Chapter 10: File System Interface

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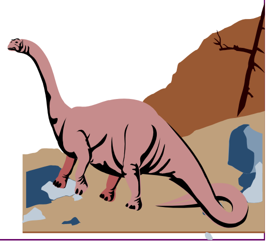
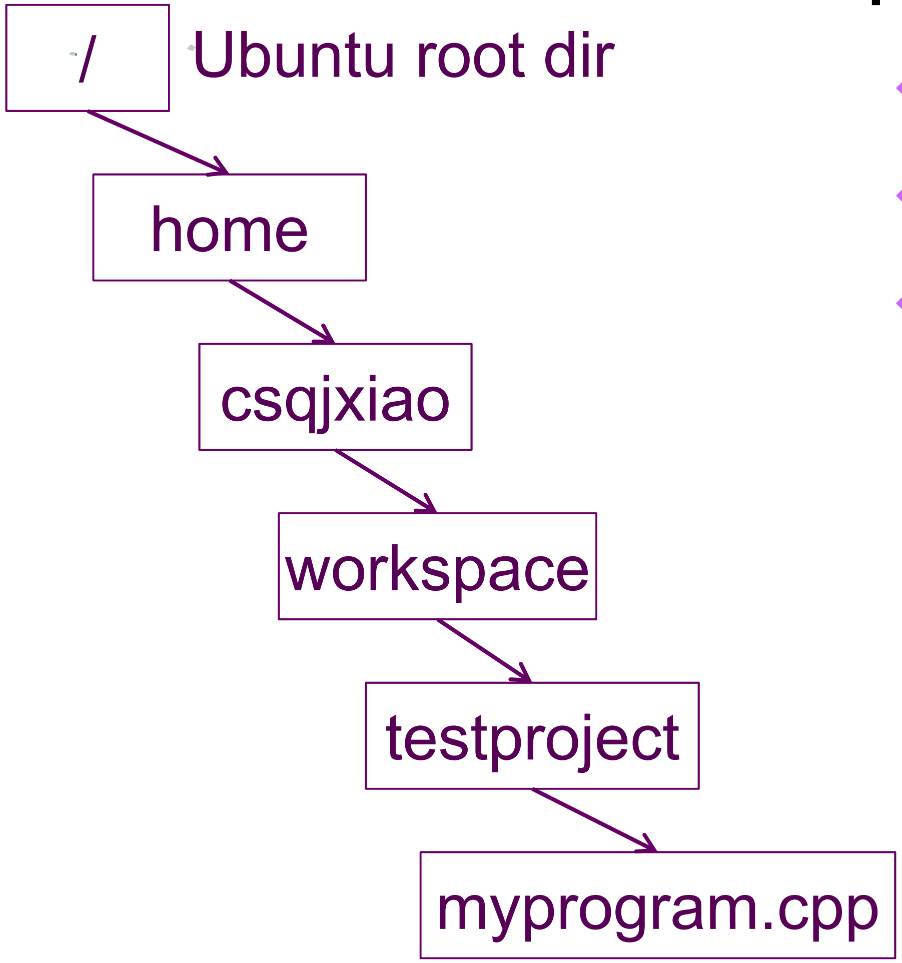
Chapter 10: File-System Interface

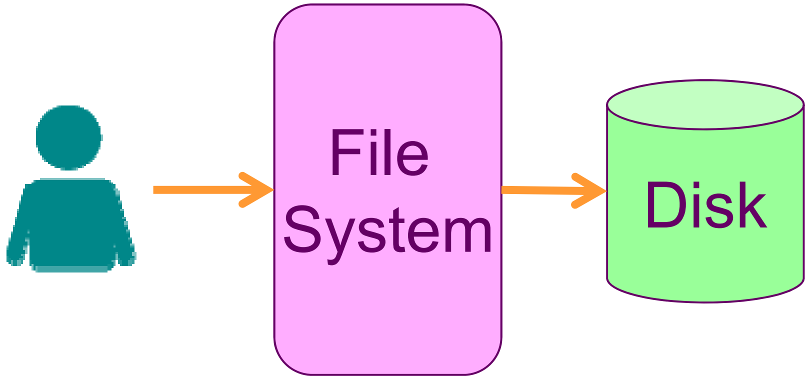
- File Concept
- Access Methods
- Directory Structure
- File System Mounting
- File Sharing
- Protection



