

# Chapter 10: File-System





# Chapter 10: File-System Interface

- File Concept
- Access Methods
- Directory Structure
- File-System Mounting
- File Sharing
- 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





# File Concept

- Contiguous logical address space
  - OS abstracts from the physical properties of storages devices to define a logical storage unit, **file**.
  - From a user's perspective, a file is the smallest allotment of logical secondary storage.
    - ▶ Data cannot be written to secondary storage unless they are within a file.
- Types:
  - Data
    - ▶ numeric
    - ▶ character
    - ▶ binary
  - Program





# 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 appropriate control characters
- Who decides:
  - Operating system
  - Program





# 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**
- **Create**
- **Write**
- **Read**
- **Reposition within file**
  - E.g., seek
- **Delete**
- **Truncate**
  - Erase the content but keep attributes
- *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





# Open File Locking

- Provided by some operating systems and file systems
- Mediates access to a file
- Mandatory or advisory:
  - **Mandatory** – access is denied depending on locks held and requested
  - **Advisory** – processes can find status of locks and decide what to do





# 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





# Access Methods

## ■ Sequential Access

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

## ■ Direct Access

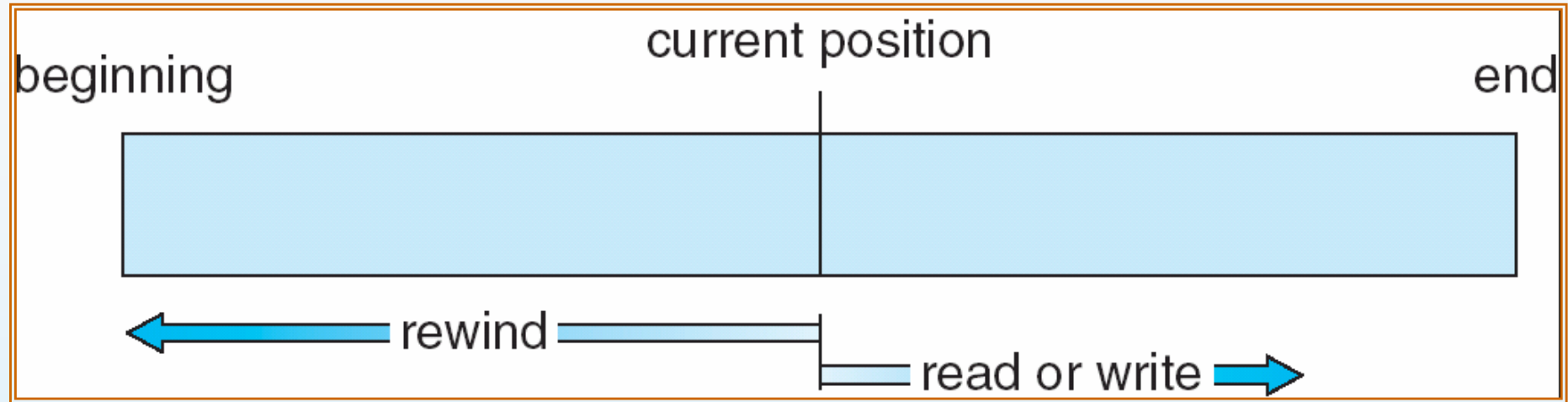
read  $n$   
write  $n$   
position to  $n$   
    read next  
    write next  
rewrite  $n$

