

# *Rational Imaging* *ImageQube*

## DICOM 3.0 Conformance Statement

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## I. INTRODUCTION

The Rational Imaging PACS system is DICOM 3.0 compliant, and the functionality outlined in this document has been verified, validated, and is operational in a commercial / clinical capacity. Additional documents are available upon request, which list the validated scanner models.

This document provides DICOM conformance information for Rational Imaging's image network (RInet) pursuant to the requirements set forth in Part 2 of the DICOM Standard V3.0. More specifically, this document provides an introduction to the DICOM connectivity provided by the Rational Imaging applications and describes the current level of support for this standard.

The digital distribution of medical information between vendors has many benefits, including but not limited to improved interpretation due to access by multiple users, improved diagnostic perception through the application of post-processing or enhancement techniques, reduction in film loss and courier costs, improved clinical efficiency, and increased cost-effectiveness. All of these either directly or indirectly result in improved patient care. It is therefore our intention to remain compliant with this standard for as long as it remains a viable method of image transmission.

## II. IMPLEMENTATION MODEL

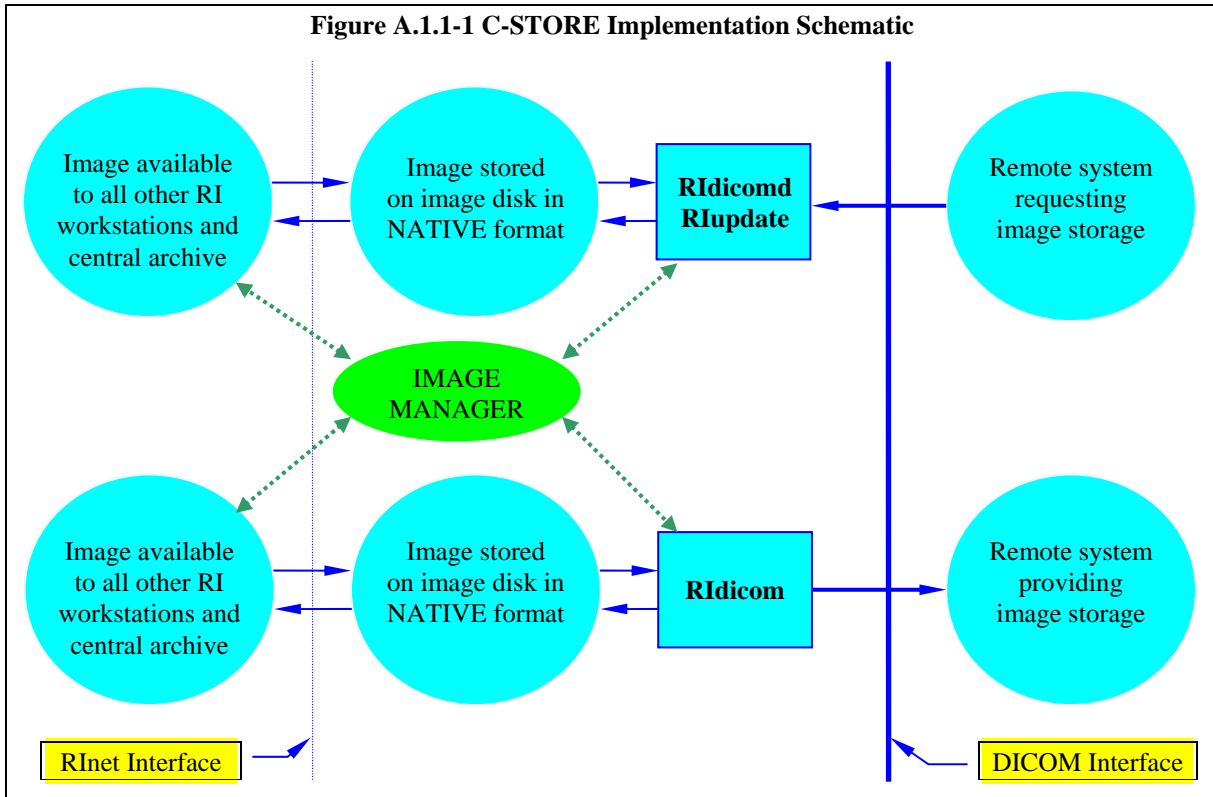
The Rational Imaging network provides image reception capabilities through the use of the DICOM storage service class. This allows our workstations to receive images from vendors who support the transmission of DICOM images to other vendor's workstations. The application entity performing this connectivity (*ridicomd*) uses the standard DICOM port (104) to negotiate the handshaking and transfer of images using TCI/IP network protocols.

