
HealthView CardioPACS 6.0

Version 6.0.4

DICOM Conformance Statement



Document Revision History

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12/20/2011	942-00749-01 Rev. B	Added statement of product conformance to the ACR-NEMA DICOM 3.0 standard
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Introduction

This DICOM Conformance Statement describes the product conformance to the ACR-NEMA DICOM 3.0 standard. It is written according to the instructions and models from part PS 3.2. LUMEDX has tested to and confirmed compliance with this standard, except where specifically noted in the following pages.

Document Sources

- Parts 1-18 of the ACR-NEMA Digital Imaging and Communications in Medicine (DICOM) Standard, Version 3.0. Refer to <http://medical.nema.org/>.
- Integrating the Healthcare Enterprise (IHE) framework. Refer to <http://www.ihe.net/>.

Abbreviations

The following abbreviations below are included this document:

Abbreviation	Definition
AE	Application Entity
DICOM	Digital Imaging and Communications in Medicine
FSC	File-set Creator
FSR	File-set Reader
FSU	File-set Updater
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IHE	Integrating the Healthcare Enterprise
NEMA	National Electrical Manufacturers Association
PDU	Protocol Data Unit
SCP	Service Class Provider
SCU	Service Class User
SOP	Service Object Pair

Abbreviation	Definition
SR	DICOM Structured Report Object
TCP/IP	Transmission Control Protocol / Internet Protocol
UID	Unique Identifier

Interoperability

The DICOM interfaces of CardioPACS are tested with third party vendor products such as acquisition, PACS, Storage, and Query/Retrieve interfaces. However, DCSs and the DICOM standard do not always guarantee interoperability.

LUMEDX recommends that the DCS documents for third-party products to be connected be compared and that a specific suite of tests be created and performed between those products to verify interoperability and to identify any issues.

CardioPACS Server Overview

The CardioPACS server is an implementation of a medical imaging storage and archive system. It is a database and a storage mechanism for DICOM AEs to send data to. DICOM AEs can send data to it, query it for data, retrieve data from it, ask that it take responsibility for the safe storage of data, and verify connectivity with it. CardioPACS server can also perform similar actions with other DICOM AEs on the network, such as forwarding data to them, querying them for data, retrieving data from them, and asking them to take responsibility for the safe archival of forwarded data.

Measurement data sent to the CardioPACS server using supported DICOM Structured Reporting templates (e.g. Echo, Vascular) imports into the CardioPACS system for use during diagnostic review on the CardioPACS workstation. Measurement data can also be mapped quickly if the data is not yet mapped into the CardioPACS system.

The CardioPACS server DICOM interface acts as a DICOM service class provider (SCP) for Query/Retrieve, Storage, Storage Commitment, and Verification Service Classes.

The CardioPACS server DICOM interface acts as a DICOM service class user (SCU) for Query/Retrieve, Storage, Storage Commitment, and Verification Service Classes.

The CardioPACS server DICOM interface allows for the parsing, mapping, and import of measurements from DICOM SR objects into the CardioPACS system.

CardioPACS Server Implementation Model

The CardioPACS server is a collection of services that listen on network interfaces to collect medical imaging data and manage the related information in a database and file system. It is a single application entity that can:

- Receive data for local storage management
- Forward previously received data to another storage management system on the network
- Send and receive queries to locate and retrieve data
- Provide for the safe storage of the data
- Verify successful networking connectivity with other networked products

CardioPACS Server Application Data Flow

Figure 1 shows the DICOM data flow to and from the CardioPACS server interfaces. This section describes the data flow displayed in the diagram.

In the remote real-world activity “Commit Objects,” an application entity (AE) opens an association with the CardioPACS server and sends a request asking that the CardioPACS server take responsibility for the safe archival of a set of SOP Instances. The CardioPACS server accepts the request and responds on a separate association to the requestor to notify it of the status of the safe archival for each SOP Instance. The CardioPACS server is also capable of sending such requests to other DICOM AEs on the network.

In the remote real-world activity “FIND Objects,” an application entity (AE) opens an association with the CardioPACS server and sends a query to find specific objects. The CardioPACS server searches its database for matching data to the requested query and returns that information to the requestor if any matches are found. The CardioPACS server is also capable of sending such queries to a remote AE as well.

In the remote real-world activity “MOVE Objects,” an application entity (AE) opens an association with the CardioPACS server and sends a query to find and then retrieve specific objects. The CardioPACS server searches its database for matching data to the requested query and then opens a separate association with the requested destination AE to send the data if matches were found. The CardioPACS server provides a status on the original requesting (MOVE) association until the operation is completed. The CardioPACS server is also capable of sending such queries to a remote AE as well.

In the remote real-world activity “Store Objects,” an application entity (AE) opens an association with the CardioPACS server and sends one or more DICOM SOP instances. The CardioPACS server writes the data in DICOM Part 10 format on its configured storage media and also registers the related information in its database. The CardioPACS server is also capable of storing SOP Instances to a remote AE as well.

In the remote real-world activity “Verification”, an application entity (AE) opens an association with the CardioPACS server and sends a DICOM verification request. The CardioPACS server will accept the request and return a response to indicate a successful connection.

