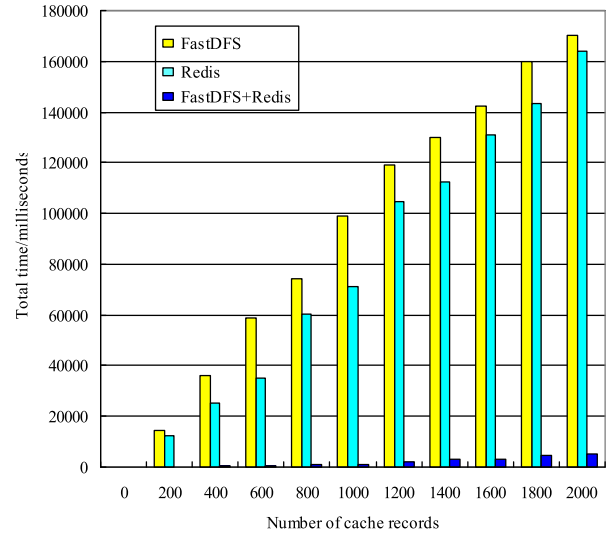


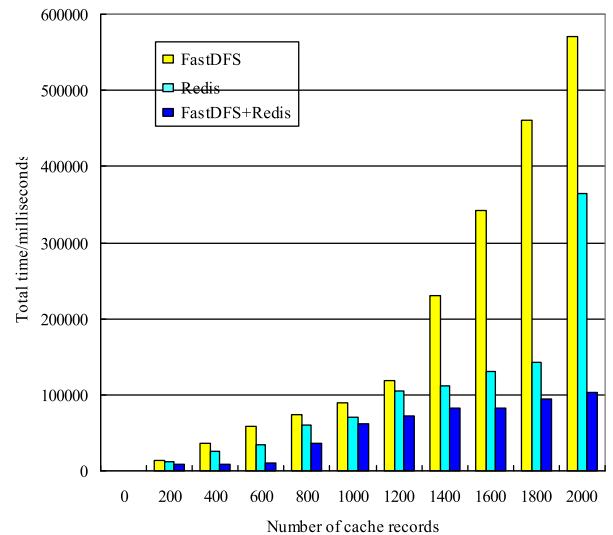
FIGURE 10. Performance comparison of single-threaded access to a single maternal image file.

image files of a patient. This article has stored the mapping relationship between the patient and the corresponding file collection in Redis. The following article reads all the files of a patient from the non-cache system and the cache system for performance testing.

As shown in Figure 10, the vertical axis represents the response time of the system. A single thread accesses all the files of the mother. The FastDFS response time is 899ms, which is a second-level response. The response time after joining Redis is 33ms. The response time is about 20 times higher than FastDFS, and the response time is increased to the millisecond level.



(a) File writing performance comparison



(b) Performance comparison of reading files

FIGURE 11. Read and write performance comparisons for all image files accessed by a single thread.

Further, this paper tests the performance comparison between non-cached system and cached system under single-threaded reading and writing of multiple maternal image files. This article selects ten women, a total of 2000 image files, a total of 1G data, compared the system read and write time with and without cache. That is, directly perform read and write performance tests on FastDFS and Redis with FastDFS, respectively. This is shown in Figure 11.

This article uses a bar chart to visually compare the read and write times of FastDFS and Redis with FastDFS. As shown in the Figure 10 and Figure 11, the time taken to read data from non-cached systems and cached systems is far greater than their write time, which may be affected by network transmission delay factors.

In addition, it is obvious that the read and write times of FastDFS are higher than the read and write times of Redis with FastDFS. FastDFS write time is about 3.1 minutes,

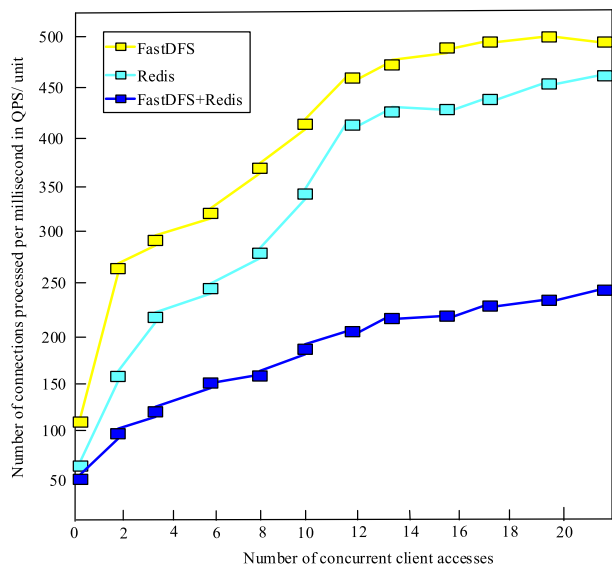


FIGURE 12. QPS comparison of systems in multi-threaded environment.

which is 16 times that of Redis. Redis with FastDFS is 12 seconds. It can be seen that although there are time-consuming operations such as serialization and metadata writing, Redis directly stores DICOM images at a very fast speed. The read time of FastDFS is 12 minutes, which is about 4.5 times that of Redis with FastDFS. The read time of Redis with FastDFS is 2 minute.

