EECS 111:

System Software

Lecture : File-System Interface

Prof. Mohammad Al Faruque

The Henry Samueli School of Engineering
Electrical Engineering & Computer Science
University of California Irvine (UCI)

File-System Interface

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

File Concept

- A file is a named collection of related information that is recorded on secondary storage.
  - OS provides a uniform logical view of the stored information
  - OS abstracts from the physical properties of its storage devices to define a logical storage units → file
- Types:
  - Data Files: numeric, character, binary
  - Program (both source and object forms)
- Files may be free form, e.g. text file or may be formatted rigidly
- Contents defined by file's creator
  - A file has a certain defined structure depending on its type
    - Consider text file (characters organized onto lines), source file (sequence of functions), executable file (sequence of code sections)

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

- **It may take more than a KB to record this information for each file**
- **In a system with many files, the size of the directory itself may be megabytes**

- 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: typically a directory entry consists' of the file's name and its unique identifier

File Operations

- File is an abstract data type
- OS provides necessary system calls

- These are the 6 basic operations → minimal set of required file operations
- Basic Operations may form other functions, e.g. copy a file to another IO device
- Most of the file operation involves searching the directory

6. 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

File Operations

- File is an abstract data type
- OS provides necessary system calls

1. Create: Two step process
   1. Check for available space
   2. An entry for the new file in the directory
2. Write – at write pointer location → input file name and information
3. Read – at read pointer location → input file name and memory address to write the block
4. Reposition within file - seek
5. Delete
6. Truncate

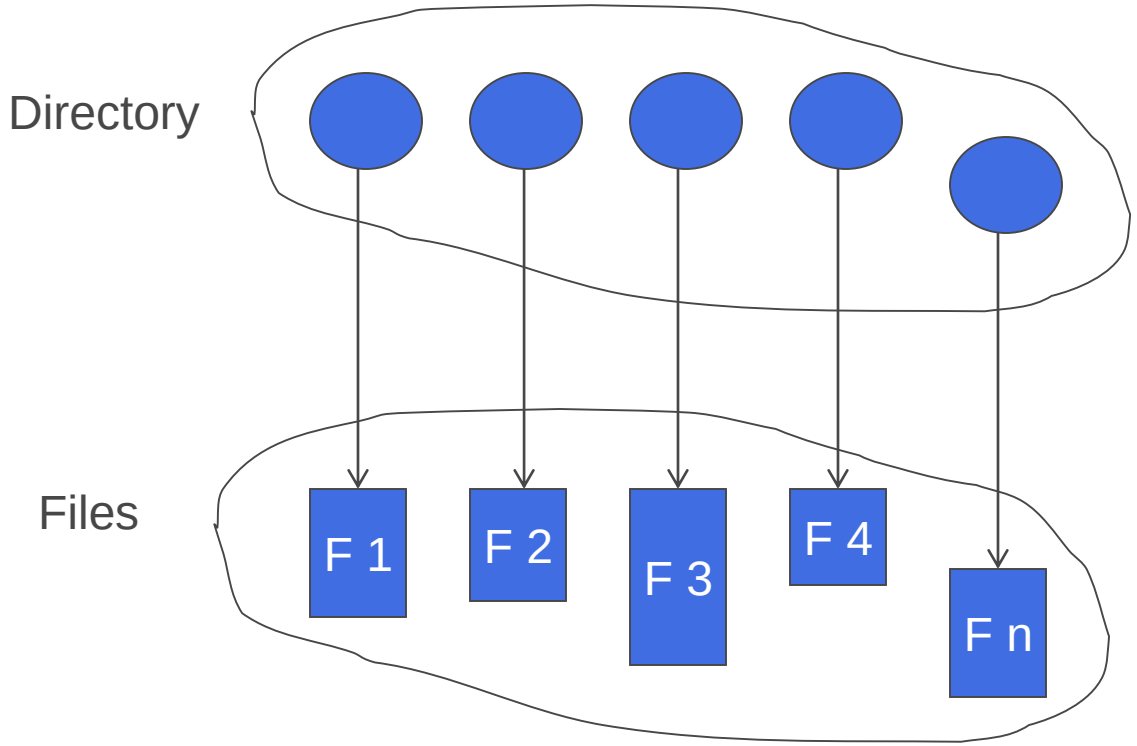
- *Open(F_i)* – search the directory structure on disk for entry F_i, and move the content of entry to memory
- *Close (F_i)* – move the content of entry F_i in memory to directory structure on disk

