DICOM RESTful Services

Jim Philbin
American College of Radiology
DICOM Standard Committee, User Co-Chair
DICOM WG-27, User Co-Chair
Overview

- Anatomy of a Transaction
- Resources & Target URLs
- Representations & Media Types
- Studies Service
  - Resources
  - Transactions
  - Media Types
- Other Services
  - Worklist Service
  - Non-Patient Instance Service
Key Concepts

Transaction

• composed of request/response message pair
• always initiated by a user agent request
• completed by an origin server behavior followed by a response.

Resource

A resource is an abstract thing or concept that is reified by a representation, which is a data object contained in an octet-stream.

Representation

A representation is a data object contained in an octet-stream that represents a resource.

Media Type

A media type defines the format and algorithms needed for encoding and decoding resources into representations.
HTTP Transactions

A Transaction is composed of request/response message pair.

Transactions are always initiated by a user agent request.

They are completed by an origin server behavior and response.
HTTP Messages

- A sequence of bytes (octet-string)
- Message formats are specified using ABNF [RFC5234]
- US-ASCII Symbols (7-bit)
- No data types – that happens at another level
Anatomy of Transaction
HTTP Message

request-line / response-line
header-fields
CRLF
[ payload ]
Anatomy of Transaction
HTTP Message

First line  ->  request-line / response-line
Metadata   ->  header-fields
Separator  ->  CRLF
Content    ->  [ payload ]
Anatomy of Transaction
HTTP Message

First line   -> request-line / response-line
Metadata    -> header-fields
Separator   -> CRLF
Content     -> [ payload ]

Where
request-line = method SP /{+resource}{?parameter*} SP version
header-fields = *( header-field CRLF )

/ ; alternatives – either request-line or response-line but not both
CRLF = %x13%x10 ; ASCII carriage return followed by linefeed – separates lines
[ ] ; optional expression, may or may not be present
Anatomy of Transaction Request Message

\begin{verbatim}
method SP /{+resource}{?parameter*} SP version
*(header-field CRLF)
CRLF
[ payload ]
\end{verbatim}

\begin{verbatim}
SP = %x20 ; Space character - used as term separator
CRLF = %x13%x10 ; Carriage Return followed by Linefeed
 ; used as line terminator
* ; zero or more of the preceding expression
( ) ; used to group terms
[ ] ; optional expression, may or may not be present
\end{verbatim}
Anatomy of Transaction Method

**Method**

```
method SP /{+resource}{?parameter*} SP version CRLF
*(header-field CRLF)
CRLF
[ payload ]
```

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONNECT</td>
<td>Connect to a server</td>
</tr>
<tr>
<td>DELETE</td>
<td>Delete a resource</td>
</tr>
<tr>
<td>GET</td>
<td>Retrieve a representation</td>
</tr>
<tr>
<td>HEAD</td>
<td>Retrieve metadata</td>
</tr>
<tr>
<td>OPTIONS</td>
<td>Retrieve capabilities</td>
</tr>
<tr>
<td>POST</td>
<td>Action with a payload, e.g. store, search...</td>
</tr>
<tr>
<td>PUT</td>
<td>Replace a representation</td>
</tr>
</tbody>
</table>
Anatomy of Transaction
Version

method SP /{+resource}{?parameter*} SP version
CRLF *(header-field CRLF)
CRLF [ payload ]

"HTTP/1.1" or "HTTPS/1.1"

Some day soon... "HTTP/2" or "HTTPS/2"
Anatomy of a Request

Header Fields

<table>
<thead>
<tr>
<th>Header Field</th>
<th>Usage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accept</td>
<td>M</td>
<td>All requests that may receive a response that includes a payload shall contain an Accept header field.</td>
</tr>
<tr>
<td>Accept-Charset</td>
<td>O</td>
<td>Indicates what charsets are acceptable in textual response content.</td>
</tr>
<tr>
<td>Accept-Encoding</td>
<td>O</td>
<td>The Accept-Encoding header field is used to indicate the transfer codings that are acceptable in the response.</td>
</tr>
<tr>
<td>Accept-Language</td>
<td>O</td>
<td>Indicate the set of natural languages that are preferred in the response.</td>
</tr>
</tbody>
</table>
Anatomy of a Request

