Research on Design of Distributed Storage Architecture for Regional Medical Images Based on Network Environment

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Abstract: Based on the Basic Research of Distributed Storage Technology and the Purchasing Situation of Medical Image Storage, This Paper Analyzes the Problems of Hadoop Technology in Constructing Regional Medical Image Storage Platform. an s-Dicom File Format Suitable for Hdfs and a Unified Storage Architecture Combining Centralized Storage (Fc San) and Distributed Storage (Hdfs Cluster) Are Designed. a Set of Sdfo(s-Dicom File Operator) Middleware is Developed to Provide Transparent Storage Access Interface for Pacs Application Components in the Upper Layer. the Pjeg2000 Compression Technology is Introduced and Combined with Large Databases to Realize Intelligent, Stable and Efficient Storage Management. It Has Effectively Solved the Current and Future Needs of Pacs in the Hospital Imaging Center for Large/Super Large Capacity Medical Image Data Storage.

1. Introduction

In Recent Years, with the Increasing Importance of Telemedicine, the Role of Regional Medicine Has Gradually Become Clear and Strengthened, While Image Data, as an Important Basic Data in the Process of Disease Diagnosis and Treatment, Plays a Remarkable Role in Regional Medicine [1]. At the Same Time, the Imaging Diagnosis is Difficult, Complicated and Professional, and the Primary Hospitals Are Extremely Short of Excellent Imaging Diagnosis Talents. the Imbalance between Medical Equipment and Talents is Also an Important Reason for the Current “Difficulty and High Cost of Medical Treatment” [2]. Medical Image Storage and Transmission System is a Combination of Radiology, Image Medicine, Digital Image Technology, Computer Technology and Communication Engineering Development. It is an Information System That Comprehensively Solves the Extraction, Display, Storage, Transmission and Management of Medical Image Data. It Mainly Uses Computer-Aided Diagnosis and Storage to Replace the Traditional Film Method, and Directly Stores the Patient's Image into the Computer through the Interconnection between the Computer and Digital Medical Equipment. and Can Use Computer Image Processing Technology to Make the Image Clearer [3]. Building a Regional Integrated Medical Cooperation Platform is an Important Way to Balance Medical Resources, Improve the Diagnosis and Treatment Level of Primary Hospitals and Realize “Orderly Medical Treatment”. the Construction of Regional Medical Image Cooperation Platform is an Important Part of Regional Medical Cooperation, But There Are Still Great Challenges in Technology and Cost to Construct Regional Medical Image Cooperation Platform [4]. This Paper Mainly Introduces the Design and Implementation of a Storage Architecture Combining Distributed Storage Based on Hadoop Platform and Traditional Centralized Storage (Fcsan).

2. Introduction to Hadoop Platform

Hadoop is One of the Most Widely Used Open Source Distributed Storage and Computing Platforms. It is an Open Source Platform Developed According to Google's Gfs Distributed File System and Map/Reduce Distributed Computing Technology. Its Design Goal is to Build a Large-Capacity, High-Performance, Highly Reliable Distributed Storage and Distributed Computing Architecture on a Common Hardware Platform [5]. We Use the Characteristics of Traditional Centralized Storage, Which is Suitable for Fast Reading and Writing of Small Files, to Form a

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Storage Architecture Combining Centralized Storage and Distributed Storage, That is, to Store a Small Amount of Medical Images Commonly Used in Recent Days [6]. the Storage Resources in the Network Can Be Randomly Scheduled, and the Scheduling Process is "Transparent", and the File System Access Interface is Provided to the User, Thus Solving the Limitation Problems of the Local File System in File Size, Number of Files, Number of Open Files, Etc. the Integrity of Medical Image Data and Related Information to Ensure That the New Images Collected by Pacs System Are Stored in the Human System Completely and without Errors. However, after a Period of Time, the Data with Low Utilization Rate Are Stored in a Distributed Manner, Thus Not Only Completing the Storage of Massive Data But Also Meeting the Clinical Real-Time Requirements [7]. Hadoop Has Been Widely Used in Yahoo, Facebook, Amazon, Baidu, China Mobile and Other Companies.