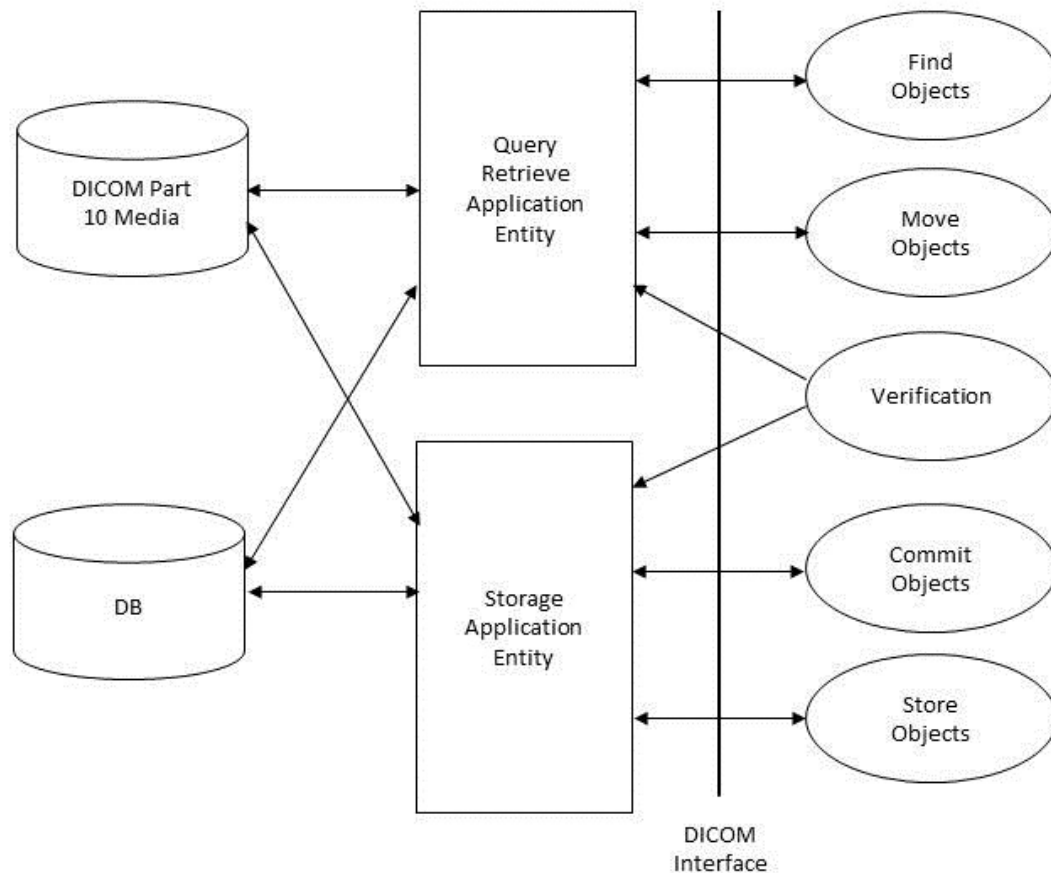


Figure 1 – Application Data Flow Diagram

Functional Definition of Application Entities

The CardioPACS server performs operations under two AE titles. The operations are described in the CardioPACS Server Application Data Flow section.

Sequencing of Real World Activities

CardioPACS server sends Storage Commitment requests only after it has sent data to a remote AE.

CardioPACS server will service retrieval requests whether data is available locally or only on a known remote AE. CardioPACS server will first retrieve objects to its local archive before sending them to the requestor when data is requested that not available locally.

AE Specifications

CardioPACS server operates using a two application entities: Storage and Q/R.

CardioPACS Server Specifications

The CardioPACS server application entities provide standard conformance to the following SOP Classes.

SOP Class Name	SOP Class UID	Role	AE
All Storage SOP Classes *	All Storage SOP Classes *	SCP/SCU	Storage
All Private Storage SOP Classes **	All Private Storage SOP Classes **	SCP/SCU	Storage
Verification SOP Class	1.2.840.10008.1.1	SCP	Q/R
			Storage
Storage Commitment Push Model SOP Class	1.2.840.10008.1.20.1	SCP/SCU	Storage
Study Root Query/Retrieve Information Model – MOVE	1.2.840.10008.5.1.4.1.2.2.2	SCP/SCU	Q/R

Figure 2 - CardioPACS Server Supported SOP Classes

* The CardioPACS server Storage SCU and SCP support all of the DICOM defined SOP Classes for the Storage Service SOP Class.

** The CardioPACS server Storage SCU and SCP will attempt to negotiate and receive objects related to privately defined Storage Service SOP Classes. If the DICOM negotiation and data are encoded correctly according to the standard then this is likely to succeed, but is not guaranteed. Be aware that archiving to a remote third party PACS for long-term storage may not succeed for such objects unless that third party PACS also supports the privatized SOP Class.

The CardioPACS server application entities provide partial conformance to the following SOP Classes.

SOP Class Name	SOP Class UID	Role	AE
Study Root Query/Retrieve Information Model – FIND	1.2.840.10008.5.1.4.1.2.2.1	SCP/SCU	Q/R

Association Policies

Context

The following application context is proposed and recognized by the CardioPACS server:

- DICOM Application Context Name – 1.2.840.10008.3.1.1.1

Number of Associations

There is no limit to the number of associations that can be opened with the CardioPACS server, other than the limits on resources made available by the host operating system.

Asynchronous Nature

The CardioPACS server does not support asynchronous operations outside of any default behaviors defined in the DICOM specification.

Implementation Identifying Information

- The CardioPACS server uses the following implementation identifying information:
- Implementation Class UID - 1.2.826.0.1.3680043.1.2.100.5.6.3.169
- Implementation Version Name - DicomObjects.NET

Association Initiation Policy

The CardioPACS server initiates associations for the following real world activities:

- Commit Objects
- FIND Objects
- MOVE Objects
- Store Objects

Real World Activity – Commit Objects (Initiate)

The CardioPACS server will request a remote DICOM AE to take ownership for the safe archival of DICOM objects. An association is created automatically after study objects have been sent to a remote DICOM AE. This occurs if the CardioPACS server configuration for that AE has Storage Commitment SCP enabled, the setting to open a new separate association is enabled (rather than using the same association as image storage), and the setting to forward study data to that remote DICOM AE is enabled. A user can also manually retry this mechanism if several attempts from the server's automatic attempts have failed.

Proposed Presentation Contexts – Commit Objects

The CardioPACS server will propose the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Storage Commitment Push Model SOP Class	1.2.840.10008.1.20.1	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

Figure 3 - Proposed Presentation Contexts - Commit Objects (Initiate)

SOP Specific Conformance – Commit Objects

The CardioPACS server application entity provides standard conformance to the Storage Commitment Push Model SOP Class.

General Behaviors – Commit Objects

The CardioPACS server sends commitment requests on a per object basis. Any of the Storage SOP Class UID's listed in Figure 2 - CardioPACS Server Supported SOP Classes may appear in a given Storage Commitment request from the CardioPACS server.

