Digital Imaging and Communications in Medicine (DICOM)

Supplement 166: Query based on ID for DICOM Objects by
Representational State Transfer (REST) Services
(QIDO-RS)

Prepared by:

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Scope and Field of Application

This Supplement defines Representational State Transfer (REST) Services for querying a server for DICOM studies, series and instances. This could be implemented as a proxy to an existing C-FIND service or as a web service interacting directly with a PACS, Vendor Neutral Archive or other searchable DICOM application.

Additionally, this supplement defines a DICOM JavaScript Object Notation (JSON) representation. RESTful change management mechanisms are not defined within this supplement.

Security is beyond the scope of the RESTful services defined in this supplement. However generic Web security mechanisms are fully compatible. Several security programming recipes are provided for reference.
Changes to NEMA Standards Publication PS 3.2-2011

Digital Imaging and Communications in Medicine (DICOM)

Part 2: Conformance

ANNEX X (Informative)  CONFORMANCE STATEMENT SAMPLE QIDO SERVICE

Disclaimer:

This document is an example DICOM Conformance Statement for a fictional application service called EXAMPLE-QIDO-SERVICE produced by a fictional vendor called EXAMPLE-PACS-PRODUCTS.

As stated in the annex title, this document is truly informative, and not normative. A conformance statement of an actual product might implement additional services and options as appropriate for its specific purpose. In addition, an actual product might implement the services described in a different manner and, for example, with different characteristics and/or sequencing of activities. In other words, this conformance statement example does not intend to standardize a particular manner that a product might implement DICOM functionality.

X.0  COVER PAGE

Company Name: EXAMPLE-PACS-PRODUCTS

Product Name: EXAMPLE-QIDO-SERVICE

Version: 1.0-rev. A.1

Internal document number: 1024-xxx-yyy-zzz rev 1

Date: YYYYMMDD
X.1 CONFORMANCE STATEMENT OVERVIEW

This fictional product EXAMPLE-QIDO-SERVICE implements QIDO-RS, which allow the client to search for studies, series or SOP instances stored in an EXAMPLE-PACS-ARCHIVE. The EXAMPLE-QIDO-SERVICE is only available as a plug in option for the EXAMPLE-PACS-ARCHIVE. All of the networking, database, and other services are provided by the EXAMPLE-PACS-ARCHIVE. This conformance claim refers to the conformance claim for the EXAMPLE-PACS-ARCHIVE for all such services.

Table X.1-1 provides an overview of the network services supported by EXAMPLE-QIDO-SERVICE.

<table>
<thead>
<tr>
<th>Network Service</th>
<th>User of Service (Client)</th>
<th>Provider of Service (Server)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query by ID for DICOM Objects (QIDO)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QIDO-RS – Search for Studies</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>QIDO-RS – Search for Series</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>QIDO-RS – Search for Instances</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

X.2 TABLE OF CONTENTS

A table of contents shall be provided to assist readers in easily finding the needed information.

X.3 INTRODUCTION

X.3.1 Revision History

<table>
<thead>
<tr>
<th>Document Version</th>
<th>Date of Issue</th>
<th>Author</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>October 24, 2011</td>
<td>WG-27</td>
<td>Version for Final Text</td>
</tr>
<tr>
<td>1.2</td>
<td>March 26, 2013</td>
<td>WG-27</td>
<td>Revised Introduction</td>
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</table>

X.3.2 AUDIENCE, REMARKS, TERMS AND DEFINITIONS, BASICS OF DICOM COMMUNICATION, ABBREVIATIONS, REFERENCES

See example text in Annex A.3.

X.3.3 ADDITIONAL REMARKS FOR THIS EXAMPLE

This document is a sample DICOM Conformance Statement created for DICOM PS 3.2. It is to be used solely as an example to illustrate how to create a DICOM Conformance Statement for a DICOM Service Class Provider (SCP). The subject of the document, EXAMPLE-QIDO-SERVICE, is a fictional product.
The QIDO-RS Provider Application receives QIDO requests from a remote AE. These requests are HTTP/1.1 GET requests. It is associated with the local real-world activity “Query Remote Device”. It uses the request to select matching Studies, Series or Instances. It then returns a set of matching Studies, Series or Instances or a response code indicating warning or failure back to the requesting device.

The reception of a QIDO-RS GET request will activate the QIDO-RS Provider. An internal query request is sent to the search capabilities of the associated PACS or Vendor Neutral Archive (VNA). The search result is based upon the URL of the QIDO-RS GET request. The response is a status code indicating the success, warning, or failure of the search along with any matching results stored in the Remote PACS or VNA.

This AE complies with PS 3.18, Section 6.7, specification for QIDO-RS.

### QIDO-RS Search For Studies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Restrictions</th>
</tr>
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<tbody>
<tr>
<td>Media Types</td>
<td>Restricted to “multipart/related; type=application/dicom+xml” or “application/json”</td>
</tr>
<tr>
<td>Matching Attributes</td>
<td>See Table X.4.2-1a</td>
</tr>
<tr>
<td>Return Attributes</td>
<td>See Table X.4.2-1a</td>
</tr>
<tr>
<td>Limit and Offset supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Person Name Matching</td>
<td>Literal, case insensitive. See X.4.2.2 Extended Negotiation.</td>
</tr>
</tbody>
</table>
### Table X.4.2-1a

<table>
<thead>
<tr>
<th>Key Word</th>
<th>Tag</th>
<th>Types of Matching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STUDY Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>StudyDate</td>
<td>00080020</td>
<td>S,*,U,R</td>
</tr>
<tr>
<td>StudyTime</td>
<td>00080030</td>
<td>S,*,U,R</td>
</tr>
<tr>
<td>AccessionNumber</td>
<td>00080050</td>
<td>S,*,U</td>
</tr>
<tr>
<td>ModalitiesInStudy</td>
<td>00080061</td>
<td>S,*,U</td>
</tr>
<tr>
<td>ReferringPhysiciansName</td>
<td>00080090</td>
<td>S,*,U</td>
</tr>
<tr>
<td>StudyDescription</td>
<td>00081030</td>
<td>S,*,U</td>
</tr>
<tr>
<td>PhysicianOfRecord</td>
<td>00081048</td>
<td>U</td>
</tr>
<tr>
<td>PatientsName</td>
<td>00100010</td>
<td>S,*,U</td>
</tr>
<tr>
<td>PatientID</td>
<td>00100020</td>
<td>S,*,U</td>
</tr>
<tr>
<td>PatientBirthDate</td>
<td>00100030</td>
<td>NONE</td>
</tr>
<tr>
<td>PatientSex</td>
<td>00100040</td>
<td>NONE</td>
</tr>
<tr>
<td>StudyInstanceUID</td>
<td>0020000D</td>
<td>UNIQUE</td>
</tr>
<tr>
<td>StudyID</td>
<td>00200010</td>
<td>S,*,U</td>
</tr>
<tr>
<td>NumberOfStudyRelatedSeries</td>
<td>00201206</td>
<td>NONE</td>
</tr>
<tr>
<td>NumberOfStudyRelatedInstances</td>
<td>00201208</td>
<td>NONE</td>
</tr>
<tr>
<td>RetrieveURL</td>
<td>00081190</td>
<td>NONE</td>
</tr>
<tr>
<td><strong>Common to all query levels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InstanceAvailability</td>
<td>00080056</td>
<td>S,*,U</td>
</tr>
<tr>
<td>SpecificCharacterSet</td>
<td>00080005</td>
<td>NONE</td>
</tr>
<tr>
<td>RetrieveURL</td>
<td>00081190</td>
<td>NONE</td>
</tr>
</tbody>
</table>

Types of Matching (see PS 3.4 C.2.2.2):

- "S" indicates the identifier attribute uses Single Value Matching
- "L" indicates UID List Matching
- "U" indicates Universal Matching.
- Note: If only Universal Matching is supported for an attribute then that attribute can only be passed as an "includefield" query key
- "*" indicates wildcard matching
- "R" indicates Range Matching
- "SEQUENCE" indicates Sequence Matching
- "NONE" indicates that no matching is supported, but that values for this Element requested will be returned with all requests
- "UNIQUE" indicates that this is the Unique Key for that query level, in which case Universal Matching or Single Value Matching is used depending on the query level (see PS 3.4 C.2.2.1.1).
X.4.2.1.2 QIDO-RS Search For Series

Table X.4.2-2

QIDO-RS SEARCH FOR SERIES Specification

<table>
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<th>Restrictions</th>
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<td>Media Types</td>
<td>Restricted to &quot;multipart/related; type=application/dicom+xml&quot; or &quot;application/json&quot;</td>
</tr>
<tr>
<td>Matching Attributes</td>
<td>See Table X.4.2-2a</td>
</tr>
<tr>
<td>Return Attributes</td>
<td>See Table X.4.2-2a</td>
</tr>
<tr>
<td>Limit and Offset supported</td>
<td>Yes</td>
</tr>
<tr>
<td>Relational Queries Supported</td>
<td>No</td>
</tr>
</tbody>
</table>

