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University Hospitals and Teaching Institutes World Wide One PACS

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***Abstract*— This paper aims at setting up a new generation of PACS network that allows medical and academic communities to access and share clinical medical images, through open networks suggested for Iraqi medical systems and educational institutions. It aims to use Internet as the major provider for computational services to applications in ubiquitous computing environments. The learners will investigate, propose and develop new distributed solutions allowing the sharing of the remote access to medical imaging repositories. The structure of the system is modular structure that makes the project easy for edit and flexible for work. This means each one of the PACS subsystems consists of number of pluggable modules, allowing to add new features later by coding them as separate modules and plugging them into the existing system; This makes it suitable for use in any hospital or medical center.**

Using PACS as the main core for the learning part system will lead to the approach of the active learning this technique that will include buzz groups and medical case studies

The project had used the open source platforms (Apache Web server, MySQL Database Server, and PHP Server Sides Scripting) as new feature, to make use of their security, reliability, robust, wide support community, and finally the main feature is that all the platform component are customizable and can be edited or modified by any programmer which make them suitable for medical and academic use or research implementations.

***Keywords*— PACS, HIS, RIS, LIS, MITSS, Learning System, Intra Created Cases, External Cases.**

I. INTRODUCTION

World Wide one PACS helps Iraqi hospitals and medical training colleges and institutions to transform information into insight. That means access to patient data where and when it's needed. And now with dynamic imaging's top-rated integrad Web-based technology. Picture archive and communication system was consisted of medical imaging and data acquisition components and storage and display subsystems which were integrated with various digital networks [1]. Medical imaging will be converted to digital form, then, the image information will be collected, transmitted, storage, management through the computer network equipment and communication system, results of effective management and utilization [2]. PACS infrastructure consists of a basic skeleton of hardware components (imaging device interfaces, storage devices, host computers, communication networks, and display systems) integrated by a standardized, flexible software system for communication, database management, storage management, job scheduling, interprocessor communication, error handling, and network monitoring [3]. The strict definition of a PACS varies, but it is generally agreed that such systems must include image display, data archiving, and data management components. Some PACS also include interfaces (which can be operated purely by software) with image acquisition modalities such as computed radiography/digital radiography, CT, and MRI, and with hard copy output devices such as film or paper printers [4].

II. HOSPITAL SYSTEMS

Hospitals are the main healthcare providers in developing countries. For this reason hospitals ought to be the primary target institutions when aiming to improve health information systems in developing countries [5]. Nowadays, each subunit comprises an individual electronic domain that is constituted by an information system and or various specialized medical applications; all named Medical Information Systems (MISs) [6]. Hospital IT systems explained as bellow:

A. Hospital Information System (HIS)

HIS was defined as a set of different interrelated application systems that works together. Each application system consists of diverse sub applications that is used by different sites within a hospital [7]. Many research institutions and health software vendors tried to define and address the issues regarding HIS integration with the PACS systems. One of those integration solutions, the appearance of healthcare data exchange standards, such as DICOM and HL7, those standards specifies the interaction between separate systems that have improved the way heterogeneous HIS sub-systems can share information [8].

B. Radiology Information System (RIS)

The radiology information system (RIS) is designed mainly to support both the administrative and clinical operation of the radiology department, in order to reduce administrative overhead, and to improve the services quality of radiological examination [3]. The RIS system are usually used in conjunction with picture archiving communications systems that is sued to manage digital radiography studies [9].

C. Picture Archiving and Communication System (PACS)

The idea of PACS systems was developed since 1980. It includes three major components; image, transfer and storage systems [10]. These components are integrated

together by digital networks, communication protocols and software as shown in Fig. 1 [11]. PACS are now a reality, most PACS systems are set up in different hospitals. In addition to the clinical advantages of this administration system equipment, the educational value must be considered. [12].

