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PACS Based on DICOM Standards for the Scalability of Research and Implementation

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Abstract

With the increasing popularity of DICOM devices, traditional medical equipment is still in a large number of applications. This paper is aimed at the shortcomings of the terminal design and expansion of the existing medical imaging system and analyze them. Complete medical imaging system based on DICOM, it also has the ability to support traditional equipment and third party software at the same time, a complete design scheme is given in this paper. We adopt a loosely coupled design between system components, data transmission uses a common XML data format and Web Service technology to achieve data transmission of distributed component. The proposed scheme has proven case to support, the system has good expansibility, it can be upgraded with the enterprise's equipment, it is compatible with old and new equipment and it greatly improve the practical and cost-effective system.

***Keywords**: medical image; DICOM standard; loose coupling; extension; Multi-layer design*

1. Introduction

With the continuous improvement and popularization of DICOM standards, most of the medical imaging equipment at home and abroad has supported this standard, DICOM protocol can output high quality medical image information, such as image, patient information, measurement data, *etc.*, it is easy to manage and develop the medical equipments [1-2]. But, there are a lot of old equipment in the domestic medical institutions, it has bad image information and image quality when using traditional video output port to output analog signal, there is no additional measurement and patient information [3-5]. The management system based on such a device needs to carry on the information management of the two times, how the system is compatible with these two types of medical equipment and supporting third party structured data, and gradually extended to the device system based on DICOM protocol. How to introduce flexible medical image management system of the different types of disease inspection data provided by different equipment manufacturers based on DICOM protocol, and how to design and consider these issues, to make the design of a system is more reasonable, more flexible, scalable, forward-looking, and the extension becomes a complete system based on the DICOM protocol, to determine the future of the system and the customer's investment return ratio [6-8].

There are also some researchers for some DICOM data transmission problems, to propose a distributed design scheme, but mainly for data transmission, image analysis of the scalability of the proposed solution, some propose storage scheme from the cloud point of view, there is not a complete PACS system from the perspective of a comprehensive model of the loose coupling [9-10].

This paper is aimed at the above problems, the loose coupling of the entire components and the components are considered in the overall design of the system, a loose coupling

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design is adopted for the processing logic of the interface and the back end. In the data transmission using a general data transmission format XML and WebService technology to achieve the loose coupling between two distributed components.

Loosely coupled design scheme achieves the lowest coupling degree between components, the loosely coupled design of data is realized by the low coupling between the components, the benefit of this is that the components can be expanded and replaced at random, the system can be used in both online and offline state, new equipment and old equipment can be expanded or deleted. The loose coupling between the components of the internal logic is achieved by the low coupling between the interface and the data logic control, the user interface can be customized to reduce the development cost of the system.

2. Systems Analysis

PACS needs to have the functions: 1) Receiving inspection data from DICOM equipment, general equipment, and the third party medical system. 2) Give diagnosis and report print. 3) Upload data to the server to provide a doctor for further diagnosis, statistics. 4) Send a report to the patient.

Medical image management system needs to design a comprehensive and flexible data interface in the system, in order to make the system have good scalability. To the uncertainties about the source of the system data, we can consider the structured data from the DICOM equipment, general medical imaging equipment and the three party system at this stage.

Medical imaging system is a comprehensive application system which is very high in load and data exchange. Comprehensive consideration of load and data exchange problems, system architecture is divided into three levels: DCIPS, DECS, DCS.

2.1. DCIPS

Data receiving medical imaging equipment(including the equipment data, video signal and third party system data based on DICOM protocol), to convert, analyze, form the data in this system, technician take a preliminary analysis of data and images, give the inspection results, *etc.*, operation can be off-line processing.

2.2. DECS

Collecting data from the terminal of each technician, to form a unified data exchange service, finally uploaded to the central server. The service integrates medical data from hospitals and even the entire city, providing online diagnosis to the attending physician, consultation support, providing decision support to the management department through the summary and statistics. These all need to be a large number of medical images and video through DECS summary, to upload to the central server step by step. DECS distributed the load of the whole system, a hospital can have multiple data exchange support center.