File System Concept

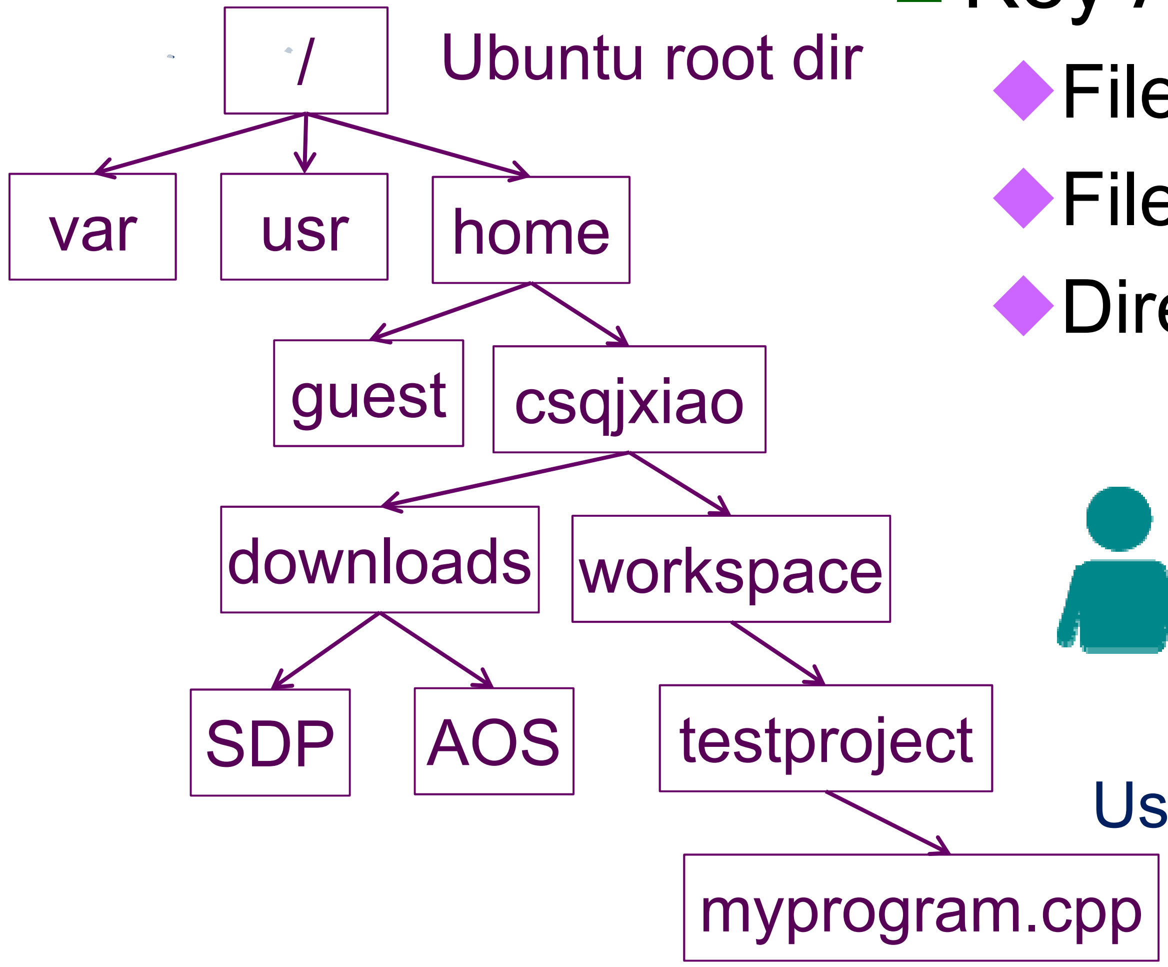


- Key Abstraction
  - File
  - Filename
  - Directory tree (folders)



Users do not access directly the file blocks on disks

File System Concept



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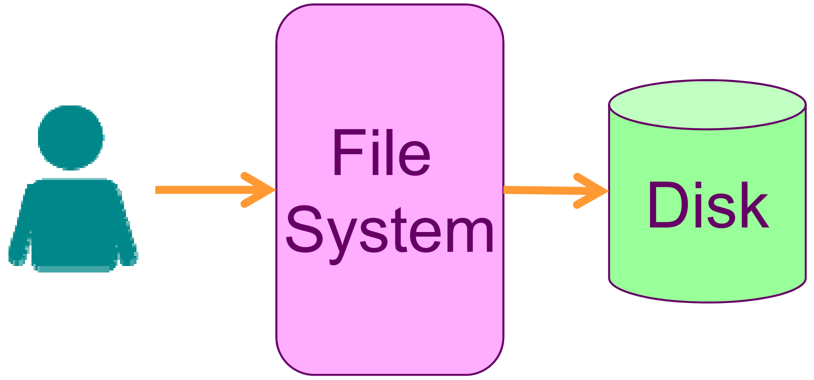

