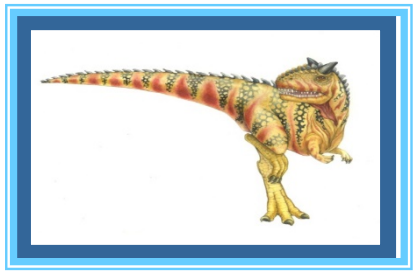
Chapter 10: File-System Interface



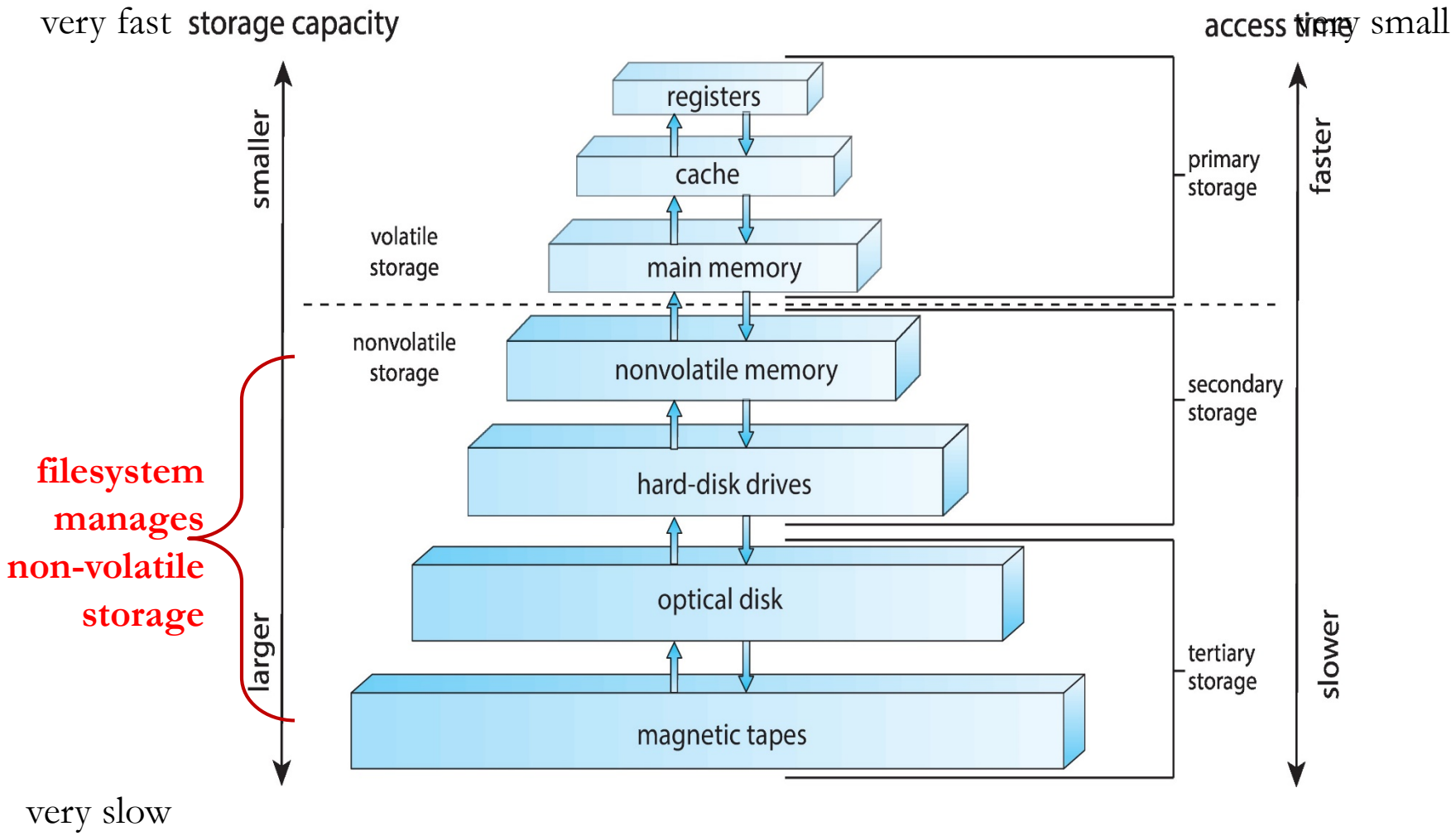
Chapter 10: File-System Interface

- 10.1 File Concept
- 10.2 Access Methods
- 10.3 Directory Structure
- 10.4 File-System Mounting
- 10.5 File Sharing
- 10.6 Protection

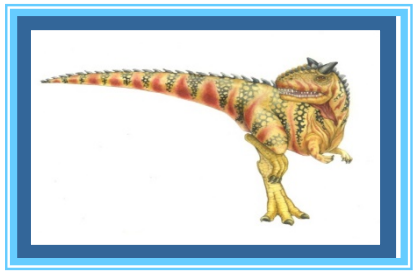
Objectives

- To explain the function of file systems
- To describe the interfaces to file systems
- To discuss file-system design tradeoffs, including access methods, file sharing, file locking, and directory structures
- To explore file-system protection

Hierarchical Storage Architecture



10.1 File Concept



File Concept（文件概念）

- 文件是存储某种介质上的（如磁盘、光盘、SSD等）并具有文件名的一组相关信息的集合
- A file is a sequence of bytes stored on some device

- Types:
  - Data
    - numeric
    - character
    - binary
  - Program

File Attributes（文件属性）

- **Name** – only information kept in human-readable form
- **Identifier** – unique tag (number) identifies file within file system
- **Type** – needed for systems that support different types
- **Location** – pointer to file location on device
- **Size** – current file size
- **Protection** – controls who can do reading, writing, executing
- **Time, date, and user identification** – data for protection, security, and usage monitoring
- Information about files are kept in the directory structure, which is maintained on the disk

File Operations（文件操作）

- File is an **abstract data type**（抽象数据类型）
  - **Create**
  - **Write**
  - **Read**
  - **Reposition within file**
  - **Delete**
  - **Truncate**
  - ***Open(F_i)*** – search the directory structure on disk for entry F_i, and move the content of entry to memory
  - ***Close (F_i)*** – move the content of entry F_i in memory to directory structure on disk

Open Files

- Several pieces of data are needed to manage open files:
  - File pointer: pointer to last read/write location, per process that has the file open
  - File-open count: counter of number of times a file is open – to allow removal of data from open-file table when last processes closes it
  - Disk location of the file: cache of data access information
  - Access rights: per-process access mode information

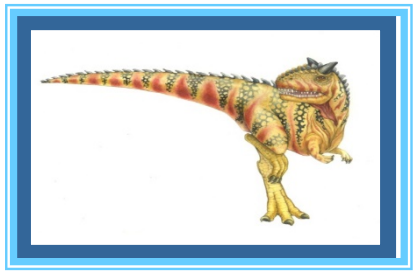
File Types （文件类型）

file type	usual extension	function
executable	exe, com, bin or none	ready-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, rtf, doc	various word-processor formats
library	lib, a, so, dll	libraries of routines for programmers
print or view	ps, pdf, jpg	ASCII or binary file in a format for printing or viewing
archive	arc, zip, tar	related files grouped into one file, sometimes com-pressed, for archiving or storage
multimedia	mpeg, mov, rm, mp3, avi	binary file containing audio or A/V information

