MODERN OPERATING SYSTEMS

Third Edition
ANDREW S. TANENBAUM

Chapter 7
Multimedia Operating Systems

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Introduction To Multimedia (1)

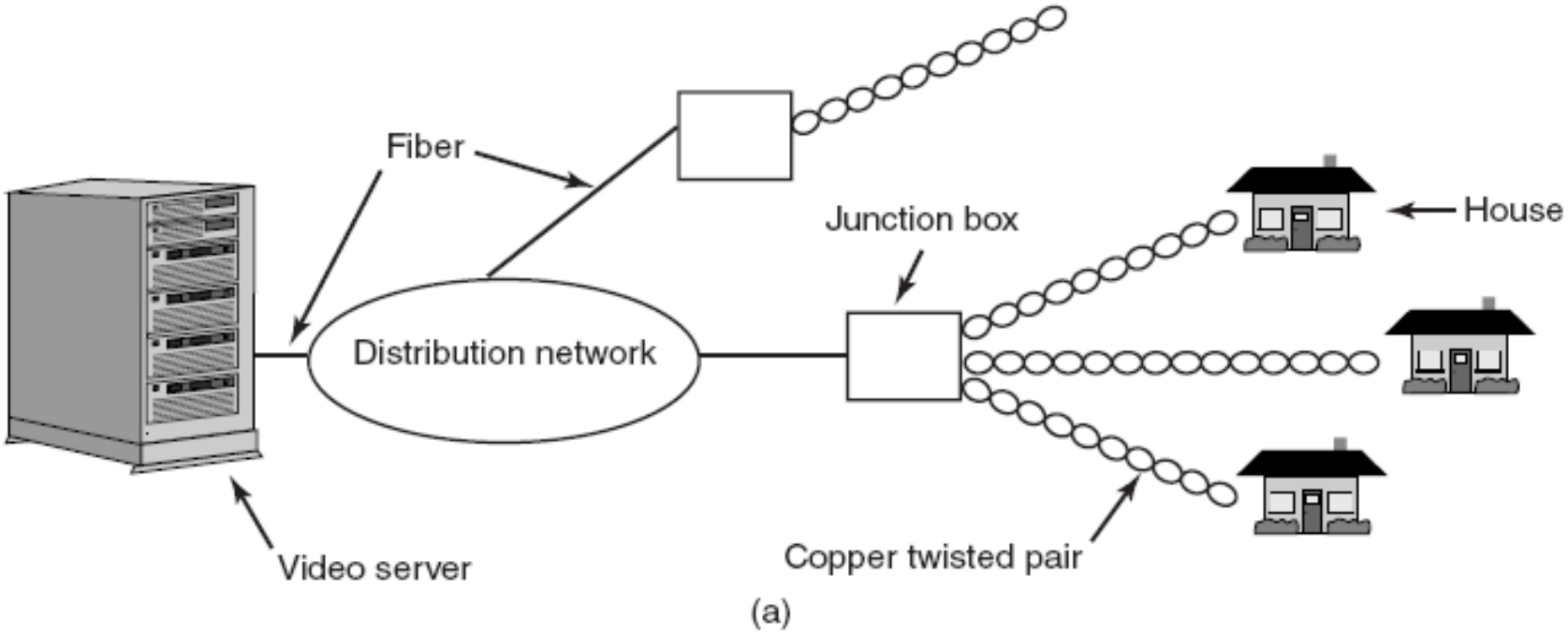

Figure 7-1. Video on demand using different local distribution technologies. (a) ADSL.

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Introduction To Multimedia (2)

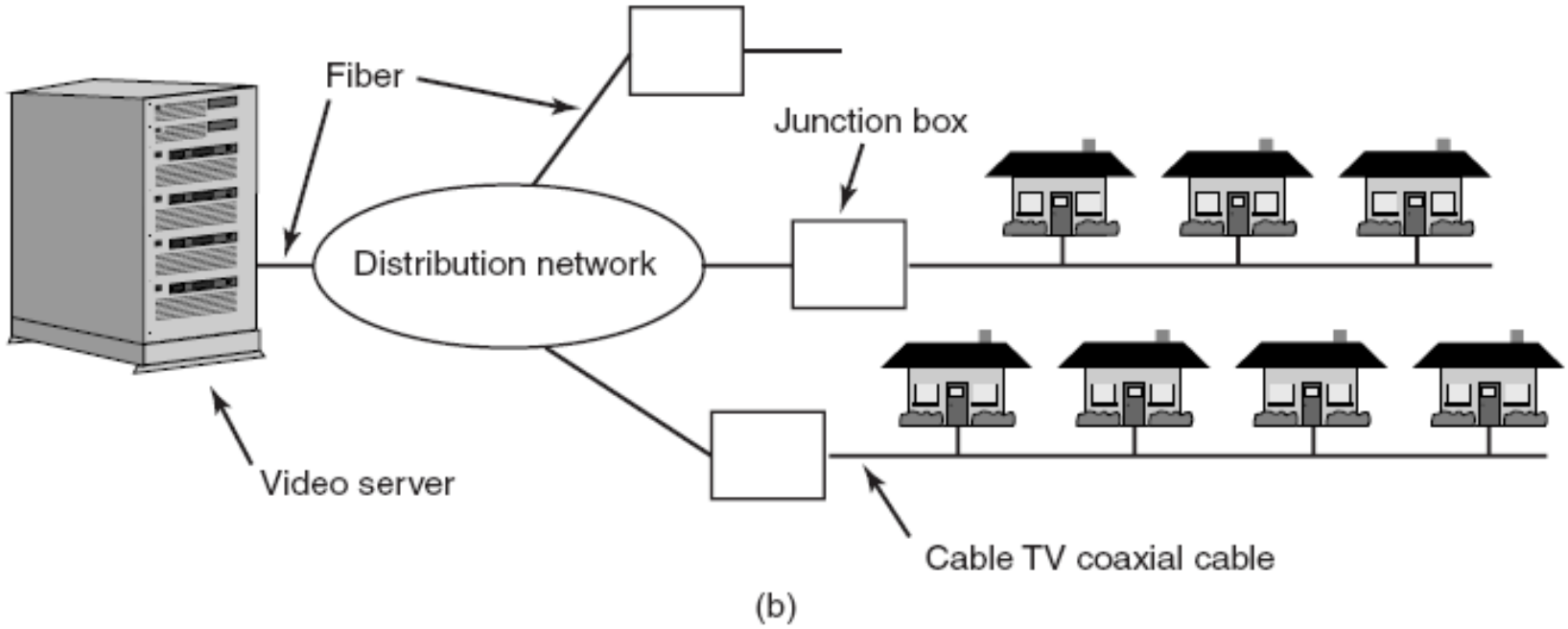

Figure 7-1. Video on demand using different local distribution technologies. (b) Cable TV.

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Introduction To Multimedia (3)

Key characteristics of multimedia:

1. Multimedia uses extremely high data rates.
2. Multimedia requires real-time playback.

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Introduction To Multimedia (4)

Source	Mbps	GB/hr
Telephone (PCM)	0.064	0.03
MP3 music	0.14	0.06
Audio CD	1.4	0.62
MPEG-2 movie (640 × 480)	4	1.76
Digital camcorder (720 × 480)	25	11
Uncompressed TV (640 × 480)	221	97
Uncompressed HDTV (1280 × 720)	648	288

Device	Mbps
Fast Ethernet	100
EIDE disk	133
ATM OC-3 network	156
IEEE 1394b (FireWire)	800
Gigabit Ethernet	1000
SATA disk	3000
Ultra-640 SCSI disk	5120

Figure 7-2. Some data rates for multimedia and high-performance I/O devices. Note that 1 Mbps is 10^6 bits/sec but 1 GB is 2^{30} bytes.

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Multimedia Files

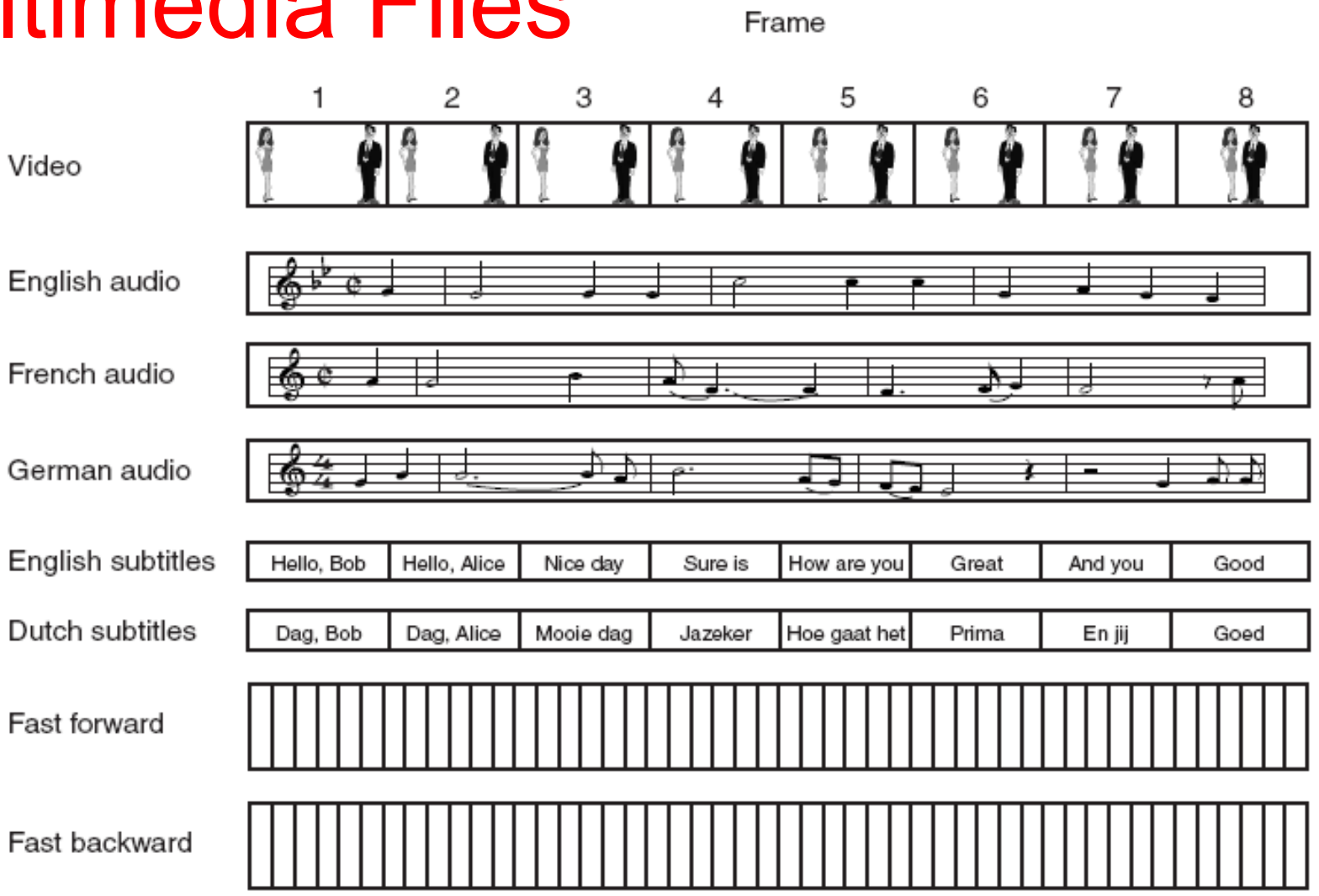

Figure 7-3. A movie may consist of several files.

