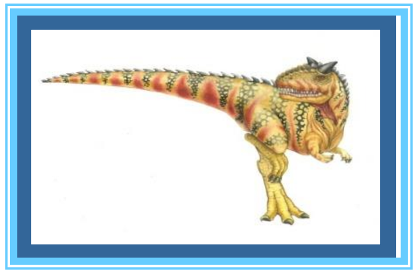
Chapter 10: File-System Interface

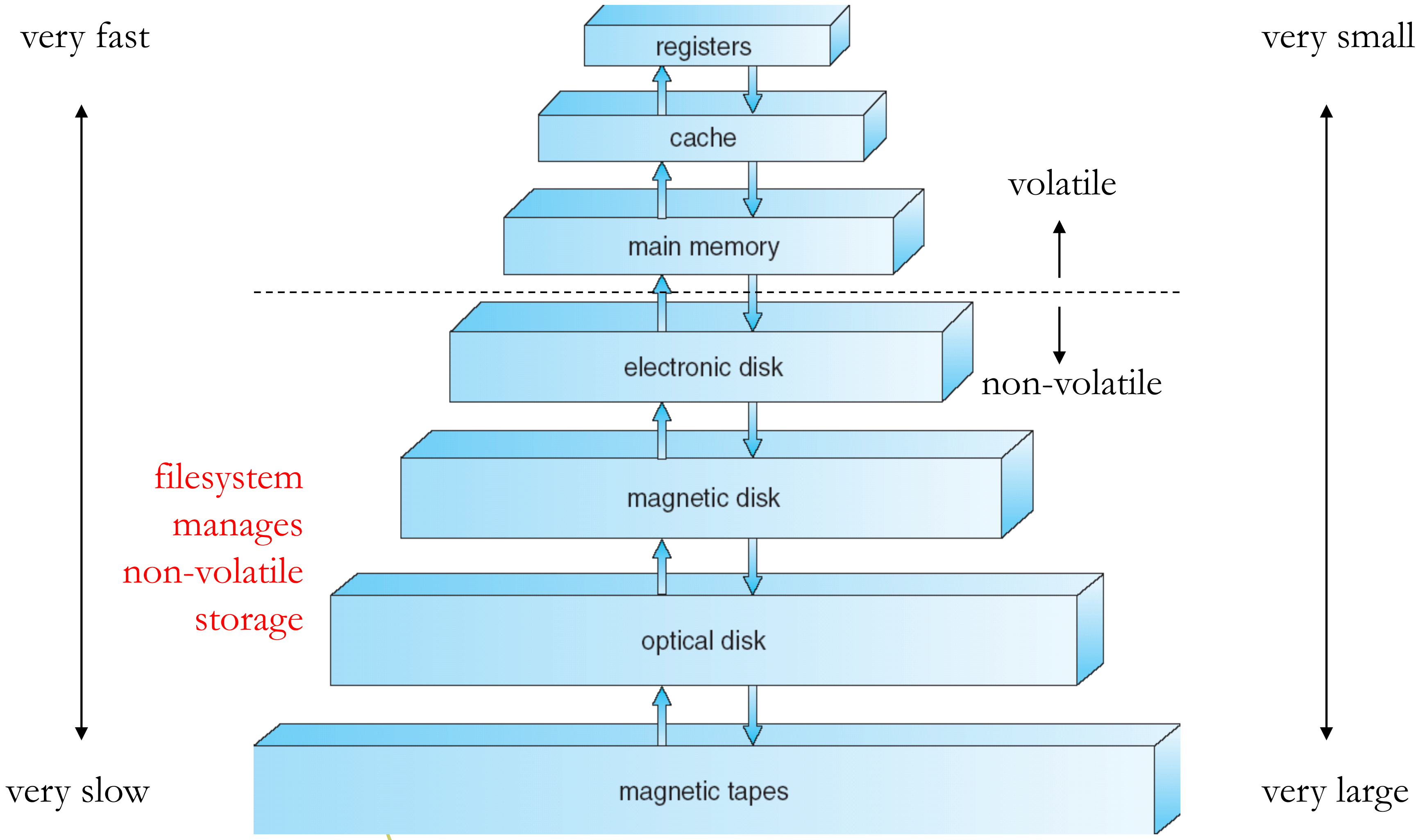


Chapter 10: File-System Interface

Objectives

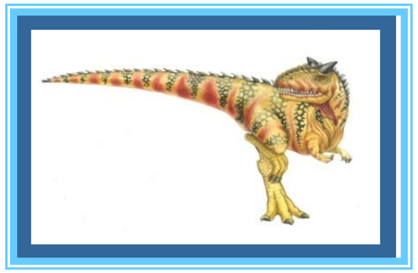
- To explain the function of file systems
- To describe the interfaces to file systems
- To discuss file-system design tradeoffs, including access methods, file sharing, file locking, and directory structures
- To explore file-system protection

