Chapter 10: File-System Interface

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Chapter 10: File-System Interface

- File Concept
- Access Methods
- 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

- Contiguous logical address space
- Types:
  - Data
    - numeric
    - character
    - binary
  - Program

之前都是廢話

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

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
  - Regular, directory, device, link (system functionality)
  - .c , .exe, .bat (user purpose)
- 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

ID

連windows都是這樣用的，只是有好好藏起來一般看不到在/winobject之下的樣子??

在kernel內也是file但不能用fopen操作

一個作為file的object，也可以打開/讀寫它

ex. 對磁碟打開讀寫就是在絕對磁區上寫東西

File Types – Name, Extension

有點危險
會有奇怪的執行檔(.exe)偽裝成圖檔(.jpg etc.)

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

UNIX File Magic Numbers 現在幾乎沒人用的東西

- Unix systems uses “magic numbers” that stored in the beginning of files to identify the types of files
- Not all files contain a magic number
- UNIX gradually migrate 轉移 to using file extensions

File Operations

Function	description
fopen()	create a new file or open a existing file
fclose()	closes a file
getc()	reads a character from a file
putc()	writes a character to a file
fscanf()	reads a set of data from a file
fprintf()	writes a set of data to a file
fread()	reads a number of bytes from a file
fwrite()	writes a number of bytes to a file
fseek()	set the position to desire point
link()	make a new name for a file
unlink()	decrement the reference count of a file (delete on ref=0)

就等同delete，把dir的entry刪掉
至於實際的file要不要刪再討論

Why Opening Files

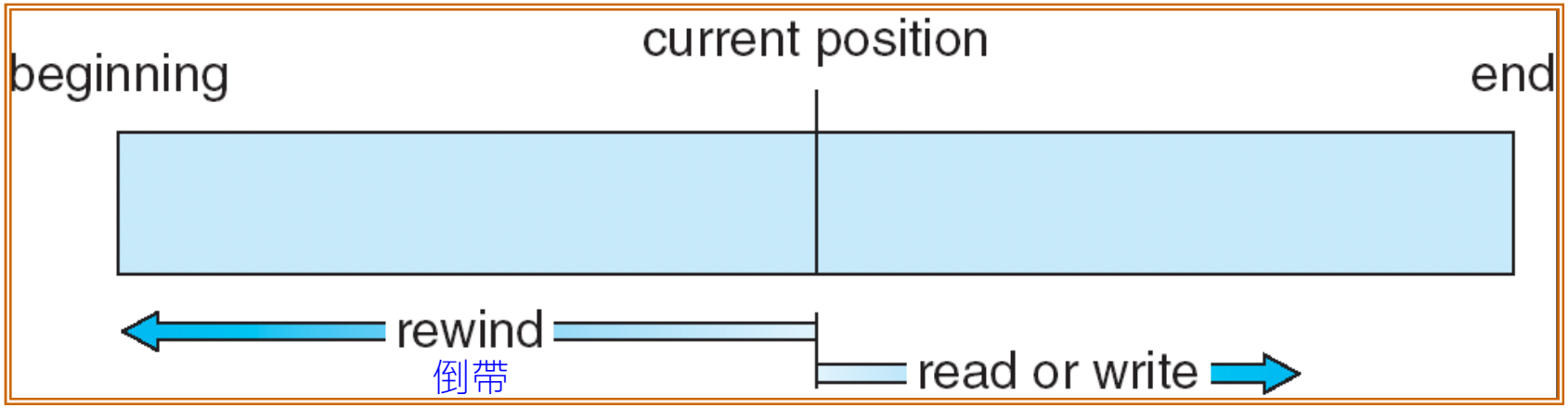
- Several data are needed to manage opened files:
  - File pointer: pointer to last read/write location, per process that has the file open
  - File-open count: counter of number of times a file is open – to allow removal of data from open-file table when last processes closes it
    - (recall the removal of USB drive in XP)
  - Disk location of the file
  - Access rights: per-process access mode information
- All the above are called "metadata", i.e., data of data
- Caching metadata upon file opening for efficient operations
- Flushing modified to disk metadata upon file closing

當(as soon as)

fopen(): Binary or Text?

- fopen(“abc.txt”,”r+t”);
- fopen(“xyz.mp3”,”rb”);
- Text mode
  - Translate Ctrl-Z into EOF
  - Translate \r\n into \n
- Binary mode
  - Raw input

