Digital Imaging and Communications in Medicine (DICOM)

Supplement 106: JPEG 2000 Interactive Protocol

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Foreword

This Supplement extends the Pixel Data Module to allow reference to a JPIP URL to access pixel data, rather than encoding it in the image instance.

This document is an extension to the following parts of the published DICOM Standard:

PS 3.3	Information Object Definitions
PS 3.4	Service Class Specifications
PS 3.5	Data Structures and Encoding
PS 3.6	Data Dictionary
PS 3.10	Media Storage and File Format for Media Interchange
PS 3.17	Explanatory Information

The use cases for this extension to the standard relate to an application's desire to gain access to a portion of DICOM pixel data without the need to wait for reception of all the pixel data. Examples are:

1) Stack Navigation of a large CT Study.

In this case, it is desirable to quickly scroll through this large set of data at a lower resolution and once the anatomy of interest is located the full resolution data is presented. Initially lower resolution images are requested from the server for the purpose of stack navigation. Once a specific image is identified the system requests the rest of the detail from the server.

2) Large Single Image Navigation

In cases such as microscopy, very large images may be generated. It is undesirable to wait for the complete pixel data to be loaded when only a small portion of the specific image is of interest. Additionally, this large image may exceed the display capabilities thus resulting in a decimation of the image when displayed. A lower resolution image (i.e. one that matches the resolution of the display) is all that is required, as additional data cannot be fully rendered. Once an area of interest is determined, the application can pan and zoom to this area and request additional detail to fill the screen resolution.

3) Thumbnails

It is desirable to generate thumbnail representations for a study. This has been accomplished through various means, many which require the client to receive the complete pixel data from the server to generate the thumbnail image. This uses significant network bandwidth.

The thumbnails can be considered low-resolution representations of the image. The application can request a low-resolution representation of the image for use as a thumbnail.

4) Display by Dimension

Multi-frame images may encode multiple dimensions. It is desirable for an application to access only the specific frames of interest in a particular dimension without the need to receive the complete pixel data set. By using the multi-dimensional description, applications using the JPIP protocol may retrieve frames of the multi-frame image.

Scope and Field of Application

JPIP is a client/server communication protocol defined in Part 9 of the JPEG 2000 suite of standards, officially entitled "Interactivity Tools, APIs and Protocols". It is officially referred to as ISO/IEC 15444-9.

JPIP enables a server to transmit only those portions of a JPEG 2000 image that are applicable to the client's needs and to enable a client to access metadata or other contents from the JPEG 2000 image file. This capability results in an improvement in bandwidth efficiency and speed when performing certain image viewing tasks in a client/server environment, while reducing the storage and processing requirements of the client. The larger the images - and the more constrained the bandwidth between the client and server- the greater the benefit of JPIP. In short, JPIP is an ISO standard that is designed to make optimal use of the JPEG 2000 Still Image Compression Standard to provide open, non-proprietary, image streaming.

The JPEG 2000 code stream is parseable, which means that it can be broken apart, rearranged, and reformatted. The parseable nature of the image codestream provides for the extraction of subsets of a JPEG 2000 image through three standard compliant image derivation techniques: 1) spatial, 2) resolution level, and 3) quality level. That is, from a single source image, a viewer application can remotely extract 1) a particular region of the image, 2) a large or small version of the image, or 3) a high or low quality version of the image or any combination of all three. JPIP can be used to progressively forward images of increasing fidelity, providing the client with viewable images as quickly as possible. JPIP can also be used to request for viewing selected frames from a multi-frame image.

In order to allow transfer of the pixel data using such a protocol, but to continue to allow access to the remainder of the DICOM information regarding the image using the existing Storage Service Class, new Transfer Syntaxes are defined that separate the Pixel Data from the rest of the existing Composite Image IODs. A URL from which the pixel data can be retrieved using JPIP is encoded to reference the pixel data.

