DICOM CONFORMANCE STATEMENT · NOVEMBER 2026

RadFuzion 7.0

DICOM router with Modality Worklist, MPPS, Query/Retrieve, Storage Commitment and DICOMweb services

Document number	RF-DCS-070
Document version	1.4
Current release	RadFuzion 7.0.0
Date	November 2026
Manufacturer	Fuzion Technologies LLC
Website	radfuzion.com
Contact	support@radfuzion.com · sales@radfuzion.com

This statement covers RadFuzion 7.0 on Windows and Linux. It describes the DICOM services of the RadFuzion server. Optional modules (RadRead, RadSR, RadMatch, RadFetch, RadList, RadGen7) are described only where they use DICOM.

RadFuzion and the RadFuzion logo are trademarks of Fuzion Technologies LLC. DICOM is the registered trademark of the National Electrical Manufacturers Association for its standards publications relating to digital communications of medical information.

2 Contents

1 Overview

- 1.1 Network services
- 1.2 DICOM web services
- 1.3 Media services
- 1.4 De-identification

3 Introduction

- 3.1 Revision history
- 3.2 Audience
- 3.3 Remarks
- 3.4 Terms and abbreviations
- 3.5 References

4 Networking

- 4.1 Implementation model
- 4.2 AE specifications
- 4.3 DICOM web services
- 4.4 Network interfaces
- 4.5 Configuration

5 Media interchange

6 Support of character sets

7 Security

- 7.1 Transport security (DICOM TLS)
- 7.2 Access control
- 7.3 De-identification
- 7.4 Audit trail messages (Syslog)

8 Annexes

- 8.1 IOD contents: objects RadFuzion creates
- 8.2 Attribute changes while routing (coerced and modified attributes)
- 8.3 Attribute mapping: HL7 orders to Modality Worklist
- 8.4 Standard extended, specialized and private SOP classes
- 8.5 Coded terminology
- 8.6 Grayscale image consistency

1 Overview

RadFuzion is a DICOM router for radiology. It receives images over DICOM and DICOMweb, applies routing rules, and delivers each study to one or more destinations: DICOM nodes (PACS, archives, workstations), DICOMweb servers (Google Cloud Healthcare API, Azure Health Data Services DICOM service, any STOW-RS server), object storage, and local folders. It also provides a Modality Worklist from HL7 orders, Modality Performed Procedure Step, Query/Retrieve against a local cache of recently forwarded studies (optionally passed through to the site's archives), Storage Commitment, and a DICOMweb origin server.

RadFuzion is not an archive. Studies are kept in a first-in, first-out image cache of configurable size. DICOMweb search serves that cache only; Query/Retrieve serves it and, with pass-through on, the archives chosen for it (4.2.5.4).

1.1 Network services

SERVICE	SOP CLASS / TRANSACTION	USER OF SERVICE (SCU)	PROVIDER OF SERVICE (SCP)
Transfer			
Storage	All Storage SOP classes (see 4.2.1.2)	Yes	Yes
Storage Commitment Push Model	`1.2.840.10008.1.20.1`	Yes (optional, per destination)	Yes (optional)
Query/Retrieve			
Study Root Q/R Information Model – FIND	`1.2.840.10008.5.1.4.1.2.2.1`	Yes	Yes (image cache, optional; archives with pass-through)
Study Root Q/R Information Model – MOVE	`1.2.840.10008.5.1.4.1.2.2.2`	Yes	Yes (image cache, optional; archives with pass-through)
Study Root Q/R Information Model – GET	`1.2.840.10008.5.1.4.1.2.2.3`	No	Yes (image cache, optional; archives with pass-through)
Patient Root Q/R Information Model – FIND / MOVE / GET	`1.2.840.10008.5.1.4.1.2.1.x`	No	No
Workflow management			
Modality Worklist Information Model – FIND	`1.2.840.10008.5.1.4.31`	Test tool only (Modality Simulator, 4.2.8)	Yes (optional)
Modality Performed Procedure Step	`1.2.840.10008.3.1.2.3.3`	Yes (passes modalities' messages on, optional; Modality Simulator, 4.2.8)	Yes (optional)
Verification			
Verification	`1.2.840.10008.1.1`	Yes	Yes

1.2 DICOM web services

SERVICE	TRANSACTION	USER AGENT	ORIGIN SERVER
Studies Service	Store (STOW-RS)	Yes	Yes (optional)
Studies Service	Search (QIDO-RS)	Yes	Yes (optional)

SERVICE	TRANSACTION	USER AGENT	ORIGIN SERVER
Studies Service	Retrieve (WADO-RS): instances, metadata, frames	Yes (instances)	Yes (optional)
Studies Service	Retrieve (WADO-RS): rendered, thumbnail, bulk data	No	No
URI Service	WADO-URI	No	No
Worklist Service	UPS-RS	No	No
Non-Patient Object Service		No	No

1.3 Media services

MEDIA STORAGE APPLICATION PROFILE	FILE-SET CREATOR (FSC)	FILE-SET READER (FSR)	FILE-SET UPDATER (FSU)
General Purpose CD-R / DVD (STD-GEN-CD, STD-GEN-DVD-RAM-like content, Explicit VR Little Endian)	Yes	No	No

RadFuzion creates a DICOM File-set as a ZIP download or for disc burning by the RadBurn companion application. See section 5.

1.4 De-identification

RadFuzion can de-identify studies while routing, using the PS3.15 Annex E Basic Application Level Confidentiality Profile with the Retain UIDs, Retain Device Identity, Retain Institution Identity, Retain Patient Characteristics and Retain Longitudinal Temporal Information (Full Dates or Modified Dates) options. It does not clean pixel data while routing. An optional add-on can save a copy of an exam with regions a person chose blacked out (download only). See section 7.3.

3 Introduction

3.1 Revision history

DOCUMENT VERSION	DATE	PRODUCT VERSION	DESCRIPTION
1.0	November 2026	RadFuzion 6.8.4	First published version
1.1	November 2026	RadFuzion 6.8.5	Patient corrections from HL7 order updates and ADT messages (8.2, 8.3.1)
1.2	November 2026	RadFuzion 6.8.5	Studies the browser viewer retrieves are not routed
1.3	November 2026	RadFuzion 6.8.7	Modality Performed Procedure Step SCP and pass-through (4.2.6.4, 4.2.6.5); Query/Retrieve pass-through to archives (4.2.5.4); C-GET role selection taken per SOP class (4.2.5.3); DICOM audit messages over Syslog (7.4)
1.4	November 2026	RadFuzion 7.0.0	Query/Retrieve answers say where a study is: Instance Availability ONLINE or NEARLINE, and an optional source name in the answer (4.2.5.2, 4.2.5.4); an instance that cannot be decoded fails alone in forwarding and in C-MOVE and C-GET (4.2.2.1, 4.2.5.3); exam check on arrival, with an optional hold (4.1.1); drop rules can keep studies in the image cache (4.1.1, 4.2.5); Modality Simulator test tool (4.2.8); objects for download from optional add-ons: Segmentation and redacted copies (8.1.6, 8.1.7), and a redacted copy can be sent to a destination a person picks (8.1.7); a rule can forward a study to the archives that already hold it, found by C-FIND or QIDO-RS (4.1.1, 4.2.7)

3.2 Audience

This document is for hospital and imaging-center IT staff, PACS administrators, integration engineers and other vendors who connect systems to RadFuzion. Readers should know the DICOM Standard and the terms in PS3.2, PS3.4, PS3.7 and PS3.18.

3.3 Remarks

- This statement describes RadFuzion's DICOM interfaces. It does not by itself guarantee interoperability with any other product. Test any connection in your own environment before clinical use.
- RadFuzion's browser viewer and the viewer placed on exported media are non-diagnostic and not FDA cleared for primary diagnostic interpretation. This document makes no regulatory claim.
- RadFuzion uses the fo-dicom 5.2.5 toolkit and the fo-dicom.Codecs 5.16 native codecs.
- All AE titles, ports and limits shown as defaults can be changed by the site administrator in the RadFuzion web interface (Settings) or configuration file.

