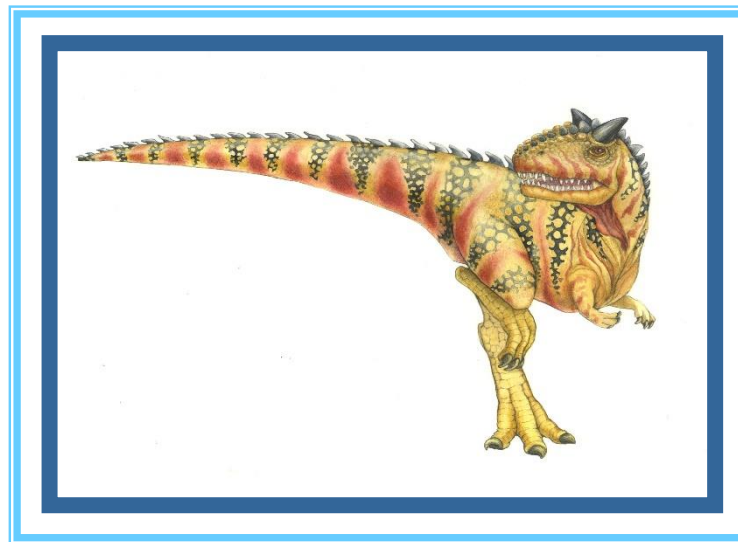


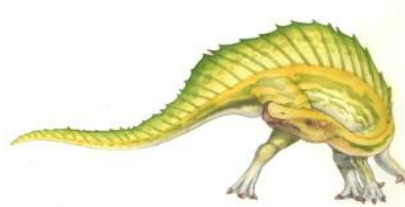
Chapter 11: File-System Interface





Chapter 11: 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
- Types:
 - Data
 - ▶ numeric
 - ▶ character
 - ▶ binary
 - Program





File Structure

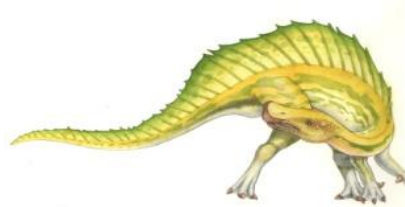
- None - sequence of words, bytes
- Simple record structure
 - Lines
 - Fixed length
 - Variable length
- Complex Structures
 - Formatted document
 - Relocatable load file
- Can simulate last two with first method by inserting appropriate control characters
- Who decides:
 - Operating system
 - Program





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**
- **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





Open File Locking

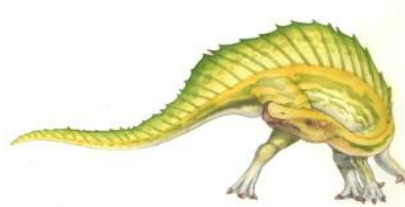
- Provided by some operating systems and file systems
- Mediates access to a file
- Mandatory or advisory:
 - **Mandatory** – access is denied depending on locks held and requested
 - **Advisory** – processes can find status of locks and decide what to do





File Locking Example – Java API

```
import java.io.*;
import java.nio.channels.*;
public class LockingExample {
    public static final boolean EXCLUSIVE = false;
    public static final boolean SHARED = true;
    public static void main(String arsg[]) throws IOException {
        FileLock sharedLock = null;
        FileLock exclusiveLock = null;
        try {
            RandomAccessFile raf = new RandomAccessFile("file.txt", "rw");
            // get the channel for the file
            FileChannel ch = raf.getChannel();
            // this locks the first half of the file - exclusive
            exclusiveLock = ch.lock(0, raf.length()/2, EXCLUSIVE);
            /** Now modify the data . . . */
            // release the lock
            exclusiveLock.release();
        }
    }
}
```





File Locking Example –Java API (Cont.)

```
// this locks the second half of the file - shared
sharedLock = ch.lock(raf.length()/2+1, raf.length(), SHARED);
/** Now read the data . . . */
// release the lock
sharedLock.release();
} catch (java.io.IOException ioe) {
    System.err.println(ioe);
}finally {
    if (exclusiveLock != null)
        exclusiveLock.release();
    if (sharedLock != null)
        sharedLock.release();
}
}
```





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

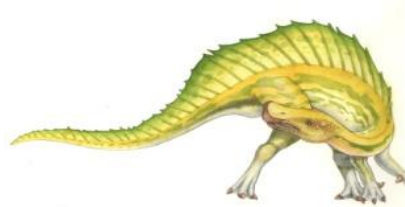
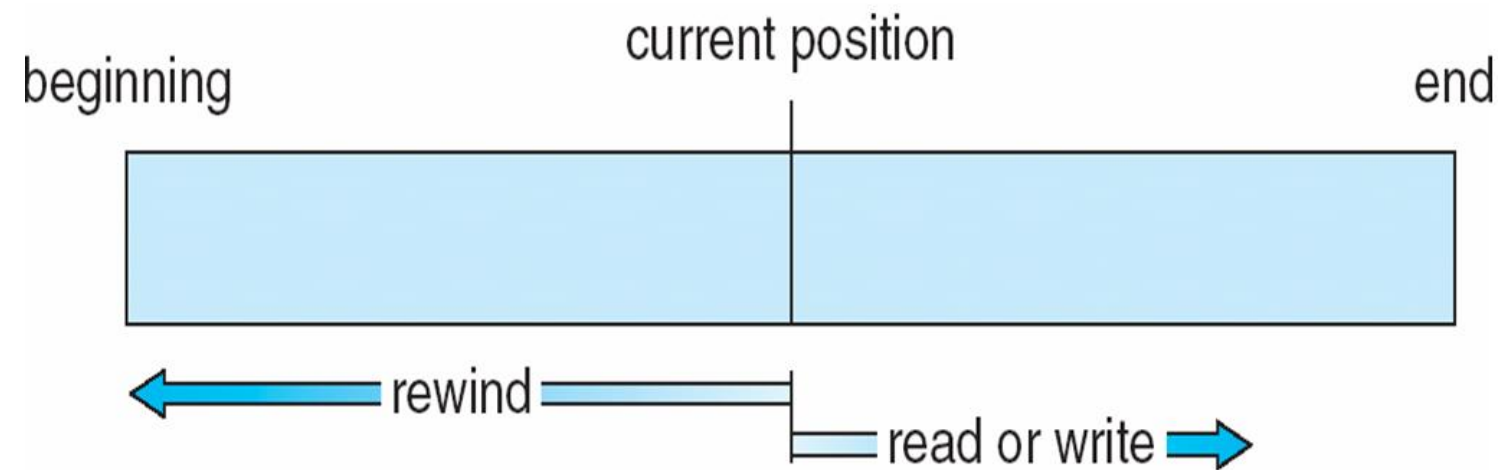
read n
write n
position to n
 read next
 write next
rewrite n