These new Transfer Syntaxes are applicable to network operations on all existing and future Image Storage SOP Classes.

Part 3

Modify Section 4 Symbols and abbreviations

JIRA	Japan Industries Association of Radiation Apparatus
JPIP	**JPEG 2000 Interactive Protocol**

Modify Table C.7-11b IMAGE PIXEL MACRO ATTRIBUTES as indicated.

Table C.7-11b
IMAGE PIXEL MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…	…	…	…
Pixel Data	(7FE0,0010)	1**C**	A data stream of the pixel samples that comprise the Image. See C.7.6.3.1.4 for further explanation. **Required if Pixel Data Provider URL (0028,7FE0) is not present.**

Add Table C.7-11a IMAGE PIXEL MODULE ATTRIBUTES as indicated.

Table C.7-11a
IMAGE PIXEL MODULE ATTRIBUTES

Pixel Data Provider URL	**(0028,7FE0)**	**1C**	**A URL of a provider service that supplies the pixel data of the Image.** **Required if the image is to be transferred in one of the following presentation contexts identified by Transfer Syntax UID:** **1.2.840.10008.1.2.4.94 (DICOM JPIP Referenced Transfer Syntax)** **1.2.840.10008.1.2.4.95 (DICOM JPIP Referenced Deflate Transfer Syntax)**

Planar Configuration	(0028,0006)	1C	Indicates whether the pixel data are sent color-by-plane or color-by-pixel. Required if Samples per Pixel (0028,0002) has a value greater than 1. See C.7.6.3.1.3 for further explanation.
…	…	…	…

2

Part 4

Modify Section 4 Symbols and abbreviations

JIRA	Japan Industries Association of Radiation Apparatus
JPIP	**JPEG 2000 Interactive Protocol**

Modify B.1.2 Service Definition as indicated.

B.1.2 Service Definition

Two peer DICOM AEs implement a SOP Class of the Storage Service Class with one serving in the SCU role and one serving in the SCP role. SOP Classes of the Storage Service Class are implemented using the C-STORE DIMSE-C service. C-STORE is described in PS 3.7. A successful completion of the C-STORE has the following semantics:

- Both the SCU and the SCP support the type of information to be stored.
- The information is stored in some medium.
- For some time frame, the information may be accessed.

Notes: **1)** Support for Storage SOP Classes does not necessarily involve support for SOP Classes of the Query/Retrieve Service Class. How the information may be accessed is implementation dependent. It is required that some access method exists. This method may require an implementation dependent operation at the SCP of the Storage Service Class. The duration of the storage is also implementation dependent, but is described in the Conformance Statement of the SCP. Storage SOP Classes are intended to be used in a variety of environments: e.g. for modalities to transfer images to workstations or archives, for archives to transfer images to workstations or back to modalities, for workstations to transfer processed images to archives, etc.

2) For the JPIP Referenced Pixel Data transfer syntaxes, transfers may result in storage of incomplete information in that the pixel data may be partially or completely transferred by some other mechanism at the discretion of the SCP.

Modify B.4.3.1 Conformance Statement for An SCU *as indicated.*

B.4.3.1 Conformance Statement for An SCU

The following issues shall be documented in the Conformance Statement of any implementation claiming conformance to the Storage SOP Class as an SCU:

- The behavior of the SCU in the case of a successful C-STORE response status shall be described.

— The behavior of the SCU in each case of an unsuccessful C-STORE response status shall be described.

— The behavior of the SCU in the case of a Warning status received in response to a C-STORE operation.

— Whether extended negotiation is supported.

— The optional elements which may be included in Storage SOP Instances for each IOD supported shall be listed.

— The standard and privately defined Functional Groups which may be included in Storage SOP Instances for each Multi-frame IOD that support Functional Groups.

— The behavior of the SCU in the case of a C-STORE operation using a referenced pixel data transfer syntax such as JPIP Referenced Pixel Data Transfer Syntax shall be described. This includes the duration of validity of the reference.

