ECE462 – Lecture 22

MPEG Coding Standards

Name	Application	Rates	Raster
Motion JPEG Digital Video (or)	Camcorders/ Editing Systems	30Mbps 25Mbps	(Various) 720x480
H.261 H.263	Interactive Video Interactive Video Eg. (Video Conferencing)	64Kbps 64-384Kbps	
MPEG-1	VCR quality streaming Video	1.5Mbps	352x240
MPEG-2	Broadcasting quality streaming Video	4-15Mbps	704x480
MPEG-4	Video from/to low rate devices	32Kbps	
HDTV	High Definition TV	20Mbps	1920x1080
MPEG-7	Search & retrieval of video in multimedia devices		
MPEG-21	Intellectual property rights management		

- MPEG coding is "asymmetrical"

- The decoder is well specified
- Implementation details of the coder are not well specified and depend on the manufacturer

(The processing requirements and resources for encoding are considerably greater compared to decoding)

- MPEG originally envisioned for non-real time applications (it may insert considerable delay)
- MPEG organization
  - System parts
  - Video coding
  - Audio Coding

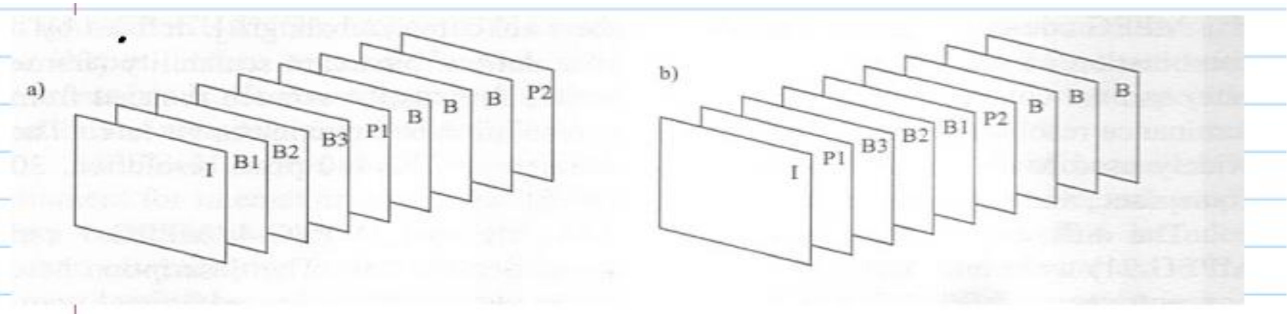
Systems part: multiplexing/demultiplexing multiple coded streams of video, audio and control signals

MPEG specifies the structure of the coded bitstream and requires only that all encoders work with a specified decoder

• <u>I, P and B frames</u>

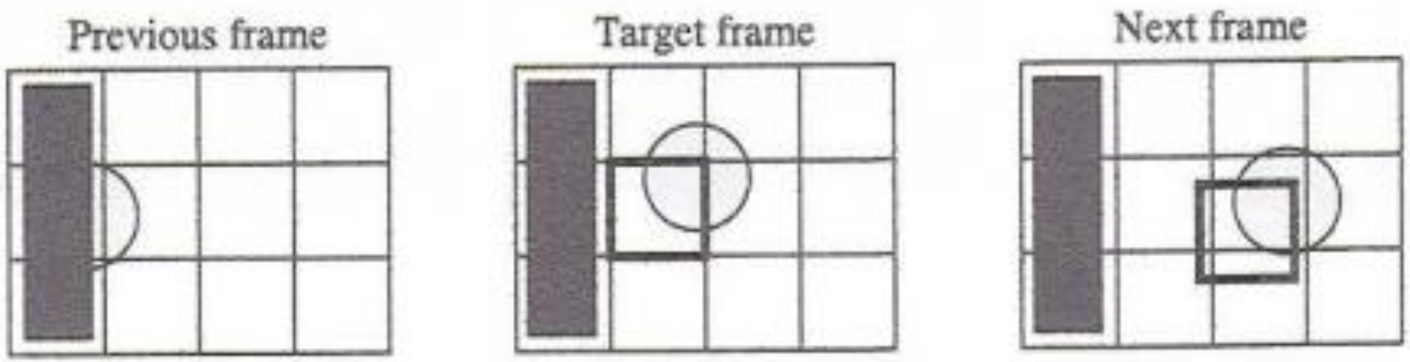
- I (independent) pictures “Intra Coded” compression by reduction of spatial redundancy (usually 6:1
- P (predictive coded: “Inter Coded” temporal compression via motion compensation and prediction (usually 15:1)

