Integration of Imaging Functionality into the Healthcare Enterprise using DICOM

Peter M. Kuzmak and Ruth E. Dayhoff

The US Department of Veterans Affairs is integrating imaging functionality into the healthcare enterprise using the Digital Imaging and Communication in Medicine (DICOM) standard protocols¹. The VA's VistA Hospital Information System (HIS) is installed at all 170 VA medical centers across the country. Image management is supported by the VistA HIS in several ways. Some VA sites have commercial Picture Archiving and Communication Systems (PACS) interfaced to the VistA HIS, while other sites use the direct image acquisition and diagnostic display capabilities of VistA itself. By supporting a small set of DICOM services, VistA can transmit patient and study text data to the image producing modalities and the commercial PACS, and enable images and study data to be transferred back. Images can be displayed on low-cost clinician's workstations or high-resolution diagnostic quality multi-monitor workstations located within a facility or elsewhere on the healthcare enterprise wide area network.

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IMAGE ACQUISITION and display functionality is needed by today's healthcare enterprises. Clinical information must be presented in an integrated fashion to provide the most benefit to medical decision makers.

Within the VA, image management is performed by the VistA HIS. Images are acquired and associated with HIS reports for over twenty different clinical specialty services, like radiology, cardiology, dental, ophthalmology, and pathology. Images and the associated patient record data can be displayed on low-cost clinician's workstations throughout the medical center. High-resolution diagnostic quality multi-monitor workstations with specialized viewing software driven by data from the VistA Radiology Information System (RIS) are used for reading radiology images.

VISTA DICOM INTERFACES

Two approaches are used to acquire and handle images within the radiology department.^{2,3} At sites having a commercial Picture Archiving and Communications System (PACS) interfaced to the VistA

HIS, VistA and the commercial PACS work synergistically to supply each other with the necessary data. VistA sends all admission, discharge, and transfer transactions (ADT), patient demographic changes, radiology orders, and radiology reports to the PACS. The PACS, in turn, sends all images to VistA for display throughout the hospital. Other sites use the integrated diagnostic display capabilities of VistA itself. At these sites, DICOM is used by VistA to supply patient and study information to the image producing modalities and to obtain images directly from them. This allows images to be correctly linked to other information about the patient's study. VistA multi-monitor diagnostic quality workstations are used for reading the images.

Data Requirements for the Commercial PACS Interface

A commercial PACS requires several different pieces of information from the VistA HIS/RIS.⁴ The HIS/RIS sends current patient identification and order entry information to the PACS so that it can register patients and process orders. All changes in patient demographic data are sent to the PACS to prevent patient mismatch and avoid the need for duplicate patient registration. Examination initiation information is sent to the PACS to trigger event processing, such as printing labels when the patient arrives. The verification of examination quality is entered on the HIS/RIS, and is passed to the PACS to trigger the release of the images. Radiology reports are entered on the HIS/RIS and are passed to the PACS so that they can be displayed on the PACS in conjunction with the images. Clinical scheduling information is also needed by the PACS to pre-fetch images from the storage archive.

From the Department of Veterans Affairs, Washington CIO Field Office, Silver Spring, MD.

Address reprint requests to Peter Kuzmak, MSBME, Dept of Veterans Affairs, Washington CIO Field Office, 8403 Colesville Rd, Suite 200, Silver Spring, MD 20910.

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Patient tracking information is used for display of patient information by ward.

The PACS must supply the HIS with information about examinations that have been performed. Notification of completion of an examination must be sent to the HIS in order to update the order status and identify which examinations have digitized images. The PACS must also send to VistA a list of the images associated with each completed order. The PACS images are transferred across the interface and stored in the VistA image file servers. They are then retrieved from the VistA file servers and displayed on the imaging workstations.

Data Requirement for the Modality Interface

Each modality should be supplied with a common set of patient and study information originating from the HIS/RIS.⁵ The modality should select the applicable set of data for the study and place it in the header of each image that it produces. This simple procedure not only alleviates the need for the data to be manually reentered at the modality (and the potential for errors), but it also standardizes the data that is placed in the image header. The modality should send its image to a storage provider and furnish notification when all the images in a study have been successfully transmitted. This "image transfer complete" notification indicates that the study should be placed on a "to-be-read" worklist on a PACS.

DICOM Services Used for Interfaces to Commercial PACS and the Modalities

Several different DICOM services are used for interfacing VistA to a commercial PACS and the modalities. VistA is a provider of the PACS text data services, the Modality Worklist service, and the Storage service. VistA is a user of the Query Retrieve service.

The VistA-PACS text data interface supports a set of VA-defined normalized DICOM services that are used to transfer event information from the HIS/RIS to the PACS and vice versa. The Modality Worklist service supplies VistA patient and study information directly to the modality so that it does not have to be manually reentered. This information is then incorporated into the image headers, making them easier to identify when they are matched to the patient and study. The Storage service is used to transmit a set of images from a

source to a destination. The Query Retrieve service is used by VistA to transfer images from the PACS.

