Figure 4.1 DPCM principles: (a) encoder/decoder schematic; (b) encoder timing.

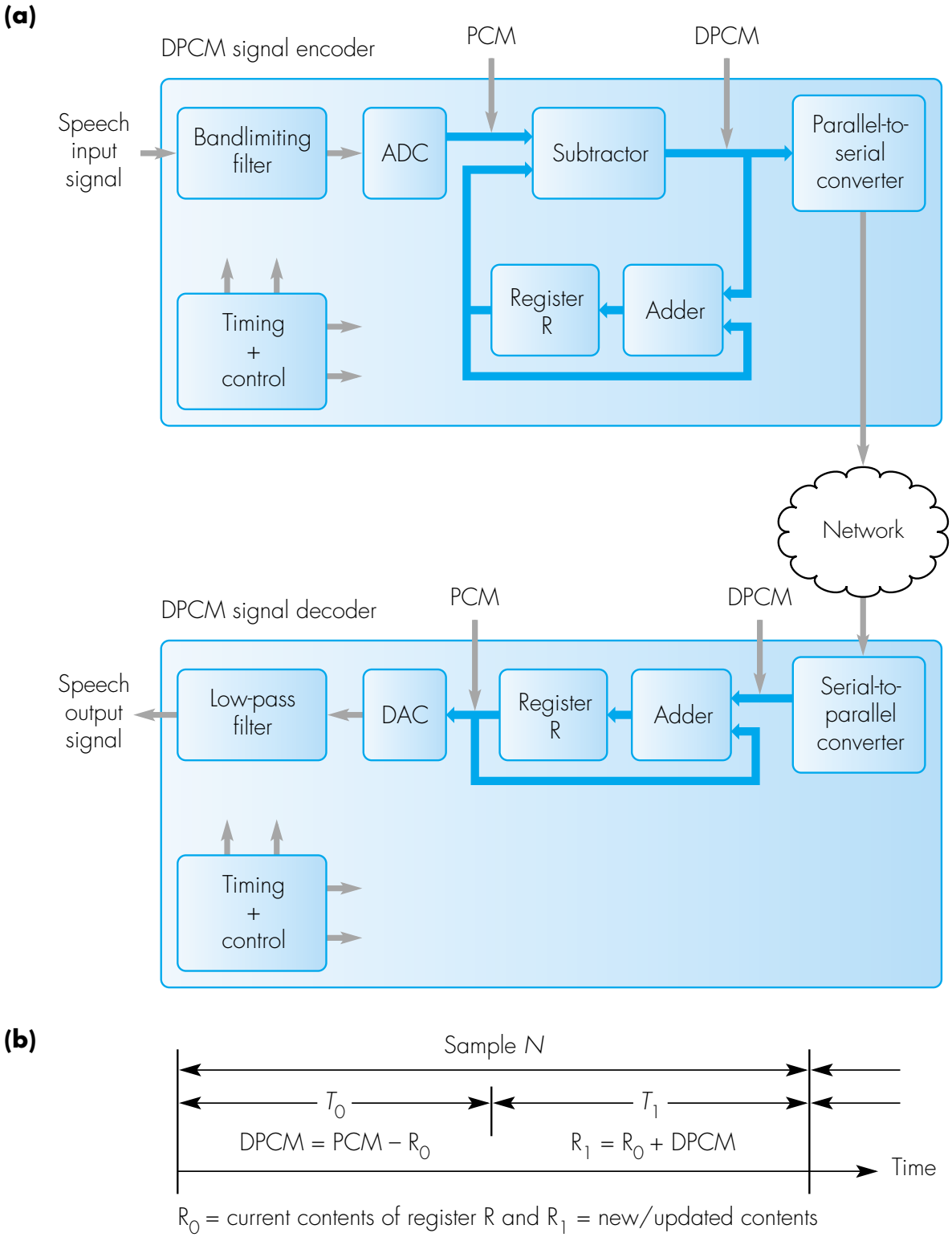
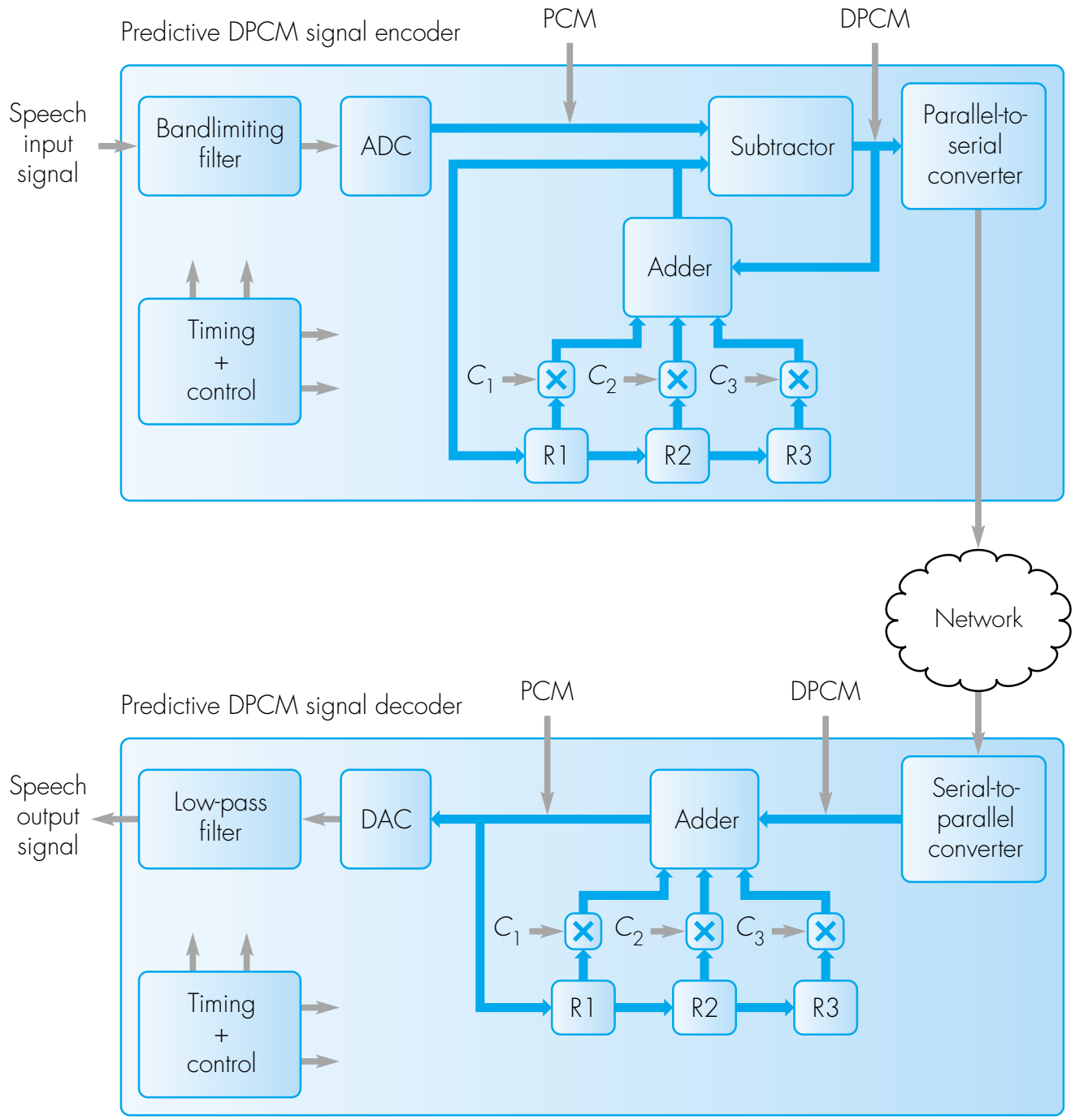


Figure 4.2 Third-order predictive DPCM signal encoder and decoder schematic.



C_1, C_2, C_3 = predictor coefficients

Figure 4.3 ADPCM subband encoder and decoder schematic.

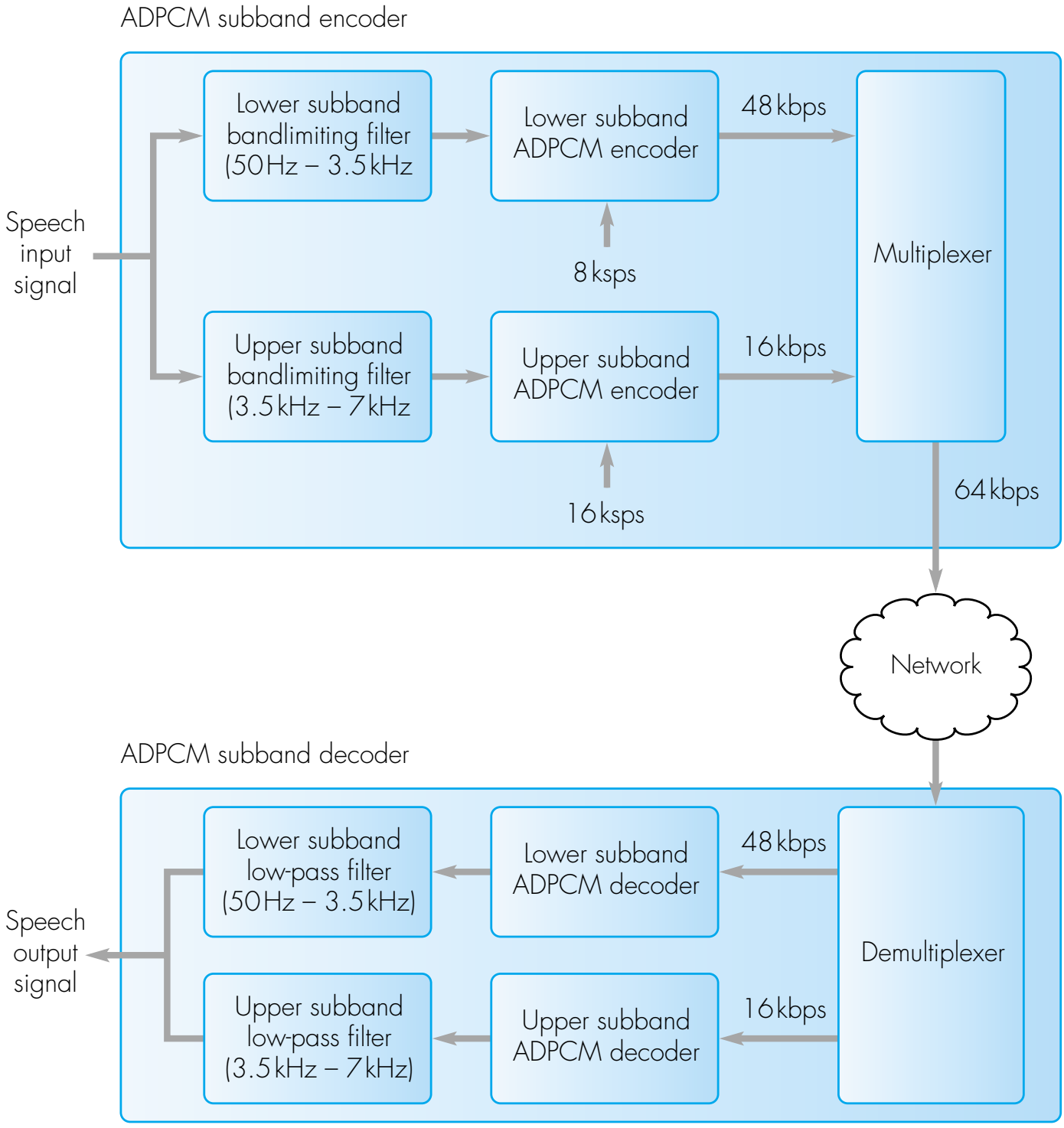


Figure 4.4 Linear predictive coding (LPC) signal encoder and decoder schematic.

