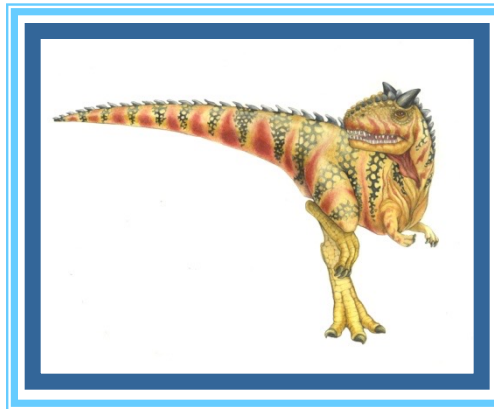


Chapter 13:

File-System Interface





Chapter 13: File-System Interface

- File Concept
- Access Methods
- Disk and 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
- Contents defined by file's creator
 - Many types
 - ▶ Consider **text file, source file, executable file**





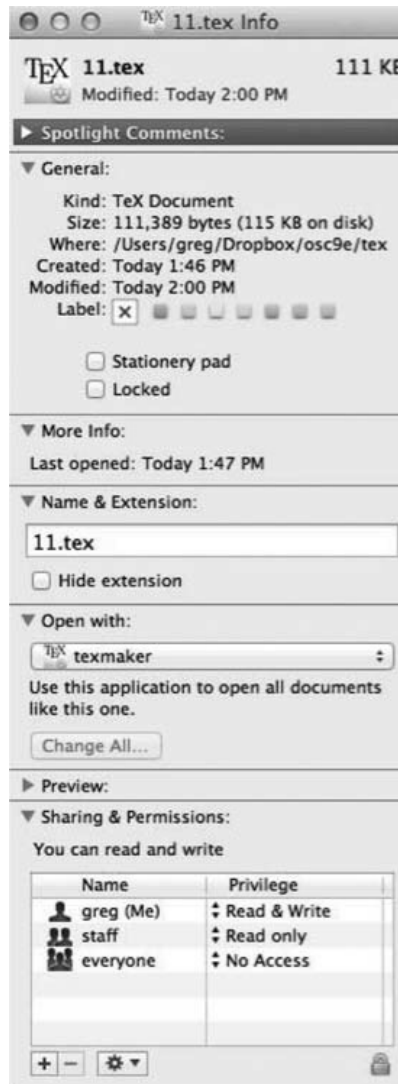
File Attributes

- **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 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
- Many variations, including extended file attributes such as file checksum
- Information kept in the directory structure





File info Window on Mac OS X





File Operations

- File is an **abstract data type**
- **Create**
- ***Open(F_i)*** – search the directory structure on disk for entry F_i , and move the content of entry to memory
- **Write** – at **write pointer** location
- **Read** – at **read pointer** location
- ***Close (F_i)*** – move the content of entry F_i in memory to directory structure on disk
- **Reposition within file - seek**
- **Delete**





Open Files

- Several pieces of data are needed to manage open files:
 - **Open-file table**: tracks 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 – 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





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





Access Methods

■ Sequential Access

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

■ Direct Access – file is fixed length [logical records](#)

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

n = [relative block number](#)