Modify Annex J Storage Commitment Service Class as indicated.

Annex J STORAGE COMMITMENT SERVICE CLASS (Normative)

J.1 OVERVIEW

J.1.1 Scope

The mechanism currently defined in DICOM for network based storage of SOP Instances, the Storage Service Class, allows a Service Class User (SCU) to transmit images and other information (such as overlays and curves) to a Service Class Provider (SCP). However, the Storage Service Class does not specify that the SCP explicitly take responsibility for the safekeeping of data into account. That is, there is no commitment that the SCP will do more than accept the transmitted SOP Instances. In order to have medical image management in addition to medical image communication, there is a need for a Service Class within DICOM that ensures that there is an explicitly defined commitment to store the SOP Instances.

The Storage Commitment Service Class defines an application-level class-of-service which facilitates this commitment to storage. The Storage Commitment Service Class enables an Application Entity (AE) acting as an SCU to request another Application Entity (AE) acting as an SCP to make the commitment for the safekeeping of the SOP Instances (i.e. that the SOP Instances will be kept for an implementation specific period of time and can be retrieved). The AE where such SOP Instances can later be retrieved may be the SCP where storage commitment was accepted or it may be distinct from that SCP.

The SCP implementation defines how it provides its commitment to storage. Certain SCPs may commit to permanently store the SOP Instances (e.g. an archive system) while other SCPs may commit to provide storage of the SOP Instances for a limited amount of time. The SCP is required to document in its Conformance Statement the nature of its commitment to storage (e.g. duration of storage, retrieve capabilities and latency, capacity).

The possession of a link to access pixel data shall not be sufficient for the SCP to commit to storage. A copy of the entire pixel data is required.

Note: This situation may arise in the context of a JPIP Referenced Pixel Data Transfer Syntax.

Once the SCP has accepted the commitment to store the SOP Instances, the SCU may decide that it is appropriate to delete its copies of the SOP Instances. These types of policies are outside the scope of this Standard, however, the SCU is required to document these policies in its Conformance Statement.

Part 5

Update Section 2 Normative References add the following references

ISO/IEC 15444-9 Information technology -- JPEG 2000 image coding system: Interactivity tools, APIs and protocols

IETF RFC2396 Uniform Resource Identifiers (URI): Generic Syntax

Add 8.x PIXEL DATA PROVIDER SERVICE

8.x Pixel Data Provider Service

Specific Transfer Syntaxes allow for the pixel data of the message to be replaced with a reference to a pixel data provider service. The pixel data provider service that is referenced supplies the pixel data using a network protocol that is defined outside DICOM.

Add 8.x.1 JPIP REFERENCED PIXEL DATA

8.x.1 JPIP REFERENCED PIXEL DATA

DICOM provides a mechanism for supporting the use of JPEG 2000 Interactive Protocol through the inclusion of a URL reference to a pixel data provider service. Annex A defines two Transfer Syntaxes that utilize URL references to a JPIP pixel data provider service.

The use of the these Transfer Syntaxes requires that the Pixel Data Provider URL specify a URL that will represent the JPIP request including the specific target information. Additional parameters required by the application may be appended to the URL when accessing the pixel data provider.

Note: For example, a JPIP request for a 200 by 200 pixel rendition of the entire image can be constructed from the Pixel Data Provider URL as follows:

Pixel Data Provider URL (0028,7FE0) = http://server.xxx/jpipserver.cgi?target=imgxyz.jp2

URL Generated by the application = http://server.xxx/jpipserver.cgi?target=imgxyz.jp2&fsiz=200,200

The JPIP client shall only request a JPEG 2000 bit stream.

The JPIP server shall return a Content-type of image/jp2, image/jpp-stream or image/jpt-stream, all of which shall be supported by the JPIP client.

The Number of Frames (0028,0008) attribute, if present in the Dataset, identifies the number of frames available for this image. Each frame is accessible as a separate JPIP code stream. Code streams referenced in the URL Target shall be sequentially numbered starting with stream 1.

