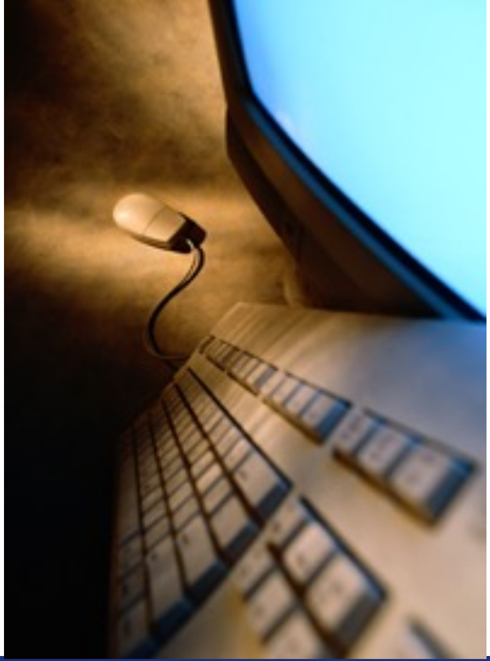
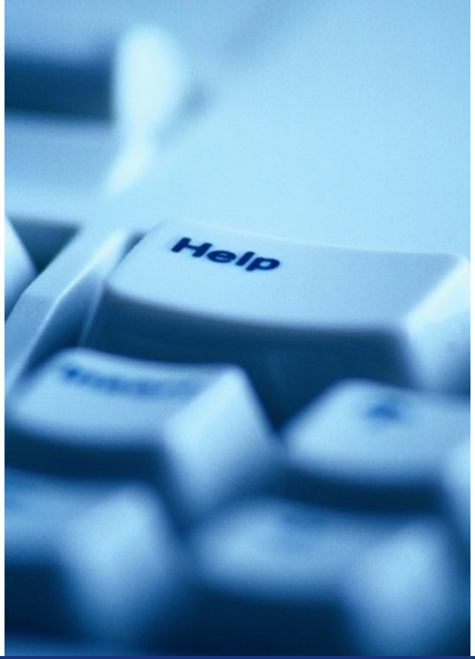



操作系统原理

Operating Systems Principles

陈亮
计算机学院

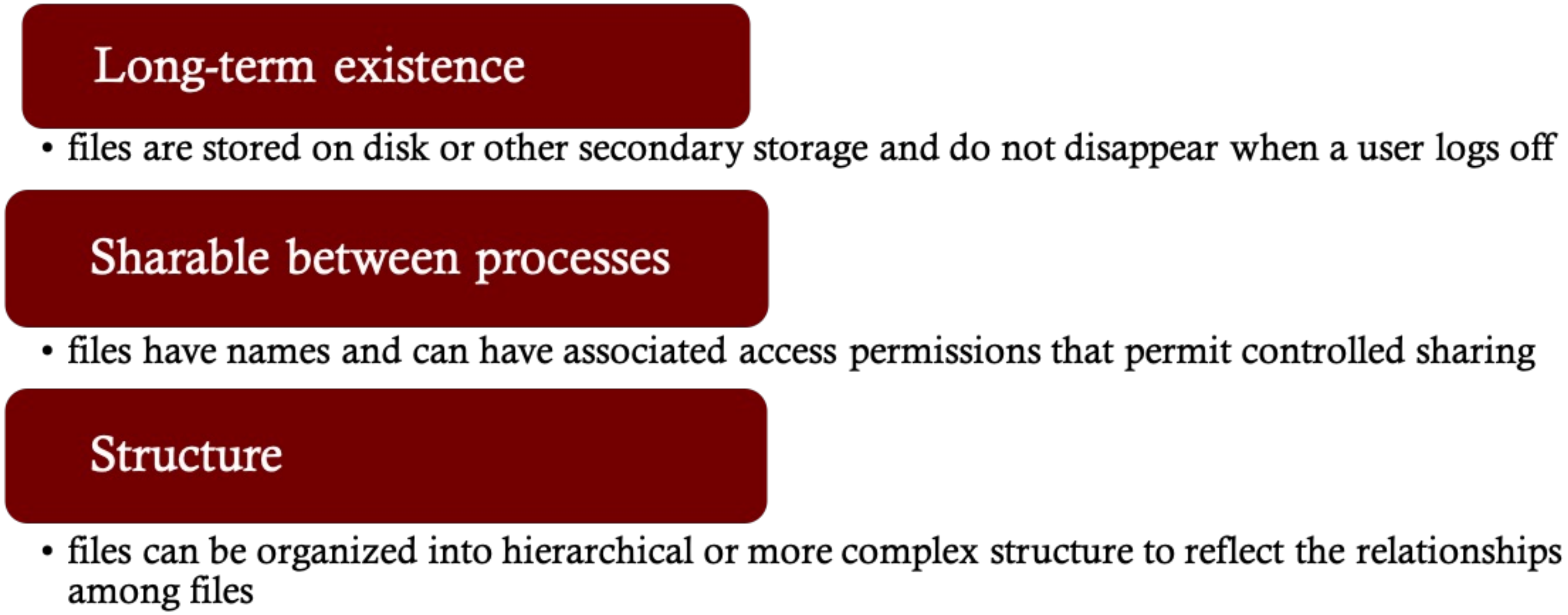
第十三讲 — 文件系统

目标

- 文件系统的功能；
- 文件系统接口；
- 文件系统的设计权衡，访问方法、共享、加锁以及目录结构；
- 文件系统保护；

文件

- 操作系统对存储设备的物理属性加以抽象，从而定义逻辑存储单位，即文件，文件由操作系统映射到物理设备上。
- **Data collections created by users;**
- **The File System is one of the most important parts of the OS to a user;**



