A CLOUD-BASED CROSS - ENTERPRISE IMAGING FRAMEWORK

By

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ABSTRACT

Digital technology in the medical field has grown so fast in the past few years which in turn has necessitated the need for applications that make it possible to effectively manage patient medical records and imaging data. The main objective of facilities working in the medical field worldwide is to give the highest quality of patient care at reduced costs. This does not seem to be an easy task in particular when exchanging information/images and transferring patients between different healthcare institutions. The exchanging of medical imaging is of great importance as it reduces unnecessary repeated images and unnecessary exposure to radiation. As a solution to this problem, there have been several recommendations to employ cloud computing to manage hospital information systems. Sharing and exchanging medical image information can be found in the cloud. The medical images information which can be found in the cloud, 1) can help doctors get the details needed, 2) patients can also receive medical attention in different healthcare facilities, and 3) reduces unnecessary transfers. Thus, there is pressing the need for a faster, more reliable way of exchanging or sharing of patient files/images. This will permit the three parties, viz., patients, healthcare professionals, and healthcare providers to gather, share, and see the diagnostic imaging reports electronically from any hospital; this will solve the archaic issue of copying medical images to CDs, reduce time, and cost connected with unnecessary exams and reduces unnecessary radiation exposure for patients. This paper proposes a framework that will highlight a cloud-based cross-enterprise imaging framework.

Keywords: Electronic Health Record (EHR), Picture Archiving and Communication System (PACS), Digital Imaging and Communications in Medicine (DICOM), Cross-Enterprise Document Sharing (XDS), Cross-Enterprise Document Sharing for Imaging (XDS-I), Unique Identifiers (UIDs), Cross-Community Access for Imaging (XCA-I).

INTRODUCTION

Images must be managed systematically regardless of the way they are captured, be it in a traditional or emerging setting. Having access to medical imaging is considered an essential component patient care. Of equal importance is Electronic Health Records (EHRs). Care groups have fragmented and separate ways to the way images are managed. Businesses also realize that many medical specialties are similar in the way images are captured, stored, and distributed. In some clinical specialties, such as cardiology or radiology, describing images is of great importance that they speak for the image itself; when texts are supplemented with images, information will be conveyed more effectively. Enterprise Imaging as a software developed for many purposes, including but not restricted to, the need to make the clinical workflow more smoothly, develop and manage IT infrastructure, devise an operational scheme and create communication to meet the medical content of enterprise multimedia, and images in the healthcare business. The name 'Enterprise Imaging' has started to increase in popularity especially among clinical and industry communities despite the recent variation in the exact definition. HIMSS-SIIM (Healthcare Information and Management Systems Society-Society for Imaging Informatics in Medicine) member workgroup defines Enterprise Imaging as a set of strategies and initiatives implemented in healthcare field to capture, index, manage, store, distribute, view, exchange, and analyze all clinical imaging and multimedia content to enhance the electronic health record (Roth et al., 2016).

Healthcare institutions have a PACS (Picture Archiving and Communication System) that is usually designed to manage medical images in a digital format and it has recently started to become part of hospital system designs that store medical images used for diagnostic purposes. If one wants to fully benefit from PACS, it is important to integrate other systems and schemes available in the medical institutions. Recently, Integrating Healthcare Enterprise (IHE) emphasizes the importance of the integrative aspect of the PACS. However, some PACS systems exist in a separate form from the information system of healthcare organizations. Regrettably, some recent PACS systems are available as separate islands away from the information flow of healthcare businesses. It is also of note that the process through which these images are shared has always been a challenge, especially when they are shared among different businesses.

Protecting healthcare-related details, such as imaging examinations and reports are regarded the primary concern of quality medical care. The main aim of exchanging patient data has always been to establish an information bank so concerned parties have access to it in order to compare it with the patient's past medical examinations and results. Moreover, this system will help healthcare institutions share information particularly when patients receive healthcare from different healthcare providers. The availability of a system that exchanges patients' information, and exam results and images will help avoid unnecessary costs, radiation exposure, and duplication of exams thus improving the public health and costs.

1. Motivation

As we have seen, it is fundamentally important for different healthcare providers to share patient's clinical information if they want to serve patients well. Healthcare providers have different healthcare systems that store, retrieve, analyze information differently. Therefore, standardizing these various systems into one system will benefit both healthcare providers and patients. CDs became the standard manner to exchange images outside the organization. Every time the patient has to go to another specialist (organization), he/she brings the CDs with him/her and faces the challenge of getting them uploaded in a different medical imaging system (for example Radiology PACS, Cardiology PACS, etc.).

One of Saudi Visions 2030 is to enhance the standard and quality of healthcare services. So The Ministry of Health (MOH) is seeking to launch several health initiatives related to the National Transformation Program (NTP) 2020 and the Saudi Vision 2030, which come as part of its series of initiatives. The MOH has carried out many achievements across its different sectors and services over the past period. As for the primary healthcare domain, which is reckoned the most important component in health system, more than 80 primary healthcare centers have been inaugurated all over the Kingdom, bringing the total number to more than 2,390 healthcare centers for providing the services of primary healthcare and vaccinations, as well as dealing with chronic diseases and maternity and children care to more than 52 million patients. During the past year, more than 2 million persons have been vaccinated against influenza, and the number of health centers working for 16 hours a day increased by 100%. The emergency care centers increased by 50%, bringing the total number to 107 centers. Besides, the number of counseling clinics which provide primary mental healthcare has been doubled to reach 55 clinics and counseling clinics have been added to 82 health centers throughout the Kingdom's regions, in addition to that anti-smoking clinics that increased by 160% to reach 160 clinics (Ministry of Health, 2018). So the strategic approach is the harmonization of processes and adoption of medical and clinical best practices to achieve the unification of all patients' medical records and exchange health data with other healthcare organizations in the Kingdom.

2. Objectives

- Share and exchange electronic clinical data and images across organizations.
- Improve the coordination of information, efficiency, and effectiveness of healthcare services when records accompany patients wherever they to receive care.
- Achieving an interoperable solution, common medical coding system standards, and health record standards.
- Improve clinical decisions by testing once and exchange with different healthcare professionals to better decision making in the medical field.
- Chances to lower radiation dose take place when image sharing devices can help avoid harmful repeats of nuclear medicine, X-ray, CT imaging, and other radiation-emitting modes.
- Support and administer the increasing volume of medical data and images.

3. Area of Research

There is now an increasing tendency among healthcare organizations to move from records based on films and papers to electronic medical images and health details (HER) system. This shift to integrate electronic images and HER systems to provide a system that captures and shares patient data holistically is quite recent (Piliouras et al., 2015).

3.1 Medical Imaging Strategies

- *Departmental PACS (Picture Archiving and Communication System)-Centric Strategy*

Disparate archives in individual PACS (for example: Radiology/PACS, Cardiology/PACS).

- *Enterprise Storage-Centric Strategy*

Enterprise storage, sometimes known as a Vendor-Neutral Archive (VNA), is a data repository that consolidates medical images and associated data from multiple imaging departments and locations into a unified archive. The VNA replaces the disparate archives in individual PACS and becomes the imaging data repository for the enterprise EHR.

- *Cross-Enterprise Strategy*

Medical imaging exchange between hospitals/imaging centers.

4. Limitations and Challenges

Today the usage of electronic health data in different fields is a debatable issue. Because health details are not homogenous, organized, or systematic, it is accessed through various formats and architectures. Electronic Health Record (EHR) systems are considered one of the most effective enabling tools for patient-centric care, and these systems also guarantee care persistence and facilitate patients' mobility. In addition, sharing of patients' information takes place when hospitals send cases to other entities same city or even different cities or countries. This necessitates the need to study if other models and protocols are available to exchange critical health information during open-ended transmission. Integrated applications that are designed for sharing and exchanging data is of great importance and creating such applications or systems is influenced by different factors pertaining to technology and the way health providers adopt such systems. Vendors have attempted to implement varied architectural approaches to create a HIS (Hospital Information System) without taking into account the integration of patients' details. These inconsistent systems can work well if they are used separately; however, they are more likely to create problems when they try to work together or talk to each other (Ministry of Health, 2018). In other words, the primary challenge is to make two systems or two components of a system exchange information and that information which has been exchanged.

Another important challenge is flexibility in the usage of the systems as medical staff, such as radiologists, cardiologists, referring physicians, and most importantly patients have no access to medical data which will increase the chance of delayed diagnosis or treatment, may cause repeat of nuclear medicine unnecessarily, X-ray, or CT imaging, especially for patients who sometimes need to be transferred from one medical entity to another or who get medical treatment at multiple healthcare facilities.

