JPEG 2000 as a PDS Archive Format: Introduction and Status

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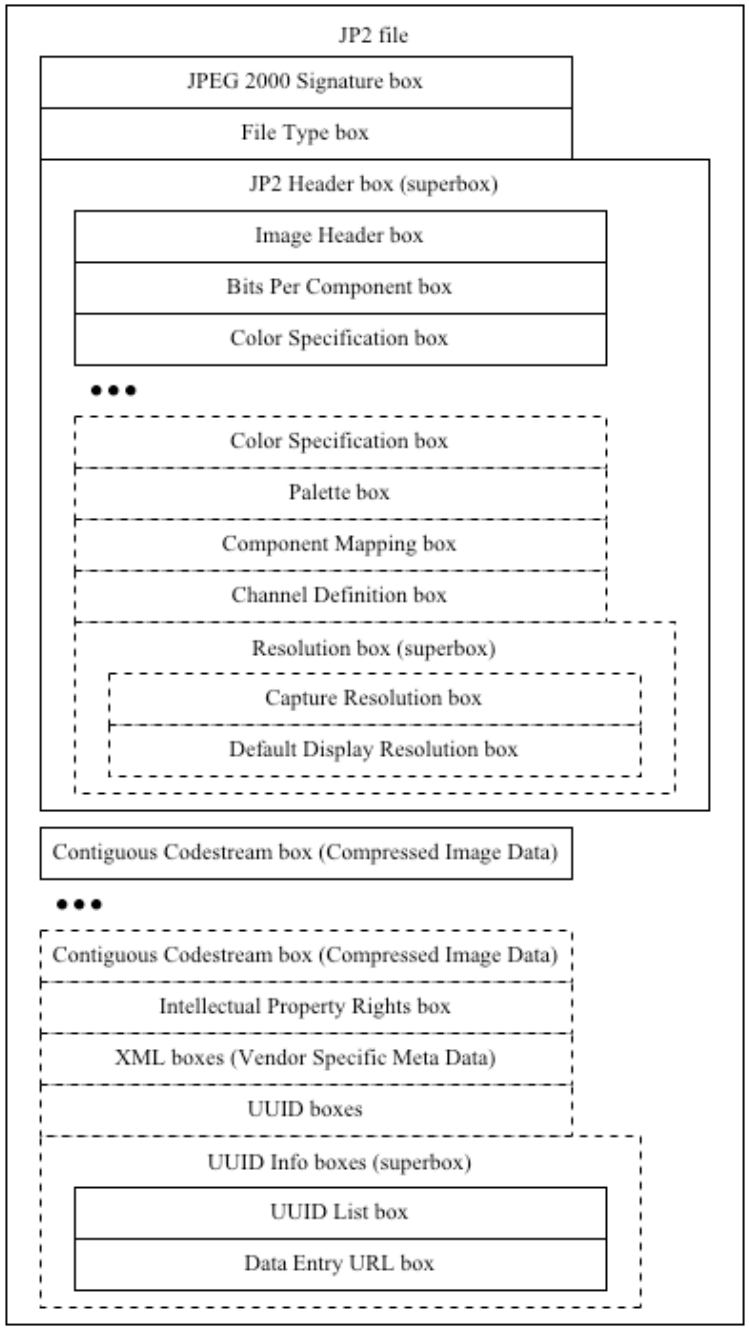
- What is JPEG 2000?
  - a compression scheme:
    - a raw image, when compressed using the JPEG 2000 compression algorithm, becomes a JPEG 2000 codestream (mime type: J2C)
  - and an image format:
    - the JPEG 2000 codestream, when encapsulated in the JPEG 2000 binary wrapper, becomes a JP2 formatted image (mime type: JP2)


JP2 file
JPEG 2000 Signature box
File Type box
JP2 Header box (superbox)
Image Header box
Bits Per Component box
Color Specification box
Color Specification box
Palette box
Component Mapping box
Channel Definition box
Resolution box (superbox)
Capture Resolution box
Default Display Resolution box
Contiguous Codestream box (Compressed Image Data)
Contiguous Codestream box (Compressed Image Data)
Intellectual Property Rights box
XML boxes (Vendor Specific Meta Data)
UUID boxes
UUID Info boxes (superbox)
UUID List box
Data Entry URL box

- What makes JPEG 2000 different from other compression algorithms?
  - The attainable compression ratios can be significanty better (cf. 3.8 for both 16-bit images using Zip compression):

	h0068_0000_s22.img		h0068_0009_s22.img	
Tile Size	16-bit	8-bit	16-bit	8-bit
1024	5.83	2.89	6.00	2.25
512	5.82	2.88	5.99	2.25
256	5.78	2.87	5.94	2.24
128	5.64	2.81	5.80	2.20

– The structure of the codestream is highly flexible. This enables selective decompression of:
  - different resolution “layers”
  - images of varying precision
  - portions (or “tiles”) of the image
  - targeted regions of interest (ROIs)

- Why should we care about the JP2 format?
  - The J2C codestream is self-contained and contains sufficient information for a conforming software program to fully decompress the image data. However...
  - Without the JP2 header, a software program can't take advantage of the additional capabilities of the JPEG 2000 format.

