

CSE 30341

Operating System Principles

File Systems

Files & File Systems

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

File Concept

- Contiguous logical address space
- File = collection of related information recorded on secondary storage
- Types:
 - Data
 - Numeric (text, ASCII; "LINE_MAX" bytes)
 - Character (text, ASCII; "LINE_MAX" bytes)
 - Binary (executable, readable by computer)
 - Program

File "interpretation" is up to user/program

File Structure

- None - sequence of words, bytes
- Simple record structure
 - Lines
 - Fixed length
 - Variable length
- Complex Structures
 - Formatted document
- Who decides:
 - Operating system
 - Program

Example Structures

CSV

Poellabauer,Christian,5,3.45
 Doe,Jane,6,3.98
 Bowyer,Kevin,4,4.25

XML

```
<Participant FN="Christian" LN="Poellabauer">
  <Publication Year="2008" />
  <Publication Year="2009" />
</Participant>
```

Structured

Poellabauer	Christian	cpoellab
Bualuan	Ramzi	rbualuan
Thain	Doug	dthain

```
struct ProfInfo
{
  char szLast[41];
  char szFirst[31];
  char szNetID[11];
};
```

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 (ACL)** – 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**
- **Basic operations on files:**
 - 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 back to directory structure on disk
- Opening files: “remember” used files; efficiency; convenience

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 (*flock* and *fcntl* system calls)
- 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

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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

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Access Methods

- **Sequential Access**

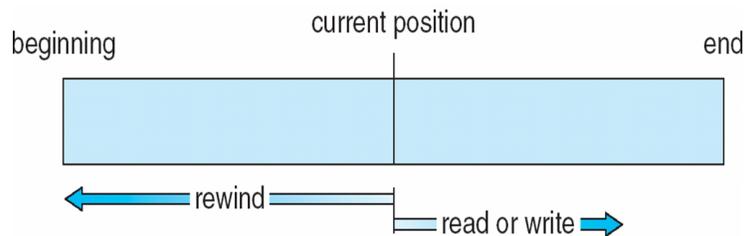
read next
write next
reset
skip forward

- **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

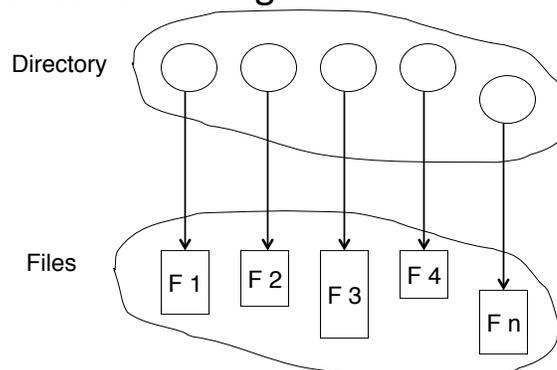
sequential access	implementation for direct access
<i>reset</i>	<i>cp = 0;</i>
<i>read next</i>	<i>read cp;</i> <i>cp = cp + 1;</i>
<i>write next</i>	<i>write cp;</i> <i>cp = cp + 1;</i>

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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

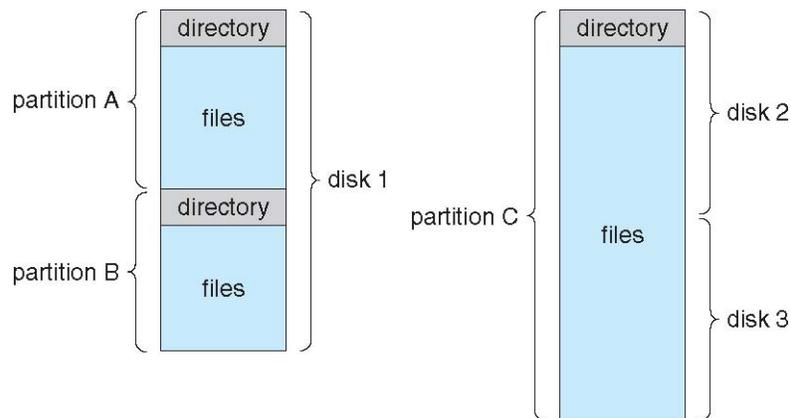
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Disk Structure

- 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**
- In addition to **general-purpose file systems**, there can be many **special-purpose file systems**

A Typical File-system Organization



Operations Performed on Directory

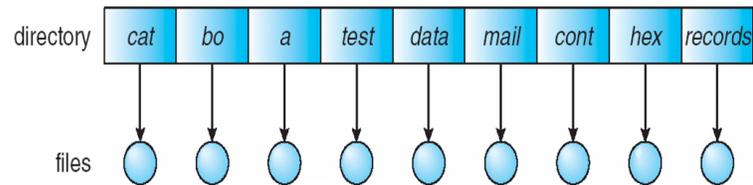
- Search for a file
- Create a file
- Delete a file
- List a directory
- Rename a file
- Traverse the file system

