Developing a Robust Multimedia Picture Archiving and Communication System (PACS)

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ABSTRACT
In medical imaging, Picture Archiving and Communication Systems (PACS) is a technology centered upon leveraging computers and data communication technologies to collect, store, process, retrieve and disperse medical imaging data to hospitals and affiliated clinics geographically spread across the world. PACS breaks down the physical and time barriers associated with traditional film-based image retrieval, distribution and display.
With the identified limitations in the traditional filmed based radiology and the existing model of PACS, we came up with an improved model for PACS. The model was implemented using the visual studios and the assumption of our model was tested to verify the validity of implementation. To this end, structured questionnaires which were moderated by experts in the field of radiology and clinical medicine were distributed to survey the degree of the accuracy and acceptance of our implementation.

This research work developed an improved model for PACS with the incorporation of new features into the existing model. Its objectives were achieved: implementing multimedia PACS; reduced transmission time and storage space requirements of radiological images. The work has contributed significantly in the field of radiology in that; PACS serves as a more convenient means of teaching students of radiology, it also reduces transmissions time requirement for referral cases and access time to images and radiological report over the network. It has also reduced the storage need of the medical images. It improves on the time of patient consultation; reduce stress associated with imaging and associated activities.

Keywords: PACS, DICOM, MRI, CT, ARCHIVING, and COMMUNICATION.

1. INTRODUCTION
In medical imaging, picture archiving and communication systems (PACS) are computers, commonly servers, dedicated to the storage, retrieval, distribution and presentation of images (Wagner et al, 2002). The medical images are stored in an independent format. The most common format for image storage is DICOM (Digital Imaging and Communications in Medicine) which is a standard in medical image transmission and storage. Electronic images and reports are transmitted digitally via PACS; this eliminates the need to manually file, retrieve or transport film jackets (Wagner et al, 2002). A PACS consists of four major components: the imaging modalities such as CT and MRI, a secured network for the transmission of patient information, workstations for interpreting and reviewing images, and long and short term archives for the storage and retrieval of images and reports. Combined with available and emerging Web technology, PACS has the ability to deliver timely and efficient access to images, interpretations and related data. PACS breaks down the physical and time barriers associated with traditional film-based image retrieval, distribution and display (Reiner et al, 2000). Most PACSs handle images from various medical imaging instruments, including ultrasound(US), magnetic resonance (MR), positron emission tomography (PET), computed tomography (CT), endoscopy (ENDO), mammograms (MG), digital radiography (DR), computed radiography (CR) etc.

Due to tremendous advances in areas such as micro-electronics and broadband Internet technologies, communication and computing are becoming ubiquitous. Progress in human machine interface technology increases the usability of the technology for the citizen and dramatically expands the application domain (Smailagic et al., 1999). Rapid advances in information technology and telecommunications, and in particular mobile and wireless communications, converge towards the emergence of a new type of infrastructure that has the potential of supporting a large spectrum of advanced services for healthcare and health (Bauer et al., 1998). Currently the ICT community produces a great effort to drill down from the vision and the promises of wireless and mobile technologies and provide practical application solutions. Research and development activities include exploration of the use of wireless networking in medical settings, including advanced technologies for data gathering and omnidirectional transfer of vital information. The ongoing evolution of wireless technology and mobile device capabilities is changing the way healthcare providers interact with information technologies. The growth and acceptance of mobile information technology at the point of care, coupled with the promise and convenience of data on demand, creates opportunities for enhanced patient care and safety. With the emergence and the introduction of communication technology in health management system, wide area in public health is going into full automation. This is achieved through the increase in flexible, well-structured and also efficient communication mechanisms (Stemm and Katz, 1997).

Many citizens are far from specialist health care services and there is a need to provide quality health care services to these set of people. With the introduction of communication technology to this area i.e. the area of remote consulting, the gap so created will be bridge. E-health is the bridge to this gap; it facilitates a better grasp of the key issues in the nation's health-care thereby improving actual statistics for planning purposes. E-heath will allow the Government to attract more external funding for health; it allows access to specialist knowledge around the world without physical presence of the specialist. E-health removes access barriers and geographical constraints (Esler et al, 1999). One of the approaches to E-health is the picture archiving and communication system (PACS). A picture archiving and communication system (PACS) is a computerized means of replacing the roles of conventional radiological film: images are acquired, stored, transmitted, and displayed digitally. When such a system is installed throughout the hospital, a filmless clinical environment results and the hospital is said to be electronic based (eHealth Initiative and Foundation for eHealth Initiative, 2008).

Picture archiving and communication systems (PACS) can result in increased efficiency in data management, eliminate the burden of film storage and retrieval, and facilitate rapid communication and remote relay of images. Thus, PACS have been widely introduced as a credible alternative to the traditional film-based radiological service (Paskins and Rai 2006).

2. ARCHITECTURE

Typically a PACS network consists of a central server which stores a database containing the images. This server is connected to one or more clients via a LAN or a WAN which provide or utilize the images. Web-based PACS is becoming more and more common: these systems utilize the Internet as their means of communication, usually via VPN or SSL (Taira et al, 1996). The software (thin or smart client) is loaded via ActiveX, Java, or .NET Framework. PACS workstations offer means of manipulating the images (crop, rotate, zoom, brightness, contrast and others).