Data migration is one of the trickiest parts of PACS integration. Depending on the size of the organization, the number of PACS involved, and whether the PACS archives are in proprietary formats, it can take anywhere from several months to a few years to migrate all of the data into a single repository. In the interim, healthcare providers need continuous access to the stored images and reports (Campbel et al., n.d.). Securities of patients' information and medical image sharing have been the primary concern of healthcare facilities. There have been many attempts in this regard to protect patients' information and data. Security means protecting physical, technological, or administrative health details from people with no authorized access or disclosure. The main constituents that makeup data security are privacy, confidentiality, integrity, and availability. Security and privacy mean the efficiency in finding a safe storage environment, which also includes data protection and recovery from any data loss in healthcare organizations. Because medical images are transmitted between health care providers when patients seek additional care from other healthcare entities, they can be more challenging to protect when compared to other facets of digital secure health data. Privacy is concerned with the protection and carefully using of patients' personal details (Shini et al., 2012).

5. Research Questions

Q1. What is needed to implement a cross-enterprise medical imaging strategy and what will be the impact of it?

Q2. What is the effective way to identify patients?

Q3. What are the security issues in Cloud-based medical image exchange?

6. Background

The Electronic Health Records are a digital version of the traditional paper-based records for the medical history for patients containing all of the clinical and personal data related to a patient's care given by a particular healthcare provider. Electronic Medical Records (EMR) are an important emerging aspect of health information technology and are being adopted or considered for adoption in many hospitals across the world. Electronic Medical Records, if implemented properly, play a major role in health care organization, making it easier for doctors, nurses, and other medical staff to share information and keep patients' information up-to-date and protected. However, EHR is not the only system that a single manufacturer or producer can handle. It is a virtual system that is the result of the cooperation of several systems that work in the healthcare field. Healthcare systems have to handle a huge amount of clinical details, such as diagnostic images, lab, and cardiology assessment results plus the various healthcare specific standards.

Many experts consider medical imaging to be a peaceful, non-invasive technique which is used to make images of the human body for purely clinical and medical purposes. Techniques used in digital imaging have been in place for around 50 years after the admission of Computer Tomography (CT scanner) in the medical field. Nowadays, the technology of taking digital medical imaging is global and it is considered an essential component of the healthcare workflow (Ribeiro et al., 2011). The notion of medical imaging in the healthcare field is indeed indisputable. To doctors, it is considered a key element in supporting clinical propositions which in turn leads to a higher quality healthcare decision. Patients' images and data are stored in local repositories in accordance with a PACS (Picture Archiving and Communication System) notion. PACS is designed for parts that are used to archive, distribute, visualize, and acquire medical images on a computer network. PACS as a system brings important benefits for the productivity, economy, and management of a healthcare institution, unlike the traditional analog film which does not have this property. It is also considered common software that many medical centers have started to implement. This wide popularity was also supported by the introduction of the DICOM (Digital Imaging and Communications in Medicine), a new system to handle, store, print, and transmit medical images. This includes data format definition, storage organization, and a protocol for network communication.

This makes it easy for PACS devices to receive from different vendors and also enables it to communicate with each other in a transparent manner.

DICOM is a program that facilitates the operations of the healthcare entities, but inter-site operations are a different matter. What normally happens is that an entity that has authorization would request access to the whole medical history of the patient which is related to a certain episode even if the medical check-ups are done in another medical entity. The aim of IHE is to work on system integration and to exterminate difficulties that hinder handling the best care to patients. IHE also permits access to integrate profile which is composed of several actors and transactions.

These actors and transactions are a replica of the healthcare information system environment. Some of the processes are completed by certain product categories (e.g. HIS, Electronic Patient Record, RIS, PACS, and clinical information systems or imaging modalities).

The recent changes in the medical cloud computing field will affect the healthcare sector greatly. Healthcare facilities allow a variety of IT applications and infrastructures that need to be updated constantly which is due to the rapid changes in services offered by healthcare institutions. Cloud computing is considered to be an innovative business model and it is an excellent and valuable way to deliver services to those in the medical field. Cloud-based medical image management can offer flexible solutions for hospitals and medical imaging facilities to allow clinicians to quickly access patient imaging data across multiple systems at the point of care. Cloud computing in healthcare entities uses adaptable systems that can easily fit various needs in various hospital departments and also fit different organizations regardless of size. Cloud provides flexible resource allocation on demand with the promise of realizing elastic, Internet accessible, computing on a pay-as-you-go basis. Cloud's design consists of servers for storage, a platform such as operating systems, and application software which is sometimes called infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS), respectively. Essentially, the Cloud-based solution is a DICOM/Non-DICOM allows imaging to be exchanged between various medical institutions and healthcare practitioners.

7. Literature Review

7.1 Digital Imaging and Communications in Medicine (DICOM) and Health Level Seven (HL7) Standards

The primary goal for health professionals and institutions has always been the efficiency of services and the exchange of health details. However, this was not an easy task. Numerous problems have always acted as a hindrance to this goal such as the incompatibility of implementation standards, e.g. HL7, DICOM (Ribeiro et al., 2014). PACS (Picture Archiving and Communication System) primarily depends on DICOM and HL7 standards to communicate with various image modalities defined below (Piliouras et al., 2015; Ribeiro et al., 2014; Oosterwijk et al., 1999; Noumeir and Pambrun, 2009; Sartipi et al., 2013; Bian et al., 2009; Greenberg et al., 2010). Image modalities are image acquisition constituents that take medical images for patients. These include X-ray, MRI, CT, fluoroscopy, etc. (Sartipi et al., 2013). DICOM is a standard software developed by American College of Radiologists (ACR) and National Electrical Manufacturers Association (NEMA) that handles the communication of medical image among various image forms and associated systems. Medical images can be exchanged between parties that use DICOM because this system includes the format of the files and its definition and network communication protocols. It has features that make it possible to do many things, such as storing, querying, and retrieving images from systems such as PACS. HL7 is an institution whose specialty is to develop standards to facilitate healthcare interoperability of medical data. HL7 helps in standardizing the exchange of medical data, its management, and integration with other medical healthcare providers. It is important to use a standardized system that uses the same format to help different healthcare providers to store and exchange medical data among heterogeneous systems (Ribeiro et al., 2014; Noumeir and Pambrun, 2009; Sartipi et al., 2013).

7.2 Cross-Enterprise Document Sharing for Imaging (XDS-I)

To make the sharing of patients' data and images easier, healthcare professionals have proposed a new major proposal called Cross-enterprise document sharing (XDS), which is also part of the Integrating Healthcare Enterprise (IHE) enterprise to handle patients' data in a more effective manner (Ribeiro et al., 2014). XDS integration profile offers guidelines to implement communities that interoperate document sharing; it also provides a built-in detection mechanism for documents in the medical field. The XDS design makes patients' information from various care delivery systems accessible by different cooperating enterprises (Noumeir and Pambrun, 2009). This model is basically a registry that employs metadata that describes all documents. Documents are saved in repositories and the registry metadata gives a name and address that permits a consumer system to get back certain documents from the repository where it is saved and stored (Noumeir and Pambrun, 2009). Figure 1 shows the way the design of the system and the flow of data. Published documents are saved in repositories. They are input under the central registry and get a name and an address. These systems that work on accessing patients' data usually target the registry in the system which in turn retrieves documents that meet certain criteria (Figure 2). While responding to the inquiry, the registry transmits information pertaining to the document location and address, a Universal Resource Identifier (URI), which enables the system to recall documents from their repositories if the need arises (Noumeir and Pambrun, 2009).

