JPEG 2000 Profile

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Overview of the profile structure

- The Goal of the profile is to define the JPEG 2000 codestream restrictions (limits of the compressed data) that all NITFS 2.1 compliant systems will be required to support.
  - While keeping in line with the commercial profiles to save money with SCOTS.
- The profile will also promote wide interoperability for all NITFS systems
  - National/primary dissemination
  - Tactical/Secondary dissemination
- Make recommendations that try to achieve the greatest functionality for the NSGI architecture
- Give examples of the most common processes that would occur using the JPEG 2000 compressed data.
- Define the interaction between NITFS file format and the JPEG 2000 bitstream headers

Overview of the profile structure

- Introduction and Methodology: Background on JPEG 2000 and the NSGI architecture
  - Gives an understanding of why JPEG 2000 and what it will bring to the NSGI
- Profile: Define all the codestream limitations of JPEG 2000 Part 1.
  - This profile is the same as the ISO JPEG Profile 1 (right now)
  - We expect to add upon this when new hard requirements are defined
    - For example, we may add multiple component compression from Part 2
- Recommendations: Define the recommended values of parameters to promote the most functionality and interoperability within the NSGI
  - Supports the multiple resolutions, quality levels, and tile parsing.

Overview of the profile structure

- Population of NITFS Image Subheaders: How do the values in the NITFS Image Subheader interact with the image header in the JPEG 2000 codestream
- JPEG 2000 Processes Flow: Defines generic flows for multiple processes that would performed by every NITFS JPEG 2000 system
  - Encoding process flow
  - Decoding process flow
  - Parsing data flow
    - Tile parsing, quality layer parsing, resolution parsing
  - Enhancement processes (not defined as of yet)
  - Repackaging procedures
- Several Annexes
  - JPEG 2000 Commercial Profiles
  - JPEG/USIGS (NSGI) background and history

The NITFS 2.1 Supported Profile

- The NITFS 2.1 Profile will be compliant to the ISO JPEG 2000 Profile-1 compliant.
- The compliance class will be dependent on NITFS compliance class
  - We expect to support both JPEG 2000 Cclass 1 and 2
- The limitation of the JPEG 2000 Profile 1
  - Rsiz = 2 (Marker that states that this is profile 1)
  - The image size is limited to less than 2^{31}
  - Tiles are limited to no greater than 1024-by-1024 and must be square (XTsiz = Ytsiz, Xtsiz/min(XRsiz, YRsiz) $\leq$ 1024) or one tile for the entire image
    - If one tile is used, the LL subband should be included that is no bigger than 128 on a side.

The NITFS 2.1 Supported Profile

- The limitation of the JPEG 2000 Profile 1
  - The image and tile origins are required to be less than 2^{31}
  - There is a limit to 37 region of interests (ROI) for each image
  - Code-block sizes are limited to 2^6 (64 maximum to a side)
- Compliance classes are not specified in the profile and will be part of the compliance testing of the JITC
  - The commercial compliance classes are found in JPEG 2000 Part-4
  - The general concept is to guarantee decoding depending on the image size, memory and computational cost to the decoder

	Cclass 0	Cclass 1	Cclass 2	Cclass 3
Image Size limits	128x128	2,048x2,048	16,384x16,384	2^{31}x2^{31}
Number of bands	1	4	256	16,384
Bit Depth	8	12	24	32
NITFS Clevel	None	Clevel 3	Clevel 5	Clevel 6, 7, 9

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NITFS Clevel	None	Clevel 3	Clevel 5	Clevel 6, 7, 9