Hierarchical Storage Architecture



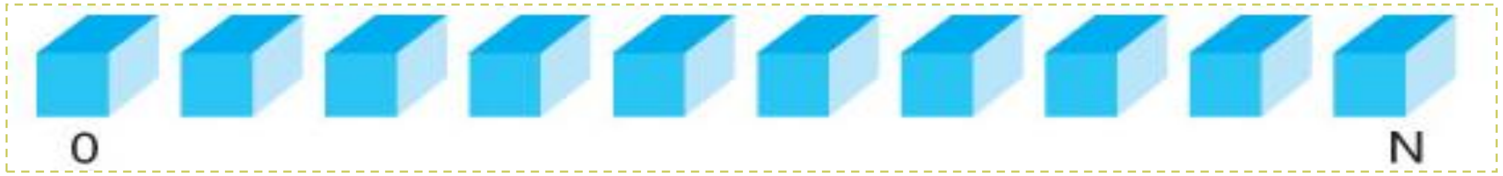
filesystem manages non-volatile storage

10.1 File Concept



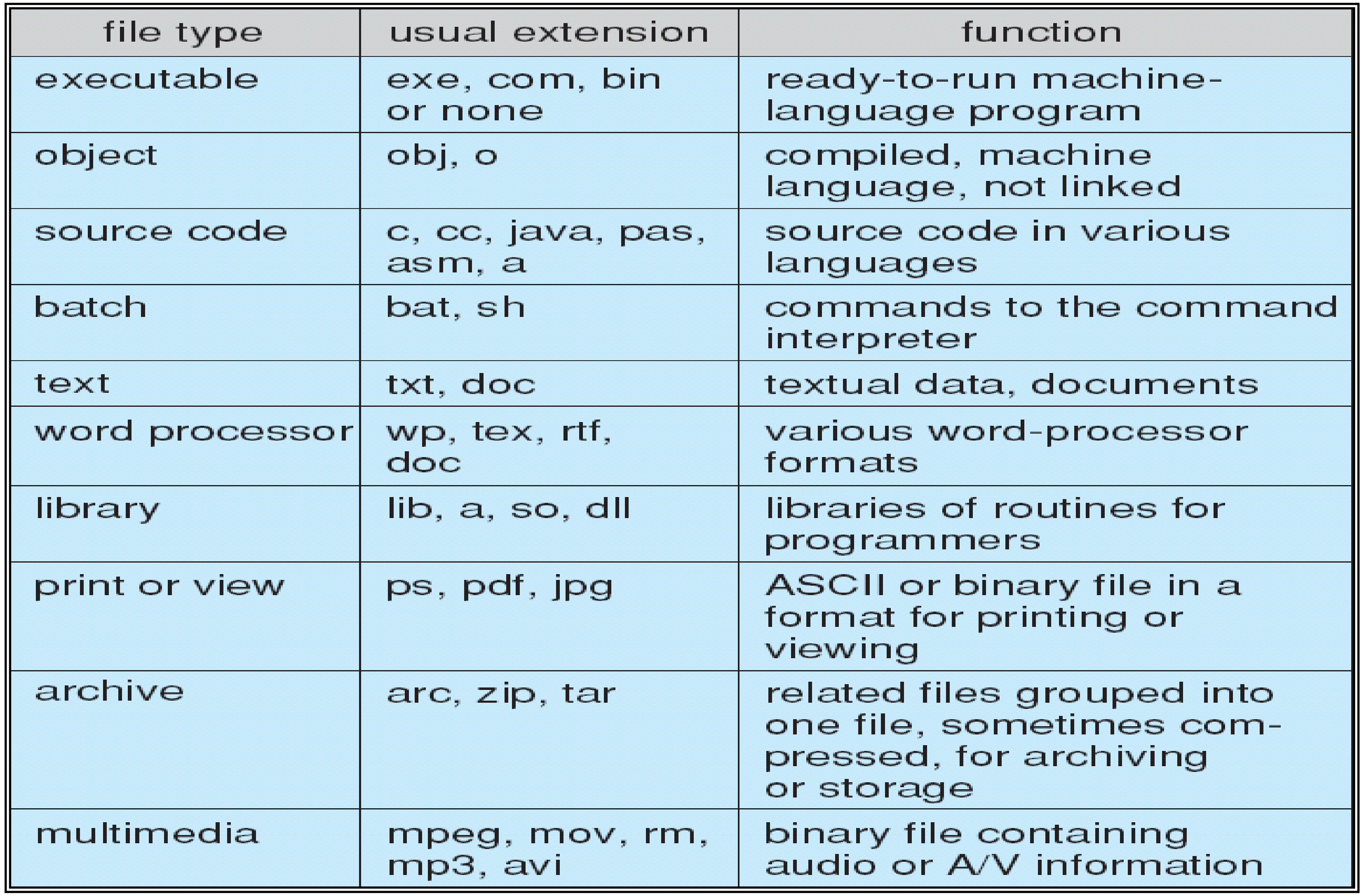
File Concept

- 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 Types – Name, Extension



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 Attributes

- **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

