Operating System
Chapter 7: File Systems

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Files

- File: a named collection of data that may be manipulated as a unit by operations such as:
  - Open, Close, Create, Destroy, Copy, Rename, List
- Individual data items within a file may be manipulated by operations like:
  - Read
  - Write
  - Update
  - Insert
  - Delete
- File characteristics include:
  - Location
  - Accessibility
  - Type
  - Volatility
- Files can consist of one or more records

File Naming

- Probably the most important characteristic of any abstraction mechanism is the way the objects being managed are named. When a process creates a file, it gives the file a name. When the process terminates, the file continues to exist and can be accessed by other processes using its name.
- The exact rules for file naming vary somewhat from system to system, but all current operating systems allow strings of one to eight letters as legal file names. Frequently digits and special characters are also permitted. *Many file systems support names as long as 255* characters.
- Some file systems distinguish between upper- and lower-case letters, whereas others do not. UNIX (including all its variants) falls in the first category; MS-DOS falls in the second.

File Structure

- None -sequence of words, bytes
- Simple record structure

  -Lines

  -Fixed length

  -Variable length
- Complex Structures
  - Formatted document
  - Relocatable load file
- Can simulate last two with first method by inserting appropriatecontrol characters
- Who decides:

  -Operating system

  -Program

File Attributes

- **Name**. The symbolic file name is the only information kept in human readable form.
- **Identifier**. This unique tag, usually a number, identifies the file within the file system; it is the non-human-readable name for the file.
- **Type.** This information is needed for systems that support different types of files.
- **Location**. This information is a pointer to a device and to the location of the file on that device.
- **Size.** The current size of the file (in bytes, words, or blocks) and possibly the maximum allowed size are included in this attribute.
- **Protection**. Access-control information determines who can do reading, writing, executing, and so on.
- **Time, date, and user identification.** This information may be kept for creation, last modification, and last use. These data can be useful for protection, security, and usage monitoring.
- Information about files are kept in the directory structure, which is maintained on the disk

File Operations

- **Creating a file:** Two steps are necessary to create a file. First, space in the file system must be found for the file. Second, an entry for the new file must be made in the directory.
- **Writing a file:** To write a file, we make a system call specifying both the name of the file and the information to be written to the file.
- **Reading a file**: To read from a file, we use a system call that specifies the name of the file and where (in memory) the next block of the file should be put.
- **Repositioning within a file:** The directory is searched for the appropriate entry, and the current-file-position is set to a given value. Repositioning within a file does not need to involve any actual I/O. This file operation is also known as a file *seek.*

File Operations(contd..)

- **Deleting a file:** To delete a file, we search the directory for the named file. Having found the associated directory entry, we release all file space, so that it can be reused by other files, and erase the directory entry.
- **Truncating a file**: The user may want to erase the contents of a file but keep its attributes. Rather than forcing the user to delete the file and then recreate it, this function allows all attributes to remain unchanged-except for file length-but lets the file be reset to length zero and its file space released.

File Types - Name, Extension

file type	usual extension	function
executable	exe, com, bin or none	read to run machine-language program
object	obj, o	compiled, machine language, not linked
source code	c, cc, java, pas, asm, a	source code in various languages
batch	bat, sh	commands to the command interpreter
text	txt, doc	textual data, documents
word processor	wp, tex, rrf, doc	various word-processor formats
library	lib, a, so, dll, mpeg, mov, rm	libraries of routines for programmers
print or view	arc, zip, tar	ASCII or binary file in a format for printing or viewing
archive	arc, zip, tar	related files grouped into one file, sometimes compressed, for archiving or storage
multimedia	mpeg, mov, rm	binary file containing audio or A/V information

Blocking And Buffering

- A physical record or block is the unit of information actually read from or written to a device. A logical record is a collection of data treated as a unit from the user’s standpoint. When each physical record contains exactly one logical record, the file is said to consist of unblocked records. When each physical record may contain several logical records, the file is said to consist of **blocked records.** In a file with fixed-length records, all records are the same length; the blocksize is ordinarily an integral multiple of the record size. In a file with variable-length records, records may vary in size up to the blocksize.

Blocking And Buffering(contd..)

- **Buffering** allows computation to proceed in parallel with input/output. Spaces are provided in primary storage to hold several physical blocks of a file at once – each of these space is called **buffer.** The most common scheme is called **double buffering** and it operates as follows(for output). There are two buffers. Initially, records generated by a running process are deposited in the first buffer until it is full. The transfer of block in the first buffer to secondary storage is then initiated. While this transfer is in progress, the process continues generating records, that are deposited in the second buffer. When the second buffer is full, and when the transfer from first buffer is complete, transfer from second buffer is initiated. The process continues generating records that are now deposited in the first buffer. This alternation between the buffers allows input/output to occur in parallel with a process’s computations.