Open Files

- **Several pieces of data are needed to manage open files:**
  - **Open-file table: tracks open files**
    - Two levels of internal tables
      - **Per-process Table:** process's use of the file→ current file pointer, access rights
      - **System-wide Table:** process independent information → location of the file to the disk, access dates, file size. Each entry in per-process table points to a system-wide open-file table
- **Information associated with the open file**
  - **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**
  - **Access rights: per-process access mode information**
  - **Disk location of the file: cache of data access information**

Directory Structure

- **A collection of nodes containing information about all files**

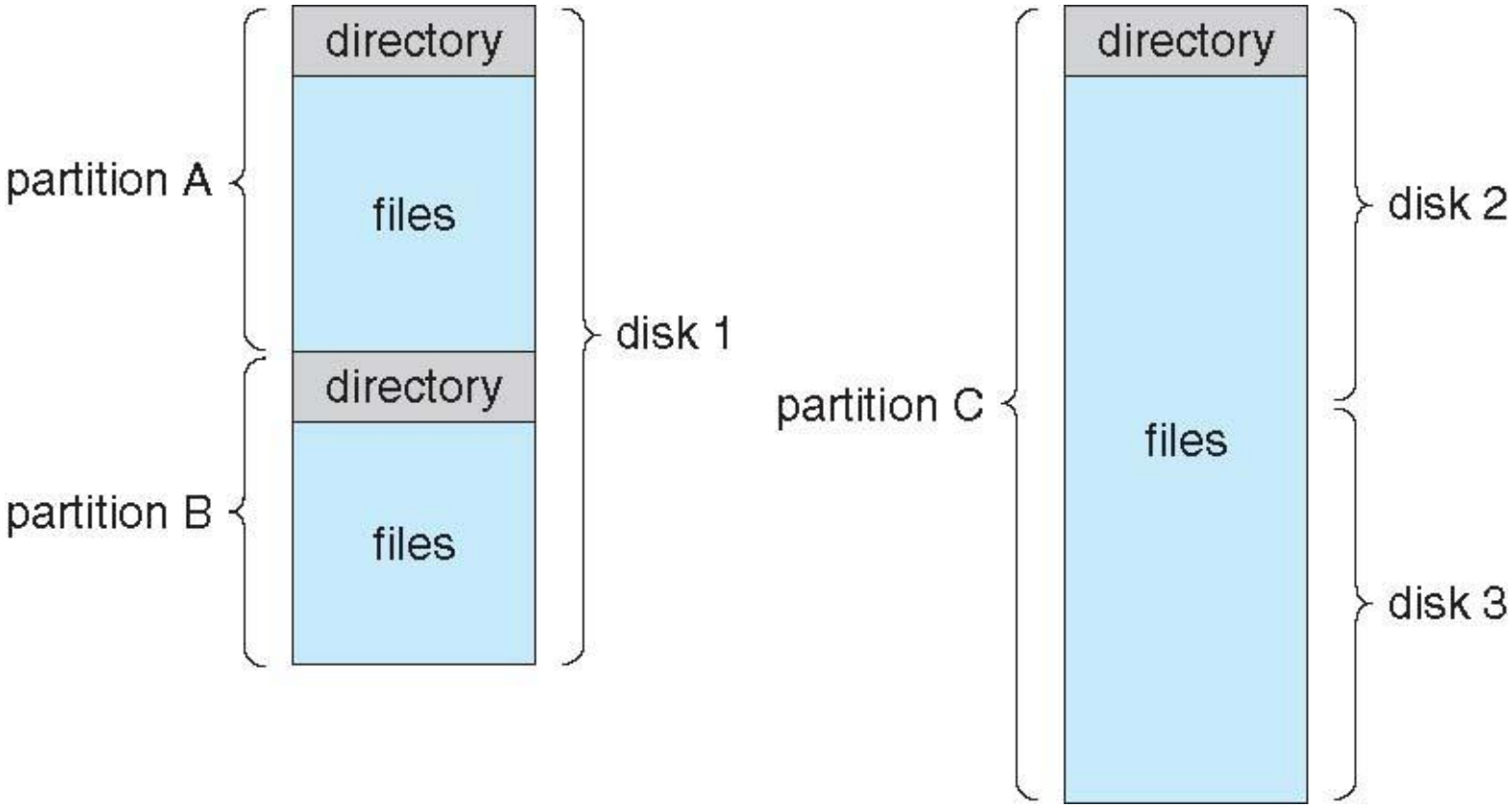


Both the directory structure and the files reside on disk

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

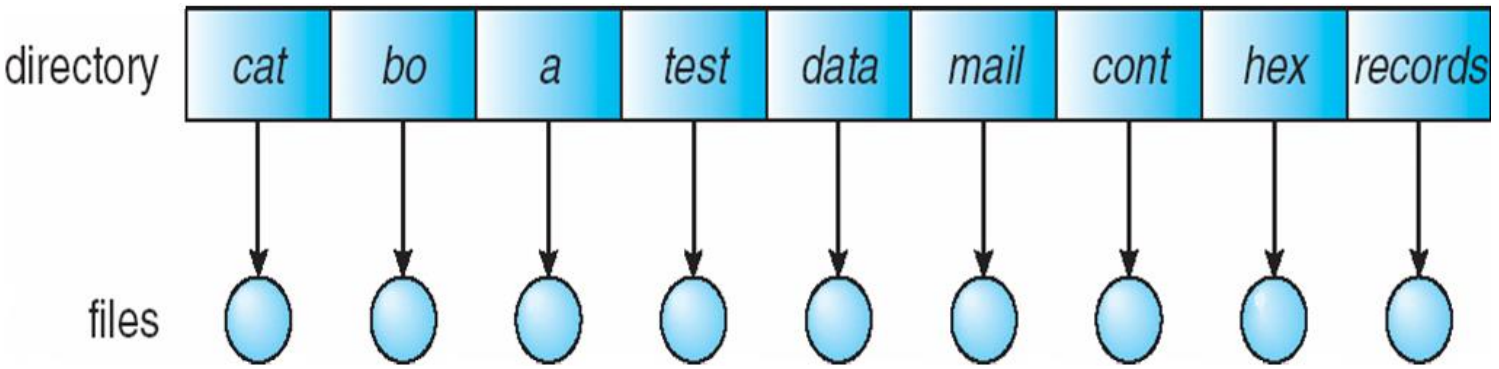
- A directory may be viewed as a symbol table that translates file names into their directory entries
- Operations to be performed on a directory
  - Search for a file
  - Create a file
  - Delete a file
  - List a directory
  - Rename a file
  - Traverse the file system

