Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 37 (2014) 16 – 23

Procedia Computer Science

The 5th International Conference on Emerging Ubiquitous Systems and Pervasive Networks (EUSPN-2014)

HIS Integration Systems using Modality Worklist and DICOM

Dr Kulwinder Singh Mann, Er Ankit Bansal*

Guru Nanak Dev Engineering College,Gill road,Ludhiana,Punjab,India
Punjab Technical University,Jalandhar-Kapurthala highway ,Jalandhar,Punjab,India

Abstract

The usability and simulation of information systems, known as Hospital Information System (HIS), Radiology Information System (RIS), and Picture Archiving, Communication System, for electronic medical records has shown a good impact for actors in the hospital. The objective is to help and make their work easier; such as for a nurse or administration staff to record the medical records of the patient, and for a patient to check their bill transparently. However, several limitations still exists on such area regarding the type of data being stored in the system, ability for data transfer, storage and protocols to support communication between medical devices and digital images. This paper reports the simulation result of integrating several systems to cope with those limitations by using the Modality Worklist and DICOM standard. It succeeds in documenting the reason of that failure so future research will gain better understanding and able to integrate those systems.

Peer-review under responsibility of the Program Chairs of EUSPN-2014 and ICTH 2014.

Keywords: DICOM; digital images; HIS; PACS; RIS; modality Worklist;

1. Introduction

Nowadays the hospital starts to reap benefit on implementing electronic medical records which consists of two parts; text data and pixel data. While the text data includes information about the patient such as his name and age, the pixel data is a picture comes from devices in digital medical imaging, such as Computed Tomography (CT) scanners, ultrasound, MRI, or PET. The information and communication technologies will increasingly become

*Er. Ankit Bansal. Tel.:+919592009208; fax: +0-000-000-0000 .
*E-mail address:*erankitbansal@gmail.com

Peer-review under responsibility of the Program Chairs of EUSPN-2014 and ICTH 2014.
doi:10.1016/j.procs.2014.08.007

ubiquitous in the inpatient, outpatient and administrative areas of healthcare. However, the speed of technological advances stands in contrast to the requirement for a reliable long-term availability of medical data [1].

The emerging idea of a digital image archive (PACS) and electronic image distribution in a hospital created the need to exchange digital images between medical devices of different manufacturers [1]. Therefore, a standard in digital medical imaging exchange must be developed and the result until now is known as Digital Imaging and Communications in Medicine (DICOM) standard. DICOM is not just an image or file format, but it includes data transfer, storage and protocols to create an open (vendor independent) platform for the communication of medical images and related data [3]. The patient's records which consist of text data and pixel data are creating DCM files, which are DICOM file extension.

This paper presents the result from the work so far in simulating an integration system which enables data medical communication between RIS, and PACS using Modality Worklist and DICOM standard.

2. Hospital Information System (HIS)

The hospital information system (HIS) is a computerized management system for handling three categories of tasks in a healthcare environment [2]:

- Support clinical and medical patient care activities in the hospital.
- Administer the hospital's daily business transactions (financial, personnel, payroll, bed census, etc.).
- Evaluate hospital performances and costs, and project the long-term forecast.

A large scale HIS consists of mainframe computers and software. Almost all HISs were developed through the integration of many information systems, starting from the days when healthcare data centers were established. Fig. 1 shows the main components of a typical HIS [2].

We can see clearly that HIS supports clinical operations and hospital's and healthcare center's business and administrative functions [2]. The software package STOR (a trade name, other HIS may use different names) provides a path for the HIS to distribute HL7- formatted data or DICOM-formatted data to the outside world.

Notice in the figure that HIS provides automation for such activities starts from patient registration, admission, and patient accounting. It also provides online access to patient clinical results (e.g., laboratory, pathology, microbiology, pharmacy, and radiology). The system broadcasts in real time the patient demographics, and when it encounters information with the HL7 standard or DICOM standard, it moves it to the RIS [2].

