Radiology Image Management in a Teaching Hospital Network Scenario : Initial Experience

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Abstract

INHS Asvini has the distinction of emerging as the first Armed Forces Hospital with networked radiology images, sourced principally from a recently installed Digital Subtraction Angiography (DSA) machine (Siemens Polystar Top 1000 MA). In recent times, newer imaging machines offer digital images that are in DICOM format. DICOM denotes 'Digital Imaging and Communications in Medicine'. Image management at INHS Asvini, involves transfer of DSA images in DICOM format, their conversion into Joint Photographic Experts Group (JPG) format and subsequent transmission of JPG images through a robust networking system that connects all departments/OPD/Wards, facilitating direct access of images to a variety of specialists and specialities. Clearly, this encouraging outcome is a small but useful step heralding the concept of 'anytime anywhere' images, and has the scalable expansibility of including CT and MRI images in future.

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Key Words : DICOM; Hospital network; Image management

Introduction

INHS Asvini is the principal Command Hospital of the Indian Navy with a 825 bed teaching facility. It is presently undergoing modernization, underscored by the rapid induction of 'state of art' medical equipment along with continual computerization and networking of various Departments, Wards and OPD. The Department of Radiodiagnosis and Imaging at INHS Asvini has recently acquired a modern DSA machine. By the presence of a most up-to-date networking system, the DSA images are transferred, albeit at no extra cost, from the Department of Radiodiagnosis and Imaging to various specialists, OPD and wards, thereby enhancing the capabilities of the network as well as exploring newer frontiers in health care delivery. An overview of the Image Management at INHS Asvini is given as Table 1. This paper dwells on the practical issues of Image management in the network scenario at INHS Asvini.

Material and Methods

The DSA system

The Department of Radiodiagnosis and Imaging averages 125 diagnostic and interventional radiology procedures per year. The newly installed Siemens Polystar Top DSA 1000 MA machine enables diagnostic and interventional radiology procedures such as cerebral, peripheral vascular and renal donor angiography, carotid and renal angioplasty, percutaneous vascular stenting, antegrade ureteric stenting and biliary stenting, to be done.

The DSA is the principal image source at the moment. In the main digital system of the DSA machine, the images are digitized and archived incorporating the Digital Communications in Medicine (DCM) format. The digitized DCM images possess a file size ranging from 900 K to 2300 K. Typically, a patient file name is referred as 1.2.592.300036.9116.2.2.2.1862616180.961732103.121216. This series of numbers contains data for a precise investigation on a particular patient on a given date with unique procedure and machine attributes.

Table 1

The overview of image management at INHS Asvini

Image management strategy	Hardware/Software components	Location
Image source	Siemens Polystar DSA	DSA Room
Radiology information systems	Siemens Leonardo Workstation	Central Workstation
DICOM image conversion	E Film Dicom Converter/Viewer	Central Workstation
Transmission	TCP/IP Protocol	Central Workstation
Network	ISDN	Entire Hospital
Hospital information System	Radiology Image Folders	Individual Client Computers
DICOM image viewer	Irfan Dicom Viewer	Individual Client Computers

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Digital Imaging and Communications in Medicine (DICOM)

The importance of digital medical image processing has increased since the introduction of Computed Tomography as the first digital modality in the 1970s. In an effort to develop a standard means by which users of different digital medical imaging equipment (CT, MRI, DSA) could interface display or other devices to these machines, the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) formed a joint committee early in 1983. The result was the advent of a standard format called DICOM (Table 2). Today, DICOM is the ubiquitous standard in radiology and imaging industry for the exchange and management of images and image related information [1]. Importantly, DICOM is also used in other image related medical fields, such as pathology, endoscopy, dentistry, ophthalmology and dermatology.

Table 2

History of digital imaging and communications in medicine (DICOM)

Year	Event
1983	American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA) develop an exchange standard
1985	ACR-NEMA standard Version 1.0 published
1988	ACR-NEMA Version 2.0 published
1993	The DICOM standard developed creating an open (vendor independent) platform for the communication of medical images
1993	DICOM Version 3.0 published

The DICOM standard facilitates the exchange and processing of vendor independent medical images in digital form. Image acquisition devices, image archives, hardcopy devices and imaging workstations from different vendors can be connected into a common information infrastructure and integrated with other information systems (eg. HIS or Hospital Information System and RIS or Radiology Information Systems). The DICOM standard achieves this by creating a DICOM image that consists of a list of data attributes of image related information : patient (name, sex, identification number), modality and imaging procedure (device parameters, calibration, radiation dose, contrast media), image (resolution, windowing). DICOM also offers Network Services that are based on the client/server concept [2].

In addition to the most basic DICOM service, image transmission, there are number of advanced services, for example : (a) DICOM image archive service (query/retrieve service class) that allows searching of images in Picture Archiving and Communication System (PACS) by certain criteria (patient, time of creation of the images, modality etc.) and downloading of images from the archive, (b) DICOM print service (print management service class) that permits access to laser cameras or printers over a network, so that multiple modalities and workstations can share printers, (c) DICOM modality worklist service that facilitates automatically download up-to-date worklist including the patient demographic data from the information system (HIS/

RIS) to the modality [3].