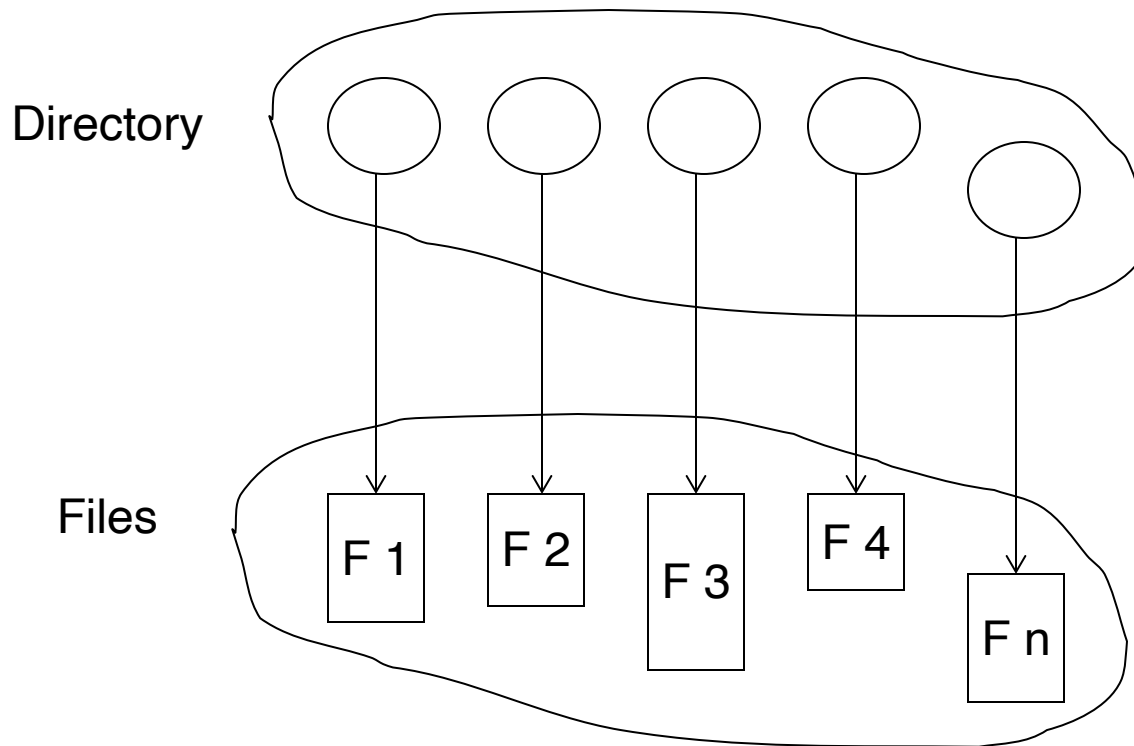
- Relative block numbers allow OS to decide where file should be placed
 - See [allocation problem](#) in Ch 12





