



Addis Ababa University

School of Information Science and School of Public Health

M.Sc. in Health Informatics Program

Designing a Web based Tele-Radiology Management System:

The Case of Danu Orthopedic Diagnostic Center, Addis Ababa.

By

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Dedication

I would like to dedicate this project to my beloved Family, to my dad Ato worku Wolassa, to my mom Adanech Wolde, and to my beloved wife Ruth H/yesus Adera.

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ACRONYMS

CT	Computed Tomography
DICOM	Digital Imaging and Communication in Medicine
FTP	File Transfer Protocol
GWS	Google Web Server
HTML	Hypertext Markup Language)
HTTP	Hypertext Transfer Protocol
ICT	Information Communication Technology
IIS	Internet Information Server
IT	Information Technology
MOH	Ministry of Health
MRI	Magnetic Resonance Imaging
OO	Object Oriented
PACS	Picture Archiving and Communication System
QUDI	Quality Use of Diagnostic Imaging
RAD	Rapid Application Development
UML	Unified Modeling Language
US	Ultra-Sonography
WHO	World Health Organization
WWW	World Wide Web

Abstract

Introduction: The advancement in health care technology has brought us a means of electronically transmitting radiographic patient images and consultative text from one location to another. This technology is called Tele-radiology. Basically, tele-radiology attempts to transfer CT scans, MRIs, and X-rays from one location to another. On the era of information age especially in health care information technology there is an enormous amount of need regarding interoperability and collaborations between organizations. These quest for collaborations range from simple outsourcing of sub processes to complex business network processes.

Objective: This project attempt to construct a web based Tele-Radiology Management System based on PACS for Danu Orthopedic Diagnostic Center.

Methodology: For the development of the system: Interview and Observation were the methods used to collect data and UML and Microsoft Visio 2003 to design and development methodology. The system was achieved including the necessary interfaces that feed the relevant data to the PACS like demographic information, patient history, examination orders, etc.

Result: The result of the project study indicated that there is need of the designed system and good understanding about the benefits of Web based tele-radiology Management System. The functions that involve in this system are storing, retrieve, insert, update, and delete image message works successfully.

Conclusion: The designed Web-based tele-radiology management system based to support orthopedic radiological medical data. The system, through its modular structure, records all the necessary medical information in terms of patient data, examinations, and operations and provides the user-expert with advanced image-processing tools for the communication, manipulation, processing, and storage of radiological images using the DICOM protocol.

Recommendation: A web based tele-radiology management system presents a service delivery model for providing cost-effective and flexible radiological services. The designed system can enable the delivery of radiological services to several diagnostic centers for patient care.

Chapter One

Introduction

1.1 Background

Tele-radiology is a means of electronically transmitting radiographic patient images and consultative text from one location to another location. Basically, tele-radiology attempts to transfer CT scans, MRIs, and X -rays from one location to another. Tele-radiology is one component of telemedicine that only deals with the transmission of radiology images. Radiology Accreditation Services engaged by the Quality Use of Diagnostic Imaging (QUDI) program to provide recommendations for technical and practice standards for accreditation requirements for tele-radiology (2).

Now days a trend shows that increasing numbers of collaborations between organizations, ranging from simple outsourcing of sub processes to complex business network processes. With the developments in information technology, the same trend is starting to appear in the healthcare domain as well. Already existing examples are tele-radiology and telemedicine (the modern version of 'in absentia healthcare'). Through this trend, the main focus shifts from the departmental functional view (as it is now) towards a cooperation view involving healthcare providers from different medical disciplines that can exist within the organization/hospital (the departments) or that exist in other hospitals and/or organizations (1).

Tele-radiology is the electronic transmission of diagnostic imaging from one location to another for the purposes of interpretation and/or consultation (3). this definition includes PACS (Picture Archiving and Communication System) networks inside hospitals as well as solutions for remote areas. It is important to underline that tele-radiology is a solution that should support the normal in-ward radiological activity. An onsite supervising qualified radiologist provides the optimum clinical environment for the patients and the referring physician by providing daily interaction, input and consultation. Only where there is difficulty in fulfilling manpower needs, tele-radiology will provide support round the clock for 24/7 reporting activity and for interpretation of complex cases.

Tele-radiology will also allow timely and efficient interpretation of radiological images, give better access to secondary consultations and improve on going education. It is mandatory that tele-radiology should never compromise the radiologist's responsibility to provide quality professional services, but it should be a quality centered and patient focused method of improving services (4).

The health care industry is currently experiencing numerous fundamental changes. Healthcare organizations are increasingly challenged to look at their operations and find new opportunities to reorganize their processes, in order to improve the efficiency and effectiveness of their services, reduce costs, be more competitive, and also provide high quality and more personalized patient care. This new business strategy requires HCOs to implement new Information and Communication Technologies, such as Internet applications, enterprise information systems, and mobile technologies, in order to achieve their desired business changes and results, mainly through better information management methods and techniques (5).

A Web-based tele-radiology management system automates the transfer of images and radiologists' reports, as well as the quality control and organization associated with tele-radiology. PACS support personnel agreed that the tele-radiology management system significantly reduced the amount of time they spent on image transfers (5).

1. 2. Statement of the Problem

Tele-radiology has the potential to bring big impact to patient care service. Radiologists have used tele-radiology to simplify geographic and overnight coverage challenges as well as to strengthen subspecialty skill. An important virtue of tele-radiology is that many smaller hospitals and diagnostic centers that struggle to maintain adequate off-hour and subspecialty coverage can rapidly provide high-quality interpretations around the clock. Centralized image distribution hubs allow efficient access to qualified tele-radiologists by hospitals and diagnostic centers needing quality reports for their imaging services. These hubs can also assist small groups to match human power capacity with volume fluctuations or vacation coverage, obviating the need for more expensive on-site solutions (6).

An adequately trained and staffed health care workforce is necessary for developing an efficient, effective, and sustainable health care system in Ethiopia. RAD-AID and its partners are in a unique position to contribute considerable training and education resources to develop the radiology workforce in Ethiopia. For example, the Johns Hopkins Department of Radiology has a strong radiology program that could potentially be adapted to assist Ethiopia in tele-radiology. Additionally, Johns Hopkins Radiology is in the early stages of implementing a radiology distance e-learning initiative that offers free-of-charge to underdeveloped nations. Potential areas of collaboration between Johns Hopkins, RAD-AID, and its other partners with the Pan-African e-network's tele-education initiative can also be explored. In May 2000 tele-radiology project was implemented in the Tigray region (7, 8, 9). The region has six hospitals with 640 beds and 18 other health centers with 220 beds, which are all owned and operated by the Ministry of Health (MOH). There are also 142 other small health stations in the region (132 MOH and 8 others). The medical and communications equipment was installed in two regional hospitals in Mekele and in the capital city Addis Ababa. The communication is done in two steps (9). The first connects a doctor traveling from village to village with the regional hospitals, and the second connects the regional hospitals to Tikur Anbessa hospital in Addis Ababa.

Currently, RAD-AID is partnered with Tikur Anbessa Hospital in Addis Ababa, Ethiopia. In addition to working with local radiology residents, RAD-AID is providing education support for Tikur Anbessa technologists as the site's first

MRI scanner is being installed and used. This project was the first step in the right direction to effectively implement telemedicine in the country.

Most of the physicians are stationed in the urban areas regional ratios show a large variation. Moreover, more than 60% of the specialists are working in the capital city; Addis Ababa (7, 8, 9).

This problem necessitates the need for developing a web based tele-radiology management system that will enable the coordination and optimal use of scarce human, financial and other resources require for providing patient care service. Accordingly, this project aims to investigate the possibility of developing a web based tele-radiology management system.

1. 3. Objective of the study

1. 3.1 General objective

The general objective of this project is to develop a web based Tele-Radiology Management system that helps the Danu Orthopedic Diagnostic Centers.

1.3.2 Specific objectives

- ❖ To assess the existing tele-radiology management system.
- ❖ To collect and analyze the system requirements and determine functional and non-functional requirements.
- ❖ To develop a web based system to support diagnostic centers
- ❖ To evaluate the performance and usability of the prototype

1. 4. Scope of the project

This project aims to gather and model the requirements and design a web based system to support diagnostic centers which use PACS system to communicate with specialist, Hospitals, and other diagnostic centers by sending Image messages.

1.5. Significance of the study

This project will be helpful for the health practitioners as well as patients by providing multidimensional functions in the process of delivering health services. Designing Web based Tele-radiology management system allows the diagnostic centers those who use PACS system for transmission of images from an imaging source to a diagnostic Centre or to the physician for accesses it remotely.

In most area there is a lack of radiologists and sometime it could be financially viable to have only one radiologist on duty for several radiological facilities or none.

For the diagnostic centers: - the system allows them to serve their customers on time, satisfy their customer, and reduce hustle from looking specialists. Further for those communities which lie at a considerable distance from a diagnostic center or physician and where there is insufficient work to justify the appointment of local radiologists, web based tele-radiology allows the images to be taken in the patient's locality and transferred for interpretation to a diagnostic center or physician.

From the radiologist side: - the specialist is benefited to serve many customers being in any geographical location. Receive request with images for daytime work as well as on duty or being at home and Send a report from anywhere he or she found to the diagnostic center.

Chapter Two

Literature Review

2.1. Healthcare Information Management System

Information Management system is an integrated user-machine system for providing information to support the operations, management, Analysis, and decision making functions in an organization (12). The system utilizes Computer hardware & software, communication facilities, manual procedures Models of analysis, planning, controlling, and decision making and a database.

Healthcare organizations are increasingly operating in data -rich and information poor environments. In today's high-tech era, constantly gathering and storing data, only to never use it, because it is inaccessible, improperly formatted or presented in an irrelevant way (10).

Technology transfer and capacity building in healthcare systems is required in the developing countries. Apart from financial constraints the other important thing is the reforms in healthcare policy and a social change which is more difficult to overcome as compared to financial crisis. Information and Communication Technology (ICT) have proven to be a tremendous accelerator of economic and social progress. The speed at which ICTs are diffusing has taken many observers by surprise. Interestingly, the developing countries are ahead of the developed ones in the mobile telephones subscriptions (11).

Healthcare management is the intersection of information science, computer science, information technology and healthcare (11). It deals with the resources, devices, and methods required in optimizing the acquisition, storage, retrieval, and use of information in health and biomedicine. This includes not only computers but also clinical guidelines, formal medical terminologies, and information and communication systems (12).

Research and development efforts within the healthcare industry and the rapid advancement in ICT over the last two decades have brought about significant advances in the quality of medical services to the patients. Developed countries are spending a lot of resources for the improvement of the healthcare systems and their integration with information technology. The definition of healthcare system has changed due to the advancement in ICT. Quick and fast access to

the medical data is available to all the stakeholders through internet and the developing countries may take advantage of it. Having said that, there is a financial constraint as well and most of the developing nations are not in a position to spend huge amount on healthcare projects like: Telemedicine, Tele-radiology and so on. (12).

2.2. Overview of tele-radiology

Tele-radiology the ability to obtain images in one location, transmit them over a distance, and view them remotely for diagnostic or consultative purposes has been explored for nearly 50 years and is part of the more encompassing concept of “telemedicine” the delivery of health care services over a distance. Major advances in telecommunications and computer systems and advances in the ability to capture medical information in digital form have accelerated the ability to apply telemedicine methods in a practical and affordable manner. These enabling factors are especially relevant to radiology, which currently stands out as one of the most technologically and clinically advanced areas for telemedicine applications (13).

The conversion from analog to digital methods in the medical imaging world, and the emergence of widely available mechanisms to quickly and affordably transmit digital images over large distances have fueled the rapid growth of tele-radiology. In modern radiology departments in both the academic and private sectors it has become commonplace to select the location of a fully functioning picture and archiving communications system (PACS) workstation based on human power and workflow considerations rather than proximity to the site of image acquisition. In addition, affordable scaled down tele-radiology solutions have allowed referring physicians and radiologists to access imaging from the convenience of their homes and offices (13).

Web-based technology platforms allow integrated delivery of desired services to users with the right time and privileges (14). The health sector has always relied on technologies. They form the backbone of the services to prevent, diagnose, and treat illness and disease. ICTs are only one category of the vast array of technologies that may be of use. Given the right policies, organization, resources, and institutions, ICTs can be powerful tools in the hands of those working to improve health (15).

Advances in information and computer technology in the last quarter of the 20th century have led to the ability to more accurately profile individual health risks,

to better understand basic physiologic and pathologic processes, and to revolutionize diagnosis through new imaging and scanning technologies. Such technological developments, however, demand that practitioners, managers, and policymakers are more responsible in assessing the appropriateness of new technologies (14, 15).