Table X.4.2-2a

QIDO-RS SERIES attribute matching

<table>
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<tr>
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<th>Tag</th>
<th>Types of Matching</th>
</tr>
</thead>
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<td><strong>SERIES Level</strong></td>
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<td></td>
</tr>
<tr>
<td>Modality</td>
<td>00080060</td>
<td>S,*,U</td>
</tr>
<tr>
<td>SeriesDescription</td>
<td>0008103E</td>
<td>NONE</td>
</tr>
<tr>
<td>SeriesInstanceUID</td>
<td>0020000E</td>
<td>UNIQUE</td>
</tr>
<tr>
<td>SeriesNumber</td>
<td>00200011</td>
<td>S,*,U</td>
</tr>
<tr>
<td>NumberOfSeriesRelatedInstances</td>
<td>00201209</td>
<td>NONE</td>
</tr>
<tr>
<td>PerformedProcedureStepStartDate</td>
<td>00400244</td>
<td>S,*,U,R</td>
</tr>
<tr>
<td>PerformedProcedureStepStartTime</td>
<td>00400245</td>
<td>S,*,U,R</td>
</tr>
<tr>
<td>RequestAttributeSequence</td>
<td>00400275</td>
<td>SEQUENCE</td>
</tr>
<tr>
<td>&gt;ScheduledProcedureStepID</td>
<td>00400009</td>
<td>S,*,U</td>
</tr>
<tr>
<td>&gt;RequestedProcedureID</td>
<td>00401001</td>
<td>S,*,U</td>
</tr>
<tr>
<td><strong>Common to all query levels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InstanceAvailability</td>
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<td>SpecificCharacterSet</td>
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<td>RetrieveURL</td>
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</tr>
</tbody>
</table>

Types of matching: see X.4.2.1.1 QIDO-RS SearchForStudies.

X.4.2.1.3 QIDO-RS Search For Instances

Table X.4.2-3

QIDO-RS SEARCH FOR Instances Specification

<table>
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<tr>
<td>Matching Attributes</td>
<td>See Table X.4.2-3a</td>
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</tbody>
</table>
Parameter | Restrictions
--- | ---
Return Attributes | See Table X.4.2-3a
Limit and Offset supported | Yes
Relational Queries Supported | Series-level, only

<table>
<thead>
<tr>
<th>Key Word</th>
<th>Tag</th>
<th>Types of Matching</th>
</tr>
</thead>
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<td><strong>SERIES Level</strong></td>
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<tr>
<td>Modality</td>
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<td>SeriesDescription</td>
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<td>RequestAttributeSequence</td>
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<td>SEQUENCE</td>
</tr>
<tr>
<td>&gt;ScheduledProcedureStepID</td>
<td>00400009</td>
<td>S,*,U</td>
</tr>
<tr>
<td>&gt;RequestedProcedureID</td>
<td>00401001</td>
<td>S,*,U</td>
</tr>
<tr>
<td><strong>COMPOSITE INSTANCE Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOPClassUID</td>
<td>00080016</td>
<td>L</td>
</tr>
<tr>
<td>SOPInstanceUID</td>
<td>00080018</td>
<td>UNIQUE</td>
</tr>
<tr>
<td>InstanceNumber</td>
<td>00200013</td>
<td>S,*,U</td>
</tr>
<tr>
<td>Rows</td>
<td>00280010</td>
<td>NONE</td>
</tr>
<tr>
<td>Columns</td>
<td>00280011</td>
<td>NONE</td>
</tr>
<tr>
<td>BitsAllocated</td>
<td>00280010</td>
<td>NONE</td>
</tr>
<tr>
<td>NumberOfFrames</td>
<td>00280008</td>
<td>NONE</td>
</tr>
<tr>
<td><strong>Common to all query levels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InstanceAvailability</td>
<td>00080056</td>
<td>S,*,U</td>
</tr>
<tr>
<td>SpecificCharacterSet</td>
<td>00080005</td>
<td>NONE</td>
</tr>
<tr>
<td>RetrieveURL</td>
<td>00081190</td>
<td>NONE</td>
</tr>
</tbody>
</table>

Types of matching: see X.4.2.1.1 QIDO-RS SearchForStudies.

### X.4.2.1.4 Connection Policies

#### X.4.2.1.4.1 General

All standard RS connection policies apply. There are no extensions for RS options.
X.4.2.1.4.2  Number of Connections

EXAMPLE-QIDO-SERVICE limits the number of simultaneous RS requests. Additional requests will be queued after the HTTP/1.1 connection is accepted. When an earlier request completes, a pending request will proceed.

<table>
<thead>
<tr>
<th>Table X.4.2-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of HTTP/1.1 requests supported</td>
</tr>
<tr>
<td>Maximum number of simultaneous RS requests</td>
</tr>
</tbody>
</table>

X.4.2.1.4.3  Asynchronous Nature

EXAMPLE-QIDO-SERVICE does not support RS asynchronous response.

X.4.2.1.4.4  Response Status

The EXAMPLE-QIDO-SERVICE shall provide a response message header containing the appropriate status code indicating success, warning, or failure as shown in Table 4.2-5.

<table>
<thead>
<tr>
<th>Table 4.2-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP/1.1 STANDARD Response Codes</td>
</tr>
<tr>
<td>Code</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>401</td>
</tr>
<tr>
<td>403</td>
</tr>
<tr>
<td>413</td>
</tr>
<tr>
<td>503</td>
</tr>
</tbody>
</table>

X.4.2.2  Extended Negotiation

EXAMPLE-QIDO-SERVICE does not support the "fuzzymatching" query key.
EXAMPLE-QIDO-SERVICE will perform case insensitive matching for PN VR attributes but will not perform other forms of fuzzy matching. This applies to the following attributes:

- Referring Physician’s Name (0008,0090)
- Physician(s) of Record (0008,1048)
- Patient’s Name (0010,0010)

X.4.3 NETWORK INTERFACES

X.4.3.1 Physical Network Interface
EXAMPLE-QIDO-SERVICE uses the network interface from the hosting EXAMPLE-PACS-ARCHIVE. See its conformance claim for details.

X.4.3.2 Additional Protocols
EXAMPLE-QIDO-SERVICE uses the network services from the hosting EXAMPLE-PACS-ARCHIVE. See its conformance claim for details.

X.4.3.3 IPv4 and IPv6 Support
This product supports both IPv4 and IPv6 connections.

X.4.4 CONFIGURATION

X.4.4.1 QIDO-RS Interface
The EXAMPLE-QIDO-SERVICE can be configured to respond on one port for TLS protected traffic. The TLS port will refuse any connection from a system that is not recognized as authenticated by a known authority.

X.5 MEDIA INTERCHANGE

Not applicable

X.6 SUPPORT OF CHARACTER SETS

EXAMPLE-QIDO-SERVICE supports Unicode UTF-8 for all RS transactions. See conformance claim for EXAMPLE-PACS-ARCHIVE for character sets used within the DICOM instances.

X.7 SECURITY

The EXAMPLE-QIDO-SERVICE supports the following transport level security measures:

- HTTP BASIC Authorization over SSL
- Digest Authorization
- SSL Client Certificates

The transport level security measures support bi-directional authentication using TLS connections. The EXAMPLE-QIDO-SERVICE can provide its certificate information, and can be configured with either a direct comparison (self-signed) certificate or a chain of trust certificate.

The EXAMPLE-QIDO-SERVICE will refuse a connection over TLS from a source that does not have a recognized authentication. For example, a certificate authenticated by "Big Hospital Provider." will not be accepted unless the EXAMPLE-QIDO-SERVICE has been configured to accept authentications from "Big
Hospital Provider." The list of acceptable certificates for EXAMPLE-QIDO-SERVICE is not shared with certificates used by other system applications and must be maintained independently.

The EXAMPLE-QIDO-SERVICE can optionally be configured to use the following session authentication mechanisms:

- Kerberos Local Domain Sessions
- Shibboleth Cross Domain Sessions (using SAML2.0)
- OAuth 2.0 complying with IHE ITI Internet User Authentication (IUA) Profile
Changes to NEMA Standards Publication PS 3.17-2012

Digital Imaging and Communications in Medicine (DICOM)

Part 17: Explanatory Information

Update to PS 3.2 Section 4 Symbols and Abbreviations

4 SYMBOLS AND ABBREVIATIONS

The following symbols and abbreviations are used in this Part.

FHIR   HL7 Fast Healthcare Interoperability Resources (draft standard)

Append below PS 3.17 Annex HHH.3

HHH.4 USES FOR QIDO SERVICES

HHH.4.1 General requirements

Imaging information is important in the context of EMR/EHR. But EMR/EHR systems often do not support DICOM service classes. The EMR/EHR vendors need access using web and web service technologies to satisfy their users.

HHH.4.2 Analysis of use cases

Examples of use cases / clinical scenarios, used as the basis for the development of the QIDO-RS requirements, include:

a. Search from EMR
b. Populating FHIR resources
c. Worklist in Viewer
d. Study Import Duplication Check
e. Multiple System Query
f. Clinical Reconstruction
g. Mobile Device Access

HHH.4.2.1 Search from EMR

A General Practitioner (GP) in a clinic would like to check for imaging studies for the current patient. These studies are stored in a PACS, Vendor Neutral Archive (VNA) or HIE that supports QIDO functionality. The GP launches an Electronic Medical Record (EMR) application, and keys in the patient demographics to search for the patient record within the EMR. Once the record is open, the EMR, using QIDO, makes requests to the back-end systems, supplying Patient ID (including issuer) and possibly other parameters (date of birth, date range, modality, etc.). That system returns the available studies along with meta-data.
for each study that will help the GP select the study to open. The meta-data would include, but is not limited to, Study Description, Study Date, Modality, and Referring Physician.