n = relative block number





Sequential-access File





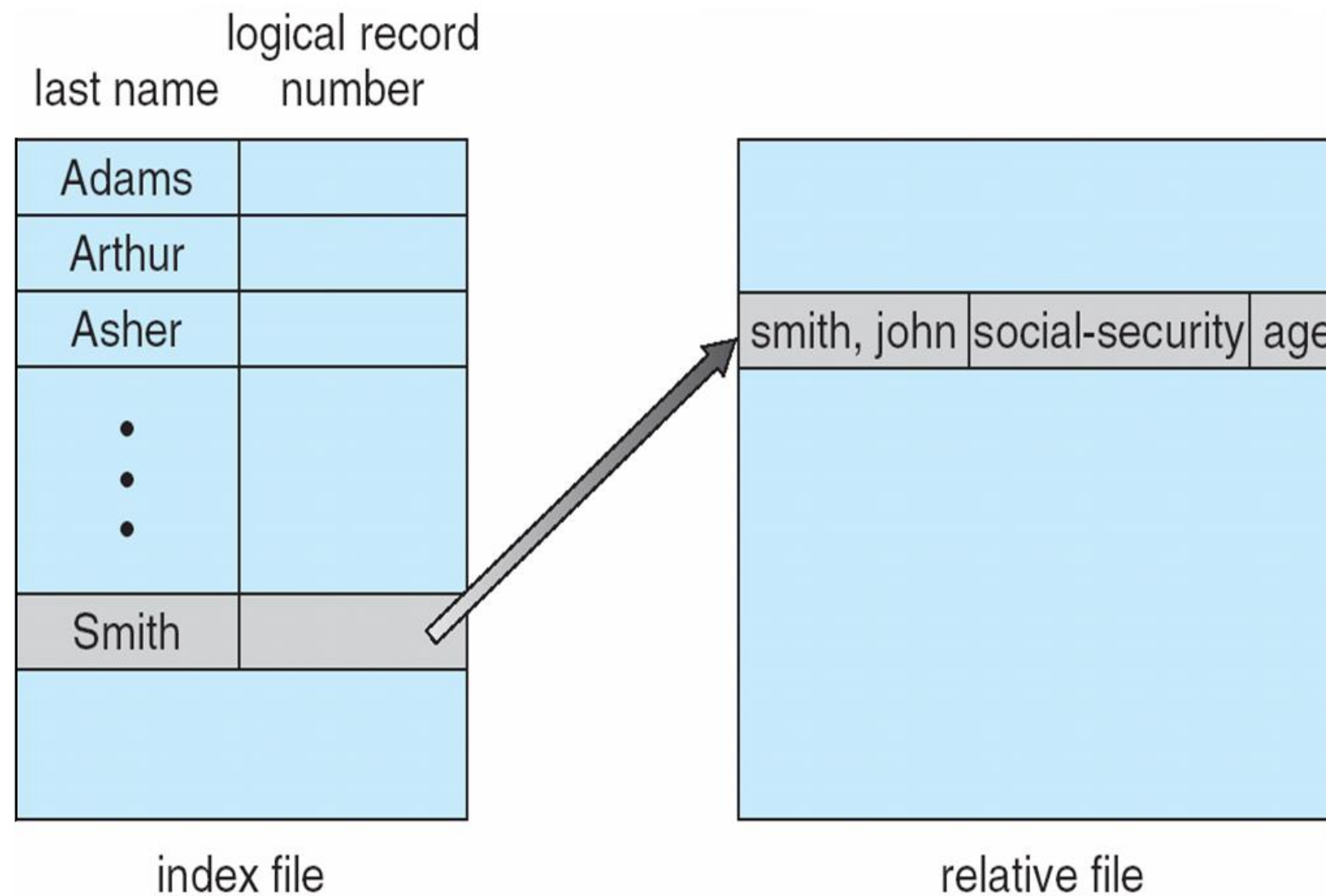
Simulation of Sequential Access on Direct-access File