  (data is motion vectors, prediction error)
- B (Bidirectionally – predictive): “Inter Coded” using the nearest preceding and following I and P frames (usually 100:1)



Display order   Transmission order

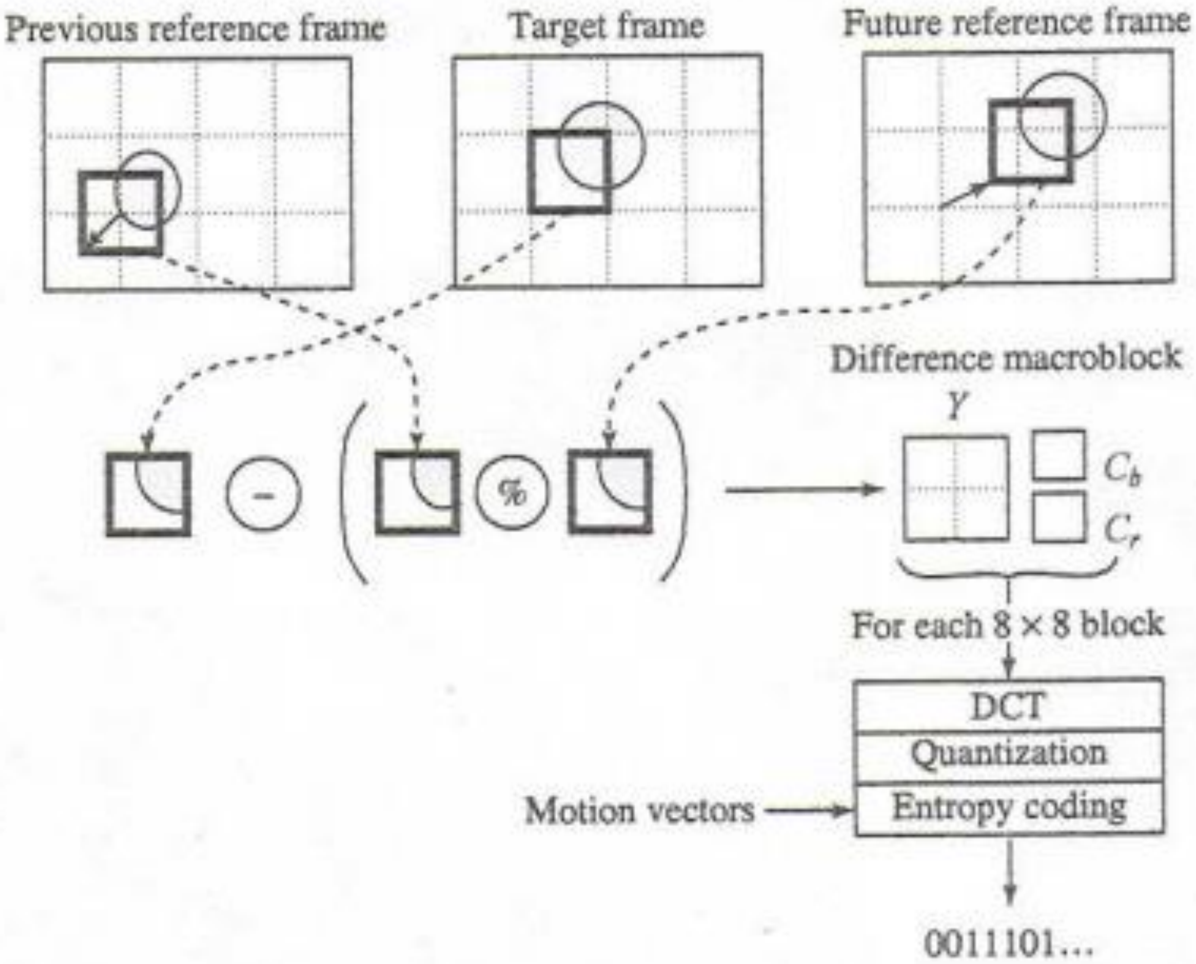
Group of pictures (GOP) in MPEG



[redacted] The Need for Bidirectional Search.