File Structure（文件内部结构）

- None - sequence of words, bytes （流文件结构）
- Simple record structure （记录文件结构）
  - Lines
  - Fixed length
  - Variable length
- Complex Structures
  - Formatted document
  - Relocatable load file
- Can simulate last two with first method by inserting appropriate control characters
- Who decides:
  - Operating system
  - Program

10.2 Access Methods（文件的访问方法）



Access Methods

- Sequential Access （顺序存取） **Fig 10.2**

  read next
  write next
  reset
  no read after last write
  (rewrite)

- Direct Access （直接存取） **Fig 10.3**

  read *n*
  write *n*
  position to *n*
  read next
  write next
  rewrite *n*

  n = relative block number **Fig 10.4**

- Indexed sequential-acess（索引顺序）

Fig 10.2 Sequential-access File

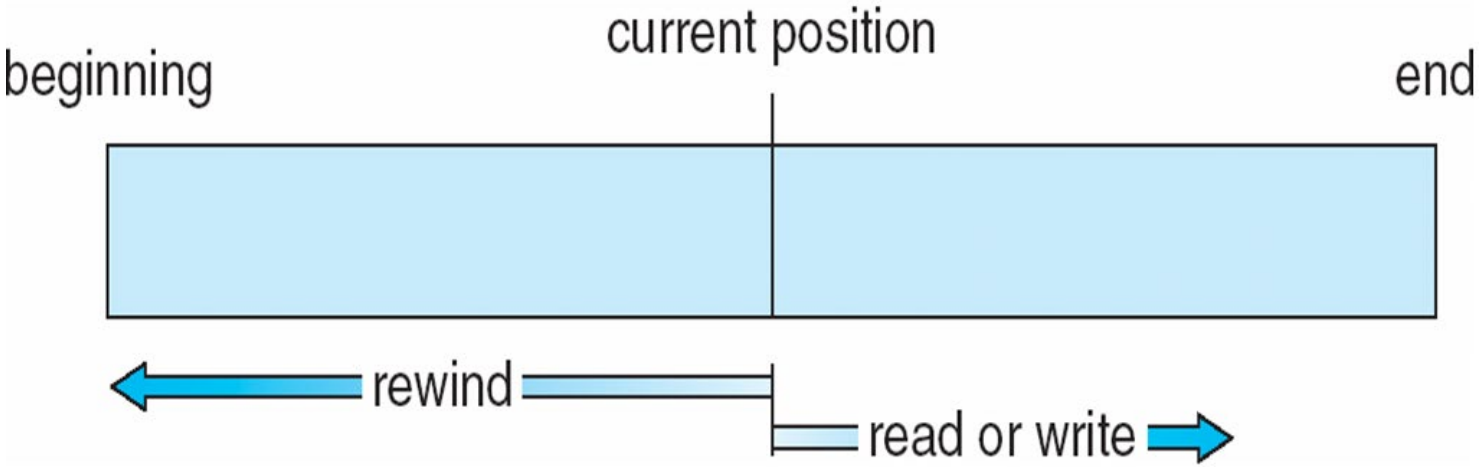
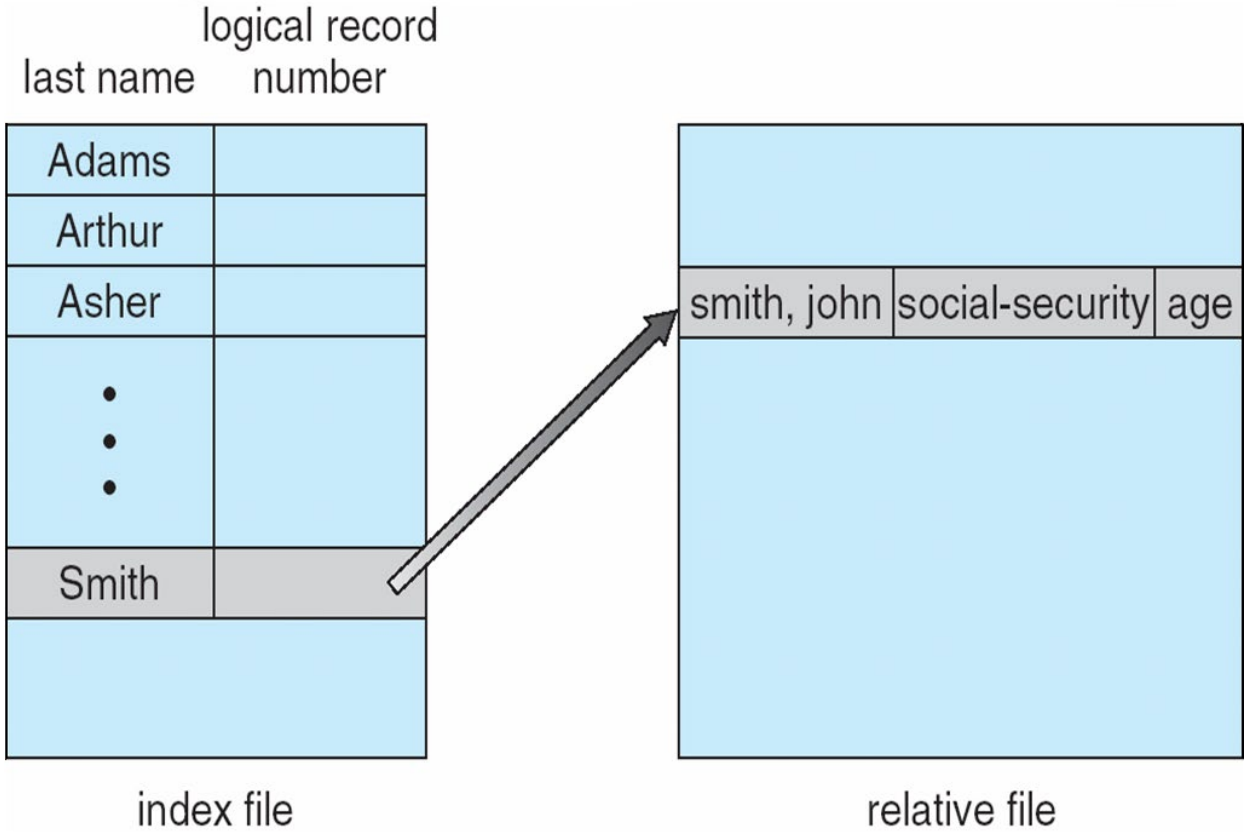


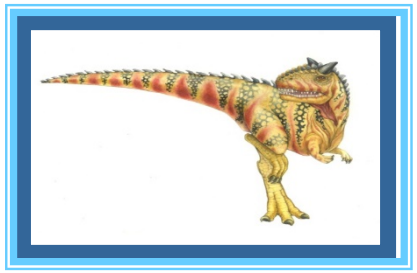
Fig 10.3 Simulation of Sequential Access on Direct-access File

