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The Department of Veterans Affairs Integration of Imaging into the Healthcare Enterprise Using the VistA Hospital Information System and Digital Imaging and Communications in Medicine

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The United States Department of Veterans Affairs is integrating imaging into the healthcare enterprise by using the Digital Imaging and Communication in Medicine (DICOM) standard protocols. Image management is directly integrated into the VistA Hospital Information System (HIS) software and clinical database. Radiology images are acquired with DICOM and are stored directly in the HIS database. Images can be displayed on low-cost clinician's workstations throughout the medical center. High-resolution diagnostic quality multimonitor VistA workstations with specialized viewing software can be used for reading radiology images. Two approaches are used to acquire and handle images within the radiology department. Some sites have a commercial Picture Archiving and Communications System (PACS) interfaced to the VistA HIS, whereas other sites use the direct image acquisition and integrated diagnostic display capabilities of VistA itself. A small set of DICOM services has been implemented by VistA to allow patient and study text data to be transmitted to image producing modalities and the commercial PACS, and to enable images and study data to be transferred back. DICOM has been the cornerstone in the ability to integrate imaging functionality into the healthcare enterprise. Because of its openness, it allows the integration of system components from commercial and noncommercial sources to work together to provide functional cost-effective solutions.

KEY WORDS: HIS/RIS, DICOM, PACS

THE UNITED STATES Department of Veterans Affairs (VA) is integrating imaging into the healthcare enterprise by using its VistA Hospital Information System (HIS) and the Digital Imaging and Communication in Medicine (DICOM) standard protocols.[1] VistA is the nationally installed HIS at all 170 VA medical centers. All of the 170 VA Medical Centers (VAMC) are now connected together by high-speed networks, making it possible to view a patient's images taken at one VA medical center at another VA facility anywhere else in the country.

Image management is directly integrated into the VistA software and clinical database. Image acquisition is performed in software packages for over twenty different clinical specialty services, like radiology, cardiology, dental, ophthalmology, and pathology. Color still images are acquired directly from National Television Standards Committee (NTSC) analog video sources and personal computer-based (PC) digital sources, utilizing Small Computer System Interface (SCSI) TWAIN interfaces and portable digital cameras. Radiology images are acquired with DICOM. Images are stored directly in the HIS database, with pointers to the images stored in the patient report records themselves. Images can be displayed on low-cost clinician's workstations throughout the medical center. High-resolution diagnostic quality multimonitor workstations with specialized viewing software integrated into the VistA Radiology Information System (RIS) are used for reading radiology images.

VistA includes a client-server architecture connecting the Windows (Microsoft Corp, Redmond, WA) workstations to the clinical database, and a complete hardware/software infrastructure supporting enterprise imaging: 100 Base TX switched networking, nationwide frame relay network, hundred gigabyte NT file servers, terabyte NT juke-

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boxes, background image processors, and selected DICOM services.

DICOM OVERVIEW

Two approaches are used to acquire and handle images within the radiology department.

Some sites have a commercial Picture Archiving and Communications System (PACS) interfaced to the VistA HIS. The Baltimore, MD VAMC pioneered this approach in October 1993 by using the American College of Radiology–National Electrical Manufacturers Association (ACR-NEMA) Version 2.0 with the Siemens-Loral (now GE Corp, Milwaukee, WI) PACS,[2] followed by DICOM interfaces at the Boston, MA VAMC with EMED (Raytheon EMED, San Antonio, TX) in November 1996 and at the West Los Angeles, CA VAMC with Agfa (Agfa Medical, Bayer Corp, Ridgfield Park, NJ) in February 1997. At these sites, 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, send all images to VistA for display throughout the hospital.

Other sites, like the Wilmington, DE and Washington, DC VAMCs, 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. Multimonitor diagnostic quality workstations with VistA software are used for reading the images.

DICOM has been the cornerstone in the ability to integrate imaging functionality into the healthcare enterprise. Because of its openness, it allows the integration of system components from commercial and noncommercial sources to work together to provide functional cost-effective solutions (Fig 1).

Integration with a Commercial PACS

Data Requirements for the PACS Interface. A commercial PACS requires several different pieces of information from the VistA HIS/RIS. 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

