UNIT IV

STORAGE MANAGEMENT

File-System Interface

- File concept
- Access methods
- Directory Structure
- Directory organization
- File system mounting
- File Sharing and Protection

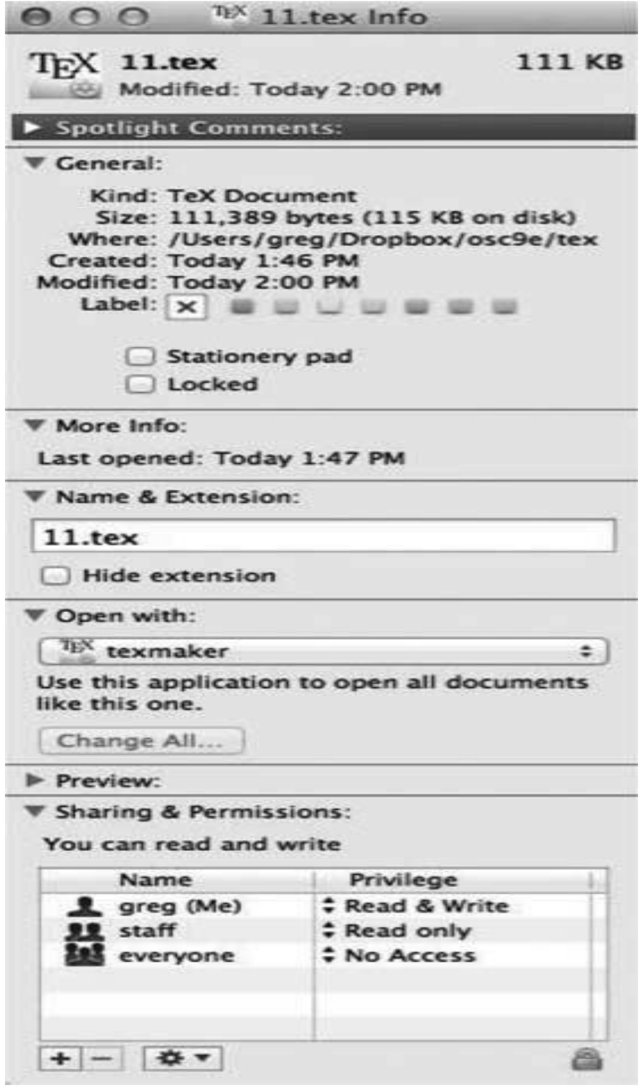
File Concept

- Contiguous logical address space
- Types:
  - **Data**
    - Numeric
    - Character
    - Binary
  - **Program**
- Contents defined by file’s creator
  - Many types
    - 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



11.tex Info

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:

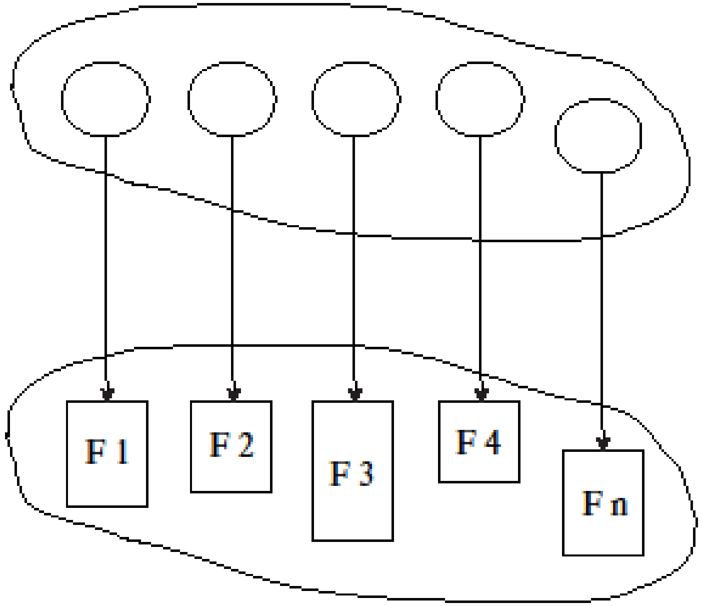
▼ Sharing & Permissions:

You can read and write

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

Directory Structure

- A collection of nodes containing information about all files



- Both the directory structure and the files reside on disk

File Operations

- **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

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 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
- 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