File Descriptor

- A file descriptor or file control block is a control block containing information the system needs to manage a file. It is a highly system-dependent structure. A typical file descriptor might include
  - Symbolic file name, location of file in secondary storage, file organization, access control data, type, disposition(permanent vs. temporary), creation date and time, destroy date, date and time last modified, access activity counts(number of reads, for example)
  - Ordinarily, file descriptor are maintained on secondary storage. They are brought to primary storage when a file is opened and is controlled by the operating system

File Access Methods

- **Sequential Access:** The simplest access method is **sequential access.** Information in the file is processed in order, one record after the other. This mode of access is by far the most common; for example, editors and compilers usually access files in this fashion.

  read next

  write next

  Reset

  no read after last write

  (rewrite)

File Access Methods(contd..)

- **Direct Access:** Another method is direct access (or relative access). A file is made up of fixed-length logical records that allow programs to read and write records rapidly in no particular order. The direct-access method is based on a disk model of a file, since disks allow random access to any file block. For direct access, the file is viewed as a numbered sequence of blocks or records. A direct-access file allows arbitrary blocks to be read or written.

  read n

  write n

  position to n

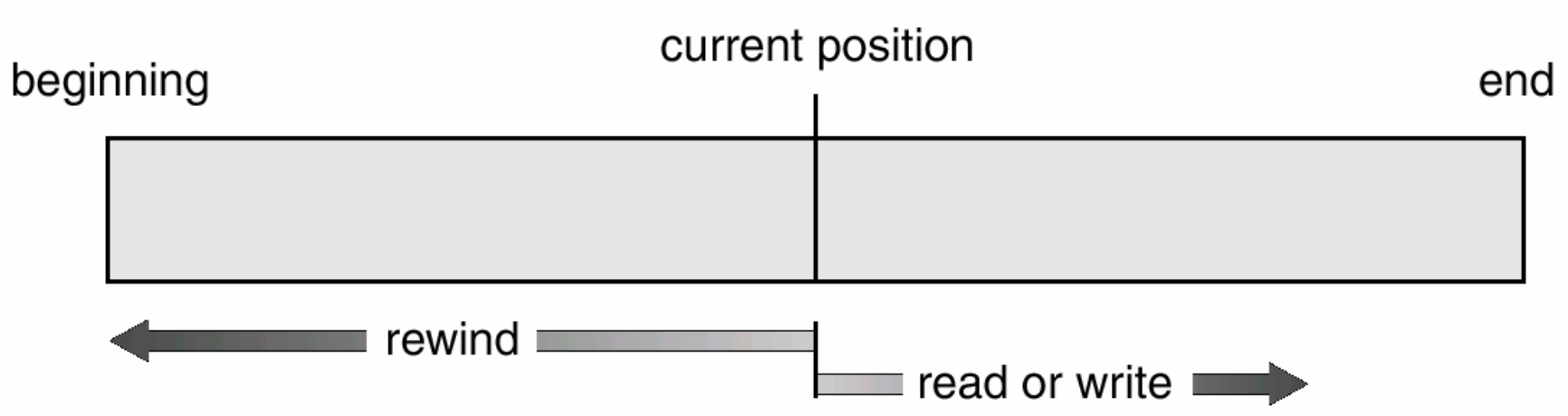
  read next

  write next

  rewrite n

  n= relative block number

Sequential-access File



Simulation of Sequential Access on a Direct access File

sequential access	implementation for direct access
reset	*cp* = 0;
read next	*read cp*; *cp* = *cp*+1;
write next	*write cp*; *cp* = *cp*+1;

File Sharing

- Sharing of files on multi-user systems is desirable
- Sharing may be done through a **protection** scheme
- On distributed systems, files may be shared across a network
- Network File System (NFS) is a common distributed file-sharing method

File Sharing – Multiple Users

- When an operating system accommodates multiple users, the issues of file sharing, file naming, and file protection become preeminent. Given a directory structure that allows files to be shared by users, the system must mediate the file sharing. The system either can allow a user to access the files of other users by default, or it may require that a user specifically grant access to the files.
- **User IDs** identify users, allowing permissions and protections to be per-user
- **Group** IDs allow users to be in groups, permitting group access rights