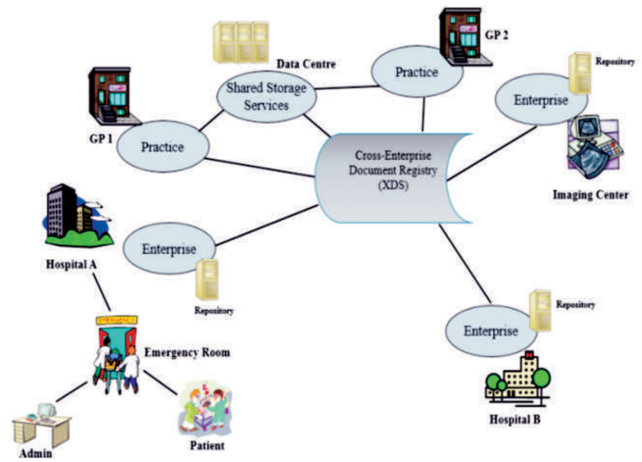

Figure 2. Connect different Systems and Share Results (One Organization Multiple Sites)

XDS-I is a content profile that has a special domain for storing the medical imaging. In that domain, systems such as PACS, RIS, or DICOM objects are regarded on the XDS design. Figure 3 illustrates the participation of actors in the XDS-I profile and the processes that might take place between them. The Imaging Document Source is the actor which distributes or maintains the medical docs e.g., PACS inside healthcare facilities. It is in charge of sending documents together with metadata to the required Document Repository. For DICOM objects, the Repository will keep the DICOM Key Object Selection (KOS). KOS objects are small DICOM objects with a list of UID references (instead of the image data itself) that makes it possible for the Document Consumer to recall the pictures from their sources. In addition to being in

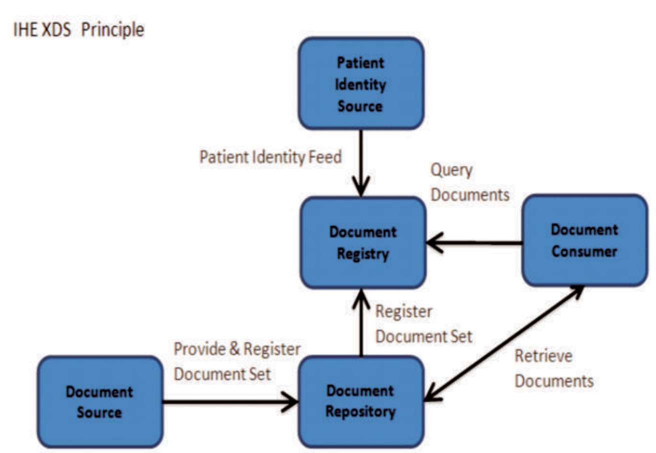

Figure 1. XDS Architecture and Data Flow

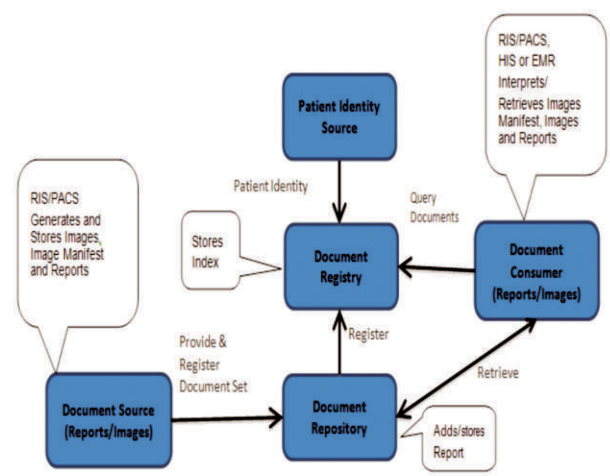

Figure 3. The XDS-I Content Profile (upon XDS blocks, in gray)

charge of repeated documents, the Registry acts on inquiries from the Consumer actor about the places where matching documents can be found. The Consumer actor questions the Registry to place the location and identifier of the document. This information will enable it to contact the respective Imaging Document Source calling for access to the DICOM object(s). If permission is given, images can be retrieved via the WADO protocol (Ribeiro et al., 2014). The Web Access to Digital Imaging and Communication in Medicine (DICOM) Persistent Objects (WADO) service is standardized as the Web extension to DICOM (Koutelakis and Lymberopoulos, 2009).

7.3 Web Access to DICOM Persistent Objects (WADO)

Since point-to-point DICOM transfer syntax is weak, ISO introduced the Web Access to DICOM Persistent Objects (WADO) service to distribute Web and display of medical pictures. The National Electrical Manufacturers Association (NEMA) and the International Organization for Standardization (ISO) have come to a decision to launch the Web Access to DICOM Persistent Objects (WADO) service for Web distribution and to project images in the medical field because of the weaknesses of point-to-point DICOM transfer syntax (Koutelakis and Lymberopoulos, 2009). The WADO is a standardized system developed by both DICOM (WG10) and ISO (TC215/WG2) as NEMA04a and ISO04c standards, respectively. WADO is neither a new medical communication protocol nor the transformation of a compatible DICOM service into its Web equivalent. It simply is a new system for accessing and presenting DICOM persistent objects (images, waveforms, reports, etc.) through Web protocols, without the need to DICOM compatible customers. Furthermore, it is a simple mechanism, through Web pages or Extensible Markup Language (XML) documents, using DICOM Unique Identifiers (UIDs). WADO is also inserted into other medical information exchange standards/profiles such as IHE Cross-Enterprise Document Sharing for Imaging (XDS-I) integration profile (Noumeir, 2005).

7.4 Vendor Neutral Archive (VNA)

A VNA is an enterprise archive that consolidates patients' medical image information and related clinical information in a final repository from multiple sources scattered across various clinical repositories (PACS). The VNA takes over data management from the PACS once the patient image has been acquired and interpreted as shown in Figure 4. Instead of archiving the data on its own storage solution, the PACS forwards it to the VNA. Information in a VNA is stored, updated, and retrieved using industry-standard DICOM and Health Level 7 formats (Karthiyayini et al., 2015).

7.5 Cross-Community Access to Imaging (XCA-I)

The Cross-Community Access (XCA) has the capability to question and retrieve patient medical data found in other communities. A community is a group of facilities/ enterprises which have agreed to operate together based on some policies and rules they agreed on for sharing clinical information through a mechanism agreed on by all parties (IHE IT Infrastructure, 2010). Figure 5 illustrates the direct involvement of actors in the XCA Integration Profile and the processes held between them.

7.5.1 XCA Detailed Interactions

Figure 6 gives an overview of the actions or transactions actors perform when the communities involved in

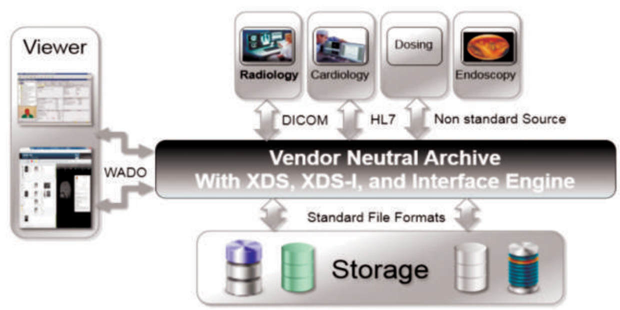

Figure 4. VNA Viewing PACS Silos

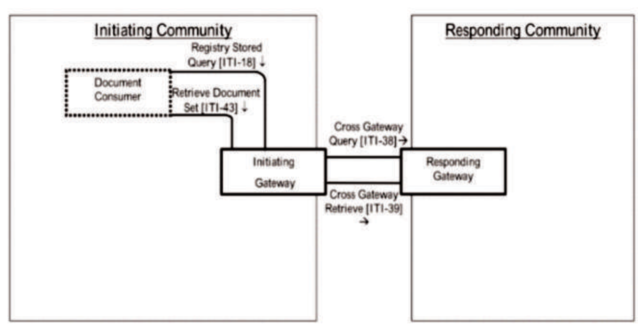

Figure 5. XCA Actor Diagram

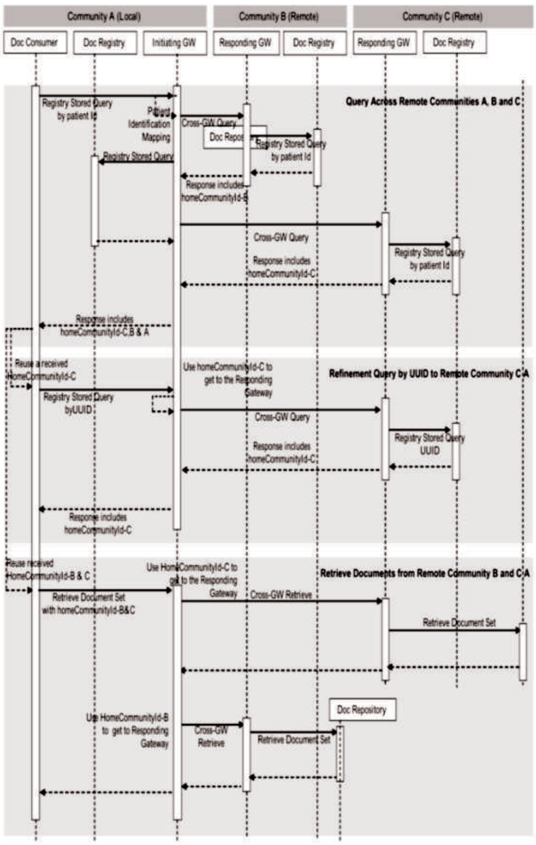

Figure 6. XCA Detailed Interactions

initiating and responding are XDS Affinity Domains, i.e. use of the XDS Affinity Domain choice and the Initiating Gateway and Responding Gateway are grouped with a Document Consumer.