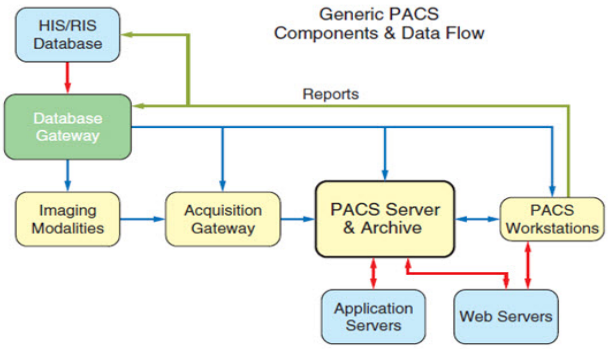

Fig.1 PACS Basic Components and Dataflow. [11]

III. Medical Training

Students under medical training frequently consult for a teaching files, which have examples of medical cases. The reason for consulting such collections of medical records is to educate them about the different information related to a condition, how the condition manifests itself in a diagnostic image, what are its attributes in the lab results, or how it was diagnoses and what treatment plans were considered for it [13]. There are many drawbacks to the hardcopy film libraries, such as physical degradation, and single copies that can be misplaced. To overcome these drawbacks and to take advantage of the rich digital information available in picture archive and communications system (PACS), teaching files should move into the electronic format. Currently, image-based teaching files exist in many radiology departments and they are useful [14].

IV. Problem Description

The overall objective of the paper is to explore the practicability of both medical and training application cases in Iraq, with particular reference to challenges and scope regarding its implementation and use. This paper is therefore based on the following research questions:

- Why is it necessary for Iraq to adopt medical and training systems technology?
- What are the challenges to this project implementation and how are they being addressed?
- How can a PACS system program be made sustainable in the context of Iraq?
- Why we need medical library of cases for training students?
- Can our Iraqi Medical Students get easy access and full experience to the hard archive copies of medical cases at their colleges?
- Is it possible to build a system for fast access and ease of use for both patients and medical staff.

In this paper, the above problems and solutions of current telemedicine system are stated an example of World Wide One PACS architecture.

V. Design Requirements

Corresponding to the medical environment, the design requirements will be classified as following:

1- Functional medical requirements.
2- Medical learning requirements.

Which are the basic requirements of the proposed system that should be fulfilled in working prototype of World Wide PACS system application.

VI. Design Phases

The purpose of this part is to create a technical solution that satisfies the requirements for the system. The challenge is to translate all of this information into technical specifications that accurately describe the design of the system, and that can be used as input to system construction. The PACS design phases explained as bellow points:

1. Planning for system design, where the existing project repositories are expanded to accommodate the system design, the technical environment and tools needed to support system design.
2. Define technical architecture, where the foundation and structure of the system are identified in terms of system hardware, system software, and supporting tools.
3. Create Database, where the actual database to be used by the system is defined, validated, and optimized to ensure the completeness, accuracy, and reliability of the data
4. The program design development, this defines the modules that need to be written and exactly what each module will do.

VII. System Design

The proposed system is web-based application. Fig. 2 shows a system layout work flow. Where it consists of three parts; the portal system part, the medical part and the learning one. Corresponding to the system requirements the portal system is the main interface of the medical and learning parts. The medical part will consist of nine subsystems; reception subsystem, chairman subsystem, specialist subsystem, pharmacy subsystem, labrotrary subsystem, PACS administrator subsystem, PACS broker subsystem, technologist subsystem and the radiologist subsystem while the educational part consists of three subsystems; supervisor subsystem, student subsystem and the administrator subsystem. The system design will explain how to go forward to accomplish those goals specified in the system requirements and it will be explained in the next sections in this paper.