Directory Structure

- A collection of nodes containing information about all files

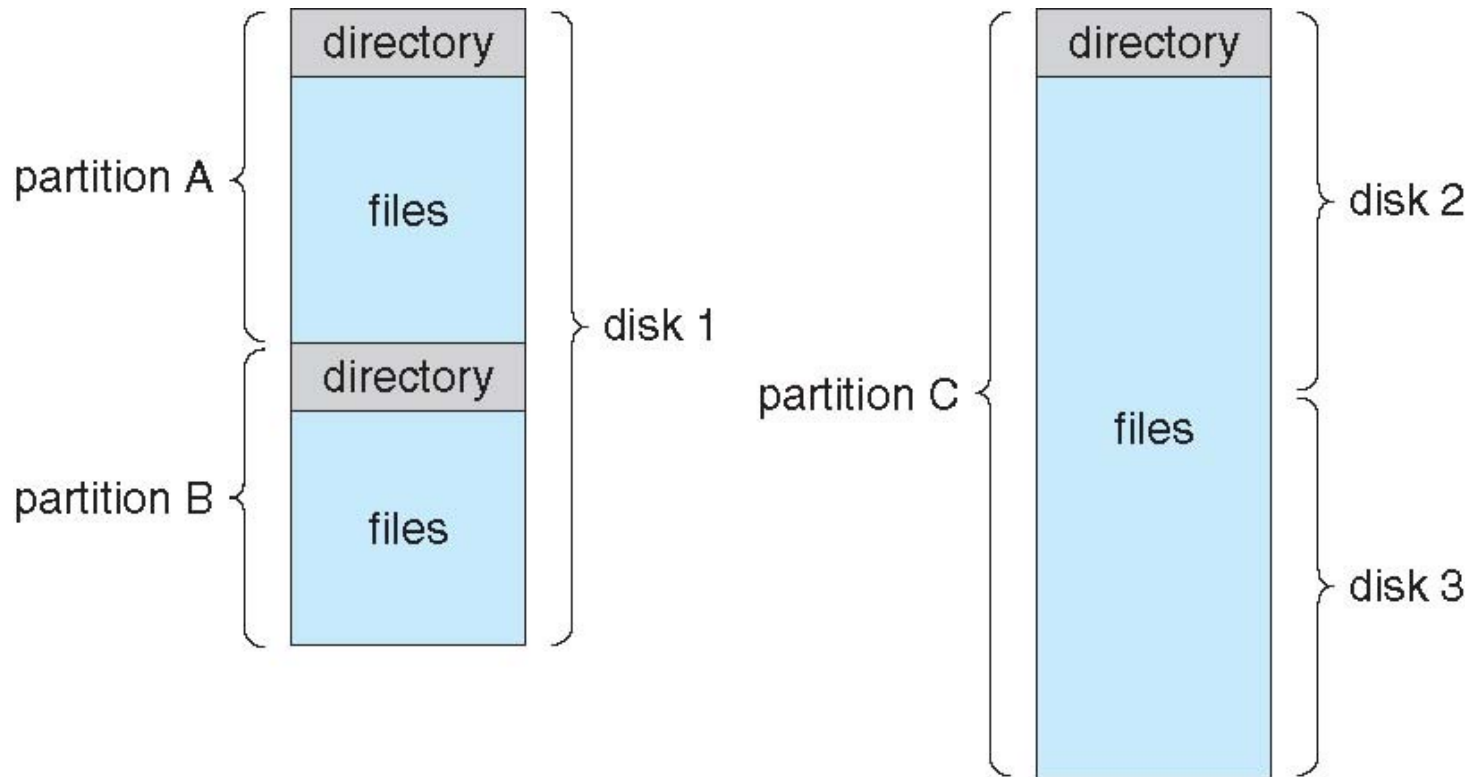


Both the directory structure and the files reside on disk





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
- Traverse the file system





Directory Organization

The directory is organized logically to obtain

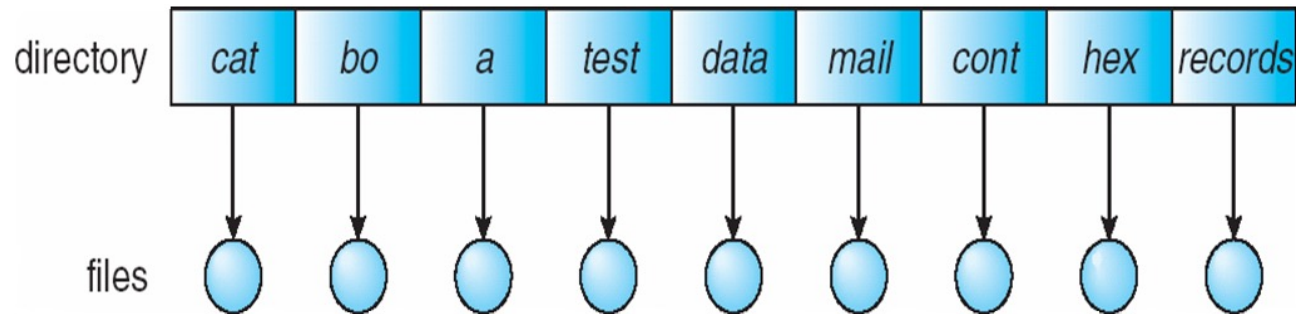
- Efficiency – locating a file quickly
- Naming – convenient to users
 - Two users can have same name for different files
 - The same file can have several different names
- Grouping – logical grouping of files by properties, (e.g., all Java programs, all games, ...)