### A. APPLICATION DATA FLOW DIAGRAM

*ridicomd* is invoked as a UNIX daemon which runs in the background to receives images from other workstations or scanners. The command line parameters are provided in Section A.5.2 of this manual. Each scanner is assigned a *ridicomd* process on a selected tcp port so as to provide reliable, responsive handshaking with each scanner. Once configured and initialized, the process will be memory resident on the selected port listening for any DICOM association requests. Authenticated requests will be accepted and given C-STORE access priveleges.

*ridicom* is a UNIX application which allows an operator to select exams, series, or images to be sent to foreign DICOM recipient. This application is a DICOM C-STORE USER and provides a mechanism to distribute images from the Rational Imaging system to other foreign imaging systems providing C-STORE capabilities. Images retained in their natural format (GE, Siemens, DICOM, Interfile, etc) will be converted to DICOM using the mandatory

elements of each SOP class (and some recommended fields) and sent to the selected destination. Multiple destinations may be configured within this application. The images can be sent to single or multiple destinations in the same operation.



## B. FUNCTIONAL DEFINITIONS OF AE'S

The *ridicomd* process is invoked at the UNIX command line or can be configured to startup automatically at boot time by adding the command in the `/etc/rc.local` file (Solaris 1) or `/etc/init.d/ri.install` file (Solaris 2). This application remains resident unless it is shutdown manually. UNIX cron tasks (timed processes) ensure that the process is always resident. When another application connects, *ridicomd* checks to make sure that it is another DICOM application by verifying its AE Title. After a connection is established, *ridicomd* will accept appropriate associations with Presentation Contexts for SOP Classes of the Storage Service Class. It will receive these images on these Presentation Contexts and write them to files in the “incoming” directory the local hard disk in the format received.

Following the reception of images into the “incoming” directory by *ridicomd*, a background daemon (*riupdate*) will periodically check this directory for images of a recognized format. When a new image is recognized, *riupdate* will update the Rational Imaging database with pertinent demographic and image information so that users at any Rational Imaging workstation may access these images. The *distributed* nature of these images is a powerful feature of the Rational Imaging system and allows optimal access to any patient’s images

while minimizing network traffic. The archive daemons can be scheduled to archive or restore the images from any workstation during the night when the network is quiet.

The *ridicom* application provides the user with a graphical user interface to select and send exams, series, or single images to a foreign imaging system via DICOM 3 protocols. *ridicom's* interface consists of a patient/exam/series/image selection list allowing the operator to select the datasets to send. In addition, the destination(s) can be selected and configured using this application. Multiple destination SCP systems can be selected and used to transfer images in a single operation. Once the exams and destinations have been selected, the operator simply clicks on the Transmit button and inter-client DICOM communications will proceed without further operator intervention. Errors which occur during the transfer will not halt subsequent C-STORE operations to other hosts, but will be reported in a status console and in the unix syslog constructs. Authentication and transfer will proceed in compliance with DICOM 3.0 protocols addressed in the networking section of this document and the DICOM standards documentation set.

Operationally, *ridicom* must convert the NATIVE image formats (GE, Siemens, Lunar, Interfile, DICOM, ...) to DICOM using demographic information available in the Image Manager. Once the images have been converted to a DICOM construct, they can then be sent to the selected destination. *ridicom* uses the mandatory fields and some recommended fields for a particular SOP class in building the DICOM images to be distributed.

This particular operational architecture allows the Rational Imaging system to fully utilize header and demographic information present in a particular manufacturer's image since it retains the NATIVE format at all times. In addition, the *ridicomd* and *ridicom* applications allow universal communication of these images following accepted medical industry standards. While this requires a more robust architecture than simply converting all incoming images to DICOM, the advantages of relational cross-referencing displays and access to proprietary patient demographics is self-evident.

## **C. SEQUENCING OF REAL-WORLD ACTIVITIES**

The Storage AE implemented in the Rational Imaging system places no restrictions on the sequencing of Real-World Activities.

### III. AE SPECIFICATIONS

All associations with this AE shall be established using the DICOM 3.0 Application Context. A single DICOM Application Context Name is defined for this version of the DICOM standard (“1.2.840.10008.3.1.1.1”).