$n$  = relative block number





# Sequential-access File





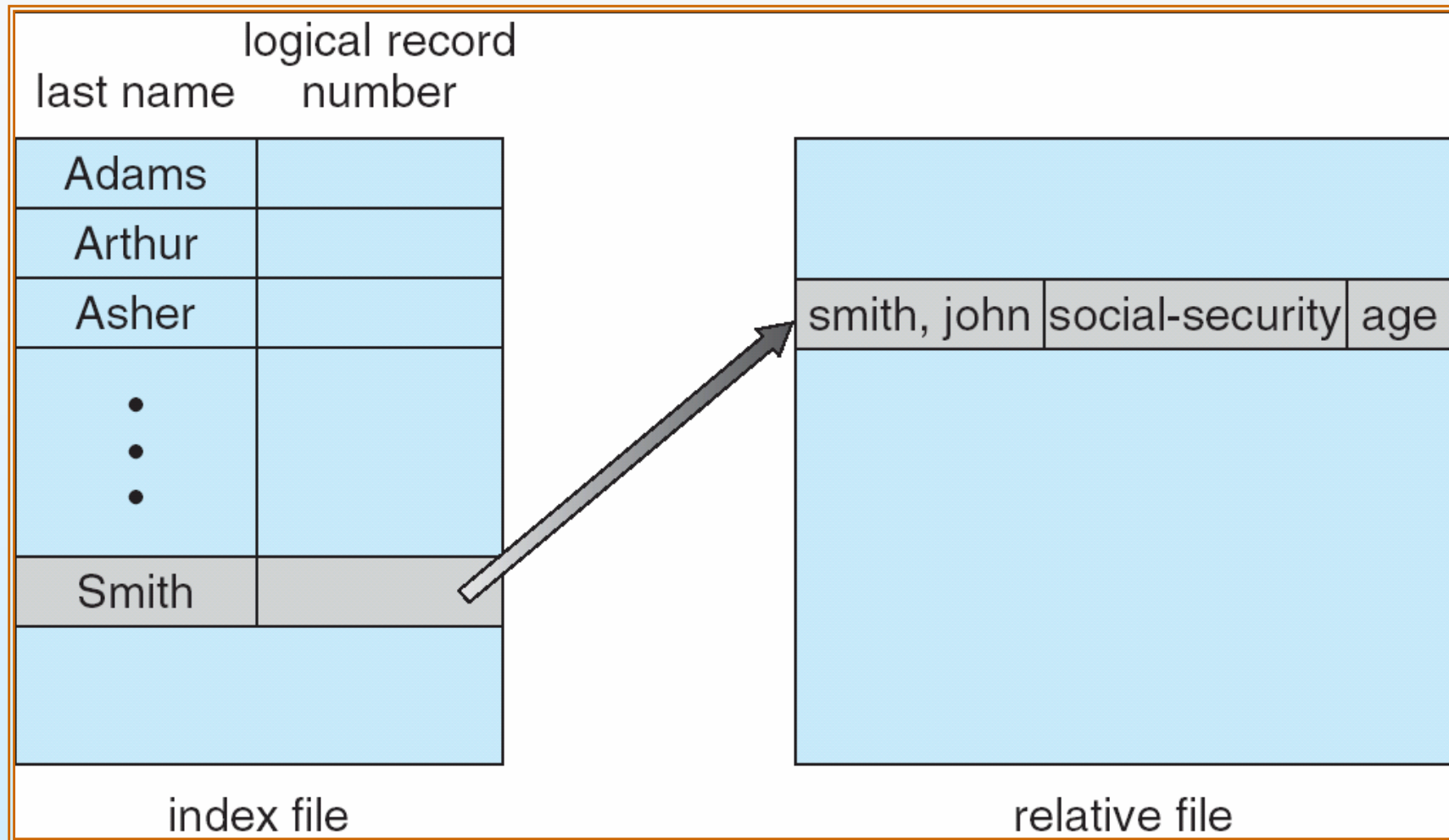
# Simulation of Sequential Access on a Direct-access File

sequential access	implementation for direct access
<i>reset</i>	<i>cp = 0;</i>
<i>read next</i>	<i>read cp;</i> <i>cp = cp + 1;</i>
<i>write next</i>	<i>write cp;</i> <i>cp = cp + 1;</i>