Single-Level Directory

- A single directory for all users



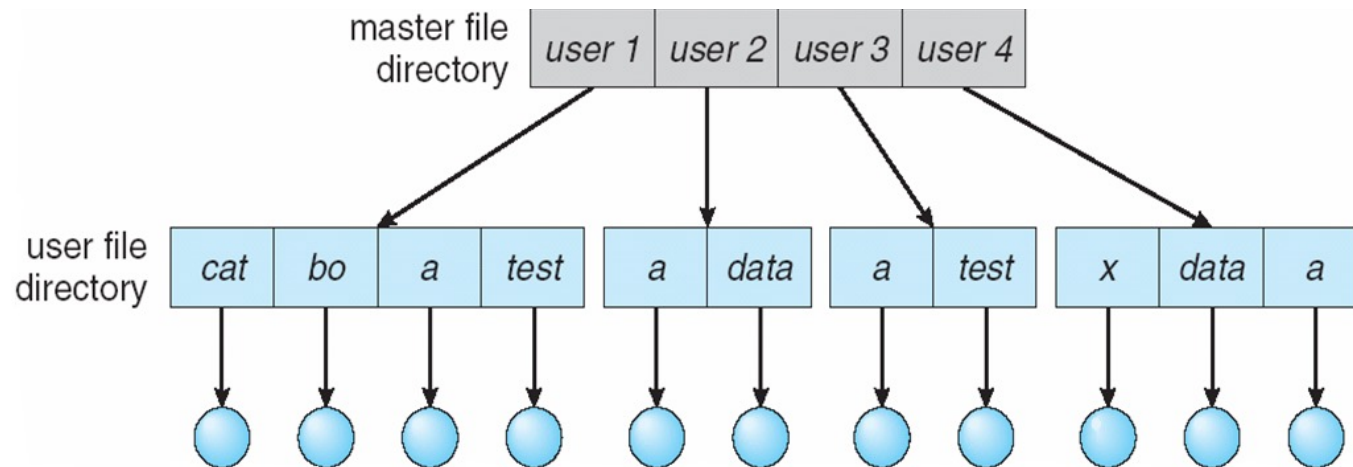
- Naming problem
- Grouping problem





Two-Level Directory

- Separate directory for each user

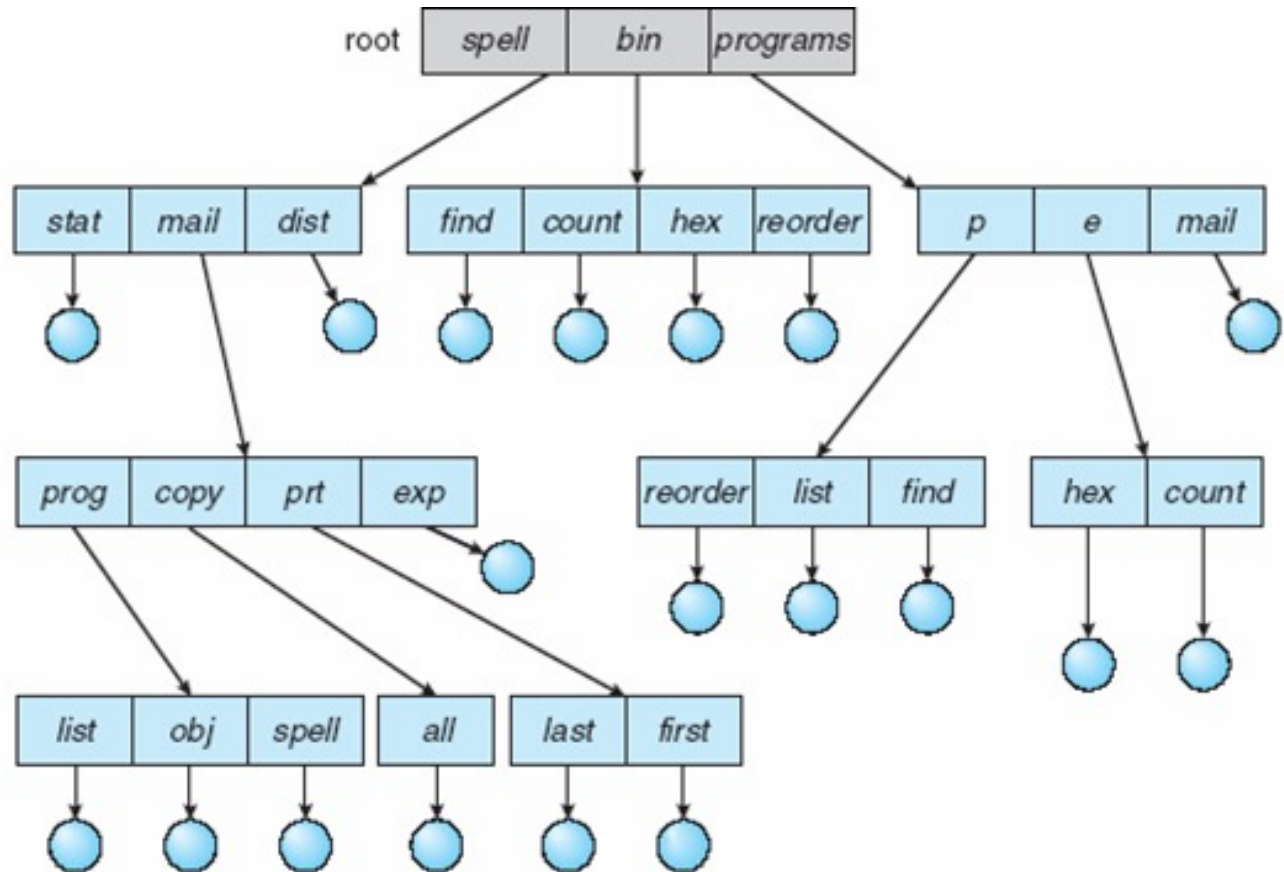


- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability





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