XCA-I Integration Profile defines actors and processes to inquire about and get back patient-related medical data which is kept in other parties or communities. The XCA-I profile expands the IT Infrastructure XCA file and accesses the imaging documents referenced in the Manifests. Figure 7 illustrates how the actors are specified in the Cross-Community Access for Imaging (XCA-I) profile and the processes that take place between them (Lindop and Tzannes, 2011).

7.6 Patient Identifier Cross-referencing (PIX)

The main goal of IHE is to ensure that medical data about patients is available and that healthcare experts can have access to it in order to make decisions about patients. IHE PIX integration file is an essential part of ITI TF (IHE IT Infrastructure, 2016). Its primary goal is to specify a patient and then obtain the related data by identifying the cross-referencing of the patient's identifiers from different health entities.

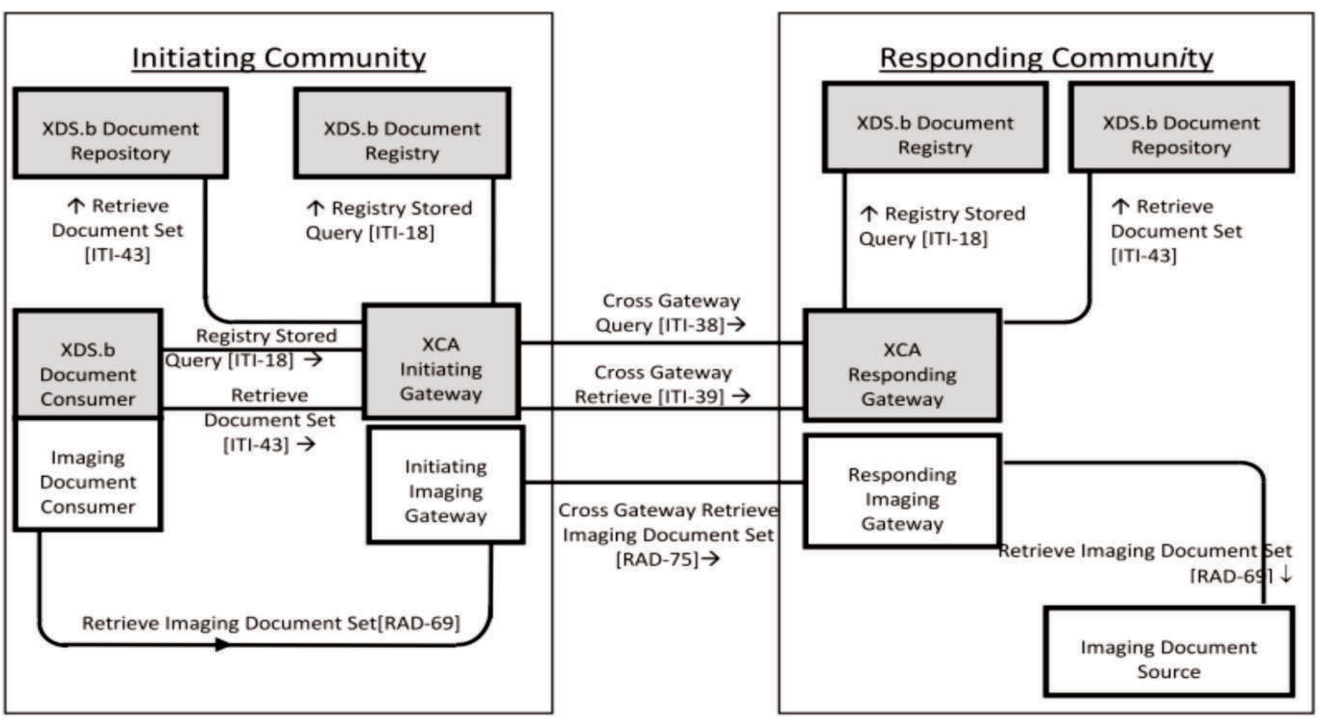

Figure 7. Cross-Community Access for Imaging Actor Diagram

The way IHE profiles work defines a subcategory for the important components of the medical project, which are actors and defines their communication with regard to a group of regulated processes. IHE PIX integrated file has some actors: Patient Identity Source, PIX Manager, and PIX Consumer, and three processes or transactions: Patient Identity Feed, PIX Query, and PIX Update (optional). The diagram below illustrates the intended range of this profile.

Figure 8 explains a normal process of how PIX is used. Patient Identification Domain (the rectangle of dashed lines) is illustrated as a mon-scheme which employs using a different recognizing scheme and issuing power for patient identifiers. A Patient Identifier Domain has a Patient Identity Source actor, which specifies a special way to identify each patient and keeps the characteristics. The instance of Patient Identification Field is a special type of healthcare institutions. A Patient Identifier Cross-reference Field (the rectangle of solid lines) has a group of Patient Identifier Domains and a PIX Manager that runs these Patient Identifier Fields.

In Figure 8, domain A, B, and C enrolls patient ID details to PIX Manager as Patient Identity Source actor, and the PIX Manager forms cross-referencing in accordance with the patient identifiers which are taken from the fields. Field A, B, and C can get a patient's data from PIX Manager (directly or indirectly) as a PIX Consumer actor. The IHE PIX profile gives the intercommunication needed and at the same time keeping adaptability to be used with any cross-referencing scheme and algorithm as required (Lijun and Jianchao, 2013).

7.6.1 Patient Identification using PIX

Figure 9 illustrates the mechanism of running patient IDs. There is optimal PIX which cross-references between domains and districts A, B, and C. This diagram presumes that a Responding or Initiating Gateway in every district communicates for the purpose of pushing patient details to the optimal PIX. The chart has no processing for the far domains communities (B and C) to reply to the query request. The optimal PIX is illustrated below; however, it is presumed to be a PIX Manager, or similar, that can be available to all communities (IHE IT Infrastructure, 2016).

7.6.2 Master Patient Identifier

An important point in Master Patient Identifier (MPI) service is to choose the best special identifier in HIE field. This service has some forms (as shown in Figure 10): patient