File Accessing Model

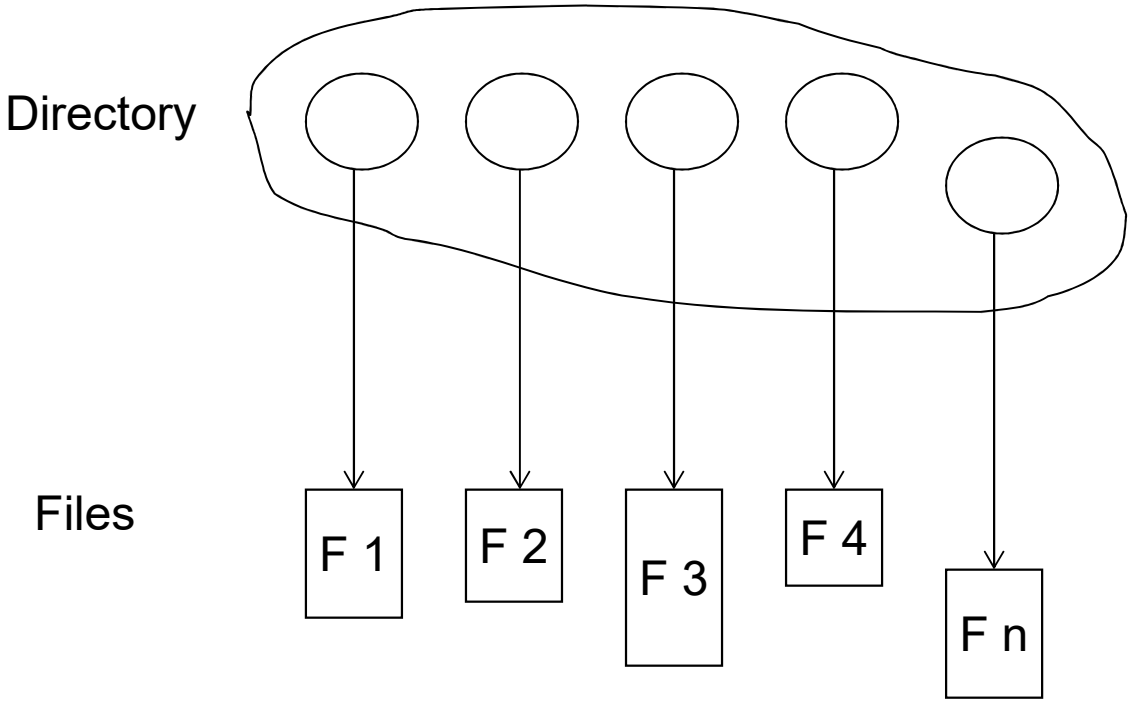


Directory Operations

- Search for a file
- Create a file
- Delete a file
  - The deleted file is a directory
    - Recursively delete all its files and sub-directories?
  - The deleted file is a regular file
- List a directory
- Rename a file

Directory Structure

- A collection of nodes containing information about all files

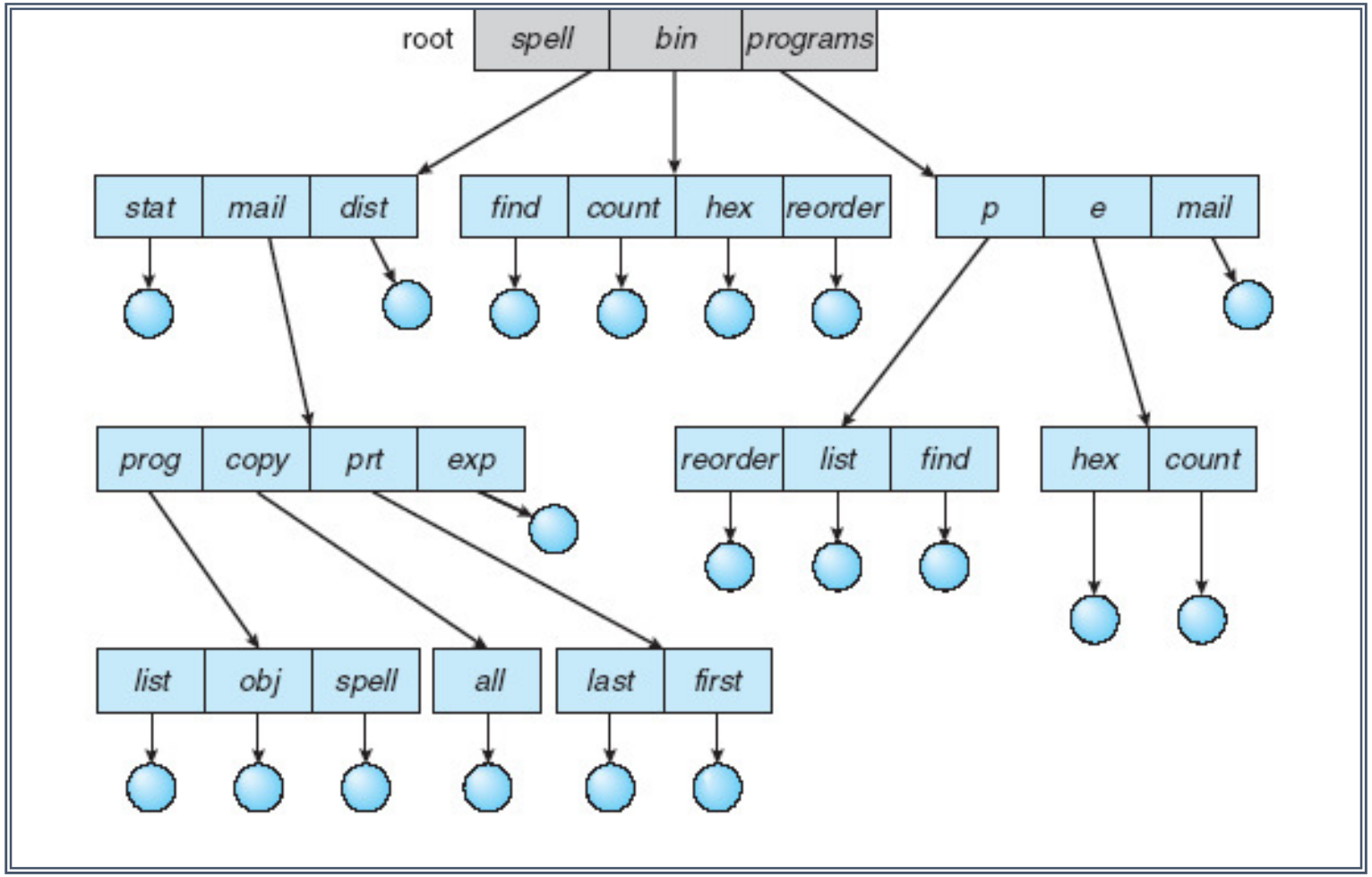


Directory itself is a file, too

Open and read a directory

```
DIR *opendir(const char *name);
struct dirent *readdir(DIR *dirp);

struct dirent {
        ino_t          d_ino;       /* Inode number */
        off_t          d_off;       /* Not an offset; see below */
        unsigned short d_reclen;    /* Length of this record */
        unsigned char  d_type;      /* Type of file; not supported
                                       by all filesystem types */
        char           d_name[256]; /* Null-terminated filename */
    };

// ------------------------------


#include <sys/types.h>
#include <dirent.h>

DIR *dir;
struct dirent *dirp;

dir = opendir("foo");
dirp = readdir(dir);
dirp = readdir(dir);
dirp = readdir(dir);
dirp = readdir(dir);
```