Note: For example, a JPIP request for a 200 by 200 pixel rendition of frame 17 of a multi-frame image can be constructed from Pixel Data Provider URL as follows:

Pixel Data Provider URL (0028,7EF0) = http://server.xxx/multiframeimage.jp2

URL Generated by the application = http://server.xxx/multiframeimage.jp2?fsiz=200,200&stream=17

A valid stream query parameter value is always less than or equal to the value in the Number of Frames (0028,0008).

The syntax of the Pixel Data Provider URL (0028,7FE0) is defined in ISO/IEC 15444-9 Annex C (Client Request). That standard respects the URI recommendations IETF RFC2396. The transport protocol shall be HTTP or HTTPS.

Note: 1. According to ISO/IEC 15444-9, "Each JPIP request is directed to a specific representation of a specific original named resource or a specific portion of that resource. That resource may be a physically stored file or object, or may be something that is created virtually by the server upon request."

"The Target request field specifies the original named resource to which the request is directed. It is specified using a PATH, which could be a simple string or a URI.
If the Target field is not specified and the request is carried over HTTP, then the JPIP request shall be directed to the resource specified through the path component of the JPIP request URL."

2. Transport over UDP or other protocols is not supported.

Modify 10.1 **DICOM default transfer syntax**

10.1 DICOM DEFAULT TRANSFER SYNTAX

DICOM defines a default Transfer Syntax, the DICOM Implicit VR Little Endian Transfer Syntax (UID = "1.2.840.10008.1.2"), which shall be supported by every conformant DICOM Implementation. This implies that:

a) If an Application Entity issues an A-ASSOCIATE request, it shall offer the DICOM Implicit VR Little Endian Transfer Syntax in at least one of the Presentation Contexts associated with each offered Abstract Syntax.

Note: Offering Abstract Syntax (AS1) in two Presentation Contexts with Transfer Syntaxes (TS1) and (TS2) is not valid, but offering AS1-TS1, AS1-TS2 and AS1-TSD is valid because the DICOM Default Little Endian Transfer Syntax (TSD) is present in at least one of the Presentation Contexts that are based on Abstract Syntax (AS1).

b) If an Application Entity receives an A-ASSOCIATE indication corresponding to a request which follows the requirements specified in Section 10.1 a), every Presentation Context related to a given Abstract Syntax cannot be rejected in an A-ASSOCIATE response for the reason that none of the Transfer Syntaxes are supported.

Both of these requirements, a) and b), are waived when the Application Entity sending the pixel data has only access to the pixel data in lossy compressed form **and a Transfer Syntax that uses a pixel data reference is not offered.**

Requirement b) to accept the default Transfer Syntax is waived if a Transfer Syntax that uses a pixel data reference is offered.

Add 10.7 Transfer syntax for JPIP REFERENCED PIXEL DATA

10.7 TRANSFER SYNTAX FOR JPIP REFERENCED PIXEL DATA

Two Transfer Syntaxes are specified for JPIP Referenced Pixel Data.

The persistence of the references in objects transferred with one of these transfer syntaxes is not defined. That is, applications should make no assumptions as to the timeframe when the referenced pixel data will be available. Due to the indeterminate time that the URL remains valid, it may be inappropriate to cache the URL. Because the pixel data may not have been retrieved in its entirety or full fidelity, it may be inappropriate to use this transfer syntax for the purpose of permanent storage or to reference such instances in Storage Commitment, Modality Performed Procedure Step and General Purpose Performed Procedure Step service classes.

These transfer syntaxes shall not be used for media storage defined by PS 3.10.