Erroneous Behaviors – Commit Objects

Successful and failed commitment responses for each object requested from the remote DICOM AE are tracked in the CardioPACS server database. Objects that have successfully been committed for safe archival on the remote AE become candidates for deletion from the local file system when free space is needed. The Storage Commitment request job will fail when Objects have not been successfully committed. The user can identify failed commitment jobs and can either retry the job or troubleshoot the problem.

Real World Activity – FIND Objects (Initiate)

The CardioPACS server queries remote DICOM AEs to find or confirm patient, study, series, and instance level DICOM information. An association is opened when the user triggers a query from a GUI on the workstation.

Proposed Presentation Contexts – FIND Objects

The CardioPACS server will propose the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		

Presentation Context					
Study Root Query/Retrieve Information Model - FIND	1.2.840.10008.5.1.4.1.2.2.1	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

Figure 4 - Proposed Presentation Contexts - FIND Objects (Initiate)

SOP Specific Conformance – FIND Objects

The CardioPACS server application entity provides partial conformance to the Study Root Query/Retrieve Information Model – FIND SOP Class with extended behavior including several optional Matching and Return keys suggested within the IHE framework. The following figures list the keys that are queried by the CardioPACS server.

Study Root Query/Retrieve Information Model - FIND			
Level	Description	Tag	DICOM Type
Study *	Patient Name	(0010,0010)	R
	Patient ID	(0010,0020)	R
	Patient Birth Date	(0010,0030)	O
	Patient Sex	(0010,0040)	O
	Study Date	(0008,0020)	R
	Study Time	(0008,0030)	R
	Accession Number	(0008,0050)	R
	Modalities in Study	(0008,0061)	O
	Referring Physician Name	(0008,0090)	O
	Study Description	(0008,1030)	O
	Study ID	(0020,0010)	R
	Study Instance UID	(0020,000D)	U
	Number of Study Related Instances	(0021,1206)	O
	Number of Study Related Instances	(0020,1208)	O
Series *	Modality *	(0008,0060)	R

Study Root Query/Retrieve Information Model - FIND			
	Series Description	(0008,103E)	O
	Series Number	(0020,0011)	R
	Series Instance UID	(0020,000E)	U
	Number of Series Related Instances	(0020,1209)	O
	Scheduled Procedure Step ID	(0040,0009)	O
	Performed Procedure Step Start Date	(0040,0244)	O
	Performed Procedure Step End Date	(0040,0250)	O
	Performed Procedure Step End Time	(0040,0251)	O
	Performed Procedure Step Start Time	(0040,0255)	O
	Requested Procedure ID	(0040,1001)	O
Instance*	SOP Class UID	(0008,0016)	O
	SOP Instance UID	(0008,0018)	U
	Instance Number	(0020,0013)	R
	Number of Frames	(0028,0008)	O
	Rows	(0028,0010)	O
	Columns	(0028,0011)	O
	Bits Allocated	(0028,0100)	O

Figure 5 – SOP Specific Conformance - FIND Objects Study Root (Initiate)

* CardioPACS sends all queries and attributes at the Study level except when a user filters for a specific Modality (0008, 0060) from the user interface. This includes attributes that meant to be sent on the Study, Series, and Instance levels. Interoperability testing is recommended as some PACS products may not return results to such queries. Please contact LUMEDX to verify if such testing has been done already or can be performed with your PACS.

General Behaviors – FIND Objects

The CardioPACS server shares the pending status and identified information from queries sent to remote DICOM AEs with the CardioPACS workstation for further processing in the workstation GUI.

Erroneous Behaviors – FIND Objects

The CardioPACS server notifies the CardioPACS workstation when warnings, failures, or any errors have occurred while performing a query to a remote DICOM AE.

The CardioPACS server does not fully support extended character sets (e.g. ISO IR-100) for matching purposes and does not send the character set in its queries if extended characters are used. Sometimes it may be necessary to query with other known information where the character set is often basic (e.g. Patient ID).

Real World Activity – MOVE Objects (Initiate)

The CardioPACS server requests that remote DICOM AEs send DICOM study, series, and/or instance objects to another DICOM AE on the network, such as the CardioPACS server DICOM AE. This real world activity occurs when a user attempts to open a study that is identified on a remote AE from a GUI on the CardioPACS workstation.

Proposed Presentation Contexts – MOVE Objects

The CardioPACS server will propose the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Patient Root Query/Retrieve Information Model - MOVE	1.2.840.10008.5.1.4.1.2.1.2	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
Study Root Query/Retrieve Information Model - MOVE	1.2.840.10008.5.1.4.1.2.2.2				

Figure 6 - Proposed Presentation Contexts - MOVE Objects (Initiate)

SOP Specific Conformance – MOVE Objects

The CardioPACS server application entity provides standard conformance to the Patient Root and Study Root Query/Retrieve Information Model – MOVE SOP Classes. The following figures list the keys that are queried for by the CardioPACS server.

Patient Root Query/Retrieve Information Model - MOVE			
Level	Description	Tag	DICOM Type

Patient Root Query/Retrieve Information Model - MOVE			
Patient	Patient ID	(0010,0020)	U
Study	Study Instance UID	(0020,000D)	U
Series	Series Instance UID	(0020,000E)	U
Instance	SOP Instance UID	(0008,0018)	U

Figure 7 – SOP Specific Conformance - MOVE Objects Patient Root (Initiate)

Study Root Query/Retrieve Information Model - MOVE			
Level	Description	Tag	DICOM Type
Study	Patient ID	(0010,0020)	R
Study	Study Instance UID	(0020,000D)	U
Series	Series Instance UID	(0020,000E)	U
Instance	SOP Instance UID	(0008,0018)	U

Figure 8 – SOP Specific Conformance - MOVE Objects Study Root (Initiate)

General Behaviors – MOVE Objects

The CardioPACS server may send move requests using the Study Root model using either a Study Level move or an Instance Level move. The CardioPACS workstation is updated by the CardioPACS server with the status of related MOVE operations as a result of the user attempting to open a study that is known to be on a remote DICOM AE. Associations are opened when the user attempts to open a study that is identified on a remote AE by using a GUI on the CardioPACS workstation, the server is configured to perform study pre-fetching, or workstations are configured to perform study caching.