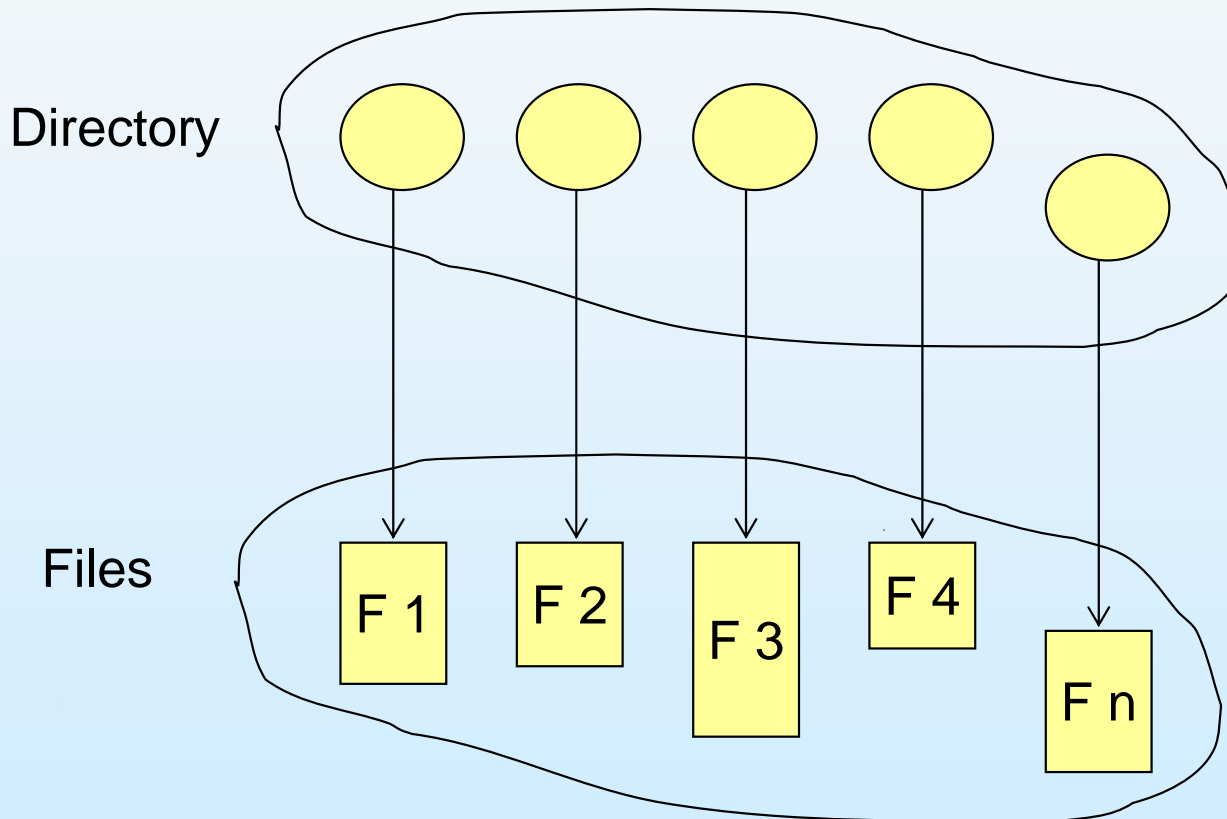
# Example of Index and Relative Files



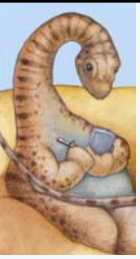


# Directory Structure

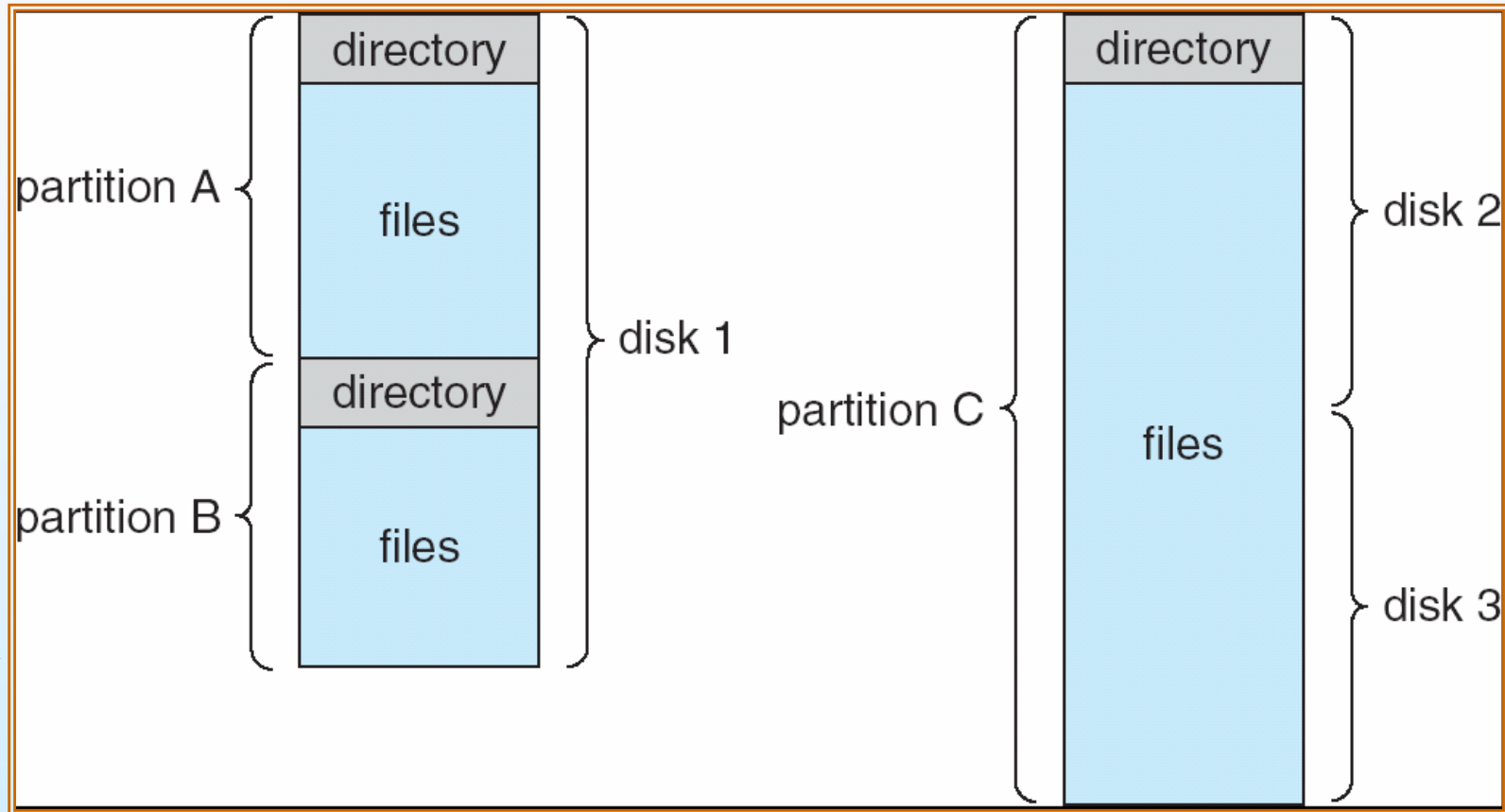
- A collection of nodes containing information about all files



