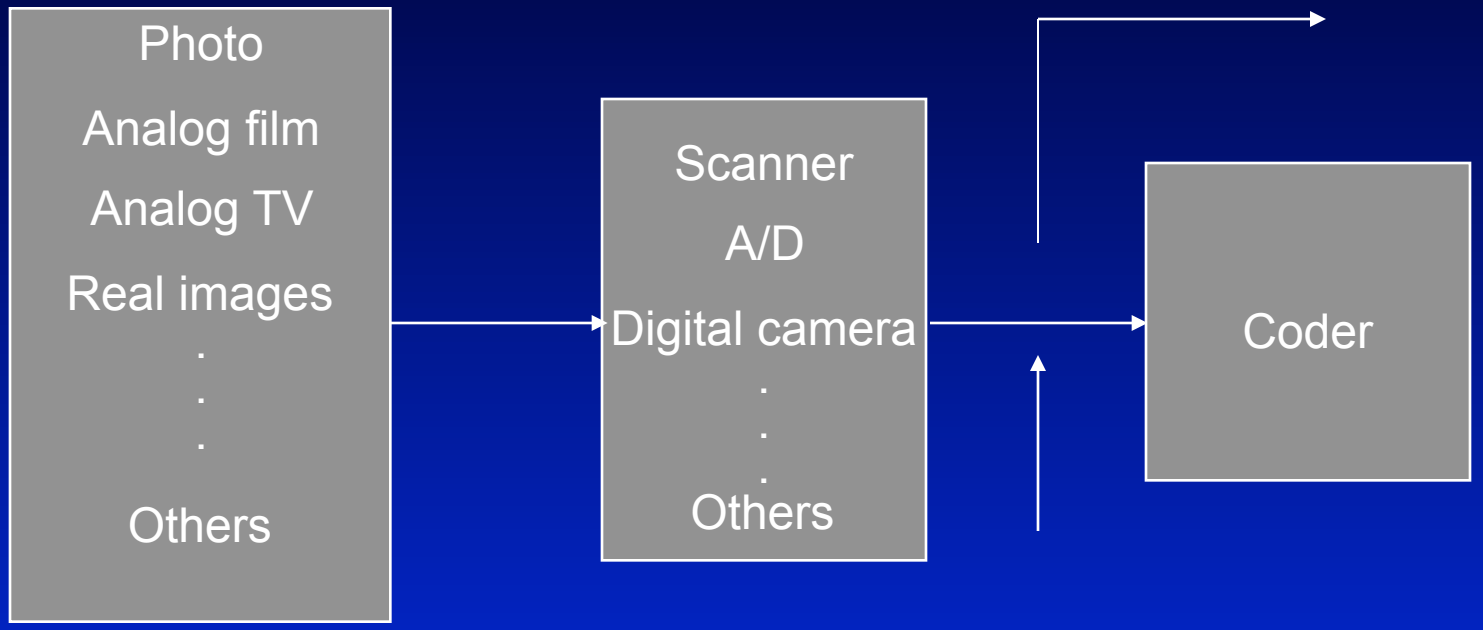
Input video signal



Y, u, v Image

PCM 8 bits

$$Y = 0.30\ R + 0.59\ G + 0.11\ B$$

$$u = B - Y$$
$$v = R - Y$$

Y u v Formats

Y u v Format

Y

U

V

RGB 24 bits/pixel

YUV 4:2:0 (12 bits/pixel)

Color spaces

- **RGB** Red-Green-Blue is an additive color system. In a [0,1] color intensity range (0,0,0) is black, (1,1,1) is white.
- **CMY** Cyan-Magenta-Yellow is a subtractive color system. (0,0,0) is white, (1,1,1) is black.
- **HSV** Hue-Saturation-Value is an encoding of RGB.
- **YUV** Luminance-Chrominance. Is a linear encoding of RGB used in television transmission. Y contains Luminance (brightness) information; U and V are colour information. (Similar colour spaces are YCrCb and YPbPr0).

The need for image compression

- 512 x 512 pixel color image

  512 x 512 x 24bits = 786 Kbytes

- Videoconference QCIF (quarter common intermediate format)

  (176 x 144 + 88 x 72 + 88 x 72) x 8 x 25 = 7.6 Mbits/s

- Digital television

  (720 x 576 + 360 x 288 + 360 x 288) x 8 x 25 = 124 Mbits/s

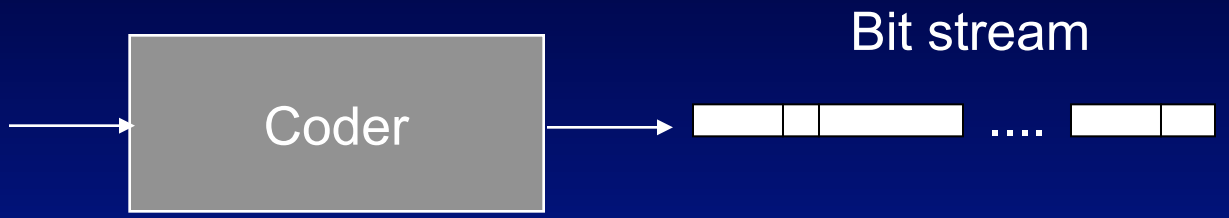
- High definition television - HDTV

  (1440 x 1152 + 720 x 576 + 720 x 576) x 8 x 25 = 497 Mbits/s

- Multispectral images (satellite)