Erroneous Behaviors – MOVE Objects

The CardioPACS server notifies the CardioPACS workstation when warnings, failures, or any errors have occurred while performing a move operation with a remote DICOM AE. These messages are available for further processing in the workstation GUI. If a move operation was erroneous as a result of the user opening a study then the move operation (job) is put into a state that identifies the issue for further action. This action is performed manually by the user, such as retrying the job or identifying the cause of the problem.

The CardioPACS server does not fully support extended character sets (e.g. ISO IR-100) for matching purposes and does not send the character set in its queries if extended characters are used. Sometimes it may be necessary to query with other known information where the character set is often basic (e.g. Patient ID).

Real World Activity – Store Objects (Initiate)

The CardioPACS server sends DICOM objects to remote DICOM AEs to share a copy of the objects or for long-term storage. This real world activity occurs when the CardioPACS server determines that it needs to archive a study to an AE that is configured as a long-term archive, and when the CardioPACS server is configured to send a copy of the objects in a study to one or more remote DICOM AEs.

Proposed Presentation Contexts – Store Objects

The CardioPACS server will propose the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
All Storage SOP Classes *		All Transfer Syntaxes *		SCU	None
All Private Storage SOP Classes *					

Figure 9 - Proposed Presentation Contexts - Store Objects (Initiate)

* See SOP Specific Conformance – Store Objects for information.

SOP Specific Conformance – Store Objects

The CardioPACS server application entity provides standard conformance to the Storage Service Class as an SCU. The CardioPACS server will attempt to send objects to a remote DICOM AE using the same SOP Class and Transfer Syntax that the objects were originally received with. This behavior occurs for both DICOM defined Storage SOP Classes and Private Storage SOP Classes. The CardioPACS server supports all of the Transfer Syntaxes defined by DICOM. It does not support any private Transfer Syntaxes. Image analysis and manipulations performed on DICOM objects within the CardioPACS system can result in the addition of the following attributes to those objects when they are exported from the CardioPACS system:

- (003x, xxxx) – Where the group “x” is the next available odd number (e.g. 1, 3, 5, 7, 9) not yet in use within the object’s header. This data is privatized information that is only expected to be understood by the CardioPACS workstation.
- (60xx,xxxx) – Where the group “xx” is the next available even number (e.g. 02, 04, 06, etc.) not yet in use within the object’s header. This data is DICOM Overlay Plane data that is expected to be understood by DICOM viewers that support DICOM Overlay viewing.

General Behaviors – Store Objects

Associations may be opened at any time depending on the configuration of each remote DICOM AE on the CardioPACS server and on incoming studies which are configured to be forwarded to remote DICOM AEs. The CardioPACS server attempts to send objects to remote AEs using the same DICOM Transfer Syntax that the objects were received with originally.

Erroneous Behaviors – Store Objects

The storage operation (job) is put into a state that identifies the issue for further action to be performed manually by the user, such as retrying the job or identifying the cause of the problem when the following occur:

- The storage job was erroneous
- The original transfer syntax of an object related to the storage job was not negotiated and the storage job is related to the long-term storage of that object.

When the CardioPACS server is configured to manage free space on its system (for example, its RAID) it only removes objects that were either successfully sent to the configured long-term archive or were both successfully sent and committed via Storage Commitment based on the configuration for that remote DICOM AE. Refer to the Real World Activity – Commit Objects (Accept) for information.

Association Acceptance Policy

The CardioPACS server accepts associations for the following real world activities:

- Commit Objects
- FIND Objects
- MOVE Objects
- Store Objects
- Verification

Associations may be refused for the CardioPACS Q/R SCP if the Calling AE is not known to the CardioPACS server. The CardioPACS Storage SCP will accept all Calling AE titles.

Real World Activity – Commit Objects (Accept)

The CardioPACS server allows a DICOM AE to request that it take ownership for the safe archival of DICOM data that was sent to it. Associations may be opened at any time with the CardioPACS server to send these requests. The CardioPACS server will verify that the data in the request was received for safe archival before it responds to the DICOM AE that sent the commitment request. The CardioPACS server can handle commitment requests from mobile devices such as ultrasound machines that connect to send data and then disconnect before a response can be sent back as recommended by IHE.

Accepted Presentation Contexts – Commit Objects

The CardioPACS server will accept the following presentation contexts for this activity:

Presentation Context			
Abstract Syntax	Transfer Syntax	Role	Extended

Presentation Context					
Name	UID	Name	UID		Negotiation
Storage Commitment Push Model SOP Class	1.2.840.10008.1.20.1	Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None

Figure 10 - Accepted Presentation Contexts - Commit Objects (Accept)

SOP Specific Conformance – Commit Objects

The CardioPACS server application entity provides standard conformance to the Storage Commitment Push Model SOP Class.

General Behaviors – Commit Objects

The CardioPACS server will attempt to send a commitment response on a new association after it determines that the data requested in the commitment request was safely received.

Erroneous Behaviors – Commit Objects

Successful and failed commitment responses to the requesting remote DICOM AE are tracked in the CardioPACS server database. CardioPACS server will retry commitment responses which previously failed to connect to the requesting DICOM AE due to the AE being disconnected from the network (for example, if the AE is mobile or is off) when that requesting AE reconnects to the CardioPACS server to send more data. If a problem occurs while parsing the requesting DICOM AE's commitment request, then no response is returned to the requesting AE.

Real World Activity – FIND Objects (Accept)

The CardioPACS server allows a DICOM AE to request matching information from the database related to the patient/study/series/instance data set by the requesting DICOM AE. Associations may be opened at any time with the CardioPACS server to send these requests to it. CardioPACS server can return status messages to relay success, failure, or other problems.

Accepted Presentation Contexts – FIND Objects

The CardioPACS server will accept the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		

Presentation Context					
Patient Root Query/Retrieve Information Model - FIND	1.2.840.10008.5.1.4.1.2.1.1	Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Study Root Query/Retrieve Information Model - FIND	1.2.840.10008.5.1.4.1.2.2.1				

Figure 11 - Accepted Presentation Contexts - FIND Objects (Accept)

SOP Specific Conformance – FIND Objects

The CardioPACS server application entity provides standard conformance to the Patient Root and Study Root Query/Retrieve Information Model – FIND SOP Classes with extended behavior, including optional Matching and Return keys suggested within the IHE framework. The following figures list the keys that are supported by the CardioPACS server.