- 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

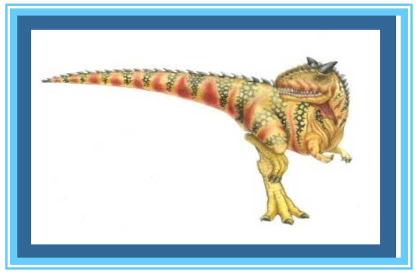
Open Files

- 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 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



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

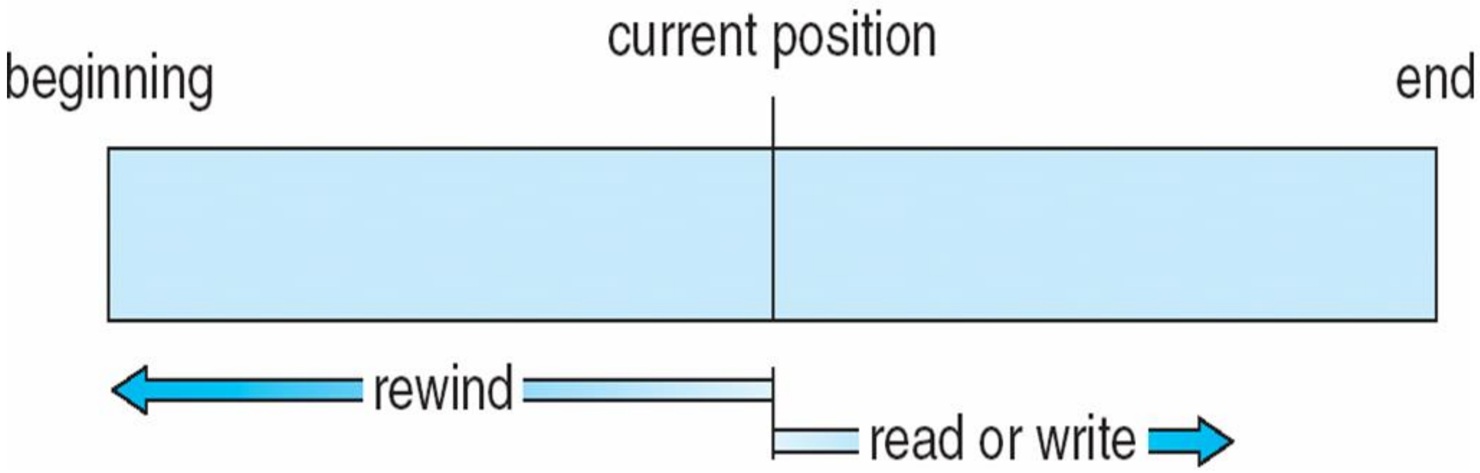
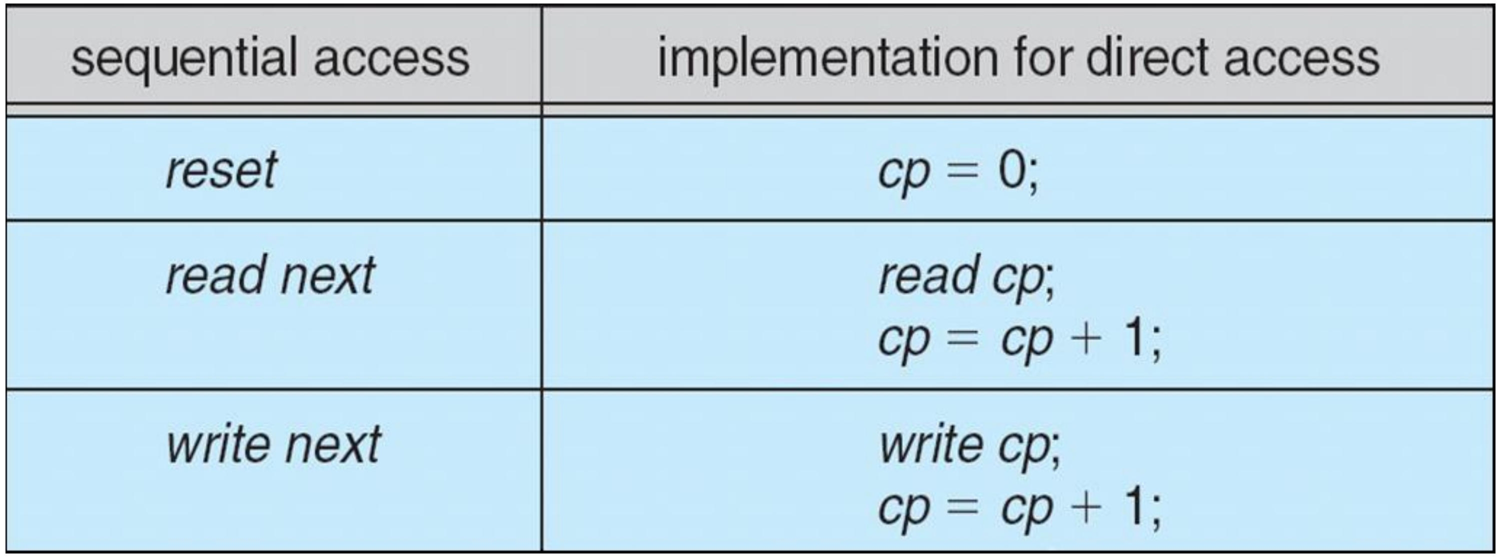
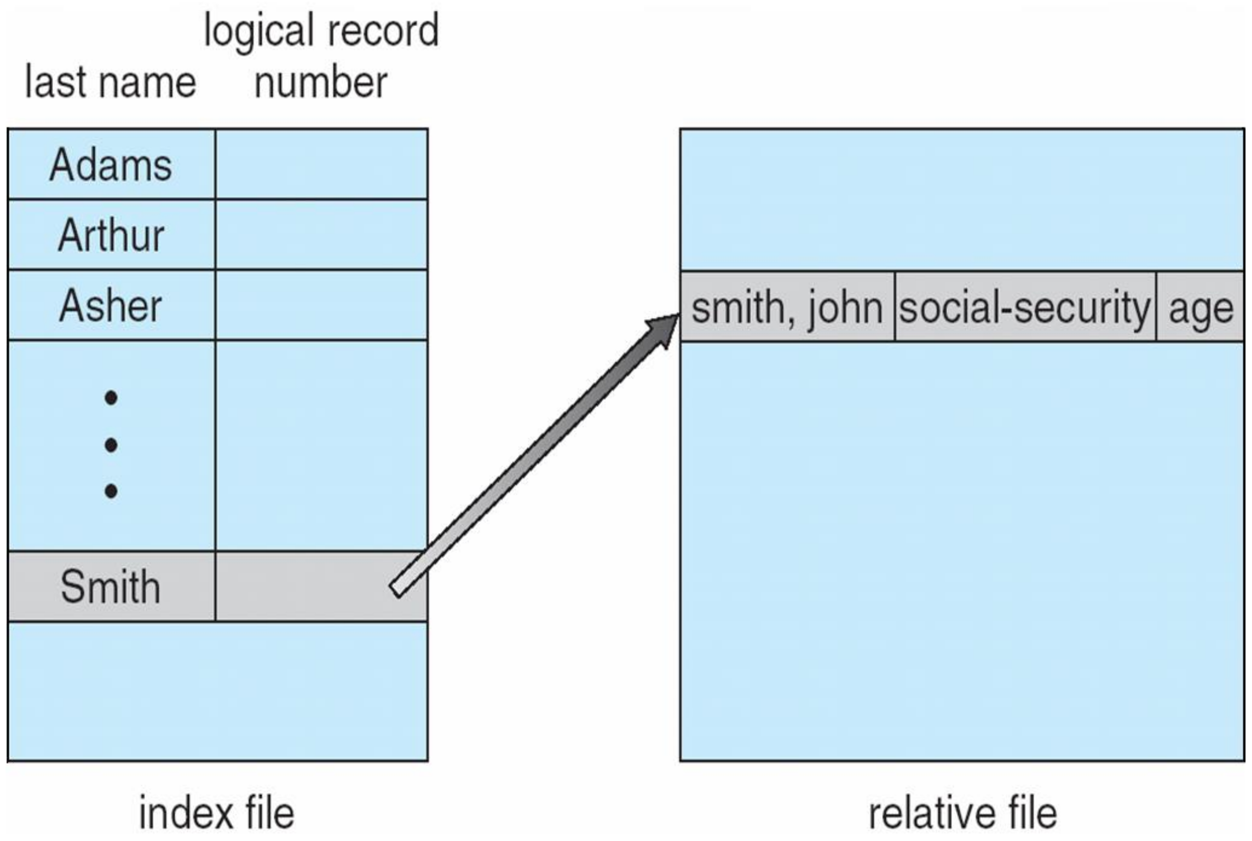