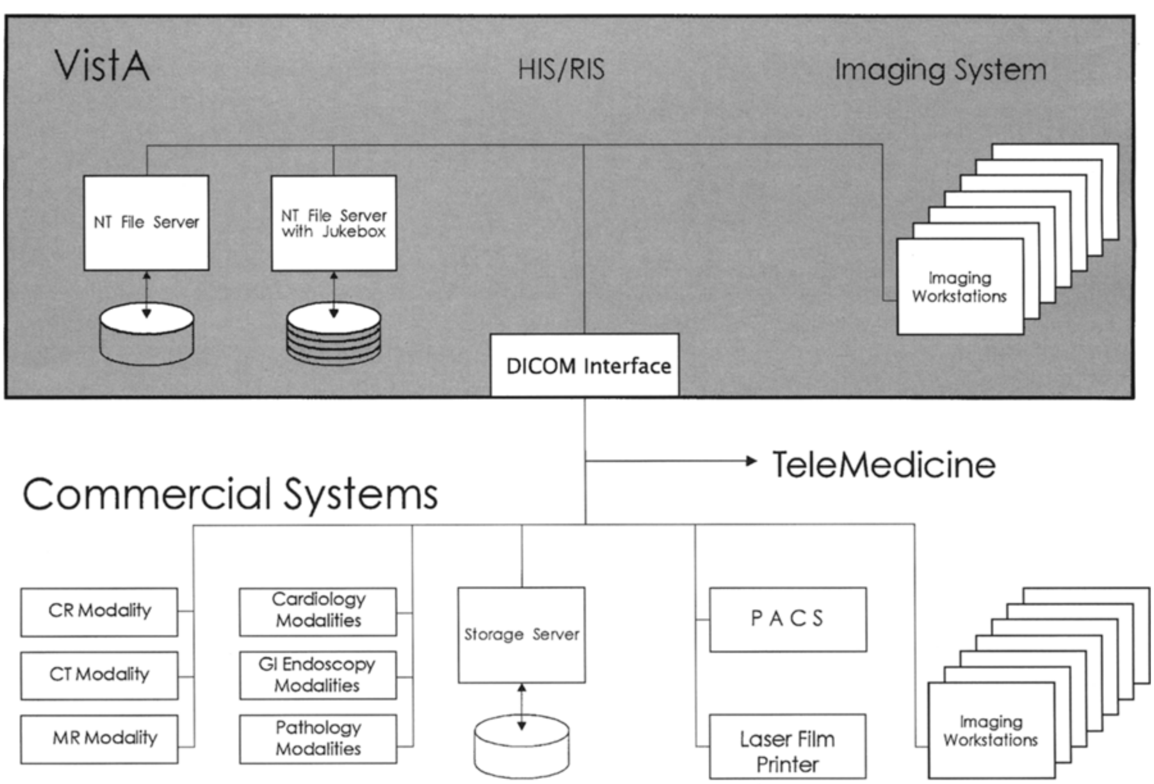

Fig 1. VistA DICOM–Commercial system connectivity

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 prefetch images from the storage archive. 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 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.

Master file updates of the HIS/RIS dictionaries, such as provider lists, must be passed to the PACS.

PACS Interface Integration Components. The integration of VistA and a commercial PACS involves several separate components: VistA, the commercial PACS, the provider(s) of the DICOM Modality Worklist service, and the image producing modalities (Fig 2).

The following series of events occurs as each study is processed:

1. The VistA HIS/RIS initiates the examination process by passing new patient and study event data to both the commercial PACS and the modality worklist provider. The same data stream is used for both the PACS and the modality worklist provider(s) (1 and 2 in Fig 2). The unique identifiers (UID) for the patient, visit, study, report, and interpretation are included in this data, allowing these entities to be correctly identified by all of the various systems.
2. The image producing modality system queries the modality worklist provider to obtain a current list of patients and studies to be performed at that station (3a, 3b, or 3c in Fig 2).
3. The image producing modality system acquires the images and places the VistA patient/study data in the image headers (4 in Fig 2).
4. The image producing modality system sends the images to the commercial PACS (5 in Fig 2).
5. The PACS sends the images to VistA to be added to the HIS database (6 in Fig 2).

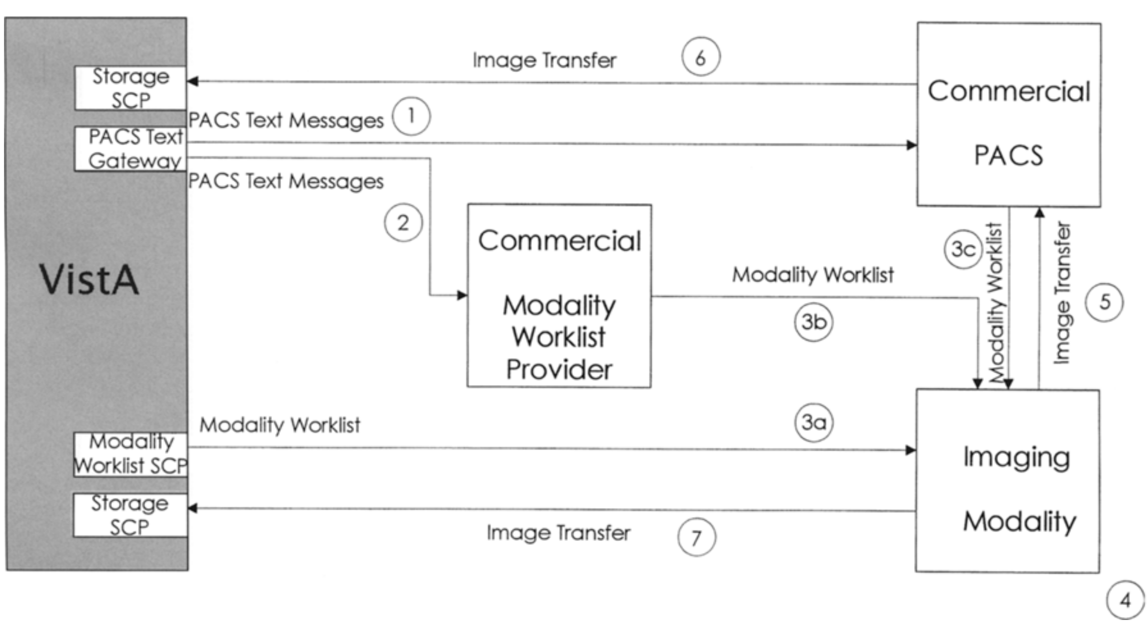

Fig 2. VistA DICOM PACS and Modality Interface options.