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

Single-Level Directory

- A single directory for all users

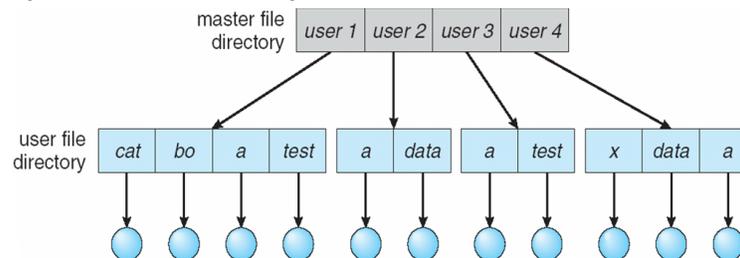


Naming problem

Grouping problem

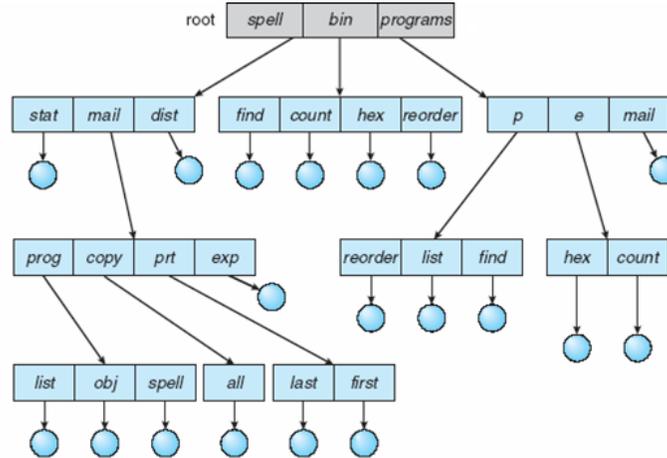
Two-Level Directory

- Separate directory for each user



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

Tree-Structured Directories



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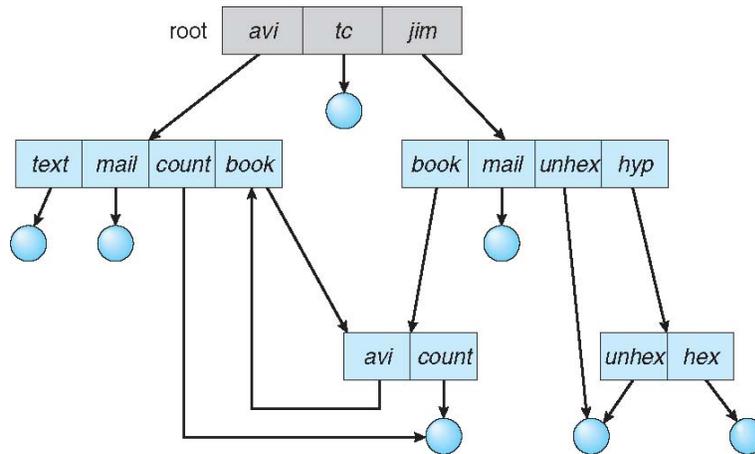
Tree-Structured Directories (Cont.)

- Efficient searching
- Grouping Capability
- Current directory (“working directory”)
 - `cd /spell/mail/prog`
 - `cd ~`
 - `cd .`
 - `cd ..`

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Acyclic-Graph Directories



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General Graph Directory (Cont.)

- How do we guarantee no cycles?
 - Allow only links to files, not subdirectories
 - Every time a new link is added use a cycle detection algorithm to determine whether it is OK
 - Ignore links for activities such as recursive search/delete/etc.

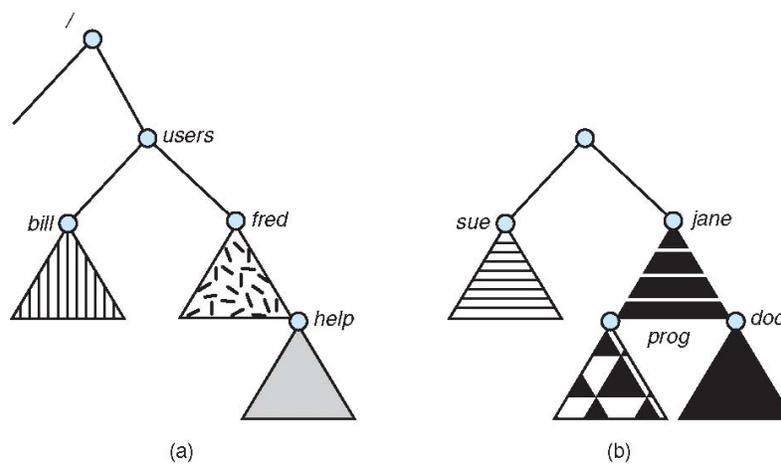
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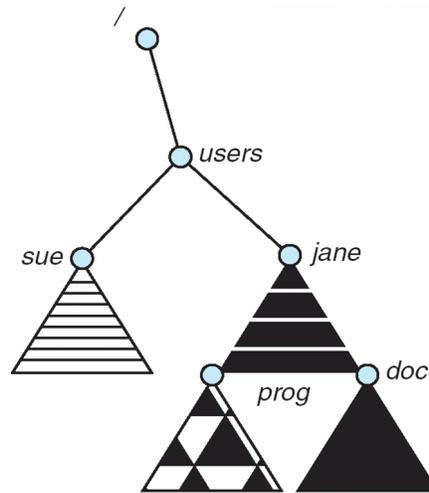
File System Mounting

- A file system must be **mounted** before it can be accessed
- A unmounted file system is mounted at a **mount point**

(a) Existing (b) Unmounted Partition



Mount Point



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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

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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

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) owner access	7	⇒	RWX 1 1 1
b) group access	6	⇒	RWX 1 1 0
c) public access	1	⇒	RWX 0 0 1

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/

```