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, …)**

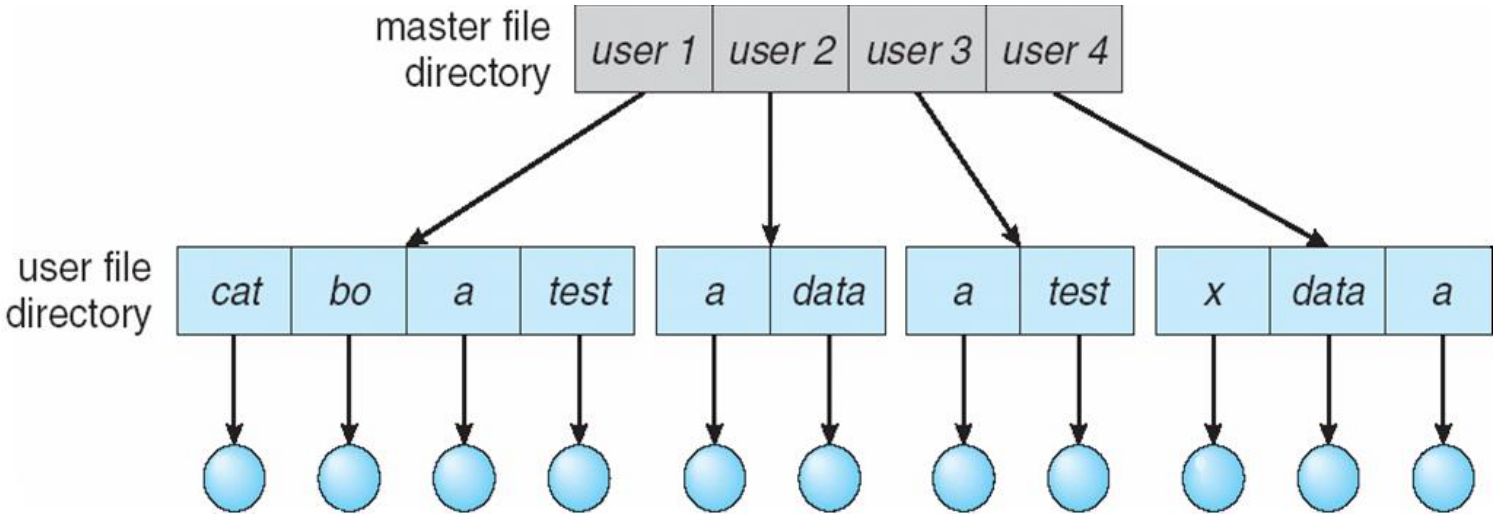
Single-Level Directory

- A single directory for all users



