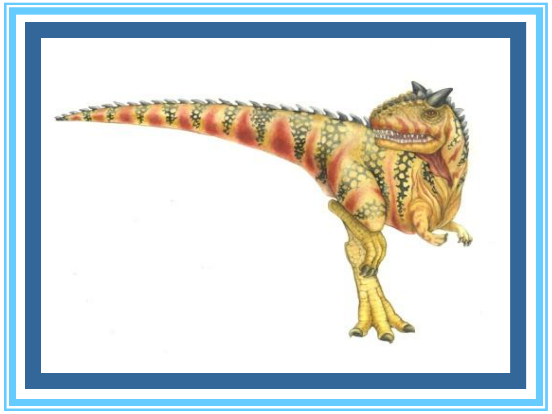
Chapter 13: File-System Interface



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

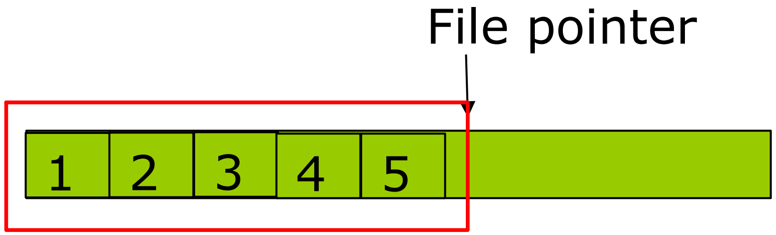
File Concept

logical object

File pointer

- 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**

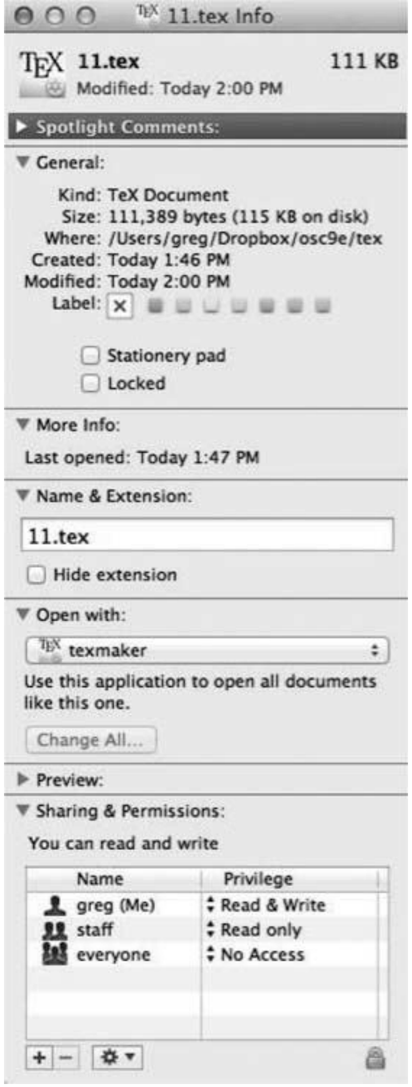
```
import java.io.RandomAccessFile;

public class ContiguousFileExample {
    public static void main(String[] args) throws Exception {
        String fileName = "contiguous_example.dat";
        try (RandomAccessFile file = new RandomAccessFile(fileName, "rw")) {
            for (int i = 1; i <= 5; i++) file.writeInt(i); // Write integers 1 to 5
            file.seek(0); // Move file pointer to the beginning
            for (int i = 1; i <= 5; i++) System.out.print(file.readInt() + " "); // Read
integers
        } // Output: 1 2 3 4 5
    }
}
```



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



11.tex Info

TEX 11.tex 111 KB

Modified: Today 2:00 PM

▶ Spotlight Comments:

▼ General:

Kind: TeX Document
Size: 111,389 bytes (115 KB on disk)
Where: /Users/greg/Dropbox/osc9e/tex
Created: Today 1:46 PM
Modified: Today 2:00 PM
Label: ☒

□ Stationery pad

□ Locked

▼ More Info:

Last opened: Today 1:47 PM

▼ Name & Extension:

11.tex

□ Hide extension

▼ Open with:

texmaker

Use this application to open all documents like this one.

Change All...

▶ Preview:

▼ Sharing & Permissions:

You can read and write

Name	Privilege
greg (Me)	Read & Write
staff	Read only
everyone	No Access

File Operations

- File is an **abstract data type**
- **Create**
- **Write** – at **write pointer** location
- **Read** – at **read pointer** location
- **Reposition within file - seek**
- **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

```
#include <stdio.h>
#include <stdlib.h>

int main() {
    FILE *file = fopen("example.bin", "wb+");
    if (file == NULL) { perror("Error"); return EXIT_FAILURE; }
                                                      ptr    size      count   stream
    for (int i = 1; i <= 5; i++) fwrite(&i, sizeof(int), 1, file);
                                              ⇒ file에 int 크기 1개에 i 쓰기
    fseek(file, 0, SEEK_SET);

    int number;
    for (int i = 1; i <= 5; i++) {
        fread(&number, sizeof(int), 1, file); file에서 int 크기 1개 읽어서 number에 저장
        printf("%d ", number);
    }

    fclose(file);
    return EXIT_SUCCESS;
}
```

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

Open File Locking

- Provided by some operating systems and file systems
  - Similar to reader-writer locks
  - **Shared lock** similar to reader lock – several processes can acquire concurrently
  - **Exclusive lock** similar to writer lock only single process can write
- Mediates access to a file
- Mandatory or advisory:
  - **Mandatory** – access is denied depending on locks held and requested 강제적 lock ⇒ 위반불가.
  - **Advisory** – processes can find status of locks and decide what to do 권고 lock ⇒ 위반가능 ∴ cooperation 중요.

