

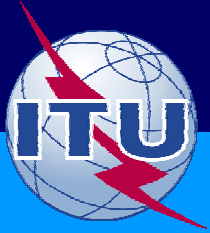
International Telecommunication Union

# JPEG 2000

## A versatile image coding system for multimedia applications

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EPFL

ITU-T VICA Workshop  
22-23 July 2005, ITU Headquarter, Geneva



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# Why another still image compression standard?

- **Low bit-rate compression**
- **Lossless and lossy compression**
- **Computer generated imaging**
- **Transmission in noisy environments**
- **Compound documents**
- **Flexible progressive coding and random access**
- **...**

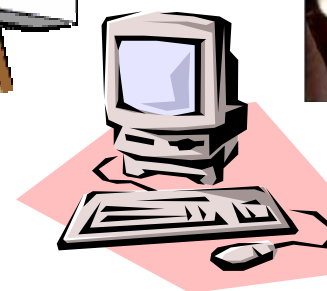
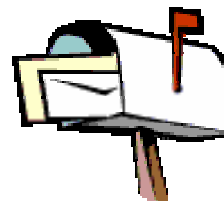




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# Markets and Applications

- Internet
- Mobile
- Printing
- Scanning
- Digital Photography
- Remote Sensing
- Facsimile
- Medical
- D-Cinema
- Digital Libraries
- E-Commerce
- Space imaging
- ...



# Markets and Applications



Non-native software

dates

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# JPEG 2000 family

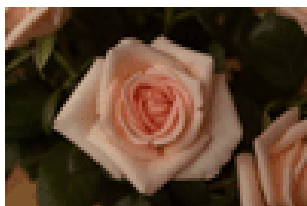
Part1: Core Coding System

Part3: Motion JPEG2000

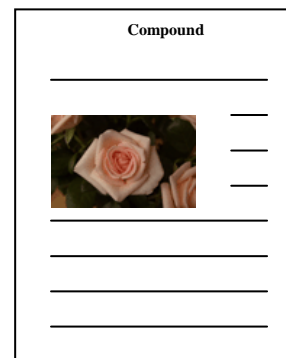
Part4: Conformance Testing

Part6: Compound Image File Format

Part2: Extensions



Part5: Reference Software

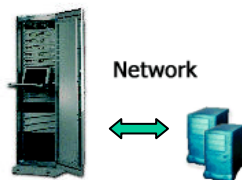


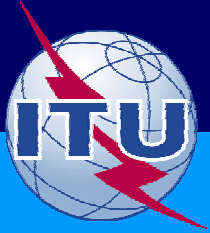
Part8: JPSEC (Secure JPEG2000)

Part9: JPIP (Interactivity)

Part10: JP3D (3-D Extensions)

Part11: JPWL (Wireless)





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# JPEG 2000 part I

- A set of tools covering a good proportion of application requirements (20-80 rules)
- Royalty fee-free, license-fee free (doesn't mean IPR free)
- Other parts are derived as extensions with backward compatibility to part I (baseline)
- Reached International Standard status on Dec. 2000
- Amendments have been defined since (one for D-cinema under progress)



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## Features in Part I

- High compression efficiency
- Lossless colour transformations
- Lossy and lossless coding in one algorithm
- Embedded lossy to lossless coding
- Progressive by resolution, quality, position, ...
- Region-of-Interest coding/decoding
- Error resilience coding
- Perceptual quality coding
- Multiple component image coding
- Tiling
- Palletized image coding
- Light file format (optional)
- ...



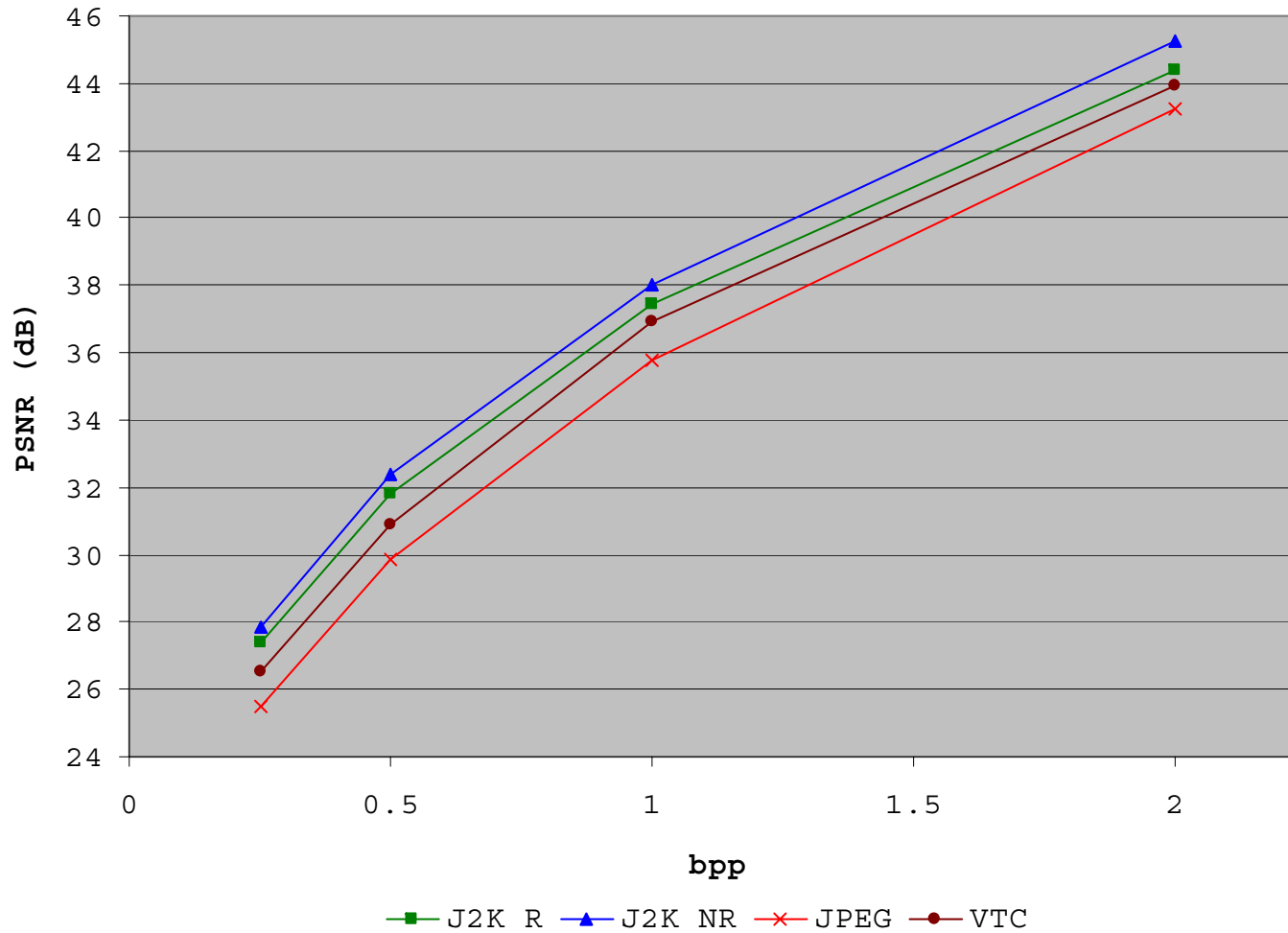
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## Comparison of various algorithms from a functionality point of view