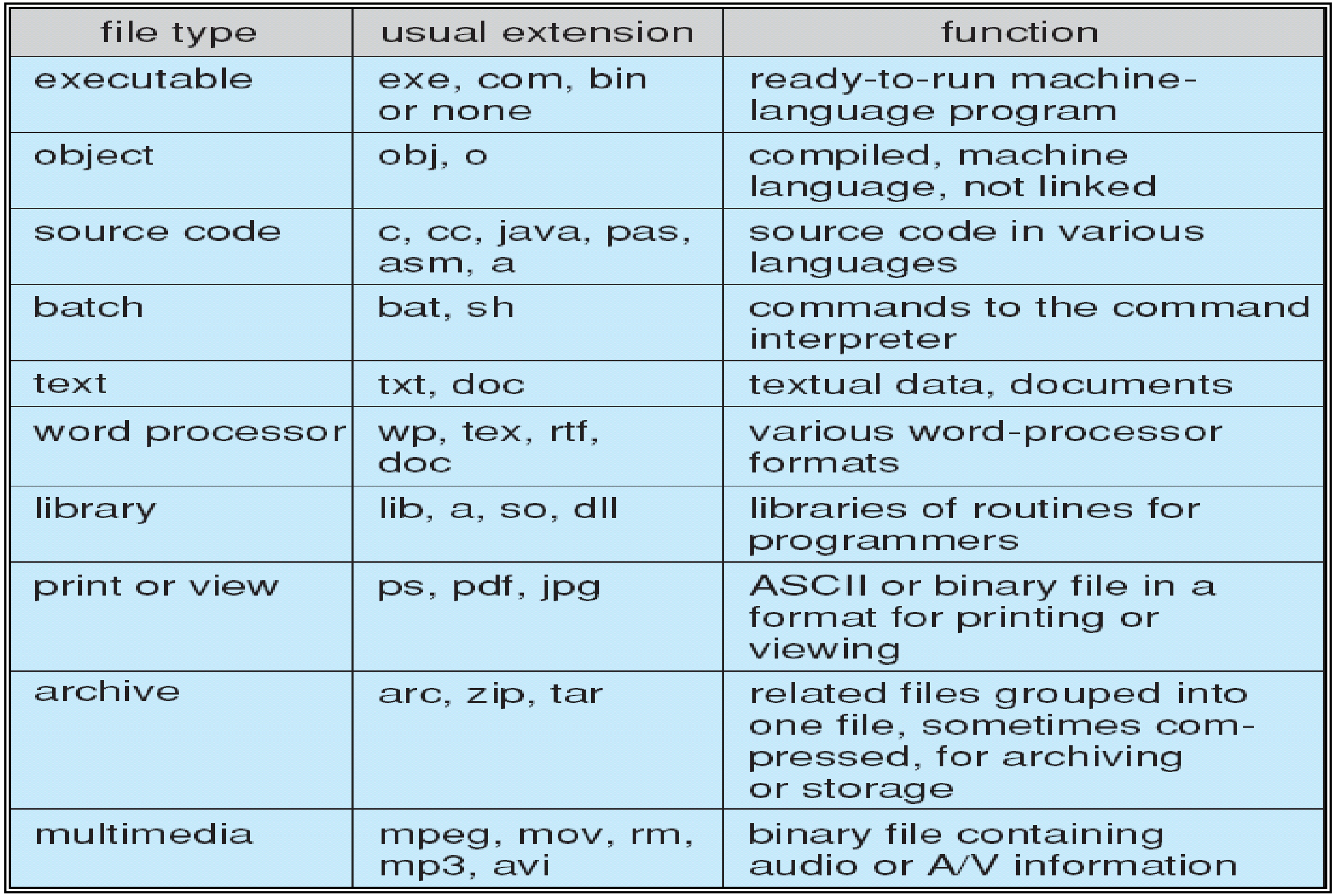
File Locking Example – Java API

```
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 arsg[]) 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

File Structure

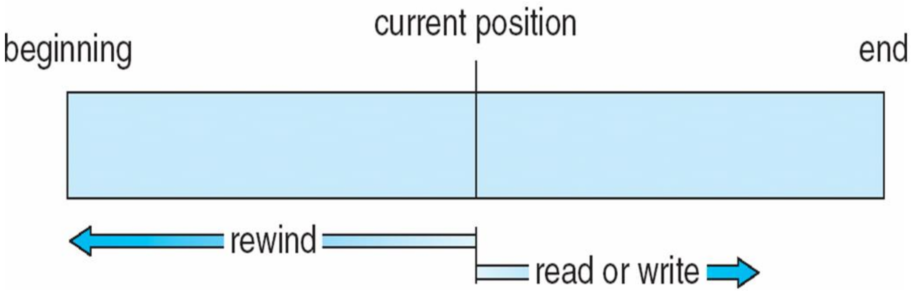
- None - sequence of words, bytes
- Simple record structure
  - Lines
  - Fixed length
  - Variable length
- Complex Structures
  - Formatted document
  - Relocatable load file
- Can simulate last two with first method by inserting appropriate control characters
- Who decides:
  - Operating system & Program

Access Methods

- A file is fixed length logical records
  - Sequential Access
  - Direct Access
  - Other Access Methods

Sequential Access

- Operations
  - **`read next`**
  - **`write next`**