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

Fig 10.4 Example of Index and Relative Files

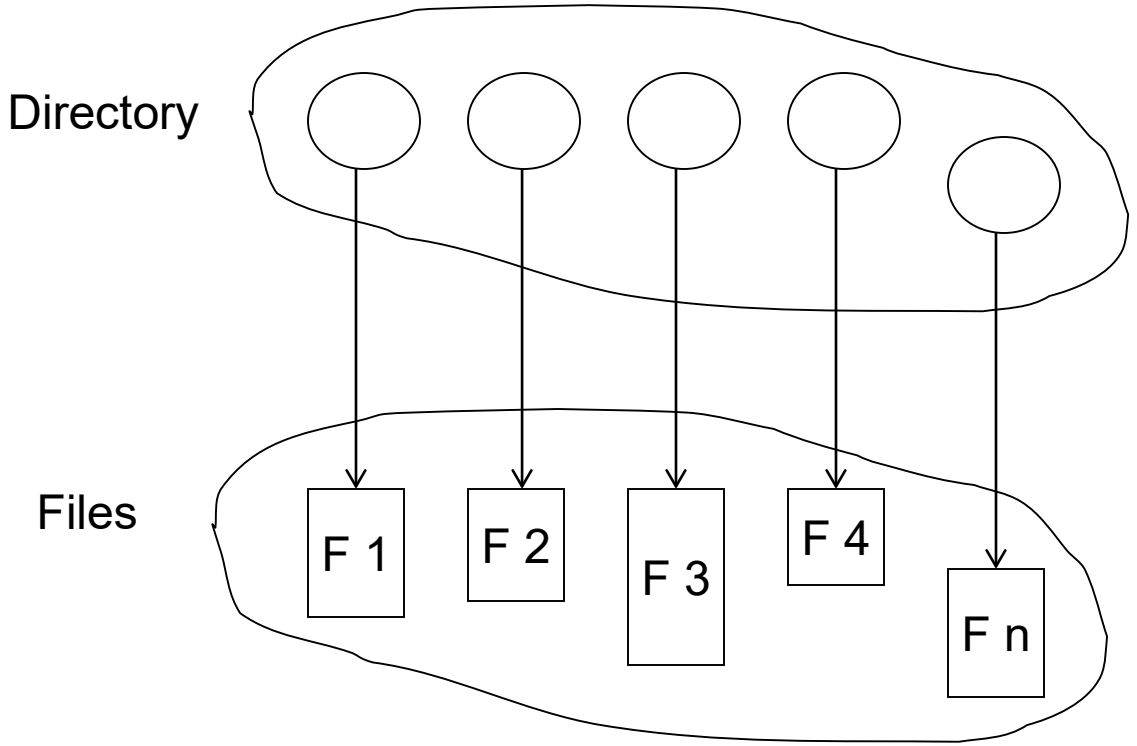


10.3 Directory Structure（目录结构）



Directory Structure

- A collection of nodes containing information about all files

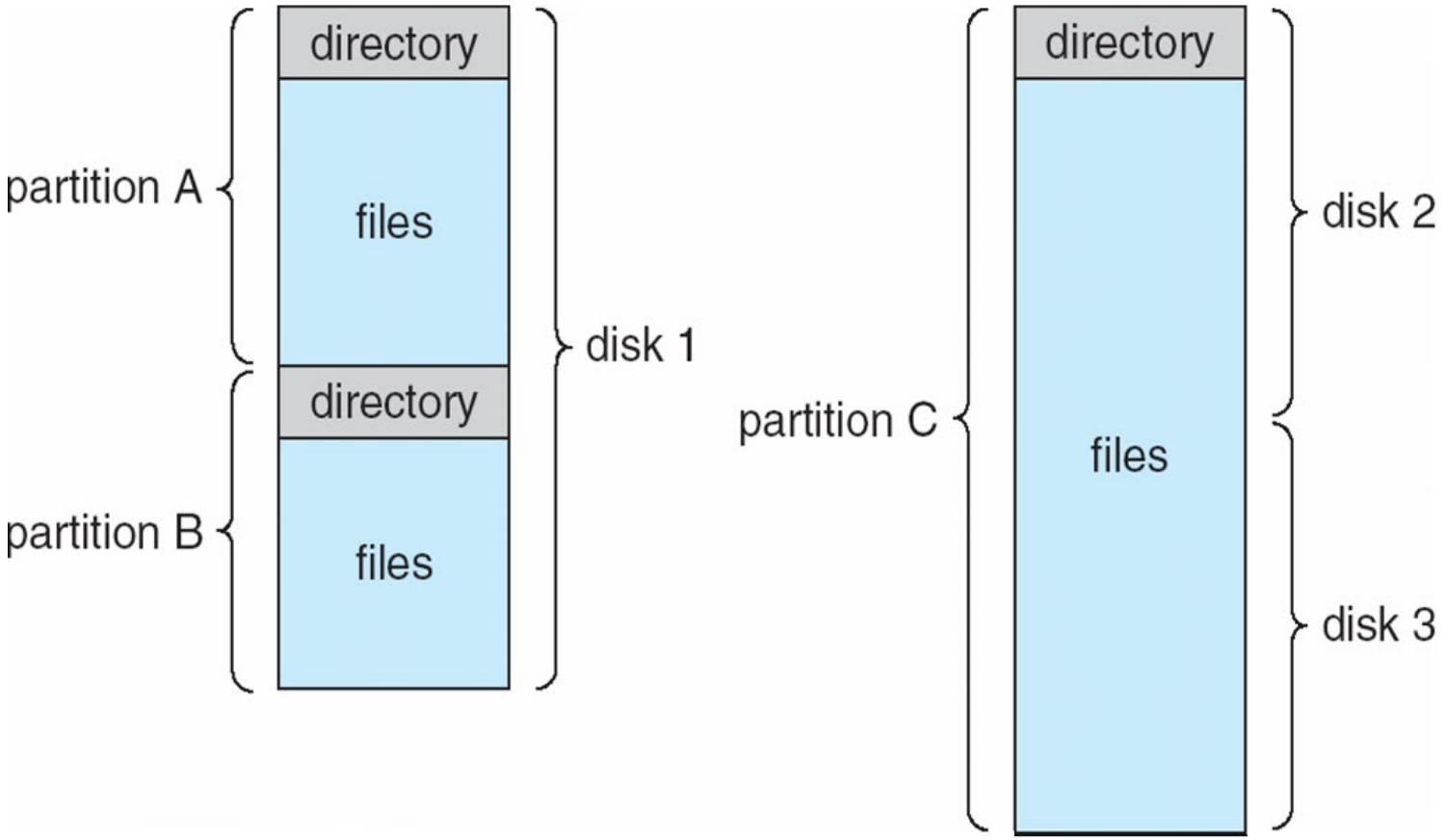


Both the directory structure and the files reside on disk
Backups of these two structures are kept on tapes

Disk Structure

- Disk can be subdivided into partitions（分区）
- Disks or partitions can be RAID protected against failure
- Disk or partition can be used raw – without a file system, or formatted with a file system
- Partitions also known as minidisks, slices
- Entity containing file system known as a volume
- Each volume containing file system also tracks that file system's info in device directory or volume table of contents
- As well as general-purpose file systems there are many special-purpose file systems, frequently all within the same operating system or computer