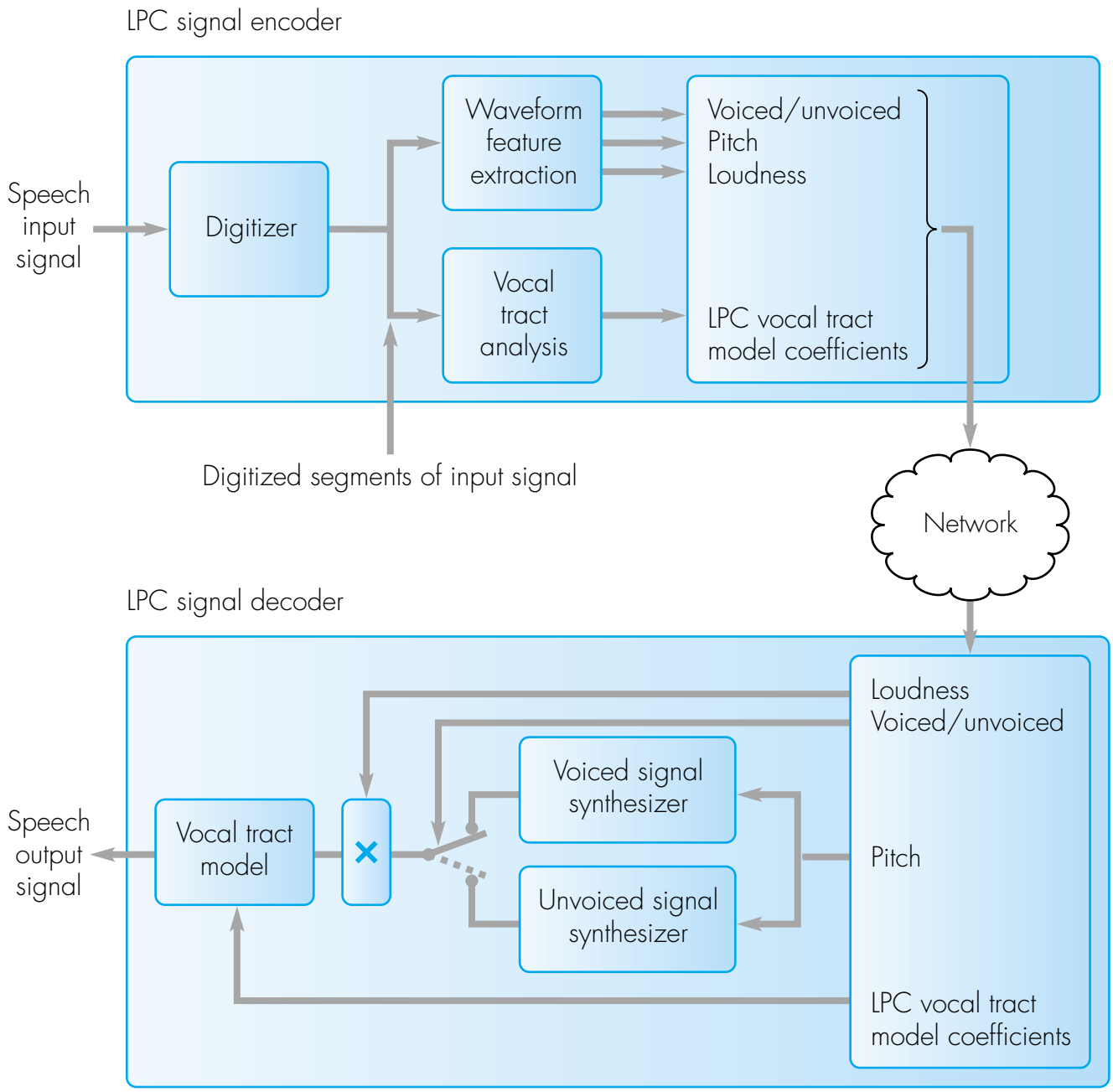


Figure 4.5 Perceptual properties of the human ear: (a) sensitivity as a function of frequency; (b) frequency masking.

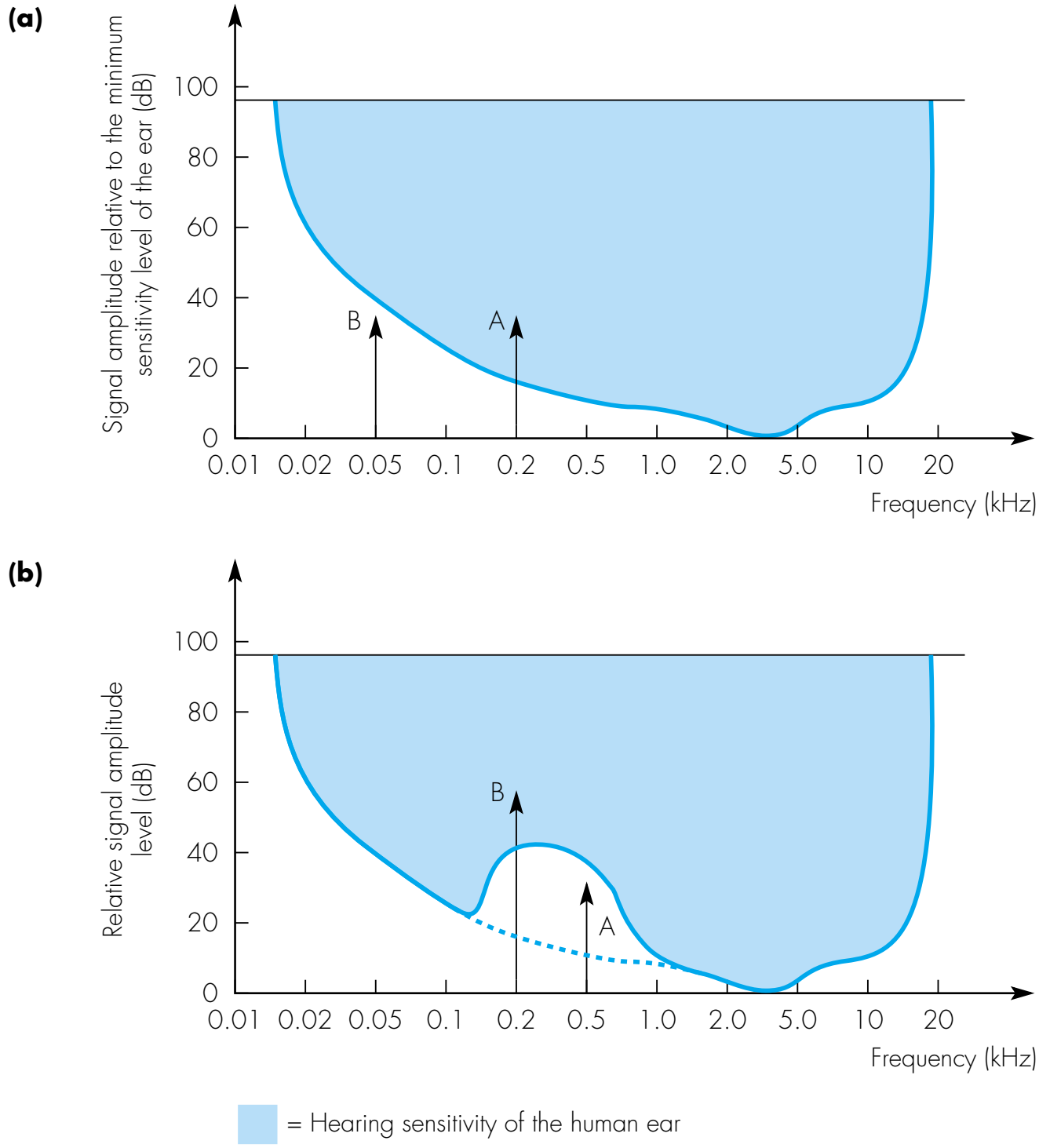


Figure 4.6 Variation with frequency of effect of frequency masking.

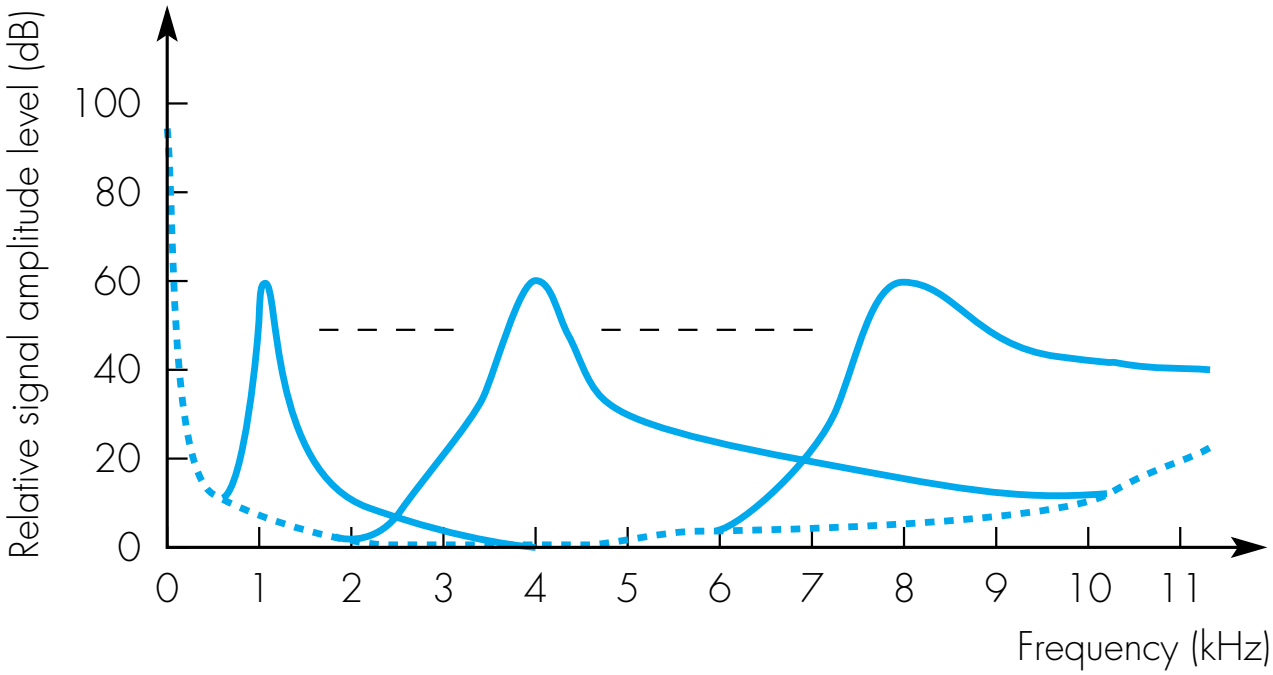


Figure 4.7 Temporal masking caused by a loud signal.

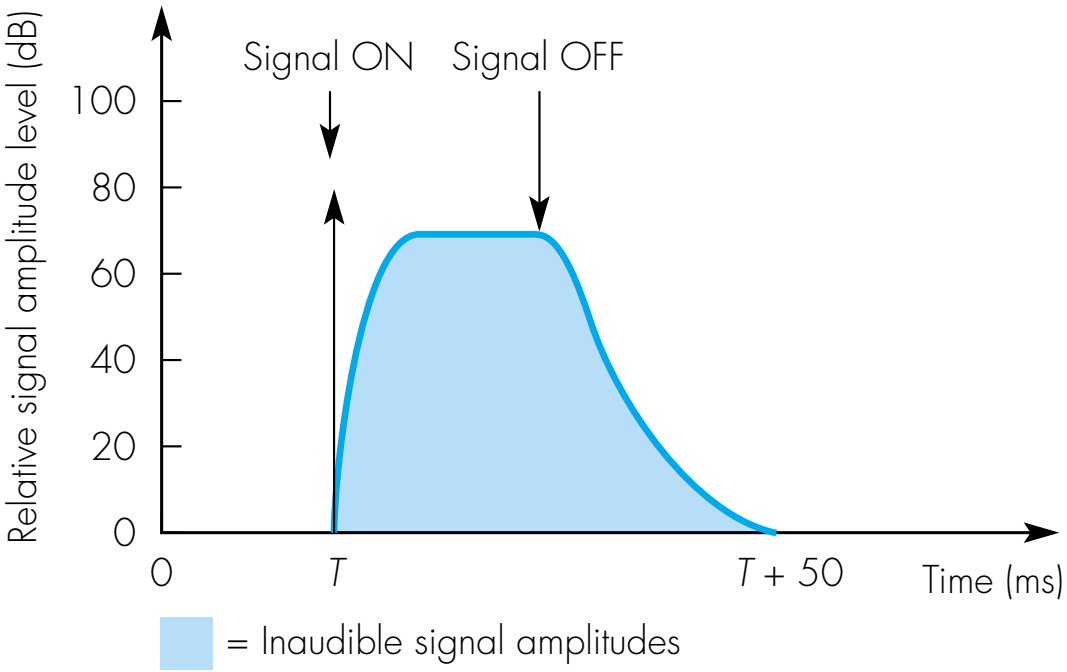


Figure 4.8 MPEG perceptual coder schematic: (a) encoder/decoder implementation schematic (b) example frame format.