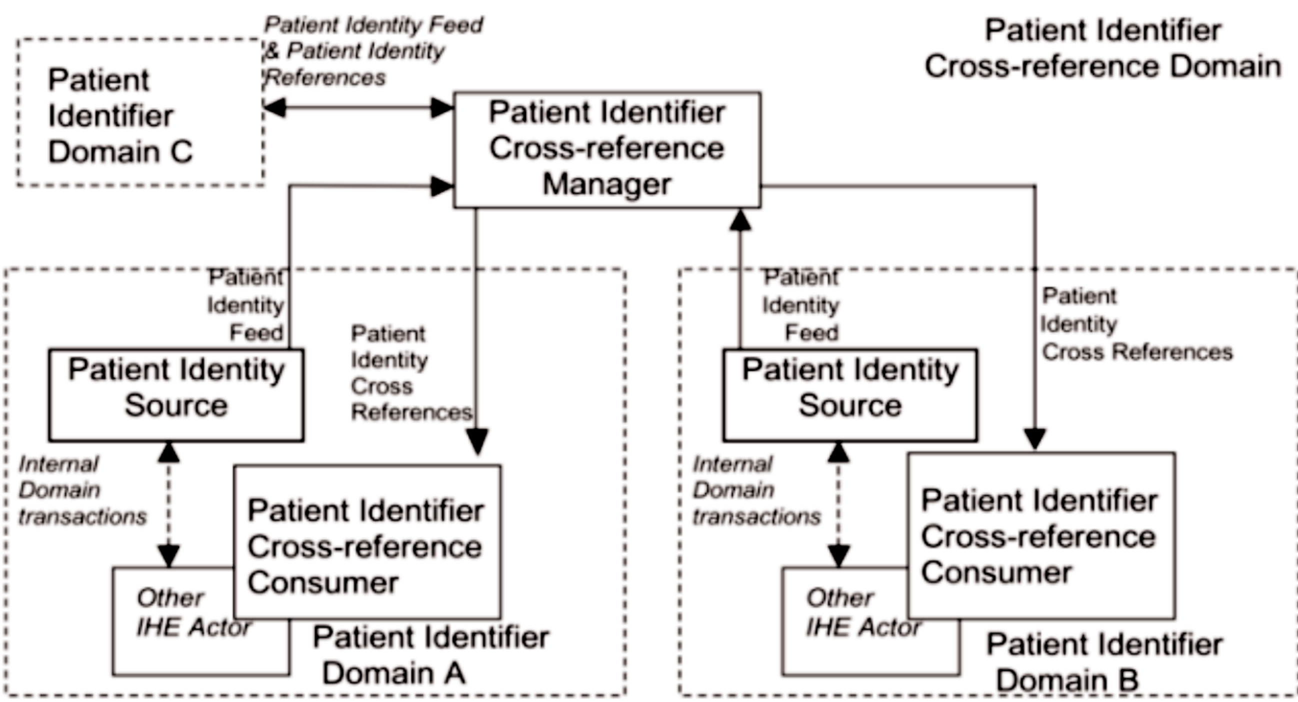

Figure 8. Process Flow with Patient Identifier Cross-referencing

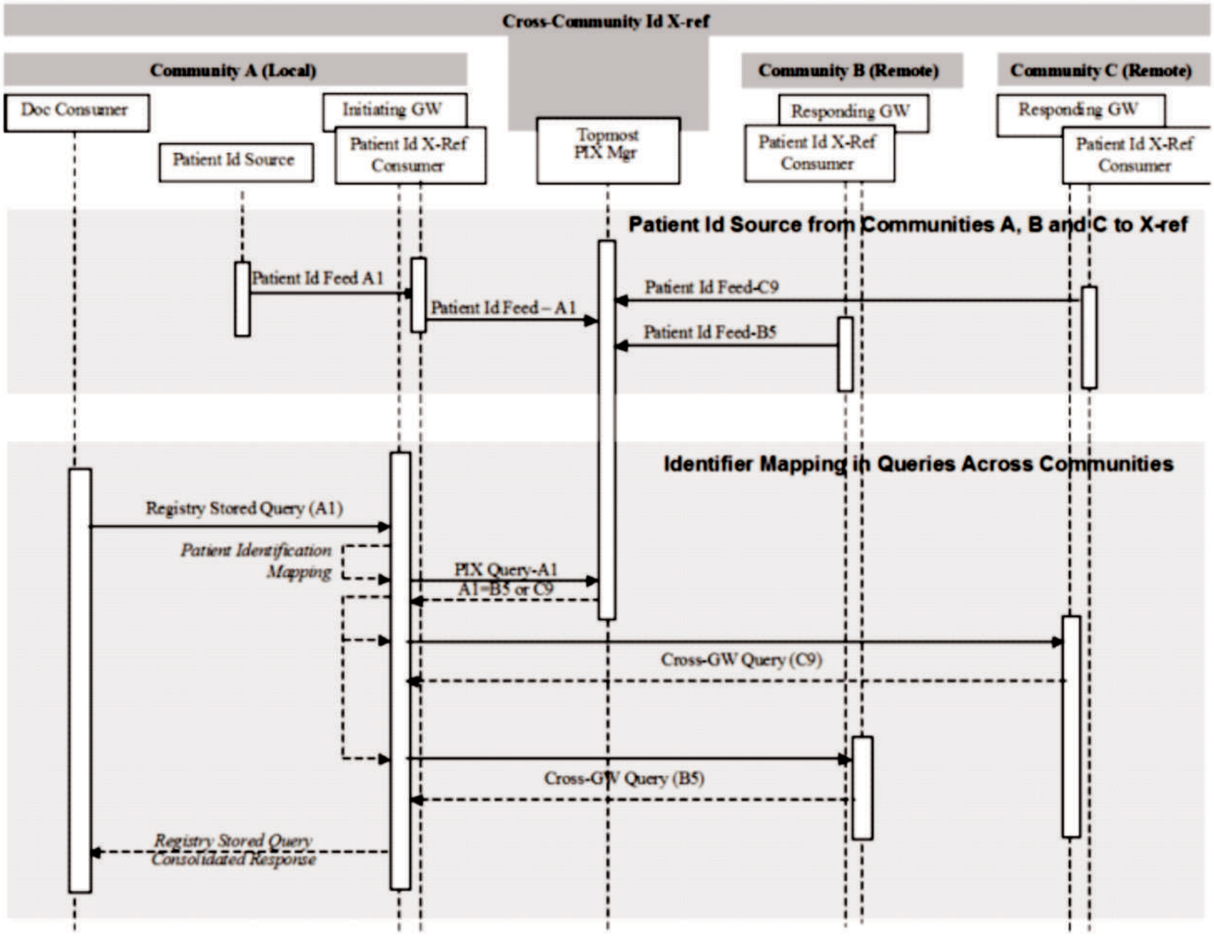

Figure 9. Patient Identification using PIX

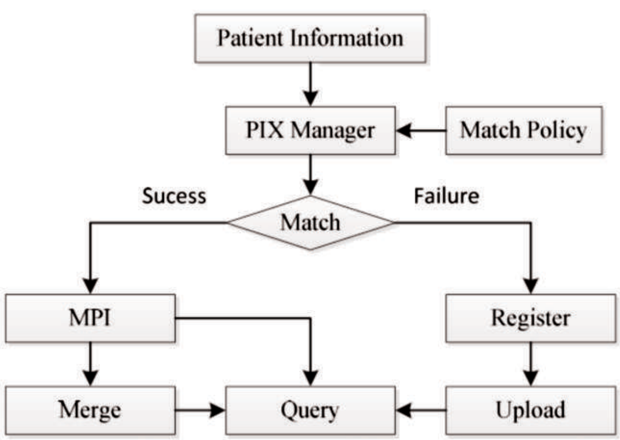

Figure 10. The Structure of HIE Identification Service

match, patient register, patient detail upload, patient details merge, and patient detail inquiry. The PIX Manager receives the patient's data and matches scheme to carry out the match. The Match engine replies to the MPI by the registering cross-reference relationship when it succeeds. MPI match engine identifies patient data request and merger. If a match is not established because of failure, the patient input details will not remain on HIE platform. Therefore, users can enroll by means of their national IDs and upload patient details in accordance with the requirement of HIE identification service. The merger takes place when registering the details. The HIE platform uses the match engine to locate any recurring clinical docs and then mix recurring details (Lijun and Jianchao, 2013).

7.6.3 Relationship between the PIX Integration Profile and eMPI

The PIX Integration Profile integrates separate Patient Identifier Domains by employing a cross-referencing plan among Patient Identifiers which have the same patient. The part talks about how the consistency of this plan with surroundings that want to start patient identifiers (MPI), or project MPI (eMPI) systems. An empire can be looked at as a special variety in applying the PIX Integrating Profile. MPI is a generic notion, but it is connected with making a patient identifier domain. Such a domain can be more practical or more enterprise-level than other identifier domains it has. Two possible shapes or configurations are reported in Figure 11.

Figure 11 describes how the Master Patient Identifier Domain (Domain C), in a popular MPI scheme, is the Identification Domain for another patient when seen in a Cross-referencing scheme. The verdict to put enterprise-wide systems such as Clinical Data Repositories into the master domain is merely a configuration option. Moreover, such a configuration often presumes that any system in Patient Domain A both administers the patient Identifiers of Domain A and knows of Domain C (IHE IT Infrastructure, 2016).