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





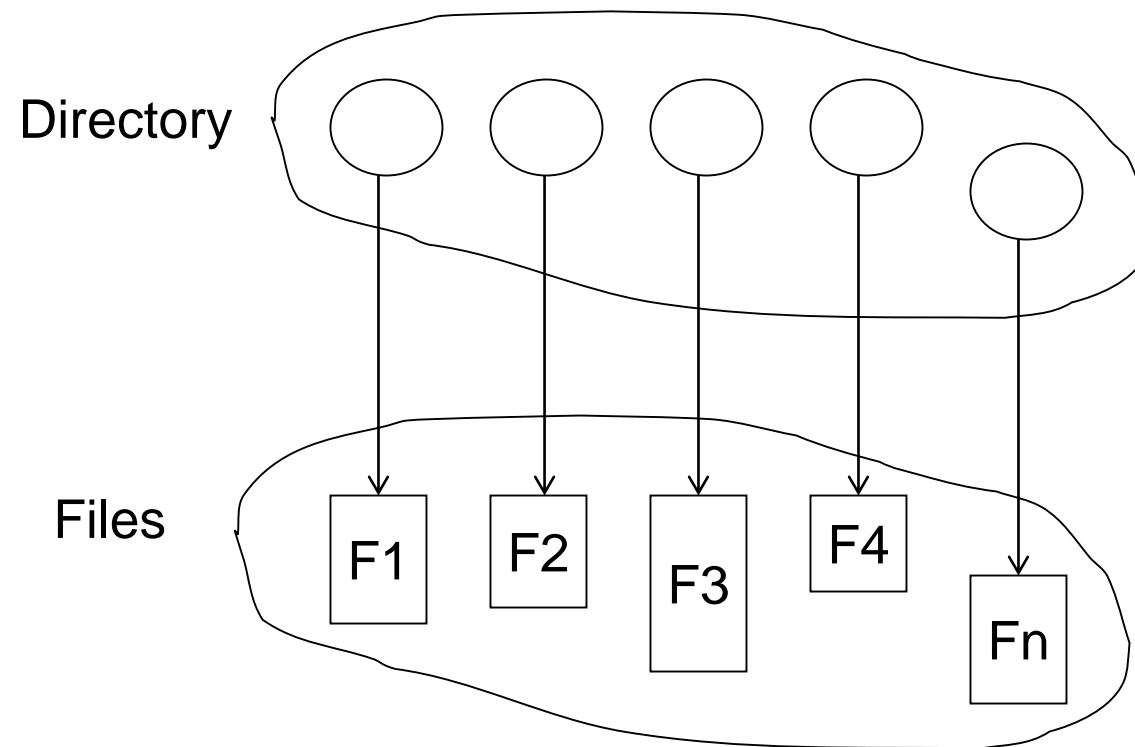
Example of Index and Relative Files





Directory Structure

- A collection of nodes containing information about all files



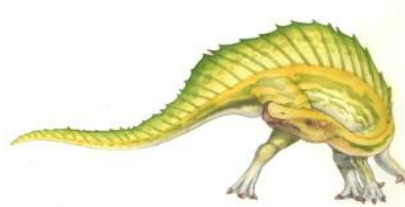
Both the directory structure and the files reside on disk
Backups of these two structures are kept on tapes





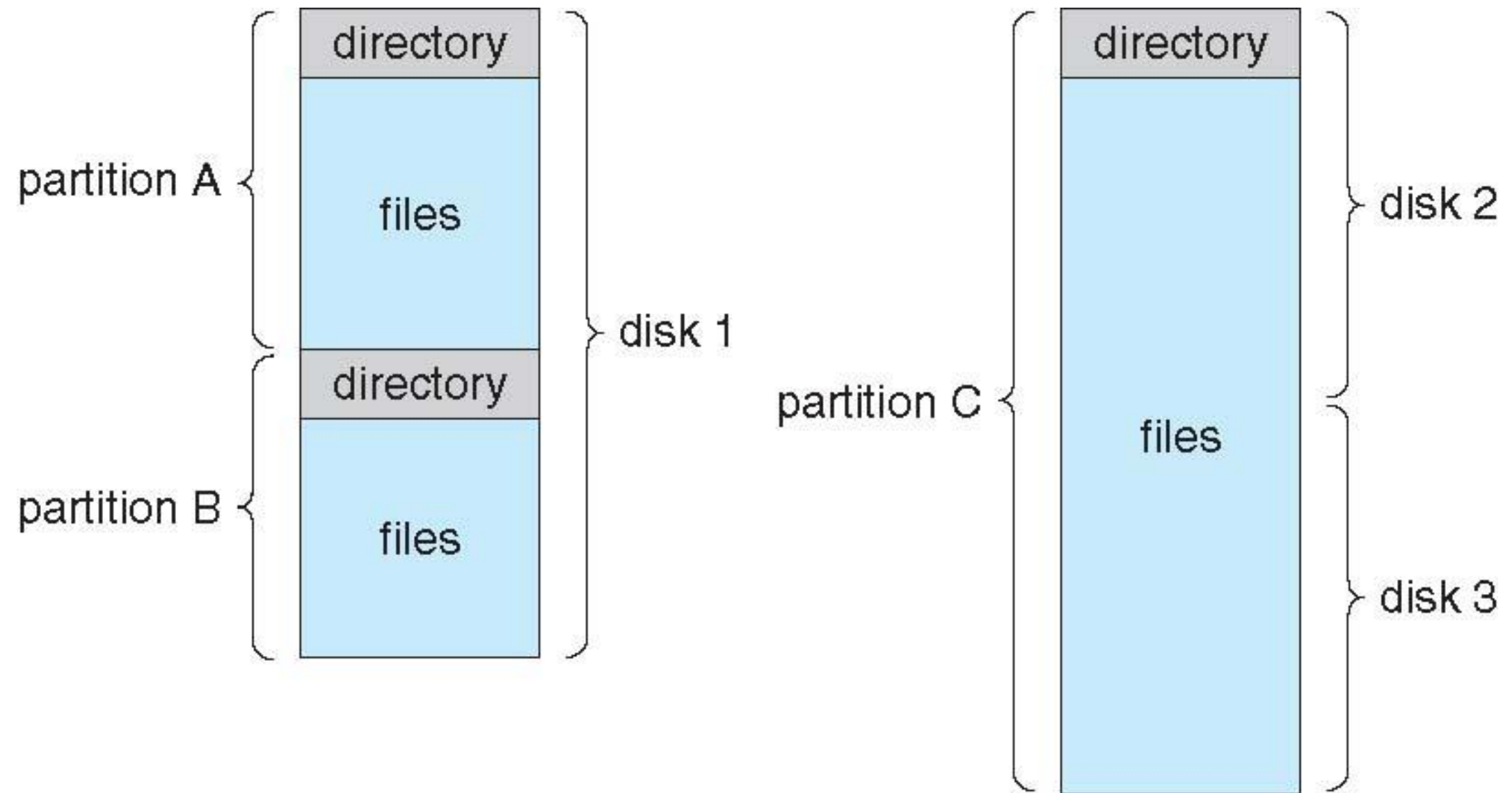
Disk Structure

- Disk can be subdivided into **partitions**
- 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





