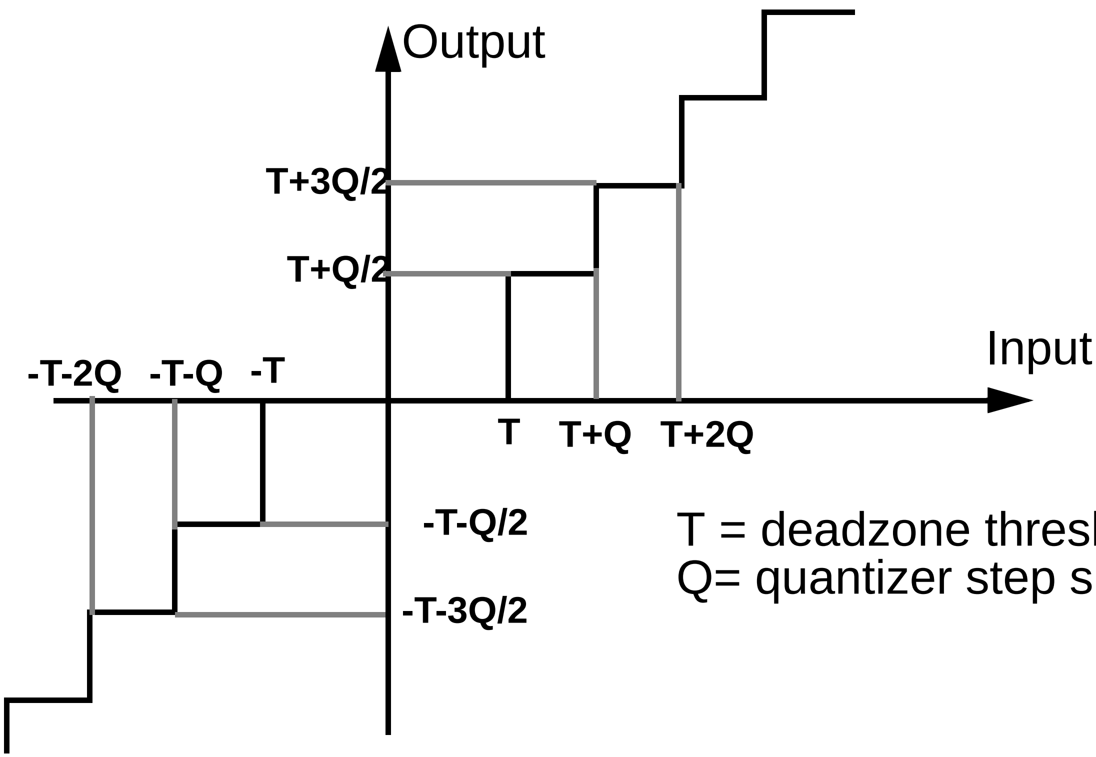
Thresholding and Quantization

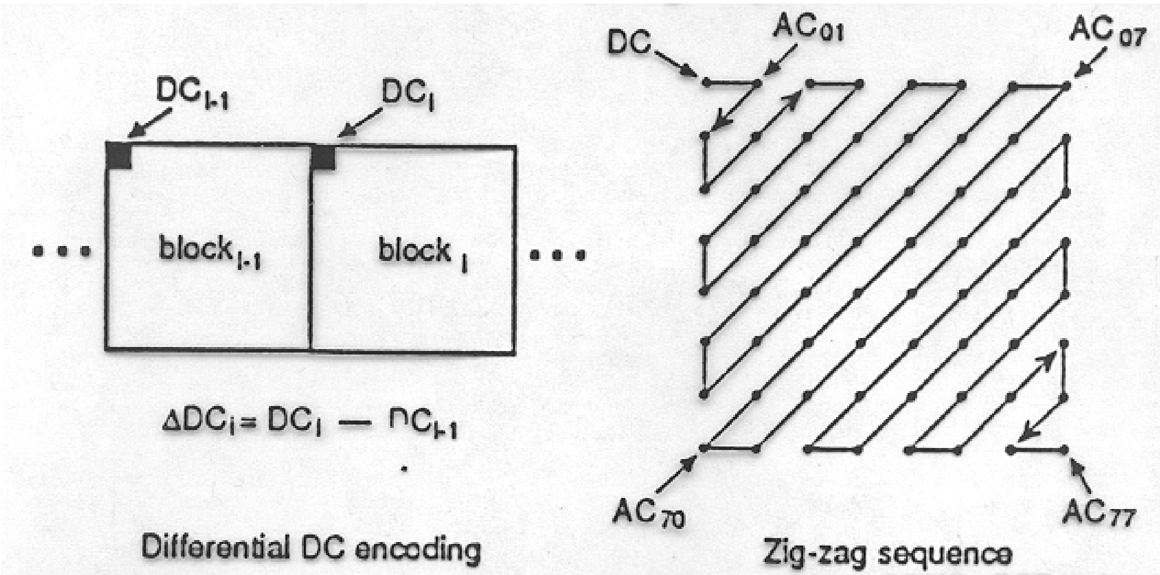
- After FDCT, the 64 DCT coefficients are quantized.
- The goal is to achieve further compression by representing DCT coefficients with the right precision according to the image quality (specified by the user, such as quality 95).
- The is principal source of lossiness in DCT-based encoders.