Modern radiology equipment, modalities, feed patient images directly to the PACS in digital form. For backwards compatibility, most hospital imaging departments and radiology practices employ a film digitizer. The medical images are stored in an independent format. The most common format for image storage is DICOM (Rosslyn, 2001) (Digital Imaging and Communications in Medicine), a NEMA standard (Hori, 1996). The basic architecture of a picture archiving and communication system is shown in figure 1 and the conceptual framework is depicted in figure 2 below. Flow chart of the operation of PACS and Information flows of PACS for a remote user is depicted on figures 3 and 4. The remote user can have access to the central database via the use of wireless connections.

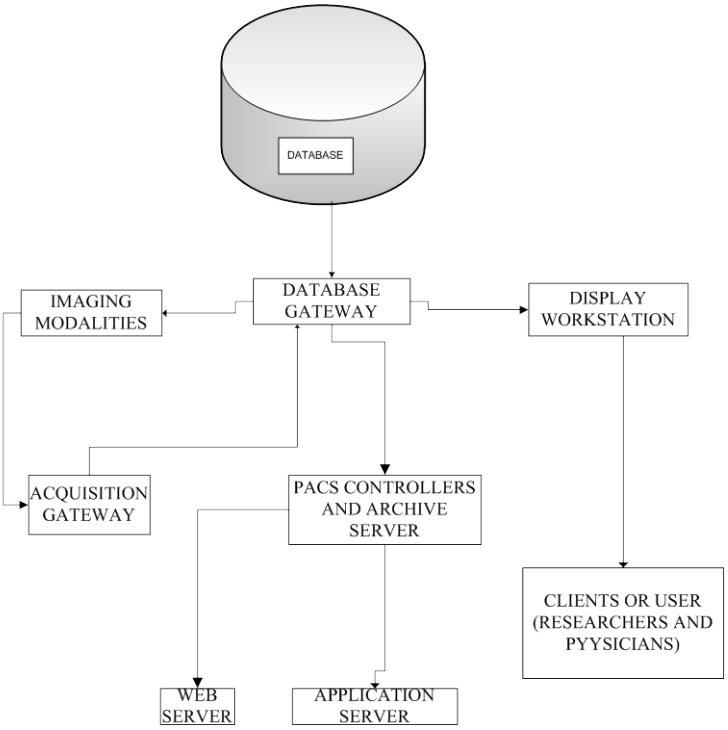

Fig 1: Basic architecture of a picture archiving and communication system.