NSGI Recommendations

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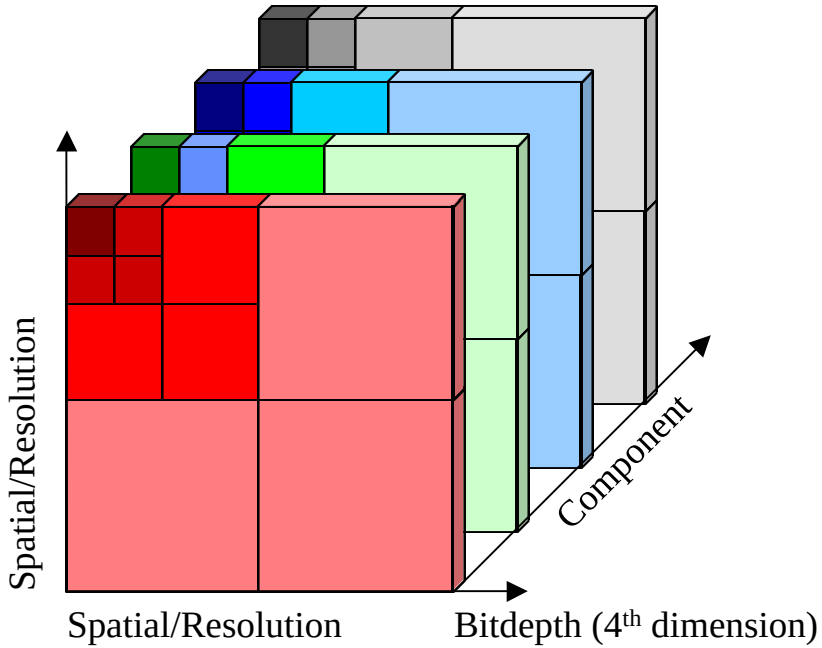
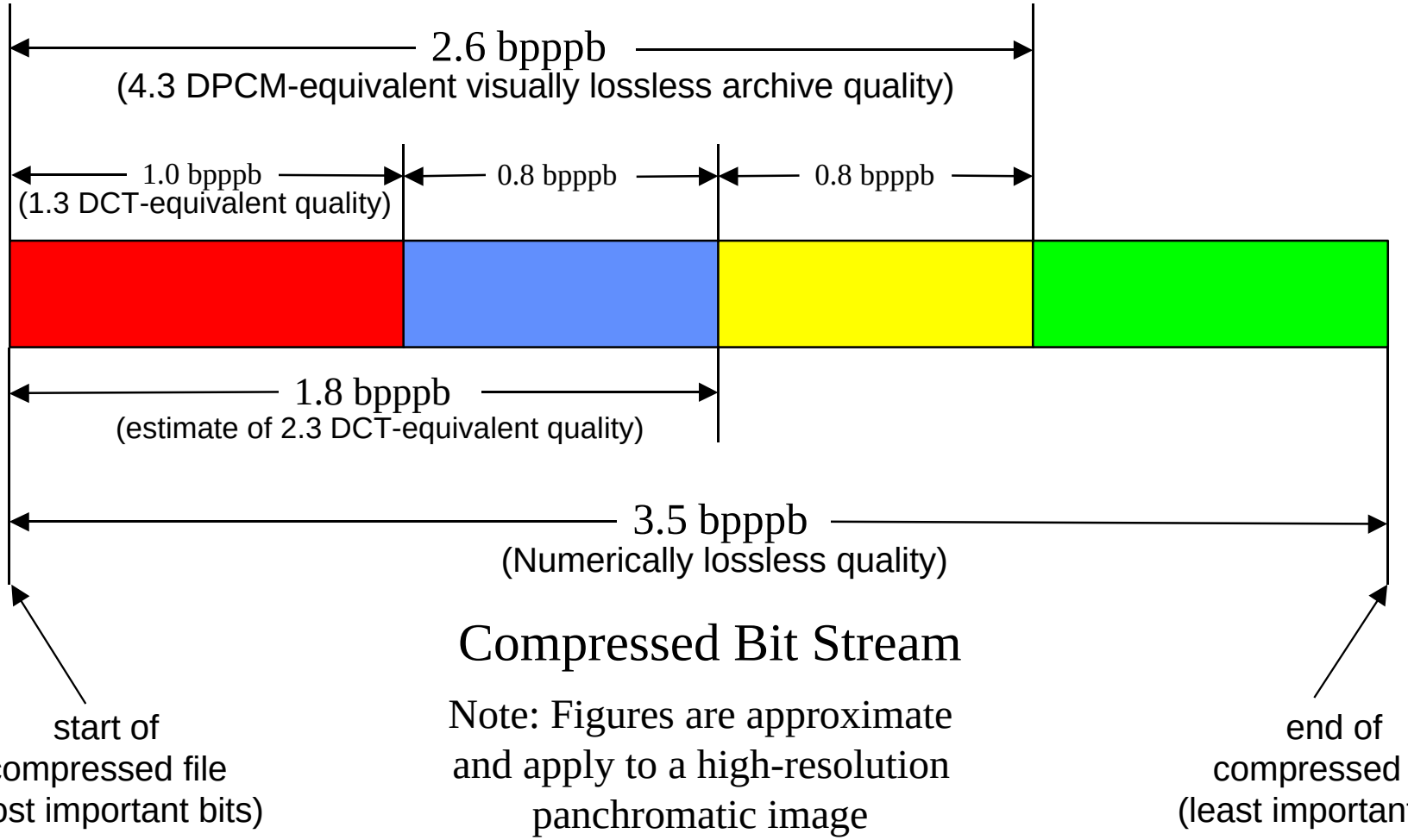
Progression in JPEG 2000

- After wavelet processing, we have a four dimensional cube of data
  - Spatial/Resolution (two)
  - Component
  - Bitdepth
- JPEG 2000 allows progression along four dimensions
  - Layer (L)
  - Resolution (R)
  - Component (C)
  - Precinct or position (P)
- These are roughly equivalent as follows
  - Resolution & Precinct ⇔ Spatial/Resolution
  - Component ⇔ Component
  - Layer ⇔ Bitdepth