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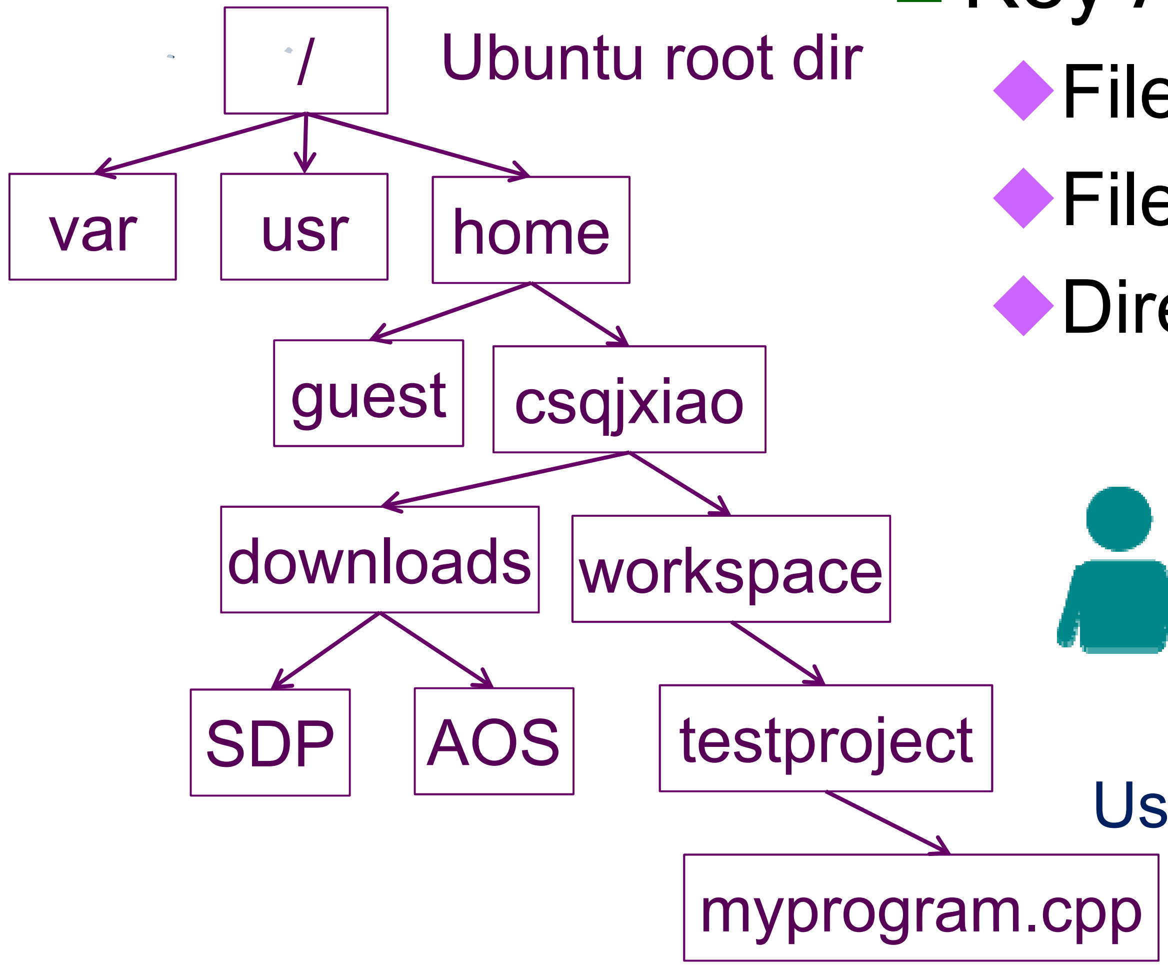
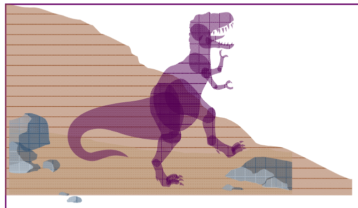
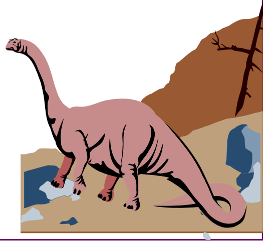
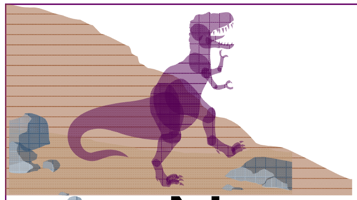




File Concept

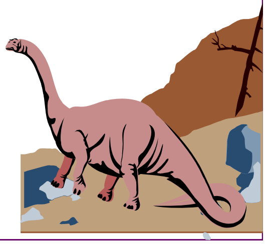
- Contiguous logical address space
- Types:
  - Data
    - ✓numeric
    - ✓character
    - ✓binary
  - Program

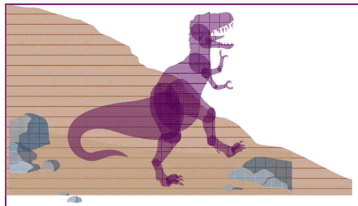




File Structure

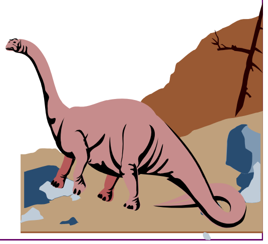
- None - sequence of words, bytes
- Simple record structure
  - Lines
  - Fixed length
  - Variable length
- Complex Structures
  - Formatted document
  - Relocatable load file
- Can simulate last two with first method by inserting appropriate control characters.
- Who decides?

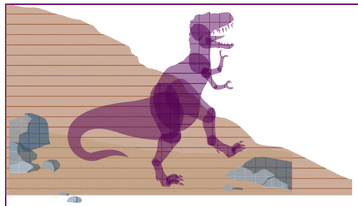




File Attributes

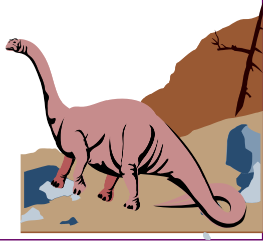
- **Name** – only information kept in human-readable form.
- **Type** – needed for systems that support different types.
- **Location** – pointer to file location on device.
- **Size** – current file size.





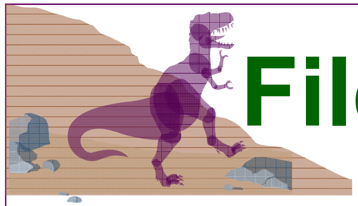
File Attributes (Cont.)

- **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.



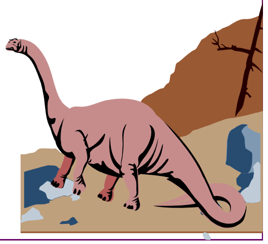
File Operations from Developer's Perspective

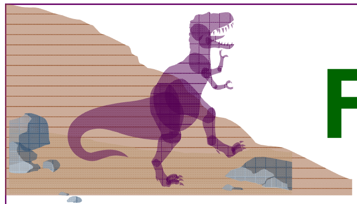
- Create
- Write
- Read
- Reposition within file – file seek
- Delete
- Truncate



File Operations from Developer’s Perspective (Cont.)