**HHH.4.2.2 Populating FHIR resources**

HL7 has introduced FHIR (Fast Healthcare Interoperability Resources) as a means of providing access to healthcare informatics information using RESTful web services.

While FHIR will not replicate the information contained in a PACS or other medical imaging storage system, it is desirable for FHIR to present a view of the medical imaging studies available for a particular patient along with the means of retrieving the imaging data using other RESTful services.

**HHH.4.2.3 Worklist in Viewer**

A Radiologist, is reading studies in the office, using software that maintains diagnostic orders for the facility. This system produces the radiology worklist of studies to be read and provides meta-data about each scheduled procedure, including the Study Instance UID. When the next study is selected to be read on the worklist, the system, using the Study Instance UID, makes a QIDO request to the local archive to discover the instances and relevant study meta-data associated with the procedure to display. Subsequent QIDO requests are made to the local archive and to connected VNA archives to discover candidate relevant prior studies for that patient.

For each candidate relevant prior, the full study metadata will be retrieved using WADO-RS and processed to generate the list of relevant priors.

**HHH.4.2.4 Multiple Systems Query**

A Radiologist is working in a satellite clinic, which has a system with QIDO functionality and small image cache. The main hospital with which the clinic is affiliated has a system with QIDO functionality and a large historical image archive or VNA. The viewing software displays a worklist of patients, and a study is selected for viewing. The viewer checks for prior studies, by making QIDO requests to both the local cache and remote archive using the Patient ID, Name and Date of Birth, if available. If the Patient Identifier isn’t available, other means (such as by other demographics, or a Master Patient Index) could be utilized. Any studies that meet relevant prior criteria can be pre-fetched.

**HHH.4.2.5 Clinical Reconstruction**

A Neurologist is preparing a surgical plan for a patient with a brain tumor using three-dimensional reconstruction software which takes CT images and builds a 3D model of various structures. After supplying the patient demographics (or Patient Identifier), the software requests a list of appropriate studies for reconstruction (based on Study Date, Body Region and Modality). Once the user has selected a study and series, the software contacts the QIDO server again, requesting the SOP Instance UIDs of all images of a certain thickness (specified in specific DICOM tags) and frame of reference to be returned. The software then uses this information to retrieve, using the WADO-RS service, the appropriate DICOM objects needed to prepare the rendered volume for display.

**HHH.4.2.6 Mobile Device Access**

A General Practitioner (GP) has left the medical ward for a few hours, and is paged with a request to look at a patient X-Ray image in order to grant a discharge. The GP carries a smart phone which has been pre-loaded with credentials and secured. The device makes a QIDO request to the server, to look for studies from the last hour that list the GP as the Referring Physician. The GP is able to retrieve and view the matching studies, and can make a determination whether to return to the ward for further review or to sign the discharge order using the phone.
HHH.4.3 Description of the Use Cases

The use cases described above in terms of clinical scenarios correspond to the following technical implementation scenarios. In each case the use is distinguished by the capabilities of the requesting system:

a. Does it prefer XML or JSON results?
b. Does it need to perform searches at the Series and Instance level or can it process the full Study metadata?
c. What attributes does it need to search against?
d. What attributes does it need for each matching Study, Series or Composite Instance?

These questions can be applied to the use cases:

a. Search from EMR
   1. JSON or XML
   2. Study
   3. Study Instance UID, Patient ID
   4. Accession Number, Issuer of Accession Number, Study Description, Study Date, Modality, Number of Series, Number of Instances

b. Populating FHIR resources
   1. JSON or XML
   2. Study, Series and Instance
   3. Patient ID and Issuer of Patient ID
   4. All attributes required by the FHIR Imaging Study Resource (see http://www.hl7.org/implement/standards/fhir/imagingstudy.htm)

c. Worklist in Viewer
   1. JSON or XML
   2. Study
   3. Study Instance UID, Patient ID, Issuer of Patient ID
   4. Series Instance UIDs, SOP Instance UIDs, patient demographics, Study Description, Study Date, Modality, Referring Physician

d. Study Import Duplication Check
   1. JSON or XML
   2. Study
   3. Study Instance UID, Series Instance UID, SOP Instance UID
   4. Study Instance UID

e. Multiple System Query
   1. JSON or XML
   2. Study
   3. Patient ID, Issuer of Patient ID, Patient Name, Patient Date of Birth
   4. Study Instance UID, Accession Number, Study Description, Study Date, Modalities in Study

f. Clinical Reconstruction
   1. JSON or XML
   2. Study, Series, Instance
3. Study Instance UID, Series Instance UID
4. SOP Instance UID, Image Instance Level Attributes

g. Mobile Device Access
   1. JSON
   2. Study, Series and Instance
      3. Patient ID, Issuer of Patient ID, Patient Name, Patient Date of Birth, Study Date, Referring Physician
      4. Instance Date/time, Modalities in Study

These then become the following technical use cases.

HHH.4.3.1 XML Study Search Use Case
   a. The requesting web-based application can make QIDO-RS requests, parse XML and then make WADO-RS requests
   b. The request specifies:
      1. Multipart XML
      2. Search parameters, including:
         a) Patient ID
         b) Issuer of Patient ID
         c) Patient Name
         d) Study Description
         e) Study Date
         f) Modalities in Study
         g) Referring Physician
         h) etc.
   c. The Response provides
      1. One PS 3.19 XML NativeDicomModel element for each matching Study
      2. All requested DICOM attributes for each matching Study
      3. WADO-RS Retrieve URL for each matching Study
   d. The requesting system identifies the Studies of interest and uses WADO-RS to retrieve data

HHH.4.3.2 XML Study, Series and Instance Search Use Case
   a. The requesting system is a simple web-based application that can make QIDO-RS requests and parse XML and then make WADO URL requests
   b. The request specifies:
      1. Multipart XML
      2. Search parameters, including:
         a) Patient ID
         b) Issuer of Patient ID
         c) Patient Name
         d) Patient Date of Birth
         e) Study Description
         f) Study Date
         g) Modalities in Study
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h) Referring Physician

c. The Response provides
   1. One PS 3.19 XML NativeDicomModel element for each matching Study
   2. All requested DICOM attributes for each matching Study
d. The requesting system identifies the Study of interest and uses Search For Series to identify a series of interest
e. [repeat b-d for Series, Instance]
f. The requesting system uses WADO URL to retrieve specific instances

HHH.4.3.3 JSON Use Case

a. The requesting system is a mobile application that can make QIDO-RS requests, parse JSON and then make WADO URL requests.
b. The request specifies:
   1. JSON
   2. Search parameters, including:
      a) Patient ID
      b) Issuer of Patient ID
      c) Patient Name
      d) Patient Date of Birth
e) Study Description
   f) Study Date
   g) Modalities in Study
   h) Referring Physician
c. The Response provides
   1. One DICOM JSON element containing all matching Studies
   2. All requested DICOM attributes for each matching Study
d. The requesting system identifies the Study of interest and uses Search For Series to identify a series of interest
e. [repeat b-d for Series, Instance]
f. The requesting system uses WADO URL to retrieve specific instances
Changes to NEMA Standards Publication PS 3.18-2012

Digital Imaging and Communications in Medicine (DICOM)

Part 18: Web Services

<table>
<thead>
<tr>
<th>Insert into PS 3.18 Section 3 Normative References (in correct alphabetical order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IETF RFC 4627</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insert into PS 3.18 Section 5 Symbols and abbreviated terms (in correct alphabetical order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QIDO-RS</td>
</tr>
</tbody>
</table>

Update PS 3.18 Section 6.1 INTERACTION as indicated.

6 Data Communication Requirements

6.1 INTERACTION

The interaction shall be as shown in Figure 6-1.

Multiple communications modes are possible:

- URI based mechanism using HTTP Get: WADO-URI Type request

- Web Services (WS*) using HTTP Post: WADO-WS, either:

  a. DICOM Requester (Retrieve Imaging Document Set)
  b. Rendered Requester (Retrieve Rendered Imaging Document Set)
  c. Metadata Requester (Retrieve Imaging Document Set Metadata)

- RESTful Services (RS) using HTTP Get: WADO-RS, either:

  a. DICOM Requester (Retrieve Study, Series, or Instance DICOM Objects)
  b. Pixel Data Requester (Retrieve Instance Frame Pixel Data)
  c. Bulk Data Requester (Retrieve Study, Series, Instance bulk data)
  d. Metadata Requester (Retrieve Study Metadata)
Query based on ID for DICOM Objects by means of Representational State Transfer (REST) Services

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— RESTful Services (RS) using HTTP Get: QIDO-RS:
  a. Query Requester (Search for Study, Series or Instance DICOM Objects)

— RESTful Services (RS) using HTTP Post: STOW-RS, either:
  a. DICOM Creator (Store Instances)
  b. Metadata and Bulk Data Creator (Store Instances)

Append below PS 3.18 Section 6.6 RS REQUEST/RESPONSE

6.7 QIDO-RS REQUEST/RESPONSE

DICOM QIDO-RS defines several action types. An implementation shall support the following action types:

a. SearchForStudies
   This action searches for DICOM Studies that match specified search parameters and returns a list of matching studies and the requested attributes for each study.

b. SearchForSeries
   This action searches for DICOM Series that match specified search parameters and returns a list of matching series and the requested attributes for each series.

c. SearchForInstances
   This action searches for DICOM Instances that match specified search parameters and returns a list of matching instances and the requested attributes for each instance.