	JPEG 2000	JPEG-LS	JPEG	MPEG-4 VTC
lossless compression performance	+++	++++	+	-
lossy compression performance	+++++	+	+++	++++
progressive bitstreams	++++	-	+	++
Region of Interest (ROI) coding	+++	-	-	+
arbitrary shaped objects	-	-	-	++
random access	++	-	-	-
low complexity	++	+++++	+++++	+
error resilience	+++	+	+	+++
non-iterative rate control	+++	-	-	+
genericity	+++	+++	++	++



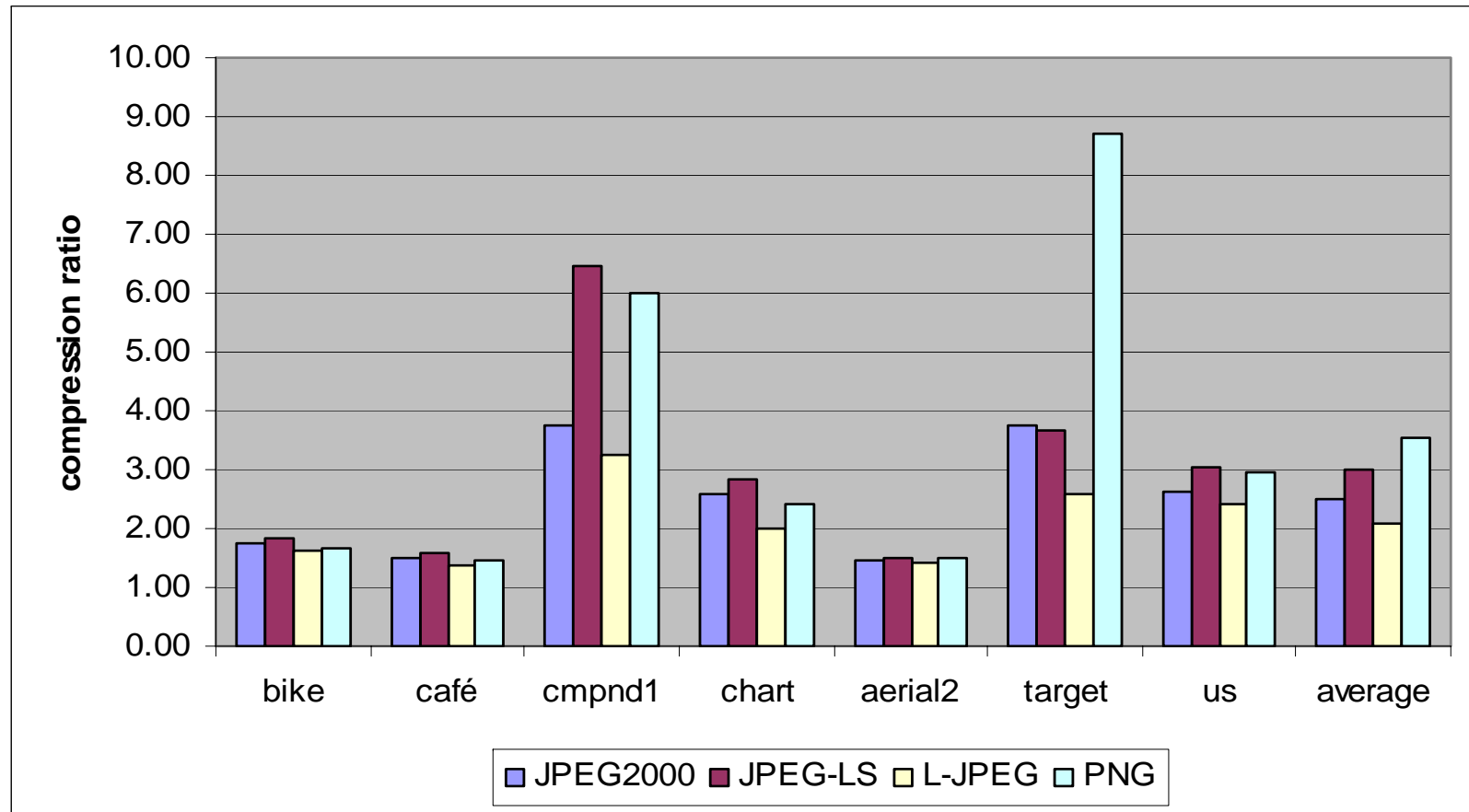
# Coding rate-distortion comparisons





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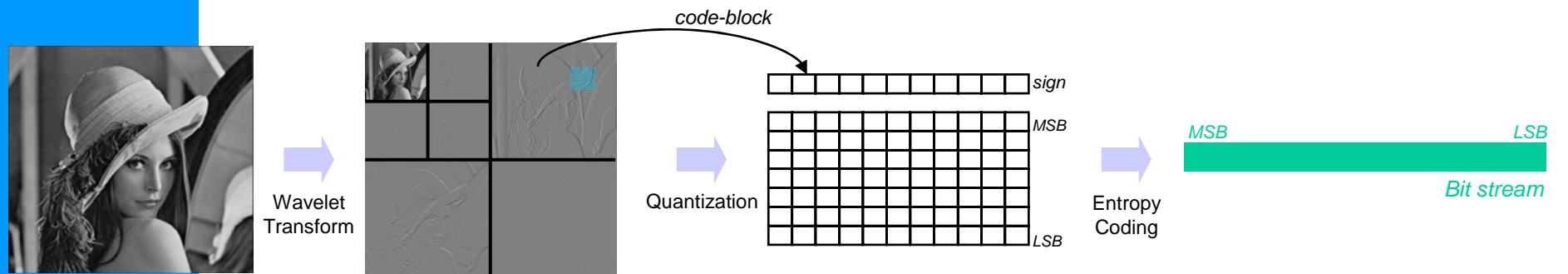
# Lossless coding performance



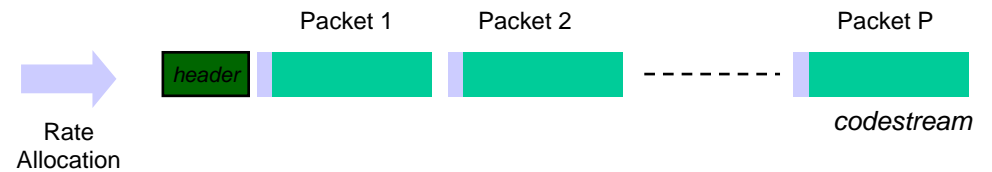
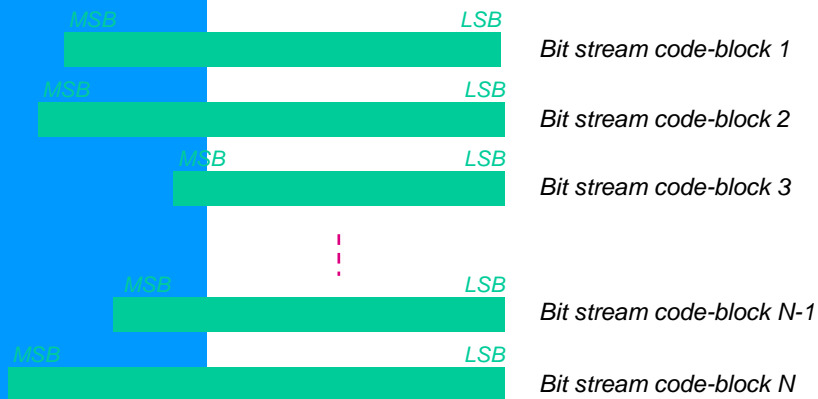


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# JPEG 2000 algorithm overview



