现 代 操 作 系 统

Modern Operating Systems

中南大学计算机学院

Chapter 6 Multimedia Operating Systems

- **6.1 Introduction**
- **6.2 Video Encoding & Audio Compression**
- **6.3 Multimedia Process Scheduling**
- **6.4 Examples of Multimedia file Systems**
- **6.5 File storage**
- **6.6 Caching**
- **6.7 Disk Scheduling**
- **6.8 Reading Materials**

6.1 Introduction---Multimedia

- Delivery of multimedia can be through:
  - DVD, Blu-ray, HD DVD etc
  - Web such as YouTube
- OS need to support multimedia in creation and delivery
- Also in games where in consists of many short clips that dynamically being selected for playing
- Video on demand – where customer at home is able to select a movie using their television remote control and have it displayed on their TV set
  - Require special infrastructure

6.1 Introduction---Multimedia

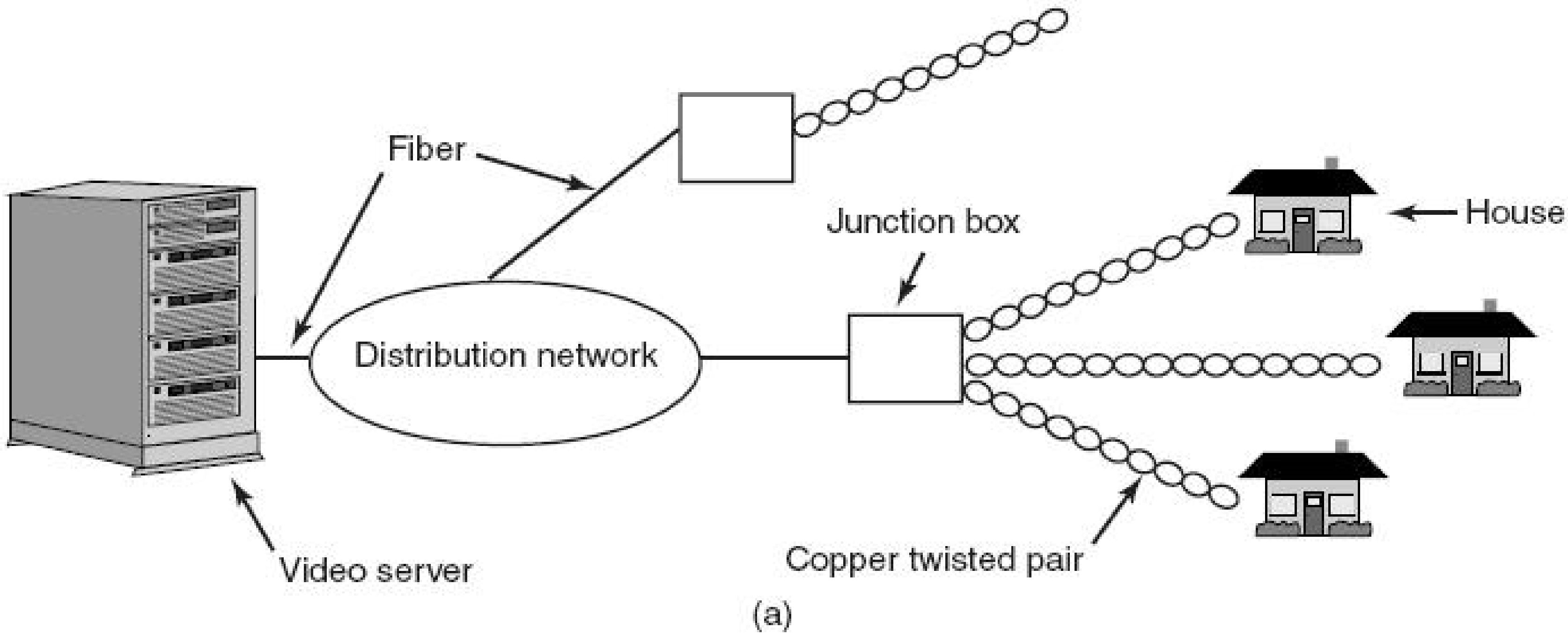


Figure 7-1. Video on demand using different local distribution technologies. (a) ADSL.

6.1 Introduction----Multimedia

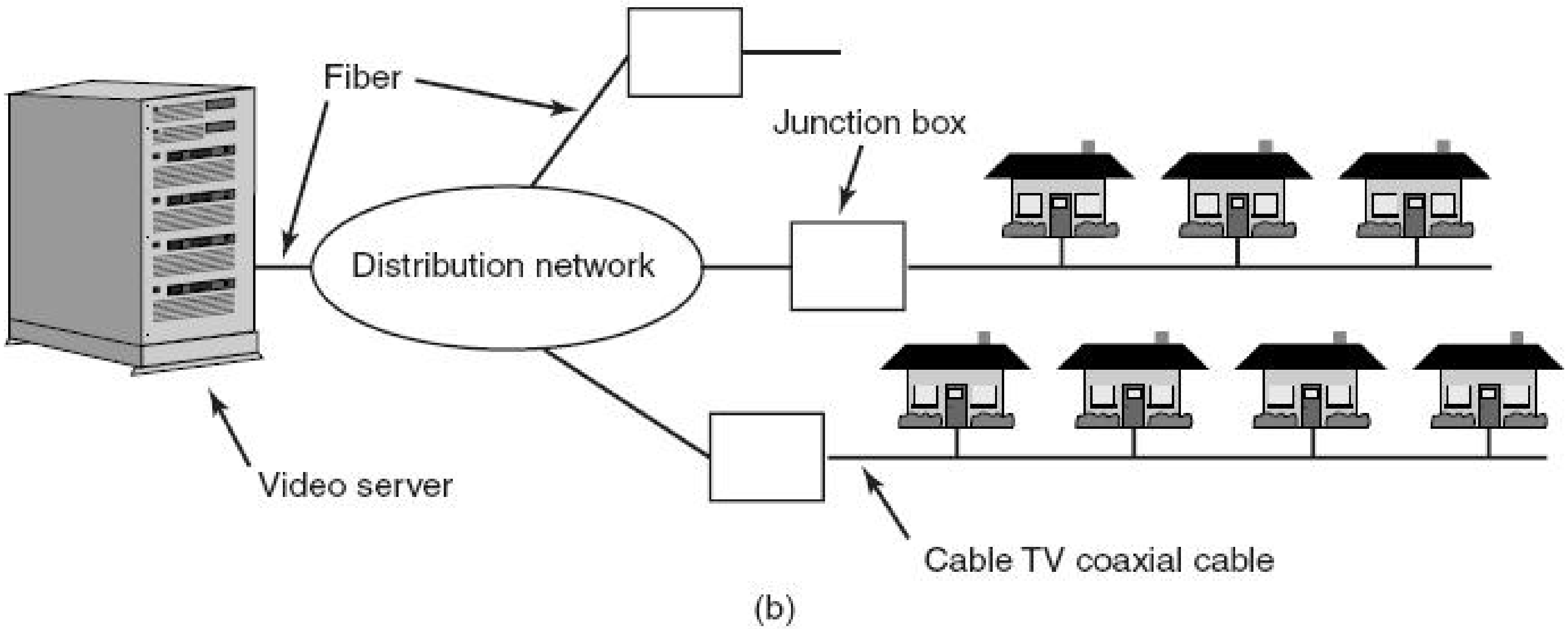


Figure 7-1. Video on demand using different local distribution technologies. (b) Cable TV.

6.1 Introduction----Multimedia

- ADSL systems
  - Provided by telephone companies
  - Use existing twisted-paired telephone line
  - Customer has dedicated lines, therefore bandwidth is not shared
  - But usually bandwidth is low (a few Mbps)
- Cable TV systems
  - Provided by cable operators
  - Use existing cable TV wiring for local distribution
  - Customers have to shared the lines
  - But higher bandwidth (at Gbps)

6.1 Introduction---- Multimedia

- Set-top box is where ADSL or TV cable terminates
  - Is a normal computer
  - Use to decode the signal before displaying on TV or monitor

6.1 Introduction----Multimedia

- Key characteristics of multimedia
  - Multimedia uses extremely high data rates.
    - Due to the nature of visual and acoustic information
    - The eye and the ear can process prodigious amounts of information per sec, and have to be fed at that rate to produce acceptable viewing experience
    - Therefore a video server requires huge amount of storage and must be supported by h/w and OS
  - Multimedia requires real-time playback.
    - Frames must be delivered at precise interval to prevent the movie from looking choppy
    - Based on standard such as NTSC, PAL and SECAM
    - Ear is more sensitive than eye, so variance of even a few ms in delivery times will be noticeable - jitter

6.1 Introduction----Multimedia

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.

6.1 Introduction----Multimedia

- Key characteristics of multimedia
  - The real-time properties required to play back multimedia acceptably are often described by quality of service (QoS) parameters.
    - Include average bandwidth available, peak bandwidth available, min and max delay (jitter) and bit loss probability
    - QoS guarantees is to reserve capacity in advance for each new customer
      - Portion of the CPU, memory buffers, disk transfer capacity, and network bandwidth
  - Diversity
    - One multimedia file probably includes video, movie or other different-language files and etc.
  - Integration
    - Integration of multimedia hardware and software
    - Integration of multimedia information
  - Interactive---controllable

6.1 Introduction----Multimedia

- Hardwares of multimedia system
  - sound card
  - Video card
  - DVD driver
  - Scanner
  - Digital camera
  - DV Digital Video

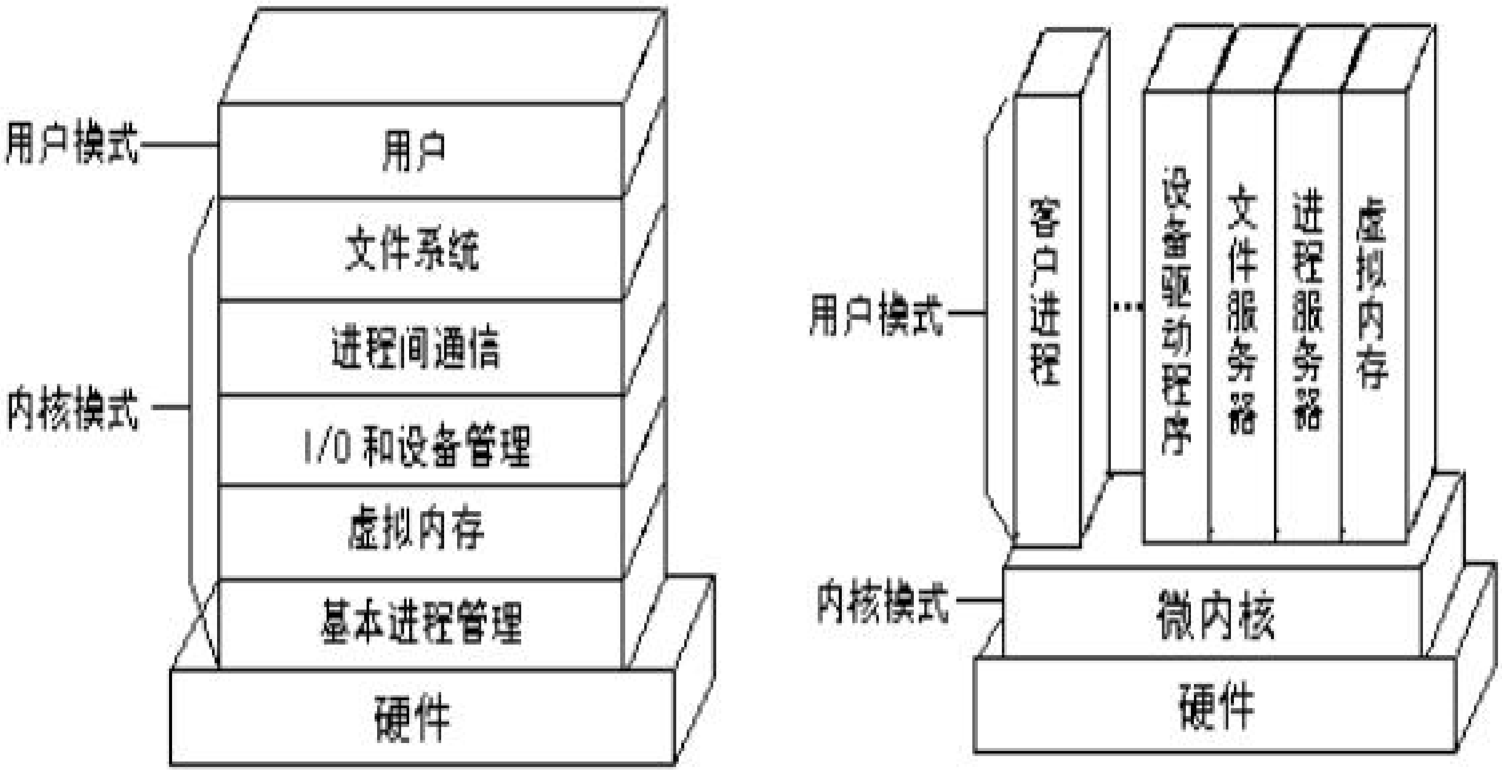
6.1 Introduction----Multimedia Operating System

- Challenge of Operating System
  - Example: users get a video file from Internet, and at the same time he has opened a txt file, so some accidental risk will be appeared---- thrashiold
  - Reasons from Operating System
    - No real-time support
    - No QoS-based resource management
    - Inefficient I/O management and controlling
    - No file system to support continuous multimedia files.
- Need to enhance some aspects of OS's support
  - Architecture
  - Resource management
  - Program design: synchronization, deadline time, real-time

6.1 Introduction----Multimedia Operating System

- Types
  - Multimedia Operating System for PC
    - Windows 95, Windows XP
  - Multimedia Operating System for Internet
    - Support resource sharing, coordinate operation, interactive of multi-computer
  - Multimedia Operating System for Distribution
    - The same management method
    - Same operating system
    - Same access method