2.2.1. The Rise of Telemedicine and Tele-radiology

Tele-ponic voice communication among providers, between providers and patients, and between other stakeholders in health care delivery is a ubiquitous telemedicine application that we all probably take for granted but without which the health care system would grind to a halt. In the ensuing 130 years from the invention of the telephone, every new method of communication has been explored for use in telemedicine applications. According to Becker and Anderson (16), the radiotelephone provided access to outside medical expertise and, likewise, allowed the medical officer to receive and provide on board medical consultations.

Among other investigators in this time frame, from Massachusetts General Hospital established an interactive television system using direct microwave transmission from Logan Airport in Boston to the hospital to provide care for travelers. In a similar vein, the Walter Reed General Hospital (Washington, DC) in-stalled a closed-circuit television connection between the department of radiology and the emergency room sometime in the mid-1960s (16). It was poor contrast and spatial resolution and the need to send each image sequentially one at a time relegated the system to novelty status, and it was never used seriously for patient care. For the most part, television-based demonstration projects from this time period were terminated after these limitations were recognized. In the 1970s and gaining momentum in the 1980s, attention turned to computer-based approaches to telemedicine, with a shift in interest from real time television applications to store and-forward methods (16).

The store-and-forward approach simplifies operations by eliminating the need for all parties—patients, providers, and other support staff—to be present at both sites simultaneously. The store-and-forward approach is now the basis of tele-radiology and many other telemedicine applications in which telemetry of data rather than direct televised face-to-face or voice contact between patients and providers can be used to deliver the service. The National Aeronautics and Space Administration (NASA) has been a pioneer in the use of telemetry of medical data to track the wellbeing of astronauts in space and have a long history of interest

in telemedicine. NASA applied lessons learned in space to a demonstration project entitled Space Technology Applied to Rural Papago Advanced Health Care, or STARPAHC, that served the Papago Indian Reservation in Arizona during a period in the 1970s. The project received mixed reviews for cost and practicality (16).

NASA has remained steadfast in its interest in telemedicine and has continued to help advance the field. It successfully undertook a recent demonstration project in the use of ultra-soundography (US) on the International Space Station. Tele-radiology systems became commercially available in the 1980s from a number of vendors but, in retrospect, were very limited in quality and scalability. The approach entailed photographing or video graphing selected hard-copy images for subsequent digitization and image transfer. More sophisticated systems used laser based digitizers for the same purpose, but both approaches were cumbersome as images were handled one at a time and these systems were rapidly eclipsed by later advances in technology. In sum, for tele-radiology up to the early to mid-1990s, the relatively low performance and high costs of available computer systems, high costs of data transmission, and lack of practical and affordable digital image handling systems (including high-resolution workstations at originating and receiving sites) continued to block widespread adoption of the approach (16).

2.2.2. Definition of Tele-radiology

The conversion from analog to digital methods in the medical imaging world and the emergence of widely available mechanisms to quickly and affordably transmit digital data over large distances have fueled the rapid growth of tele-radiology. In modern radiology departments in both the academic and private sectors it has become commonplace to select the location of a fully functioning picture and archiving communications system (PACS) workstation based on manpower and workflow considerations rather than proximity to the site of image acquisition. In addition, affordable scaled down tele-radiology solutions have allowed referring physicians and radiologists to access imaging from the convenience of their homes and offices (16).

This definition includes inter facility PACS networks as well as remote tele-radiology. An onsite supervising qualified radiologist provides the optimum clinical environment for patients and referring physician providing daily interaction, input and consultation. Where there is difficulty in filling human power needs, tele-radiology will provide support for night, weekend and vacation

leave, for excess workload and for interpretation of complex cases. Tele-radiology must be a quality centered, patient focused method of augmenting services. It must never compromise the radiologist responsibility to provide quality professional services (16).

2.3. Importance of Tele-radiology

Tele-radiology belongs to patient-related telemedicine according to the proposed classification. Tele-radiology allows timelier and efficient interpretation of radiological images, give greater access to secondary consultations and improve continuing education (17).

The implementation of image file transfer applications in the early 90s was a primary phase in tele-radiology in which the original image quality could be preserved. This was not the case with video-conferencing tools. The ACR NEMA standard defined a vendor independent file format and even a transfer protocol but, in fact, the protocol was not used to transfer data between vendors. Even the image file format did not yet meet the required standardization due to vendor specific additions and interpretations (17).

Most of these applications are relatively cheap and simple. The disadvantages of such solutions are that they are not secure and very often unreliable. In particular, PC-based implementations under DOS were unstable since any user could change global operating system settings and additional hardware extension cards influenced the operation of the existing configuration. The connections with the digital modality were due to a lack of sufficient standards, i.e. vendor-modality and version-dependent ad-hoc solutions. This kind of solution can still be found today. Modality vendors currently extend the local area network with ISDN lines to submit images to viewing stations or film printers at remote sites. The DICOM standard is nowadays used but proprietary vendor-specific image transfer protocols are still in use. The remaining problems (even with DICOM) are data security and privacy, failure recovery, logging of transfers, flexibility (definition of additional communication partners) and user friendliness (18).

2.4. Functions of Tele-radiology

Tele-radiology is an evolving technology. New goals will continue to emerge as the accessibility of usage and radiology results are simply in the current goals of tele-radiology includes the following (18):

- providing consultative and interpretative radiologic services

- Making radiologic consultations available in medical facilities without on-site radiologic support.
- Providing timely availability of radiologic images and image Interpretation in emergent and non-emergent clinical care areas.
- Facilitating radiologic interpretations in on-call situations.
- Providing subspecialty radiologic support as needed.
- Enhancing educational opportunities for practicing Radiologists.
- Promoting efficiency and quality improvement.
- Providing Interpreted images to referring providers.
- Supporting telemedicine.
- Providing supervision of off-site imaging studies.

Tele-radiology can be performed locally (and even within the same facility), between buildings in the same grounds, or in collaboration with other health facilities anywhere in the world. It offers alternatives to traditional imaging interpretation approaches, which require on-site staff capable of radiological interpretation.

Tele-radiology can:

- Improve access to expert medical opinion, either for primary or secondary interpretation;
- Provide access to medical image reporting for underserved centers;
- Support patient consultations and inform patient treatment decisions (for instance, on the need to transfer patients to a higher level of care facility);
- Provide access to image interpretation for remote regions;
- Provide reporting in shifts to provide timely interpretation after normal working hours;

2.5. Technical Requirements for Tele-radiology

The key components of a Tele-radiology system include a picture archiving and communications system (PACS), a radiology information system (RIS) and a reliable and secure high-speed connectivity between the remote sites. These put together with standards for imaging and systems/procedures for security and contingency practices complete the technical aspects of Tele-radiology. These are further discussed in the following sections (19).

2.5.1 Picture Archiving and Communications System

An efficient web-based PACS is the cornerstone of a clinical tele-radiology practice. PACS is the information system used for the acquisition, storage, communication, archival, viewing and manipulation of radiologic images and related data. This definition of PACS indicates that PACS is made up of several important components. These are:

Acquisition Devices: These could be modalities with digital output capabilities or devices such as frame grabber and digitizers that convert the analog output from imaging modalities to a digital format (19).

Storage: This includes short term as well as long-term archival solutions. This allows radiologists to have easy access to relevant prior studies for comparison. Long-term archives need not have instant accessibility and hence optical disks or tape drives could be used for this purpose (19).

Communication: PACS requires high-speed connectivity to enable rapid transfer of images to viewing workstations, over LAN and WAN (the latter is what constitutes tele-radiology). Transmission of images is based on protocols of imaging standards called DICOM. Transmission of non-image data like text uses HL7 standards. More on DICOM and HL7 will be discussed in later sections (21).

Software: Image viewing and manipulation software are most often an integral part of PACS. Image viewers can be on a Diagnostic workstation, review workstation or could be done utilizing a web-based module. Diagnostic workstations are high end systems with high resolution flat panel displays while review workstations/ web viewers can be standard desktop PCs (20).

Image Compression: Given the large file size of typical radiologic images, an important feature required facilitating rapid image transfer and throughput in Tele-radiology is compression. Compression algorithms used may be industry standard like JPEG 2000 or could be proprietary to the vendor. It has been noted that compression settings of up to 10:1 can be tolerated in clinical tele-radiology without compromise or loss of clinically relevant data, for review of CT images (21). In the case of plain radiographs, even higher settings may be tolerated.

2.5.2 Radiological Information Systems

RIS is often a subsystem of Hospital Information System (HIS), but can be also be a stand-alone entity and may or may not be connected to PACS and/or RIS. While PACS mainly deals with images, RIS/ HIS deals with data associated with patient demography, studies and reports. RIS is often what guides the workflow of a Tele-radiology practice (22). Though RIS was used as a report generation and distribution tool earlier, commercially available RIS packages currently have integrated many features like voice recognition, staff scheduling, work distribution, invoicing, etc. Tele-Radiology Solutions, a RIS has been developed by an in-house software development team and customized using radiologists' input to meet the requirements of a busy tele-radiology practice (22).

2.5.3 Connectivity Requirements

With optical fiber cables traversing the depths of our oceans, high volume data transfer across geographically separated locations, in the present day, is a non-issue. These high speed connections allow Tele-radiology service providers to serve clients half way around the globe, with report turn-around times comparable to the ones from local radiologists (22).

An ideal connectivity solution for Tele-radiology providers would be multiple T1 lines which would each provide bandwidths of up to 1.544 Mb/s. A single radiologist working from home may use DSL connectivity, provided adequate throughput is confirmed prior to clinical use. Apart from bandwidth, one would also require other networking components such as routers, firewalls, VPN concentrators, and intrusion detection and prevention systems (22).

As the service being provided is a clinical service, typically in the emergency setting, a high level of communication between the site of origin and interpretation of the images is mandatory. This involves the utilization of fax systems capable of handling high volume data, direct telephonic contact and video and teleconferencing (22).

2.5.4 Data Standards

Digital Imaging and Communication in Medicine (DICOM) is the industry standard used for transfer of radiologic images between different hosts claiming conformance. DICOM is a standard developed by a joint committee set up by

American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA). HL7 (Health Level Seven) is the standard for the exchange, management and integration of electronic healthcare information like clinical and administrative data. Using HL7 compatible software streamlines the workflow considerably. For example, if PACS and RIS of a Tele-radiology practice are HL7 enabled, as soon as a new study is received by the PACS a new order is created on RIS, using patient demography and study details from the DICOM file, eliminating duplication of work (22).

2.6. System Analysis and Design Approaches

2.6.1. System analysis and design approach

The most common approach to System Design Life Cycle (SDLC) is a structured methodology based on waterfall model. It adopts a formal step-by step approach to SDLC phase and activities. The activities of one phase must be completed before moving to next phase. At completion of each phase, a document produced must be approved by the stakeholders before moving to the next activity (26).

2.6.2. Object oriented approach

The goal of object-oriented analysis is to first understand the domain of the problem and the system's responsibilities by understanding how the users use or will use the system.

Object oriented approach describes the system through a set of business processes; it performs as well object class that these processes deal with. It uses a set of diagrams or models to represent various view and functionality of a system and is commonly known as UML. The Object-oriented approaches later become known as the Unified process (26, 27).

The UA allows iterative development by allowing going back and forth between the design and the modeling or analysis phases. An analysis phase makes backtracking very easy and departs from the linear waterfall process, which allows no form of backtracking (27).

2.6.3. Rapid Application Development approach

RAD refers to a development life cycle designed to give much faster development and higher quality system than the traditional life cycle. The key objectives of RAD are: High speed, High Quality and Low cost (27).

When organization adopts rapid development approach, it avoids role and responsibility confusion and communication breakdown within the development team, and between the team and the client (27).

2.7. Related works on Tele-radiology

The University of Arizona tele-radiology program was established in 1997(20), because of the radiology department's leadership's close association with the leadership of the Arizona Telemedicine Program. The radiology department had been and continues to be a world leader in digital imaging, and its research collaborations with departments like Electrical and Computer Engineering laid the early foundations for the creation of the Arizona Telemedicine Network. By 1997, the technology for digital image transmission and reception had matured enough to permit the practical establishment of tele-radiology throughout the United States, and early pilot studies done at the University of Arizona (21). The initial impetus for tele-radiology was for after-hours coverage and for provision of radiologic services to small remote, rural hospitals and clinics with limited access to radiologists (20).

From 1997 to 2009 the tele-radiology practice of the department greatly expanded. More than 1,000,000 tele-radiology cases have been officially interpreted, and more than 30 sites have been covered at various times during the years. Most tele-radiology practices, including university-based practices, experience considerable turnover in clientele from year to year (20). New sites are added periodically, and older clients are lost or dropped from time to time for several reasons. Sometimes, clients increase their in-house radiologist coverage and no longer need tele-radiology services. At other times, they become dissatisfied with their current tele-radiology coverage and contract with a new vendor. This dissatisfaction may be a combination of too expensive pricing, long turnaround times for reports, and/or perceived poor quality of the radiology coverage (20, 22).