  (6000 x 6000) x 8 x 6 = 216 Mbytes

Image coding



Objective: To find a way to represent
the original image without (?) distortion
with the minimum number of bits possible

Lossless image coding

Lossy image coding

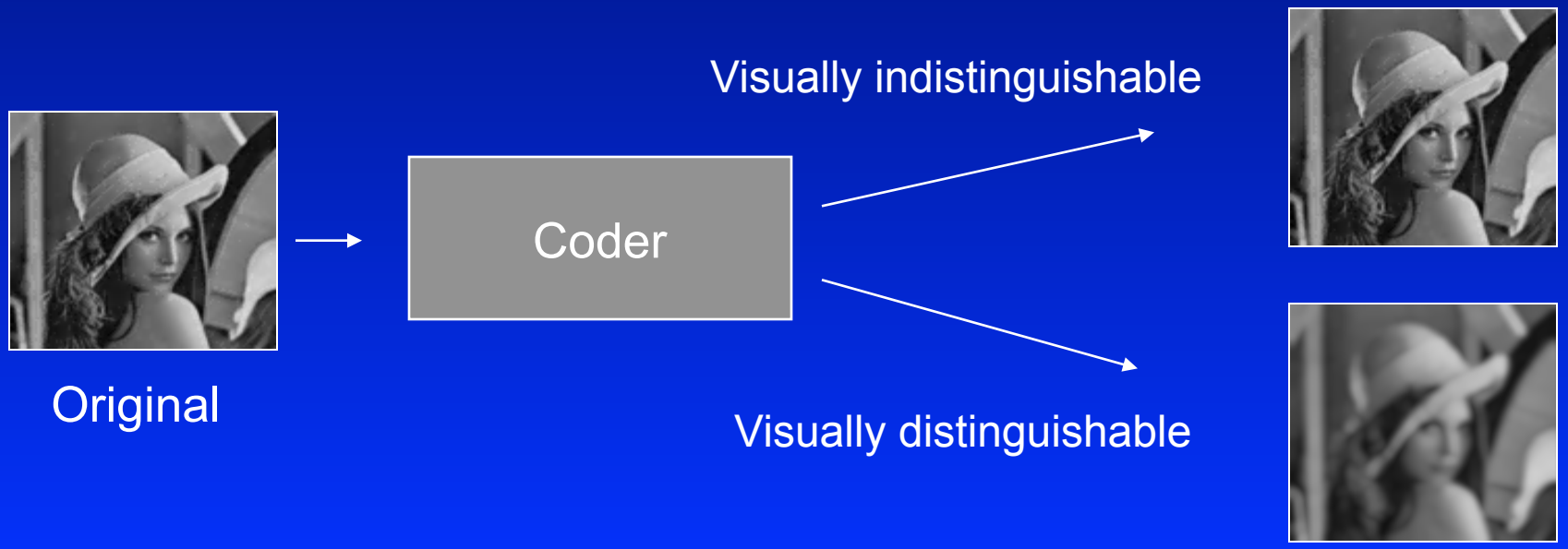
Lossless and lossy image coding

- Lossless image coding :

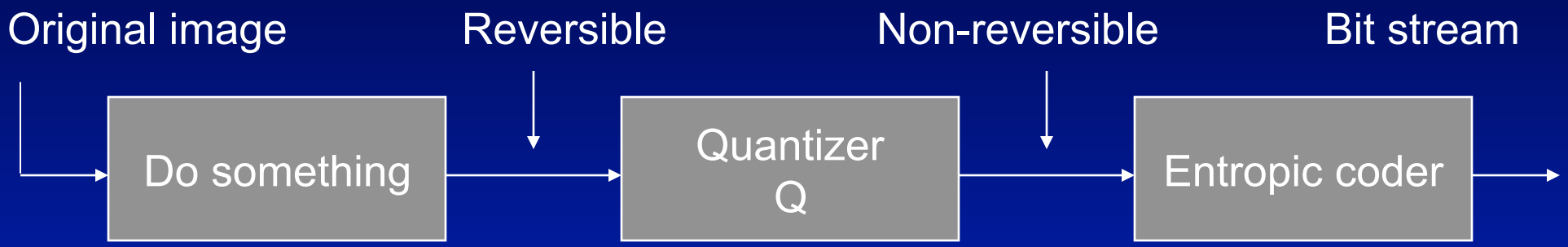
  The decoded image is pixel by pixel identical to the original

- Lossy image coding :