Fig 10.3 Simulation of Sequential Access on Direct-access File

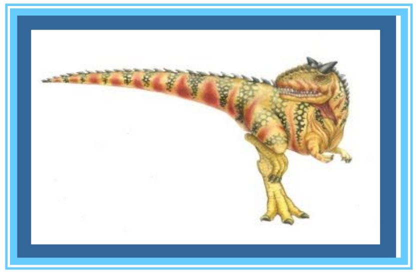


sequential access	implementation for direct access
reset	*cp* = 0;
read next	*read cp*; *cp* = *cp* + 1;
write next	*write cp*; *cp* = *cp* + 1;

Fig 10.4 Example of Index and Relative Files

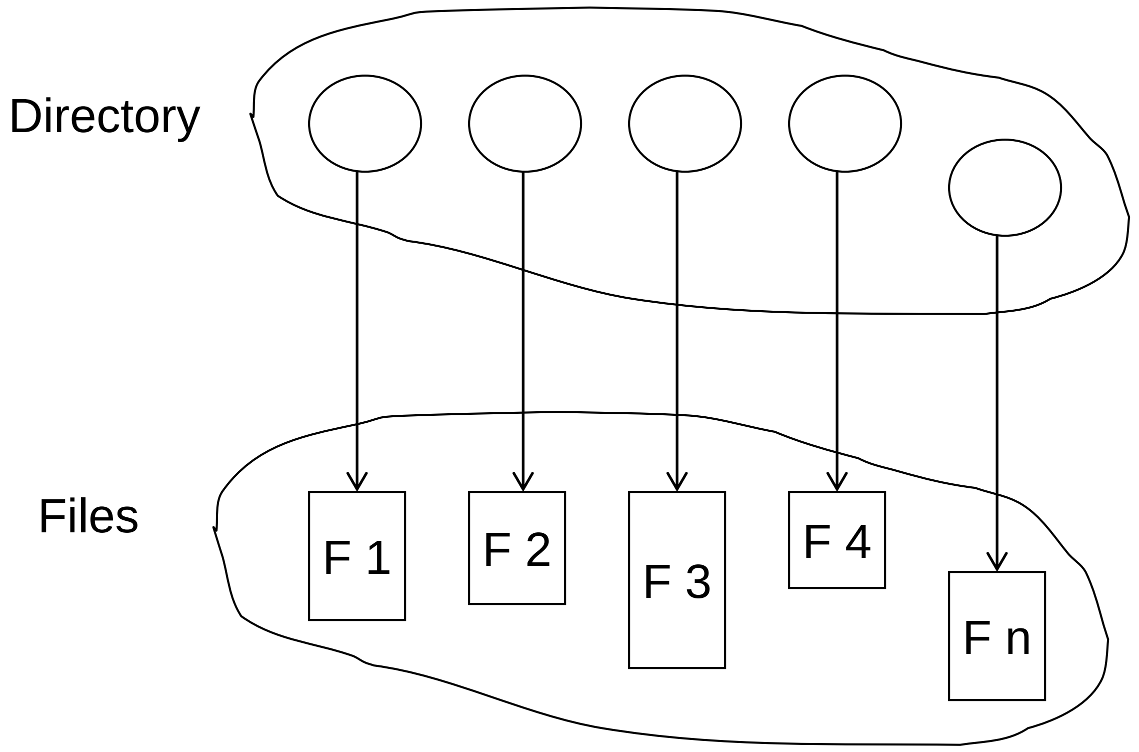


10.3 Directory Structure（目录结构）



Directory Structure

- A collection of nodes containing information about all files

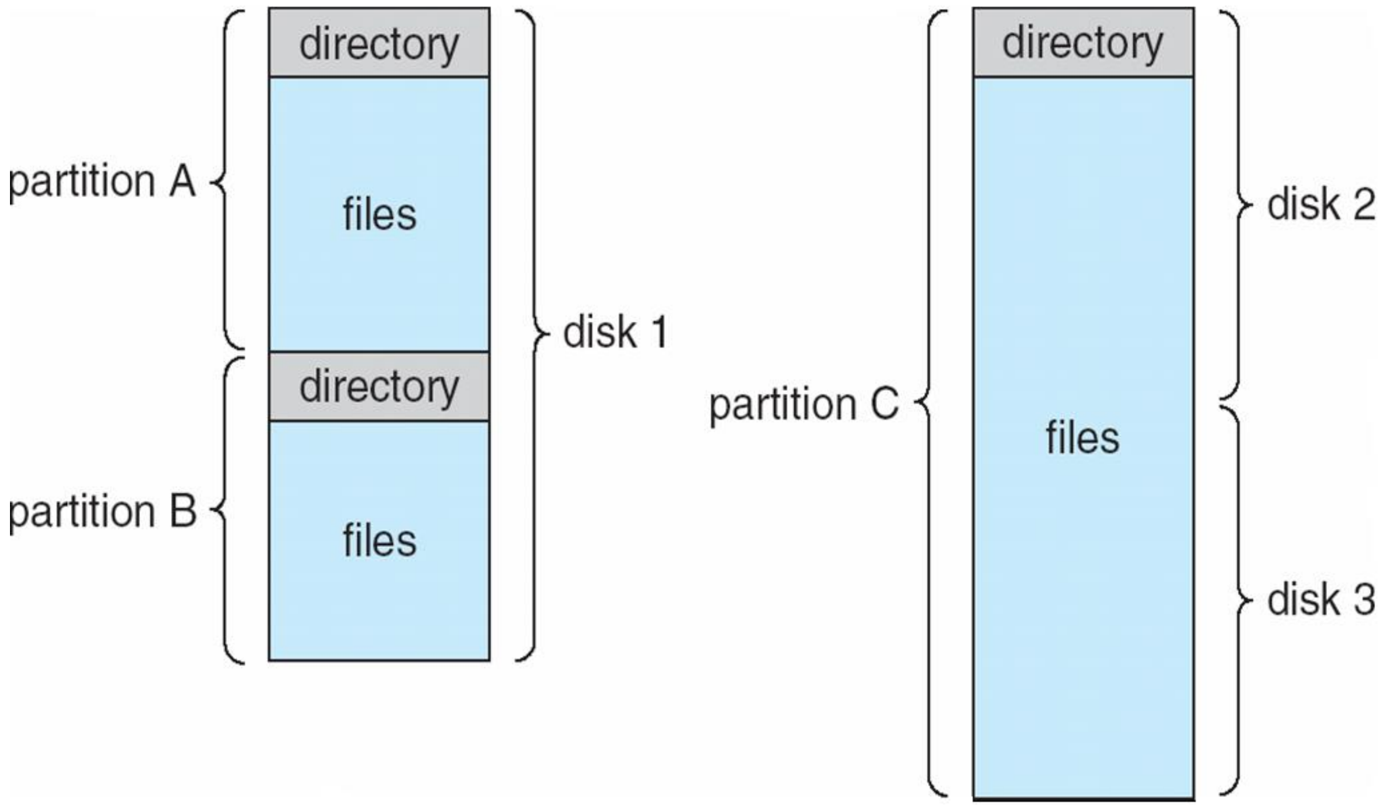


Both the directory structure and the files reside on disk
Backups of these two structures are kept on tapes

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

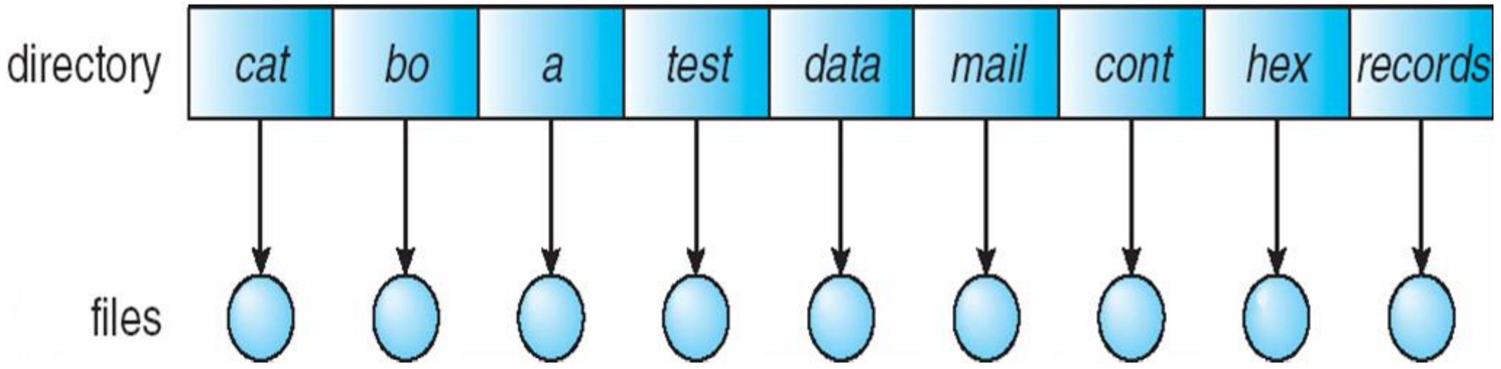
- Search for a file
- Create a file
- Delete a file
- List a directory
- Rename a file
- Traverse the file system（遍历文件系统）

