File-System Interface

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

File Concept

- A file is named collection of related information that is recorded on secondary storage
- From User's perspective, a file is the smallest allotment of logical secondary storage.
- Data can not be written to secondary storage unless they are within file

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 a device and file location on that 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**
- *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:** The information needed to locate the file on disk is kept in memory to avoid having to read it from disk for every operation.
  - **Access rights:** per-process access mode information.

File Types – Name, Extension

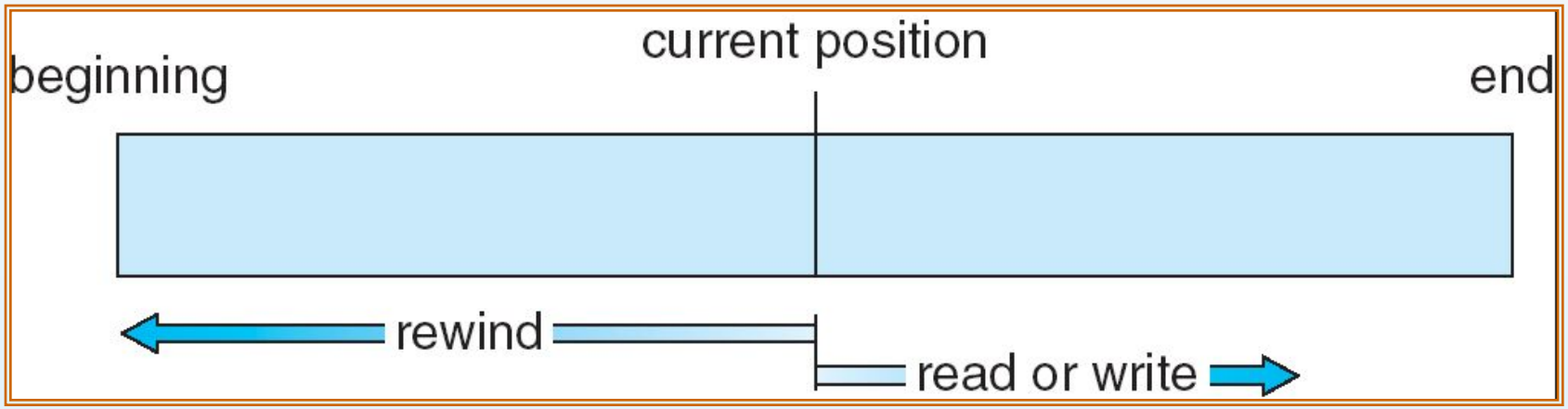
file type	usual extension	function
executable	exe, com, bin or none	ready-to-run machine-language program
object	obj, o	compiled, machine language, not linked
source code	c, cc, java, pas, asm, a	source code in various languages
batch	bat, sh	commands to the command interpreter
text	txt, doc	textual 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 compressed, 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