Long-term existence

- files are stored on disk or other secondary storage and do not disappear when a user logs off

Sharable between processes

- files have names and can have associated access permissions that permit controlled sharing

Structure

- files can be organized into hierarchical or more complex structure to reflect the relationships among files

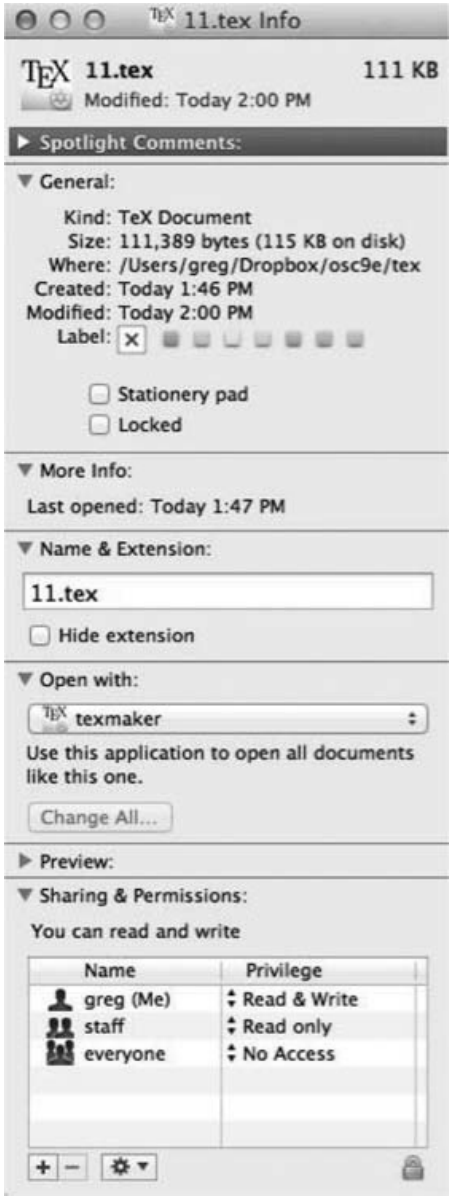
文件概念

- **Contiguous logical address space**
- **Types:**
  - Data
    - Numeric
    - Character
    - Binary
  - Program
- **Contents defined by file's creator**
  - Many types
    - **text file,**
    - **source file,**
    - **executable file**

文件属性

- **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**

Mac OS上的文件属性



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:

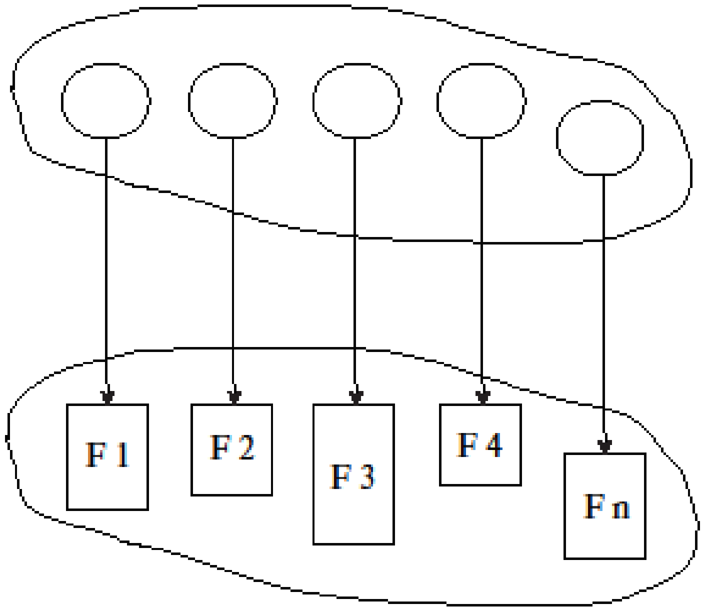
▼ Sharing & Permissions:

You can read and write

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

文件目录结构

- A collection of nodes containing information about all files



- Both the directory structure and the files reside on disk

文件操作

- Create
- Write – at write pointer location
- Read – at read pointer location
- Reposition within file - seek
- Delete
- Truncate 截断

这6个基本操作组成了所需文件操作的最小集合

- *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

文件打开（Open）

- **Several pieces of data are needed to manage open files:**
  - **Open-file table**: tracks open files （进程打开表、系统打开表）
  - 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（访问权限）: per-process access mode information