A tele-radiology connection was built between Kuusamo Primary Health Care Centre and Oulu University Hospital in Northern Finland (23). Kuusamo Primary Health Care Centre is situated 230 km from the University Hospital and its

medical staff includes general practitioners as well as specialists in surgery, pediatrics, gynecology and internal medicine. It is equipped with modern X-ray equipment. They perform over 14 000 X-ray or ultrasound examinations annually. A radiologist visits the premises every 2 weeks to perform special examinations and report cases needing an expert opinion. In more urgent cases, the general practitioner reads the X-ray images himself and decides the correct diagnosis or sends the patient with the images to the University Hospital. Tele-radiology was introduced to offer a new service in these situations, where local expertise was not available. The present tele-radiology research and development program started in the Department of Diagnostic Radiology in 1991. In the beginning, most of the emphasis was put on the technical aspects of tele-radiology. During the tele-radiology study, the radiologists carried out every day clinical image interpretation on computer screens for the first time. In current practice inside the department, all images are printed on films, even though MRI and CT scans are preliminarily viewed on monitors (23).

In Africa, the first reported use of modern telemedicine was in 1984, when a diagnosis of Crouzon's syndrome was made via a satellite link using slow scan television transmission between Swaziland and London, England (23).

There is little doubt that radio was used prior to tele-radiology to provide medical advice in Africa as was the telephone. By 1987, clinical case conferencing was taking place by satellite audio-conferencing between Canada, Kenya and Uganda (24,25). As reported by (25), the first Ethiopian telemedicine project had failed due to high firm over rate. During the lifespan of the Ethiopian telemedicine pilot project, between 2004 and 2006, 20% of the physicians participating left their respective working places (either they were transferred or joined private/nongovernmental organizations) some of them as soon as the project had started. 15% did not participate in the pilot despite their presence and availability at the working place, due to unspecified reasons, and 65% of the participants used the system for medical web-browsing and/or e-mail communication. Only 58 telemedicine consultations were undertaken throughout the duration of the pilot and most consultations were conducted by the three hospitals participating in the technical task force group in the capital Addis Ababa as soon the new Telemed-ETH software was developed. However, after a short period of time, it was decided that the well running Basel University tele-pathology service, available on the iPath web-platform, could be used for the referral of specific anatomy-pathology cases, taking advantage of a well-established tele-consultation network; the Telemed-ETH software has been thereafter used only for radiology and dermatology consultations [25].

CHAPTER THREE

METHODOLOGY OF THE STUDY

To develop web based tele-radiology management system, a set of methods and techniques are used. Primarily it is important to understand the current activities of tele-radiology at DANU orthopedic, trauma Diagnostic center. To understand the current efforts made regarding tele-radiology, documents have been reviewed and interviews were conducted. Basically, the study is qualitative study, interview conducted as the primary data sources. The interviews were used for requirements analysis.

The project follows design science methodology which is a paradigm that seeks to extent the boundary of human organizational capabilities by creating new and innovative and artifacts.

3.1 Study Design

This study employs Waterfall Methodology and Object Oriented (OO) Approach for analysis and design web based system to support image transferring among diagnostic centers and to different geographically located physicians. The object oriented approach is generally considered data centric. It uses a set of entities (or more correctly, “classes”) that encapsulate both the data (attributes) and processes(“methods”) associated with each entity type (27). RAD refers to a development life cycle designed to give much faster development and higher quality system than the traditional life cycle. The key objectives of RAD are: High speed, High Quality and Low cost. It is a people-centered and incremental development approach (27). The system is modeled using UML tools. It is an appropriate method to develop the system, hence there are different objects interacting with the system, like diagnostic centers, physicians, and different organizations. And besides its maintainability, reusability and scalability nature make the system to be preferable.

3.1.1 Study area and period

The project study area is Addis Ababa, the capital city of Ethiopia. The second aspect of the project includes a snapshot of the current tele-radiology infrastructure in Addis Ababa. This is performed by a request for technical information on a standard form from available stakeholders. The study is conducted from December 2015 to Jun 2016 in Addis Ababa at Danu Orthopedics Diagnostic Centers, which found in Arada sub-city.

3.1.2 Source population and sampling

For the designing and development of the system, a set of methods and techniques were used, primarily it requires deep understanding of the existing system in Danu Orthopedic Diagnostic Centers. The source population is the workers of Danu Orthopedic Diagnostic Center. The Center has different staffs, these include radiographers, Specialists, nurses, general practitioners, and IT officers.

Purposive sampling method was used for the sake of collecting necessary data form key informants. The questionnaire was designed in accordance with the objectives and the projects informational need. The project involved nonrandom technique for selecting the samples. Simply put, the researcher decides what needs to be known and sets out to find people who can and are willing to provide the information by virtue of knowledge or experience (28).

The researcher took one system admin, five radiographers and eight diagnostic specialists for sampling.

3.2. Methods of Data collection

Primary data are those which are collected for the first time and are always given in the form of raw data and are original in character. These types of data need the application of statistical methods for the purpose of analysis and interpretation. While secondary data are those which have already been collected by someone and have gone thought the statistical analysis. They are usually refined.

An interview was conducted with focused group discussion with the key informants in Danu Orthopedic Diagnostic center, and also observation and analysis of different files and documents for farther data collection was done.

3.2.1. Interview

A face to face open interview conducted to get primary data from the existing Tele-radiology and PACS system on focused group. The interview was conducted with fourteen staffs. The response recorded is used as an essential input for defining the requirements which is important in designing the web based information system.

3.2.2. Observation and Document Analysis

Analyzing of different local based storages, reports and registered documents observed. Having information and gaining an awareness of the structure, activities and patterns of information flow in local radiology storage.

3.3. Analysis and Design Techniques

In the designing of the web Based Tele-Radiology Management system an Object oriented software development Methodology an iterative and incremental approach was used. Object Oriented Analysis and Design modeling and different components in the system were described using UML tools. These UML modeling tools include use case, class and sequence diagrams.

Use case diagrams: - are a set of use cases, actors and their relationships. They represent the use case view of a system. A use case represents a particular functionality of a system and a set of actions performed by a system for a specific goal.

Class diagram: - Class diagrams are the most common diagrams used in UML. Class diagram consists of classes, interfaces, associations and collaboration. Class diagrams basically represent the object oriented view of a system which is static in nature. Active class is used in a class diagram to represent the concurrency of the system. It represents the object orientation of a system. So it is generally used for development purpose. This is the most widely used diagram at the time of system construction.

Activity Diagram: - describes the flow of control in a system. So it consists of activities and links. The flow can be sequential, concurrent or branched. Activities are nothing but the functions of a system. Numbers of activity diagrams are prepared to capture the entire flow in a system. Activity diagrams

are used to visualize the flow of controls in a system. This is prepared to have an idea of how the system will work when executed.

System Architecture: - Architectural model represents the overall framework of the system. It contains both structural and behavioral elements of the system. It can be defined as the blue print of the entire system.

3.4 development tools

In this design of a web based system to support radiology managing system Visio 2010 and UML were used as software tools. HTML is used to construct user-friendly interface for accessing the database. At the middle ware, PHP enables links of the data entered in the created graphics user interface to the data base. At the back end, MY SQL is used. It is low-cost data base language, it can run on variety of operating system such as windows, Linux, and others. It is secured and technical support is widely available on the internet (34).

3.5. Evaluation procedures

The goal of the system performance evaluation is to determine the usability of a web based system to support tele-radiology. The evaluation often refers the question how well users can understand the designed system functionality.

Heuristic evaluation is one of the most commonly used discount evaluation methods due to its low cost. It is an inspection method that can prospectively uncovered problems with a user interface. Indicates the severity of the problems and make suggestions for fixing the problems. This method is used both during the initial development of an application and during the configuration and customization of an application (30).

Researchers has to follow these steps to prepare the evaluation:

- Decide on the scope of the inspection. Will it be applied to the whole product? To the sections that have been customized?
- Identify the roles and characteristics of the users who will be using the system.
- Make a list of the tasks that users will perform frequently with the system.

- Create a form that evaluators will use to record the problems they see, showing on which page of the system it occurred. (See ANNEX II for a sample form.)
- Make the System screen shots available to those who will inspect it.

3.6. Ethical Consideration

Ethical clearance has given from Addis Ababa University School of Public health to conduct this project. In addition, official letter to make the diagnostic centers to cooperate willingly.

Chapter Four

Requirements Analysis and design of the system

When a system is developed, there are expected level of capabilities. These are functionalities expected by users'/Danu Orthopedic, Trauma Diagnostic center of the system. Different requirements of a system are provoked by observation and interviewing users of the system.

4.1 Current System

Danu Orthopedic, Trauma diagnostic center has been grounding service for the last few years in the health sector. Starting 2014 the center gives imaging service, it uses the radiology service in the center only. That is, it does have connection with other centers. Rather they send the radiology images using CDs for other specialist who work in other centers those use PACS system. It has eight specialists those works in different shifts; among these, three of them are foreigners, five radiographers, three of whom are duty workers and the remaining two are regular workers and one IT officer.

To standardize imaging metrics and improve tracking data fidelity is to displace manual procedure tracking though the utilization of Digital Imaging and Communications in Medicine (DICOM) services. The center specialized in orthopedic, but side by side they serve emergency services.

4.1.1. Software

The diagnostic center delivered the medical equipment and Image viewing and manipulation software from Boston Medical and Machinery delivers, and they install the software that runs on XP window. The medical equipment and Image viewing and manipulation software are most often an integral part of PACS. Image viewers can be on a diagnostic workstation, review workstation or could be done utilizing a web-based module. Diagnostic workstations are high end systems with high resolution flat panel displays while review workstations/ web viewers can be standard desktop PCs.

4.1.2. Hardware

The center has 50 personal computers and two servers. Among these only two PCs are used for Radiology department and one server for PACS. The other server is used for HMIS. The system has the following specification for their Computers: 4GB RAM, 160 GB Hard Disk, 2.6MHZ processor.

The current working system performs as follow: Patient demographics (patient identifier, name, sex, date of birth, weight, height, etc.) The radiology department uses the radiology Information System (RIS) to Manage patient visits to radiology then schedule and track diagnostic procedures and store diagnosis and results. The radiographer sends billable items to billing officer. The technologist simply selects a patient and procedure at the modality. Once the procedure is completed, all of the patient demographics are automatically included with the resulting images and sent to the Specialist if he/she is available in the diagnostic center, unless the patient given another appointment to see the specialist or referred to location/diagnostic center where the specialist is found with the diagnosis result CD.

Based on existing system analysis, we attempt to identify functional and non-functional requirement of the proposed web based system. The proposed system capture, transmit, store and review patient image data. It is used as an environment where users can collaborate via sending image messages. It could be applicable for all diagnostic tasks.

4.2. Functional Requirements

Functional requirements describe the interactions between the system and its environment independent of its implementation (29). The environment includes users and any other system that interacts with the system.

The system is a web based Radiology system that enables users to collaborate to improve healthcare. To structure service provision, users who are using the system must be determined. Hence, before using the system, users need to get registered and logged into the system. As a store-and-forward and receive tele-radiology system, it facilitates communication among users of the system via the messaging environment.

The system allows major Image messaging functionalities, such as sending, receiving, deleting, forwarding and replying Image-messages as an attachment.

Table 4.1 Functional Requirement Table

Req ID	Requirement
RQ-1	The system shall enable the identification of different users and their roles
RQ-2	The system shall support the control of actor relationships.
RQ-3	The system should have a feature to manage system users.
RQ-4	The system should register experts based on their specialization.
RQ-5	The system should allow notification and comment of store and forward errors
RQ-6	The system should enable storing of radiographic images
RQ-7	The system should enable upload stored radiographic images
RQ-8	The system shall enable registration of system Users
RQ-9	The system shall enable the system Administrator to view and update users' information.
RQ-10	The system shall enable the system user to view image messages on selected basis.
RQ-11	The system shall enable image message composing and send via web server to the specialist.
RQ-12	The system shall enable replying image result message to the Diagnostic center via web server.

The above functional requirements are driven out from the interview and the document observation and Analysis done at the time of requirement collection.

4.3. Non-functional Requirements

Non-functional requirements describe requirements of the system that are user considerate but not directly related to the functional behavior of the system. Usually, these are constraints of the system to improve quality of service.

User Interface:-The usability of a system is highly affected by the way its user interface is designed. In this case simplicity is a key characteristic of a user interface. To complement the low level of information technology usage in the country, the system needs to have a simple and attractive interface. Making the system web based put any user familiar with internet at ease in using the system. Since it uses familiar links to work with different components of the system, it makes users comfortable in using it.