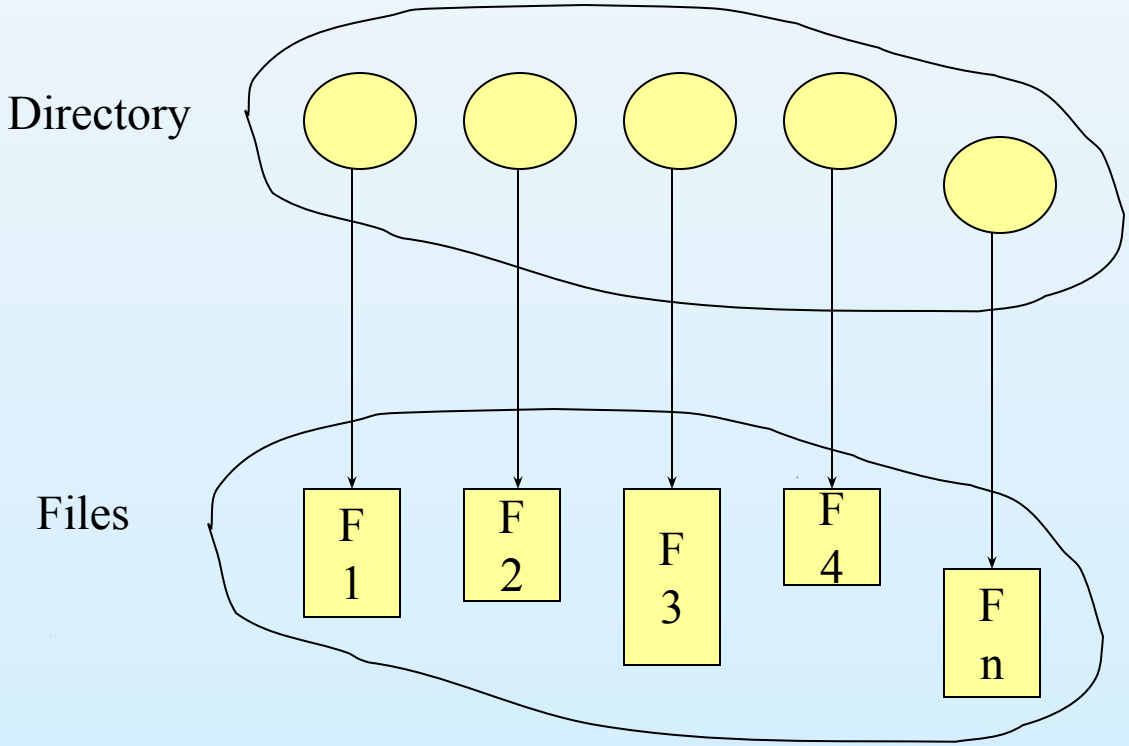


Simulation of Sequential Access on a Direct-access File

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

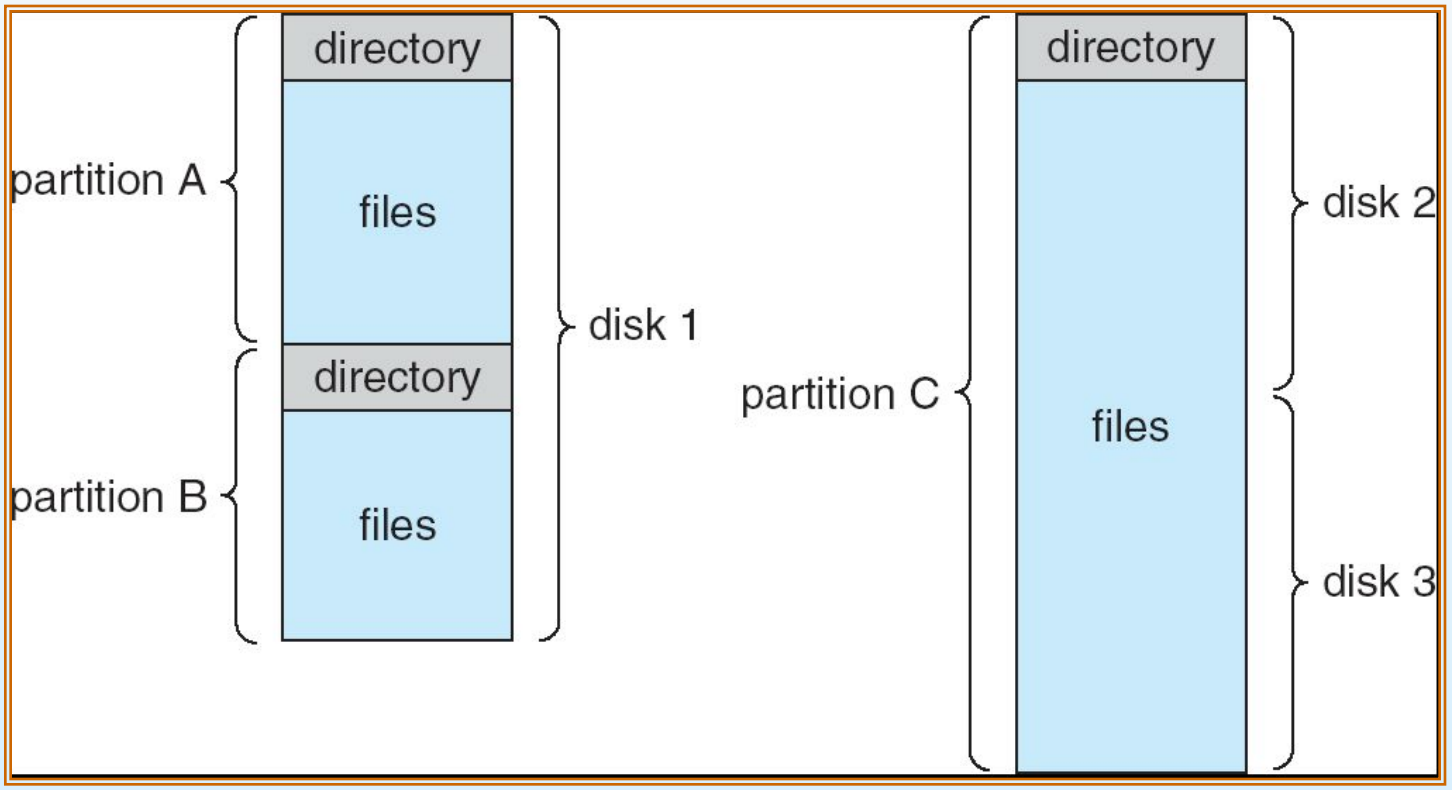
Directory Structure

- A collection of nodes containing information about all files



Both the directory structure and the files reside on disk.