文件锁

- **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 (Windows)
  - **Advisory** – processes can find status of locks and decide what to do （Unix）

文件锁案例——Java

```
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();
```

文件锁案例——Java

```
                    // 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();
            }
        }
    }
```

文件类型

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

Windows通过扩展名识别文件类型，Unix系统通过文件开始部分的magic数字来识别类型

文件结构

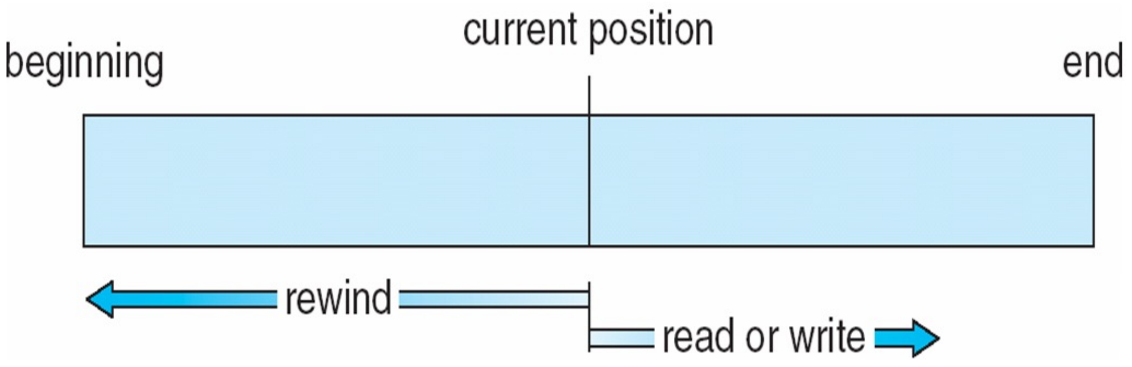
- **None - sequence of words, bytes**
- **Simple record structure**
  - Lines
  - Fixed length
  - Variable length
- **Complex Structures**
  - Formatted document
  - Relocatable load file
- **Can simulate last two with first method by inserting appropriate control characters**
- **Who decides:**
  -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

文件访问方法

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

顺序访问

- Operations
  - read next
  - write next
  - Reset
- Figure



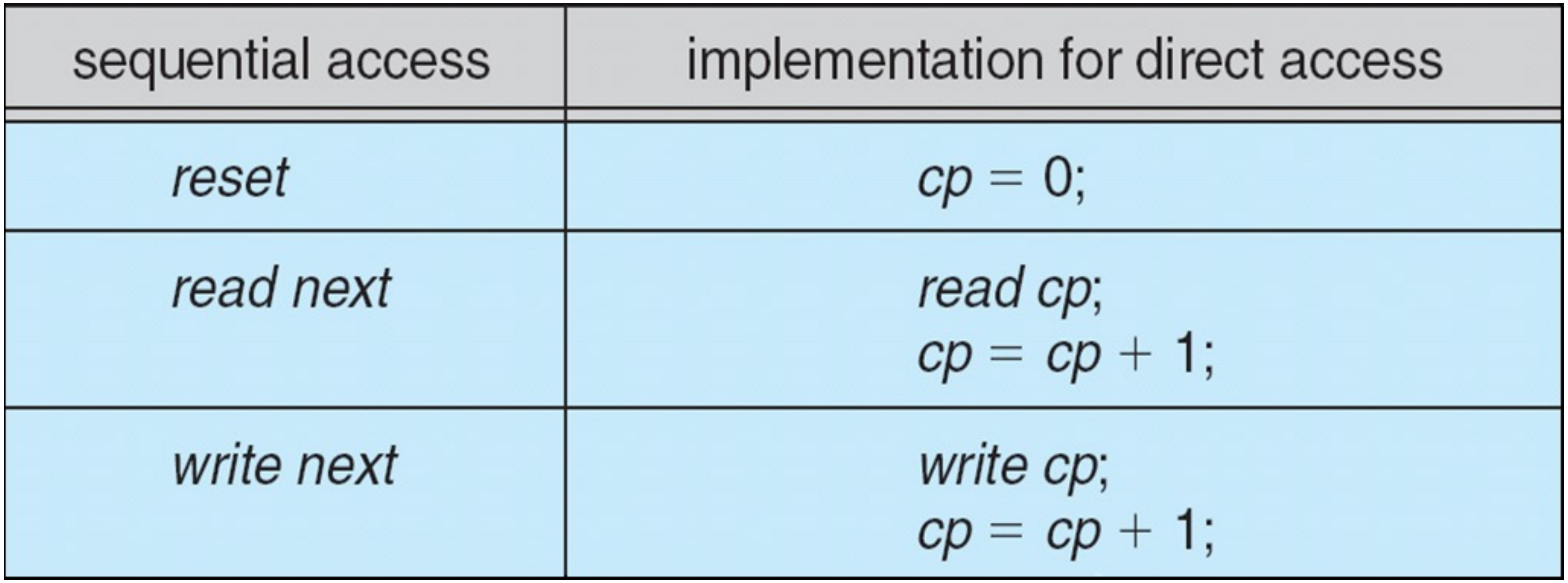
直接访问

- **Operations** 适用于由固定长度的逻辑记录组成的文件；
  - **read *n***
  - **write *n***
  - **position to *n***
    - **read next**
    - **write next**
    - **rewrite *n***