6.1 Introduction----Multimedia Operating System



Layer architecture & Micro Kernel

6.1 Introduction----Multimedia Files

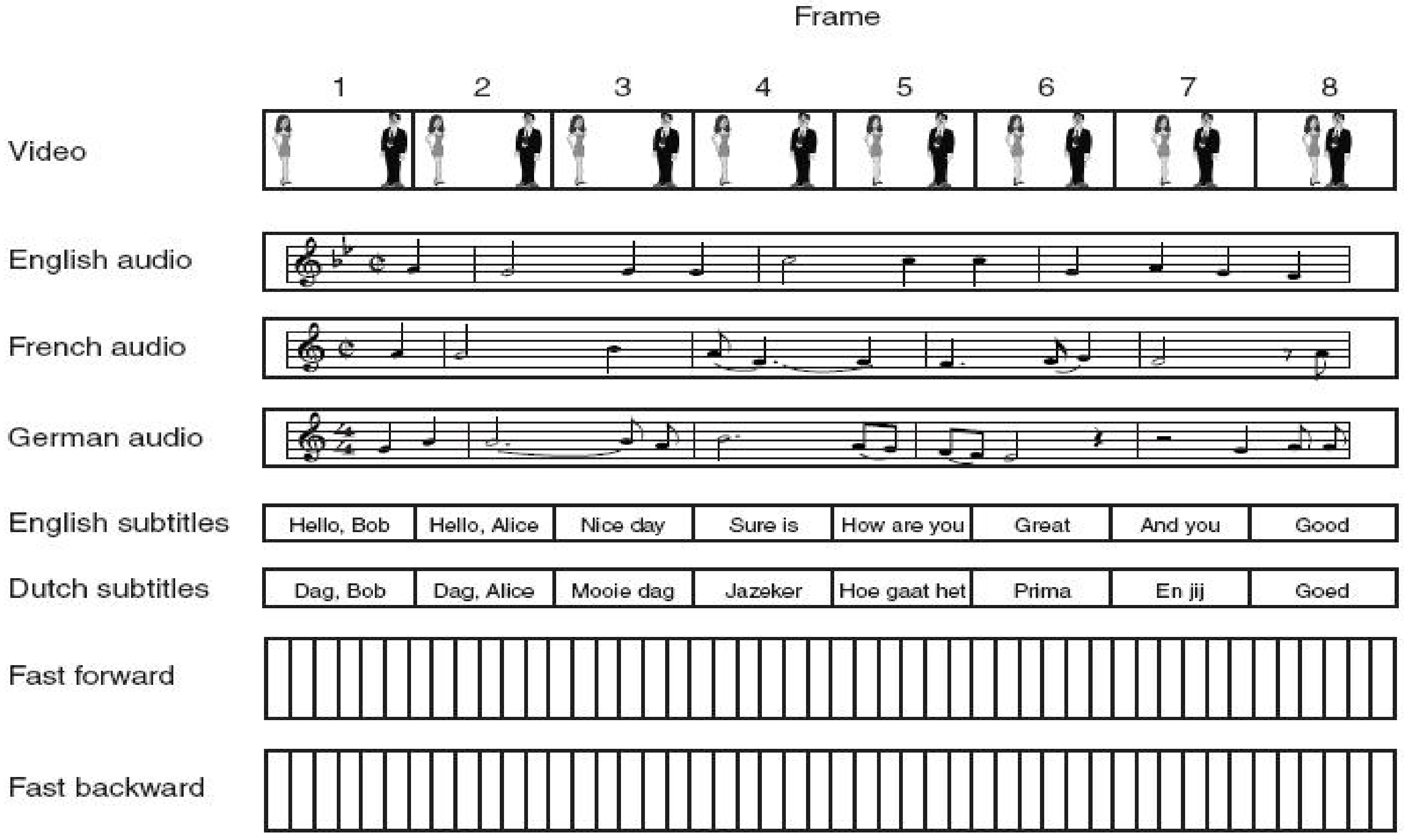


Figure 7-3. A movie may consist of several files.

6.1 Introduction----Multimedia Files

- Digital movie may actually consist of many files:
  - One video file
  - Multiple audio files
  - Multiple text files
- The file system needs to keep track of multiple “subfiles” per file.
  - Manage each subfile as a traditional file and to have a new data structure that lists all the subfiles per multimedia file
  - Or invent a kind of two-dimensional i-node, with each column listing the blocks of each subfiles
- Organization must be such that the viewer can dynamically choose which audio and subtitle tracks to use at the time the movie is viewed
  - Synchronization required

6.1 Introduction----Video Encoding

- Human eye has the property that when an image is flashed on the retina, it is retained for some number of ms before decaying
  - 50 or more images/s, the eye does not notice that it is looking at discrete images.

6.1 Introduction----Video Encoding

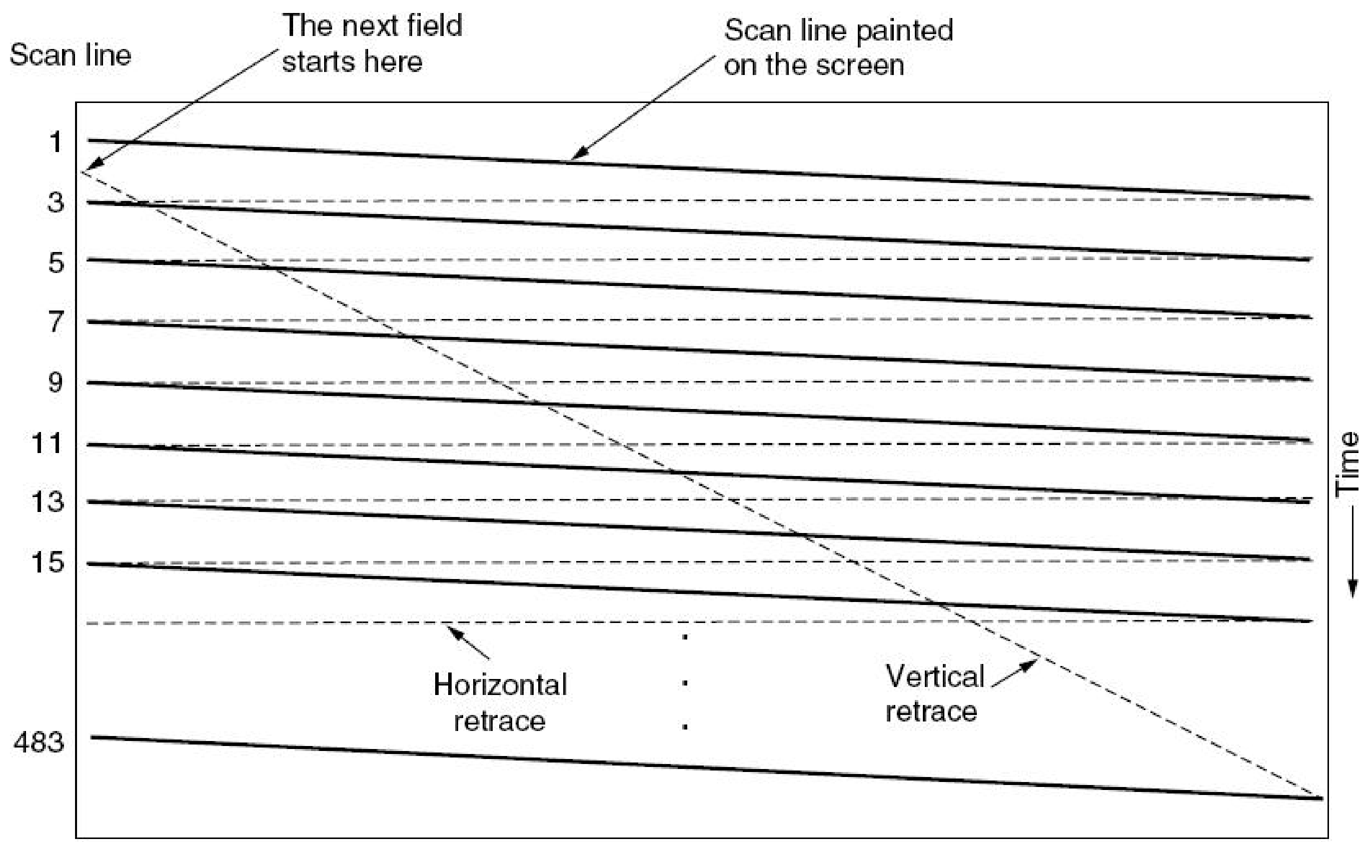


Figure 7-4. The scanning pattern used for NTSC video and television.

6.1 Introduction----Audio Encoding

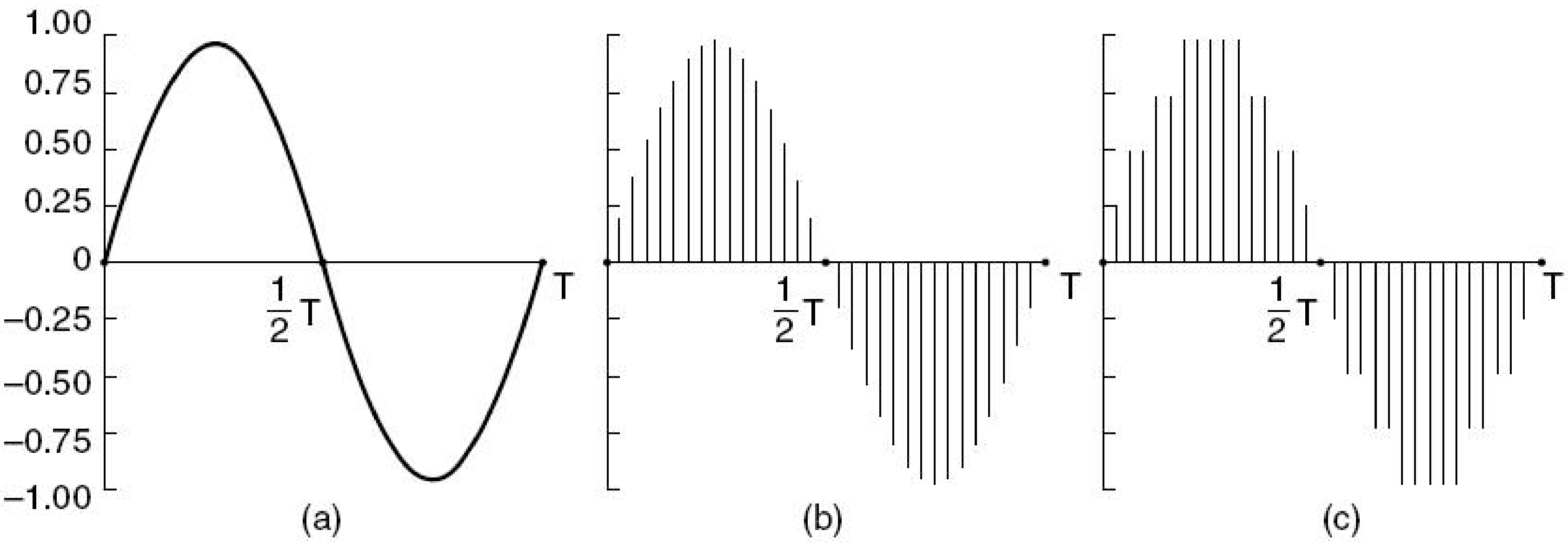


Figure 7-5. (a) A sine wave. (b) Sampling the sine wave.
(c) Quantizing the samples to 4 bits.

6.2.1 The JPEG Standard

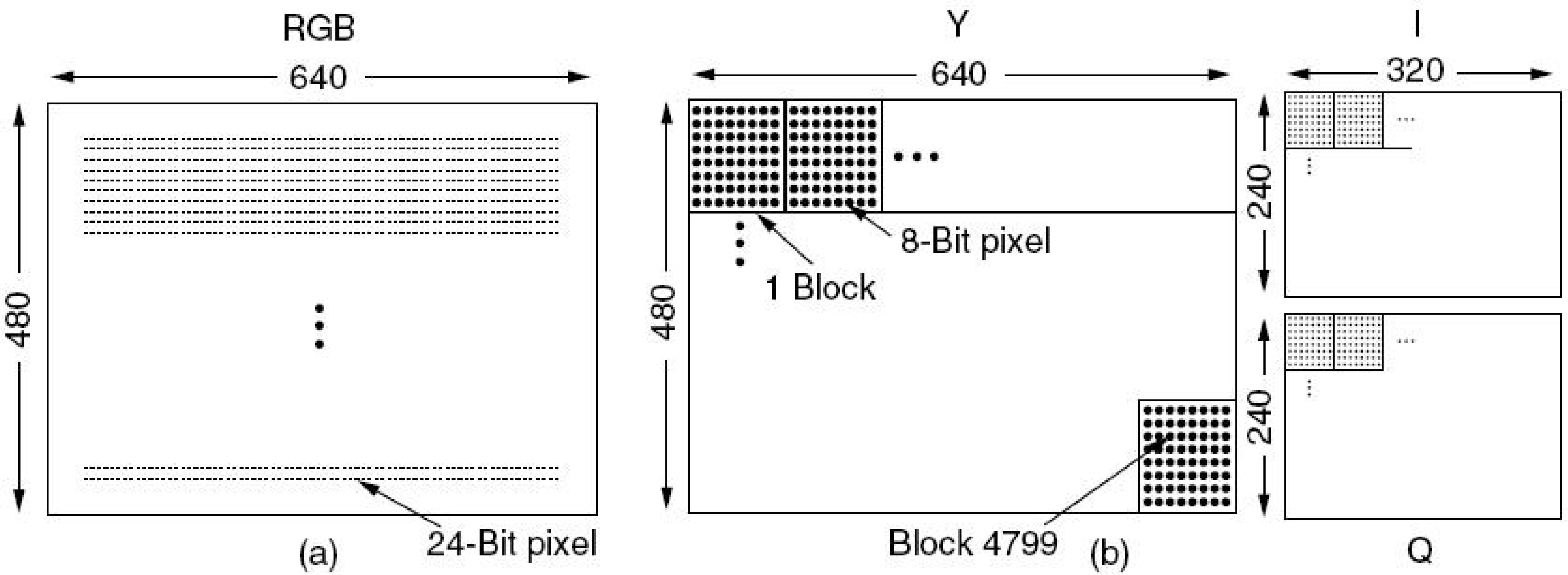


Figure 7-6. (a) RGB input data. (b) After block preparation.