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Video Encoding

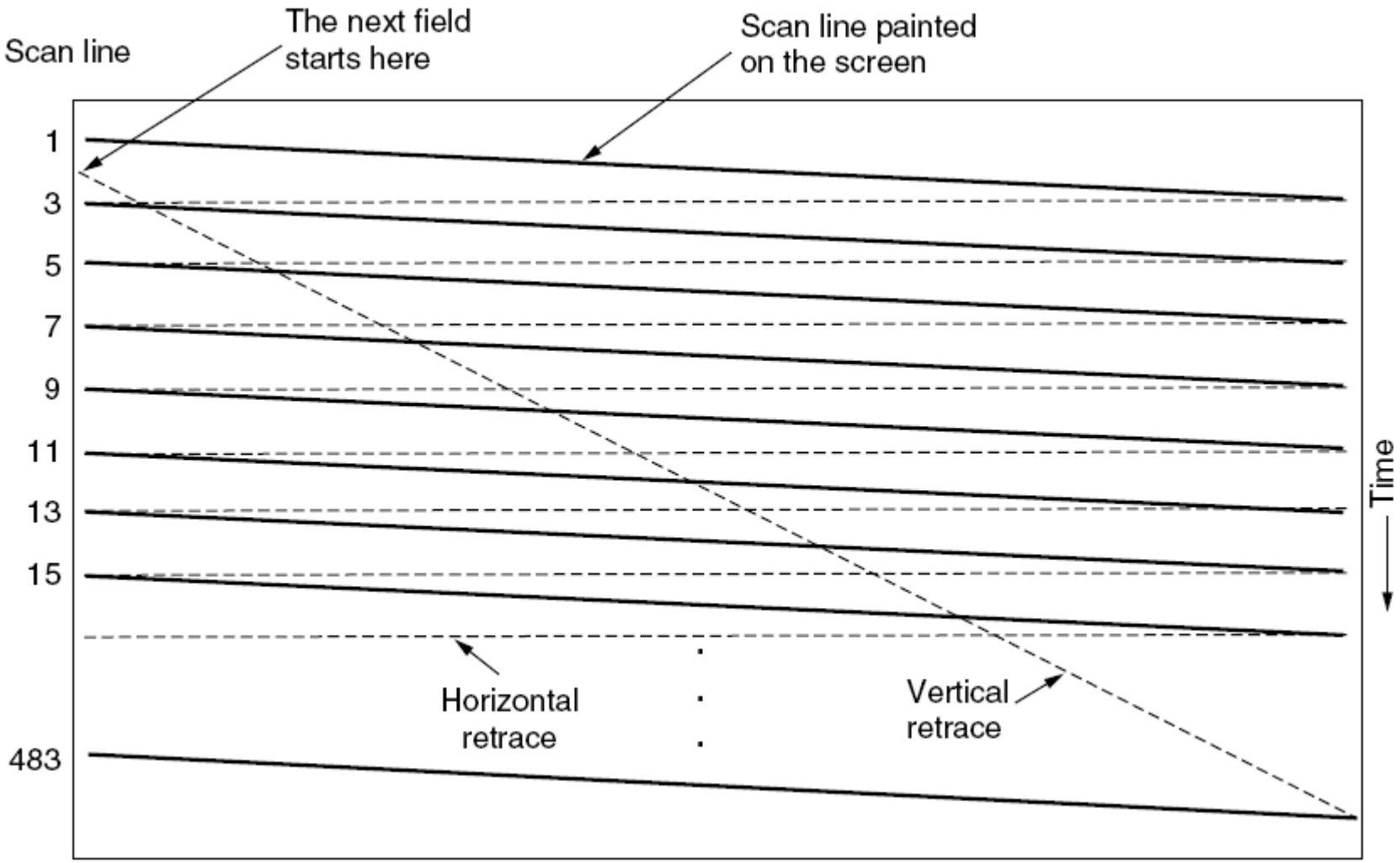

Figure 7-4. The scanning pattern used for NTSC video and television.

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Audio Encoding

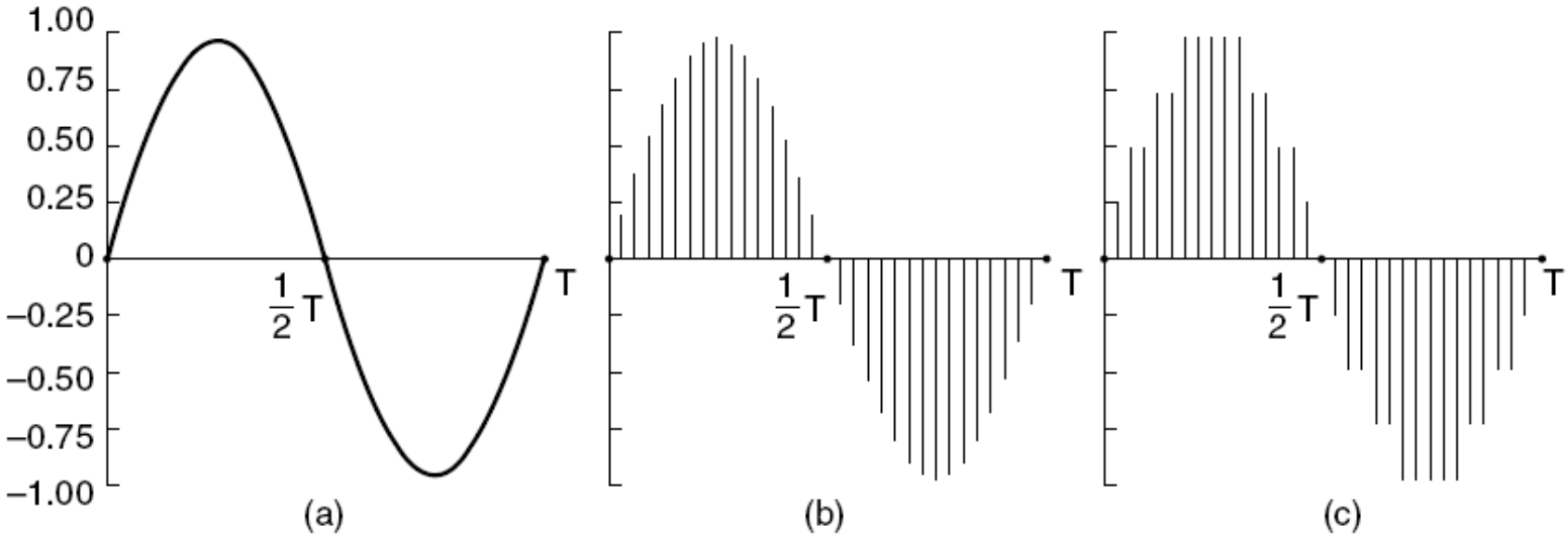

Figure 7-5. (a) A sine wave. (b) Sampling the sine wave. (c) Quantizing the samples to 4 bits.

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The JPEG Standard (1)

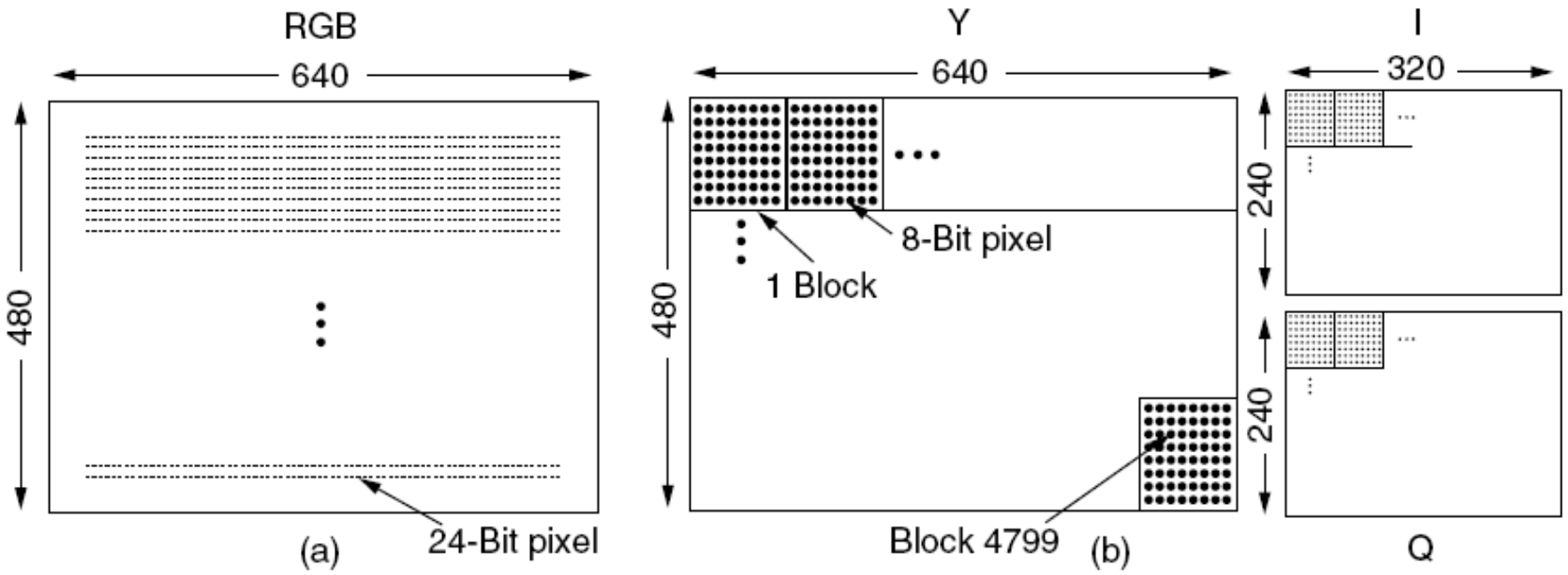

Figure 7-6. (a) RGB input data. (b) After block preparation.

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The JPEG Standard (2)

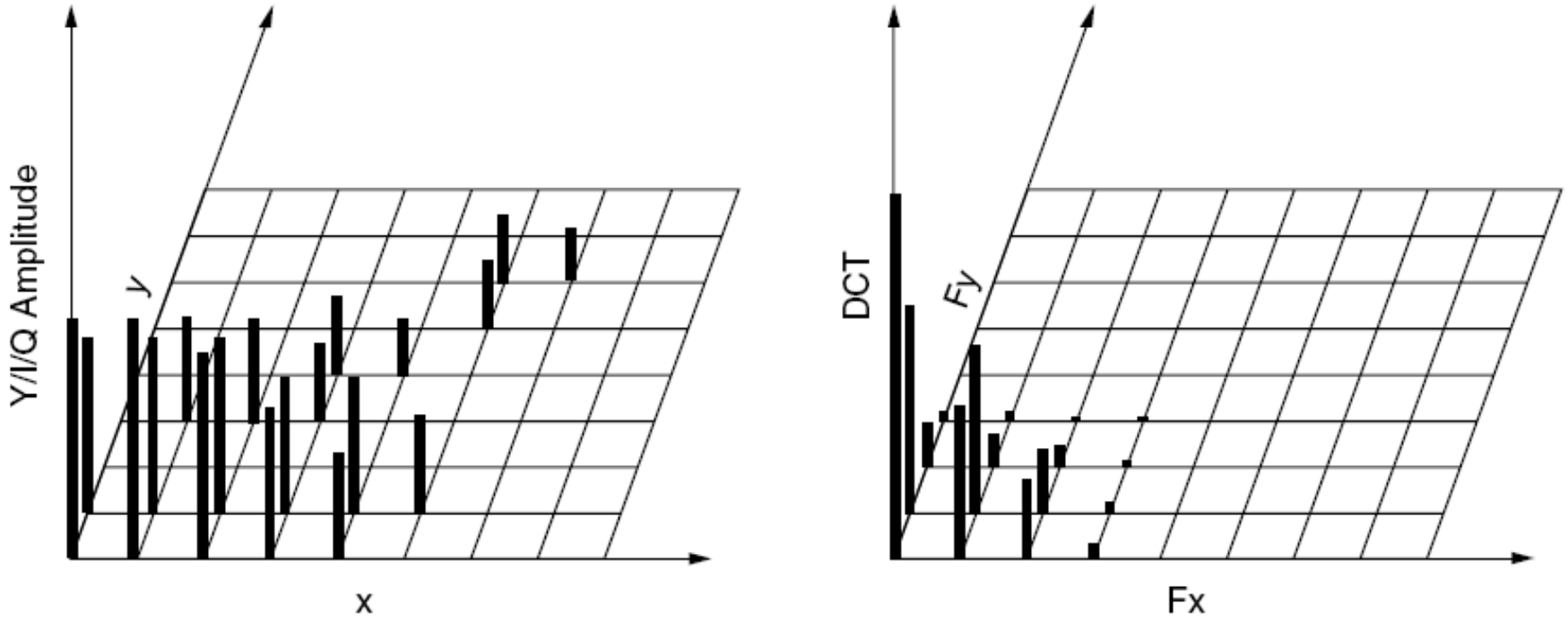

Figure 7-7. (a) One block of the Y matrix.
(b) The DCT coefficients.

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The JPEG Standard (3)

DCT Coefficients

150	80	40	14	4	2	1	0
92	75	36	10	6	1	0	0
52	38	26	8	7	4	0	0
12	8	6	4	2	1	0	0
4	3	2	0	0	0	0	0
2	2	1	1	0	0	0	0
1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Quantized coefficients

150	80	20	4	1	0	0	0
92	75	18	3	1	0	0	0
26	19	13	2	1	0	0	0
3	2	2	1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Quantization table

1	1	2	4	8	16	32	64
1	1	2	4	8	16	32	64
2	2	2	4	8	16	32	64
4	4	4	4	8	16	32	64
8	8	8	8	8	16	32	64
16	16	16	16	16	16	32	64
32	32	32	32	32	32	32	64
64	64	64	64	64	64	64	64

Figure 7-8. Computation of the quantized DCT coefficients.