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

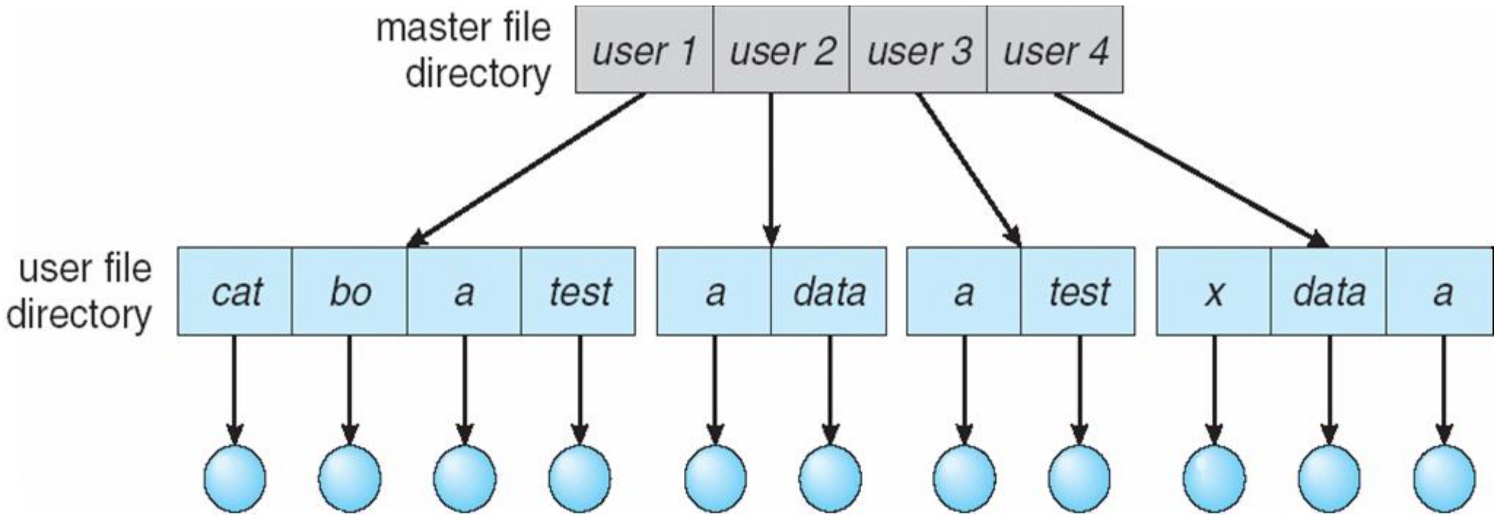


Naming problem

Grouping problem

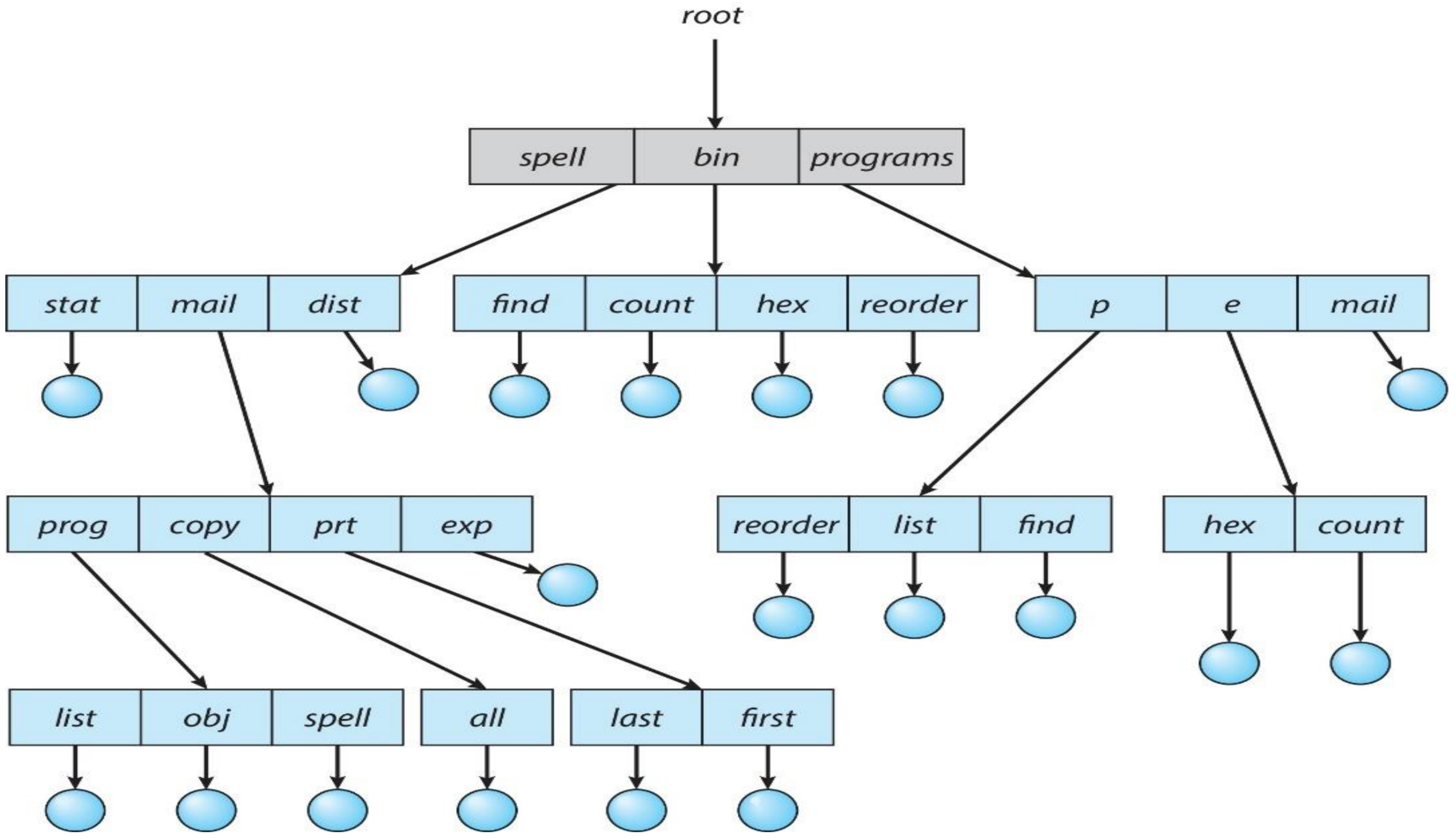
Two-Level Directory（二级目录）

- 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

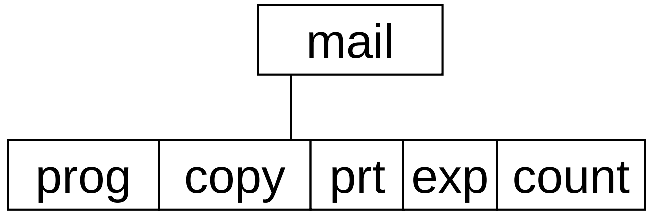
  rm <file-name>

- Creating a new subdirectory is done in current directory