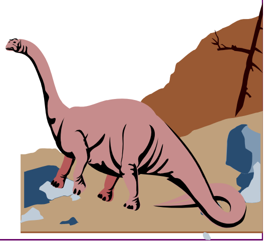
- open(F_i) – search the directory structure on disk for entry F_i, and move the content of entry to memory.
- close(F_i) – move the content of entry F_i in memory to directory structure on disk.
- read(F_i) – read the file content
- write(F_i) – write to the file
- fseek(F_i) – reposition the file cursor





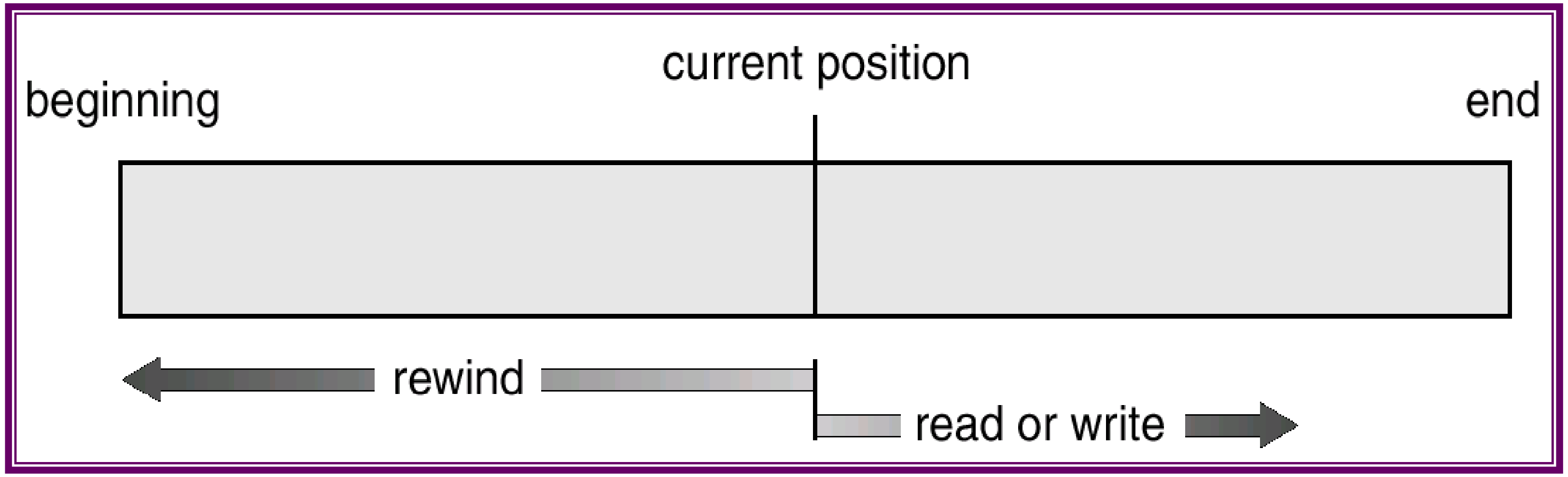
File Types – Name, Extension

file type	usual extension	function
executable	exe, com, bin or none	read 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, rrf, doc	various word-processor formats
library	lib, a, so, dll, mpeg, mov, rm	libraries of routines for programmers
print or view	arc, zip, tar	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	binary file containing audio or A/V information

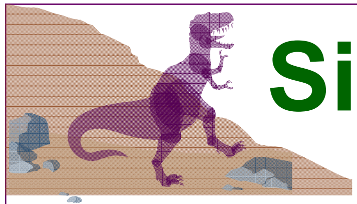


Access Methods

- **Sequential Access**

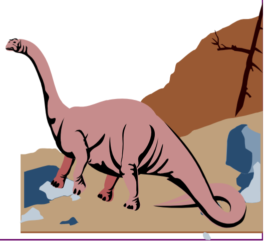


- **Direct Access**



Simulation of Sequential Access on a 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;