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The JPEG Standard (4)

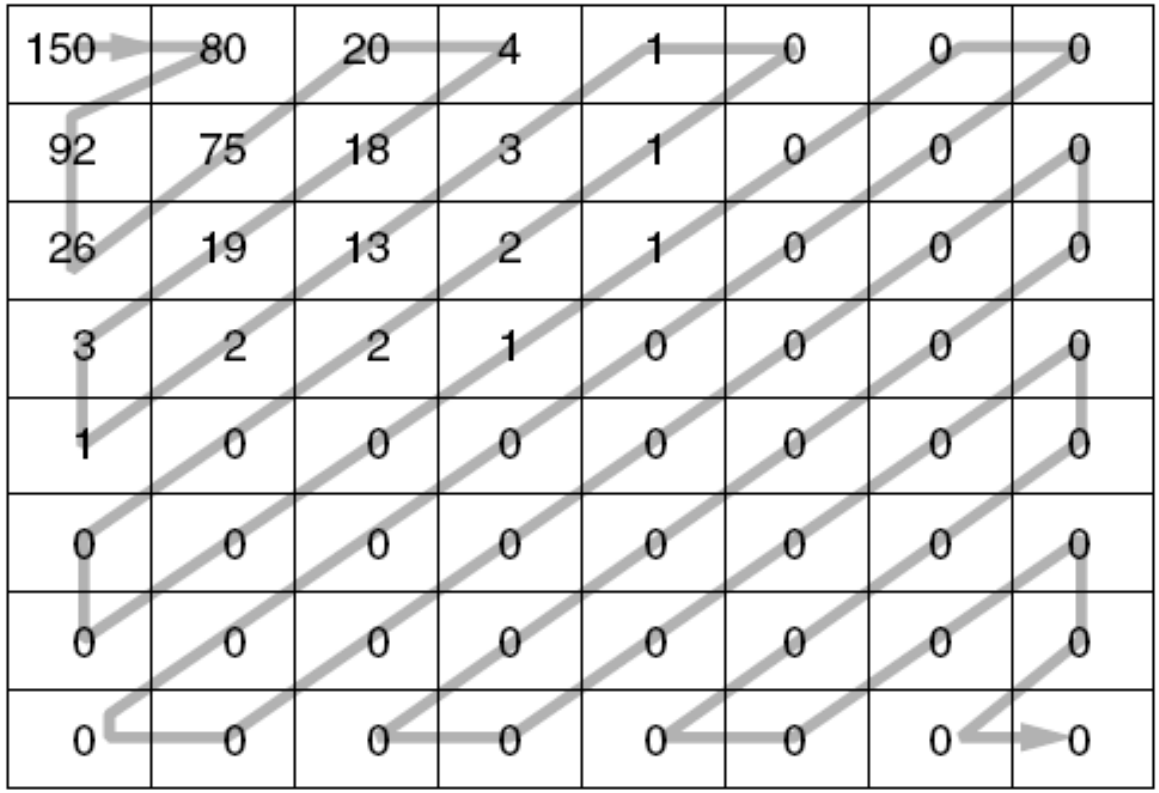

Figure 7-9. The order in which the quantized values are transmitted.

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The MPEG Standard (1)

Three types of MPEG-2 frames processed by the viewing program:

1. I (Intracoded) frames: Self-contained JPEG-encoded still pictures.
2. P (Predictive) frames: Block-by-block difference with the last frame.
3. B (Bidirectional) frames: Differences with the last and next frame.

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The MPEG Standard (2)

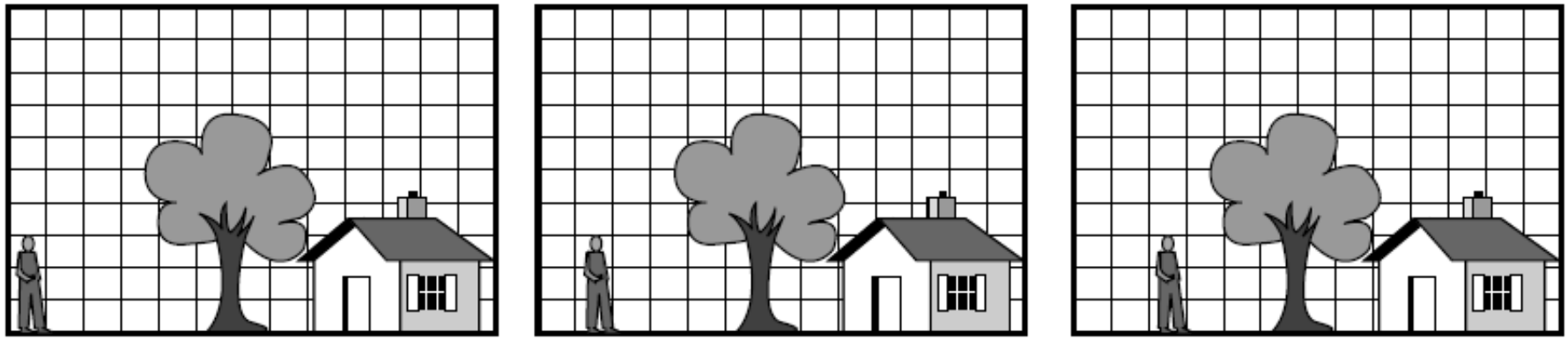

Figure 7-10. Three consecutive video frames.

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Audio Compression (1)

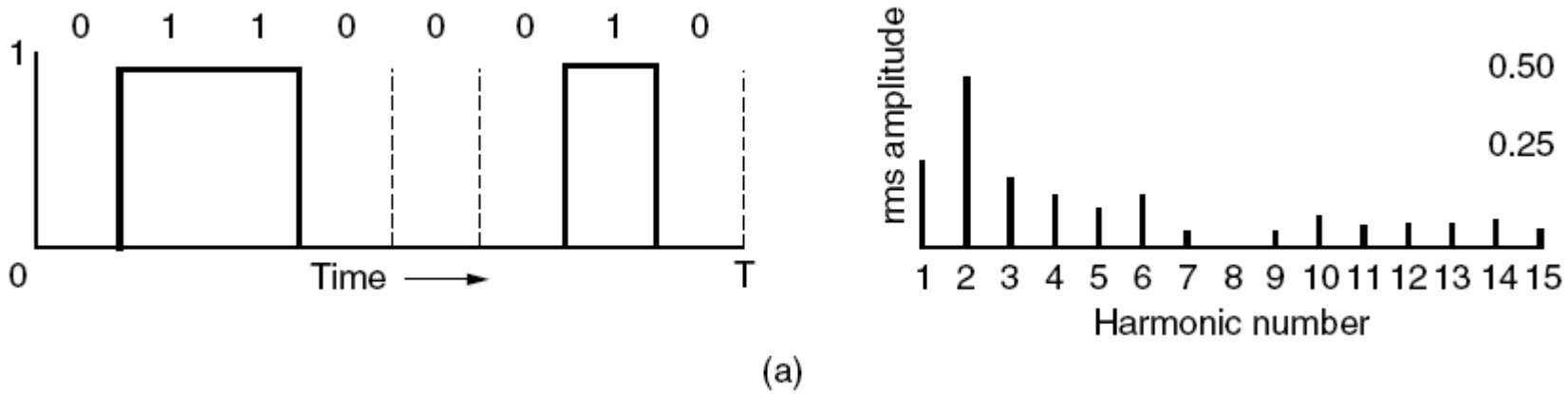

Figure 7-11. (a) A binary signal and its root-mean-square Fourier amplitudes.

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Audio Compression (2)

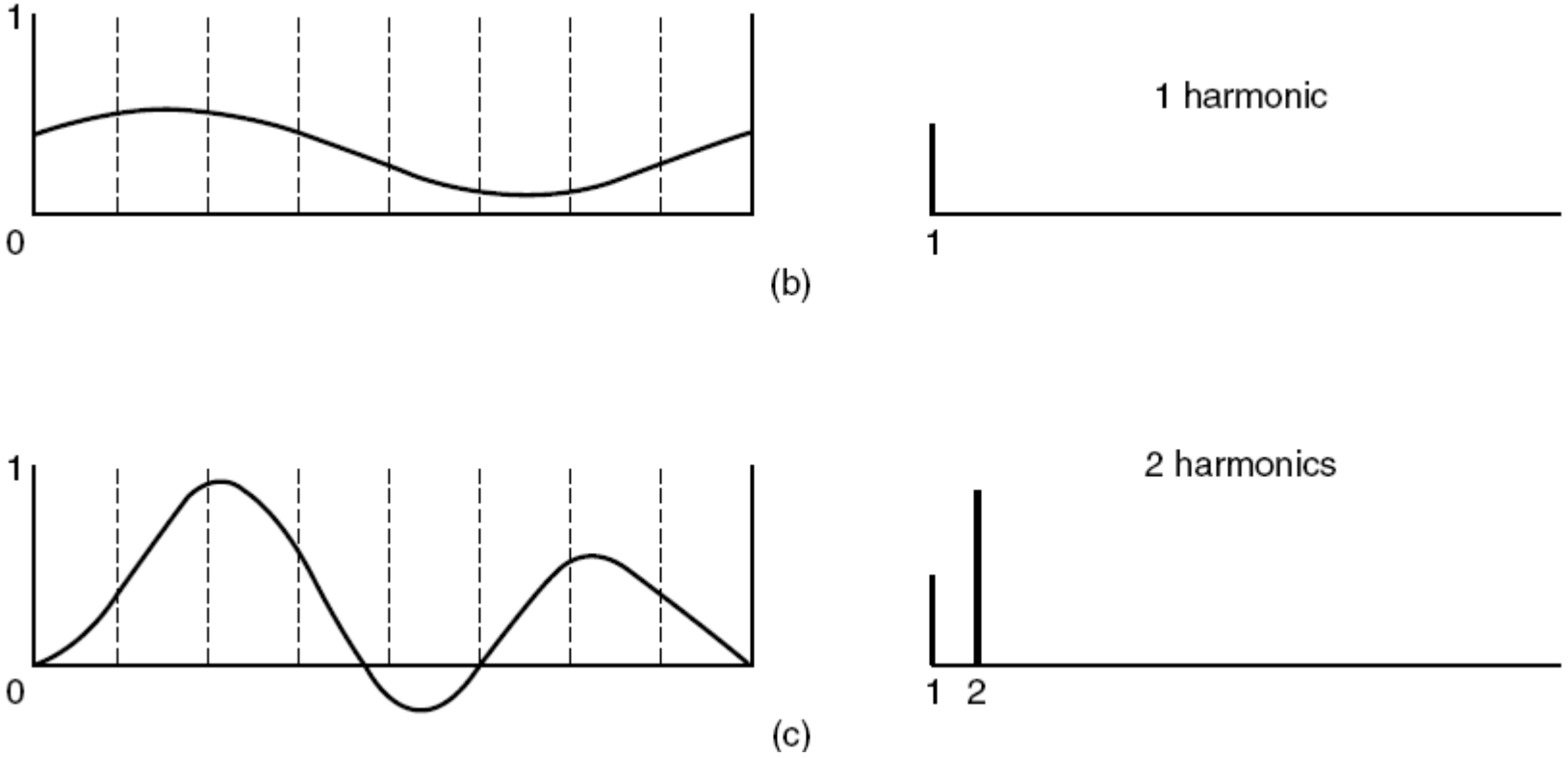

Figure 7-11. (b)–(e) Successive approximations to the original signal.

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Audio Compression (3)

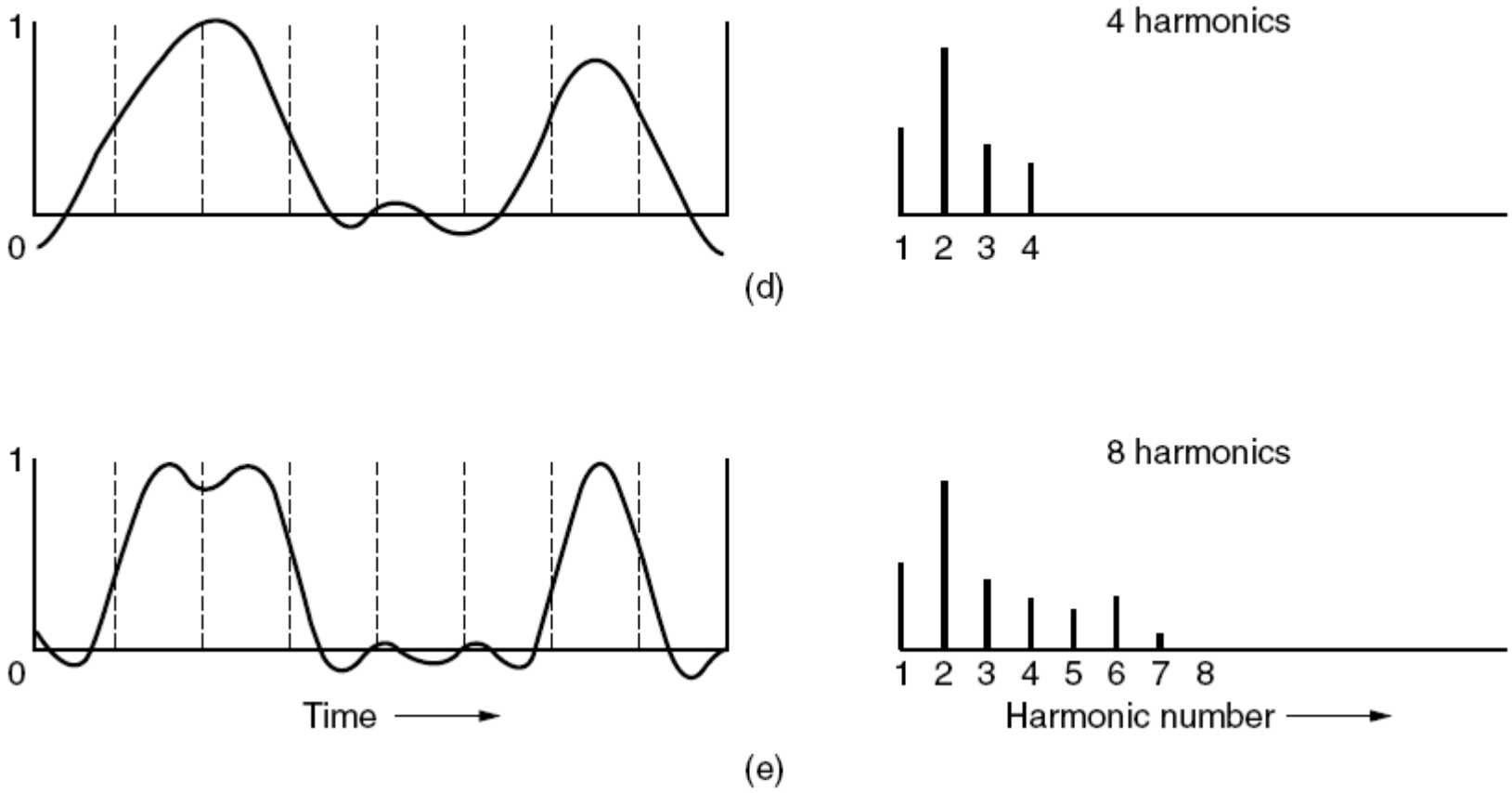

Figure 7-11. (b)–(e) Successive approximations to the original signal.