File Sharing – Remote File Systems

- Uses networking to allow file system access between systems
  - Manually via programs like FTP
  - Automatically, seamlessly using **distributed file systems**
  - Semi automatically via the **world wide web**
- **Client-server** model allows clients to mount remote file systems from servers
  - Server can serve multiple clients
  - Client and user-on-client identification is insecure or complicated
  - **NFS** is standard UNIX client-server file sharing protocol
  - **CIFS** is standard Windows protocol
  - Standard operating system file calls are translated into remote calls
- Distributed Information Systems (**distributed naming services)** such as LDAP, DNS, NIS implement unified access to information needed for remote computing

File Sharing– Failure Modes

- Remote file systems add new failure modes, due to network failure, server failure
- Recovery from failure can involve state information about status of each remote request
- Stateless protocols such as NFS include all information in each request, allowing easy recovery but less security

ACL(Access Control List)

- The technique which consists of associating with each object an (ordered) list containing all the domains that may access the object, and how. This list is called the **Access Control List or ACL** and is illustrated in Fig. 1.
- When a user requests access to a particular file, the operating system checks the access list associated with that file. If that user is listed for the requested access, the access is allowed. Otherwise, a protection violation occurs, and the user job is denied access to the file.
- Here we see three processes, each belonging to a different domain. *A, B, and C, and three files F1, F2, and F3. For simplicity, we will assume that each domain* corresponds to exactly one user, in this case, users *A, B, and C. Often in the security literature,* the users are called **subjects or principals,** to contrast them with the things owned, the **objects,** such as files.

ACL(contd…)

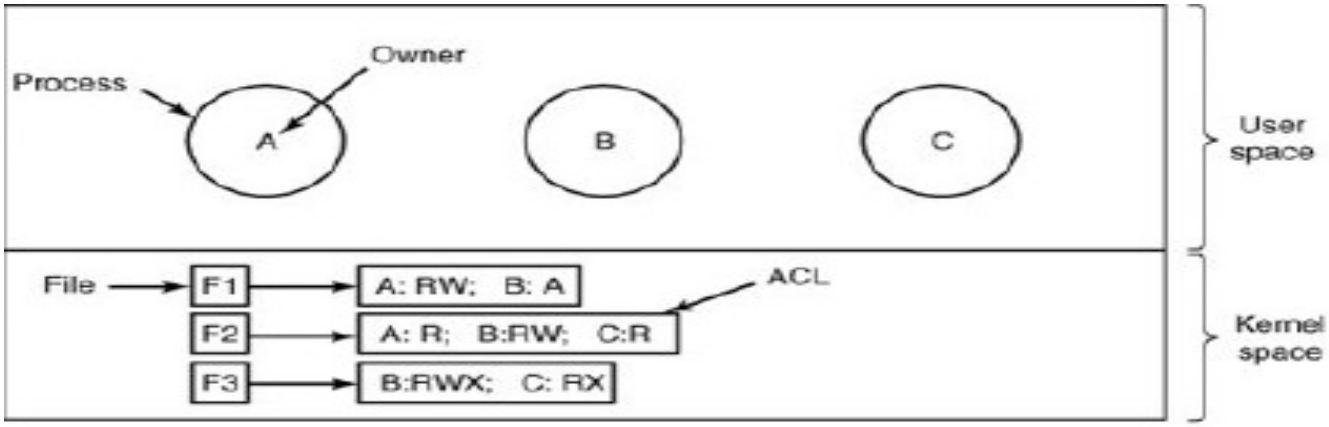


Figure 1. Use of access control lists to manage file access.

•Each file has an ACL associated with it. File *F1 has two entries in its ACL (separated by a* semicolon). The first entry says that any process owned by user *A may read and write the file.* The second entry says that any process owned by user *B may read the file. All other accesses by* these users and all accesses by other users are forbidden. Note that the rights are granted by user, not by process. As far as the protection system goes, any process owned by user *A can read* and write file *F1. It does not matter if there is one such process or 100 of them. It is the owner,* not the process ID, that matters. File *F2 has three entries in its ACL: A, B, and C can all read the file, and in addition B can also* write it. No other accesses are allowed. File *F3 is apparently an executable program, since B and C can both read and execute it. B can also write it.*