Wavelet processed components

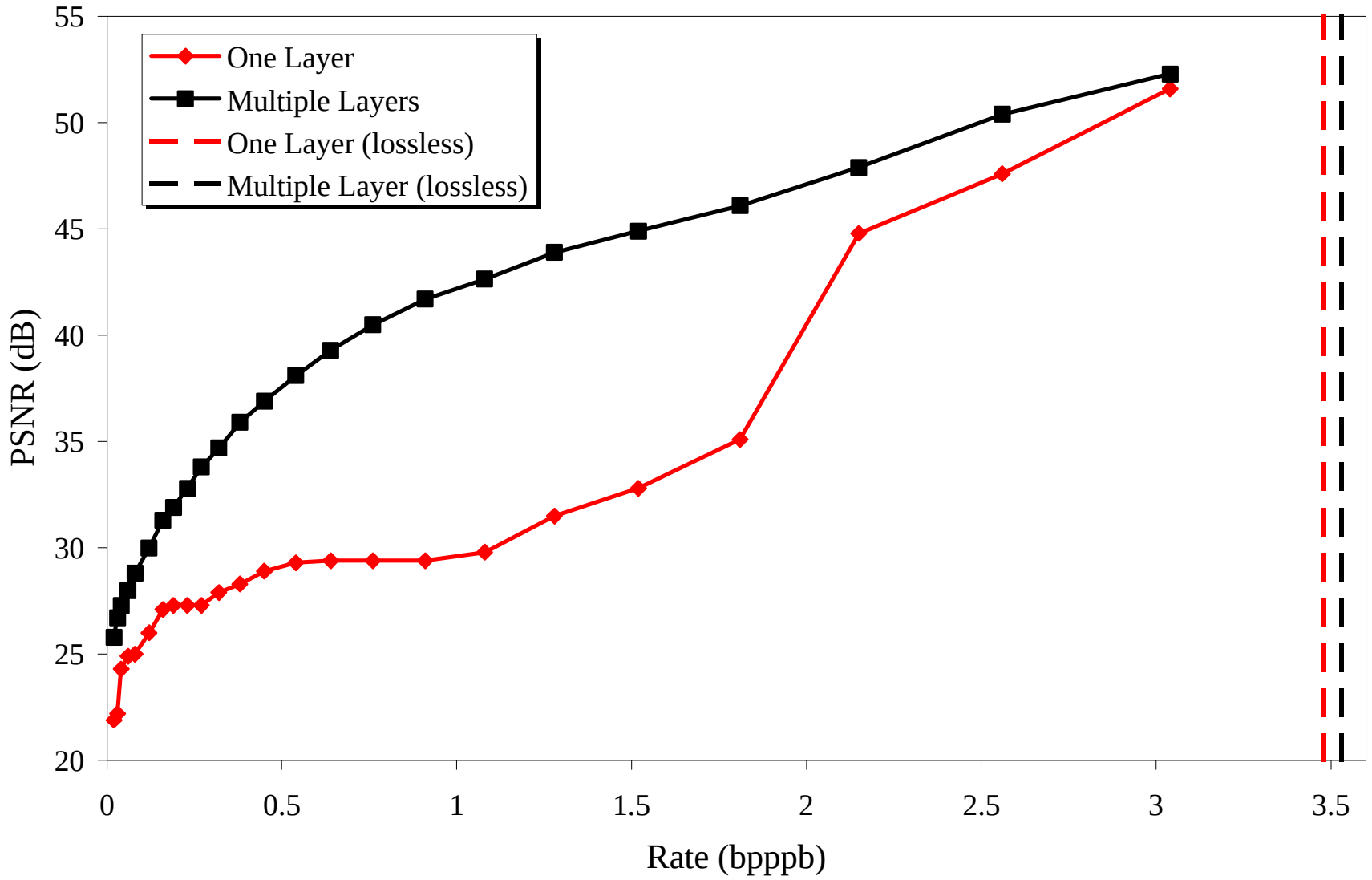
Progressive Decoding Videos



Why Layers Are Important

Effects of Layering

One Layer vs. Multiple Layers (LRCP)



Proposed Layers and Applications

- Layers enable *quality* scalability
- If *numerically* lossless compression is needed
  - Use the 5-3R integer reversible wavelet transform
  - 5-3R can also be used for lossy compression
- For lossy only compression
  - Use the 9-7I irreversible floating point wavelet transform
  - Better lossy performance than the 5-3R

Layer	Bits Per Pixel (bpp)	Application(s)
Layer 19 (5-3R filter)	Lossless	Radiometric
Layer 19 (9-7I filter)	Visual lossless	MC&G
Layer 18	3.5 bpp	MC&G
Layer 17	2.3 bpp	MC&G
Layer 16	2.0 bpp	MC&G
Layer 15	1.7 bpp	MC&G Visual exploitation
Layer 14	1.5 bpp	Visual exploitation
Layer 13	1.3 bpp	Visual exploitation
Layer 12	1.2 bpp	Visual exploitation
Layer 11	1.1 bpp	Visual exploitation
Layer 10	1.0 bpp	Visual exploitation and Tactical users
Layer 9	0.9 bpp	Tactical users
Layer 8	0.8 bpp	Tactical users
Layer 7	0.7 bpp	Tactical users
Layer 6	0.6 bpp	Tactical users
Layer 5	0.5 bpp	Tactical users
Layer 4	0.25 bpp	BW constrained users
Layer 3	0.125 bpp	BW constrained users
Layer 2	0.0625 bpp	BW constrained users
Layer 1	0.03125 bpp	BW constrained users