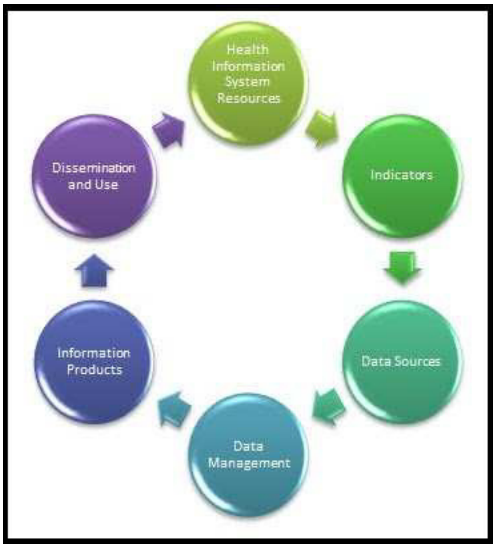

Figure 1 The six components of a health information system

3. Radiology Information System (RIS)

Most clinical departments in a healthcare center, mainly radiology, pathology, pharmacy, and clinical laboratories, have their own specific operational requirements that differ from the general hospital operations. For this reason special information systems may be needed in these departments [2]. These information systems usually are under the umbrella of the HIS, which supports their operations. However, there are also departments that have different workflow environments that may not be covered by the HIS. So they may need their own separate information systems and must develop mechanisms to integrate data between these systems and the HIS [2]. Such is the story behind RIS, which began as a component of HIS; later an independent RIS was developed because of the limited support from HIS in handling the special data and information required by the radiology operation [2]. However, the integration of these two systems is extremely important for the healthcare center to operate as a total functional entity.

To be specific, the Radiology Information System (RIS) is designed to support both the administrative and clinical operation of the radiology department, to reduce administrative overhead, and to improve the quality of radiological examination service [2]. Therefore the RIS manages general radiology patient information, from scheduling to examination to reporting. The RIS configuration is very similar to that of HIS except it is smaller in scale. RIS equipment consists of a computer system with peripheral devices such as RIS workstations (normally without image display capability), printers, and bar code readers. Most independent RIS are autonomous systems with limited access to HIS. Some HIS offers embedded RIS as a subsystem with a higher degree of integration.

The RIS maintains many types of patient- and examination related information. Patient-related information includes medical, administrative, patient demographics, and billing information. Examination-related information includes procedural descriptions and scheduling, diagnostic reporting, patient arrival documentation, film location, film movement, and examination room scheduling [2].

The described functions of RIS and the services of messaging and translation are provided by the proposed architecture that is depicted in Fig. 2. In this graphic, RIS is presented as part of a cooperative scheme with PACS's main components and the units that interact are shown [4]. RIS architecture is composed by five structural entities: RIS Data Store, HL7 Server, HL7/DICOM Translator, Clinician Terminal and Radiologist Terminal.