Patient Root Query/Retrieve Information Model - FIND			
Level	Description	Tag	DICOM Type
Patient	Patient Name	(0010,0010)	R
	Patient ID	(0010,0020)	U
	Patient Birth Date	(0010,0030)	O
	Patient Sex	(0010,0040)	O
Study	Study Date	(0008,0020)	R
	Study Time	(0008,0030)	R
	Accession Number	(0008,0050)	R
	Modalities in Study	(0008,0061)	O
	Referring Physician Name	(0008,0090)	O
	Study Description	(0008,1030)	O
	Study ID	(0020,0010)	R
	Study Instance UID	(0020,000D)	U
	Number of Study Related Series *	(0020,1206)	O

Patient Root Query/Retrieve Information Model - FIND			
	Number of Study Related Instances *	(0020,1208)	O
Series	Modality	(0008,0060)	R
	Series Description	(0008,103E)	O
	Series Number	(0020,0011)	R
	Series Instance UID	(0020,000E)	U
	Number of Series Related Instances *	(0020,1209)	O
	Scheduled Procedure Step ID	(0040,0009)	O
	Performed Procedure Step Start Date	(0040,0244)	O
	Performed Procedure Step Start Time	(0040,0255)	O
	Requested Procedure ID	(0040,1001)	O
Instance	SOP Class UID	(0008,0016)	O
	SOP Instance UID	(0008,0018)	U
	Instance Number	(0020,0013)	R
	Number of Frames *	(0028,0008)	O
	Rows *	(0028,0010)	O
	Columns *	(0028,0011)	O
	Bits Allocated *	(0028,0100)	O

Figure 12 – SOP Specific Conformance - FIND Objects Patient Root (Accept)

* These optional attributes are not supported as matching keys. They are supported as return keys.

Study Root Query/Retrieve Information Model - FIND			
Level	Description	Tag	DICOM Type
Study	Patient Name	(0010,0010)	R
	Patient ID	(0010,0020)	R
	Patient Birth Date	(0010,0030)	O
	Patient Sex	(0010,0040)	O

Study Root Query/Retrieve Information Model - FIND			
	Study Date	(0008,0020)	R
	Study Time	(0008,0030)	R
	Accession Number	(0008,0050)	R
	Modalities in Study	(0008,0061)	O
	Referring Physician Name	(0008,0090)	O
	Study Description	(0008,1030)	O
	Study ID	(0020,0010)	R
	Study Instance UID	(0020,000D)	U
	Number of Study Related Series *	(0020,1206)	O
	Number of Study Related Instances*	(0020,1208)	O
Series	See Patient Root Q/R Model FIND (Figure 5 – SOP Specific Conformance - FIND Objects Patient Root (Initiate)) **		
Instance	See Patient Root Q/R Model FIND (Figure 5 – SOP Specific Conformance - FIND Objects Patient Root (Initiate)) **		

Figure 13 - SOP Specific Conformance - FIND Objects Study Root (Accept)

* These optional attributes are not supported for matching; however, they are returned if asked for in the request.

** The Series and Instance level keys supported in queries using the Study Root FIND model are the same as those supported in the Patient Root FIND model at their respective query levels.

General Behaviors – FIND Objects

The CardioPACS server will populate supported matching and return keys with their respective values if they are known in the CardioPACS system. Matching performed on Person Name value representations (for example, Patient Name) are always performed case insensitive by CardioPACS server. The DICOM required pending status is sent to the requesting DICOM AE while matching results are being returned. A status of success is returned if no problems occurred during the matching and responding process and that process has finished. The status messages are:

- 0000 – Success
- FF00 - Pending

Erroneous Behaviors – FIND Objects

The CardioPACS server can respond with statuses other than success or pending when problems have occurred. CardioPACS server will return the refused status if an unconstrained query is received. The status messages are:

- A700 – Refused (Out of resources or unconstrained query received)
- C000 – Failure (Unable to process)
- FE00 – Cancel (Cancel request received)

The CardioPACS server does not fully support extended character sets (e.g. ISO IR-100) for matching purposes and may not return matching data or the specific character set attribute with a value when queries with characters of from those extended character sets are requested. Sometimes it may be necessary to query CardioPACS with other known information where the character set is often basic (e.g. Patient ID).

Real World Activity – MOVE Objects (Accept)

The CardioPACS server allows a DICOM AE to request that CardioPACS server send DICOM data to a specific remote DICOM AE on the network. Associations may be opened at any time with the CardioPACS server to send these requests to it. CardioPACS server can return status messages to relay success, failure, or other problems.

Accepted Presentation Contexts – MOVE Objects

The CardioPACS server will accept the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Patient Root Query/Retrieve Information Model - MOVE	1.2.840.10008.5.1.4.1.2.1.2	Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
Study Root Query/Retrieve Information Model - MOVE	1.2.840.10008.5.1.4.1.2.2.2				

Figure 14 - Accepted Presentation Contexts - MOVE Objects (Accept)

SOP Specific Conformance – MOVE Objects

The CardioPACS server application entity provides standard conformance to the Patient Root and Study Root Query/Retrieve Information Model – MOVE Service Classes.