2.3. DCS

It includes Web server, Ftp server, database server. Functions are the online data processing, the preservation of image files and the role of query data. DCS provides online processing of cases, statistical analysis.

The three service layer finally supports the medical imaging system based on DICOM protocol, and has a very good structure.

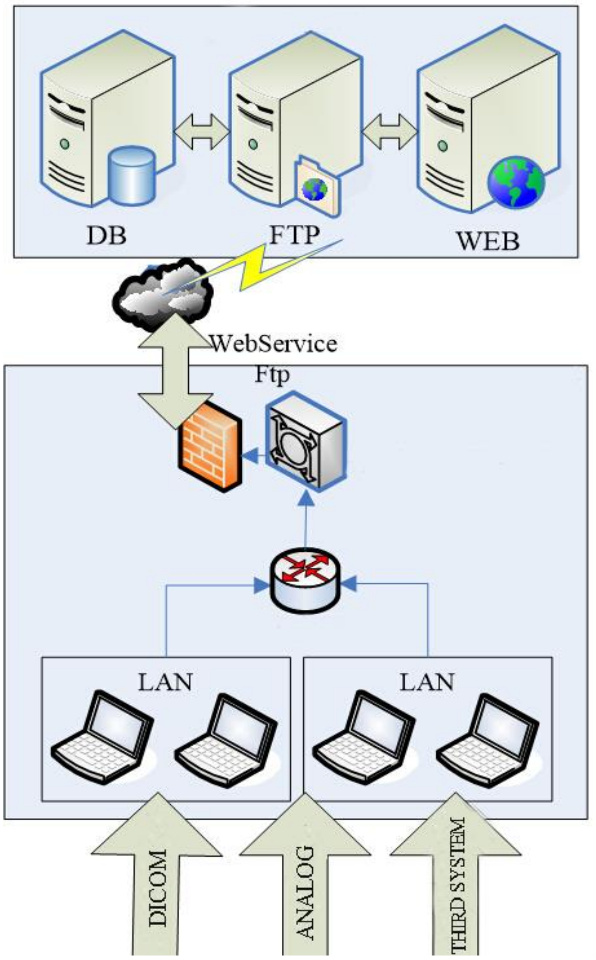

Figure 1. Three Service Layer

3. System Service Implementation

3.1. DCIPS Realization

1. DCIS

In order to enable the system to receive the device and the three party system and data, description check (Study) data format must be capable of flexible conversion and exchange, it has a very good structure to use XML to describe the system Study data structure, descriptive, expansion, exchange, it is a good expression of the data structure of Study. In order to make the data receiving system of the system have good scalability, each service is designed to be a background service (process or thread), they are based on uniform interface design, it is easy to expand the system in the future.

Each background data processing service has been designed as a periodic scheduling task (Timer/Quartz), it can be set according to the needs of the system cycle, to handle data from different aspects regularly. Each service is based on the interface IWatcherProcess, lead into Adapter Processor abstract class, it provides a convenient way to plan the task service and template for each specific Processor processor, it will execute the Process operation time, to make DicomProcessor, CommonProccessor and ThirdpartyProccessor more uniform. Each Proccessor accepts the data in their respective areas, the standard XML Study format can be identified by the formation of the imaging system through Process method to conduct data reception and XML conversion.

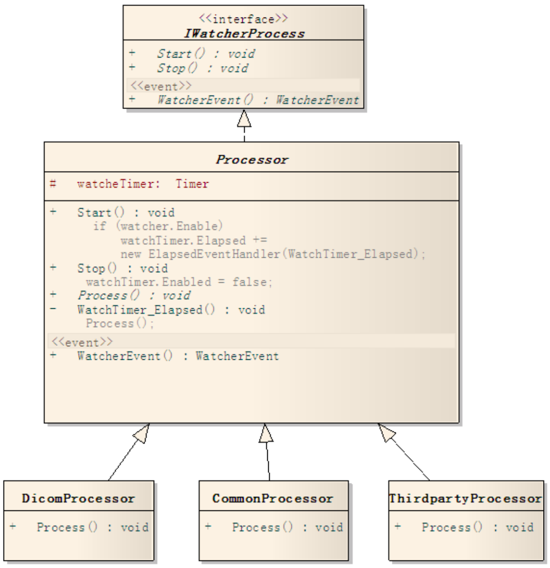

Figure 2. Data Receiving Service Class Diagram

If you want to introduce a non-periodic data interface service, it can be directly inherited from the IWatcherProcess implementation, so we can agree with the design of the system's data acquisition interface, and it has a good scalability.