Header Field | Usage | Description
---|---|---
**Content-Length** | MC | Specifies the decimal number of octets in the payload. It shall not be present if the message has a Content-Encoding header field. It should be present otherwise, *even is the size of the payload is zero.*
*If the response message has a payload, and does not have a Content-Encoding header field, it shall have a Content-Length header field specifying the length in octets (bytes) of the payload.*

**Content-Range** | MC | Specifies the range of a partial representation contained in a payload.

**Trailer** | MC | See [RFC7230, Section 4.4](https://tools.ietf.org/html/rfc7230#section-4.4).

**Transfer-Encoding** | MC | See [RFC7230, Section 3.3.1](https://tools.ietf.org/html/rfc7230#section-3.3.1).
Anatomy of a Request

Header Fields

<table>
<thead>
<tr>
<th>Header Field</th>
<th>Usage</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content-Type</td>
<td>M</td>
<td>Specifies the media type of the representation contained in the payload. If a message has a payload, it shall have a Content-Type header field.</td>
</tr>
<tr>
<td>Content-Encoding</td>
<td>MC</td>
<td>Specifies any content encodings applied to the representation and thus what decoding to apply to obtain a representation in the media type specified by the Content-TypeContent-Encoding allow <strong>compression, encryption, and/or authentication</strong> of representations.</td>
</tr>
<tr>
<td>Content-Language</td>
<td>O</td>
<td>Specifies the natural language(s) of the intended audience used in representation.</td>
</tr>
<tr>
<td>Content-Location</td>
<td>MC</td>
<td>Contains a URL that references the specific <strong>resource</strong> corresponding to the representation in the payload. It should be present in any message that has a payload containing a representation of a resource.</td>
</tr>
</tbody>
</table>
Anatomy of a Request

Payload

method SP /{+resource}{?parameter*} SP version CRLF *(header-field CRLF) CRLF
[ payload ]

An octet-string containing one or more representations
Anatomy of a Request

Target Resource

```
method SP /{+resource}{?parameter*} SP
version CRLF
*(header-field CRLF)
CRLF
[ payload ]
```

The target resource is a URL composed of three components:

/  Origin Server Root Path
{+resource}  Target Resource
{?parameter*}  Query Parameters
Target Resource Template

/{+resource}{?parameter*}

- Specified using URI Templates [RFC6570]
- {} enclose components
- + indicates that reserved characters may be used
- ? Indicates a query component parameter
- * Indicate zero of more instances of the parameter
- ... and several other operators
RESTful Studies Service
## Study Service Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>URI Template and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studies Service</td>
<td>/</td>
</tr>
<tr>
<td>All Studies</td>
<td>/studies</td>
</tr>
<tr>
<td>Study</td>
<td>/studies/{study}</td>
</tr>
<tr>
<td>Study Metadata</td>
<td>/studies/{study}/metadata</td>
</tr>
<tr>
<td>Study’s Series</td>
<td>/studies/{study}/series</td>
</tr>
<tr>
<td>Study’s Instances</td>
<td>/studies/{study}/instances</td>
</tr>
<tr>
<td>All Series</td>
<td>/series</td>
</tr>
<tr>
<td>Series</td>
<td>/studies/{study}/series/{series}</td>
</tr>
<tr>
<td>Series Metadata</td>
<td>/studies/{study}/series/{series}/metadata</td>
</tr>
<tr>
<td>Series’ Instances</td>
<td>/studies/{study}/series/{series}/instances</td>
</tr>
<tr>
<td>All Instances</td>
<td>/instances</td>
</tr>
<tr>
<td>Instance</td>
<td>/studies/{study}/series/{series}/instances/{instance}</td>
</tr>
<tr>
<td>Instance Metadata</td>
<td>/studies/{study}/series/{series}/instances/{instance}/metadata</td>
</tr>
<tr>
<td>Frame List</td>
<td>/studies/{study}/series/{series}/instances/{instance}/frames/{frame_list}</td>
</tr>
<tr>
<td>Bulkdata</td>
<td>/{+bulkdata}</td>
</tr>
</tbody>
</table>
Study Service
Resources