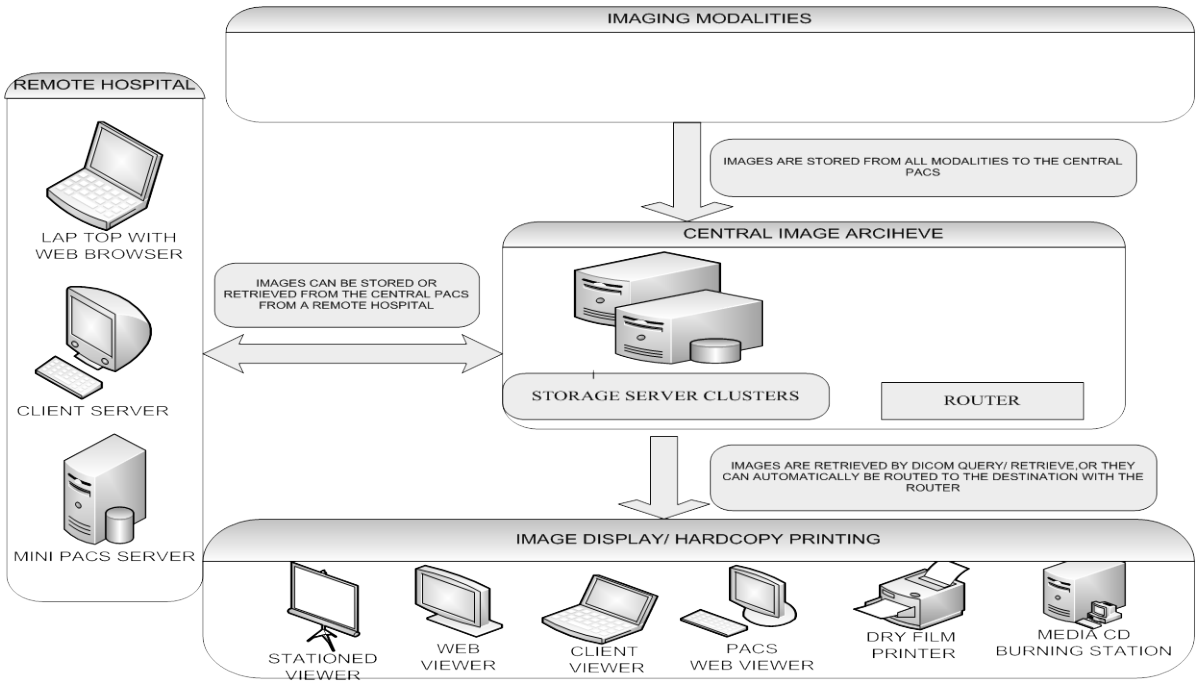

Fig 2: Conceptual frameworks of PACS

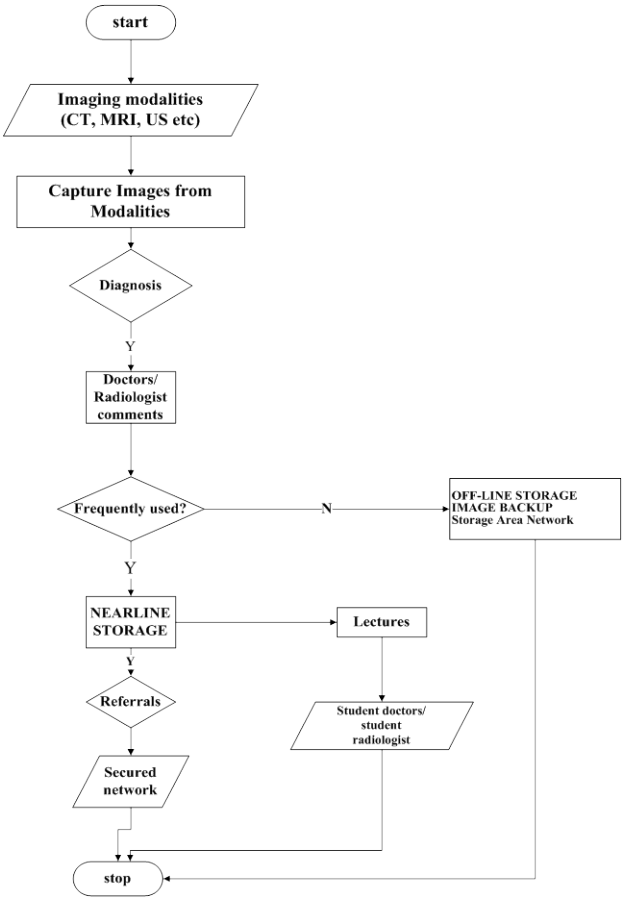

Fig 3 Flow chart of the operation of PACS

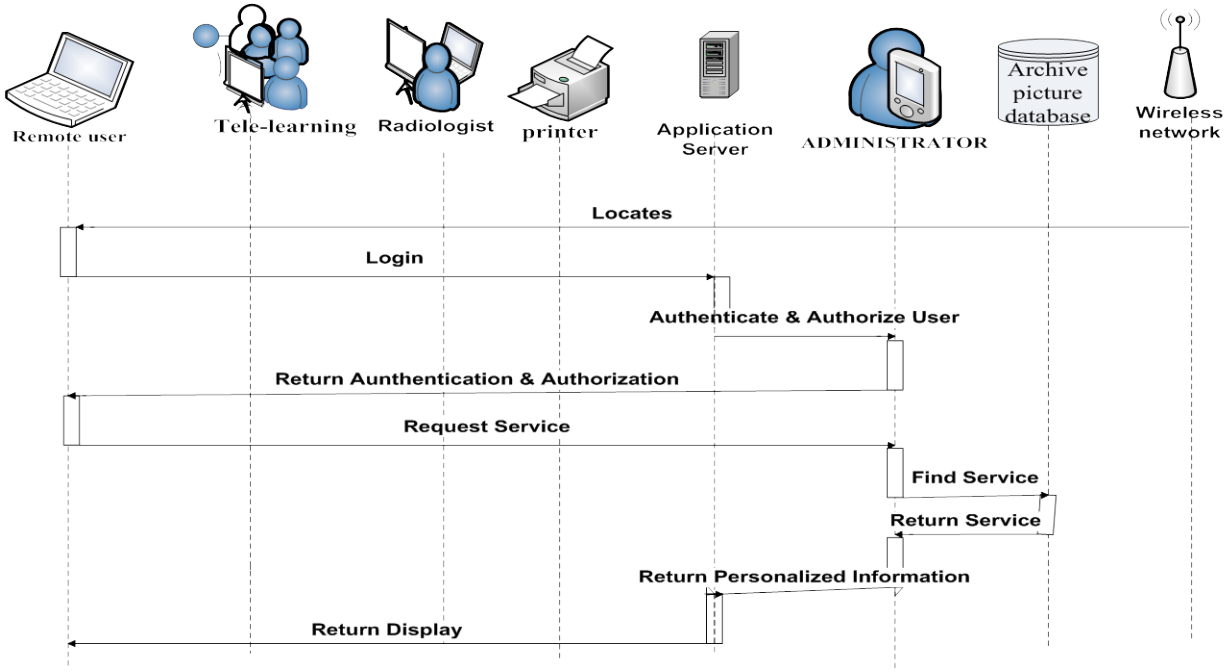

Fig 4 Information flows of PACS for a remote user

3. IMPLEMENTATION AND RESULTS PRESENTATION

3.1 Implementation Model

Class libraries and data models for all components have been designed. There is sufficient information to generate the code for implementation. An appropriate framework and technology have to be considered to make sure that components are implemented on an open platform, where integration with other existing components is possible. Microsoft.Net is considered to cater for that platform with its web service technology which is platform and language neutral, and its ASP.Net Mobile controls that use adaptive rendering for different browsers of mobile devices. The picture archiving and communication system was implemented using the visual studios. A user interface was designed for log-in and some administrative work. The interfaces include the radiologist's page, the doctor's page, student's page, and the administrator console.

3.2 Implementation Environment

.NET is the Microsoft Web services strategy to connect information, people, systems, and devices through software. Integrated across the Microsoft platform, .NET technology provides the ability to quickly build, deploy, manage, and use connected, security-enhanced solutions with Web services. .NET-connected solutions enable heterogeneous systems to integrate more rapidly and in a more agile manner and help them to realize the promise of information anytime, anywhere, on any device. .NET is not just about easy-to implement components. .NET applications run under the control of a runtime called the common language runtime (CLR).The CLR performs a just-in-time compilation of all code at runtime, allocate memory when you create new objects, and does garbage collection of objects that are no longer required, which automatically frees up memory which is no longer needed by.NET objects.