A Typical File-system Organization



Operations Performed on Directory

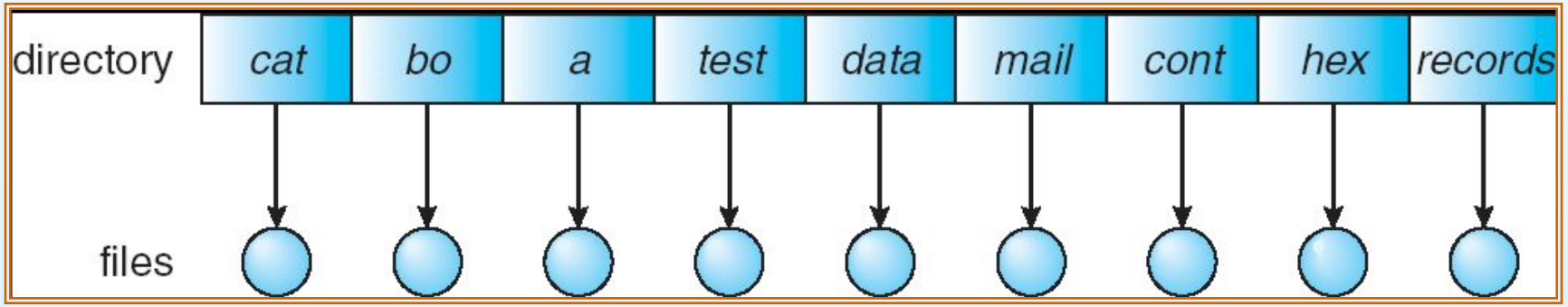
- Search for a file
- Create a file
- Delete a file
- List a directory
- Rename a file