URI Template
/studies/{study}/series/{series}/instances/{instance}

URL
/studies/1.2.3/series/4.5.6/instances/7.8.9

UID
### Studies Service Transactions

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Method</th>
<th>Success Payload</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve Capabilities</td>
<td>OPTIONS</td>
<td>N/A</td>
<td>Retrieves a description of the Studies Service, including transactions, resources, query…</td>
</tr>
<tr>
<td>Retrieve DICOM</td>
<td>GET</td>
<td>N/A</td>
<td>Retrieves DICOM representations</td>
</tr>
<tr>
<td>Retrieve Rendered</td>
<td>GET</td>
<td>N/A</td>
<td>Retrieves rendered representations</td>
</tr>
<tr>
<td>Store</td>
<td>POST</td>
<td>Instance(s)</td>
<td>Stores one or more DICOM representations</td>
</tr>
<tr>
<td>Search</td>
<td>GET</td>
<td>N/A</td>
<td>Searches the target resource and returns objects matching the search parameters</td>
</tr>
</tbody>
</table>
## Studies Service
**Transactions and Target Resources**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Retrieve DICOM</th>
<th>Retrieve Rendered</th>
<th>Store</th>
<th>Search</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studies Service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>All Studies</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Study</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study Metadata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Study's Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Study's Instances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>All Series</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Series</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Series Metadata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Series’ Instances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>All Instances</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Instance</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instance Metadata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame List</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulkdata</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## DICOM Media Types

### DICOM Media Types Supported by URI, WS, and RS Modes

<table>
<thead>
<tr>
<th>Media Type</th>
<th>Default Charset</th>
<th>URI</th>
<th>WS</th>
<th>RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>application/dicom</td>
<td>US-ASCII</td>
<td>default</td>
<td>n/a</td>
<td>default</td>
</tr>
<tr>
<td>application/dicom+xml</td>
<td>UTF-8</td>
<td>n/a</td>
<td>required</td>
<td>required</td>
</tr>
<tr>
<td>application/json</td>
<td>UTF-8</td>
<td>n/a</td>
<td>n/a</td>
<td>required</td>
</tr>
<tr>
<td>application/octet-stream</td>
<td>undefined</td>
<td>n/a</td>
<td>recommended</td>
<td>required</td>
</tr>
</tbody>
</table>

**Note:** The URI column indicates the default URI for the respective media type. The WS and RS columns reflect the required or recommended interaction modes for each media type. The **n/a** stands for not applicable, and *undefined* indicates an unspecified default behavior.
## Rendered Media Types