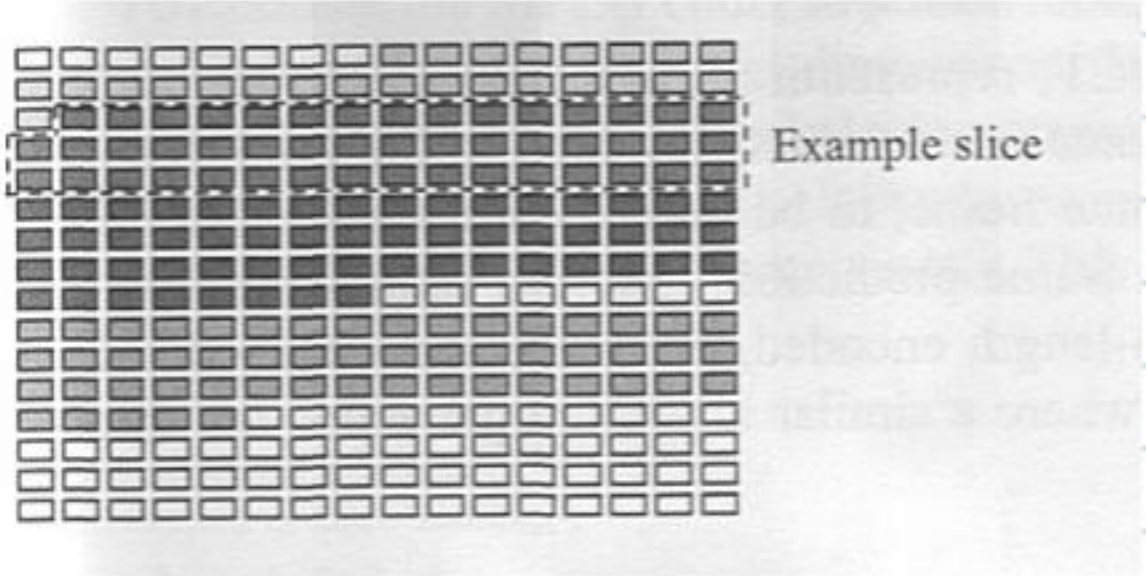
The MB containing part of a ball in the Target frame cannot find a good matching MB in the previous frame because half of the ball was occluded by another object. A match however can readily be obtained from the next frame.