Directories

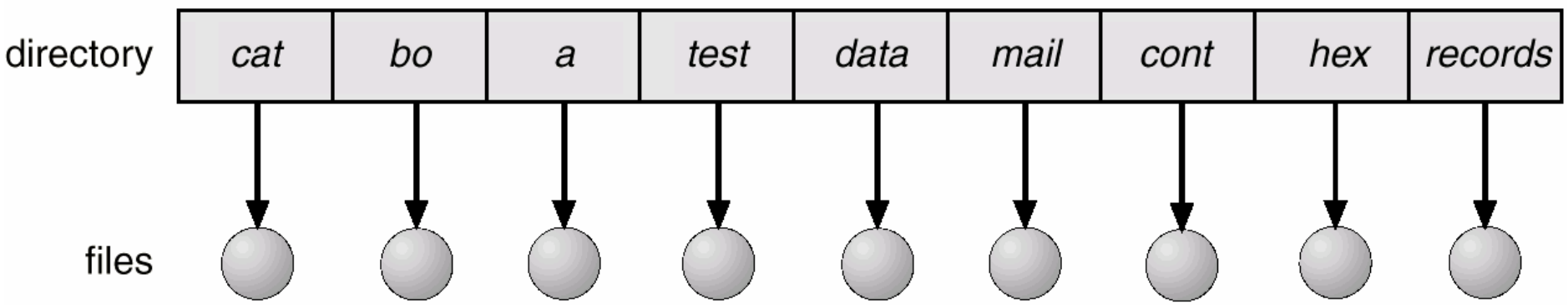
- Directories:
  – Files containing the names and locations of other files in the file system, to organize and quickly locate files
- Directory entry stores information such as:
  – File name
  – Location
  – Size
  – Type
  – Accessed
  – Modified and creation times

Directory Operations

- **Create a file**: New files need to be created and added to the directory.
- **Delete a file:** When a file is no longer needed, we want to remove it from the directory.
- **List a directory:** We need to be able to list the files in a directory, and the contents of the directory entry for each file in the list.
- **Rename a file:** Because the name of a file represents its contents to its users, the name must be changeable when the contents or use of the file changes. Renaming a file may also allow its position within the directory structure to be changed.
- **Traverse the file system:** We may wish to access every directory, and every file within a directory structure. For reliability, it is a good idea to save the contents and structure of the entire file system at regular intervals.

Single-level (or flat) directory:

- Simplest file system organization
- Stores all of its files using one directory
- No two files can have the same name
- File system must perform a linear search of the directory contents to locate each file, which can lead to poor performance



Hierarchical Directory

- A root indicates where on the storage device the root directory begins
- The root directory points to the various directories, each of which contains an entry for each of its files
- File names need be unique only within a given user directory
- The name of a file is usually formed as the pathname from the root directory to the file

