Minimum PACS system based on DICOM standard

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Abstract

The main target of this research was the analysis, design and implementation of a PACS system based on DICOM standard.

This project was developed in four stages: Analysis.- identification of the system's needs based on the Problem Recognition, Shaping and Specification. Design.- the system was defined for its interpretation and physical implementation, designing the database, the user interface and the Classes. Implementation.- creation of the graphic and web interfaces. Testing.- application of images acquisition tests to the graphic interface and information display to the WEB interface.

The result was a system with the following characteristics: it manages the patient's information database; it has the libraries for the different types of images; an image and database server that can give service to multiple clients and that supports the DICOM protocol for the acquisition of medic images loading Composed Information Objects (IOD-Composed); it possesses a graphic interface for the image acquisition – the system shows the information of the patient, medical research, equipment, series, and image according to the user (Visualizer) request, using a WEB interface; Mechanisms were implemented for the privacy protection of the system, controlling the access to the database through SSL. The image acquisition graphic interface controls the access.

Key words.

PACS, DICOM, Client/Server, UML, Systems Architecture, user interface design, Database Design, Mysql, JDBC, Java, SSL, Apache, Tomcat.

I.Introduction.

The Picture Archiving and Communications System (PACS) that manages the x-ray images and reports and that communicates with the medic archive storing systems, the Hospital Information Systems (HIS), the Radiologic Information Systems (RIS), the Laboratory Information Systems, and the on-line CD-ROM archives, are embedded and can be used over the net. This means that the system is oriented towards the Integrated Electronic Hospital. Figure 1 shows image digitalization for a better manipulation.

Nowadays there are commercial PACS systems created by medical equipment producer enterprises like AGFA, Siemens, among others. These systems work under the Digital Imaging and Communications in Medicine (DICOM) standard. Nevertheless, these systems are sold at high price, which is the reason why few national hospitals use them. This work will allow the doctors to access the medical images for their analysis and processing, giving a better diagnostic to the patients.

Fig. 1 Digitalization of the study images for a better manipulation.

The medical archives' standardization makes possible, through a safe transmission, the patients' data movement from department to department, from hospital to hospital, which makes this information can be watched remotely from the images acquisition zone. This allows doctors to diagnose from their homes, to obtain different opinions from other specialists or experts in an easy and fast way, to maintain a more effective and secure data structure, among other advantages.

DICOM is the industrial standard for the digital images' and medic information's transference between computers. DICOM allows the digital communication between diagnostic or therapeutic equipment and between systems of different manufacturers. The standard gives the possibility of interconnecting computing systems of different

manufactures, which is very useful in a hospital environment where there are several brands of medical equipment due to the fact of the specialization.

In the field of the medicine, there are a great variety of diagnostic image types, as the x-ray, the computer x-ray (CR), computer tomography (CT), magnetic resonance (MRI), ultrasound, nuclear medicine (NMI), digital subtraction angiography (DSA), etcetera. The management of these images has become complicated, overall when printing and archiving.

The proliferation of the digital systems in the 80's has driven to the idea of building a completely digital x-ray or image management department. It would use a visualization stations network along with the image storing and acquisition systems. A full system of this type is known as PACS. The generalized use of this kind of systems in our country would generate a fundamental change in the x-ray and image management departments' function scheme, improving their efficiency drastically, along with the significant improve of management and communication along with an important improvement in the medical attention quality. This covers not only the electronic media visualization paradigm but also the incorporation of other type of information like the multimodal images display, image emboss and the computer aid diagnostic.

Justification

In the clinic practice the PACS's improve the medical center's personnel competence. The medics do not need to wait for the patient's information so he can make an interpretation of a study's image.

The approach of time, film, and storage saving, among others, is used to justify the system. Nevertheless, this turns to be insignificant compared with the productivity changes that can be expected. The remote diagnostic can be the best source of improvements because other specialists can give their opinions regardless of the place they are at the moment.