  mkdir <dir-name>

  Example: if in current directory /mail

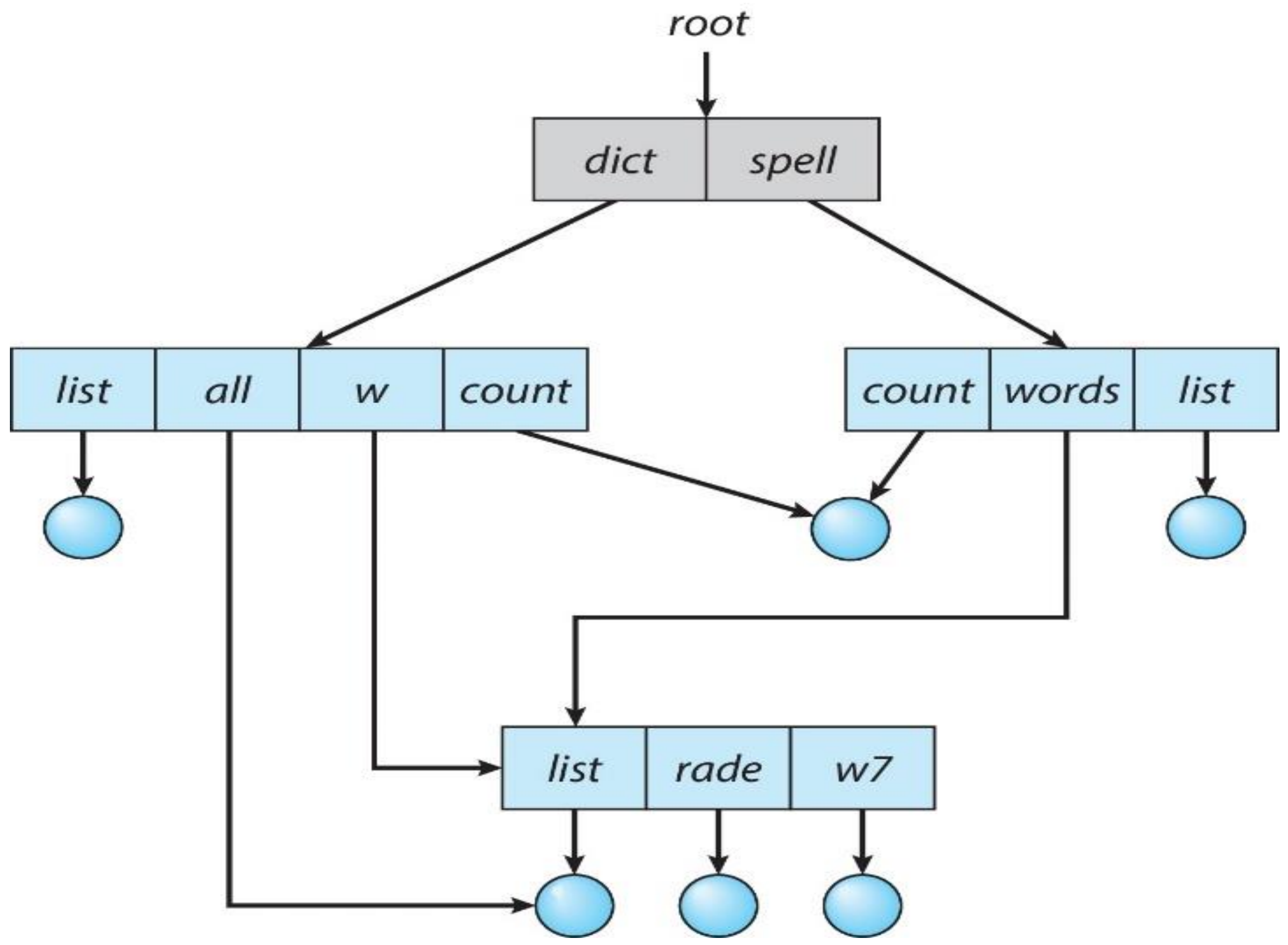
  mkdir count



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

Acyclic-Graph Directories无环图结构目录

- Have shared subdirectories and files

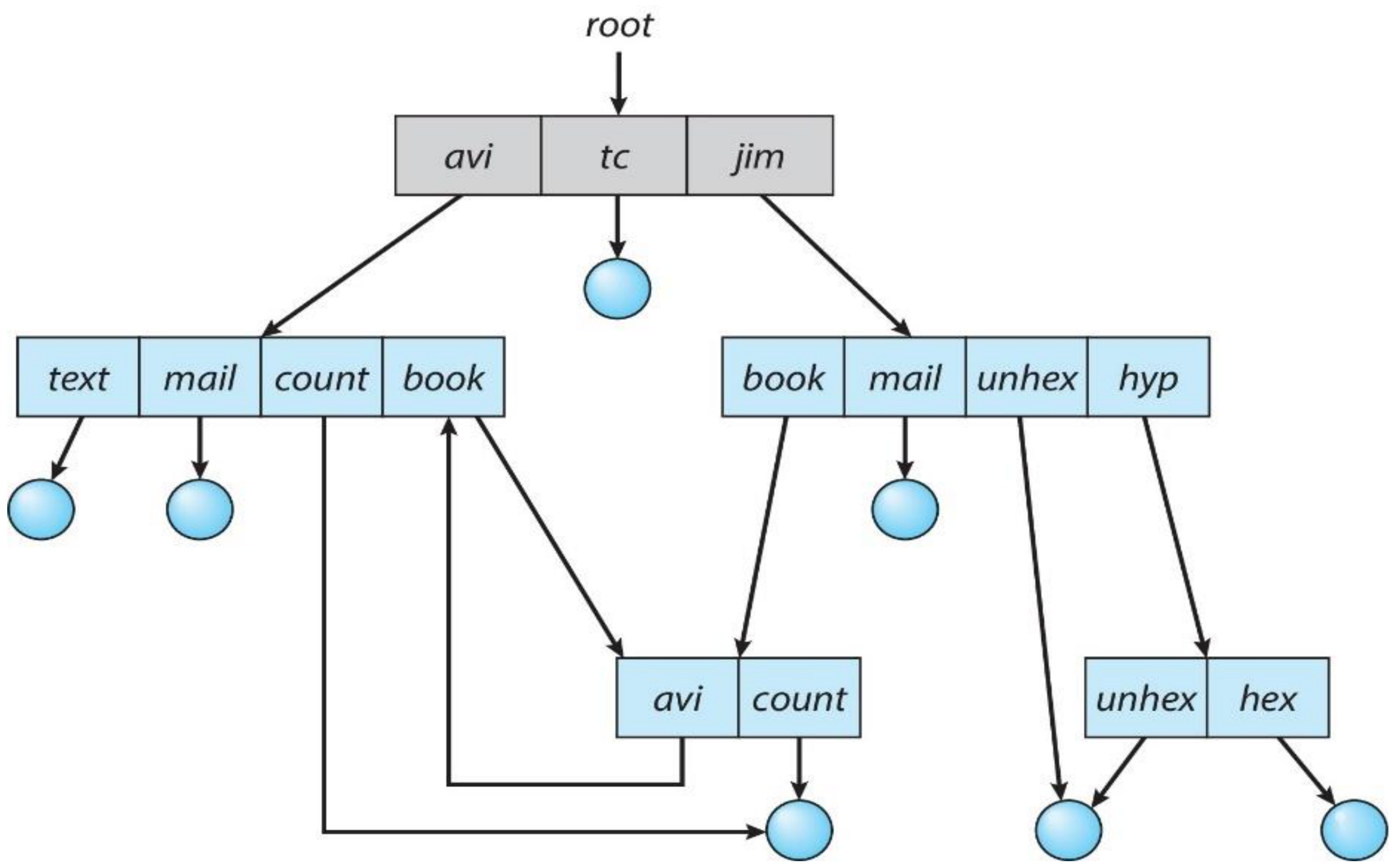


Acyclic-Graph Directories (Cont.)