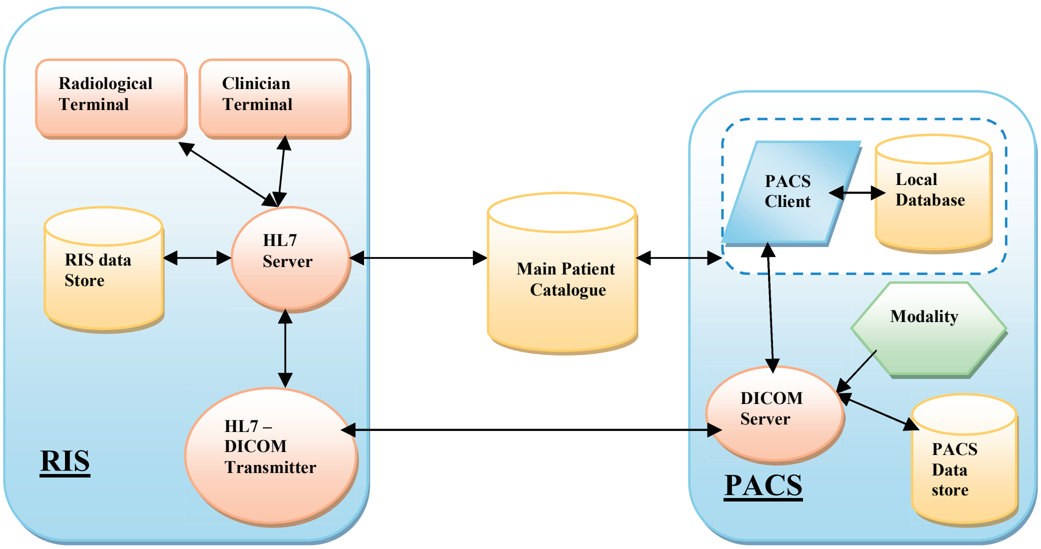

Figure 2 RIS architecture as part of a cooperative scheme with PACS

RIS Data Store is DSU of RIS and hosts the information that is needed to support the functions of RIS and HL7 messaging.
Clinician and Radiologist Terminals are two types of terminals correspond to the two groups of users that have been defined for RIS. It provides the application programs and the graphical user interface that support the scheduling, transcription and allocation functions.
HL7 Server is the component that provides the messaging service by implementing the specifications of MCS. It is

the ‘heart’ of RIS as it communicates with all the other components of the architecture [4]. In addition, it serves the interaction process between RIS and HIS and exchange information with the main patient catalogue of hospital.
HL7-DICOM Translator component implements the features and mechanisms of TCS and provides the translation service for the transcription function. It communicates with the HL7 and the DICOM Servers according to the form that is specified by HL7-DICOM Translator [4]. An additional operation of Translator is the forwarding of imaging files to HL7 Server for the production of valid and integrated medical reports.

4. Integration Systems

4.1 Modality Worklist (MWL)

Modality Worklist function allows an automated, reliable, error-free transfer of the information stored in the HIS directly to the modality, in a standard way which is supported by almost all manufacturers of digital DICOM modalities. A hospital needs to handle many patients every day whom referred by the physician to take medical imaging in the radiology department. However, it takes so many steps in the procedure in order to make it right. Therefore, the modality worklist was introduced to solve this problem.
Modality Performed Procedure Step (MPPS) allows updating records in the Modality database and HIS database which will inform the person at reception side that the specific patient study is COMPLETE or IN PROGRESS.
When modality technologists come to work, they really would like to know the current list of patients to scan, and even better, to have patient data already loaded into the modality.
This is exactly what the MWL SOP does: it preloads patient and scheduling data into the modalities [5]. This places MWL at the very beginning of any DICOM workflow, well before images are stored or even scanned. To provide scanning schedules to the modalities, the MWL SCP needs to get them from somewhere. In the majority of cases, the schedules come from the Radiology Information System (RIS) where the patients were already registered for imaging scans.
When patient data is passed from an RIS on the MWL SCP, it is ready for the modalities to populate their worklists. Modalities are usually configured to auto query the MWL SCP on a regular basis (every minute or two) to retrieve their current worklists. For these queries, the modality type (e.g., CT, MR, ultra sound) and the AE title (CTSCANNER1, for example) are used to identify the studies destined for a particular modality [5]. Thus, MWL eliminates manual data entry on the modalities, reducing the main source for human errors and wasted time. Automatically fetching them directly from the RIS makes the entire process clinically sound and robust.

4.1.1 Picture Archiving and Communication System (PACS)

A picture archiving and communication system (PACS) consists of medical image and data acquisition, storage, and display subsystems integrated by digital networks and application software [2]. It can be as simple as a film digitizer connected to several display workstations with a small image data base and storage device or as complex as an enterprise image management system and its design should focus on system connectivity and workflow efficiency. The PACS infrastructure design provides the necessary framework for the integration of distributed and heterogeneous imaging devices and makes possible intelligent database management of all patient-related information [6]. Moreover it offers an efficient means of viewing, analyzing, and documenting study results, and thus a method for effectively communicating study results to the referring physicians.