6.2.1 The JPEG Standard

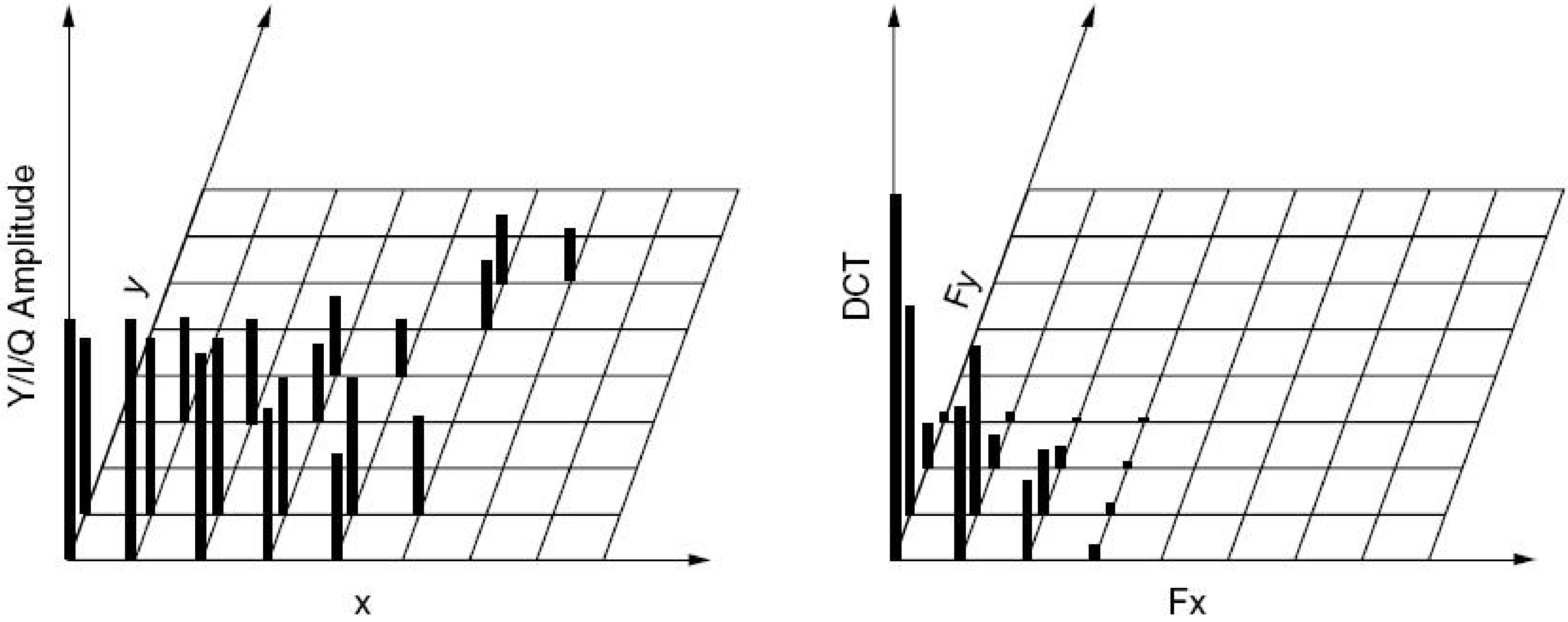


Figure 7-7. (a) One block of the Y matrix. (b) The DCT coefficients.

6.2.1 The JPEG Standard

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.

6.2.1 The JPEG Standard

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

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

6.2.2 The MPEG Standard

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

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

6.2.2 The MPEG Standard

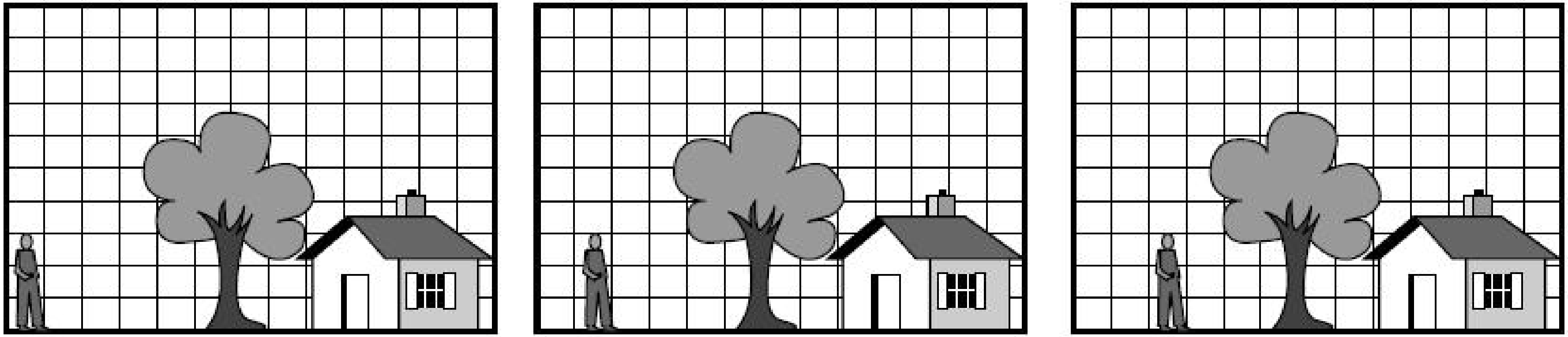


Figure 7-10. Three consecutive video frames.

6.2 Audio Compression

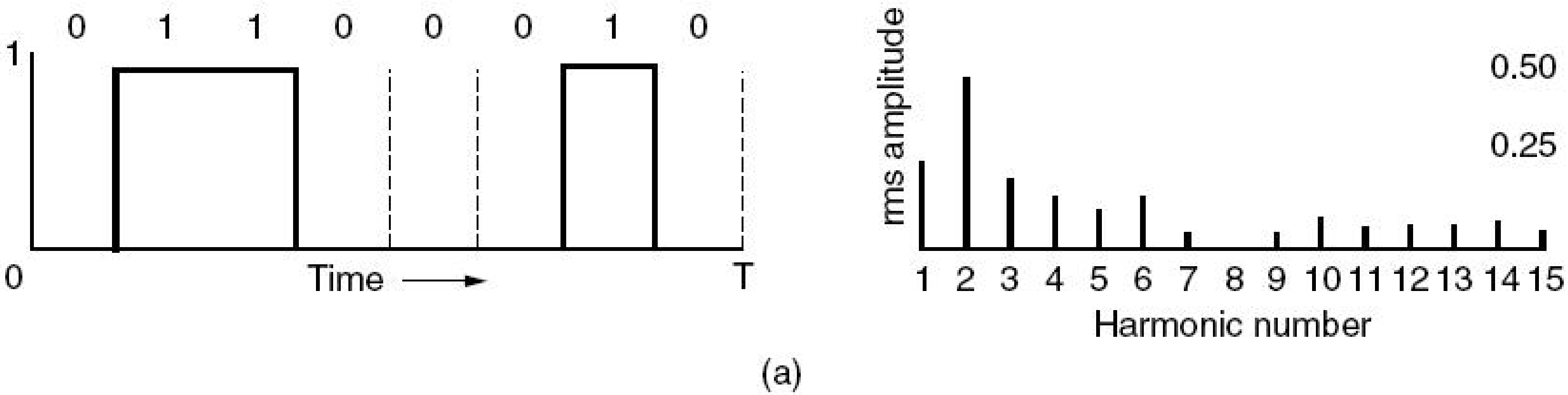


Figure 7-11. (a) A binary signal and its root-mean-square Fourier amplitudes.

6.2 Audio Compression

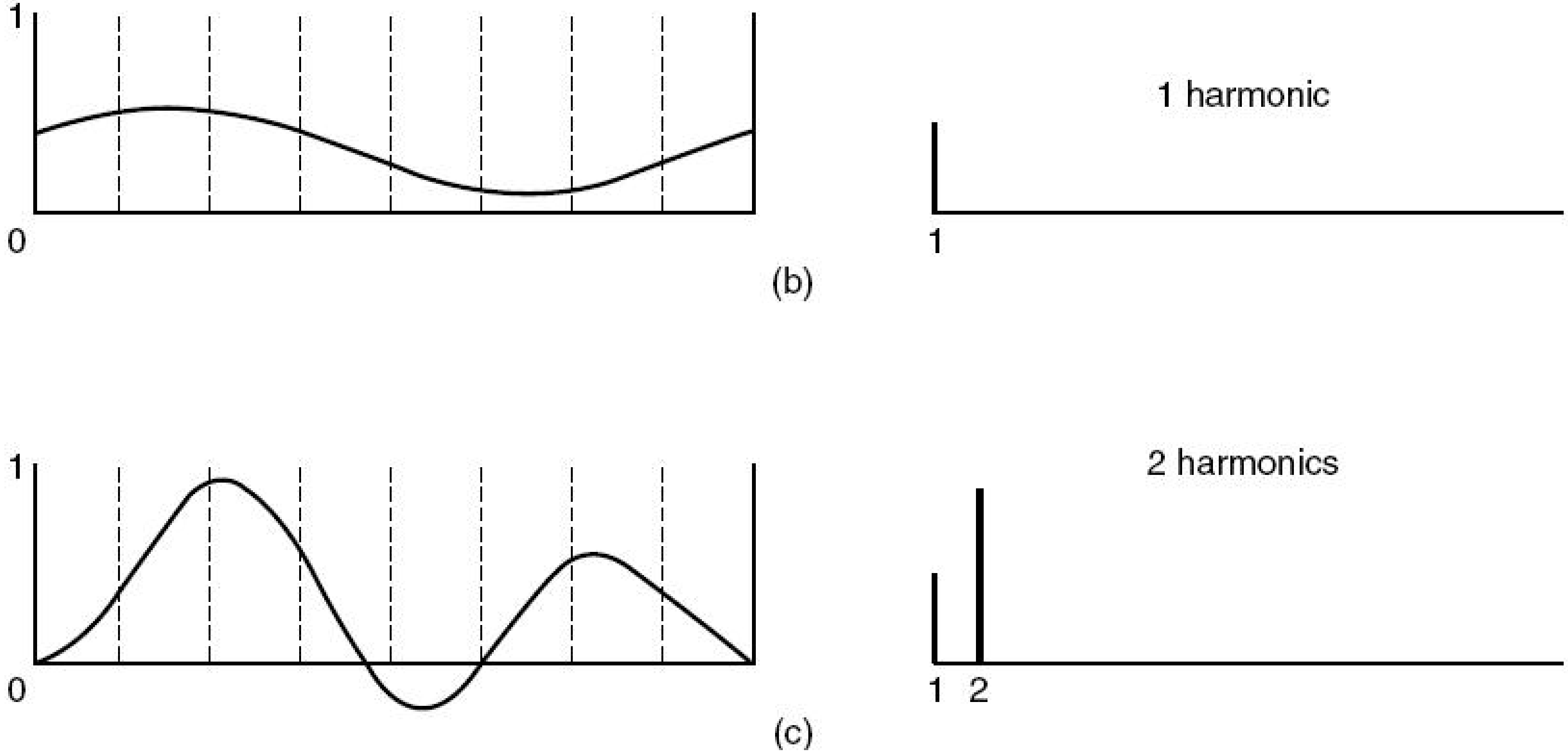


Figure 7-11. (b)–(e) Successive approximations to the original signal.

6.2 Audio Compression

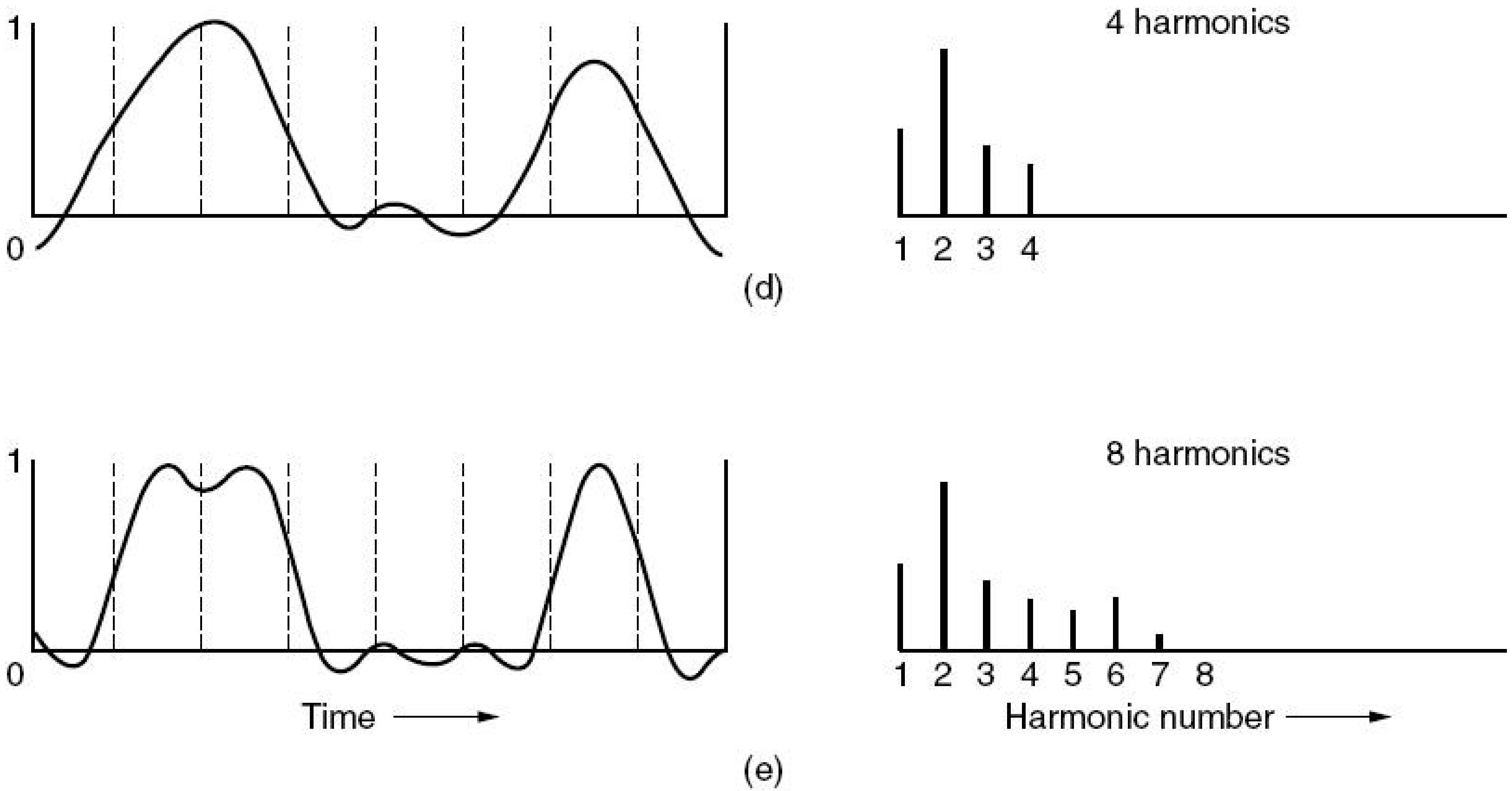


Figure 7-11. (b)–(e) Successive approximations to the original signal.