Organize the Directory (Logically) to Obtain

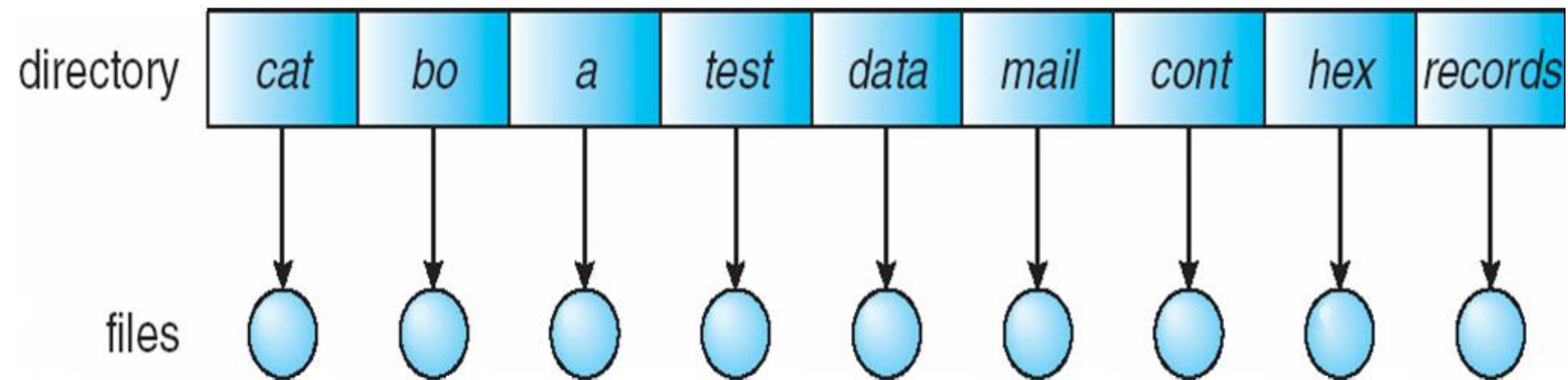
- Efficiency – locating a file quickly
- Naming – convenient to users
 - Two users can have same name for different files
 - The same file can have several different names
- Grouping – logical grouping of files by properties, (e.g., all Java programs, all games, ...)