A Typical File-system Organization



Operations Performed on Directory

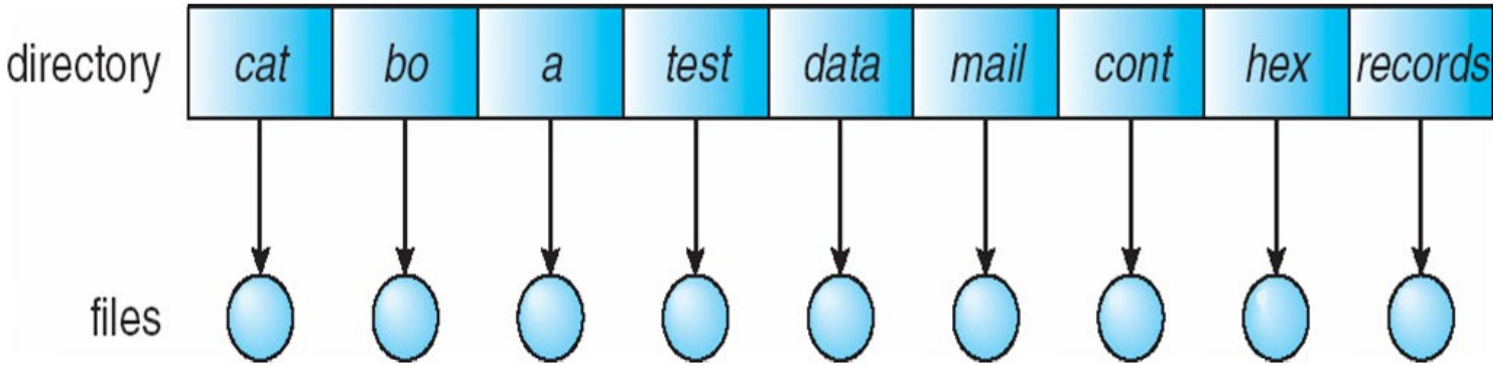
- ✓ Search for a file
- ✓ Create a file
- ✓ Delete a file
- ✓ List a directory
- ✓ Rename a file
- ✓ Traverse the file system（遍历文件系统）

Organize the Directory (Logically) to Obtain

- Efficiency – locating a file quickly
- Naming（重名） – convenient to users
  - Two users can have same name for different files
  - The same file can have several different names
- Grouping（分组） – logical grouping of files by properties, (e.g., all Java programs, all games, …)