Availability: - Any system needs to be available whenever it is required to be accessed. The development of a web based systems related to healthcare improves this requirement. This system is expected to be available at any time when professionals need to use the system.

Performance: - Since it is a web based system, it runs on any system capable of running web browsers. Although clients can run on a PC, the server should be a powerful computer which is capable of handling requests even during high traffic times. It is designed to run on the existing network infrastructure, hence, the bandwidth regarding the data transferred should be considered so as not to frustrate system performance.

Security: - Security and privacy issues in healthcare data are very sensitive, exceptionally to other forms of data. The data transferred to a remote site should be secure and users should have access to part of data they are supposed to. Patient information should be kept secret and unmodified, but the data should be available when needed in patient care. The privacy policy means that only authorized persons are allowed to see personal health data. These requirements are common in any type of tele-radiology. A systematic approach to data security development facilitates the process, but does not give answers to all practical questions. The security and privacy protection of any tele-radiology system must be planned in advance, and the necessary security and privacy enhancing tools should be selected based on risk analysis and requirements.

Image Compression: - Given the large file size of typical radiologic images, an important feature required facilitating rapid image transfer and throughput in Tele-radiology is compression. Compression algorithms used may be industry standard like JPEG 2000 or could be proprietary to the vendor. It has been noted that compression settings of up to 10:1 can be tolerated in clinical tele-radiology without compromise or loss of clinically relevant data, for review of CT images (32). In the case of plain radiographs, even higher settings may be tolerated.

Scalability: -This project considers currently available health diagnostic center and level of professionals in the country. But the numbers of healthcare providers as well as professionals are increasing. Therefore, the system should scale up to accommodate this increasing need without a noticeable performance downgrading. The system has a major aim of increasing interoperability between the diagnostic centers with the external professionals. Since the number of employees, employers, diagnostic centers are increasing in number through time; the system should be scalable to accommodate these changes. Though the tele-radiology web system is designed in a way to accommodate the growth the network architecture should also be designed to accommodate this change. These web based tele-radiology management system uses the web as a platform which makes it easy to accommodate any changes. In addition to the issue of scalability the system can be extensible (35).

4.4. Modeling the proposed System

System modeling is a tool used to understand and for analysis of the system. Models are developed to represent the system view under consideration and to explain the behavior of various components of the system [31]. Different components in the system are described using UML tools. These tools are used to model these components of the system so as to better understand it and to depict the requirements in an easy manner.

4.4.1 Contextual Diagram

The contextual diagram shows the entire in the context of the environment and it shows the overall business process as one process and how the system modeled. It also defines the boundary of the system to be developed.

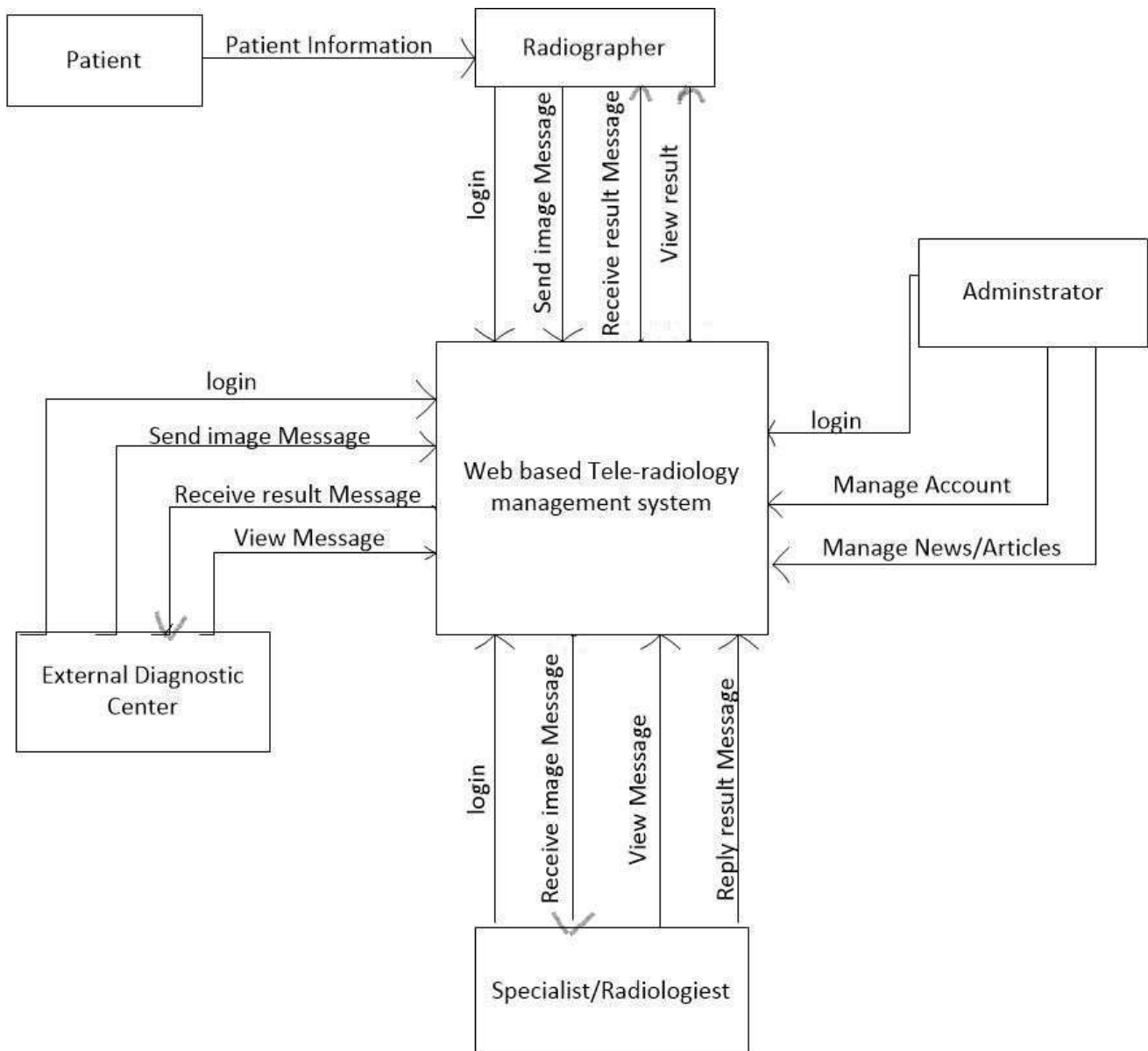


fig 4.1 Contextual diagram for the proposed system

4.4.2 Actors of the system

An actor is a person, organization, or external system that plays a role in one or more interactions with a system (34). In the proposed system, there are about four groups of users. As shown in table 4.2, the administrator is one type of user of the system and it is basically set to administer the system. The Administrator is responsible to register, modify and Remove Account of user of the system. Some of the functionalities in the system web services.

Table 4.2: List of Actors and their responsibility in the system

Actor Name	Description
Administrator	Performs all administrative related tasks. It may deactivate or delete Diagnostic Centers, approve or remove uploaded news and articles.
Radiographer	A health professional that is a member of a Diagnostic center. S/he is able to consult a specialist on the other end by way of sending Radiology image messages.
Radiologist /Specialist	A health professional that is a member or has a contract with Diagnostic Center. S/he has specialty in the Tele-radiology and responds to case requested.
External Diagnostic Centers	Other centers and institutes in need of the system can access functionalities that are open as services through registration by the Administrator. These are available as web services.

4.4.3 Use Case Model

A system includes functions and features with specific outputs contributing to the system goal. These functions are initiated by users that can be inside or outside the system. Use case diagrams describe these behavioral requirements of the system (34). The use case diagram is followed by a description of each use case given separately in a use case description.

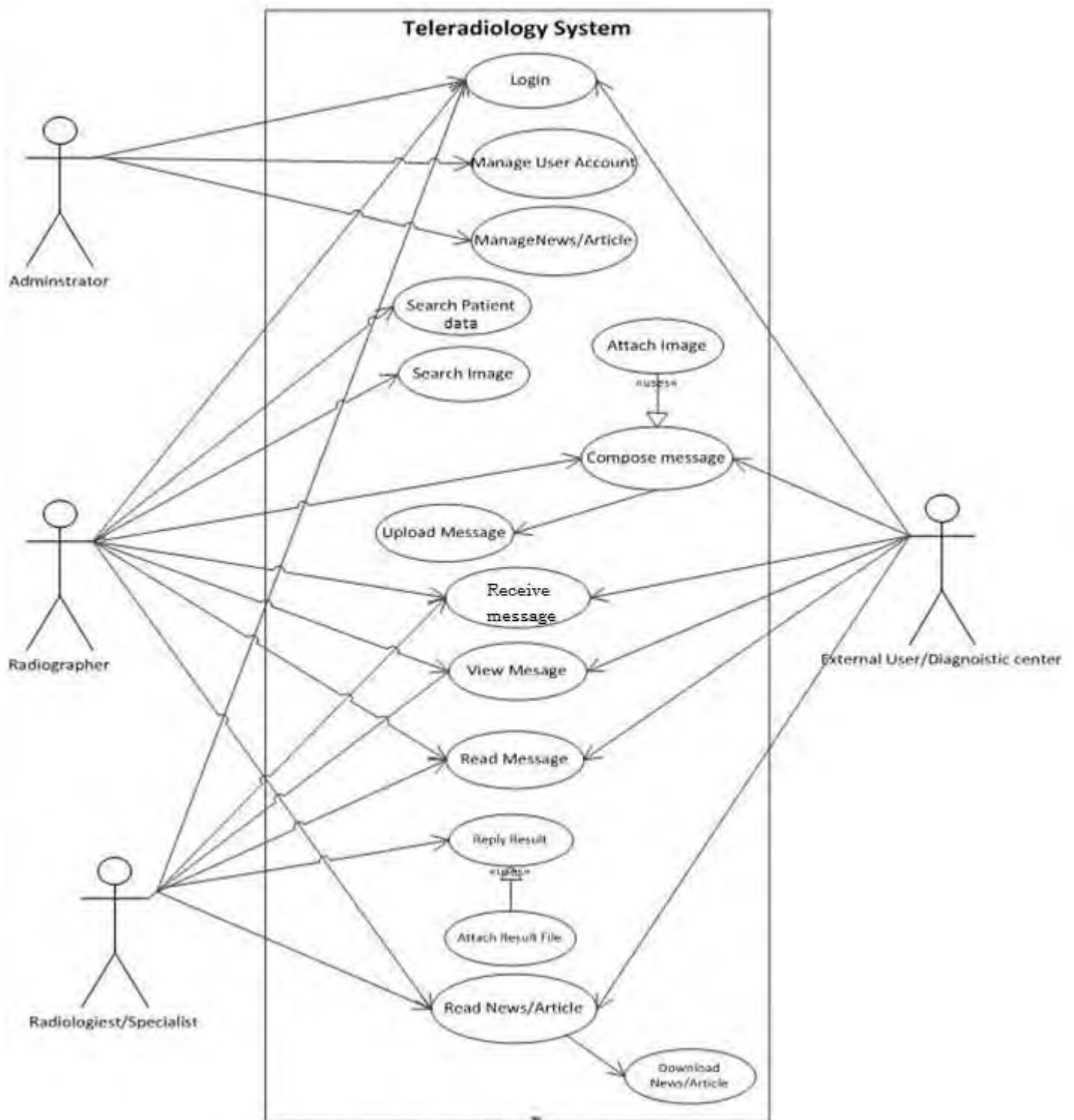


Fig 4.2: Use case diagrams for tele-radiology

4.4.4 Use Case Description

Description is required for each use case so that how it is accomplished, what is required to complete it is easily understood. A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a use case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals, and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed by which actor. Roles of the actors in the system are describes as follows.

Name: Login

Identifier: UC01

Description:

Allow registered users to log into the system so that s/he can use it

Precondition:

Registered users must exit

Post condition:

Users logged into the system

Basic course of action:

1. User enter username and password to the system
2. System determines that the user is legitimate (Alt Course A: Invalid user name or Password is entered)
3. System displays the message form and the use case ends

Alternative course of action A: Invalid user name or password is entered

A-2. The system determines the user is illegitimate

A-3. Use case displays error message and resumes at step 1

Name; Manage Account**Identifiers: UC02-UC05****Name:** Register Diagnostic centers/specialists**Identifier:** UC02**Description:**

Create a new Diagnostic centers/specialists system. Usually this will be Diagnostic center/specialists which will be added as members later as a user of the system.