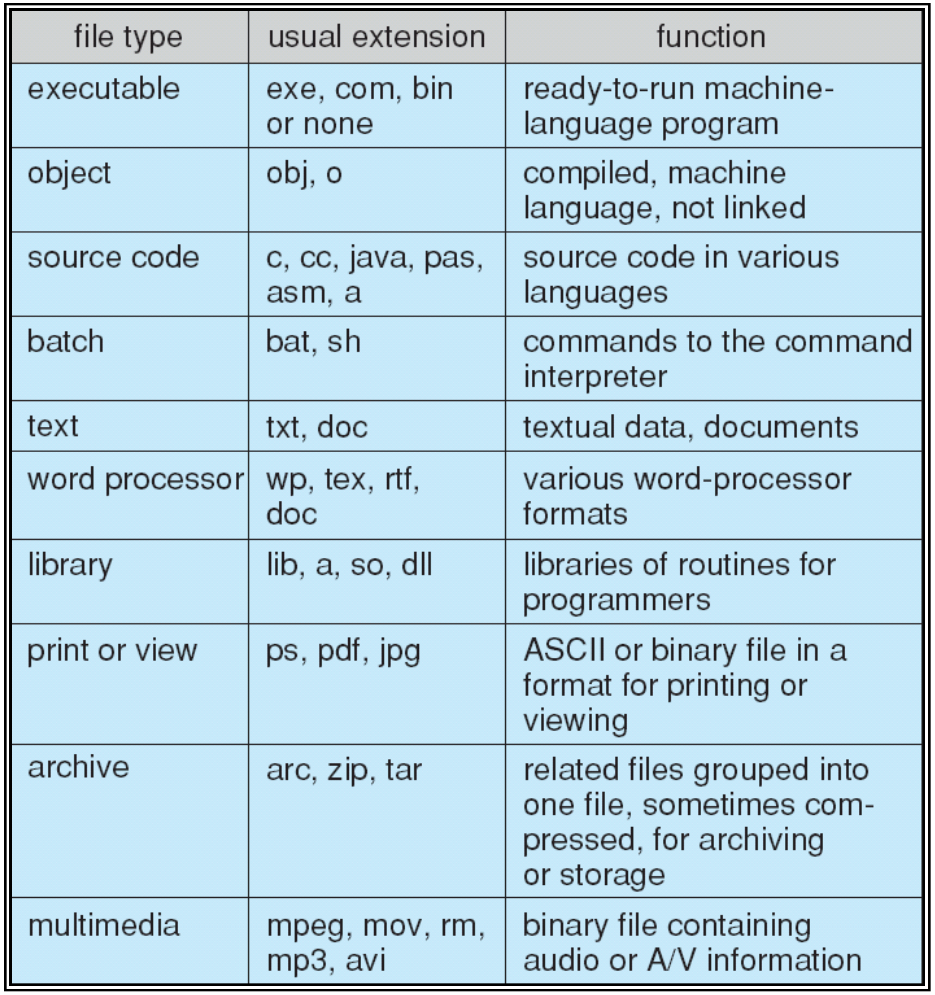
File Locking Example – Java API

```
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 args[]) 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



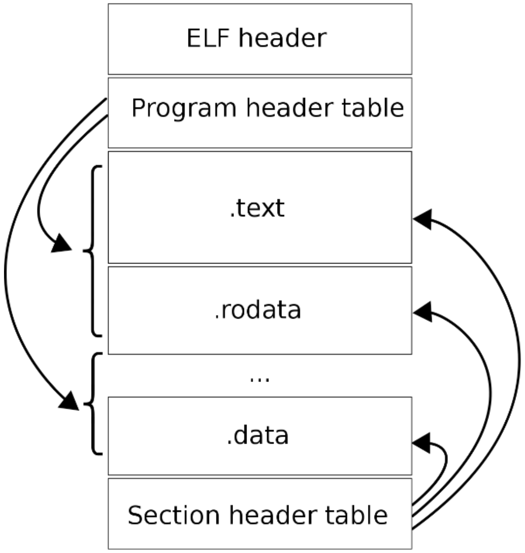
file type	usual extension	function
executable	exe, com, bin or none	ready-to-run machine-language program
object	obj, o	compiled, machine language, not linked
source code	c, cc, java, pas, asm, a	source code in various languages
batch	bat, sh	commands to the command interpreter
text	txt, doc	textual 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 compressed, for archiving or storage
multimedia	mpeg, mov, rm, mp3, avi	binary file containing audio or A/V information

test.java

doc.pdf

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



Linux executable file format

...... \n ...... \n ..... \n ..... \n ...

Simple text file format (.txt)

Access Methods

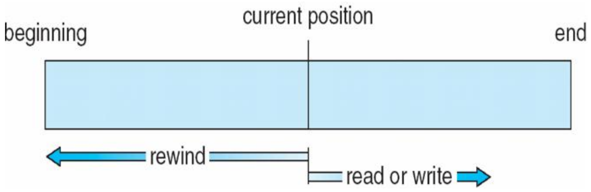
- **Sequential Access**

  uni-direction.

  No Backward.

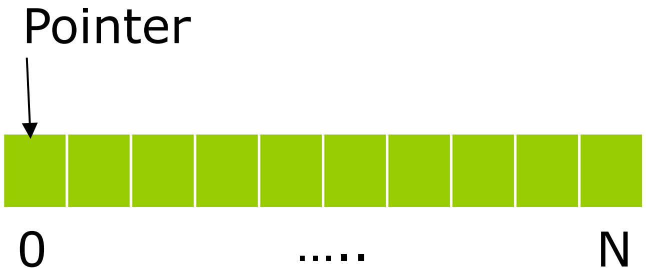
```
read next
write next
reset
```

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
```