6.2 Audio Compression

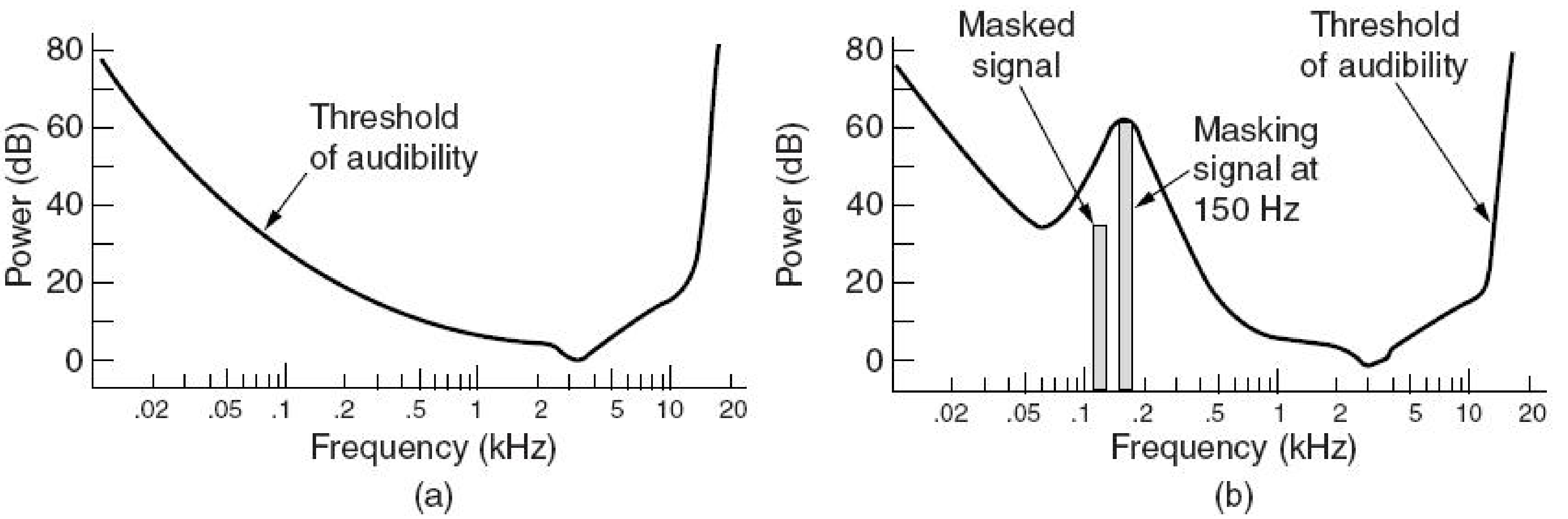


Figure 7-12. (a) The threshold of audibility as a function of frequency. (b) The masking effect.

6.2 Audio Compression

Possible sampling configurations:

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

6.3 Multimedia Process Scheduling

- OS support for multimedia in three main ways:
  - Process scheduling
  - File systems
  - Disk scheduling
- Scheduling Homogeneous Processes
  - Simplest kind
    - Fixed number of movies, using same frame rate, video resolution, data rates and other parameters
    - All processes are equally important, have the same amount of work to do per frame, and block when they finished processing the current frame:-round robin

6.3 General Real-Time Scheduling(1)

- Simple scheduling technique will fail due to
  - Number of viewers changes all the time
  - Frame sizes are varied due to compression
  - Different movies have different resolutions
- Thus, different process may run at different frequencies, with different amount of works to do and with different deadline
  - Multiple processes competing for the CPU
  - Real-time scheduling

6.3 General Real-Time Scheduling(2)

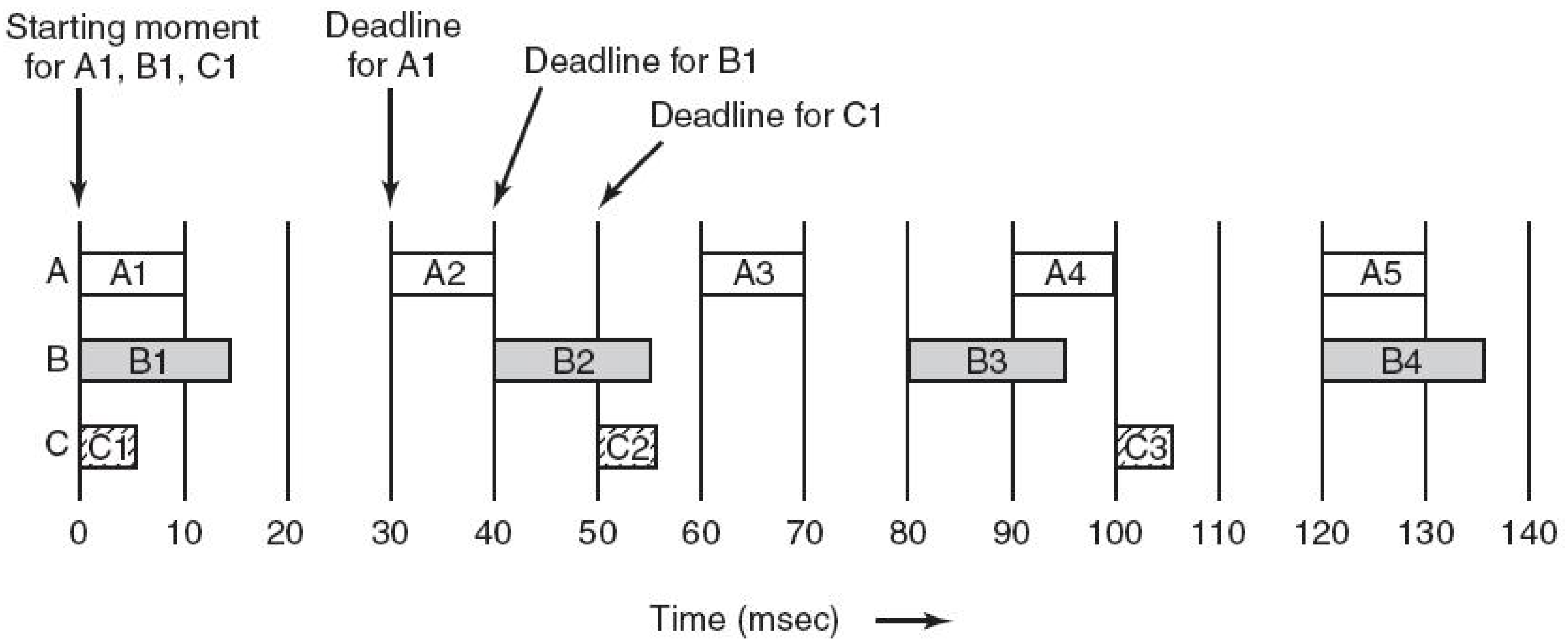


Figure 7-13. Three periodic processes, each displaying a movie. The frame rates and processing requirements per frame are different for each movie.

6.3 General Real-Time Scheduling (3)

- Judge that whether this set of processes is schedulable at all?

$$\sum_{i=1}^{m} \frac{C_i}{P_i} \leq 1$$

  - m: the number of processes
  - Pi: the period time for process i
  - Ci: the required CPU time per frame of process i
- Scheduling mode
  - Preemptable vs. nonpreemptable
  - Static vs. dynamic

6.3 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.

6.3 Rate Monotonic Scheduling (2)

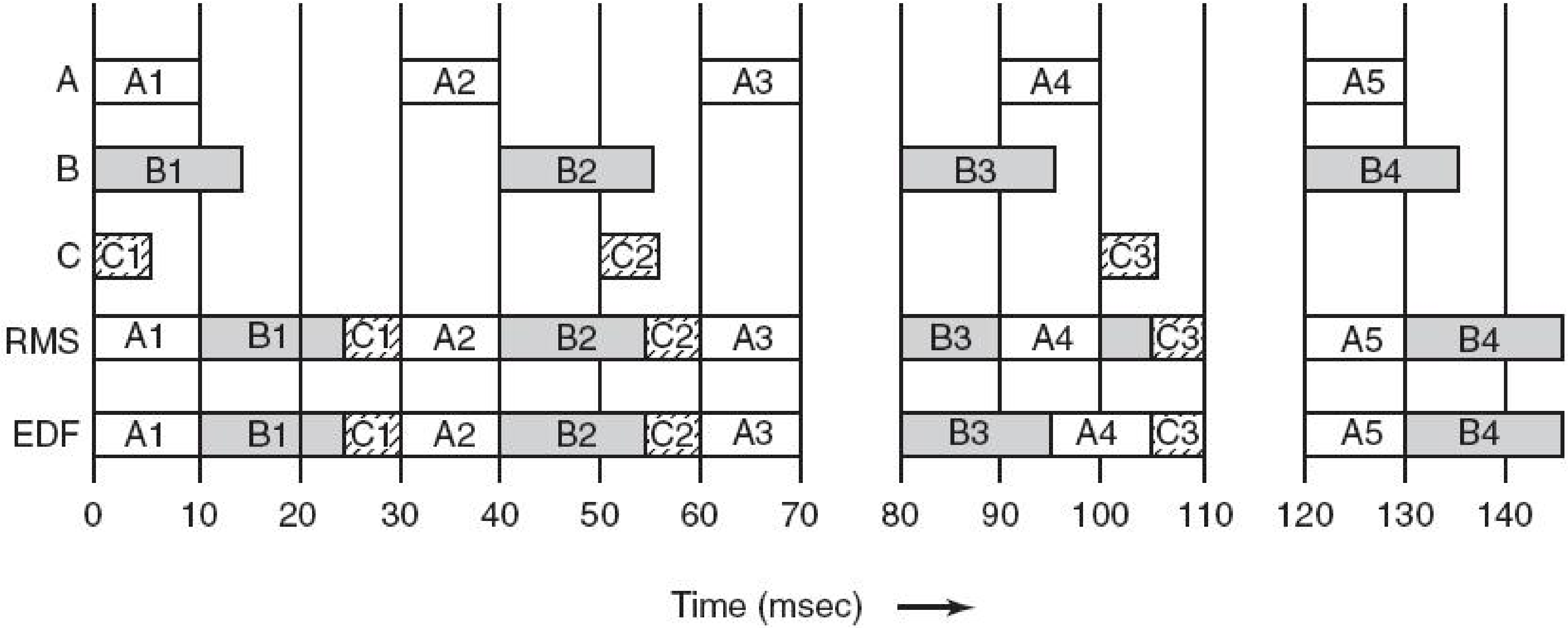


Figure 7-14. An example of RMS and EDF real-time scheduling.

6.3 Rate Monotonic Scheduling (3)

- Liu and Layland proved that RMS is optimal among the class of static scheduling algorithms.

- question
  - If processing each frame requires 5 ms, what is the maximum number of PAL streams that can be sustained by a server running RMS?

6.3 Earliest Deadline First Scheduling

- a dynamic algorithm that does not require processes to be periodic
- it doesn’t require the same run time per CPU burst
- The algorithm runs the first process on the list, the one with the closest deadline.

6.3 EDF Scheduling

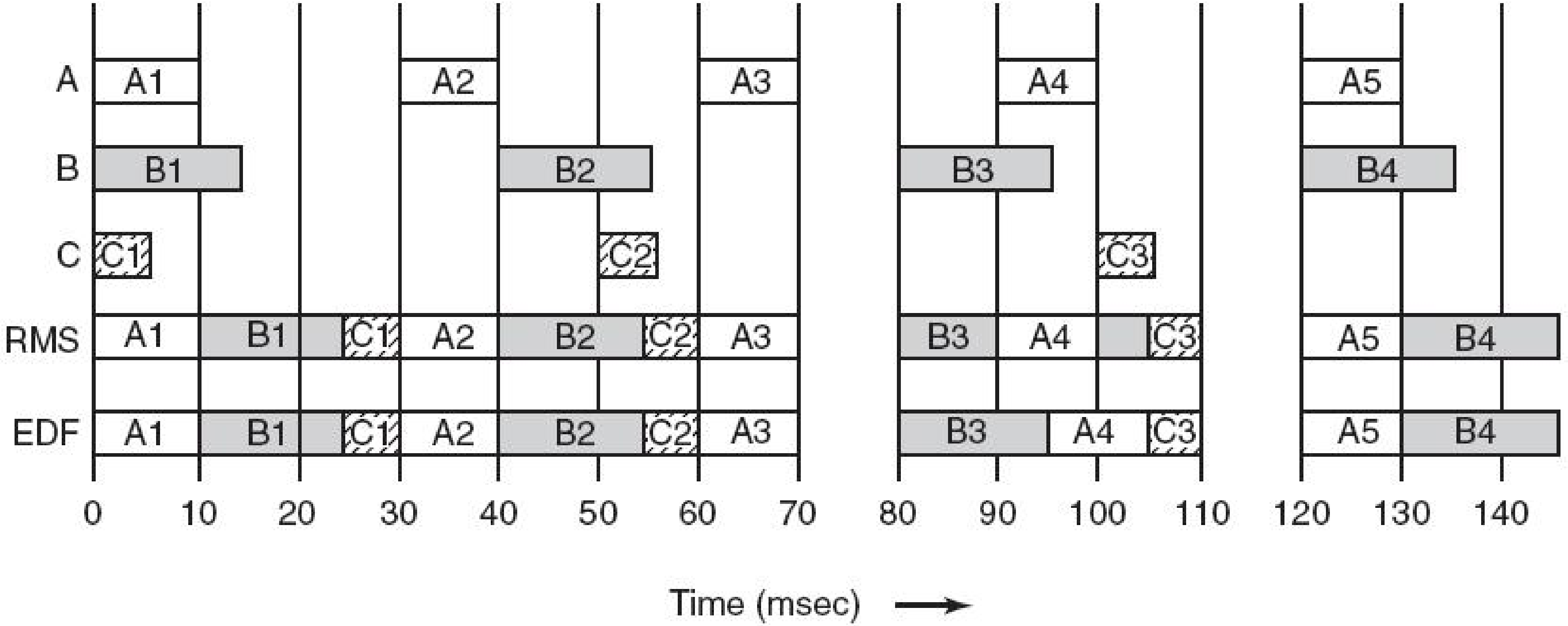


Figure 7-14. An example of RMS and EDF real-time scheduling.