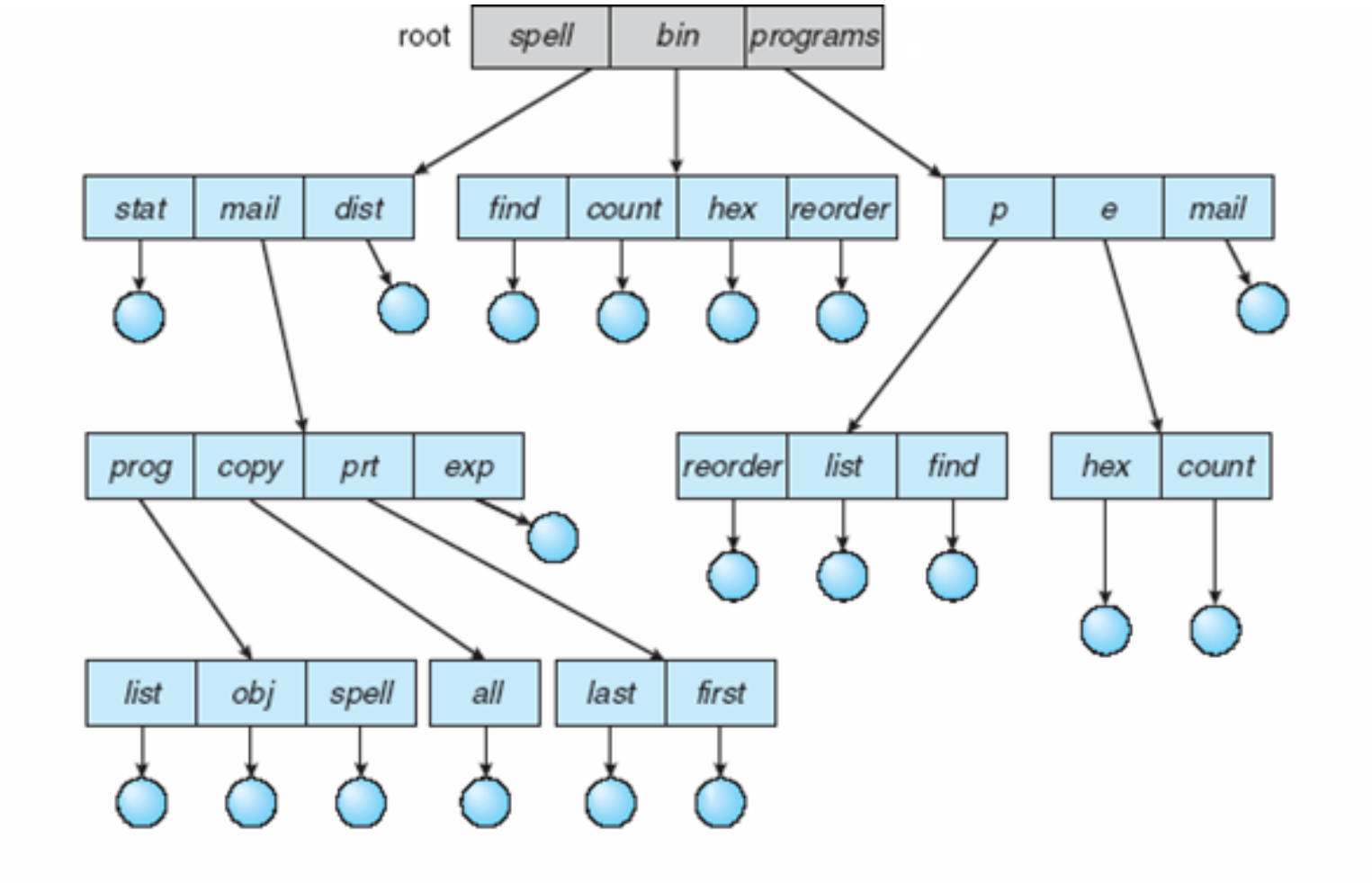
Two-Level Directory

- Separate directory for each user



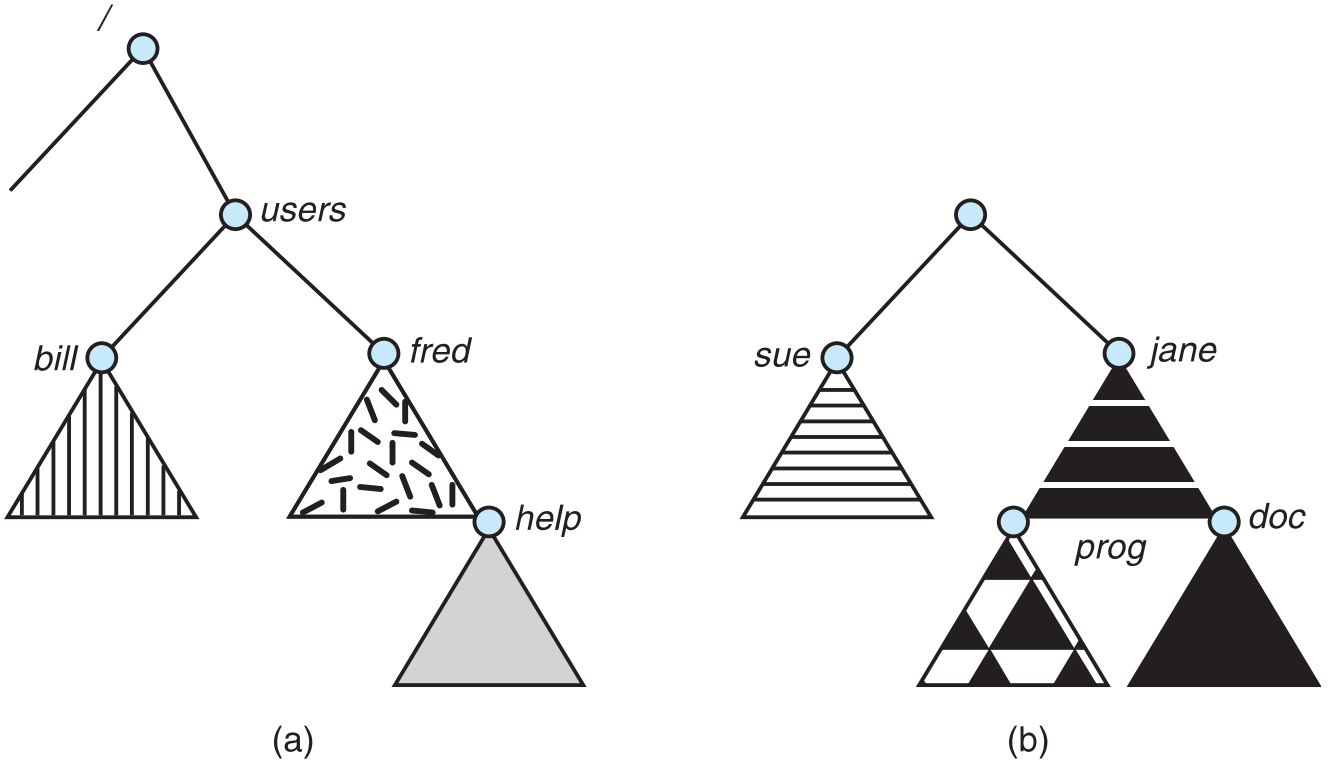
- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability

Tree-Structured Directories

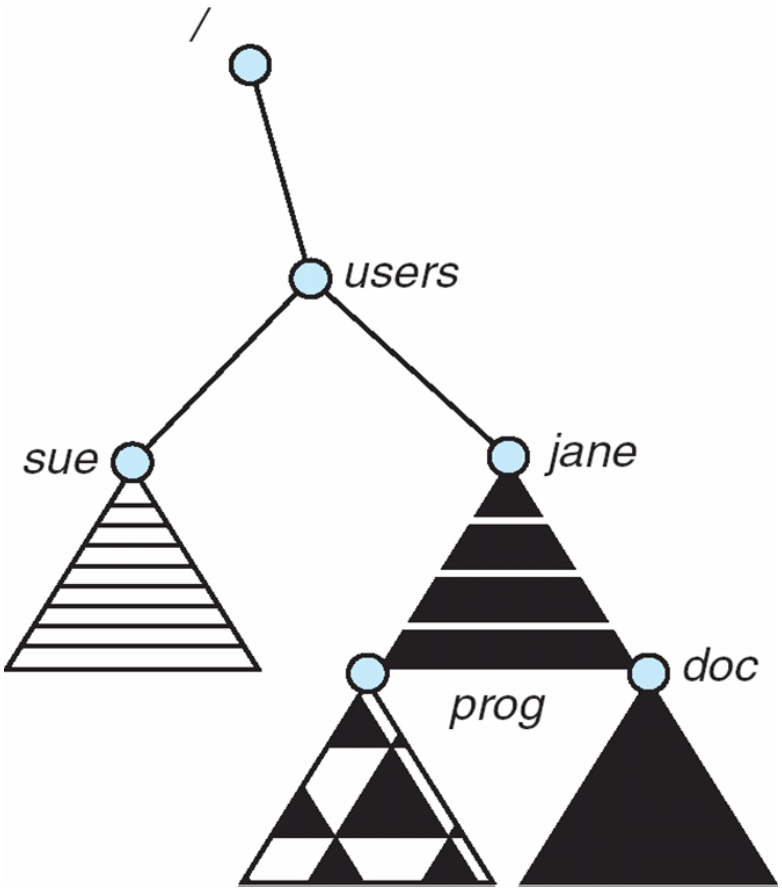


File System Mounting

- 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



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

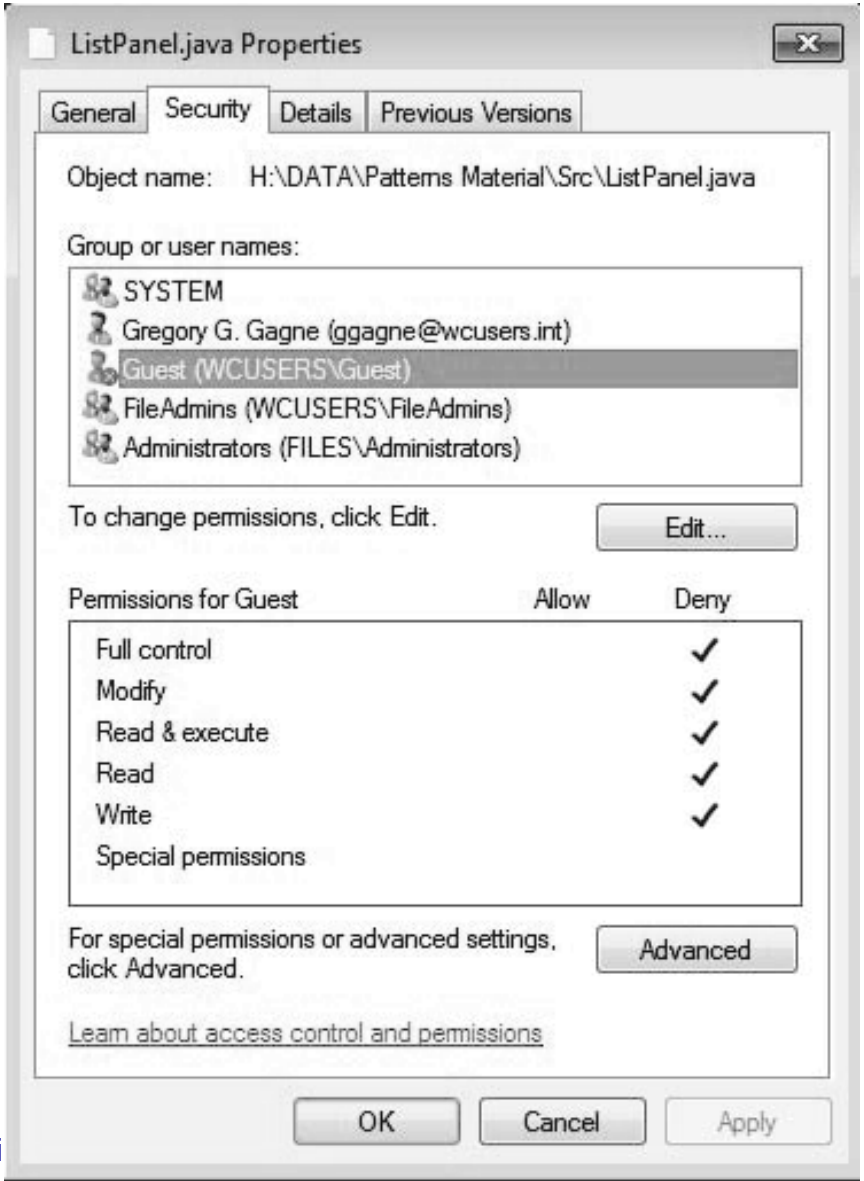
Access Lists and Groups

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

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/

Summary

- The major task of OS is to map the logical file concept onto physical storage device
- 6 basic operations on a file and some other optional and helpful operations
- Directory structure and various operations
- OS provides file system mounting
- File protection and access rights

References

Part of the contents of this lecture has been adapted from the book Abraham Silberschatz, Peter B. Galvin, Greg Gagne: "Operating System Concept ", Publisher : Wiley; 9 edition (December 17, 2012), ISBN-13: 978-1118063330

Slides also contain lecture materials from John Kubiatowicz (Berkeley), John Ousterhout (Stanford), Nalini (UCI), Rainer (UCI), and others

Some slides adapted from http://www-inst.eecs.berkeley.edu/~cs162/ Copyright © 2010 UCB

Thank you for your attention