2.1 Characteristics and Applicability of Hadoop Cluster

Hadoop HDFS distributed file system has the following characteristics: it is very suitable for mass data storage and processing; The scalability is high, and the linear growth of storage capacity and computing power can be realized by simply adding the number of servers. Data redundancy is high. By default, each data is backed up on 3 servers. It is suitable for "streaming" access, i.e. write once, read many times, with little modification after data is written, which is very suitable for the characteristics of medical image files [8]. Make it suitable for distributed storage. We use H -H-DICOM, a serialized medical image file format, to merge the images generated by patient examination into a large, ordered file in the form of Key/value key-value pairs to meet Hadoop storage requirements. According to the information distributed tree structure, the image data and related information are analyzed and stored in the online storage device [9] through the server. The data management module stores the image data in the online storage area in the form of files, and stores relevant information in the central database at the same time. The dynamic domain name system (DNS) combined with the interface IP virtualization technology and the object index node are adopted to better solve the problems of data addressing and fault tolerance, facilitate the scalability and data management of big data, and also have good guarantee for data security. In addition to the data storage capacity, Hadoop Map Reduce distributed computing framework can also make full use of the computing resources of each server CPU, which is convenient for later image fusion based on massive medical image data.

2.2 Existing Problem

Hadoop still has the following problems when constructing medical image storage systems: Hadoop's design concept is optimized for large files, and its default block size is 64 MB, while the image sizes of CT and MRI commonly used in medical image data are mostly about 512 KB [10]. It is much smaller than Hadoop's default 64-in IB block space. Once a large number of such small files are stored, the performance of the entire cluster will be degraded due to too much metadata. In clinical application, the real-time requirement of image data is high, while Hadoop's reading and writing performance is slow, which is not suitable for high real-time requirement. If these large number of small files are directly stored in HDFS file system, too many small files will cause the memory consumption of the HDFS master node Name Node to be too large, which will reduce the performance of the entire cluster.

3. System Design

To solve the above problems, we have designed a serial DICOM file format (S-DICOM) suitable for Hadoop platform, and a set of S-DICOM file storage architecture combining traditional centralized storage and HDFS distributed file system.

3.1 S-Dicom File Format

Although the size of DICOM files such as CT and MRI is only about 512 KB, the examination of each part of the patient usually has 100-200 pictures, thus the data volume of each examination of each patient will reach 50-100 MB. HDFS as a whole consists of a management node Name Node and a plurality of data nodes Data Node. Name Node is unique as the core, and any operation must pass through Name Node. When the image equipment needs to acquire images from the storage system, the network communication modules IFND SCP and MOVE SCP service send the request to the storage system, and the data management module analyzes the specific query conditions according to the FIND SCP service. Data management and load balancing scheduling interacting with the basic data platform realize load balancing and management through a layer of soft interface layer, and data index management is carried out by a database server. Therefore, it is reasonable to merge all the images of a patient for one examination into one file and store them in HDFS. Firstly, a task is decomposed into multiple tasks by Map function, and after a series of calculations, the results are merged by Reduce function. A distributed system is a cluster of machines made up of many nodes, which can just take tasks apart and hand them over to idle nodes for processing. We use Hadoop's Sequence File format to convert each DICOM file into a key/value, and then merge into a separate S-DICOM file, where key is the original DICOM file name and value is the DICOM file content.