Original image

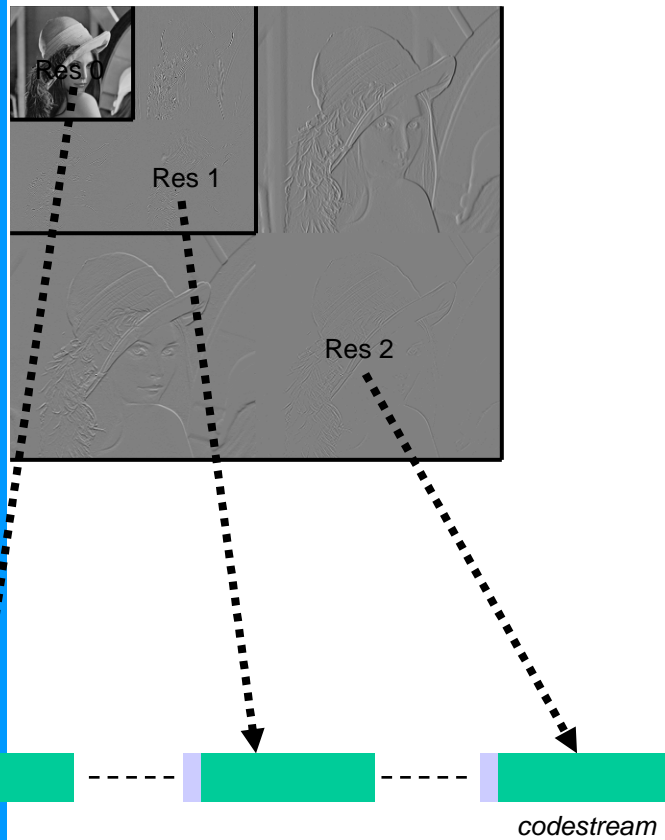




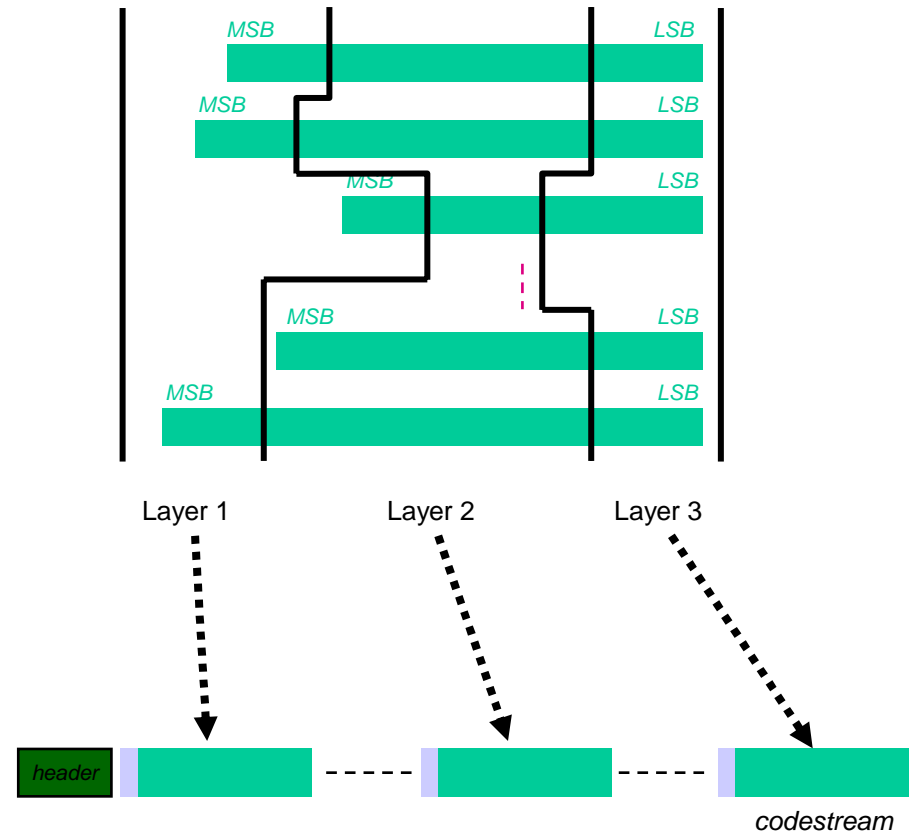
# JPEG 2000 algorithm overview

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Progressive by resolution