3.4 Terms and abbreviations

TERM	MEANING
AE	Application Entity
Image cache	RadFuzion's first-in, first-out on-disk store of studies it has forwarded (default size 10 GB)
Destination	A configured target RadFuzion delivers to (DICOM node, DICOMweb server, object storage or folder)
Routing rule	A site-defined rule that matches DICOM attributes or AE titles and picks destinations and changes
ELE / ILE	Explicit VR Little Endian / Implicit VR Little Endian

TERM	MEANING
FSC / FSR / FSU	File-set Creator / Reader / Updater
MPPS	Modality Performed Procedure Step
MWL	Modality Worklist
SCU / SCP	Service Class User / Provider
TLS	Transport Layer Security

3.5 References

- NEMA PS3 / ISO 12052, Digital Imaging and Communications in Medicine (DICOM) Standard, current edition: dicom.nema.org
- PS3.2 Conformance; PS3.3 Information Object Definitions; PS3.4 Service Class Specifications; PS3.5 Data Structures and Encoding; PS3.7 Message Exchange; PS3.8 Network Communication Support; PS3.10 Media Storage and File Format; PS3.11 Media Storage Application Profiles; PS3.15 Security and System Management Profiles; PS3.16 Content Mapping Resource; PS3.18 Web Services
- HL7 Version 2.x (order messages for the Modality Worklist; order updates and ADT messages for patient corrections)

4 Networking

4.1 Implementation model

4.1.1 Application data flow

RadFuzion runs as one server process (a Windows service or a Linux service) with these DICOM Application Entities:

- **RADFUZION (Storage SCP).** Receives instances with C-STORE on one or more ports, and instances sent by DICOMweb clients with STOW-RS. Each instance is written to disk as received, under its study.
- **Study completion.** A study is complete when no new instance has arrived for a configurable time (default 10 seconds).
- **Hold for order (optional).** A complete study can wait for a matching HL7 order, matched by Accession Number. If no order arrives in time (default 15 minutes), the study waits in the Needs attention list with its images kept, for staff to send it without the order or delete it, or it is sent without the order if the site chooses that.
- **Required-tags check (on by default).** A study missing Patient's Name, Patient's Birth Date or Patient ID is held for staff to correct instead of being forwarded. The C-STORE itself still succeeds.
- **Exam check (optional, per rule).** A rule can have each study it matches checked when it is forwarded: every series and image is examined for missing slices, inconsistent geometry, attributes the image's IOD requires, and pixel data that does not decode. Problems are reported to staff. If the rule says so, a study with problems is held for staff to review and send instead of being forwarded; warnings never hold a study. The C-STORE itself still succeeds.
- **Route to existing study (optional, per rule).** Before a study is forwarded, a rule can ask the archives it names whether they already hold it (C-FIND, see 4.2.7; QIDO-RS for DICOMweb, Google Cloud and Azure DICOM stores, see 4.3.2), matching on Study Instance UID, Accession Number or both, and forward the study to each archive that does, in addition to the rule's own destinations. Returned matches are compared with the study's own values before they are believed. If no archive holds it, or an archive does not answer after three attempts, the study is held for staff to choose a destination and nothing is forwarded; an archive that does not answer is never treated as not holding the study. The C-STORE itself still succeeds.
- **Routing.** Rules are evaluated in priority order. A rule can match DICOM attributes, the Calling and Called AE title, and the AE title and IP address of the first sender. Matching rules add destinations, attribute changes, de-identification and transcoding.
- **Forwarding (Storage SCU and DICOMweb user agent).** Each destination receives its copy in parallel. Failed deliveries are retried; a destination that is down is rechecked and its studies are sent when it recovers.
- **Storage Commitment SCU (optional).** After delivery, RadFuzion asks DICOM destinations to commit the instances they accepted.
- **Image cache.** Forwarded studies are kept in the image cache, which RADFUZION_QR (Q/R SCP) and the DICOMweb origin server serve. A rule that discards what it matches (a drop rule) forwards nothing; it can be set to keep those studies in the image cache too (off by default), for troubleshooting.
- **Modality Simulator (test tool).** On request from the web interface, RadFuzion acts as a modality toward itself or another system: worklist query, MPPS, test images and a storage commitment request (4.2.8).
- **RADFUZION_MWL (MWL SCP).** Serves orders received over HL7 or entered by staff.
- **MPPS SCP (optional).** On RADFUZION_MWL and, unless turned off, on RADFUZION's ports: takes modalities' N-CREATE and N-SET, keeps each step, and can update the worklist from it.
- **MPPS SCU (optional).** Passes every MPPS message on, as received and in order, to the RIS or PACS destinations chosen for it.
- **Query/Retrieve pass-through (optional).** RADFUZION_QR relays C-FIND to the chosen archives and pulls from them what the cache lacks before sending it on.
- **Query/Retrieve SCU.** Searches and retrieves from configured archives for manual search, prior retrieval (RadFetch), resending, and the browser viewer. Retrieved instances are moved to RADFUZION and routed like any other study. The

exception is the browser viewer: what it retrieves goes to the viewer's cache and is not routed.

4.1.2 Functional definitions of AEs

AE (DEFAULT TITLE)	DEFAULT PORT	DEFAULT STATE	SERVICES
RADFUZION	104 (11104 in the Linux package); more ports optional; DICOM TLS port 2762 (off by default)	On	Storage SCP, Verification SCP, Storage Commitment SCP (optional), Storage Commitment SCU report receiver, MPPS SCP (optional)
RADFUZION (calling AE for outbound associations; can be set per destination)	–	On	Storage SCU, Q/R SCU (FIND, MOVE), Verification SCU, Storage Commitment SCU, MPPS SCU (optional)
RADFUZION_QR	11113; DICOM TLS port 11115 (off by default)	Off	Study Root Q/R SCP (FIND, MOVE, GET), Verification SCP; Storage SCU for C-MOVE and C-GET sub-operations
RADFUZION_MWL	5010; DICOM TLS port 5011 (off by default)	Off	MWL SCP, MPPS SCP (optional), Verification SCP
DICOMweb origin server	Web interface port (HTTP 8003 / HTTPS 8443), base path `/dicomweb`	Off	STOW-RS, QIDO-RS, WADO-RS
Modality Simulator (calling AE chosen by the operator; test tool)	–	On request	Verification SCU, MWL SCU, MPPS SCU, Storage SCU, Storage Commitment SCU

4.1.3 Sequencing of real-world activities

- An instance can be retrieved with Q/R or DICOMweb only after its study has been forwarded and added to the image cache, or (DICOMweb Retrieve only) while it waits in RadFuzion for delivery.
- A Storage Commitment request is sent to a destination only after RadFuzion has delivered the instances to it.
- With the "confirm once delivered" policy, RadFuzion answers a modality's Storage Commitment request only after every destination of the study has accepted the instances.
- An MWL order is available from the moment its HL7 order message is accepted, and leaves the worklist when images with its Accession Number arrive (configurable), when it is canceled or discontinued, or when it is completed. With MPPS updating the worklist (on by default when MPPS is on), an order is STARTED while its procedure step is IN PROGRESS, leaves the worklist when the step is COMPLETED, and is SCHEDULED again when the step is DISCONTINUED.
- An MPPS message is passed on to its destinations after RadFuzion has answered the modality. Messages for one step go to each destination in the order they were received; a later one waits until the earlier ones have been taken.
- With Query/Retrieve pass-through, an instance only the archive has is retrieved from it when a C-MOVE or C-GET asks for it, and sent on once it has arrived.

4.2 AE specifications

4.2.1 RADFUZION – Storage SCP

4.2.1.1 SOP classes

RADFUZION accepts the Verification SOP class, the Storage Commitment Push Model SOP class (when the Storage Commitment SCP is on, or when a destination is set to request Storage Commitment; see 4.2.4), the Modality Performed Procedure Step SOP class (when MPPS is on and accepted on the receiver's ports; see 4.2.6.4, with ELE and ILE, whatever the storage-only rule), and any Storage SOP class: every Storage SOP class defined in PS3.4 Annex B of the current edition, retired ones, and private or unknown SOP classes. Known non-storage SOP classes (for example Query/Retrieve and Modality Worklist) are rejected with result "abstract syntax not supported".

An optional **storage only** access rule also rejects unknown SOP classes.

4.2.1.2 Association policies

ITEM	VALUE
Application context name	`1.2.840.10008.3.1.1.1`
Maximum PDU size received	262144 bytes
Number of associations	8 per listening port by default (configurable). An association over the limit is rejected with result 2 (rejected-transient), source 3, reason 2 (local limit exceeded).
Association request (ARTIM)	A connection that sends no A-ASSOCIATE-RQ within 30 seconds is closed.
Idle association	An association with no activity for 300 seconds (configurable; 0 = never) is aborted.
Asynchronous operations	Not supported. Operations are performed one at a time; a proposed window is answered with 1/1.
Implementation Class UID	`2.25.72225067613334992804349279445625406467`
Implementation Version Name	`RADFUZION_6_8`

4.2.1.3 Association acceptance policy

- **Called AE title.** Any called AE title is accepted, unless the optional called AE check is on, in which case it must be RADFUZION's AE title. Rejection: result 1 (permanent), source 1 (service user), reason 7 (called AE title not recognized).
- **Calling AE title.** Any calling AE title is accepted, unless the optional allow-list is on. Allowed senders are listed by AE title, optionally limited to an IP address or range; configured DICOM destinations and Q/R sources are allowed by default. Rejection: result 1, source 1, reason 3 (calling AE title not recognized).
- Refused associations are logged and counted in the web interface.
- **Transfer syntax.** For each presentation context, RADFUZION accepts the first transfer syntax the requester proposes. Any transfer syntax known to the DICOM Standard is accepted; a presentation context with no transfer syntax is rejected.
- **Roles.** SCP/SCU Role Selection items are answered with the roles as proposed. RADFUZION performs only the SCP role for storage; for Storage Commitment the proposed roles let destinations send N-EVENT-REPORTs to it.

4.2.1.4 SOP-specific conformance: Storage SCP

RADFUZION is a Level 2 (Full) Storage SCP: it stores the complete data set as received, with no change to its attributes or pixel data, and does not discard any element. Attribute validation is not performed on receipt; instances with non-conforming values are stored and forwarded as received. Instances are kept until they have been delivered and then for the image cache's lifetime; RadFuzion does not guarantee long-term storage.