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

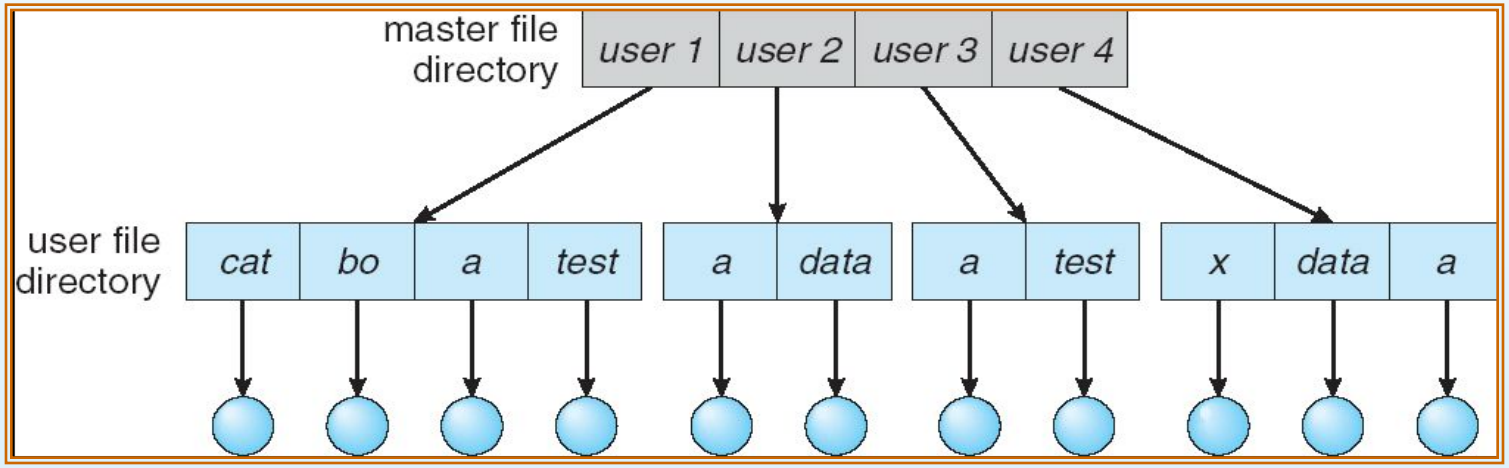


Naming problem

Grouping problem

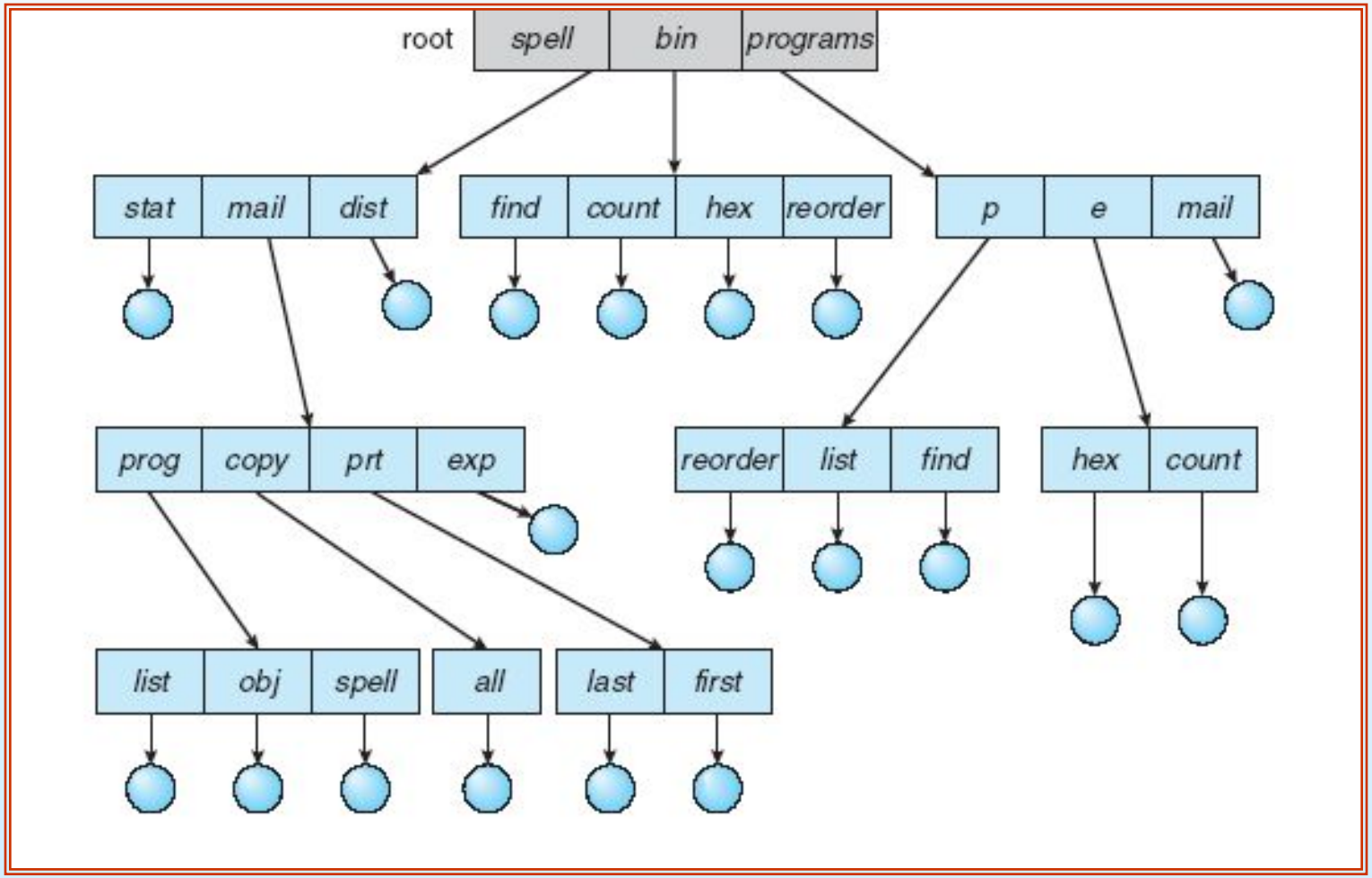
Two-Level Directory

- **Separate directory for each user**



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