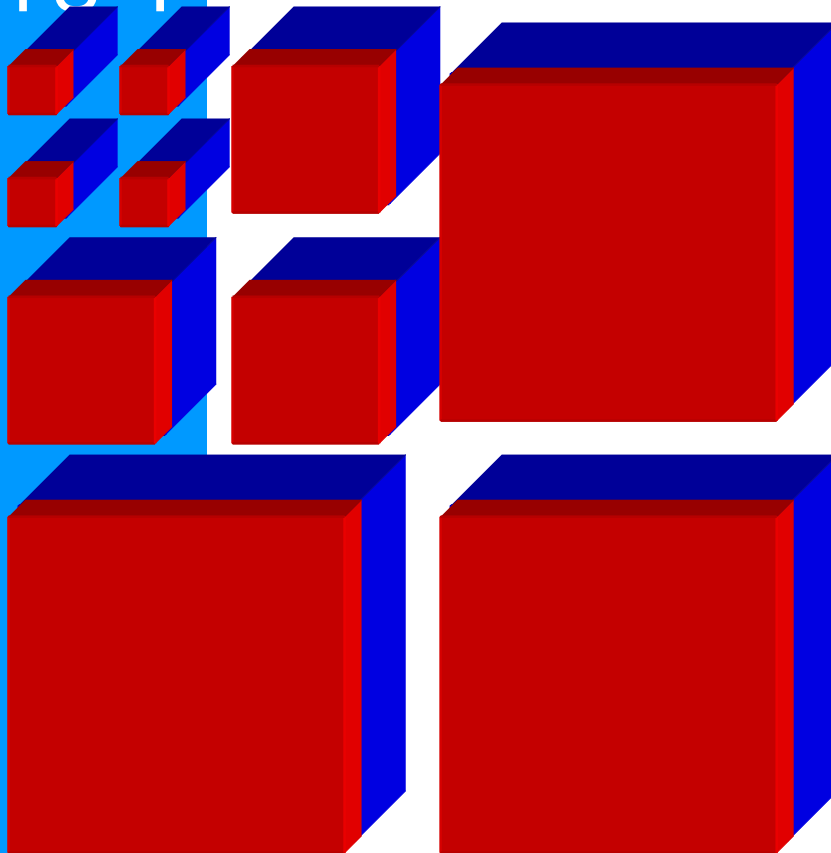
Progressive by quality





# Layer (SNR) progressive example

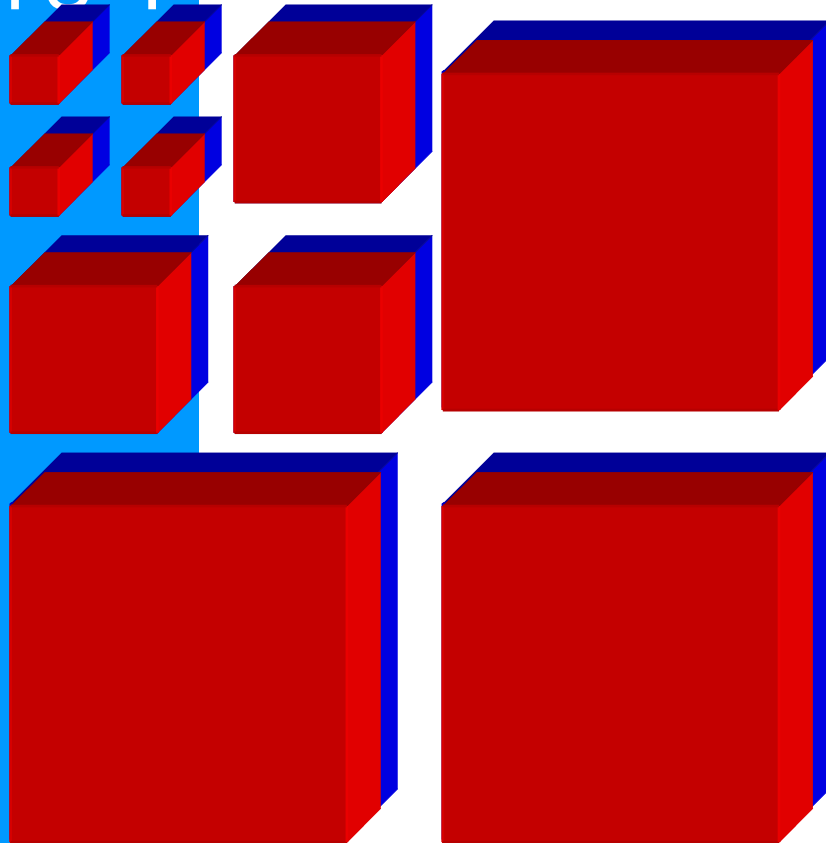
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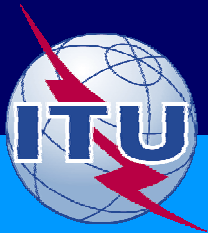