7.7 Enterprise Imaging Platform (Infrastructure)

The Enterprise Imaging (EI) gives frameworks, methods, devices, and points to base the scheme on (Figure 12). It is essential to the EI platform to have a standard-based DICOM and non-DICOM clinical image and video storage repository. Maybe the essential repository is a seller neutral archive or if it fulfills specific enterprise conditions, present PACS archive. It has a list of the image

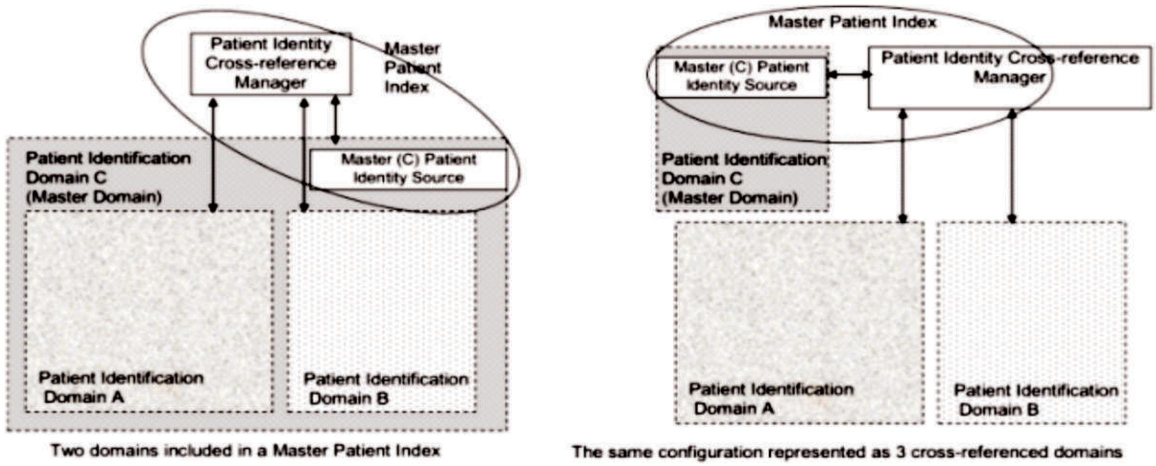

Figure 11. PIX Profile Relationship to eMPI

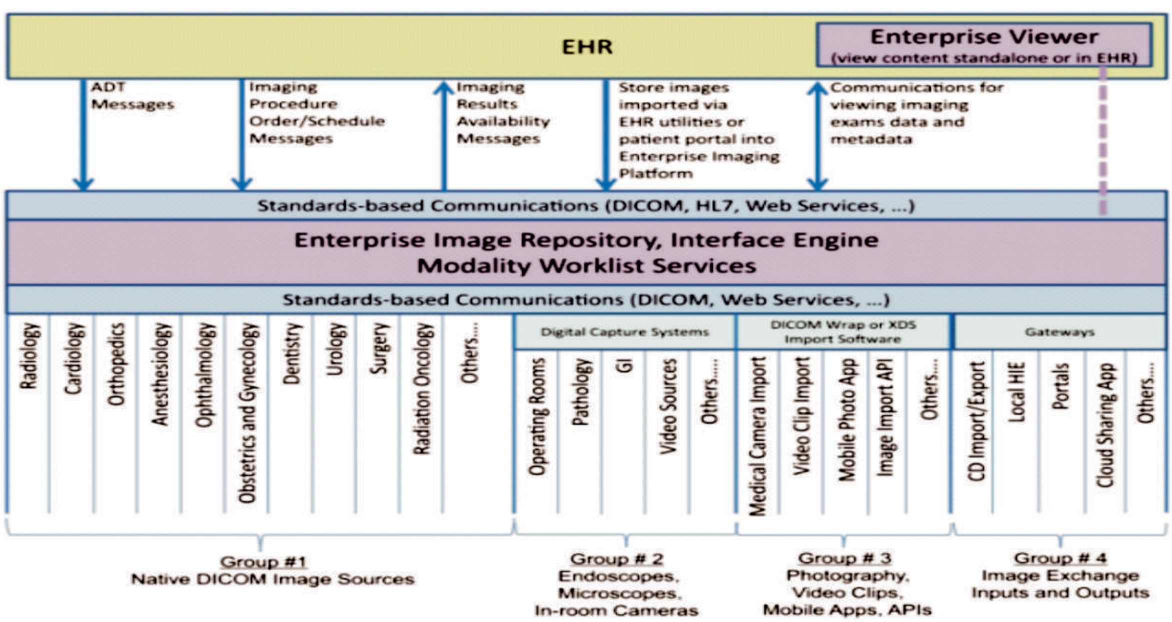

Figure 12. An Enterprise Imaging Platform

and meta-information in the storage. The archive could be a method agnostic, modality vendor agnostic, specialty and service line agnostic, and viewer agnostic. Standards-based mixing and communications, including DICOM, HL7, and standards-based Web Services, connect, enable, and support image acquisition workflows across modalities and departments. Image acquisition devices which back up the measures can keep their images, with meta-information, into the VNA (Roth et al., 2016). Acquisition devices backed up have DICOM imaging methods and modalities, point-of-care acquisition modalities or methods, tool image or video apps, digital capture systems, picture exchange gateways, and application schemed to get content as a soft copy or received by coming from another part or by patient portals.

7.8 Cloud Computing

Cloud computing is defined as delivering service provider rather than a product seller. In cloud computing, data, resources, and programs are handled over the internet to computers or other devices as services. Cloud computing giver services in computer and software and helps access and store data (Kanagaraj and Sumathi, 2011).

7.8.1 Taxonomy of Health Care Clouds

It stands for the taxonomy of healthcare Cloud that depends on cloud service modes and cloud deployment models. This reliance on this service allows us to split healthcare cloud product offers into three levels (Figure 13):

7.8.1.1 Applications in the cloud (Software as a Service - SaaS)

This level enables customers to exploit the giver's software and work on a cloud infrastructure. To exemplify, the software can be accessed by different customer items via a tiny customer interface like a Web browser. The customer does not run or control underneath cloud infrastructure, which includes network, servers, operating systems, storage, or personal application abilities. In such a cloud service mode, protection and security of private information are given as an essential part of the SaaS to the healthcare customers (Kanagaraj and Sumathi, 2011).

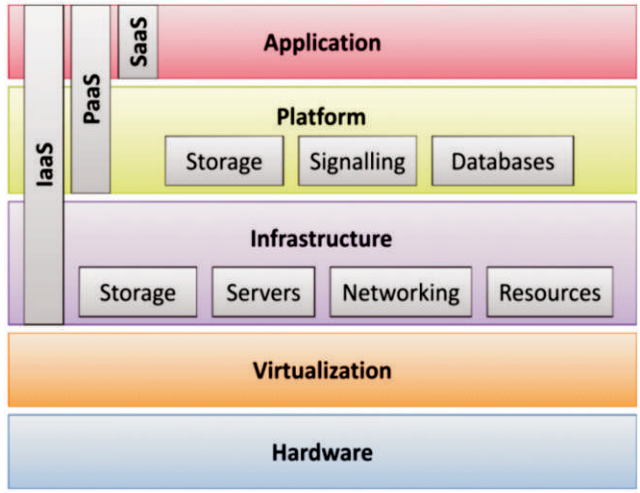

Figure 13. Cloud Computing Layers

7.8.1.2 Platforms in the cloud (Platform as a service - PaaS)

This level gives the ability to customers to use customers. There are established or gained software created by employing programming languages and devices backed up via a cloud provider.

Customers do not run or have no control over the hidden cloud infrastructure, which includes network, servers, operating systems, or storage, but controls the used applications and perhaps application hosts the proper environment for configuration. Such cloud service model requires two layers of security and protection. At the lower system level, the cloud giver can grant essential protection ways, such as end-to-end encryption, authentication, and authorization. At the higher application level, customers must specify and set up policies for application dependent access control, authenticity conditions, and needs, etc. (Kanagaraj and Sumathi, 2011).

7.8.1.3 Infrastructure in the cloud (Infrastructure as a Service -IaaS)

This cloud service form enables customers to process provision, storing, network, and essential sources pertaining to computers, in which the customer can use and manage the arbitrary program which could include operating systems and software. Consumers do not administer or have no control over the cloud infrastructure but control operating systems, storing, used applications, and perhaps bounded control of some networking devices (e.g., host firewalls). In the Infrastructure cloud mode, developers of healthcare application are fully responsible for the protection of patients' security and privacy (Kanagaraj and Sumathi, 2011).

7.9 Security and Privacy of Healthcare Data with Cloud Computing

As a result, before using or having access to any cloud-based healthcare services, we must ensure that strict security measures and guarantees are taken and enforced. The government also has a role to play; their rules and regulations should also be enforced to ensure that cloud service providers stick to the rules and regulations and implement all necessary measures to help in protecting the privacy and security of patients' details. The Health Insurance Portability and Accountability Act (HIPAA) monitors and regulates privacy and security of patients' details and data regardless of whether cloud systems were involved in this or not.