Because the CLR compiles all code at execution time, it implements strict type checking. Errors such as unsafe casting of one object type to another, addressing an array of bounds, or writing past the end of a buffer are just not possible. The common language runtime also manages security, allowing much finer control over the functions that a piece of code is allowed to perform and the resources it may access.

3.3 Design space

The design space is the primary point of security, where any of the users can log in with their user name and password assigned to them by the administrator. Any staff of the hospital therefore needs to get a user name and password. The password inputted or supplied by the user is compared with that in the database and hence you are granted access to use the software on the condition that you had been preregistered. When the program is executed the design space looks like the figure in figure 5. It is the active form of the design space. The user after obtaining his/her password can gain access to the software in the degree of use and its functionality. An individual can log-in as a radiologist, a doctor, a student and others. There are options that an individual can log on as: as the administrator, as a doctor, as a radiological student and other users.

3.4 Radiologist interface

It serves as the administrator's page where the major activities on the software can be managed. The administrator assigns each user with a specific and unique username and

password, in the case where a user needs to change his/her password; it is being handled solely by the administrator to enforce security. The radiologist is responsible for loading images into the database after it has been acquired and necessary documentation done on the image. These images can then be accessed by other users, it therefore suffice to say that the radiologist must be logged-on before any users can have access to the images in the database. Any changes made on the images like comments, and annotations must be effected through the radiologist. The radiologist can view images, change passwords, delete images from the database as shown in Figures 6 to 9 below.