Single-Level Directory（单级目录）

- A single directory for all users

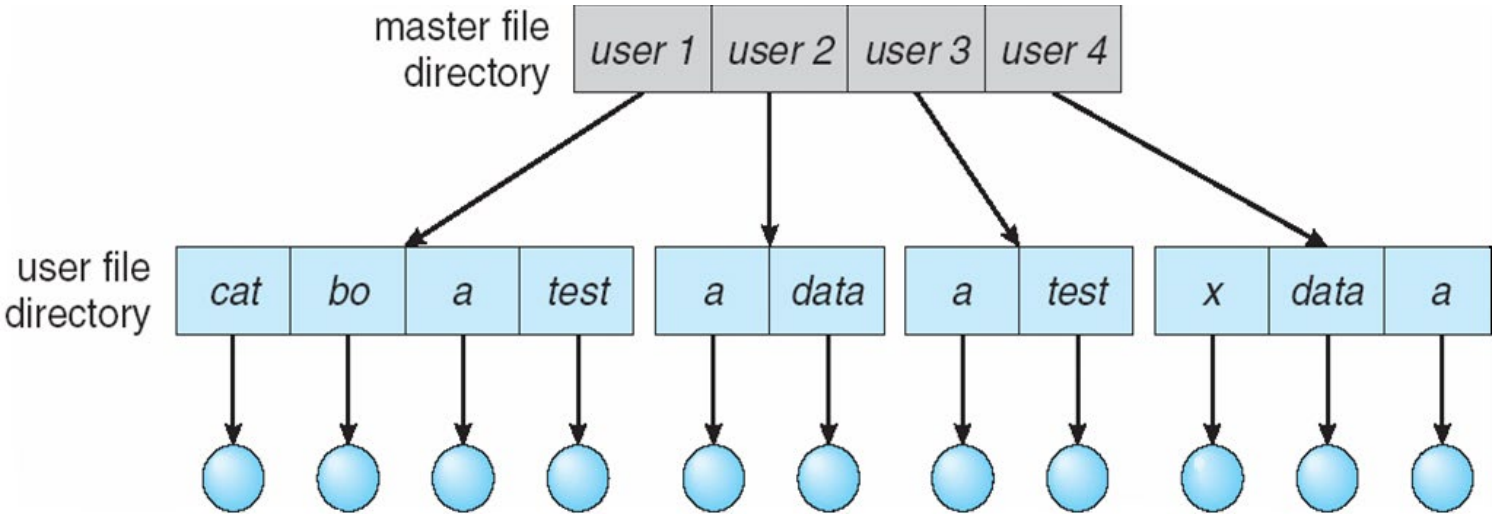


Naming problem

Grouping problem

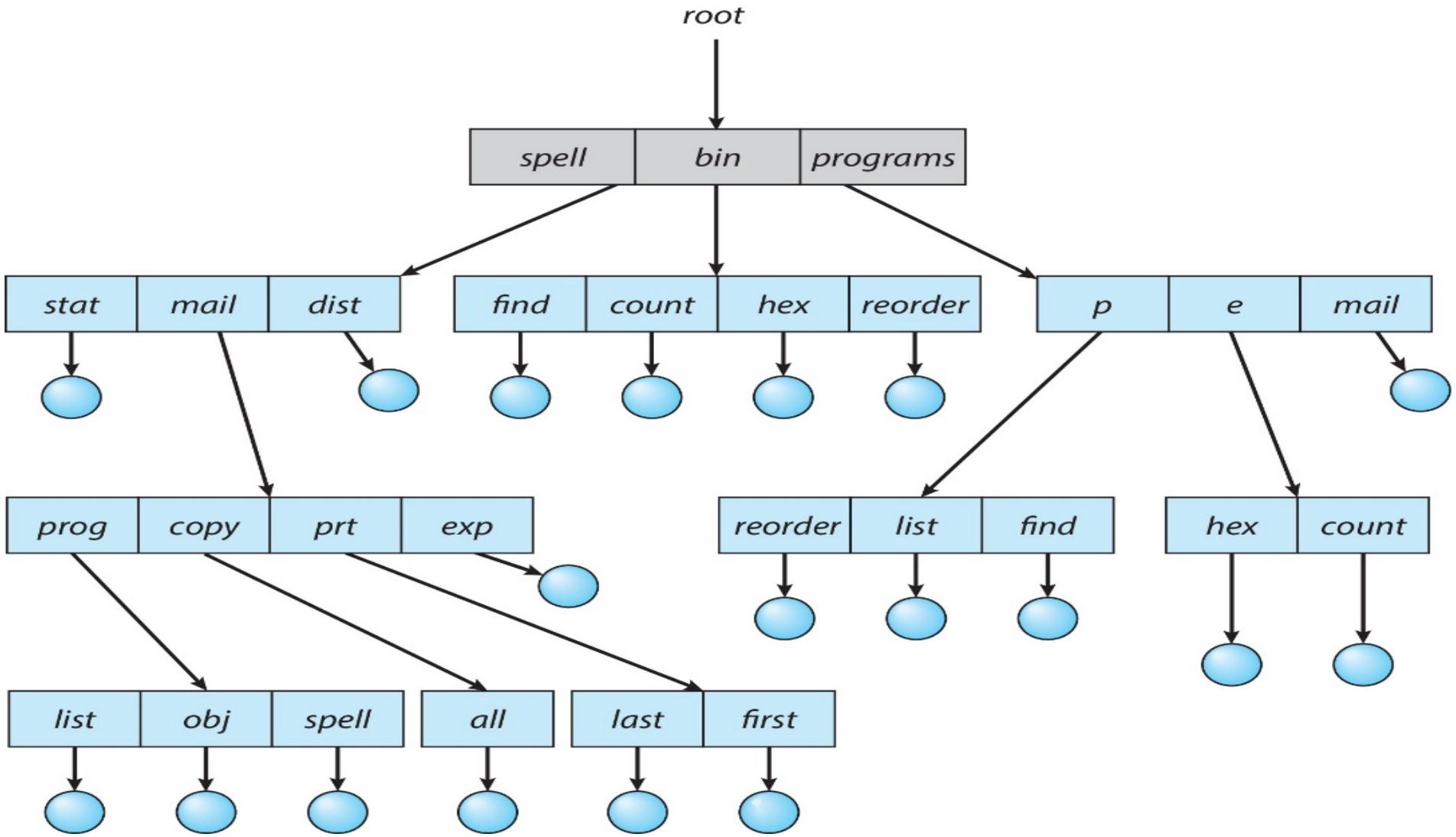
Two-Level Directory（二级目录）

- Separate directory for each user



- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability

Tree-Structured Directories（树型目录）



Tree-Structured Directories (Cont)

- Efficient searching
- Grouping Capability
- Current directory (working directory)
  - cd /spell/mail/prog
  - type list

Tree-Structured Directories (Cont)

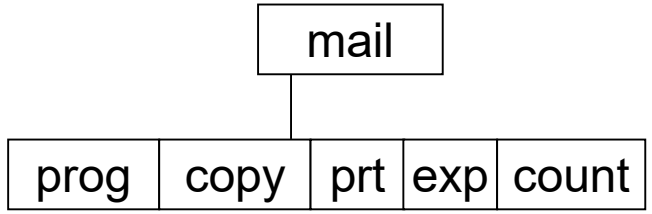
- **Absolute** or **relative** path name 绝对路径、相对路径
- Creating a new file is done in current directory
- Delete a file

  rm <file-name>
- Creating a new subdirectory is done in current directory

  mkdir <dir-name>

  Example: if in current directory /mail

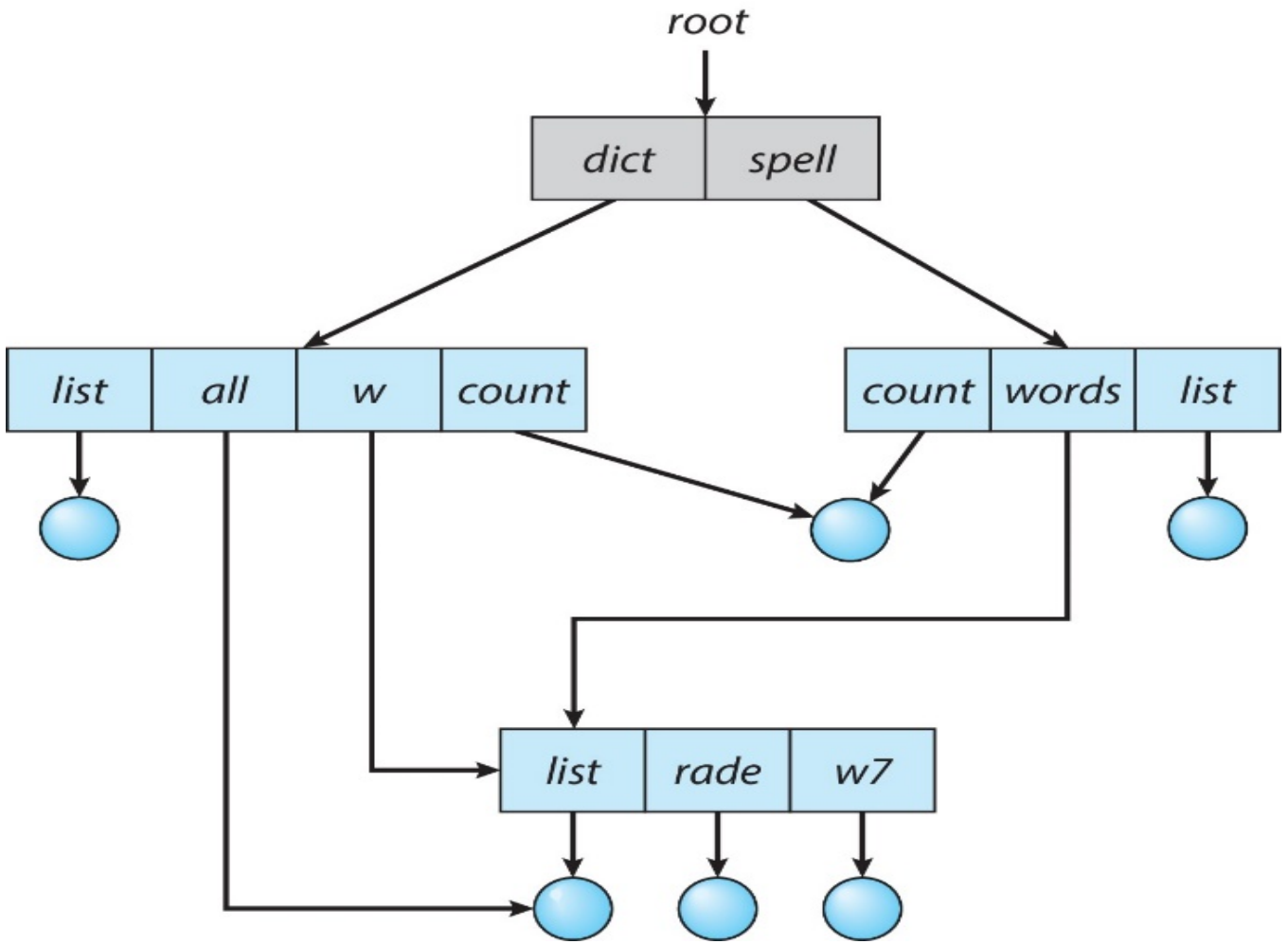
  mkdir count



Deleting “mail” ⇒ deleting the entire subtree rooted by “mail”

Acyclic-Graph Directories无环图结构目录

- Have shared subdirectories and files



Acyclic-Graph Directories (Cont.)