Add A.x DICOM JPIP REFERENCED TRANSFER SYNTAX (EXPLICIT VR)

A.X DICOM JPIP REFERENCED TRANSFER SYNTAX (EXPLICIT VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Little Endian Transfer Syntax the following requirements shall be met:

a) The Data Elements contained in the Data Set structure shall be encoded with Explicit VR (with a VR Field) as specified in Section 7.1.2.

b) The encoding of the overall Data Set structure (Data Element Tags, Value Length, and Value) shall be in Little Endian as specified in Section 7.3.

c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:

— For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.

— For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:

  — Data Element (7FE0,0010) Pixel Data shall not be present, but rather pixel data shall be referenced via Data Element (0028,7FE0) Pixel Data Provider URL

  — Overlay data, if present, shall only be encoded in the Overlay Data attribute (60xx,3000), which shall have the Value Representation OB or OW and shall be encoded in Little Endian.

  — Data Element (0028,0004) Photometric Interpretation shall be limited to the values: MONOCHROME1, MONOCHROME2, YBR_ICT and YBR_RCT.

This DICOM JPIP REFERENCED Transfer Syntax shall be identified by a UID of Value "1.2.840.10008.1.2.4.94 ".

Add A.y DICOM JPIP REFERENCED DEFLATE TRANSFER SYNTAX (EXPLICIT VR)

A.Y DICOM JPIP REFERENCED DEFLATE TRANSFER SYNTAX (EXPLICIT VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set.

The entire Data Set is first encoded according to the rules specified in Section A.X DICOM JPIP Referenced Transfer Syntax (Explicit VR).

The entire byte stream is then compressed using the “Deflate” algorithm defined in Internet RFC 1951.

This DICOM JPIP Referenced DeflateTransfer Syntax shall be identified by a UID of Value "1.2.840.10008.1.2.4. 95".

Part 6

Add New Attribute Tags to Section 6

Tag	Name	VR	VM
(0028,7FE0)	**Pixel Data Provider URL**	**UT**	**1**
(0040,E010)	Retrieve URI	~~**ST**~~**UT**	1

Add New Transfer Syntax UIDs to Annex A

1.2.840.10008.1.2.4.94	**JPIP Referenced**	**Transfer Syntax**	**PS 3.5**
1.2.840.10008.1.2.4.95	**JPIP Referenced Deflate**	**Transfer Syntax**	**PS 3.5**

Part 10

Modify Table 7.1-1 as follows

Media Storage SOP Instance UID	(0002,0003)	1	Uniquely identifies the SOP Instance associated with the Data Set placed in the file and following the File Meta Information.
Transfer Syntax UID	(0002,0010)	1	Uniquely identifies the Transfer Syntax used to encode the following Data Set. This Transfer Syntax does not apply to the File Meta Information. Note: It is recommended to use one of the DICOM Transfer Syntaxes supporting explicit Value Representation encoding to facilitate interpretation of File Meta Element Values. **JPIP Referenced Pixel Data Transfer Syntaxes are not used** (See PS 3.5 of the DICOM Standard).
Implementation Class UID	(0002,0012)	1	Uniquely identifies the implementation which wrote this file and its content. It provides an unambiguous identification of the type of implementation which last wrote the file in the event of interchange problems. It follows the same policies as defined by PS 3.7 of the DICOM Standard (association negotiation).

Part 17 Addendum

Add the following Annex to Part 17:

Annex X – JPIP Referenced Pixel Data Transfer Syntax Negotiation

The JPIP Referenced Pixel Data transfer syntaxes allow transfer of image objects with a reference to a non-DICOM network service that provides the pixel data rather than encoding the pixel data in (7FE0,0010).

The use cases for this extension to the standard relate to an application's desire to gain access to a portion of DICOM pixel data without the need to wait for reception of all the pixel data. Examples are:

1) Stack Navigation of a large CT Study.

In this case, it is desirable to quickly scroll through this large set of data at a lower resolution and once the anatomy of interest is located the full resolution data is presented. Initially lower resolution images are requested from the server for the purpose of stack navigation. Once a specific image is identified the system requests the rest of the detail from the server.

