A Generic Digital Imaging and Communications in Medicine Solution for a Bidirectional Interface Between the Modality and the Radiology Information System

Edward M. Smith, Joshua D. Ruffel, and Michael Fisher

The Relay is a generic Digital Imaging and Communications in Medicine (DICOM)-compliant software package. It is a bidirectional interface between the modality and the radiology information system (RIS) that uses DICOM modality worklist and modality-performed procedure step services. This device can eliminate discrepancies between patient demographic information contained in the RIS and that entered at the imaging modality. The Relay receives the worklist for a modality from the RIS. It verifies the accession number (ACC#) and medical record number (MRN) received from the RIS for a study against the ACC# and MRN entered at the modality after that study is pushed to the Relay by the modality. If the values for the ACC# and MRN contained in the image header coincide with the values stored on the RIS, the patient demographics and study protocol contained in the RIS is downloaded into the image header. The study is then automatically routed to the specified destination without technologist intervention. Images whose header does not coincide with data on the RIS are flagged for subsequent reconciliation by the technologist. When the study is completed, the Relay updates the status of the study in the RIS, if the RIS provides DICOM performed procedure step service. When required, the Relay is able to split a single study into two or more series and assign each an ACC#. Other Relay functionality includes sending studies to multiple DICOM devices, adding comments to the image header, and DICOM print service. Should the archive be unavailable to receive images for whatever reason, the Relay can store studies so image acquisition can continue without interruption or it can divert studies directly to a diagnostic workstation. This Relay provides redundancy and fault-tolerance capabilities for picture archiving and communications systems. It is vendor-independent and will function with any DICOM modality, RIS, or archive.

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FOR A PICTURE ARCHIVING and communications system (PACS) to be successful, it must improve the workflow within the radiology department and, more importantly, ensure the timely delivery of clinical reports and images to the referring physicians. One of the major problems resulting in the delay in the availability of images for interpretation in a PACS environment is discrepancies between the patient ID (medical record number [MRN]) and requisition number (accession number [ACC#]) entered at the imaging modality and the demographic data provided by the radiol-

ogy information system (RIS). These discrepancies, known as exceptions, must be resolved before a study can be interpreted and can approach 20% of the studies performed in a clinical environment. This results in significant delays in image interpretation and can result in having to employ one or more full-time equivalents (FTEs) to manually reconcile the studies in question.

Smith et al¹ described "the Facilitator," a DICOM-compliant device that would use the DICOM modality worklist² and DICOM modality performed procedure step³ services. It was to be the bidirectional interface between the imaging modality and the RIS via the PACS Broker to provide automatic reconciliation of studies, as well as other functionality. The PACS Broker is a bidirectional interface that converts the RIS health level 7 (HL-7) communication standard to the PACS Digital Imaging and Communication in Medicine (DICOM) Version 3.0 communication standard. This hardware and software package was to be jointly developed by Digital Equipment Corporation (DEC), now Compaq Computer (Houston, TX), and the Radiology Department of the University of Rochester Medical Center (URMC).

During the initial phase of developing the Facilitator, it was learned that Mitra Imaging, Inc (Waterloo, Ontario, Canada) was developing a commercial version of the Facilitator that had the majority of the features of the Facilitator. The development project on the Facilitator was halted since Mitra Imaging had a long history of successfully building and integrating HL-7 and DICOM Version 3.0 interfaces. The Department of Radiology, URMC signed a "beta" testing agreement with Mitra Imaging to evaluate the Relay in their PACS, the Medical Information, Communication and Archive

From the Department of Radiology, University of Rochester Medical Center, Rochester, NY; and Mitra Imaging, Inc, Waterloo, Ontario, Canada.

Address reprint requests to Edward M. Smith, ScD, Professor of Radiology, University of Rochester Medical Center, 601 Elmwood Ave, Box 620, Rochester, NY 14642-8648.