  ***n* = relative block number**

- **Relative block numbers（相对块号） allow OS to decide where file should be placed**

直接访问模拟顺序访问



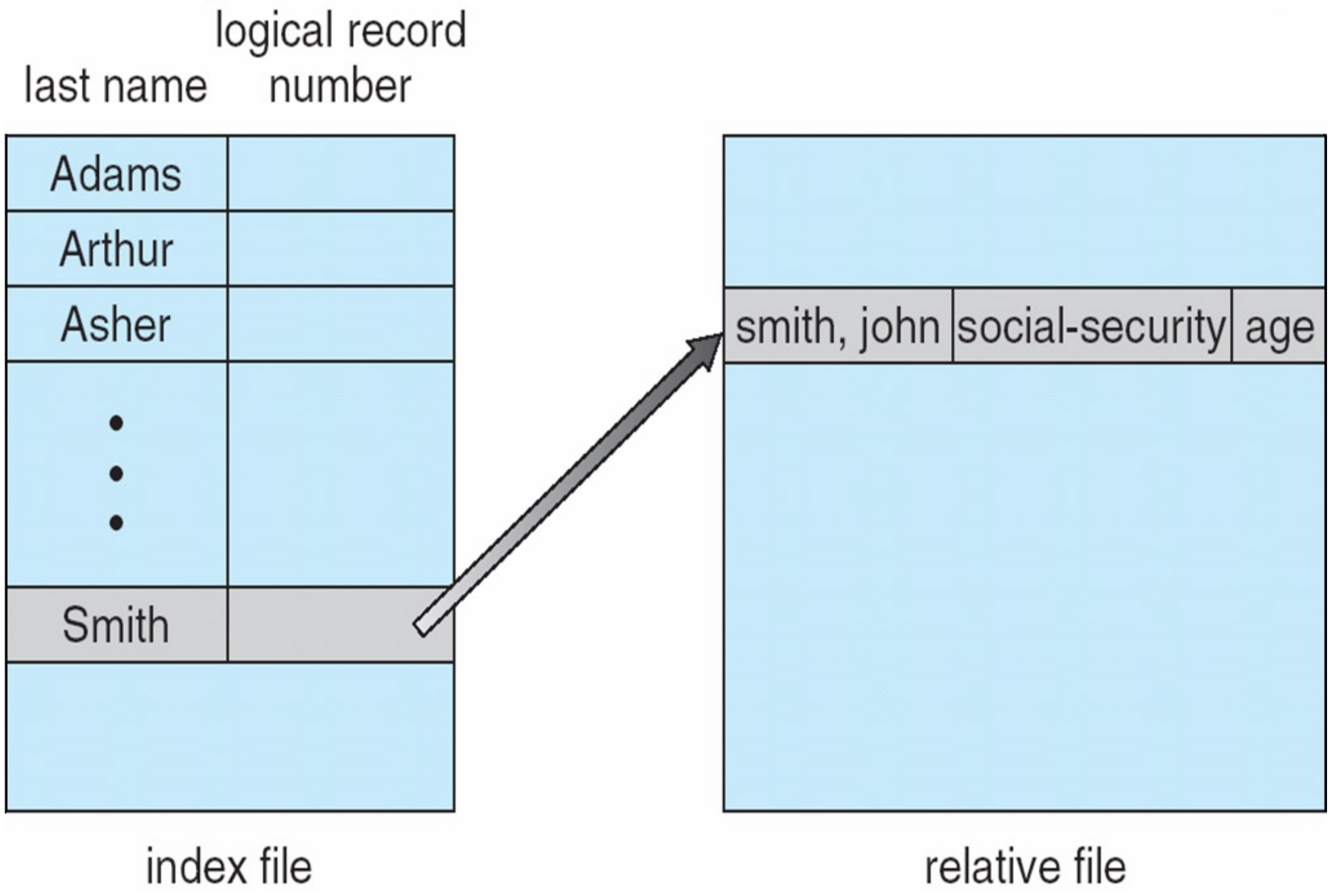
sequential access	implementation for direct access
reset	*cp* = 0;
read next	*read cp*; *cp* = *cp* + 1;
write next	*write cp*; *cp* = *cp* + 1;