General Behaviors – MOVE Objects

Destination AEs that send the MOVE request must be configured within the CardioPACS server before the CardioPACS server can successfully connect to the Destination AE. A new association is opened by the CardioPACS with the Destination AE from the MOVE request so that the CardioPACS server can perform storage sub-operations. The CardioPACS server will provide pending status updates to the requestor of the MOVE association while performing storage sub-operations on a separate association. The pending status updates contain remaining, completed, failed, and warning sub-operation information. When storage sub-operations are complete, with or without a failure, the storage association is closed and a final status is returned to the requestor on the original MOVE association. The requestor can then close the MOVE association. The status update messages are:

- 0000 – Success (Sub-operations are complete without failure)
- FF00 – Pending (Sub-operations are continuing)

Erroneous Behaviors – MOVE Objects

The CardioPACS server can return the following error status messages on the MOVE association:

- A702 – Failure (Refused: Unable to perform sub-operations)
- A801 – Failure (Refused: Move destination unknown)
- B000 – Warning (Sub-operations completed with one or more failures)
- C000 – Failure (Unable to process)
- FE00 – Cancel (Sub-operations terminated due to Cancel instruction)

The CardioPACS server does not fully support extended character sets (e.g. ISO IR-100) for matching purposes and may not generate subsequent storage operations in response to a MOVE request when queries with characters of from those extended character sets are requested. Sometimes it may be necessary to query CardioPACS with other known information where the character set is often basic (e.g. Patient ID).

Real World Activity – Store Objects (Accept)

The CardioPACS server allows a DICOM AE to send DICOM objects to it for storage. Associations can be opened at any time with the CardioPACS server to store objects. CardioPACS server returns status messages to relay success, failure, or other problems for each object storage operation. The CardioPACS server can be configured to forward a copy of the received objects to other DICOM AEs on the network.

Accepted Presentation Contexts – Store Objects

The CardioPACS server will accept the following presentation contexts for this activity:

Presentation Context

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
All Storage SOP Classes *		All Transfer Syntaxes *		SCP	None
All Private Storage SOP Classes *					

Figure 15 - Accepted Presentation Contexts - Store Objects (Accept)

* Refer to the SOP Specific Conformance – Store Objects section for information.

SOP Specific Conformance – Store Objects

The CardioPACS server provides Level 2 (Full) conformance to the DICOM Storage Service Class as an SCP. No optional attributes are removed. Type 1, 2, and 3 attributes are retained.

The CardioPACS server and workstation client may modify any of the following DICOM attributes to match values maintained within the LUMEDX CVIS. The modified data is maintained when it is exported from the CardioPACS system.

Applicable DICOM Data for Modification		
DICOM Attribute Name	DICOM Tag	Modification Location
Instance Creation Date	(0008,0012)	Workstation
Instance Creation Time	(0008,0013)	Workstation
Study Date	(0008,0020)	Workstation
Series Date	(0008,0021)	Workstation
Study Time	(0008,0030)	Workstation
Series Time	(0008,0031)	Workstation
Accession Number	(0008,0050)	Workstation
Referring Physicians Name	(0008,0090)	Workstation
Study Description	(0008,1030)	Workstation
Series Description	(0008,103E)	Workstation
Performing Physicians Name	(0008,1050)	Workstation
Operator Name	(0008,1070)	Workstation
Patient's Name	(0010,0010)	Server and Workstation

Applicable DICOM Data for Modification		
Patient ID	(0010,0020)	Server and Workstation
Patient Birth Date	(0010,0030)	Workstation
Patient's Sex	(0010,0040)	Workstation
Patient's Age	(0010,0010)	Workstation
Patient's Size	(0010,1020)	Workstation
Patient's Weight	(0010,1030)	Workstation
Study ID	(0020,0010)	Workstation
Series Number	(0020,0011)	Workstation
Instance Number	(0020,0013)	Workstation
Image Comments	(0020,4000)	Workstation

Figure 16 – Applicable DICOM Data for Modification

General Behaviors – Store Objects

The CardioPACS server supports all of the Transfer Syntaxes defined by DICOM for Storage SOP Classes. It does not support any private Transfer Syntaxes.

If an object is received with the same Study, Series, and SOP Instance UID of an object that already exists in the CardioPACS system then the existing object may be overwritten or a new object (new SOP Instance UID) will be generated, depending on the configuration of the CardioPACS server Storage SCP. The default setting is to overwrite the existing object.

Transfer Syntax Selection Behavior

CardioPACS server has a default Transfer Syntax selection order that is used when multiple Transfer Syntaxes are offered for the same Presentation Context. The default selection order is:

Default Selection Order

1. JPEG Lossless (Process 14)
2. RLE Lossless
3. Explicit VR Little Endian
4. Implicit VR Little Endian
5. JPEG Lossy (Process 1)

If only one DICOM defined Transfer Syntax is offered for a Presentation Context then it will be accepted if the SOP Class is supported and the Transfer Syntax is DICOM defined.

Erroneous Behaviors – Store Objects

CardioPACS server can return one of the following C-STORE-RSP statuses if an issue exists or has occurred during the operation:

- A701 – (Refused: Out of Resources – No storage volume space available)
- C000 – (Failure: Unable to process)

If a problem occurs during the parsing and internal storage of a received DICOM object then the CardioPACS server will return the C000 status in the C-STORE-RSP.

Real World Activity – Verification (Accept)

The CardioPACS server accepts verification request from remote DICOM AEs at any time.

Accepted Presentation Contexts – Verification

The CardioPACS server will accept the following presentation contexts for this activity:

Presentation Context					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Verification	1.2.840.10008.1.1	Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None

Figure 17 - Accepted Presentation Contexts - Verification (Accept)

SOP Specific Conformance – Verification

The CardioPACS server application entity provides standard conformance to the Verification Service Class.

General Behaviors – Verification

Associations may be opened at any time with any CardioPACS server DICOM SCP to perform Verification requests. CardioPACS server will respond to Verification requests.

Communication Interfaces

TCP/IP

The CardioPACS server conforms to the IPv4 TCP/IP Network Communication Support definition from the DICOM 3.0 Standard (Part 8). The physical medium used to perform TCP/IP communication does not affect CardioPACS (for example, 1 Gb NIC or 100Mb NIC.).

CardioPACS Workstation Overview

The CardioPACS workstation is an implementation of a medical imaging review station. The workstation allows users to display, manipulate, analyze, and post-process DICOM medical imaging data that is available on the CardioPACS server. All imaging SOP Classes and Transfer Syntaxes conforming to the DICOM standard can be viewed on the CardioPACS workstation; however, additional analysis tools are provided to enhance the overall diagnosis experience for the following SOP Classes: US, USMF, XA, SC, NM, PET, CT, and MR. Measurement data imported from DICOM Structured Report (SR) objects at the CardioPACS server are accessible at the CardioPACS workstation. Measurement mapping updates can be performed quickly on the CardioPACS server using supported SR templates (for example, Echo, Vascular, and Pediatric Echo) if any are missing.