Tree-Structured Directories



Tree-Structured Directories (Cont)

current working directory(cwd)

- The *current directory* environment variable (per process)
  - cd /spell/mail/prog
  - type list
  - “.” and “..”
- Absolute or relative path name
- Traverse the file system

```
char *getcwd(char *buf, size_t size);
int chdir(const char *path);
```

Tree-Structured Directories (Cont)

- Creating a new file is done in current directory
- Delete a file

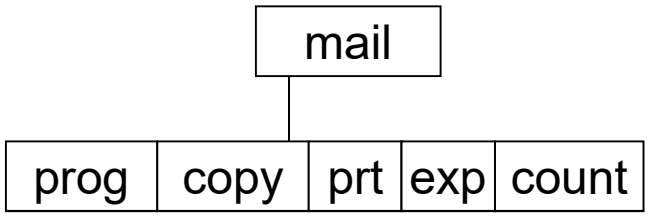
  rm <file-name>

- 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”
rm -r or del /s

File Aliasing

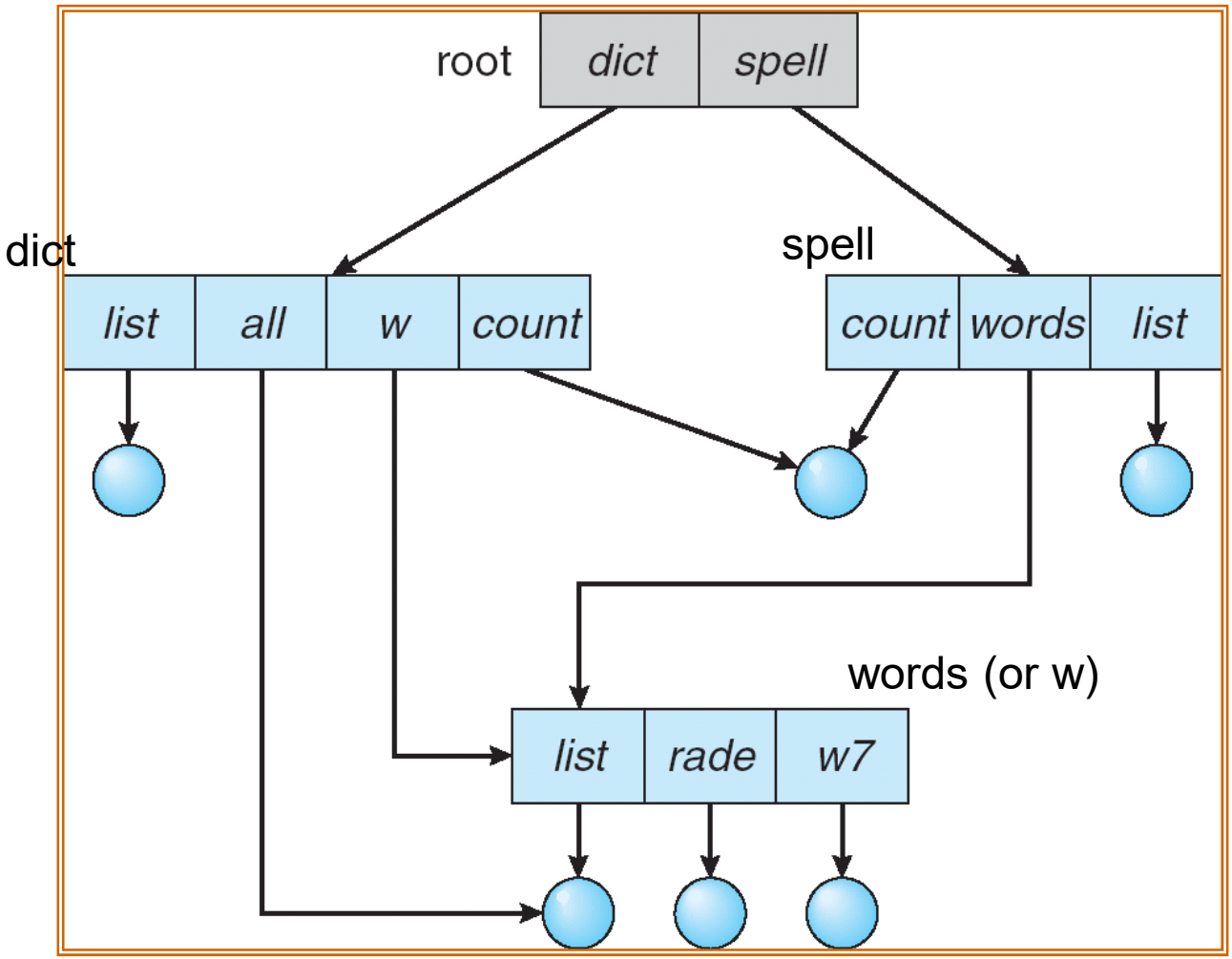
/sbin/ls
/usr/local/bin/ls
/usr/sbin/ls
...
實際上都是指到同一檔案

- A file may have two different names (alias)

  如果需要在不同資料夾存在，就不用做兩份副本，可以避免不同步和節省空間

- Link: a new type of directory entry
  - Another name (pointer) to an existing file
  - Resolve the link – follow pointer to locate the file

Acyclic-Graph Directories



Softlinks

- Softlinks (symbolic link)
  - String substitution
  - Independent of file system
- Usage
  - UNIX: ln -s [target] [link]
  - Windows (NTFS): junction.exe [link] [target]

Hardlinks

- Hardlinks　　沒有講的話一般大部分都是hardlink
  - A link file points to the disk location of the target file
  - File-system-dependent　不能跨磁碟，因為是使用磁碟位置