  The decoded image is NOT pixel by pixel identical to the original



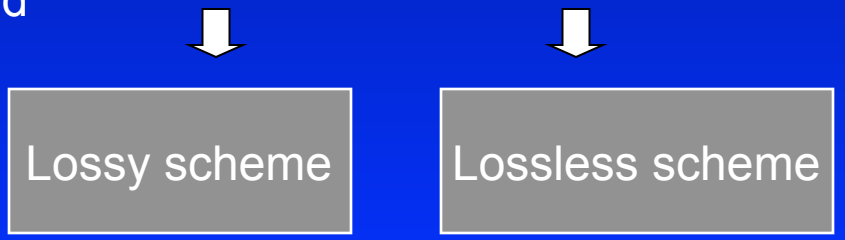
General scheme of image coding (compression)



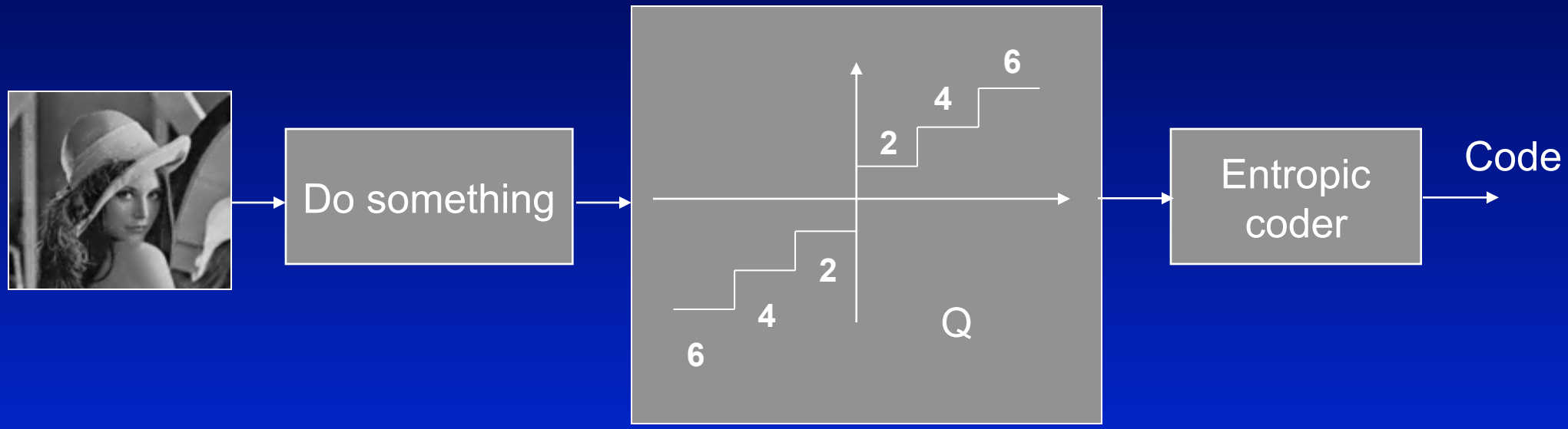
- *To prepare* the image
- To remove redundancy
- This an optional block. Although almost always exists
- DCT, wavelets, hybrid

- Quantizer
- Scalar or vectorial
- This an optional block. Although almost always exists