4.1.2 Digital Imaging and Communications in Medicine (DICOM)

DICOM is an object oriented principle which is the most important standard for data and services in medical field. It is not just an image or file format for medical images and related data, but it includes network oriented services such as: image transmission, query of an image archive (PACS), print (hardcopy), and RIS – PACS – modality integration as shown in fig 3. A DICOM image consists of a list of data elements related to patient information (name, sex, identification number), also includes the modality and imaging procedure information (device parameters, calibration, radiation dose, contrast media), and image information (resolution, windowing).

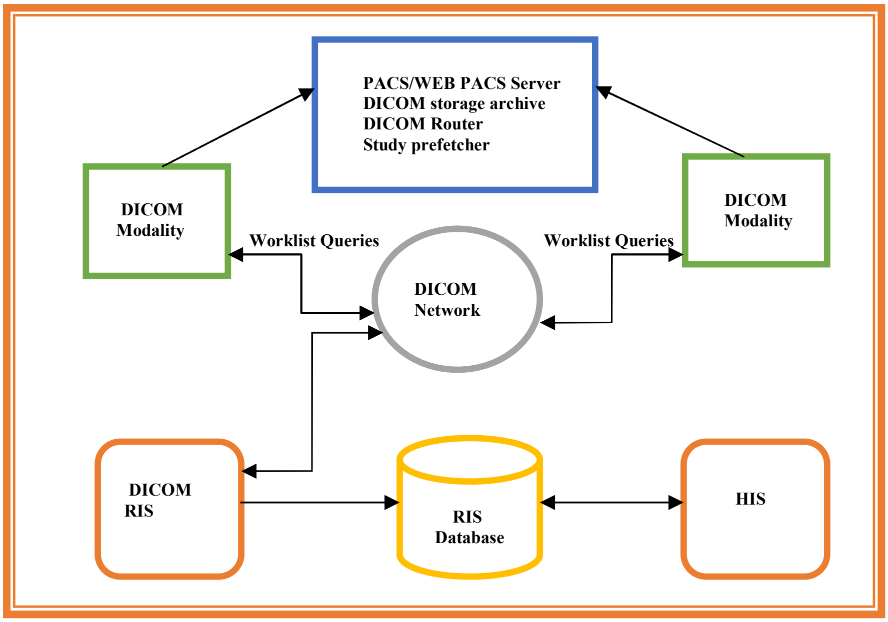

Figure 3 DICOM- modality integration

The objective of DICOM is to ensure the interoperability of systems used to: produce, store, display, process, send, retrieve, query, or print medical images. DICOM will entirely helpful for the hospitals, clinics, imaging centers or specialists by purchasing only equipment and information systems that conform to the DICOM standard [1]. These tools will work together to produce, manage and distribute medical images regardless of current or future vendors. The services in DICOM principles are related to handling DCM files in the networks.
The two most important principles are called SCP, mean the device which is listening or receiving and SCU, is the device which is speaking or transmitting in the network [3]. The DICOM image archive service ("Query/ Retrieve Service Class") allows to search images in a PACS archive by certain criteria (patient, time of creation of the images, modality etc.) and to selectively download images from this archive.
The most basic DICOM service is “image transmission” (or “Storage Service Class” in DICOM terminology) and there are number of advanced services, such as [1]:

- The DICOM print service ("Print Management Service Class") allows to access laser cameras or printers over a network, so that multiple modalities and workstations can share one printer.
- The DICOM modality worklist service allows to automatically downloading up-to-date worklists including a patient's demographic data from an information system (HIS/RIS) to the modality.