Single-Level Directory

- A single directory for all users



Naming problem

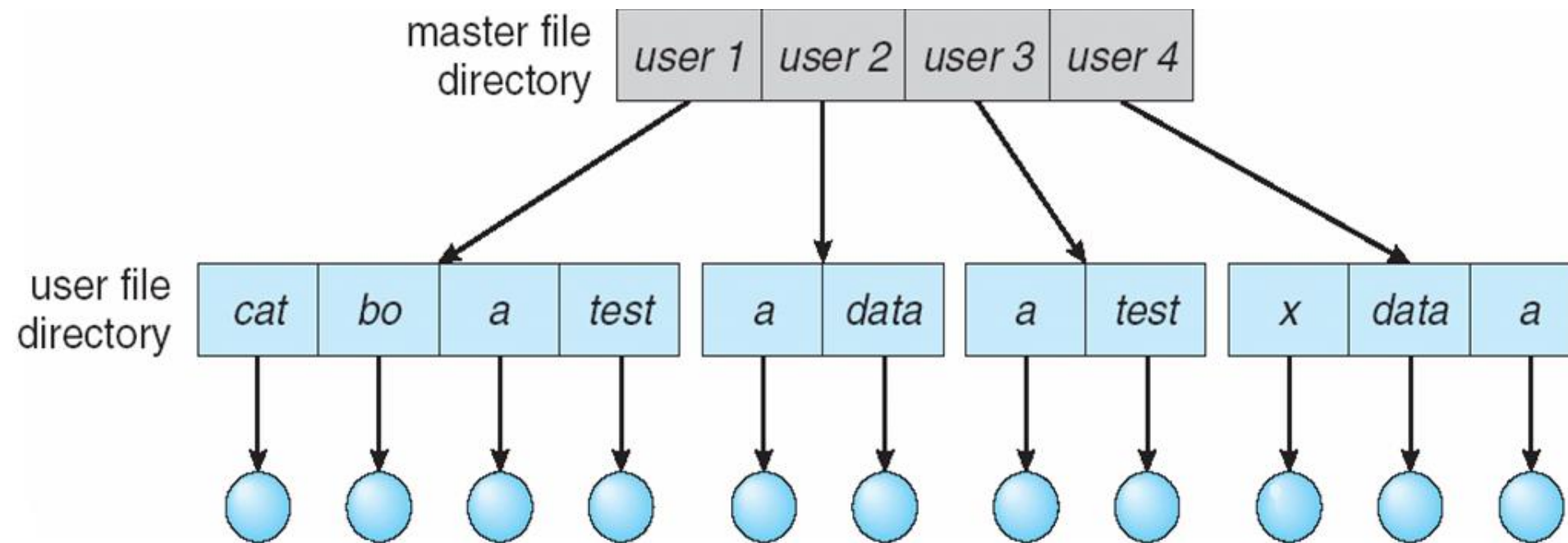
Grouping problem





Two-Level Directory

- Separate directory for each user

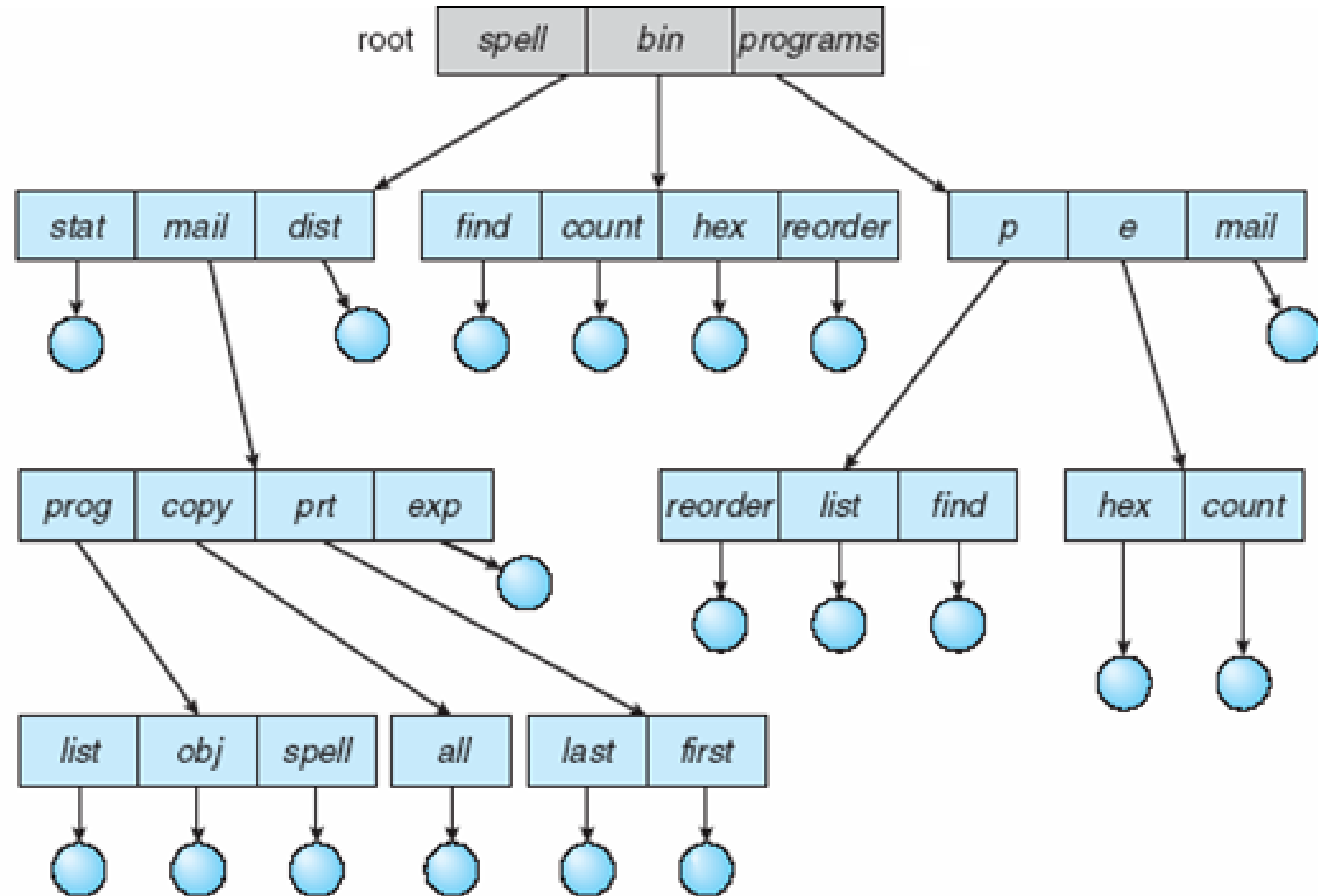


- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability





Tree-Structured Directories





Tree-Structured Directories (Cont.)

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





Tree-Structured Directories (Cont)

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

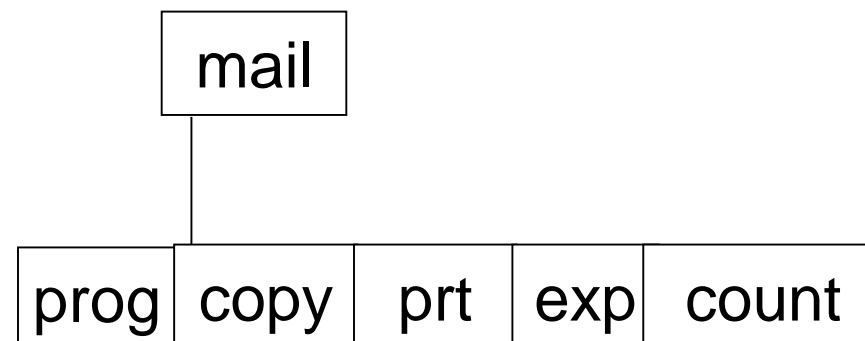
rm <file-name>

- Creating a new subdirectory is done in current directory

mkdir <dir-name>

Example: if in current directory **/mail**

mkdir count



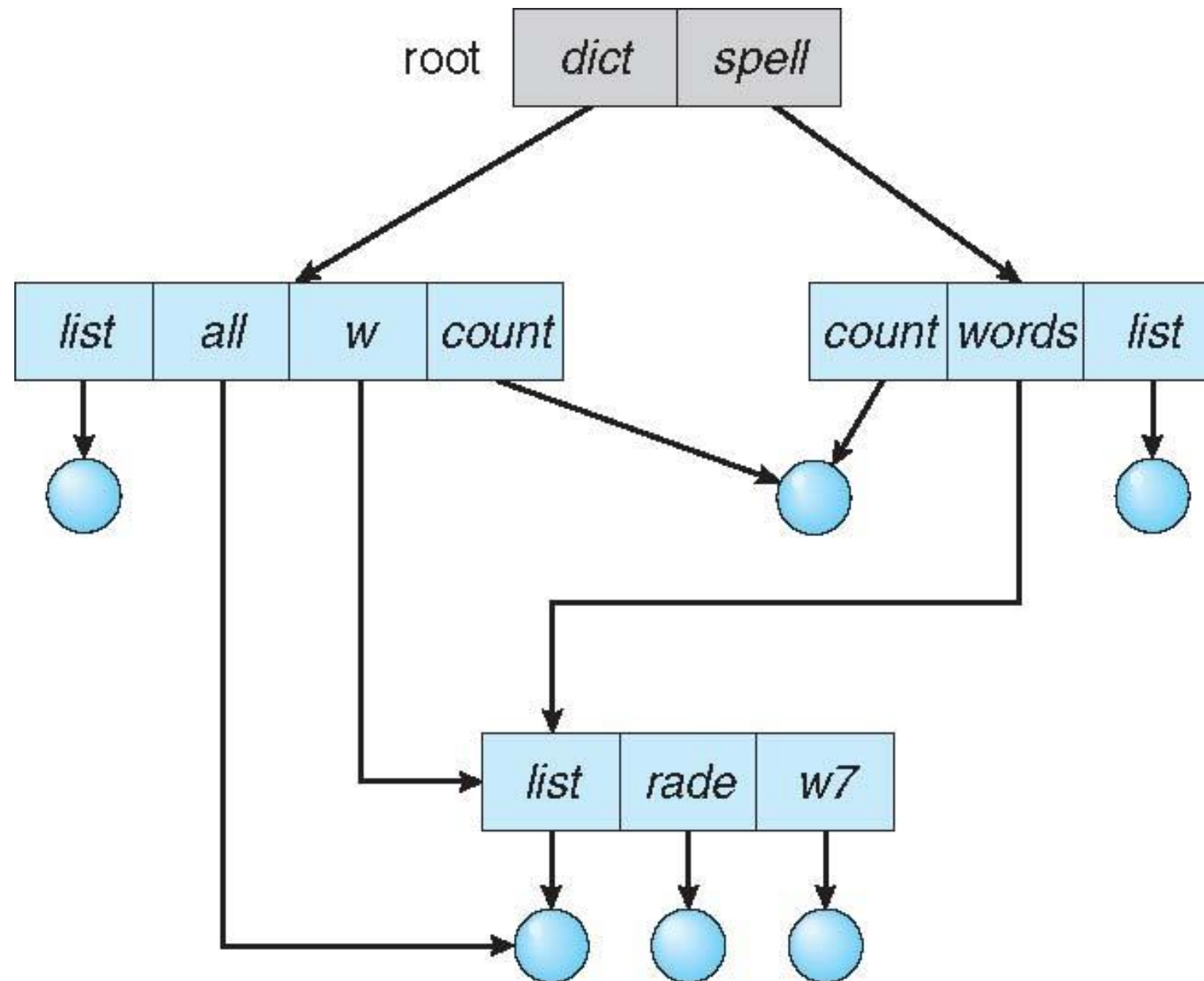
Deleting “mail” \Rightarrow deleting the entire subtree rooted by “mail”