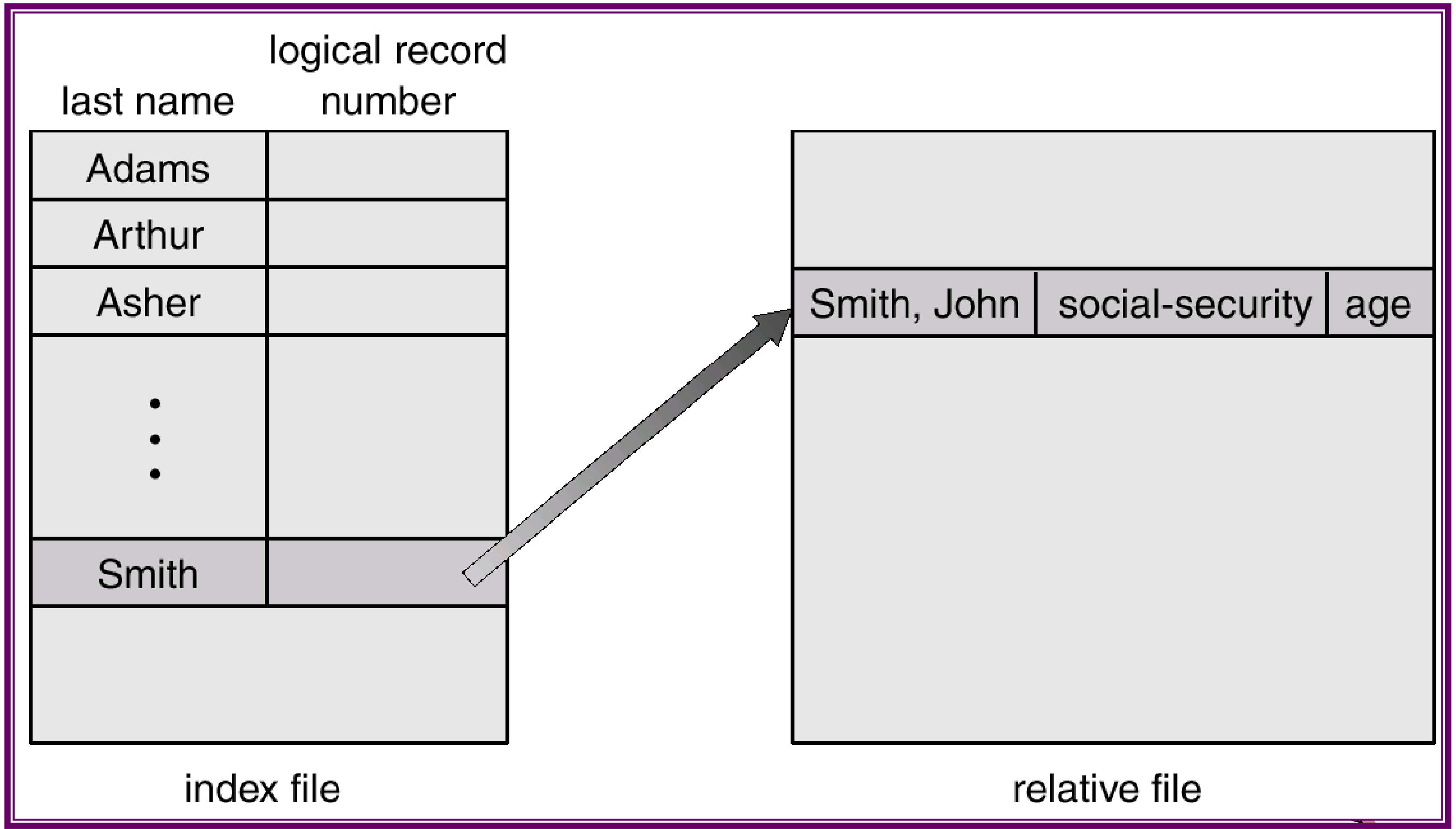


Code Modifying a Key-Value Pair

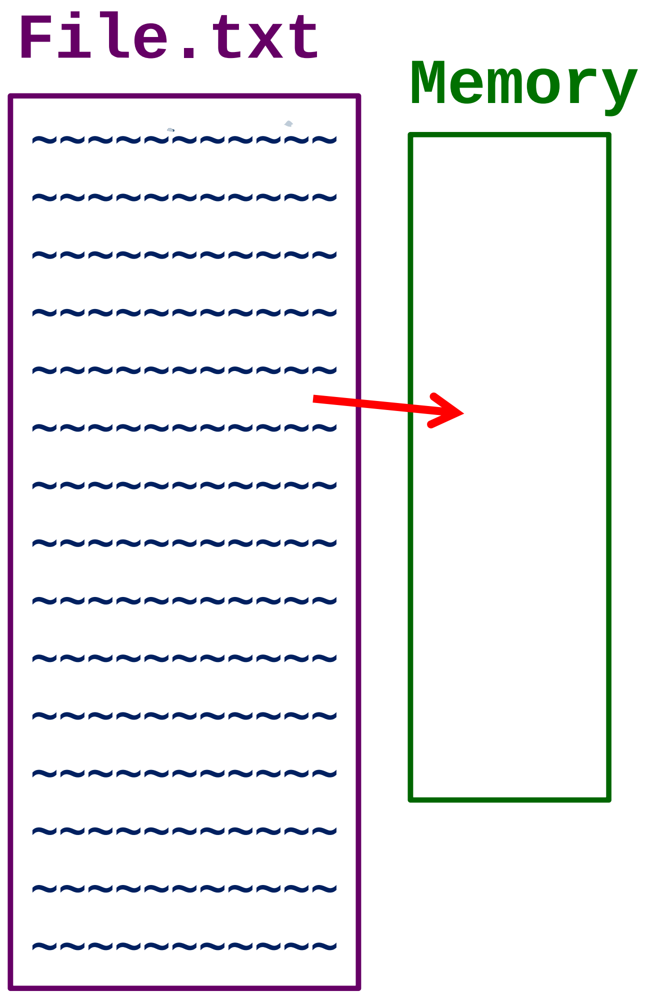
KEY	VALUE
integer	integer

```
ssize_t len;
char * filename;
int key, srch_key, new_value;
filename = argv[1];
srch_key = strtol(argv[2], NULL, 10);
new_value = strtol(argv[3], NULL, 10);
int fd = open(filename, O_RDWR);
while(sizeof(int) == read(fd, key, sizeof(int))) {
        if(key != srch_key)
                lseek(fd, sizeof(int), SEEK_CUR);
        else {
                write(fd, &new_value, sizeof(int));
                close(fd);
                return EXIT_SUCCESS;
        }
}
fprintf(stderr, “key not found!”);
return EXIT_FAILURE;
```