B-frame coding

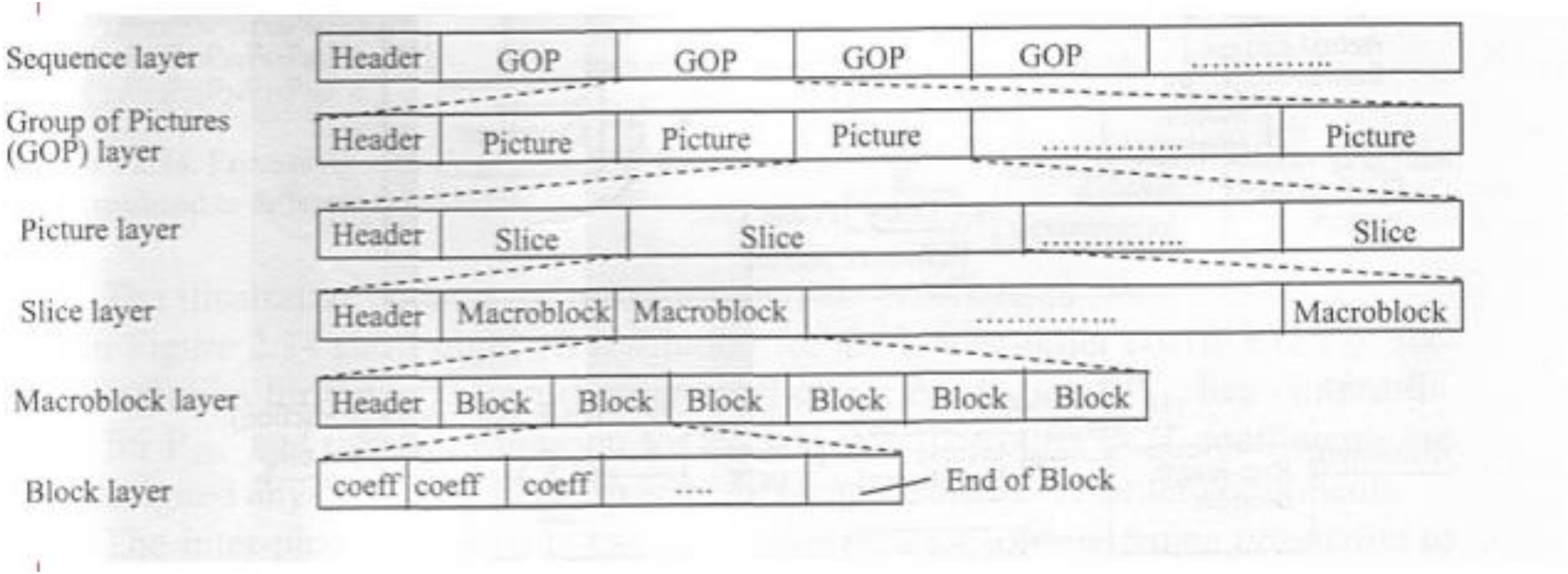


- MPEG pictures are divided into one or more slices. A SLICE

➢ May contain variable # of macroblocks in a single picture
➢ May start and end anywhere as long as they fill the whole picture
➢ Each slice is coded independently (flexibility) in bit rate



• Layers in MPEG bitstream



- Quantization:

  - MPEG-1 quantization uses different quantization tables for intra and Inter coding (Table 11.2 and 11.3). below