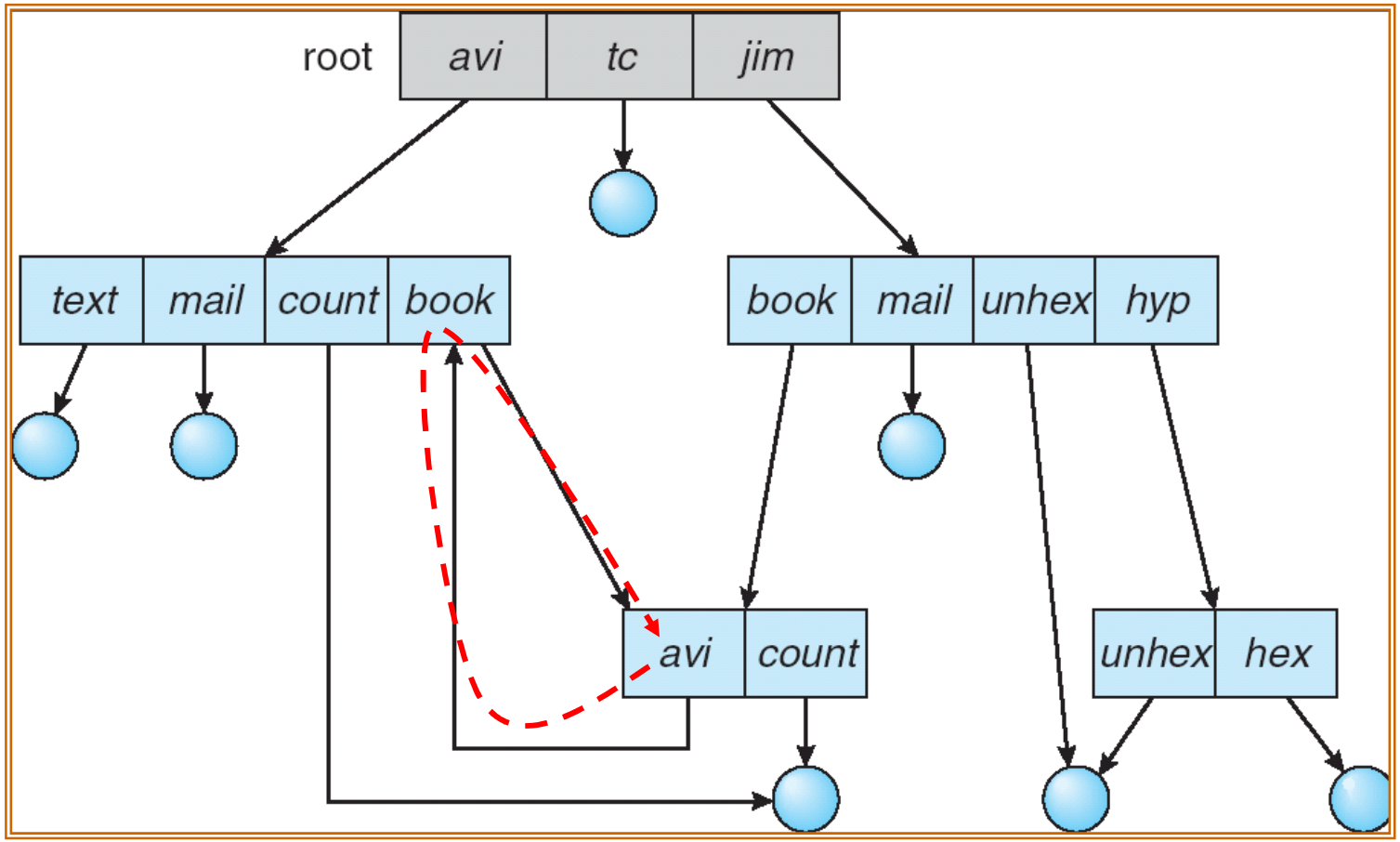
- Usage
  - UNIX: ln [target] [link]
  - Windows (NTFS): fsutil hardlink create [link] [target]

FilesyStemUtility

Problems with Aliasing

- Backup– Duplication problem
  - May duplicate files during backup
  - “cp -a” to preserve hard links
- Loop – Endless file path
  - Allow only links to file not subdirectories
  - Every time a new link is added use a cycle detection algorithm to determine whether it is OK
  - Practical solutions
  - Linux: Keep a time-to-live counter (e.g., 40)
  - Windows: Limiting the pathname length (~ 260 chars)