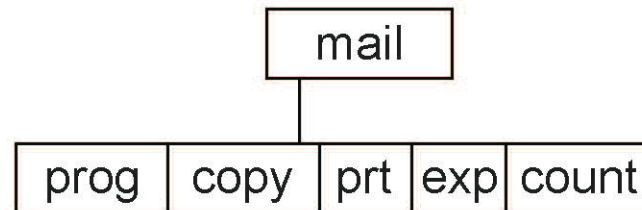
`rm <file-name>`

- Creating a new subdirectory is done in current directory

`mkdir <dir-name>`

Example: if in current directory `/mail`

`mkdir count`



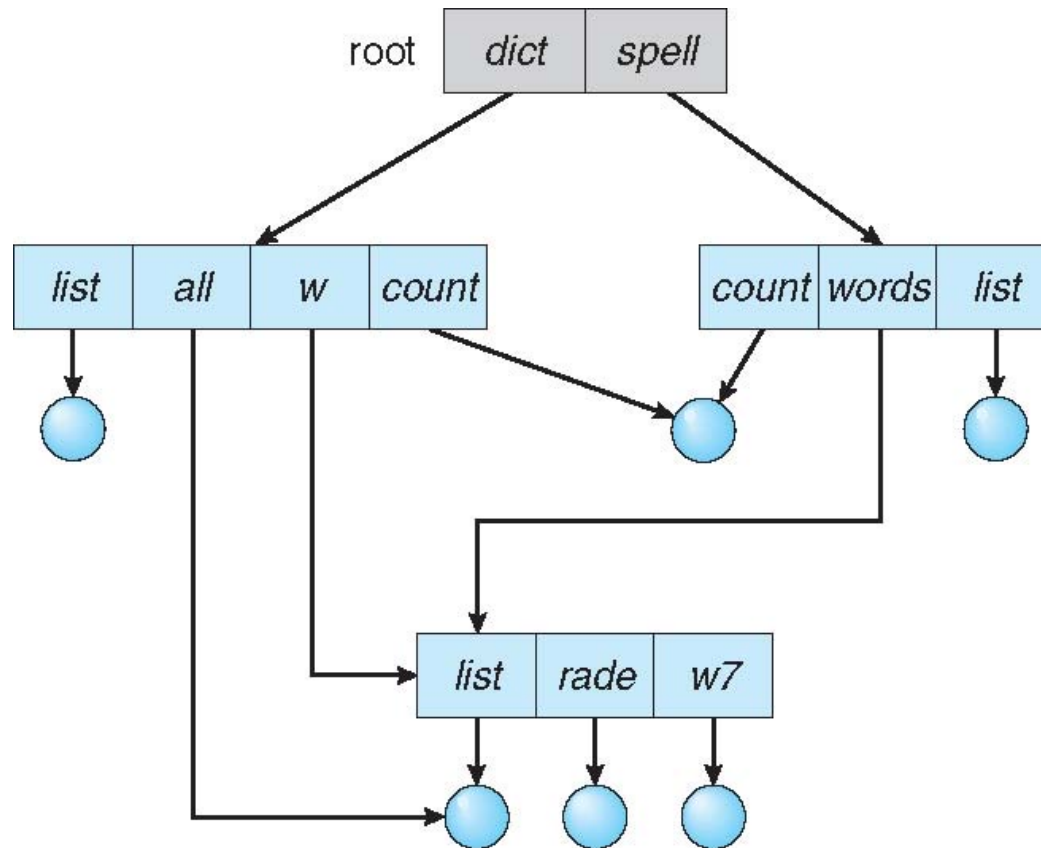
Deleting “mail” \Rightarrow deleting the entire subtree rooted by “mail”