Example of Index and Relative Files

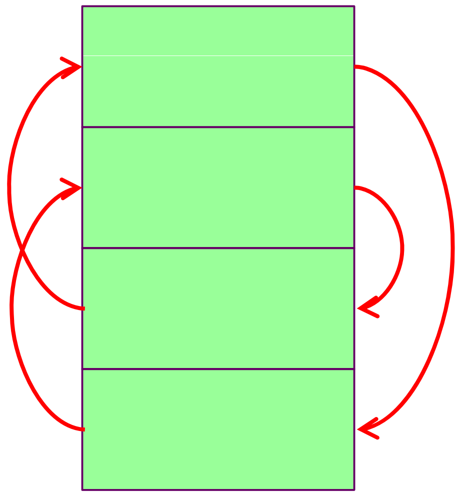


Memory Mapped File

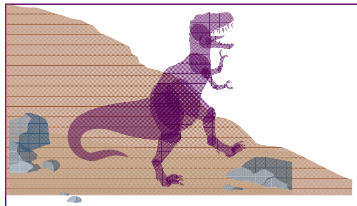


```
fd = open("file.txt", ….);
buffer = mmap(…, fd, …);

// manipulate the buffer

munmap(buf, …);
close(fd);
```

Example of Memory Mapped File: Shuffle a File

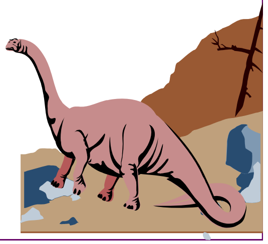


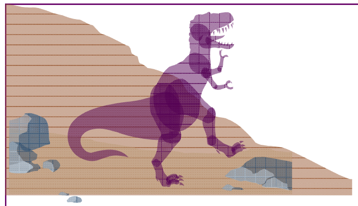
```
filename = argv[1];
card_size = strtol(argv[2], NULL, 10);
fd = open(filename, O_RDWR);
len = lseek(fd, 0, SEEK_END);
lseek(fd, 0, SEEK_SET);
buf = mmap(NULL, len, PROT_READ | PROT_WRITE, MAP_FILE
| MAP_SHARED, fd, 0);
if( buf == (void*) -1) {
      fprintf(stderr, “mmap failed.\n”);
      exit(EXIT_FAILURE);
}
memshuffle(buf, len, card_size);
munmap(buf, len);
close(fd);
return EXIT_SUCCESS;
```



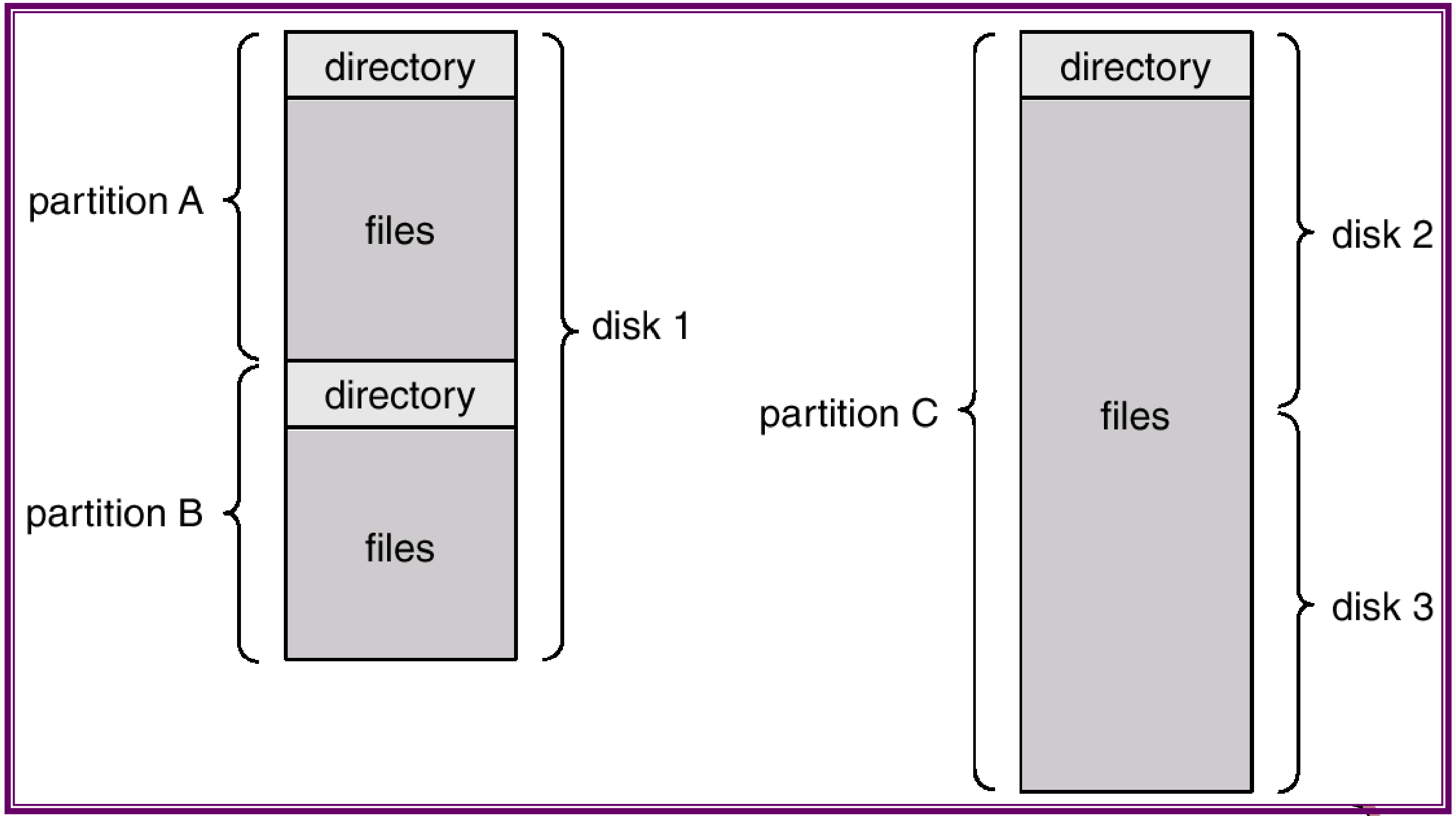
Directory Structure

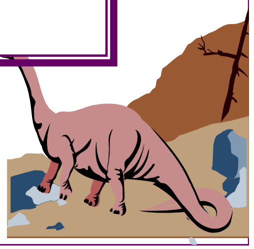
- disks are split into one or more partitions.
- each partition contains information about files within it
- The information is kept in entries in a device directory or volume table of contents