CONDITION	C-STORE STATUS
Instance stored	`0000` Success
Duplicate SOP Instance UID, duplicates allowed (default)	`0000` Success; the earlier copy is replaced
Duplicate SOP Instance UID, duplicates disabled	`0000` Success; the new copy is discarded
Study, Series or SOP Instance UID missing	`0110` Processing failure
Disk full	`A700` Out of resources
Any other error while storing	`0110` Processing failure

The Calling AE title, Called AE title and IP address of the sender are recorded with every study.

4.2.1.5 SOP-specific conformance: Verification SCP

C-ECHO always returns `0000` Success, on every AE.

4.2.2 RADFUZION – Storage SCU (forwarding)

4.2.2.1 Association initiation

RADFUZION opens associations to DICOM destinations to forward studies, to send C-MOVE sub-operations (as RADFUZION_QR), and to send objects RadFuzion creates (section 8.1).

- One presentation context is proposed per SOP class with the instance's stored transfer syntax (or the rule's transcoding target), plus a second presentation context for the same SOP class with Implicit VR Little Endian.
- If the destination accepts only the second context, RADFUZION decompresses the instance to Implicit VR Little Endian before sending. If an instance cannot be decoded into an accepted transfer syntax (for example video encodings, or pixel data that is damaged), that instance is not sent and is reported as failed; the other instances on the association are delivered. RADFUZION never sends an instance with its pixel data removed. Compressed pixel data is decoded in a separate process, so a damaged instance cannot stop the server.
- If the destination accepts no presentation context for a SOP class, those instances are reported as failed and are not retried automatically.
- Instances are grouped into associations by size; up to 8 studies are forwarded at once.
- Calling AE title: the destination's calling AE, or RADFUZION.

ITEM	VALUE
Maximum PDU size proposed	262144 bytes
Association request timeout	5 seconds, tried up to 3 times
C-STORE timeout	180 seconds per batch, longer for large batches
Asynchronous operations	Not proposed

4.2.2.2 Transfer syntaxes and transcoding

A routing rule can transcode a study before sending. The targets offered in the web interface:

TARGET	UID	NOTES
Explicit VR Little Endian	`1.2.840.10008.1.2.1`	
Implicit VR Little Endian	`1.2.840.10008.1.2`	
JPEG Lossless, First-Order Prediction (Process 14, SV1)	`1.2.840.10008.1.2.4.70`	
JPEG 2000 Image Compression (Lossless Only)	`1.2.840.10008.1.2.4.90`	
RLE Lossless	`1.2.840.10008.1.2.5`	
High-Throughput JPEG 2000 (Lossless Only)	`1.2.840.10008.1.2.4.201`	Multi-frame instances are sent as JPEG 2000 Lossless
High-Throughput JPEG 2000 with RPCL Options (Lossless Only)	`1.2.840.10008.1.2.4.202`	Multi-frame instances are sent as JPEG 2000 Lossless
JPEG Baseline (Process 1)	`1.2.840.10008.1.2.4.50`	**Lossy.** Images with more than 8 bits stored are sent as JPEG Extended (Process 2 & 4) `1.2.840.10008.1.2.4.51`

Lossy compression (section 8.1.5):

- A lossy-compressed copy is a new instance: it receives a new SOP Instance UID, Image Type value 1 DERIVED, Lossy Image Compression (0028,2110) `01`, Lossy Image Compression Ratio and Method, a Derivation Code Sequence item (DCM 113040 "Lossy Compression") and a Source Image Sequence item that references the original (DCM 121320 "Uncompressed predecessor").
- The new SOP Instance UID is derived from the original UID and the target transfer syntax, so every destination and every retry receives the same UID.
- An instance that is already lossy compressed is not compressed again with a lossy method.

If transcoding fails for any other reason, the instance is sent in its stored transfer syntax and the fallback is logged.

4.2.2.3 Status handling

C-STORE RESPONSE	RADFUZION BEHAVIOR
`0000` Success	Delivered
`Bxxx` Warning	Delivered (the warning is logged)
`Axxx`, `Cxxx` and other failures	Failed; retried
No response, refused or lost connection	Destination treated as down; the study is held and sent when the destination answers C-ECHO again

Failed deliveries are retried 5 times within a forwarding pass and then in up to 20 later passes with increasing delays (up to 1 hour). A study that runs out of retries keeps its images and stays in the transfer list until staff resend or delete it.

4.2.3 RADFUZION – Verification SCU

RADFUZION checks each DICOM destination with C-ECHO every 60 seconds (10-second timeout) and on request from the web interface. The Verification SOP class is proposed with Implicit VR Little Endian.

4.2.4 Storage Commitment Push Model

4.2.4.1 Storage Commitment SCP (on RADFUZION; off by default)

A modality can ask RADFUZION to commit instances it sent. RADFUZION answers N-ACTION and sends the result in an N-EVENT-REPORT.

N-ACTION CONDITION	STATUS
Request accepted	`0000` Success
Requested SOP Instance UID is not `1.2.840.10008.1.20.1.1`	`0112` No such SOP instance (`0117` Invalid object instance if malformed)
Action Type ID other than 1	`0123` No such action type
Transaction UID missing	`0120` Missing attribute
Referenced SOP Sequence empty	`0115` Invalid argument value
Transaction UID is one RADFUZION itself issued	`0210` Duplicate invocation
SCP turned off (context accepted only because a destination uses Storage Commitment)	`0122` SOP class not supported
Internal error	`0110` Processing failure

When an instance counts as committed is a site setting:

POLICY	COMMITTED WHEN	OTHERWISE
Confirm once stored (default)	RADFUZION holds the instance	Failure Reason `0112` (not received) or `0110` (no longer available)
Confirm once delivered	Every destination the study is routed to has accepted the instance	RADFUZION waits up to 60 minutes (configurable), then reports undelivered instances with Failure Reason `0110`. If forwarding has finished and an instance is missing at a destination, it is reported failed at once.

A Referenced SOP Class UID that does not match the stored instance is reported with Failure Reason `0119` (class-instance conflict).

The N-EVENT-REPORT (Event Type ID 1 if all committed, 2 if any failed) contains the Transaction UID, the Referenced SOP Sequence and the Failed SOP Sequence. It is sent:

1. On the same association, right after the N-ACTION response, when the result is already known and the requester keeps the association open (RADFUZION waits up to 60 seconds for the N-EVENT-REPORT response).
2. Otherwise on a new association from RADFUZION to the requester, which RADFUZION looks up by calling AE title in its Reply AE list and then among its DICOM destinations. RADFUZION proposes the SCP role (SCU=0, SCP=1) with Explicit and Implicit VR Little Endian, and retries at 30 seconds, 2, 5, 15 and 30 minutes, and 1, 2, 4 and 8 hours.

Retrieve AE Title is not included. Commitment requests and their state survive a restart and are kept for 30 days.

4.2.4.2 Storage Commitment SCU (per DICOM destination; off by default)

- After each forwarding pass to a destination with "Request storage commitment" on, RADFUZION sends one N-ACTION (Action Type ID 1) listing every instance the destination accepted in that pass, with a new Transaction UID.
- The presentation context is the Storage Commitment Push Model SOP class with the SCU role (SCU=1, SCP=0), Explicit and Implicit VR Little Endian, using the destination's DICOM TLS setting.
- RADFUZION keeps the association open for 5 seconds after the N-ACTION response to receive an N-EVENT-REPORT on it; otherwise the destination sends the report to RADFUZION's receiver port.
- An N-EVENT-REPORT is accepted only from the AE title the request was sent to. Responses: `0000` Success; `0118` wrong SOP class; `0113` Event Type ID not 1 or 2; `0120` Transaction UID missing; `0110` report from a different AE title or internal error. A report for an unknown Transaction UID is acknowledged and ignored.
- If no report arrives in 60 minutes (configurable per destination), the study is shown as not committed with an "Ask again" action. Committed / Not committed is shown per study and destination.

4.2.5 RADFUZION_QR – Query/Retrieve SCP (image cache and pass-through)

RADFUZION_QR is off by default. It serves the image cache: studies RadFuzion has recently forwarded (and those a drop rule is set to keep), until they are evicted. It is not an archive. With pass-through on, it also answers from the archives chosen for it (4.2.5.4).

4.2.5.1 SOP classes and association policies

SOP CLASS	UID	TRANSFER SYNTAXES
Study Root Q/R – FIND	`1.2.840.10008.5.1.4.1.2.2.1`	ELE, ILE
Study Root Q/R – MOVE	`1.2.840.10008.5.1.4.1.2.2.2`	ELE, ILE
Study Root Q/R – GET	`1.2.840.10008.5.1.4.1.2.2.3`	ELE, ILE
Verification	`1.2.840.10008.1.1`	ELE, ILE
Storage SOP classes (C-GET sub-operations)	any	ELE, ILE, JPEG-LS Lossless `.4.80`, JPEG 2000 Lossless `.4.90`, JPEG Lossless SV1 `.4.70`, RLE Lossless `.5`

- Patient Root and all other abstract syntaxes are rejected (abstract syntax not supported).

- The called AE title must be RADFUZION_QR's (else reason 7). The calling AE title must be on the Q/R allow-list; **an empty allow-list rejects every caller** (reason 3).
- Maximum 16 concurrent associations (configurable); over the limit: result 2, source 3, reason 2. A connection with no association request is closed after 30 seconds; idle associations are aborted after 300 seconds.
- Maximum PDU 262144 bytes; asynchronous operations not supported; relational queries and other extended negotiation not supported.