  - **`Reset`**
  - no read after last write (rewrite)
- Figure



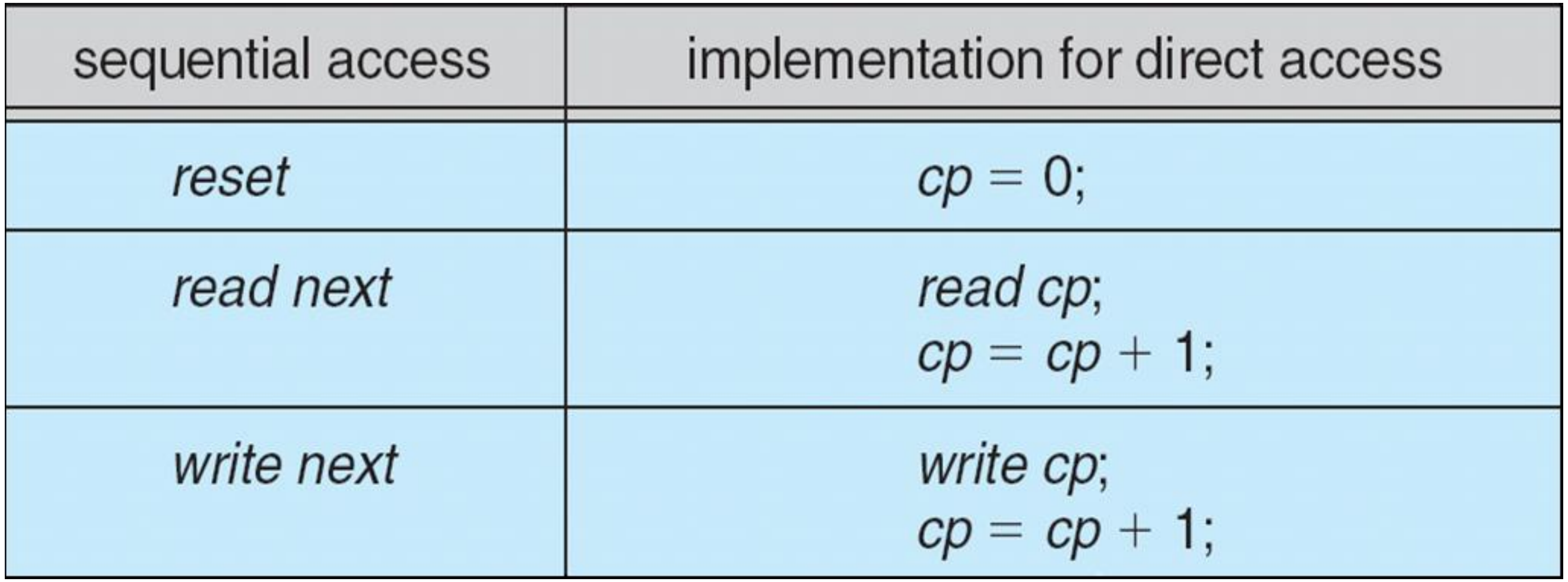
Direct Access

- Operations
  - `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

Simulation of Sequential Access on Direct-access File

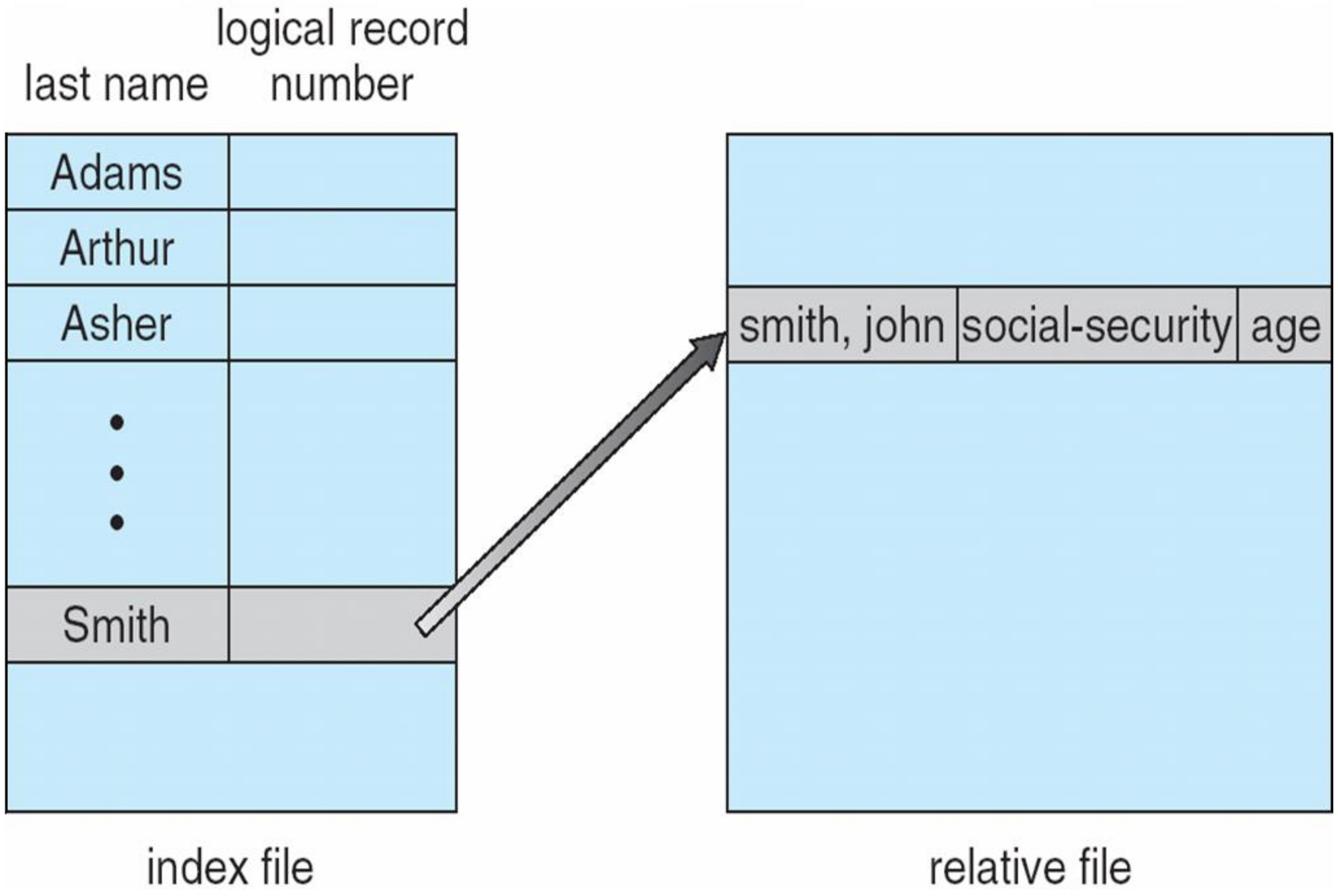


sequential access	implementation for direct access
reset	*cp* = 0;
read next	*read cp*; *cp* = *cp* + 1;
write next	*write cp*; *cp* = *cp* + 1;

Other Access Methods

- Can be other access methods 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 Universal Produce Code (UPC code) plus record of data about that item)
- If the index is too large, create an in-memory index, which an index of a disk index
- 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