6.7.1 QIDO-RS – Search

6.7.1.1 Request

The specific resources to be used for the search actions shall be as follows:

— Resource
  — SearchForStudies
    — {SERVICE}/studies[?query]
  — SearchForSeries
    — {SERVICE}/studies/{StudyInstanceUID}/series[?query]
    — {SERVICE}/series[?query]
  — SearchForInstances
    — {SERVICE}/studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances[?query]
    — {SERVICE}/instances[?query]
  where
    — {SERVICE} is the base URL for the QIDO RESTful service. This may be a combination of scheme (http or https), host, port, and application.
    — {StudyInstanceUID} is the unique Study Instance UID for a single study.
    — {SeriesInstanceUID} is the unique Series Instance UID for a single series.

— Method
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— GET

— Headers

— Accept – The Media Type of the query results. The types allowed for this request header are:
  — multipart/related; type=application/dicom+xml (default)
  Specifies that the results should be DICOM PS3.19 XML (one part per result)
  — application/json
  Specifies that the results should be DICOM JSON

A QIDO-RS provider shall support both Accept header values

— Cache-control: no-cache (recommended)
If included, specifies that search results returned should be current and not cached.

— Query key=value pairs

— {attributeID}={value}
  0-n / {attributeID}={value} pairs allowed

— includefield={attributeID} | all
  0-n includefield / {attributeID} pairs allowed, where "all" indicates that all available attributes should be included for each response.

Each {attributeID} must refer to one of:
  — Patient IE attributes
  — Study IE attributes
  — Series IE attributes (SearchForSeries or SearchForInstances requests only)
  — Composite Instance IE attributes (SearchForInstances requests only)
  — Additional Query / Retrieve Attributes (DICOM PS 3.4 C.3.4)
  — Timezone Offset From UTC (0008,0201)

Each {attributeID} query value must be unique unless the associated DICOM Attribute allows UID List matching (see DICOM PS3.4 C.2.2.2.2), in which case each {value} will be interpreted to be an element of the UID List.

The acceptable values for {value} are determined by the types of matching allowed by C-FIND for its associated {attributeID} (see PS3.4 C.2.2.2). All characters in {value} that are disallowed for URLs must be URL encoded. See IETF RFC 1738 for details.

If an {attributeID} is passed as the value of an "includefield" query key this is equivalent to C-FIND Universal matching for the specified attribute (see DICOM PS3.4 C.2.2.2.3).

— fuzzymatching=true | false
— limit={maximumResults}
— offset={skippedResults}

{attributeID} can be one of the following:

— {dicomTag}
Query based on ID for DICOM Objects by means of Representational State Transfer (REST) Services

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— {dicomKeyword}

618 — {dicomTag}.{attributeID}, where {attributeID} is an element of the sequence specified by {dicomTag}

— {dicomKeyword}.{attributeID}, where {attributeID} is an element of the sequence specified by {dicomKeyword}

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{dicomTag} is the eight character hexadecimal string corresponding to the Tag of a DICOM Attribute (see PS3.6 Section 6).

{dicomKeyword} is the Keyword of a DICOM Attribute (see PS3.6 Section 6).

Note: Examples of valid values for {attributeID}:

— 0020000D
— StudyInstanceUID
— 0010002.00100020
— OtherPatientIDsSequence.PatientID
— 0010002.00100024.00400032
— OtherPatientIDsSequence.IssuerOfPatientIDQualifiersSequence.UniversalEntityID

Note: Examples of valid QIDO-RS URLs:

— http://dicomrs/studies?StudyInstanceUID=11235813
— http://dicomrs/studies?PatientID=11235813&StudyDate=20130509
— http://dicomrs/studies?00100010=SMITH*&OtherPatientIDsSequence.00100020=11235813
— http://dicomrs/studies?PatientID=11235813&includefield=00081048&includefield=00081049 &includefield=00081060
— http://dicomrs/studies?PatientID=11235813&StudyDate=20130509-20130510
— http://dicomrs/studies?StudyInstanceUID=1.2.392.200036.9116.2.2.2.2162893313.1029997326.94587

642 94587%2c1.2.392.200036.9116.2.2.2.2162893313.1029997326.94583

644 6.7.1.2 Response

The Server shall perform the query indicated in the request. The Server shall return the query results or, when the query cannot be performed, an error code.

If the limit query key is not specified or its value exceeds the total number of matching results then {maximumResults} is the lesser of the number of matching results and the maximum number of results supported by the Server.

If the offset query key is not specified or its value is less than zero then {skippedResults} is zero.

The first result returned shall be result number ({skippedResults} + 1). The last result returned shall be result number ({skippedResults} + (maximumResults)). If ({skippedResults} + 1) exceeds (maximumResults) then no results are returned.

If the number of results exceeds the maximum supported by the server, the server shall return the maximum supported results and the response shall include the following HTTP/1.1 Warning header (see RFC 2616 Section 14.46):
Warning: 299 \{SERVICE\}: "The number of results exceeded the maximum supported by the server. Additional results can be requested."

Note: The client can request additional results by specifying a value for the "offset" query key.

The server shall be idempotent so that if the list of results is the same, the response to a request with a specific set of parameters shall always be the same, including order. If the complete list of results is different for subsequent transactions the responses may be different. In a situation where results are changing due to changes in the server contents, queries using the limit and offset may be inconsistent.

The response format depends on the Accept header specified in the request.

### 6.7.1.2.1 Matching

The matching semantics for each attribute are determined by the types of matching allowed by C-FIND (see PS3.4 C.2.2.2).

Matching results shall be generated according to the Hierarchical Search Method described in PS 3.4 C.4.1.3.1.1.

Combined Datetime matching shall be performed (see DICOM PS3.4 C.2.2.2.5).

Note: If a QIDO-RS provider is acting as a proxy for a C-FIND SCP that does not support combined Datetime matching the QIDO-RS provider will need to perform a C-FIND request using Date only and filter results outside the time range before returning a QIDO-RS response.

If the TimezoneOffsetFromUTC / 00080201 query key is included in the request, dates and times in the request are to be interpreted in the specified time zone.

If the "fuzzymatching=true" query key/value is included in the request and it is supported then additional fuzzy semantic matching of person names shall be performed in the manner specified in the DICOM Conformance Statement for the service provider.

If the "fuzzymatching=true" query key/value is included in the request and it is not supported, the response shall include the following HTTP/1.1 Warning header (see RFC 2616 Section 14.46):

```
Warning: 299 \{SERVICE\}: "The fuzzymatching parameter is not supported. Only literal matching has been performed."
```

where \{SERVICE\} is the base URL for the QIDO-RS provider. This may be a combination of scheme (http or https), host, port, and application.

Note: The Warning header is separate from the Status Line and does not affect the returned Status Code.

### 6.7.1.2.1.1 Study Matching

Providers of the SearchForStudies service shall support the search query keys described in Table 6.7.1-1:

<table>
<thead>
<tr>
<th>Key Word</th>
<th>Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>StudyDate</td>
<td>00080020</td>
</tr>
<tr>
<td>StudyTime</td>
<td>00080030</td>
</tr>
<tr>
<td>AccessionNumber</td>
<td>00080050</td>
</tr>
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</table>
6.7.1.2.1.2 Series Matching

Providers of the SearchForSeries service shall support the search query keys described in Table 6.7.1-1a:

Table 6.7.1-1a
QIDO-RS SERIES Search Query Keys

<table>
<thead>
<tr>
<th>Key Word</th>
<th>Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality</td>
<td>00080060</td>
</tr>
<tr>
<td>SeriesInstanceUID</td>
<td>0020000E</td>
</tr>
<tr>
<td>SeriesNumber</td>
<td>00200011</td>
</tr>
<tr>
<td>PerformedProcedureStepStartDate</td>
<td>00400244</td>
</tr>
<tr>
<td>PerformedProcedureStepStartTime</td>
<td>00400245</td>
</tr>
<tr>
<td>RequestAttributeSequence</td>
<td>00400275</td>
</tr>
<tr>
<td>&gt;ScheduledProcedureStepID</td>
<td>00400009</td>
</tr>
<tr>
<td>&gt;RequestedProcedureID</td>
<td>00401001</td>
</tr>
</tbody>
</table>

If {StudyInstanceUID} is not specified in the URL and this form of Relational Query is supported, all Study-level attributes specified in Table 6.7.1-1 shall also be supported.