4.2.5.2 C-FIND

Query levels STUDY, SERIES and IMAGE are supported (hierarchical query only). SERIES and IMAGE queries require the Study Instance UID. Matching is done against RadFuzion's cache index; with pass-through, also by the archives (4.2.5.4). The tables below describe the cache's matching.

STUDY level:

ATTRIBUTE	TAG	MATCHING	RETURNED
Patient's Name	(0010,0010)	S, *, U	Yes
Patient ID	(0010,0020)	S, *, U	Yes
Patient's Birth Date	(0010,0030)	S, R, U	Yes
Patient's Sex	(0010,0040)	–	Yes
Study Instance UID	(0020,000D)	UID, L	Yes
Study Date	(0008,0020)	S, R, U	Yes
Study Time	(0008,0030)	–	Yes
Accession Number	(0008,0050)	S, *, U	Yes
Study ID	(0020,0010)	–	Yes
Study Description	(0008,1030)	S, *, U	Yes
Referring Physician's Name	(0008,0090)	–	Yes
Modalities in Study	(0008,0061)	S, *, L, U	Yes (all modalities in the study)
Number of Study Related Series	(0020,1206)	–	Yes
Number of Study Related Instances	(0020,1208)	–	Yes
Retrieve AE Title	(0008,0054)	–	Yes (RADFUZION_QR)
Instance Availability	(0008,0056)	–	Yes (ONLINE; with pass-through, NEARLINE for what only an archive has)
Specific Character Set	(0008,0005)	–	When needed (ISO_IR 192)

SERIES level: Study Instance UID (required, single value), Series Instance UID (UID, L), Series Number (S), Series Description (S, *), Modality (S, *, L); returned with Number of Series Related Instances (0020,1209).

IMAGE level: Study Instance UID (required), Series Instance UID (UID, L), SOP Instance UID (UID, L); returned with SOP Class UID (0008,0016) and Instance Number (0020,0013).

Matching types: S single value, * wildcard (`*` and `?`), U universal, R range (dates), L list of values separated by `\`, UID single or list of UIDs. Text matching is case-insensitive, and a Patient's Name value without ^ also matches any single name component. These are extensions of the standard matching rules.

CONDITION	STATUS
Each match	FF00 Pending, or FF01 when the request contained optional keys that are not supported as matching keys
Matching complete	0000 Success
Missing or unsupported Query/Retrieve Level, or SERIES/IMAGE without Study Instance UID	A900 Identifier does not match SOP class
Error reading the cache (and, with pass-through, no archive answered)	C000 Unable to process
Pass-through: no archive answered and the cache has no match	C000 Unable to process, Error Comment "Archive unavailable"

Study Time, Study ID, Retrieve AE Title and Instance Availability are always returned; Patient's Sex and Referring Physician's Name are returned when requested. Results stop after 1000 matches at STUDY and SERIES level (configurable; a warning is logged and the status is still Success); IMAGE level is not limited. C-CANCEL is not supported.

4.2.5.3 C-MOVE and C-GET

- C-MOVE: the Move Destination must be on RADFUZION_QR's list of move destinations and must exist as a DICOM destination with that AE title, else A801 Move destination unknown. Sub-operations are C-STORE requests on a new association from RADFUZION_QR to that destination, using its DICOM TLS setting, with Move Originator AE Title and Message ID set.
- C-GET: sub-operations are C-STORE requests on the same association; the final response is sent after the last C-STORE response. Instances whose storage SOP class the requester did not propose, or for which it did not take the SCP role, are counted as failed. Role selection is taken per SOP class: a requester that offers a class in several presentation contexts (one per transfer syntax, for example) and takes the SCP role for it in one role selection item has taken it for all of them. If a C-STORE response does not arrive within 5 minutes, the association is aborted.
- Retrieval is at STUDY, SERIES or IMAGE level with single or listed UIDs. A request without the required unique keys gets A900.
- Sub-operations send the cached file; if the requester does not accept its transfer syntax, it is decompressed to an accepted one when possible, else the sub-operation fails. An instance that cannot be decoded fails alone: the other sub-operations go on, and the final status is B000 with that instance in the Failed SOP Instance UID List.

CONDITION	STATUS
Sub-operations in progress	FF00 Pending, with Remaining, Completed, Failed and Warning counts
All sub-operations succeeded	0000 Success
Some sub-operations failed or returned a warning	B000 Warning, with Failed SOP Instance UID List (0008,0058)
All sub-operations failed	A702 Out of resources – unable to perform sub-operations, with Failed SOP Instance UID List
Move destination unknown	A801
Required unique key missing	A900

4.2.5.4 Pass-through to archives (off by default)

With **Also answer from archives** on, the site chooses one or more DICOM destinations (archives) in order. RADFUZION_QR uses its Q/R SCU (4.2.7) toward them; the same allowed callers and move destinations apply.

- **C-FIND.** The request's identifier, with its level, is relayed to every chosen archive at once. Their matches come first, one per unique key of the level (Study, Series or SOP Instance UID): the first archive's answer for a key is kept as the archive gave it, except that Retrieve AE Title (0008,0054) is set to RADFUZION_QR. Matches only the cache has follow. An archive that fails

or does not answer is logged and left out; if no archive answered and the cache has no match, the answer is `C000` "Archive unavailable" rather than an empty Success. Archive matches are sent with `FF00`; cache matches as in 4.2.5.2. The 1000-match cap applies to the merged answer at STUDY and SERIES level.

- **C-MOVE and C-GET.** RADFUZION_QR asks the archives in order, with a C-FIND at the retrieve's level for its unique keys, which has what is requested and how many instances (Number of Study / Series Related Instances, or the matches at IMAGE level). The first archive that has it is used. It retrieves from the archive when the cache has none of it, or when the archive reports more instances than the cache holds; when the archive does not report a count and the cache has some, the cache is used.
- **The pull.** RADFUZION C-MOVEs the request from the archive to its own receiver: one C-MOVE per study for a study-level request with several studies, otherwise the request's level and keys. The archive's C-STOREs are recognized by Move Originator AE Title, or by the archive's AE title or address, and stored in a staging folder. They are not routed, processed or added to the image cache; one with no Move Originator from an unrecognized sender is also taken in normally, so nothing meant for routing is lost. While the pull runs, the requester receives `FF00` Pending responses every 5 seconds. The sub-operations then send what arrived, plus anything only the cache has; the staging folder is deleted afterwards. The C-MOVE to the archive uses the timeouts in 4.2.7.
- If the archives cannot be asked, the cache serves the retrieve.
- **Where an answer came from.** In C-FIND responses, Instance Availability (0008,0056) is ONLINE when the image cache has what the answer describes and NEARLINE when only an archive has it (a retrieve pulls it first). The site can also have the source's name (the archive's name in RadFuzion, or a name chosen for the cache) written into one attribute of each answer: Institution Name (0008,0080), Station Name (0008,1010), Institutional Department Name (0008,1040) or Study ID (0020,0010). This is off by default, replaces the value the archive returned in that attribute, and changes the C-FIND response only: stored instances are never changed.

4.2.6 RADFUZION_MWL – Modality Worklist SCP

RADFUZION_MWL is off by default. It serves orders received as HL7 order messages (section 8.3) or entered by staff in the web interface.

4.2.6.1 Association policies

- SOP classes: Modality Worklist Information Model – FIND and Verification, and Modality Performed Procedure Step when MPPS is on (4.2.6.4), with ELE and ILE. Other abstract syntaxes are rejected.
- The called AE title must be RADFUZION_MWL's (reason 7). An optional calling AE allow-list (empty = open; reason 3).
- Up to 50 concurrent associations (over the limit: result 2, source 3, reason 2). A connection with no association request is closed after 30 seconds; idle associations are aborted after 300 seconds.
- Optional per-station filtering: a modality's calling AE can be mapped to the modalities it may see, and an order addressed to a station (HL7 OBR-21 AE title, or an OBR-20 station name mapped to an AE) is shown only to that station.

4.2.6.2 Matching keys

ATTRIBUTE	TAG	MATCHING
Patient's Name	(0010,0010)	S, *, U (case-insensitive; trailing empty components ignored)
Patient ID	(0010,0020)	S, *, L, U
Patient's Birth Date	(0010,0030)	S, R, U
Accession Number	(0008,0050)	S, *, L, U
Scheduled Procedure Step Sequence > Modality	(0008,0060)	S, *, L, U
> Scheduled Procedure Step Start Date	(0040,0002)	S, R, U
> Scheduled Procedure Step Start Time	(0040,0003)	S, R, U (combined with the date as a date-time range)
> Scheduled Station AE Title	(0040,0001)	S, *, U

ATTRIBUTE	TAG	MATCHING
> Scheduled Performing Physician's Name	(0040,0006)	S, *, U (matched against the referring physician)

Other matching keys are ignored (treated as universal).