3.2 Hybrid Storage Architecture

Simple HDFS distributed file system is not suitable for real-time application, but it has the characteristics of low cost, high scalability, high performance and high reliability. Traditional centralized storage (FC SAN) is very suitable for fast reading and writing of small files. The core is H-DICOM File OPerator, whose main function is to provide operation interfaces for upper-level applications while shielding detailed operations at the bottom. HDFO is mainly composed of five parts: positioning module, reading module, writing module, conversion module and customer module. Usually TB is used as the unit, so the storage structure adopts multi-level distributed technology for storage management. Based on a variety of storage devices, scientific distribution of image data in CS data stream is realized. Various applications provide open interfaces, which can be provided to authorized users for application combination and integration to form a new application path layer on top of the standard application layer to achieve application expansion. The core of SDFO is mainly composed of five parts: SDFO Locator, SDFO Reader, SDFO Writer, SDFO Converter and SDFO Client. SDFO Locator is used to retrieve the storage location of DICOM files and SDFO Reader is used to read DICOM files. The function of the writing module is to write the images from the image equipment into the centralized storage system, while the conversion module will periodically convert the images in the centralized storage system into H-DICOM format and store them in HDFS after merging. , SDFO Converter is responsible for regularly converting DICOM images in FC SAN into S-DICOM format and storing them in HDFS after merging. Its system framework (Figure 1).

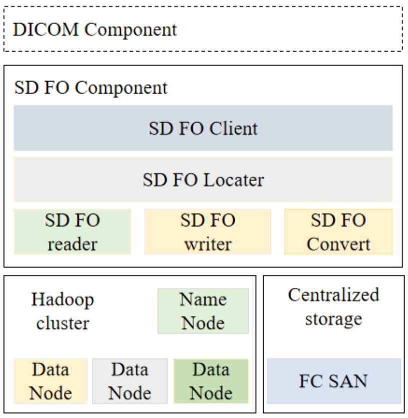

Fig.1 System Framework

3.2.1 Image Reading Process

SDFO's process of retrieving and reading images from Hadoop HDFS cluster and FC SAN

(Figure 2).

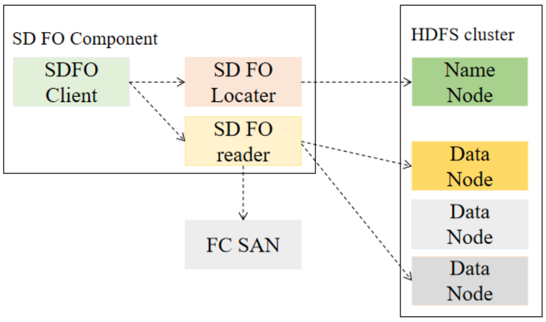

Fig.2 Image Reading Process

Obtain the path of image storage from DICOM Locator. If the image is stored in FC SAN, skip to step 6. It is usually stored by optical disk and magnetic tape, and its storage capacity is theoretically infinite. The continuous storage and expansion of NAS system basically ensures the integrity storage of image data, but in order to prevent accidents, offline data storage is also essential. Calling SDFO's read method to start acquiring images; Obtaining the first data block from Data Node 1 of HDFS, and so on to other data blocks, this step can be operated in parallel; An open application interface API provides a module interface for network or business execution. It can be used by a wider range of developers to quickly integrate different modules by calling various functions provided by the Open Application Programming Interface (API) to build new applications. The offline storage medium we choose is magnetic tape, because the cost of magnetic tape is the lowest among all backup media, the speed is at the medium and upper level, the storage time is longer, and it has higher cost performance. DICOM files stored in FC SAN are directly read through JAVA's local file system interface.

3.2.2 Image Writing Process

The writing method of DICOM files in SDFO middleware is the same as the traditional file writing method, directly writing to FC SAN through JAVA local file system interface. After receiving the query request from the client, analyze the query information to determine its query level and the approximate location of the information stored in the database. Open standardized interfaces for data access, application access and programming development, allowing third parties to develop their own services on the service platform and provide services to users. For image query, the idea of breadth query is used to query online, near-line and offline storage areas in chronological order, and the query results are fed back to the client in time.

3.2.3 Image Conversion Process

The image conversion process periodically merges DICOM files in FC SAN into S-DICOM files and stores them in HDFS. The newly stored image has not been backed up, so it is added to the backup queue. The backup system will back up the image data in the backup queue to the near-line storage area and update the near-line database according to the backup strategy set by the user. In order to save storage space, the image is compressed while being backed up. In medical images, usually the lesion area has different gray values compared with other normal tissues and background areas, thus making the gray histogram corresponding to the image appear double peaks. Calling JAVA's local file system interface, cyclically acquiring a file list under a folder in FCSAN (all images of each patient for each examination are stored in a separate folder), converting each DI-COM file into a key/value pair, and sequentially writing the key/vlaue key pair into a separate S-DICOM file data stream; As the backup process needs to take up certain system resources, we set the backup time at night or at a time when users have relatively small access to the system, so as to avoid resource shortage and affect the access speed of users. The integrity of online data can be ensured by relocating the image data in NAS system back to online storage equipment. If the image data of NAS system is unexpected, offline data in magnetic tape can be transferred back to Nperson S system to ensure the integrity of image data of N-garment S system.