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



# 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





# Organize the Directory (Logically) to Obtain

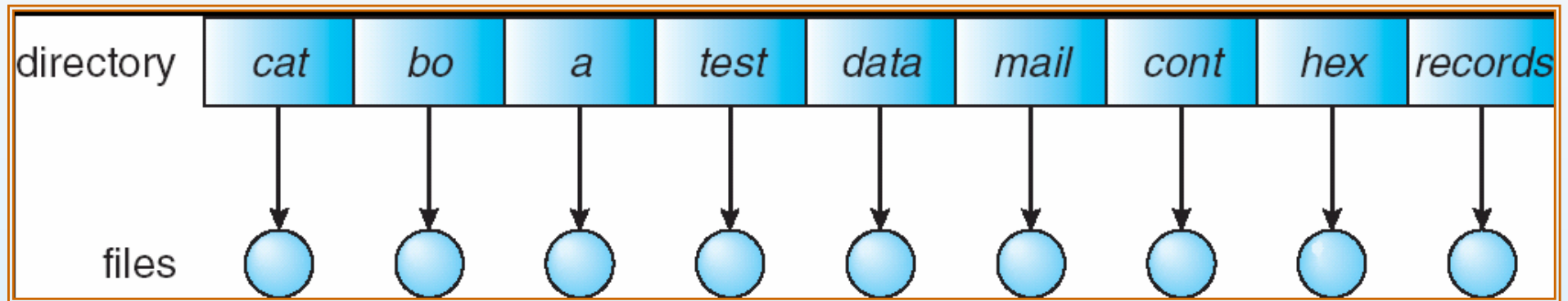
- Efficiency – locating a file quickly
- Naming – convenient to users
  - Two users can have same name for different files
  - The same file can have several different names
- Grouping – logical grouping of files by properties, (e.g., all Java programs, all games, ...)