For DCT coefficients in Intra mode:

$$QDCT[i,j] = round\left(\frac{8 \times DCT[i,j]}{step\_size[i,j]}\right) = round\left(\frac{8 \times DCT[i,j]}{Q_1[i,j] * scale}\right)$$

For DCT coefficients in Inter mode,

$$QDCT[i,j] = \left\lfloor\frac{8 \times DCT[i,j]}{step\_size[i,j]}\right\rfloor = \left\lfloor\frac{8 \times DCT[i,j]}{Q_2[i,j] * scale}\right\rfloor$$

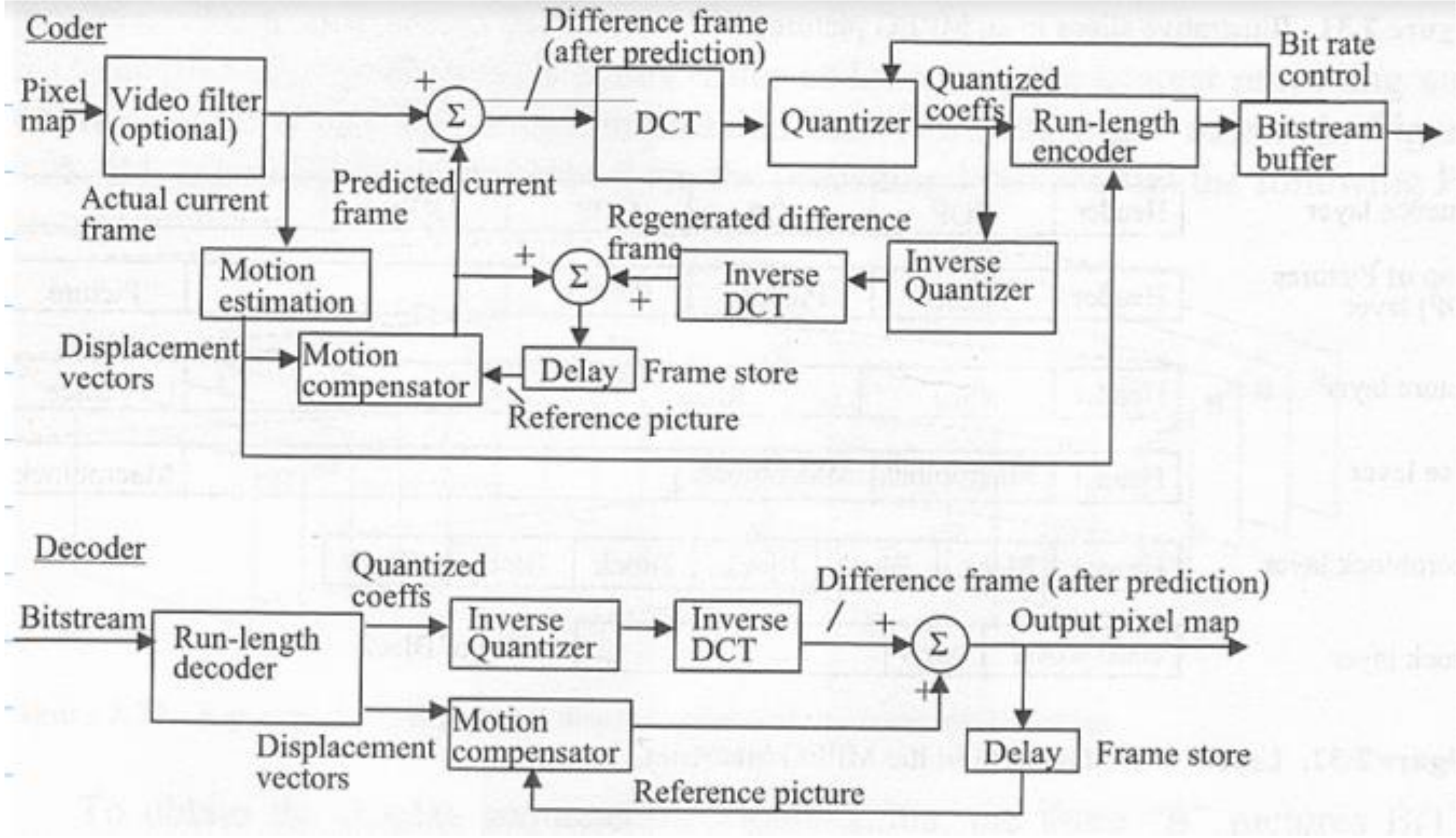
Default Quantization Table (Q_1) for Intra-Coding

