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Picture Archiving and Communications System (PACS) for Government Hospitals in Sri Lanka

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Abstract- ***In this modern world, Healthcare medical imaging system plays and important and central role in critical factor for the quality of diagnostic and treatments. Picture archiving and Communication System (PACS) is the backbone of the analysis of medical images as it is well adapt with several standards such as DICOM and HL7.***

Keywords— Health informatics, PACS, DICOM, HL7, Spring, Hibernate

I. INTRODUCTION

There have been a number of studies carried out to overcome the storing and receiving of medical images in Health Information Systems. Even though there are several system developed, as a solution for the above problem none of these systems are used in Sri Lanka due to these inability to match with Sri Lankan requirements and healthcare protocols. Most of the solutions provided were not capable of handling and maintaining those systems in the Sri Lankan Government hospitals due to lack of technical knowledge of staff and as well as requirement of advanced equipment for these systems. Government hospitals in Sri Lanka need more user friendly and easy-to-handle system for their busy daily routine and to maintain.

A. *PACS Concept.*

Advanced in digital technologies, particularly in the field of computing, imaging and in communications, have progressed to the point that it is now possible to acquire medical images in digital form[6] , archive them on computer systems, and display them in diagnostic quality. The display monitor used to represent the image can be at an adjacent or distant location to the original point of acquisition. Indeed, there can be multiple monitors at multiple locations, since once the 'master' image file has been archived, it is only ever a copy of the data that is transmitted for display.

A picture Archiving and communications System(PACS) typically comprise data storage device, image display device, database management software and links to image and/or image acquisition devices, connected to computer networks. There may, in addition, be network connections to other information systems such as Hospital Information System (HIS), Patient Administration System (PAS) or Radiology Information System (RIS). For the purpose of this document, a PACS consider as database management software, image display devices, data storage devices, film printers and other relevant computer networks.

B. *Advantaged and Disadvantages.*

PACS has several advantages [1]. Quick and easy access to patient images and reports, Reduce the number of duplicate images hence space saving, Zoom in on images and manipulate, Environmental benefits, Allows physicians to acquire a chronological view of patients' radiology histories and increase the efficiency, Decrease costs as well as more user-friendly for staff and beneficial to patient care.

Apart from these advantages there are several potential disadvantages [4] as well. Major disadvantage of a PACS is high capital investment. Ongoing cost also considerably high in PACS; it requires training, specialist staff and equipment and so on. Initially there are may not be necessary infrastructure available. PACS can place high demand on

TABLE 1
COMPARISON OF EXISTING SYSTEMS

Features / Systems	DICOM Viewer					PAC system			
	Image Processing	Annotation	Resolution Mgt.	Tiling	3D	Web	Stand-alone	Security	Audio/Video
My Free PACS	Moderate	Moderate	No		No	No	Yes	Moderate	No
PAC One	Moderate	Moderate	No		No	No	Yes	Moderate	No
OsiriX	High	High	No		Yes	Yes	Yes	High	Yes
RadiAnt	Moderate	Moderate	No		No	Yes	No	Low	No
Agnosco Viwer	Moderate	Low	No		No	Yes	No	Low	No
Rubo medical Dicom	Moderate	Low	No		No	Yes	No	Low	No

computer networks, and so it may be necessary to install a new network. In most advanced PACS requirement of high technical skills is a must. Due to short supply of such skills are major handicap of PACS.

Although many benefits and cost saving are claimed for a PACS, on their own these may not be sufficient to justify the large capital investment required [5]. However PACS can see as one of the first step on the road towards a fully digital hospital data management system.

C. *Standards used in PACS*

Several standards have provided themselves useful in implementing a PACS, notably Digital Imaging and Communications in Medicine (DICOM) and Health Level 7(HL7) [7]. Of increasing importance are the Integrating of Healthcare Enterprise (IHE) initiative, and the Clinical Object Workgroup (CCOW) standard.