# Layer (SNR) progressive example

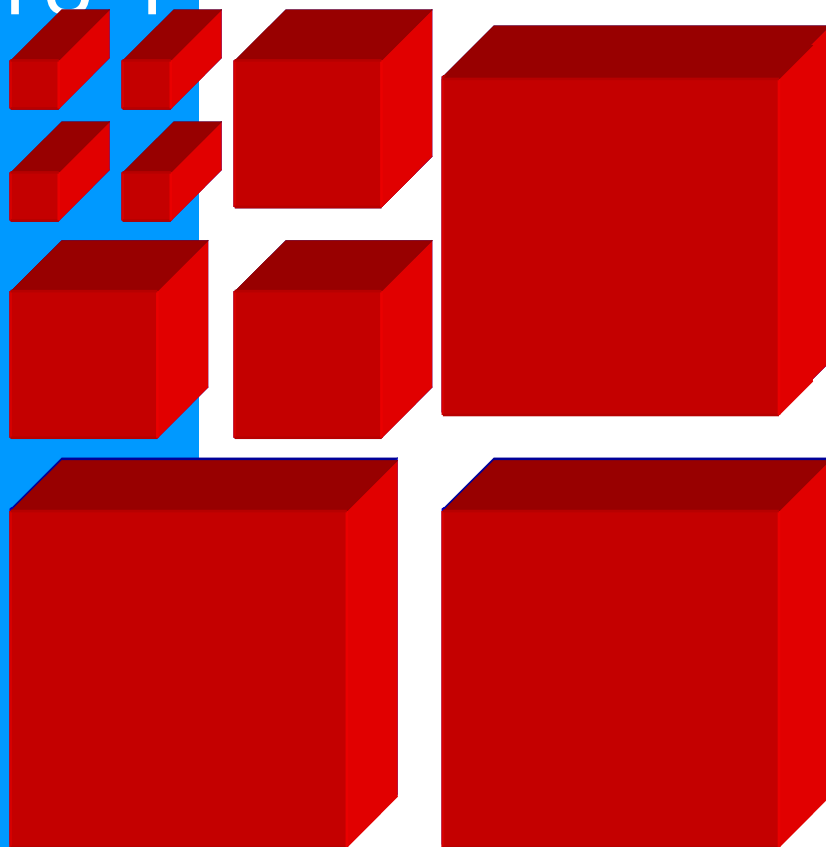
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# Layer (SNR) progressive example

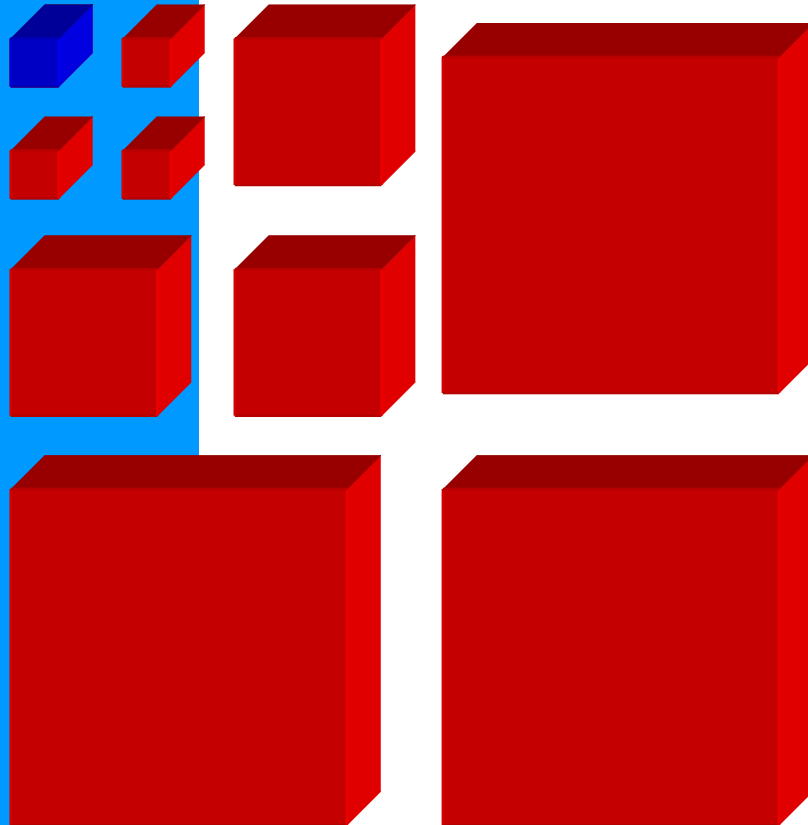
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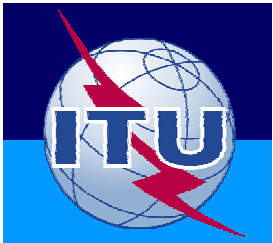


# Resolution progressive example

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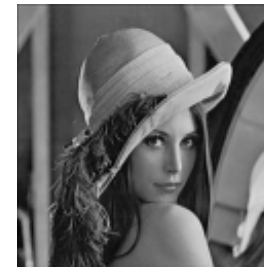
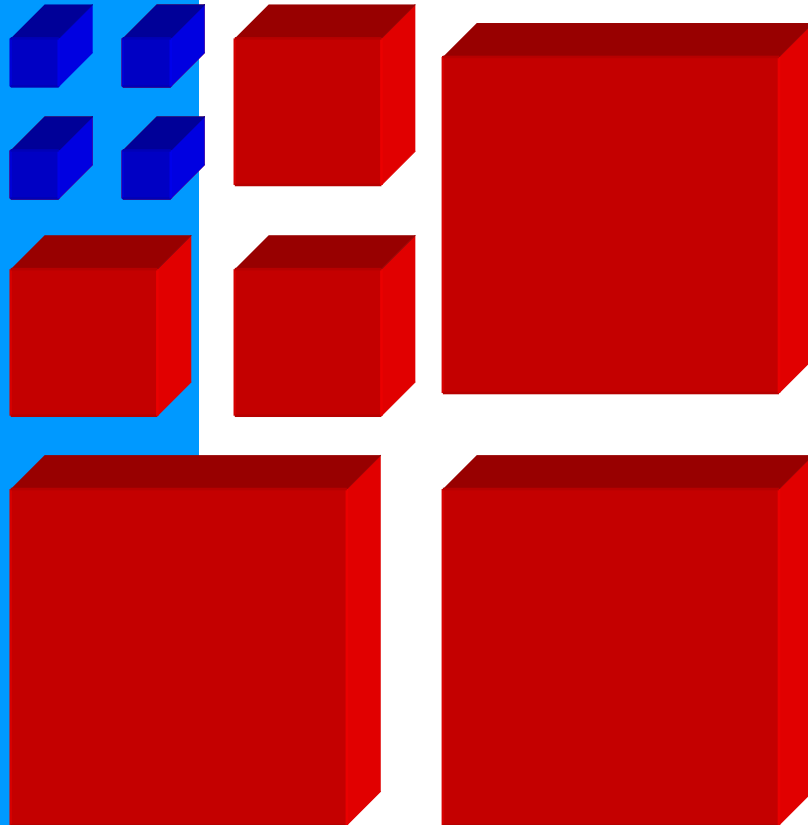