6.7.1.2.1.3 Instance Matching

Providers of the SearchForInstances service shall support the search query keys described in Table 6.7.1-1c:

Table 6.7.1-1b
QIDO-RS INSTANCE Search Query Keys

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>SOPClassUID</td>
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<td>SOPInstanceUID</td>
<td>00080018</td>
</tr>
<tr>
<td>InstanceNumber</td>
<td>00200013</td>
</tr>
</tbody>
</table>

If {StudyInstanceUID} is not specified in the URL and this form of Relational Query is supported, all Study-level attributes specified in Table 6.7.1-1 shall also be supported.

If {SeriesInstanceUID} is not specified in the URL and this form of Relational Query is supported, all Series-level attributes specified in Table 6.7.1-1a shall also be supported.
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6.7.1.2.2 Query Result Attributes

6.7.1.2.2.1 Study Result Attributes

For each matching Study, the QIDO-RS provider shall return all attributes in accordance with Table 6.7.1-2:

Table 6.7.1-2
QIDO-RS STUDY Returned Attributes

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Character Set</td>
<td>(0008,0005)</td>
<td>If necessary for encoding any returned attributes</td>
</tr>
<tr>
<td>Study Date</td>
<td>(0008,0020)</td>
<td></td>
</tr>
<tr>
<td>Study Time</td>
<td>(0008,0030)</td>
<td></td>
</tr>
<tr>
<td>Accession Number</td>
<td>(0008,0050)</td>
<td></td>
</tr>
<tr>
<td>Instance Availability</td>
<td>(0008,0056)</td>
<td></td>
</tr>
<tr>
<td>Modalities in Study</td>
<td>(0008,0061)</td>
<td></td>
</tr>
<tr>
<td>Referring Physician’s Name</td>
<td>(0008,0090)</td>
<td></td>
</tr>
<tr>
<td>Timezone Offset From UTC</td>
<td>(0008,0201)</td>
<td>May be absent if no value is available</td>
</tr>
<tr>
<td>Retrieve URL</td>
<td>(0008,1190)</td>
<td>Shall be empty if the resource cannot be retrieved via WADO-RS</td>
</tr>
<tr>
<td>Patient’s Name</td>
<td>(0010,0010)</td>
<td></td>
</tr>
<tr>
<td>Patient ID</td>
<td>(0010,0020)</td>
<td></td>
</tr>
<tr>
<td>Patient’s Birth Date</td>
<td>(0010,0030)</td>
<td></td>
</tr>
<tr>
<td>Patient’s Sex</td>
<td>(0010,0040)</td>
<td></td>
</tr>
<tr>
<td>Study Instance UID</td>
<td>(0020,000D)</td>
<td></td>
</tr>
<tr>
<td>Study ID</td>
<td>(0020,0010)</td>
<td></td>
</tr>
<tr>
<td>Number of Study Related Series</td>
<td>(0020,1206)</td>
<td></td>
</tr>
<tr>
<td>Number of Study Related Instances</td>
<td>(0020,1208)</td>
<td></td>
</tr>
</tbody>
</table>

All other Study Level DICOM Attributes passed as {attributeID} query keys that are supported by the service provider as matching or return attributes.

All other Study Level DICOM Attributes passed as “includefield” query values that are supported by the service provider as return attributes.

All available Study Level DICOM Attributes if the “includefield” query key is included with a value of “all”.

Series Level and Instance Level attributes passed as “includefield” query values shall not be returned.

Note: The above list is consistent with those required for IHE RAD-14 (see http://www.ihe.net/Technical_Framework/upload/IHE_RAD_TF_Vol2.pdf Table 4.14-1).

6.7.1.2.2.2 Series Result Attributes

For each matching Series, the QIDO-RS provider shall return all attributes listed in Table 6.7.1-2a:

Table 6.7.1-2a
QIDO-RS SERIES Returned Attributes

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient’s Name</td>
<td>(0010,0010)</td>
<td></td>
</tr>
<tr>
<td>Patient ID</td>
<td>(0010,0020)</td>
<td></td>
</tr>
<tr>
<td>Patient’s Birth Date</td>
<td>(0010,0030)</td>
<td></td>
</tr>
<tr>
<td>Patient’s Sex</td>
<td>(0010,0040)</td>
<td></td>
</tr>
<tr>
<td>Study Instance UID</td>
<td>(0020,000D)</td>
<td></td>
</tr>
<tr>
<td>Study ID</td>
<td>(0020,0010)</td>
<td></td>
</tr>
<tr>
<td>Number of Study Related Series</td>
<td>(0020,1206)</td>
<td></td>
</tr>
<tr>
<td>Number of Study Related Instances</td>
<td>(0020,1208)</td>
<td></td>
</tr>
</tbody>
</table>

All other Study Level DICOM Attributes passed as {attributeID} query keys that are supported by the service provider as matching or return attributes.

All other Study Level DICOM Attributes passed as “includefield” query values that are supported by the service provider as return attributes.

All available Study Level DICOM Attributes if the “includefield” query key is included with a value of “all”.

Series Level and Instance Level attributes passed as “includefield” query values shall not be returned.
Potential Character Set (0008,0005)

If necessary for encoding any returned attributes

Modality (0008,0056)

Timezone Offset From UTC (0008,0201) May be absent if no value is available

Series Description (0008,103E) May be absent if no value is available

Retrieve URL (0008,1190) Shall be empty if the resource cannot be retrieved via WADO-RS

Series Instance UID (0020,000E)

Series Number (0020,0011)

Number of Series Related Instances (0020,1209)

Performed Procedure Step Start Date (0040,0244) May be absent if no value is available

Performed Procedure Step Start Time (0040,0245) May be absent if no value is available

Request Attribute Sequence (0040,0275)

All other Series Level DICOM Attributes passed as {attributeID} query keys that are supported by the service provider as matching or return attributes

All other Study or Series Level DICOM Attributes passed as "includefield" query values that are supported by the service provider as return attributes

All available Instance Level DICOM Attributes if the "includefield" query key is included with a value of "all"

If {StudyInstanceUID} is not specified, all Study-level attributes specified in Table 6.7.1-2

If {StudyInstanceUID} is not specified, all Study-level attributes specified in Table 6.7.1-2

Note: The above list is consistent with the attributes required for IHE RAD-14 (see http://www.ihe.net/Technical_Framework/upload/IHE_RAD_TF_Vol2.pdf Table 4.14-1).
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<table>
<thead>
<tr>
<th>Instance Number</th>
<th>(0020,0013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows</td>
<td>(0028,0010)</td>
</tr>
<tr>
<td>Columns</td>
<td>(0028,0011)</td>
</tr>
<tr>
<td>Bits Allocated</td>
<td>(0028,0100)</td>
</tr>
<tr>
<td>Number of Frames</td>
<td>(0028,0008)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>attributeID</th>
<th>query keys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only present for Image Instances</td>
<td></td>
</tr>
</tbody>
</table>

All other Instance Level DICOM Attributes passed as (attributeID) query keys that are supported by the service provider as matching or return attributes

All other Study, Series or Instance Level DICOM Attributes passed as “includefield” query values that are supported by the service provider as return attributes

All available Instance Level DICOM Attributes if the “includefield” query key is included with a value of “all”

If {StudyInstanceUID} is not specified, all Study-level attributes specified in Table 6.7.1-2

If {SeriesInstanceUID} is not specified, all Series-level attributes specified in Table 6.7.1-2a

Note: The above list is consistent with the attributes required for IHE RAD-14 (see http://www.ihe.net/Technical_Framework/upload/IHE_RAD_TF_Vol2.pdf Tables 4.14-1 and 4.14-2).

6.7.1.2.3 Query Result Messages

The server shall support returning query results as:

— XML Results
— JSON Results

The result format used shall depend on the Accept header of the request.

6.7.1.2.3.1 XML Results

— Content-Type: multipart/related; type=application/dicom+xml

— The response is a multipart message body where each part is a DICOM PS 3.19 XML NativeDicomModel element containing the attributes for one matching Study, Series or Instance (see DICOM PS 3.19 Annex A.1).

— The provider of the QIDO service may use a BulkData reference at its discretion (see DICOM PS 3.19 Table A.1.5-2 and 6.5.6). For example, this might be done to avoid encoding a large DICOM Value Field, such as an image thumbnail.

— If there are no matching results, the message body will be empty.

— Each item in the multipart response will contain the following HTTP/1.1 headers:

— Content-Type: application/dicom+xml

6.7.1.2.3.2 JSON Results

— Content-Type: application/json

— The response is a DICOM JSON message containing a DICOM JSON property for each matching study, series or instance containing sub-properties describing the matching attributes for each study, series or instance (see F.2).
The provider of the QIDO service may use a BulkDataURI reference at its discretion (see F.2.6). For example, this might be done to avoid encoding a large DICOM Value Field, such as an image thumbnail.

If there are no matching results, the JSON message is empty.

