A literature Review On Medical Imaging Transfer

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Abstract—**DICOM is a standard which provides protocol support for the transfer the medical images across multivendor and multimodality workstations. The standard provides way for message exchanges for sending, moving and querying about patient data across the network. There are various protocols supported by DICOM like C-Store, CMove, CFind etc. In each of these message exchange mechanism, there are basic steps involved to transfer the data. With increasing size of images which are captured from patients and increase in the IOD's supported by DICOM there is a requirement to find an optimal way to improve the performance of image transfers from one machine to another. This literature survey aims at finding out different techniques and methodologies adapted to achieve better performance in medical imaging by various researchers across the world. This literature survey is based on the latest DICOM standard 2015.**

Keywords—DICOM;Image Transfer; cloud;telemedicine;

I. INTRODUCTION TO MEDICAL IMAGING

Medical Imaging is the technique of capturing medical data from a patient by passing any medium, be it light rays, or other high precision rays .The proceduce can be invasive or noninvasive. There are various modalities who are involved in this technology as described by K.D. Toennies[1] like Digitized X-ray, Computed Tomography (CT),Magnetic Resonance Imaging (MRI) ,Ultrasound (US),Positron Emission Tomography (PET) ,Nuclear Medicine (NM),Radiation Therapy.

The modalities differ mainly in the following ways

1. The physics of medical imaging

2. The accuracy of the scan (outcome)

3. The price of the scan

Xray was the primary imaging method in most of the radiology departments as explained by Rowlands[2]until later 90s.The difference in the pricing of the scans by different modalities played a key role in the studies getting doubled for CT and tripled for MR according to the report published by Medical News Today[3].So ideally the data is increasing. Based on the growing trend, it was estimated that over 100000 terrabytes of data will be performed in the United States during year 2014, which will generate Petabytes of data [4]. A report by Kenneth pegs the volume of healthcare data at 153 Exabytes in 2013 and to 2,314 Exabytes by 2020[5] at the projected growth rate.

II. MEDICAL IMAGING DATA ON RISE

With the humongous growth of the medical data, there is a necessity to move the data from one place to another in order to facilitate early patient diagnosis and care. With the increase in globalization of medical issues and medical tourism, there requires a robust and fast method of retrieving the medical data across different hospitals for the same patient from multiple locations .The patient should not be forced to carry the bundles of scan reports across the world to discuss his medical problem.

The data which is captured from the patient is very important and has a high risk because

1. Once captured ,it is captured. The data cannot be changed or delayed because it may lead to wrong diagnosis. Recapturing affects the patient because of exposure. One of the major drives in near future in medical imaging is reducing radiation exposure in contradiction to last 50 years where image quality was prominent as explained by John[6].

2. The data is used for accurate diagnosis of a disease.

3. The patient is subjected to an external medium to acquire the data, which means there is a risk. .

McEvoy et.al describe about the security threats when medical data is transmitted through a Compact Disc(CD) and used for diagnostic imaging in 1999[7].Ultimately, the data is highly important that it cannot be allowed for even a single byte of tamper, change or loss. Hence there are certain set of rules for ensuring the security of data which are defined by HIPAA.

III. HIPAA

Health Insurance Portability And Accountability Act(HIPAA) as defined by US department of Health and Human Services[8] mandates the medical imaging modalities, manufacturers to follow certain set of rules and regulations for ensuring the security of the Patient Health Information.

The following are some of the mandates defined by HIPAA

1. Functional Security (privilege to perform an activity)
2. Data Security (permission to create/read/write/delete data object)
3. Auditing (protocol recording „who did what on which object“)
4. User Management (needed to get human identity).

5. Risk Analysis and Management.

It covers mechanisms to authenticate the users, to protect application functionality with user specific privileges, to protect access to a data set with user specific permissions, to log each access to a data set in a special log file.

Dr. Kibbe et.al describes about the steps needed to be taken to move towards HIPAA Compliance [9].Any medical imaging vendor should mandatorily follow the HIPAA compliance to ensure safety of the patient and the security of the medical information.

IV. DICOM-A STANDARD FOR IMAGE EXCHANGE IN MEDICINE

DICOM is a standard developed by National Electrical Manufacturer's Association(NEMA). As described by Michelle et.al [10] the format mainly achieves score for wide acceptance. There are various protocols supported by DICOM like C-Store, CMove, CFind etc. In each of these message exchange mechanisms, there are basic steps involved to transfer the data.

In any DICOM message transfer the following are the basic steps involved.