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Audio Compression (4)

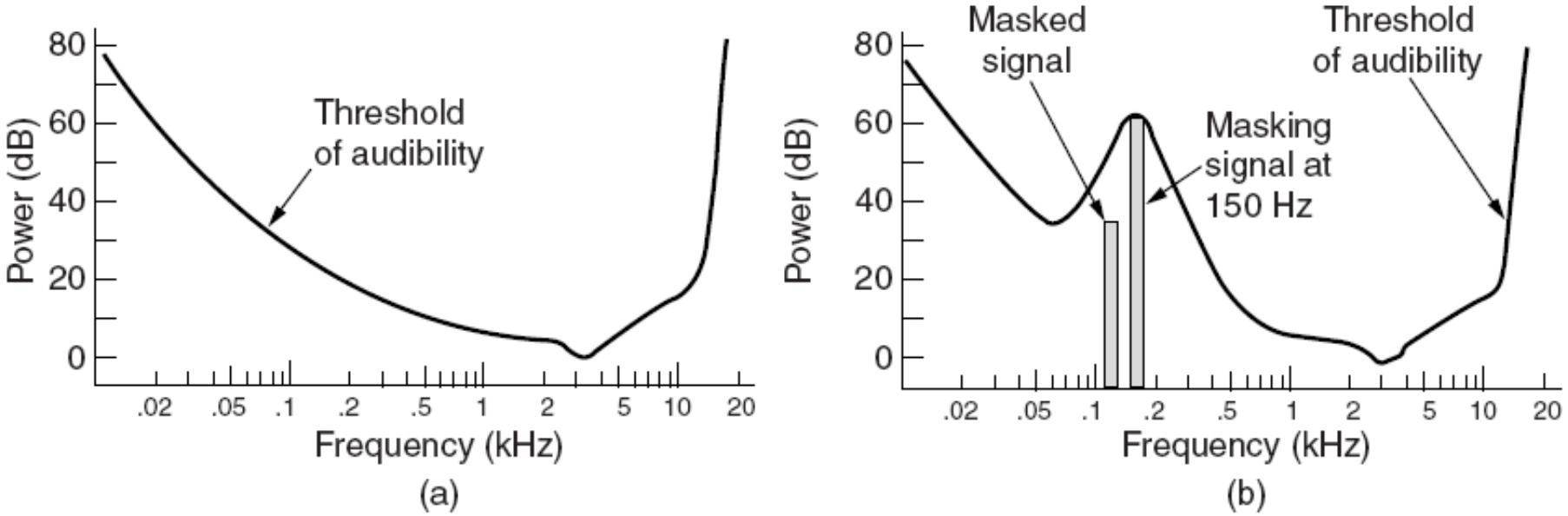

Figure 7-12. (a) The threshold of audibility as a function of frequency. (b) The masking effect.

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Audio Compression (5)

Possible sampling configurations:

1. Monophonic (a single input stream).
2. Dual monophonic (e.g., an English and a Japanese soundtrack).
3. Disjoint stereo (each channel compressed separately).
4. Joint stereo (interchannel redundancy fully exploited).

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General Real-Time Scheduling

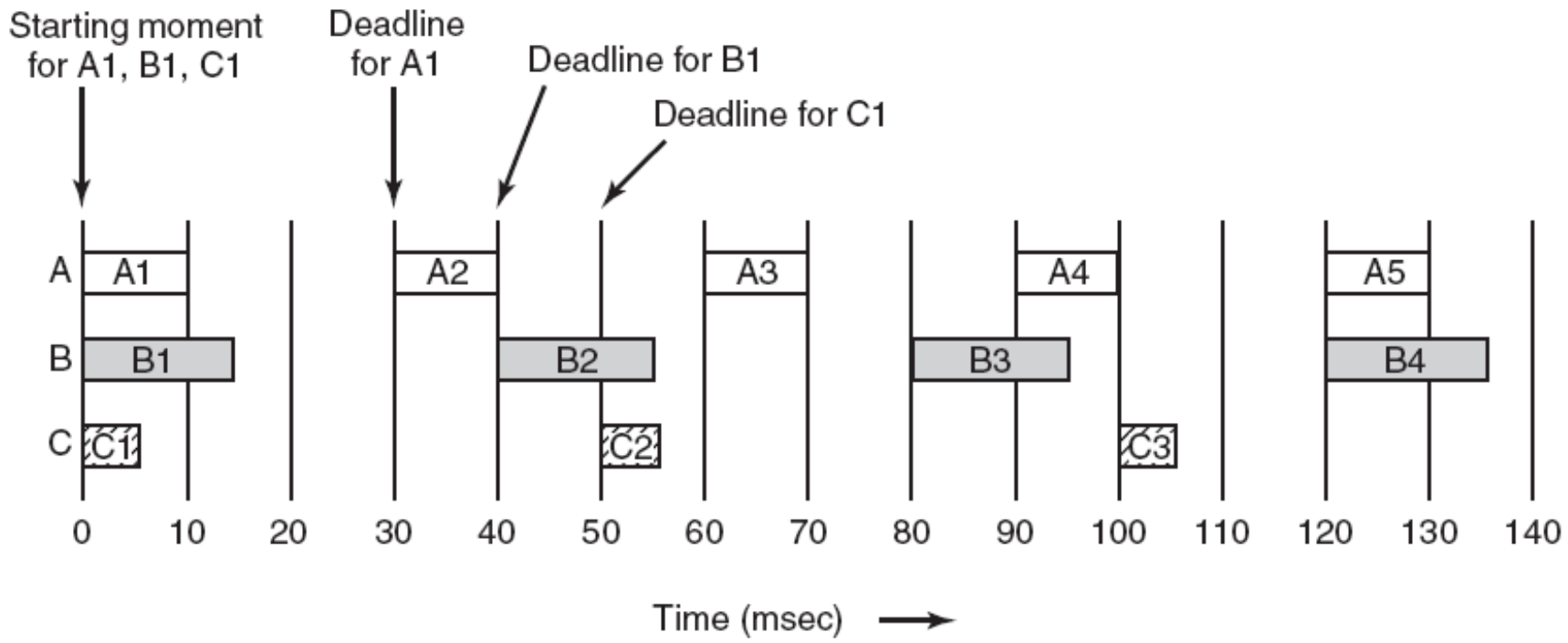

Figure 7-13. Three periodic processes, each displaying a movie. The frame rates and processing requirements per frame are different for each movie.

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Rate Monotonic Scheduling (1)

Required conditions for RMS:

1. Each periodic process must complete within its period.
2. No process is dependent on any other process.
3. Each process needs same amount of CPU time on each burst.
4. Nonperiodic processes have no deadlines.
5. Process preemption occurs instantaneously and with no overhead.

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Rate Monotonic Scheduling (2)

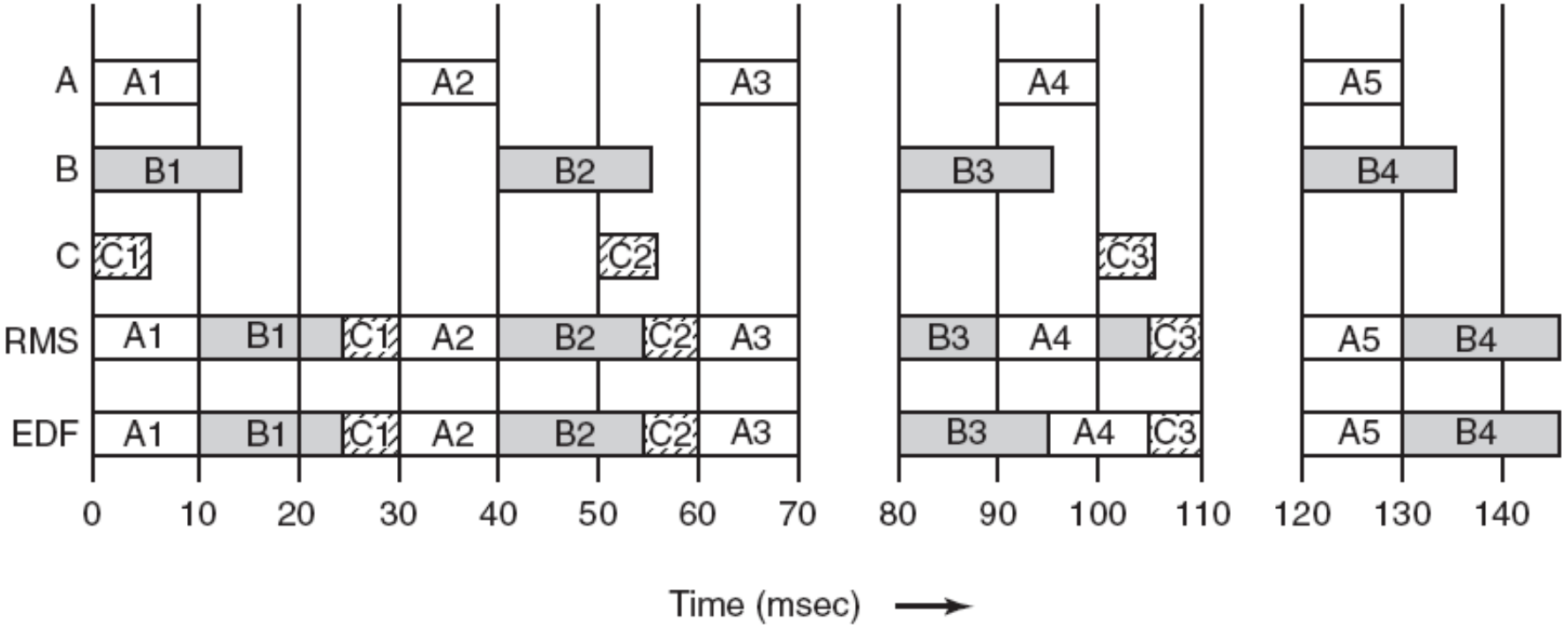

Figure 7-14. An example of RMS and EDF real-time scheduling.