#### A. SOP CLASSES SUPPORTED

The *ridicom* (SCU) and *ridicomd* (SCP) applications provide Standard Conformance to the following DICOM V3.0 SOP Classes providing both user and provider C-STORE operations.

DESCRIPTION	UID
<b>Verification Service Class:</b>	
Verification SOP Class	1.2.840.10008.1.1
<b>Storage Service Class:</b>	
Computed Radiography Image Storage	1.2.840.10008.5.1.4.1.1.1
Digital Radiography	1.2.840.10008.5.1.4.1.1.1.1
Raw Digital Radiography	1.2.840.10008.5.1.4.1.1.1.1.1
Digital Mammography	1.2.840.10008.5.1.4.1.1.1.2
Raw Digital Mammography	1.2.840.10008.5.1.4.1.1.1.2.1
Digital IntraOral XRay	1.2.840.10008.5.1.4.1.1.1.3
Computed Tomography Image Storage	1.2.840.10008.5.1.4.1.1.2
Ultrasound Multiframe Image Storage	1.2.840.10008.5.1.4.1.1.3
New Ultrasound Multiframe Image Storage	1.2.840.10008.5.1.4.1.1.3.1
Magnetic Resonance Image Storage	1.2.840.10008.5.1.4.1.1.4
Nuclear Medicine Old Image Storage	1.2.840.10008.5.1.4.1.1.5
Ultrasound Image Storage - Retired	1.2.840.10008.5.1.4.1.1.6
Ultrasound Image Storage - New	1.2.840.10008.5.1.4.1.1.6.1
Secondary Capture Image Storage	1.2.840.10008.5.1.4.1.1.7
Stand Alone Overlay	1.2.840.10008.5.1.4.1.1.8
Stand Alone Curve	1.2.840.10008.5.1.4.1.1.9
Stand Alone Modality LUT	1.2.840.10008.5.1.4.1.1.10
Stand Alone VOILUT	1.2.840.10008.5.1.4.1.1.11
Presentation State	1.2.840.10008.5.1.4.1.1.11.1
XRay Angio	1.2.840.10008.5.1.4.1.1.12.1
XRay Fluoro	1.2.840.10008.5.1.4.1.1.12.2
Nuclear Medicine Image Storage	1.2.840.10008.5.1.4.1.1.20
Hardcopy Greyscale	1.2.840.10008.5.1.4.1.1.29
Hardcopy Color	1.2.840.10008.5.1.4.1.1.30
Positron Emission Tomography	1.2.840.10008.5.1.4.1.1.128
Stand Alone Pet Curve	1.2.840.10008.5.1.4.1.1.129

## B. ASSOCIATION ESTABLISHMENT POLICIES

### 1. GENERAL

The Rational Imaging storage AE “*ridicomd*” will attempt to establish an association whenever it is invoked with valid association requests. The DICOM association must contain valid Abstract and Transfer Syntax, and the contents of the image file must contain information pertinent for its SOP class.

The maximum PDU length for this Storage AE is 16384.

### 2. NUMBER OF ASSOCIATIONS

The number of simultaneous associations which will be accepted by *ridicomd* are limited only by the parameters of the UNIX TCP/IP implementation or available system resources such as memory and disk space. To minimize tcp/ip contention and “busy” processes, each scanner is assigned a unique port number with which to handshake and transfer images between itself and a dedicated *ridicomd* process. Therefore, a *ridicomd* process must be configured and initialized for each scanner. If a workstation receives images from N scanners, then it should have N *ridicomd* processes running on consecutive port numbers (104,105, ..., 104+N-1).

### 3. ASYNCHRONOUS NATURE

Synchronous mode of operation is supported on all Associations. No asynchronous operations will be performed by *ridicomd* since each image transferred must follow correct syntactical associations.

### 4. IMPLEMENTATION IDENTIFYING INFORMATION

A single Implementation Class UID is used by *ridicomd* which is “1.2.840.113696.1” with an Implementation Version Name of “RI\_DICOM”. The Application Entity (AE) Title for the Rational Imaging Storage AE is “RI\_DICOM”. This is a configurable parameter on the command line.

## C. ASSOCIATION INITIATION POLICY

The Storage AE *ridicomd* will not initiate associations. It acts only as a SCP (Service Class Provider).