Loop in directories

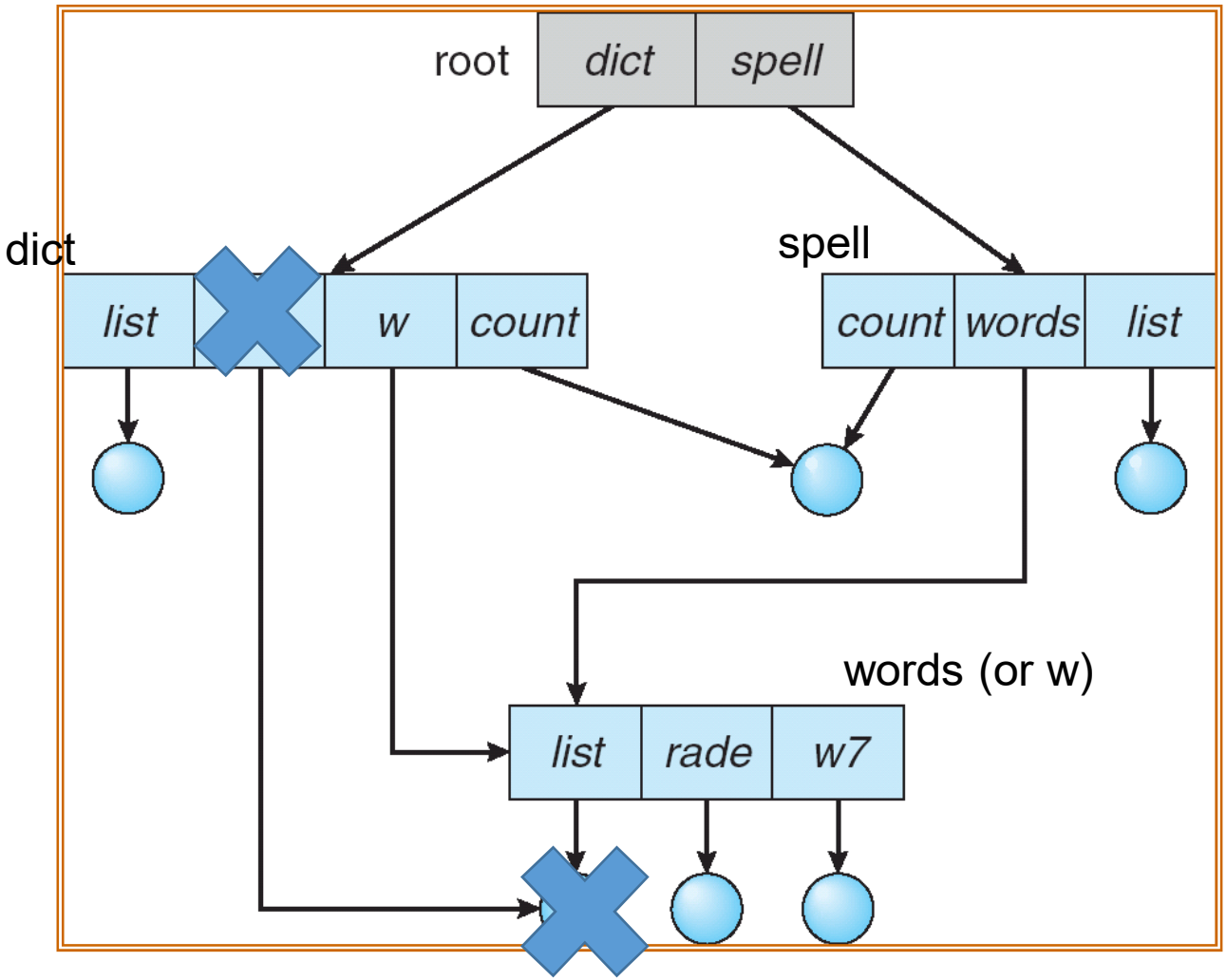


Problems with Aliasing

刪掉Alias難道也要把它指向的檔案也刪掉嗎?(可能有其他人也指向該檔案)

- Deletion– Dangling pointer problem
  - If dict deletes “all”
- Solutions:
  - Backpointers, so we can delete all pointers
  - Entry-hold-count solution

Acyclic-Graph Directories



Problems with Aliasing

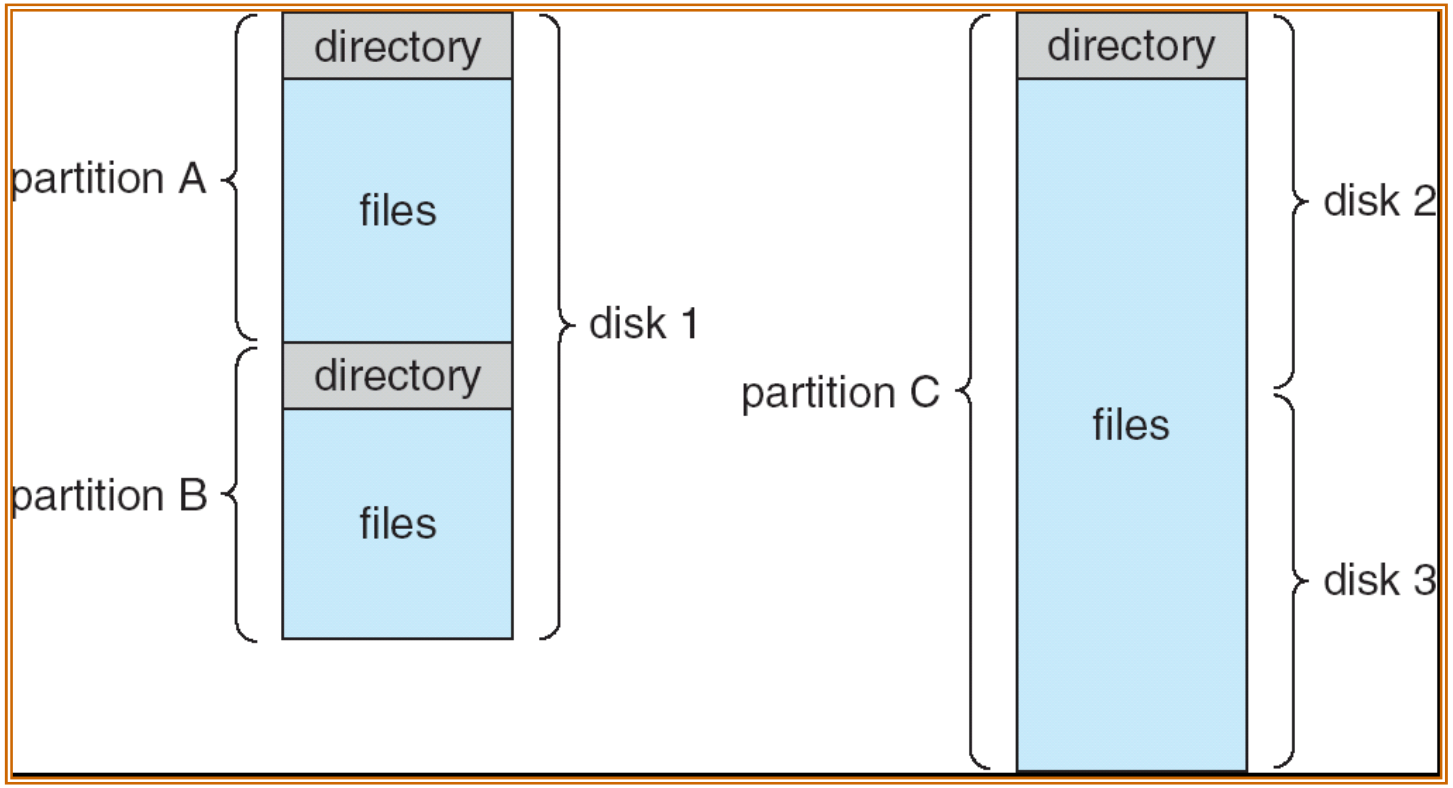
- Dangling pointers 指向的檔案被刪掉→這個pointer指向了一個未知的宇宙XDD
- Softlink (symbolic link)
  - Simply leave the symbolic link dangling
  - /bin/ls → /sbin/ls
- Hardlink
  - link is established inside the file system
  - Keep a reference count
  - Creating hardlink to the file: +count
  - Removing a hardlink to the file: -count
  - When count==0: remove the file