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Earliest Deadline First Scheduling

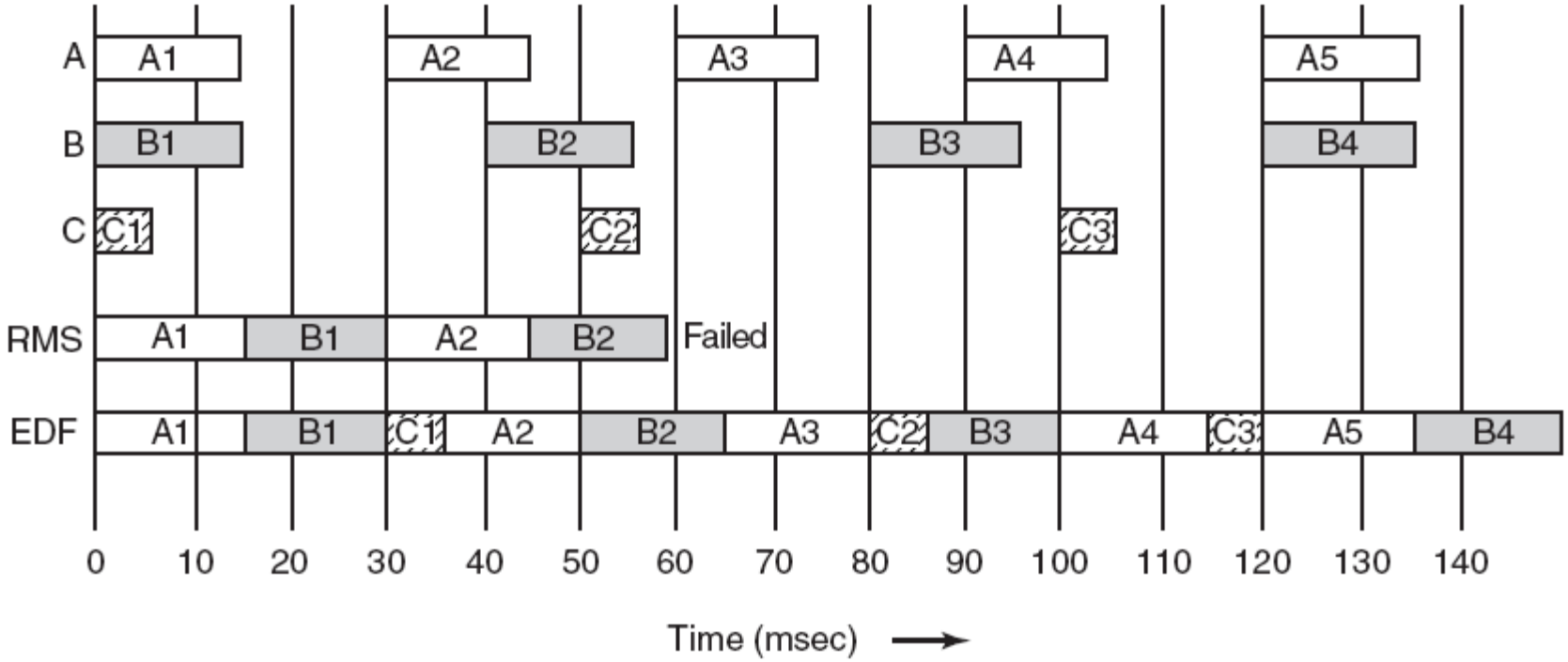

Figure 7-15. Another example of real-time scheduling with RMS and EDF.

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Multimedia File System Paradigms

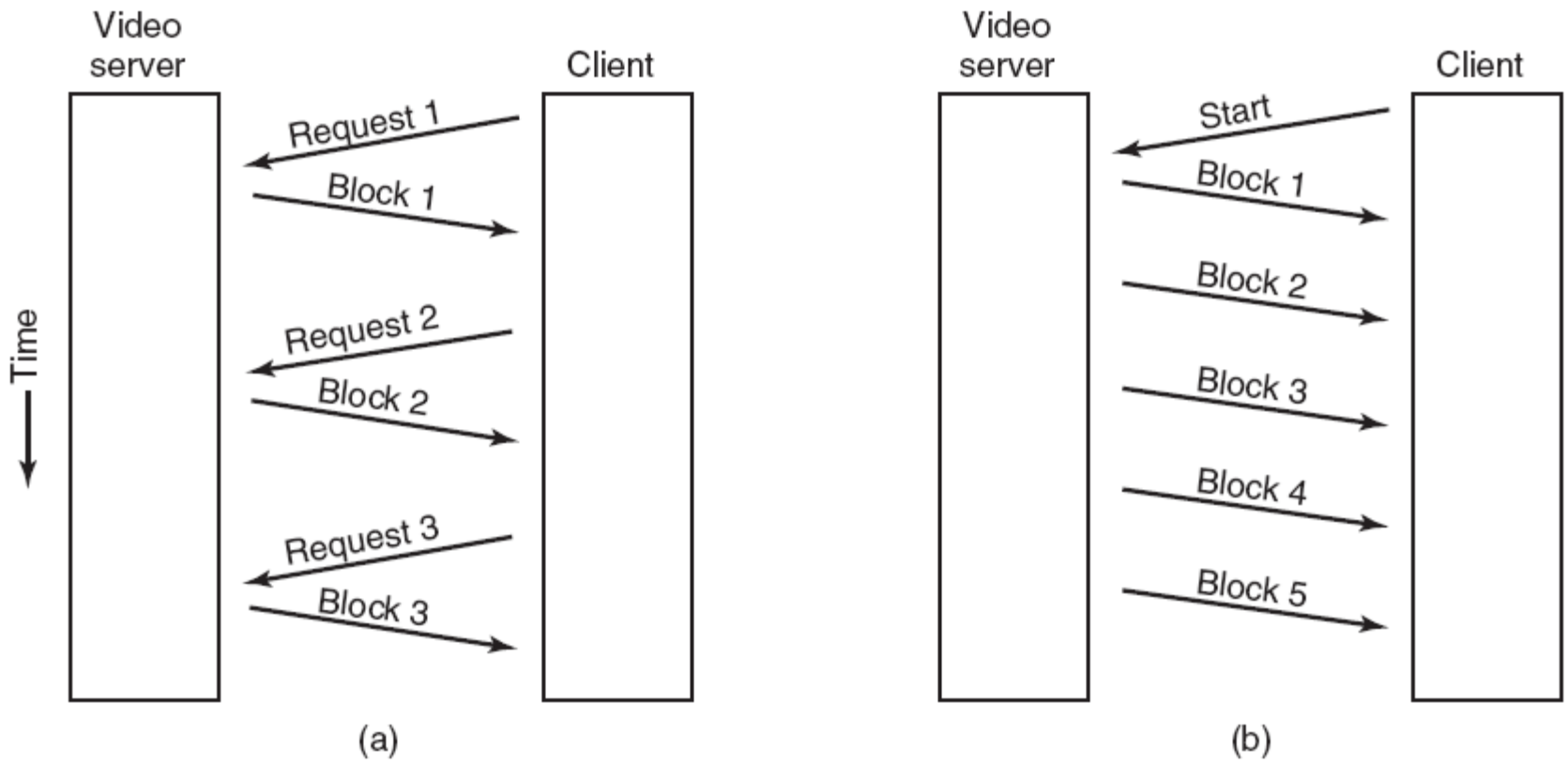

Figure 7-16. (a) A pull server. (b) A push server.

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Near Video on Demand

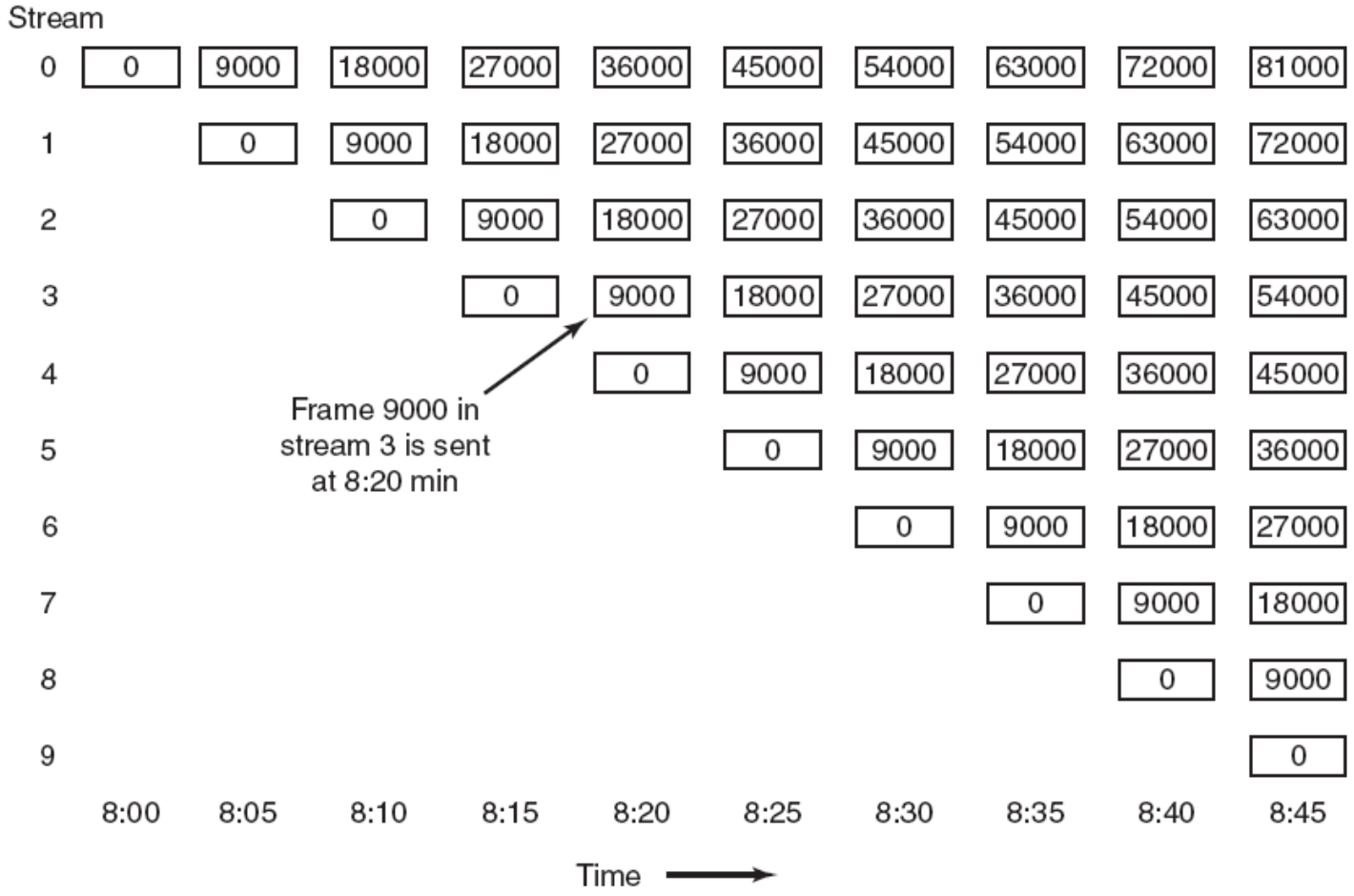

Figure 7-17. Near video on demand has a new stream starting at regular intervals, in this example every 5 minutes (9000 frames).

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Near Video on Demand with VCR Functions (1)

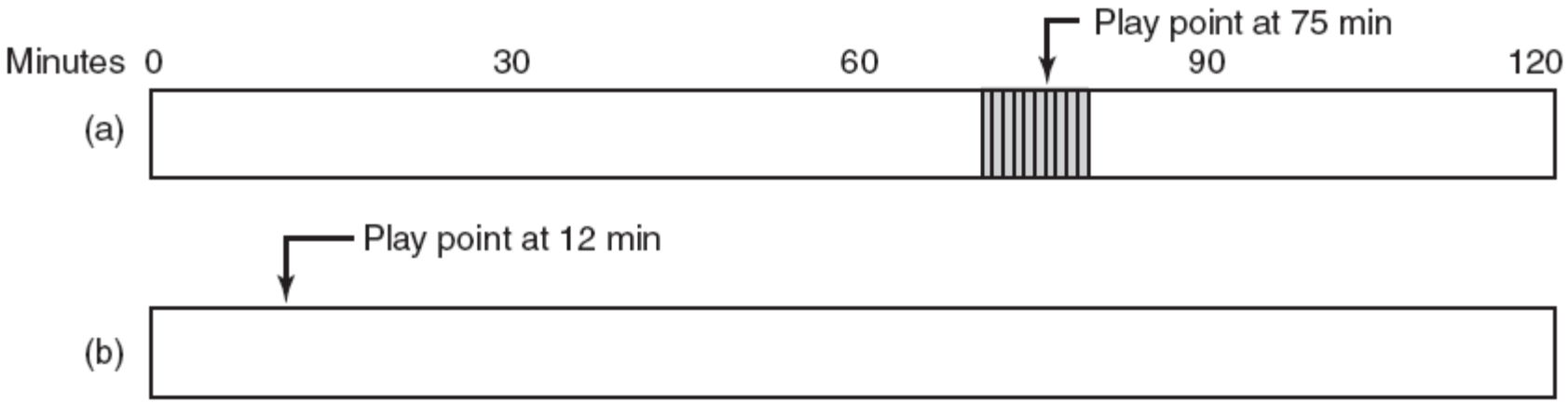

Figure 7-18. (a) Initial situation. (b) After a rewind to 12 min

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Near Video on Demand with VCR Functions (2)