# Single-Level Directory

- A single directory for all users



Naming problem

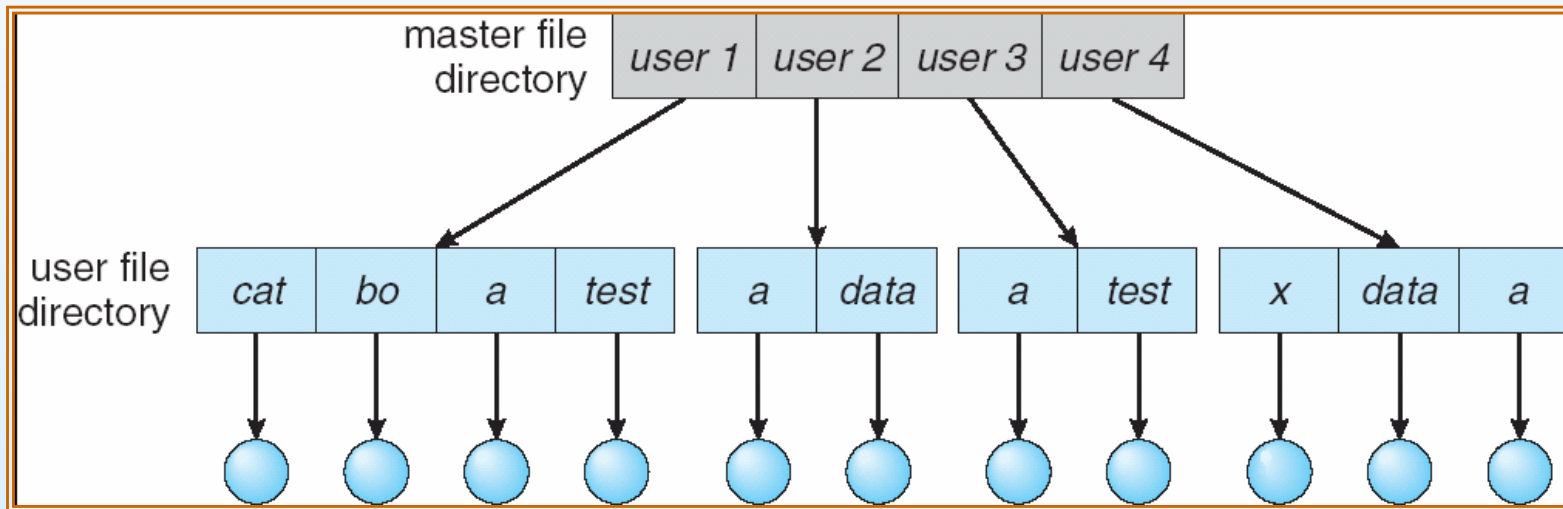
Grouping problem





# Two-Level Directory

- Separate directory for each user

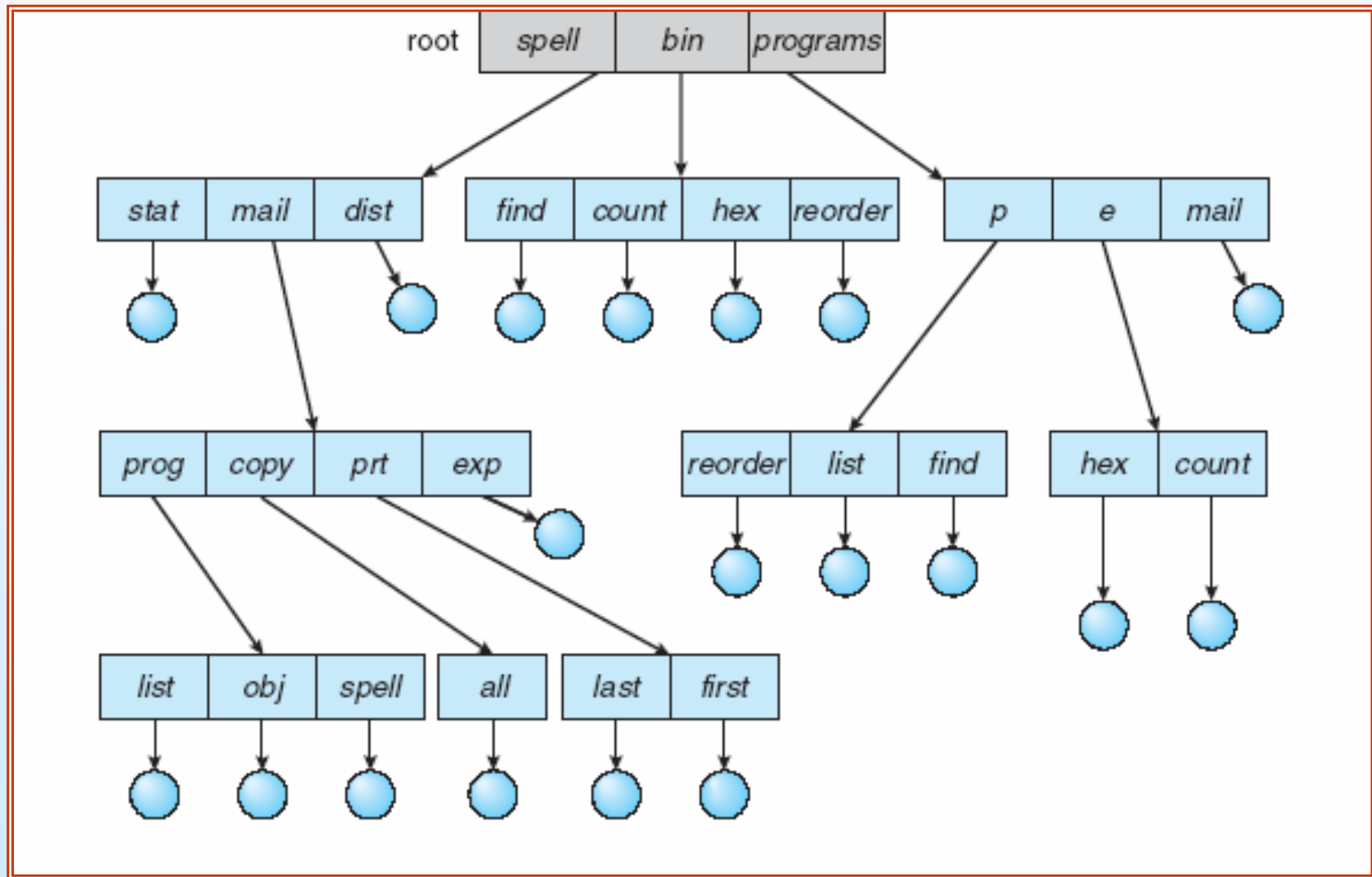


- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability





# Tree-Structured Directories





# Tree-Structured Directories (Cont)

- Efficient searching
- Grouping Capability
- Current directory (working directory)
  - `cd /spell/mail/prog`
  - `ls`





# Tree-Structured Directories (Cont)

- **Absolute** or **relative** path name
- Creating a new file is done in current directory
- Delete a file