其他访问方法

- **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 (see next slide)**

通过记录的键至多两次的直接访问就可以定位记录

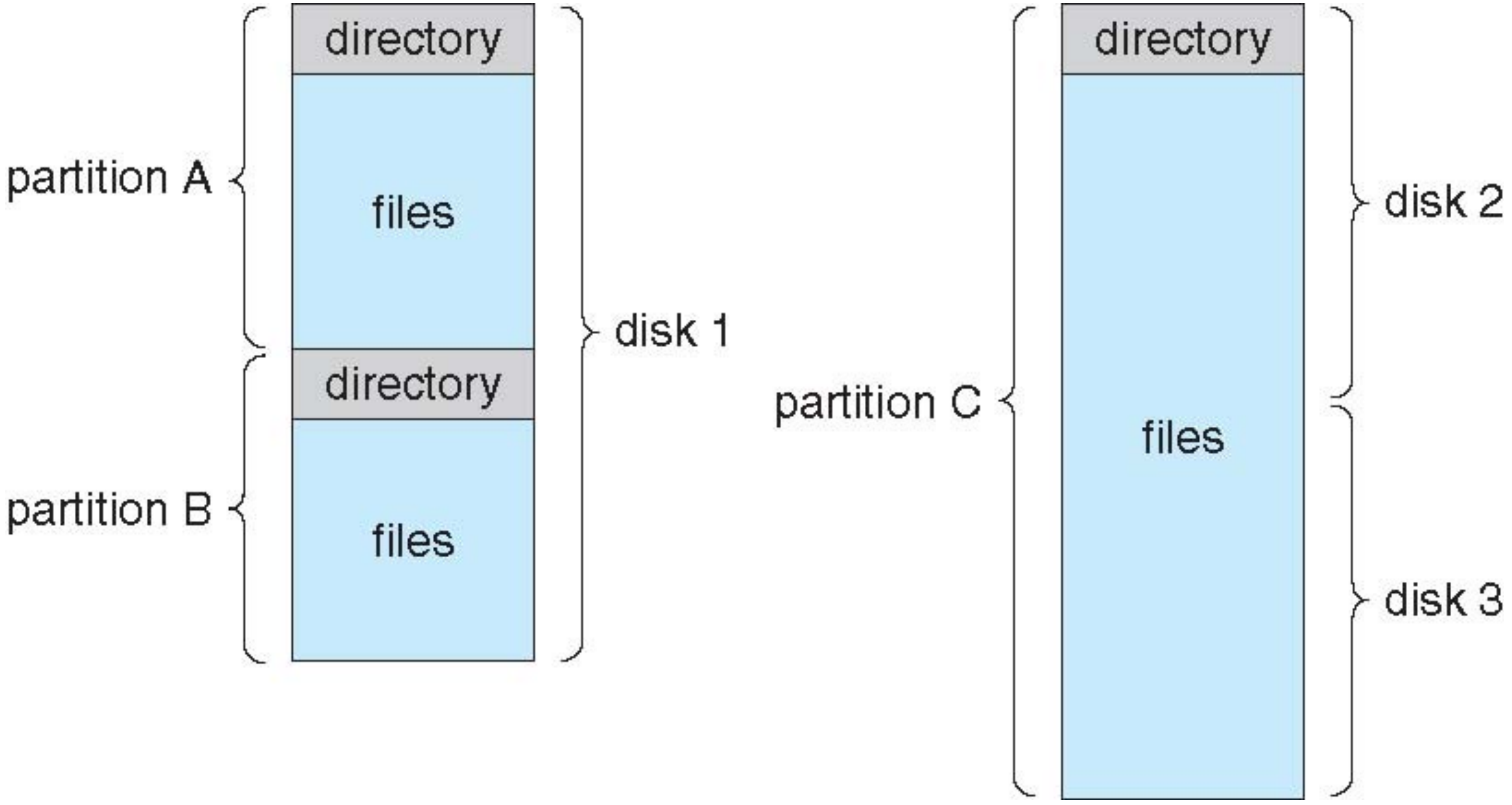
索引文件和相关文件的例子



磁盘结构

- 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(卷)
- 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

存储结构

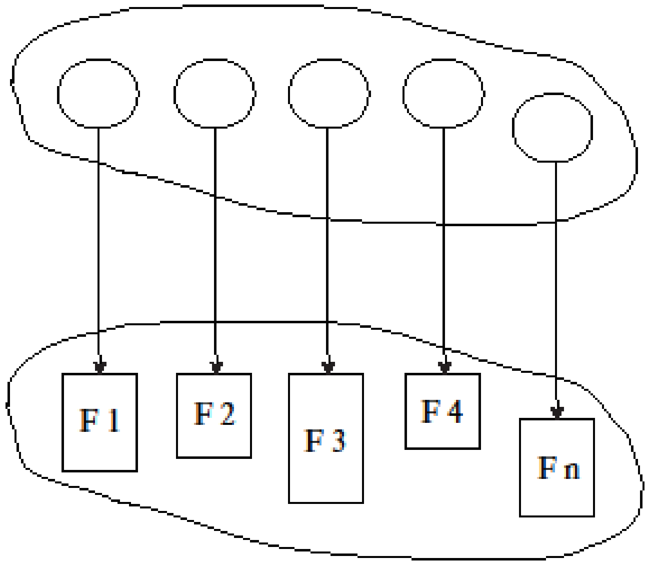

directory
files
directory
files
partition A
partition B
disk 1
directory
files
partition C
disk 2
disk 3