6. Non-radiology "visible light" images may be transferred directly from the modality to VistA, bypassing the PACS (7 in Fig 2).

VistA Modality Interface

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. 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 associated 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 allows the study to be placed on a "to-be-read" worklist on a PACS.

All of the data requirements for the modality can be satisfied with DICOM services.

Components of the VistA Modality Interface. Four separate components are required for the VistA Modality interface: the VistA HIS/RIS, the modality worklist provider(s), the image producing modalities, and one or more VistA storage providers. The VistA Modality interface presently supports both the DICOM Modality Worklist service and the DICOM Storage services (Fig 3).

The Modality Worklist service supplies new VistA patient and study information directly to the modality so that it does not have to be manually entered. The Storage service is used to transmit a set of images from the modality to VistA. The information supplied by the Modality Worklist service is incorporated into the image headers, making them easier to identify when they are processed on VistA.

In the future, the DICOM Storage Commitment and Performed Procedure Step services will be added to VistA, to notify the recipient of the images at the completion of the study (see later section, "VA DICOM").

IMPLEMENTATION DETAILS

VistA DICOM Architecture

The majority of the VistA DICOM application is written in MUMPS, the same language as the VistA HIS.[3-5] MUMPS handles DICOM communications, DICOM association negotiation, reading and writing DICOM datasets, access to the VistA database, interfaces to the HIS/RIS, and higher level applications. The communications portion of the image transfer application (ie, the DICOM C-STORE service) and image processing functions are written in C for the sake of speed. The VistA DICOM

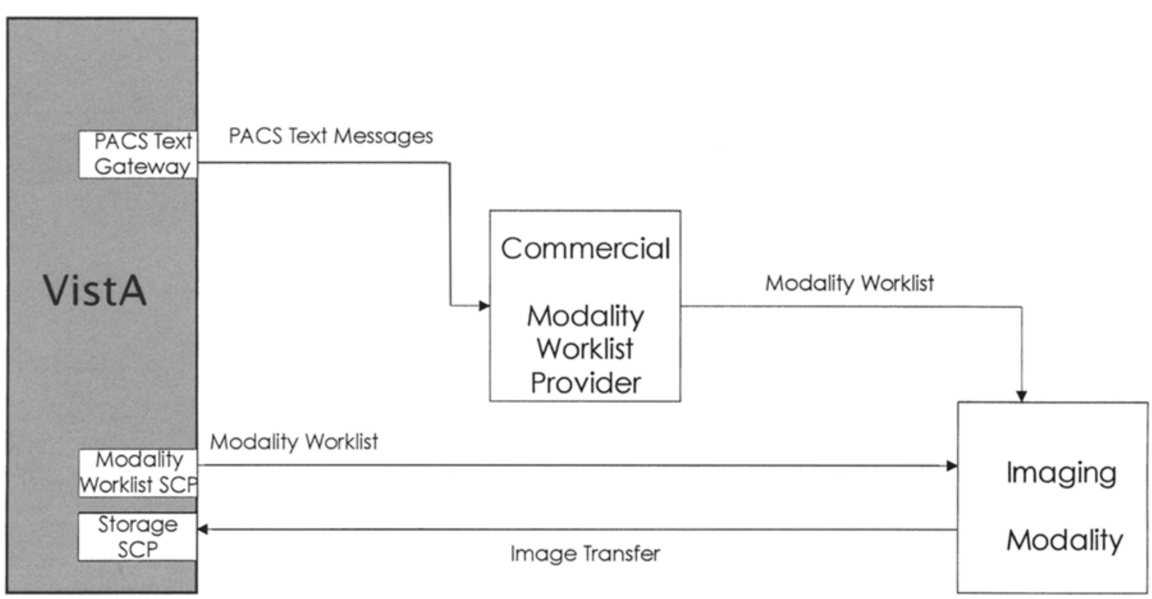

Fig 3. VistA DICOM Modality Interface options.

application runs on top of the Microsoft Windows NT Workstation, Version 4.0 operating system.

The Micronetics MSM-NT Version 4.3.2 of MUMPS is currently used for the VistA DICOM application.[6]

DICOM Message Dataset Files

Each DICOM message dataset transfer requires a message processing step and a message communication step. DICOM message datasets are stored in NT operating system files between these two steps. An incoming message dataset is placed into a file as it is received, and is read out of the file as it is processed. An outgoing message dataset is placed into a file as it is generated, and is read out of the file as it is sent.

These two steps are performed in different ways to support the synchronous and asynchronous modes of operation of DICOM.

Synchronous Mode of Operation. The synchronous mode of DICOM operations requires completing one message request at a time. A single system task performs both the message processing step and the message communications step. The request and response message datasets are stored in files between the two steps.

Asynchronous Mode of Operation. The asynchronous mode of DICOM operations requires handling any number of message requests at a time. Separate tasks are used to perform the message processing step and the message communications step. The message dataset files are organized into first-in-first-out queues, which form a buffer between the task performing the processing and the task performing the communications. Incoming messages are stored in the queue and are processed in the order they were received. Outgoing messages are stored in the queue and are sent in the order they were generated. This technique was developed to handle the bursty nature of transactions in a hospital information system.