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System (MICAS), which is a multivendor, phased implementation of PACS.^{1,4,5}

FUNCTIONALITY OF THE RELAY

The Relay is a DICOM-compliant Microsoft Windows NT software (Microsoft, Redmond, WA) application that can reside on a separate computer near the modality workstation or reside on an existing computer that is used with other applications such as the RIS. The Relay displays the worklist for a modality using the DICOM modality worklist service from the RIS via the PACS Broker. The DICOM modality worklist service provides the mechanism for transferring patient and procedure information from the RIS to the modality. If the data (ACC# and MRN) entered manually or automatically scanned in at the modality for the study matches the data for the selected study in the worklist, the study is automatically reconciled. It may then be routed to the specified destination, eg, archive or diagnostic workstation, without intervention by the technologist. If demographic and study procedure data are available from the RIS, these data are automatically added to the image header of the study. The Relay can also be used to add comments to the image header by the technologist.

For studies where the ACC# and MRN entered at the modality do not match the data for a study on the modality worklist, the study is flagged for reconciliation by the technologist at the modality. The technologist verifies the MRN and ACC# of the patient imaged against the modality worklist and identifies the incorrect value. This value is corrected by the Relay and the study is reconciled and routed to the archive.

Once the study is complete, the Relay uses DICOM modality performed procedure step service to update the status of the study in the RIS, if the RIS is capable of receiving information back from the modality via the PACS Broker. The DICOM modality performed procedure step service permits the modality to communicate back to the RIS such information as procedure start and completion times and the number of images in a series and number of series in a study.

Modern computed tomography (CT) scanners can scan a patient from the cervical to lumbar spine in a single pass acquiring chest, abdomen, and pelvic as a single series (study) with a single ACC#. Significant human intervention is required to separate this study into individual series with separate

ACC#. If this is not done, it may be difficult to locate the specific segment of the study needed for interpretation and this can affect the ability to bill for three studies, rather than just one. The Relay can split a study that contains multiple series and can assign each an ACC#. Thumbnail images of all the frames in the study are displayed on the monitor and the technologist can segment them into series as required by the physician.

The Relay provides redundancy and fault tolerance to the PACS. It can store studies should the archive fail and function as a DICOM router to route studies to destinations other than the archive for immediate interpretation. The Relay can route studies to multiple locations, eg, archive and emergency department workstation. It can also provide DICOM print service capability.

CLINICAL OPERATION

The Relay application is running on personal computers (PCs) that also have the RIS application running, IDXrad (IDX, Burlington, VT). This conserves space and hardware, and is convenient for the technologist. The PCs are Pentium II (Intel, Santa Clara, CA) 300 MHz, 128 MB RAM, 2 or 4 GB hard drives and 10/100 Mbit network interface cards. These computers are located adjacent to the CT, magnetic resonance, and computed radiography (CR) modality consoles. Each PC is connected directly to the Cabletron SmartSwitch 6000 (Cabletron, Rochester, NH) that is at the center of the PACS star network configuration. The Relay is being used with a GE (Milwaukee, WI) CT 2X HiSpeed Advantage, GE CT HiLight Advantage, GE CT CTi, 2 GE MRs 5.5 Signa Horizon, and 2 Kodak (Rochester, NY) Digital Science CR System 400.

Should the archive be unavailable to receive studies for whatever reason, the Relay can store studies so that image acquisition can continue without interruption or it can divert the studies directly to a diagnostic workstation or to a printer. The studies will be transmitted to the archive when it becomes available.

Currently, IDXrad Version 9.5 is being used. This version of IDXrad does not support DICOM modality performed procedure step service.

The Relay is being routinely used on the GE CT HiLight Advantage and the GE MR 5.5 Signa Horizon. The reconciliation of studies error rate has been reduced from 10% to 30% to approximately

0% depending on the technologist operating the scanner and the intensity of work on the scanner.

SUMMARY

The Relay is a generic device that is vendor-independent and will function with any DICOM-compliant modality, RIS, or archive. Work is underway to use the Relay with legacy devices. The Relay provides the capability to eliminate discrepancies between data manually entered at the modality and that stored in the RIS for a study, as well as

providing other functionality. Most importantly, the Relay provides the potential to implement redundancy and fault-tolerance capabilities to the PACS as a result of its ability to store studies locally and function as a DICOM router.

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