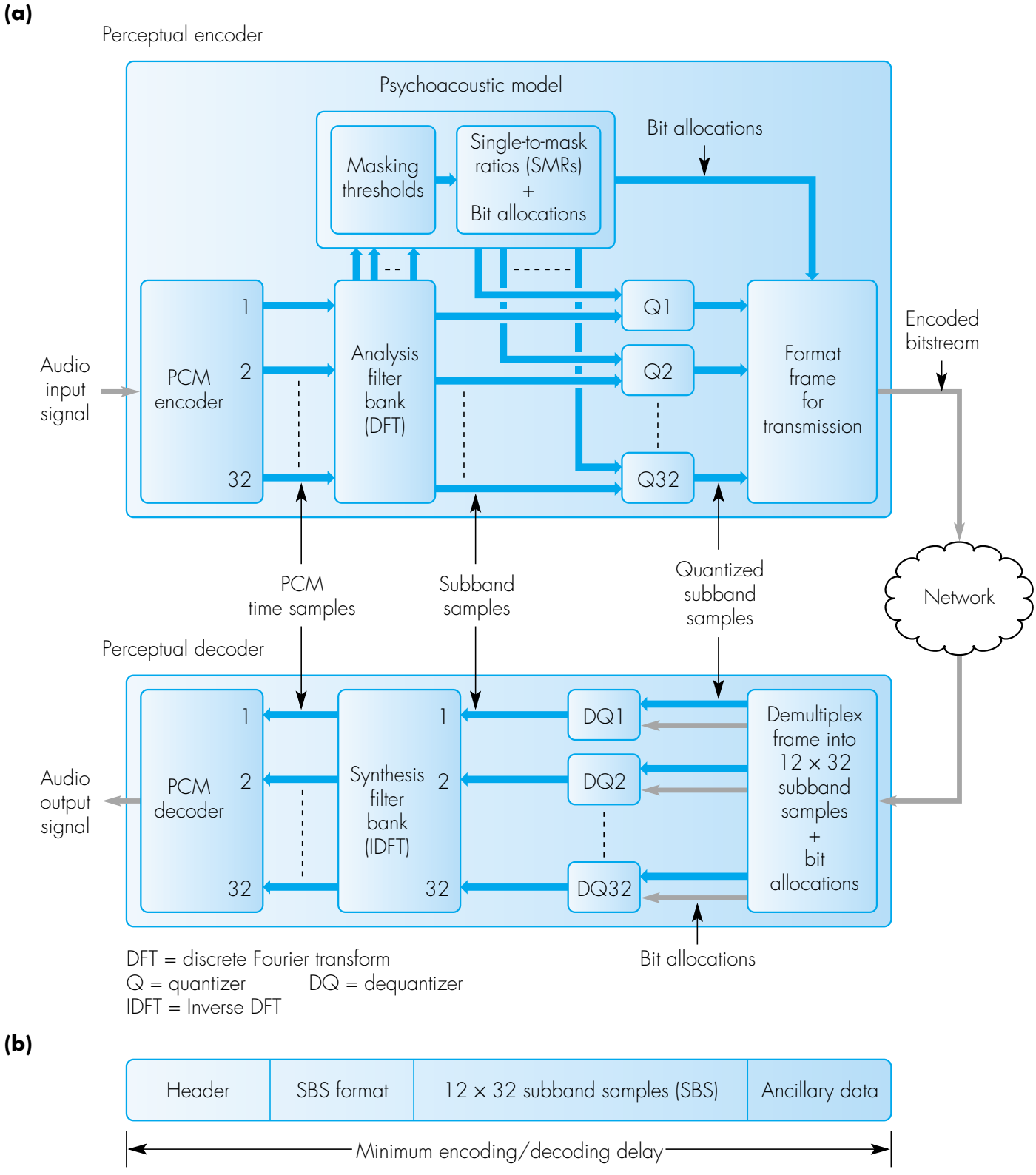


Figure 4.9 Perceptual coder schematics: (a) forward adaptive bit allocation (MPEG); (b) fixed bit allocation (Dolby AC-1).

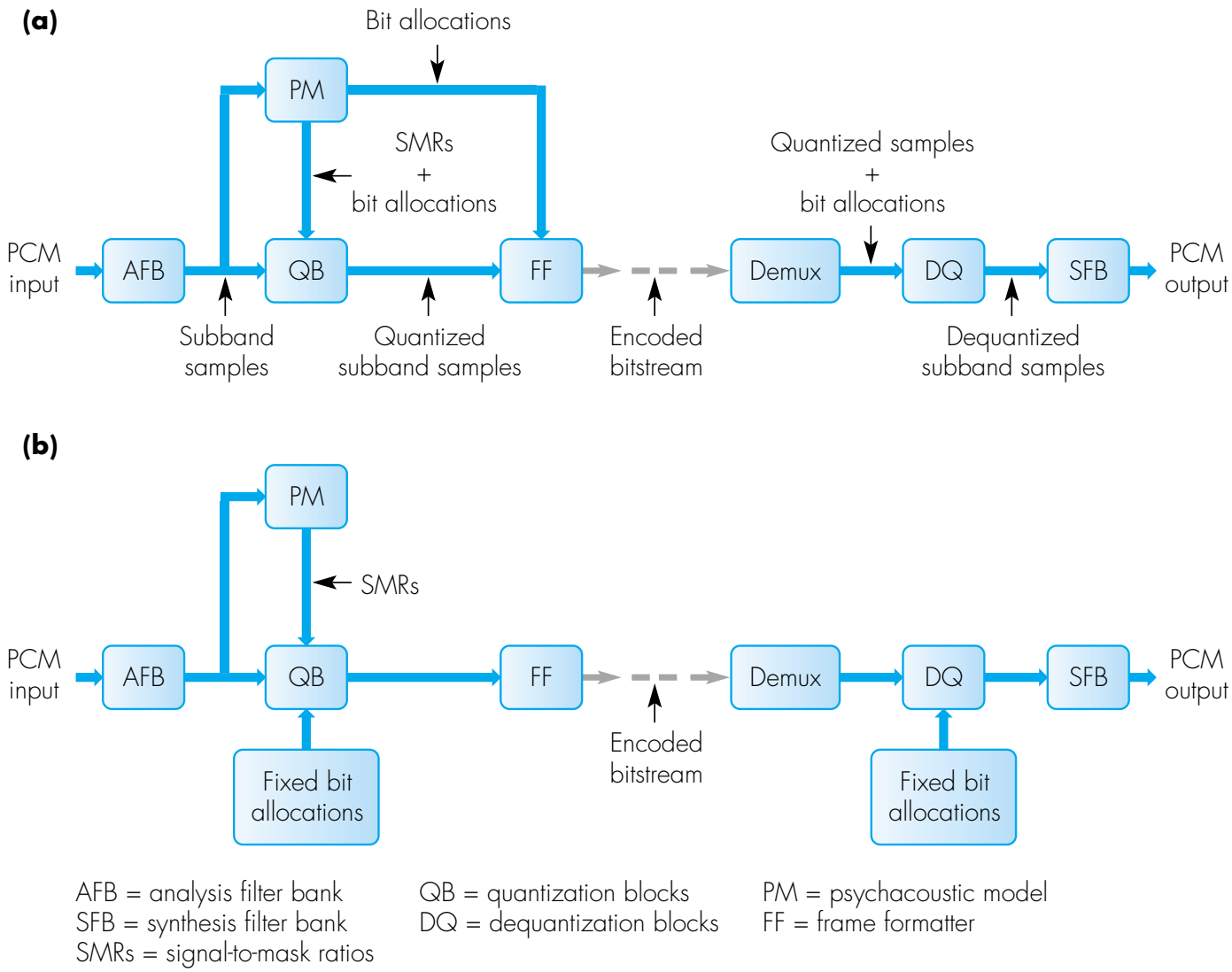
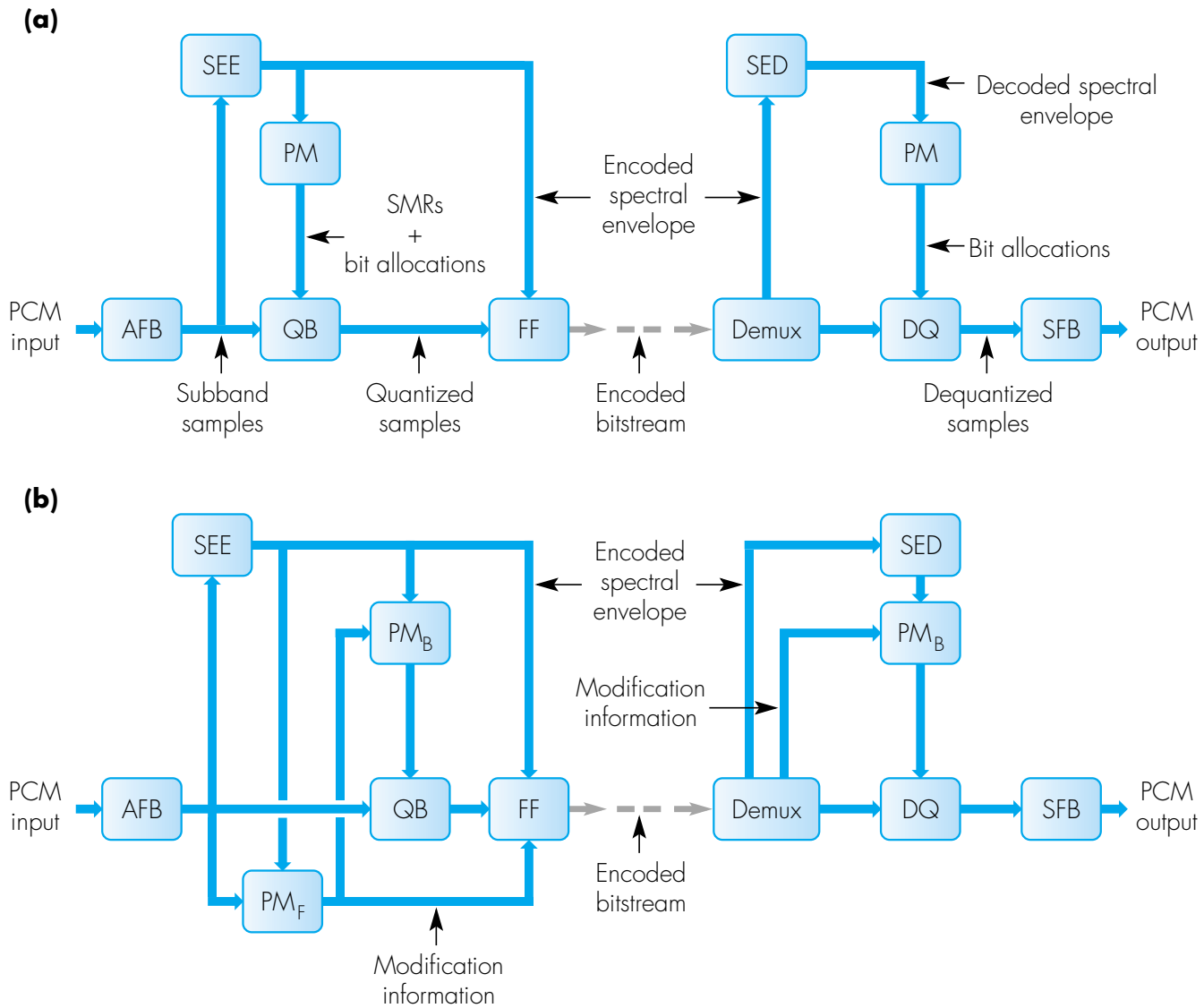


Figure 4.10 Perceptual coder schematic: (a) backward adaptive bit allocation (Dolby AC-2); (b) hybrid backward/forward adaptive bit allocation (Dolby AC-s).



AFB = analysis filter bank
SFB = synthesis filter bank
SEE = spectral envelope encoder
QB = quantization blocks
DQ = dequantization blocks
SED = spectral envelope decoder
PM = psychoacoustic model
FF = frame formatter

Figure 4.11 Example frame sequences with: (a) I- and P-frames only; (b) I-, P- and B-frames; (c) PB-frames.