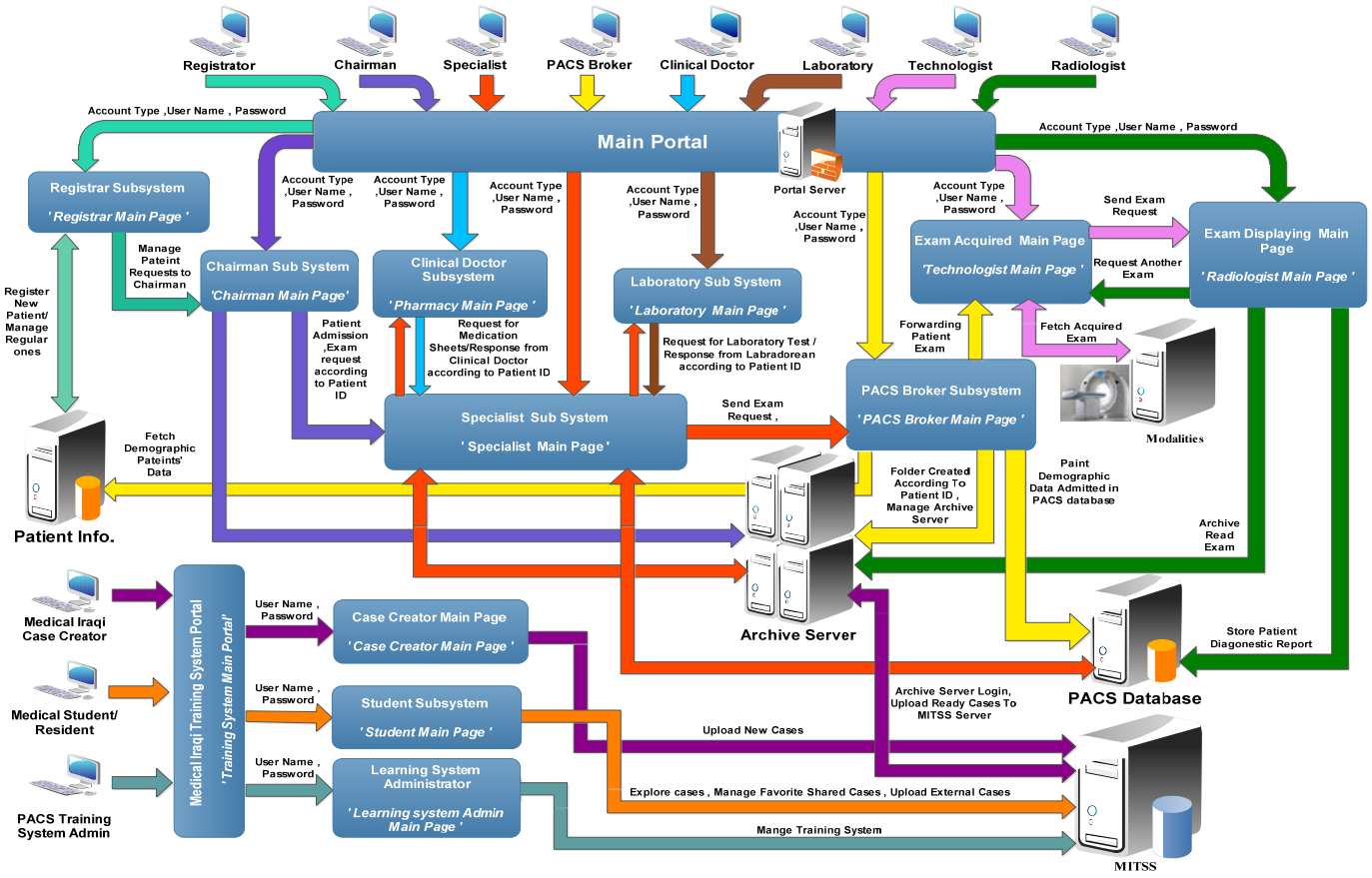

Fig.2 World Wide one PACS system Network Work Flow.

A. *Portal Main Interface*

Portal interface part is the main interface where all of the other subsystems are interacting with it, this interface represents the gateway to the other subsystems. Fig. 3 shows the main portal structure.

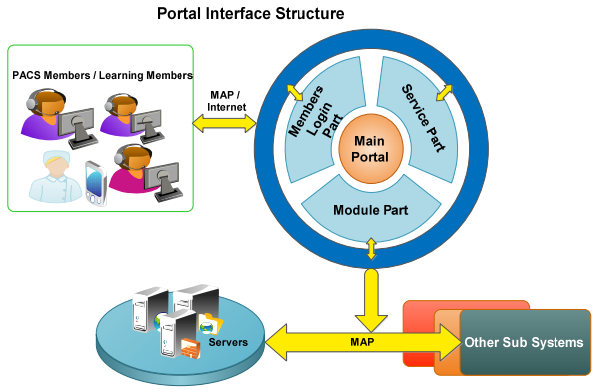

Fig.3 Portal Main Interface Structure.