DICOM headers are unlike most image formats, which have a fit size. DICOM headers can be of variable size, and the fields within the header are indexed by two numbers (in hexadecimal notation): a group and an element [8].

5. SYSTEM ANALYSIS

In order to support the research activities to prove how an integration systems be a helpful thing for the hospital, a simulation must be done before the real implementation adapted to the organization. Fig.4 shows the typical current system in a hospital for treatment procedure that includes a radiology department.

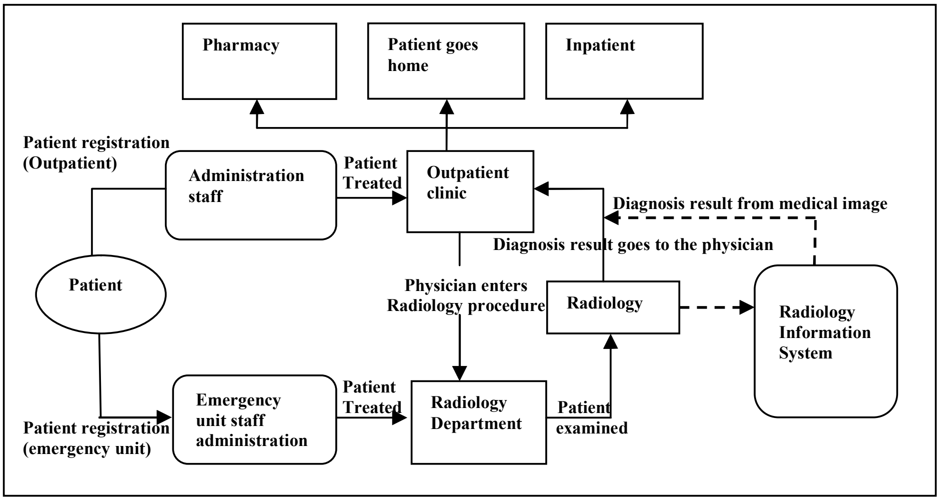

Figure 4 Current System in the Hospital

Fig. 5 shows an integration system of HIS-RIS-PACS using DICOM standard to help the clinical operations and hospital's business and administrative functions. The brief explanations for every system in fig. 5 are as follows:

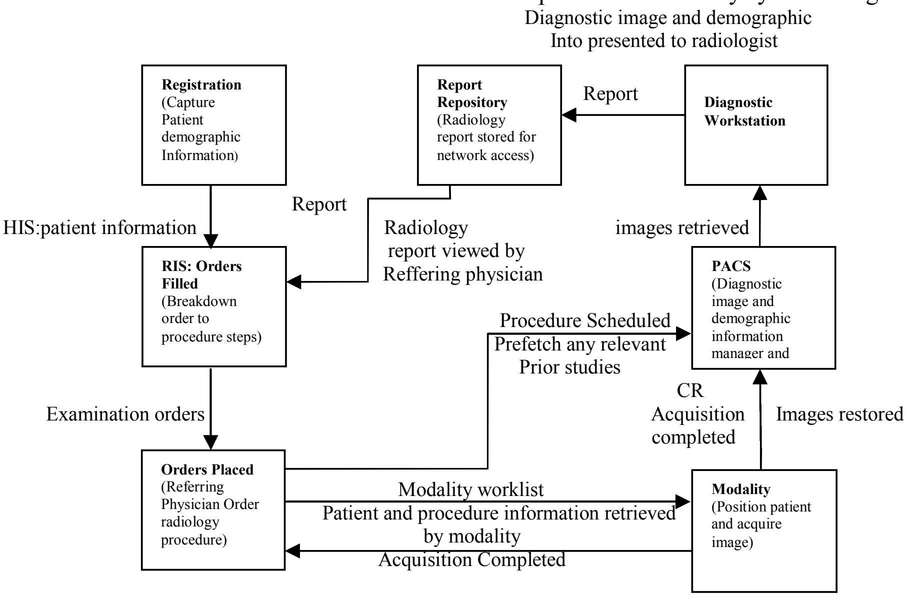

Figure 5 Integrating Systems - HIS, RIS, and PACS [3]

- HIS, we build a simple web module for implementing patient registration procedure and as the DICOM Viewer for the image result of the patient.
- RIS, at first we want to use RIS for the simulation we rely on software called RIS Emulator since the current version of RIS do not support modality worklist and the developer still working on that using the RIS Emulator because it was not an open source and we could not adapt it to connect to HIS or Modality.