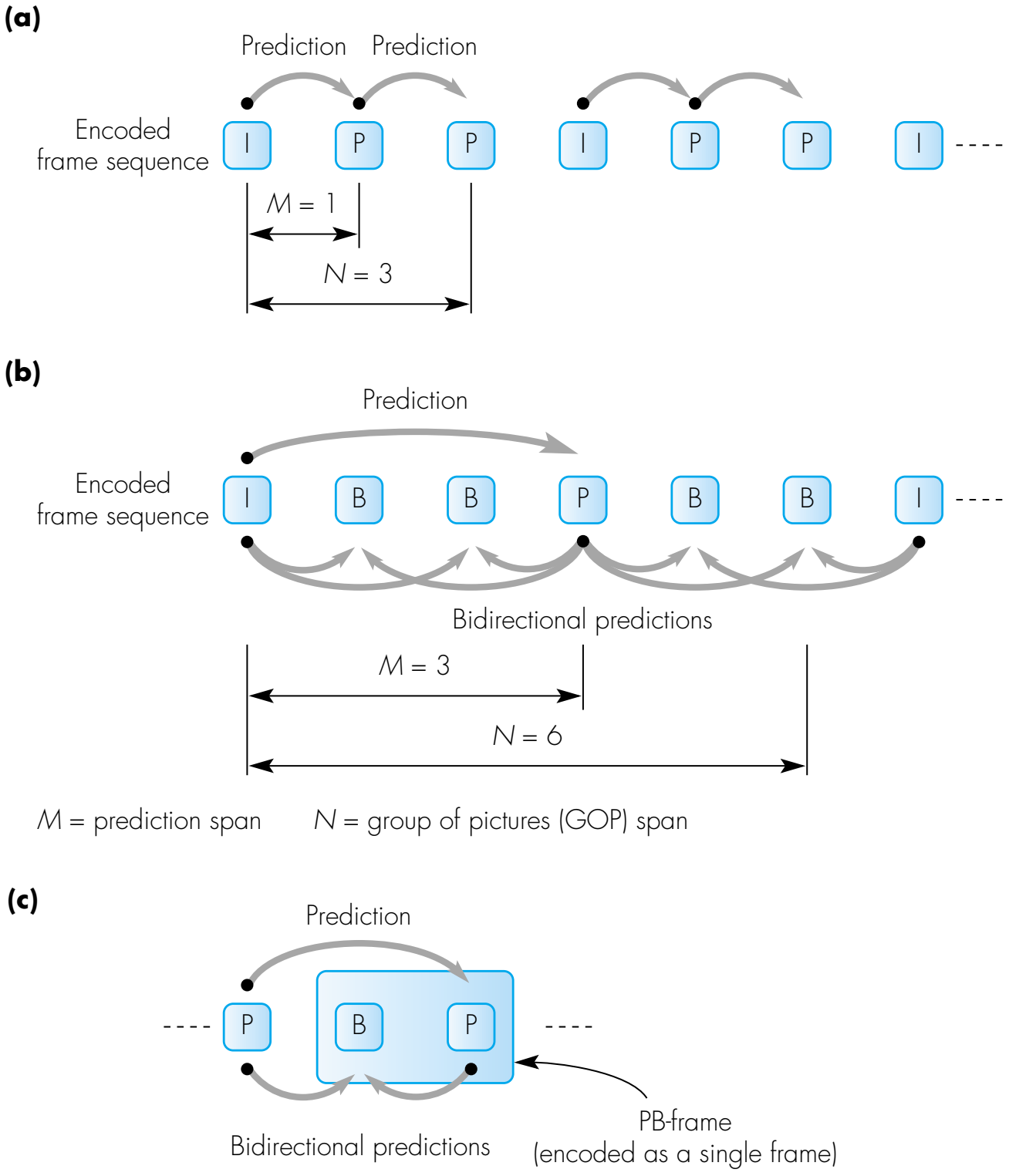


Figure 4.12 P-frame encoding: (a) macroblock structure; (b) encoding procedure.

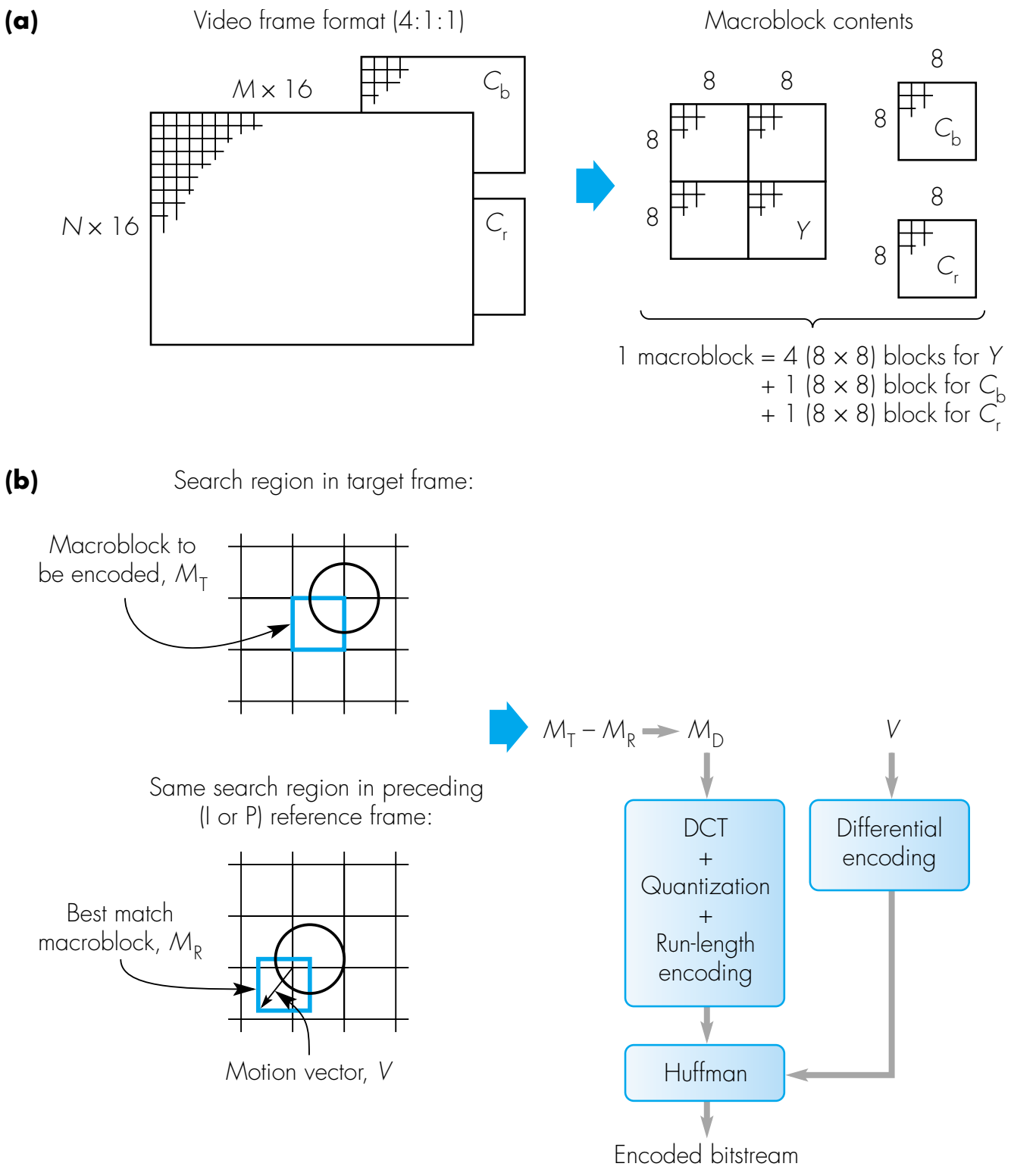


Figure 4.13 B-frame encoding procedure.

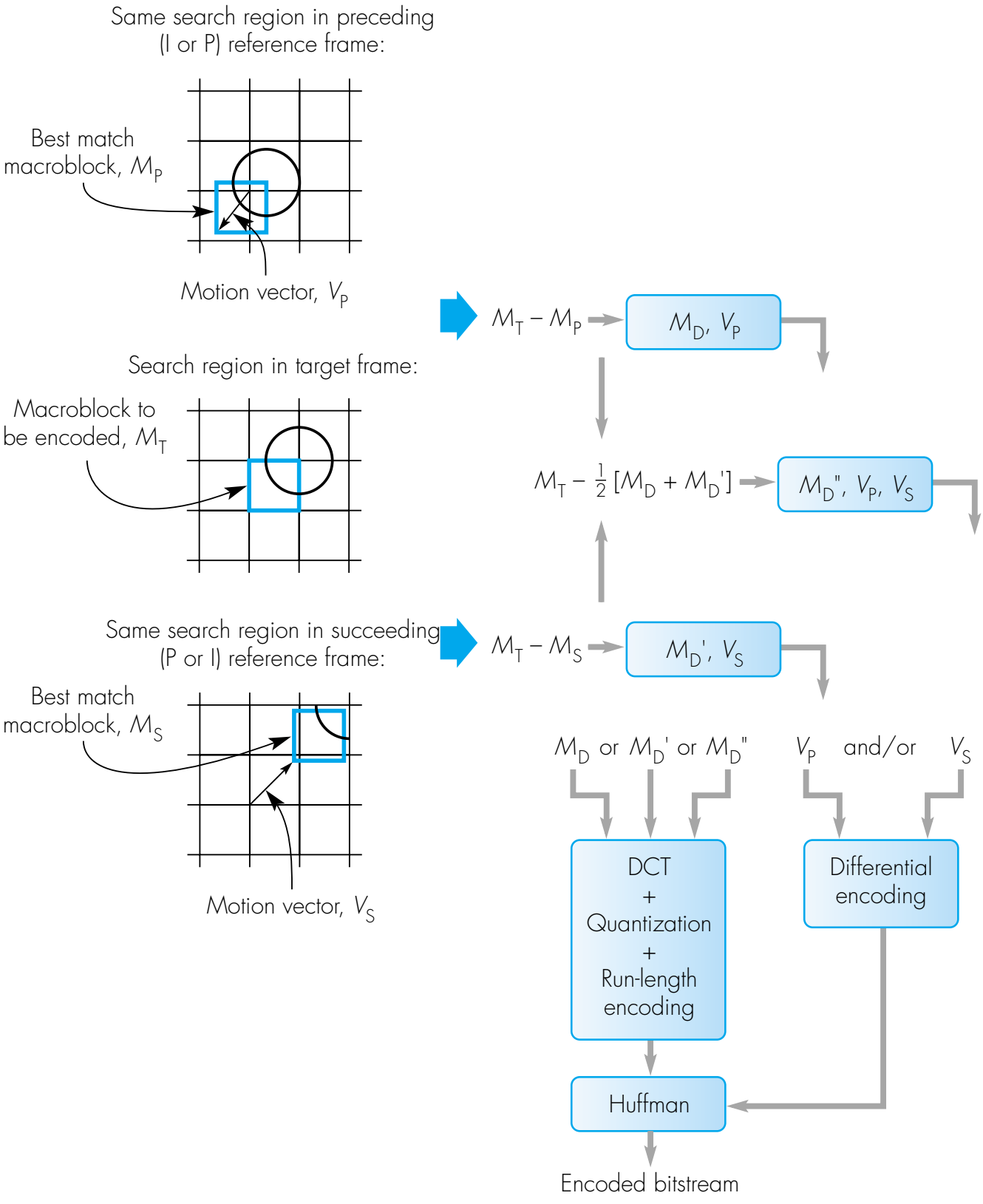


Figure 4.14 Implementation schematics: (a) I-frames; (b) P-frames; (c) B-frames; (d) example macroblock encoded bitstream format.

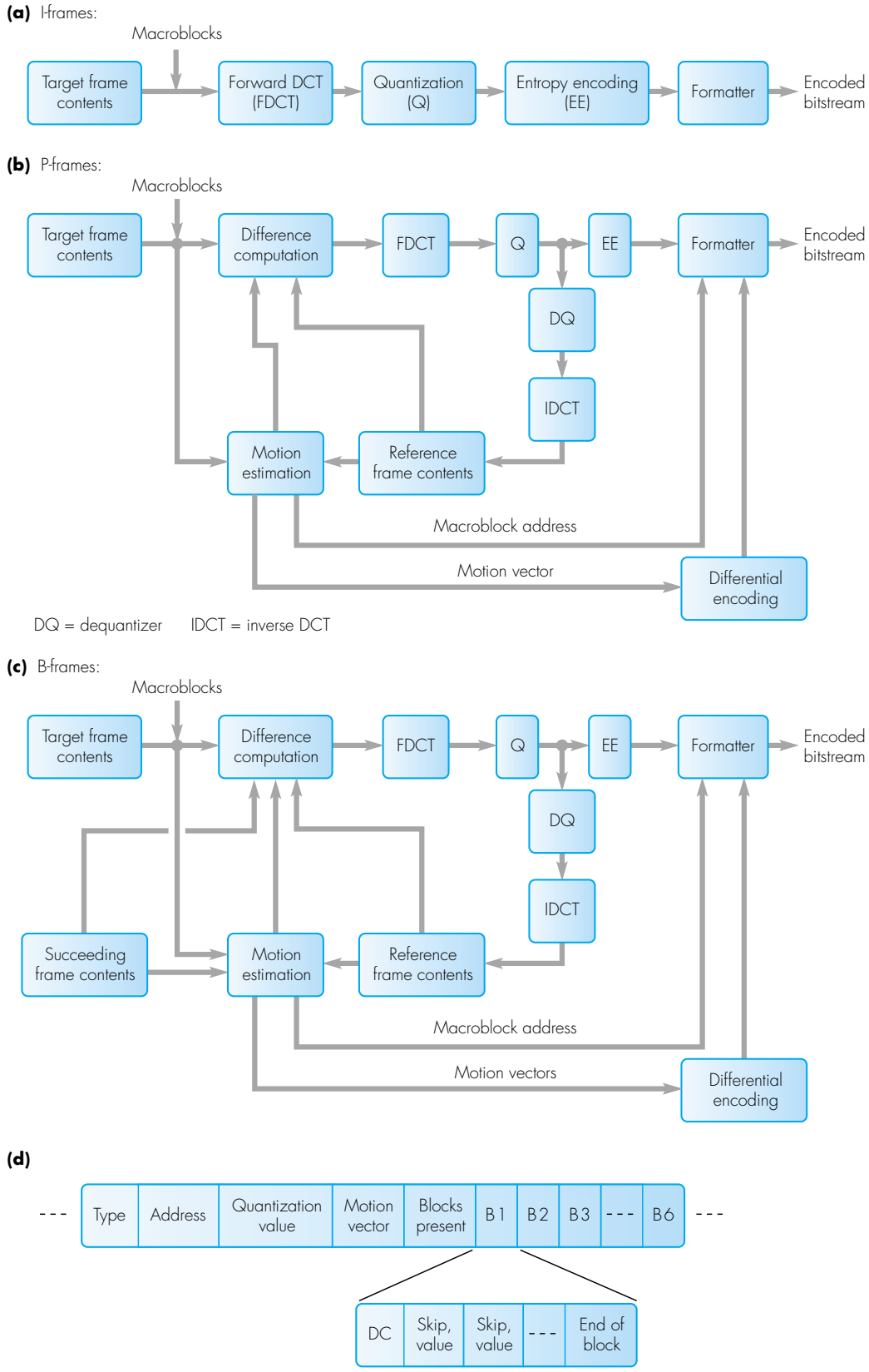


Figure 4.15 H.261 encoding formats: (a) macroblock format; (b) frame/picture format; (c) GOB structure.