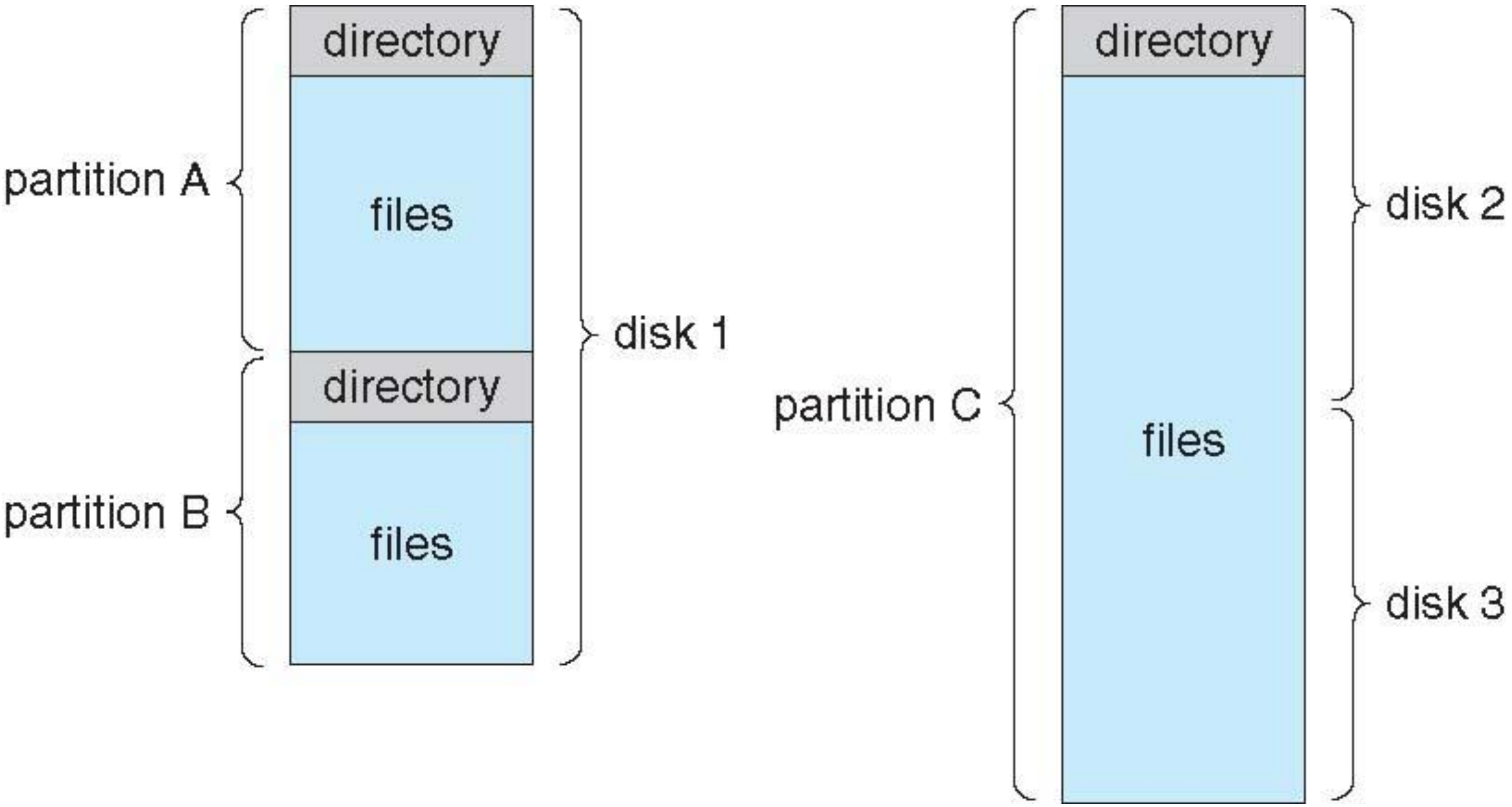
Example of Index and Relative Files



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 is known as a **volume**
- Each volume containing a 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 are many **special-purpose file systems**, frequently all within the same operating system or computer

A Typical File-system Organization

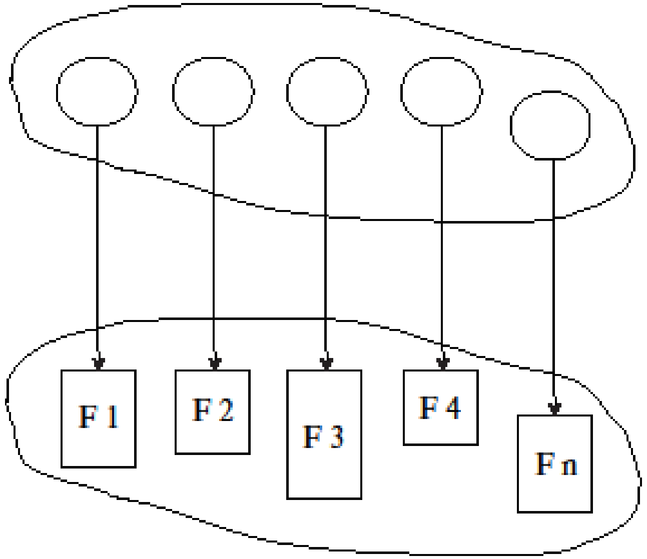


Types of File Systems

- We mostly talk of general-purpose file systems
- But systems frequently have may file systems, some general- and some special-purpose
- Consider **Solaris** has
  - tmpfs – memory-based volatile FS for fast, temporary I/O
  - objfs – interface into kernel memory to get kernel symbols for debugging