Soft link vs. Hard link: Revisit

- Softlink
  - Can span over different file systems
  - Dangling pointer problem

- Hardlink
  - No Dangling pointer problem
  - Can not span over different file systems
  - There is no way to tell a regular file from a hard link (may cause recursion in traveling directories)

A Typical File-system Organization



Use a logical volume manager

A disk = a (physical) disk volume

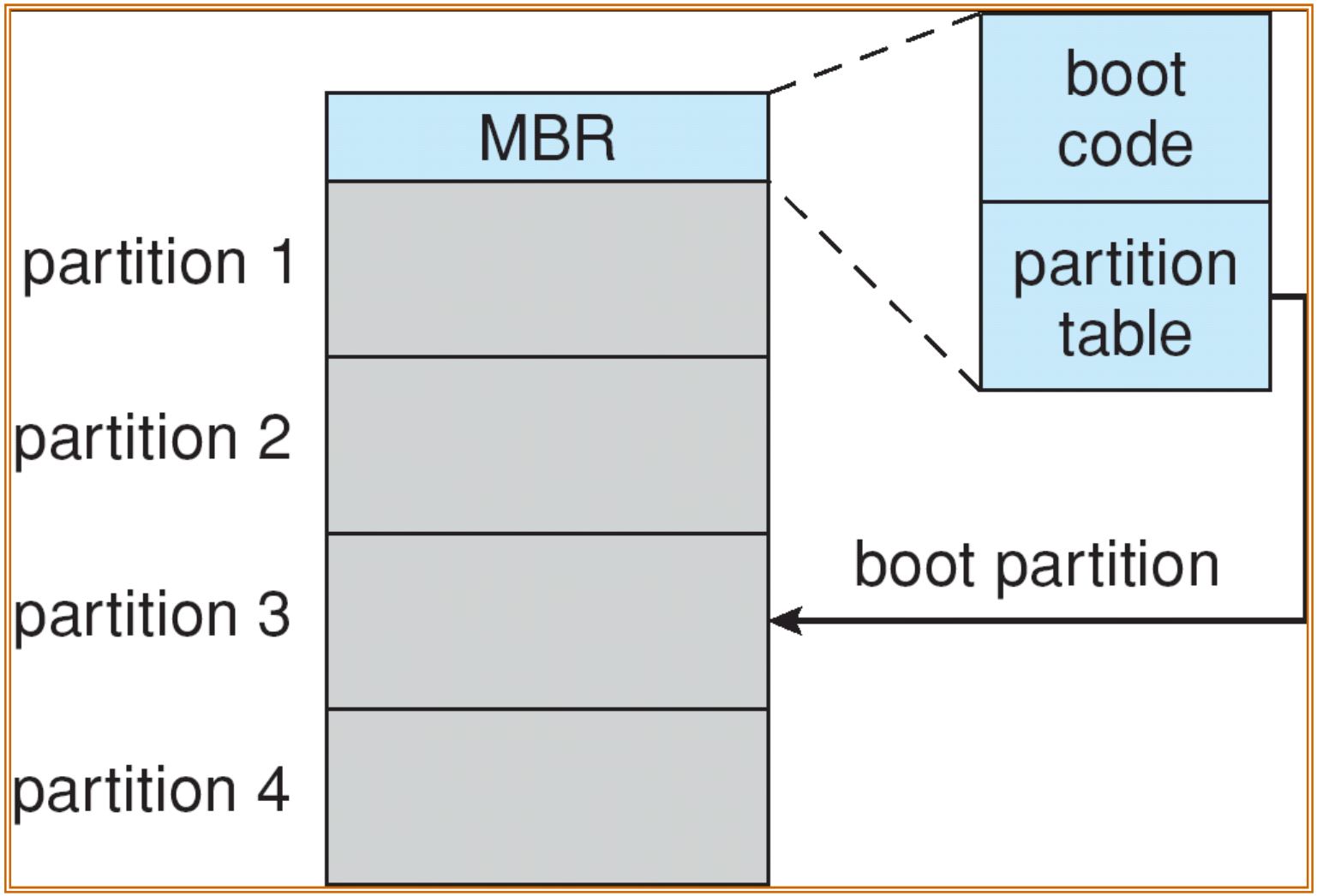
A logical disk volume may span over many disks

Disk Management

把備用的磁區<->壞軌mapping清掉，可能壞掉XDD

- Low-level formatting, or physical formatting — Dividing a disk into sectors that the disk controller can read and write.
  - Remapping bad tracks to spare tracks
  - Zoned-bit encoding
- To use a disk to hold files, the operating system still needs to record its own data structures on the disk.
  - Logical formatting or “making a file system”. 把磁碟的metadata重設
  - Writing file system metadata
- Boot block initializes system.
  - 1st bootstrap loader is stored in ROM (BIOS)
  - BIOS loads 2nd bootstrap loader from MBR
  - MBR loads OS loader