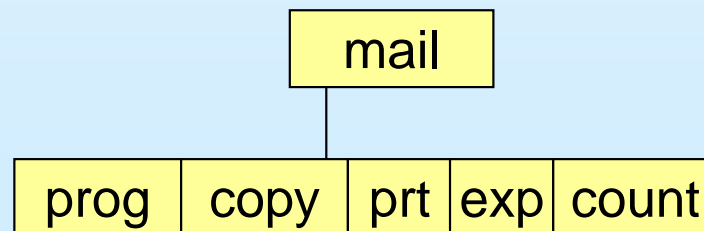
`rm <file-name>`

- Creating a new subdirectory is done in current directory

`mkdir <dir-name>`

Example: if in current directory `/mail`

`mkdir count`

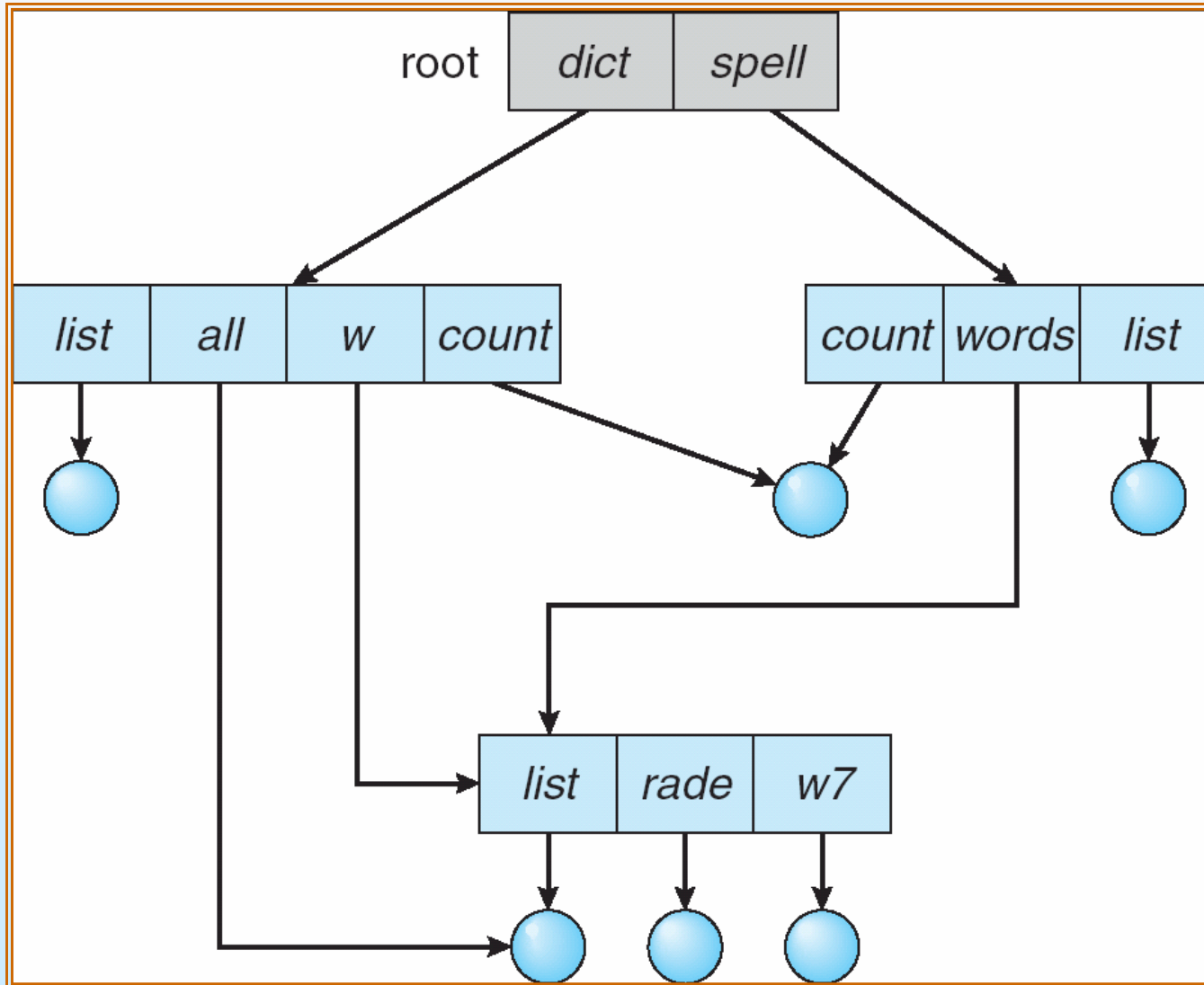


Deleting “mail”  $\Rightarrow$  deleting the entire subtree rooted by “mail”



# Acyclic-Graph Directories

- Have shared subdirectories and files





# Acyclic-Graph Directories (Cont.)

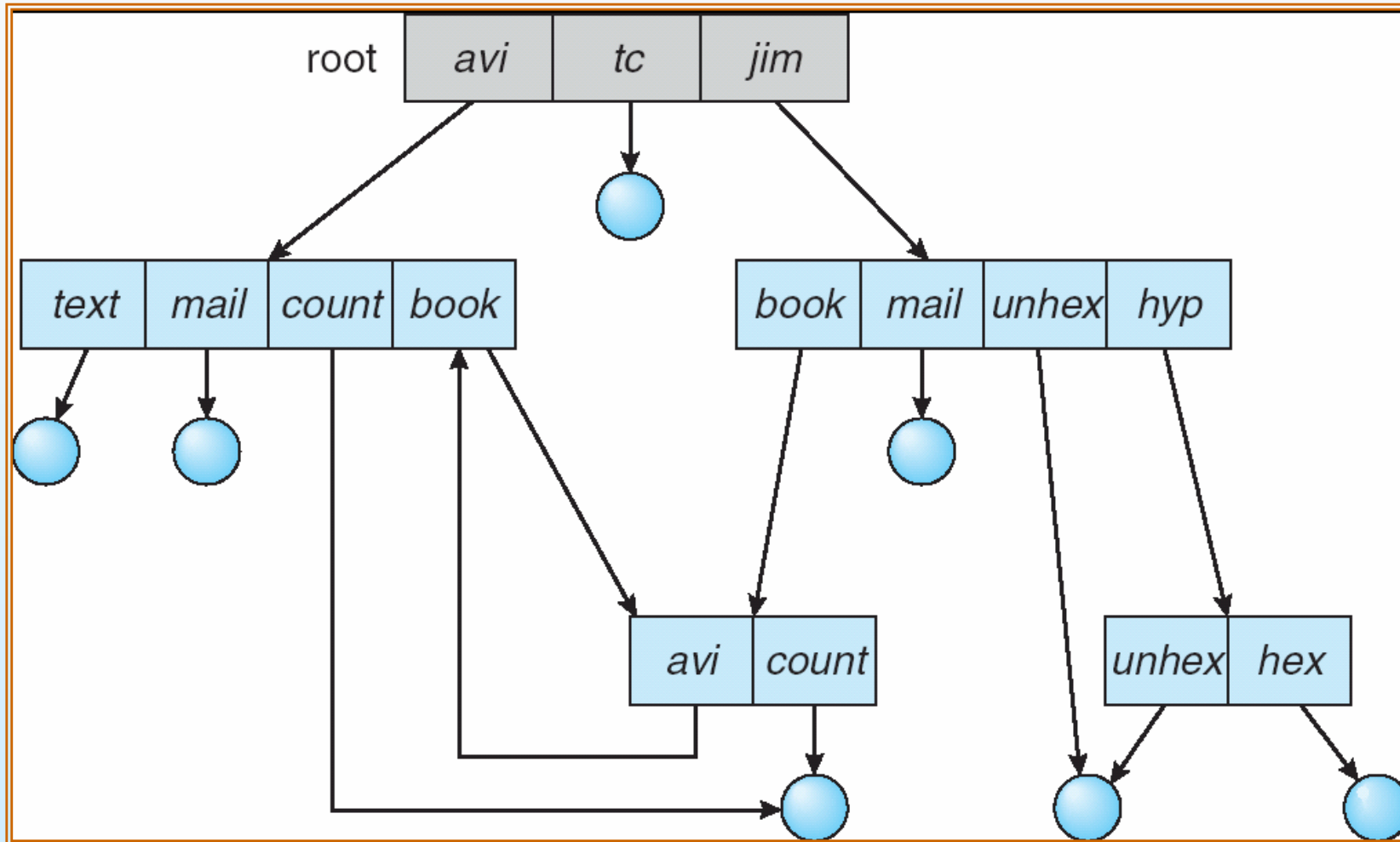
- Two different names (aliasing)
- If *dict* deletes *all*  $\Rightarrow$  dangling pointer