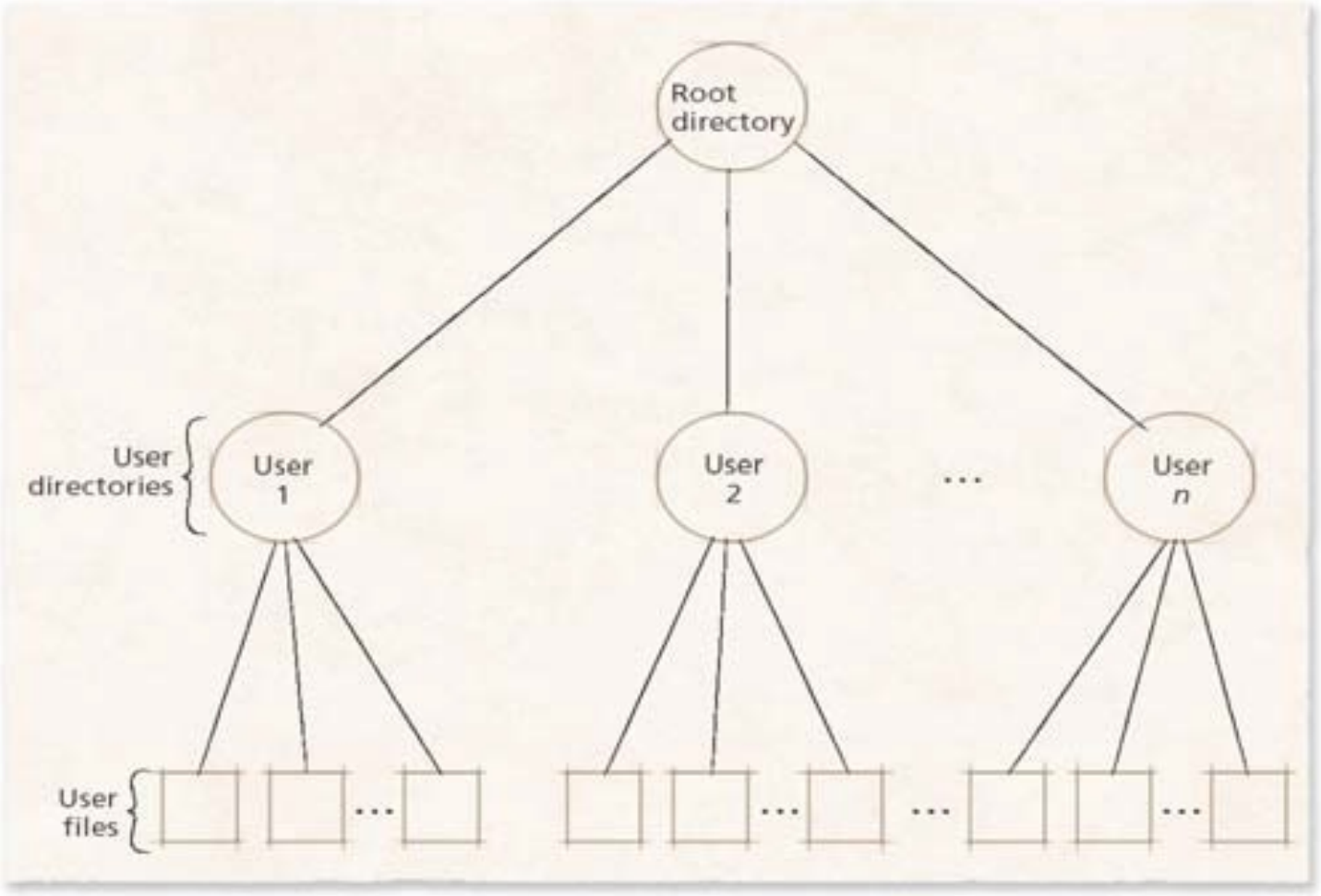


Figure : Two-level hierarchical file system.