The Central Work Station

Located at the Department of Radiodiagnosis and Imaging is the central workstation, which performs two important roles in the image management. Firstly, the DSA source images in DCM format at Siemens DSA Leonardo Workstation, needs conversion to JPG format. Secondly, the DSA images require transfer to a Network computer and thereafter to the Hospital's Network. To achieve this, two diverse computers are present, one representing the image source from Siemens Leonardo Workstation, and the other nominated as X-ray 2 representing the Hospital Network. The images at Siemens DSA Leonardo Workstation are in DCM format, while the Network are in JPG format.

Specifically, the first task focuses on DICOM conversion to JPG. The DCM image from Siemens Leonardo Workstation is transferred to X-ray 2 computer. The X-ray 2 computer acts as an intermediary, converting the images from DCM to JPG. The second task is accomplished by a TCP/IP protocol (Transmission control protocol/Internet protocol) between the two computers. Two Network cards in the X-ray 2 computer, support distinctly separate connections to the Siemens DSA Leonardo Workstation and Asvini Information Management System (AIMS) Network at 10/100 Mbps. This enables transfer of images from Siemens DSA Leonardo Workstation to the X-ray2 computer and on to the AIMS Network. At central workstation, the images are placed in X-ray 2 computer of the Network Neighbourhood, within the Radiology Images folder, under various referring specialities and specialists. The folders are password protected and updated periodically.

Dicom Converters

Dicom Converters are software programmes that assist in DCM to Joint Photographic Experts Group/Tagged Image File Format/Windows Bitmap/ (JPG/TIFF/BMP) conversion. The need for image conversion arises because a typical PC with a Windows operating system or MS Word/Power Point programme is unable to handle DCM images while easily supporting viewing JPG/TIF/BMP images. Today, JPG format is a popular choice because of the tremendous compression ratios (1:20) applied on images without sacrificing perceived image quality. This is advantageous, since native diagnostic quality images are of large file size. A comparison of image data and digital file size is given as Table 3. Moreover, the JPG format allows preservation of both 24 bit color ("true" color) as well as "17 million" color ("diagnostic" quality color). As a result of these significant advantages any significant lesion on a DSA/CT/MRI image can be demonstrated with diagnostic quality, in less than 100K, by today's standards. Illustrating this point, a mosaic of sample image in DCM/JPG/TIF/BMP formats is shown in Table 4.

Hospital Network

The Hospital Network is the highway, facilitating the transfer of images. Originating from AIMS Data Centre at

Table 3

Image data and comparison of digital file size

(Adapted from reference: *Going digital: Image preparation for biomedical publishing* Michael P Schenk*, Richard J Manning, Mark H Paalman. *The Anatomical Record* Volume 257, Issue 4, 1999) Note : dpi denotes (dots per inch resolution)

Subject	Resolution (dpi)					
	800	600	400	200	100	72
B/W photograph of MRI (head region) 3 ½" x 4 ½"	2.6 MB	1.5 B	728 K	243 K	117 K	97 K
B/W photograph of human brain (brainstem) 5" X 6"	3.4 MB	1.9 MB	922 K	291 K	146 K	97 K

Table 4

A mosaic of image in DCM, JPG/TIF/BMP formats

Biliary stenting images in current popular formats and file sizes (shown in clockwise direction from right top corner) : Tagged image file format (TIF) image 873 K; Joint Photographic Experts Group Format (JPG) 117 K; Windows Bitmap files (BMP) 1026 K and Digital Communications in Medicine (DCM) 913 K

DCM
(Digital
Communications
in Medicine)
913 K

TIF
(Tagged
Image
File Format)
873 K

BMP
(Windows
Bitmap
Files)
1026 K

JPG
(Joint
Photographic
Experts Group
Format)
117 K

the Department of Medical Informatics in the OPD block, four multimode fiberoptic backbone-networking cables begin and run through the hospital connecting nearly 150 stand-alone client computers.

Supporting this fibre optic backbone network are full duplex managed switches. Besides, the network has structured semicentralised cabling type of architecture, based on international standards defined by Krone. The fibre optic backbone Local Area Network forms the critical part of the Hospital Network system with a data transfer rate of 100 Mbps [4]. A tabulated data on network transfer speeds for

various hardware channels is given as Table 5 [5]. The main information system (AIMS) is of Client-Server Architecture, established on Oracle 8 database on Solaris 2.6 Operating System and based on Developer 2000 of Windows 2000. The entire information system is powered by the presence of two Sun Ultra II Enterprise Servers.