Nowadays, we found commercial PACS created by medical equipment enterprises like AGFA or SIEMENS, which work under the DICOM standard but are sold at a very high price. This is the reason why they are used rarely in the National Hospitals.

The purpose of this system is to decrease the technological dependency without the need of paying for the intellectual cost of the generated project. This will allow the implementation of a PACS in the National Hospitals.

Objectives

The general objective of this research was to fulfill the Analysis, Design and Implementation of a DICOM based PACS, with the purpose of obtaining a quality software that does not result too expensive. This objective comprehends the next issues:

- A database and images server that must be capable of attending multiple clients and that supports the DICOM protocol to attend the services requested by the clients.
- A client application with the ability to communicate itself with the database and images server.
- The libraries for the different types of images (codification for each kind of image).
- The patient's information database management.
- Secure communication inside the system using a TDES encryption technique.
- Validation tests.

II.Previous Works

The studied jobs related to our project are:

PACS installation and operation (storage and images communication): main characteristics[5]

It describes the solutions to the described problems that are based on the application of the digital technology to introduce image management and storage systems. The solutions can go from the design and construction of a simple but functional system until the acquisition of a commercial complete PACS.

There is a description of a PACS basic components: images acquisition, communication network, databases, diagnostic and visualization stations, and Storage systems.

PACS-CNR Systems: A technological proposal[16]

Author describes the situation of the National Rehabilitation Center (NRC) in which, like in many other health centers, the increase in the demand of images manipulation and storage, the necessity of transferring the from the equipment that produce them to the medic areas that require them, and the technology evolution, have driven to the proposal of an efficient computer network that consists of image acquisition, visualization, consult, diagnostic, storage, and printing stations, known as PACS, as an alternative to reduce the inconvenient created by the conventional procedures of the radiographic data management. According to this, a study on the institutional convenience, the technical practicability and the economic benefit of the design, development

and installation of an ad-hoc PACS, distributed throughout the National Rehabilitation Center is presented, according to the requirements of the medic area, with the objectives of the technological dependency decrease, the drop of the authoring and maintenance costs, and the existence of a development platform that can be upgraded constantly with base on the last technological and scientific advances.

Introduction to the acquisition, archive manager and images storage[7]

Smith shows relation between different types of archives and components of communication system for the PACS, and the failures tolerance configuration for the archives showing the "Heart-beat" and the load balancing (sharing).

Furthermore, author shows the characteristics of the common images and studies size by modality; it describes the archives' components along with their manager and the storage.

Real-time teleconsulting solution for teleradiology based on PACS[40]

The PACS extension helps to overcome the challenge of a large quantity of teleconsults. Medical images can be very big (4 Mb or more), while the real time images manipulation (rotation or zoom for example) must occur almost at the same time so the doctors can study the information from anyplace at the moment it is required. Besides, the practical use of PACS work both on PC's and on UNIX workstations, but over different graphical systems (Windows and X11 respectively), and with different hardware. These two possibilities have been considered on the design, a unique platform or a heterogeneous solution. The heterogeneous platform solution will work as the base for developing a standard protocol for watching the image of the PACS vendors. The unique platform solution has been put to work and has been proved among two Israel's hospitals and has demonstrated to be effective using a short bandwidth. Doctors in a rural hospital can call an expert in the hospital's central radiology department of the other hospital and discuss the case in real-time.

The Development of a Client/Server Architecture for Standardized Medical Application Network Services[36]

The specification and design of the behavior of the client and of the superior layer server of the DICOM standard using an objects oriented language were discussed in this project. The State chart Architecture Principle is used to provide the standard understanding, giving a visual formalism for the specification. This specification defines the behavior of the upper layer services as a client or a server. Finally, a state chart object oriented pattern language is used to translate the specification into design, and a class diagram for the server is presented in UML notation.