Tree-Structured Directories



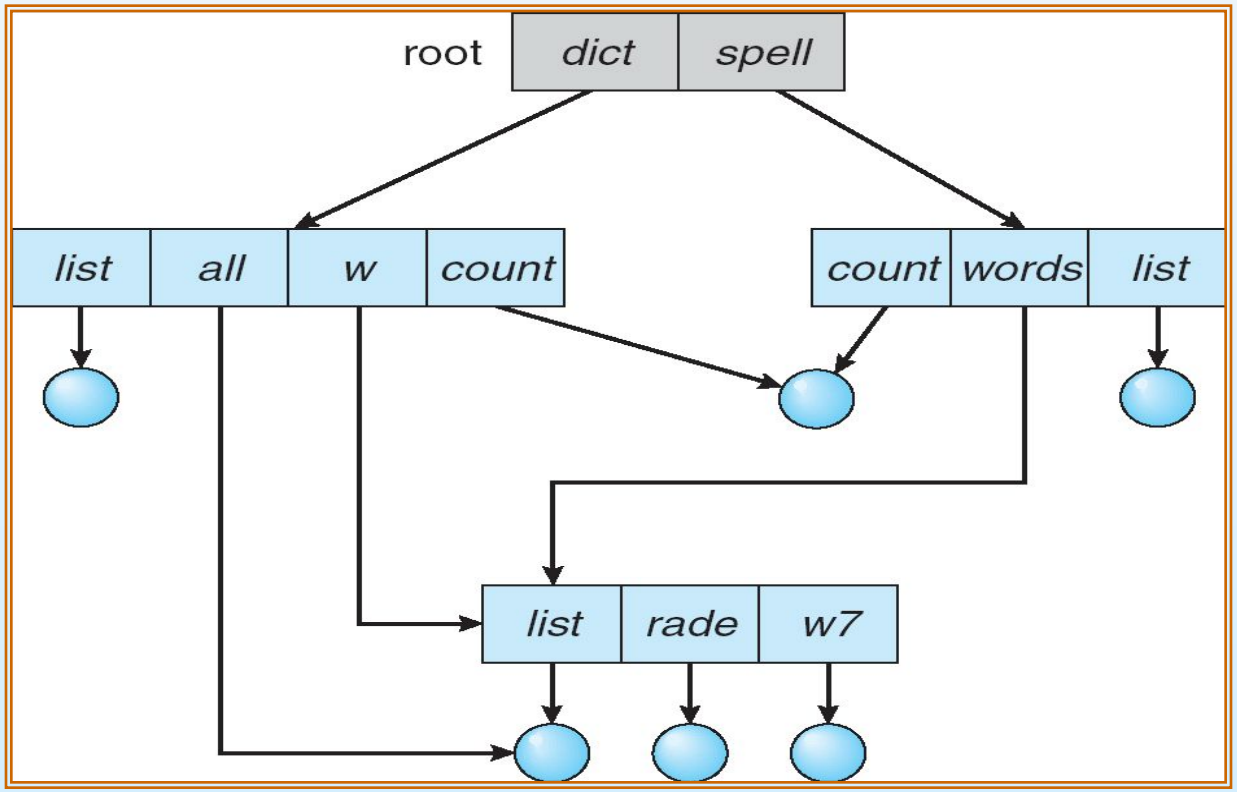
Tree-Structured Directories (Cont)

- **Absolute or relative path name**. A absolute path begins at the root and follows a path down to the specified file whereas relative path name defines a path from current directory.