1. Association Negotiation, Association Establishment
2. Request Transfer from SCU to SCP
3. Request acknowledgement(response)
4. Association disconnect.

Each DICOM Message adheres to a particular set of tags which are defined by part 6 of the Dicom Standards Document[11].

V. HISTORY OF DICOM

1985 - First version of the standard distributed at the 1985-RSNA meeting.

1988 - Second version of the standard

1989 - The name was changed to separate the standard from the originating body.

1993 - DICOM parts 1- 9 approved

1994 - Part 10 : Media storage and File format

1995 - Parts 11-13 and supplements

1998- Version 3.0 with amendments

From 1998 onwards the version 3.0 is continuously developing to cope up with the latest requirements related to medical imaging.

VI. BASICS OF DICOM

DICOM defines the image object as tag value pairs. There are different types of tags type1 being mandatory and type 2 being optional. Each tag is given a value which is defined by the value representation. A group of tags form information Object Definitions(IODs). W. Dean Bidgood et.al describes the tag value pairs as attribute[12] . A DICOM Service-Object-Pair (SOP) Class specifies the combination of an IOD and the set of services ,which is specified as DICOM Message Serive Element(DIMSE) service group that are useful for a given purpose[12].Any application which is the initiator of a request is called as a DICOM SCU and the one which receives and processes the request is called as a DICOM SCP. Every DICOM Application is identified by AETITLE. For some of the DICOM request the AETITLE of the SCU is mandatory attribute in the message.

VII. DATA IS RISING MEANS MORE DATA TRANSFER REQUIRED

The medical data from 1990-1998 is mostly in the form of hardcopy films. Various researches were done to move towards electronic form. By using PACS we can move from conventional hardcopy interpretation to softcopy images [13].One of the studies in 1998[14] revealed that report time is not affected by moving towards PACS. The medical data in last decade is majorly through electronic media. According to the study by Christopher et.al, ,Without any significant change in the volume of cases, there is a reduction in hardcopy film sheets and there was a considerable increase in data transferred through CD ROM between 2007 and 2010[15].Jane Hawner confirms the technical feasibility of filmless radiology[16].When we say that data is on the rise, it indirectly means that data should be moved. With the forecast report published by Frost and Sullivan[17] ,the data grows because of increase in number of diseass compared to last decade and hence requires more scans to be performed. Richard [18] explains how the medical imaging grew in the last decade.

With the increase in data we have to finally decide the way the data is moved from one place to another without security issues. With the development electronic image communication with PACS kind of applications, Radiology is taken to new heights as described by[19] William et.al .

This literature study involves the various mechanisms in practice for transferring and storing medical images.The following table describes about the mechanisms used in medical imaging transfer and their parameters.

The electronic image transfer acts as a quick means for diagnosis and hence it is very important to ensure the safety and security of the data. From table 1 it is evident that the electronic image transfer, which is one to one and wired is the most secure form of transfer because it happens in a private and controlled environment. With electronic image transfer study time and bottlenecks are reduced. It makes clinical trials more streamlined[20].

VIII. NEED FOR PERFORMANCE IMPROVEMENT

James Phibin says that radiologists spend a fair amount of time to download the medical images and there is always a need to improve medical image transfer speed [21].When the images are transferred through medias like CD, DVD and memory stick, the data becomes offline.

Technology	*Data transfer*	*HIPAA compliance*	*Patient convenience*	*Speed*	*Security*
Electronic Image transfer(one-one)	DICOM/HL7	High	medium	low	Very high
Web Technology	Html/https	Medium	high	high	low
MINT	Proprietory protocol	High	low	high	high
Teleradiology	Html/https	Low	medium	medium	low
Cloud	Service provider protocol	Low	high	medium	medium
Mobile	3G/4G/CDMA	Very Low	Very high	high	Very low
CD/External Meium	flat file	low	medium	low	Very low

TABLE I. COMPARISON OF VARIOUS MEDICAL IMAGE TRANSFERS

When the images are to be transferred within the hospital network, the electronic image transfer mechanisms necessitated a high speed and
faster transfer options. Various frameworks were analyzed and proposed for better performance for transfer of medical images[11]. Liron et.al. have discussed about the latency issues when the images are moved between international locations and importance of reliable and high speed transfer for telepathology solutions[23]. Irfan Pyarali et.al defines that medical imaging transfers are bandwidth intensive and delay sensitive and hence performance improvements can be crucial [27].