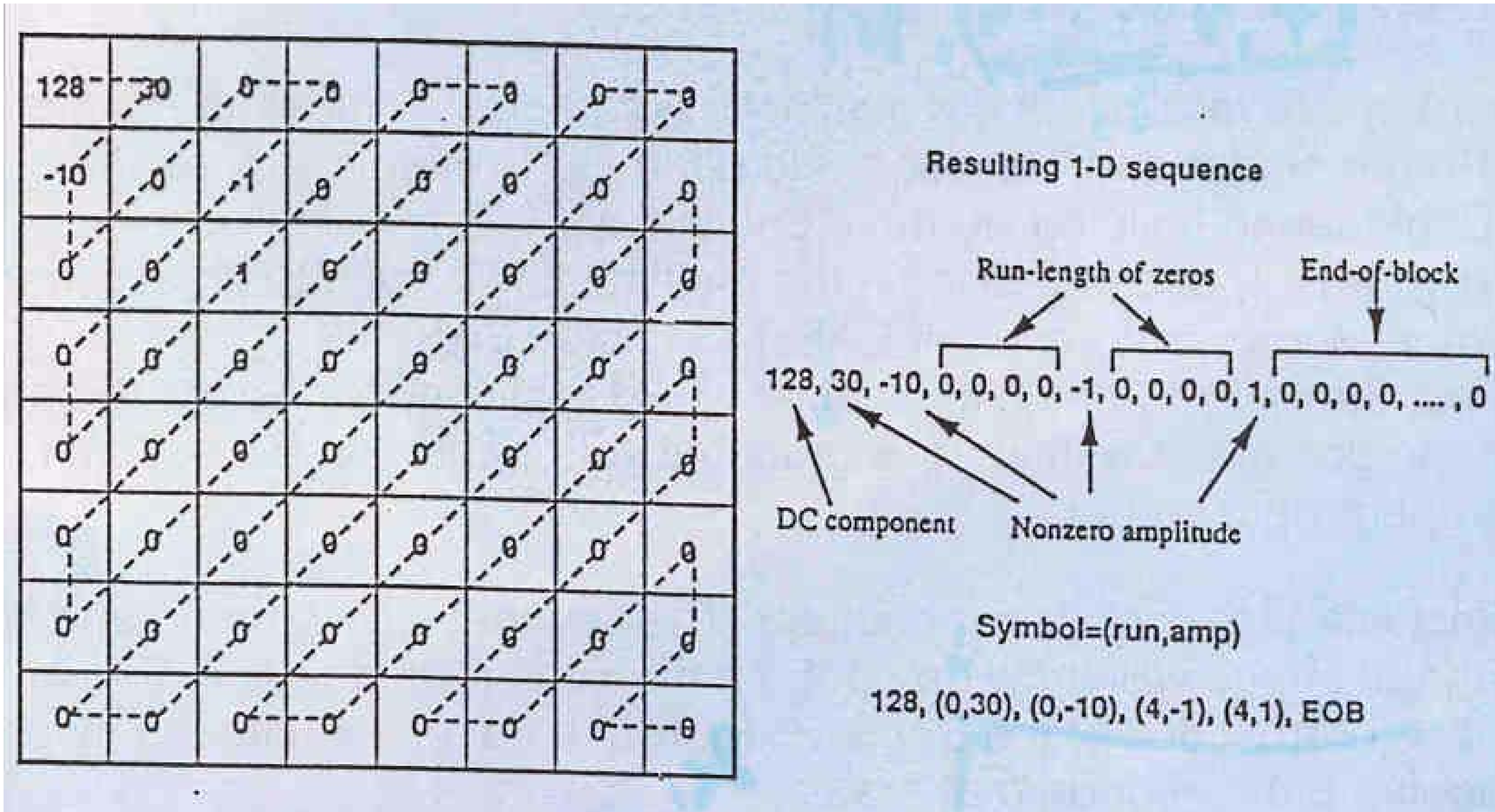
T = deadzone threshold
Q= quantizer step size