4. Application Test Effect

4.1 Hardware and Software Configuration

We have now built a Hadoop cluster of 20 servers. CPU:Intel Xeon E5504; Memory: 8 GB DDR3. Network cards: two 1000 Mbps Ethernet cards; Hard drive: 4 1 TB SATA. In addition to the main medical work related modules, it also includes the hospital's internal financial, product, group and other management modules, as well as the system administrator's related modules, user information, permissions and other settings and management functions. The image management module is mainly divided into three functions. The radiology department information system cannot directly manage all digital medical imaging equipment, so it is difficult to realize the complete digital medical treatment in the hospital radiology department. Each server is connected to a gigabit convergence layer switch and the convergence layer switch is connected at 10,000 megabytes. Operating system: 64-bit CentOS 5.4. Java environment: jdk1.6.0-b09; Hadoop platform: Hadoop 0.20.2.

4.2 Test Result

The writing of DICOM images and the reading of images within 3 months are completed directly through FC SAN, and its performance is not different from that of ordinary PACS environment. Therefore, we mainly test the performance of reading S-DI-COM images 3 months ago and merging DICOM images into S-DICOM images. The image background region is transformed by IPEGZX(X) standard high compression ratio and compressed by quantization method. For the lesion region, MAXSIHFT algorithm is used to realize the region of interest technical coding. At this time, the SCU is required to have STORESCP service, which can receive and store the acquired images. As MOVESCP, the storage system, besides handling MOVESCU requests, must also be able to send out images using C-STORE. Hadoop supports distributed reading and writing. When we tested 1~5 SDFO Client respectively, the performance of S-DICOM reading and conversion is shown in Table 1 below (unit: MB/s).

Table 1 Test Results (m B/s)

Mode	CIients quantity			
	1	2	3	4
	82.22	160.11	274.37	323.12
	10.25	15.49	26.59	30.84

From the test results, it can be seen that the reading performance of SDFO is basically linearly related to the number of Client. This is because the data blocks in Hadoop are evenly distributed in each Data Node. When reading files, the network bandwidth of each Data Node can be aggregated. With the increase of the number of DataNodes, the image coding of the region of interest sets the priority in the coding condition of the lesion region higher than that of other image regions (background), which can relatively improve the image quality. In the transmission process, the region of interest is encoded into the highest priority bit plane to achieve high image quality. According to the test results, the client can read and convert the S-DICOM file of a patient for one examination at the same time for about 1~2 s, which is negligible for PACS system operation. According to the results, combined with the actual application scene and the characteristics of medical image data, the effect of this system is very obvious, which not only facilitates the reading of images, but also improves the reading speed of recent images.

5. Conclusion

Medical imaging is one of the most common and important diagnostic bases in clinical diagnosis, and it is also the reason why PACS has developed rapidly in the field of clinical medicine. However, the safe storage of massive data has also been a bottleneck hindering the rapid development of

PACS. This paper analyzes the significance and existing problems of building a regional medical image storage platform. Through the improvement of Hadoop storage architecture and medical image file format, the key technical problems such as difficult storage of medical image data and high real-time requirements are well solved. The introduction of JPEG2000 compression technology reduces the demand for storage capacity and the cost of long-term storage of data. It can fully meet the actual needs of the hospital for image data storage now and in the future, and greatly promote the hospital to realize the complete digitization of radiotherapy. A set of SDFO middleware is developed to provide transparent DICOM file access interface for PACS application components in the upper layer. The system has achieved satisfactory results on the test platform and can meet the functional and performance requirements of large regional medical imaging centers.

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