# Resolution progressive example

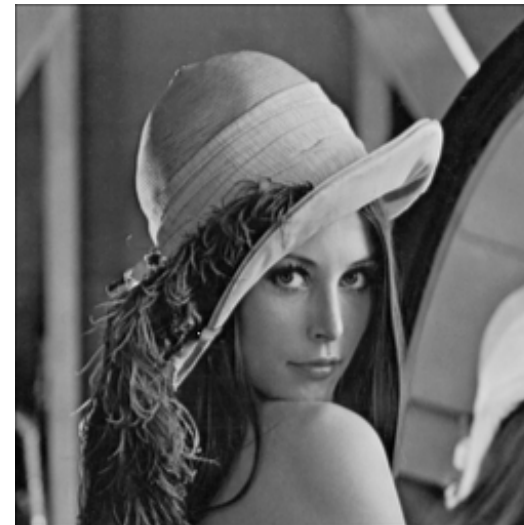
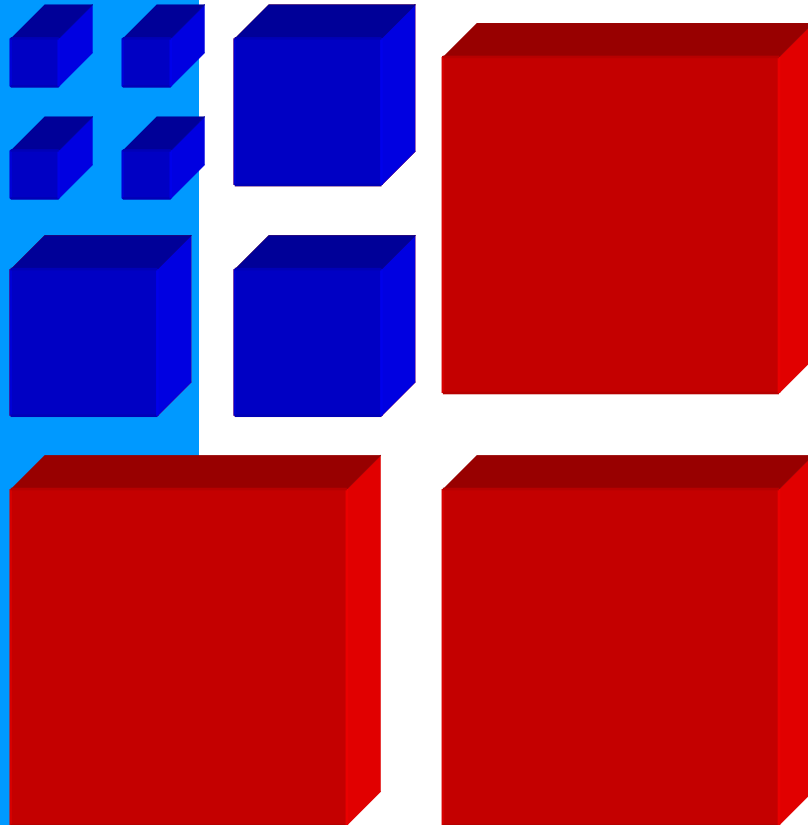
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# Resolution progressive example

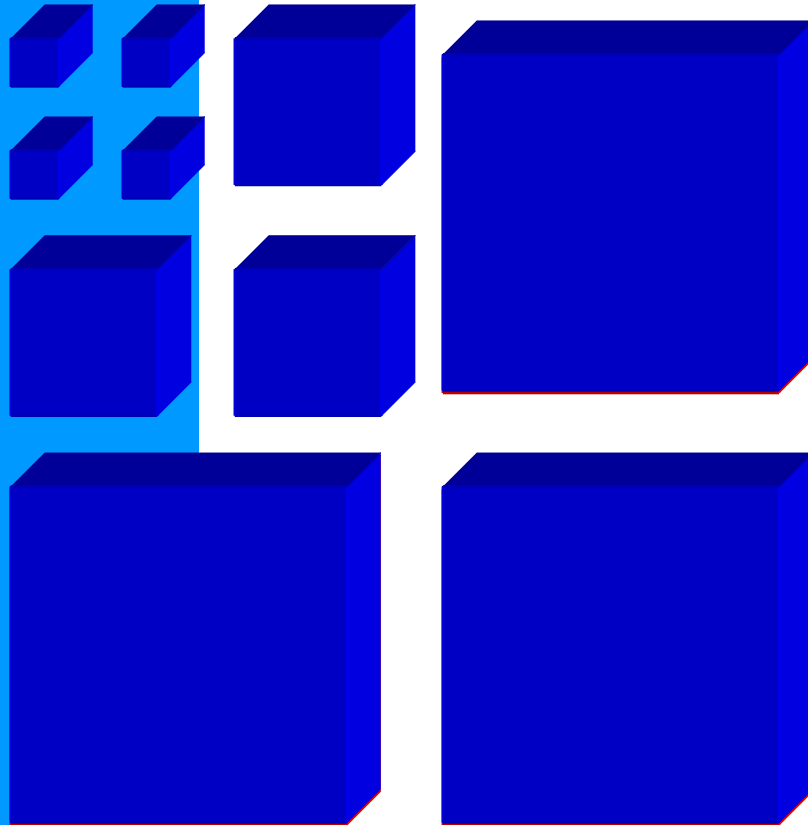
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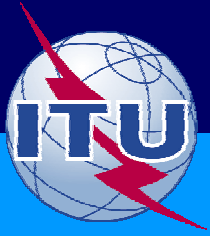