The Storage AE *ridicom* acts as the DICOM C-STORE SCU (Service Class User). It will initiate associations with preconfigured foreign imaging systems providing C-STORE capabilities. Patient exams, series, and images may be selected and sent to these foreign systems. Single or multiple destinations may be utilized in a single transfer operation. Calling and receiving AE\_TITLES, Port numbers and hostnames are completely configurable within the *ridicom* application.

## D. ASSOCIATION ACCEPTANCE POLICY

The Storage AE *ridicomd* will accept associations compliant with the DICOM 3.0 specifications and will receive any images transmitted on that association. No restrictions

are placed on who may connect to *ridicomd*, nor on the number of simultaneous connections it will support.

### 1. ASSOCIATED REAL-WORLD ACTIVITY

The associated Real-World Activity associated with the C-STORE operation is the storage of the image on the local disk of the system upon which *ridicomd* is running. *ridicomd* will issue a failure status if it is unable to store the image on disk, or if the image transferred does not conform to the IOD of the SOP Class under which it was transmitted.

*ridicomd* can also be configured to be forgiving with regards to the IOD information. This startup configuration specified on the command line will be discussed in Section A.5.2.

### 2. PROPOSED PRESENTATION CONTEXTS

Any of the Presentation Contexts specified in Table B.2.1.3.2-1 are acceptable for *ridicomd* to receive images.

**Table B.2.1.3.2-1**

Presentation Context Name					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Verification	1.2.840.10008.1.1	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Computer Radiography	1.2.840.10008.5.1.4.1.1.1	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Computed Radiography	1.2.840.10008.5.1.4.1.1.1	DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
Computed Radiography	1.2.840.10008.5.1.4.1.1.1	DICOM Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None
Computed Tomography	1.2.840.10008.5.1.4.1.1.2	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Computed Tomography	1.2.840.10008.5.1.4.1.1.2	DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
Computed Tomography	1.2.840.10008.5.1.4.1.1.2	DICOM Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None
Magnetic Resonance	1.2.840.10008.5.1.4.1.1.4	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Magnetic Resonance	1.2.840.10008.5.1.4.1.1.4	DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
Magnetic Resonance	1.2.840.10008.5.1.4.1.1.4	DICOM Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None
Nuclear Medicine	1.2.840.10008.5.1.4.1.1.5	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Nuclear Medicine	1.2.840.10008.5.1.4.1.1.5	DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
Nuclear Medicine	1.2.840.10008.5.1.4.1.1.5	DICOM Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None
Ultrasound	1.2.840.10008.5.1.4.1.1.6	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Ultrasound	1.2.840.10008.5.1.4.1.1.6	DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
Ultrasound	1.2.840.10008.5.1.4.1.1.6	DICOM Explicit	1.2.840.10008.1.2.2	SCP	None

		VR Big Endian			
Secondary Capture	1.2.840.10008.5.1.4.1.1.7	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Secondary Capture	1.2.840.10008.5.1.4.1.1.7	DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
Secondary Capture	1.2.840.10008.5.1.4.1.1.7	DICOM Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None

### 3. SOP SPECIFIC CONFORMANCE

#### a. SOP Specific Conformance to Verification SOP Class

*ridicomd* provides standard conformance to the DICOM Verification Service Class.

#### b. SOP Specific Conformance to Storage SOP Class

*ridicomd* conforms to the SOP's of the Storage Service Class at Level 2 (Full). No elements are discarded or modified by *ridicomd*. In the event of a successful C-STORE operation, the image has successfully been written to a local disk as a standard UNIX file. *ridicomd* will never delete a file which it has received; the duration of the storage of the image on the local disk is determined by the archive applications, at which point the image will be moved from short term storage (disk) to medium term storage (tape jukebox). At some point in the time, the tape containing the image will be moved from medium term storage (jukebox) to long term storage (tape archive shelves in central library).

Upon successful reception of the image, the filename of the image is changed so that it will be recognized as a complete DICOM image by riupdate. The format of the image file is Ridicom.nnn where nnn is a sequential number which is meaningless except that it provides the filename with a unique existence.

### 4. PRESENTATION CONTEXT ACCEPTANCE CRITERION

*ridicomd* will always accept a Presentation Context for the Verification SOP Class with the DICOM Default Transfer Syntax. In addition to this, *ridicomd* will accept up to three Presentation Contexts on an association provided that all of the Presentation Contexts specify the same Abstract Syntax. The acceptable Presentation Contexts which *ridicomd* may accept are specified in the table A.2.1.3.2-1. *ridicomd* will examine the proposed Presentation Contexts in the order proposed. The first acceptable Presentation Context (other than Verification) determines the Abstract Syntax which will be used for the association.