DICOM requires supporting three levels of priority: high, medium, and low. Different messages may be assigned different levels of priority. The VistA application code gives orders and changes to orders top priority, patient demographic changes and radiology reports medium priority, and examination pull requests low priority. Three sets of first-in-first-out queues are used, one set for high priority messages, one set for medium priority messages, and one set for low priority messages. All the messages in the high priority queue are processed first, those in the medium priority queue are processed second, and those in the low priority queue are processed last (Fig 4).

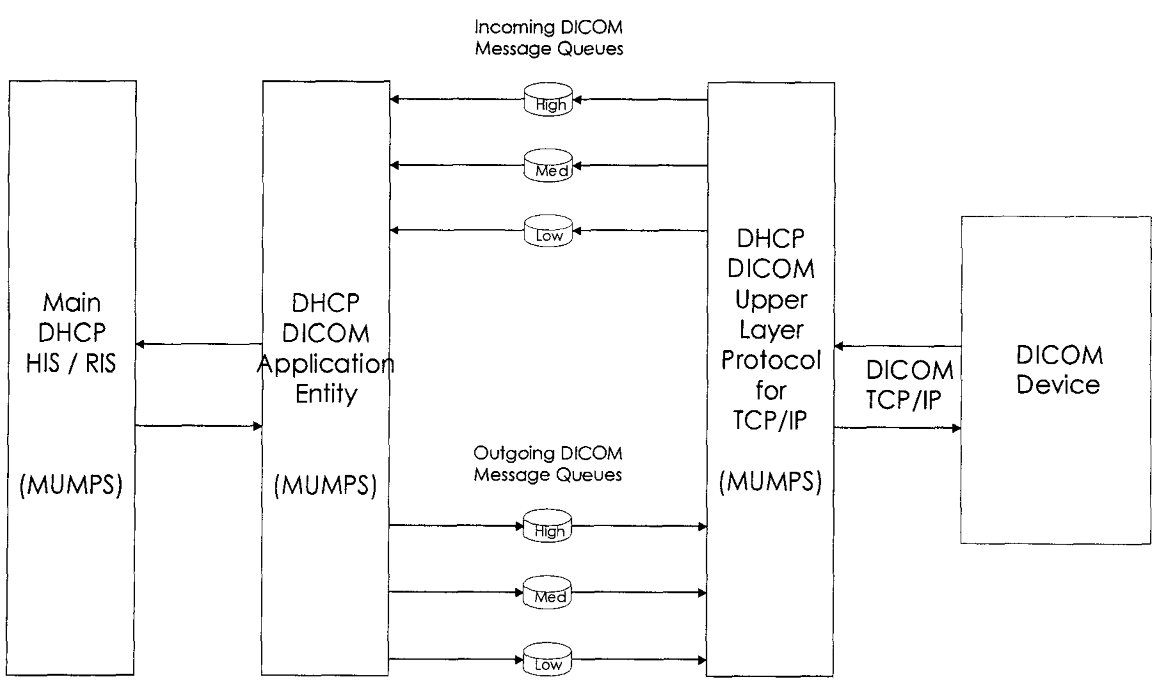

Fig 4. VistA DICOM architecture, excluding the storage service class.

Commercial PACS Interface Messages

The VistA HIS/RIS is designed to acquire data about patient care events and to "push" this data to external systems. The asynchronous mode of operations is used to queue and prioritize the DICOM messages that are sent to the commercial PACS.[7]

An interface design goal is that there be a one-to-one mapping of events to the DICOM messages. Every event maps to a single DICOM N-EVENT-REPORT request message. Each applicable data field is translated into its corresponding DICOM element. All of the patient information from each event transaction is included in each DICOM request message. Providing the patient information in every message makes the interface simpler because the PACS does not have to query (ie, issue an N-GET) the HIS to get this data.

VA-specific Standard Operating Procedure (SOP) Classes were created for the event transactions. These are listed in Table 1.

Modality Worklist Provider

The Modality Worklist Service is the DICOM service that obtains patient and study information from the hospital radiology information system and supplies it to the image producing modalities. This service is designed to operate around a query mechanism that allows the modality to "pull" selected patient and study information on demand. The VistA HIS/RIS can function as the provider of the Modality Worklist service. The VistA Modality Worklist provider maintains a database of active studies. The Order Entry transaction causes a new study record to be added to the active study database, while the Examination Verification or the Examination Change (cancel) transaction causes the records for study to be deleted from the active study database. A query from the modality (ie, a C-FIND Request) causes VistA to return data from one or more records in the database. The VistA Modality Worklist provider is implemented by using the synchronous mode of operation. Each query request is handled by a separate spawned task that interrogates the database and transmits the results. The synchronous mode lets VistA process multiple simultaneous query requests on different associations.

A commercial Modality Worklist provider may be furnished as part of a modality package. VistA can send the DICOM HIS/RIS patient/study event data stream (described in earlier section, "Commercial PACS Interfaces Messages") to one or more commercial providers of the Modality Worklist service. The commercial service providers can then handle their respective modalities.

Whereas the Modality Worklist service is generally used to convey information about current studies to the modality, an important feature of the VistA Modality Worklist service provider is that it can also supply information about old studies as well. If the requested study is not in the active database, the information will be obtained from the long-term HIS/RIS database. This is particularly useful for film digitizing when old films are being scanned, and is a capability not found in most of the commercial products.