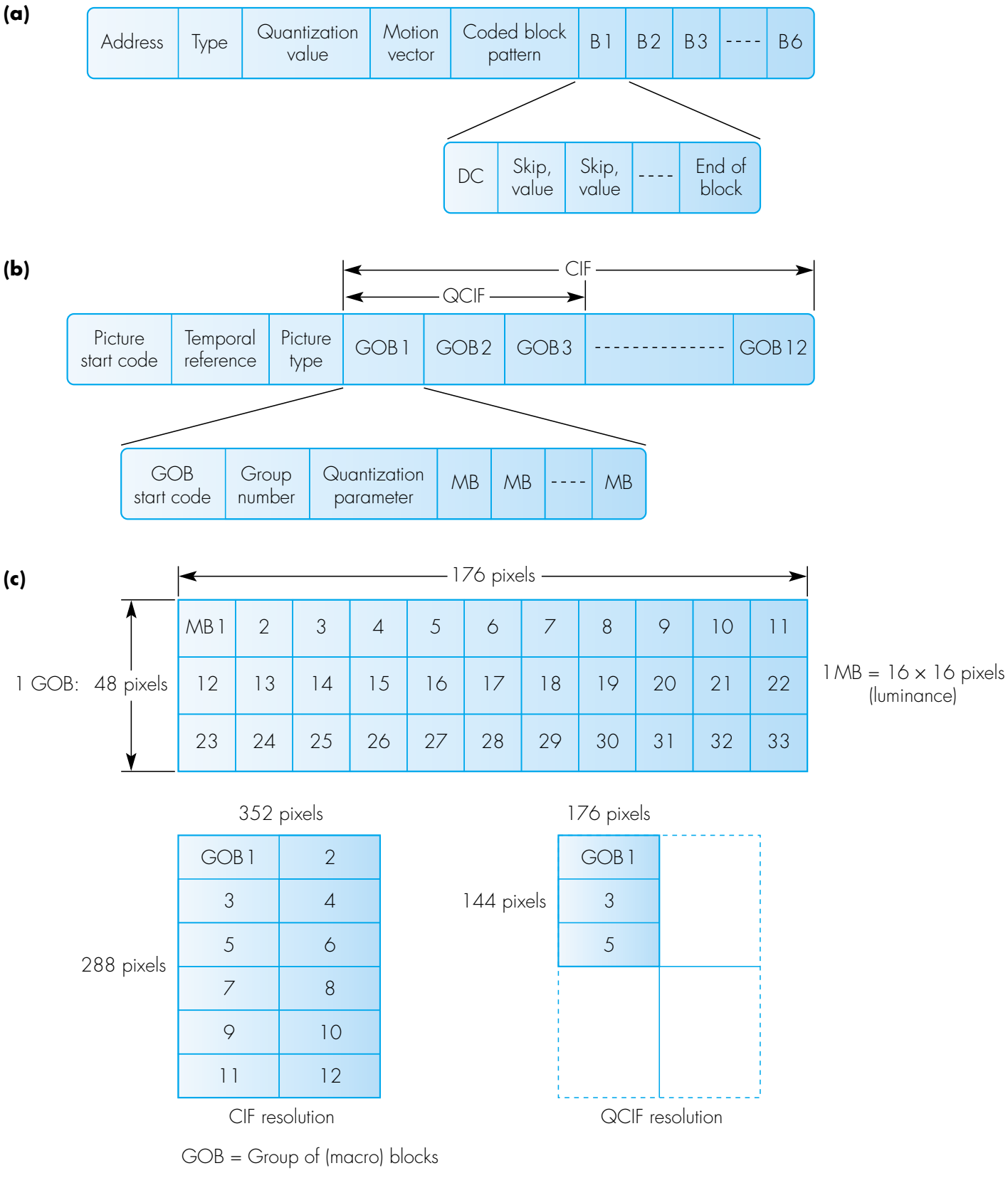
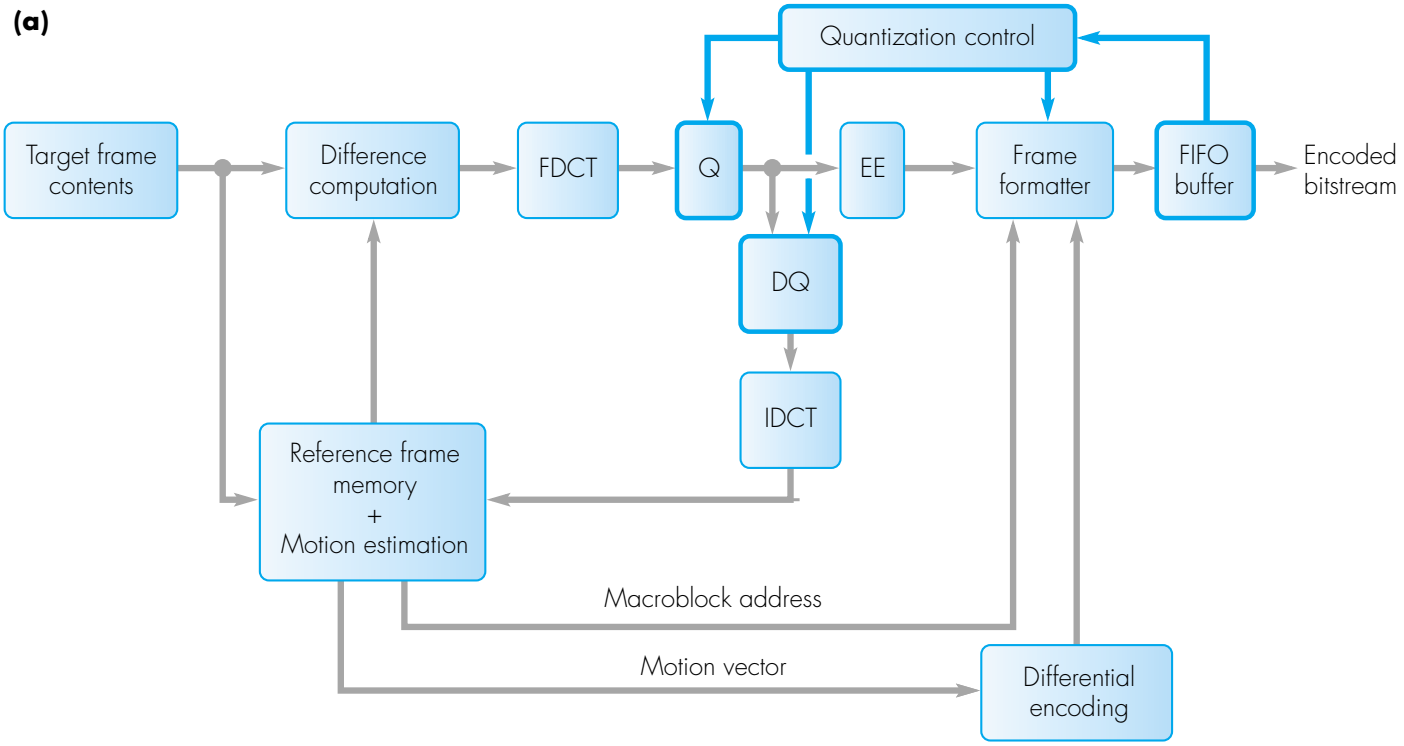


Figure 4.16 H.261 video encoder principles: (a) implementation schematic; (b) FIFO buffer operation.



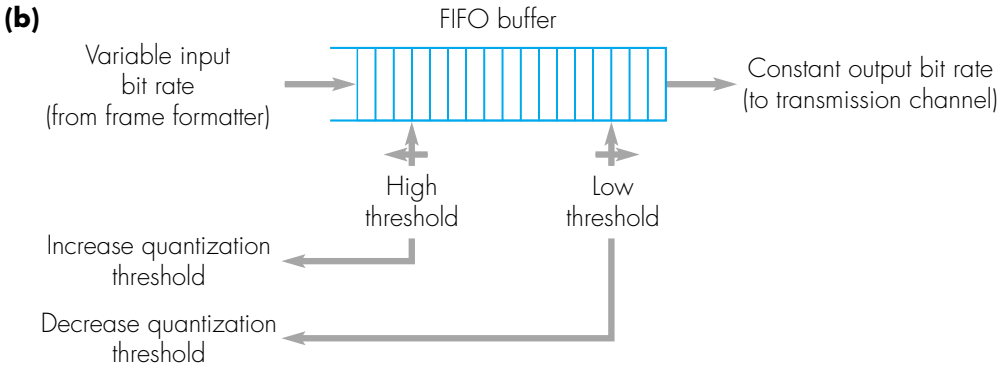


Figure 4.17 H.263 error tracking scheme: (a) example error propagation; (b) same example with error tracking applied.

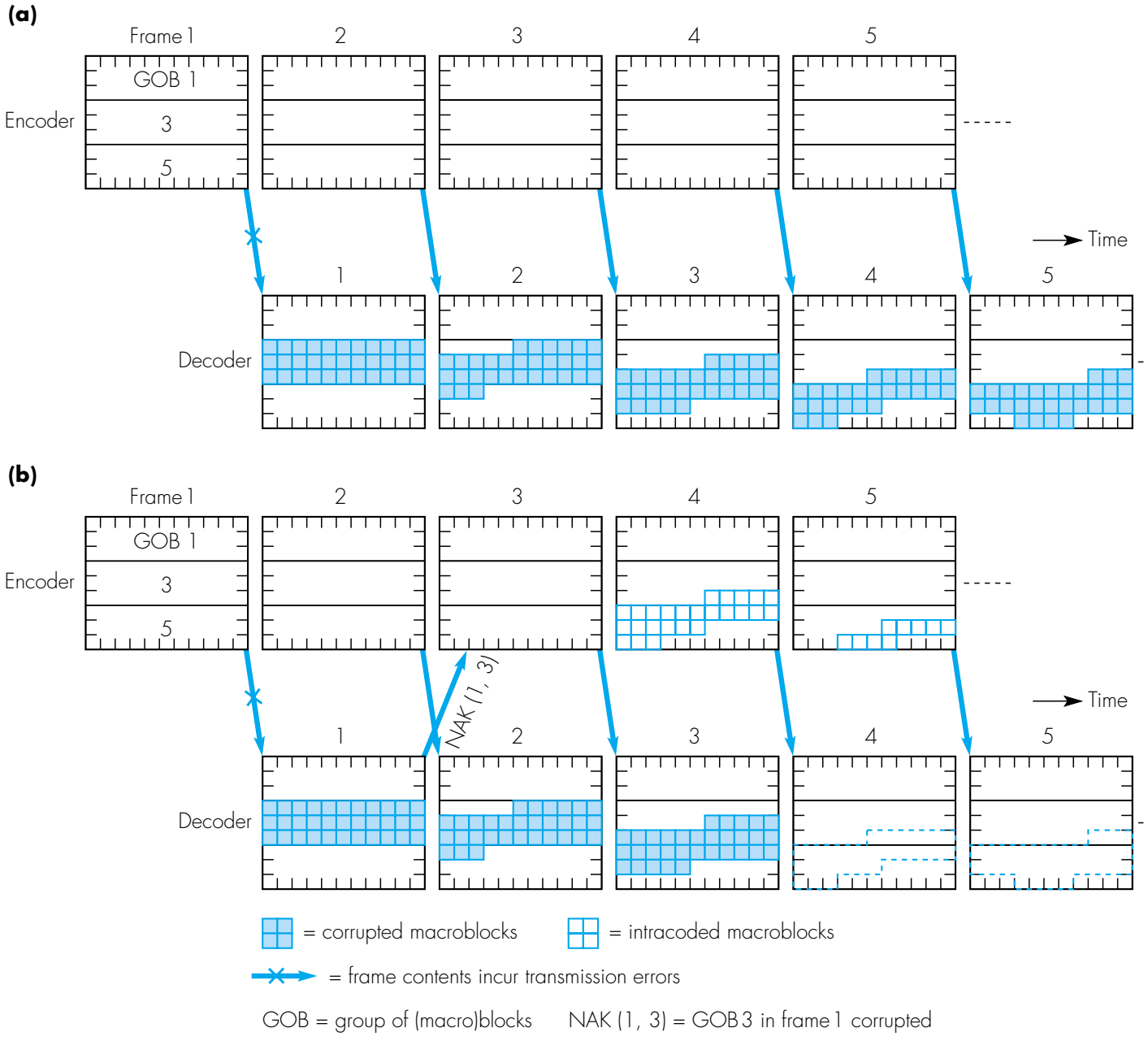


Figure 4.18 Independent segment decoding: (a) effect of a GOB being corrupted; (b) when used with error tracking.