The Audit Trail and Node Authentication (ATNA) Profile defines the essential components required by different kinds of protection systems: node authentication, user authentication, event logging (audit), and tele communications encryption. In addition, it is utilized to refer to the fact that internal security characteristics, such as access control, configuration control, and privilege restrictions are given. Many other IHE profiles need or suggest mapping and categorizing with ATNA actors for security purposes.

8. Methodology

The main objective in doing this research is to present a summary of the literature review with the aim of answering the research questions and to give a framework for cross-enterprise medical imaging. The search was controlled by English-language published articles and research that probed into the medical imaging exchange. After studying and analyzing the relevant literature review and proposing the appropriate solutions, this research outcomes and findings were shared with professionals, who in turn were called to validate these findings. This section will give the answers to research questions, proposed solution, and validate the impact of patients' data exchange between different institutions or enterprises.

Here we can talk about two choices to exchange the images within an enterprise:

a) If VNA is available, one can have access to the VNA via a global viewer.

b) If there is no VNA, a workflow manager that sits in between the viewer and multiple image sources must be made available (i.e. PACS systems) and should be able to give a global list of things to do. Such workflow engines are accessible through third parties and/or PACS vendors and are very effective, especially if they know how to interact and interface with the various PACS vendors' archive/ image management systems.

An important concern to the healthcare IT world is the level of complexity and overhead of the already-established communication protocols, especially DICOM and HL7 when implemented for Internet access. These criteria are verified, vigorous and practical, but one cannot ask a new software programmer, who is familiar with web services, to design and develop an imaging application in a few days by employing these somewhat old and traditional protocols which date back to the 1980s and 90's. Instead, we are in need of web-friendly protocols using RESTful (Representational State Transfer) services which work as a companion set of interface criteria, i.e. the HL7, FHIR (Fast Healthcare Interoperability Resources), and DICOM web protocols.

This new protocol changes will allow for rapid development of new applications that use existing Internet services. Images, results, and other healthcare information will become simply resources on a connected infrastructure.

Assuming we have selected a protocol that we can use for cross-enterprise access to the information, there are two scenarios: If the access is for an affiliated organization, for example, a radiology group that reads for multiple institutions which are separate enterprises, there is typically a direct connection to the PACS and/or VNA, very similar to how it would be from within an enterprise.

The second scenario is when the reader or information consumer is not directly affiliated with the information source. In this case, we need dedicated building blocks for these cross-enterprise communications, i.e. gateways and Health Information Exchanges (HIEs). A gateway is used for point-to-point discovery, as well as query-and-retrieve between what IHE calls different communities. For example, a patient who is spending some of his or her time every year in Riyadh (in Saudi Arabia) over the winter could have procedures done in that locale, which needs to be accessed by a primary physician back in Jeddah during the summer. The Jeddah community gateway would do the query of the Riyadh gateway by issuing a standard patient discovery and be able to retrieve the applicable information after the patient information is matched. Gateways are used for infrequent ad-hoc image and document exchanges. The same physician might also want to have access to records from the patient's local cardiologist and any records from a local hospital about recent procedures and admissions. These are done through the use of an intermediary, i.e. the HIE, again using the appropriate standard protocols which are PIX (Patient Identity Cross-referencing) and XDS (cross-enterprise information sharing).

Regarding question number 1, Cross-enterprise imaging using an HIE is not trivial to implement as there are many consent issues and privacy policies to be addressed. Make sure that your vendor supports the required standards to allow information exchange. Also, storing images into the cloud, e.g. using a broker also is not the same as a having a true cross-enterprise imaging strategy either, it is a limited solution, which might work for some of the use cases, but will not provide you with a comprehensive solution.

When implementing cross-enterprise imaging one should be prepared to a deal with interoperability issues such as finding the right comparisons and priors from other image sources as body part descriptions and protocol definitions are non-standard and likely differ. Hanging protocols for studies from different enterprises might not work requiring configuration changes and/or changes in the image metadata to make them consistent.

Regarding question number 2, the positive identification of patients with a challenge that should be considered very carefully to make sure that patients do not have access to each other's images in EHR. Rules for You will need to set the rules that data components require an identical match between the DICOM test or other unique details and the EHR data, and which users can, and the necessary tools required, override a failed exact match and match an outside exam to a patient such as, if a patient did their exams in another healthcare institution and their last name is spelling differently. In addition, you must determine the work needed such as when wills a registration be established and who will be in-charge of establishing it. Some pioneer institutions in this field have already started considering this concern for some reasons (essential transitions of care, scanning of medical details and images, importing of images from a CD, etc.). They may be able to use again or change the process which is already in place to efficiently handle image exchange.

Regarding question number 3, security has been the primary focus in cloud-based medical image sharing and movements have been made on multiple fronts to protect the information. Security refers to physical, technological or administrative safeguards or tools used to protect identifiable health data from unauthorized access or disclosure. The main data security components are privacy, confidentiality, integrity, and availability. Security and privacy requirements extend to all aspects of the storage environment, including data protection and disaster recovery representing another burden on already stressed healthcare organizations. Securing medical images can be more challenging compared to other aspects of electronic protected health information as they are often transmitted between providers if a patient moves or seeks additional care from another entity. Privacy is about the protection and careful use of the personal information of patients. Confidentiality is the assurance that sensitive information is not disclosed. For example, medical image data should not be accessed by unauthorized parties. Integrity checking mechanisms prevent unauthorized modification of data. Availability refers to the notion that data and services are available when needed (Shini et al., 2012).

9. Proposed Solution

The proposal is a scheme that helps store and exchanges patients' details in the cloud and the healthcare institutions can reach such data through a potential personal network (VPN) and access it from a public network. Figure 14 illustrates the suggested cloud service for the exchange and management of medical Image. This framework is simple to understand through the addition of a network module or a center for control which is usually linked to systems that already exist. The network module is to connect to the cloud and can use the resources in the cloud to realize hardware, software, and data storage whenever needed. Employing this way to improve and gradually decrease HIS, which leads to obtaining a structure that is both adjustable and flexible. It is cost-effective for medical IT services to employ cloud computing; some medical institutions share the infrastructure which is created by linking various systems together; this will increase hospital efficiency and reduce construction costs.

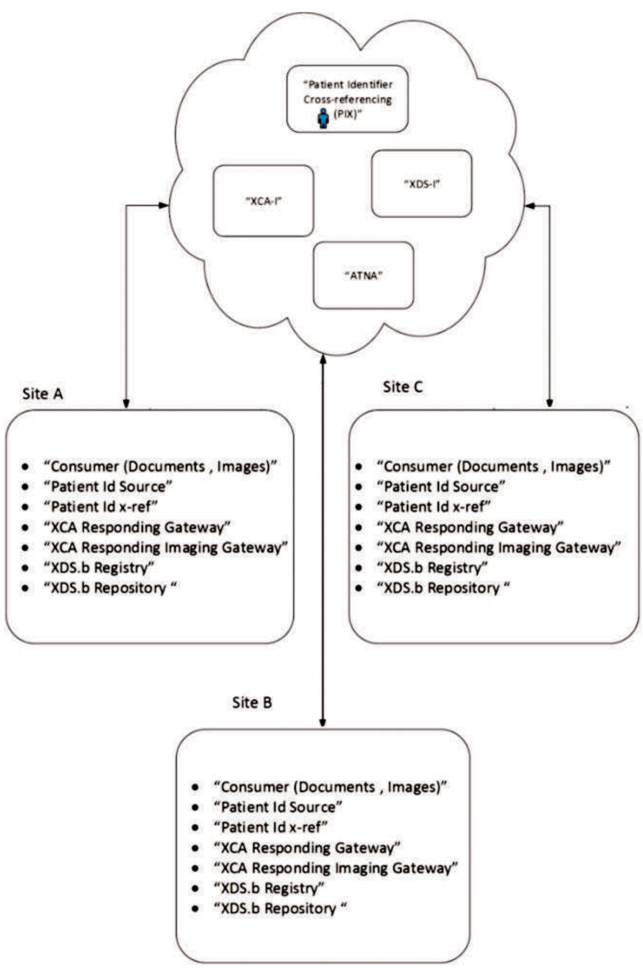

Figure 14. Proposed Cloud Service for Medical Image Exchange and Management

Many healthcare institutions send scanned images manually, by land mail or DVDs. FTP connections are implemented to send images, but the speed is very slow and can consume a lot of time at take-off and arrival stations. These ways are sometimes disconnected as well. A Cloud-based Image exchange could be the best solution to solve such issues and time concerns in order to give healthcare practitioners all day around access to medical data, simply, and easily accessible via the Internet.