VistA Storage Class Provider-Image Acquisition

The VistA storage class provider acquires the images from the modalities and temporarily stores them until they can be matched with the proper patient and study in the HIS/RIS database. The VistA storage class provider consists of a C process and a MUMPS process. The C process functions at a low-level and transfers image datasets from the network to files on magnetic disk. The MUMPS

Table 1. VA-Specific SOP Classes

Real World Event	Direction	Detached VA SOP Class & Event Type
Patient Demographic Change	VistA → PACS	Patient Management, Patient Updated
ADT	VistA → PACS	Visit Management, Visit Updated
Examination Pull	VistA → PACS	Visit Management, Visit Scheduled
Order Entry	VistA → PACS	Study Management, Study Created
Examination Change (cancel)	VistA → PACS	Study Management, Study Updated
Examination Verification	VistA → PACS	Study Management, Study Updated
Examination Complete	VistA ← PACS	N-CREATE of the Study Component Management
Get Image Request	VistA → PACS	C-MOVE request of Query/Retrieve
Get Image Data	VistA ← PACS	C-STORE of Storage Service
Get Image Response	VistA ← PACS	C-MOVE response of Query/Retrieve
Report Transfer	VistA → PACS	Interpretation Management, Interpretation Updated

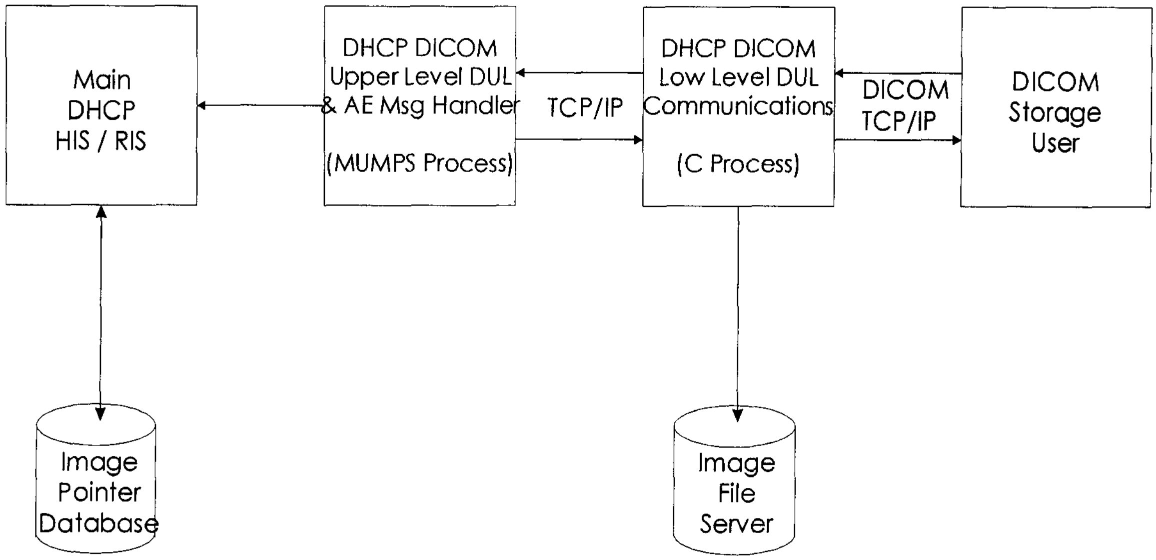

Fig 5. VistA DICOM architecture and storage service SOP class provider.

process performs all of the housekeeping chores required for image acquisition. It negotiates the association, handles the C-STORE request, accesses the VistA database, determines where to store the image, stores a pointer to the image file in the VistA database, and generates the C-STORE response (Fig 5). VistA DICOM storage has been verified with twelve commercial modalities.

A single VistA DICOM PC can support several modalities simultaneously. Mouse clicking on a modality icon starts a modality storage provider process. This launches the C process, which then starts the MUMPS process, communicating with it through TCP/IP (Fig 6).

VistA obtains images from a commercial PACS using the DICOM Query/Retrieve service. The PACS sends the Study UID to VistA in the Examination Complete message. VistA then issues a