  - ctfs – contract file system for managing daemons
  - lofs – loopback file system allows one FS to be accessed in place of another
  - procfs – kernel interface to process structures
  - ufs, zfs – general purpose file systems

Directory Structure

- A collection of nodes containing information about all files



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

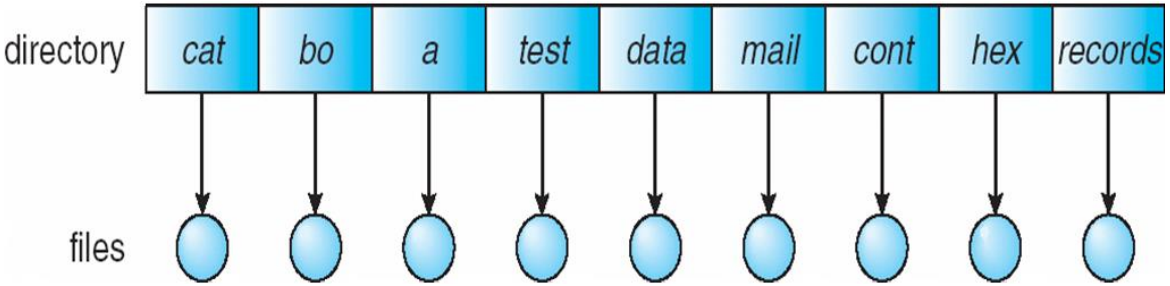
The directory is organized logically to obtain

- Efficiency – locating a file quickly
- Naming – convenient to users
    - Two users can have same name for different files

      or
    - 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

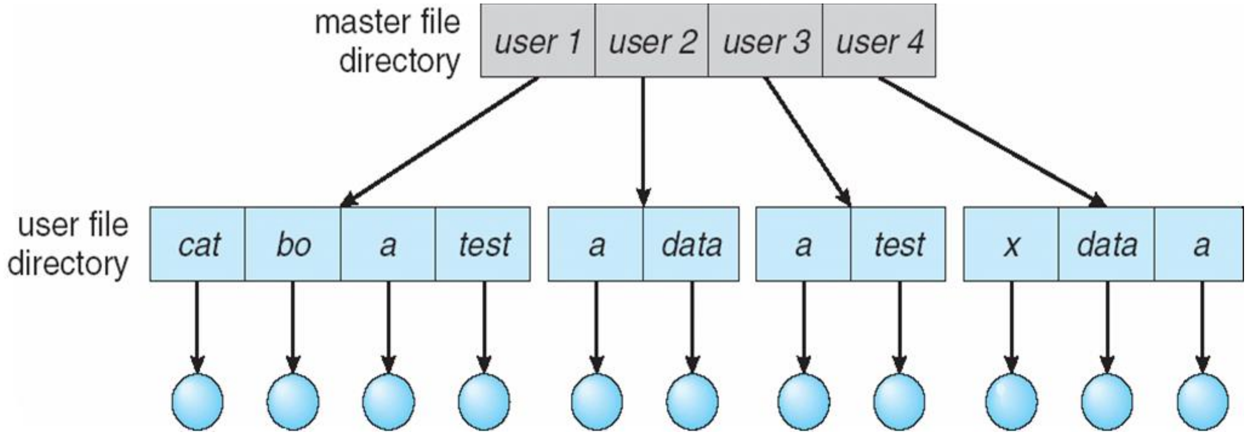
- A single directory for all users



- Naming problem