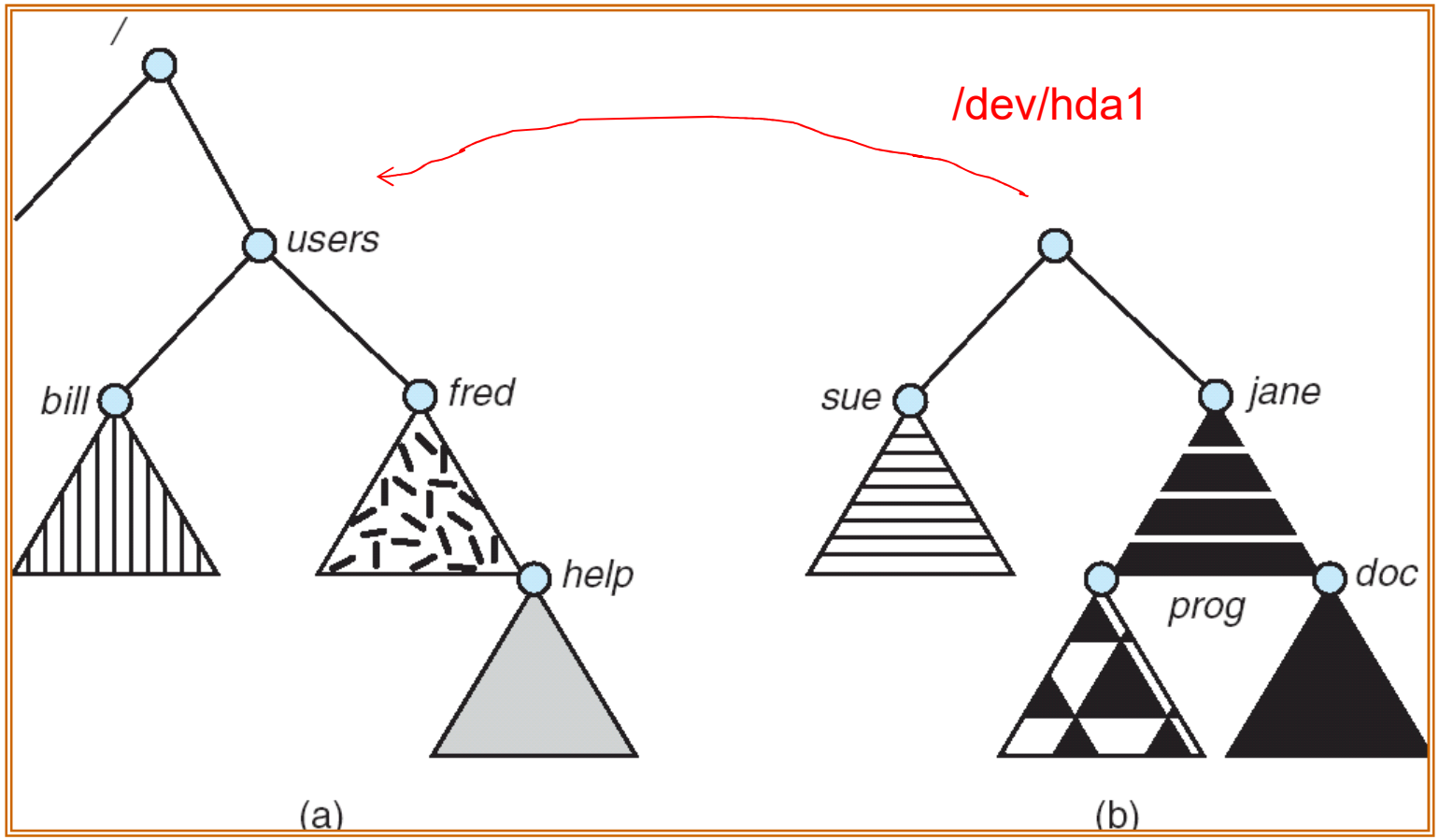
Booting from Disk in Windows 2000



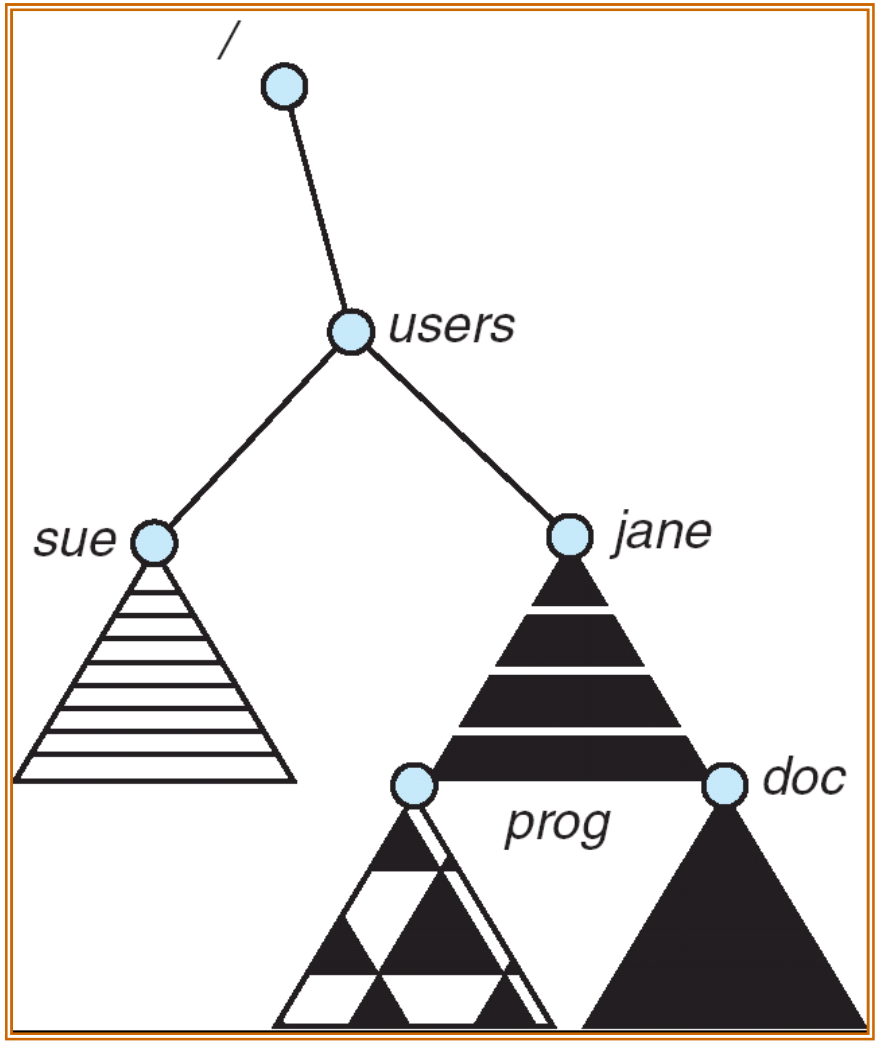
File System Mounting

- A file system must be mounted before it can be accessed
- A unmounted file system is mounted at a mount point
- Mounting a file system
  - `mount -t` **`ext4 /users /dev/hda1`**
  - Specify the file system type
  - Find the file-system superblock in the partition
  - Specify the mounting point of the file-system naming space

(a) Existing. (b) Unmounted Partition



Mount Point



Protection

- File owner/creator should be able to control:
  - what can be done
  - by whom

- Types of access
  - Read
  - Write
  - Execute
  - Append (regards to disk space)
  - Delete
  - List

考慮

FTP

File Sharing – Multiple Users

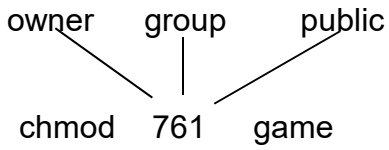
- User IDs identify users, allowing permissions and protections to be per-user
- Group IDs allow users to be in groups, permitting group access rights