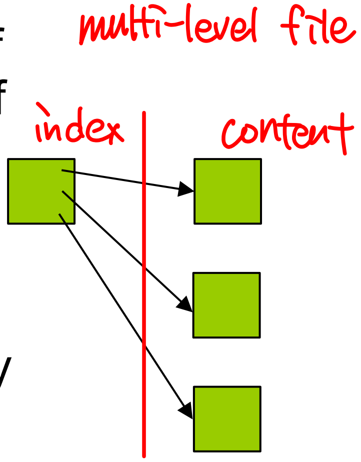


n = relative block number

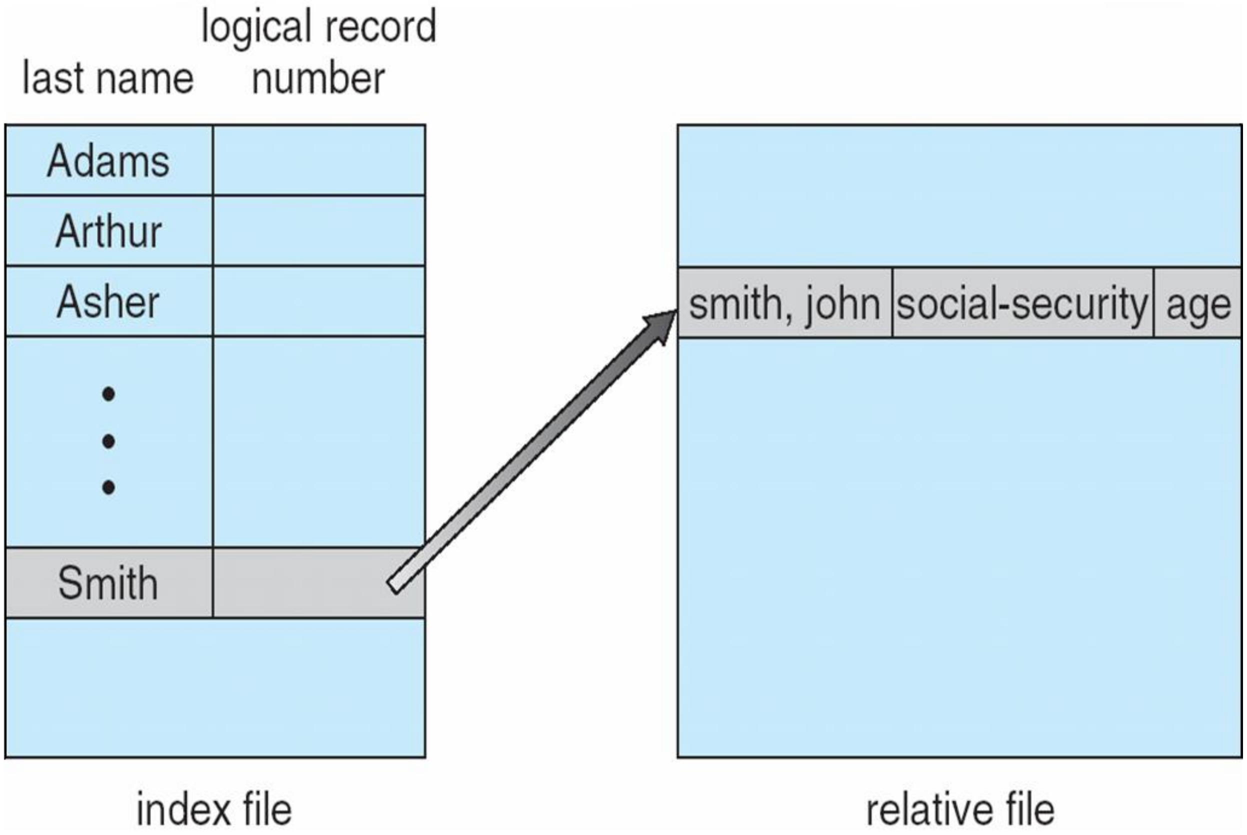
- Relative block numbers allow OS to decide where file should be placed
  - See allocation problem in Ch 14

Other Access Methods

- Can be built on top of base methods
- General involve creation of an index for the file
- Keep index in memory for fast determination of location of data to be operated on (consider UPC code plus record of data about that item)
- If too large, index (in memory) of the index (on disk)
- IBM indexed sequential-access method (ISAM)
  - Small master index, points to disk blocks of secondary index
  - File kept sorted on a defined key
  - All done by the OS
- VMS operating system provides index and relative files as another example (see next slide)