2) Large Single Image Navigation

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It is desirable to generate thumbnail representations for a study. This has been accomplished through various means, many of which require the client to receive the complete pixel data from the server to generate the thumbnail image. This uses significant network bandwidth.

The thumbnails can be considered low-resolution representations of the image. The application can request a low-resolution representation of the image for use as a thumbnail.

4) Display by Dimension

Multi-frame images may encode multiple dimensions. It is desirable for an application to access only the specific frames of interest in a particular dimension without the need to receive the complete pixel data set. By using the multi-dimensional description, applications using the JPIP protocol may request frames of the multi-frame image.

The association negotiation between the initiator and acceptor controls when this method of transfer is used. An acceptor can potentially accept both the JPIP Referenced Pixel Data transfer syntax and a non-JPIP transfer syntax on different presentation contexts. When an acceptor accepts both of these transfer syntaxes, the initiator chooses the presentation context.

Examples:

For the following cases:

- AE1 requests images from AE2
- AE1 implements a C-MOVE SCU, as well as a C-STORE SCP. AE2 implements a C-MOVE SCP, as well as a C-STORE SCU

Case 1:

- AE1 and AE2 both support both a JPIP Referenced Pixel Data Transfer Syntax and a non-JPIP Transfer Syntax
- AE1 makes a C-MOVE request to AE2
- AE2 proposes two presentation contexts to AE1, one for with a JPIP Referenced Pixel Data Transfer Syntax, and the other with a non-JPIP Transfer Syntax
- AE1 accepts both presentation contexts
- AE2 may choose either presentation context to send the object
- AE1 must be able to either receive the pixel data in the C-STORE message, or to be able to obtain it from the provider URL

Case 2:

- AE1 supports only the JPIP Referenced Pixel Data Transfer Syntax
- AE2 supports both a JPIP Referenced Pixel Data Transfer Syntax and a non-JPIP Transfer Syntax
- AE1 makes a C-MOVE request to AE2
- AE2 proposes to AE1 either
    - two presentation contexts, one for with a JPIP Referenced Pixel Data Transfer Syntax, and the other with a non-JPIP Transfer Syntax, or
    - a single presentation context with both a JPIP Referenced Pixel Data Transfer Syntax and a non-JPIP Transfer Syntax
- AE1 accepts only the presentation context with the JPIP Referenced Pixel Data Transfer Syntax, or only the JPIP Referenced Pixel Data Transfer Syntax within the single presentation context proposed
- AE2 sends the object with the JPIP Referenced Pixel Data Transfer Syntax
- AE1 must be able to either retrieve the pixel data from the provider URL

For the following cases:

- AE1 requests images from AE2
- AE1 implements a C-GET SCU. AE2 implements a C-GET SCP

Case 3:

- AE1 and AE2 both support both a JPIP Referenced Pixel Data Transfer Syntax and a non-JPIP Transfer Syntax
- In addition to the C-GET presentation context, AE2 proposes to AE1 two presentation contexts for storage sub-operations, one for with a JPIP Referenced Pixel Data Transfer Syntax, and the other with a non-JPIP Transfer Syntax
- AE2 accepts both storage presentation contexts
- AE1 makes a C-GET request to AE2
- AE2 may choose either presentation context to send the object
- AE1 must be able to either receive the pixel data in the C-STORE message, or to be able to obtain it from the provider URL

Case 4:

- AE1 supports only the JPIP Referenced Pixel Data Transfer Syntax
- AE2 supports both a JPIP Referenced Pixel Data Transfer Syntax and a non-JPIP Transfer Syntax
- In addition to the C-GET presentation context, AE2 proposes to AE1 a single presentation context for storage sub-operations with a JPIP Referenced Pixel Data Transfer Syntax
- AE2 accepts the storage presentation context
- AE1 makes a C-GET request to AE2
- AE2 sends the object with the JPIP Referenced Pixel Data Transfer Syntax
- AE1 must be able to either retrieve the pixel data from the provider URL