- Entropic coder
- This block always exists



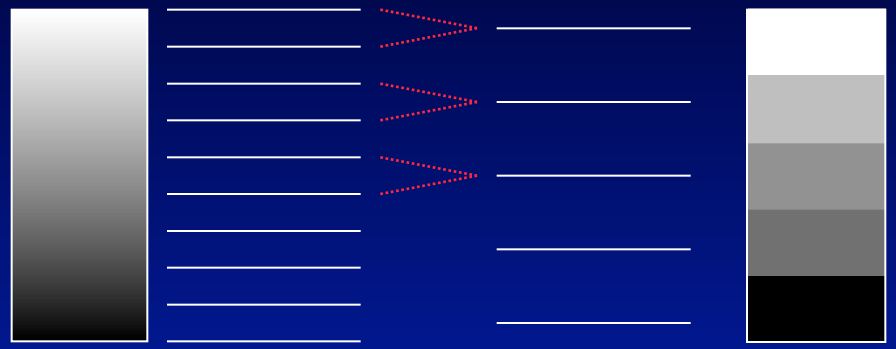
Quantization

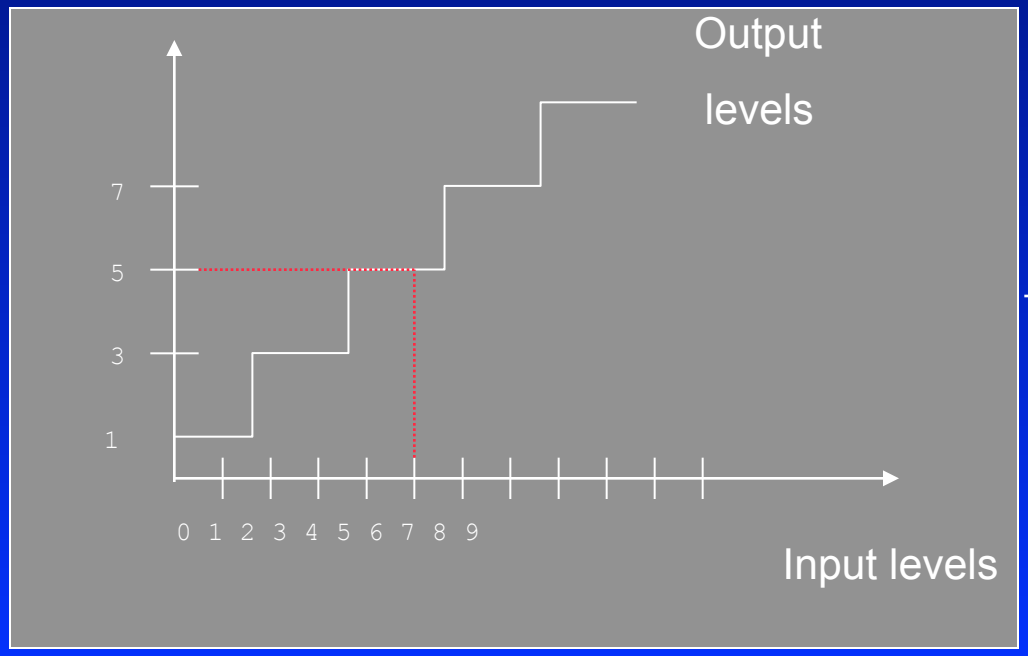


Quantization (1)