D. *Existing System Comparison*

Following comparison is done for the widely used PACS and DICOM viewers worldwide [2] [3]. (Table 1)

II. METHODOLOGY

PAC System mainly comprise of two part; back-end and the front-end. For the backend Spring, Hibernate and MySQL are used. Hibernate is used to map database into objects in according to make easy access. This is used as a persistence layer in backend. To provide a particular service to client, service layer is used which is capable of result a certain output by manipulating data. Front end part comprise of imaging viewer.

A. *DICOM Viewer*

DICOM viewer which can be be accessed through common browser or from any computer. Since web browsers are simple and robust technology they provide easy access to all medical images at any place in the hospital regardless of having a specific workstation. Once the image file has been created and converted to JPEG format image can be displayed by transmitting this data file to the workstation (DICOM Viewer). For diagnostic reporting from medical images highest quality display monitors are required. However due to special techniques such as image tiling technique used in this product normal monitors available in the hospital can be used as viewing stations.

B. *Interfaces to external systems*

Some external system: HIS, RIS PACS broker. Description of the information that PACS is likely to require from external systems. When designing and implementing a PACS it is important to give much thought to non-image data (e.g. Patient demographic data, examination details, clinical appointments etc.) Since this system is developed as an individual PACS to acquire some information special search queue feature is implemented. It uses
Accession no, acquisition number for each Medical image, patient ID, patient name, referred Doctor and also by the modality of the imaging (CT, MRI, X-Ray etc.).

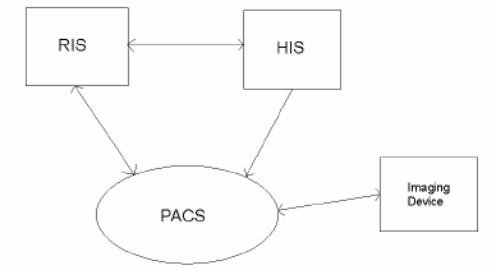

Fig. 1 Information flow between various hospital systems

C. *Image Conversion*

When the DICOM image file is uploaded header of the images are filtered at the backend. For every patient folder structure is created using patient ID, study UID and series UID. Then the DICOM image is converted using the ImageIO library. Those are stored in the file hierarchy. DICOM images are converted to JPEG 2000 file format by lossless compression.

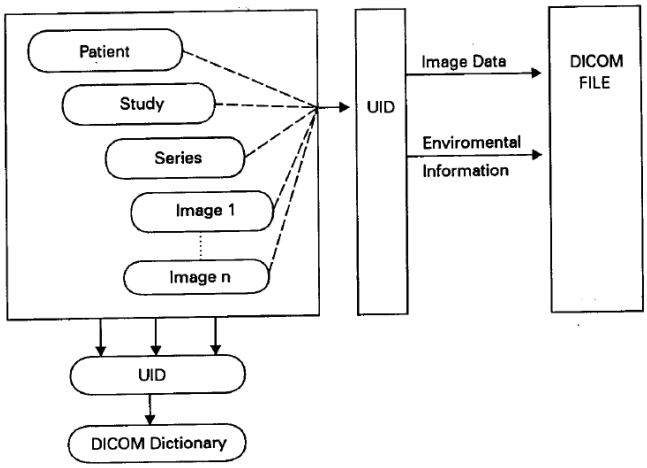

Fig. 2 Module architecture form DICOM file interpretation

Several image processing techniques are available in the DICOM viewer. Basic image processing techniques such as gray scale, image negative, brightness, contrast, sharpening, negation, Emboss technique, Sepia etc.

D. *Image Tiling*

The major problem that developers face while developing web base medical image (DICOM Images) handling system compare with other image sharing system is file size of the image(average 5-20 MB) and have to apply the loss-less compression because of all most all data that comes with medical image are important. When increasing file size of the image, system performance reduced and network bandwidth is complicated. To achieve these problems Image Tiling concept has been introduced.

DICOM image repository is maintained with different Image layers and each layer with Image Tiles. In Image layers different resolutions maintain for same DICOM image and each layered image divided to N number of sub images. When DICOM image displays image tiles sequence load from appropriate resolution image layer and merge these tiles in DICOM Viewer Canvas. By using this approach bandwidth issues are achieved and considerably increase overall system performance.