# Resolution progressive example

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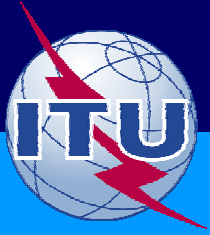
dates

# Compression example

**JPEG** at 0.25 bpp (detail)



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# Compression example

**JPEG2000** at 0.25 bpp (detail)



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Original Image



Jpeg 20:1



Jpeg 50:1



Jp2 20:1



Jp2 50:1



Jp2 100:1

# Compression example

## Comparison between Jpeg/Jpeg 2000



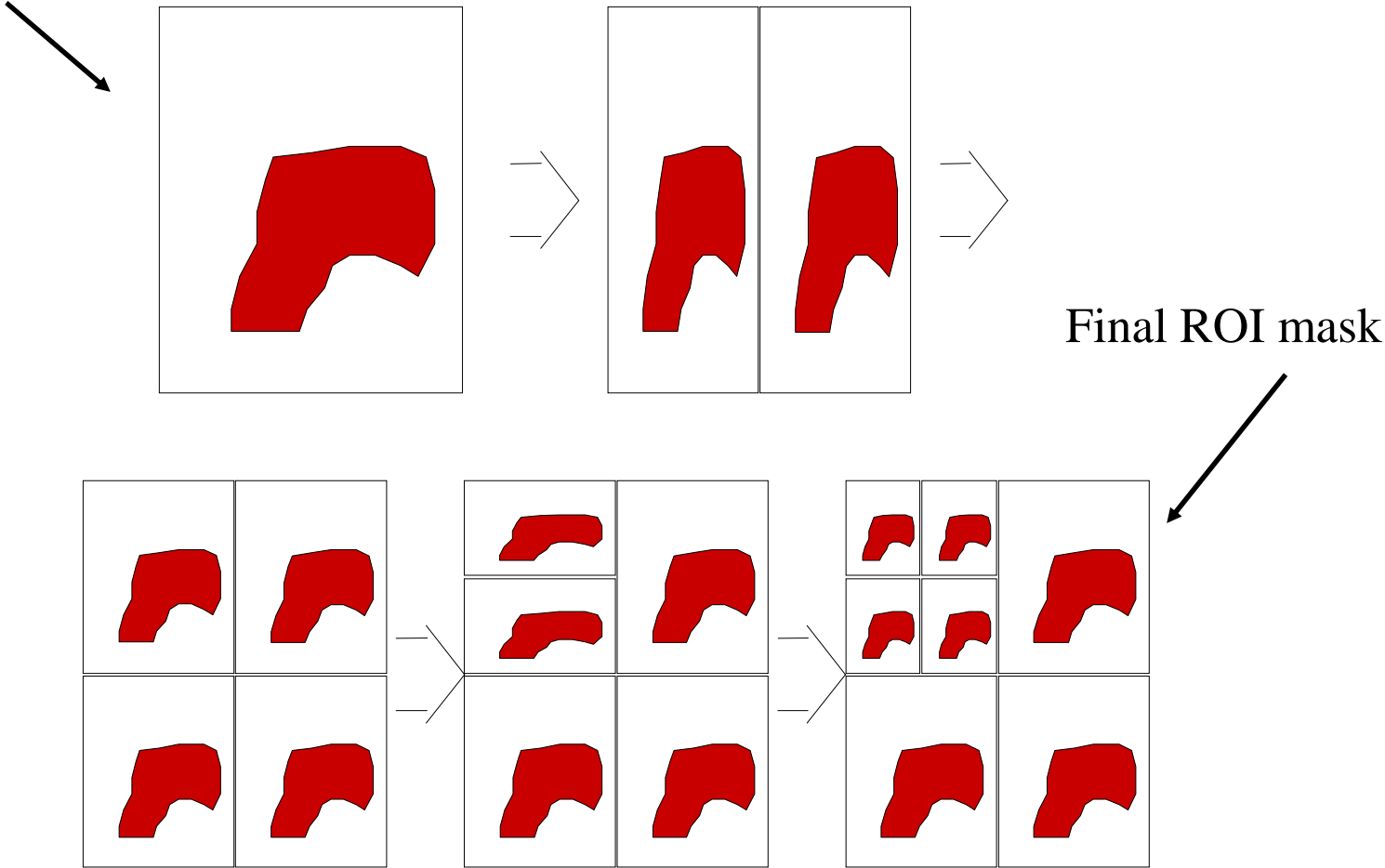
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# Region of Interest coding principle

- o Region of Interest (ROI) coding allows a non-uniform distribution of quality. The ROI is coded with a higher quality than the background (BG). A higher compression ratio can be achieved with same or higher quality inside ROIs.
- o Static ROIs are defined at encoding time and are suitable for storage, fixed transmission, remote sensing, etc. Commonly referred to as ROI coding.
- o Dynamic ROIs are defined interactively by a user in a client/server situation during a progressive transmission. Suitable for telemedicine, PDAs, mobile communications, etc. They can be achieved by the dynamic generation of layers matching the user's request.