6.3 Earliest Deadline First Scheduling

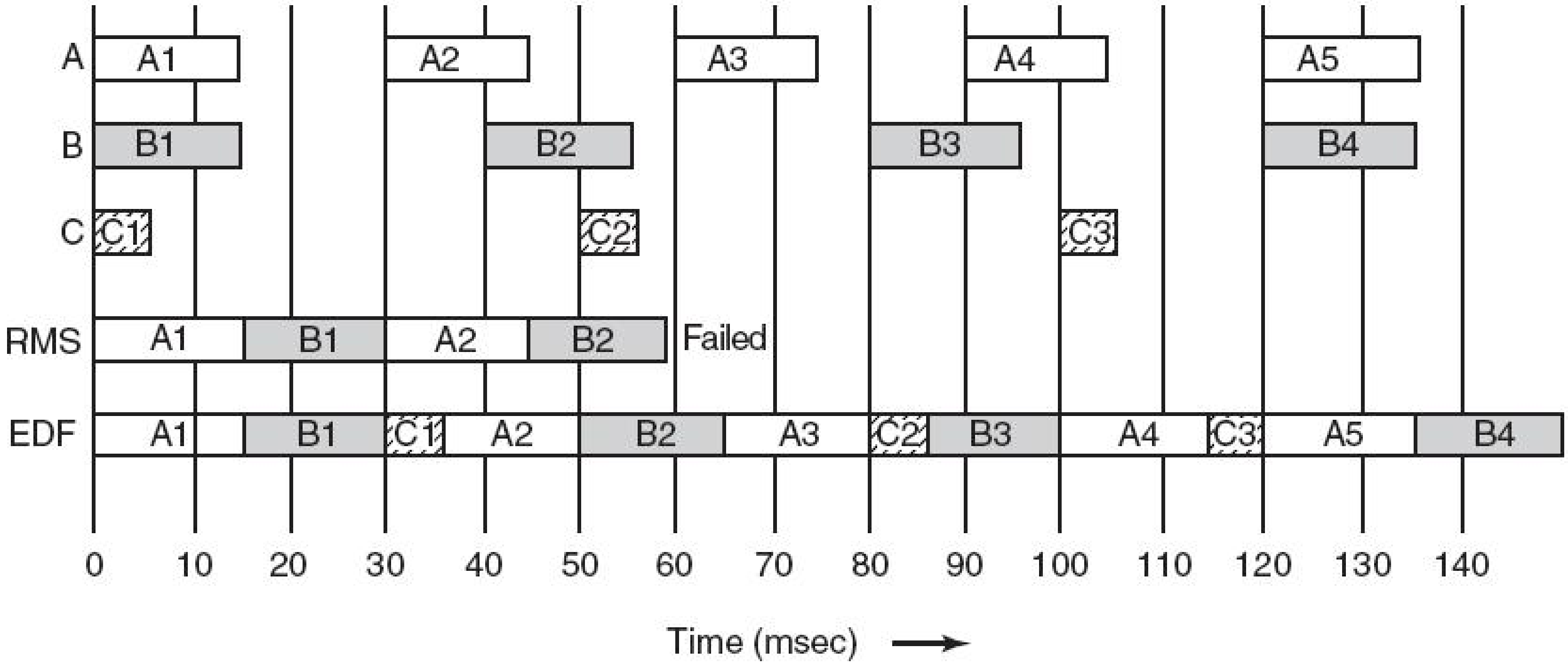


Figure 7-15. Another example of real-time scheduling with RMS and EDF.

6.3 Earliest Deadline First Scheduling

- using static priorities only works if the CPU utilization is not too high.
- Liu and Layland (1973) proved that for any system of periodic processes, if

$$\sum_{i=1}^{m} \frac{C_i}{P_i} \leq m(2^{1/m} - 1)$$

then RMS is guaranteed to work.

6.3 Earliest Deadline First Scheduling

- Question
  - The CPU of a video server has a utilization of 65%. How many movies can it show using RMS scheduling?
  - In Fig. 7-15, EDF keeps the CPU busy 100% of the time up to t = 150. It cannot keep the CPU busy indefinitely because there is only 975-msec work per second for it to do so. Extend the figure beyond 150 msec and determine when the CPU first goes idle with EDF.

6.4 Multimedia File System Paradigms

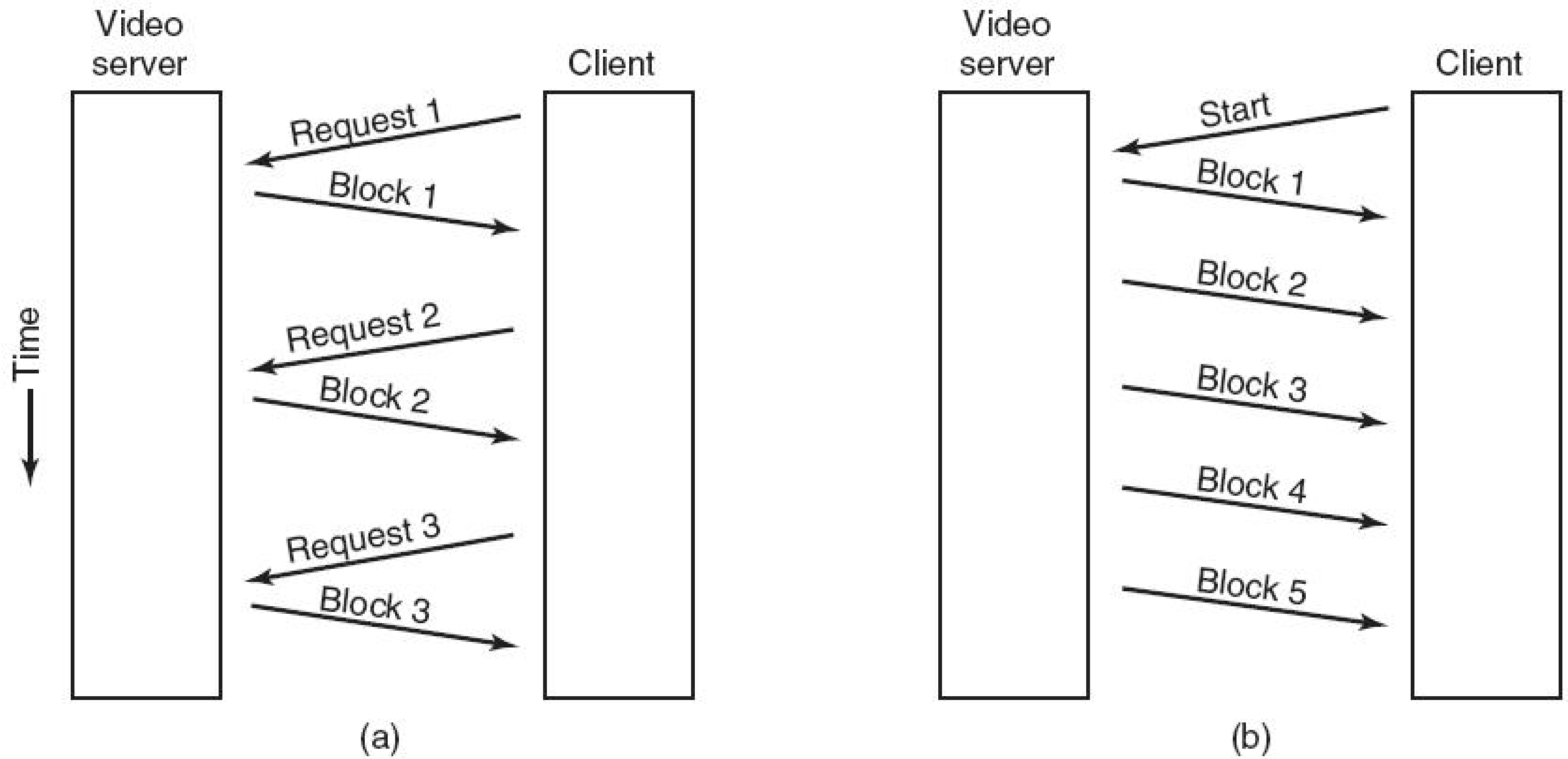


Figure 7-16. (a) A pull server. (b) A push server.

6.4.1 VCR Control Functions

- VCR: Video Cassette Recorders
- standard VCR control functions
  - Pause
  - fast forward
  - Rewind
- Problems
  - For acceptable performance, the server may reserve resources(disk bandwidth and memory buffers)for each outgoing stream
  - Compression takes more complication.

6.4.2 Near Video on Demand

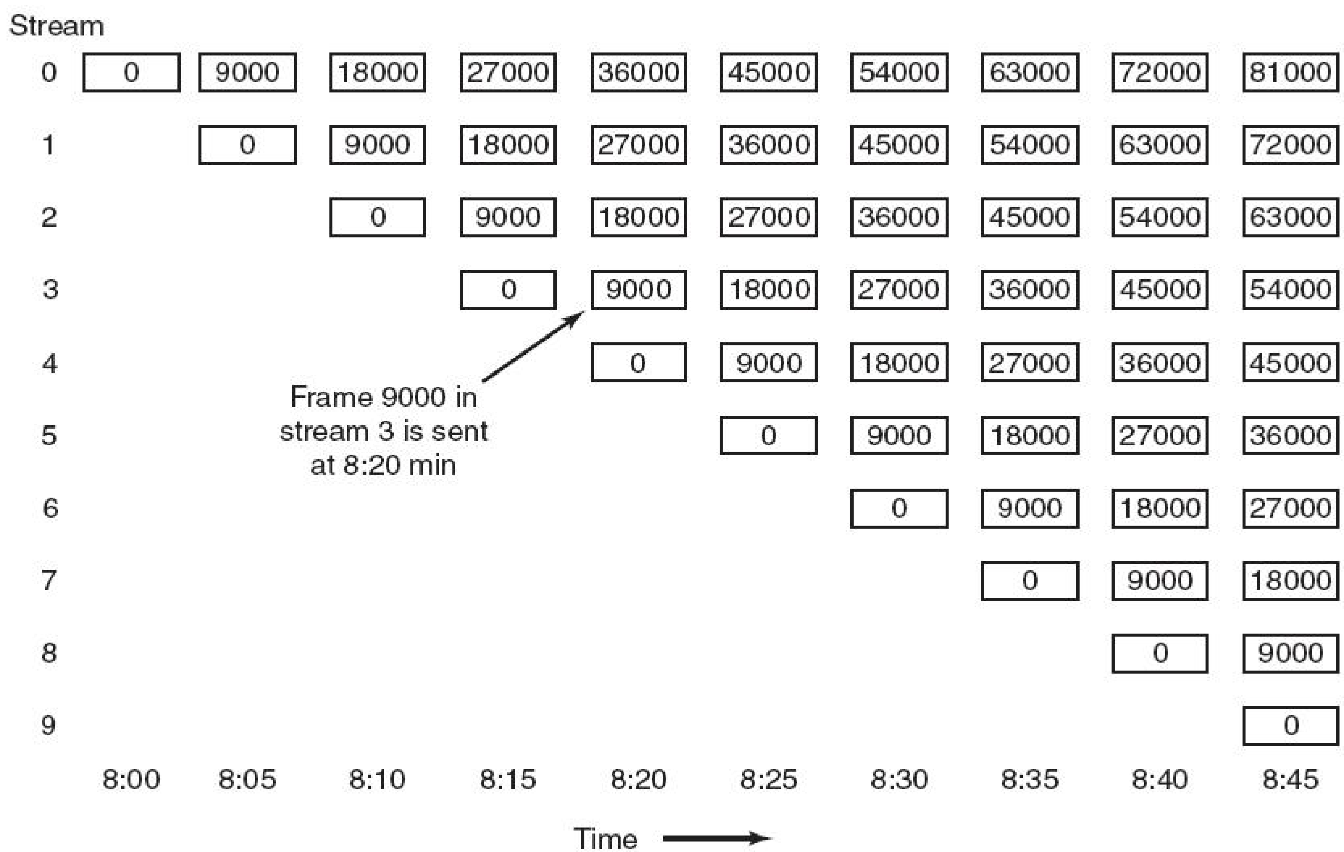


Figure 7-17. Near video on demand has a new stream starting at regular intervals, in this example every 5 minutes (9000 frames).

6.4.2 Near Video on Demand

- Question
  - The operators of a near video-on-demand system have discovered that people in a certain city are not willing to wait more than 6 minutes for a movie to start. How many parallel streams do they need for a 3-hour movie?