- What impact does this have on the use of JPEG 2000 in PDS archives?
  - The working group is proposing that we permit data providers to provide data files in either J2C or JP2 format.

- What would a JPEG 2000 product label look like?
  - Because JP2 formatted files can contain intermingled header and image data, they are best considered as a single, compressed entity, rather than as a set of independently compressed objects. Thus, the combined detached labeling approach most accurately describes the file.

JPEG 2000 as a PDS Archive Format

```
PDS_VERSION_ID                = PDS3

(identification and descriptive data elements)

OBJECT                        = COMPRESSED_FILE
  FILE_NAME                   = “filename.jp2”
  RECORD_TYPE                 = UNDEFINED
  ENCODING_TYPE               = “JP2”
  ENCODING_TYPE_VERSION_NAME  = “ISO/IEC15444-1:2004”
  INTERCHANGE_FORMAT          = BINARY
  UNCOMPRESSED_FILE_NAME      = “filename.img”
  REQUIRED_STORAGE_BYTES      = nnnn
  ^DESCRIPTION                = “jp2_description.txt”
END_OBJECT                    = COMPRESSED_FILE

OBJECT                        = UNCOMPRESSED_FILE
  FILE_NAME                   = “filename.img”
  RECORD_TYPE                 = FIXED_LENGTH
  RECORD_BYTES                = nnn
  FILE_RECORDS                = nnn

/* POINTER TO DATA OBJECT */

  ^IMAGE                      = “filename.img”

/* DATA OBJECT DEFINITION */

  OBJECT                      = IMAGE
    LINES                     = nnn
    LINE_SAMPLES              = nnn
    (etc.)
  END_OBJECT                  = IMAGE
END_OBJECT                    = UNCOMPRESSED_FILE
END
```

- What other issues are there surrounding the JPEG 2000 compression format?
  - The JPEG 2000 specification permits both lossless and lossy compression.
  - We propose that the PDS should limit the use of this compression algorithm to lossless compression.

JPEG 2000 as a PDS Archive Format

- Data conforming to part 1 of the JPEG 2000 specification are available on a “royalty and license fee free” basis.
- Extensions to the format providing additional capabilities are described in other parts of the specification. These may require the payment of royalties or licensing fees.
- We propose that JPEG 2000 formatted data in the PDS be limited to the syntax and features defined in part 1 of the specification.

- What impact would acceptance of JPEG 2000 have on PDS tools?
  - Reference decompression software (including source code) is freely available in C and Java.
  - The Object Access Library would need to be updated to include these decompression algorithms.
  - NASAView would require some minor modifications.

- Summary:
  - The JPEG 2000 compression algorithm is better at compressing data and has more flexibility than other compression algorithms.
  - The JPEG 2000 specification is an ISO standard, and is therefore well documented. The PDS has a copy of that specification.
  - Decompression algorithms and software are freely available and will be included in the archive.
  - The Imaging Node is committed to ensuring that data will be validated for compliance with the JPEG 2000 specification.
  - The compression algorithm, when limited to Part 1 of the spec., has no royalty or licensing issues.

- Status

	Schedule:	Actual:
Informative presentation to Tech Session	08/31/05	08/31/05
SCR and StdRef update distributed to SCR WG for review	09/12/05	09/26/05
Present full draft of SCR to Tech Group	09/28/05	09/28/05
Informative presentation to MC	10/05/05	10/06/05
Tech Group vote on draft	10/26/05	10/03/05
Full SCR distributed to MC for their review	11/07/05	Sent to R. Beebe 10/04/05
MC vote on SCR	11/15/05	
Complete implementation into PSDD and StdRef	12/31/05	

Supplementary Material

- What precedents exist in the PDS for handling compressed data and data in non-PDS formats?
  - The precedents for compressed data can be broken down into two main categories:
    - data files containing distinct objects, some or all of which consist of compressed data
    - data files where the entire file is a single, compressed entity

JPEG 2000 as a PDS Archive Format

– PDS archived, compressed data sets which consist of data files containing distinct objects are:

- the Clementine image EDRs
- the MGS MOC SDPs (essentially EDRs)
- the Viking Orbiter image EDRs
- the Voyager image EDRs

JPEG 2000 as a PDS Archive Format

- The data products in each of these data sets have attached PDS labels which contain information describing both the compressed and the decompressed files within a single, implicit FILE object.