Essentially, the Cloud-based solution is a DICOM/Non-DICOM imaging exchange between Hospitals/Imaging institutions or organizations and healthcare practitioners.

Figure 14 shows the proposed diagram for cross-enterprise imaging strategy that contains cloud service as the main component for exchanging the medical images between the healthcare organizations. The cloud service contains the integration profiles in the below:

1. PIX (Patient Identifier Cross-referencing) and MPI (master patient identifiers): to specify a patient and obtain their relevant details by clearly identifying the cross-referencing of the patient's identifiers from various health entities.

2. XDS-I (Cross-Enterprise Document Sharing for Imaging): enables to obtain patient's details, from various healthcare businesses and share them as documents, between cooperating businesses.

3. XCA-I (Cross-Community Access for Imaging): backs up the means to inquire and retrieve medical details related to patients which are usually held by other entities.

4. ATNA (The Audit Trail and Node Authentication): defines a way to verify the nodes in a network and which means that other internal security characteristics, such as access control, configuration control, and privilege controls are also given.

9.1 Validation (Expert Opinions)

At the beginning, the authors communicated with experts people from Saudi Arabia and abroad. The communication was by mobile phone, email, and interviews. After the experts accepted the idea of the research work, they asked to send the document to them by email. After that they received the reply from five experts in different organizations and their feedback was positive and they had some notes that had been added to the research.

9.1.1 Job Title of the Experts

- National PACS program director at Ministry of Health, Saudi Arabia.
- President at Otech Inc the United States of America.
- Project manager at Ministry of Health, Saudi Arabia.
- Executive manager health sector at Al-Elm Information Security Company, Saudi Arabia.
- Health informatics analyst at Aldara Hospital and Medical Center, Saudi Arabia.

9.2 The Impact of Exchange between Different Enterprises

Health cloud gives different services that can be applied to administer and deal with medical images in a cloud infrastructure through ways that are secure, practical, and cost-effective. The services employ the advantages given by cloud computing, such as on-demand services, scaling, accessing control, paying as you leave. It is also of note that adopting cloud computing can assist solve a lot of medical data/images issues that health care field is facing nowadays. Cloud computing can support and administer the increasing volume of medical data/images, share/exchange information between healthcare entities, and maximize the costs of operations in a given business. Cloud computing can also back up the healthcare business and align its IT needs based on practical requirements, rather than on pure assumptions. Health cloud is a good way to bring down operational, management costs, and give less costly medical services in developing economies.

Exchanging the medical information/images between different enterprises could reduce cost by using common standards, legal agreements, and governance reduced legal expenses and custom interfaces, also improve clinical and business decisions by testing once and exchange with different healthcare professionals and payers need to better decision making in the medical field, patient security, and process improvements. Chances to lower radiation dose take place when image sharing devices can help avoid harmful repeats of nuclear medicine, X-ray, CT imaging, and other radiation-emitting modes, especially for patients who might be moved from one healthcare entity to another or who get medical attention at different healthcare facilities.

10. Analysis

The authors have evaluated six studies of image sharing and exchanging for cross-enterprise health care that was based on the IHE profiles. There were some differences in these five applications in the implementation of image sharing and exchanging architecture model. Therefore, they created a table (Table 1) to compare these five studies from the point of view of data flow, Standards, implementation of IHE profiles, and the ability to share and exchange patient information/images between multiple organizations.

In (Yang et al., 2010), the authors suggested a system called MIFAS (Medical Image File Accessing System) to resolve the problems associated with the exchange, storage, and sharing of medical images. It helps maintain

Study	Standards	IHE Profiles	Exchange Patient Information/Images	Cloud Environment
Study 1 (Yang et al., 2010)	Not mentioned	Not mentioned	Replication instead of exchanging	Yes
Study 2 (Teng et al., 2010)	DICOM	Not mentioned	Exchanging was not mentioned in multiple organizations.	Yes
Study 3 (Ribeiro et al., 2013)	HL7	XDS-I and PIX	Yes	No
Study 4 (Li et al., 2015)	HL7 CDA and XML files	XDS	Patient information (reports)	No
Study 5 (Bashi et al., 2016)	Not mentioned	XDS	Radiology departments only	No
Study 6 (Zhang et al., 2015)	HL7, DICOM,and WADO	XDS, XDS-I,and PIX	Radiology departments only	Yes

Table 1. Comparisons of Five Studies

reliability by copying the data across multiple hosts, so MIFAS is a good solution for the organizations that looking for replication instead of exchanging the medical information/images when they need them. This proposed solution stores and exchanges the medical images in the cloud and the hospitals can access such data when they need them, no need for replicating the data between the hospitals.

In (Teng et al., 2010), authors implemented a service for archiving medical image using DICOM standard as a solution that is based on cloud computing under Microsoft Windows Azure platform and tools. They did not mention anything related to exchanging the medical images across multiple organizations. In this proposed solution, the medical information/images presented in the cloud can give to health specialists the information needed and the patient can look for treatment in different entities.

In (Ribeiro et al., 2013), the authors proposed a solution that combines XDS-I and PIX profiles without using XCA-I and ATNA profiles, unlike what it is mentioned in this research.

In (Li et al., 2015), the authors created the national electronic medical record exchange Centre (EEC). They did not mention that the system can exchange the medical images across multiple organizations. In addition to that, they did not mention that XDS-I, XCA-I, and ATNA profiles had been used.

In (Bashi et al., 2016), the study was conducted in the radiology department only and the perception of research held by radiology staff in general. The challenge in achieving medical images exchange is to exchanging information/images and moving patients from one department to another in the same hospital or between different hospitals. So this proposed solution introduced a framework that can be able to share and exchange patient information/images between hospital departments or between different hospitals.

In (Zhang et al., 2015), the study was conducted in the radiology department only and the perception of research held by radiology staff in general. In addition to that, the authors did not mention that XCA-I and ATNA profiles had been used.

Conclusion and Future Work

Exchanging images successfully can be transformational for both caregivers and patients. It creates new services, different levels of service, and care that are not possible when images are transported on CDs. There needs to be an improvement in information and image exchange in EMR by employing a device that health caregivers that are both convenient and familiar to the care providers. Electronic integration of medical details and images among healthcare entities and internal systems (PACS and VNA) makes outside images available for departments use in their daily work.

Patient health information sharing is always a critical problem either in normal healthcare or coordinated care, especially when dealing with chronic diseases. Most of the current healthcare systems are a hospital-centered model, in which doctors make treatment decisions, and patients barely participate in their own healthcare. The status of aged population and growing chronic disease patients calls for a new patient-centered model, which requires a continuing collaboration and connection among patients, different healthcare providers, communities, and research institutions. It requires the active participation of patients and widely accessible patient information. The sharing of health information is the key to this kind of new healthcare model.

IT and healthcare specialists expect that the volume of medical data and medical docs will continue to rise in the next few years, particularly in the field of medicine (Ribeiro et al., 2014). Therefore, the demands for storing and keep medical docs safe will continue to rise in the future. Incorporating IHE actors as part of the cloud is a great step towards backing up IHE communities which in turn yields many benefits, such as the high rate of availability, a more flexible source for allocation, and a more effective source for storage. The proposed framework gives different services to administer and deal with medical data/images through a cloud infrastructure that is safe, in a secure, trustworthy, and cost-effective. Such services try to implement the advantages of suing cloud computing such as on-demand services, scaling and access control. Introducing cloud computing is a great way to address many challenges that healthcare providers face these days, especially in medical details management, storing, and retrieving. The proposed framework gives different services to administer and deal with medical data/images through a cloud infrastructure that is safe, in a secure, trustworthy and cost-effective. Such services try to implement the advantages of suing cloud computing, such as on-demand services, scaling, and access control. Introducing cloud computing is a great way to address many challenges that healthcare providers face these days, especially in medical details management, storing, and retrieving. This will, in turn, assist in managing the increasing amount of medical details that need to be efficiently communicated between different healthcare businesses and at the same time lowers the costs that result from such managing.

The proposed solution is driving force for good interoperability and no patient data locked in one product. There seems to be a vast array of EMR products, which patients may be got locked into one product and then find it is not compatible with a better or updated product from the previous system provider. Also, the automatic way of health data collection is not only to facilitate patients to record massive data, but also to reduce errors due to lacking medical knowledge. In the proposed solution, data will be contained in a widely identified international standard and all the data will have an entire backup in the cloud.

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