Choosing A Progression

RLCP Progression

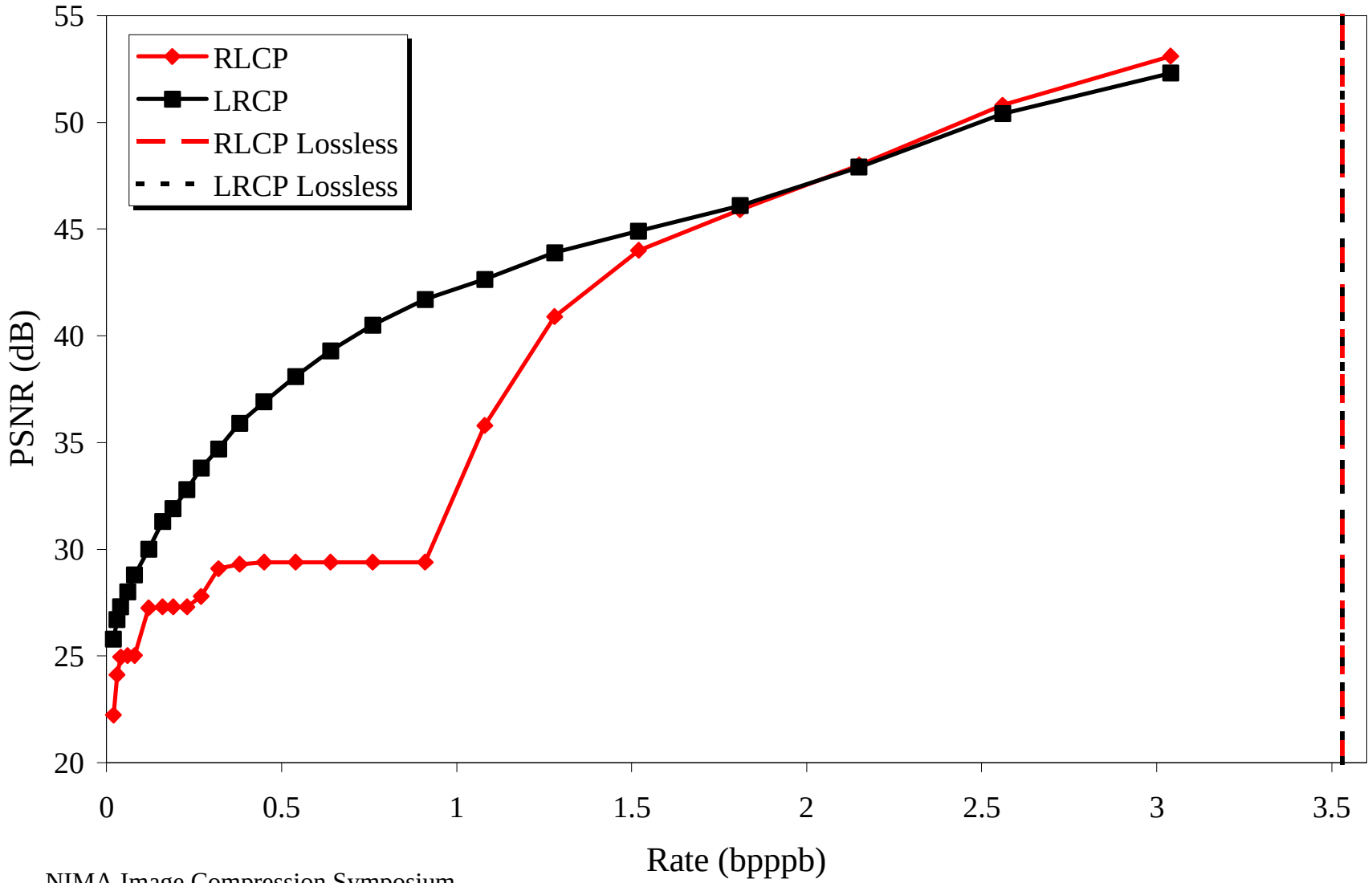
LRCP Progression

0.02 bpppb

0.02 bpppb

rlcp.avi

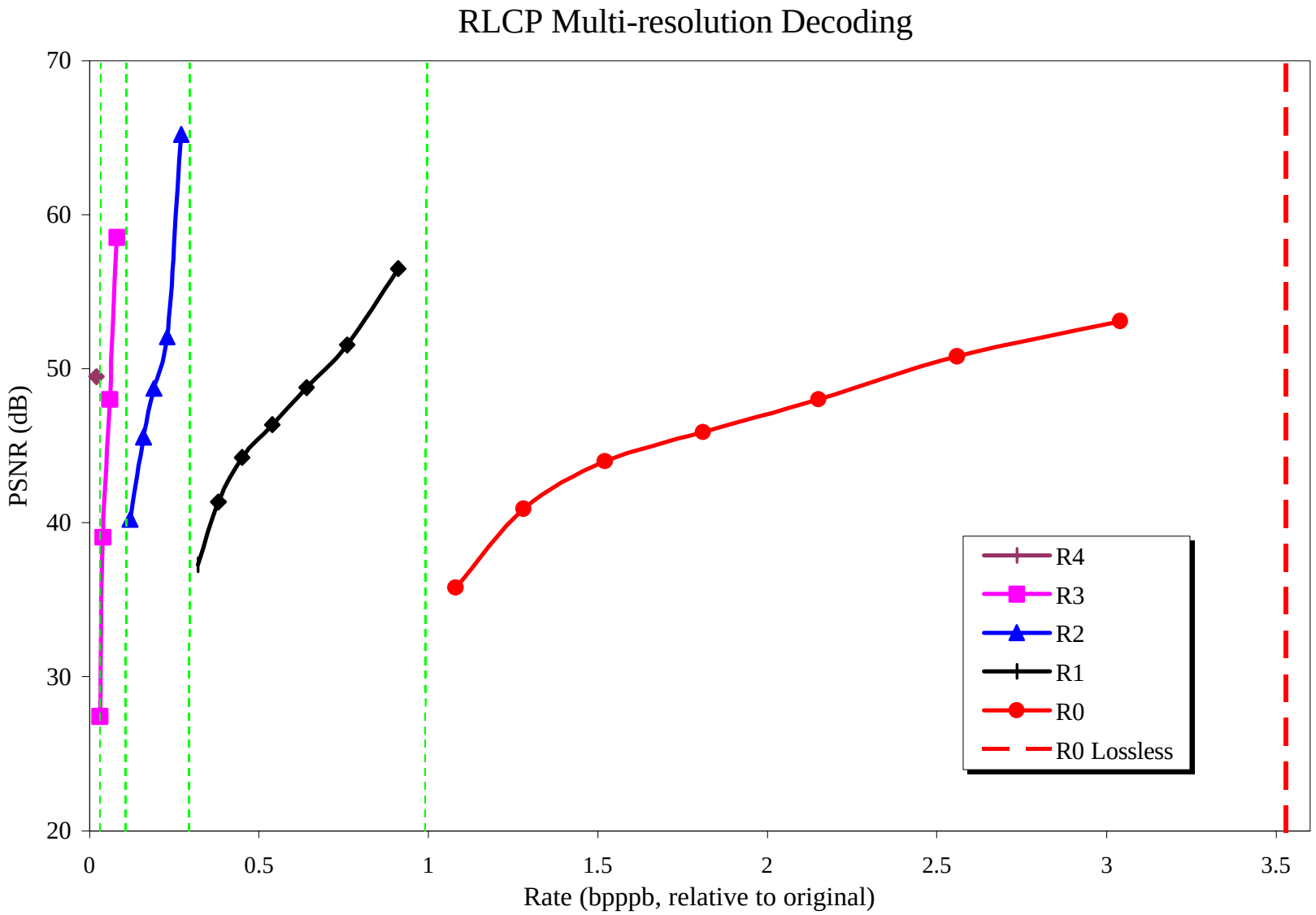
Effects of Progression



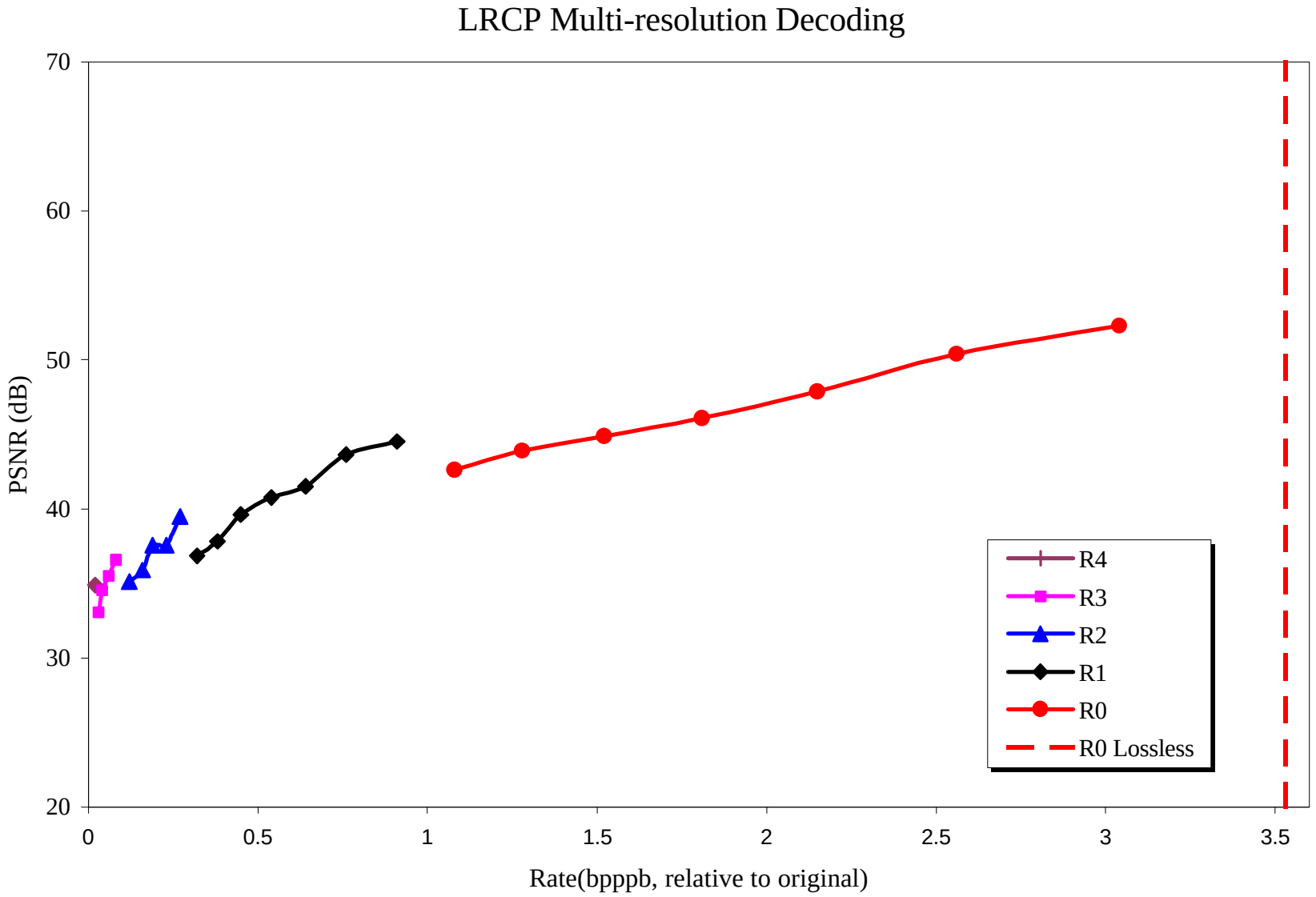
Multi-resolution Decoding

- Previous slides looked at RLCP and LRCP progressions decoded at full resolution, R0
  - Both files encoded using four wavelet decomposition levels ⇒ five resolution levels [R4, R3, R2, R1, R0]
  - Files were truncated and the received data decoded
  - LRCP file is optimally ordered for this type of decoding
    - Intermixes data from different resolution levels to optimize SNR at a given bitrate for full resolution decoding
- RLCP file is ordered so that
  - All of R4 appears before R3
  - All of R3 appears before R2
  - …
- Multi-resolution decoding
  - Again truncate files and decode
  - Decode RLCP file only to highest resolution level present
  - Similarly decode the LRCP file and compare
  - RLCP has better SNR and slightly better visual quality