B. *Core PACS Part*

In a wide view for this section, this part was developed using special framework that can support PACS images delivery and data visualization to provide a web based GUI that let user to interact with the system. Specialist subsystem as a part of the core medical PACS is very important subsystem, it has direct interaction with laboratory information subsystem, PACS Broker subsystem, chairman subsystem and pharmacy information subsystems. Specialist can do several jobs using the available tools, he can manage Patients' departments' admission, bed reservation, discharge, consultation, and medical record data transfer. Patient's demographics data, medical record, admission requests and exams orders are forwarded to PACS Broker, laboratory information subsystem and pharmacy sub system. Also it Helps the physicians to access patients' medical results directly when he access the archived cases. The specialist must be able to select which case is candidate to be uploaded to the learning system and he can use the chairman opinion for that case. Fig. 4 shows the specialist subsystem structure.

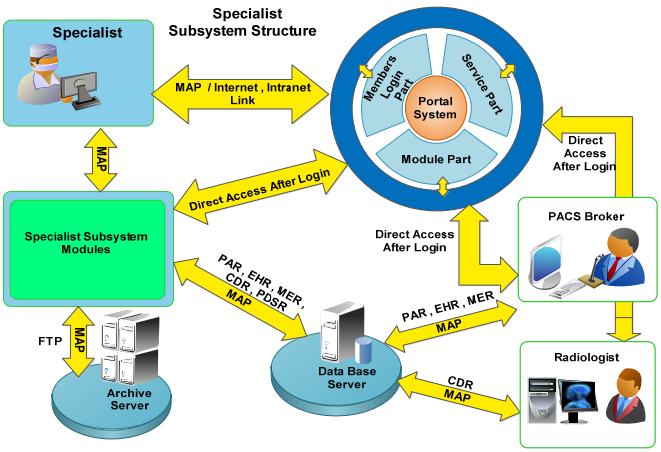

Fig.4 Specialist Subsystem Structure.

C. *Learning Part*

There are many situations in Iraq at which the students, residents any kind of medical learners need group of medical cases prepared and published from the radiology department under the control of the supervisor doctor in the specified hospital department. The available medical cases remains difficult for the learners because those cases may be stored as a hard copies in different places so that searching, collecting and managing all these cases is difficult and may take huge time. Another reason is that the Iraqi medical colleges have a huge problem to deal with information technology solutions. In this project special medical learning modules is designed to solve the previously mentioned problems for our Iraqi medical colleges regarding how to deal with huge number of medical cases and how to sort, manage and retrieve those cases.

This part of the project divides the control process into number of levels. The user of each one of these levels is supported by number of privileges according to his/her account type, the system can be constrained in three levels explained as below:

- Level A: Administration that allows the administrator to manage complete system, administrate members' acquire uploaded cases, and members/users privileges.
- Level B: Supervisor level or case creator which allows supervisor doctor (specialist member in the medical PACS part) to create, manage, and discuss cases. Supervisors can demand new membership from the learning system administrator.
- Level C: Trainer level this level accsesed by medical students via internet and resident, they can explore cases and download them if necessary and add the specified cases to their favourite cases.

The project structure is a "Modular Structure"; so the available structure and features are subjected to change or modification according to the needs of the developing team, this features bring into view the power of the modular open sources projects. The modular architecture of the learning part is shown in Fig. 5.