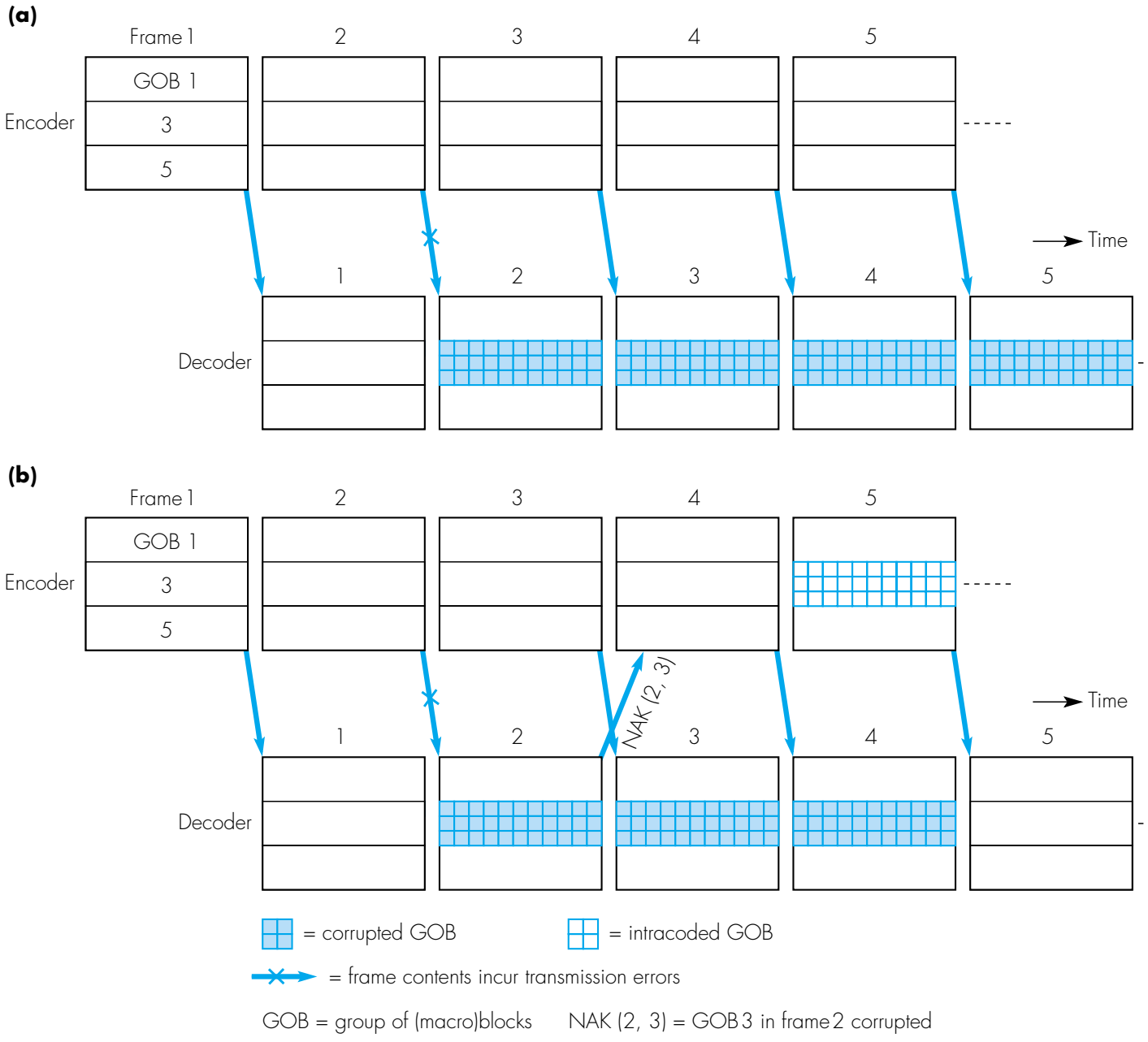
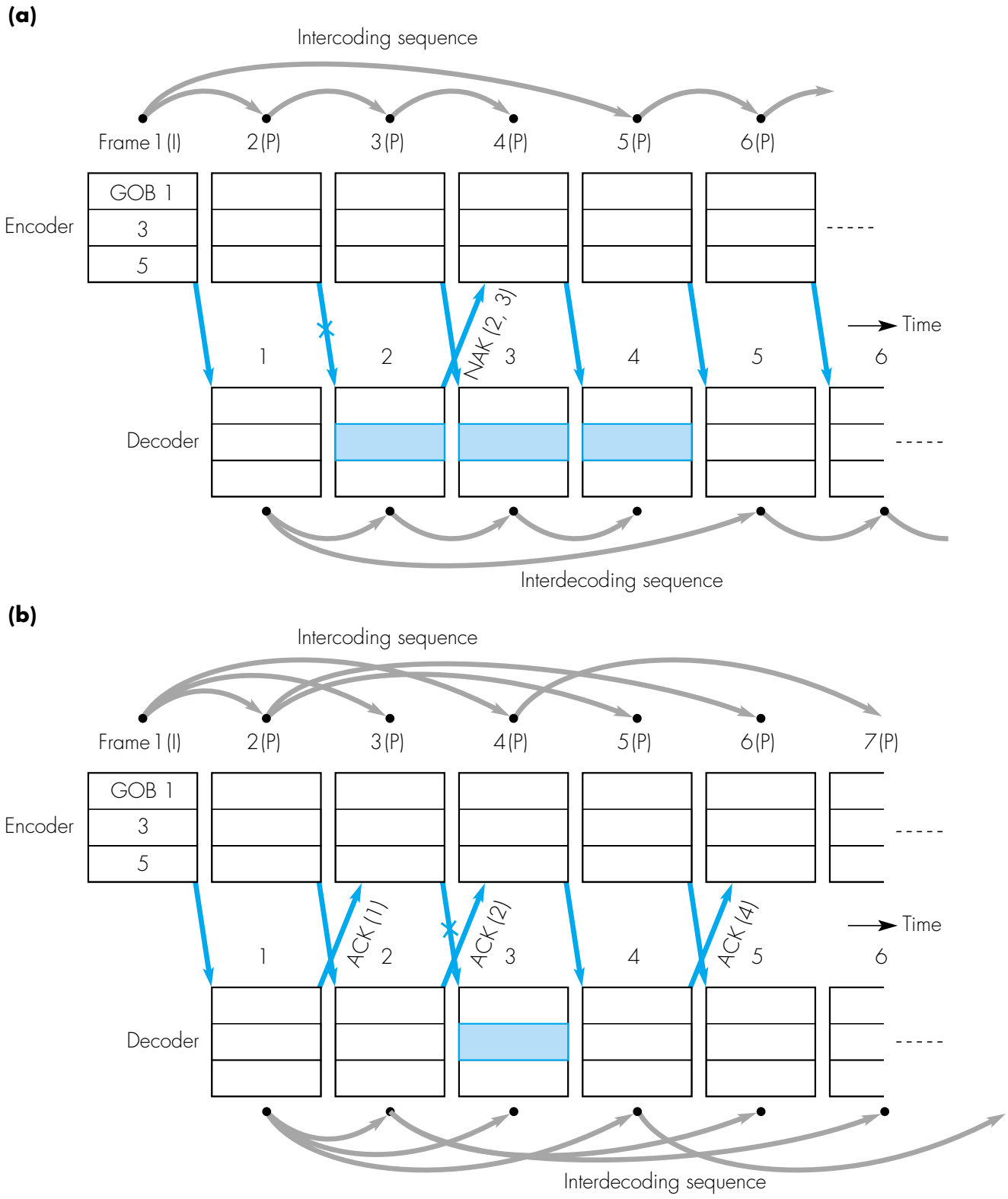


Figure 4.19 Reference picture selection with independent segment decoding: (a) NAK mode; (b) ACK mode.



I = intracoded frame P = predicted/intercoded frame

Figure 4.20 MPEG-1 example frame sequence.

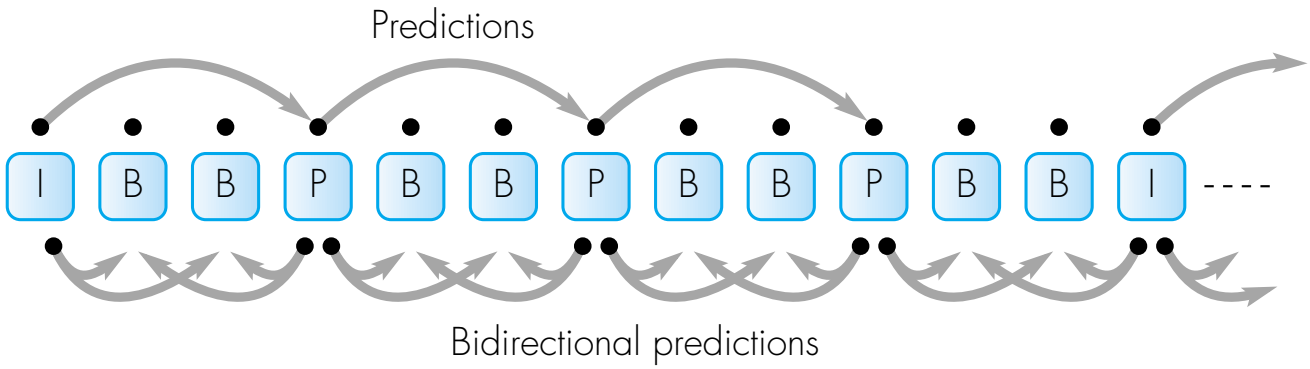


Figure 4.21 MPEG-1 video bitstream structure: (a) composition; (b) format.

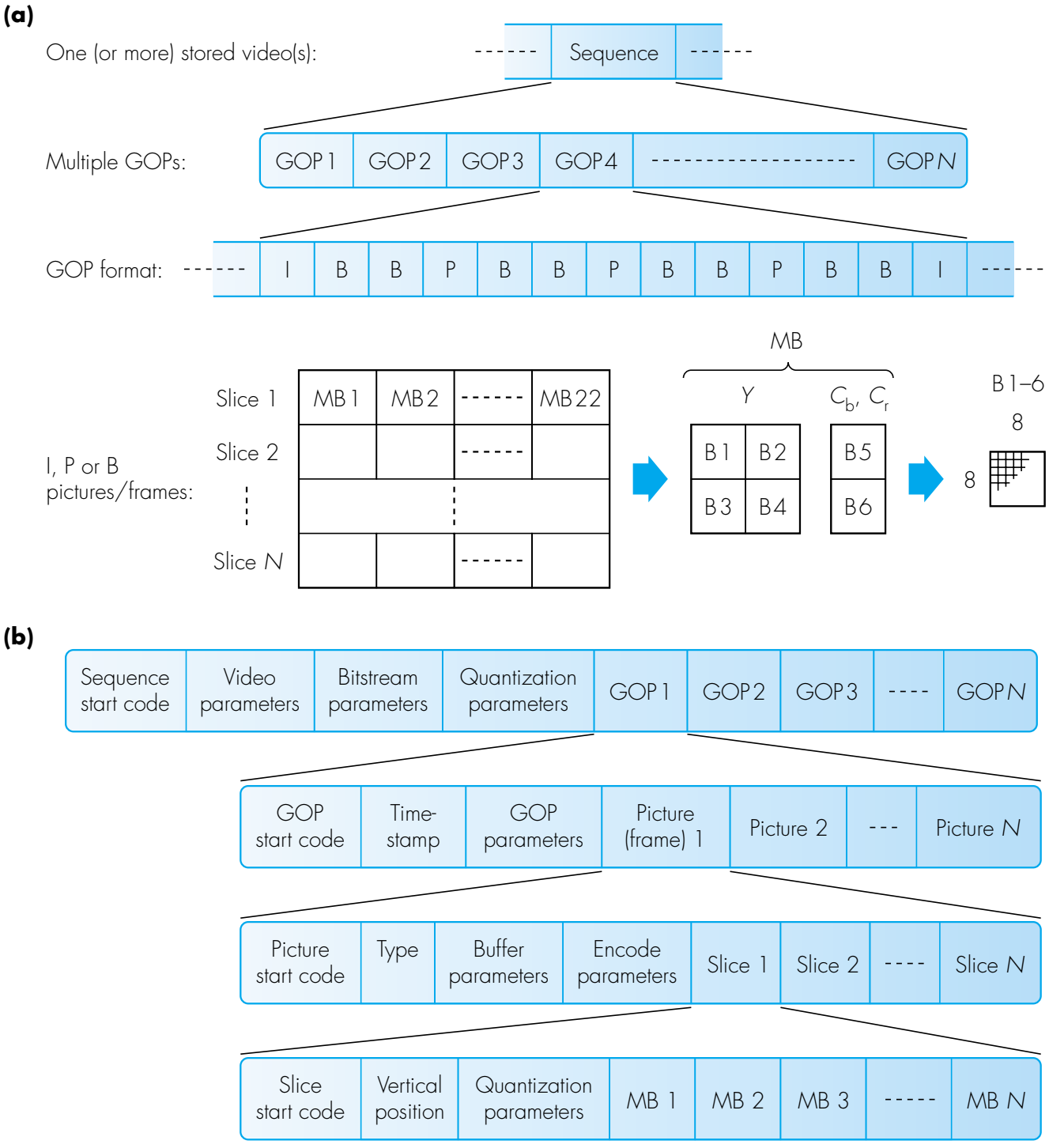


Figure 4.22 MPEG-2 DCT block derivation with I-frames: (a) effect of interlaced scanning; (b) field mode; (c) frame mode.