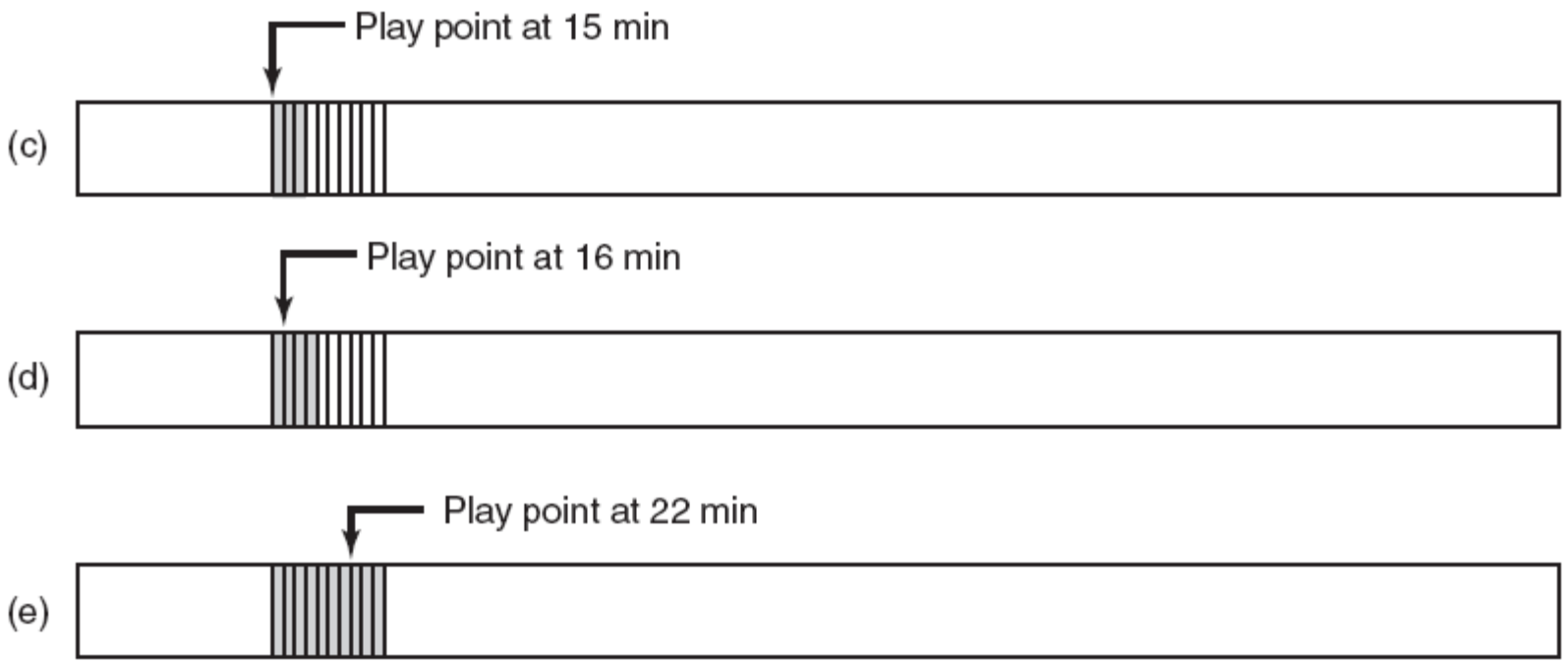

Figure 7-18. (c) After waiting 3 min.
(d) After starting to refill the buffer. (e) Buffer full.

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Placing a File on a Single Disk

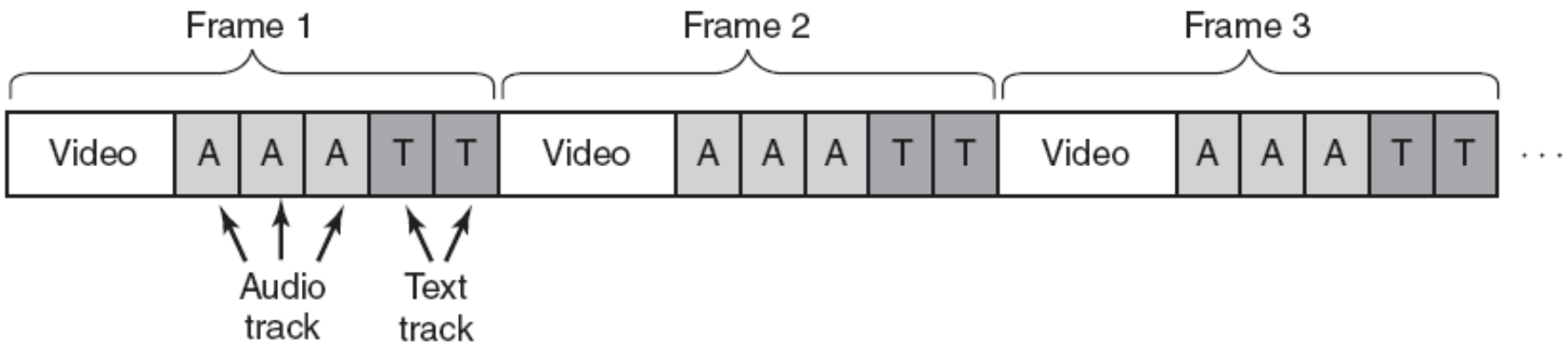

Figure 7-19. Interleaving video, audio, and text in a single contiguous file per movie.

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Two Alternative File Organization Strategies (1)

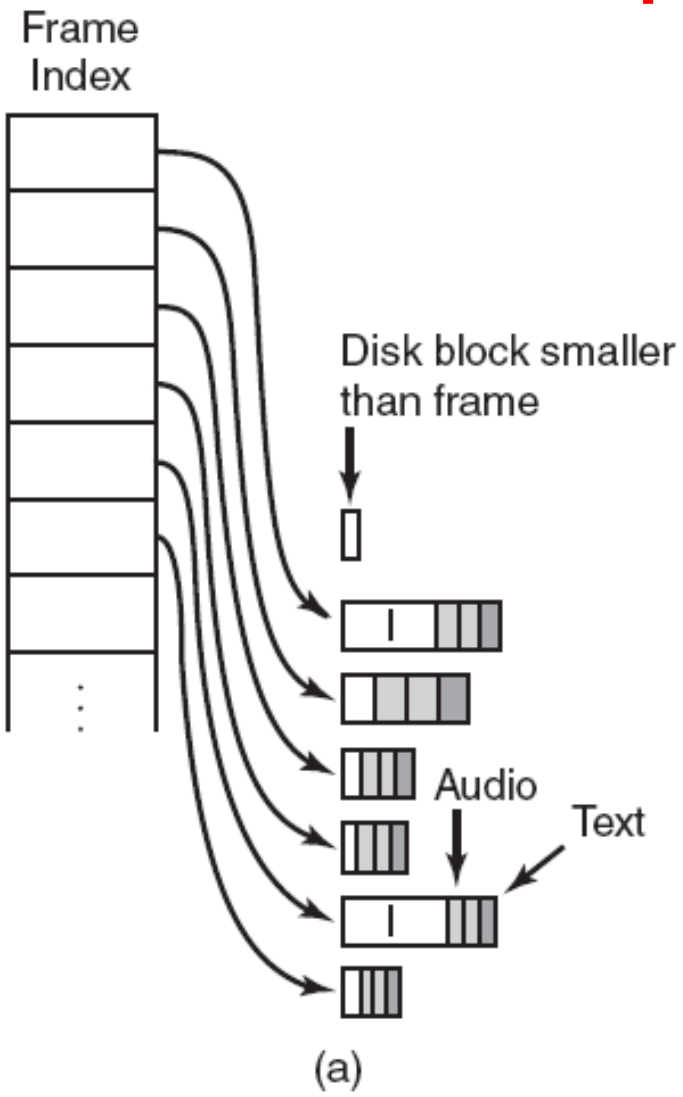

Figure 7-20. Noncontiguous movie storage. (a) Small disk blocks.

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Two Alternative File Organization Strategies (2)

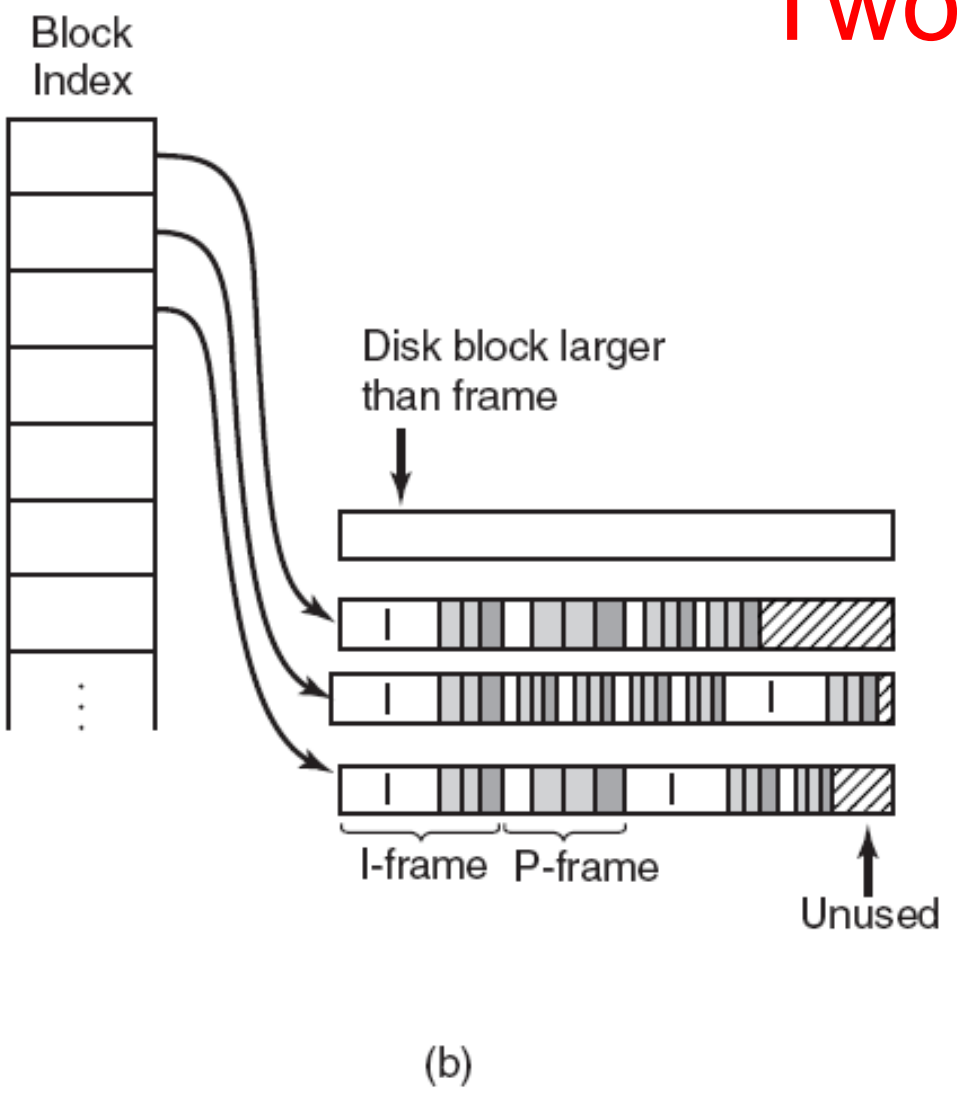

Figure 7-20. Noncontiguous movie storage (b) Large disk blocks.

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Two Alternative File Organization Strategies (3)

Trade-offs involved in these alternatives:

1. Frame index: Heavier RAM usage while movie is playing; little disk wastage.
2. Block index (no splitting frames over blocks): Low RAM usage; major disk wastage.
3. Block index (splitting frames over blocks is allowed): Low RAM usage; no disk wastage; extra seeks.

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Placing Files for Near Video on Demand

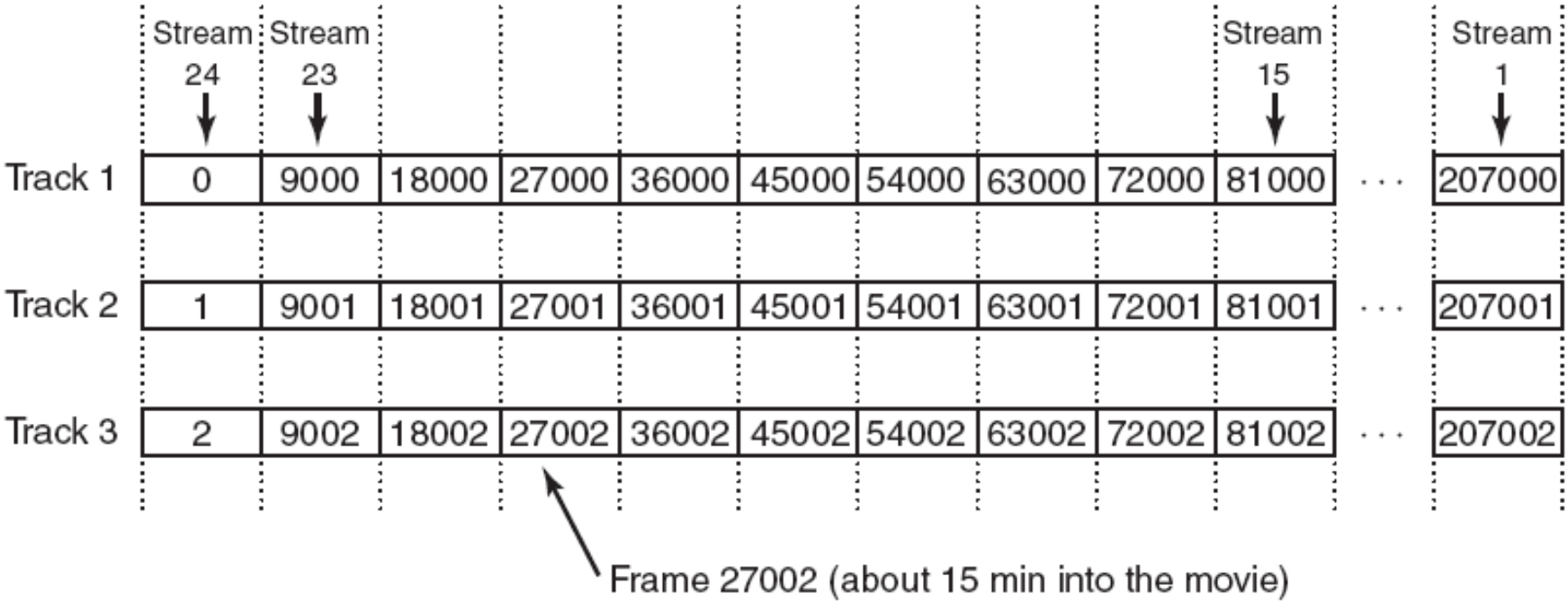

Figure 7-21. Optimal frame placement for near video on demand.