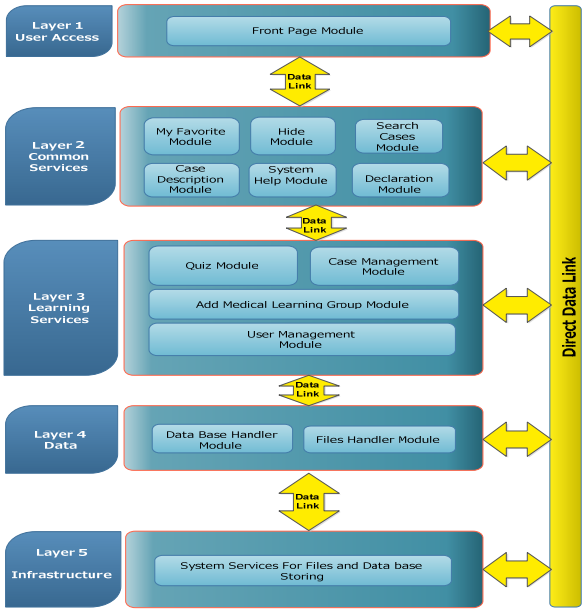

Fig.5 Learning Part Modular Architecture.

The learning part consists of number of n-tiers and each tier (layer) is divided into number of components as shown in Fig. 6. Each component has number of modules. Using of these modules lead to flexible programing by adding new features after coding them. This makes the available structure and features are able to be modified or updated efficiently.

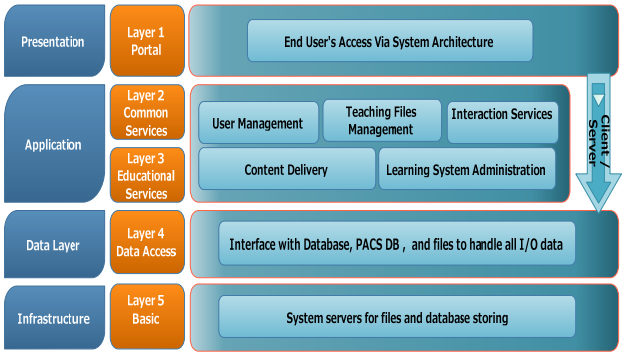

Fig.6 Learning Part Architecture.

VII. Project Environment and Results

The project is implemented using open source platform. The Pre-processed Hypertext (PHP) is used widely in the different parts of project. The open source server side scripting language is used mainly in developing some systems where sometimes is embedded with HTML. The system home page and other linked pages are a set of pre-made HTML pages that are dynamically created and displayed by the server. PHP has built-in features for communication with MySQL, that are great properties like, popular, platform independent, stable, easy to be used, an expansibled. The servers that are required to implement this project are:

1. PACS server: Apache HTTP server and MySQL database server is used as Web server software to host

and deliver the PACS core Webpages. This server should have PHP as server-side scripting language.

2. Medical Iraqi Learning System server: Apache HTTP server and MySQL database server is used as Web server software to host and deliver medical system Webpages. This server should have PHP as server-side scripting language.

Fig. 7 bellow illustrates the whole system implemented network.

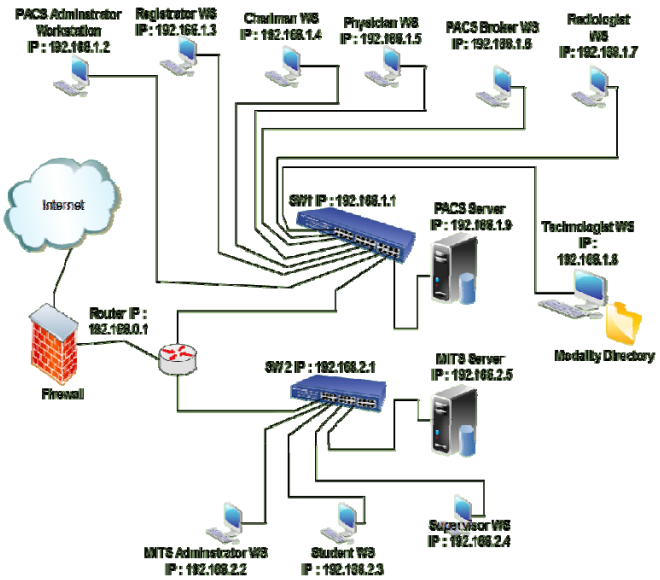

Fig.7 Project implemented Network.

The above network is implemented at Al-Naharain University College of information engineering researching laboratory and includes the following infrastructure hardware as shown in Table I, which mainly consists of three parts; part one : device name; part two: device type and part three: ip address.