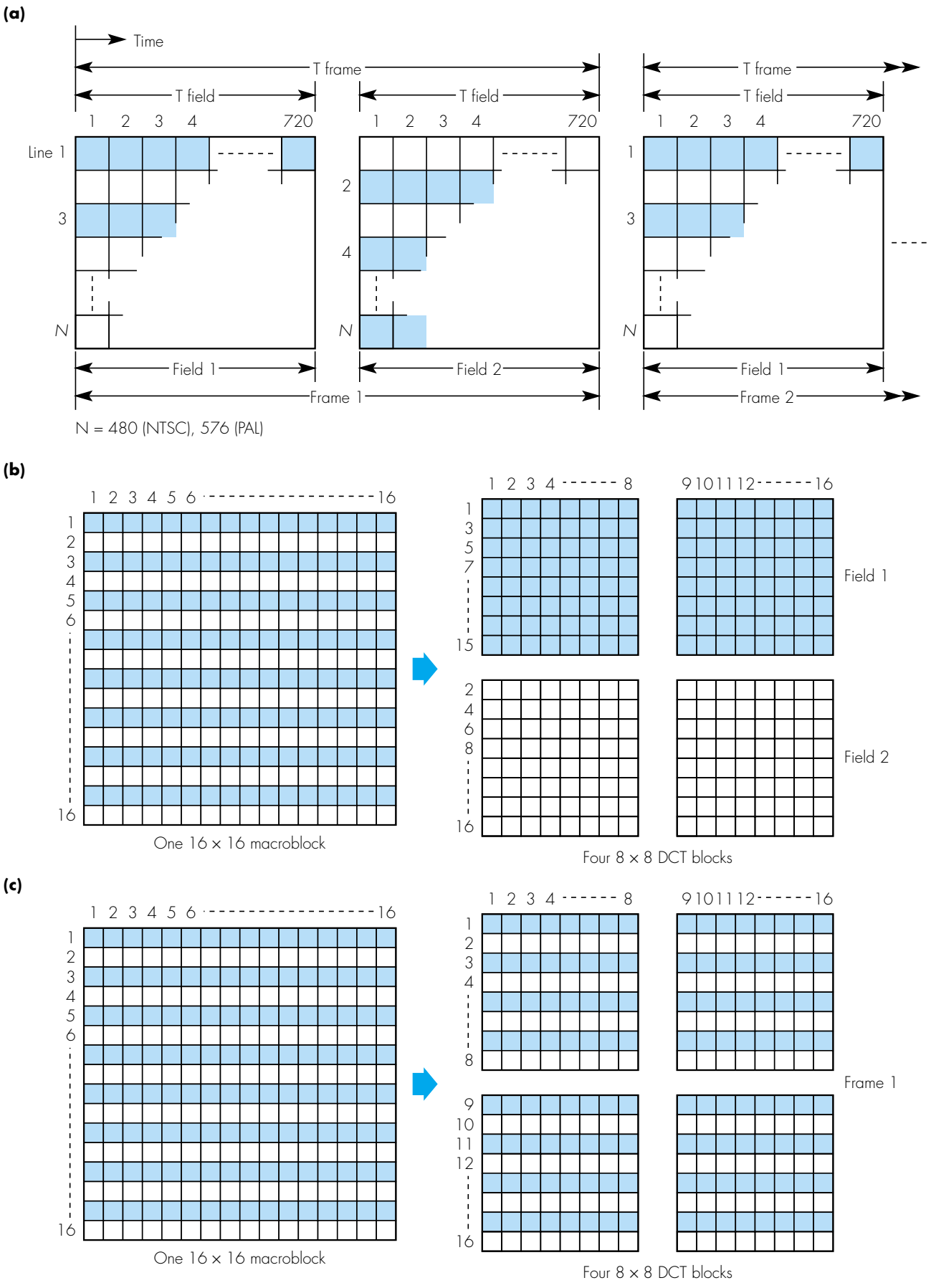


Figure 4.23 Content-based video coding principles showing how a frame/scene is defined in the form of multiple video object planes.

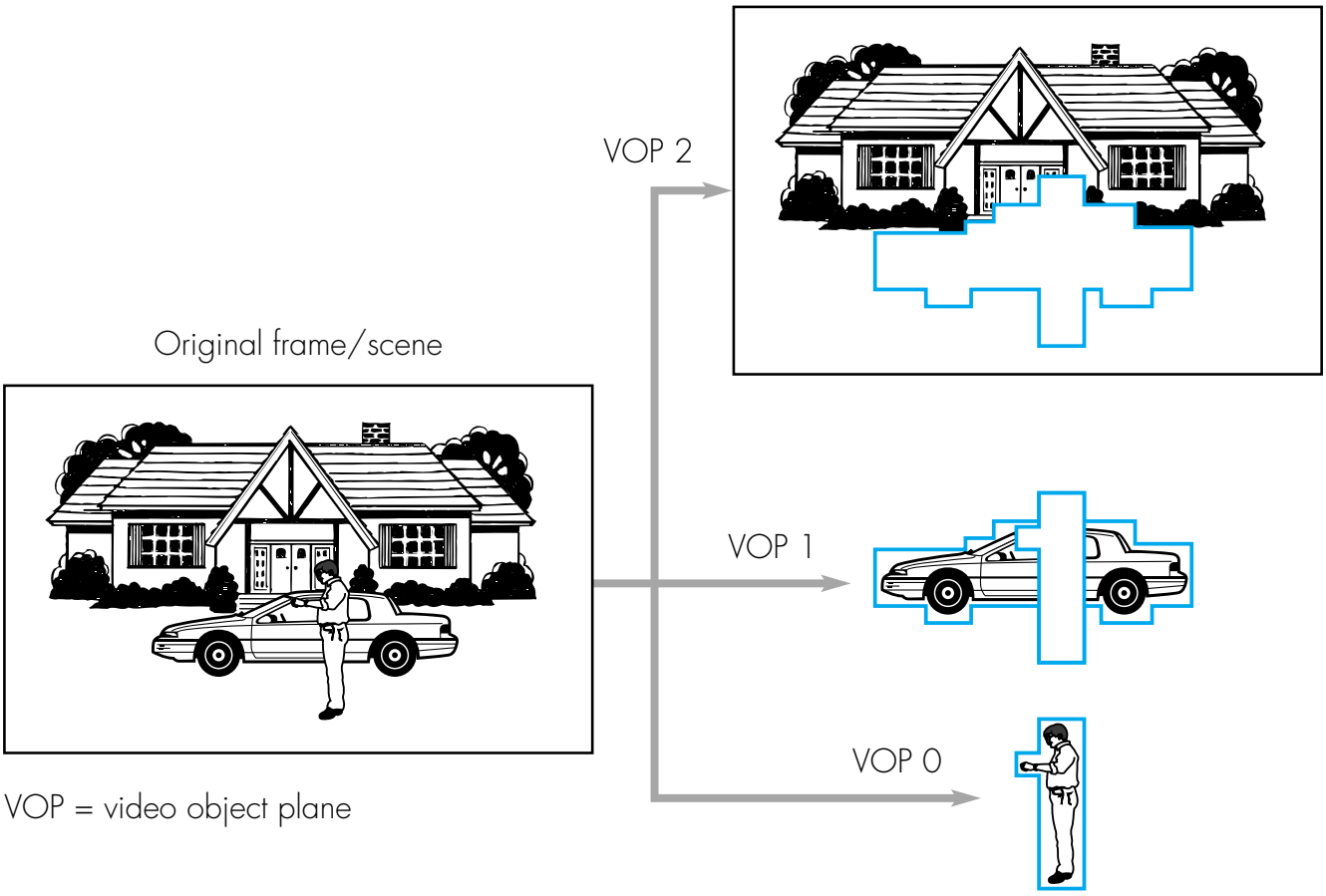


Figure 4.24 MPEG-4 coding principles: (a) encoder/decoder schematics; (b) VOP encoder schematic.

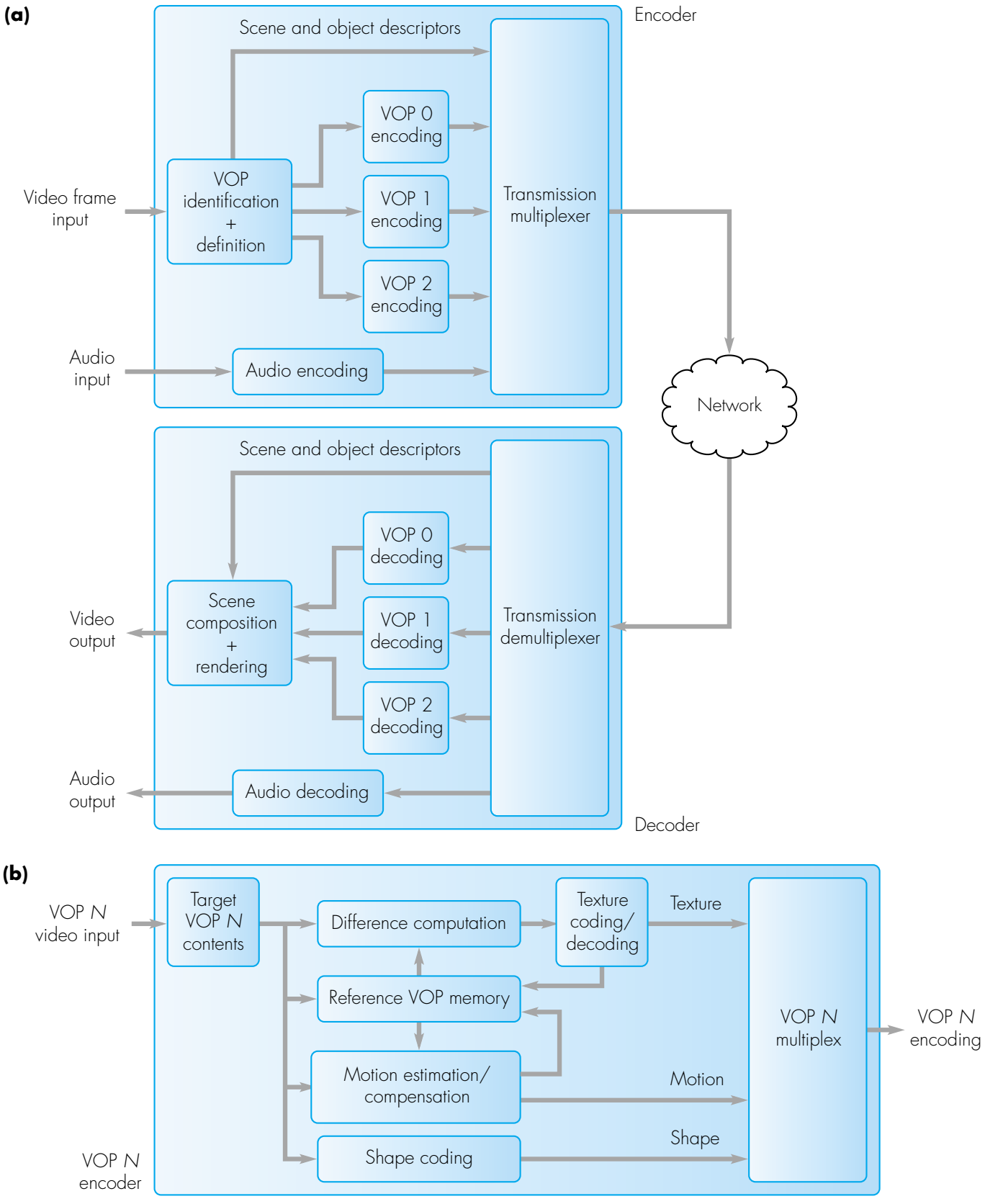


Figure 4.25 MPEG-4 decoder schematic.