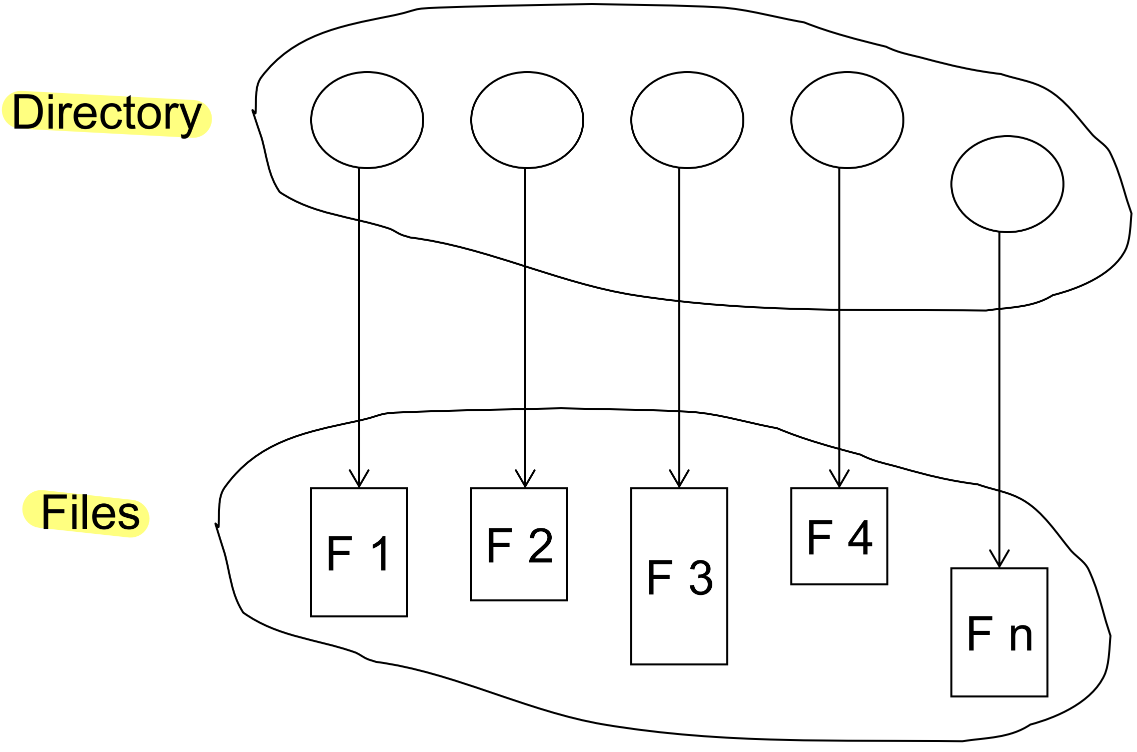


Example of Index and Relative Files



Directory Structure

- A collection of nodes containing information about all files

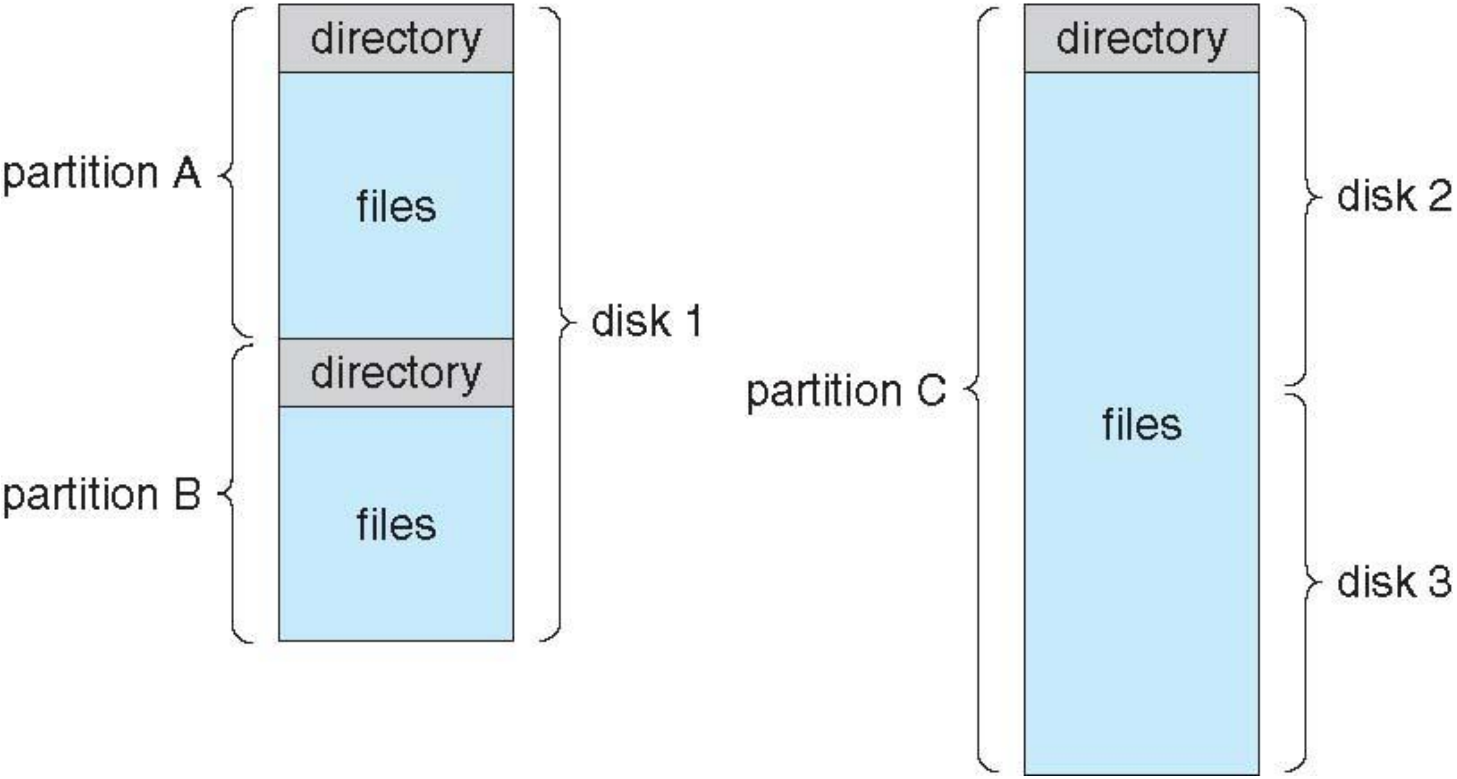


Both the directory structure and the files reside on disk

Disk Structure

- Disk can be subdivided into **partitions** HW
- Disk or partition can be used **raw** – without a file system, or **formatted** with a file system
- Partitions also known as minidisks, slices → Single, or set of partitions
- Entity containing file system known as a **volume** ··· formatted partition
- 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