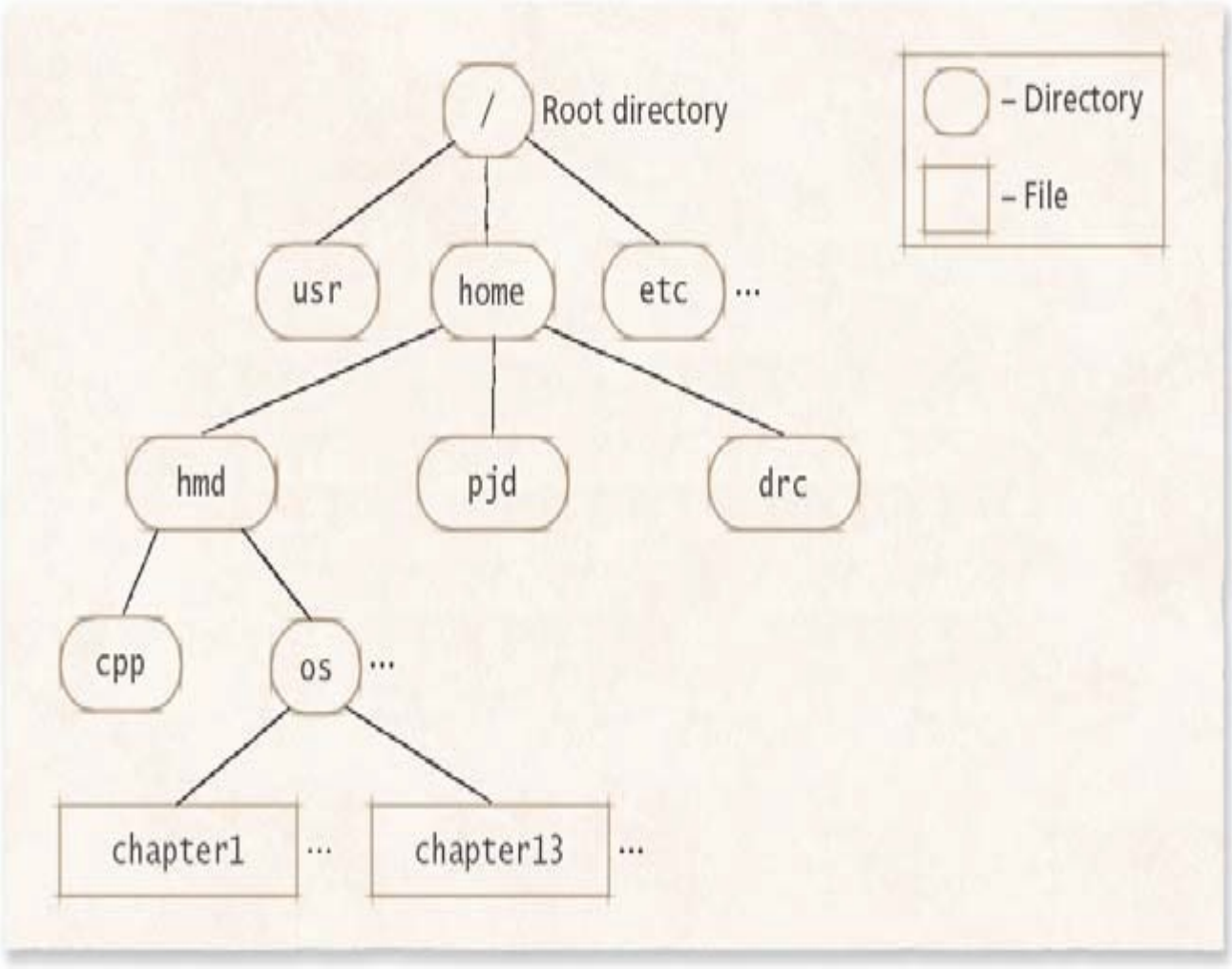


Figure : Example hierarchical file system contents.

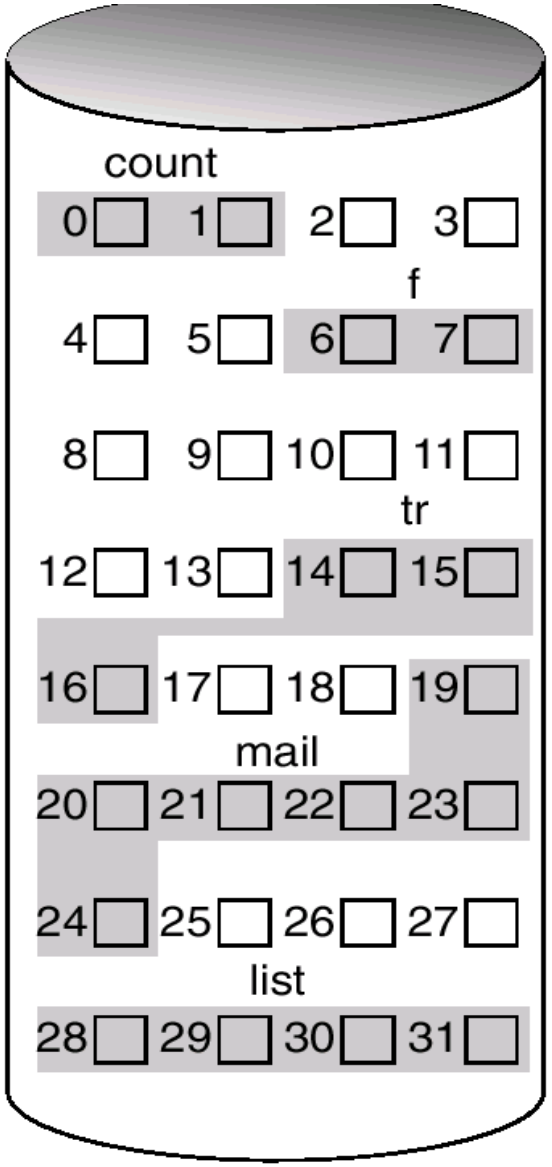
File System Implementation

- File allocation
  - Problem of allocating and freeing space on secondary storage is somewhat like that experienced in primary storage allocation under variable-partition multiprogramming
- An allocation method refers to how disk blocks are allocated for files:
- Contiguous allocation
- Linked allocation
- Indexed allocation

Contiguous Allocation

- The **contiguous-allocation** method requires each file to occupy a set of contiguous blocks on the disk. Disk addresses define a linear ordering on the disk. With this ordering, assuming that only one job is accessing the disk, accessing block b + 1 after block b normally requires no head movement. When head movement is needed (from the last sector of one cylinder to the first sector of the next cylinder), it is only one track. Thus, the number of disk seeks required for accessing contiguously allocated files is minimal, as is seek time when a seek is finally needed. It access randomly and is wasteful of sapce.