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Placing Multiple Files on a Single Disk (1)

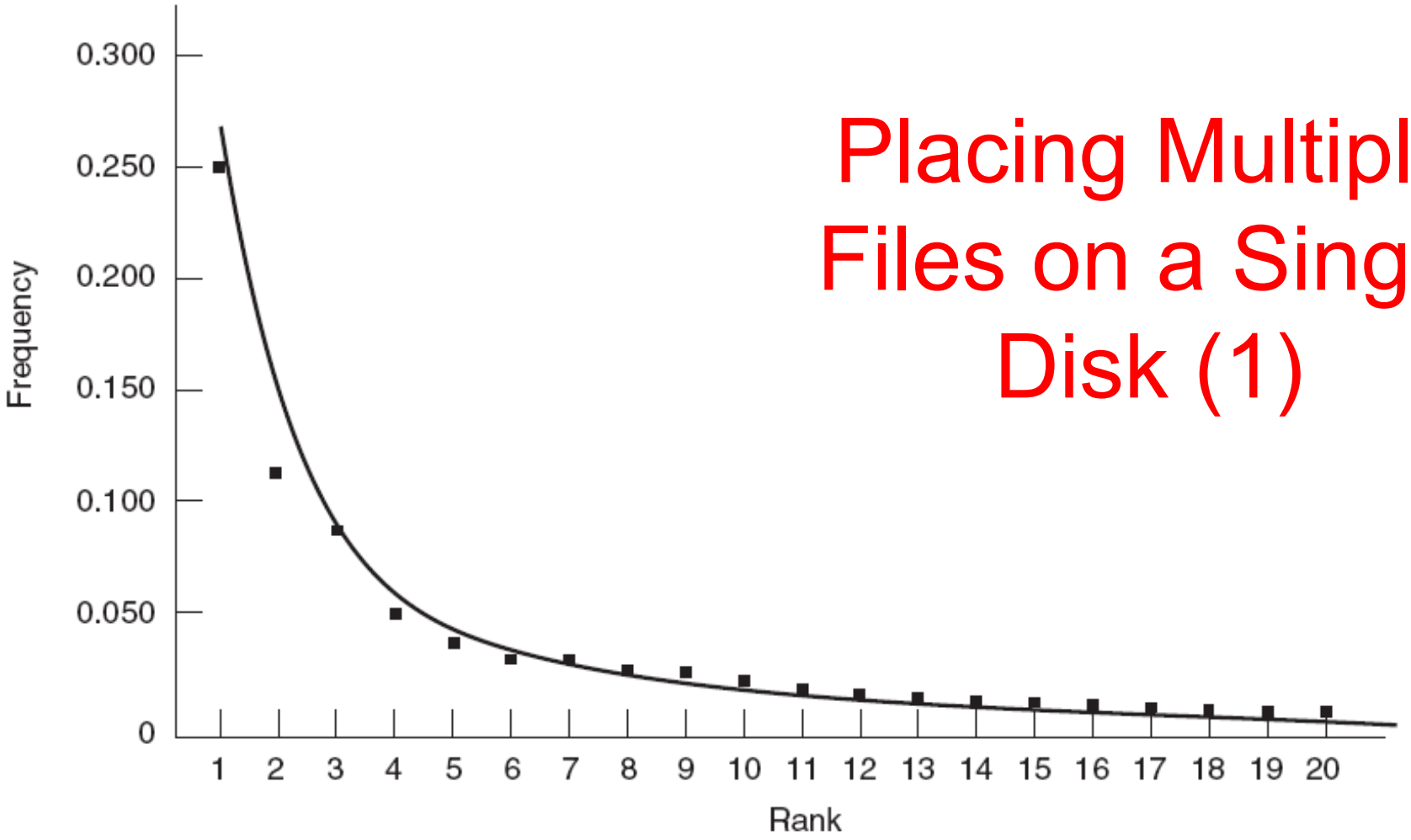

Figure 7-22. The curve gives Zipf's law for N = 20. The squares represent the populations of the 20 largest cities in the U.S., sorted on rank order (New York is 1, Los Angeles is 2, Chicago is 3, etc.).

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Placing Multiple Files on a Single Disk (2)

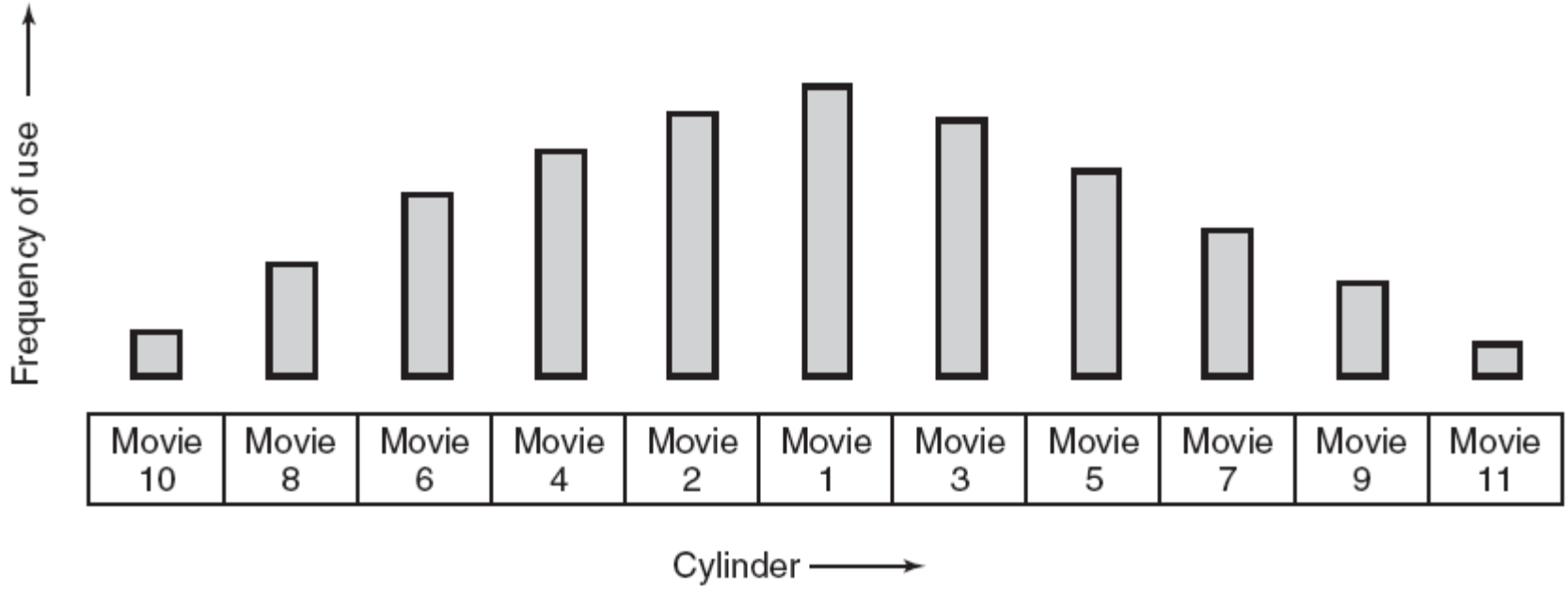

Figure 7-23. The organ-pipe distribution of files on a video server.

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Placing Files on Multiple Disks (1)

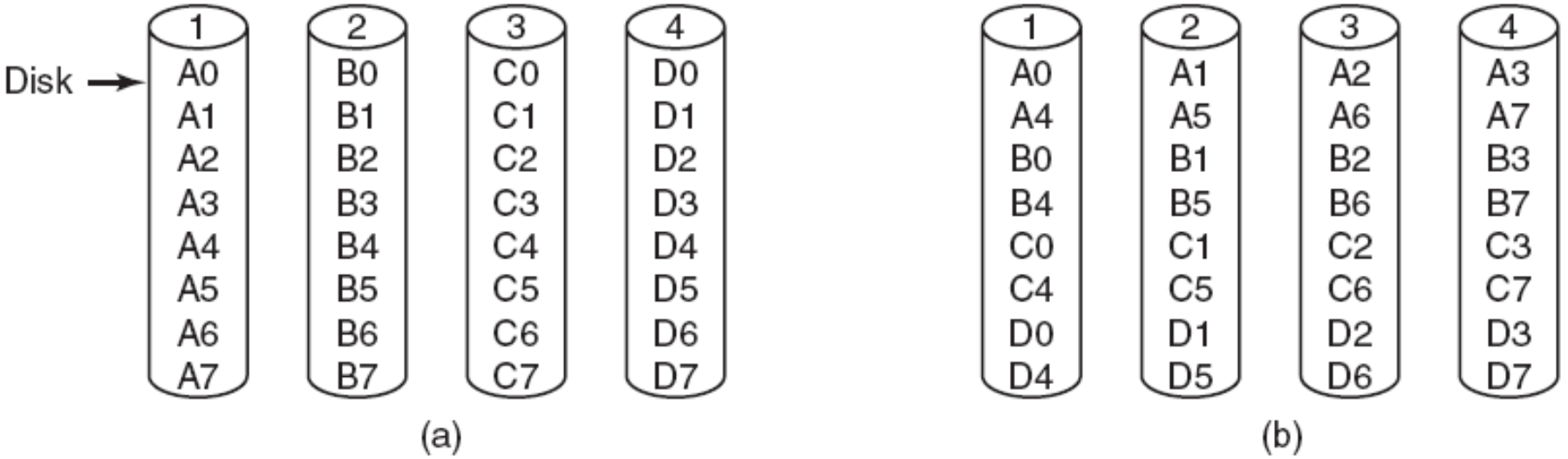

Figure 7-24. Four ways of organizing multimedia files over multiple disks. (a) No striping. (b) Same striping all files.

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Placing Files on Multiple Disks (2)

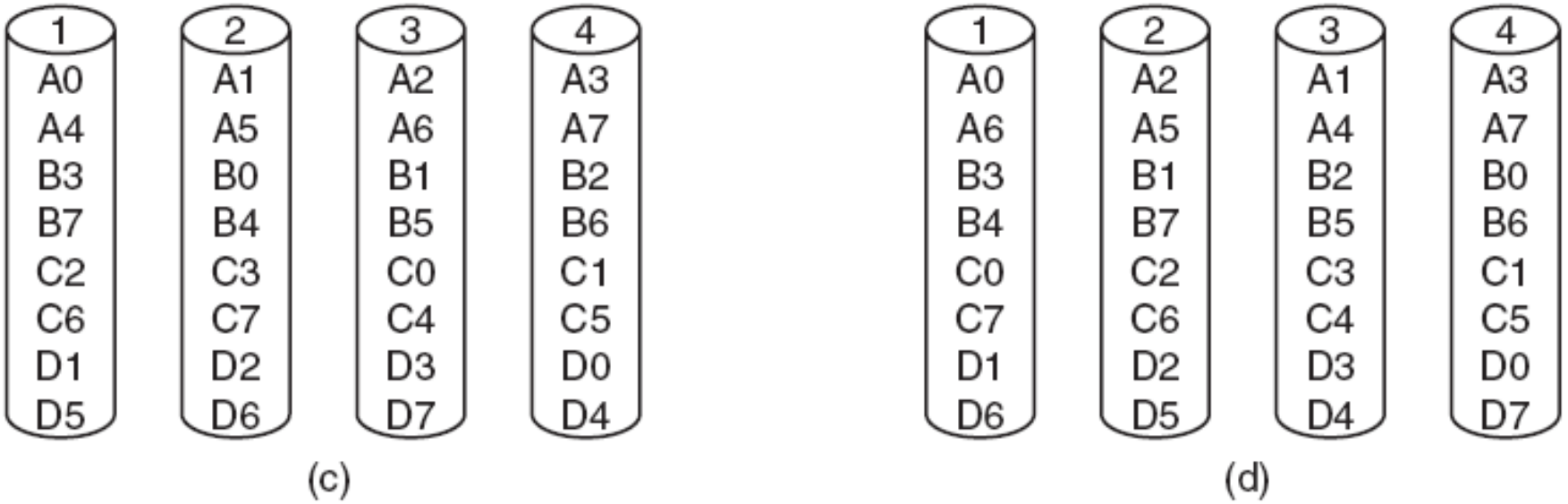

Figure 7-24. Four ways of organizing multimedia files over multiple disks. (c) Staggered striping. (d) Random striping.