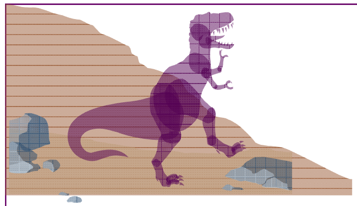




A Typical File-system Organization

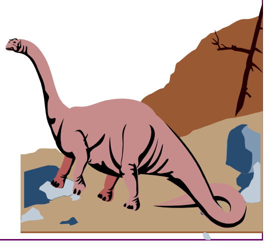


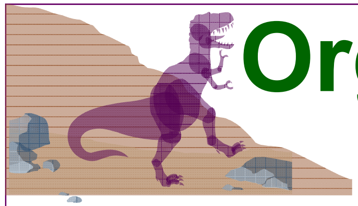




Operations Performed on Directory

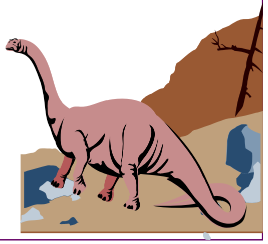
- Search for a file
- Create a file
- Delete a file
- List a directory
- Rename a file
- Traverse the file system





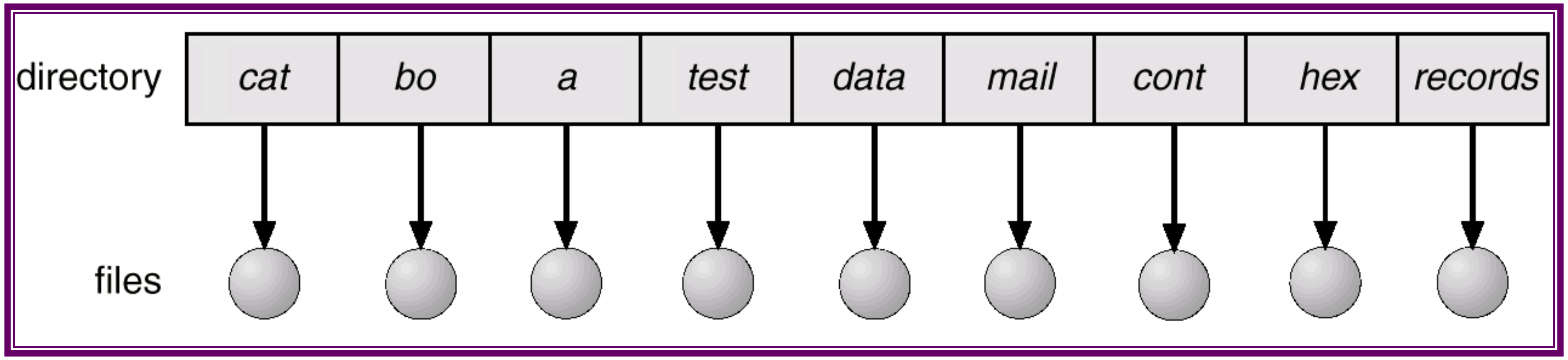
Organize the Directory (Logically) to Obtain

- **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, (e.g., all Java programs, all games, …)



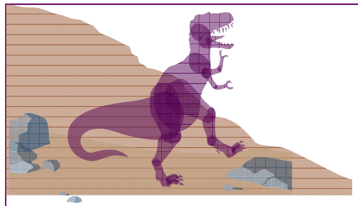
Single-Level Directory

- A single directory for all users.