Contiguous Allocation of Disk Space



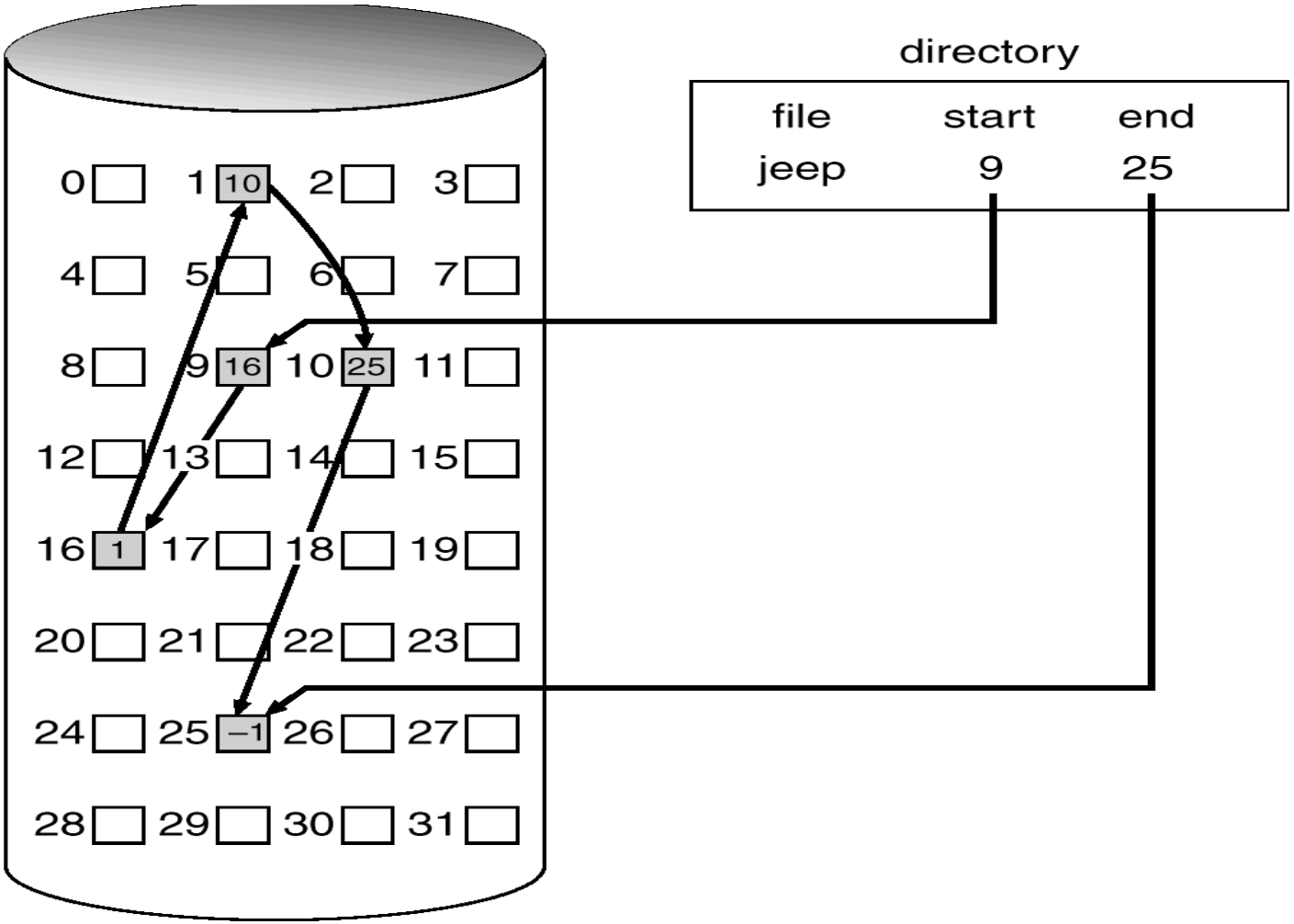
directory

file	start	length
count	0	2
tr	14	3
mail	19	6
list	28	4
f	6	2

Linked List Allocation

- With linked allocation, each file is a linked list of disk blocks; the disk blocks may be scattered anywhere on the disk. The directory contains a pointer to the first and last blocks of the file. For example, a file of five blocks might start at block 9, continue at block 16, then block 1, block 10, and finally block 25 (Figure 12.6). Each block contains a pointer to the next block. These pointers are not made available to the user. It does not access randomly and provide free space management system so there is no waste of space.

Linked Allocation



Index Allocation

- Brings all pointers together into the *index block.*
- Need index table
- Random access
- Dynamic access without external fragmentation, but have overhead of index block.
- Mapping from logical to physical in a file of maximum size of 256K words and block size of 512 words. We need only 1 block for index table.