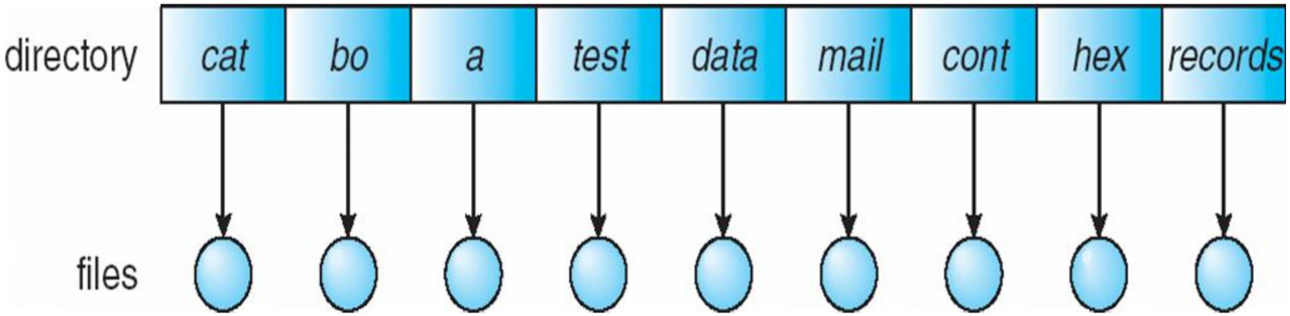
Directory Organization

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 저장공간 내부 구조.