Solutions:

- Symbolic link, distinguish link and original file
  - ▶ Deletion of link does not affect original file
  - ▶ What to do with links if original file is deleted
  - ▶ What if a file is deleted and another file of same name is created
- Backpointers, so we can delete all pointers
  - Variable size records a problem
    - ▶ Entry-hold-count solution: does not actually delete files unless all links are deleted – hard links on UNIX
- New directory entry type
  - **Link** – another name (pointer) to an existing file
  - **Resolve the link** – follow pointer to locate the file



# General Graph Directory





# General Graph Directory (Cont.)

- Problems with cycles
  - Hard to ensure traverse each component once
    - ▶ A poorly designed algorithm might result in an infinite loop
  - Hard to determine if a file can be actually removed
    - ▶ Entry-hold-count count does not work
    - ▶ Need garbage collection – mark and sweep
- How do we guarantee no cycles?
  - Allow only links to file not subdirectories
  - Every time a new link is added use a cycle detection algorithm to determine whether it is OK





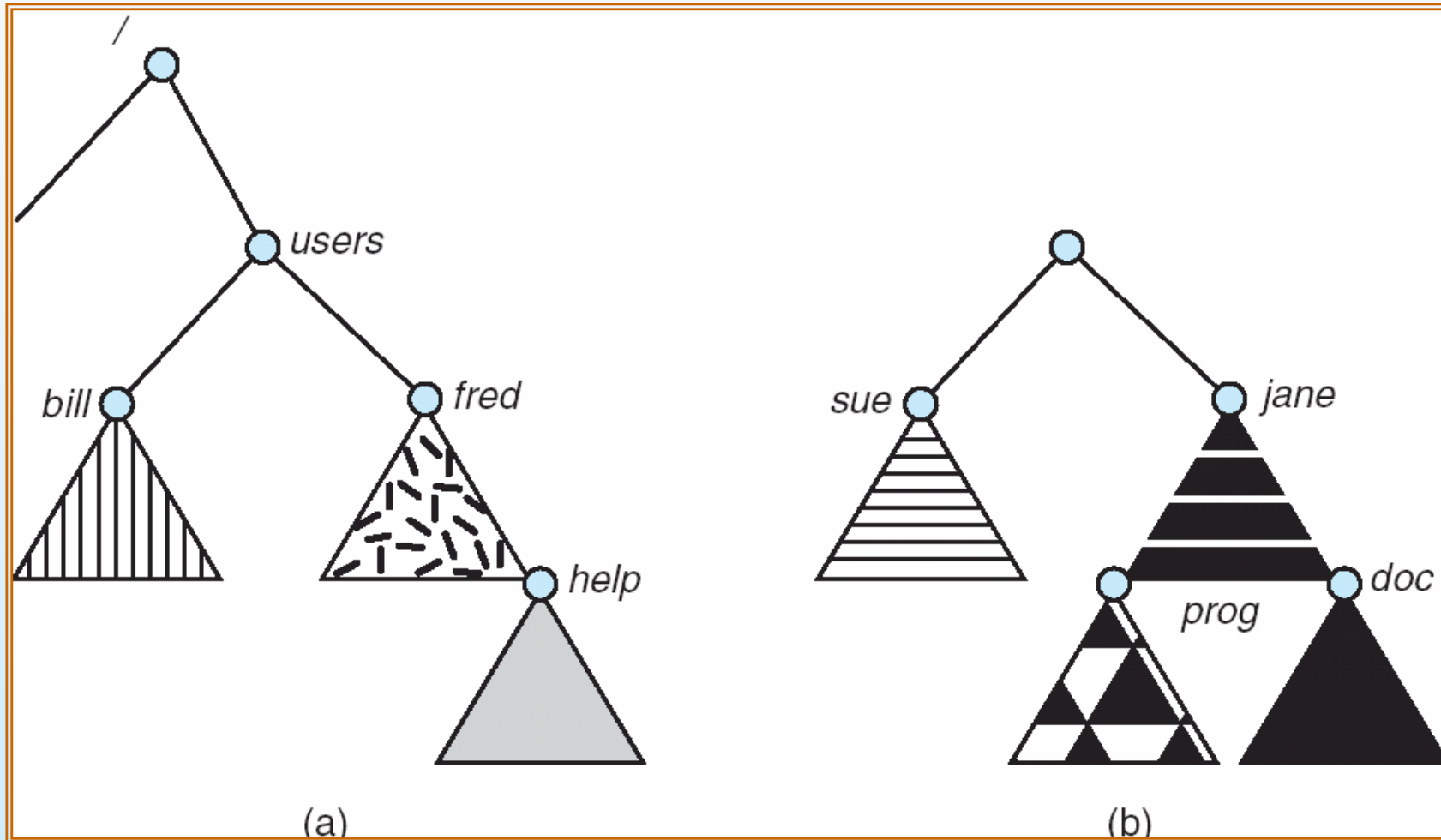
# File System Mounting

- 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**



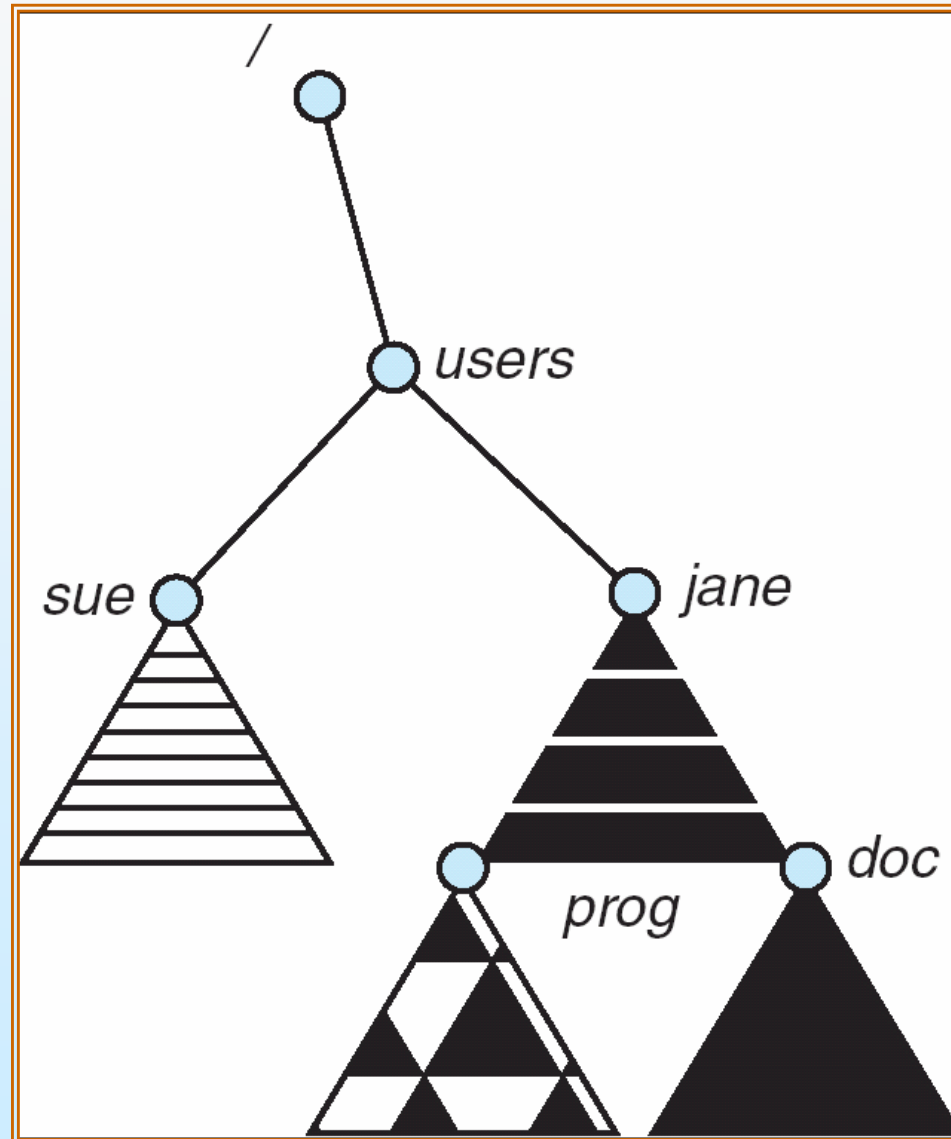


# (a) Existing. (b) Unmounted Partition





# Mount Point





# 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 – specify when modifications of data by one user will be observable by other users.
  - Similar to Ch 6 process synchronization algorithms
    - ▶ Complex and tend not to be implemented in case of file I/O 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





# Protection

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



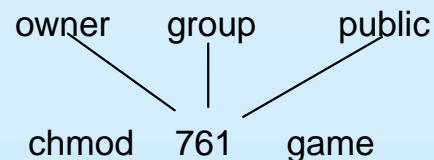


# Access Lists and Groups

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

a) <b>owner access</b>	7	⇒	RWX 1 1 1
b) <b>group access</b>	6	⇒	RWX 1 1 0
c) <b>public access</b>	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

10.tex Properties

General Security Summary

Group or user names:

- Administrators (PBG-LAPTOP\Administrators)
- Guest (PBG-LAPTOP\Guest)**
- pbj (CTI\pbj)
- SYSTEM
- Users (PBG-LAPTOP\Users)

Add... Remove

Permissions for Guest

	Allow	Deny
Full Control	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Modify	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Read & Execute	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Read	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Write	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Special Permissions	<input type="checkbox"/>	<input type="checkbox"/>

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/



# End of Chapter 10