Acyclic-Graph Directories

- Have shared subdirectories and files





Acyclic-Graph Directories (Cont.)

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

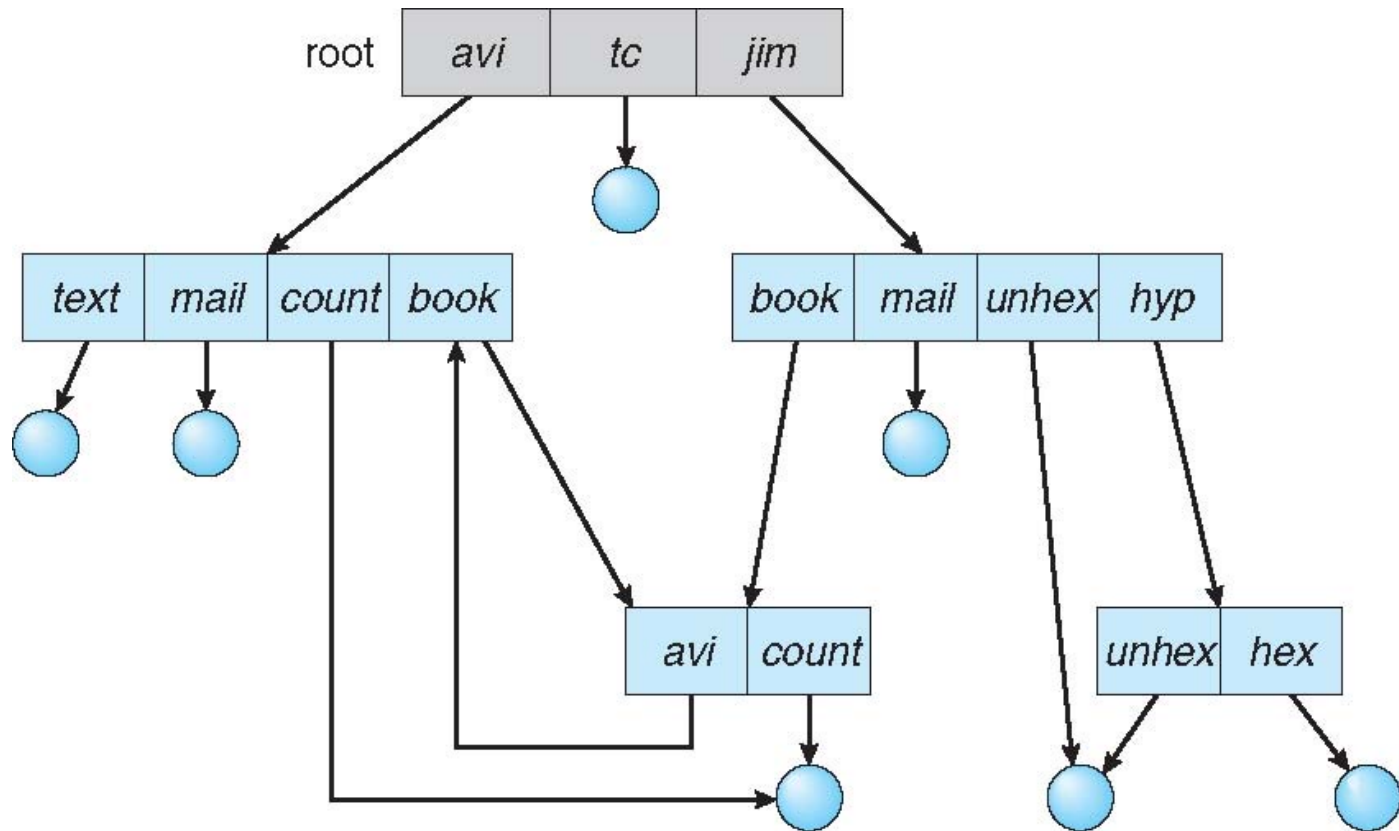
Solutions:

- 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 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
- If multi-user system
 - **User IDs** identify users, allowing permissions and protections to be per-user
 - **Group IDs** allow users to be in groups, permitting group access rights
 - Owner of a file / directory
 - Group of a file / directory





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 – Consistency Semantics

- Specify how multiple users are to access a shared file simultaneously
 - Similar to Ch 5 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**



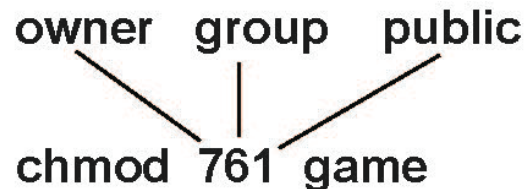


Access Lists and Groups

- Mode of access: read, write, execute
- Three classes of users on Unix / Linux

			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.



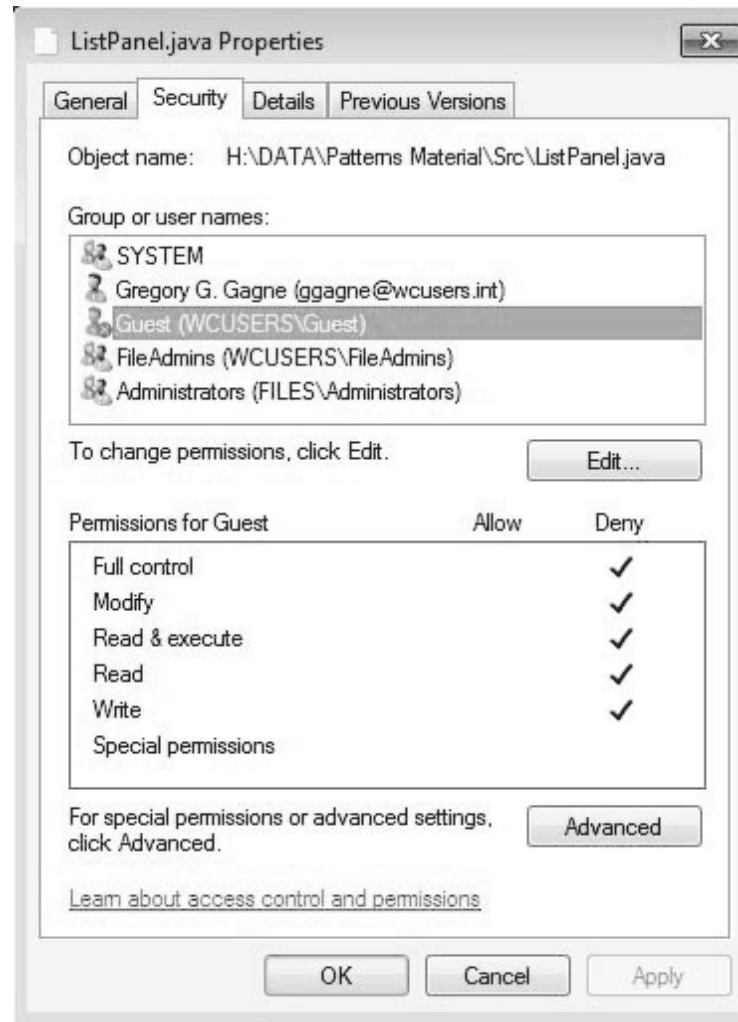
Attach a group to a file

chgrp G game





Windows 7 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 13