III.Bases

The development of this project required the research (Figure 2) of the following concepts: a)UML. b)PACS. c)DICOM. d) Systems architecture. e)Database Design. f)User Interface Design. g)Mysql. h)JDBC. i)Java / NetBeans. j)SSL. k)Apache. l)Tomcat.

Fig. 2 Researched concepts for the system design.

IV.Methodology

There were four phases for reaching the objectives of the project: Analysis. Design. Implementation and Tests.

Analysis

The necessity of the system was identified based on:

- Problem recognition: Study of DICOM standard, PACS and UML characteristics; existing visualizers analysis.
- Modeling: cases of study determination according to the information management and storing; the architecture model was defined.
- Specification: hardware and software requirements.

Design

This phase had the objective of defining the system with enough details for its interpretation and physical construction.

It encloses the following points: Database design. User interface design. Classes design.

Implementation

Our system is implemented based on the past phases.

A Linux server with Java, Apache, Tomcat, and Mysql was installed and configured.

The graphic and Web interfaces were implemented, the last one having a security layer using SSL.

Tests

Three tests were applied on the system's graphic interface for the image acquisition, web interface for the information visualization, and security for the web application.

V. Results

The case of use and the system's architecture were developed in the modeling.

For the case of use the actors are: Compound IOD archive, DICOM Tags dictionary archive, and User. The case of use are: Comun_Mysql, DicomData, DicomDic, DicomFile, DicomvalueData, DicomValueDic, ImageData, ImageProcessor, JFrameSobreSistema, JPanelErrors, jtable_3, Principal, Vectors, Visualizer, Consult, Communication, Session.

The architecture of the system is a client / server one.

The server will give HTML service using SSL/Apache with Tomcat. JSP/Servlet is used for the dynamic web pages and JDBC and Mysql for the data management (Figure 3).

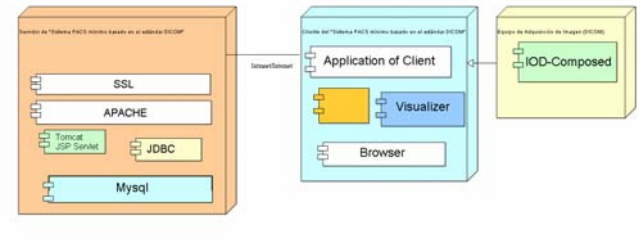

Fig. 3 System architecture.

The client is formed by a compound IOD acquisition graphic interface and the WEB interface.

The image acquisition equipment will deliver the information under the DICOM standard using compound IOD (Information object definition).

The system's specifications are:

- Image acquisition: the system acquires the information and the images through an archive that contains the Compound IOD, reason why a class (Principal) that can read and upload the information to the database must be created. As it counts with a tags dictionary used by DICOM, any kind of study can be opened and seen.
- Communication network: the communication will work according to the university's resources and characteristics and to the assigned equipment for the development of this project. The system's programming is focused on the Internet.
- Database and Storage system: We will use MySql for our database management. The storage capacity will depend on the characteristics of the destined machine for this project. JDBC is used because it allows any Java program to access the database system.
- Visualization and diagnostic stations: the user will be able to use the browser, reason why this application supports dynamic pages. SSL was implemented to allow the confidentiality and authentication in the Internet transactions done by the system.

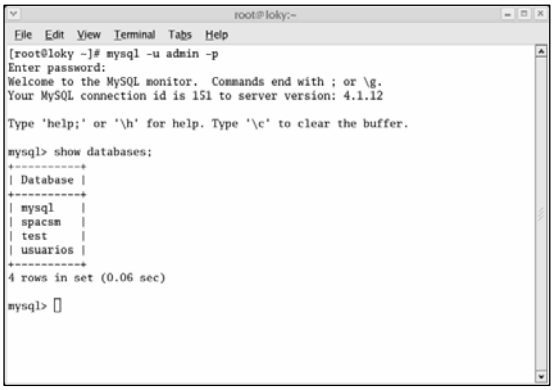

Fig. 4 Database in the server.