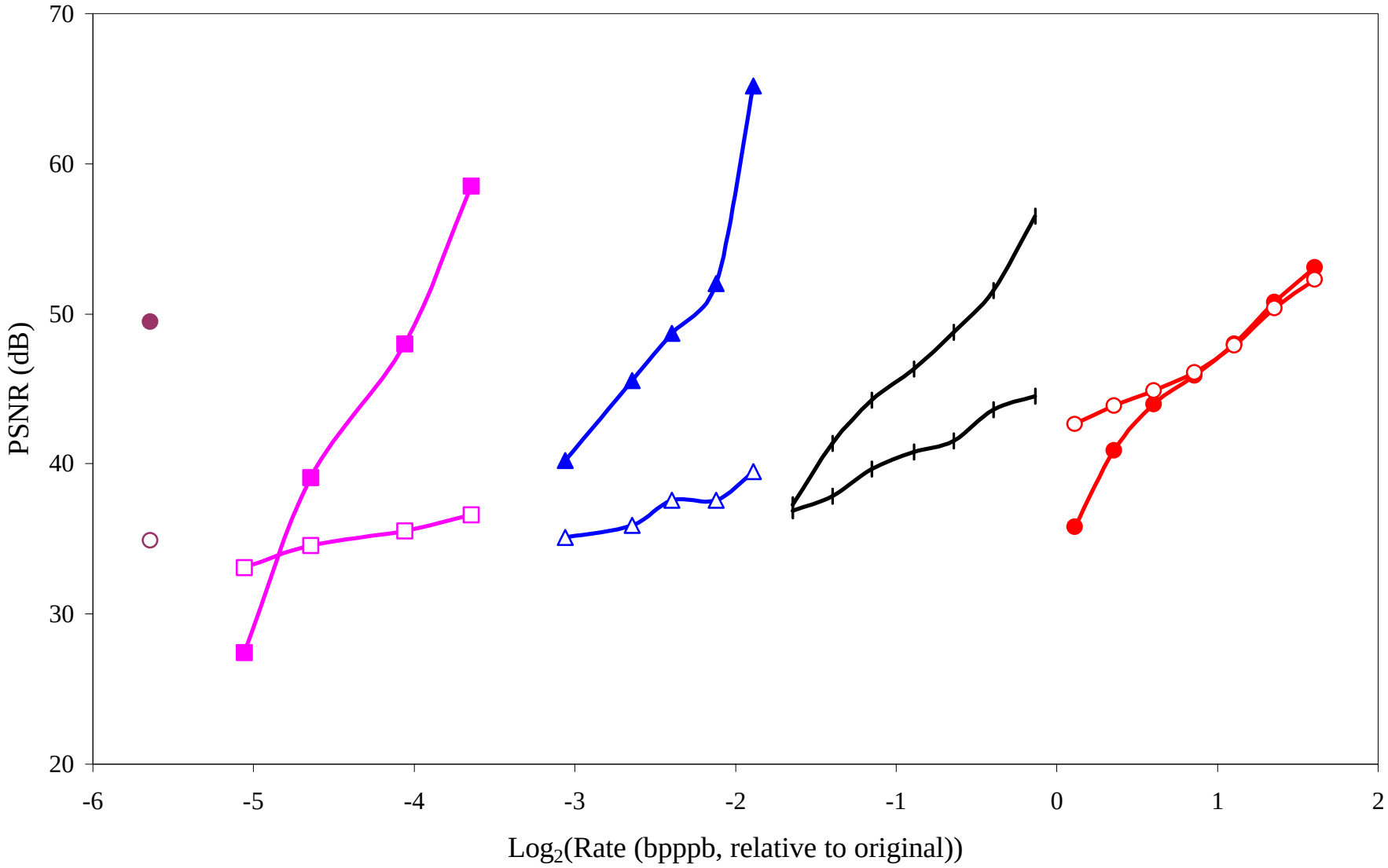
Multi-resolution Decoding



Multi-resolution Decoding



Multi-resolution Decoding



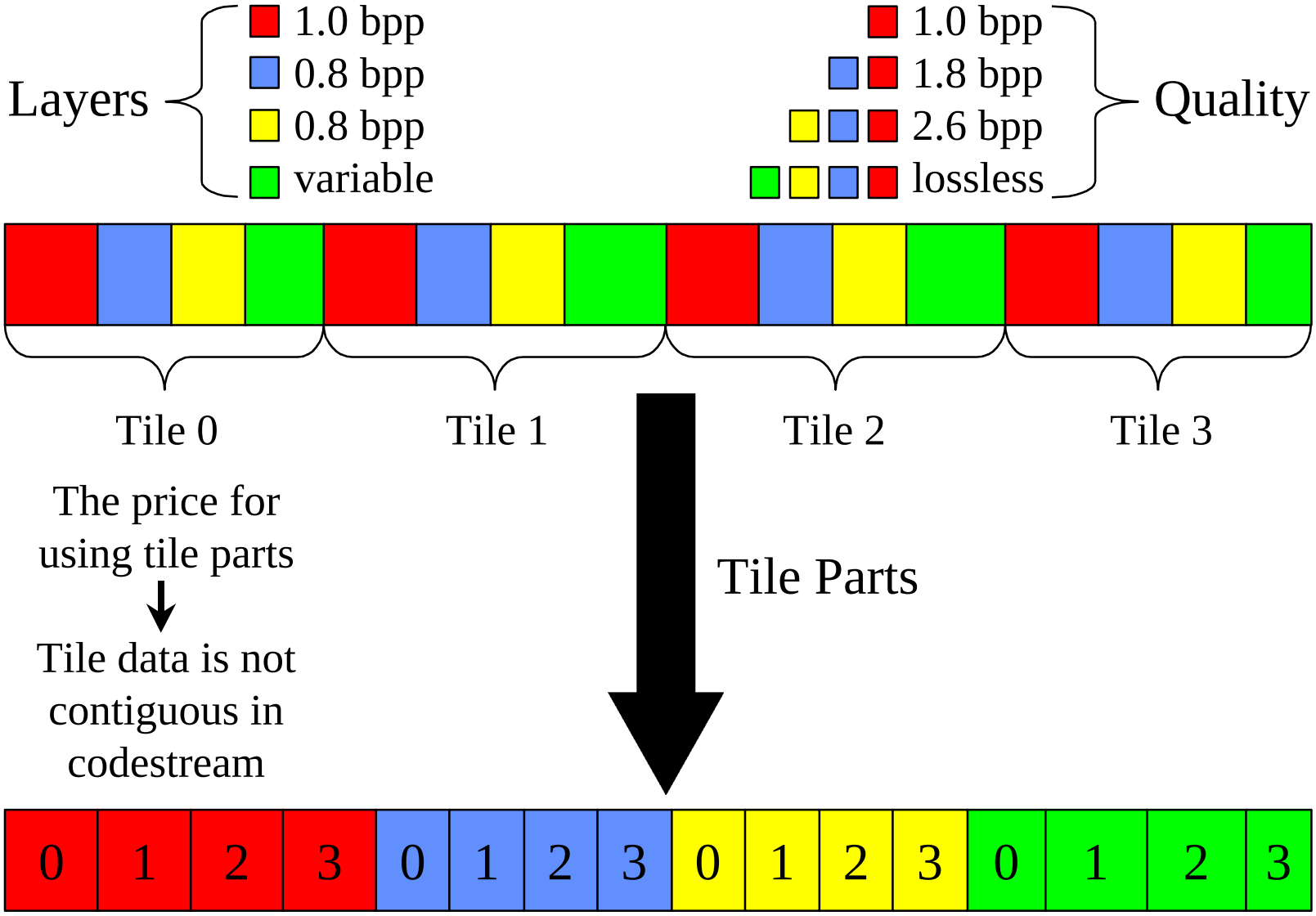
Progression Recommendation

- Recommend “LRCP”
  - Assume want best R0 quality as a function of rate
  - Other progressions will occur in commercial imagery!
    - Libraries must be able to read such files
    - Libraries should be able to change “transcode” from one progression to another
- JPEG 2000 allows for the progression order to change within a file (POC marker)
  - Useful for interactive streaming sessions
    - Server streams data to user
    - User may tell server to concentrate on an area or resolution
  - If you don’t want full resolution or have different resolutions within a mosaic

Tiles

- Tiles are independently coded sub images. Nothing crosses tile boundaries
  - Wavelet
  - Entropy coding
  - Layers
  - Progressions
- Tiles may be broken into tile parts.
  - Tile parts from different tiles can be interspersed in codestream
  - Only mechanism available to achieve “tile progression”
  - Impairs ability to randomly access a tile
- In general, need to parse data out of tiles to achieve a different image quality
  - If all tiles are compressed at 2.0 bpp and you want 1.0 bpp, then need to go into each tile and get the 1.0 bpp

Tile Codestream



Need For Parsing

No Parsing Performed

Parsing Performed

Tile and Wavelet Recommendations

- Recommend images tiled at 1024 x 1024 pixels
  - Allow fast access to spatial chips
  - At least five levels of wavelet decomposition (R0 through R5)
    - Enables resolution scalability