4.2.6.3 Return keys

All of the following are returned in every response:

ATTRIBUTE	TAG	VALUE
Specific Character Set	(0008,0005)	ISO_IR 100, or ISO_IR 192 when a value is outside Latin-1
Accession Number	(0008,0050)	Order accession
Patient's Name / Patient ID / Birth Date / Sex	(0010,0010) / (0010,0020) / (0010,0030) / (0010,0040)	From the order; Sex M, F, O or empty
Medical Alerts / Allergies	(0010,2000) / (0010,2110)	From the order
Study Instance UID	(0020,000D)	Assigned once per order and kept when the order changes
Study Date / Time / Description	(0008,0020) / (0008,0030) / (0008,1030)	Scheduled date and time; procedure description
Referring Physician's Name / Requesting Physician	(0008,0090) / (0032,1032)	From the order
Requested Procedure ID / Description	(0040,1001) / (0032,1060)	Procedure code (accession if none) / description
Requested Procedure Code Sequence	(0032,1064)	Procedure code, coding scheme, meaning (when the order has a code)
Requested Procedure Priority	(0040,1003)	STAT, HIGH, ROUTINE or MEDIUM
Reason for the Requested Procedure	(0040,1002)	From the order
Patient Transport Arrangements / Admission ID	(0040,1004) / (0038,0010)	Empty
Current Patient Location	(0038,0300)	Station name
Referenced Study Sequence / Referenced Patient Sequence	(0008,1110) / (0008,1120)	Empty
Scheduled Procedure Step Sequence	(0040,0100)	One item: Modality; Start Date and Time (order received time if not scheduled); Scheduled Station AE Title (the caller if not set); Scheduled Station Name; Scheduled Performing Physician's Name (the referring physician); SPS ID (the accession); SPS Description; SPS Location; SPS Status (SCHEDULED, ARRIVED, READY or STARTED); Scheduled Protocol Code Sequence (when the order has a code)

CONDITION	STATUS
Each match	`FF00` Pending
Complete	`0000` Success
Error	`0110` Processing failure

At most 2000 matches are returned (configurable), newest first; a warning is logged when more match. C-CANCEL is not supported.

4.2.6.4 Modality Performed Procedure Step SCP (off by default)

With MPPS on, RADFUZION_MWL and (unless turned off) RADFUZION answer the MPPS SOP class `1.2.840.10008.3.1.2.3.3`. Each step and every message are stored before the response is sent, so a restart loses nothing a modality was told was taken.

CONDITION	STATUS
N-CREATE taken	`0000` Success, with Affected SOP Instance UID (RADFUZION makes a 2.25 UID when the request has none)
N-CREATE for a SOP Instance UID that already exists	`0111` Duplicate SOP instance
N-CREATE with Performed Procedure Step Status other than IN PROGRESS	`0106` Invalid attribute value
N-CREATE without a data set	`0120` Missing attribute
N-SET taken	`0000` Success
N-SET for an unknown SOP Instance UID	`0112` No such object instance
N-SET after the step is COMPLETED or DISCONTINUED	`0110` Processing failure, Error ID `A710`
N-SET with a status other than IN PROGRESS, COMPLETED or DISCONTINUED	`0106` Invalid attribute value
MPPS off, or not the MPPS SOP class	`0122` SOP class not supported (the presentation context is rejected when MPPS is off)

- An N-SET's attributes replace the stored ones (sequences whole). Other attribute checks of PS3.4 F.7 are not enforced: what the modality sends is kept and passed on as sent.
- N-GET, N-ACTION, N-DELETE and N-EVENT-REPORT are refused with `0122`. The MPPS Retrieve and Notification SOP classes are not supported.
- **Worklist.** With "update the worklist" on (default), the accessions in Scheduled Step Attributes Sequence (0040,0270) are matched to orders: IN PROGRESS sets the order to STARTED (SPS Status STARTED), COMPLETED takes it off the worklist, DISCONTINUED sets it to SCHEDULED again.
- The steps, with what each message was and how its delivery went, are listed in RadList. Finished steps are kept 30 days (configurable).

4.2.6.5 MPPS SCU (passing MPPS on; off by default)

Each N-CREATE and N-SET is passed on to every DICOM destination chosen for MPPS (a RIS or PACS), with the data set as received and the same SOP Instance UID.

- One association per message, from RADFUZION's calling AE (or the destination's own), or from the modality's calling AE title when "send as the modality's AE" is on. ELE and ILE are proposed. A destination with DICOM TLS on is reached over TLS.
- Messages for one step go in the order received; a later one is sent only after the earlier ones were taken.

- `0000` and warning statuses count as delivered, and so does `0111` for an N-CREATE (the destination already has the step). `0122` or `0118`, or a destination that accepts no MPPS presentation context, fails the message at once. `0213` and unreachable destinations are retried at 30 seconds, doubling up to 15 minutes, for 24 hours (configurable); other failure statuses fail the message. A failed message holds back the step's later messages until it is sent again from RadList.

4.2.7 Query/Retrieve SCU

RADFUZION searches and retrieves from DICOM archives configured as Q/R sources: for staff searches, prior retrieval (RadFetch, up to six sources in priority order), resending and reprocessing, and the browser viewer. A routing rule can also ask DICOM destinations whether they hold a study, with one STUDY-level C-FIND each carrying Study Instance UID, Accession Number or both (route to existing study, 4.1.1).

- **C-FIND:** Study Root, STUDY and SERIES levels, priority MEDIUM, Implicit VR Little Endian proposed. Keys sent at STUDY level: Query/Retrieve Level, Study Instance UID, Patient ID, Patient's Name (with `*` added to each component), Patient's Birth Date (value or range), Patient's Sex (only M, F or O), Accession Number, Study Date (range for the look-back window), Study Time, Modalities in Study, Study Description (`*text*`), Number of Study Related Instances. Specific Character Set ISO_IR 192 is added when a value is not ASCII. At SERIES level: Study Instance UID, Series Instance UID, Number of Series Related Instances (and Modality, Series Number, Series Description, Series Date and Time when reprocessing).
- Responses with `FF00` and `FF01` are both used. A failure final status (for example `A700`, `C000`, `A900`) is reported as an error, not as "no results". A C-FIND with no response for 30 seconds is aborted.
- **C-MOVE:** Study Root at STUDY level (SERIES for reprocessing), with the source's move destination AE title (default RADFUZION). Pending responses and arriving images keep the request alive; it ends after 120 seconds with neither (configurable) or after 60 minutes in total. `0000` is success; `Bxxx` is a partial success (instances that arrived are kept and the failed list is logged); failures are retried with back-off. C-CANCEL is not sent; on timeout the association is released.
- **Pass-through (4.2.5.4):** C-FIND at the requester's level (STUDY, SERIES or IMAGE) with the requester's identifier; C-MOVE at the requester's level to RADFUZION.
- At most 4 associations at once to each archive (shared by searches, retrieves, pass-through and health checks).
- C-GET and Patient Root are not used.

4.2.8 Modality Simulator (test tool)

The Modality Simulator is a troubleshooting tool in the web interface. A signed-in member of staff with the permission for it uses it to try RadFuzion, or another system through or beside it, without a real modality: at go-live, for training, or to reproduce a problem. Nothing here runs by itself: every association is opened by that person's request. It is not a modality and is not for clinical use.

The operator chooses the Calling AE title and Station Name (a "setup") and, for each role, the system to talk to: this RadFuzion, one of its DICOM destinations (with that destination's DICOM TLS setting), or a host, port and AE title typed in.

STEP	SERVICE	NOTES
Check connections	Verification SCU (C-ECHO)	To each system chosen
Query the worklist	Modality Worklist Information Model – FIND SCU	Matching keys sent: Modality, Scheduled Procedure Step Start Date, Patient's Name (optional) and Scheduled Station AE Title (optional). One order is picked from the answers, or typed in instead
Start the exam	MPPS SCU, N-CREATE	Performed Procedure Step Status IN PROGRESS, with the order's Study Instance UID, Accession Number and Scheduled Step Attributes Sequence
Send the images	Storage SCU (C-STORE)	See below. Request Attributes Sequence and Referenced Performed Procedure Step Sequence are set from the order
Finish the exam	MPPS SCU, N-SET	COMPLETED with the Performed Series Sequence listing what was sent, or DISCONTINUED with a reason from CID 9300

STEP	SERVICE	NOTES
Ask for commitment (optional)	Storage Commitment Push Model SCU (N-ACTION)	The N-EVENT-REPORT is awaited on the same association for 30 seconds

Images sent. Either test images RadFuzion generates, or files the operator supplies (uploaded, or from a folder on the server), re-stamped with the order's patient, accession and Study Instance UID and given new Series and SOP Instance UIDs.

- Generated test images are synthetic patterns, not patient images, and each has the word SIMULATED in its pixel data. SOP classes: Computed Radiography Image Storage, Digital X-Ray Image Storage – For Presentation, CT Image Storage, MR Image Storage, Ultrasound Image Storage, Digital Mammography X-Ray Image Storage – For Presentation, Nuclear Medicine Image Storage, Positron Emission Tomography Image Storage and Secondary Capture Image Storage. Transfer syntax Explicit VR Little Endian; a picture supplied as JPEG is sent as Secondary Capture with JPEG Baseline (Process 1).
- Supplied files are sent with the SOP class and transfer syntax they have.
- Presentation contexts, timeouts and status handling are those of the Storage SCU (4.2.2). A typed-in order with no birth date or sex is given made-up ones, so the receiving system's required-attribute checks are not tripped by the test.