### 5. TRANSFER SYNTAX SELECTION POLICIES

*ridicomd* prefers to receive images encoded using an explicit transfer syntax. It may be configured to prefer either explicit big endian or explicit little endian. If offered a choice of Transfer Syntaxes in a Presentation Context, it will apply the following priority to the choice of Transfer Syntax:

1. Configured explicit Transfer Syntax
2. Other explicit Transfer Syntax
3. Default Transfer Syntax

*Ridicom* will use the explicit little endian transfer syntax and support the same SOP classes as *ridicomd*.

## IV. COMMUNICATION PROFILES

### A. SUPPORTED COMMUNICATION STACKS (PARTS 8,9)

*ridcom* and *ridicomd* applications provide support for the DICOM V3.0 TCP/IP Network Communication Support as defined in Part 8 of the DICOM Standard.

### B. TCP/IP STACK

*ridcom* and *ridicomd* use the TCP/IP stack inherent in the UNIX operating system upon which they execute.

#### 1. API

The *ridcom* and *ridicomd* applications have been tested with Solaris 2.3-2.6 of the SUN operating system. These UNIX implementations are based on Berkeley Sockets, however nothing inherent in these applications should limit the operation to these flavors of UNIX. These applications have also been validated on both the **Sparc and Intel** versions of **Solaris 2**.

#### 2. PHYSICAL MEDIA SUPPORT

Both *ridcom* and *ridicomd* are insensitive to the physical media upon which the TCP/IP packets are transmitted. However, transmission speed will be compromised if insufficient bandwidth is provided for appropriate image transfer. Network timeouts will occur if the bandwidth is insufficient to maintain inter-client communication (eg: A heavily used ISDN line would be inappropriate for reliable DICOM communications).

## V. DICOM PRINT CLASS

The following tables display a list of Rational Imaging supported and non-supported print options. The Support column will indicate whether a feature is supported by providing a “Y” for supported options and an “N” for non-supported features. Where applicable, available values will be displayed in the Values column.

### A. FILM SESSION

Option	Support	Values
Number of Copies	Y	
Print Priority	Y	Default = Medium
Medium Type	Y	Current, Clear, Blue, Paper
Film Destination	Y	By AE_TITLE
Film Session Label	N	

### B. FILM BOX

Option	Support	Values
Image Display Format (Standard)	Y	Films are preformatted and printed on 1x1

Image Display Format (Slide 35mm)	N	
Image Display Format (Row)	N	
Image Display Format (Custom)	N	
Film Orientation	Y	Default = Portrait
Film Size ID	Y	14INX17IN, Current, configurable
Magnification Type	Y	Default = BiLinear
Max Density	Y	Default = 0
Configuration Information	Y	Field is blank
Annotation Display Format ID	N	
Smoothing Type	Y	Field is blank
Border Density	Y	Default = BLACK
Empty Image Density	N	
Min Density	Y	Default = 0
Illumination	N	
Reflective Ambient Light	N	
Trim	Y	NO

### C. IMAGE BOX

Option	Support	Values
Image Position	Y	Default = 1
Polarity	Y	Default = "Normal"
Magnification Type	Y	Default = "BILEAR"
Smoothing Type	Y	Default = 0
Configuration Information	N	
Requested Image Size	Y	Field is blank
Body Part Examined	N	
Modality	Y	
Image Tone Adjustment	N	

## VI. STUDY CONTENT NOTIFICATION

The PACS can communicate to the RIS system, if the RIS possesses the feature, certain exam status information including knowledge of exam existence, status of exam archive, or status of deletion. DICOM Study Content Notification allows for information to be forwarded from the PACS to RIS system. The following notification events are currently logged and forwarded:

- 1) New exam imported into PACS
- 2) Exam archived and removed (Only available if retrieved)
- 3) Exam retrieved from jukebox and now available again
- 4) Tape removed from jukebox (exams only available via phone request)
- 5) Tape inserted back into jukebox (exams may be retrieved)
- 6) Exam Deleted before archiving (No longer available on the PACS)

## VII. DICOM QUERY/RETRIEVE

The PACS can accept queries from third party DICOM vendors through the Query/Retrieve protocol. The *riqueryd* application provides Standard Conformance to the following DICOM V3.0 SOP Classes:

<i>Query/Retrieve:</i>	
Patient Query Find	1.2.840.10008.5.1.4.1.2.1.1
Patient Query Move	1.2.840.10008.5.1.4.1.2.1.2
Study Query Find	1.2.840.10008.5.1.4.1.2.2.1
Study Query Move	1.2.840.10008.5.1.4.1.2.2.2
Patient Study Query Find	1.2.840.10008.5.1.4.1.2.3.1
Patient Study Query Move	1.2.840.10008.5.1.4.1.2.3.2

### A. ASSOCIATION ESTABLISHMENT POLICIES

#### 1. GENERAL

The Rational Imaging query/retrieve AE “*riqueryd*” will attempt to establish an association whenever it is invoked with valid association requests.

#### 2. NUMBER OF ASSOCIATIONS

The number of simultaneous associations which will be accepted by *riqueryd* are limited only by the parameters of the UNIX TCP/IP implementation or available system resources such as memory and disk space. To minimize tcp/ip contention and “busy” processes, each scanner may be assigned a unique port number with which to handshake with the dedicated *riqueryd* process. Therefore, a *riqueryd* process can be configured and initialized for each scanner. In addition, the query/retrieve process can be distributed across several servers, to help distribute the load in a multi-site environment.

#### 3. ASYNCHRONOUS NATURE

Synchronous mode of operation is supported on all Associations. No asynchronous operations will be performed by *riqueryd*.

#### 4. IMPLEMENTATION IDENTIFYING INFORMATION

A single Implementation Class UID is used by *riqueryd* which is “1.2.840.113696.1” with an Implementation Version Name of “RI\_QUERY”. The Application Entity (AE) Title for the Rational Imaging Storage AE is “RI\_QUERY”. This is a configurable parameter on the process command line.

### B. ASSOCIATION INITIATION POLICY

The Query/Retrieve Server AE *riqueryd* will not initiate associations. It acts only as a SCP (Service Class Provider).

The Query/Retrieve AE *retrieve* acts as the DICOM Query/Retrieve SCU (Service Class User). It will initiate associations with preconfigured foreign imaging systems providing query/move capabilities. Patient exams may be selected and sent to any preconfigured DICOM C-STORE destination. Single or multiple destinations may be utilized in a single transfer operation. Calling and receiving AE\_TITLES, Port numbers and hostnames are completely configurable within the *ridicom* application.

## C. ASSOCIATION ACCEPTANCE POLICY

The Query/Retrieve AE *riqueryd* will accept associations compliant with the DICOM 3.0 specifications and will receive any requests transmitted on that association. No restrictions are placed on who may connect to *riqueryd*, nor on the number of simultaneous connections it will support. However the process can be configured to run in secure mode validating each request.

### 1. ASSOCIATED REAL-WORLD ACTIVITY

The associated Real-World Activity associated with the Query/Retrieve operation is the storage of the image on the local disk of the system upon which *riqueryd* server has been requested in the C-MOVE request. *riqueryd* will issue a failure status if it is unable to store the image on disk, or if the image transferred does not conform to the IOD of the SOP Class under which it was transmitted.

## VIII. CONFIGURATION

*ridicomd* may be configured on the command line as specified in the following sections.

### A. AE TITLE/PRESENTATION ADDRESS MAPPING

The AE Title and Presentation Address Mapping may be specified on the command line as follows:

```
ridicomd -t AE_TITLE -p PORT_NUMBER ↵
```

The default AE\_TITLE is “RI\_DICOM” and the default Port Number specified by the DICOM standard is “104”. These values combined with the hostname make the *ridicomd* process unique so that associations occurring between the scanner and the RI workstation do not get interrupted.

## B. CONFIGURABLE PARAMETERS

The AE\_TITLE and port number configurations were presented in the previous section. Other command line parameters may be added to achieve the desired effects. They are as follows:

- v     Verbose (for debugging)
- f     Forgiving (for moderately-compliant DICOM applications)
- m #   maxPDU = #.

These configurable parameters are established in the “*inittab*” located in the /etc directory. The inittab addition is added as a part of the normal installation, and just needs to be turned on in /etc/inittab.

Change 'off' to 'respawn' in the following line in /etc/inittab:

```
r4:34:off:/opt/ist/scripts/ireceive104.sh
```

---

## IX. SUPPORT OF EXTENDED CHARACTER SETS

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Both *ridcom* and *ridicomd* are indifferent to Extended Character Sets and does not rely on the information contained within the data elements.