C. THE EFFECT OF CACHING ON READ AND WRITE PERFORMANCE UNDER MULTI-THREADED LOAD

In reality, multiple doctors access maternal image files. Based on this, we use multi-threaded technology to simulate a doctor’s concurrent access to maternal image files. The multi-threaded configuration of the system has been completed. We have separately set up zero to 1000 threads to perform access tests on Redis with FastDFS and FastDFS respectively.

This article uses a linear graph to compare visually the QPS of a cache-less system and a cached system under different concurrency numbers. As shown in Figure 12, both Redis and FastDFS have good performance for concurrent access. When the amount of concurrency reaches more than 100, the QPS of the system increases linearly with the increase in the number of concurrency. However, FastDFS shows a downward trend between 0-50. In addition, after the increase for concurrency, QPS increased significantly less than Redis with FastDFS. This article analyzes that in addition to transmission delay factors, FastDFS’s synchronization mechanism also affects concurrent processing.

In addition to focusing on QPS indicators, we also care about the system’s CPU utilization when facing high concurrent access. Next, we will compare the performance of cached and non-cached systems from CPU utilization. It can be seen from Figure 13 that as the amount of concurrency increases, the system utilization CPU continues to increase. However, the performance after joining Redis is very good. For the

TABLE 1. Comparison of system performance under different records.

Number of cache records	Time/ms	Cache hit ratio	Redis footprint
2256	301	0.121	885.06M
2618	312	0.304	915.08M
2815	395	0.902	978.58M
3177	412	0.751	1.105G
3581	432	0.149	1.205G
3751	398	0.105	1.115G
3952	451	0.136	1.125G
4102	467	0.137	1.257G
4158	358	0.158	1.315G
4322	367	0.167	1.325G
4501	337	0.188	1.365G

highest 1000 concurrency, the CPU resource consumption is also only 3%, which shows that Redis is very suitable for dealing with high concurrency operations. FastDFS performs well with concurrency levels below 100, less than 4%. Nevertheless, after the amount of concurrency reached 1000, FastDFS’s CPU utilization reached 16%. This shows that FastDFS consumes more CPU resources for highly concurrent operations than Redis with FastDFS. Nevertheless, within the controllable range, it will not affect the availability of the system, and it is not realistic to use memory Redis to store a large amount of data.

Therefore, the experiment shows that the integrated storage of FastDFS and Redis, Redis as the cache to store image data, and FastDFS storage of non-image data is a very good solution to cope with the high concurrency of medical image storage by a large number of different maternal images.

D. CLUSTER PERFORMANCE ANALYSIS OF OBSTETRIC IMAGING DIAGNOSTIC PLATFORM

We stored all the remaining 49G data in FastDFS and tested the performance of the obstetrical imaging diagnosis platform proposed in this paper through multi-threaded access. First, we need to determine how many key substitutions Redis should achieve in our configuration.

According to the comparison of system performance under different records in Table 1, when the number of caches is around 2500, the time is around 305ms. When the number of caches is around 3000, the time is around 405ms, and the cache-hit ratio is greatly improved. As the number of caches increases, so does the time spent, and the cache-hit ratio varies from high to low. When the cache is not full, only the files accessed are put into the cache, which not only increases the access time and memory load of Redis, but also has randomness in the hit ratio. When the cache was set to reach about 3500 keys, we swapped out the last data, and the cache was controlled at about 1.39g. The cache-hit ratio was stable between 11 and 14 and time was stable between 376ms and 395ms compared with the previous method. Therefore, we specify that the cache is full after the number of keys in the cache reaches 3500.

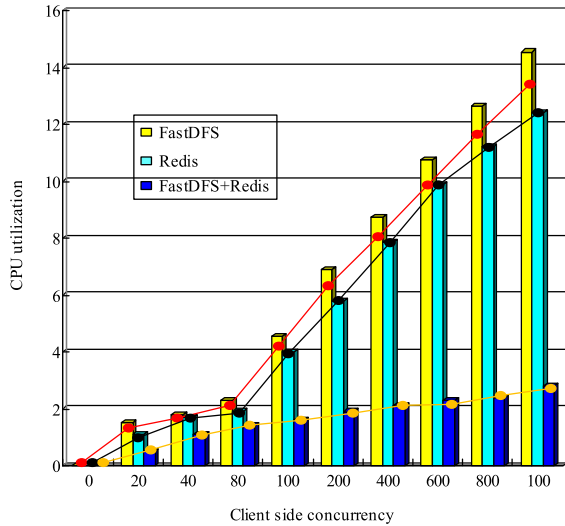


FIGURE 13. Comparison of CPU utilization in a multi-threaded system.