Modality, we have modality emulator and it goes the same problem that we face with RIS Emulator: no flexibility was provided by the software to be able send image to PACS or DICOM Gateway as shown in Fig 6. The initial step needed to operate the modality emulator is to configure the remote system contained in the RIS, modality Emulator, and PACS.

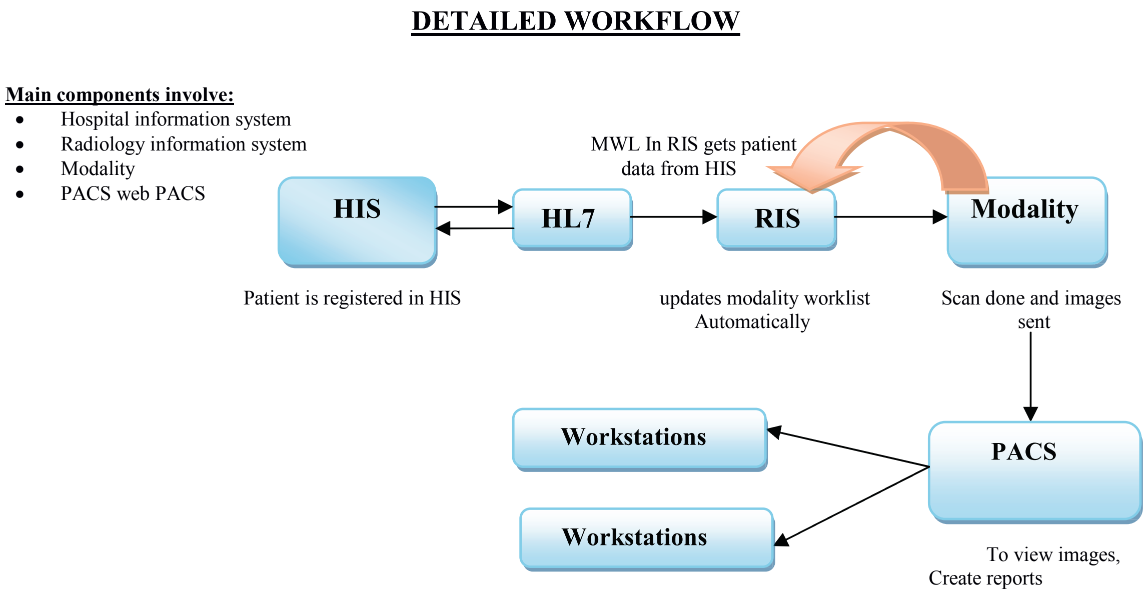

Figure 6 Detailed Workflow- HIS, RIS, Modality and PACS

After determining which patients will be processed, continue with connection test between modality emulator and the PACS. Before sending images to PACS, make sure that the folder indicated in the "Image Storage" already contained an image. The next step is to test TCP/IP connection and DICOM association between modality and PACS Emulator. Once the connection is established, sending images along with patient data can be done [7].

- PACS, we built the PACS which consist of two main parts: the converter and database. The converter is performed by using the freely distributed program and open source named "DICOMIZER". Small modification has been made to the program in which the data (patient demography and the modality information) will not be inserted manually but retrieve it from database. In the database, the folder path will be stored and DICOM viewer (in this case, we use HIS) will display the image to the physicians or radiologists.