Preconditions:

- Administrator is logged in
- Manually filled form submitted

Post conditions:

- Diagnostic center account is created

Basic Course of Action:

1. The use case begins when the administrator shows intent of creating a user From a filled form
2. The administrator enter name, location and other profile data to the system
3. The system validates the data supplied (Alt Course A: *Invalid data supplied*)
4. The use case ends when it displays a successful creation of users

Alternate Course A: *Invalid data supplied*

A-3. The system determines the data is invalid

A-4. The use case resumes step 2 showing error message

Name: Create Account

Identifier: UC03

Description:

Create Account for the system users. This is completed by administrators. These members are Radiographer, specialists, and external Diagnostic centers.

Precondition:

- Administrator logged into the system

Post condition:

- New member/ user is added under an administrator.

Basic course of action:

1. The use case begins when the institution indicates s/he wants to add member
2. Institution enters name, profession and related profiles to the system
3. The system validates the entered value is correct (Alt Course A: *Invalid form data entered*)
4. The use case ends after displaying message about successful addition of members

Alternate course of action A: Invalid form data entered

A-3. The system determines the entered value is invalid

A-4. The use case ends after displaying error message

Name: Remove Account

Identifier: UC04

Description:

When Diagnostic center or professionals need to become inactive in the system, they would be denied from participating in services of the system

Precondition:

- Administrator is logged in
- There exists an active user

Post condition:

- Diagnostic center/professionals is inactive

Basic course of action:

1. The administrator chooses an account to remove and clicks the deactivate button
2. She/he approves to remove the users (Alt Course A: *administrator cancels Operation*)
3. Use case ends displaying updated list of Diagnostic center/professionals and showing a success message

Alternative course of action A: *Administrator cancels operation*

A-3. S/He wants to cancel the removal action

A-4. Use case ends by displaying list of users

Name: Edit Account/Privileges

Identifier: UC05

Description:

- Administrator can edit professionals or users Account.
- Removes professionals or users from the Account.

Precondition:

- Administrator is logged in
- Edit/Delete

Post condition:

- User selected from the list then click Edit/Delete by administrator

Basic course of action:

1. System Administrator indicates /select user
2. System Administrator click Edit
3. The system validates Editing the users privilege

OR

4. Use case begins when administrator select user to delete
5. Administrator indicate to remove the user
6. System confirms the removal action
4. Use case ends removing the selected user and display the list

Name: Manage News/Article**Identifier:** UC06-09

Name: Upload News/Articles

Identifier: UC06

Description:

- Administrator uploads articles, which will be available for others

Precondition:

- Administrator is logged into the system

Post condition:

- The News/article document uploaded

Basic course of action:

1. User indicates to upload an article
2. User choose the article document
3. The system validates the chosen article
4. Use case ends displaying acknowledgment message when article document is uploaded

Name: View News/Articles

Identifier: UC07

Description:

Online health related news from different sources will be displayed

Precondition:

- User has logged in

Post condition:

- News/Articles are listed

Basic course of action:

1. Use case begins by listing News/Articles titles along with their link
2. User indicates to view News/Articles
3. Use case ends displaying the News/Articles following a link

Name: Download News/Articles

Identifier: UC08

Description:

Displayed list of News/articles that are possible to be downloaded for utilization.

Precondition:

- News/Articles are uploaded
- User is logged in

Post condition:

- News/Articles is downloaded

Basic course of action:

1. User indicate to download a News/Articles from the list

Name: Remove News/Articles

Identifier: UC09

Description:

Removes Uploaded News/Articles when it is no more wanted to be available

Precondition:

- Administrator is logged in
- News/Articles is uploaded
- List of articles is displayed

Post condition:

- News/Articles is removed

Basic course of action:

1. Use case begins when administrator select a News/Articles to delete
2. Administrator indicate to remove the News/Articles
3. System confirms the removal action
4. Use case ends removing the selected News/Articles and display the list

Name: Search Patient and Patient Image**Identifier:** UC10-11

Name: Search Patient image

Identifier: UC10

Description:

Search patient image using a given criteria and display the list of patient image satisfying the criteria

Precondition:

- The Radiographer logged in
- List of patient messages is displayed

Post Condition:

- Image satisfying criteria are displayed

Basic Course of Action:

1. User indicates to search image
2. The system displays the search form
3. User fills the appropriate criteria fields – subject, and date or date range

Name: Search Patient

Identifier: UC11

Description:

Search patient using a given criteria and display the list of patients satisfying the criteria

Precondition:

- The Radiographer logged in
- List of patient is displayed

Post Condition:

- Patient satisfying criteria are displayed

Basic Course of Action:

1. Radiographer indicates to search patient
2. The system displays the search form
3. User fills the appropriate criteria fields – subject, and date or date range
4. System gets list of patient satisfying the required criteria
5. The use case ends displaying the search result

Name: Manage Image Message

Identifier: UC12-17

Name: Display Sent Item

Identifier: UC12

Description:

Allow Radiographer or Specialists to display and view list of sent messages

Precondition:

- The users are logged in

Post Condition:

- System displays list previously sent messages

Basic Course of Action:

1. The user indicates to view list of sent message
2. The system displays list of sent messages
3. The use case ends

Name: Read Message

Identifier: UC13

Description:

Allows the user to read messages sent to him/her.

Precondition:

- The user is logged in
- System displays the inbox page

Post Condition:

- The user reads incoming messages sent to him/her

Basic Course of Action:

1. The user indicates to read a message
2. The user selects the mail to read
3. The system displays the message to the user
4. The use case ends

Name: Reply Message

Identifier: UC14

Description:

Allows the user to reply messages sent to him/her

Precondition:

- User is logged into the system

Post Condition:

- The user clicks on reply to a message

Basic Course of Action:

1. The user indicates to reply to a message
2. The user completes and submits the message to be sent (Alt Course A: *Blank Subject line*)
3. The system sends the message to the receiver
4. The system displays confirmation message
5. The use case ends

Alternative Course A: *Blank Subject line*

A-2. The system displays error message

A-3. se case resumes at step 2

Name: Compose Message

Identifier: UC15

Description:

- Allow users to compose a message so that they can send it to a recipient

Precondition:

- The user is logged in

Post Condition:

- New message is composed (prepared)

Basic Course of Action:

1. The user indicates to compose new message
2. The system displays the compose form
3. User fills the appropriate fields – select to whom, caption, note, and the actual message body
4. The use case ends

Name: Attach image

Identifier: UC15

Description:

Attaches a medical image to the radiographer/Specialist with patient information.

Precondition:

- The user is logged in
- User is currently composing a message

Post Condition:

- A medical image is attached to a message

Basic Course of Action:

1. User indicates to attach a file
2. User selects the medical image to attach
3. User submits the selected image to be attached (Alt Course A: Invalid image Type Selected)
4. Use case shows success of the attachment and ends

Alt Course A: Invalid File Type Selected

A-3. System shows error message

A-4. Use case resumes at step 2

Name: Send Message

Identifier: UC17

Description:

Upload the message to the recipient on the web server.

Precondition:

- The user is logged in
- There is a composed message

Post Condition:

- The message is sent to another user

Basic Course of Action:

1. The user has a composed message and indicates to send it
2. The system validates various fields of the message (Alt Course A: blank recipient address)
3. User checks the availability of the recipient (Alt Course B: invalid recipient)
4. The system sends the message to the given recipient
5. The system sends the message to the webserver
6. The use case ends

Alt Course A: Blank Recipient

A-2. System displays error message to correct the illegal values

A-3. Use case resumes at step 2

Alt Course B: Invalid Recipient

B-3. System displays error message showing the unavailability of the recipient

B-4. Use case resumes at step 3

4.4.5 UML Class Diagram

UML class diagram is a mechanism of depicting the different class and their activities together with the relationship that exist among the classes (34). A class diagram shows the declarative model components such as classes, types with their contents and relationships. They contain behavioral elements, but their dynamics are shown using other diagrams. In the diagram, while the Institution class represents the institutions, the Clinician and Specialist classes are used to define the members created by institutions. Messages transmitted between users are defined via the Inbox, Draft, and Sent classes. The Article class is used to define articles to be shared among users of the system.

Figure 4.3 shows the class diagram of tele-radiology system designed in this project.

4.4.6 UML Activity Diagram

UML Activity diagram is a technique that shows the workflow using stepwise activities and actions which has beginning and ending events (34). Activity diagrams show the interaction among business processes. Activity diagrams convey what is happening inside a use case or inside a class through activity description. These are used to model the flow of the system.

The system basically provides an Image messaging service and other documents. The system provides a messaging environment where by users communicate via Image and text messaging. The flow of activities that occurred in messaging is shown in figure 4.4 to figure 4.8. In the diagram to use the messaging functionality, users must login and these users must have either physician or specialist role. Other role is administrator role, liable to send and/or receive messages.

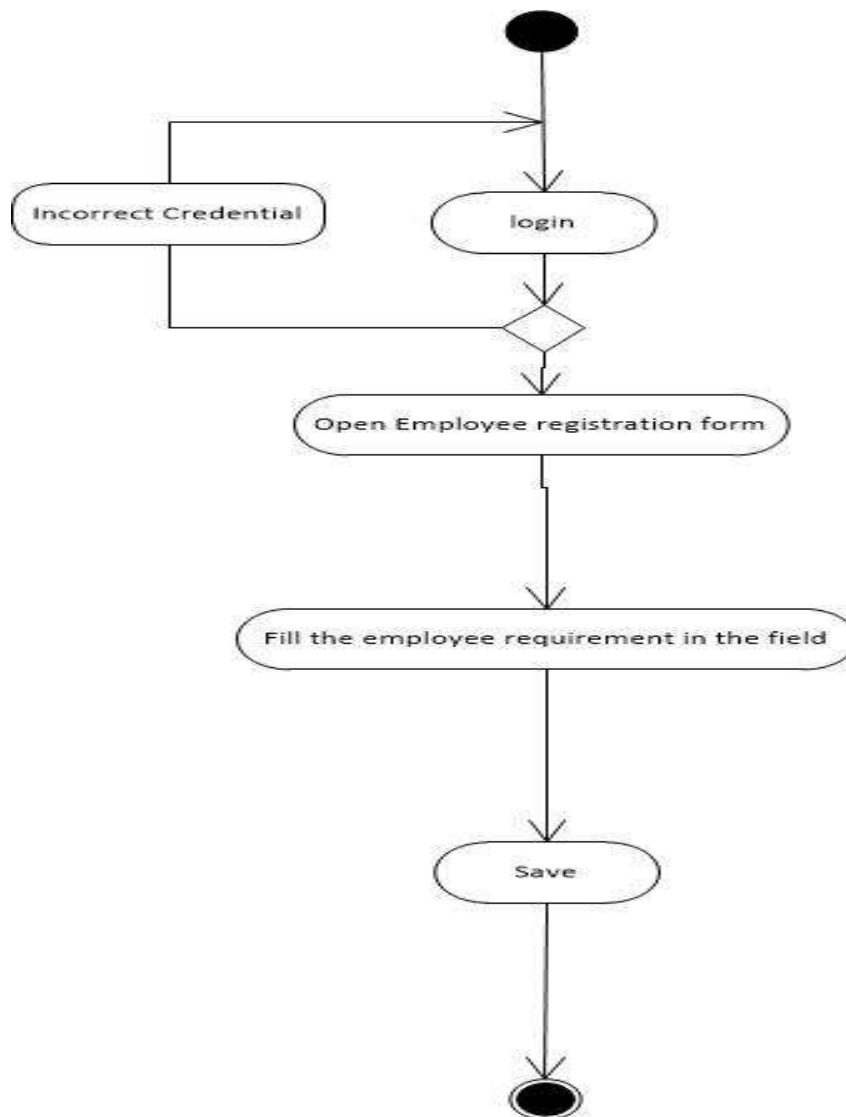


Fig 4.4: New employee registration Activity Diagram

The above activity diagram shows how the system allows the administrator register new employee in the data base. The administrator must log in the system with correct user name and pass word otherwise the system will not let the person access the system. After entering the privileged page, the employee registration form will be displayed. The administrator must fill the form with

important information of the employee then click on save button to store a new user in the data base.