### DICOM Transfer Syntax by Resource Class

<table>
<thead>
<tr>
<th>Resource Class</th>
<th>Transfer Syntax Name</th>
<th>URI</th>
<th>WS</th>
<th>RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Frame Image</td>
<td>image/dicom</td>
<td>default</td>
<td>default</td>
<td>default</td>
</tr>
<tr>
<td></td>
<td>image/dicom+jpeg</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td></td>
<td>image/dicom+rle</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td></td>
<td>image/dicom+jpeg-ls</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td></td>
<td>image/dicom+jp2</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td></td>
<td>image/dicom+jpx</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td>Multi-Frame Image</td>
<td>image/dicom</td>
<td>default</td>
<td>default</td>
<td>default</td>
</tr>
<tr>
<td></td>
<td>image/dicom+jpx</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td>Video</td>
<td>image/dicom</td>
<td>default</td>
<td>default</td>
<td>default</td>
</tr>
<tr>
<td></td>
<td>video/mpeg</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td></td>
<td>video/mp4</td>
<td>recommended</td>
<td>recommended</td>
<td>required</td>
</tr>
<tr>
<td></td>
<td>video/H265</td>
<td>recommended</td>
<td>recommended</td>
<td>recommended</td>
</tr>
<tr>
<td>Other</td>
<td>image/dicom</td>
<td>default</td>
<td>default</td>
<td>default</td>
</tr>
</tbody>
</table>
GET SP /{+resource} SP version CRLF
Accept: dicom-media-type CRLF
[ If-None-Match: entity-tag CRLF]
*(header-field CRLF)
CRLF
version SP status-code SP reason-phrase CRLF
Content-Type: dicom-media-type CRLF
([ Content-Length: uint] /
  [ Transfer-Coding: coding]
[ ETag: entity-tag CRLF]
[ Last-Modified: http-date CRLF]
*(header-field CRLF)
CRLF
payload
POST SP /studies[/{study}] SP version CRLF
Content-Type: dicom-media-type CRLF
*(header-field CRLF)
CRLF
payload
version SP status-code SP reason-phrase CRLF
Content-Type: dicom-media-type
*(header-field CRLF)
CRLF
payload
Studies Service
Retrieve Request

GET SP /{+resource} SP version CRLF
Accept: dicom-media-type CRLF
*(header-field CRLF)
CRLF
Studies Service
Conditional Retrieve Request

GET SP /{+resource} SP version CRLF
Accept: dicom-media-type CRLF
[ If-None-Match: entity-tag CRLF]
*(header-field CRLF)
CRLF

Used to avoid unnecessary retrieves!
Studies Service

Conditional Store Request

POST SP /studies[/{study}] SP version CRLF
Content-Type: dicom-media-type CRLF
[ If-None-Match: entity-tag CRLF]
*(header-field CRLF)
CRLF
payload

Used to ensure consistent updates!
Studies Service
Search Request

POST  SP  /{+resource}{?parameter*}  SP  version  CRLF
Accept: 1#docom-media-type  CRLF
*(header-field  CRLF)
CRLF
payload

{?parameter*}  =  ?{&match*}
  {&fuzzymatching}
  {&includefield*}
  {&offset}  {&limit}
Studies Service
Search Request

```plaintext
{&match*} = #(attribute "=" values)

{&fuzzymatching} = "fuzzymatching=" "true" / "false"

{&includefield*} = "includefield=" (1#attribute / "all")

{&offset} = "offset=" uint

{&limit} = "offset=" uint
```
version SP status-code SP reason-phrase CRLF
Content-Type: dicom-media-type
*(header-field CRLF)
CRLF
payload
## Work in Progress Notifications

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Method</th>
<th>Success Payload</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Channel</td>
<td>UPGRADE</td>
<td>No</td>
<td>SDD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Opens a notification channel between user agent and origin server</td>
</tr>
<tr>
<td>Send Event</td>
<td>**</td>
<td>Report</td>
<td>Ack/Nck</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Origin server sends an event notification</td>
</tr>
<tr>
<td>Create Subscription</td>
<td>POST</td>
<td>No</td>
<td>SDD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>User agent subscribes for notifications</td>
</tr>
<tr>
<td>Delete Subscription</td>
<td>DELETE</td>
<td>No</td>
<td>SDD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>User agent deletes subscription</td>
</tr>
</tbody>
</table>
Questions?
A DICOM Study Storage Service

Resources
Studies, Series, Instance, Frames, Metadata, Bulkdata

Media Types
- Application/dicom
- Application/dicom+xml
- Application/json

Transactions
- Retrieve DICOM representation
- Retrieve rendered representations
- Store DICOM representations
- Search for DICOM resources