The CardioPACS workstation transfers DICOM data to and from the CardioPACS server and remote DICOM AEs on the network using internal proprietary mechanisms with the CardioPACS Server. The CardioPACS workstation can read and write DICOM Media with a DICOMDIR, individual files, or directories of files written to disk, in DICOM Part 10 format.

The CardioPACS workstation performs the following DICOM functions directly while all other DICOM functionality is performed via internal interfacing with the CardioPACS server:

- Reading DICOM data from DICOM Media Storage – File-set Reader (FSR)
- Writing DICOM data to DICOM Media Storage – File-set Creator (FSC)

CardioPACS Workstation Implementation Model

The CardioPACS workstation transfers DICOM data to and from the CardioPACS server and remote DICOM AEs on the network using internal proprietary mechanisms with the CardioPACS Server. There are no DICOM networking interfaces for the workstation.

CardioPACS Workstation AE Specifications

The CardioPACS workstation transfers DICOM data to and from the CardioPACS server and remote DICOM AEs on the network using internal proprietary mechanisms with the CardioPACS Server. There are no DICOM AEs to be specified for the workstation.

The user can manually modify any of the DICOM attributes listed in Figure 16 at the workstation during image review. The modified data is maintained when it is exported from the CardioPACS system.

Communication Interfaces

TCP/IP

The CardioPACS workstation communicates with the CardioPACS server over an IPv4 TCP/IP network connection. The physical medium used to perform TCP/IP communication does not affect CardioPACS (for example 1 GB NIC or 100 MB NIC).

Protocols

HTTP

The CardioPACS workstation can be configured to communicate using HTTP with the CardioPACS server. The port is configurable. This type of configuration is often used for workstations that are outside of the hospital LAN or are remotely located.

HTTPS

The CardioPACS workstation can be configured to communicate using HTTPS with the CardioPACS server. The port is configurable. This type of configuration is often used for workstations that are outside of the hospital LAN or are remotely located.

TCP/IP

The CardioPACS workstation can be configured to communicate using direct TCP/IP sockets with the CardioPACS server. The port is configurable. This type of configuration is often used for workstations that are part of the hospital LAN.

TCP/IP with TLS

The CardioPACS workstation can be configured to use Transport Layer Security (TLS) when configured for communication with the server over Direct TCP/IP.

Media Interchange

This section of the DCS describes the DICOM Media Interchange capabilities of the CardioPACS workstation. Support for DICOM Media Storage Application Roles and Profiles are also described.

The CardioPACS workstation provides use of its DICOM interchange abilities via CD, DVD, and USB removable media as well as on any accessible path to a hard disk drive, such as the workstation's local hard drive or a network share. The CD, DVD, and USB support are dependent on available hardware on the workstation. DICOM has defined interchangeable media for CD, DVD, and USB. Other media such as

the local hard disk, a network share, a mounted NAS volume, etc. may not be defined by DICOM but are supported and available for reading and creation using the CardioPACS workstation.

Implementation Model

Application Data Flow Diagram

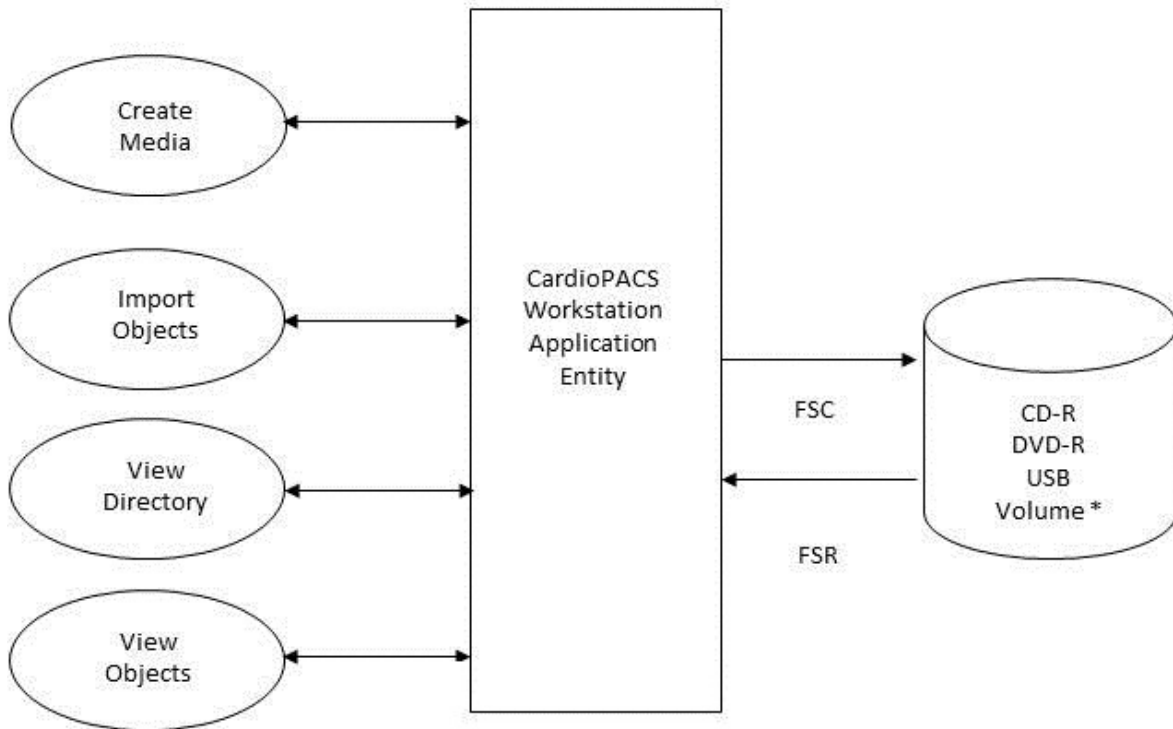


Figure 18 - Data Flow Diagram

CD-R

The CardioPACS workstation Application Entity (AE) can perform the Real-World activities in Figure 18 - Data Flow Diagram with CD-R media: View Directory, View Objects, Import Objects, and Create Media. These activities are performed by user actions in the UI of the workstation.