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Block Caching (1)

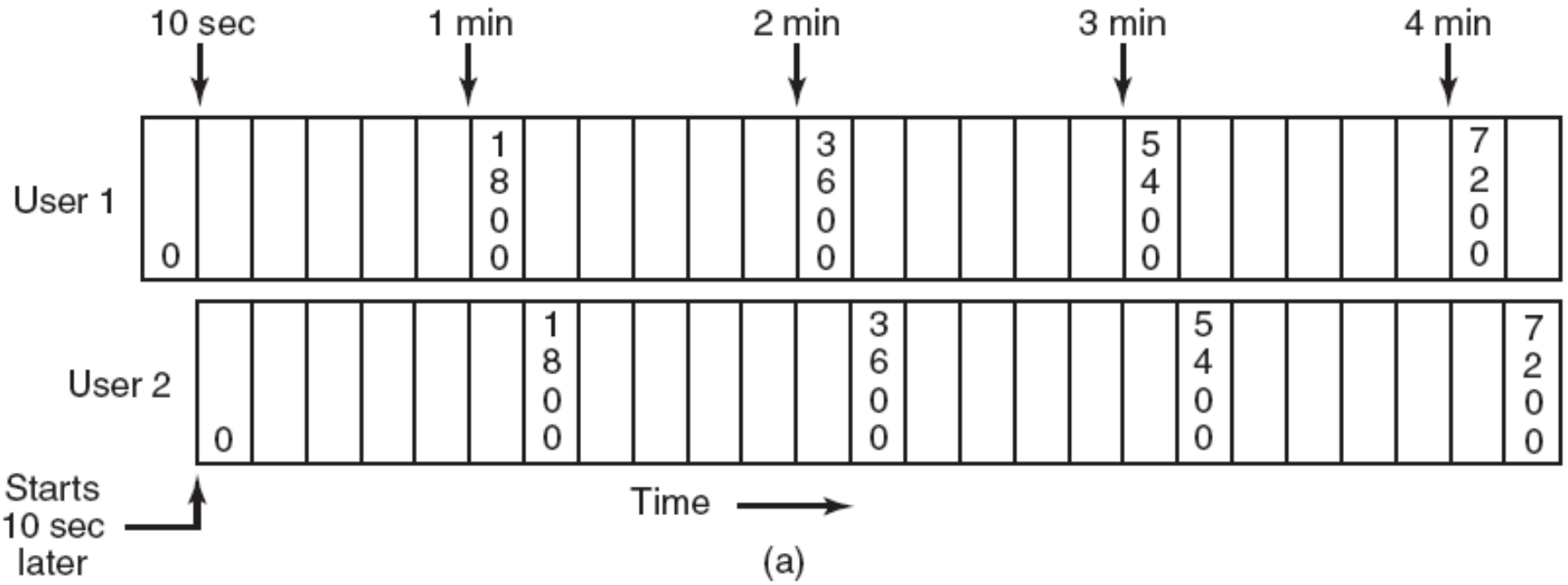

Figure 7-25. (a) Two users watching the same movie 10 sec out of sync.

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Block Caching (2)

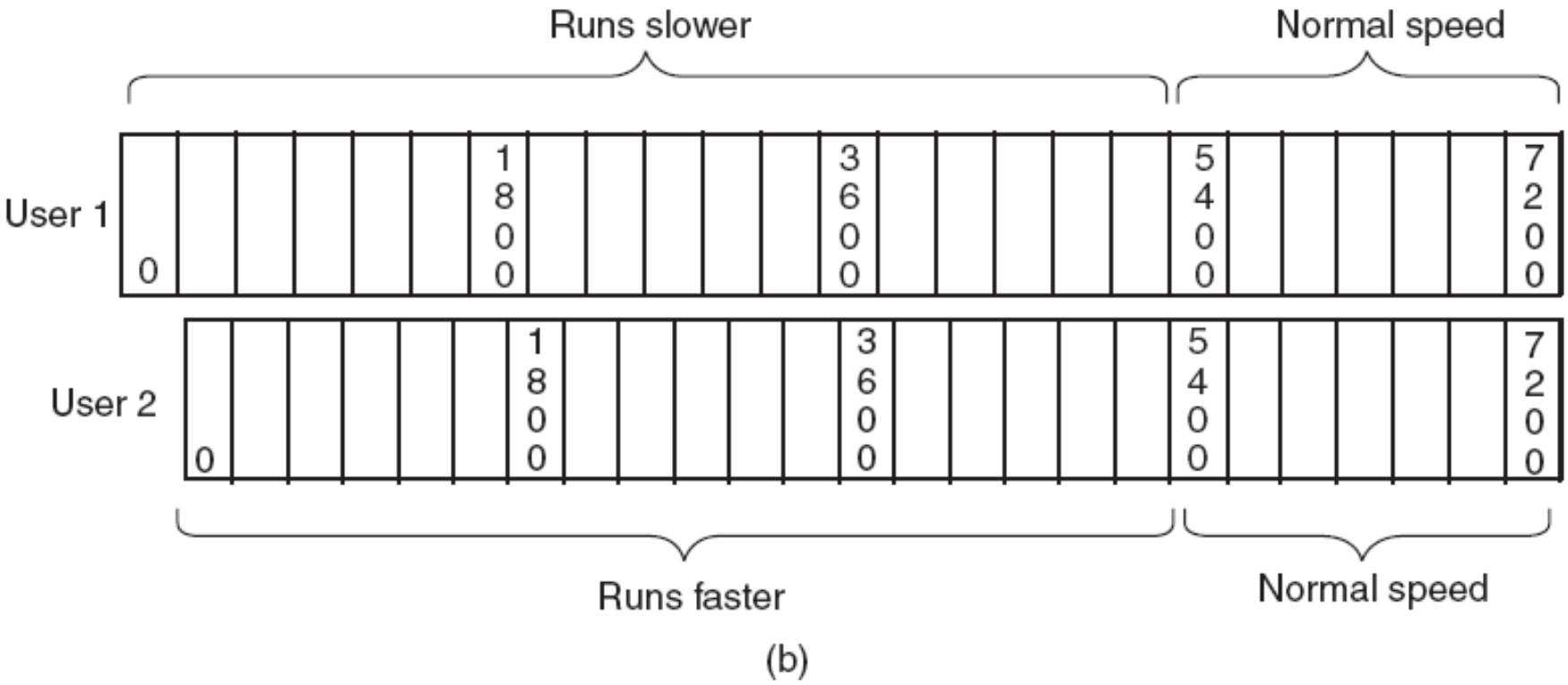

Figure 7-25. (b) Merging the two streams into one.

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Static Disk Scheduling

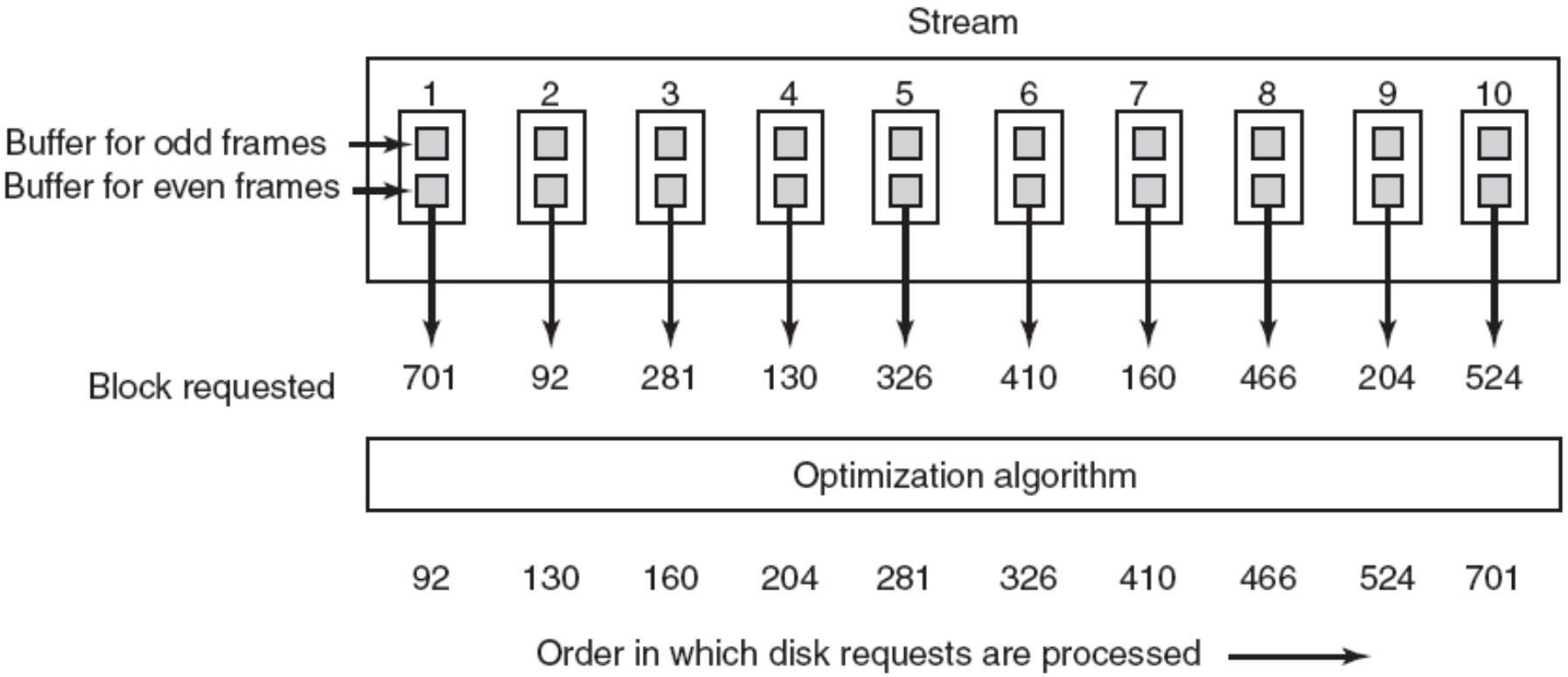

Figure 7-26. In one round, each movie asks for one frame.

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Dynamic Disk Scheduling

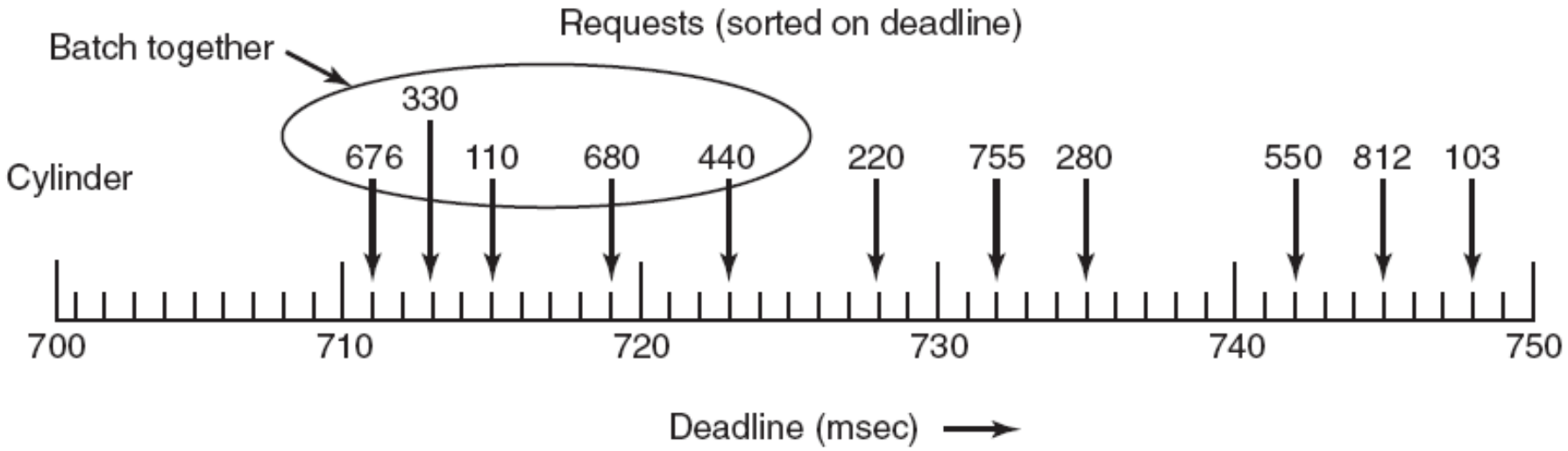

Figure 7-27. The scan-EDF algorithm uses deadlines and cylinder numbers for scheduling.

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