Access Lists and Groups

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

			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.
- Attach a group to a file: chgrp G game



UNIX File Permission Management Utilities

- adduser: create a user
- mkgrp: create a group
- addgrp: add a user to a group
- chown: change the owner of a file
- chgrp: change the group of a file
- chmod: change file permissions

- Users are managed by /etc/password
- Groups are managed by /etc/group

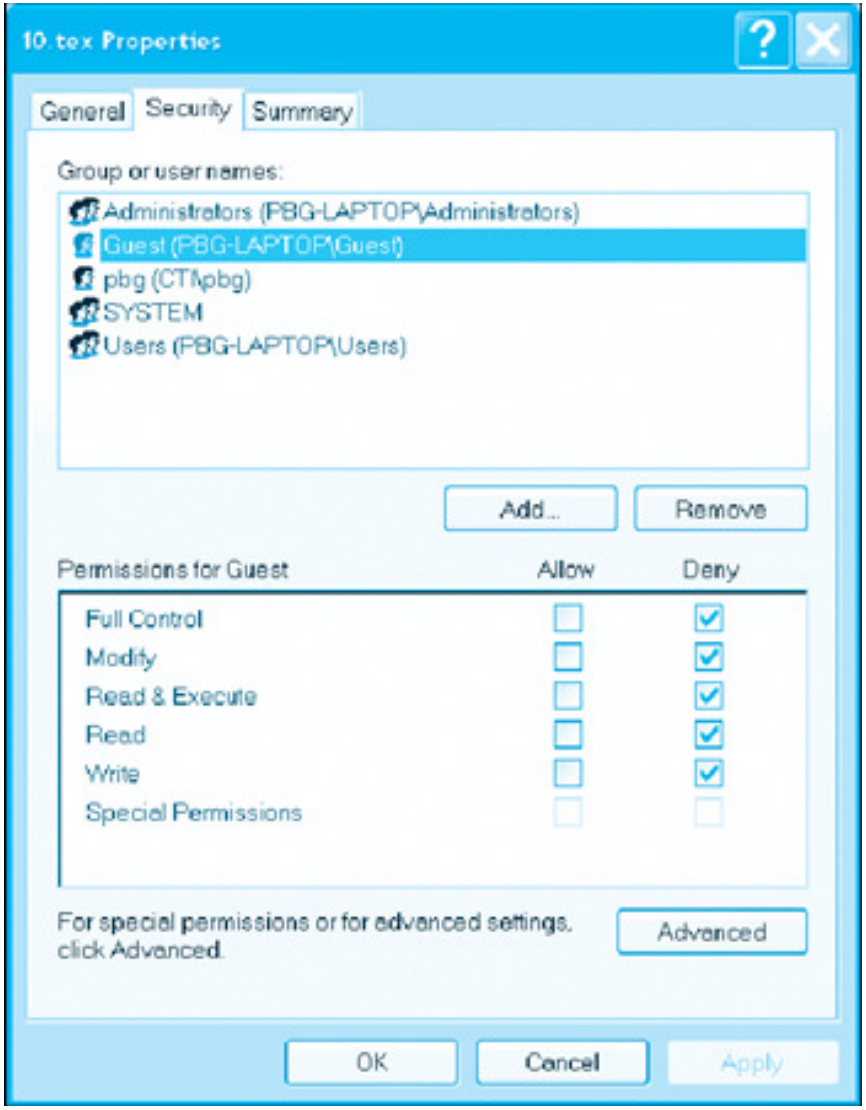
A Sample UNIX Directory Listing

-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/

[Permission] [hard link count][Owner] [group] [filesize] [date] [filename]

- Regular file: link count >=1, file is deleted when link count =0
- A subdirectory: link count >=2
  - 1 from the parent directory
  - 1 from the subdirectory itself 資料夾下會有一個"."指向自己

Windows XP Access-control List Management



End of Chapter 10