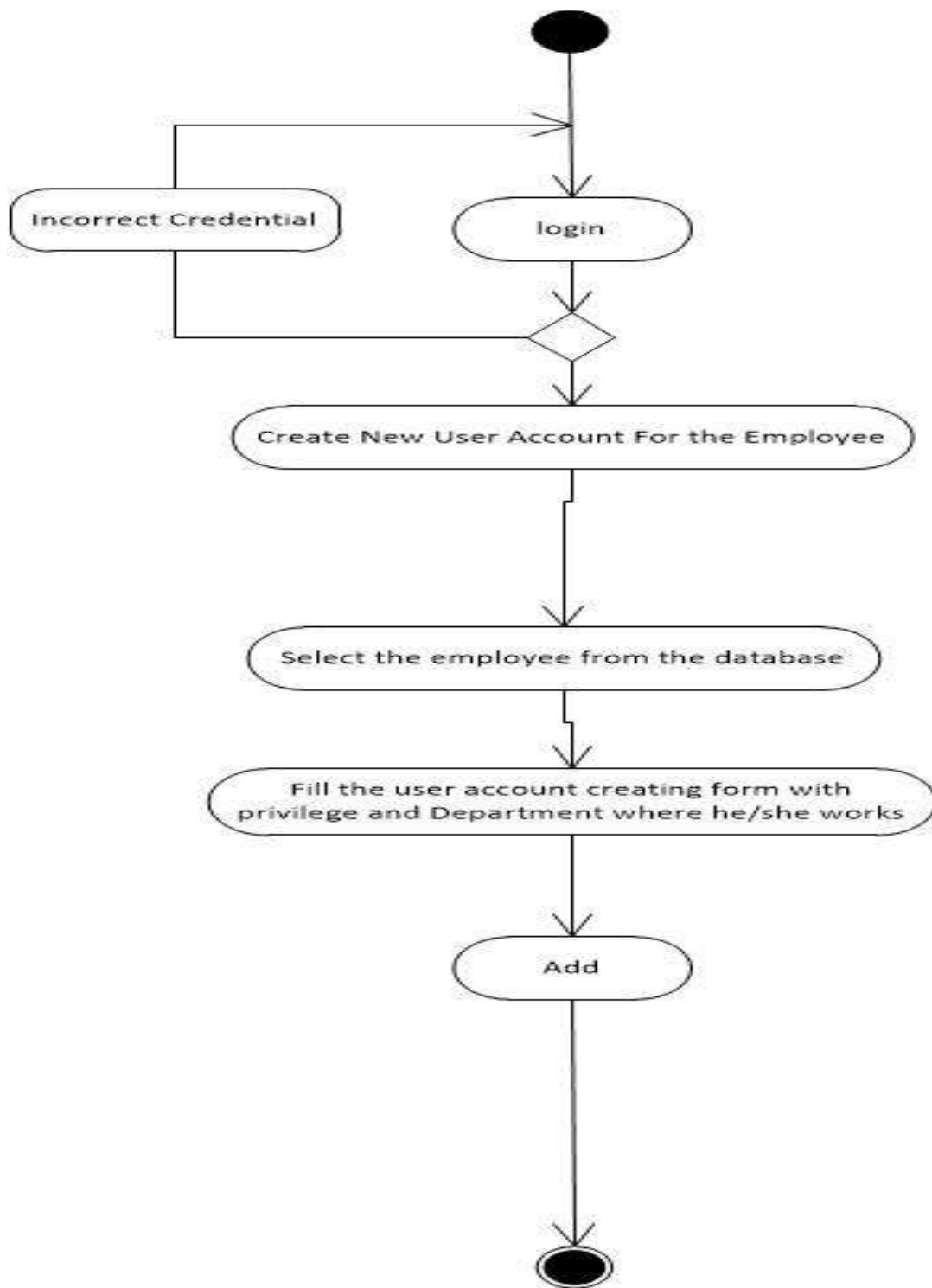


Fig 4.5: User account creating Activity Diagram

The above activity diagram shows how the system allows the administrator to generate user account for new employee. The administrator must log in the system with correct user name and pass word otherwise it will not let the person access the system. After entering the privileged page, the user account creating form will displayed. The administrator must fill the form with important information of the employee then click on save button to provide a new user account for the employee.

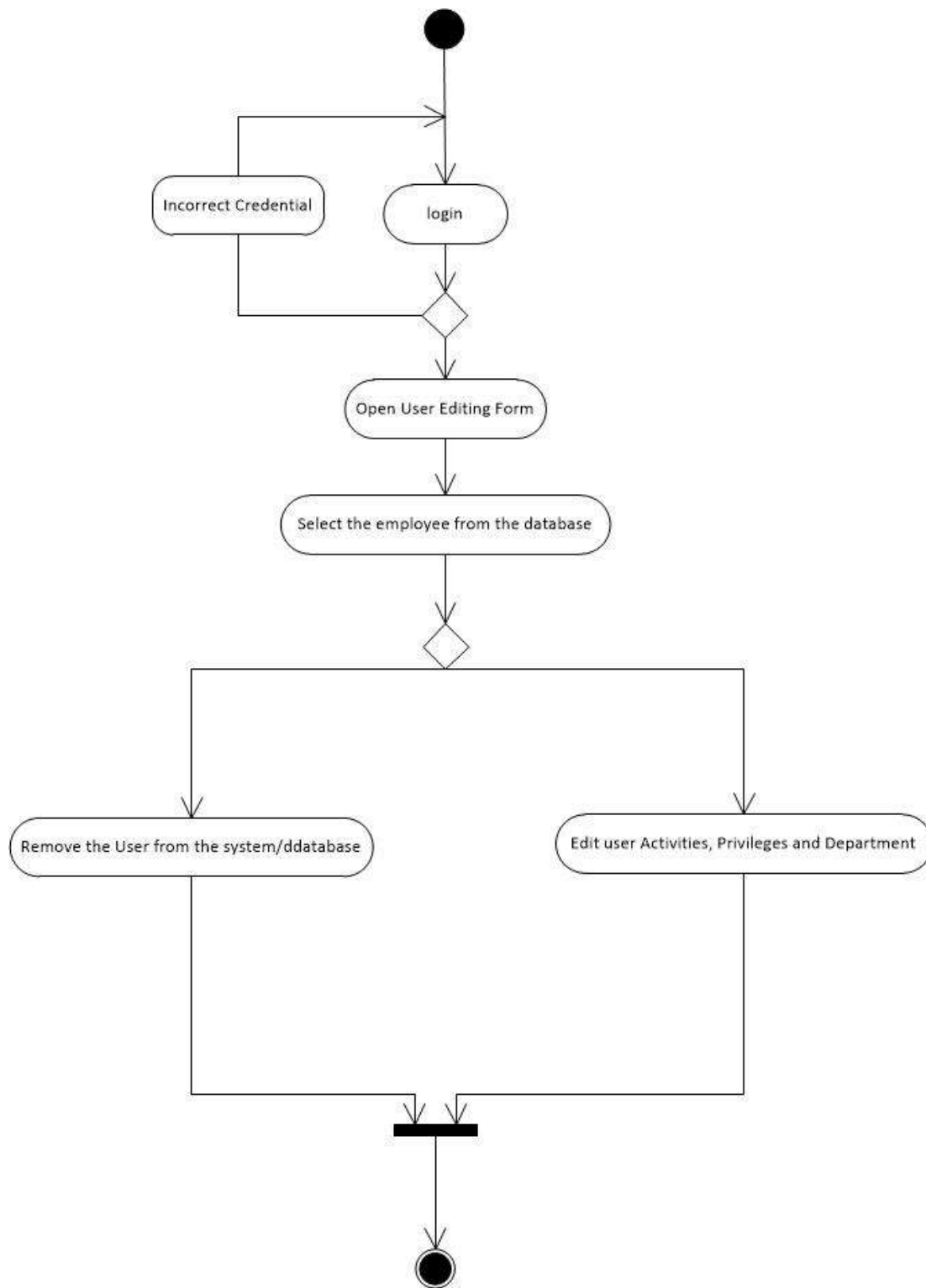


Fig 4.6: Users privilege editing or removing Activity Diagram

The above activity diagram shows how the system allows the administrator to edit employee privileges or remove employee from the data base. The administrator must log in the system with correct user name and pass word otherwise it will not let the person access the system. After entering the privileged page, the user editing form will displayed. The administrator can edit the form with important information of the employee then click on save button to save the edited information or delete button to removing the employee from the data base.

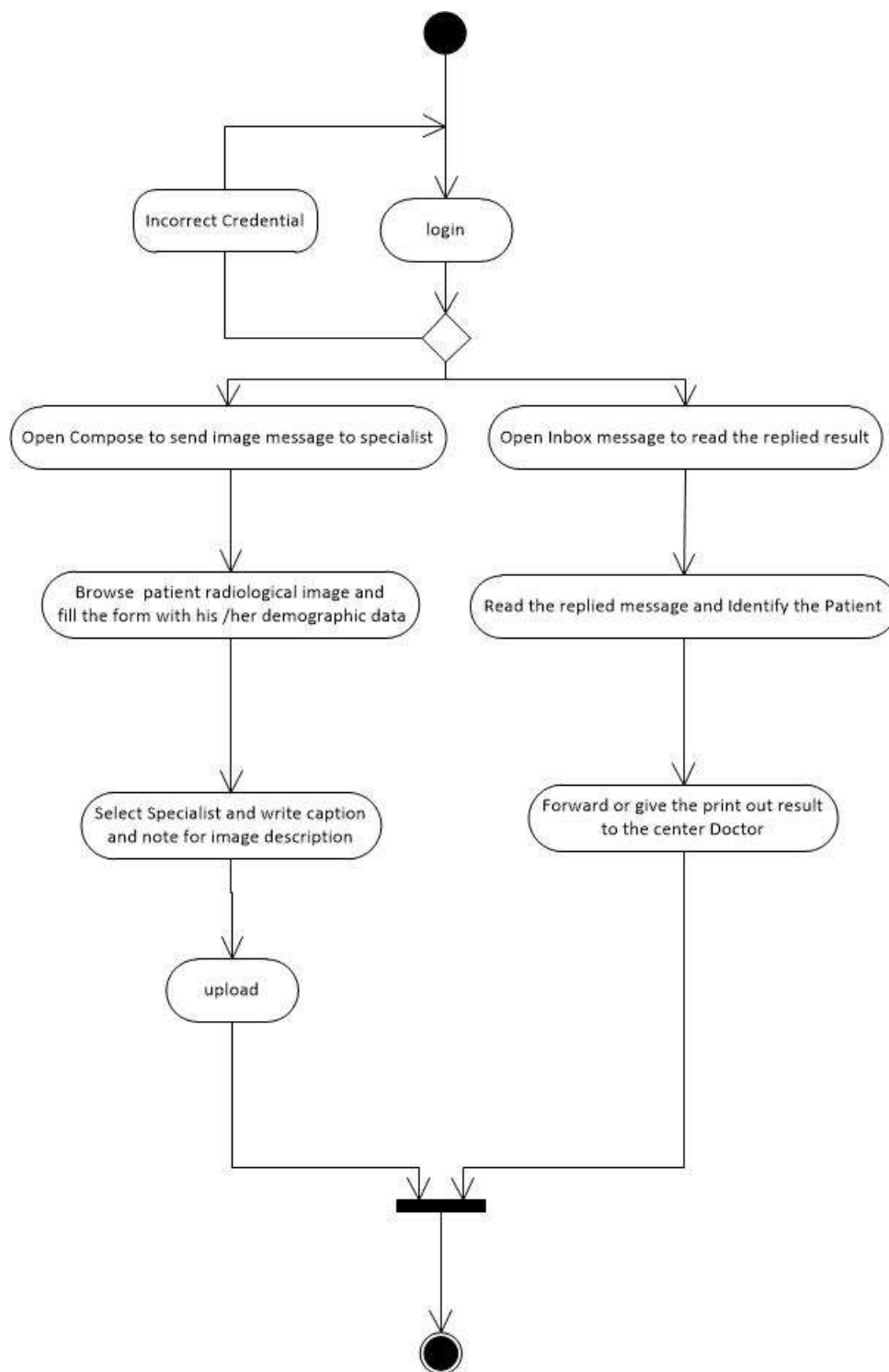


Fig 4.7: Message Sending and receiving Activity Diagram

The above activity diagram shows how the system allows the Radiographer send image message and display inbox messages. The Radiographer must log in the system with correct user name and pass word otherwise it will not let the person access the system. After entering the privileged page, the Radiographer select compose menu then message composing form will displayed. The Radiographer must fill the form with important information like: patient information, patent radiological image, write caption, select the specialist, write additional note, and finally upload the message in to the web server.

To read or view the patient result sent from specialist. The Radiographer must select result menu, then inbox messages will display. Therefore, He / she can view the responded result.