### 6.7.1.3 Status Codes

Table 6.7-1 lists the HTTP/1.1 status codes that shall be used to report any of the associated error and warning situations. Other error codes may be present for other error and warning situations.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>OK</td>
<td>The query completed and any matching results are returned in the message body.</td>
</tr>
</tbody>
</table>

**Failure**

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Bad Request</td>
<td>The QIDO-RS Provider was unable to perform the query because the Service Provider cannot understand the query component.</td>
</tr>
<tr>
<td>401</td>
<td>Unauthorized</td>
<td>The QIDO-RS Provider refused to perform the query because the client is not authenticated.</td>
</tr>
<tr>
<td>403</td>
<td>Forbidden</td>
<td>The QIDO-RS Provider understood the request, but is refusing to perform the query (e.g. an authenticated user with insufficient privileges).</td>
</tr>
<tr>
<td>413</td>
<td>Request entity too large</td>
<td>The query was too broad and a narrower query or paging should be requested. The use of this status code should be documented in the conformance statement.</td>
</tr>
<tr>
<td>503</td>
<td>Busy</td>
<td>Service is unavailable.</td>
</tr>
</tbody>
</table>

Append PS 3.18 by the following annex.

### Annex F DICOM JSON Model

**F.1 INTRODUCTION TO JAVASCRIPT OBJECT NOTATION (JSON)**

JSON is a text-based open standard, derived from JavaScript, for representing data structures and associated arrays. It is language-independent, and primarily used for serializing and transmitting

The DICOM JSON Model complements the XML-based Native DICOM Model, by providing a lightweight representation of data returned by DICOM web services. While this representation can be used to encode any type of DICOM Data Set it is expected to be used by client applications, especially mobile clients, such as described in the QIDO-RS use cases (see PS 3.17 Annex HHH).

**F.2 DICOM JSON MODEL**

The DICOM JSON Model follows the Native DICOM Model for XML very closely, so that systems can take advantage of both formats without much retooling. The Media Type for DICOM JSON is application/json. The default character repertoire shall be UTF-8 / ISO_IR 192.

**F.2.1 Multiple Results Structure**

Multiple results returned in JSON are organized as a single top-level array of JSON objects. This differs from the Native DICOM Model, which returns multiple results as a multi-part collection of singular XML documents.

**F.2.1.1 Examples**

**F.2.1.1.1 Native DICOM Model**

```xml
<?xml version="1.0" encoding="UTF-8" xml:space="preserve" ?>
<NativeDicomModel>
  <DicomAttribute tag="0020000D" vr="UI" keyword="StudyInstanceUID">
    <Value number="1">1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873</Value>
  </DicomAttribute>
</NativeDicomModel>
...

<?xml version="1.0" encoding="UTF-8" xml:space="preserve" ?>
<NativeDicomModel>
  <DicomAttribute tag="0020000D" vr="UI" keyword="StudyInstanceUID">
    <Value number="1">1.2.444.200036.9116.2.2.2.1762893313.1029997326.945876</Value>
  </DicomAttribute>
</NativeDicomModel>
```

**F.2.1.2 DICOM JSON Model**

```json
[
  {
    "0020000D": {
      "vr": "UI",
      "Value": [ "1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873" ]
    }
  },
  {
    "0020000D": {
      "vr": "UI",
      "Value": [ "1.2.392.200036.9116.2.2.2.2162893313.1029997326.945876" ]
    }
  }
]
```
F.2.2 DICOM JSON Model Object Structure

The DICOM JSON Model object is a representation of a DICOM Data Set.

The internal structure of the DICOM JSON Model object is a sequence of objects representing attributes within the DICOM Data Set.

Attribute objects within a DICOM JSON Model object must be ordered by their property name in ascending order.

Group Length (gigg,0000) attributes shall not be included in a DICOM JSON Model object.

     — The eight character uppercase hexadecimal representation of a DICOM Tag

Each attribute object contains the following named child objects:

     — vr: A string encoding the DICOM Value Representation. The mapping between DICOM Value Representations and JSON Value Representations is described in F.2.3

     — At most one of:

       — Value: An array containing one of:

         — The Value Field elements of a DICOM attribute with a VR other than PN, SQ, OB, OD, OF, OW, or UN (described in F.2.4)

         The encoding of empty Value Field elements is described in F.2.5

         — The Value Field elements of a DICOM attribute with a VR of PN. The non-empty name components of each element are encoded as a JSON strings with the following names:

           — Alphabetic
           — Ideographic
           — Phonetic

         — JSON DICOM Model objects corresponding to the sequence items of an attribute with a VR of SQ

         Empty sequence items are represented by empty objects

       — BulkDataURI: A string encoding the WADO-RS URL of a bulk data item describing the Value Field of an enclosing Attribute with a VR of FL, FD, IS, LT, OB, OD, OF, OW, SL, SS, ST, UL, UN, US, or UT (described in F.2.6)

       — InlineBinary: A base64 string encoding the Value Field of an enclosing Attribute with a VR of OB, OD, OF, OW, or UN (described in F.2.7)

Note: 1. For Private Data Elements, the group and element numbers will follow the rules specified in PS 3.5 Section 7.8.1

2. The person name representation is more closely aligned with the DICOM Data Element representation than the DICOM PS 3.19 XML representation.

F.2.3 DICOM JSON Value Representation

The value representation (VR) is included in each DICOM JSON Model attribute object and named “vr”.

For example:

"vr": "CS"
All DICOM Value Representations are mapped to specified JSON Data Types (see Table F.2.3-1). The JSON encodings shall conform to the Definition, Character Repertoire (if applicable) and Length of Value specified for that Value Representation (see PS 3.5 Section 6.2) with the following exceptions:

- Attributes with a Value Representation of AT shall be restricted to eight character uppercase hexadecimal representation of a DICOM Tag

<table>
<thead>
<tr>
<th>VR Name</th>
<th>Type</th>
<th>JSON Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>Application Entity</td>
<td>String</td>
</tr>
<tr>
<td>AS</td>
<td>Age String</td>
<td>String</td>
</tr>
<tr>
<td>AT</td>
<td>Attribute Tag</td>
<td>String</td>
</tr>
<tr>
<td>CS</td>
<td>Code String</td>
<td>String</td>
</tr>
<tr>
<td>DA</td>
<td>Date</td>
<td>String</td>
</tr>
<tr>
<td>DS</td>
<td>Decimal</td>
<td>Number</td>
</tr>
<tr>
<td>DT</td>
<td>Date Time</td>
<td>String</td>
</tr>
<tr>
<td>FL</td>
<td>Floating Point Single</td>
<td>Number</td>
</tr>
<tr>
<td>FD</td>
<td>Floating Point Double</td>
<td>Number</td>
</tr>
<tr>
<td>IS</td>
<td>Integer String</td>
<td>Number</td>
</tr>
<tr>
<td>LO</td>
<td>Long String</td>
<td>String</td>
</tr>
<tr>
<td>LT</td>
<td>Long Text</td>
<td>String</td>
</tr>
<tr>
<td>OB</td>
<td>Other Byte String</td>
<td>Base64 encoded string</td>
</tr>
<tr>
<td>OD</td>
<td>Other Double String</td>
<td>Base64 encoded string</td>
</tr>
<tr>
<td>OF</td>
<td>Other Float String</td>
<td>Base64 encoded string</td>
</tr>
<tr>
<td>OW</td>
<td>Other Word String</td>
<td>Base64 encoded string</td>
</tr>
<tr>
<td>PN</td>
<td>Person Name</td>
<td>Object containing Person Name component groups as strings (see F.2.2)</td>
</tr>
<tr>
<td>SH</td>
<td>Short String</td>
<td>String</td>
</tr>
<tr>
<td>SL</td>
<td>Signed Long</td>
<td>Number</td>
</tr>
</tbody>
</table>
Although data, such as dates, are represented in the DICOM JSON model as strings, it is expected that they will be treated in the same manner as the original attribute as defined by DICOM PS 3.6 section 6.

**F.2.4 DICOM JSON Value Multiplicity**

The value or values of a given DICOM attribute are given in the “Value” array. The value multiplicity (VM) is not contained in the DICOM JSON object.

For example:

```
"Value": [ "bar", "foo" ]
```

or:

```
"Value": [ "bar" ]
```

**F.2.5 DICOM JSON Model Null Values**

If an attribute is present in DICOM but empty (i.e. Value Length is 0), it shall be preserved in the DICOM JSON attribute object containing no “Value”, “BulkDataURI” or “InlineBinary”.

If a multi-valued attribute has one or more empty values these are represented as “null” array elements.

For example:

```
"Value": [ "bar", null, "foo" ]
```

If a sequence contains empty items these are represented as empty JSON object in the array.

```
"Value": [ { ... }, {}, { ... } ]
```

**F.2.6 BulkDataURI**

If an attribute contains a “BulkDataURI”, this contains the URI of a bulk data element as defined in DICOM PS 3.19 Table A.1.5-2.

**F.2.7 InlineBinary**

If an attribute contains an “InlineBinary”, this contains the base64 encoding of the enclosing attribute’s Value Field.
There is a single InlineBinary value representing the entire Value Field, and not one per Value in the case where the Value Multiplicity is greater than one. E.g., a LUT with 4096 16 bit entries that may be encoded in DICOM with a Value Representation of OW, with a VL of 8192 and a VM of 1, or a US VR with a VL of 8192 and a VM of 4096 would both be represented as a single InlineBinary string.

All rules (e.g. byte ordering and swapping) in DICOM PS 3.5 apply.