6. DISCUSSION

There are several issues that must be prepared to build an enterprise image management system, which we are not well known before, that will described clearly as follows:

- To support the simulation, a simple HIS already built which can be used to register patient and store the demography data in the database.
- Neither RIS Emulator nor Modality Emulator were given as an open source, therefore it is difficult for us to fully control the connection between our HIS, RIS Emulator, and Modality Emulator for patient's data transmission.
- We did not identify important things that must be followed in order to make the integration system to be real [6]. Therefore, we try to find that information from literature and here are several important issues:

a. DICOM network services are based on the client/server concept. In case two DICOM applications want to exchange information, they must establish a connection and agree on several parameters such as who is client and who is server, which DICOM services are to be used, and format of the data that will be transmitted (e.g. compressed or uncompressed) [1].

b. If you are working on establishing MWL connectivity, always start by revising the list of attributes (e.g., Patient Name, Patient ID, Patient's Birth Date, Patient's Sex, Pregnancy status, and so on) required on the modality and making sure they can all be provided [5]. Sometimes, a particular modality will require more data, which should be reflected in the modality's DICOM Conformance Statement.

- The major reason for considering integration system to support clinical operations and business and administrative functions in hospital is the service, which includes the workflow reduction that reduces the time for a patient be treated for radiology and physicians to diagnose them [8].
- RIS (or its substitute, used at a particular clinical location) is not DICOM-based, it uses the HL7 standard instead, and so either the MWL server or some additional DICOM broker converts RIS data into DICOM [5].
- One way to test the integration system specifically for the DICOM communication can be done using DICOM Network Snooper. However, an in-depth description of DICOM testing will be taken for the next future Research.

7. CONCLUSION

Most of the research is to find all important information in order to do an integration systems are based on DICOM standard. An integrated HIS-RIS-PACS system provides solutions for some of these obstacles. It has adopted DICOM and HL7 standards for imaging and text, respectively, images and patient-related data are entered into the system almost automatically, and the majority of imaging manufacturers have adopted DICOM and HL7 as de facto industrial standards. DICOM has become an indispensable component for the integration of digital imaging systems in medicine. DICOM offers solutions for many communication related applications in a network as well as off-line.

References

1. Medical Image Communication Standardization, Retrieved November 2011, from http://dicom.offis.de/index.php.en

2. H. K. Huang, PACS and Imaging Informatics: basic principles and applications, 2nd ed., Wiley-Blackwell, 2010

3. S. H. Abdul-Jauwad, M. I. AlJaroudi, "Developing a Wireless DICOM for Osirix," Proceeding of the IEEE-EMBS Biomedical and Health Informatics (BHI), Jan 2012, pp.89-92, in press.

4. L. Kolovou, G. Koutelakis, G. Mandellos, A. Darras, D. Lymperopoulos, 'Innovative cooperative scheme of novel RIS and PACS', *The IASTED International Conference on BIOMEDICAL ENGINEERING-BioMED 2005*, 16-18, 2005, Innsbruck, Austria, February 2005

5. O. S. Pianykh, Digital Imaging and Communications in Medicine (DICOM): A Practical Introduction and Survival Guide, Springer-Verlag Berlin Heidelberg, 2008.

6. Elisa MargarethSibarani, "*Simulating an Integration Systems: Hospital Information System, Radiology Information System and Picture Archiving and Communication System",* International Conference on Uncertainty Reasoning and Knowledge Engineering, 2012.

7. T. Fitrayana, I. K. E. Purnama, D. P. Wulandari, "Interkoneksi Simulator Modalitidengan Picture Archiving and Communication System (PACS) BerbasisProtokol DICOM", unpublished.

8. J. A. Maldjian, J. Listerud, and S. Khalsa, "Integrating Postprocessed Functional MR Images with Picture Archiving and Communication Systems", AJNR Am J Neuroradiol 23, pp. 1393-1397, September 2002, in press.