Fig 5: Radiologist and Administrators' portal

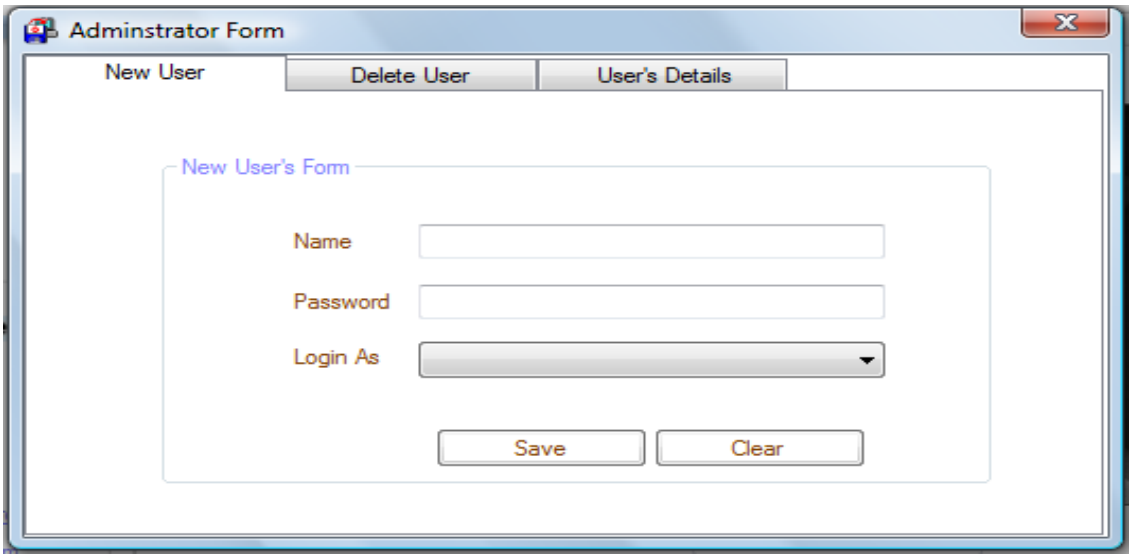

Fig 6 Radiologist and Administrators' portal for registration of new users

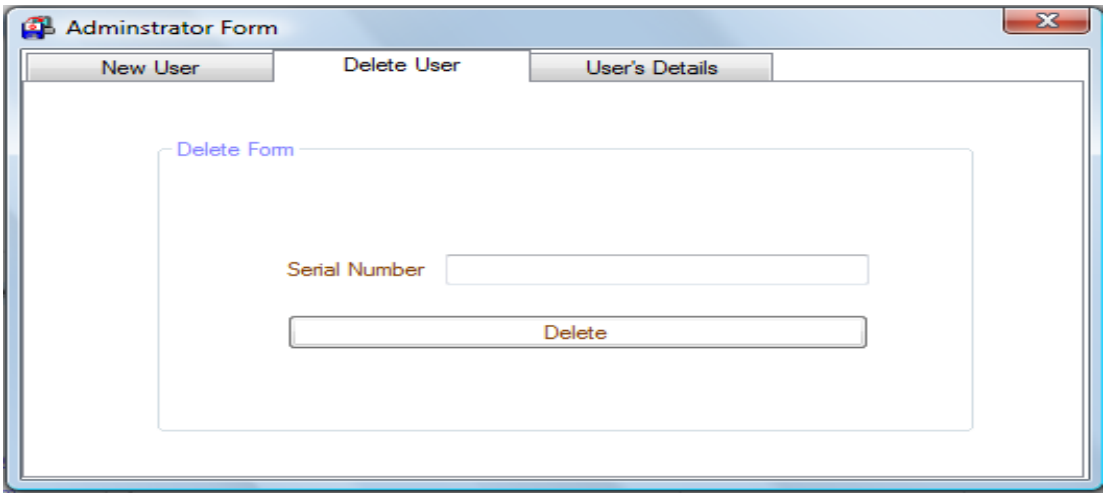

Fig7: Radiologist and Administrators' portal for deleting existing users

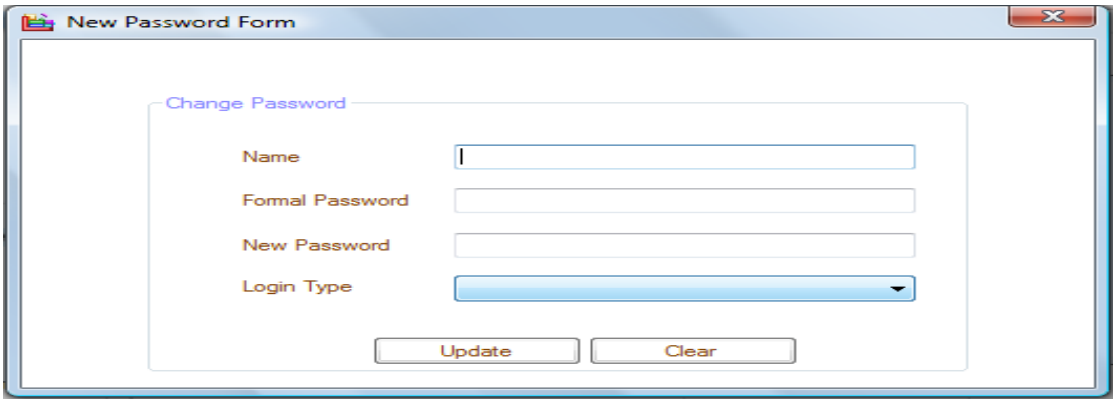

Fig 8 : Radiologist and Administrators' portal for assigning passwords

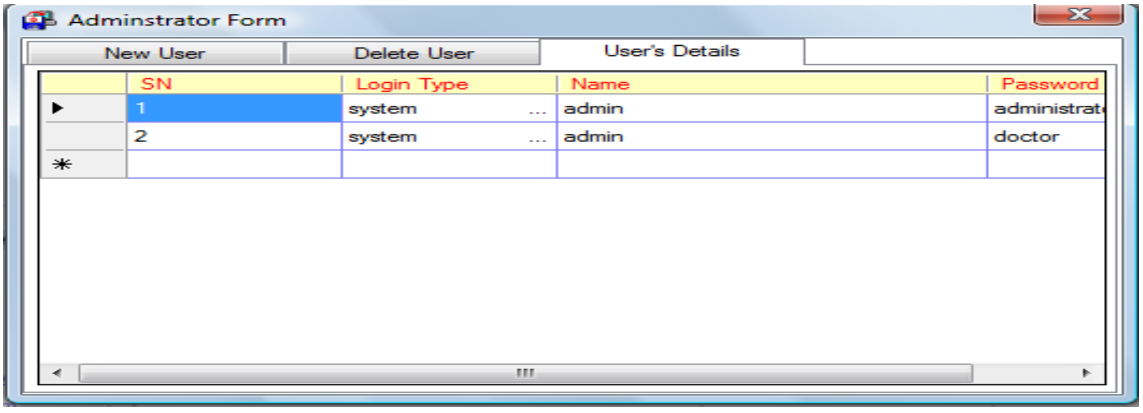

Fig 9 Radiologist and Administrators' portal displaying registered member

3.5 Doctors' Interface Design

The doctors' page is similar to that of the radiologist, but with some of the security features disabled. The doctors and other users can only log-on when the radiologist is already logged in. the date, day and time of log-on is displayed at the left hand side of the interface to keep tract of the time of login and logout. The individual logged on appears on the space for the client so that traffic can be managed effectively. The doctor can view images, request for images and edit information/add

information providing more details on the database. The doctor can also send messages on his/her portal to any member on the server. This whole functionality is shown in Figure 10

Fig 10: Doctors' page

4. OPERATIONAL DETAILS

4.1 Launching the Server

The software is designed to conform to the client-server architecture; hence the server serves as the coordinating point for all the users. In as much as we want to communicate remotely with some other hospitals using the internet or the intranet as the case may be, we need to acquire an internet protocol (IP) address for communication on the TCP/IP. When the server is launched, it provides a space where you can enter the IP address of the hospital or clinic where the software is deployed. The space serves as the entering point for the IP address. On entry of the address, the ok button is clicked on, the server is connected for other clients on the network to login and a prompt is displayed to show a successful connection as shown in Figure 11. To disconnect the close button is used to disconnect from the server. However the server has to be running to maintain the connection on the network. Once the connection is achieved, the administrator can log on to manage the affairs of the others.