Input digital levels

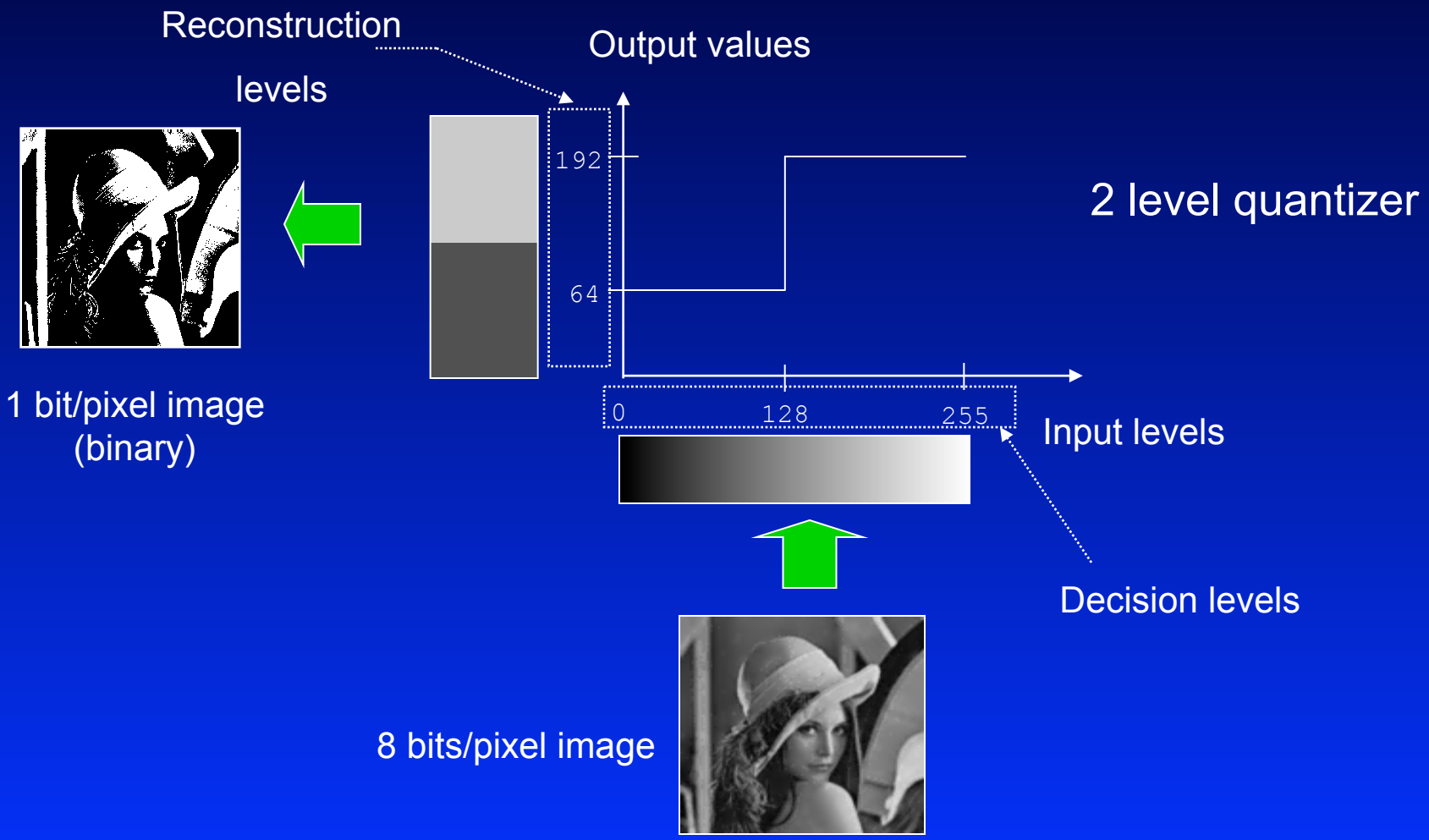
Output levels



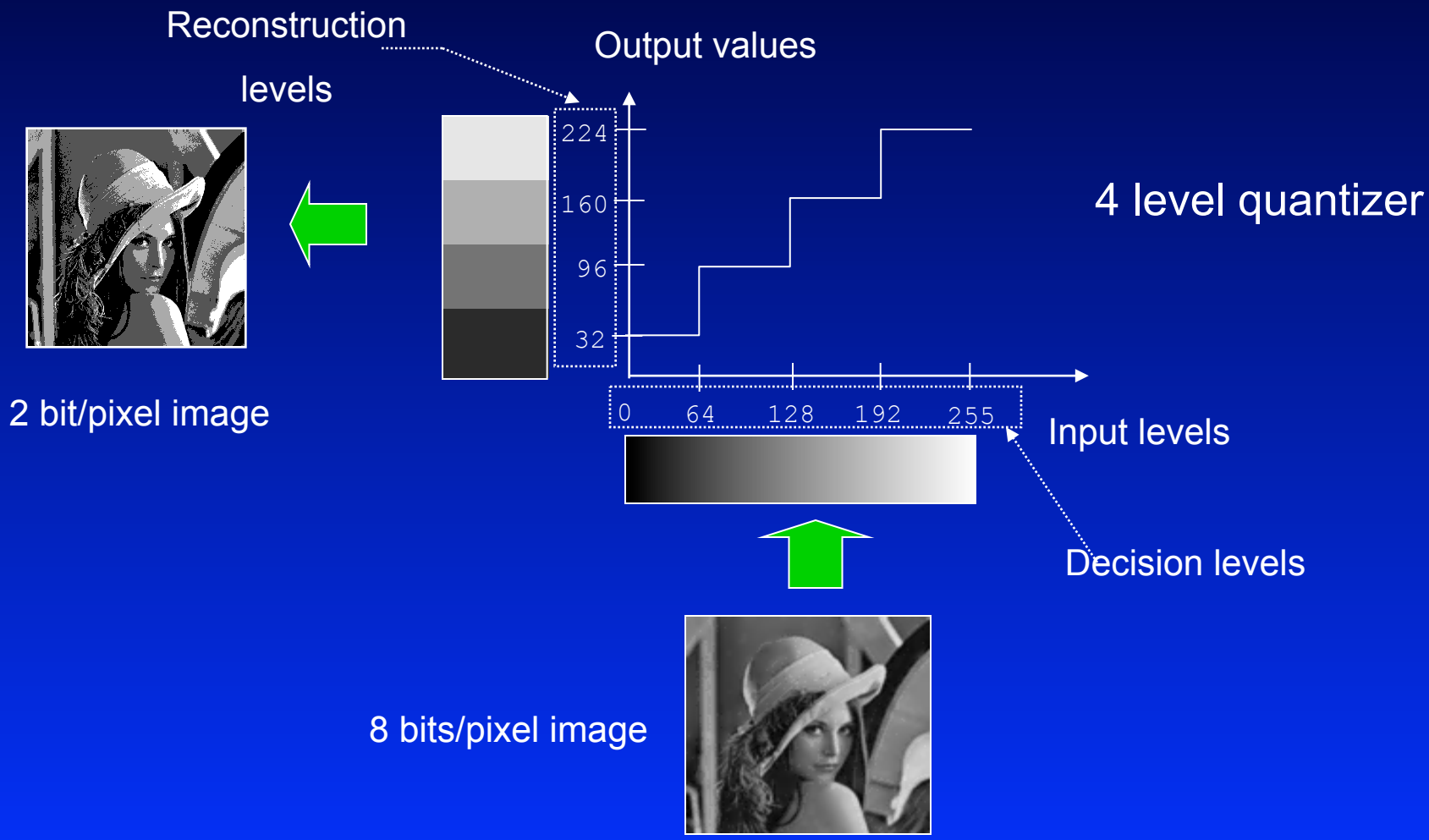


Entropic coder

Quantization (2)



Quantization (3)



Uniform quantizer

4 bits

2 bits

3 bits

1 bit

Image formats

	ITU - 601	CIF
Sampled signals	Y, u, v	Y, u, v
Sampling frequency Mhz.	(Y) 13.5 - (u,v) 6.75	(Y) 6.75 - (u,v) 3.375
Sampling structure	orthogonal 1:1	orthogonal 1:1
Pixels / image	(Y): 720 x 576	(Y): 352 x 288
	(u,v): 360 x 288	(u,v): 176 x 144
Bits/pixel	8	8

Measure of the compression (1)

$$\text{Compression factor} = \frac{\text{Bits original image}}{\text{Bits compressed image}}$$

$$\text{Bits/pixel} = \frac{\text{Bits compressed image}}{\text{Number of pixels}}$$

Measure of the compression (2)