When VistA is interfaced to a commercial PACS, the modality uses the DICOM Storage service to send images to the commercial PACS. VistA then uses the Query Retrieve Service to request the images. The PACS responds to the transfer request using the DICOM Storage service to send the images to VistA. When VistA is interfaced directly to the modalities, the modality uses the DICOM Storage service to send the images to VistA.

The VistA-PACS text data interface can also send event information to a commercial Modality Worklist service provider, which can then supply the data to the modality. In some situations, this is a convenient alternative method for getting patient and study information to the modality.

EXAMPLES OF OPERATIONAL SYSTEMS

ACR-NEMA/DICOM Hybrid Commercial PACS Interface

Since 1993, a bi-directional ACR-NEMA Version 2.0 interface has been in routine operation between the HIS/RIS and the commercial PACS (Siemens-Loral, Lockheed Martin, GE) at the Baltimore VAMC. This interface has turned out to be critical to the success of filmless radiology at this site. More than one-half million text messages and over 1.7 million images have been transmitted from the PACS to the HIS/RIS at the Baltimore VAMC. In late 1997, the Baltimore GE PACS to VistA image transfer was upgraded to use the DICOM Query/Retrieve service.

Text and Image DICOM Commercial PACS Interfaces

The first DICOM text interface with a commercial PACS was with EMED E-Systems Raytheon at the Boston VAMC in late 1996. In 1997, the DICOM Query/Retrieve service became operational for image transfer from the EMED PACS to VistA. Six thousand images a day are being sent to VistA across this interface. In 1997, DICOM text interfaces were installed with Agfa, IBM/Brit, Parameter Development, and Kodak PACS.

Vista Diagnostic Radiology Image Management

There is a current ongoing development effort that extends the capabilities of the Windows-based VistA Image System to support radiology applications. The Wilmington VAMC is the first facility to

use the capabilities of VistA for diagnostic reading with a goal of becoming completely digital. The Wilmington VAMC has an inpatient capacity of 78 hospital beds and has 114,000 outpatient visits per year. The radiology department performs about 26,000 studies annually. There are three VistA DICOM Storage providers for eleven modalities. Three four-monitor diagnostic quality workstations are used for reading the images. Over one hundred clinical workstations are installed throughout the medical center, each with a 17-inch (1280 × 1024) color VGA monitor. All digital modalities are operational, and images are acquired for all studies. The system is being very well received by the radiology staff, the medical staff, and the administration.

EXPERIENCES WITH DICOM

General Experiences

Overall, the VA experience with DICOM has been very favorable. An unprecedented degree of interoperability has already been achieved, along with new levels of operational reliability and robustness.

DICOM has enabled the VistA Imaging System to easily interface directly with the image producing modalities. This is an extremely useful capability. DICOM is also being used to interface with vendor-supplied PACS. The commercial DICOM offerings that we have interfaced and tested have been developed using toolkits that are quite mature. Interfacing to them has been fairly easy.

Room for Improvement in the DICOM Standard

We found DICOM-imposed length limitations on string and text data to be far too restrictive. Our HIS/RIS was written well before DICOM and supports unlimited length free-text data fields. We found fields containing string data on our HIS/RIS that were longer than the corresponding DICOM allotment. We also found value representation mismatches between the free-text fields on our HIS/RIS and the corresponding DICOM string elements. The DICOM Committee is actively working to improve this situation.

Problems Encountered with Current Modality Implementations of DICOM

There is too much diversity and some serious lack of capability in the current modality implementations of DICOM. In spite of the fact that the DICOM Accession Number element (0008,0050)

must be in every image header (and is required by all PACS to identify the study), most modality implementers have not provided a mechanism for entering it. Of the dozen or so modalities that we have in production, there are seven different ways to pass the element. Six of these ways require transferring it in another field!

There appears to be an inconstant usage of the Photometric Interpretation element (0028,0004). The values MONOCHROME1 and MONOCHROME2 seem have opposite meaning between digital radiofluoroscopy and the other xray modalities. In digital radiofluoroscopy, black bone is MONOCHROME2 and white bone is MONOCHROME1, while in the other xray modalities, it is the other way around.

Additional problems exist. Clearly, the whole PACS industry would greatly benefit by having a correct, uniform, proper, and consistent usage of the DICOM standard by the modality industry. The VA is writing a national modality DICOM compliance document that will attempt to address these issues.

SUMMARY

The VA has achieved significant success in its attempt thus far to support DICOM capabilities with its VistA HIS/RIS. DICOM has been the cornerstone in our ability to integrate imaging functionality into the Healthcare Enterprise. Because of its openness, it allows the flexible integration of system components from commercial and non-commercial sources to work together to provide functional cost-effective solutions. The use of DICOM reduces costs by allowing open systems solutions consisting of in-house and commercial multi-vendor offerings. Because of DICOM, and as a consequence of our work, the VA now has a variety of different options for radiology imaging systems. By capitalizing on the success of the DICOM Standard and the resulting open systems environment, the VA expects a significant cost benefit that will accelerate the deployment of digital imaging nationally within its medical centers. The VA will deploy many DICOM applications on a large scale across its entire hospital system in the near future.

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