6.4.3 Near Video on Demand with VCR Functions (1)

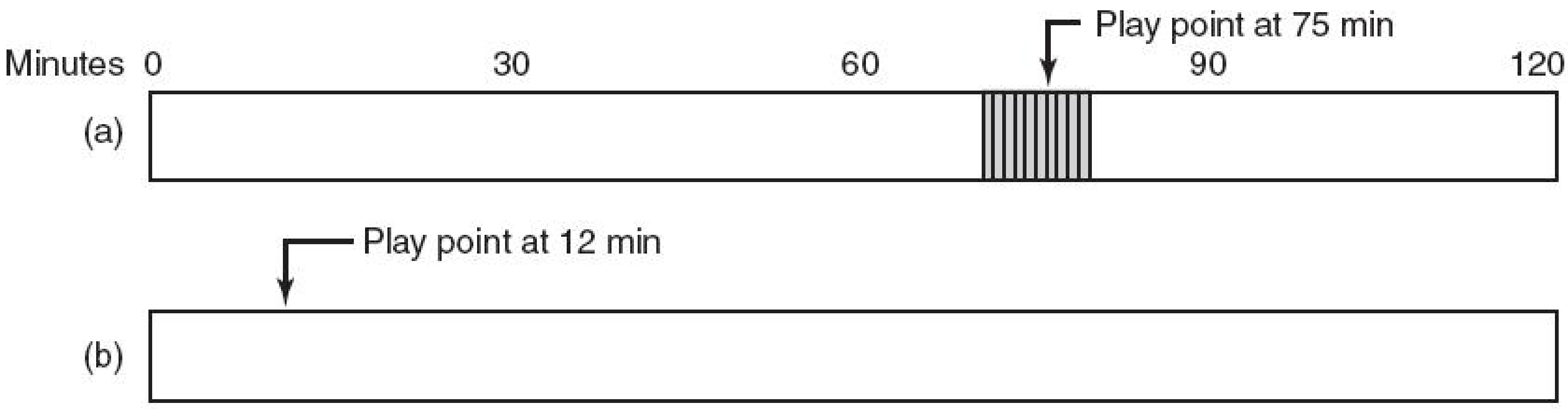


Figure 7-18. (a) Initial situation. (b) After a rewind to 12 min

6.4.3 Near Video on Demand with VCR Functions (2)

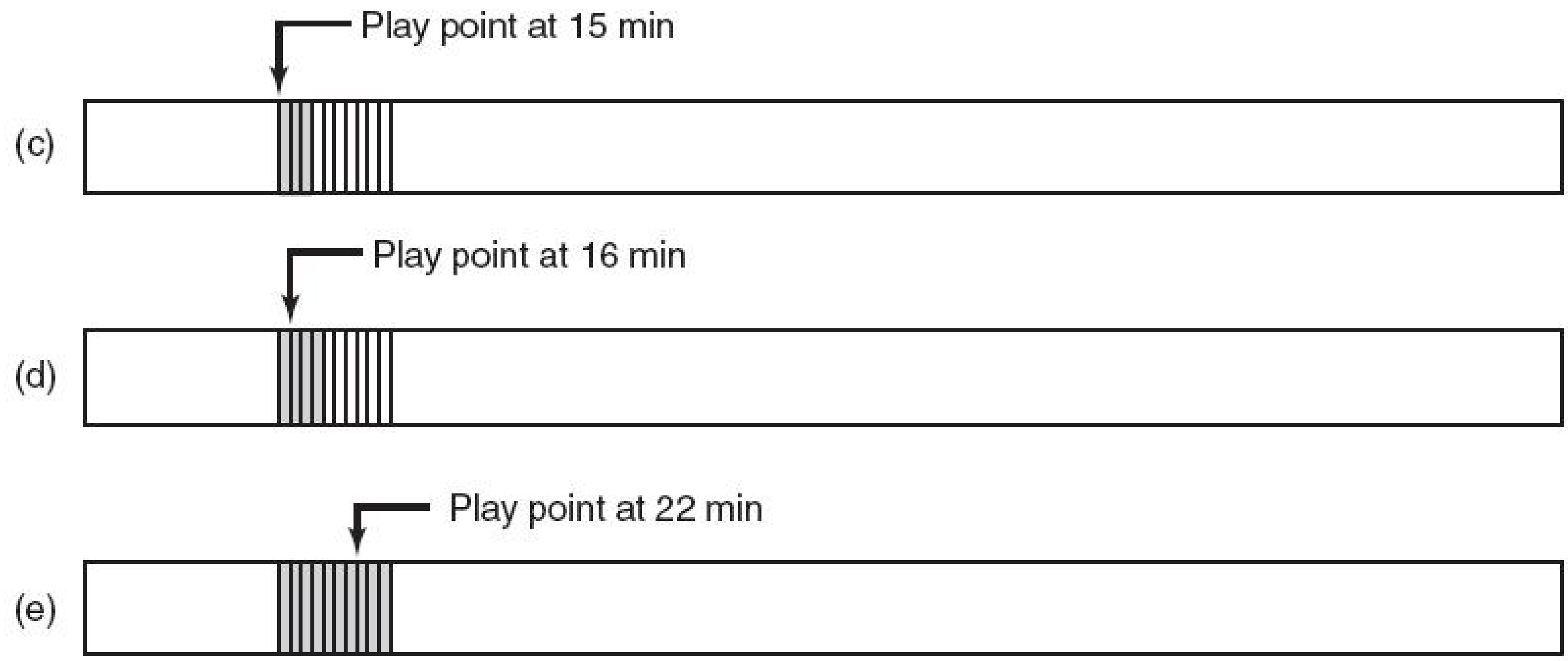


Figure 7-18. (c) After waiting 3 min. (d) After starting to refill the buffer. (e) Buffer full.

6.5 FILE PLACEMENT

- Features of Multimedia files
  - Very large
  - Written only once but read many times
  - Tend to be accessed sequentially
  - Playback must meet strict quality of service criteria
- Requirement for Multimedia files Placement
  - Data can be streamed to the network or output device at the requisite speed and without jitter

6.5.1 Placing a File on a Single Disk

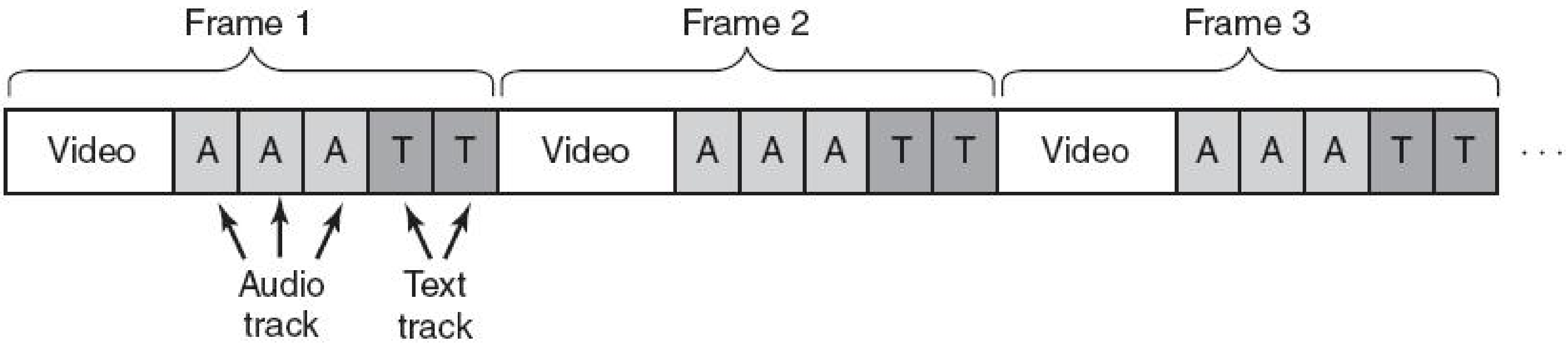


Figure 7-19. Interleaving video, audio, and text in a single contiguous file per movie.

6.5.2 Two Alternative File Organization Strategies

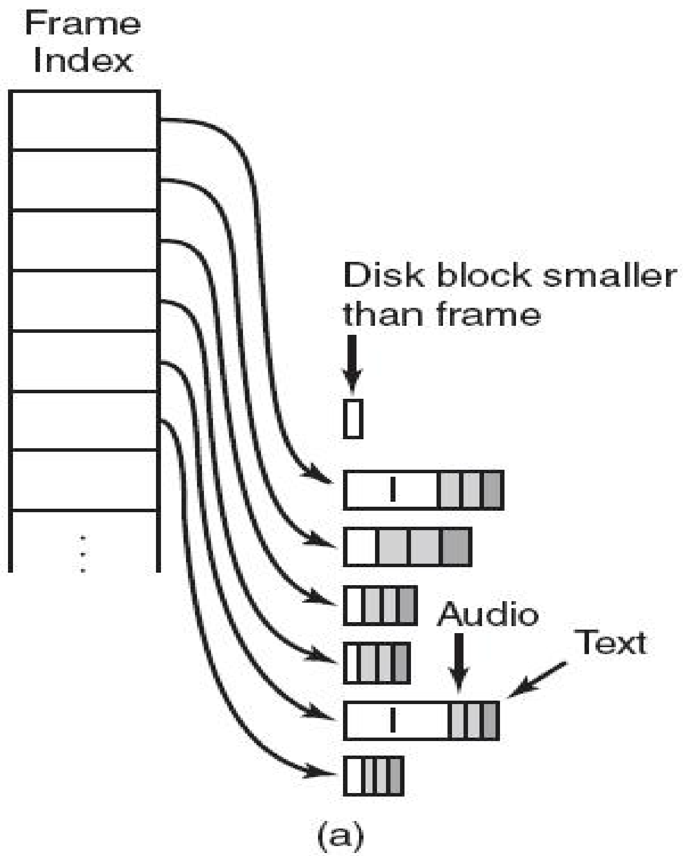


Figure 7-20. Noncontiguous movie storage. (a) Small disk blocks.

6.5.2 Two Alternative File Organization Strategies

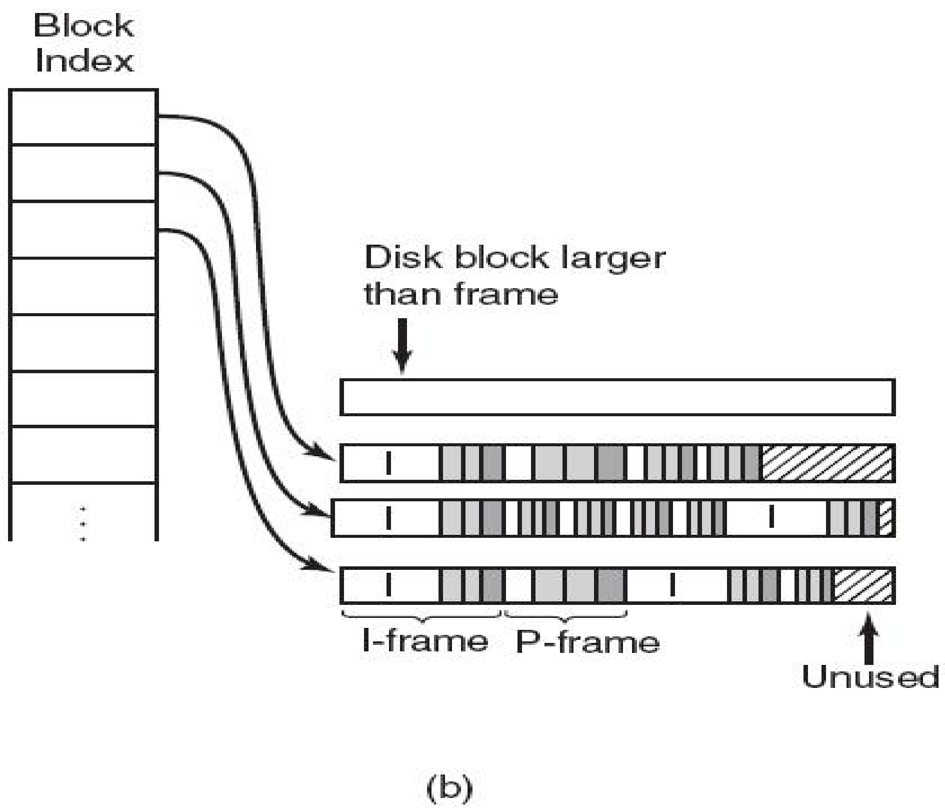


Figure 7-20. Noncontiguous movie storage (b) Large disk blocks.

6.5.2 Two Alternative File Organization Strategies

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.

6.5.2 Two Alternative File Organization Strategies

model	fragement	buffer	disk storage management	Disk performance	Fast forward function
Small disk blocks	a fraction of the last block in each frame	Double buffer	complex	Constant time length	easy
Large disk blocks (no splitting)	internal	Circular transmission buffer	Simple	Constant data length	hard
Large disk blocks (splitting)	No	Circular transmission buffer	middle	Constant data length	hard

6.5.3 Placing Files for Near Video on Demand

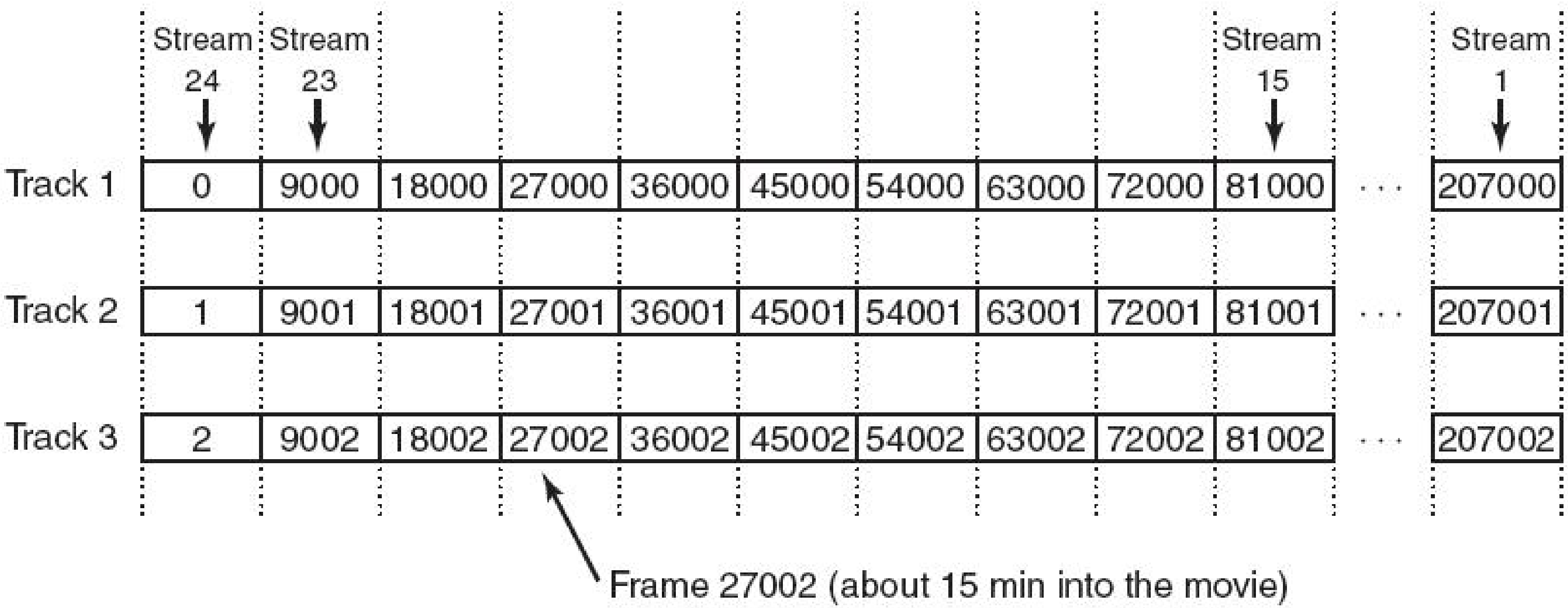


Figure 7-21. Optimal frame placement for near video on demand.