Note: Implementers should in particular pay attention the PS 3.5 rules regarding the value representations of OD, OF and OW.

### F.3 TRANSFORMATION WITH OTHER DICOM FORMATS

#### F.3.1 Native DICOM Model XML

The transformation between the Native DICOM Model XML and the DICOM JSON model cannot be done through the use of generic XML - JSON converters.

The mapping between the two formats is as follows (see also Table F.3.1-1):

- The XML "NativeDicomModel" element maps to the DICOM JSON Model Object
- Each "DicomAttribute" element maps to an attribute object within the DICOM JSON model object
  - The "tag" attribute maps to the JSON object name
  - The Native DICOM Model XML allows for duplicate Tag values and the DICOM JSON model does not. To resolve this, private attribute Tag values must be remapped according to the conflict avoidance rules specified in PS 3.5 Section 7.8.1.
  - The "vr" attribute maps to the "vr" child string
- "Value" elements map to members of the "Value" child array
  - A "Value" element with the attribute "number=n" maps to "Value[n-1]"
  - Empty "Value" elements are represented by "null" entries in the "Value" array
- "PersonName" elements map to objects within the "Value" array. For a "PersonName" element with the attribute "number=n":
  - The "Alphabetic" element maps to "Value[n-1].Alphabetic"
  - The "Ideographic" element maps to "PersonName[n].Ideographic"
  - The "Phonetic" element maps to "PersonName[n].Phonetic"
- "Item" elements map to members of the "Value" child array
  - An "Item" element with the attribute "number=n" maps to "Value[n-1]"
  - Empty "Item" elements are represented by empty JSON property entries in the "Value" array
- The "uri" attribute of the "BulkData" element maps to the "BulkDataURI" string
- The "InlineBinary" element maps to the "InlineBinary" string

Table F.3.1-1

| XML to JSON Mapping |
### DICOM PS 3.19 XML

```xml
<NativeDicomModel>
  <DicomAttribute tag="ggggee01" ...
  <DicomAttribute tag="ggggee02" ...
  ...
</NativeDicomModel>

<DicomAttribute tag="ggggee00" vr="VR">
  <Value number="1">Value</Value>
</DicomAttribute>

<DicomAttribute tag="ggggee03" ...
  <Value number="1">Value1</Value>
  <Value number="2">Value2</Value>
  ...
</DicomAttribute>

<DicomAttribute tag="ggggee04" vr="PN">
  <PersonName number="1">
    <Alphabetic>
      <FamilyName>SB1</FamilyName>
      <GivenName>SB2</GivenName>
      <MiddleName>SB3</MiddleName>
      <NamePrefix>SB4</NamePrefix>
      <NameSuffix>SB5</NameSuffix>
    </Alphabetic>
    <Ideographic>
      <FamilyName>ID1</FamilyName>
    </Ideographic>
    
    <Phonetic>
      <FamilyName>PH1</FamilyName>
    </Phonetic>
  </PersonName>

  <PersonName number="2">
    <Alphabetic>
      <FamilyName>SB6</FamilyName>
    </Alphabetic>
    <Phonetic>
      ...
    </Phonetic>
  </PersonName>
</DicomAttribute>
```

### DICOM JSON Model

```json
{
  "ggggee01": { ... },
  "ggggee02": { ... },
  ...
}

"ggggee00": {
  "vr": "VR",
  "Value": [ Value ]
}

"ggggee03": {
  ...
  "Value": [ Value1, Value2, ... ]
}

"ggggee04": {
  ...
}

"ggggee04": {
  ...
  "vr": "PN",
  "Value": [ Alphabetic: "SB1^SB2^SB3^SB4^SB5", Ideographic: "ID1^ID2^ID3^ID4^ID5", Phonetic: "PH1^PH2^PH3^PH4^PH5" ]
  
  { "Alphabetic": "SB6" }
  
}
```

---

**Supplement 166 Query based on ID for DICOM Objects by means of Representational State Transfer (REST) Services**

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F.4 DICOM JSON MODEL EXAMPLE

// The following example is a QIDO-RS SearchForStudies response consisting of two matching studies, corresponding to the example QIDO-RS request:

// GET http://qido.nema.org/studies?PatientID=12345&includefield=all&limit=2

```json