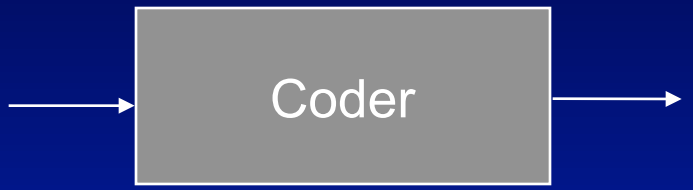
Original image
256 x 256 x 8 bits

Compressed image
40.000 bits

$$\text{Bits/pixel} = \frac{40.000}{256 \times 256} = 0.61 \text{ bpp}$$

$$\text{C. F.} = \frac{8 \text{ bpp}}{0.61 \text{ bpp}} = 13.1$$

Measures of the compression quality



X(m,n)

Y(m,n)

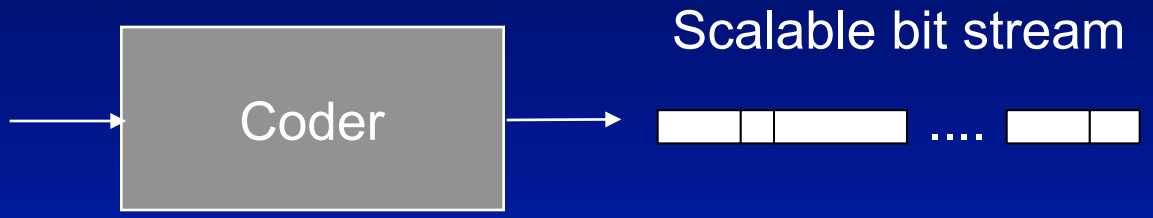
Subjective measure → Opinions over a scale of 5

Objective measure →

$$\mathrm{PSNR(dB)} = 10\log_{10}\frac{255^2}{\mathrm{MSE}}$$

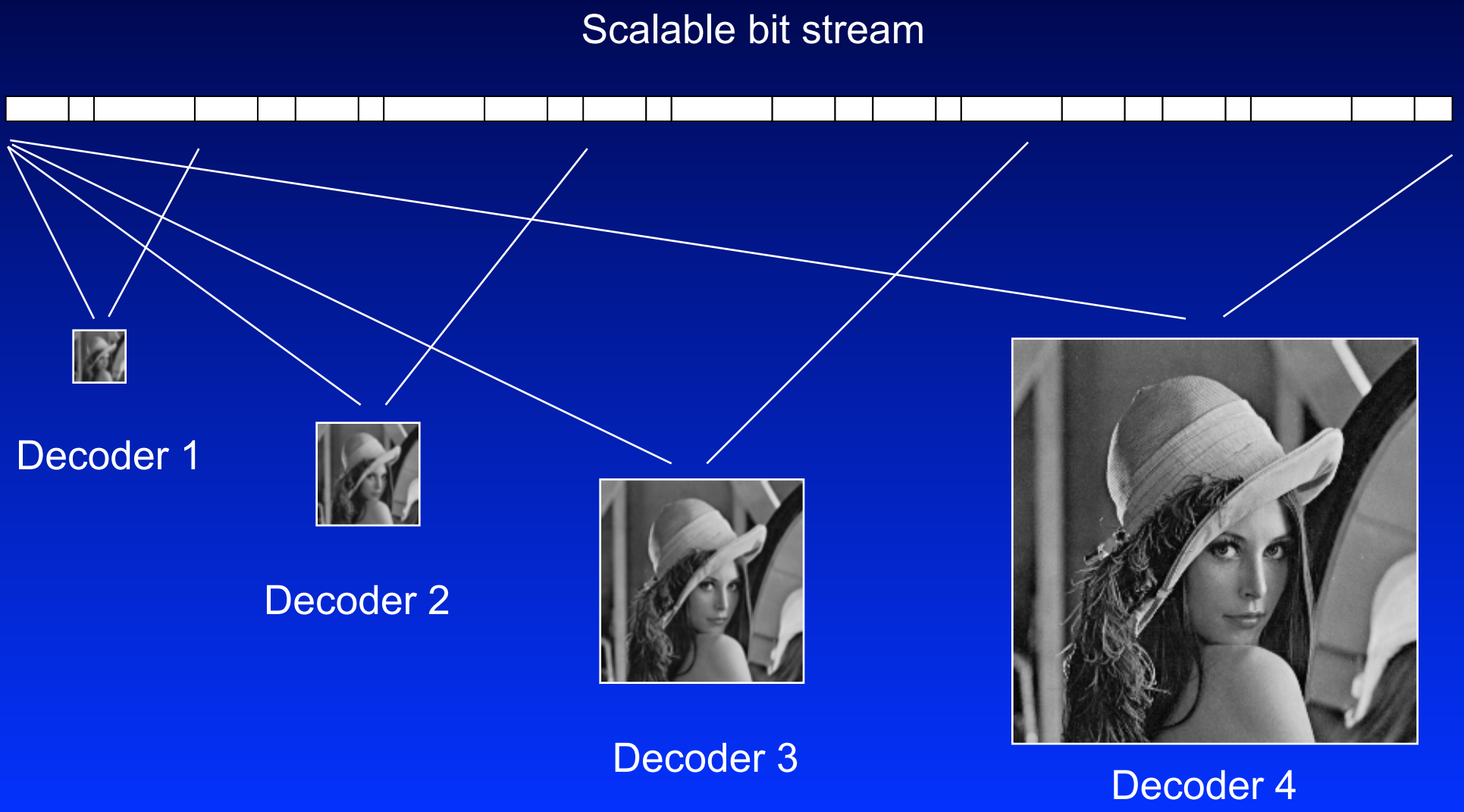
$$\mathrm{MSE} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(y_{ij} - x_{ij})^2$$