6.5.4 Placing Multiple Files on a Single Disk (2)

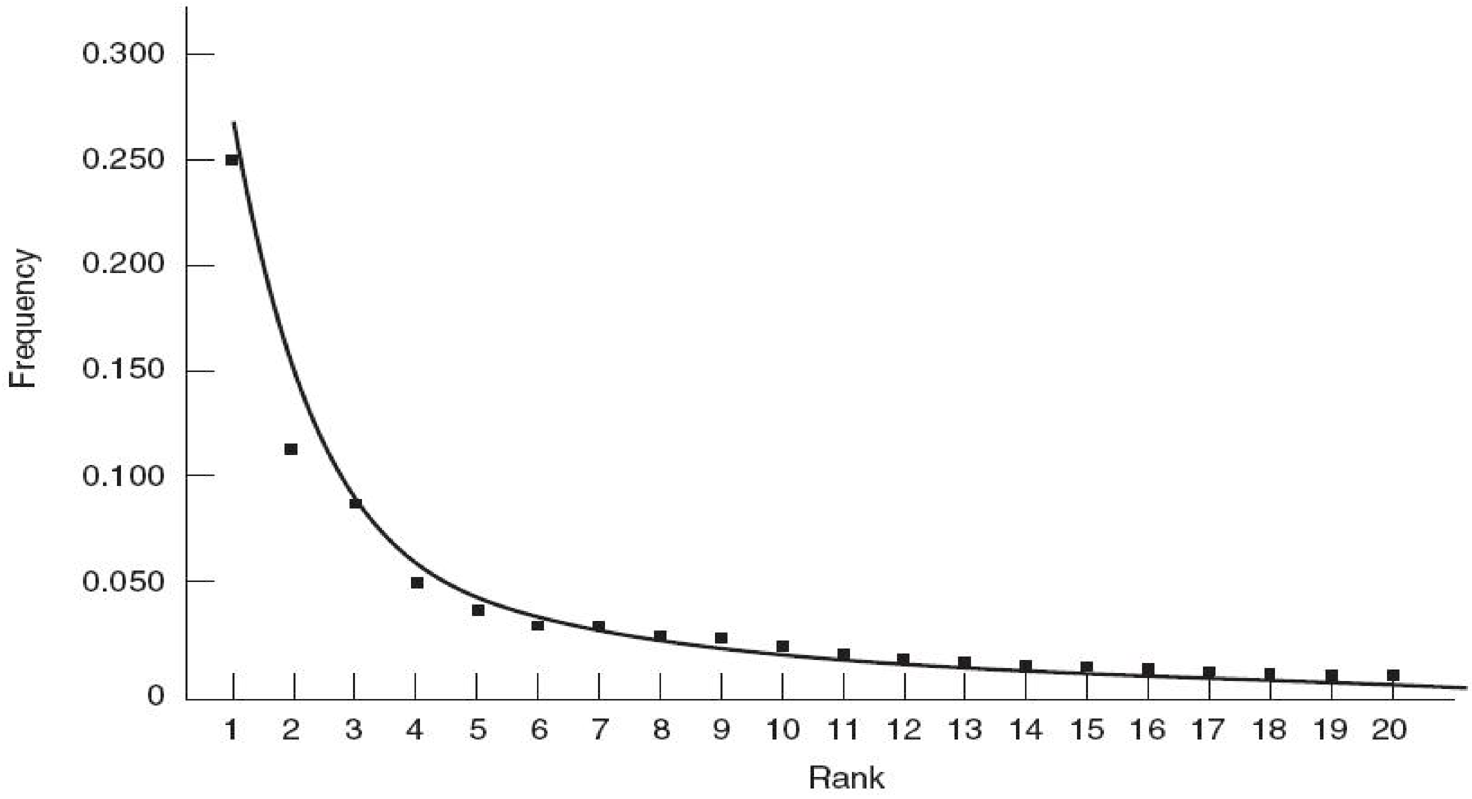


Figure 7-22. The curve gives Zipf's law for N = 20. The squares represent the populations of the 20 largest cities in the U.S., sorted on rank order (New York is 1, Los Angeles is 2, Chicago is 3, etc.).

6.5.4 Placing Multiple Files on a Single disk(1)

- Zipf's law
  - If the movies, books, Web pages, or words are ranked on their popularity, the probability that the next customer will choose the item ranked k-th in the list is *C/k,* where C is a normalization constant.
- The best strategy for modeling the performance of a video server and for placing files
  - organ-pipe algorithm (Grossman and Silverman,
  - 1973; and Wong, 1983)
  - simple and distribution independent

6.5.4 Placing Multiple Files on a Single Disk (3)

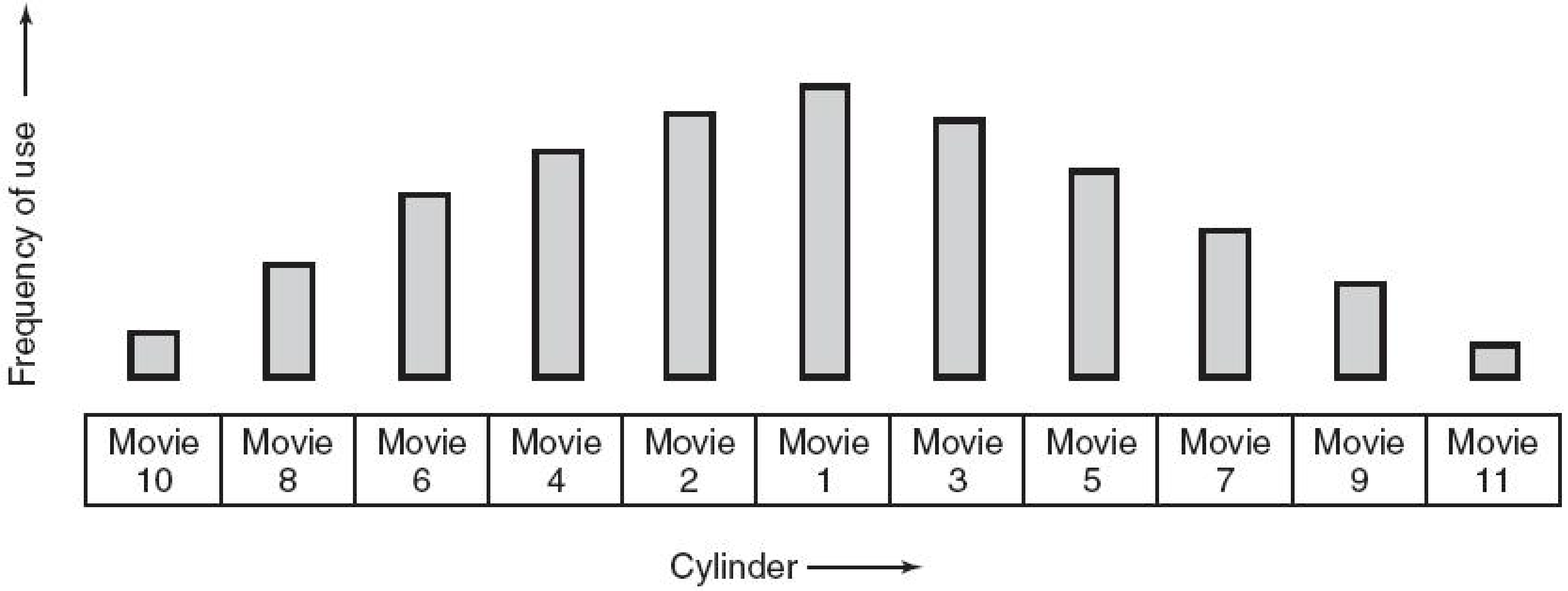


Figure 7-23. The organ-pipe distribution of files on a video server.

6.5.5 Placing Files on Multiple Disks (1)

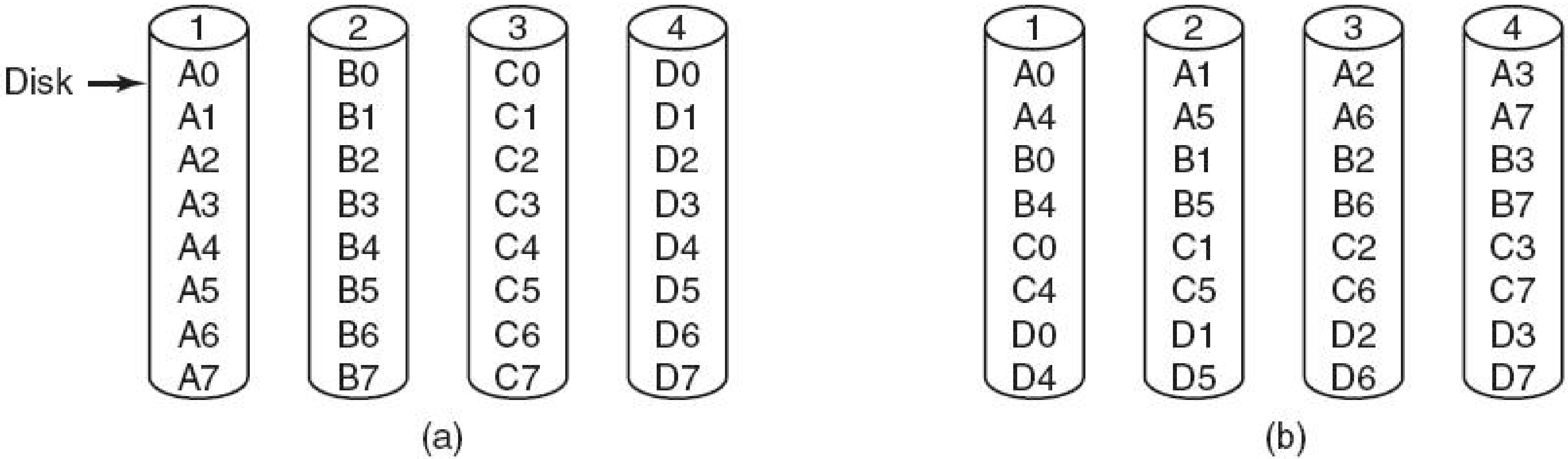


Figure 7-24. Four ways of organizing multimedia files over multiple disks. (a) No striping. (b) Same striping all files.

6.5.5 Placing Files on Multiple Disks (2)

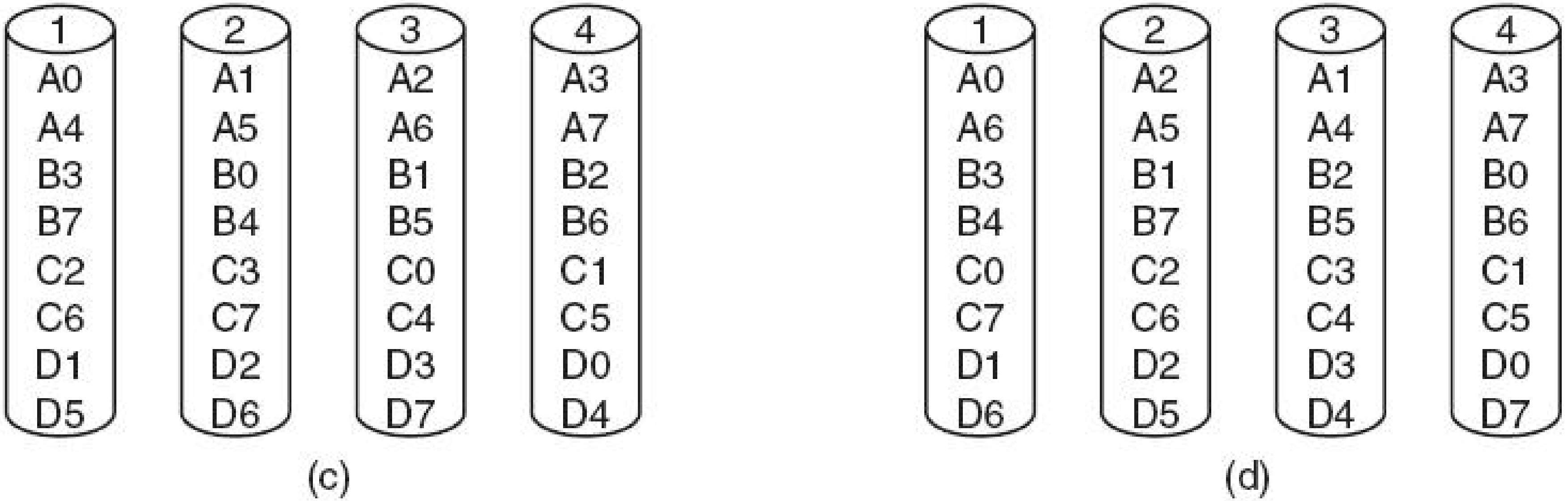


Figure 7-24. Four ways of organizing multimedia files over multiple disks. (c) Staggered striping. (d) Random striping.

6.5.5 Placing Files on Multiple Disks (3)

- How to stripe
  - stripe by frame
  - stripe by block.
- how many disks to stripe over.
  - Wide striping
    - balancing the load
    - if every movie uses every disk and one disk goes down, no movie can be shown
  - Narrow striping
    - Suffer from hot spots

6.6 Cache

- Traditional LRU file caching
  - Is not suitable for multimedia files
- Features of Multimedia files
  - Be sequentially unless rewinding
  - Be predictable
- New caching method for multimedia
  - Block caching
  - File caching

6.6.1 Block Caching (1)

- For the first scene
  - Suppose that two users are watching the same movie, with one of them having started 2 sec after the other
- Must caching
  - Depending on how long it has to be cached and how tight memory is
  - Different strategy

    •Every movie that has a second viewer within some time AT of the first viewer can be marked as cachable and all its blocks cached until the second (and possibly third) viewer has used them.