- Grouping problem

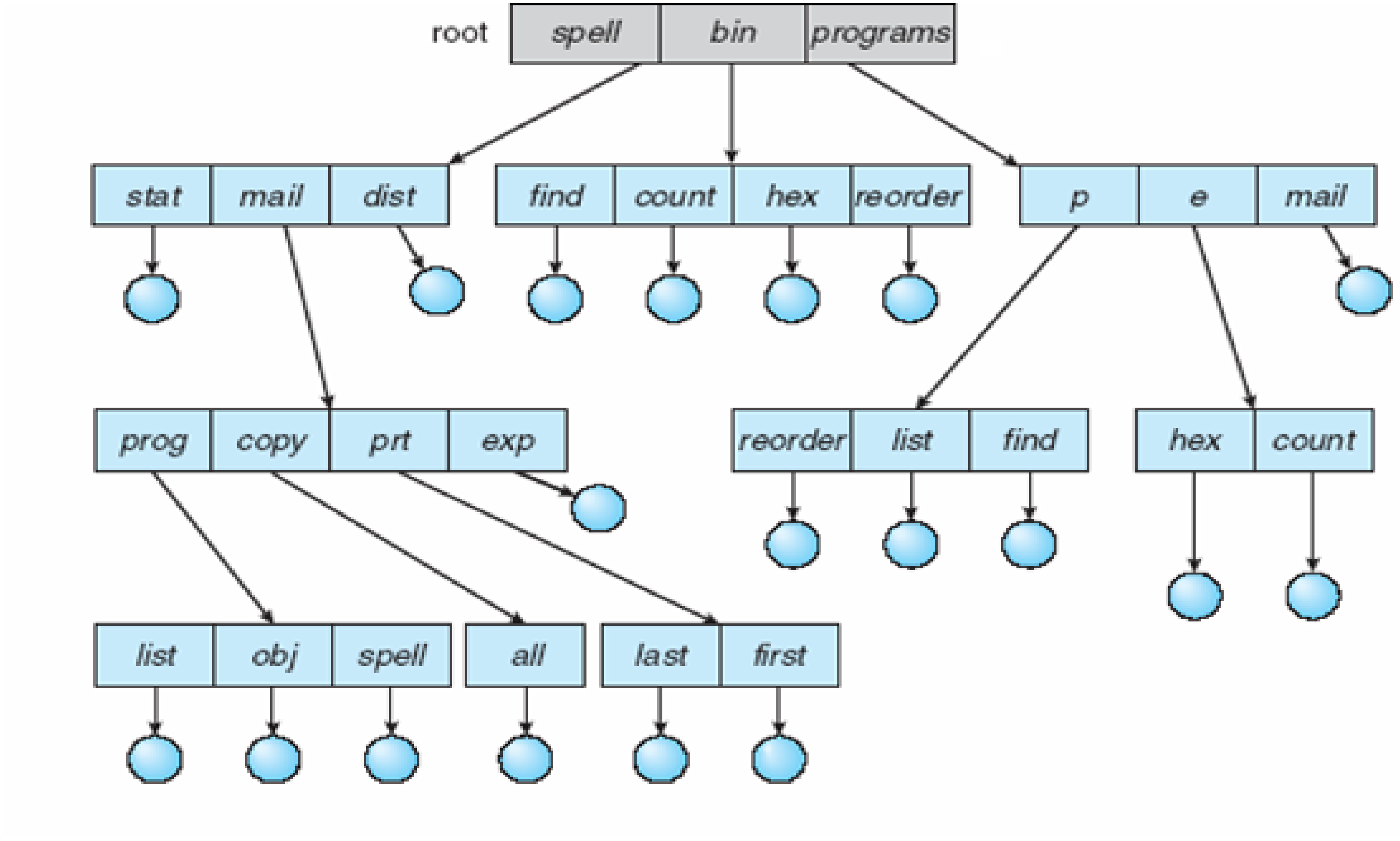
Two-Level Directory

- Separate directory for each user



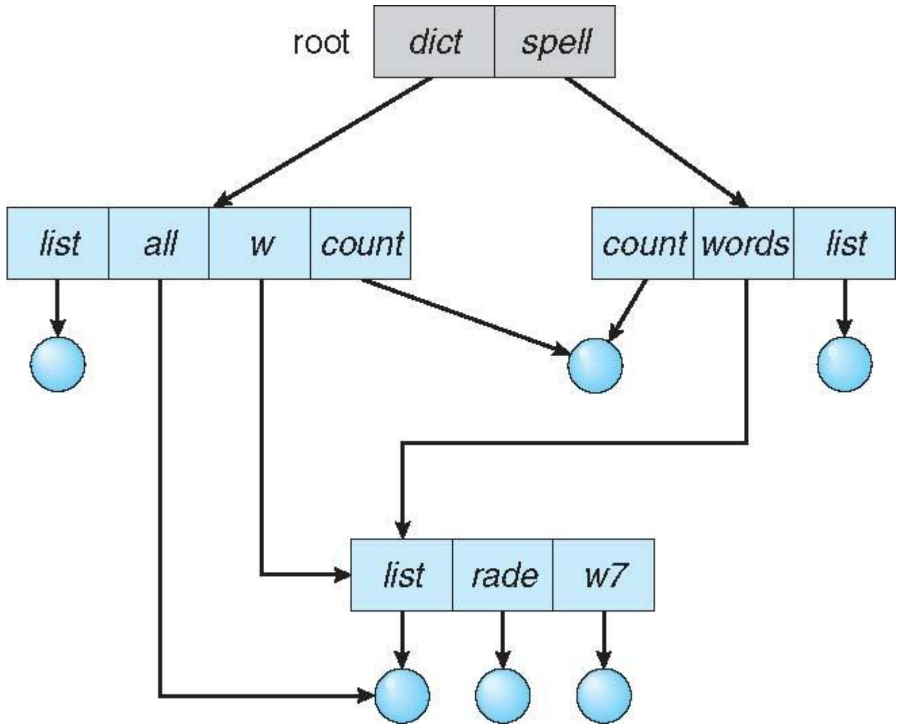
- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability

Tree-Structured Directories



Acyclic-Graph Directories

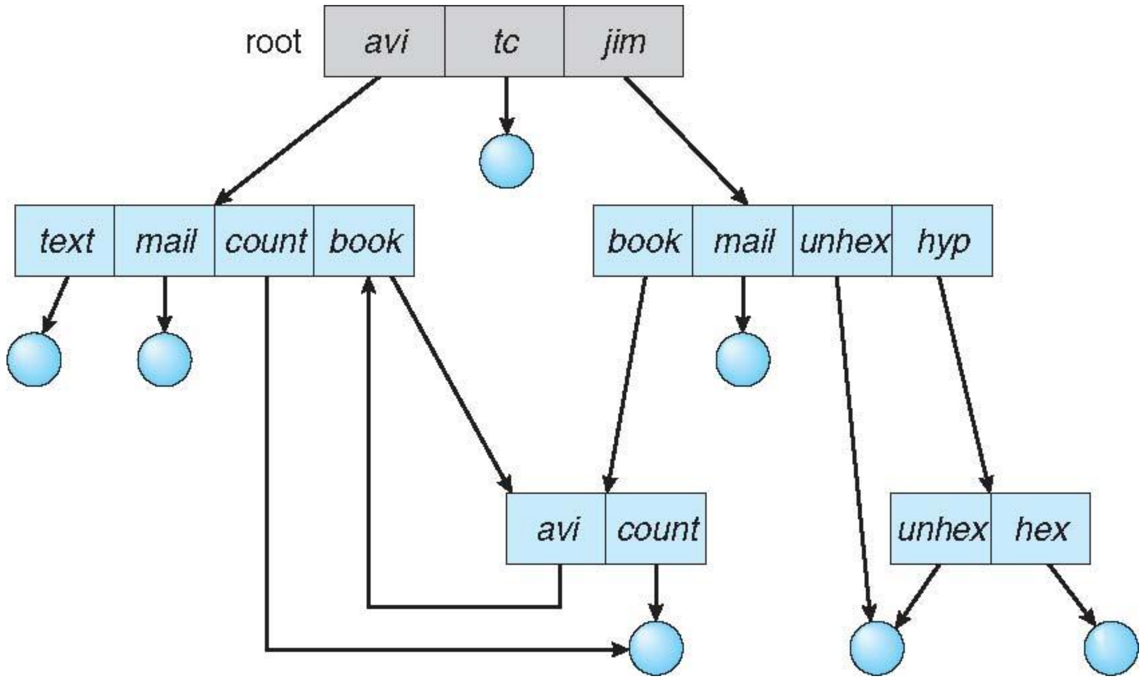
- Have shared subdirectories and files
- Example



Acyclic-Graph Directories (Cont.)

- Two different names (aliasing)
- If dict deletes w/list ⇒ 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

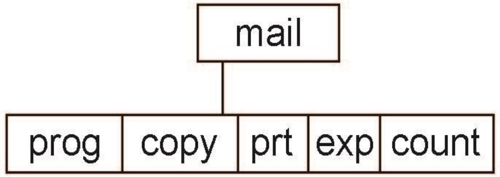


General Graph Directory (Cont.)

- How do we guarantee no cycles?
- Allow only links to files not subdirectories
- Garbage collection