- Two different names (aliasing)

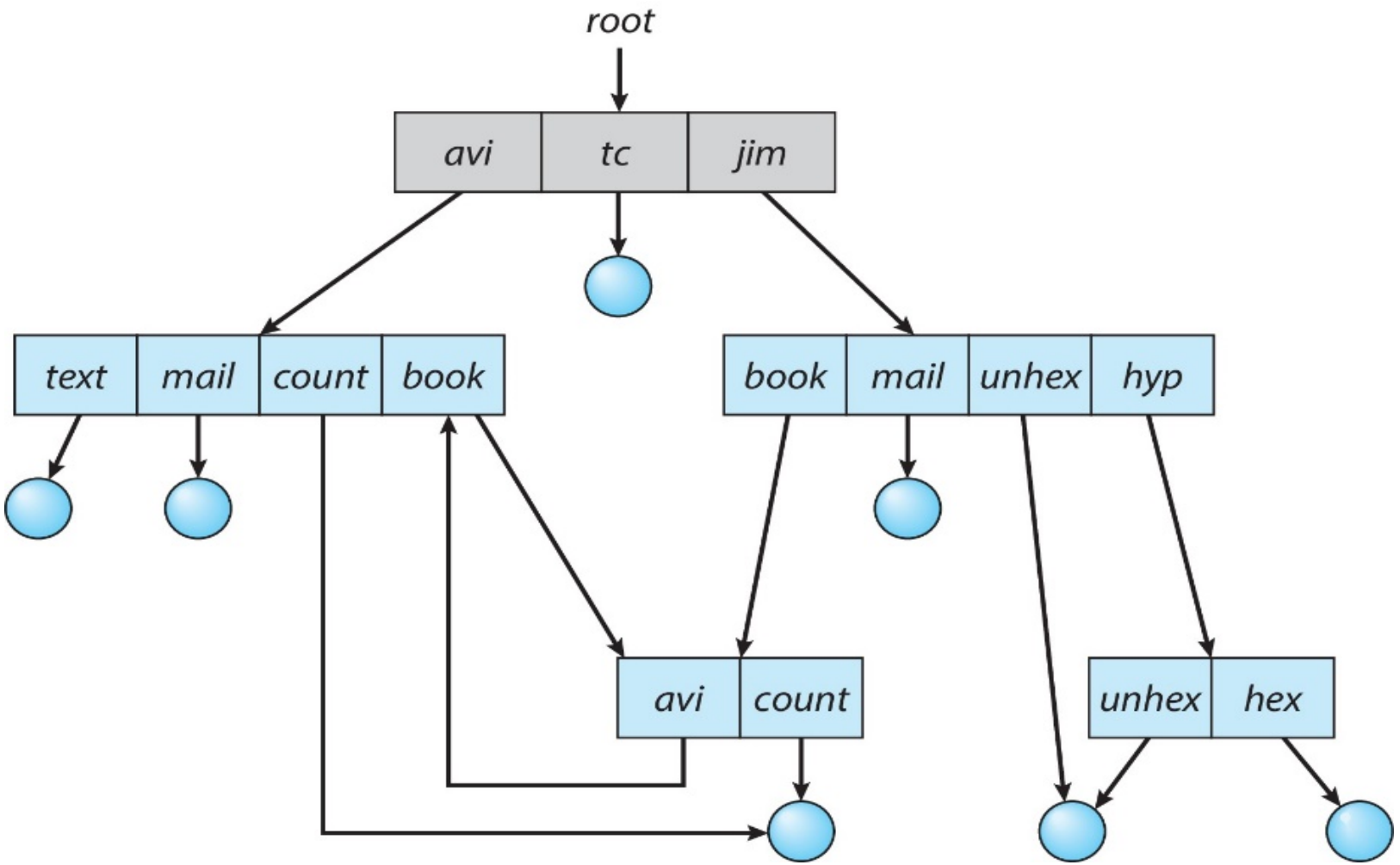
- If *dict* deletes *all* ⇒ dangling pointer

  Solutions:

  - Backpointers（逆向指针）, so we can delete all pointers
    Variable size records a problem
  - Backpointers using a daisy chain organization
  - Entry-hold-count solution （表项保留计数）
    - **unix、linux:hard links**

- New directory entry type
  - **Link** – another name (pointer) to an existing file
  - **Resolve the link** – follow pointer to locate the file

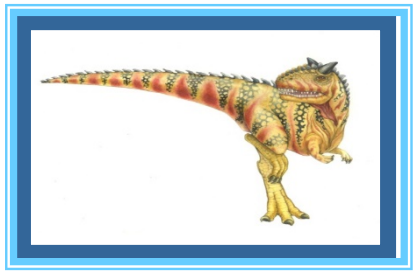
General Graph Directory （普通图结构目录）



General Graph Directory (Cont.)

- How do we guarantee no cycles?
  - Allow only links to file not subdirectories
  - Garbage collection
  - Every time a new link is added use a cycle detection algorithm（环检测算法） to determine whether it is OK