文件系统的类型

- **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

目录结构

- A collection of nodes containing information about all files



- Both the directory structure and the files reside on disk

目录结构

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

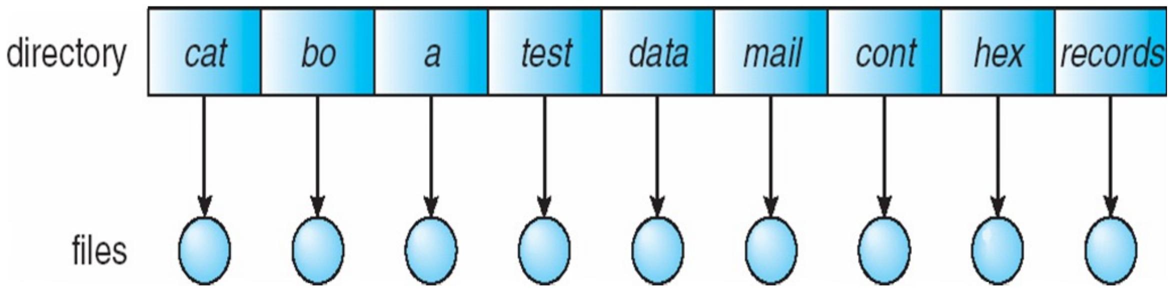
目录结构

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, …)**

单级目录

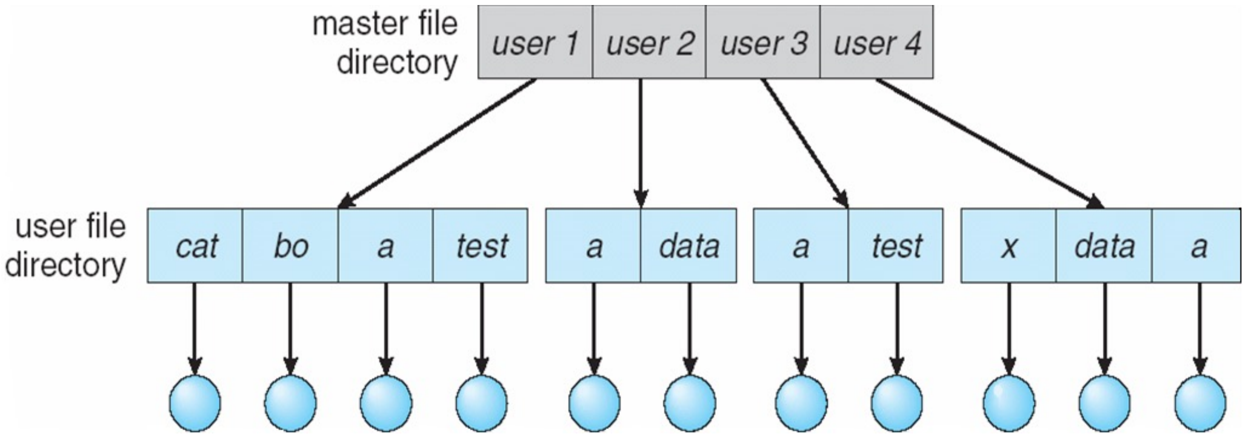