- Every time a new link is added use a cycle detection algorithm to determine whether it is OK

Current Directory

- Can designate one of the directories as the current (working) directory
  - cd /spell/mail/prog
  - type list
- Creating and deleting a file is done in current directory
- Example of creating a new file
  - If in current directory is /mail
  - The command mkdir <dir-name>
- Results in:



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

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 in Unix

Mode of access: read, write, execute

Three classes of users on Unix / Linux

RWX

a) owner access 7 ⇒ 1 1 1

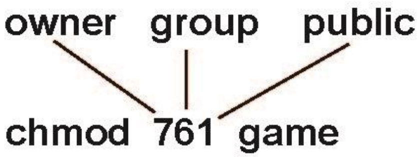
RWX

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 file (say game) or subdirectory, define an appropriate access.



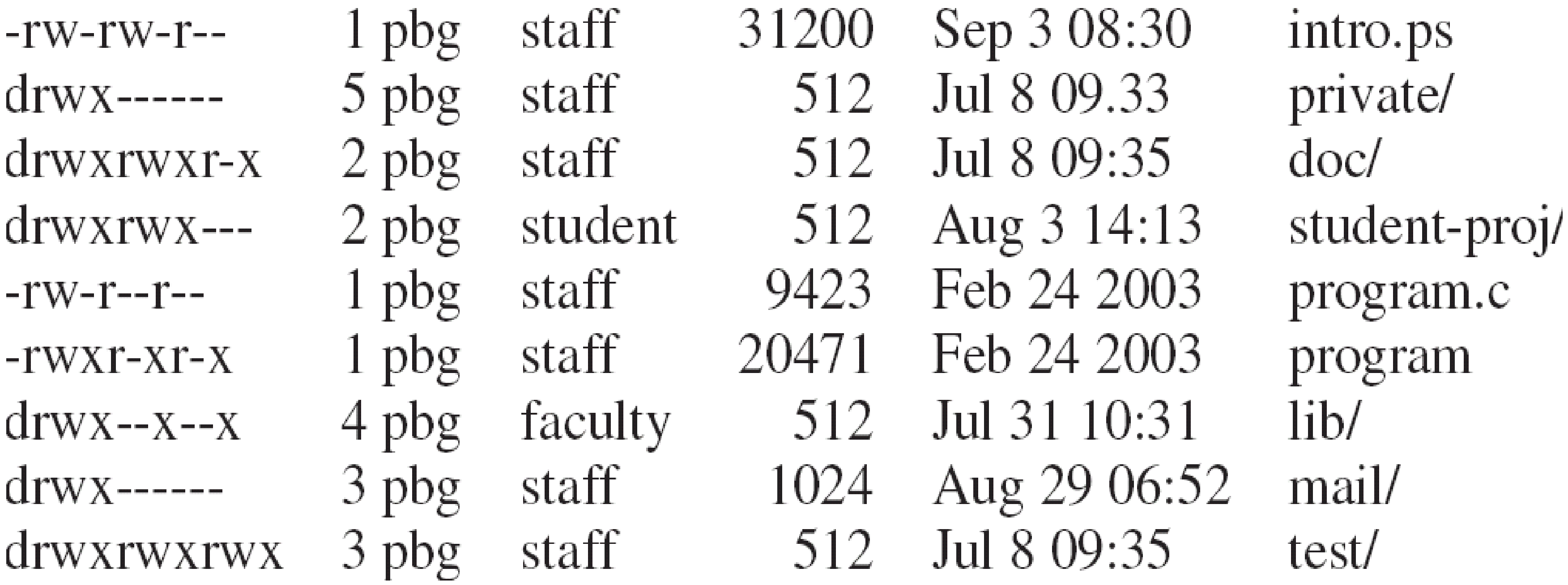
owner group public

chmod 761 game

- Attach a group to a file

```
chgrp G game
```

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/
```

TEXT BOOK

1. Abraham Silberschatz, Peter B. Galvin, “Operating System Concepts”, 10th Edition, John Wiley & Sons, Inc., 2018.

2. Andrew S Tanenbaum, Herbert Bos, Modern Operating systems, Pearson, 5th Edition,2022 New Delhi.

REFERENCES

1. Ramaz Elmasri, A. Gil Carrick, David Levine, “ Operating Systems – A Spiral Approach”, Tata McGraw Hill Edition, 2010.
2. William Stallings, Operating Systems: Internals and Design Principles, 7th Edition, Prentice Hall, 2018
3. Achyut S.Godbole, Atul Kahate, “Operating Systems”, McGraw Hill Education, 2016.

THANK YOU