- In each case, the decompression software included in the archive produces a decompressed image file with an attached PDS label modified from the original label to describe only the decompressed file.

JPEG 2000 as a PDS Archive Format

– An attached PDS Viking label for a compressed product:

```
CCSD3ZF0000100000001NJPL3IF0PDS200000001 = SFDU_LABEL
/*  FILE FORMAT AND LENGTH */
RECORD_TYPE                          = VARIABLE_LENGTH
RECORD_BYTES                         = 1204
FILE_RECORDS                         = 2176
LABEL_RECORDS                        = 60
/*  POINTERS TO START RECORDS OF MAJOR OBJECTS IN FILE */
^IMAGE_HISTOGRAM                     = 61
^ENCODING_HISTOGRAM                  = 62
^ENGINEERING_TABLE                   = 64
^LINE_HEADER_TABLE                   = 65
^IMAGE                               = 1121
/*  IMAGE DESCRIPTION */
...
OBJECT                               = IMAGE
 ENCODING_TYPE                       = HUFFMAN_FIRST_DIFFERENCE
 LINES                               = 1056
 LINE_SAMPLES                        = 1204
 SAMPLE_TYPE                         = UNSIGNED_INTEGER
 SAMPLE_BITS                         = 8
 SAMPLE_BIT_MASK                     = 2#11111110#
 CHECKSUM                            = 18081344
END_OBJECT
END
```

JPEG 2000 as a PDS Archive Format

– An attached PDS Viking label for a decompressed product:

```
CCSD3ZF0000100000001NJPL3IF0PDS200000001 = SFDU_LABEL
/*  FILE FORMAT AND LENGTH */
RECORD_TYPE                          = FIXED_LENGTH
RECORD_BYTES                         = 1204
FILE_RECORDS                         = 1115
LABEL_RECORDS                        = 2
/*  POINTERS TO START RECORDS OF MAJOR OBJECTS IN FILE */
^IMAGE_HISTOGRAM                     = 3
^ENGINEERING_TABLE                   = 4
^LINE_HEADER_TABLE                   = 5
^IMAGE                               = 60
/*  IMAGE DESCRIPTION */
...
OBJECT                               = IMAGE
 LINES                               = 1056
 LINE_SAMPLES                        = 1204
 SAMPLE_TYPE                         = UNSIGNED_INTEGER
 SAMPLE_BITS                         = 8
 SAMPLE_BIT_MASK                     = 2#11111110#
END_OBJECT
END
```

JPEG 2000 as a PDS Archive Format

– PDS archived, compressed data sets which consist of data files treated as a single, compressed entity have, to date, exclusively used Zip compression. They are:

- the MPF Rover Engineering data
- the Cassini Radar LBDR data
- the MER mobility reports
- the HST Saturn Ring Plane Crossing supplementary data files

JPEG 2000 as a PDS Archive Format

– A combined detached Cassini LBDR label:

```
PDS_VERSION_ID                = PDS3

/*       PRODUCT DESCRIPTION */

DATA_SET_ID                   = "CO-V/E/J/S-RADAR-3-LBDR-V1.0"
DATA_SET_NAME                 = "CASSINI RADAR LONG BURST DATA RECORD"
...
OBJECT                        = COMPRESSED_FILE
  FILE_NAME                   = "LBDR_02_003_V01.ZIP"
  RECORD_TYPE                 = UNDEFINED
  ENCODING_TYPE               = ZIP
  INTERCHANGE_FORMAT          = BINARY
  UNCOMPRESSED_FILE_NAME      = "LBDR_02_003_V01.TAB"
  REQUIRED_STORAGE_BYTES      = 80994528
  ^DESCRIPTION                = "SOFTWARE/SOFTINFO.TXT"
END_OBJECT                    = COMPRESSED_FILE

OBJECT                        = UNCOMPRESSED_FILE
  FILE_NAME                   = "LBDR_02_003_V01.TAB"
  RECORD_TYPE                 = FIXED_LENGTH
  RECORD_BYTES                = 132344
  FILE_RECORDS                = 612
  LABEL_RECORDS               = 1

/*       POINTERS TO START RECORDS OF OBJECTS IN FILE */
 ^LBDR_TABLE                  = ("LBDR_02_003_V01.TAB", 2)
...
```

JPEG 2000 as a PDS Archive Format

- Non-PDS formats for data files which have been included in PDS archives are:
  - FITS images
  - ISIS images
  - ISIS qubes
  - VICAR images
- Data sets which include these formats have provided a combination of attached and detached labels to provide both the PDS and native format labeling information. Typically, the PDS label has been the detached label.