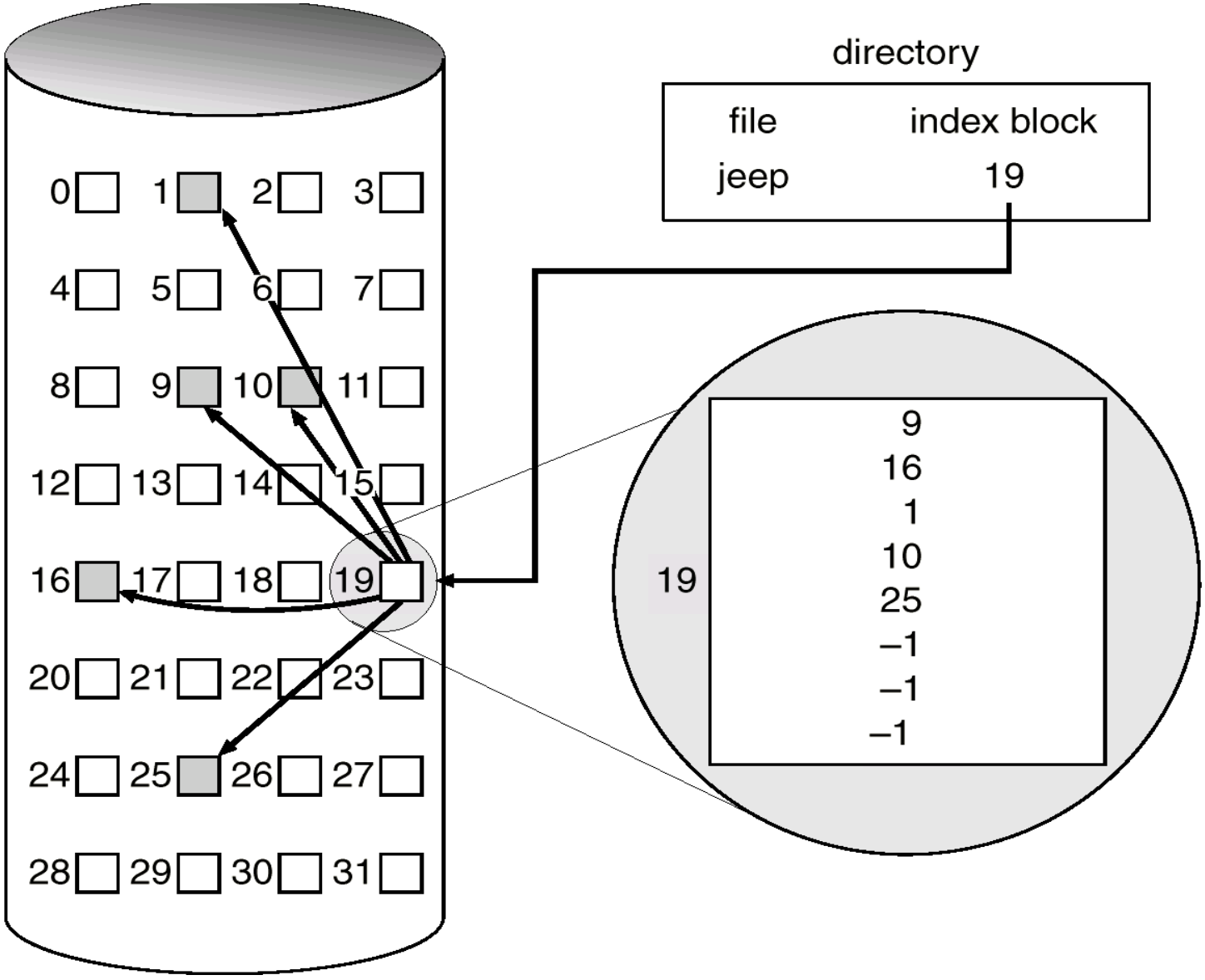
  Q

  LA/512

  R

- Q = displacement into index table
- R = displacement into block

Example of Indexed Allocation



Security and Multimedia Files

- **Protection:**
- File owner/creator should be able to control:
  - what can be done
  - by whom
- Types of access
  -Read
  - Write
  - Execute
  - Append
  - Delete
  - List

Access Lists and Groups

- Mode of access: read, write, execute
- Three classes of users

RWX

a) **owner access7⇒1 1 1**

RWX

b) **group access6⇒1 1 0**

RWX

c) **public access1⇒0 0 1**

Multi-media Files

- Multimedia comes in many different formats. It can be almost anything you can hear or see.
- Examples: Pictures, music, sound, videos, records, films, animations, and more.
- Modern web pages often have embedded multimedia elements, and modern browsers have support for various multimedia formats.

Example of multimedia file format and their extension

Format	File	Description
AVI	.avi	AVI (Audio Video Interleave) was developed by Microsoft, and is therefore playable on all Windows computers. It is commonly used in video cameras and TV hardware, but is difficult to play on non-Windows computers.
WMV	.wmv	WMV (Windows Media Video) was developed by Microsoft, and is therefore playable on all Windows computers. It is commonly used in