Acyclic-Graph Directories

- Have shared subdirectories and files





Acyclic-Graph Directories (Cont.)

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

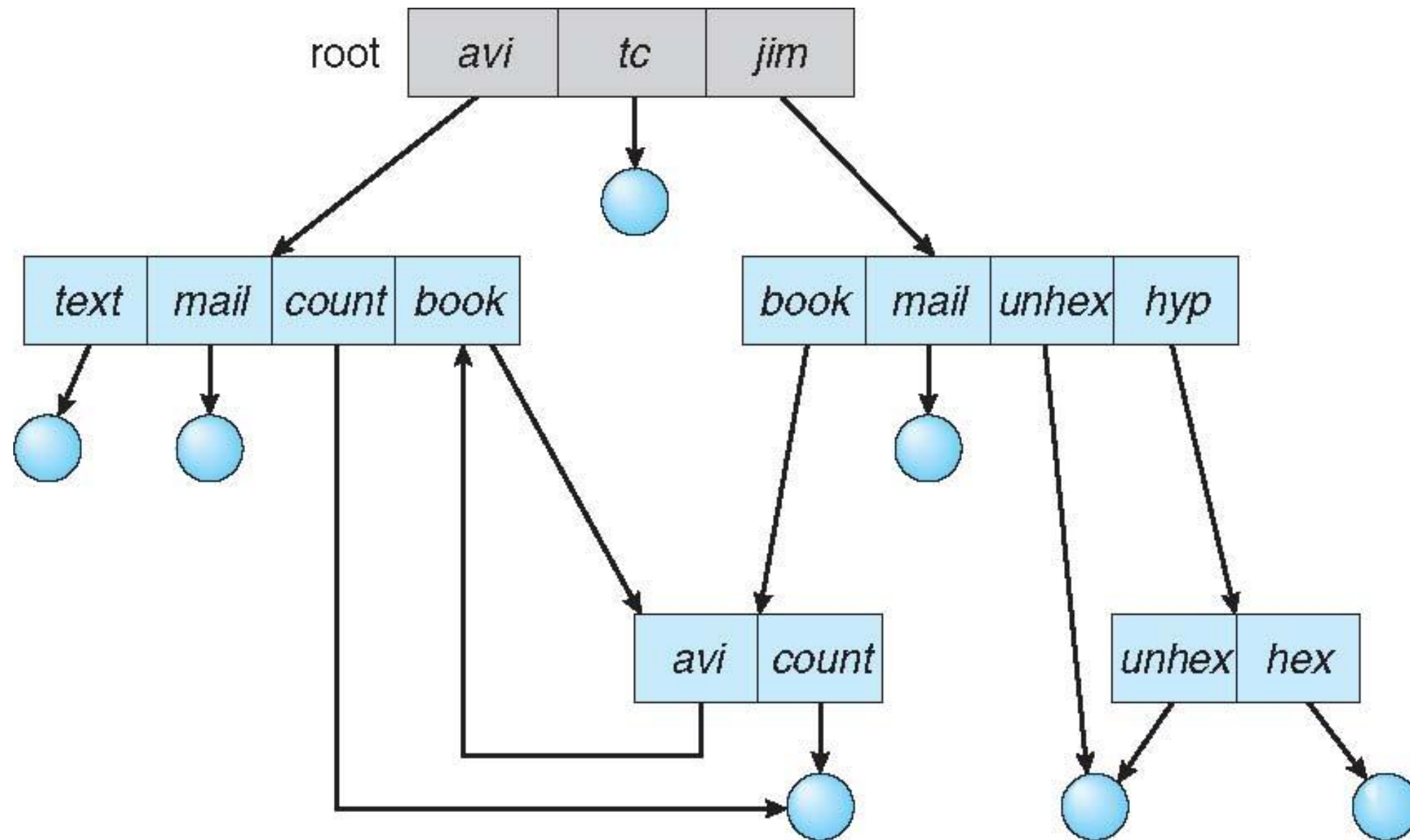
Solutions:

- Backpointers, so we can delete all pointers
Variable size records a problem
 - Backpointers using a daisy chain organization
 - Entry-hold-count solution
-
- New directory entry type
 - **Link** – another name (pointer) to an existing file
 - **Resolve the link** – follow pointer to locate the file





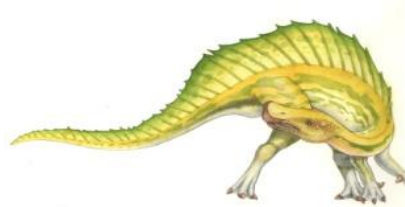
General Graph Directory





General Graph Directory (Cont.)