- Creating a new file is done in current directory

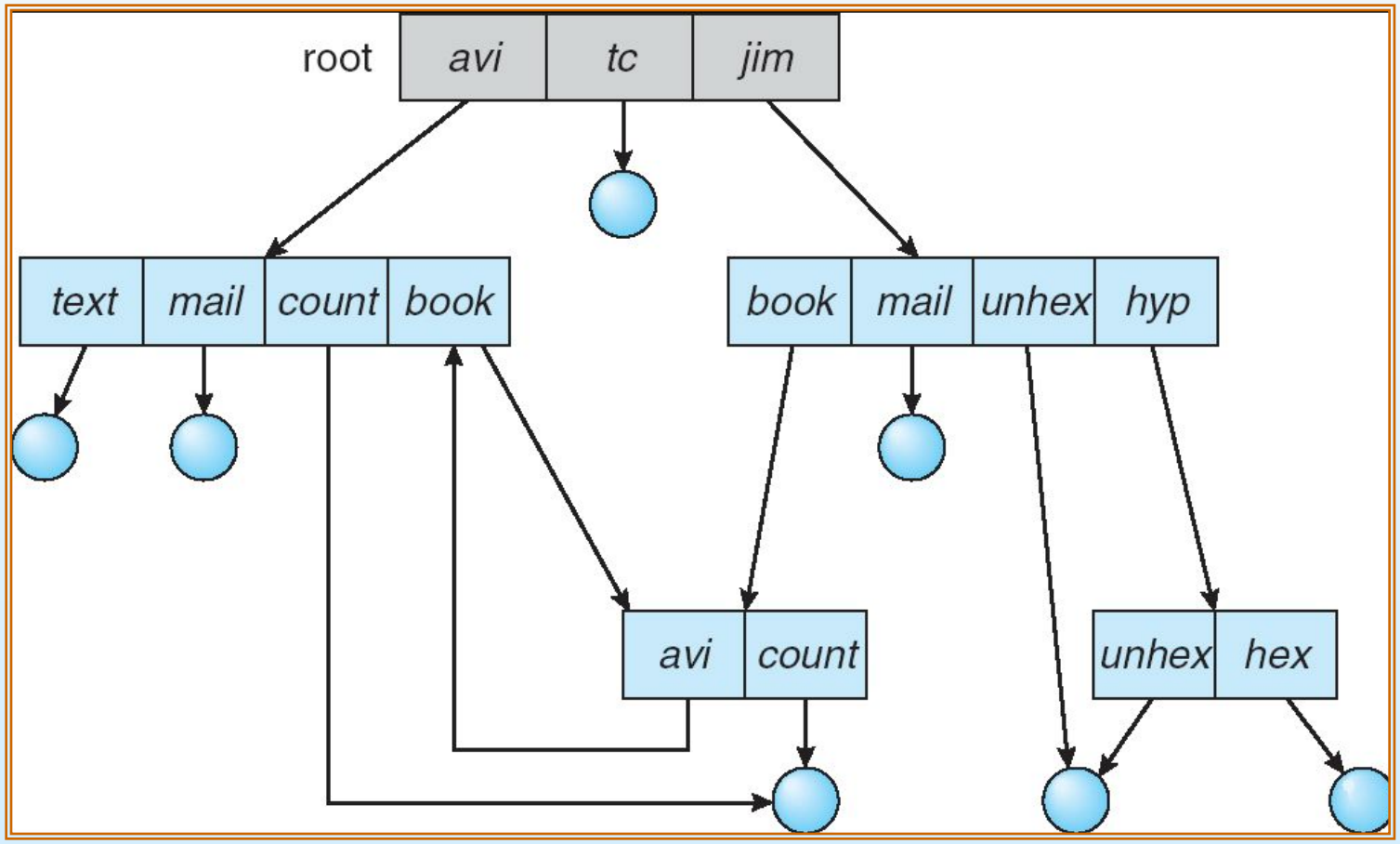
Acyclic-Graph Directories

- Have shared subdirectories and files



One serious problem with it is ensuring that there is no cycle.

General Graph Directory



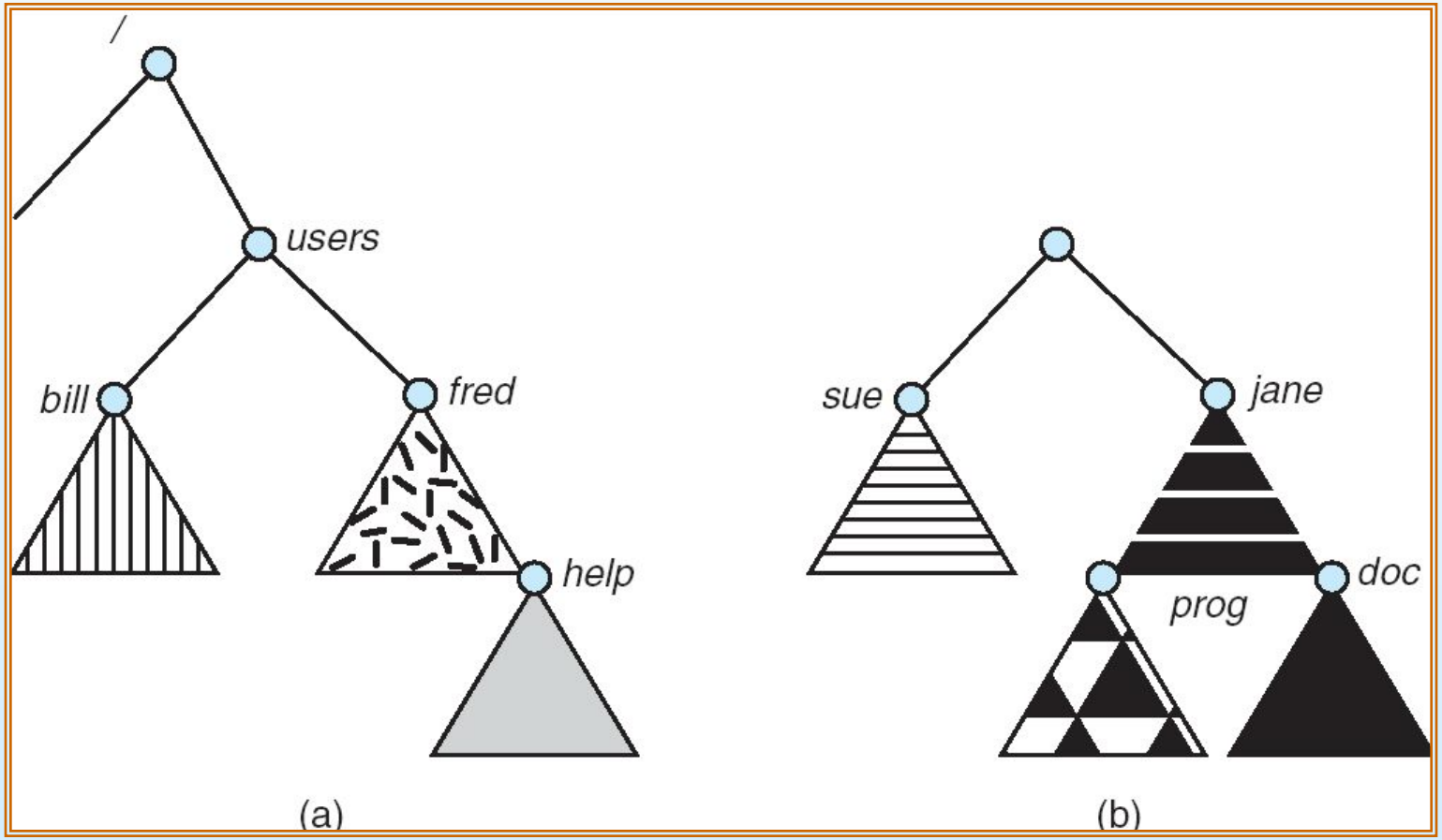
General Graph Directory (Cont.)