- A single directory for all users



- Naming problem
- Grouping problem

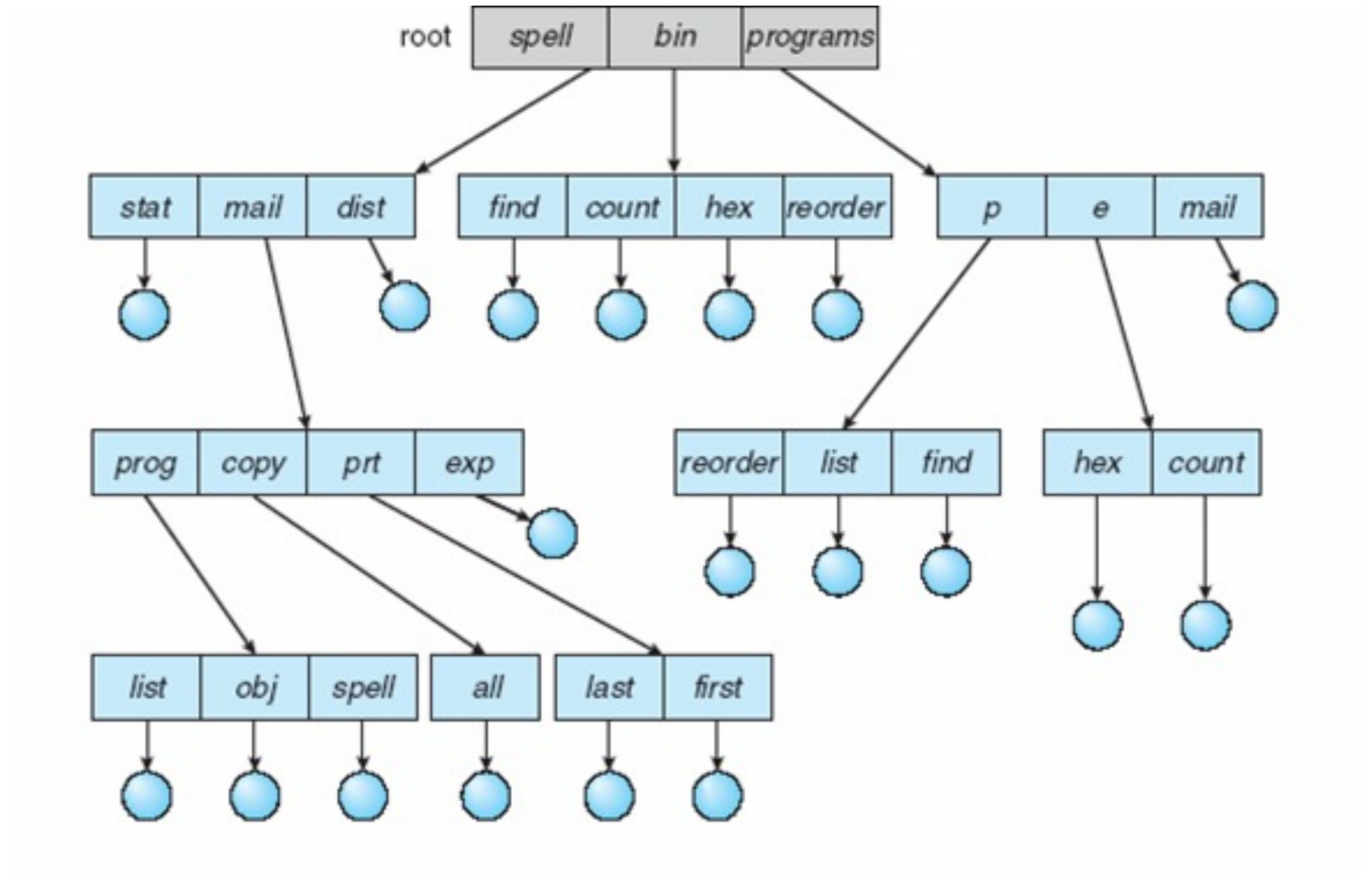
两级目录结构

- **Separate directory for each user**



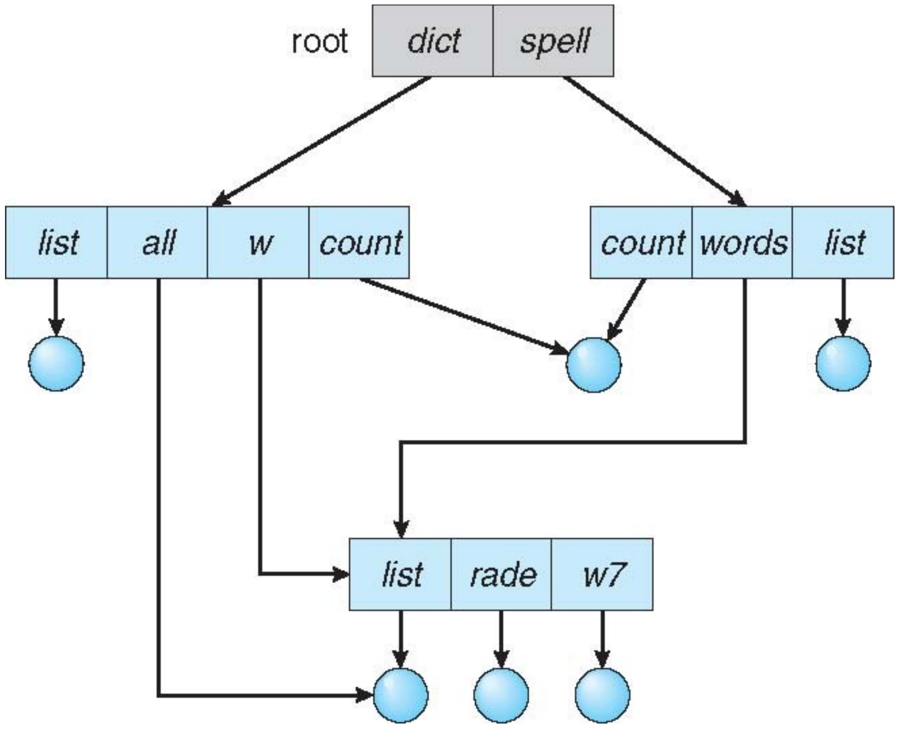
- Path name
- Can have the same file name for different user
- Efficient searching

树形目录


root
spell
bin
programs
stat
mail
dist
find
count
hex
reorder
p
e
mail
prog
copy
prt
exp
reorder
list
find
hex
count
list
obj
spell
all
last
first