- 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 to determine whether it is OK





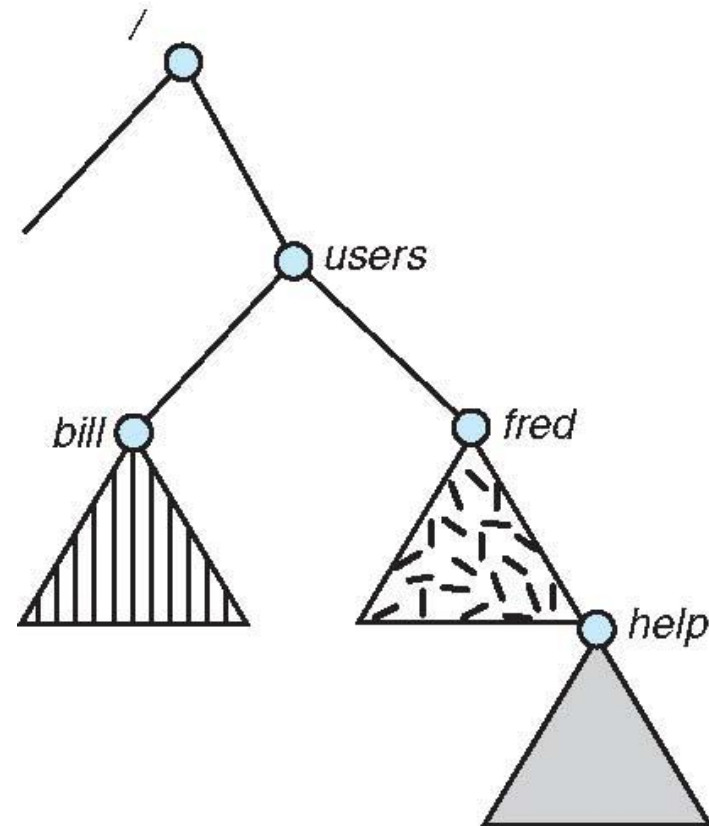
File System Mounting

- 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**

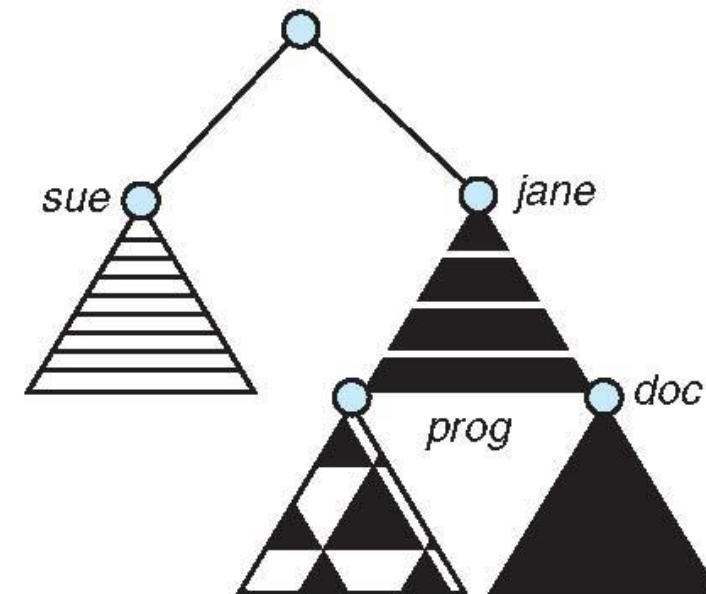




(a) Existing (b) Unmounted Partition



(a)

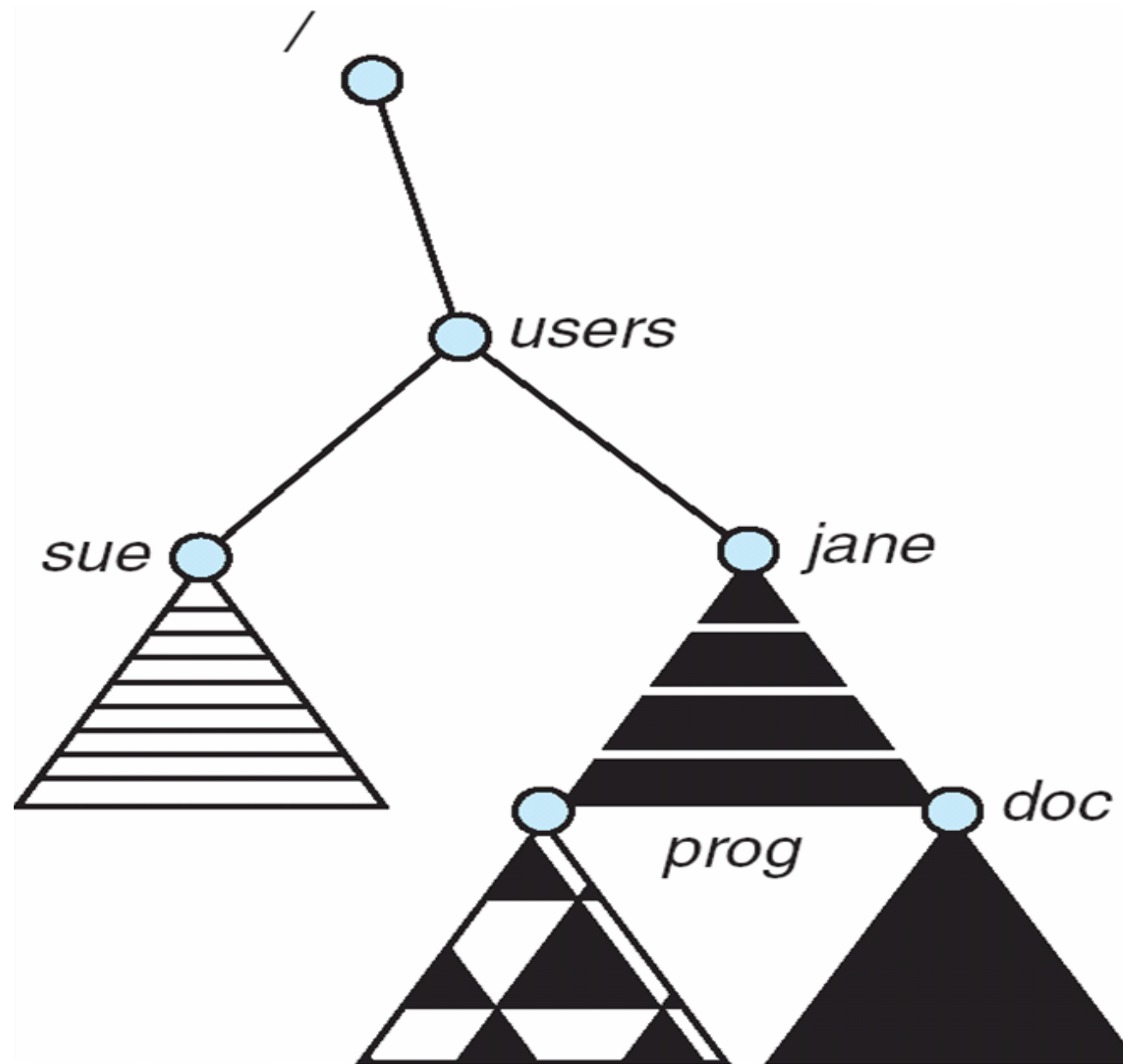


(b)