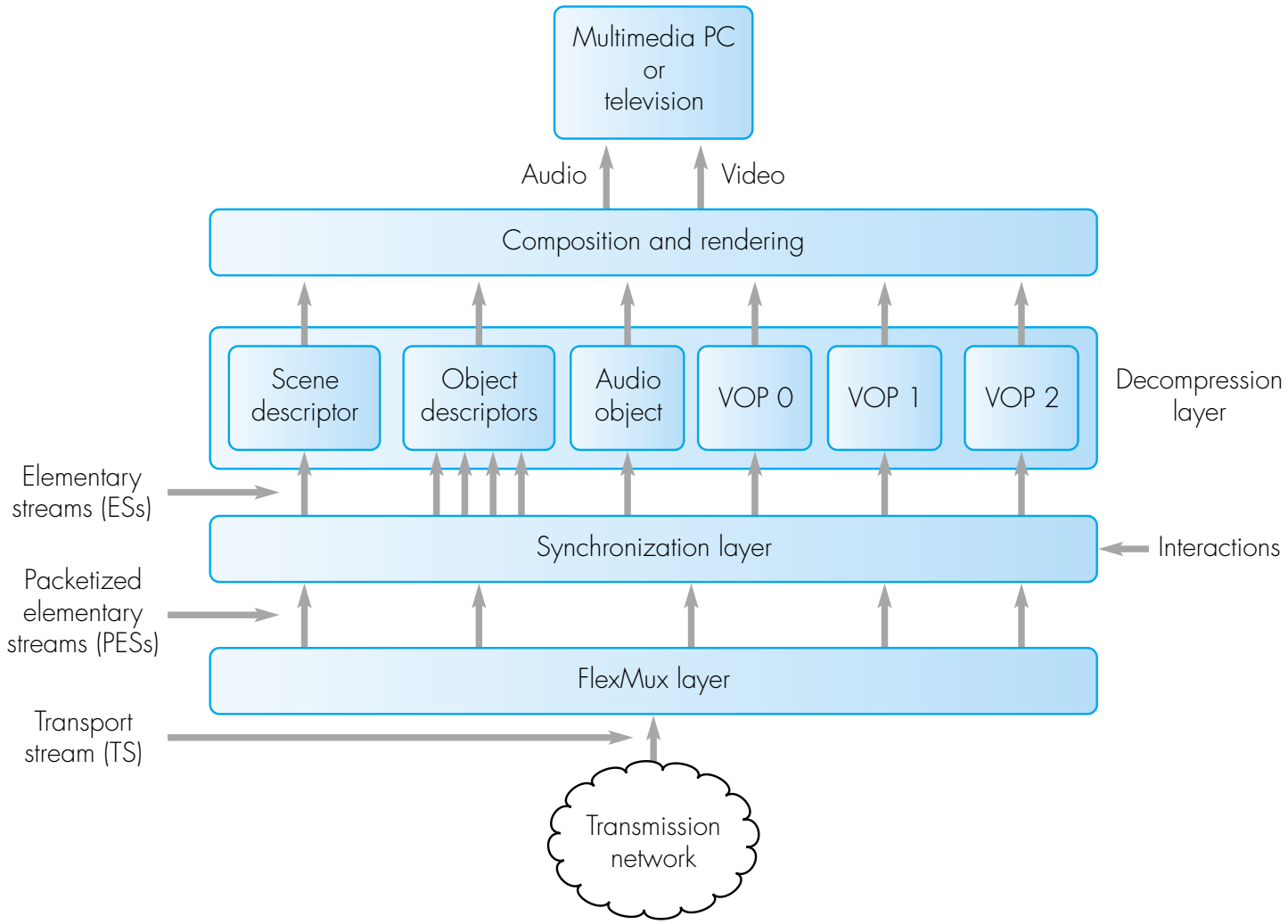


Figure 4.26 MPEG-4 encoding: (a) conventional GOB approach; (b) using fixed-length video packets; (c) video packet format.

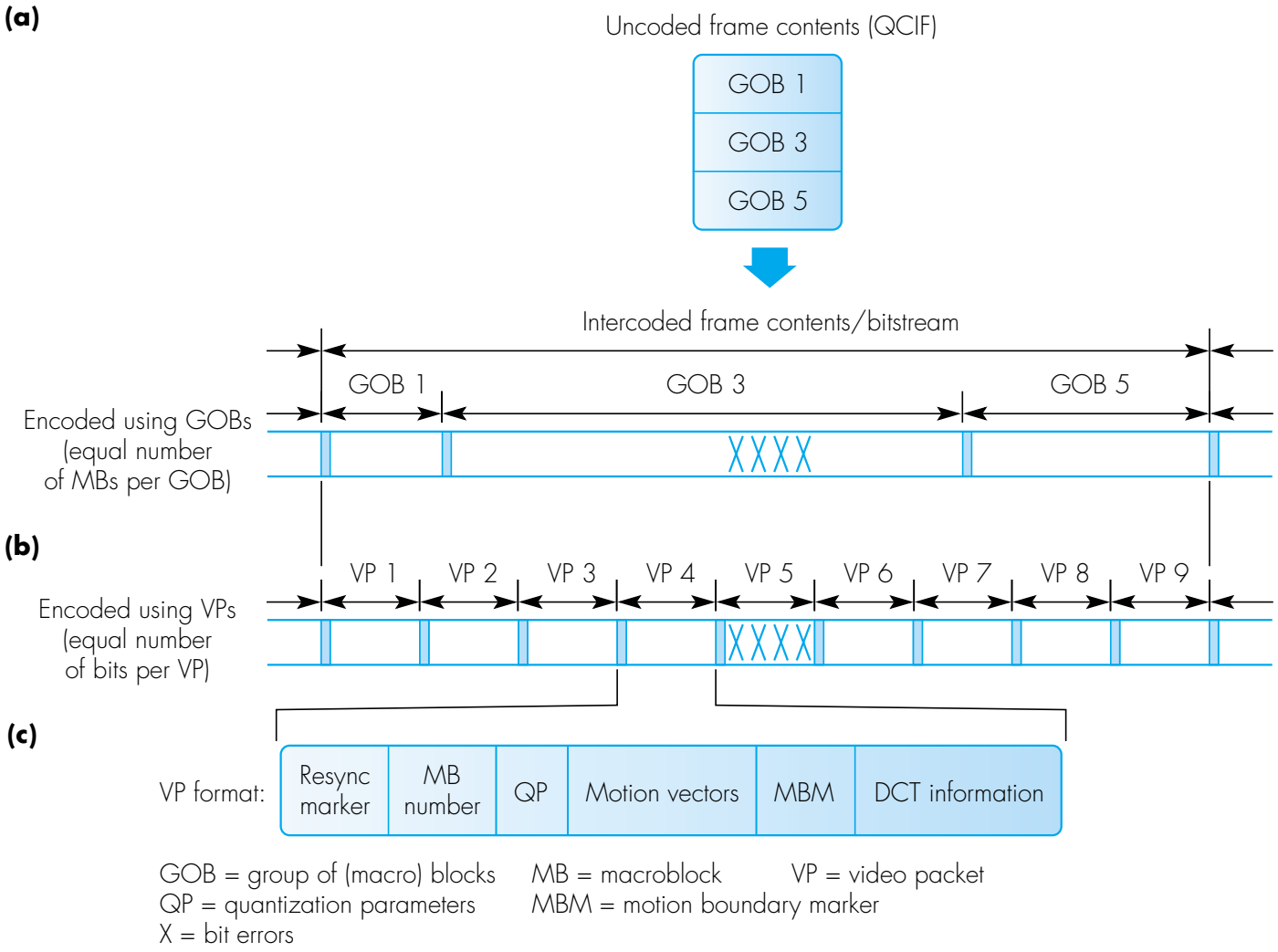


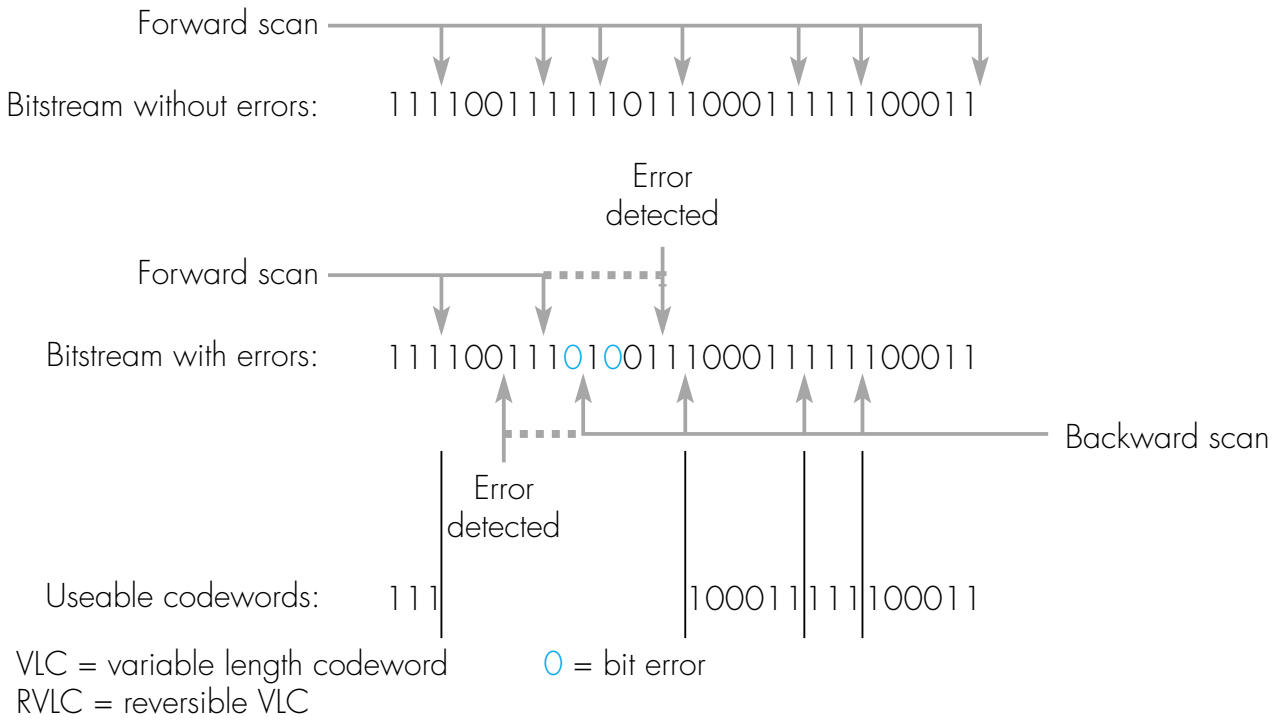
Figure 4.27 Reversible VLCs: (a) example codeword set; (b) effect of transmission errors on decoding procedure.

(a)

VLC	RVLC
1	111
01	1011
001	10011
0001	100011

Maximum codeword length = 6 bits

(b)



Example 4.1

An MPEG-1 system uses the frame sequence shown in Figure 4.20.

(i) Define the terms *M* and *N* and hence determine their values for the sequence shown in the figure.

(ii) Derive a suitable reordered sequence that ensures firstly, only two frames must be stored in the decoder, and secondly, the required I- and/or P-frames are available to decode each P- and B-frame as they are received.

Answer:

(i) As we described earlier in Section 4.3.1 under the subheading of "Frame types", *M* is the distance (in frames) between a P-frame and the immediately preceding I- or P- frame, and *N* is the number of frames between two successive I-frames. The latter is known as a group of pictures or GOP. Hence for the frame sequence shown in Figure 4.20, $M = 3$ and $N = 12$.

(ii) A suitable reordered frame sequence that meets the defined requirements is:

IPBBPBBPBBIBBPBB ...

Example 4.2

A digitized video is to be compressed using the MPEG-1 standard. Assuming a frame sequence of:

IBBPBBPBBPBBI...

and average compression ratios of 10:1 (I), 20:1 (P) and 50:1 (B), derive the average bit rate that is generated by the encoder for both the NTSC and PAL digitization formats.

Answer:

Frame sequence = IBBPBBPBBPBBI...

Hence: 1/12 of frames are I-frames, 3/12 are P-frames, and 8/12 are B-frames.

and Average compression ratio $= (1 \times 0.1 + 3 \times 0.05 + 8 \times 0.02)/12$

$= 0.0342$ or 29.24:1

NTSC frame size:

Without compression $= 352 \times 240 \times 8 + 2\ (176 \times 120 \times 8)$

$= 1.013760$ Mbits per frame

With compression $= 1.01376 \times 1/29.24$

$= 34.670$ kbits per frame

Hence bit rate generated at 30 fps = 1.040 Mbps

PAL frame size:

$$\begin{aligned}\text{Without compression} &= 352 \times 288 \times 8 + 2\ (176 \times 144 \times 8)\\ &= 1.216512\ \text{Mbits per frame}\\ \text{With compression} &= 1.216512 \times 1/29.24\\ &= 41.604\ \text{kbits per frame}\end{aligned}$$

Hence bit rate generated at 25 fps = 1.040 Mbps

Normally, allowing for packetization and multiplexing overheads, a bandwidth of 1.2 Mbps is allocated for the video. Hence, assuming a maximum bit rate of 1.5 Mbps, this leaves 300 kbps for the compressed audio stream.