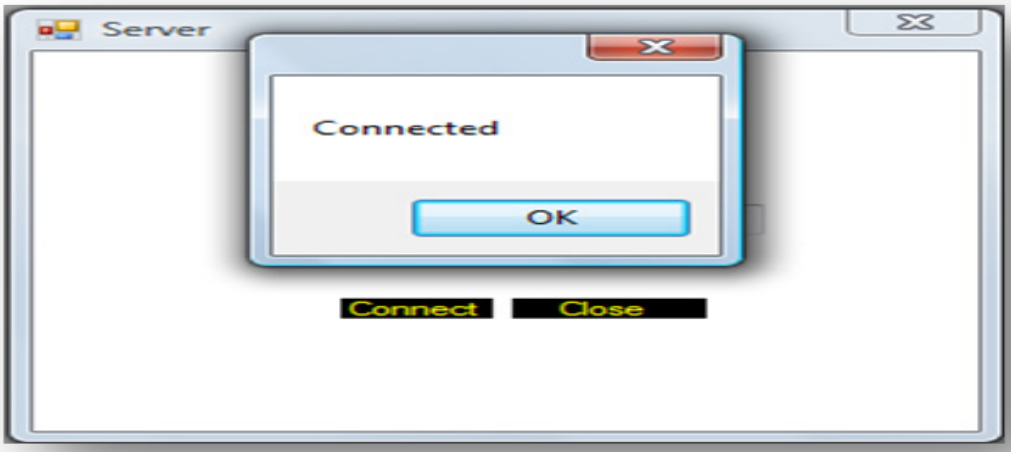

Fig 11: Successful connections to the server.

4.2 Launching the Radiologist Page

Once the server is running the radiologist page can then be launched, on the console of the visual studios environment, this starts the debugging process, which commutates into the authentication stage where the user is prompted to supply his/her username and password. Once this is correctly done a page comes up which looks like the one in Figure 12. The radiologist page affords the administrator the

opportunity to upload radiological images acquired from image modalities into the database. It also affords the administrator to view image for editing and correction of mistakes on the comments on the image. Once the image is uploaded in the database, it can then be used by other users as reference image. Once the radiologist is logged on, the doctors and other users can get access to communicate with the administrator and with one another.

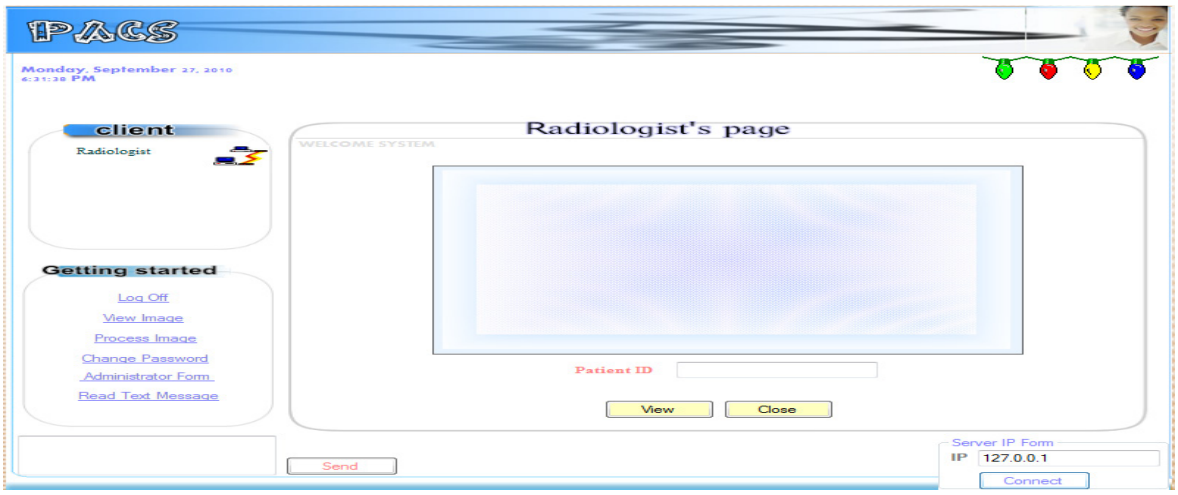

Fig 12: The launched radiologist page

4.3. Loading radiological images on the PACS

On the administrator's page as shown in Figure 13, a portion on the design space with the instruction to double click to load picture, once that is done the source to obtain the image is located and it pops up as shown in Figure 14. the image is then selected, the address is loaded into the address space and the image is loaded into the interface as shown in Figure 15, the comments on the image is typed in by the expert, which can be revisited by the doctors. The doctors can write their own observations on the radiological image also. A valid patient ID is asigned to the image for searching it out at a later time and to avoid mixup of patient information. The ID assigned to the image is inputed into the patient information on the hospital information management system. If the image is succesfully uploaded it is stored permanantly by clicking on the save botton, else the close botton is used to clear the image and clear the page to the idle mode for the next operation. A successful save marks the successful upload of the image into the database as shown in Figure 4.16.