Scalability



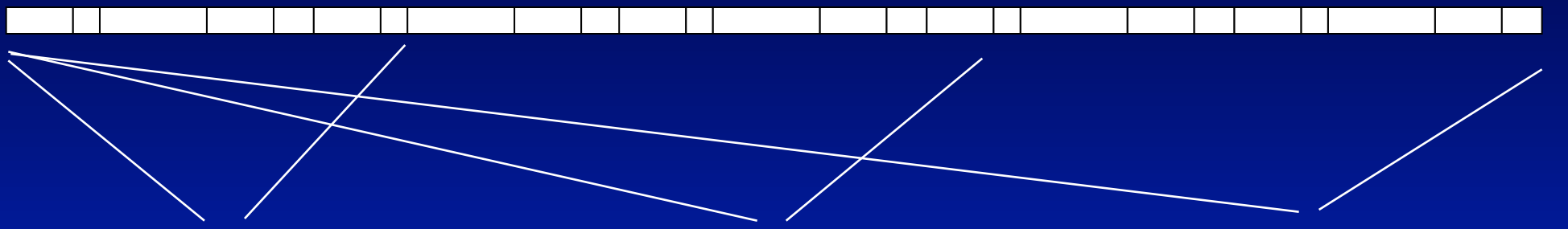
- Spatial scalability
- PSNR scalability (quality)
- Non-scalable

Spatial scalability



PSNR scalability (quality)