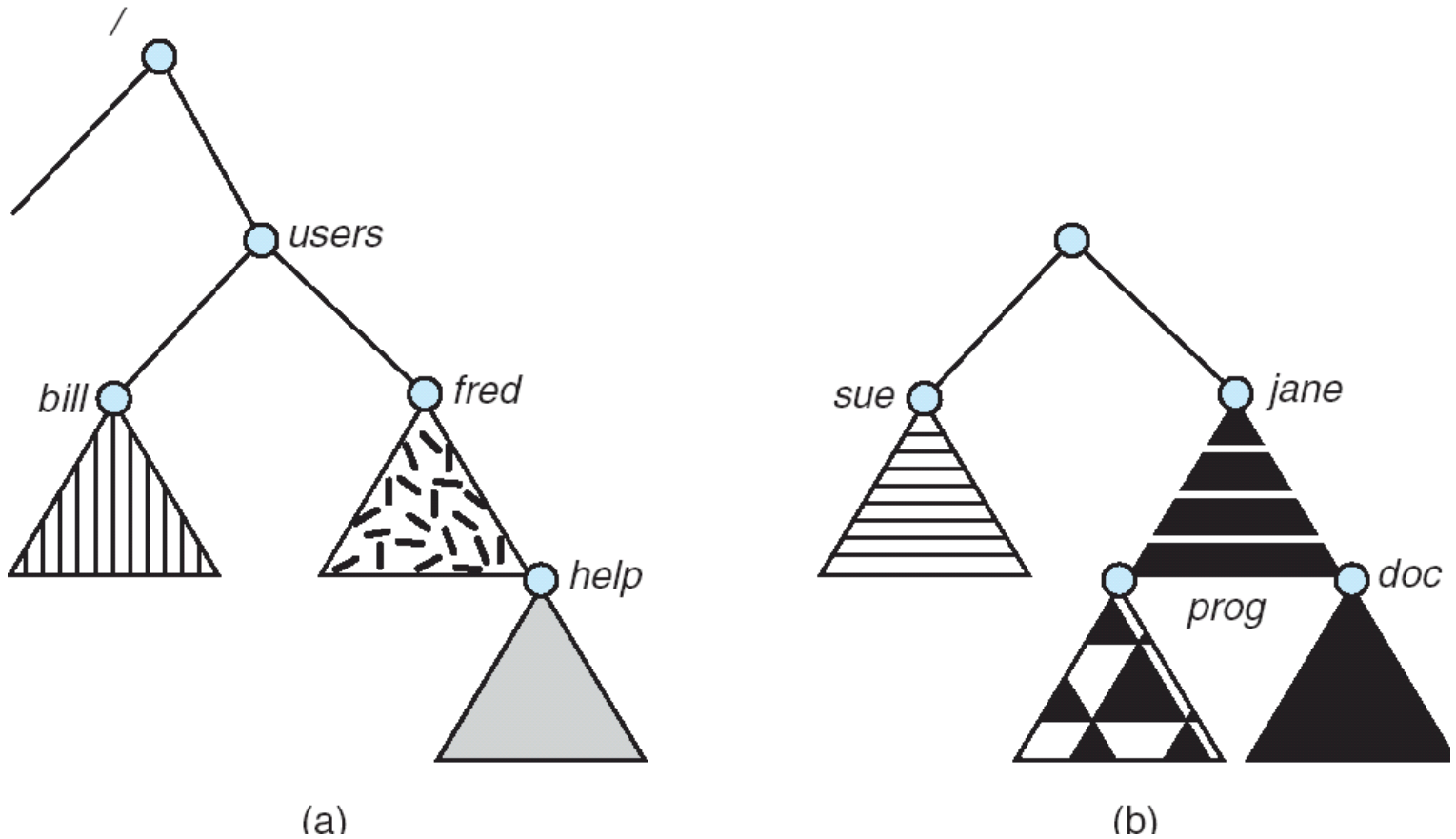
10.4 File System Mounting



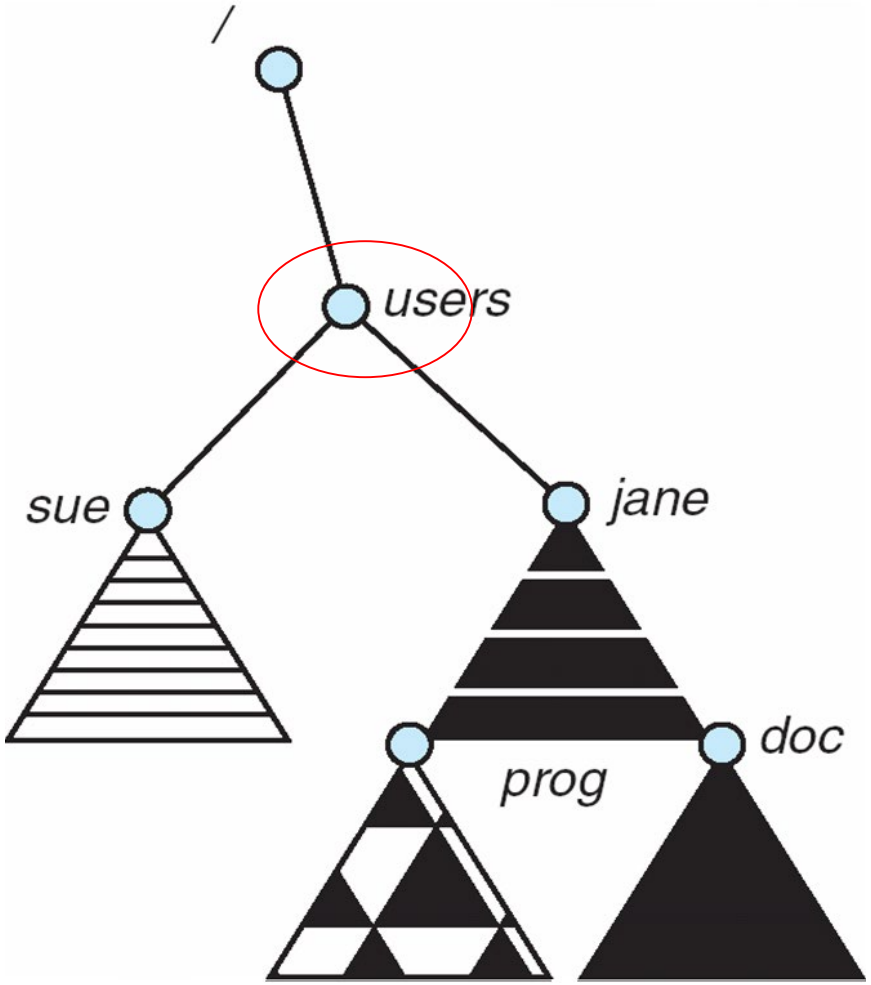
File System Mounting

- A file system must be **mounted** before it can be accessed
- A unmounted file system (i.e. Fig. 11-11(b)) is mounted at a **mount point**

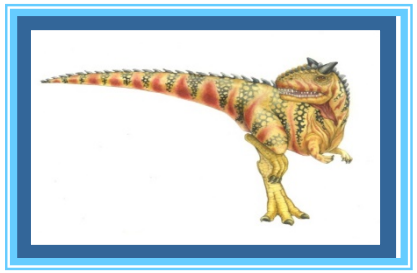
(a) Existing. (b) Unmounted Partition



Mount Point



10.5 File Sharing



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

- **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, Active Directory implement unified access to information needed for remote computing

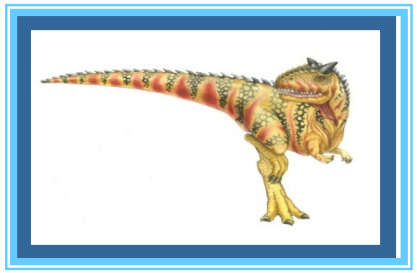
File Sharing – Failure Modes

- 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

File Sharing – Consistency Semantics

- **Consistency semantics** specify how multiple users are to access a shared file simultaneously
  - Similar to Ch 7 process synchronization algorithms
    - Tend to be less complex due to disk I/O and network latency (for remote file systems
  - Andrew File System (AFS) implemented complex remote file sharing semantics
  - Unix file system (UFS) implements:
    - Writes to an open file visible immediately to other users of the same open file
    - Sharing file pointer to allow multiple users to read and write concurrently
  - AFS has session semantics
    - Writes only visible to sessions starting after the file is closed

10.6 Protection



Protection

- File owner/creator should be able to control:
  - what can be done
  - by whom

- Types of access
  - **Read**
  - **Write**
  - **Execute**
  - **Append**
  - **Delete**
  - **List**

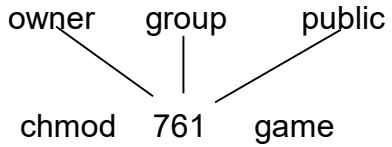
Access Lists and Groups

Unix、Linux

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

			RWX
a) **owner access**	7	⇒	1 1 1
b) **group access**	6	⇒	RWX 1 1 0
c) **public access**	1	⇒	RWX 0 0 1