XML format has the ability to describe the complex Study structure in figure 3, it is adapted to the future of complex data processing, description and expansion:

(1) PatientInfo node: Patient information, it corresponds to Patient, it is the result of the Patient class, different types of Study can have different Patient, it also has different PatientData data.

(2) StudyInfo node: Describe all Study's total information, including Id, type, technicians, priority, Study time, etc, it is the result of the StudyBase class.

(3) Report node: The data information of different Study types is described, Array, Data and List can be described in his son node, it covers all the data description types, ImageInfo node stores received image information, including single Frame, Video as well as accessory information.

Different Study types can be inherited according to the need of StudyBase to achieve their own data expansion in figure 4, system supports List<Primary>, List<Class> and Primary, it meets the complex information description of Study, it corresponds with the results of XML.

List<Frame> Frames

```
<RecordSet name="Frame" type="List">
<Record>
    <Data name="Name"
type="String">a.png</Data>
    <Data name="Thumbnail"
type="String">a.bmp</Data>
</Record>
<Record>
    <Data name="Name"
type="String">b.png</Data>
    <Data name="Thumbnail"
type="String">b.bmp</Data>
</Record>
</RecordSet>
```

List<string> Medication
<RecordSet name="Medication" type="Array"> <Record><Data type="String">Med 1</Data> </Record> <Record><Data type="String">Med 3</Data> </Record> </RecordSet>
string Procedure
<Data name="Procedure" type="String">Right AC</Data>

```xml
<?xml version="1.0" encoding="utf-8"?>
<Study version="1.0">
  <PatientInfo>
    <PatientData name="PatientName" type="String">Robert</PatientData>
    <PatientData name="Gender" type="String">Male</PatientData>
  </PatientInfo>
  <StudyInfo>
    <StudyData name="StudyId" type="String">2006051710182548036</StudyData>
    <StudyData name="StudyTypeId" type="Int32">1</StudyData>
  </StudyInfo>
  <Report>
    <RecordSet name="Medication" type="Array">
      <Record><Data type="String">Med 1</Data></Record>
      <Record><Data type="String">Med 3</Data></Record>
    </RecordSet>
    <Data name="InjectionSiteName" type="String">Right AC</Data>
    <RecordSet name="ExerciseStress" type="List">
      <Record>
        <Data name="StageOrInfusionRate" type="String">BASELINE</Data>
        <Data name="BPSystolic" type="String">60</Data>
      </Record>
      <Record/>
    </RecordSet>
  </Report>
  <ImageInfo>
    <RecordSet name="Frame" type="List">
      <Record>
        <Data name="Name" type="String">a.png</Data>
        <Data name="Thumbnail" type="String">a.bmp</Data>
      </Record>
      <Record/>
    </RecordSet>
    <RecordSet name="Video" type="List"/>
    <RecordSet name="Attachment" type="List"/>
  </ImageInfo>
</Study>
```

Figure 3. Study XML Structure

Unified DCS design and standard XML data format design, so that the data receiving and processing of the system has a unified and good expansibility.