Image Viewing

The real power of Radiology images in the INHS Asvini Network is realized, once they are available on the Network. The advantages that emerge range from simple viewing of

Table 5

Network transfer speeds

(Adapted from http://www.lumisys.com/support_techref/network_speeds.html)

Hardware/Channel	Bandwidth table		
	Bit transfer rate	Byte transfer rate	Time 1MB file
Gigabit LAN adapter	1.0 Gb/s	125 MB/s	8 ms
DS4 (T4)	274 Mb/s	34.2 MB/s	29 ms
100Mb LAN card	100 Mb/s	12.5 MB/s	80 ms
DS3 (T3)	44.7 Mb/s	5.6 MB/s	179 ms
Cable modem	10 Mb/s	1.25 MB/s	800 ms
10 Mb LAN card	10 Mb/s	1.25 MB/s	900 ms
DS2 (T2)	6.3 Mb/s	789 KB/s	1.3 sec
DS1 (T1)	1.54 Mb/s	193 KB/s	5.2 sec
ISDN - 2B	128 Kb/s	14.2 KB/s	70 sec
DS0 (ISDN)	64 Kb/s	8.0 KB/s	2.08 min
56K modem	56 Kb/s	7.0 KB/s	2.38 min

Table 6

Few DICOM software viewers and converters

Name	Dicom Capabilities	URL and location
E Film	Dicom Converters	http://www.efilm.ca University Health Network and Mount Sinai Hospital in Toronto, Canada
MRicro	Dicom Converters	http://www.psychology.nottingham.ac.uk/staff/cr1/mricro.html School of Psychology, Nottingham University
Osiris	Dicom Converters	http://www.expasy.ch/UIN/html1/projects/osiris/DownloadOsiris.html University of Geneva
AccuImage Lite	Dicom Viewers	http://www.accuimage.com
ImageJ	Dicom Viewers	http://rsb.info.nih.gov/ij/ ImageJ developed by Wayne Rasband
Irfan	Dicom Viewers	http://www.irfanview.com Irfan View developed by Irfan Skiljan

images to advanced applications such as copying and pasting images in a variety of applications such as MS Word, MS Power Point etc. Other inherent advantages include the ability of referring specialists to view any specific images, from any computer in the Network. All this makes possible the retrieval of images "anywhere anytime" by the referring specialities and specialists.

Discussion

There are four areas of practical importance concerning image management in a network scenario : firstly, the DSA/CT/MRI vendor source images need to be viewed by remote computers, secondly, though the vendors are different, the digitized source images are standardized DCM format, thirdly, the file size of image during conversion should not be larger than the original image, which will determine image transmission speeds in a network; fourthly, the image should not lose useful information during conversion (the notion behind lossless

and lossy compression). Keeping these fundamental doctrines at the core of its functioning are a set of specialised image software called as DICOM Converters and DICOM Viewers. Table 6 is a list of DICOM Converters and Viewers such as E Film, Irfan Viewer and Osiris, all freely downloadable from the Internet.

Advantages

Concerning the advantages of image management, a key starting point, is the convenience factor. DSA derived images are available for all specialists at any computer, manifestly facilitating the delivery of quality health care. Moreover, the images can be accessed at any time for a relook or closer examination. The speed of image transmission and image retrieval is instantaneous by virtue of the presence of a fast network. In addition, the images can be utilized for training and CME presentation at individual departments, notwithstanding the ease of incorporation into slides for presentation at departmental lectures, auditorium and clinical meetings. Besides, there is a potential infrastructure that can accommodate the creation of a filmless department with a Picture Archiving System (PACS) at Department of Radiodiagnosis and Imaging in the future [6].

Difficult Areas

Data redundancy and security are two areas of perceived difficulty. Data redundancy is an area of concern, presently addressed by periodic erasing after archiving of data. Once an image is transmitted from the central workstation, it is placed in the Network for at least four months, until it is erased after obtaining a CD archive of all image files. Security issues have been addressed in several ways. The DICOM 3.0 compliant systems using classes to authenticate each modality, each server and each user, prevents unauthorized hosts from accessing the DSA machines or scanners or servers directly via the DICOM protocol. Similarly, the Network server employs both host level security and username-password authentication. However, this level of security is inadequate when a PACS network is connected to the Internet [7]. Therefore, the AIMS Network is not connected to the Internet at the moment, providing more tight control and access.

Future

Inherent to the aforementioned concepts and based on the success of DSA images in the INHS Asvini Network, CT and MRI images have been chosen as the next DCM sources for our image management project. With the availability of cine-run in all the three modalities, it is expected that the Network will handle more real-time online color video with better image

quality. It has also been proposed to incorporate image retrieval from the newer imaging modalities such as DSA, CT and MRI directly from servers in the Department of Medical informatics, as a specific enhancement to the modular scalable AIMS software. In future, the Department of Radiodiagnosis and Imaging will strive and enter into the era of PACS by the installation of the following servers : modality, data, retrieval, archival and teleradiology servers [8].

To conclude, INHS Asvini has the distinction of emerging as the first Armed Forces Hospital with networked radiology images. Image management in a network scenario at INHS Asvini has been accomplished by the presence of (i) a 'state of art' DSA machine (ii) image processing at central workstation and (iii) up-to-date and fast networking system. Using quality workstations combined with specialized servers, the Hospital Network capability has been enhanced, newer frontiers in health care delivery explored, all at no extra cost to the Government. Stemming from this initiative, the image management system encourages the concept of 'anytime anywhere' images, emerges as a strong model for PACS development, forms a basis for filmless image

administration and accommodates increasingly scalable expansion by the inclusion of CT and MRI images.

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