- System's hardware and software specifications: the equipment used for the development of this project follows the next characteristics:
  - Software development packages and tools: Office, WinMysql, Mysql Administrator, NetBeans, Java, DB Designer 4, ArgoUML
  - Computer in which the project was developed:
    - Operating System: Centos 4.2 (Linux).
    - Software: Apache, Tomcat, Mysql, NetBeans, Java.

Mysql was installed and configured both over Windows XP and Linux for the database management. For the images data system, tables were created and the information for the dictionary was uploaded. Our server's name is loky.uam.mx, which contains the session control database. Figure 4 the server's databases.

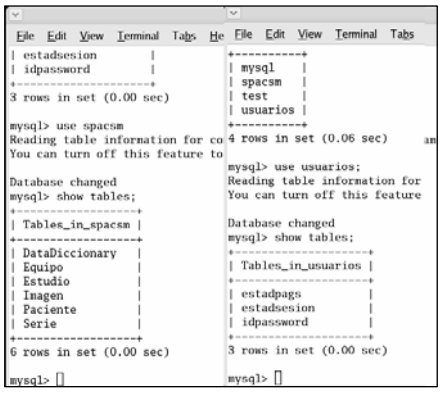

Fig. 5 tables contained in the server.

Figure 5 shows the tables were the image's information is stored along with the information associated with itself.

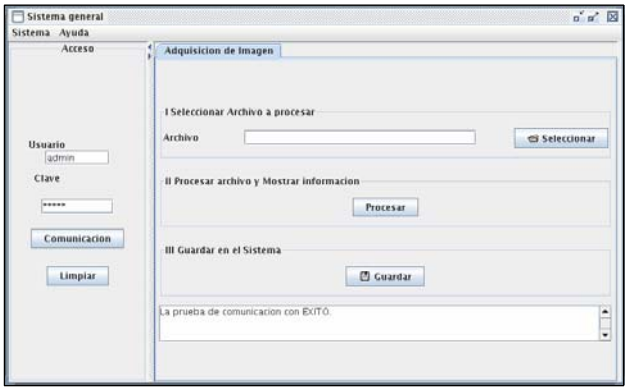

Figure 6 Graphic Interface.

The graphic interface is formed by three elements: menu bar, access control, and image acquisition (see Figure 6).

- Access control: this section checks the authenticity of the given login and password when the button "confirm" is clicked. When the "process" button is clicked, it shows the information contained in the Compound IOD table and the image. This information can be edited in the same window (Figure 7).

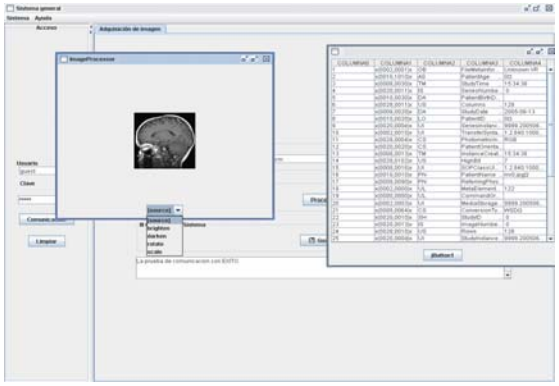

Fig. 7 Windows generated by the interface

In figure 7 we can see a menu in the image's window with controls to change the contrast, the size and the position of such image. In the other window we can see the number, data type, description, and contain for each Tag.

Web interface. It is necessary to open the browser and to write the URL: http://loky.uam.mx/spacsm/principal.html (See Figure 8).