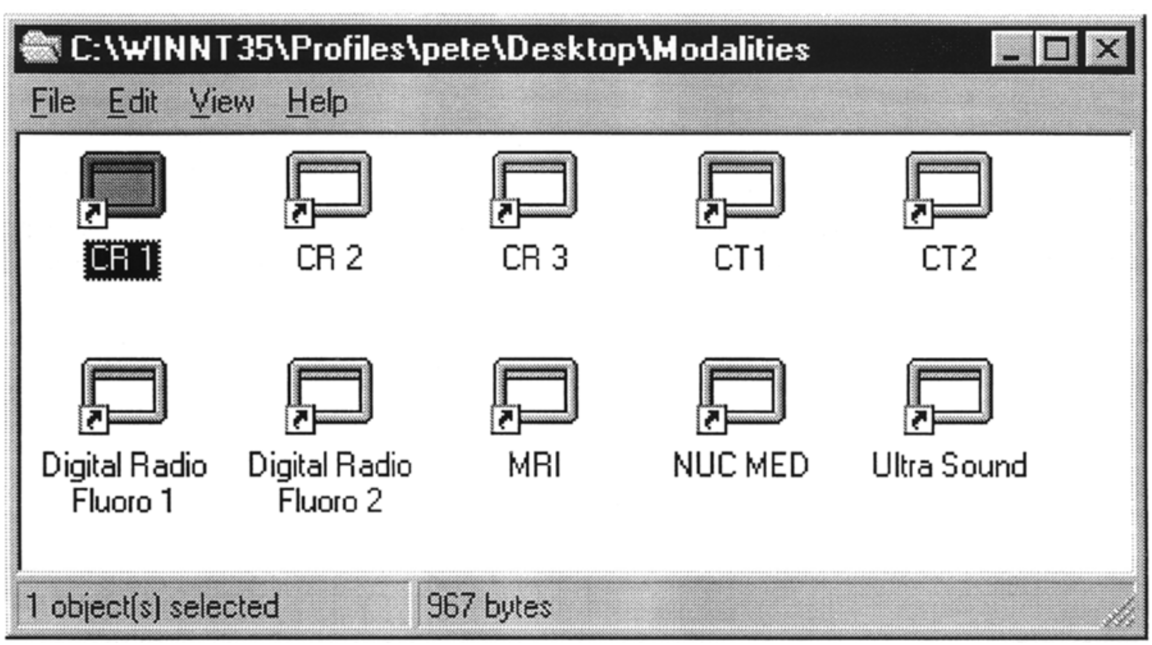

Fig 6. Modality folders.

C-MOVE request to copy all the images to the VistA storage provider.

Image Processing

After the DICOM images have been acquired by the VistA storage class provider, they must be correctly matched to the proper patient and study in the HIS/RIS database. Matching the image to the original study requires correct patient and study identification to be present in the DICOM image header. Since the usage and format of the DICOM fields containing this information is not yet uniform in the industry, manufacturer/model specific techniques are used to extract and process the data. The identification information can either be automatically acquired via the Modality Worklist Service, or it can be manually entered at the modality console. Because manual data entry is chronically error prone, however, additional manual procedures are then needed to link incorrectly identified images to the proper patients and studies.

The VA is working on a specification listing the data items that are required to be placed into the image headers by the modality (see later section, "VA DICOM").

Once the images are properly identified, they are converted into a format that can be rapidly displayed on VistA workstations. The DICOM Standard accommodates a variety of formats for expressing image data. First, multiframe DICOM objects are converted into a set of single image files. Second, the DICOM image headers are stripped off, converted to ASCII, and stored in text files. Then, the images in different formats are converted into a "normalized" form, where all adjustments have been made to the data prior to the viewing. The VistA display workstation uses an 8 to 12 bit unsigned integer monochrome pixel format, where zero is intended to be displayed as black. Raw DICOM pixel values are converted into this format using modality manufacturer/model specific filtering to adjust the pixel values and remove hardware generated artifacts. VistA also generates separate down-sampled computed radiography images for use at reference-quality clinician's workstations.

In the future, VistA will incorporate commercial DICOM display toolkits capable of showing DICOM images directly, without requiring this image normalization step.

Image Display

The general-purpose VistA Clinician Workstation can display images on a standard PC super VGA monitor. These are currently available with up to 1600×1200 pixel resolution.

The special-purpose VistA Radiologist Workstation features up to four 2K $\times$ 2K portrait mode monochrome monitors for diagnostic quality viewing. The software is written using the DOME DimplX toolkit.[7]

VistA Storage User-Image Transmission

The VistA storage user is currently manually invoked to transmit DICOM images. Shortly, a VistA Query/Retrieve Provider will be included to permit DICOM workstations to access the image database directly. To send an image to a DICOM storage provider, the image has to be reconstituted in DICOM format from the processed normalized image and its ASCII text header. Once done, a utility transfers the DICOM image over the network to the storage provider.

EXAMPLES OF OPERATIONAL SYSTEMS

Commercial PACS Interfaces

GE PACS—Baltimore, MD VAMC. Since 1993, at the Baltimore VA Medical Center (VAMC) a bidirectional ACR-NEMA Version 2.0 interface has been in routine operation between the HIS/RIS and the commercial PACS (Siemens-Loral, Lockheed Martin, GE). This interface turned out to be critical to the success of filmless radiology at the Baltimore VAMC. More than 500,000 text messages and over 1,700,000 images have been transmitted between the HIS/RIS and the PACS at the Baltimore VAMC.

After the Baltimore system became operational, a text-only portion of the interface was created and installed at the Houston VAMC for use with the AVP (Raytheon EMED) PACS. The text portion of the interface was subsequently modified to work with the Department of Defense CHCS HIS and has been installed at twelve Department of Defense medical centers. These interfaces have been successful, with several million text messages exchanged at the various sites. Six additional GE PACS systems have been installed in the VA in 1997, along with one in the Indian Health Service, all with the ACR-NEMA 2.0 interface.

In late 1997, the Baltimore GE PACS to VistA image transfer was upgraded to use the DICOM

Query/Retrieve service. GE's additional VA installations will start using the DICOM Query/Retrieve service early in 1998. The GE PACS continues to use ACR-NEMA Version 2.0 for text transfer.

EMED PACS—Boston, MA VAMC. 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.