# Lossless ROI mask generation

ROI in image domain



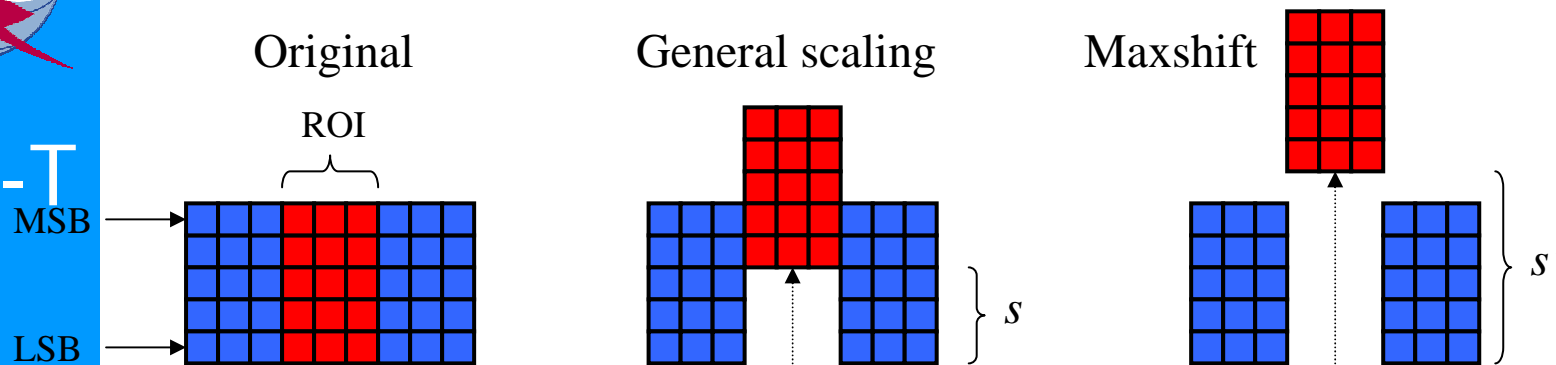




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MSB  
LSB

# Encoding ROIs: scaling

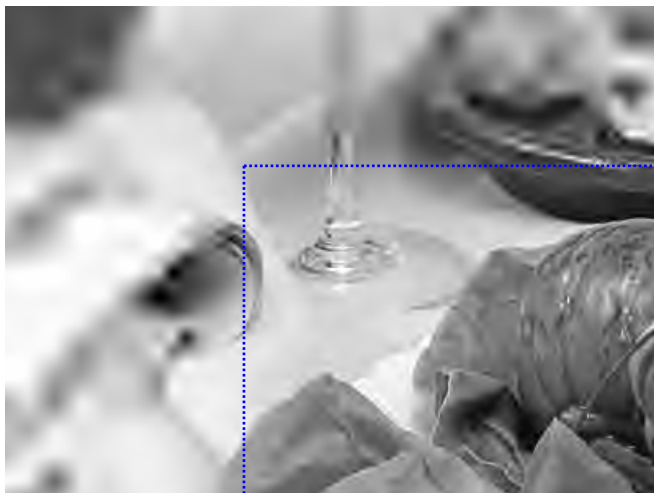


- Shift up quantized ROI coefficients by  $s$  bitplanes. The value of  $s$  is recorded in the codestream header for each ROI.
- At decoder ROI coefficients are unshifted prior to dequantization.
- The ROI mask is required at both, encoder and decoder.
- In maxshift,  $s$  is large enough to separate ROI and BG
  - No ROI mask required at decoder
  - ROI  $\leftrightarrow$  BG quality differential not controlled



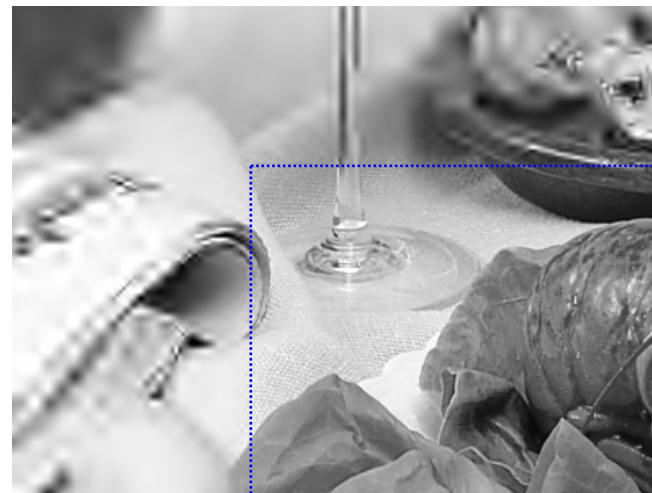
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# ROI Maxshift example



256:1

ROI



45:1 (almost all ROI decoded)



No ROI



ROI covers 5% of image, 2 lowest resolution levels in ROI mask. Magnified portion shown.

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# ROI Maxshift example (cont'd)



16:1

ROI



4:1 (complete decode)



No ROI



ROI covers 5% of image, 2 lowest resolution levels in ROI mask. Magnified portion shown.



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# Error resilience example

16:1 compression ratio. Transmission error rate  $10^{-5}$ . No errors in codestream header.  
Magnified portion shown.

No transmission errors



No error resilience



Full error resilience



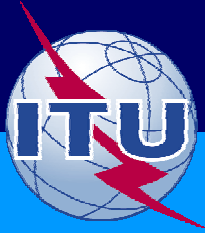


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# Error protection techniques

- o Coded image data
  - Code-block partition
  - Regular termination of arithmetic coder
  - Segmentation symbols
- o Packet heads
  - Start of packet markers
  - Packet heads in main / tile codestream header
  - Partition of packets into precincts





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# Error resilience visual results

Bit error rate =  $10^{-5}$



JPEG 16:1 CR



JPEG 2000 16:1 CR

Images with median quality, of 200 runs



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# Error resilience visual results

Bit error rate =  $10^{-4}$



JPEG 16:1 CR



JPEG 2000 16:1 CR

Images with median quality, of 200 runs



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## JPEG 2000 File Format: JP2

- o JP2 is the optional JPEG 2000 file format to encapsulate JPEG 2000 codestreams.
  - Extension: jp2
  - Allows to embed XML information (e.g., metadata)
  - Alpha channel (e.g., transparency)
  - Accurate color interpretation
  - “True color” and “palette color” supported
  - Intellectual property information
  - Capture and default display resolution
  - File “magic number”
  - File transfer errors (ASCII ftp, 7 bit e-mail, etc.)