```
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"Value": [ "11235813" ]
}
974
"00080056": {
  "vr": "CS",
  "Value": [ "ONLINE" ]
976
},
"00080061": {
  "vr": "CS",
  "Value": [ "CT",
             "PET"
978
  ]
980
},
"00080090": {
  "vr": "PN",
  "Value": [ { "Alphabetic": "^Bob^^Dr." }
982
  ]
984
},
"00081190": {
  "vr": "UT",
  "Value": [ "http://wado.nema.org/studies/1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873" ]
986
},
"00090010": {
  "vr": "LO",
  "Value": [ "Vendor A" ]
988
},
"00091002": {
  "vr": "UN",
  "Value": [ "z0x9c8v7" ]
990
},
"00100010": {
  "vr": "PN",
  "Value": [ { "Alphabetic": "Wang^XiaoDong",
              "Ideographic": "王^小東"
992
            } ]
994
},
"00100020": {
  "vr": "LO",
  "Value": [ "12345" ]
996
},
"00100021": {
  "vr": "LO",
  "Value": [ "Hospital A" ]
998
},
"00100030": {
  "vr": "DT",
1000
}
```
"Value": [ "19670701" ]
}],
"00100040": {
  "vr": "CS",
  "Value": [ "M" ]
},
"00101002": {
  "vr": "SQ",
  "Value": [
    {
      "00100020": {
        "vr": "LO",
        "Value": [ "54321" ]
      },
      "00100021": {
        "vr": "LO",
        "Value": [ "Hospital B" ]
      }
    },
    {
      "00100020": {
        "vr": "LO",
        "Value": [ "24680" ]
      },
      "00100021": {
        "vr": "LO",
        "Value": [ "Hospital C" ]
      }
    }
  ]
},
"0020000D": {
  "vr": "UI",
  "Value": [ "1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873" ]
},
"00200010": {
  "vr": "SH",
  "Value": [ "11235813" ]
},
"00201206": {
  "vr": "IS",
  "Value": [ 4 ]
},
"00201208": {
  "vr": "IS",
  "Value": [ 942 ]
}]
} // Result 2
"00080005": {
  "vr": "CS",
  "Value": [ "ISO_IR192" ]
}
},
```
Supplement 166 Query based on ID for DICOM Objects by means of Representational State Transfer (REST) Services
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"00080020": {
  "vr": "DT",
  "Value": [ "20130309" ]
},
"00080030": {
  "vr": "TM",
  "Value": [ "111900.0000" ]
},
"00080050": {
  "vr": "SH",
  "Value": [ "11235821" ]
},
"00080056": {
  "vr": "CS",
  "Value": [ "ONLINE" ]
},
"00080061": {
  "vr": "CS",
  "Value": [ "CT", "PET" ]
},
"00080090": {
  "vr": "PN",
  "Value": [ {
    "Alphabetic": "^Bob^Dr."
  } ]
},
"00081190": {
  "vr": "UT",
  "Value": [ "http://wado.nema.org/studies/1.2.392.200036.9116.2.2.2.2162893313.1029997326.945876" ]
},
"00090010": {
  "vr": "LO",
  "Value": [ "Vendor A" ]
},
"00091002": {
  "vr": "UN",
  "Value": [ "z0x9c8v7" ]
},
"00100010": {
  "vr": "PN",
  "Value": [ {
    "Alphabetic": "Wang^XiaoDong",
    "Ideographic": "王^小東"
  } ]
}
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```
"00100020": {
    "vr": "LO",
    "Value": [ "12345" ]
},
"00100021": {
    "vr": "LO",
    "Value": [ "Hospital A" ]
},
"00100030": {
    "vr": "DT",
    "Value": [ "19670701" ]
},
"00100040": {
    "vr": "CS",
    "Value": [ "M" ]
},
"00101002": {
    "vr": "SQ",
    "Value": [ 
        { "00100020": {
            "vr": "LO",
            "Value": [ "54321" ]
        },
        "00100021": {
            "vr": "LO",
            "Value": [ "Hospital B" ]
        }
    }
}],
"0020000D": {
    "vr": "UI",
    "Value": [ "1.2.392.200036.9116.2.2.2.2162893313.1029997326.945876" ]
},
"00200010": {
    "vr": "SH",
    "Value": [ "11235821" ]
},
"00201206": {
    "vr": "IS",
    "Value": [ 5 ]
}
```

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"00201208": {
    "vr": "IS",
    "Value": [1123]
}

F.5 REFERENCES


JSON. http://www.json.org/ (Informative)


JSON in FHIR. http://www.hl7.org/implement/standards/fhir/formats.htm#json (Informative)

Changes to NEMA Standards Publication PS 3.19-2011

Digital Imaging and Communications in Medicine (DICOM)
Part 19: Application Hosting

Update PS 3.19 A.1.1 Usage as shown below.

A.1.1 Usage

The Native DICOM Model defines a representation of binary-encoded DICOM SOP Instances as XML Infosets that allows a recipient of data to navigate through a binary DICOM data set using XML-based tools instead of relying on toolkits that understand the binary encoding of DICOM.

Note: It is not the intention that this form be utilized as the basis for other uses. This form does not take advantage of the self-validation features that could be possible with a pure XML representation of the data.

With the exception of padding, a data source that is creating a new instance of a native DICOM Model (e.g. the result from some analysis application) shall follow the DICOM encoding rules (e.g. the handling of character sets) in creating Values for the DicomAttributes within the instance of the Native DICOM Model.

Group Length (gqqq,0000) attributes shall not be included in a Native DICOM Model instance.

A data recipient that converts data from an instance of the Native DICOM Model back into a binary encoded DICOM object shall adjust the padding as necessary to meet the encoding rules specified in DICOM PS3.5.

Update PS 3.19 A.1.4 Information as shown below.

A.1.4 Information Model

A diagram of the Native DICOM Model appears in Figure A.1.4-1.
Update PS 3.19 Table A.1.5-2 DICOM Data Set Macro

class Native DICOM Model

NativeDicomModel

DicomAttribute
+ keyword: xs:token [0..1]
+ tag: xs:string
+ vr: xs:token
+ privateCreator: xs:string [0..1]

Value
+ number: xs:positiveInteger

BulkData
+ uuidUUID: UUID
+ uriURI: xs:anyURI

PersonName
+ number: xs:positiveInteger

AlphabeticName

IdeographicName

PhoneticName

FamilyName

GivenName

MiddleName

NamePrefix

NameSuffix

xs:string

xs:token

xs:positiveInteger
Table A.1.5-2 DICOM Data Set Macro

<table>
<thead>
<tr>
<th>Name</th>
<th>Optionality</th>
<th>Cardinality</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DicomAttribute</td>
<td>O</td>
<td>0-n</td>
<td>An Infoset element corresponding to each DICOM Attribute.</td>
</tr>
<tr>
<td>&gt;keyword</td>
<td>C</td>
<td>A</td>
<td>The keyword as defined in PS3.6. Required unless the DICOM Data Element is unknown to the host.</td>
</tr>
<tr>
<td>&gt;tag</td>
<td>R</td>
<td>A</td>
<td>The four-digit zero-padded hexadecimal values of the Group and Element Numbers of the Data Element Tag, concatenated as a single string without a delimiter <strong>and with lowercase letters disallowed</strong>. E.g., Data Element (0010,0020) would have a tag of “00100020”. For Private Data Elements, the two most significant hexadecimal characters of the Element Number shall be 00, since the Private Creator is explicitly conveyed and the block used in the DICOM encoding shall not be sent (i.e., a Private Data Element has the form gggg00ee).</td>
</tr>
<tr>
<td>&gt;Value</td>
<td>C</td>
<td>1-n</td>
<td>A Value from the Value Field of the DICOM Data Element. There is one Infoset Value element for each DICOM Value or Sequence Item. Required if the DICOM Data Element represented is not zero length and an Item, PersonName, or BulkData XML element is not present. Shall not be used if the VR of the enclosing Attribute is either SQ or PN.</td>
</tr>
<tr>
<td>&gt;&gt;number</td>
<td>R</td>
<td>A</td>
<td>The order in which the Value occurs within the DICOM Value Field, as a number monotonically increasing starting from 1 by 1. Note: The Number XML Attribute is used to preserve the original order.</td>
</tr>
<tr>
<td>&gt;&gt;plain character data</td>
<td>C</td>
<td>1</td>
<td>A single DICOM value encoded as plain character data. E.g., a DICOM Decimal String Value Field that contained two delimiter-separated</td>
</tr>
</tbody>
</table>
values, e.g., "0.5/0.4" would be encoded as two Infoset Value elements:

\[
\begin{align*}
\text{<Value number="1">0.5</Value>}
\text{<Value number="2">0.4</Value>}
\end{align*}
\]

A Code String Value Field that containing three delimiter-separated values, the second of which was zero length, "MPG\XR3", would be encoded as:

\[
\begin{align*}
\text{<Value number="1">MPG</Value>}
\text{<Value number="2"></Value>}
\text{<Value number="3">XR3</Value>}
\end{align*}
\]

Contrast the latter example with a zero length Value Field, in which case there would be no Infoset Value elements at all.

**For DICOM Data Elements whose VR is AT, each value shall be encoded as the four-digit zero-padded hexadecimal values of the Group and Element Numbers of the Data Element Tag, concatenated as a single string without a delimiter and with lowercase letters disallowed.**

The character encoding is that declared for the Infoset, regardless of any DICOM Specific Character Set, and any necessary translation from the DICOM Specific Character Set to the Infoset character encoding shall have been performed.

Note: This translation might not be completely lossless, particularly with Asian character sets.

---

> **BulkData**

<table>
<thead>
<tr>
<th>C</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>A reference to a blob of data that the recipient may retrieve through use of the GetData() method, a WADO-RS call, or a STOW-RS call. Required if the DICOM Data Element represented is not zero length and an XML Infoset Value, Item, InlineBinary, or PersonName element is not present. The provider of the data may use a BulkData reference at its discretion to avoid encoding a large DICOM Value</td>
<td></td>
</tr>
</tbody>
</table>
Field by value in the Infoset, for example, pixel data or look up tables.

There is a single BulkData Infoset element representing the entire Value Field, and not one per Value in the case where the Value Multiplicity is greater than one. E.g., a LUT with 4096 16 bit entries that may be encoded in DICOM with a Value Representation of OW, with a VL of 8192 and a VM of 1, or a US VR with a VL of 8192 and a VM of 4096 would both be represented as a single BulkData element.

All rules (e.g. byte ordering and swapping) in DICOM PS 3.5 apply.

Note: Implementers should in particular pay attention the PS 3.5 rules regarding the value representations of OW and OF.

If the BulkData has a string or text Value Representation, the value(s) of the DICOM Specific Character Set Data Element, if present, might be necessary to determine its encoding.

An identifier of this bulk data reference formatted as a UUID using the hexadecimal representation defined in ITU-T Recommendation X.667.

Required if BulkData URI is not present. Shall not be present otherwise.

The HTTP(S) URI for this bulk data reference.

Required if the NativeDicomModel was:
- returned in response to a WADO-RS Retrieve Metadata request

Shall not be present otherwise.

Update PS 3.19 A.1.6 Schema as shown below.

1228  A.1.6  Schema
The Normative version of the XML Schema for the Native DICOM Model follows:

default namespace="http://dicom.nema.org/PS3.19/models/NativeDICOM"
# This schema was created as an intermediary, a means of describing
# native binary encoded DICOM objects as XML Infosets, thus allowing
# one to manipulate binary DICOM objects using familiar XML tools.
# As such, the schema is designed to facilitate a simple, mechanical,
# bi-directional translation between binary encoded DICOM and XML-like
# constructs without constraints, and to simplify identifying portions
# of a DICOM object using XPath statements.

# Since this schema has minimal type checking, it is neither intended
# to be used for any operation that involves hand coding, nor to
# describe a definitive, fully validating encoding of DICOM concepts
# into XML, as what one might use, for example, in a robust XML
# database system or in XML-based forms, though it may be used
# as a means for translating binary DICOM Objects into such a form
# (e.g. through an XSLT script).

start = element NativeDicomModel { DicomDataSet }

# A DICOM Data Set is as defined in PS3.5. It does not appear
# as an XML Element, since it does not appear in the binary encoded
# DICOM objects. It exists here merely as a documentation aid.
DicomDataSet = DicomAttribute*

DicomAttribute = element DicomAttribute {
    Tag, VR, keyword?, PrivateCreator?,
    (BulkData | Value+ | Item+ | PersonName+ | InlineBinary )?
}

BulkData = element BulkData { (UUID | URI) }

Value = element Value { Number, xsd:string }

InlineBinary = element InlineBinary { xsd:base64Binary }

Item = element Item { Number, DicomDataSet }

PersonName = element PersonName {
    Number,
    element AlphabeticSingleByte { NameComponents }?,
    element Ideographic { NameComponents }?,
    element Phonetic { NameComponents }?
}

NameComponents =
    element FamilyName {xsd:string }?,
    element GivenName {xsd:string }?,
    element MiddleName {xsd:string }?,
    element NamePrefix {xsd:string }?,
    element NameSuffix {xsd:string }?

# keyword is the attribute tag from PS3.6
# (derived from the DICOM Attribute's name)

Keyword = attribute keyword { xsd:token }

# canonical XML definition of Hex, with lowercase letters disallowed
Tag = attribute tag { xsd:string { minLength="8" maxLength="8" pattern="^[0-9A-F]{8}$" } }

VR = attribute vr { "AE" | "AS" | "AT" | "CS" | "DA" | "DS" | "DT" | "FL" | "FD"
    | "IS" | "LO" | "LT" | "OB" | "OF" | "OW" | "PN" | "SH" | "SL"
    | "SQ" | "SS" | "ST" | "TM" | "UI" | "UI" | "UN" | "US" | "UT" }

PrivateCreator = attribute privateCreator { xsd:string }

UUID = attribute uuid { xsd:string }

URI = attribute uri { xsd:anyURI }

Number = attribute number { xsd:positiveInteger }