DC Coding and Zig-Zag Sequence

- The DC coefficient, F(0,0), is a measure of the average value of 64 samples.
- Strong correlation between the DC coefficients of adjacent 8x8 blocks
- The quantized DC coefficient is encoded as the difference from the DC term of pervious block in the encoding order.
- This special treatment is worthwhile since DC term contains important image information.
- The coefficients are encoded in Zig-Zag sequence with low-frequency go first



An 8x8 Block Coding Example



Entropy Coding

- Losslessly compress the quantized DCT coefficient sequence based on statistical characteristics.
- Usually, there are few nonzero and many zero-valued AC coefficients.
- Huffman coding and arithmetic coding are proposed.
- A two-step process:
  1. convert DCT coefficients into an intermediate sequence of symbol.
  2. assign variable-length codes to the symbols.
- Each nonzero AC coefficient is represented by two symbols.
  (Runlength, Size) (Amplitude)
  symbol-1 symbol-2
  where Runlength is the number of consecutive zero-value preceding AC coef.
  it can be zero-runs of length 0 to 15.
  (15, 0) represents extension, there can be 3 extensions.
  (0, 0), EOB, is used to terminate the sequence.
  Size is the number of bits used to encode Amplitude, (1-10bits) for 8bit samples.
  Amplitude is the value of the nonzero AC coefficient. $[-2^{10}, 2^{10}-1]$

Entropy coding

- DC coefficients are encoded using differential coding technique, because the strong correlation.
- The differential DC coefficients are encoded as
  (Size) (Amplitude)
  symbol-1 symbol-2
- Amplitude range=$[-2^{11}, 2^{11}-1]$
- symbol-1 is encoded using Huffman coding (VLC)
- symbol-2 is encoded using Variable-Length Integer (VLI) coding

Baseline Huffman Coding Symbol-1 Structure

		SIZE					
		0	1	2	...	9	10
RUNLENGTH	0	EOB					
	.	X					
	.	X			RUN-SIZE VALUES		
	.	X					
	15	ZRL					

Baseline Entropy Coding Symbol-2 Structure

SIZE	AMPLITUDE
1	−1,1
2	−3,−2,2,3
3	−7..−4,4..7
4	−15..−8,8..15
5	−31..−16,16..31
6	−63..−32,32..63
7	−127..−64,64..127
8	−255..−128,128..255
9	−511..−256,256..511
10	−1023..−512,512..1023

Variable Length Integer (VLI) Coding

- It encodes a number by two values, (size, amplitude).
  size = the number of bits used to encode the amplitude values.
  amplitude encodes the number using a biased-number scheme.
- VLI coding table

Size	Amplitude
1	-1,1
2	-3,-2,2,3
3	-7..-4,4..7
4	-15..-8,8..15
5	-31..-16,16..31
6	-63..-32,32..63
7	-127..-64,64..127
8	-255..-128,128..255
9	-511..-256,256..511
10	-1023..-512,512..1023
11	-2047..-1024,1024..2047

Examples:

$1 \longrightarrow (1, 1)$

$-1 \longrightarrow (1, -1+1)=(1,0)$

$-10 \longrightarrow (4, -10+\mathit{15})=(4,5)$

$30 \longrightarrow (5, 30)$

bias value (the italic 15)