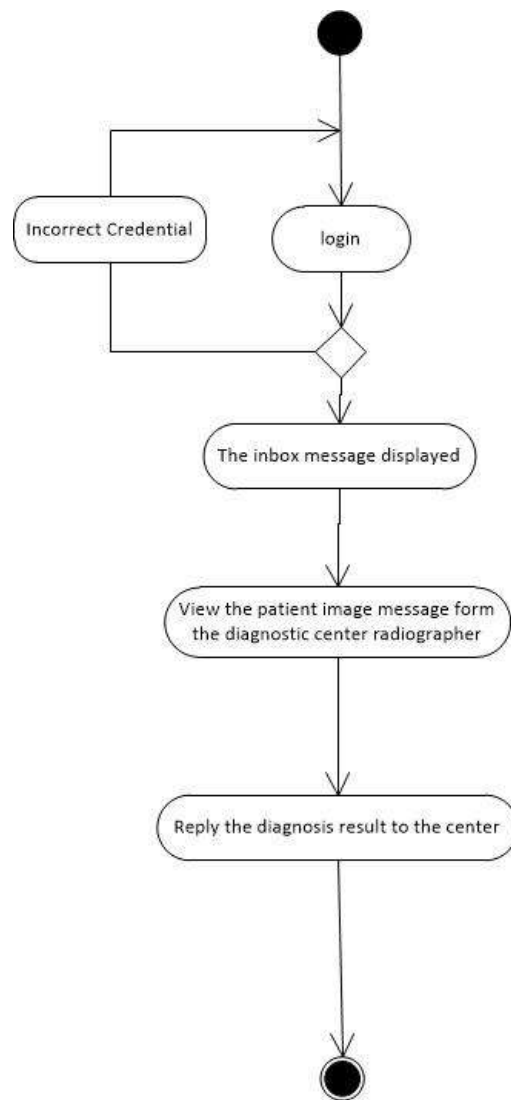


Fig 4.8: Inbox message displaying Activity Diagram

The above activity diagram shows how the system allows the radiographer or the specialist to display the inbox messages. Radiographer or the specialist must log in the system with correct user name and pass word otherwise it will not let them access the system. After entering the privileged page, they can display the inbox messages and access it. The radiographer forwards the result to local physician. The specialist reply result for the image message he/she interpreted/ diagnosed.

Chapter Five

System Architecture and implementation

In this project an attempt is made to design and develop tele-radiology management system. The system is designed using various tools that are used to accomplish different tasks and define a certain components of the system. Since it is web based, it is developed using ASP.NET web forms using .NET Framework 2.0.

5.1. System Architecture

Figure 5.1 below shows the architecture of web-based tele-radiology management system implementation in the project.

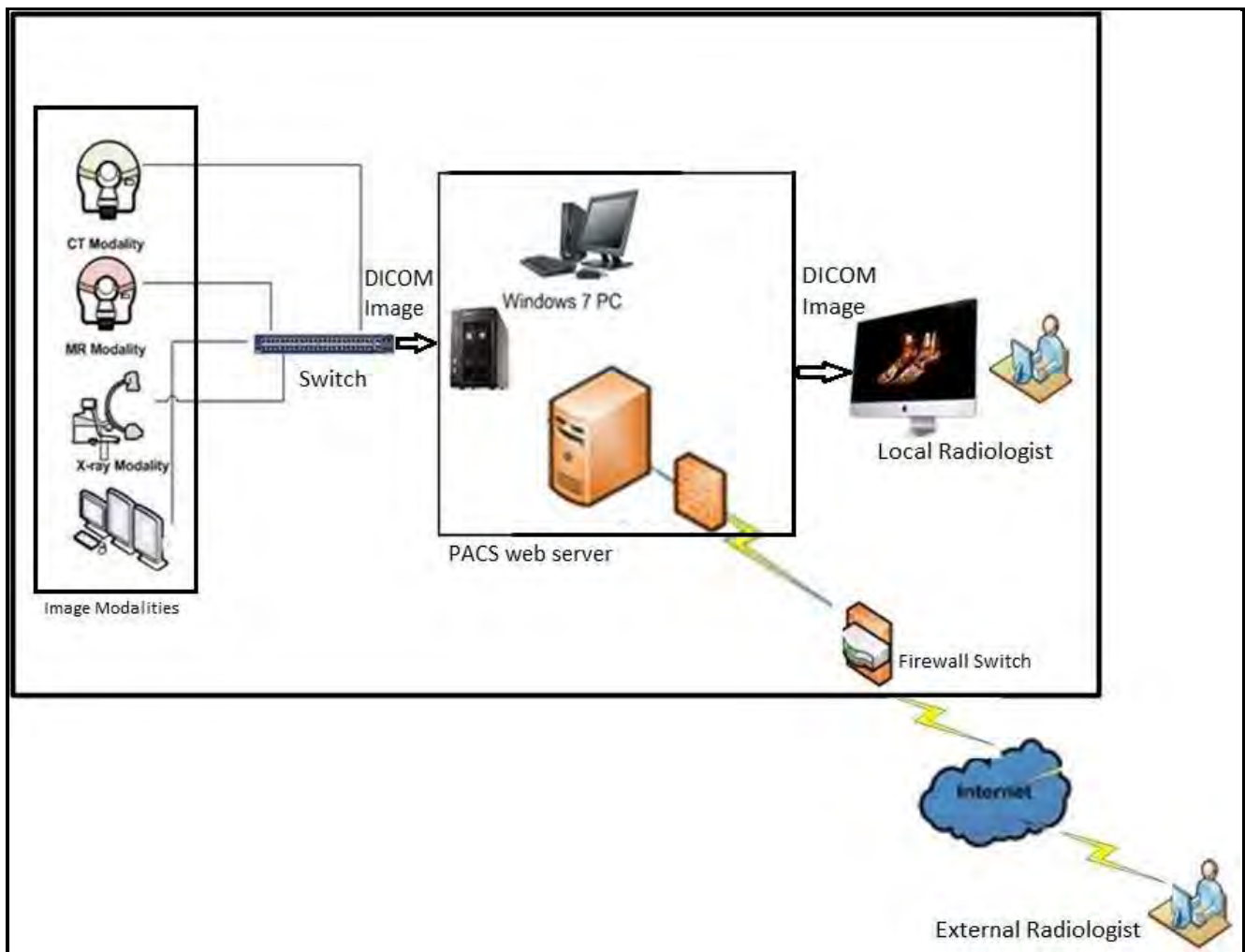


Fig 5.1: system Architecture

The user interface is designed using Macromedia Dreamweaver, the system uses data base to store Image messages as well as user profiles and shared documents. This database is developed using Microsoft SQL Server. Finally, as a web based system developed via ASP.NET, it runs under Microsoft Internet Information Server (IIS). The developed system will be installed in the web server.

5.1.1 Web Server

Web-based tele-radiology is mostly used by hospital or larger clinics to distribute images to various parts of the hospitals or clinics, or outside of the hospital. A web server is designed where filtered images from PAC systems are either pushed from the PACS server to, or pulled by the Web server. Filtered images mean that the Web server has a predetermined directory to manage the image distribution based on certain criteria like what types of images to where and to whom, and so on. The clients can view these filtered images from the client workstation through the web server. The clients can be referring physicians who just want to take a look at the images or for radiologists to make a remote diagnosis.

Web-based tele-radiology is very convenient and low cost to set up because most technologies are readily available, especially within the hospital intranet environment. The drawback is that since Web is a general technology, the viewing capability and conditions are not as good as that in a regular PACS workstation where the setup is geared for radiology diagnosis. In order to have full DCIOM image resolution for visualization and manipulation at the clients, the Web Server has to receive full 12 bits/pixel data from the PACS server.

5.2 Prototype

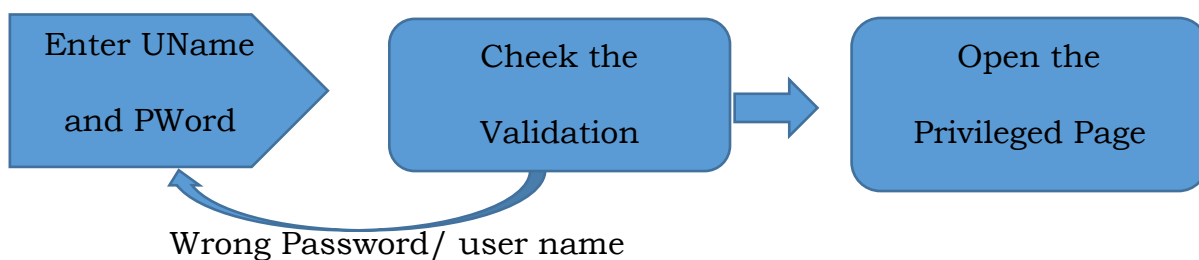
When the system starts, it displays the login form with the Danu Home page, so that users should authenticate to use the system.



Fig 5.2: Login Form for privileged Users (Administrator, Radiographer, and Specialist)

The front page has menus that help the users to login the system, to administrate their tasks. The system allows only the actors listed in the use case description. Administrator, Radiographer, Specialist (Radiologist), and Diagnostic Center that need the service from the system owner.

All the users have their own username and password privilege that is given by the system Administrator. If they are not privileged the system denies the service.



DANU Orthopedic
Diagnostic center

Home User Forms About Logout

logged: Administrator

Employee:
Username
Privilage Administrator
Password
Confirm password

	Employee	Username	Privilage	Status
☐	Desta	des	Department	Active
☐	Nati	nat	Department	Active
☐	Nebiyu	neb	Administrator	Active
☐	Samiya	sam	Department	Active
☐	Tigist	tg	Store	Active

Fig 5.3: Administrator page for Adding, Editing, and Deleting Users

This page allows the administrator to give different privileges to the different actors (users). Adding, editing, and removing employees from the database is performed in this form. In addition to this, the user's password encrypted by function which is in php coding part. The administrator can remove employee by checking the cheek box and selecting delete button. Or s/he can edit the employee username, privilege, and status by checking the cheek box and selecting edit button, then it allows the admin to change and renew users' status.

The screenshot shows a web application interface for the 'DANU Orthopedic Diagnostic center'. The header features the center's name on a blue background and a medical illustration of a human arm with a red joint. Below the header is a navigation bar with buttons for 'Home', 'User Forms', 'About', and 'Logout'. The main content area is titled 'Employee Form' and contains a registration form with the following fields: 'Name' (text input), 'Position' (dropdown menu with 'Accountant' selected), and 'Department:' (dropdown menu). A 'Save' button is located at the bottom of the form.

Fig 5.4: Administrator page for registering new employee

This Form/page allows the administrator to add new employee in the data base, assigning the employee position and in which department he or she are going to be allocated. The admin must fill the name field with employee name, in the position selection dropdown menu allows him/her to select the position, and also the department gives the same option to select from the menu. After completing the employee form the administrator must click the save to store employee data in the system database.

The screenshot shows a web application interface for the 'DANU Orthopedic Diagnostic center'. The header features the center's name on a blue background and a 3D anatomical model of a human arm with a red joint. Below the header is a navigation bar with buttons for 'Home', 'User Forms', 'About', and 'Logout'. The main content area displays the 'Username: radiographer' and a form for editing user details. The form includes three rows: 'Privilage' with a 'Department' input field, 'Status' with an 'Active' input field, and 'Reset password' with an empty input field. At the bottom of the form are 'Save' and 'Cancel' buttons.

Username: radiographer	
Privilage	Department
Status	Active
Reset password	

Save Cancel

Fig. 5.5: Administrator page for editing Users privilege, Status and Password

This form is the place where the Administrator will edit/ assign users/ employees privilege in the working environment, change the status of the employee (making the employee active or inactive) from using the web page. The administrator has to fill the field with employee privilege, change status to activate or to deactivate the employee from using the system, and change the pass word. After filling the form, the administrator can save it.

Fig 5.6: Radiographer page for sending Image messages

This form display when the radiographer login to the system. Patient information fetched from the database, the orthopedic image of the patient that stored will browsed, records all the necessary medical information in the fields, examinations should have written on the note, and after selecting the Specialist to whom this image message referred, then upload the message to the web server.