- 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

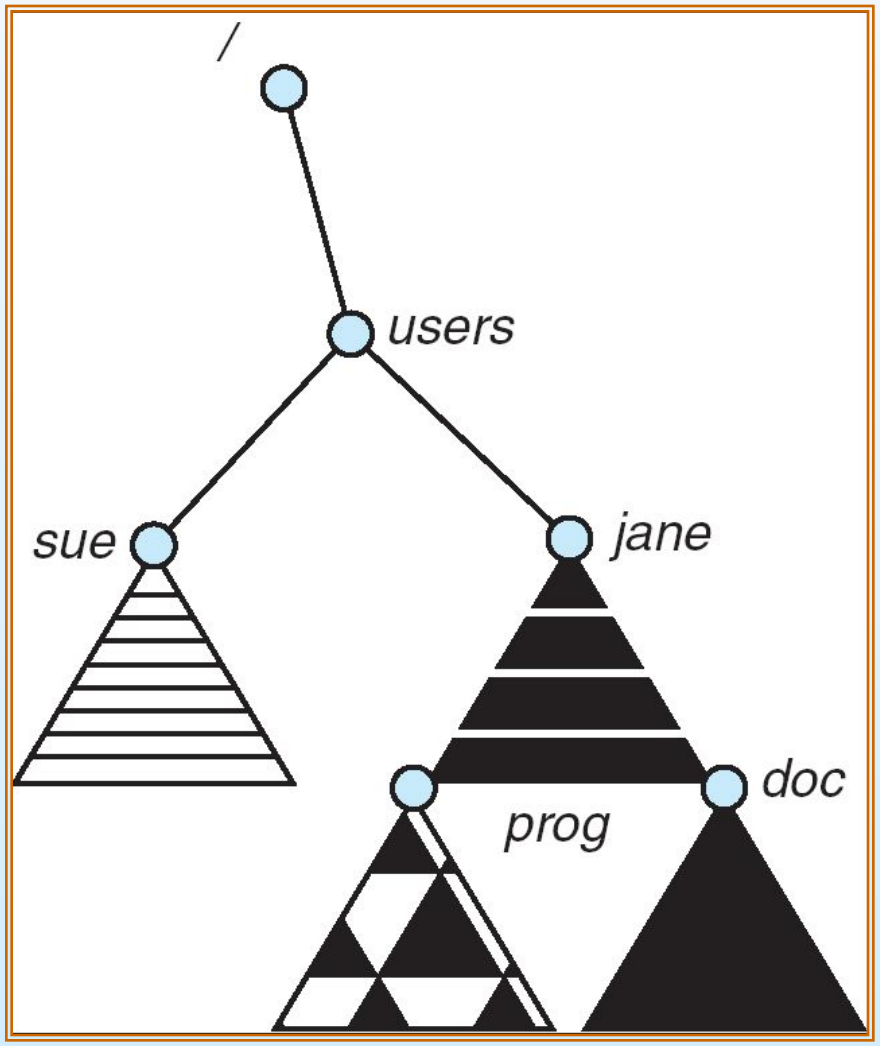
File System Mounting

- A file system must be **mounted** before it can be accessed
- The directory structure can be built out of multiple partitions, which must be mounted to make them available within the file system name space.
- A unmounted file system is mounted at a **mount point**