    - R5 is 32 x 32 in size
    - R6+ generation is an issue
      - Do more wavelet levels initially
      - Mosaic R5s and wavelet transform
- Recommend one tile part per tile
  - Chipping is more important “tile progression”
- Tile Length Markers (TLM markers) are recommended to speed access to tiles
  - Appears in codestream main header
  - Can be used to derive pointers to start of each tile
- Packet Length Tile markers (PLT markers) are recommended to facilitate parsing of packets
  - Appears in each tile header
  - Facilitates parsing of packets (units of entropy coded wavelet coefficients)

Other Recommendations

- Code blocks
  - 64 x 64 in size recommended
    - Increase arithmetic coder efficiency
    - In commercial imagery may see 32 x 32 and possibly 1024 x 4
- Precincts (tiling within wavelet subbands)
  - Not recommending their use since we use tiles
    - Standard allows you to use both in one codestream
  - Will definitely see this in commercial images
- Reference Grid
  - Image offsets (XOsiz, YOsiz) set to (0, 0)
  - Tile offsets (XTOsiz, YTOsiz) set to (0, 0)
  - 1024 x 1024 tile size will allow us to chip and maintain these values
  - Imagery with other tile sizes or tile/image offsets may require manipulation of these values when chipped

Proposed JPEG 2000 Tag

- NITF TRE
  - Communicate information regarding original and parsed image layers
  - A more advanced tag is envisioned for the future

Field	Name/description	Size bytes	Format	Value Range
	TAG information			
CETAG	Unique Extension Type Identifier Unique TRE identifier registered with the NTB.	6	BCS-A	J2K-T