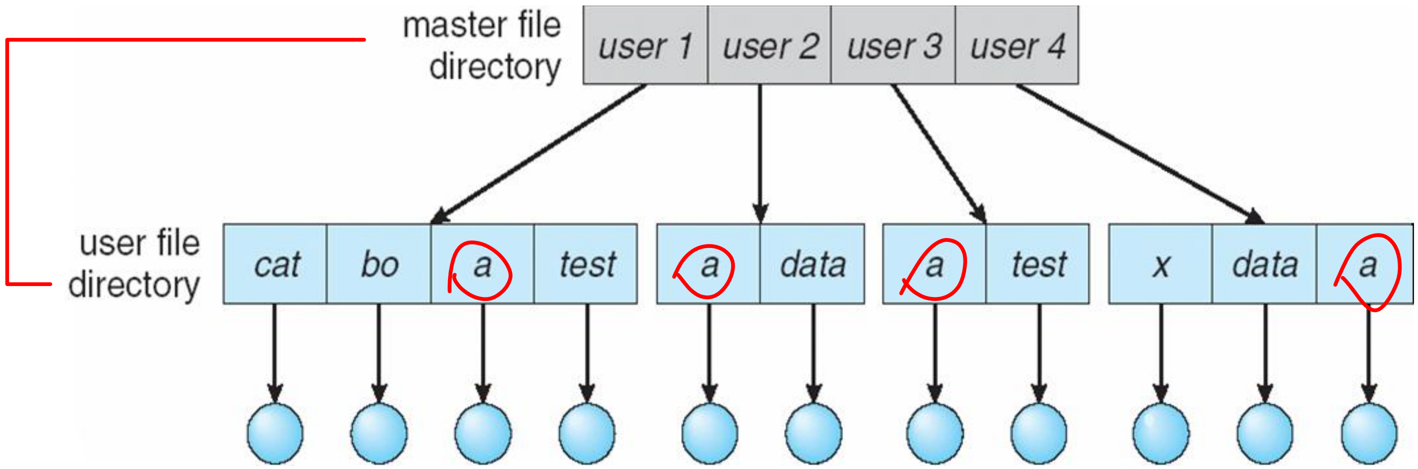
- A single directory for all users



- Naming problem no duplicate file name
- Grouping problem cannot group files

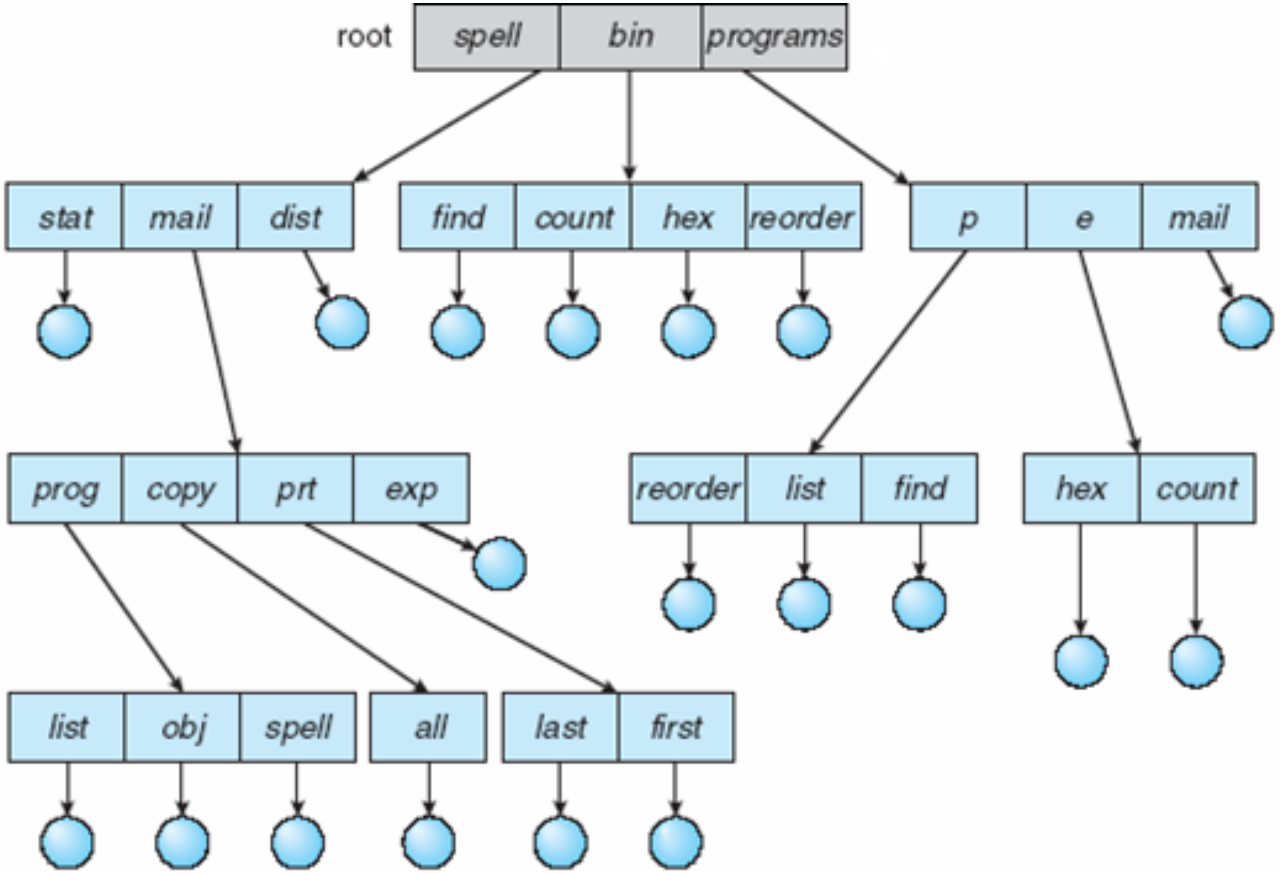
Two-Level Directory

- Separate directory for each user



- Path name username + filename
- 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

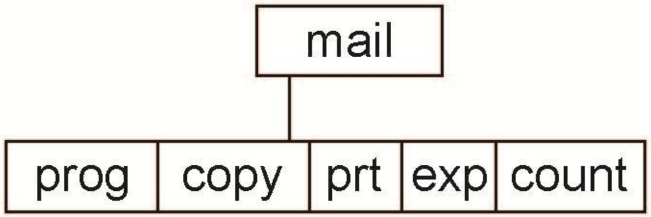
```
rm <file-name>
```

- Creating a new subdirectory is done in current directory

```
mkdir <dir-name>
```

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

```
mkdir count
```

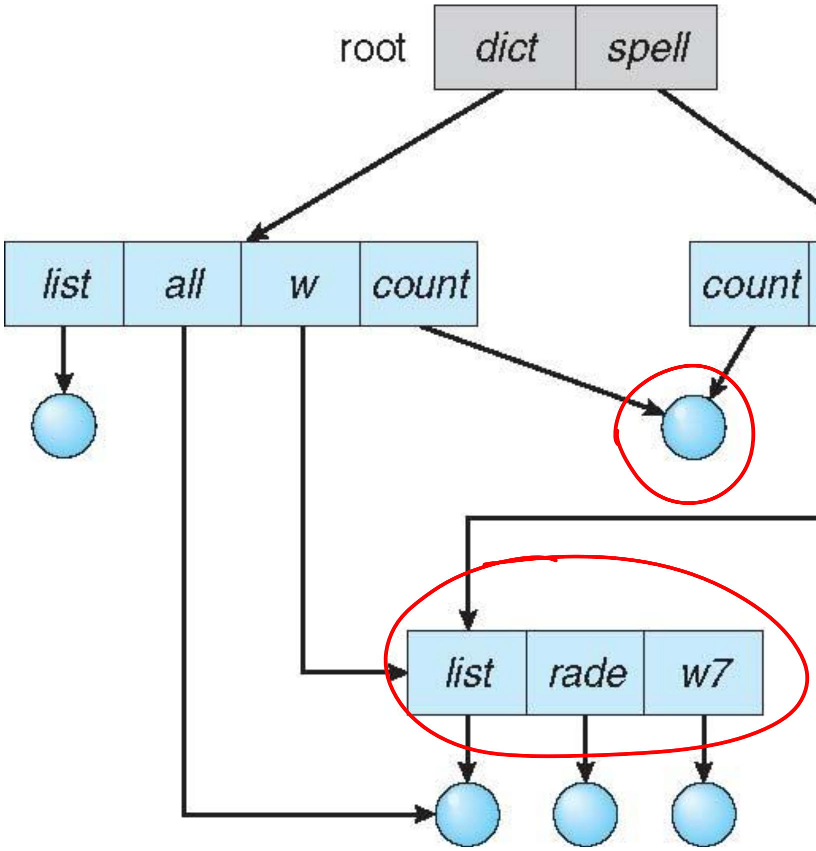


Deleting “mail” ⇒ deleting the entire subtree rooted by “mail”

Acyclic-Graph Directories

- Have shared subdirectories and files

share files & sub-directories



Acyclic-Graph Directories (Cont.)