Additional DICOM Text Interfaces. In early 1997, the Agfa PACS at the Los Angeles, CA VAMC became the second facility in the VA to become operational with the DICOM text interface, followed by the Agfa PACS at Leavenworth, KS in late spring. In the summer of 1997, the interface with Parameter Development's PACS at the Houston VAMC became operational. Late in 1997, the interface with IBM/BRIT's PACS (IBM, White Plains, NY) at the Dallas VAMC became operational. Interfaces are currently planned with Cemax-Icon at the Palo Alto VAMC and other sites. It is also anticipated that the Query/Retrieve service will become operational at some of these sites in 1998, so that images from the PACS will be able to be seen on VistA workstations throughout the medical center.

Vista Diagnostic Radiology Image Management

There is a current ongoing development effort that extends the capabilities of the Windows-based VistA Imaging System to support radiology applications.

Wilmington, DE VAMC. The Wilmington VAMC is the first facility to use the capabilities of VistA for diagnostic reading with a goal of becoming completely digital. Although they were able to purchase digital image producing modalities, budgetary constraints ruled out obtaining a commercial PACS. The Wilmington staff decided to provide diagnostic radiology image management using VistA Imaging components.

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.

The network architecture of the Wilmington system is shown in Fig 7. There are three VistA DICOM Storage providers for eleven modalities. Processed images are placed on one of two 40-gigabyte Digital Alpha NT file servers, and then are immediately copied to a two-terabyte jukebox. 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. As the system is still quite new and the radiology staff is in a learning mode, film is printed for all studies. As system verification is completed and confidence in the digital capabilities is established, the film printing will be discontinued.

The system is being very well received by the radiology staff, the medical staff, and the administration. There is a very high level of enthusiasm and acceptance surrounding the project. The radiologists are excited by being able to see more detail in the digital images than in the film, and by potentially being able to make more accurate diagnosis. The medical staff enjoy being able to see reference quality computed radiography (CR) images and full resolution computed tomography (CT) images on their PC workstations. The administration likes the fact that the newly constructed facility is functioning well, that VistA PACS is totally integrated within their HIS/RIS, and that quality of service and productivity seem to be on the rise.

Washington, DC VAMC. The Washington VAMC is the second pilot site for VistA diagnostic radiology image management. The Washington VAMC has an inpatient capacity of 376 beds and has 305,000 outpatient visits per year. The radiology department performs about 73,000 studies annually.

All digital images from one Fuji CR AC3 (Fuji Medical Systems USA Inc, Stanford, CT), two Picker PQ2000 CT's, and a Picker Edge (Picker International, Cleveland, OH) MRI are already being sent to the VistA system. However, these images are only being seen by the clinicians, as the diagnostic quality workstations have not yet been installed. The Washington VAMC has just undergone a complete upgrade of its digital network infrastructure, with new vertical fiber optic cable, wire closet hubs, and horizontal Category 5 unshielded twisted pair installed everywhere. A total of 450 clinical imaging workstations are being installed.