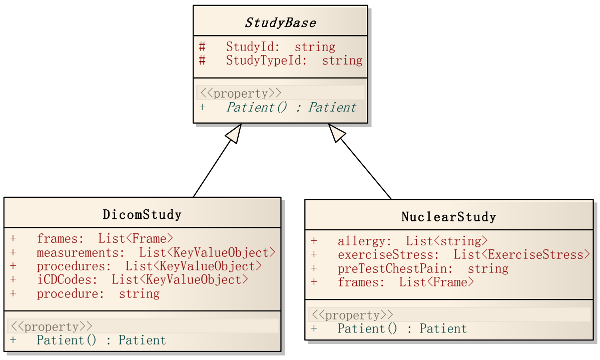

Figure 4. Study Class Diagram

2. DIPS

After the system receives the data from the device, the technician should further process and give the diagnosis and other information, this requires that the system has the ability to handle different Study types of data, each type of Study is different from the data format and display interface UI, the system must have the ability to display different interface UI according to different Study types. This must make the system of data processing interface, control, logic, data state effectively separated, reducing the coupling, it can be able to adapt to the complex interface and data processing requirements, according to different types of dynamic and interface and logical combination, it meets the needs of the system, at the same time, it also increases the reuse of the function code, and also gives the user a good experience.

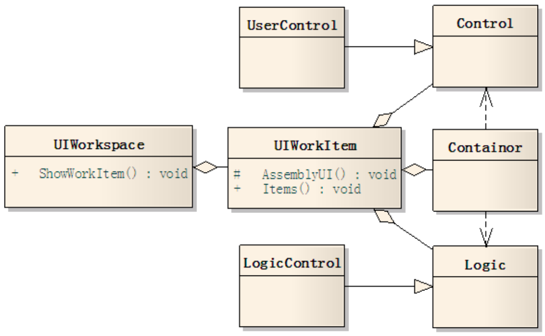

Figure 5. Interface UI Loosely Coupled Structure Diagram

According to the needs of the combination of UIWorkItem, to form user interface required, and unified display through UIWorkspace. UIWorkItem unified process Logic Controller, Study status data and UI combination. Every part of the independent function is designed to be a UserControl, they are combined into a Container, at the same time, the system will automatically inject the corresponding control logic, system will combine UserControl, Container according to the needs, and let them be a complete Study data processing interface UI.

The system uses the IoC idea and framework, so that the data can be dynamically injected into the structure, the structure is fully decoupled, the system structure is clear, the expansion and maintainability is strong.

Logic Control and Study state data are injected using the existing IoC framework, Spring，Castle or ObjectBuilder, it can be very good for the various business levels of the system to be very good separation and coupling.

3.2. DECS

Data exchange (DE) includes the collection of equipment data, technicians analysis data as well as the upload service image video, also including the latest system data downloaded from the central server, it is easy to the terminal for offline data processing.

Single machine version of medical image processing system, DICOM and Study data cannot be fully utilized and played to the acquisition of the device, the application value of the system cannot be fully reflected, it must be able to send the processed data to the shared center server, to make medical data stored, data sharing, analysis and statistics, in order to make medical imaging system more practical value, it can form a complete application system.

So, DECS's design makes the system's functional expansion and practicality further enhanced, DCS system is composed of database server and file server, the whole system is based on B/S WEB structure, providing Web service to the outside, the doctor can carry out online browsing and processing of Study in different network locations, and print reports, complete paperless office and information transfer, and make full use of the function of the WEB system, greatly expanded the practicality of medical imaging system.

In order to make the system adapt to different network structures, DECS must be designed independently, and deployed in the local area network as a middle service layer, it is responsible for receiving terminal image data, but also responsible for downloading the latest system data from DCS, to maintain the latest data on the terminal system. The existence of DECS system guarantees the exchange of data, but also ensures the automatic renewal of the terminal, so that the whole system can deploy and upgrade. The terminal is a working terminal in the LAN, which is usually connected with the equipment, it can not access WEB directly, so the process of upgrading and the end of the end of the basic data updates need DECS, this terminal can work independently, can also be online upload data.

1. DECS implementation

Through the planning task, the periodic processing of the image data from the terminal and XML Study data, DCS services provided by the WebService data communication and data integrity verification, through the Ftp service to upload the corresponding image data. The design scheme of the DCIPS data acquisition data can be used to design and implement the scheme.