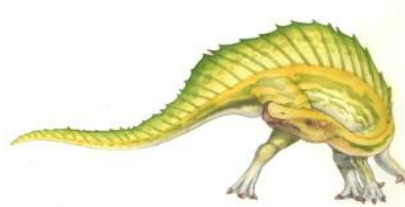
Mount Point





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

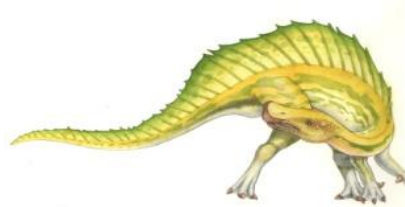
- Remote file systems add new failure modes, due to network failure, server failure
- Recovery from failure can involve state information about status of each remote request
- Stateless protocols such as NFS include all information in each request, allowing easy recovery but less security





File Sharing – Consistency Semantics

- **Consistency semantics** specify how multiple users are to access a shared file simultaneously
 - 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





Protection

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

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



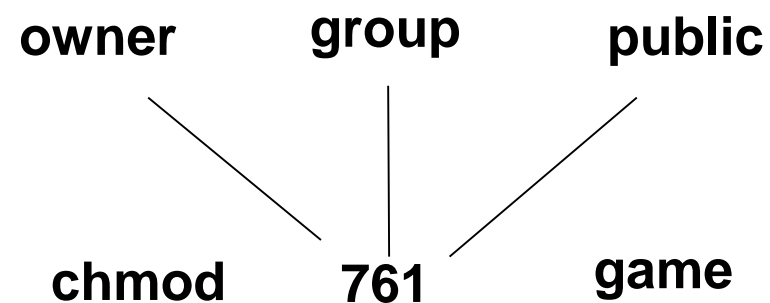


Access Lists and Groups

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

			RWX
a) owner 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.



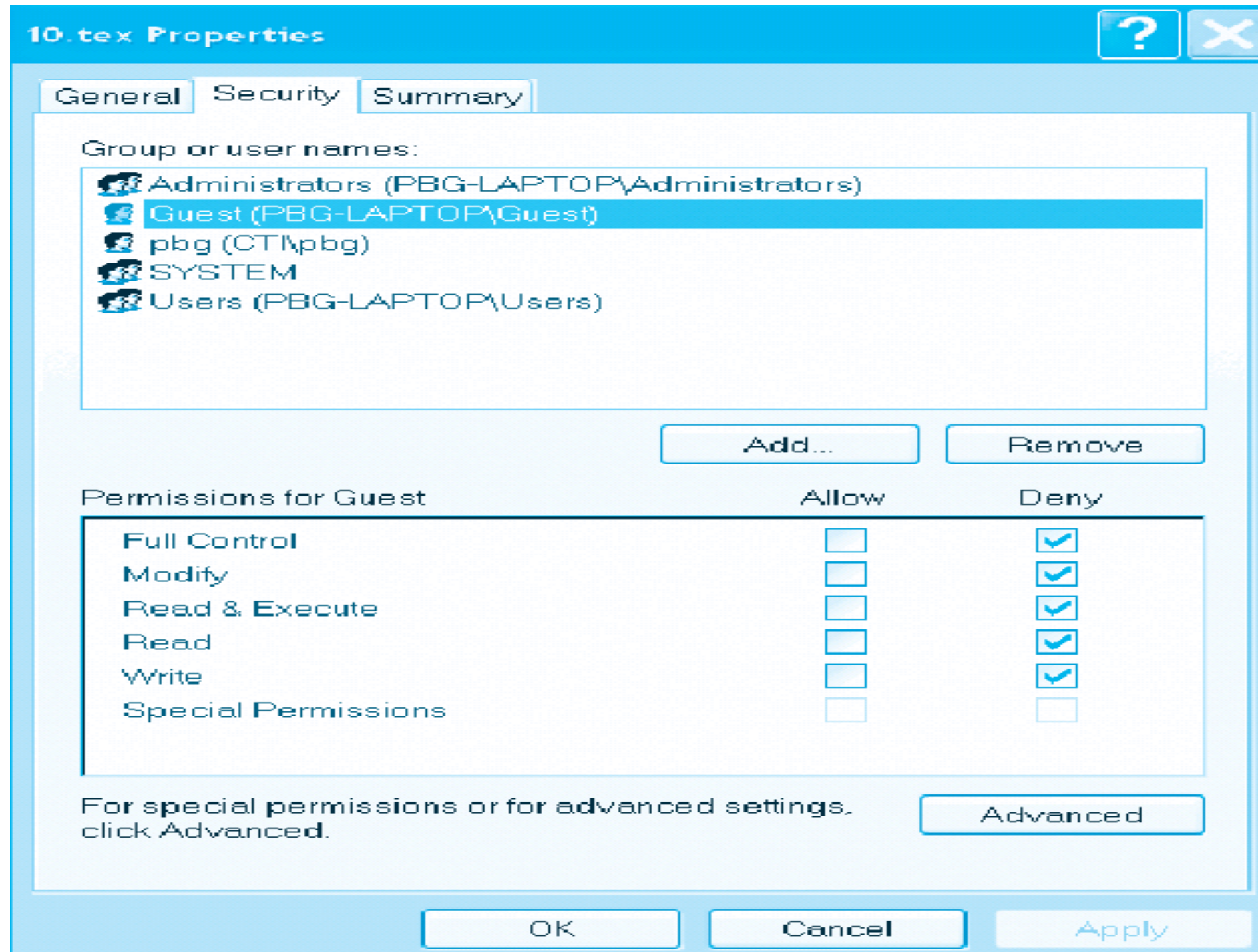
Attach a group to a file

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/



End of Chapter 11