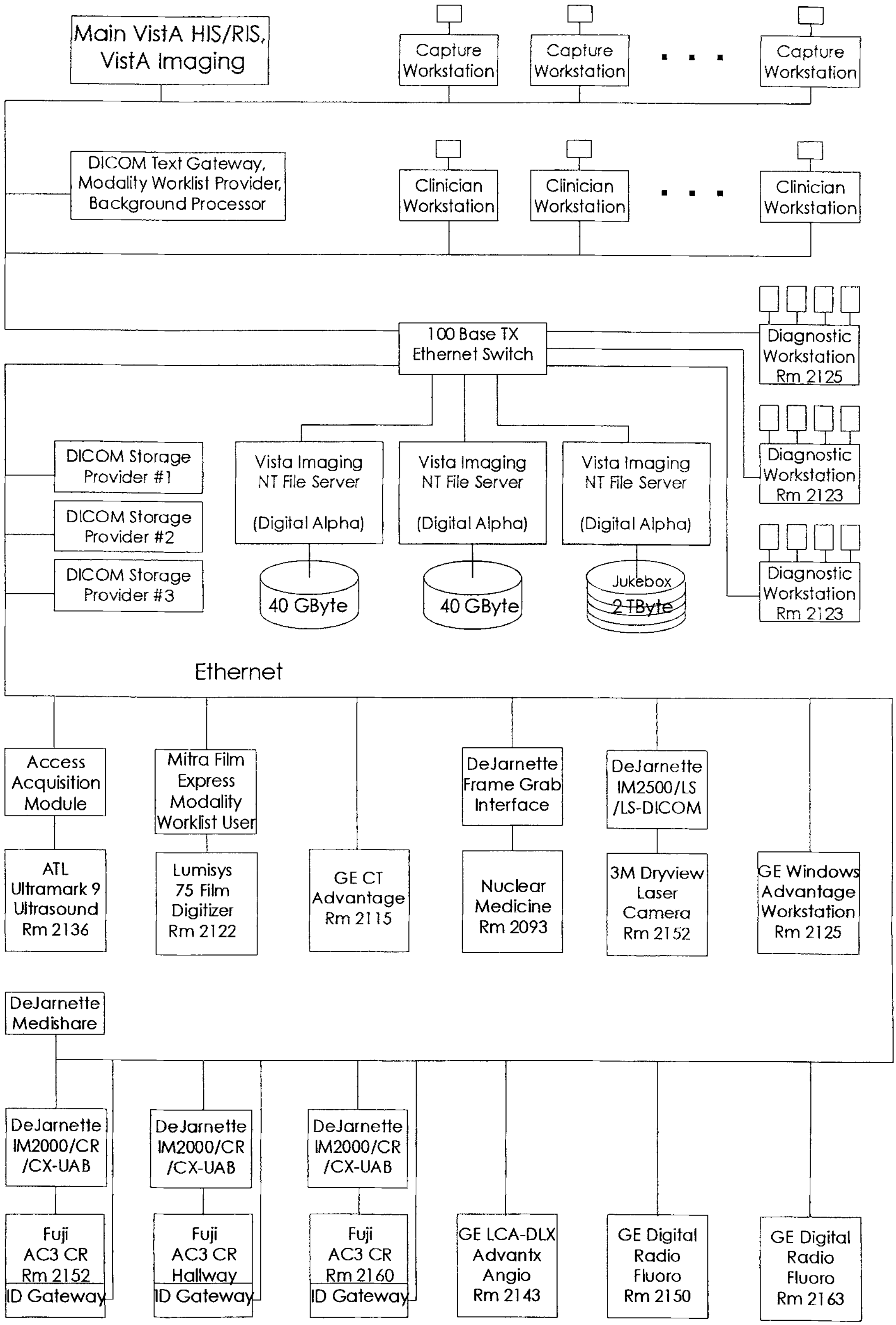

Fig 7. Wilmington, DE VAMC VistA imaging network.

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 interface directly with the image producing modalities, and this is an extremely useful capability. DICOM is also being used to interface with vendor-supplied PACS. The commercial DICOM offerings that we have tested and interfaced with were developed using toolkits that are quite mature, and interfacing to them has been fairly easy.

The DICOM unique identification scheme for the patient and study form the information structure necessary for teleradiology. This is a great benefit of DICOM. We expect this to be widely used within the federal government in the future.

Room for Improvement in the DICOM Standard

There are several parts of the DICOM standard that we would like to see changed.[9] More interoperability is possible and more is necessary.

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.

The lack of a standard DICOM facility for communication of institutional master file data is another concern for us. We would like to see a DICOM standard produced for the propagation of master file data.

A related issue is that DICOM does not treat physicians or institutional locations as entities. DICOM does not support the unique identification codes for physicians and locations. Without them, it is difficult to differentiate between two providers with the same name. This becomes particularly troublesome when a commercial PACS must send provider information in messages to a HIS/RIS that requires such codes.

We encountered several difficulties interfacing DICOM to the VA's existing HIS/RIS. The original DIMSE-N normalized message scheme was found to be poorly suited for use with the existing VA HIS/RIS. This was replaced with a VA-designed specialization, which did not require the N-GET service.

Need for a Uniform and Consistent Usage of DICOM by Modalities

Problems Encountered with Current Modality Implementations of DICOM. There is too much diversity and some serious lack of capability in today's current modality implementations of DICOM.

Despite 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 accession number. Six of these ways require transferring it from some other 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 radiograph modalities. In digital radiofluoroscopy, black bone is MONOCHROME2 and white bone is MONOCHROME1, whereas in the other radiograph modalities it is the other way around.

It is currently very difficult to determine when the PACS has received all the images from the modality so that the study can be placed on an "Unread Study Worklist."

The PACS industry would greatly benefit by having a uniform, proper, and consistent usage of the DICOM standard by the modality industry.

VA DICOM Compliance Requirement for Modalities

The VA is writing a national modality DICOM compliance document that will attempt to address these problems.[10] This document will include a standard list of data elements that are required to be in every image header. It will state that the modality shall obtain these data items through the Modality Worklist Service Class. Rules will be included on the Photometric Interpretation element's usage. The modality will be required to provide a notification mechanism as to when all the images have been sent to the storage provider. All modality manufacturers must use a uniform, consistent core subset of DICOM services to satisfy these requirements.

VistA DICOM Simulator

The VistA DICOM applications are constructed so that they can run in simulator mode without an actual connection to the HIS/RIS. The VA provides a VistA DICOM simulator to their DICOM vendors so that they can do all of their testing in-house. A set of real patient data (sanitized to protect confidentiality) is supplied with the simulator to mimic as closely as possible the actual events. Further testing can be performed across the Internet between the vendor site and our software development facility. Final testing is performed on-site with test data before live operation.

The presence of the simulator at vendor sites has been a major factor contributing to the overall success of the project. Several vendors have stated that providing them with our VistA DICOM simulator has greatly facilitated their development work and improved the reliability and quality of their product when installed on site.

The Future: Visible Light

The Olympus Endoscope Division will be beta testing their DICOM storage capabilities later this year with the VistA Imaging System.

SUMMARY

The VA has achieved significant success in its attempt thus far to support DICOM capabilities with its VistA HIS/RIS. The VA's experience is that DICOM is truly fulfilling its promise to bring open system technology to the medical imaging marketplace. We are demonstrating the benefits of integrating DICOM with our HIS/RIS.

The use of DICOM has the potential to reduce costs by allowing open systems solutions consisting of in-house and commercial multivendor 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. Hopefully, the VA will deploy many DICOM applications on a large scale across its entire hospital system in the near future.

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