(a) Existing. (b) Unmounted Partition



Mount Point



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

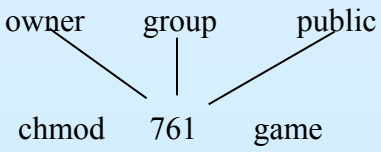
- Mode of access: read, write, execute
- Three classes of users

  RWX
  a) **owner access** 7 ⇒ 1 1 1

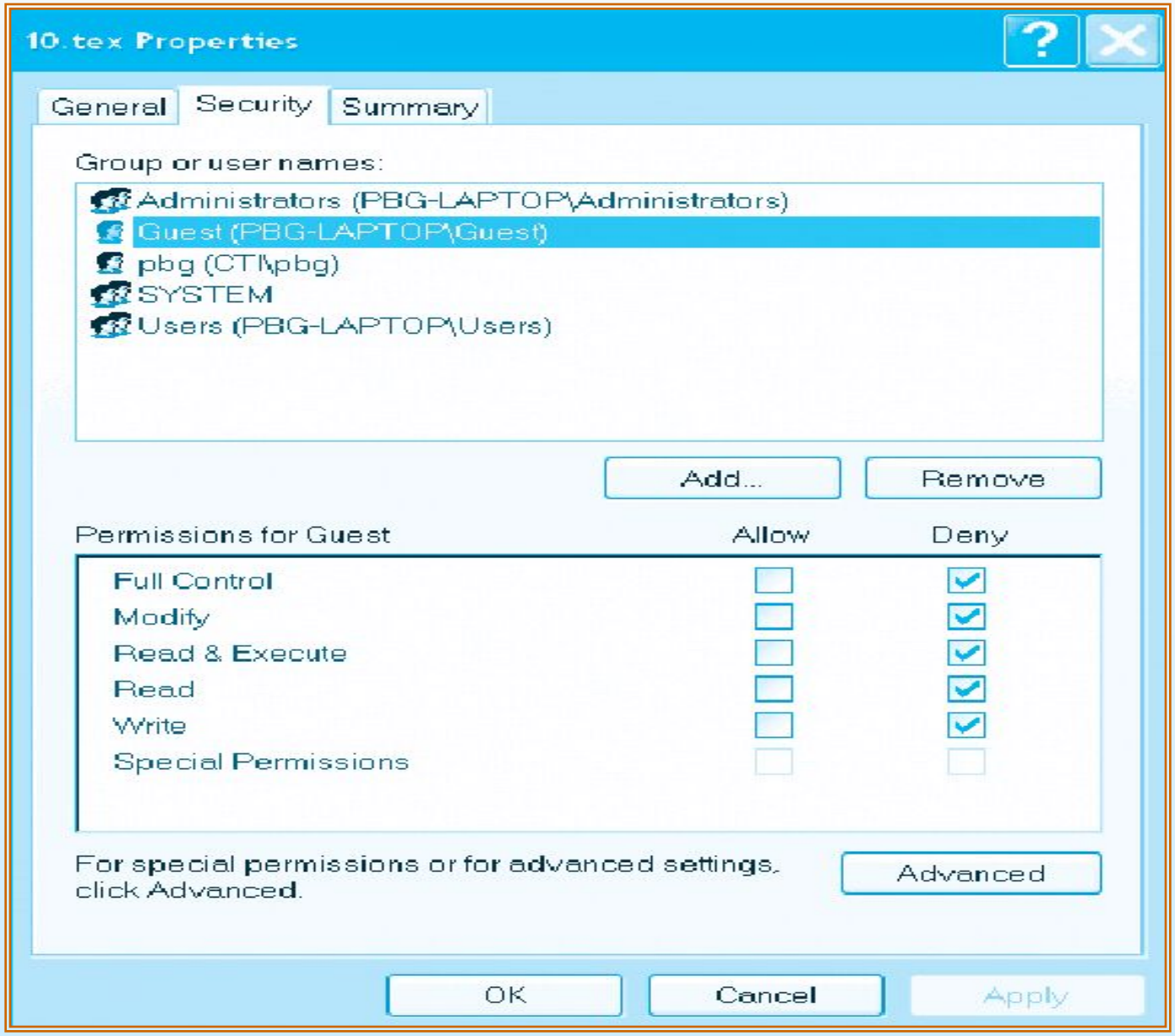
  RWX
  b) **group access** 6 ⇒ 1 1 0

  RWX
  c) **public access** 1 ⇒ 0 0 1

- For a particular file (say *game*) or subdirectory, define an appropriate access.



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/