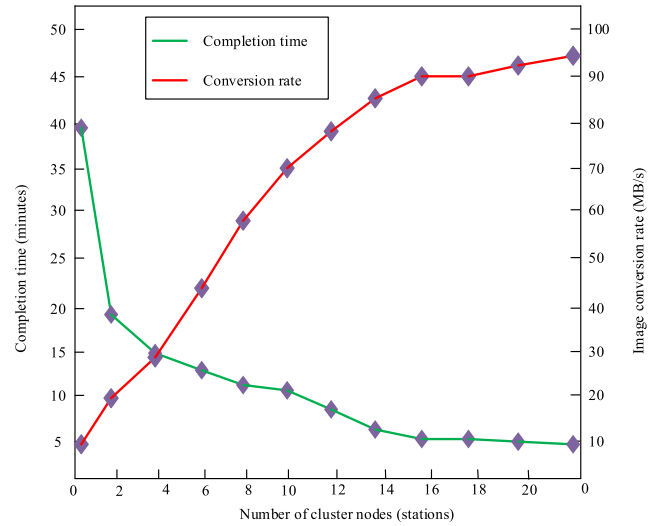


FIGURE 15. Number of cluster nodes and image conversion performance.

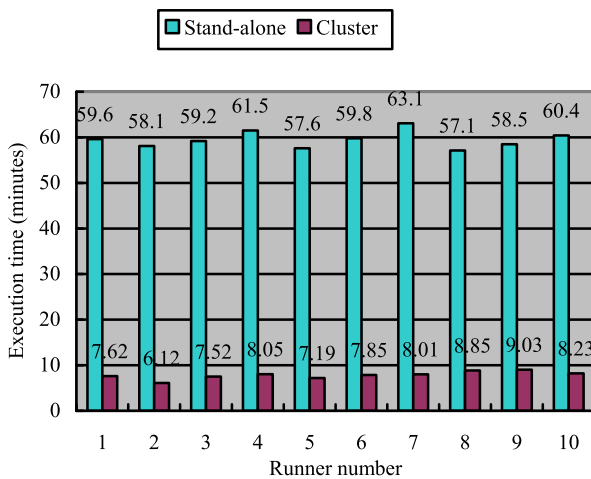


FIGURE 14. Performance comparison between standalone and cluster.

We tested the performance of converting images to JPEG on a single computer and a cluster of 16 nodes. The test data were obstetrical imaging data of 10 days. The total number of images is 98,000. The data volume is 50.9GB in total. There were 16 cluster nodes, and 10 tests were carried out for each single machine and cluster. The test results are shown in Figure 14.

The test results show that it takes 6 to 7 minutes to convert about 50GB images in a cluster of 16 nodes. The single-machine execution takes nearly an hour, and the performance of the cluster is much higher than that of the single-machine program. However, the cluster performance of 16 nodes is not 16 times that of a single machine. In our test environment, it was only 8-9 times. The main reason is that the communication between cluster nodes and the access of intermediate result data take time.

In order to test the effect of the number of cluster nodes on the transformation performance of obstetric image,

we adopted the method of reducing two nodes each time and taking the average value of each test for 10 times. The amount of transformed data was the same as the above example, with 98,000 obstetric images and a total of 50.9GB of data.

As the number of nodes is reduced, the number of copies of cluster data blocks will be insufficient, and the cluster will automatically start the data replication process in the background to ensure that the system sets the requirement of three copies of each data block. The data replication process can impose significant network overhead and disk load on the cluster. In order to prevent the background data replication process from affecting the test data, we confirm that the cluster completes the replication after each node reduction, and then conduct the test after reaching the stable state. The test results are shown in Figure 15.

It can be seen from the test results that with the increase of the number of nodes, the image conversion rate increases approximately linearly with the number of nodes. In addition, compared with the previous experimental results, we can see that the performance of the two-node cluster in processing 40GB of data is only slightly higher than that of the single-machine conversion program, and the performance of the single-machine version of the program performance of a single node is still a certain gap. The reason is that the cluster's own heartbeat detection and metadata storage will increase the load on the system.

V. CONCLUSION

This paper proposes an obstetric image diagnosis platform based on cloud computing technology. First, a medical imaging platform was designed by combining cloud computing technology, caching technology, and a distributed file system. Secondly, by using contrast-enhanced ultrasound technology, more accurate ultrasound images are provided for assessing the structure, size, location, and presence of developmental abnormalities in the placenta. Finally, the effectiveness of

the obstetric imaging diagnostic platform proposed in this paper is verified by experiments. The platform has fast data processing speed and easy to use. The platform proposed in this paper can use digital image processing software technology to process audiograms, which is conducive to improving the quality of audiograms. The hospital only needs to collect the obstetric image of the patient at the front end, transfer it to the cloud for image processing, and finally diagnose the disease. Greatly reduced the cost of medical equipment and improved efficiency. At the same time, a sufficient reference information database is provided to improve the accuracy and reliability of the diagnosis.

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