- 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

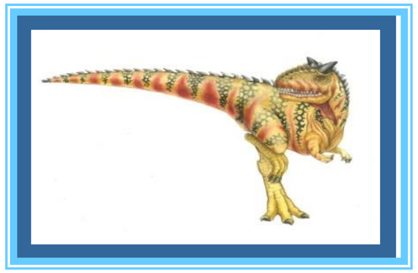
General Graph Directory （普通图结构目录）



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

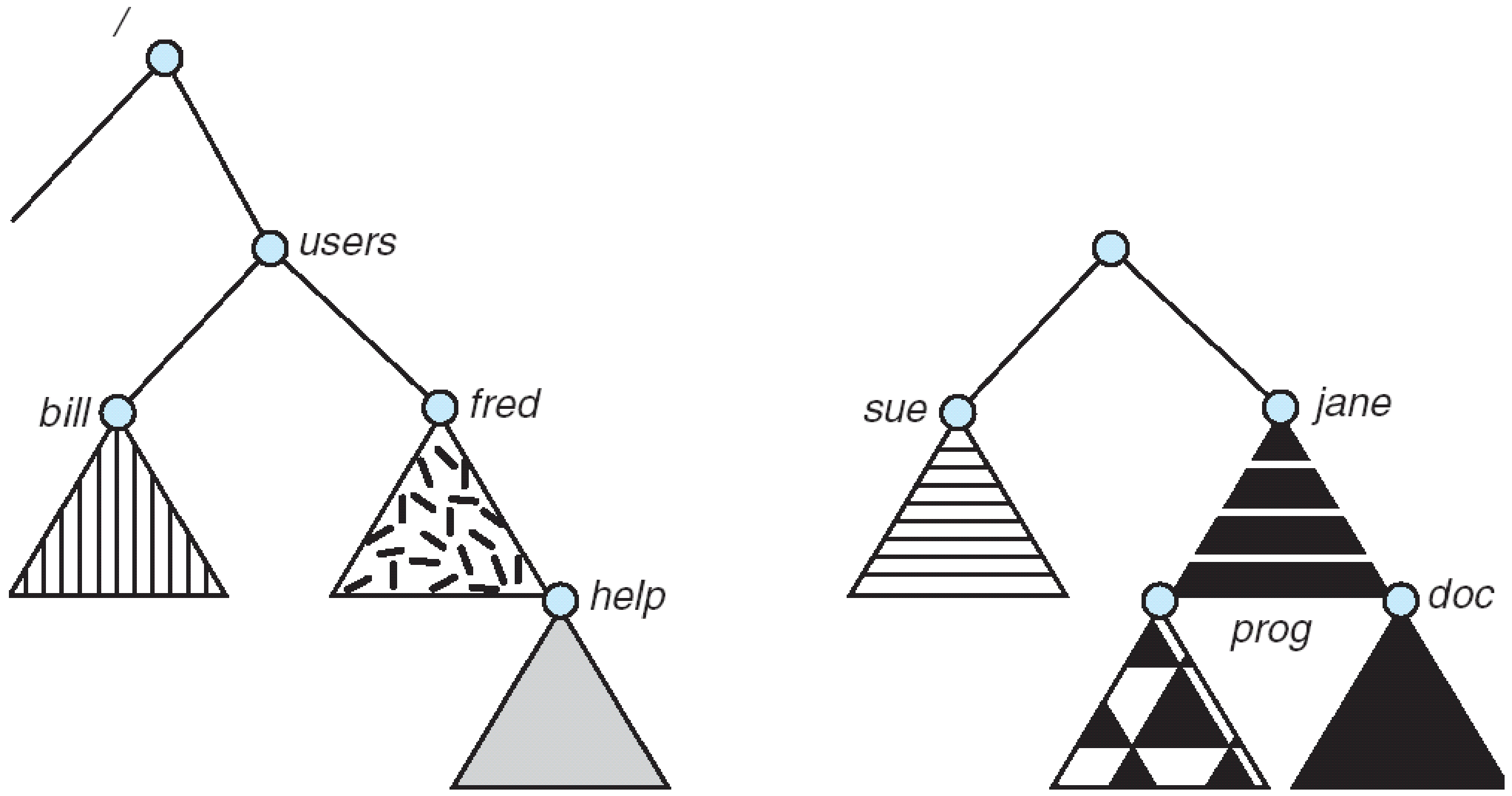
10.4 File System Mounting



File System Mounting

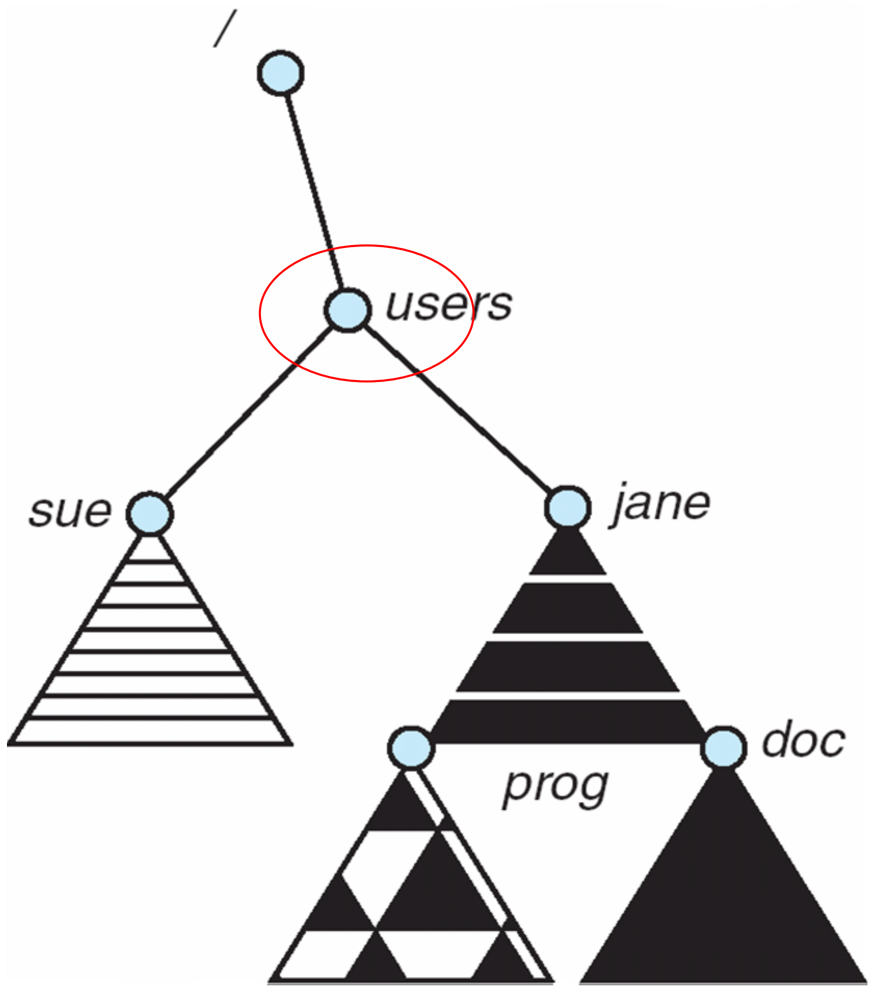
- A file system must be **mounted** before it can be accessed
- A unmounted file system (i.e. Fig. 11-11(b)) is mounted at a **mount point**

(a) Existing. (b) Unmounted Partition

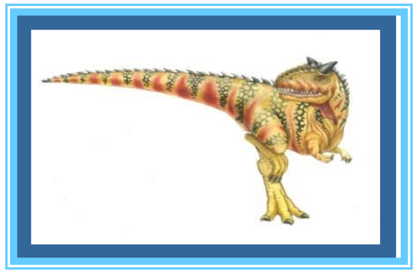


(a)   (b)

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

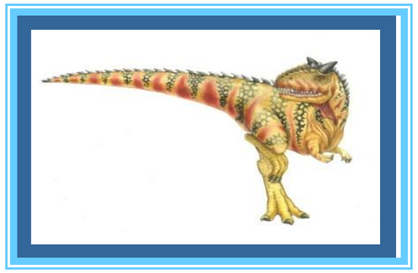
File Sharing – Failure Modes

- 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**

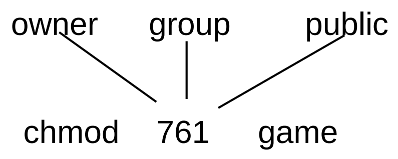
Access Lists and Groups

Unix、Linux

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

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

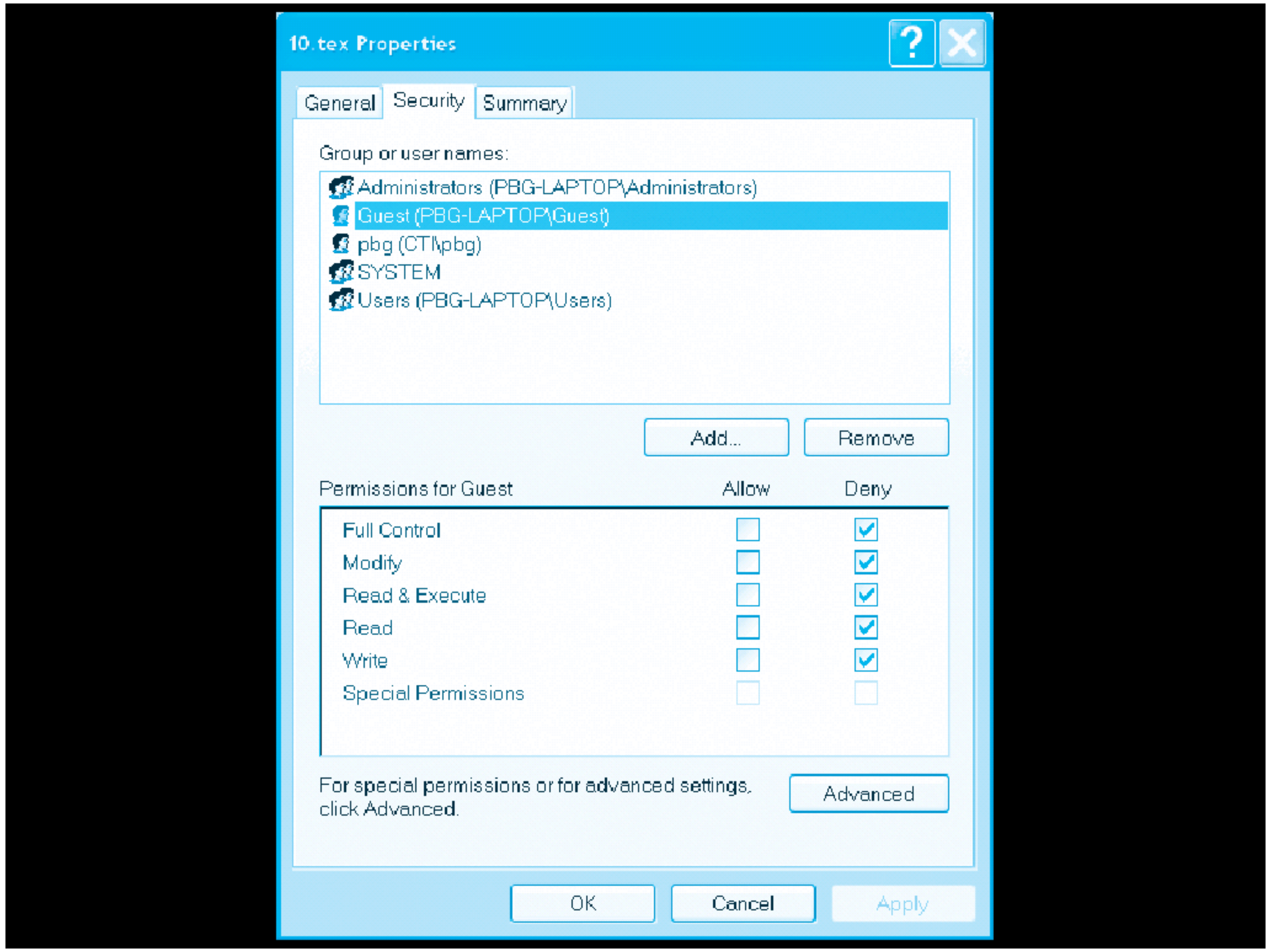


```
chmod   761   game
```

Attach a group to a file：

```
chgrp   G   game
```

Windows XP Access-control List Management



10.tex Properties

General | Security | Summary

Group or user names:

- Administrators (PBG-LAPTOP\Administrators)
- Guest (PBG-LAPTOP\Guest)
- pbg (CTI\pbg)
- SYSTEM
- Users (PBG-LAPTOP\Users)

Add... | Remove

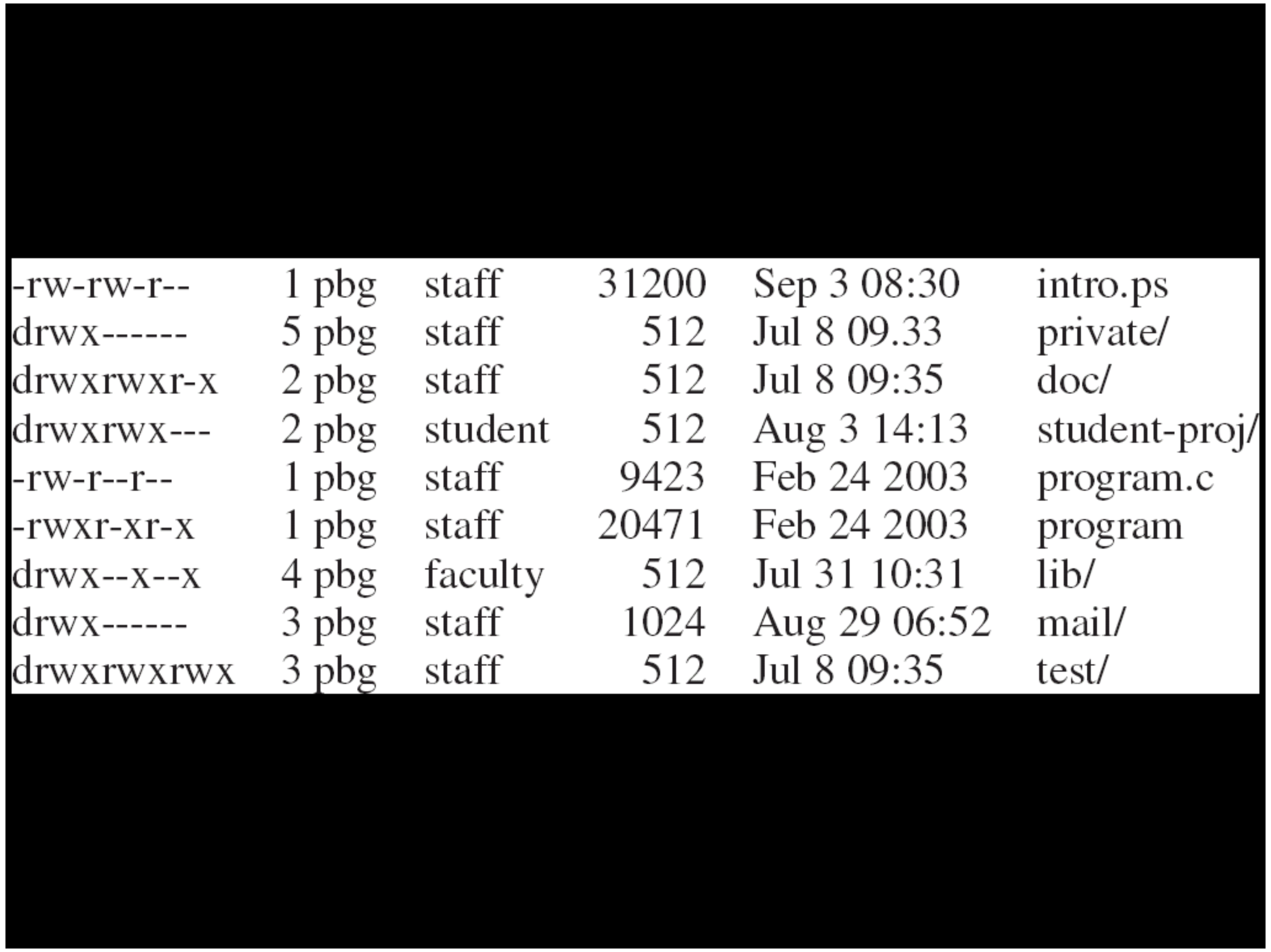
Permissions for Guest	Allow	Deny
Full Control	☐	✓
Modify	☐	✓
Read & Execute	☐	✓
Read	☐	✓
Write	☐	✓
Special Permissions	☐	☐

For special permissions or for advanced settings, click Advanced.

Advanced

OK | Cancel | Apply

A Sample UNIX Directory Listing



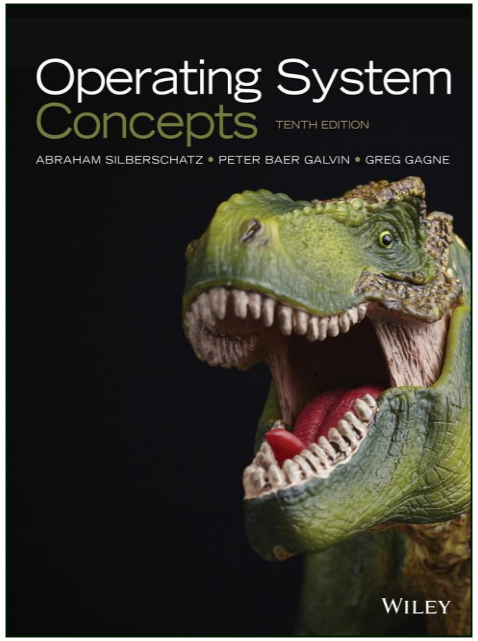
```
-rw-rw-r--     1 pbg   staff      31200   Sep 3 08:30    intro.ps
drwx------     5 pbg   staff        512   Jul 8 09.33    private/
drwxrwxr-x     2 pbg   staff        512   Jul 8 09:35    doc/
drwxrwx---     2 pbg   student      512   Aug 3 14:13    student-proj/
-rw-r--r--     1 pbg   staff       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/
```

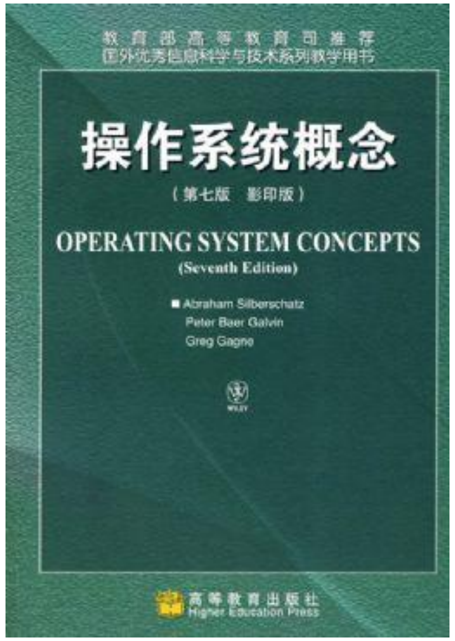
Homework

- 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:


Operating System Concepts
TENTH EDITION
ABRAHAM SILBERSCHATZ • PETER BAER GALVIN • GREG GAGNE
WILEY



End of Chapter 10