TABLE I
WORLD WIDE ONE PACS SYSTEM HARDWARE SPECIFICATIONS

Device Name	Device Type	IP Address
Router	Microteck router board 2011	192.168.0.1
Switch 1	Mickroteck router board 493	192.168.1.1
Switch 2	Mickroteck router board 493	192.168.2.1

A. *Portal Part Implemented Modules*

The main portal login port is categorized into two sections the first one for medical staff members and the second section for the learning members, each member has unique user name and password after he/she fills the login fields member will be directed to the requested subsystem according to his/her membership type (registrator, chairman, PACS Broker, student, learning system administrator, etc.), see Fig. 8.

Fig.8 Portal Main Page.

B. *PACS Core Implemented Modules*

Reception subsystem as a part of PACS part where it's the first page will accessed by the registrar when he/she logs into the PACS successfully, Fig. 9 shows patients registration form.

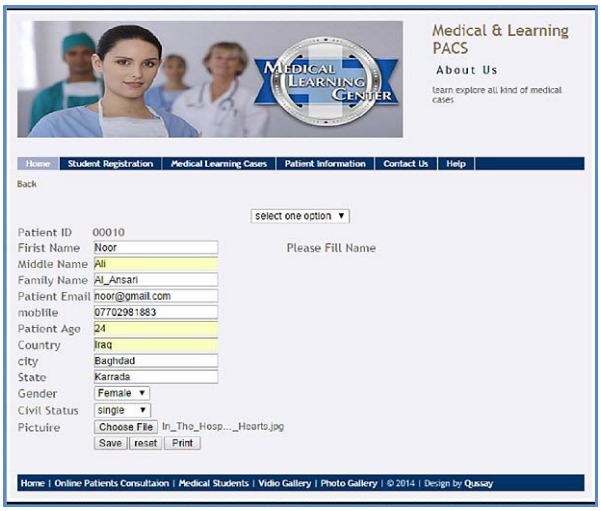

Fig.9 Patient Registration Form.

After patient registration another modules are implemented to help the chairman in the chairman subsystem to admit the patients and send medical exam

request to the intended physician in according to the selected department from the drop down list, see Fig. 10.

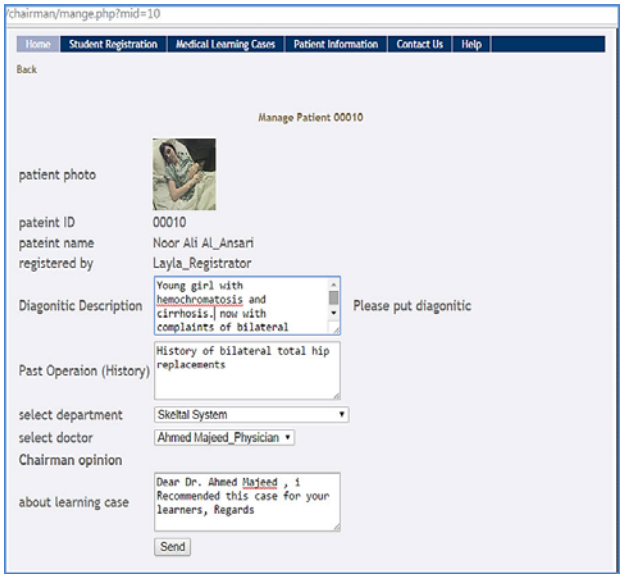

Fig.10 Medical Exam Request by the Chairman.

Special modules designed to support the physician subsystem to manage pending exams requests from the chairman, these modules is shown in Fig. 11 and explained as bellow:

- Send Exam Request to PACS Broker Module: this module helps the physician to forward the received exams to the PACS Broker subsystem for radiology test.
- Send Exam Request to Labrotrary Module: this module helps the physician to forward the patient exams to the labrotrarty subsystem for labrotrary test.