- Two different names (aliasing)
- If ***dict*** deletes **w/*list*** ⇒ dangling pointer 죽은 참조

  Solutions: 참조가 어디서 왔는지 추적하는 포인터. ∵ 참조 출처

  point who referenced myself

  - Backpointers, so we can delete all pointers
    Variable size records a problem
  - Backpointers using a daisy chain organization
  - Entry-hold-count solution

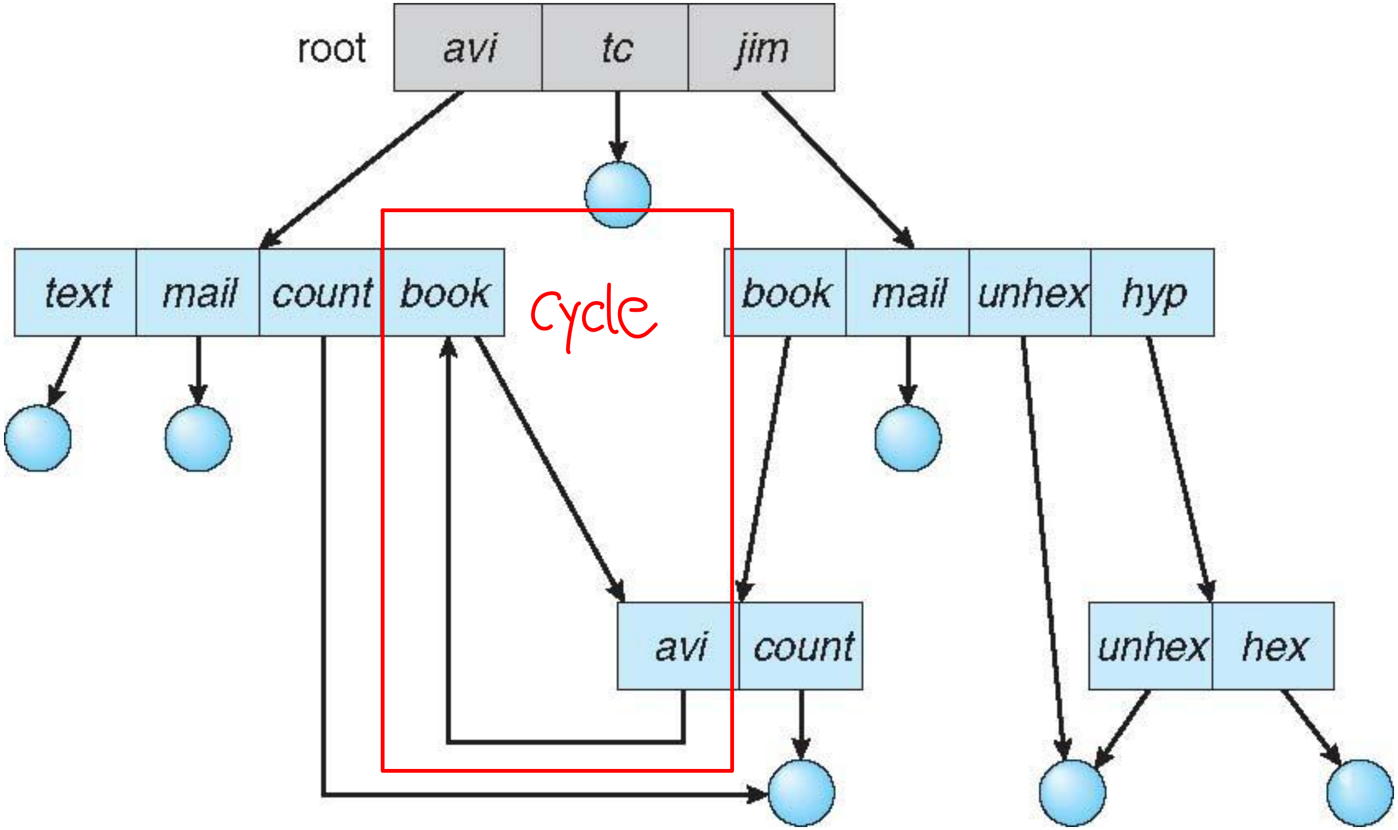
  # backpointer =0, able to remove.

- New directory entry type

  하나의 파일을 여러 경로로 접근 가능! ∵ 참조 생성

  - **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
  - file creator
    Owner of a file / directory
  - Group of a file / directory
    owner belongs to

Protection

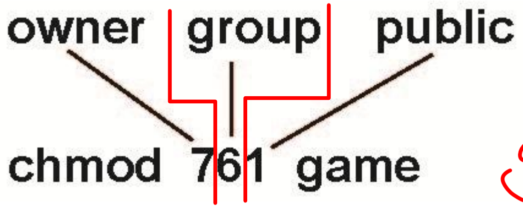
- File owner/creator should be able to control:
  - what can be done
  - by whom
- Types of access
  - **Read**
  - **Write**
  - **Execute**
  - **Append**
  - **Delete**
  - **List**

Access Lists and Groups

- Mode of access: read, write, execute 2^3
- 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.