4.3 DICOM web services

4.3.1 Origin server (off by default)

The origin server runs on the RadFuzion web interface port under a base path (default `/dicomweb`). Every request is authenticated (section 7.2). Resources:

RESOURCE	METHODS
`/studies`	GET (search studies), POST (store)
`/studies/{study}`	GET (retrieve study), POST (store, study must match)
`/studies/{study}/metadata`, `/studies/{study}/series/{series}/metadata`, `.../instances/{instance}/metadata`	GET
`/series`, `/instances`, `/studies/{study}/series`, `/studies/{study}/instances`, `/studies/{study}/series/{series}/instances`	GET (search)
`/studies/{study}/series/{series}` and `.../instances/{instance}`	GET (retrieve)
`.../instances/{instance}/frames/{list}`	GET
rendered, thumbnail, bulkdata, pixeldata	Not supported (404)

Other methods get 405. There is no capabilities resource and no CORS support.

STOW-RS. Accepts `multipart/related; type="application/dicom"` (and, as an extension, a single `application/dicom` body) and metadata with bulk data as `multipart/related; type="application/dicom+json"` or `type="application/dicom+xml"`. Instances go through the same intake as C-STORE (recorded with called AE `DICOMWEB` and the client name). The response is DICOM JSON or XML as the Accept header asks (406 otherwise), with Referenced SOP Sequence, Failed SOP Sequence (Failure Reason `C000` cannot understand, `A900` study mismatch, `A700` out of resources, `0110` processing failure), Other Failures Sequence for unreadable parts, and Retrieve URL. HTTP status: 200 all stored, 202 some failed, 409 none stored, 503 none stored for lack of resources, 400 unreadable request, 415 unsupported media type. Bulk data for compressed pixel data needs Rows, Columns and Bits Allocated in the metadata; bulk data is supported for OB, OW, OF, OD, OL and UN attributes.

QIDO-RS. Responses as `application/dicom+json` or `multipart/related; type="application/dicom+xml"`, with Specific Character Set ISO_IR 192. Searches cover the image cache only.

- Matching keys (by keyword or tag): study level StudyInstanceUID, PatientID, PatientName, PatientBirthDate, PatientSex, StudyDate, StudyTime, AccessionNumber, ModalitiesInStudy, StudyDescription, StudyID, ReferringPhysicianName; series level adds SeriesInstanceUID, Modality, SeriesNumber, SeriesDescription; instance level adds SOPInstanceUID, SOPClassUID, InstanceNumber.
- Matching: universal, single value, wildcard, list, date and time ranges; case-insensitive.
- Returned attributes: the matching keys plus InstanceAvailability, the counts of related series and instances, RetrieveURL; series also Performed Procedure Step Start Date and Time; instances also Rows, Columns, BitsAllocated and NumberOfFrames.
- `limit` (up to 1000 by default) and `offset` are supported. `includefield` for attributes not listed above, unsupported keys and `fuzzymatching=true` are answered with a `Warning: 299` header; only literal matching is performed. More matches than the limit also add a 299 warning.

WADO-RS. Studies, series and instances as `multipart/related; type="application/dicom"` (single `application/dicom` for one instance), metadata as DICOM JSON or XML (without pixel data), and frames as `application/octet-stream` (uncompressed) or in their stored compressed media type.

- With no transfer syntax named, instances are sent as Explicit VR Little Endian, except lossy-compressed instances and instances too large to decompress, which are sent as stored; `transfer-syntax=*` sends them as stored. A named transfer syntax is produced by transcoding (a lossy target gives a new SOP Instance UID, section 8.1.5).
- If a requested transfer syntax cannot be produced: 406 for a single instance; in a multipart response the instance is left out and a `Warning: 299` header says how many.
- Retrieval covers the image cache and instances waiting in RadFuzion for delivery.
- A request with no Accept header gets the default media type (an extension; PS3.18 calls for 406).

HTTP STATUS	WHEN
200 / 202	Success / STOW partial success
400	Invalid query parameter, frame list or request body
401	Missing or wrong credentials
403	Not permitted (service or client right turned off)
404	Unknown resource, not found, or server off
405	Method not allowed
406	Requested media type or transfer syntax not available
409 / 503	STOW nothing stored / out of resources
415	STOW unsupported media type
429	Too many failed sign-in attempts from one address

4.3.2 User agent

TARGET	TRANSACTIONS	AUTHENTICATION
Google Cloud Healthcare API DICOM store	STOW-RS, QIDO-RS, WADO-RS	Service account key or application default credentials (OAuth 2.0 bearer)
Azure Health Data Services DICOM service (API v1 or v2, data partitions)	STOW-RS, QIDO-RS, WADO-RS	Microsoft Entra ID client credentials (OAuth 2.0 bearer)
Any DICOMweb server	STOW-RS, QIDO-RS, WADO-RS	Bearer token or HTTP Basic

- **STOW-RS:** `multipart/related; type="application/dicom"`, one instance per part, up to 50 instances per request (1 for mammography, slide microscopy and instances over 100 MB), `Accept: application/dicom+json`. The Referenced and Failed SOP Sequences are read per instance (JSON or XML); an instance not confirmed by the server is sent again; Failure Reason `0111` (already exists) counts as delivered. 4xx responses other than 408 and 429 are not retried; Retry-After is honored.
- **QIDO-RS:** study and series searches with `includefield`, `limit` and (Google) `offset`, `Accept: application/dicom+json`.
- **WADO-RS:** instance-level retrieval with `Accept: application/dicom; transfer-syntax=*` (Explicit VR Little Endian for Google), with study-level `multipart/related; type="application/dicom"` as fallback.
- All connections use HTTPS with the operating system's trusted certificates (plain HTTP only if the configured URL uses it).

Other destination types that are not DICOM services: Amazon S3 and Google Cloud Storage buckets and local folders (Part 10 files).

4.4 Network interfaces

- **Physical network:** any network supported by the operating system (Windows Server / Windows 10 and later, or Linux).
- **IP:** DICOM listeners accept connections on all IPv4 addresses of the server. Outbound connections use host names or IPv4/IPv6 addresses.
- **TLS:** see section 7.1. The DICOM TLS ports are separate from the plain DICOM ports.
- The web interface and DICOMweb origin server listen on HTTP 8003 and/or HTTPS 8443 (configurable).

4.5 Configuration

- **AE title / presentation address mapping:** each DICOM destination and Q/R source is configured with AE title, host, port, calling AE title (optional), move destination AE title (Q/R sources), DICOM TLS settings and Storage Commitment settings.
- **Configurable parameters:** RadFuzion AE titles and ports, extra receiver ports, TLS ports and certificates, receiver access rules (allow-list, called AE check, storage only), maximum associations, idle timeout, duplicate handling, study completion time, hold for order and its timeout, required tags, Q/R allow-list and move destinations, C-GET on or off, maximum results, MWL allow-list, station mappings and maximum results, Storage Commitment policy and timeouts, MPPS on or off, on the receiver's ports, destinations, calling AE, worklist updates, retry time and retention, Q/R pass-through and its archives, DICOMweb server base path, public address, clients and their rights, C-FIND and C-MOVE timeouts, image cache size, audit messages to Syslog (7.4).

---

5 Media interchange

RadFuzion is a File-set Creator only. It does not read or update DICOMDIRs.

- A study (or several) can be exported as a ZIP file containing a File-set, or handed to the RadBurn companion application to burn a CD or DVD.
- Media Storage Directory (DICOMDIR) with File-set ID `RADFUZION` and Source AE `RADFUZION`. Directory records: PATIENT, STUDY, SERIES, then IMAGE, SR DOCUMENT, KEY OBJECT DOC, PRESENTATION, ENCAP DOC, WAVEFORM, RT records, REGISTRATION, FIDUCIAL, RAW DATA or SPECTROSCOPY according to the SOP class.
- File IDs: `DICOM\ST000001\SE000001\IM000001` (ISO 9660 compatible, at most 8 characters per component).
- Every instance is written in Explicit VR Little Endian. Compressed instances are decompressed; an instance that cannot be decompressed is left off the media and listed in `README.TXT`. Enhanced MR and CT multi-frame images are also written as classic single-frame MR and CT images (section 8.1.4) so older viewers can open them.
- The media also carry a non-diagnostic HTML viewer and, optionally, a Windows viewer program.
- The content follows the General Purpose CD-R Interchange profile (STD-GEN-CD) when burned to CD-R, and the equivalent general-purpose content for DVD and USB.

6 Support of character sets

WHERE	CHARACTER SETS
Received objects (C-STORE, STOW-RS)	Any; stored and forwarded unchanged
Q/R SCP C-FIND responses	ISO_IR 192 (UTF-8) when any value is not ASCII; otherwise the default repertoire. With pass-through, an archive's answer keeps the archive's character set
MPPS	Stored and passed on with the modality's Specific Character Set
Q/R SCP matching	Request values are decoded with the request's Specific Character Set and compared with the Unicode values in the cache index
MWL SCP responses	ISO_IR 100 (Latin-1), or ISO_IR 192 when a value is outside Latin-1
HL7 orders	Decoded per MSH-18 (UNICODE UTF-8, 8859/1); without MSH-18 as UTF-8, or Latin-1 if not valid UTF-8
Q/R SCU C-FIND requests	ISO_IR 192 when a value is not ASCII
DICOMweb QIDO-RS	ISO_IR 192
Objects RadFuzion creates	ISO_IR 100 (uploaded PDFs, RadGen7 placeholders); SR to OT pages copy the source SR's character set

7 Security

7.1 Transport security (DICOM TLS)

- RADFUZION, RADFUZION_QR and RADFUZION_MWL can each open a DICOM TLS port beside the plain port (defaults 2762, 11115 and 5011; off by default). The server certificate comes from a PFX file, the Windows certificate store, or the web interface's certificate. Client certificates can be required (mutual TLS) and checked against the system trust store or pinned certificates.
- Every outbound DICOM association to a destination or Q/R source with DICOM TLS on (C-STORE, C-FIND, C-MOVE, C-ECHO, Storage Commitment) uses TLS. The server is checked against the system trust store or pinned certificates; a client certificate can be presented.
- TLS 1.2 and TLS 1.3 only, with the cipher suites the operating system enables. Certificate revocation (CRL, OCSP) is not checked.
- The HL7 order receiver and HL7 outputs can also use TLS (MLLP over TLS).