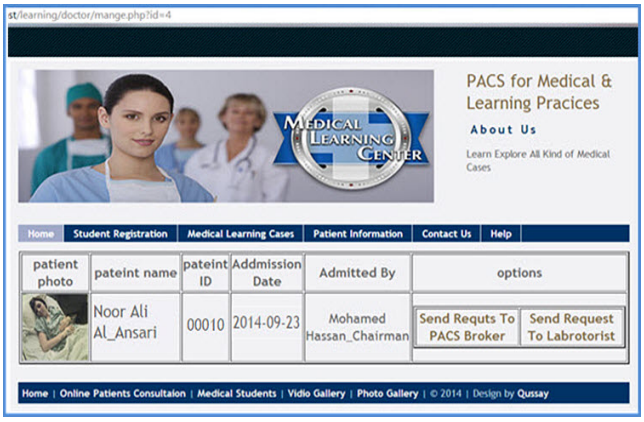

Fig.11 Manage Exams Requests by The Physician.

According to the workflow specified previously in Fig. 2, the physician can forward the received exams to the labrotorary subsystem and then to the PACS Broker or directly to the PACS Broker if there is no need for labortrary test. Then the exam will be forwarded to the pharmacy subsystem for lab medication sheets. Fig. 12 shows the received labrotrary test.

Fig.12 Received Labrotrary Report.

Fig. 13 shows the exam request form sent to the PACS Broker for radiology test, a radio bottom is programed to help the physician to select that if the patient case is useful for the students to be uploaded for the training section or not. He/she also can write full description for the radiologist to let him/her know about the case issue.

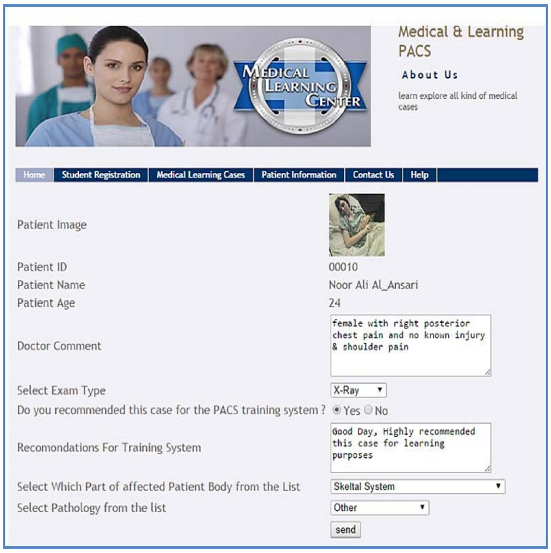

Fig.13 Exam Request to the PACS Broker.

On the other side the radiology information system have another list of modules, this modules helps both the radiologic technologist and the radiologist to do their jobs properly, Fig. 14 shows the radiologist ER report and some of the main modules listed as bellow:

- Upload Acquired Exams Module: this module used by the radiologic technologist to upload acquired exams from modalities.
- Explore Modality Exams Folder: this module used by the radiologist to view acquired patient exams in the modalities directory.
- Send Medical Exam Report: this module programed to help the radiologist to send digital radiologist report to the requested physician.

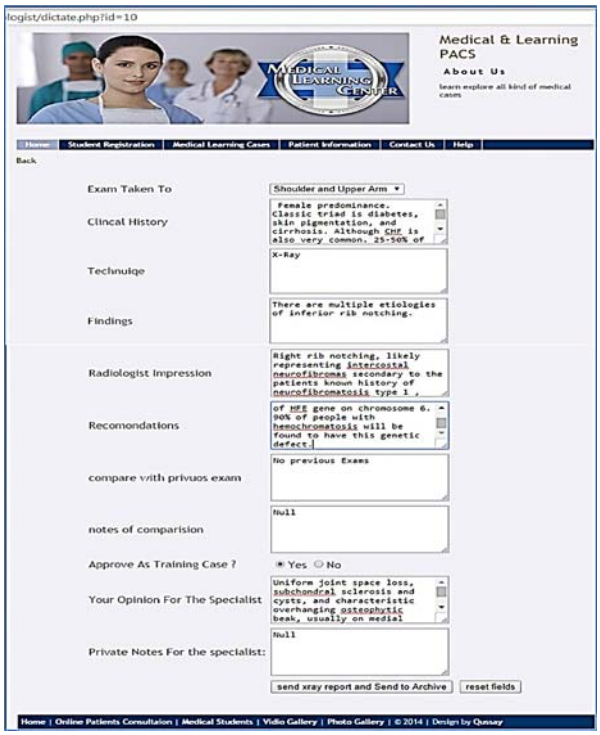

Fig.14 Radiologist Electronic Report.