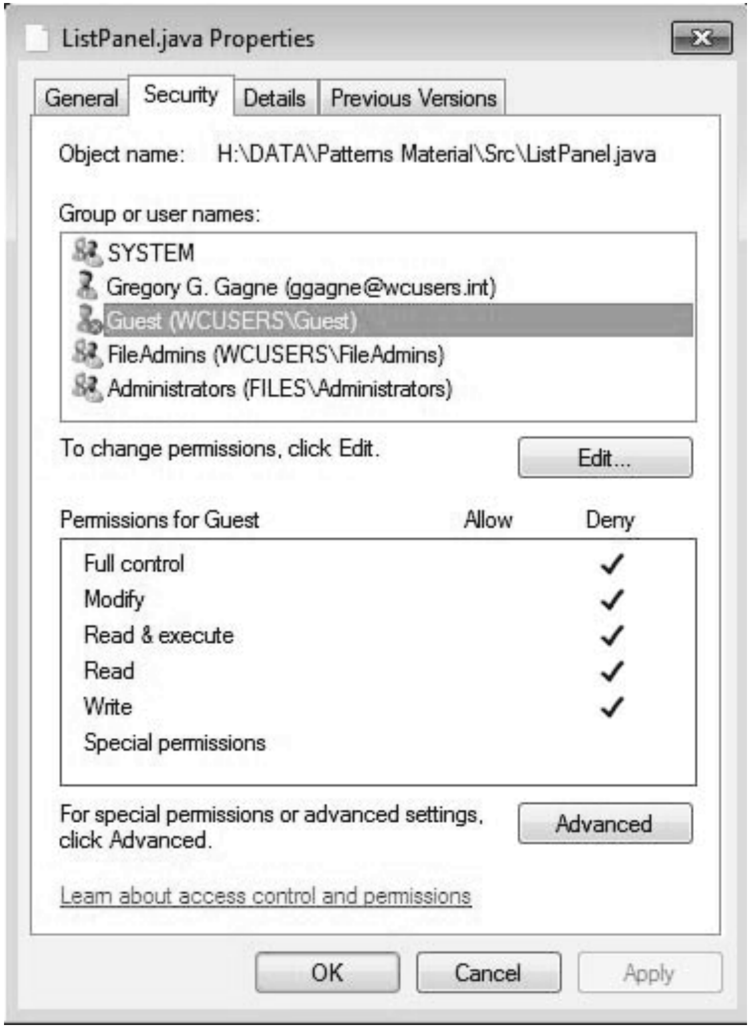
game 이라는 file에 7/6/1 권한 설정

Attach a group to a file

```
chgrp      G      game
```

game 이라는 file의 그룹을 G로 변경

Windows 7 Access-Control List Management



Object name: H:\DATA\Patterns Material\Src\ListPanel.java

Group or user names:

- SYSTEM
- Gregory G. Gagne (ggagne@wcusers.int)
- Guest (WCUSERS\Guest)
- FileAdmins (WCUSERS\FileAdmins)
- Administrators (FILES\Administrators)

To change permissions, click Edit.

Permissions for Guest	Allow	Deny
Full control		✓
Modify		✓
Read & execute		✓
Read		✓
Write		✓
Special permissions		

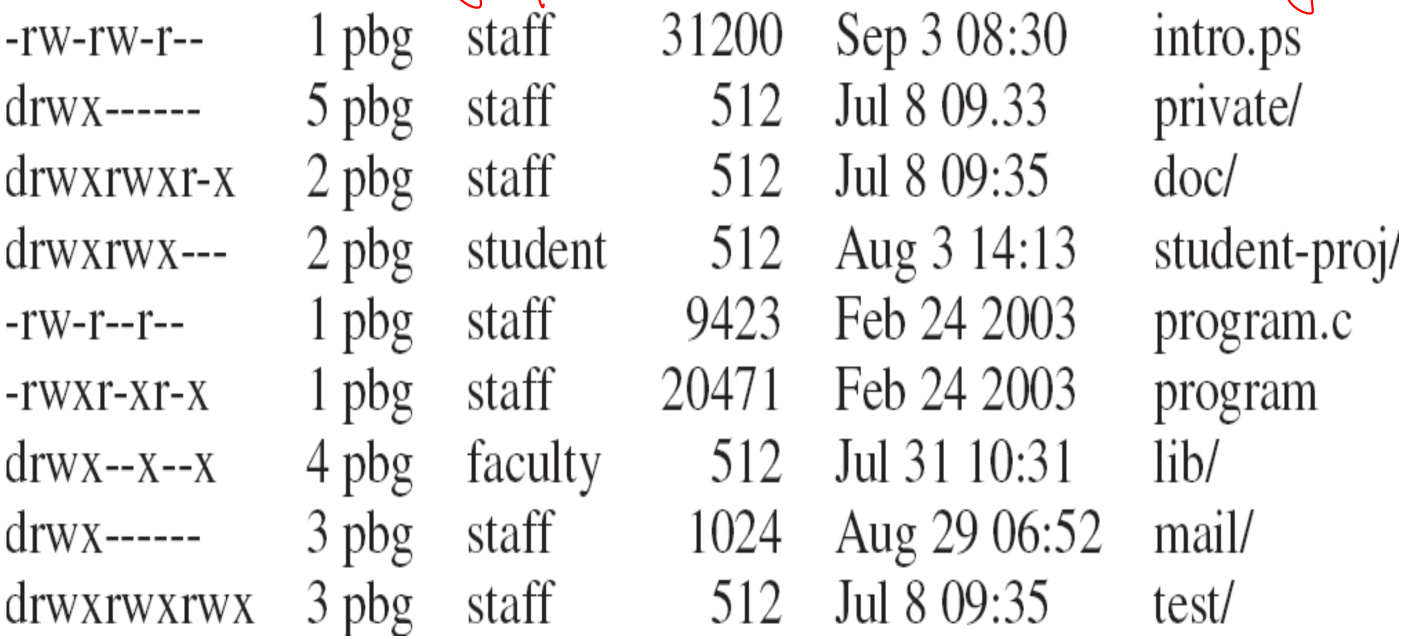
For special permissions or advanced settings, click Advanced.

Learn about access control and permissions

A Sample UNIX Directory Listing

d ⇓ subdirectory also

owner rwx   group rwx   public rwx   id   group   size   creation file   directory or file



```
-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