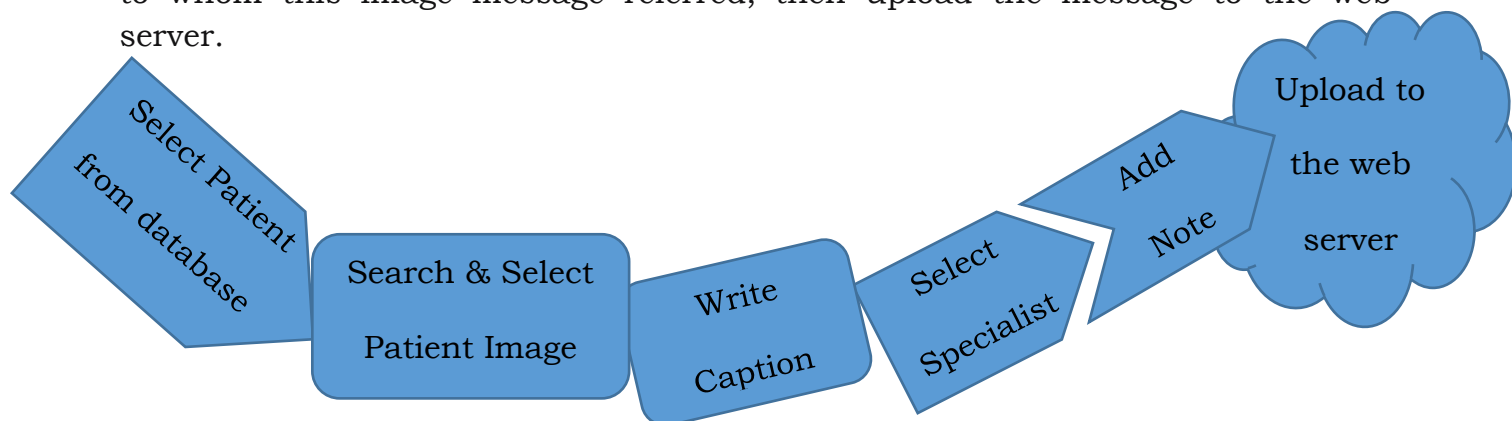




Fig 5.7: Radiographer outbox/sent message viewing page

The radiographer should know the message that he/she uploaded was correctly uploaded on the server to the right specialist/ endpoint, with the patient essential information. The message sender or radiographer can view the sent message by clicking the sent button from the menu bar, then the sent message box displayed on the screen. The sent message box contains the sender name, date, patient name, note written, and the radiological Image. Therefore this page helps to reduce medical errors in the system.



Fig 5.8: Radiographer Inbox Message

After the specialist observes and justifies the image message, he/she has to reply the result to the center. This page shows the inbox messages of the radiographer. After viewing the result of the patient the radiographer gives the return patient result to the doctor who examine the patient.

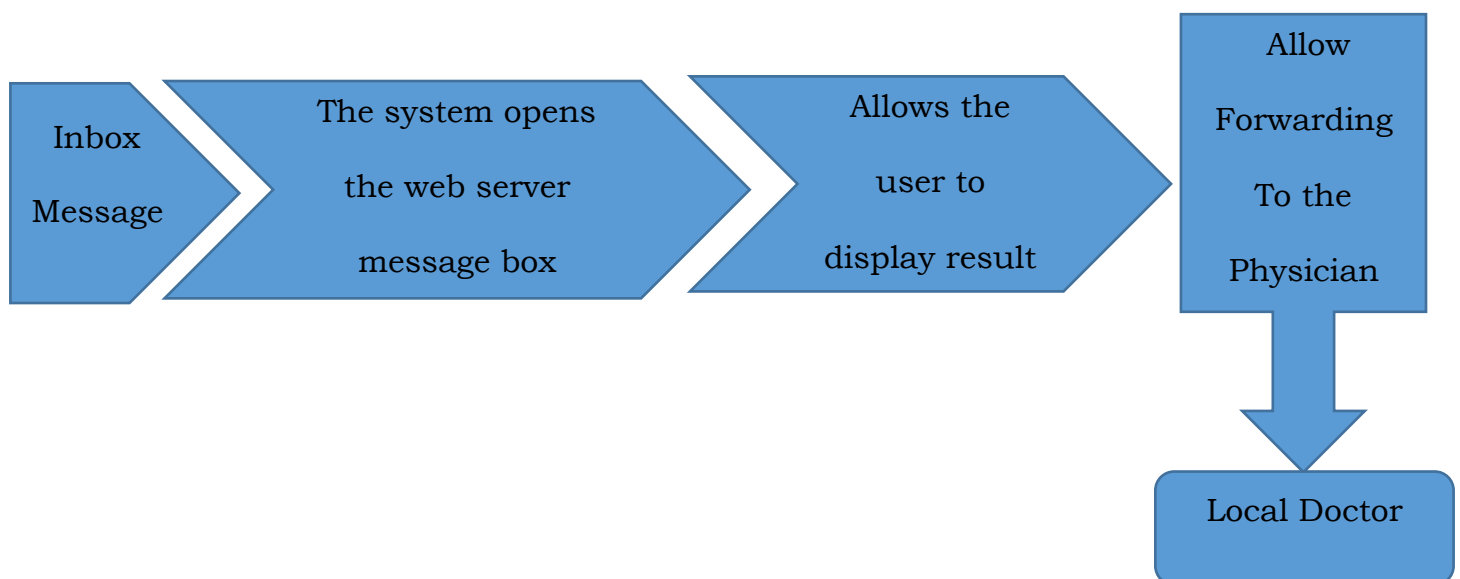




Fig 5.9: Specialist Inbox Messages

The center has agreement with external specialist that can use the web based radiology system to help their patients. This form, allows the specialist to display the radiological images with patient demographic records and all the necessary medical information. The specialist can found the inbox message in the message menu bar.

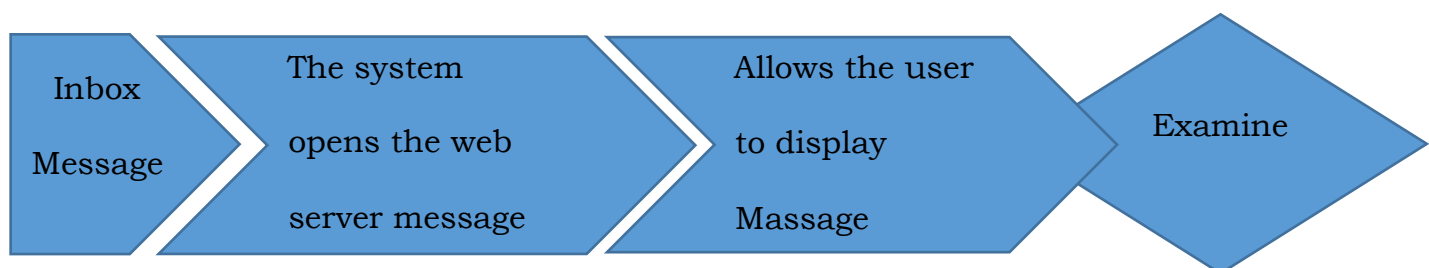




Fig 5.10: Specialist Displaying Image messages

The image message in the inbox will be displayed by clicking on the image text, then the patient image and records all the necessary medical information on the note displayed. After the specialist examine the image, he/she has to click on “reply to radiographer” link to reply the result message.



Fig 5.11: Specialist Result Sending page

After “reply to radiographer” link is selected the above for is displayed. Based on the image message and note that written about the patient, the specialist can reply the result to the diagnostic center using “reply to radiographer” link. The result typing txt box is flexible or stretch and scrolled to give enough writing area to the result, then finally clicking send button submits the result message in to the server.



5.3. System Performance Evaluation

The system performance evaluation is to determine the usability of a web based tele-radiology system to support the Danu Orthopedic diagnostic centers. The test environment consists of Personal Computer and free software. The database server has an Intel processor of four cores and 8 GB of RAM. It runs Windows 7 as the operating system, http server Apache with PHP as an application interface between the users and the database, and MySQL as a relational database management system. Workstations are simple computers equipped with processors Intel P-IV of 2.6 GHz clock speed.

5.4 User Acceptance Testing

Systems are methodical and systematic approach to the elements of software development: requirements analysis, modeling, design and architecture. To what extent of curiosity is the entire process carried out, some mistakes in the process of development are unavoidable. Hence, systems are subject to tests before implementation in order to:

- Minimize error
- Discover potential problems
- Ensure the right software product is delivered
- Achieve user satisfaction and customer acceptance

In order to deliver web based tele-radiology Management System without compromising its functional requirements. Usability tests on the system were carried out to ensure the functionalities of the system. Although, professionals informally respond that they are using general purpose email services, filming, and CD copy as a best tool. But with the newly developed web based tele-radiology management system it would be easy to store, retrieve and secure transaction of radiologic data.

5.4.1. Evaluation of the prototype

The evaluation of the proposed system was made. This evaluation includes system users, radiologists, radiographers, and IT expertise. It includes 14 users, one IT officer eight specialists five radiographers.

The questionnaires have five close ended questions.

Table 5.1: Users Acceptance and Testing table

No	Criteria	Scale				
		Excellent	V. Good	Good	Satisfactory	poor
1	I found the system is significant	10	3	1		
2	I found the system is stable in heavy work load	9	4	1		
3	Time taken to complete the task makes you comfortable	12	2			
4	I found the output of the image natural	12	2			
5	I found the user interface easy to interact	9	4	1		
	Average result	74.3%	21.4%	4.3%		
	Total good response value	95.7%				

The above questionnaires help to capture the opinion of the respondents and individual interest for the system use. From the total of fourteen users, 74.3% of them respond excellent, 21.4% of uses respond very good, and 4.3% users of the system respond good. Therefore, according to the acceptance testing and the users' remarks, it indicates that: implementing this system within the center with better infrastructure and network connection will benefit them. This system helps the center with different specialty services, helps to invite different specialists with different disciplines, and also it supports by integrating with different modalities.

Chapter Six

Conclusion and Future works

6.1 Conclusions

A Web-based tele-radiology management system has been developed for the management and processing of orthopedic and radiological medical data. The system, through its modular structure, records all the necessary medical information in terms of patient data, examinations, and operations for the communication, manipulation, processing, and storage of radiological images using the DICOM protocol. It can be installed in a hospital and Diagnostic centers which use PACS System, for bringing together medical experts from different fields such as gynecologists and radiologists within the hospital / Diagnostic centers as well as experts located outside the hospital/ Diagnostic centers through the Internet.

Based on the interest of system owners, tele-radiology systems could be tailored to a specialty area or serve for any clinical discipline. Different applications of telemedicine are referred with terms starting with 'tele' as in tele-consultation, tele-radiology, tele-cardiology, etc.

In this sense, the system is designed as a store-and-forward tele-radiology system. It allows users communicate each other via web based system with a possibility of attaching an image and patient demographic data. The system doesn't focus on another specialty field; rather, any orthopedic case can be consulted.

Using the system, health professionals in rural areas can reach specialists residing in any location. This enable to lift the level of healthcare delivered to patients, Specialists could also reach wider patients.

6.2 Recommendation

The system is a tele-radiology application enabling users communicative via image message in store-and-forward concept. The following features are thought to be future point of importance on this system.

- Allowing multiple image message on the single message
- Sending alert message to specialist's mobile phone as SMS
- Allowing Patient online registration
- Maintaining its simplicity, improving the user interface

From Danu side

- Need good infrastructure to deploy the system
- Need a system in the future for supporting others specialties

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ANNEX I

ADDIS ABEBA UNIVERSITY SCHOOL OF INFORMATION SCIENCE AND SCHOOL OF PUBLIC HEALTH MSC IN HEALTH INFORMATICS PROGRAM

My name is Desta Worku. I am post graduate student of health informatics program in Addis Ababa University. I am doing a research project on designing web based tele-radiology management system. The following interview is designed to strengthen the informational need of the project to design, implement and achieve an improved diagnostic center health care delivery. Thus you are kindly requested to provide genuine and correct answers for the questions posed by the principal investigator. The information's you provide are confidential and will be used only for the purpose of this study. Sir/madam, if you have anything, you want to be clarified do not hesitate to ask the investigator/the interviewer. Your full cooperation and participation until the completion of the interview is crucial for the completion of the assessment. I kindly ask you to provide your genuine willingness. Besides, you have the right to turn down if you are not voluntary to participate on the interview.

THANK YOU IN ADVANCE FOR YOUR COOPERATION

1. How are patient image data stored?
2. where do you store image data and how?
3. How many computers do you have in the center?
4. For what purpose do you use them?
5. what are the current problems regarding image store and forwarding?
6. What type of errors occurred frequently?
7. How does patient image send to the specialist?
8. How long it takes for image result replied?
9. How often specialist visit the patient in the center?
10. What are the device used to send image message to specialist?
11. Who is responsible for patient image result error?
12. What does radiology management infrastructure look like?
13. How many stuffs does the center has?
14. What is the patient respond for the radiology service time taking?
15. Does the radiology department deliver all services?
16. Is there any planned approach to improve the current system?

ANNEX II

Users Acceptance and Testing table

No	Criteria	Scale				
		Excellent	V. Good	Good	Satisfactory	poor
1	I found the system is significant					
2	I found the system is stable in heavy work load					
3	Time taken to complete the task makes you comfortable					
4	I found the output of the image natural					
5	I found the user interface easy to interact					
	Average result					
	Total good response value					

Declaration

I declare that this project is my original work and has not been presented for a degree in any other university.

Signature

Date

The project has been submitted for examination with my approval as university advisor.

Name and signature of Advisors

Name	Signature	Date
1. Dr. Milion Meshesha (Phd)	_____	_____
2. Dr. Ababai Zergaw (Phd)	_____	_____

Jun 2016, Addis Ababa, Ethiopia