$128 \longrightarrow (8, 128)$

8x8 Block Coding Example

128, 30,-10,0,0,0,0,-1,0,0,0,0,1,0,0,...,0

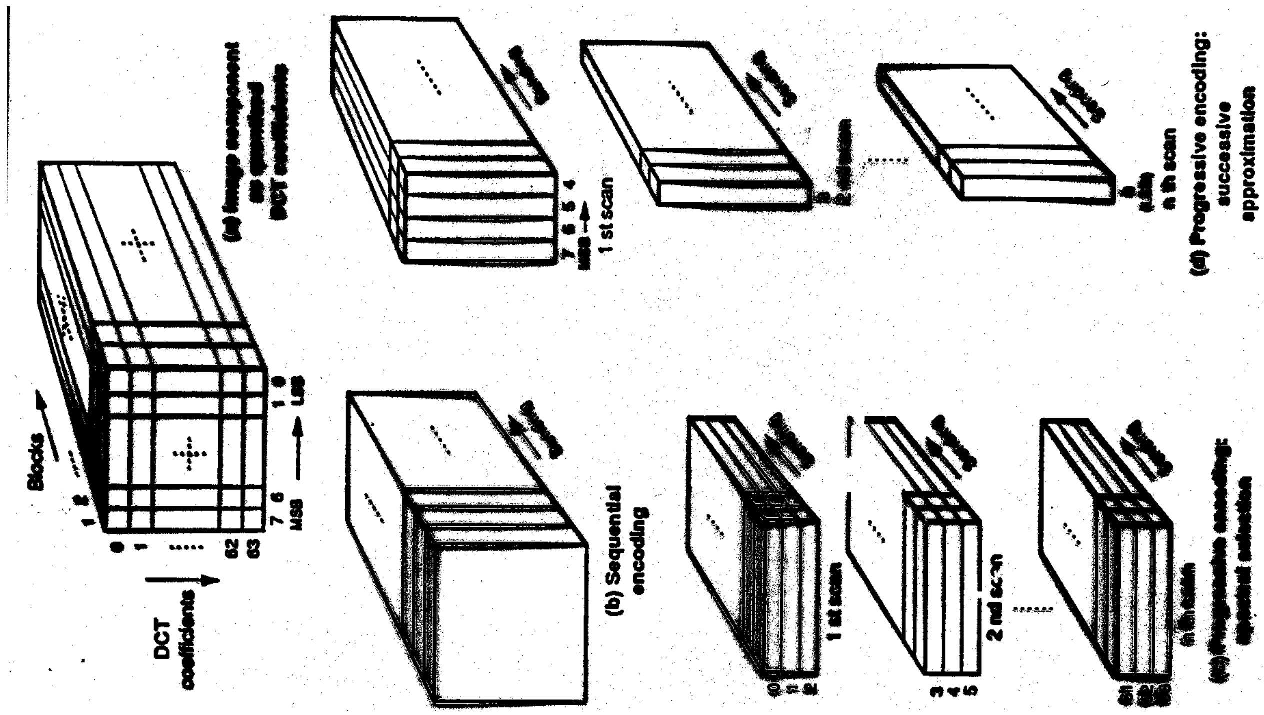
will be encoded as

(8,128), ((0,5), 30), ((0,4), 5), ((4,1), 0), ((4,1), 1), (0, 0)

Note that for symbol 1=(15, 4) represents a coef. with 15 leading zeros and size 4.
(15, 0)(0,5) represents a coef. with 16 leading zeros with size 5.
(15,0)(15,0)(15,0)(14,3) represents a coef. with 62 leading zeros with size 3.

Progressive Mode Operation

Each Image encoded in multiple scans(with increasing quality)
rough but recognized scan can be transmitted quickly.
require image-sized buffer memory at the output of quantizer.



Hierarchical Mode Operation

- Provide a “pyramidal” encoding at multiple resolutions.
- Encoding Steps:

  a. Filter and down-sample (by multiples of 2) the original image to the lowest resolution.

  b. Encode the reduced-size image using DCT.

  c. Decode the image and interpolate and up-sample by 2.

  d. Use this up-sampled image as a prediction of the original at this resolution
  and encode the difference image using DCT.

  e. Repeat steps c) and d) until full resolution of the image encoded.
- Use when a high resolution image must be access by a lower-resolution device, which does not the buffer capacity to reconstruct the image at the full resolution and then scale it down.

JPEG

- Joint Photographic Expert Group
- Formed in 1986, ISO-IEC/JTC1/SC29/WG10
- Proposal submission: June 1987
  12 proposed methods, 3 chosen for further refinement (DCT, ADPCM, GBTC)
- ADCT was selected Jan. 1988 for best quality over a range of bit rates.
- Committee Draft (CD) 1990
  Draft International Standard (DIS 10918): 1991
  International Standard (IS 10918): 1992
- Baseline process (required by all JPEG DCT-based codecs)
  DCT-based
  Input pixel accuracy = 8bits/pel/component
  sequential mode operation
  max # of Huffman tables = 2AC and 2DC tables
  max # of components = 4
  interleaved and non-leaved scan.
- xv command can view .jpg files, http://cs.uccs.edu/~cs525/jpeg/jpeg.FAQ
  includes info about the source. (Thanks Ed Hughes)