DVD-R

The CardioPACS workstation Application Entity (AE) can perform the Real-World activities in Figure 18 - Data Flow Diagram with DVD-R media: View Directory, View Objects, Import Objects, and Create Media. These activities are performed by user actions in the UI of the workstation.

USB

The CardioPACS workstation Application Entity (AE) can perform the Real-World activities in Figure 18 - Data Flow Diagram with USB media: View Directory, View Objects, Import Objects, and Create Media. These activities are performed by user actions in the UI of the workstation.

Volume *

The CardioPACS workstation Application Entity (AE) can perform the Real-World activities in Figure 18 - Data Flow Diagram with any non-removable volume acting as media: View Directory, View Objects, Import Objects, and Create Media. Examples of this kind of media include: a network share, a mounted NAS drive, a local hard drive, and any path the Operating System can browse to and write to. These activities are performed by user actions in the UI of the workstation.

Functional Definition of AEs

The CardioPACS workstation acts as one Application Entity (AE). It performs the following functions:

- Creating a DICOM File Set on supported media – File-set Creator (FSC)
- Importing a DICOM File Set from supported media – File-set Reader (FSR)
- Viewing the directory for a DICOM File Set from supported media – File-set Reader (FSR)
- Viewing the contents of a DICOM File Set from supported media – File-set Reader (FSR)

Sequencing of Real World Activities

Removable CD-R and DVD-R media must be empty (not written to) in order for the File-set Creation to work successfully. USB and Volume media need to have read/write permissions for the logged in user on the CardioPACS workstation. A DICOM File Set (with or without a DICOMDIR) must exist in the selected source media or source directory in order for the CardioPACS workstation to read and display the contents of it.

File Meta Information for Implementation Class and Version

The following implementation information is used by the CardioPACS workstation:

File Meta Information Version	602
Implementation Class UID	1.2.826.0.1.3680043.1.2.100.5.6.3.143
Implementation Version Name	DicomObjects.NET

AE Specifications

CardioPACS Workstation Application Entity

The CardioPACS workstation AE provides conformance to the following profiles of the DICOM Interchange Option for the Media Storage Service Class:

Application Profile	Real-World Activity or Activities	Roles	SC Option	CC Option
VOLUME *	Create Media	FSC	Interchange	Interchange
STD-CTMR-CD	<p>Import Objects</p> <p>View Directory</p> <p>View Objects</p>	FSR	Interchange	Interchange
STD-CTMR-DVD				
STD-CTMR-DVD-RAM				
STD-DEN-CD				
STD-DVD-MPEG2-MPML				
STD-GEN-CD				
STD-GEN-CF-J2K				
STD-GEN-CF-JPEG				
STD-GEN-DVD-J2K				
STD-GEN-DVD-JPEG				
STD-GEN-DVD-RAM				
STD-GEN-MMC-J2K				
STD-GEN-MMC-JPEG				
STD-GEN-SD-J2K				
STD-GEN-SD-JPEG				
STD-GEN-USB-J2K				
STD-GEN-USB-JPEG				
STD-XABC-CD				
STD-XA1K-CD				
STD-XA1K-DVD				

Application Profile	Real-World Activity or Activities	Roles	SC Option	CC Option
STD-US-ID-MF-CDR				
STD-US-ID-MF-DVD				
STD-US-CC-MF-CDR				
STD-US-CC-MF-DVD				
STD-US-SC-MF-CDR				
STD-US-SC-MF-DVD				
VOLUME **				

Figure 19 - Supported Media Application Profiles

* CD, DVD, and USB removable media on the workstation and any accessible non-removable media volume that can be browsed to by the operating system can be targeted as a medium of DICOM data (files or a DICOMDIR) for the CardioPACS workstation to write data to.

** Any accessible volume that can be browsed to by the operating system can be targeted as a medium of DICOM data (files or a DICOMDIR) for the CardioPACS workstation to read from. Encrypted or secured DICOM data sets are not supported using this browsing method.

Real World Activities for CardioPACS Workstation AE

- Create Media. In this activity the CardioPACS workstation is acting as a File-Set Creator.
- Import Objects, View Directory, View Objects. In these activities the CardioPACS workstation is acting as a File-Set Reader.

Real World Activity: Create Media

The CardioPACS workstation AE acts as an FSC when performing this activity. This AE provides for the creation of DICOM media from studies that are in context (for example, are opened or selected in the workstation application). It writes data using a compilation of common DICOMDIR requirements from several DICOM Application Profiles with the intention that a File-set Reader (FSR) will be able to identify all of the objects referenced in the DICOMDIR, including objects that are beyond the limited scope of the existing defined profiles (for example, a 2048x2048 XA image). The STD-GEN profiles are very similar to what CardioPACS workstation creates.

Real World Activity: Import Objects

The CardioPACS workstation AE acts as an FSR when importing objects from the target medium into the CardioPACS local archive. This AE provides for the import of DICOM objects that were found while loading the contents from the medium (for example, DICOMDIR references or DICOM files scanned).

Real World Activity: View Directory

The CardioPACS workstation AE acts as an FSR when viewing a directory or a summarized list of information that was discovered on the target medium by reading the DICOMDIR or by scanning DICOM files. This AE provides for the viewing of a high level summary of the DICOM data found on the target medium.

Real World Activity: View Objects

The CardioPACS workstation AE acts as an FSR when viewing DICOM objects that were discovered on the target medium by reading the DICOMDIR or by scanning DICOM files. This AE provides for the viewing of those objects without importing them to the local CardioPACS archive.

Augmented and Private Application Profiles

The CardioPACS workstation has no augmented or private Application Profiles.

Media Configuration

The CardioPACS workstation uses the host name of the PC that it is being used as the Source AE Title for the File Meta Information when creating media.

Support of Character Sets

The CardioPACS workstation supports all character sets that are supported by the ApolloLX CVIS. They include the following DICOM character sets:

- ISO-IR 6 (ISO 646) – Default repertoire