7.2 Access control

- RADFUZION: optional calling AE allow-list (AE title with optional IP address or range), called AE check and storage-only rule; all off by default.
- RADFUZION_QR: calling AE allow-list required (empty list rejects everyone).
- RADFUZION_MWL: optional calling AE allow-list.
- DICOM User Identity Negotiation is not supported: a proposed User Identity item is acknowledged with an empty server response and its credentials are not checked. Use the AE title and IP allow-lists and DICOM TLS with client certificates instead.
- DICOMweb origin server: each client has its own API key (at least 16 characters), sent as `Authorization: Bearer`, HTTP Basic (key as password) or `X-RadFuzion-ApiKey`, with separate rights to store and to search/retrieve. Optionally, signed-in RadFuzion users with the matching permissions. Keys are stored encrypted (AES-256-GCM) and compared in constant time. After 10 failed attempts in 5 minutes an address is refused (429) for 5 minutes. Serve DICOMweb over HTTPS; RadFuzion warns when keys are sent over plain HTTP from another machine.
- RadFuzion keeps a user access audit log (sign-ins, patient data views and exports, DICOMweb requests, configuration changes, and RadFuzion starting and stopping), which it can send to a Syslog server (7.4).

7.3 De-identification

A de-identification profile can be attached to a routing rule; the de-identified copy is what the rule's destinations receive.

- **Basic Application Level Confidentiality Profile** (PS3.15 Table E.1-1, 2026d edition), applied to every attribute at every nesting level. Options: Retain UIDs, Retain Device Identity, Retain Institution Identity, Retain Patient Characteristics, Retain Longitudinal Temporal Information with Full Dates or with Modified Dates (whole-day shift, fixed or per patient). Not supported: Retain Safe Private, Clean Pixel Data, Clean Recognizable Visual Features, Clean Graphics, Clean Structured Content, Clean Descriptors.
- Patient Identity Removed (0012,0062) is set to YES, De-identification Method (0012,0063) is added, and De-identification Method Code Sequence (0012,0064) lists DCM 113100 and the option codes (113106, 113107, 113108, 113109, 113110, 113112). Longitudinal Temporal Information Modified (0028,0303) is set.
- Private attributes are removed (a keep list by private creator is available outside the Basic Profile). Original Attributes Sequence is removed.
- UIDs are replaced with 2.25 UIDs derived from the originals with a per-installation key, so references within and between studies stay consistent.

- Pixel data is not changed while routing. Images with Burned In Annotation (0028,0301) = YES are logged, or skipped if the profile says so. The optional Pixel PHI add-on can find text burned into images for a person to review, and make a redacted copy to download or to send to a destination (8.1.7); text recognition can miss text, so that copy is only as clean as its review. Structured report content is replaced with an empty content item and encapsulated PDFs with a blank page.
- Profiles can also use individual attribute rules (remove, replace, empty, keep, salted hash, date shift, new UID) without the Basic Profile; such output is not marked as de-identified.

7.4 Audit trail messages (Syslog)

Off by default. Each user access audit log event is sent, in order, as it is recorded, as an RFC 5424 Syslog message:

- **Transport:** TLS (RFC 5425; default, port 6514), TCP with octet counting (RFC 6587), or UDP (RFC 5426; messages over 65,000 bytes are cut). TLS 1.2 or 1.3; the server is checked against the system trust store or pinned certificates; a client certificate can be presented (mutual TLS).
- **Header:** PRI from the facility (default 10, security/authorization) and severity 5 (notice), or 4 (warning) for refused or failed actions. HOSTNAME is the configured source name (default the computer name), APP-NAME `RadFuzion`, PROCID the process ID. No structured data; no BOM.
- **JSON format:** MSGID is the action (for example `view_study`, `login_failed`); the body is one JSON object with the time, event ID, user, role, client IP, action, category, outcome, accession, Study Instance UIDs and Patient ID (when RadFuzion still has the exam), request path and status. Event details (which can include search terms) only when turned on.
- **IHE ATNA format:** MSGID `IHE+RFC-3881`; the body is a DICOM Audit Message (PS3.15 A.5.1) in UTF-8 XML. Events: sign-in and sign-out as User Authentication (110114) with Login (110122) or Logout (110123); opening an exam and DICOMweb retrieves as DICOM Instances Accessed (110103); searches as Query (110112); exports, pushes, Resend with Rule and AI requests as Export (110106); uploads and STOW-RS as Import (110107); RadFuzion starting and stopping as Application Activity (110100) with Application Start / Stop (110120 / 110121); setting changes as Security Alert (110113) with Software Configuration (110131), or Security Configuration (110129) for users and roles. Outcome 0, 4 (refused) or 8 (error). Audit Source Type Code 4. An exam is a Study participant (110180 Study Instance UID, with its Accession in ParticipantObjectDescription) and a Patient participant (Patient Number), when RadFuzion still has it; otherwise the accession alone (ID type `ACSN`, coding scheme `HL7`).
- **Delivery:** at least once. RadFuzion records where it has got to after each event the server takes, so events wait while the server is down (and across restarts) and are sent in order once it is back; after a failure an event can be sent twice. Turning sending on starts with new events, not the existing log.

8 Annexes

8.1 IOD contents: objects RadFuzion creates

8.1.1 SR to OT pages – Secondary Capture Image Storage (`1.2.840.10008.5.1.4.1.1.7`)

Optional, per routing rule: each Basic Text SR (or other SR classes chosen in the rule) is also sent as rendered page images in the same study.

MODULE	ATTRIBUTE	VALUE
Patient, General Study	Patient's Name, Patient ID, Issuer of Patient ID, Birth Date, Sex; Study Instance UID, Date, Time, ID, Accession Number, Description, Referring Physician's Name, Issuer of Accession Number Sequence, Procedure Code Sequence	Copied from the SR (Type 2 attributes empty when the SR has none)
General Series	Series Instance UID	Derived from the Study Instance UID (one series per study)
	Modality / Series Number / Series Description	OT / 999 / SR Report

MODULE	ATTRIBUTE	VALUE
General Equipment	Manufacturer / Model / Software Versions	RadFuzion / RadFuzion SR to OT / product version
SC Equipment	Conversion Type	WSD
General Image	Instance Number; Content Date and Time; Image Type	Page number; render time; DERIVED\SECONDARY
	Patient Orientation	Empty
	Burned In Annotation	YES
	Derivation Description	Report drawn from DICOM SR
	Source Instance Sequence	The SR, purpose DCM 128225 "Source report"
Image Pixel	Samples per Pixel 1, MONOCHROME2, 8 bits, 1224 × 1584 (US Letter at 144 dpi)	
SOP Common	SOP Instance UID; Specific Character Set	Derived from the SR's SOP Instance UID and page; copied from the SR

SR to OT pages are not created when the rule also de-identifies the study.

8.1.2 RadGen7 placeholder – Secondary Capture Image Storage

Optional: a one-image study created from an HL7 order (512 × 512, MONOCHROME2) so the order appears in a PACS before images exist. Patient and study attributes come from the order (Patient's Name and ID default to UNKNOWN; Type 2 attributes empty when not in the order). Study, Series and SOP Instance UIDs are new. Series Description RADGEN7 ORM PLACEHOLDER; Conversion Type SYN; Burned In Annotation NO; Manufacturer RadFuzion; Specific Character Set ISO_IR 100.

8.1.3 Uploaded PDF – Encapsulated PDF Storage (`1.2.840.10008.5.1.4.1.1.104.1`)

Staff can upload a PDF with patient and study details entered in a form. Patient's Name, ID, Accession Number, Study Description and Study Date come from the form; Birth Date, Sex, Referring Physician's Name, Acquisition DateTime and Concept Name Code Sequence are empty unless given. Modality OT (or as chosen), Series Description PDF DOCUMENT, Conversion Type WSD, Burned In Annotation NO, Document Title from the file name, MIME Type application/pdf. Study Instance UID from the form if valid, else new; Series and SOP Instance UIDs are new.

8.1.4 Enhanced to classic MR and CT

Optional per rule, and always on exported media: an Enhanced MR (…`1.1.4.1`) or Enhanced CT (…`1.1.2.1`) multi-frame image is also produced as single-frame MR Image Storage (…`1.1.4`) or CT Image Storage (…`1.1.2`) images.