2. DCS

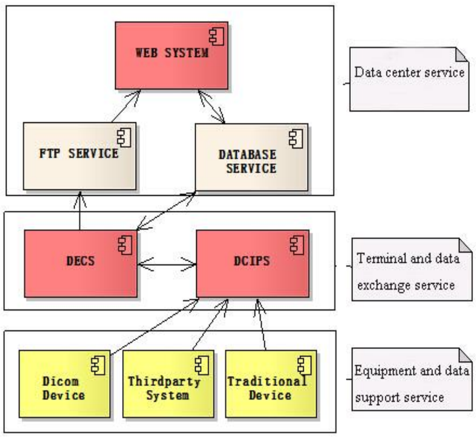

Figure 6. System Structure

The central server is a large Web service system, which includes a database server, Ftp server and database server, it provides WebService services to the, and provides services to the DECS: including system data updates, terminal program upgrade, DECS data upload and verification services, to provide a specified extension services to other systems.

It is a complete medical imaging system component system structure diagram, where the data exchange service layer (DECS) is responsible for data exchange between the terminal and the database server and the file server. This structure makes the terminal can be extended, and has the function of automatic upgrade, DICOM terminal on the equipment to collect data after processing through DECS Study XML data into the database server, at the same time, the video data is uploaded to the FTP server through the Ftp protocol. Ultimately, all of the data and its file supply to ECS, the doctor can handle the Study through the browser online, greatly enhanced the system's practicality and scalability, deployment flexibility.

4. Application of System

The modern medical imaging system with very flexible structure is realized by using the above structure and design idea, the system is convenient and easy to upgrade. It is very strong and it greatly improves the competitiveness of the software system, and it is in a leading position in the same industry.

The following figure is the use of the above system structure design of the DICOM medical imaging system terminal, supporting a large number of DICOM devices and traditional equipment, with the ability to edit and print Study reports, it is a complete system of technicians terminal image.

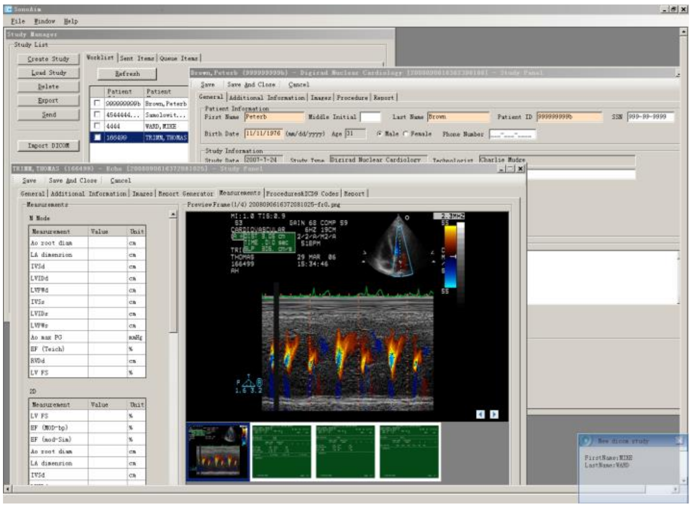

Figure 7. DICOM Medical Imaging System Terminal

The system can be flexible to expand the DICOM and third party equipment, the terminal can let technicians handle all kinds of different types of Study, data exchange server can support data and files from different hospitals, data exchange server provides data to Web application system, data access and operation requirements for doctors and other personnel, and can be carried out in a comprehensive statistical data and report forms.

5. Conclusion

Medical imaging system is a comprehensive system, which integrates data acquisition, image processing, network transmission, integrated image archiving and communication system using Web, in every part of the design to make the system a good quality of the operation, at the same time, it has a very strong expansion to meet the needs of customers. The unified design of data acquisition and the use of general XML data format to meet the general system data receiving, so that the system to receive any device and the third party system data become possible.

Data processing terminal, which satisfies the different types of Study, in the system design phase, the full decoupling technique of the interface UI and the back end control logic is adopted, through the flexible organization of UI IoC structure, to achieve a different Study to provide different UI purposes, greatly improving the customer experience. The design idea of data exchange service to meet the problem of data transmission in different network structures, adapted to the different network structure of each hospital, the terminal can smoothly transfer data and files to the central server, provided to the WEB application.

In summary, the design of each layer is fully considered the needs of the whole service system, low coupling design, it meets the system of data acquisition, processing, rapid transmission, storage, statistics, report printing and so on.

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