E. *Annotations, Measurements and Comments*

Basic radiological annotations are included in the DICOM viewer. Broad range of medical image annotation objects including geometric shapes such as circles, pointers, arrows, lines and squares are also available. These annotations can be drawn on the presentation layer or can be embedded into the JPEG image. Due to that clinician efficiency increases in considerable amount. Measuring distance is another important feature available in the DICOM viewer. When selecting two locations it give the total length of that particular area. In medical it is important to get angle between two variable. Clinicians able to get angle through the angle measuring too which is widely used in X-Ray images processing. Comments can be added on to any location in the image. This help clinician for easy-viewing process of previously added comments which prevent reading lengthy reports.

F. *Image Player*

DICOM Images can be categorized according to the modality of the scan such CT and MRI. These two scanning mechanisms contain sequential image orders. Those Image frames are obtained from a certain part of the body of a patient to identify the variations of a disorder. To diagnose the disorder that the patient has by the doctor rather than viewing image by image it is better to looping through the image sequence.

In order to looping through the DICOM image sequence DICOM image player is used. As result of the animating DICOM image sequences doctors can easily diagnose the variations in a disorder. For an example spread of a cancer can be diagnosed by playing the image sequence. DICOM image sequence player has all the specific features such as moving from frame to frame back and forth. If the doctors need to pause the image loop and view it fame wise it is also possible in the DICOM image player.

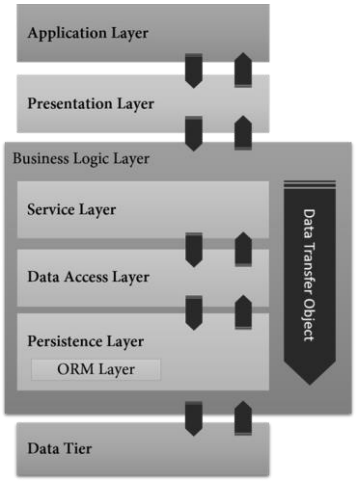

Fig. 3 System architectural diagram

G. *Technologies used*

In this product latest technologies are used which greatly support in product maintenance. Such technologies used and importance are mentioned below.

1) Spring Framework

This framework used for handle IOC – Inversion of Conversion. Reason for having such framework is users are not allowed to create objects. This framework automatically handle the creation of objects.

2) Hibernate

This is used to handle the persistence layer. Database tables are mapped to objects using this framework. Due to this maintenance become easy in persistence layer.

3) CodeIgniter

It is quick and easy learning framework hence it easy to do maintenance in source code.

4) Dcm4Che

This is the widely used library to read header data of .dcm images and also for filtering and many other important DICOM image handling.

III. RESULTS

Final outcome of this research is the completed PAC System. DICOM viewer can be used to manipulate, image processing, annotating, as well as for reporting purposes. Image archiver is used to store original .dcm file from image source (X-Ray machine, MRI machine etc.), converted .jpeg image and manipulated or processed image in DICOM viewer. Video sequencing of some images and recordings for voice commenting are also major parts of the PAC System. Back-end data are encoded according to HL7 standard.

Fig. 4 DICOM Viewer interface

IV. CONCLUSIONS

A stable PACS software is developed using numerous open source technologies such as Spring, Hibernate and MySQL in the back end and a PHP based front end.

V. DISCUSSION

The implement of a PACS will have an impact both on the mix of staff supporting the radiology service and the working patterns of many members of the radiology staff. Installation of a PACS is likely to mean the loss of an on-site film store. A PACS is a technically complex system, and its management is a specialist task. However due to user-friendliness of the developed system such special skills are not required; even a clinician can perform image processing techniques. Quality control and quality assurance tasks that will require scientific support include checks on display monitors, and if appropriate film printers as well. Staff (Clinicians) training is crucial to success of a PACS project.

Number of routine tasks must be performed for smooth operation of a PACS. These include creation of user accounts to enable staff members to access the system at a level appropriate for their requirements, management of system backups and the safe storage of backup media. It is also necessary to manage and monitor the interfaces between the PACS and external systems.

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