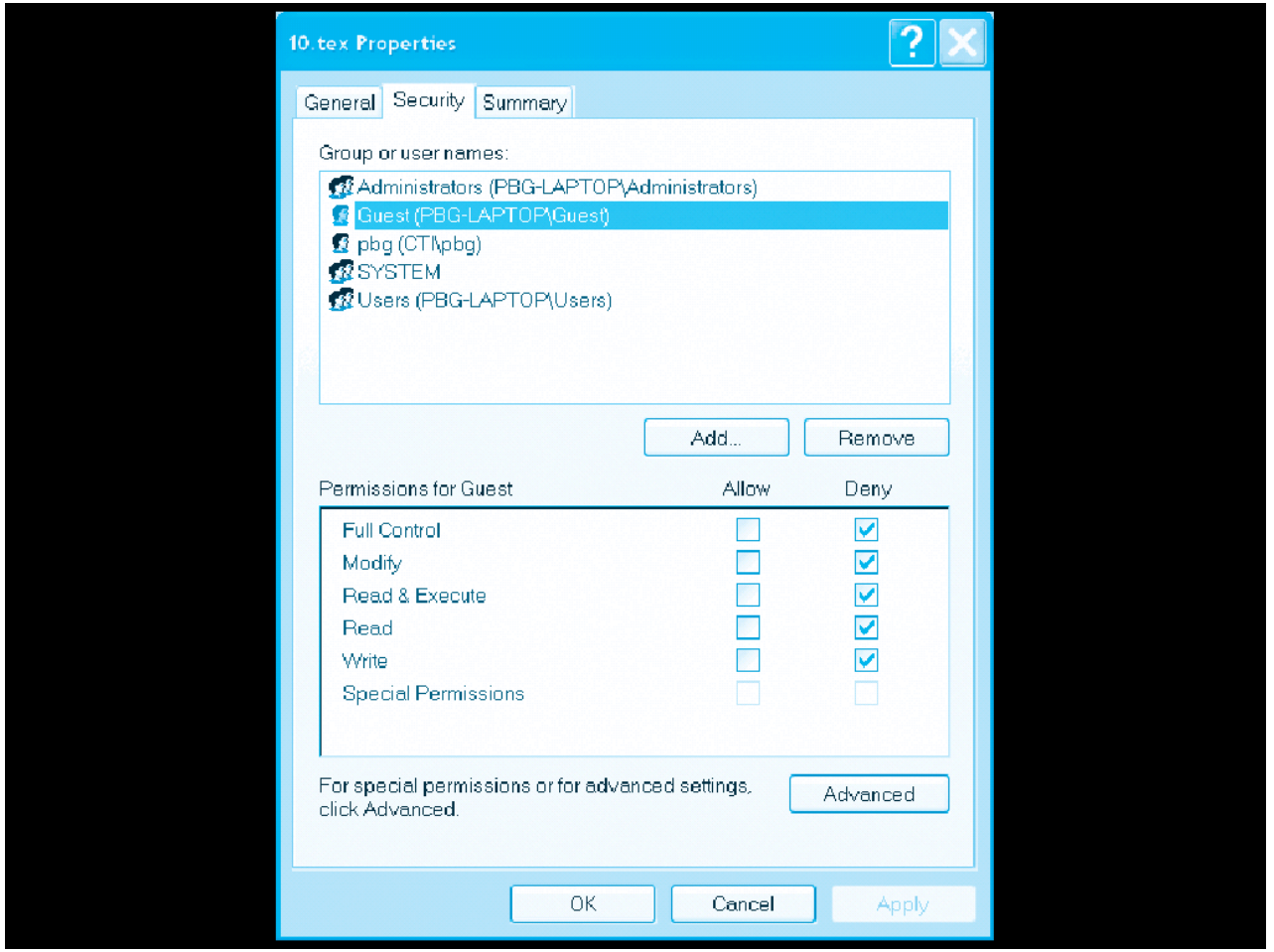
- Ask manager to create a group (unique name), say G, and add some users to the group.
- For a particular file (say *game*) or subdirectory, define an appropriate access.



Attach a group to a file：

chgrp G game

Windows XP Access-control List Management



A Sample UNIX Directory Listing

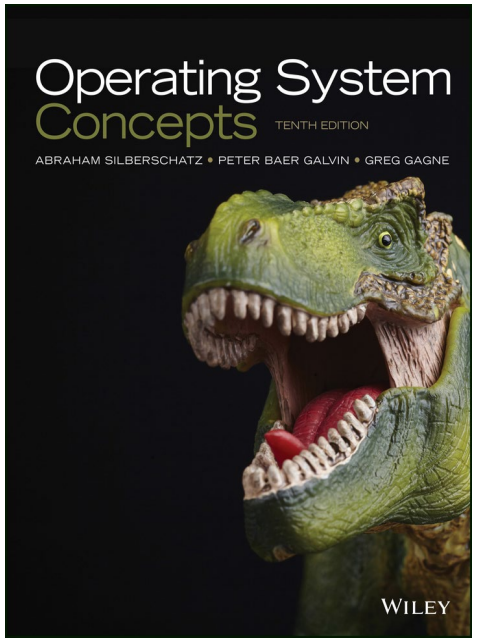
-rw-rw-r--	1 pbg	staff	31200	Sep 3 08:30	intro.ps
drwx------	5 pbg	staff	512	Jul 8 09.33	private/
drwxrwxr-x	2 pbg	staff	512	Jul 8 09:35	doc/
drwxrwx---	2 pbg	student	512	Aug 3 14:13	student-proj/
-rw-r--r--	1 pbg	staff	9423	Feb 24 2003	program.c
-rwxr-xr-x	1 pbg	staff	20471	Feb 24 2003	program
drwx--x--x	4 pbg	faculty	512	Jul 31 10:31	lib/
drwx------	3 pbg	staff	1024	Aug 29 06:52	mail/
drwxrwxrwx	3 pbg	staff	512	Jul 8 09:35	test/

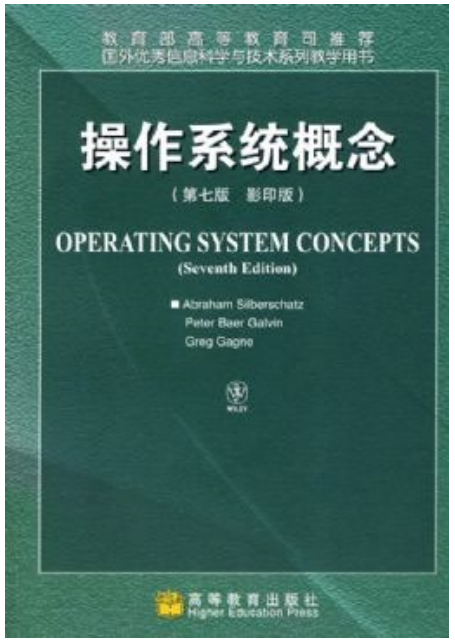
Homework

- 学在浙大

Reading Assignments

- **Read for this week:**
  - **Chapters 10**
    of the text book:
- **Read for next week:**
  - **Chapters 11**
    of the text book:





End of Chapter 10