6.6.1 Block Caching (2)

- For the second scene
  - Suppose that two users are watching the same movie but with a 10-sec delay between them
- Must caching and merging two streams
  - Goals: try to make the two streams in synchronization
  - Different strategy
    - by changing the frame rate for both movies.
    - give users the option of having commercials in their movies, presumably for a lower viewing price than commercial-free movies

6.6.1 Block Caching (3)

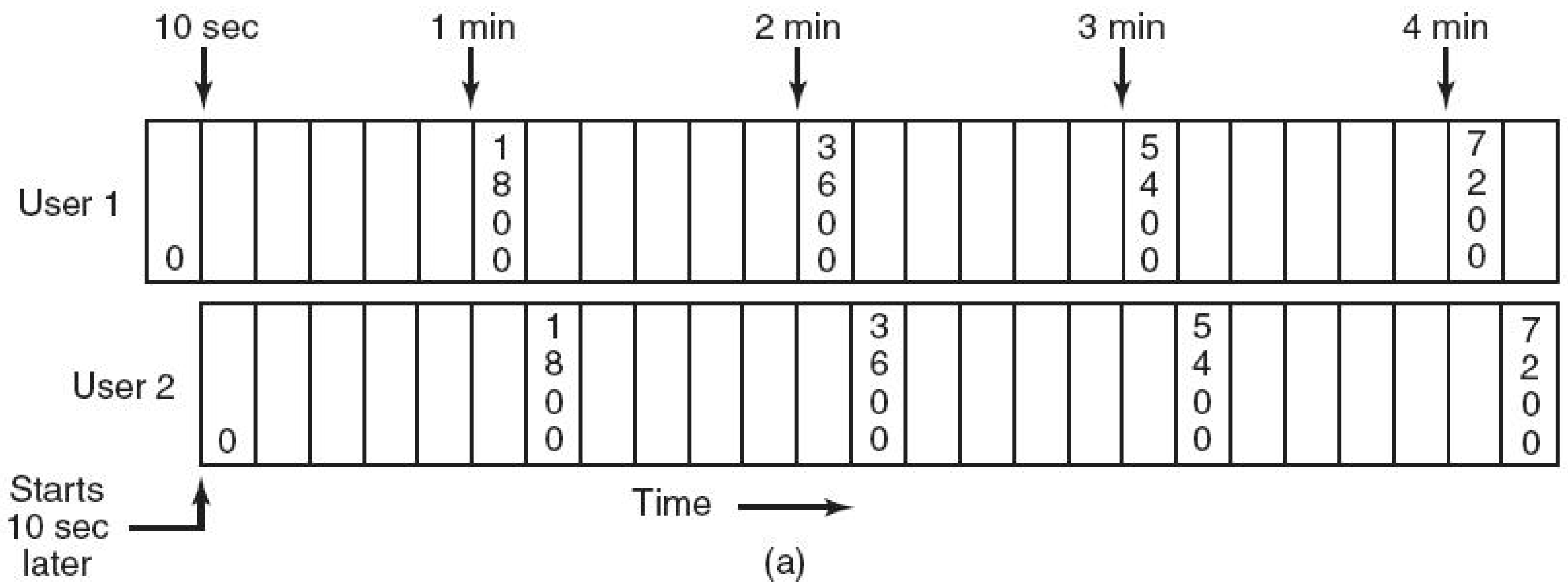


Figure 7-25. (a) Two users watching the same movie 10 sec out of sync.

6.6 Block Caching (4)

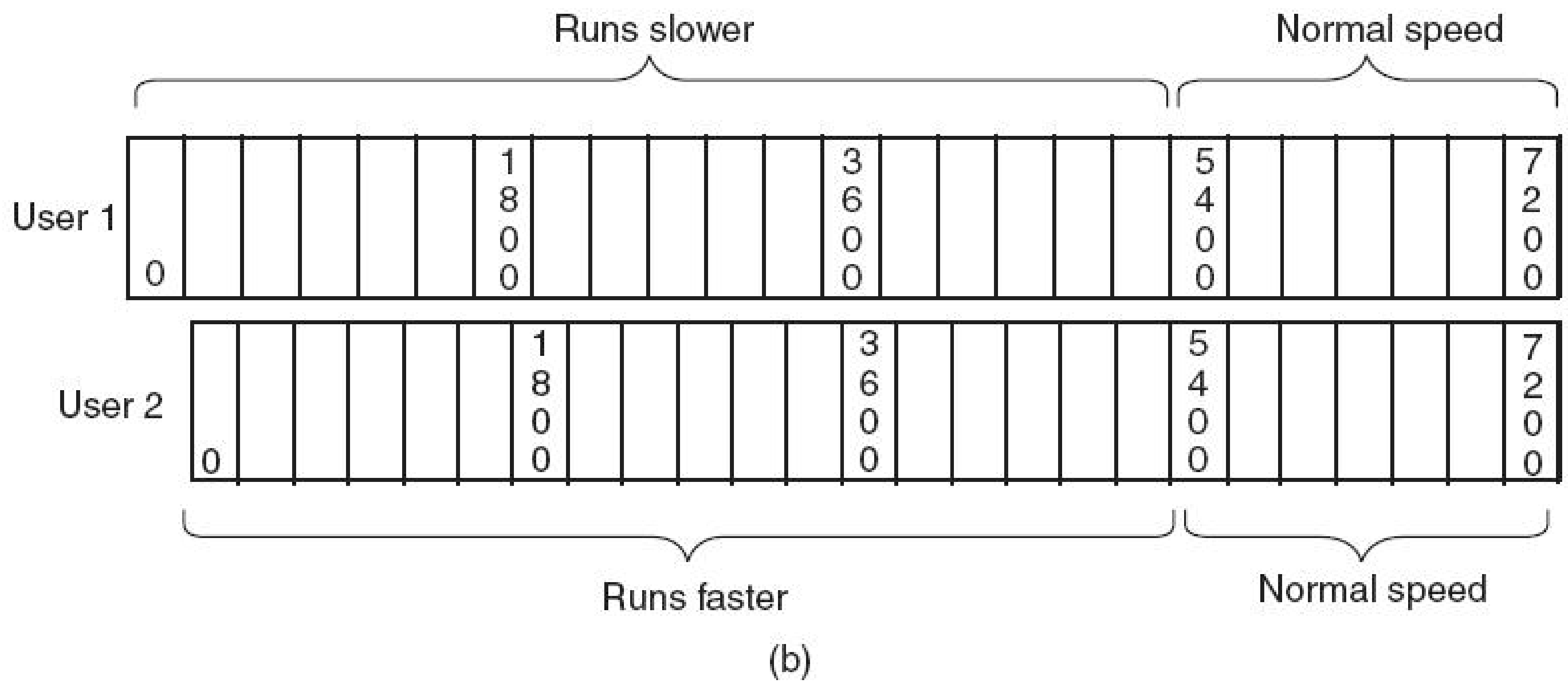


Figure 7-25. (b) Merging the two streams into one.

6.6.2 File Caching

- Due to the large size of most movies (3-6 GB), video servers often cannot store all their movies on disk, so they keep them on DVD or tape.
  - Disk cache of the most heavily requested movies
  - Another way: is to keep the first few minutes of each movie on disk.

6.7 Disk scheduling for multimedia

- Different demands on the disks for multimedia
  - High data rate
  - Real-time delivery of the data
  - The economic pressure to have a single server handle thousands of clients simultaneously
- Disk scheduling methods
  - Static disk scheduling
  - Dynamic disk scheduling

6.7.1 Static Disk scheduling

- Features for multimedia files
  - Predictability
  - Each active stream puts a well-defined load on the system
- Assume
  - All movies have the same resolution, frame rate, and other properties.
  - Just one disk and there are 10 users, each one viewing a different movie.
  - All movies have the same resolution, frame rate, and other properties.

6.7.1 Static Disk Scheduling

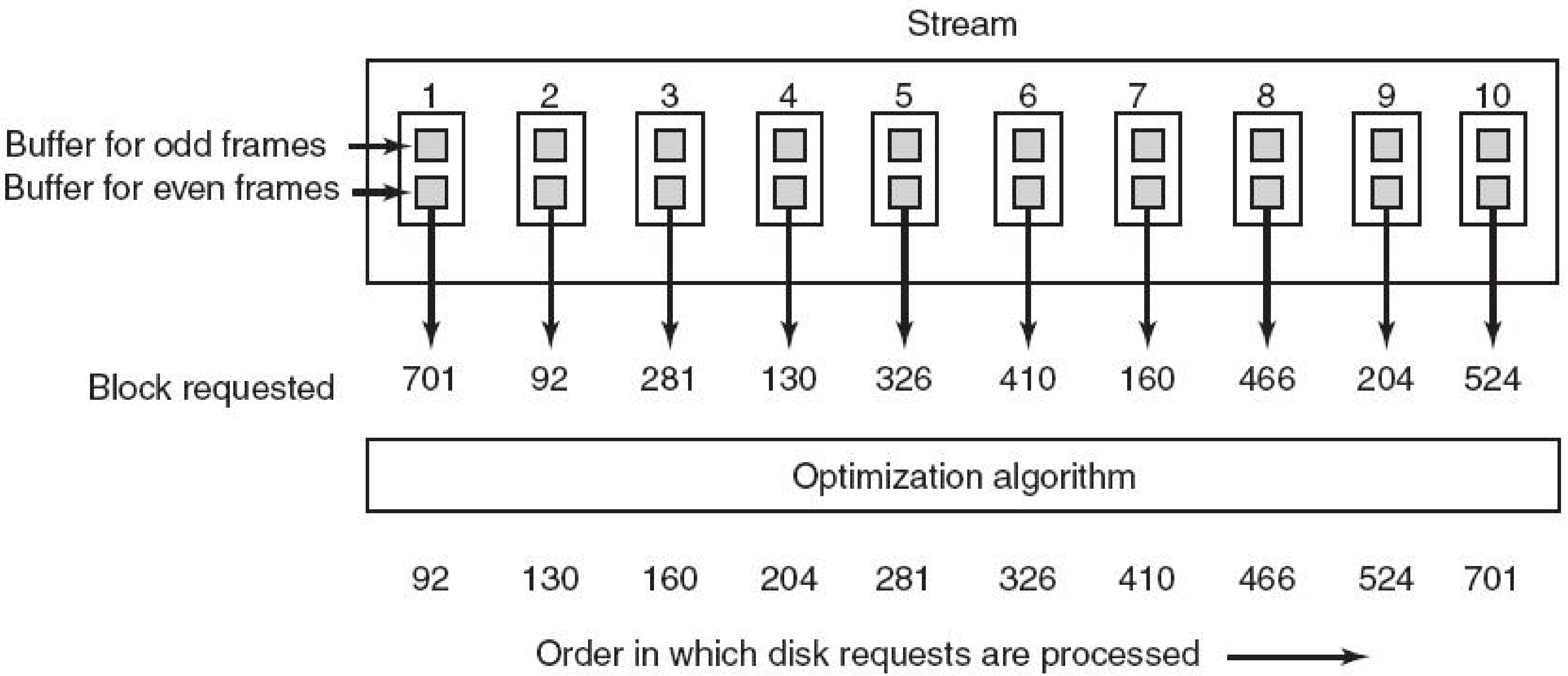


Figure 7-26. In one round, each movie asks for one frame.

6.7.1 Static Disk scheduling

- Must use double buffering in order to keep the flow of data out to the clients moving smoothly
- How many buffers is used can depending on the relative availability, performance, and cost of memory versus disk I/O.

6.7.2 Dynamic Disk scheduling

- Different movies may now have different data rates, and so on.
- So the scheduling algorithm must consider the next two aspects
  - minimizes total seek time
  - Meet the deadline of every process
- scan-EDF algorithm
  - basic idea: to collect requests whose deadlines are relatively close together into batches and process these in cylinder order.

6.7 Dynamic Disk Scheduling

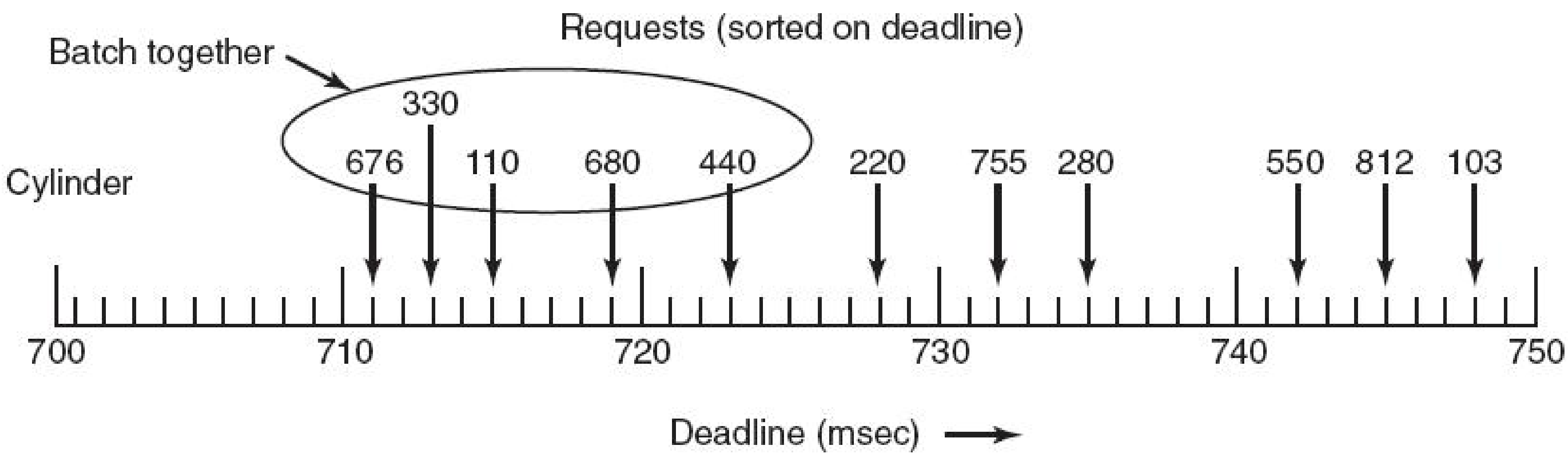


Figure 7-27. The scan-EDF algorithm uses deadlines and cylinder numbers for scheduling.

6.7.2 Dynamic Disk scheduling

- When different streams have different data rates, a serious issue arises when a new customer shows up: should the customer be admitted?
  - One way: to assume that each customer needs a certain amount of resources on the average, for example, disk bandwidth, memory buffers, CPU time, etc. If there is enough of each left for an average customer, the new one is admitted.
  - Another way: the server takes a look at the specific movie the new customer wants and looks up the data rate for that movie, which differs for black and white versus color, cartoons versus filmed, and even love stories versus war films. If the server has enough capacity for the specific film the new customer wants, then admission is granted; otherwise it is denied.

Reading Materials

- File system support for multimedia
- Quality of service in multimedia systems
- CPU scheduling and disk scheduling
- Security of broadcasting multimedia

Exercises

1. For the Chen and Thapar method, assume that a 3-hour movie encoded in PAL format needs to be streamed every 15 minutes. How many concurrent streams are needed?
2. A small video server has eight movies. What does Zipf's law predict as the probabilities for the most popular movie, second most popular movie, and so on down to the least popular movie?
3. Two video-on-demand customers started watching the same PAL movie 6 sec apart. If the system speeds up one stream and slows down the other to get them to merge, what percent speed up/down is needed to merge them in 3 min?
4. Consider the following set of requests to the disk. Each request is represented by a tuple (Deadline in msec, Cylinder). The scan-EDF algorithm is used, where four upcoming deadlines are clustered together and served. If the average time to service each request is 6 msec, is there a missed deadline?

    (32, 300); (36, 500); (40, 210); (34, 310)

Assume that the current time is 15 msec.

谢 谢！