无环图目录

- **Have shared subdirectories and files**
- **Example**



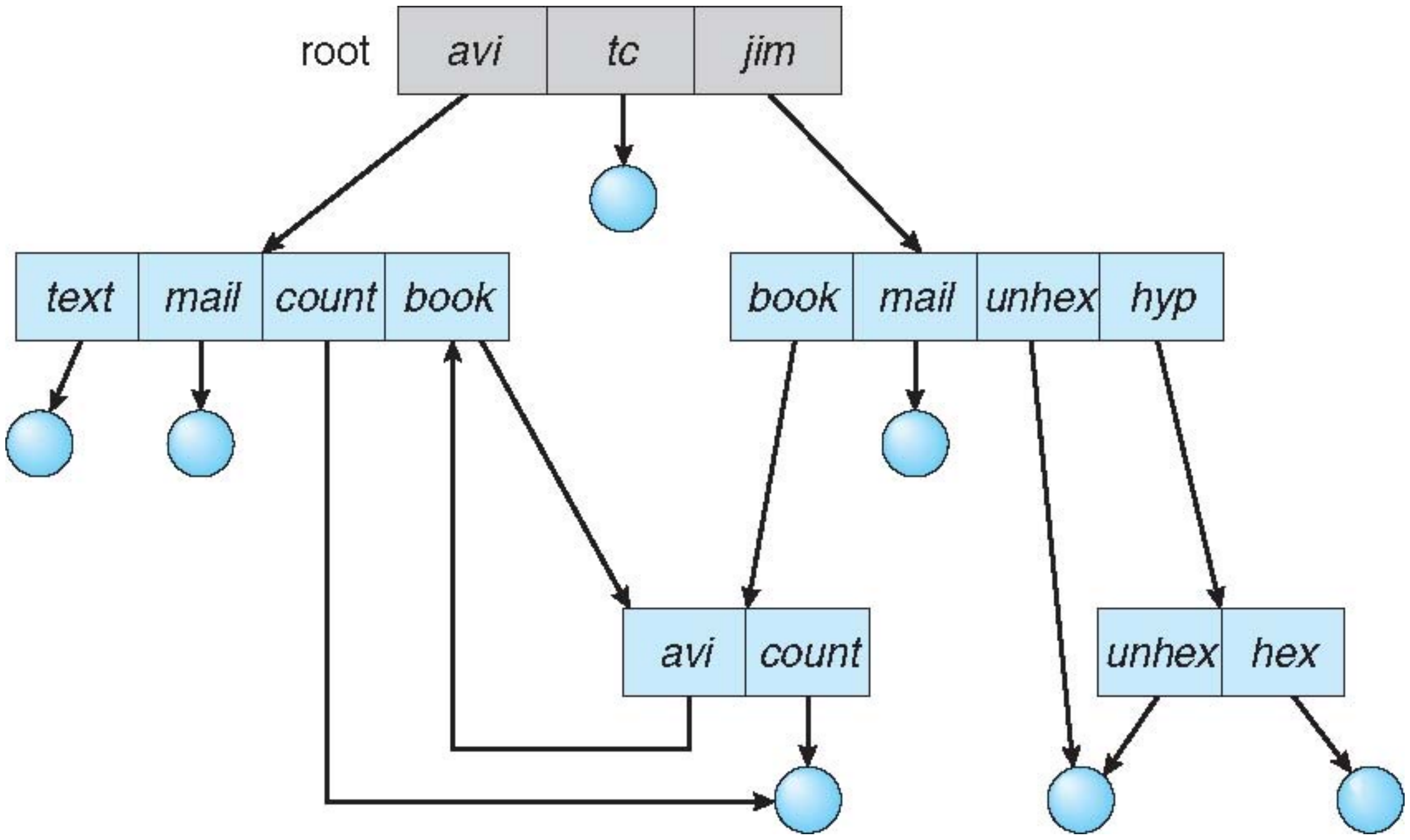
无环图目录

- **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

软链接、硬链接

通用图目录


root
avi
tc
jim
text
mail
count
book
book
mail
unhex
hyp
avi
count
unhex
hex

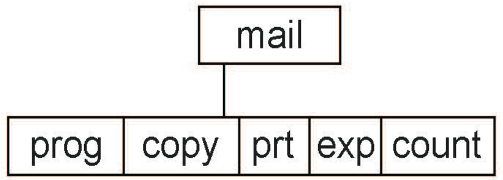
通用图目录

- **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

当前目录

- **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”

文件系统保护

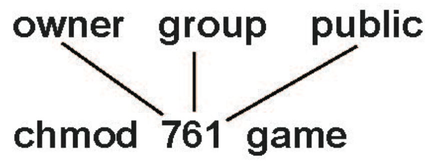
- **File owner/creator should be able to control:**
  - What can be done
  - By whom
- **Types of access**
  - **Read**
  - **Write**
  - **Execute**
  - **Append**
  - **Delete**
  - **List**

Linux文件访问

- **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.**



- **Attach a group to a file**

```
chgrp    G    game
```

Unix文件目录

```
-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/
```

谢谢