8	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	26	27	29	34	37	40
22	26	27	29	32	35	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

Default Quantization Table (Q_2) for Inter-Coding

16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16

• MPEG Encoder – decoder

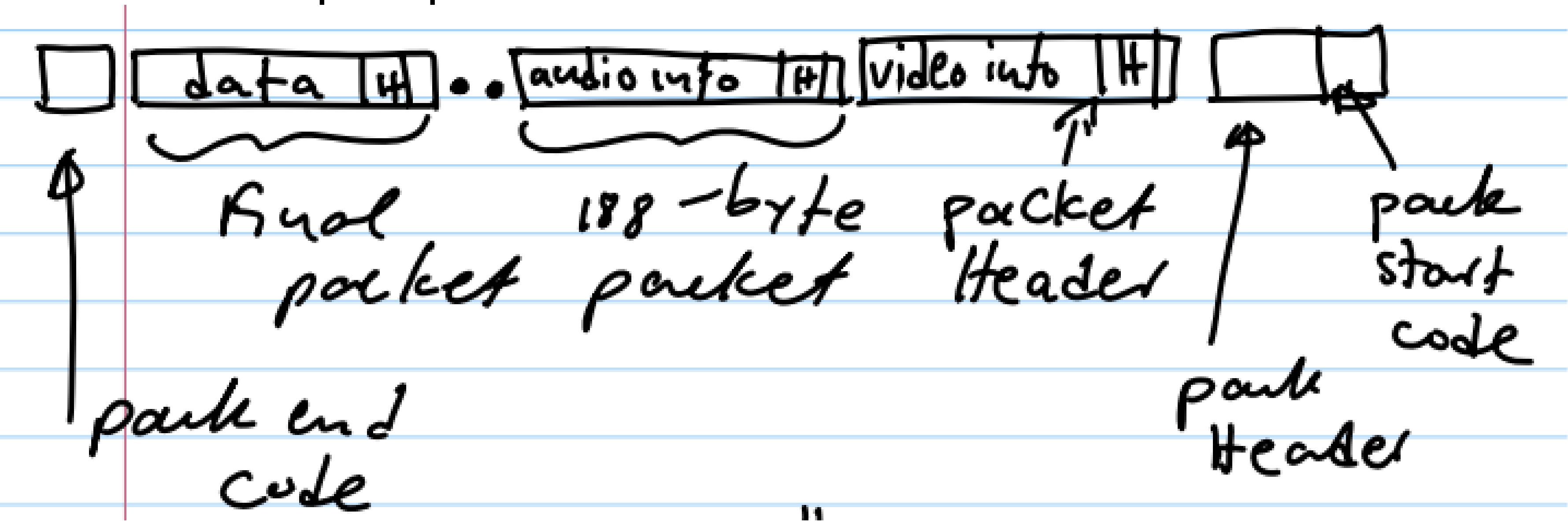


The MPEG stream can be adjusted to any rate by changing the rate at which the bitstream buffer is drained → bitrate control feedback to quantizer

MPEG Systems Layer

- Transmission packet structure

    "Transport pack"

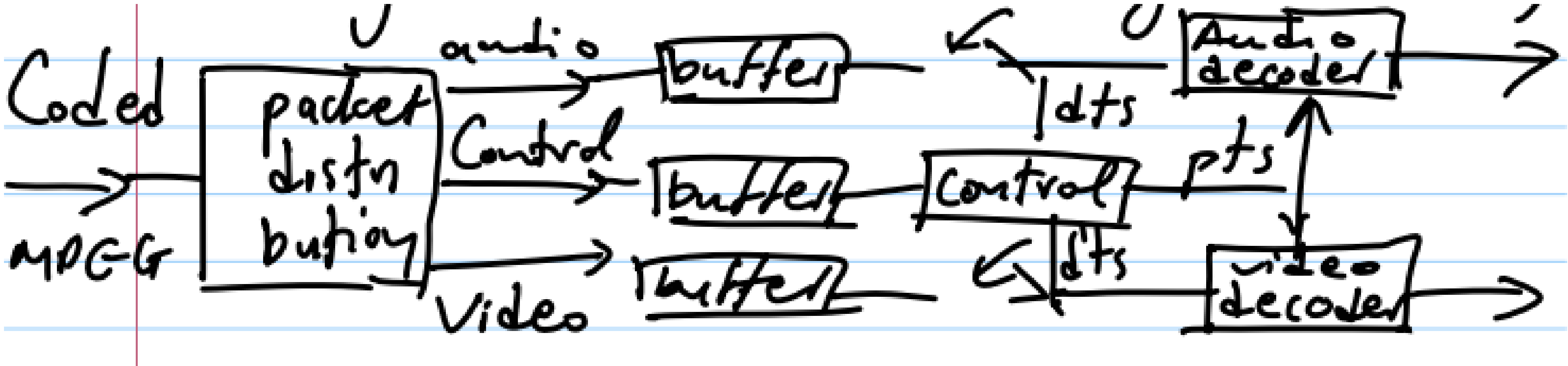


Control data include decoding and presentation

"timestamps" (dts and pts)