C. *Medical Learning Part Implemented Modules*

The system provides many clinical operations and online access to many real cases that cover all body organs, that cases proved helping for researchers and radiologists learners such as medical students, residents and clinical doctors, etc. The cases are created by the students' supervisor in two ways:

1. Intra PACS Learning Cases Creation: When the supervisor sees an interesting medical case, he can select the case information and mark them as a teaching file then send the teaching medical case to the administrator of the learning section in order to admit the case as a learning one. This operation doesn't slow down the labrotarist, pharmacist and the radiologist because the case information fetched from the database and stored within the uploaded medical cases.
2. External Learning Cases Creation: the supervisor can use special form to upload external medical cases, after filling the required cases information form , the system will check the data, store them, and then the system direct the supervisor to the image's upload software that help him/her to upload the medical images, see Fig. 15.

Fig. 15 External Case Creation.

Another modules implemented to help the supervisor doctor in the learning part to create mailing groups for his/her admitted students. The recipient need to have a teaching file account, mailing groups creation is shown in Fig. 16.

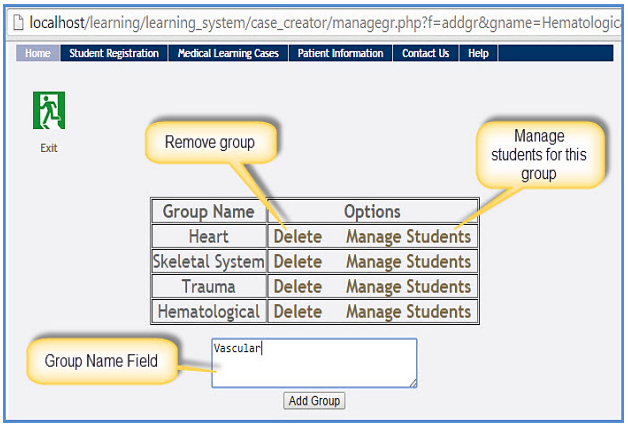

Fig. 16 Supervisor Mailing Cases List Groups.

Students can post comments to any case but they must be sure that they are previously registered as students in order to be able to use comment module. Learners must be registered first in order to be able to download cases as pdf or using special modules that help them to mark any case they want as a favourite one in order to re-read the case again. Fig 17 shows the Intra created case and the student interaction with the supervisor that create the medical case.

Fig. 17 Intra PACS Medical Case.

CONCLUSIONS

We have successfully implemented the project. The investigation of the proposed designed system gives the following conclusions:

1. The medical section is designed to provide services that will speed up the diagnosis and treatment processes by reducing the report turnaround time (the interval between the exam completion by the technologist and report completion by the radiologist).
2. The medical section is designed in an easy and flexible way in order to help for transferring the images electronically which will reduce the rate of lost or misplaced films.
3. The medical part is designed to use the electronic health records which is better when compared to paper-based medical records, because it can provide physicians with complete, real-time and easy access to patient information which helps to improve the quality of health care. Also it provides rich resources for scientific researches, teaching, and public health and optimize medical information exchange.
4. Students' orientation in the learning section is one of the factors that makes any educational system works successfully, because the entire system had been found to help them to get the educational services in easy way. The reaction of the system test users (students especially) were vary from very zealous students to unconfident ones, this variation giving bright view about the digital divide from one student to another, Commenting module and the available students that will join medical groups makes the supervisors able to determine how the student share ideas and interact with the shared cases. While the supervisors' response was very hopeful that this system will increase the time using efficiency for both supervisors and students by using the off-print education materials from the online shared cases with full supervisor's observation.
5. This project include the design of medical testing for some of special cases, this test based on quizzes which is added by the student's supervisors. It will improve the clinical skills of the student without spending more time waiting for some special cases in the hospital.

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