Fig13: Uploading images in the database

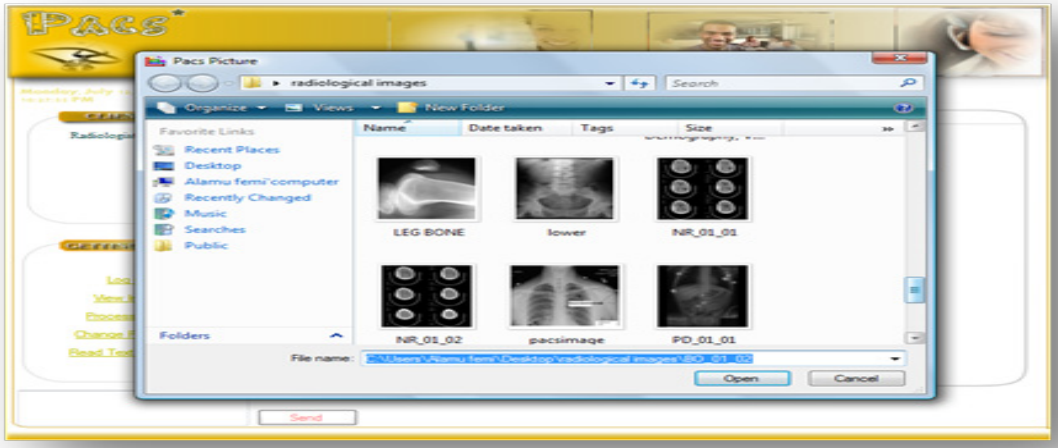

Fig 14: Source of Images

Fig15: Loaded image

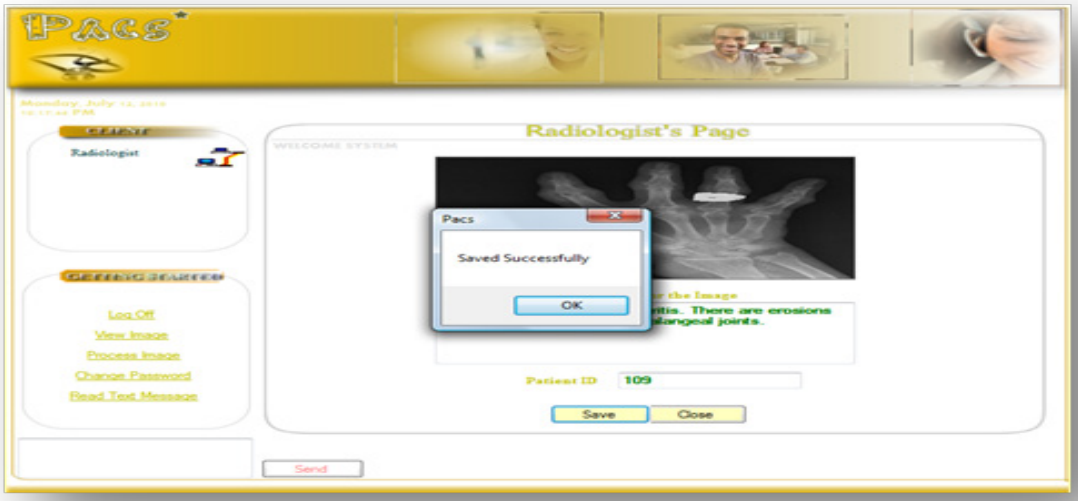

Fig 16: Successful upload of image to database

4.4 Requesting for an Image

Request for an image can be done by the doctors alone; this is to avoid unnecessary comments on the images by unqualified persons, which may be tantamount to compromising the consistency of the information in the database. The comment for the image can be written onto the space provided for the comment as shown in Figure 4.18 below. To request for the image, the patient ID must be entered into the space provided; the request button is click, there is a little processing and the image so requested for is shown. On entering the comment, the doctor can save the comment; exit the page by clicking on close button. The flow chart for requesting for the image is shown in Figure 17 below.