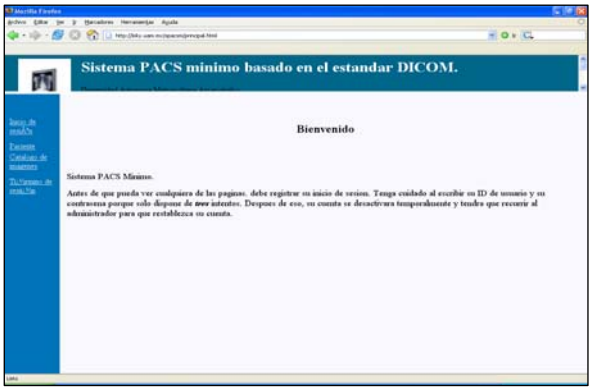

Fig. 8 WEB interface.

This will show a welcome screen were we can select session start from the options menu to enter the requested information. If the authentication fails three times, the user will be disabled and only the users with such privileges would be able to restore him (a users control web application is generated for these tasks).

Figure 9 shows the image and its associated information.

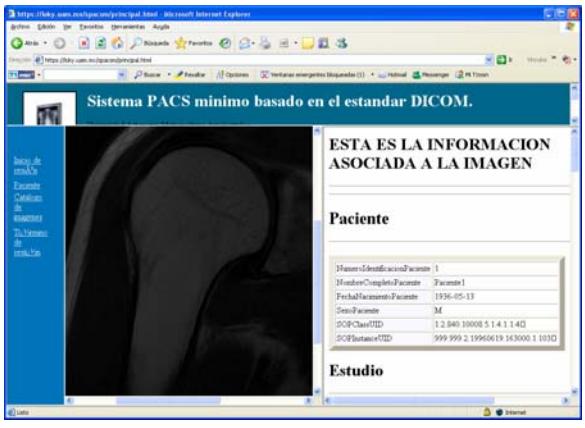

Fig. 9 image and its associated information.

VI.Conclusion and perspectives.

Computer concepts and techniques were integrated in this project to solve the problem of images control and medical studies information. The minimum PACS system is based on the DICOM standard,

which fully describes a multiplatform system (because it uses Java as programming language) developed to manage the medical diagnostic through the network (Intranet o Internet). It also uses a security layer, which generated the necessity of evaluating different computer alternatives.

The analysis, design, implementation, and minimum PACS system tests were developed based on the purposed objectives. The system has the following characteristics (See **Figure 10**):

- Libraries for the different types of images (because we count with a DICOM tags dictionary)
- Manages patients information database.
- Database and images sever which is capable of attending multiple clients and supporting the DICOM protocol for the medical images acquisition loading compound Information objects (Compound IOD)
- Graphic interface for the images acquisition where information is shown and where we can edit each tag's characteristics. We can change image's brightness, size and rotation.
- The system shows the patients, study, equipment, series and image information as the user (visualizer) request it using a web interface.
- A secure communication because privacy protection mechanisms were implemented controling the access and the privacy of the data for the web interface using SSL.

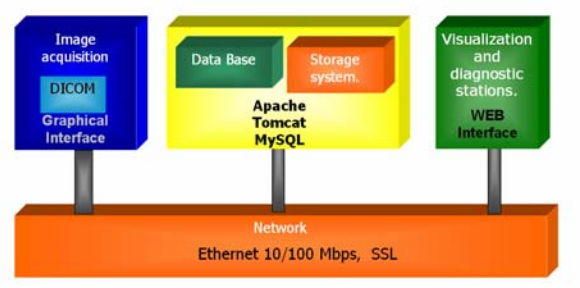

Fig. 10 Minimum PACS system based on DICOM standard.

Without a doubt all software implementation can be improved, and, for this project, we can work on:

- The visualizer: we could develop visual tools that allow us to make a zoom, to control the brightness, the contrast, make a rotation inside the image, among others.
- In the images storing systems, a demand probability dependant hierarchical strutcure could be created. In general, the new acquired images are consulted more often, and this frequency drops quickly with the pass of time.
- To negotiate the loan of medical equipment under the DICOM standard to establish a direct communication with it.
- To implant this system in production.

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