Scalable Bit stream

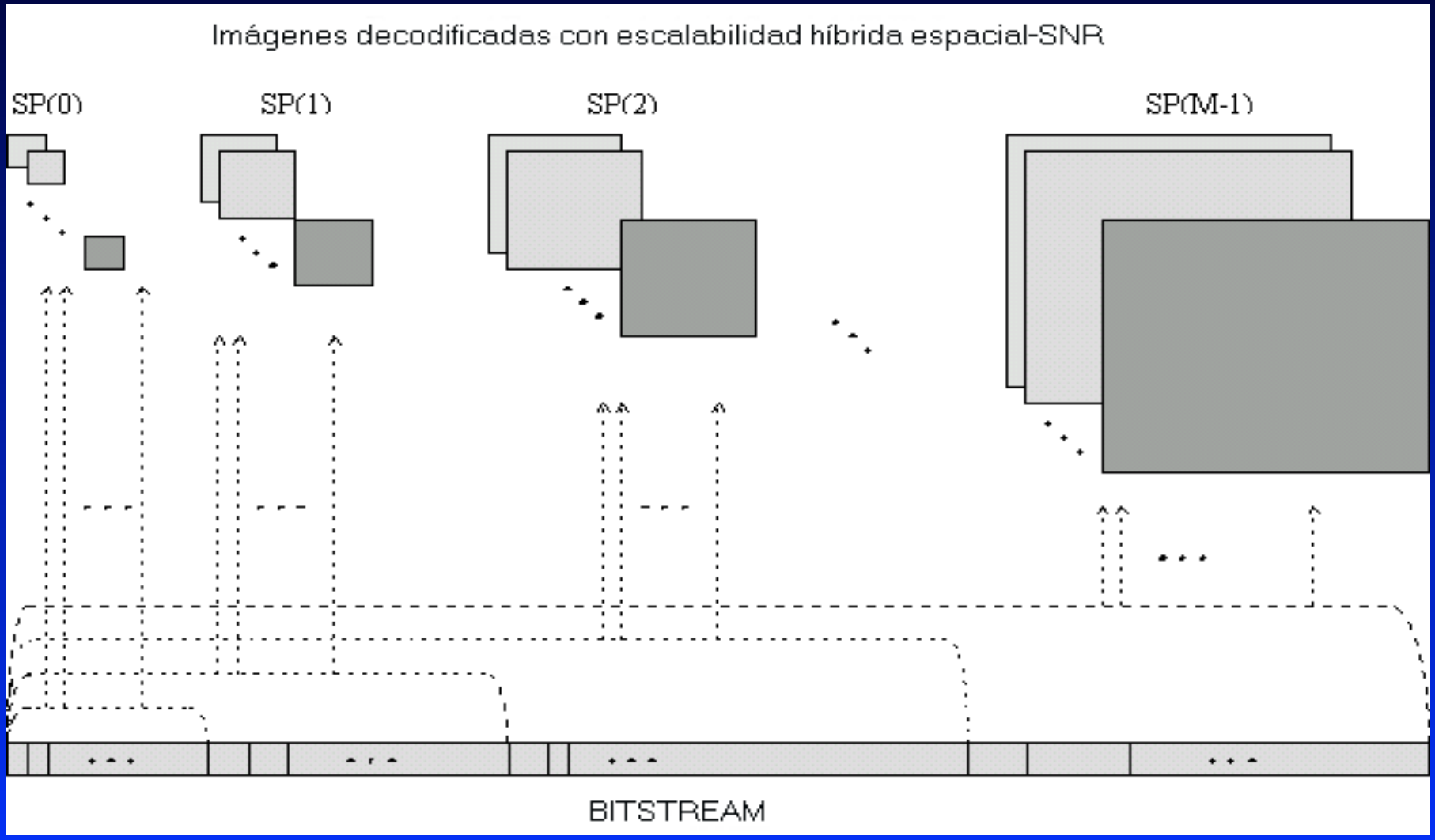


Decoder 1

Decoder 2

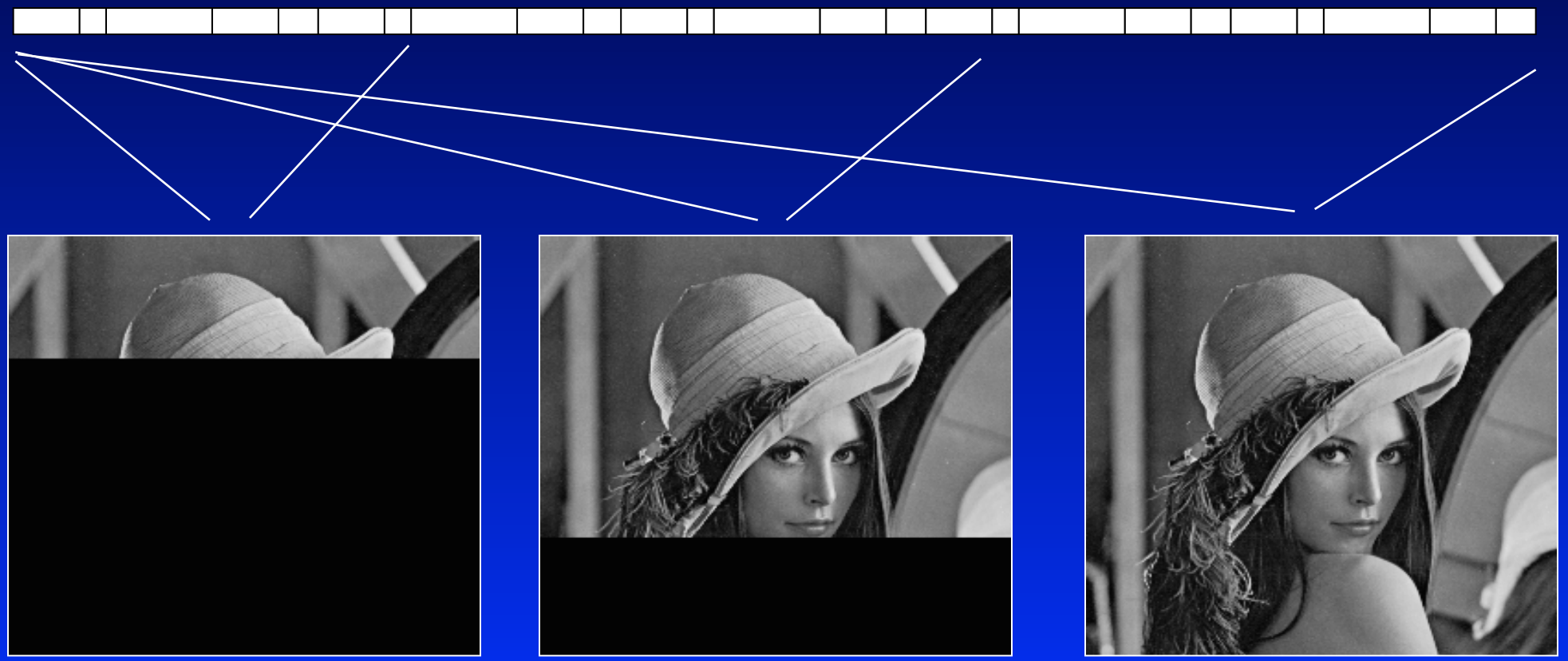
Decoder 3

Spatial – PSNR scalability



Non-scalable

Non-scalable Bit stream



Decoder 1 Decoder 2 Decoder 3

Asymmetric coder

- Coder complexity different than decoder complexity
- The decoder should be as simple as possible

JPEG: Symmetric

MPEG 1- 2: Very asymmetric

Image coding standards

JPEG

JPEG 2000

0.15 bits / pixel : Recognizable

0.25 bits / pixel : Useful

0.75 bits / pixel: Excellent

1.50 bits / pixel: Indistinguishable

20% more compression than JPEG for same quality
More functionalities

Video coding standards