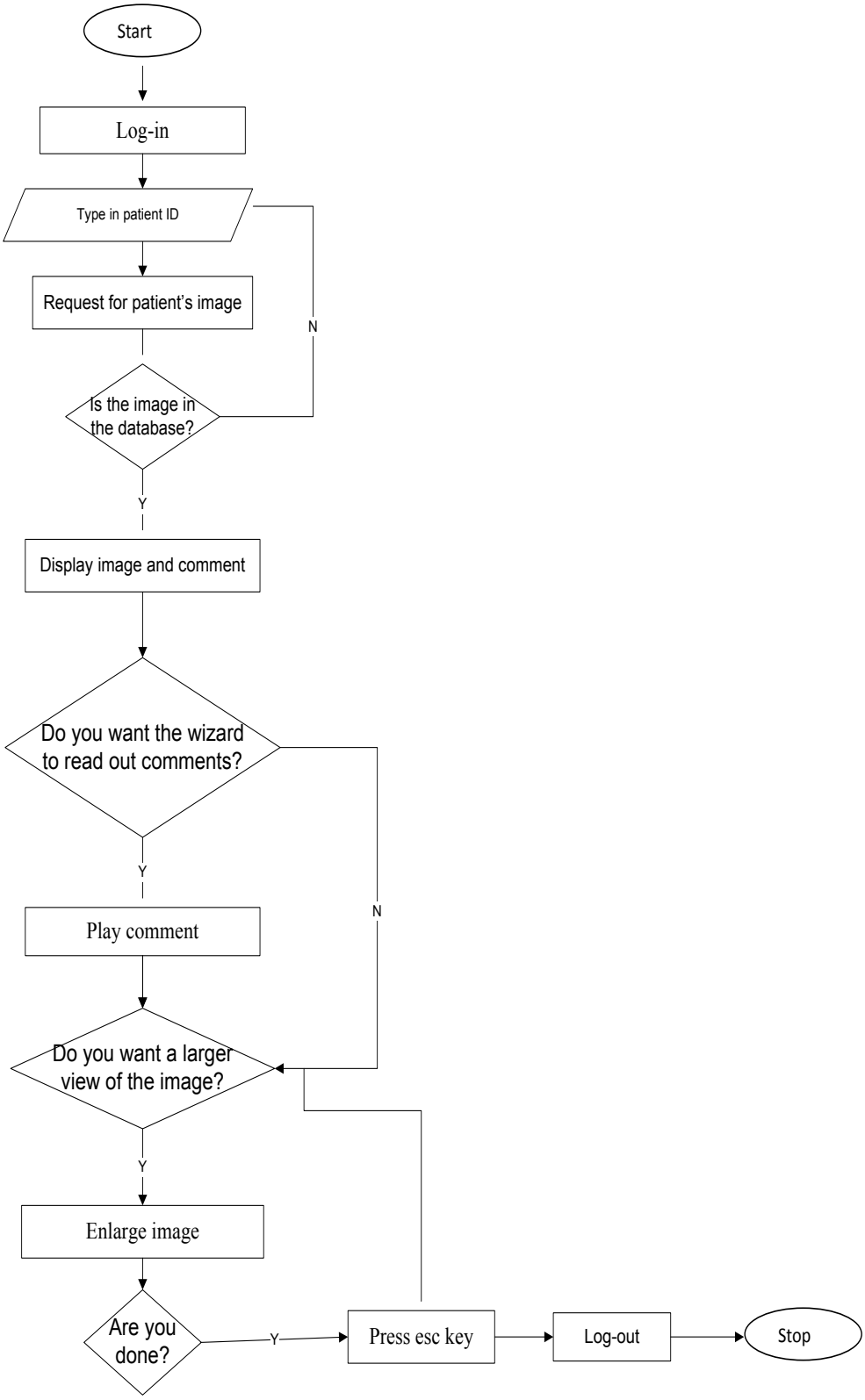

Fig 17: Flow chart for image request

Fig 18: Requesting for image

4.5. Viewing Images

When the image has been successfully loaded into the database, it can be viewed by any "user" on the network. This is to serve as a tutor for the student/trainee radiology and resident doctors respectively to understand abnormalities in the radiological images. The patient ID is entered into the address space as shown in Figure 4.19, the view button is clicked upon and the image appears for necessary observation and teaching purposes. This is one of the major problems addressed by this research work i.e. to serves as a better teaching aids for radiologist and doctors, this will also make it more accessible to other users for a better of understanding of radiological process. The image on the interface may be enlarged to have a better and larger view by double clicking on the image. Once the image pops up, a wizard comes up to read out the comments on the image as shown in Figure 4.20 this aspects also improves the multimedia capacity of the implementation. The escape key on the keyboard can be used to restore the image to its original form. Options to enlarge the image, read comments or play comment is also included in the implementation to cater for those with special medical impairments as shown in Figure 4.16, the image can also be enlarged to for larger viewing as depicted in Figure 4. 21.

Fig 19: Entering patients ID

Fig 20: Image found and the comment read out by the wizard

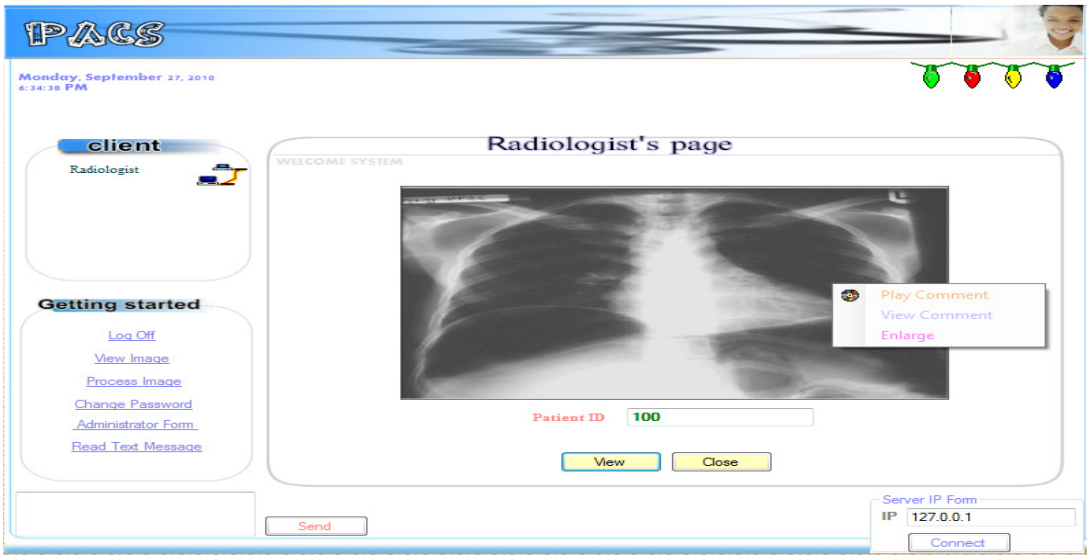

Fig 21: Options for enlarging, reading and playing comments

Fig 22: Enlarged radiological image

5. CONCLUSION

This paper has attempted to solve some of the inherent problems identified with the radiological unit of health care provider by automating major processes in the acquisition, transmission, storage and interactions among medical personnel in the handling of images. With fast evolving automation of medical processes and developments in e-health and telemedicine framework, the importance and the contribution to knowledge of this work are

- A significant improvement on the present model of PACS was achieved; this will improve on the cost effectiveness of the deployment and installation of PACS in healthcare institutions.
- The implementation of this work in a multimedia form will improve on the user friendliness of PACS and hence improve the efficiency of health care delivery and better means of training student radiologist

6. REFERENCES

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