- One image per frame, in a new series whose UID is derived from the original series. SOP Instance UIDs are derived from the original SOP Instance UID and frame number, so they are the same every time.
- Image Type value 1 DERIVED; Source Image Sequence references the Enhanced instance and frame (DCM 121322 "Source image for image processing operation").
- Per-frame and shared functional group values are copied to the classic attributes: Image Position and Orientation (Patient), Pixel Spacing, Slice Thickness, Spacing Between Slices, Slice Location, Rescale and Window values, Echo Time, Repetition Time, Flip Angle, Echo Train Length, Acquisition Date and Time. Required classic MR attributes missing from the source (Scanning Sequence, Sequence Variant, Scan Options, MR Acquisition Type) are filled in.
- Enhanced-only attributes that remain make these Standard Extended SOP instances (section 8.4).

8.1.5 Lossy-compressed copies

When a rule or a WADO-RS request compresses an instance with a lossy transfer syntax, the copy is a new instance (section 4.2.2.2): new SOP Instance UID derived from the original and the transfer syntax, Image Type DERIVED, Lossy Image

Compression attributes, Derivation Code Sequence DCM 113040 and Source Image Sequence (DCM 121320) referencing the original.

8.1.6 Organ outlines – Segmentation Storage (`1.2.840.10008.5.1.4.1.1.66.4`) (optional add-on)

With the optional TotalSegmentator add-on installed, the browser viewer can outline the anatomy of a CT or MR series and, on request, write the outlines as a DICOM Segmentation object for download. It is written inside the add-on by the open-source highdicom library from the series' own images, which it references. It is offered as a download only: RadFuzion does not store it with the study, send it to a destination or serve it over Q/R or DICOMweb. A routing rule can have the first axial CT or MR series of each study it matches outlined without a click, after the study is forwarded; those outlines are kept the same way, in the add-on's own storage, and nothing made from them is forwarded, resent or added to the study. The outlines are not for diagnosis.

8.1.7 Redacted copies (optional add-on)

With the optional Pixel PHI add-on installed, staff can have the text burned into an exam's images found, review it image by image, and download a copy with the regions they chose blacked out, in every frame, or send that copy to a destination.

- Each image of the copy keeps its SOP class and is de-identified with the Basic Profile of section 7.3 (dates shifted; device identity and patient characteristics kept; private attributes removed), with new UIDs.
- Image Type value 1 is DERIVED and Derivation Description (0008,2111) says the text was blacked out and reviewed by a person.
- Burned In Annotation (0028,0301) is NO only when every piece of text that looked like patient information was blacked out; otherwise it is YES.
- Patient's Name, Patient's Birth Date and Accession Number are empty in the copy; Patient ID is ANONYMIZED.
- As a download, the copy is a ZIP of DICOM files. The original instances are never changed, and a downloaded copy is not stored with the study, sent to a destination or served over Q/R or DICOMweb.
- Sent to a destination, the copy goes to the one destination a person picked, with the Storage SCU of section 4.2.2 or the DICOMweb user agent of section 4.3.2, and never by a routing rule. The original study is not sent. RadFuzion files the copy as a study of its own (it has a new Study Instance UID), listed with a name that starts REDACTED-, and from then on treats it as it does any study it forwarded, the image cache included. The required-tags check of section 4.1.1 does not hold it, since its patient attributes are empty on purpose.

8.2 Attribute changes while routing (coerced and modified attributes)

RadFuzion changes received instances only when the site configures it, when the RIS corrects the patient (8.3.1), or when staff correct a study. The changes are written into RadFuzion's copy before delivery, so every destination receives the same values.

CHANGE	ATTRIBUTES	RECORDED IN ORIGINAL ATTRIBUTES SEQUENCE
Routing rule attribute changes (set, add if missing, copy, look up, remove)	Top-level attributes with text value representations. Never: SOP, Series, Study and Frame of Reference UIDs, transfer syntax, pixel data and its description, image geometry, rescale and window, Series and Instance Number, Specific Character Set, de-identification and lossy compression attributes	Yes, reason COERCE, but only for attributes that cannot identify the patient (see below)
Generated Accession Number (studies received without one, optional)	Accession Number	No (identifying)
Study Instance UID unification (one study received under several Study Instance UIDs, optional)	Study Instance UID	No (identifying)

CHANGE	ATTRIBUTES	RECORDED IN ORIGINAL ATTRIBUTES SEQUENCE
New Study Instance UID (rule option)	Study, Series and SOP Instance UIDs, and references to them inside the instances	No (identifying)
Study description normalization (RadMatch, optional)	Study Description	No (identifying)
Patient corrections from the RIS: HL7 order update or ADT (8.3.1; 6.8.5 and later, on by default)	Patient ID, Patient's Name, Patient's Birth Date, Patient's Sex	Yes, reason CORRECT (all changed attributes)
Staff corrections: tag editor, Fix Tags, merge, split	Any attribute except UIDs, File Meta and pixel description; merge and split also give moved instances new Series and SOP Instance UIDs and update references	Yes, reason CORRECT (all changed attributes)
De-identification	See 7.3	No (removed)

Automatic changes never record the earlier value of an identifying attribute: patient attributes (group 0010), person names, private attributes, and any attribute the PS3.15 Basic Profile removes or replaces. Sites often use rules to blank such values, and recording them would send them on. Removed attributes are not recorded. An automatic change with nothing recordable adds no item.

Each Original Attributes Sequence item has Modified Attributes Sequence (the earlier values), Attribute Modification DateTime, Modifying System RADFUZION, Source of Previous Values (the sending AE title when known) and Reason for the Attribute Modification.

8.3 Attribute mapping: HL7 orders to Modality Worklist

Field paths are the defaults and can be changed by the site.

HL7 FIELD	DICOM ATTRIBUTE(S)
OBR-3.1	Accession Number; SPS ID
PID-3.1	Patient ID
PID-5 (XPN, first repetition)	Patient's Name (converted to DICOM component order)
PID-7	Patient's Birth Date
PID-8 (M, F, O)	Patient's Sex
OBR-4.1 / 4.2 / 4.3	Requested Procedure ID; Requested Procedure Description, Study Description, SPS Description; Requested Procedure Code Sequence and Scheduled Protocol Code Sequence
OBR-7	SPS Start Date and Time; Study Date and Time
OBR-16, else PV1-8, else PV1-7 (XCN)	Referring Physician's Name, Requesting Physician, Scheduled Performing Physician's Name
OBR-20	Scheduled Station Name, SPS Location, Current Patient Location
OBR-21	Scheduled Station AE Title
OBR-24	Modality
OBR-27.6 (S, A, R, T)	Requested Procedure Priority (STAT, HIGH, ROUTINE, MEDIUM)

HL7 FIELD	DICOM ATTRIBUTE(S)
OBR-31.1	Reason for the Requested Procedure
AL1-3.2 (all AL1 segments)	Allergies
ORC-5, else ORC-1	SPS Status (IP gives STARTED); CA, DC and OC remove the order; CM takes it off the worklist

Received images are matched to orders by Accession Number. RadFuzion does not copy order values into the images, except a patient correction (8.3.1).

8.3.1 Patient corrections from HL7

From RadFuzion 6.8.5 (setting "Apply patient updates", on by default), a change the RIS makes to a patient is written into the instances of every study RadFuzion has not yet delivered, before routing and delivery, with the earlier values in the Original Attributes Sequence (reason CORRECT). Only Patient ID (0010,0020), Patient's Name (0010,0010), Patient's Birth Date (0010,0030) and Patient's Sex (0010,0040) change; a value the message leaves empty never blanks one.

HL7 MESSAGE	WHAT CHANGES
Order (ORM) for an Accession Number that already has an order, with a different patient	That study: Patient ID, Name, Birth Date, Sex as in the new order
ADT A01, A04, A05, A08, A28, A31	Orders and undelivered studies with the patient's Patient ID (PID-3.1): Name, Birth Date, Sex. Patient ID is never changed by these.
ADT A47, A46, A40, A34, A18, A30	Orders and undelivered studies with the earlier Patient ID (MRG-1.1, else MRG-4.1): Patient ID becomes PID-3.1, with Name, Birth Date and Sex from PID

- A study already delivered, in whole or in part, is not delivered again. RadFuzion records on the study what the destination received. A study delivered in part gets the correction for the instances not yet sent.
- An ADT that names no earlier Patient ID (no MRG segment) does not change a Patient ID. RadFuzion does not match patients by name or birth date.
- Every ADT message is acknowledged with AA and logged, including events RadFuzion does not act on.
- Values from HL7 are converted to DICOM form: PID-5 to Person Name component order, PID-7 to its first eight digits, PID-8 M, F or O (other values are not written).

8.4 Standard extended, specialized and private SOP classes

- Classic MR and CT images made from Enhanced images (8.1.4) are Standard Extended SOP instances: they keep Enhanced-only attributes that the classic IODs do not define.
- RadFuzion defines no specialized or private SOP classes and no private transfer syntaxes. It writes no private attributes into the objects it sends.

8.5 Coded terminology

CODE	SCHEME	MEANING	USED IN
113040	DCM	Lossy Compression	Derivation Code Sequence of lossy copies
121320	DCM	Uncompressed predecessor	Source Image Sequence of lossy copies
121322	DCM	Source image for image processing operation	Source Image Sequence of Enhanced-to-classic images
128225	DCM	Source report	Source Instance Sequence of SR to OT pages

CODE	SCHEME	MEANING	USED IN
113100, 113106–113110, 113112	DCM	De-identification profile and options	De-identification Method Code Sequence

8.6 Grayscale image consistency

RadFuzion does not support the Grayscale Standard Display Function and does not create Presentation States.