CEL	Length of User-Defined Data Length in bytes of data contained in subsequent TRE fields. (TRE length is 11 plus the value given in the CEL field)	5	BCS-N	Variable
ORIG	Original Compressed Data Flag Indicates if the image is original or it has been parsed. The conditional fields (NLEVELS_I, NLAYERS_I, NBANDS_I) are only present if ORIG = 1.	1	BCS-N	0 - Original 1 - Parsed
	Original compressed image information			
NLEVELS_O	Number of Wavelet Levels in Original Image Indicates the default number of wavelet decompositions levels performed for each image.	5	BCS-N	00 - 32
NLAYERS_O	Number of Layers in Original Image Indicates the number of layers in original image.	5	BCS-N	00001 - 65535
NBANDS_O	Number of bands in Original Image Indicates the number of bands in original image.	5	BCS-N	00001 - 16384

Proposed JPEG 2000 Tag

Field	Name/description	Size bytes	Format	Value Range
	Layer information			
$LAYER\_ID_n$	Layer ID Number Indicates the number of layer being described. Layers are number from 0 to NUM_LAYERS –1.	5	BCS-N	00000 - 65535
$BITRATE_n$	Bitrate Indicates the bitrate target associated with the layer. It may happen that the bitrate was not achieved due to data characteristics. May include a lossless indicator.	8	BCS-A	variable
	Conditional field if the data has been parsed			
NLEVELS_I	Number of Wavelet Levels in Parsed Image Indicates the number of default wavelet decompositions levels included in image.	5	BCS-N	00 - 32
NLAYERS_I	Number of Layers in Parsed Image Indicates the number of default layers in image.	5	BCS-N	00001 - 65535
NBANDS_I	Number of Bands in Parsed Image Indicates the number of bands in image.	5	BCS-N	00001 - 16384