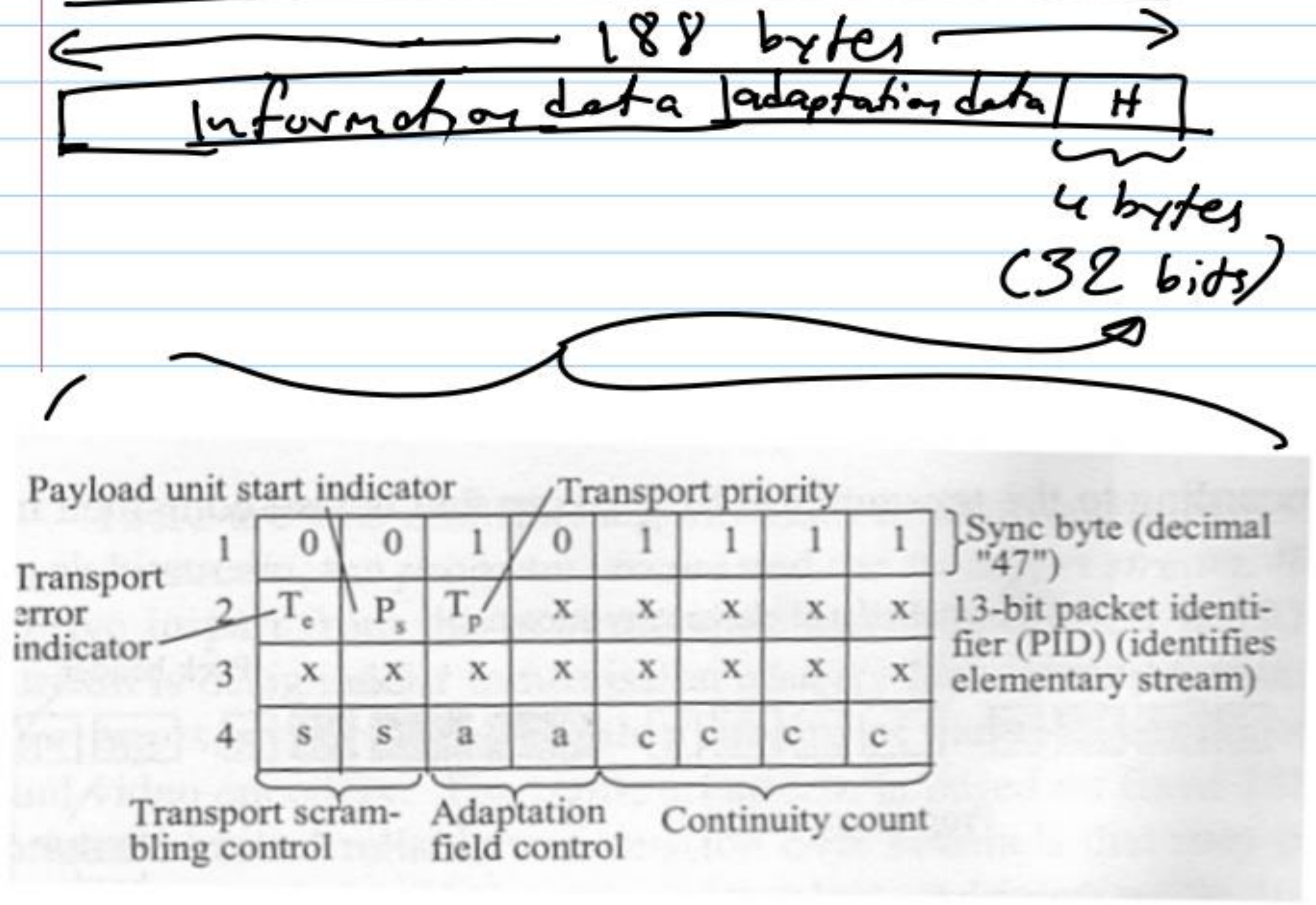
(necessary due to the reordering of frames)

MPEG Systems Layer



MPEG Decoding system

MPEG transport packet



MPEG-2

- The user can select from a set of “profiles” and “levels”

Profiles (decoder for a profile i works with profiles i-i as well)

1. Simple (no B frames)
2. Main Typical
3. SNR scalable
4. Spatially Scalable
5. High

User of more than one bitstreams to encode the cideo

Levels

1. Low (frames 352x240)
2. Main (frames 720x480)
3. High 1440 (frames 1440x1152)
4. High (frames 1920x1080)

- Example on "SNR-Scalability"

Suppose after DCT we obtain a set of coefficients

X_{ij} : 29.75   6.1   -6.03   1.93   -2.01   1.23   -0.95…

Let us quantize this set of coefficients as follows:

$Y_{ij} = \text{round}\left(\frac{X_{ij}}{Q_{ij}}\right)$ where we choose $Q_{ij} = 4$

Then the reconstructed values will be $X_{ij} = Y_{ij} \times Q_{ij}$

$\hat{x}_{ij}$: 28 8   -8   0   -4   0   -0   …….

The error e_{ij} = $x_{ij} - \hat{x}_{ij}$ is

1.75 -1.9 1.97 1.93 1.99 1.23 -0.95 …….

If availability of bandwidth permits we may wish to further quantize the difference signal (error) and send it to the decoder for enhancement. Suppose we use $Q_{ij} = 2$ for the error. Then then reconstructed

$\hat{e}_{ij}$: 2 -2 2   2   2   2 0.

Then: $\hat{x}_{ij} + \hat{e}_{ij}$: 30 6   -6 2 -2 2 0 ….

Which is an "enhanced" reconstruction of X_{ij} (i-e, lower error)