With all these issues, the best way to achieve performance improvement is to use the intrinsic capabilities of the hardware and network and optimize the transfers. Flux et.al discuss the importance of using the CPU,OS network capability and bandwidth to arrive at an optimal limit for medical image transfer[20].So future endeavors are moving towards faster patient data access for the radiologists. One of the key trend of medical imaging in 2015 as identified by [6] is easy accessibility of medical image information for tele-providers. Richard describes that the increased and faster access to electronic health records by radiologists provides way for more meaningful interpretation [18].Meanwhile the security of the data also is given utmost importance since the data deals with a patient and crucial for diagnosing the disease. The data can be life saving.

IX. DIFFERENT TECHNOLOGIES INVOLVED IN TRANSFERRING MEDICAL IMAGES

A. Electronic Image Transfer(wired)

Today's high speed networks are used for the data transfer seamlessly but there are really intrinsic issues like utilization of bandwidth, speed of transfer, reliability of transfer. The major factors regulating the transfer of images on a network are the size of the images or communicating speed[27].There are additional parameters also in a Ethernet connection which will influence the speed of transfer like protocol used ,number, size of the DICOM image etc. The physical network with coaxial cables and star topology is widely used as a medium to transfer the RT objects in the radiotherapy[24]. Reference [25] describes that by using advanced communications technology to transmit medical data and imaging in real-time, and linking patients to providers for direct consultation, the diagnosis removes geographical barriers and allows people to receive the medical care they beyond time and place. Ryan explains how the use of an electronic image transfer solution creates a faster, more accurate process for all clinical trial data[26].

B. Web Technology-TeleMedicine

Hafey explains that when we make the medical imaging transfer from medical network and use web technology, we can taper the strength of a lot of tools and programming languages[21].An article by Speedmatters.org describes that real time transmission of medical imagery by different modalities makes interpretation possible in telemedicine[25]. The advancement of telemedicine leads to the possibility of availability of the medical care even though the doctor providing the treatment is not near the patient.

C. Discovery Of MINT

With the discovery of MINT protocol in 2010, a lot of issues persisting to medical imaging transfers is addressed.

Basically MINT has attractive features like[27]

1 .Transferring only the metadata of the medical image

2. Transfer of batch images instead of single image per message.

The experiments to discover such a protocol started as early as 2008, mainly to target an efficient medical networking environment in which network latencies, bottlenecks are overcome. The main advantage of this being the DICOM data can be transferred without pixel data of the image. In this case , a lot of optimization is achieved by transferring only the required data. The major issue involved is the standardization of such information exchange in multi manufacturer environment.

D. TeleRadiology

The concept of Teleradiology started is origin in the last decade where patient convenience is one of the key factor that has to be addressed. Nishigandha et.al describes "Teleradiology" as a branch of telemedicine in which telecommunication systems are used to transmit radiological images from one location to another[28].The major issues in telemedicine is the security of the data that is transferred across.

E. Cloud Computing

Cloud technology makes access to the medical data more easier .In [29], the authors describe that the main advantages of using cloud is that the quality of medical care is improved, Patient safety as well as the cost for the treatment is reduced. However there are a list of security concerns which is inherent to the technology and it pushes up since we are dealing with medical images and transfer of medical image data. Eventhough there are no evidences of performance improvements achieved by using cloud technology for medical imaging, the data access becomes much easier across various geographical locations. There are already research groups working on improvement of security aspects of medical imaging over cloud like the description in [30],the performance improvements are yet to be analyzed.

Pranavet.al describes that improved access to the internet is one of the main reasons for moving towards cloud[31].The medical data requires to be anonymized since it is exposed to cloud and the overhead of anonymization and deanonymization adds to overall time taken.

F. Mobile

The study done by Filip et.al .[32] revealed that the final diagnosis made by the doctor by seeing the MRI images on phone and the workstation consultations does not differ. There are no evidences of security and accuracy of the medical images when accessed through smartphones. Another trial performed by Chritoph Primmer et.al.[33], concludes that when the medical images are transmitted along with speech and annotation over the mobile, there are significant positive outcomes.

X. CONCLUSION AND FUTURE WORK:

With a tremendous amount of technology development , the majority of modalities still work towards transferring the medical image data from the acquisition to the post processing workstations by one to one connectivity. Hence further research demands to increase the performance of medical image transfers in a one to one network by deploying the technical advancements in OS and the developing hardware .From the survey, it is evident that the most reliable form of image transfer is the wired electronic image transfer and it is more secure. Hence there develops an inherent need to explore the performance improvement of medical imaging transfers and the future scope of this survey is to analyze the use of multicore to improve the performance of medical imaging transfers.

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