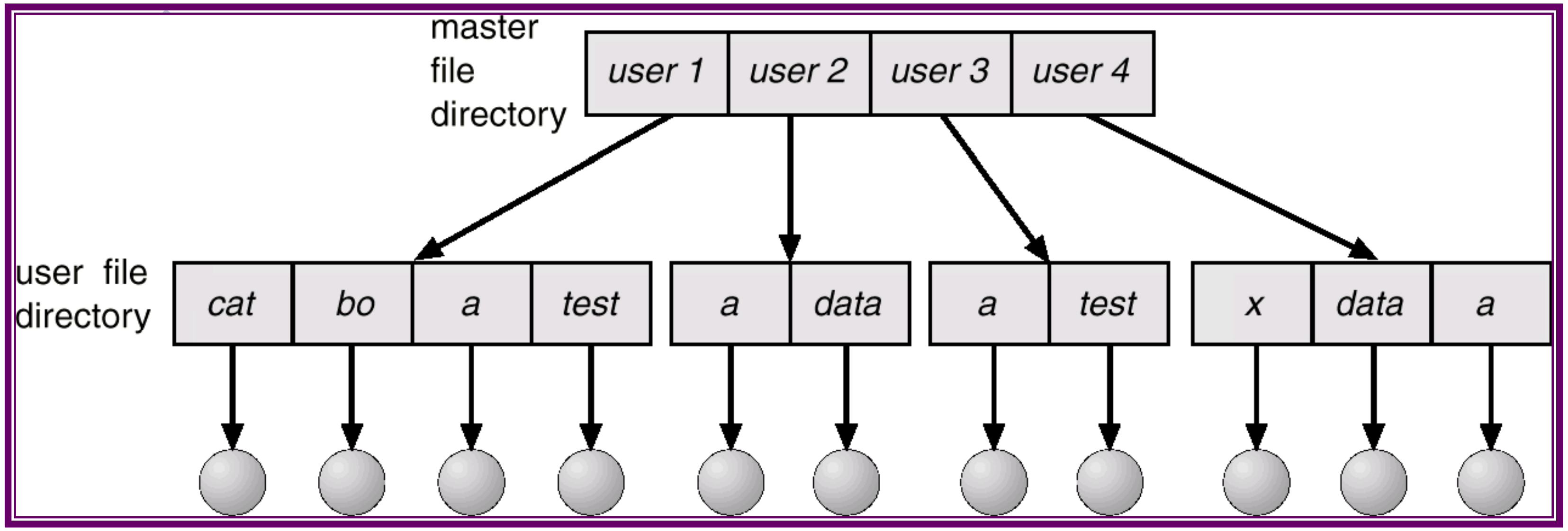
Naming problem

Grouping problem

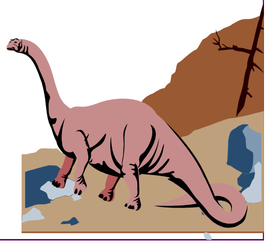


Two-Level Directory

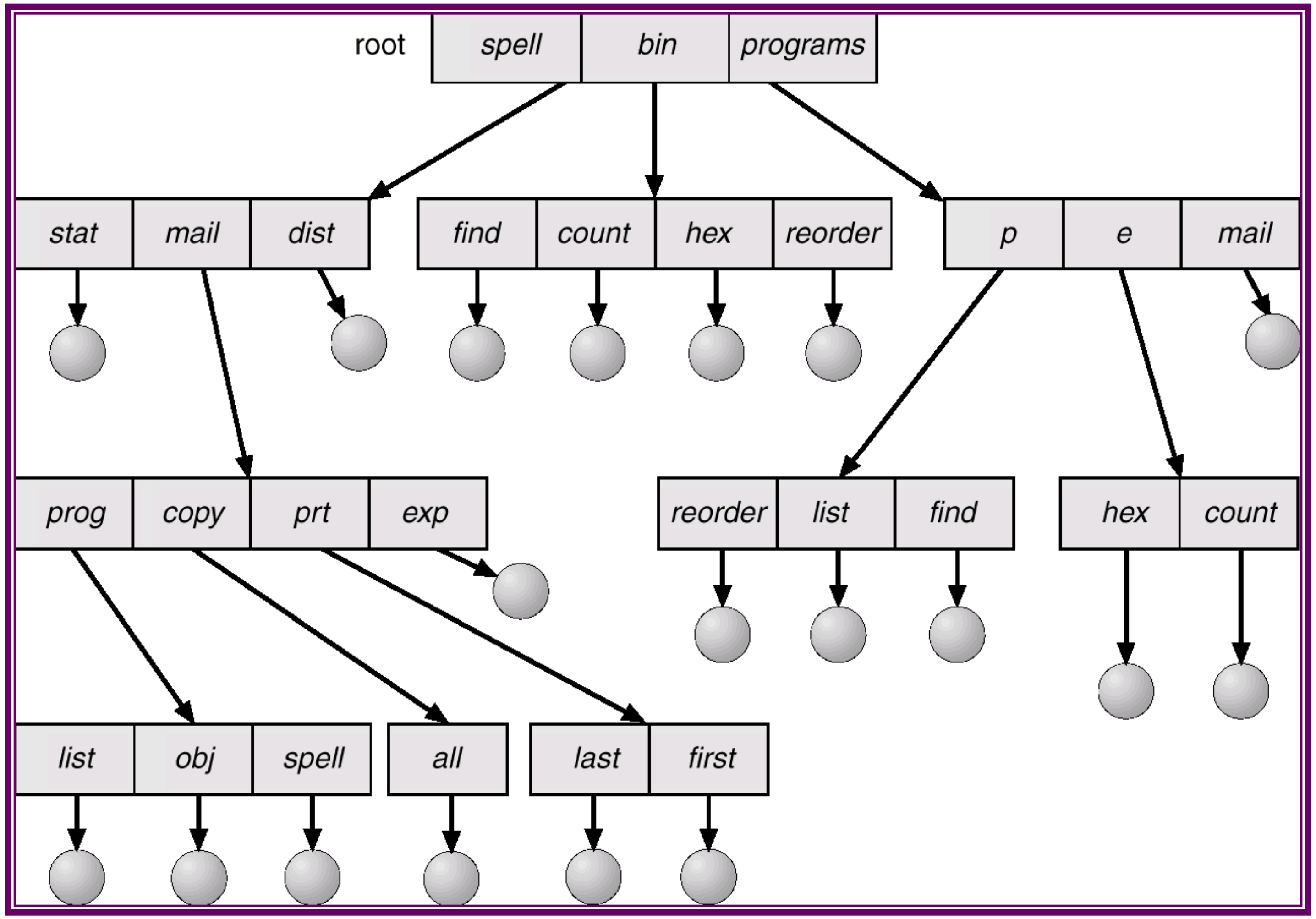
- Separate directory for each user.

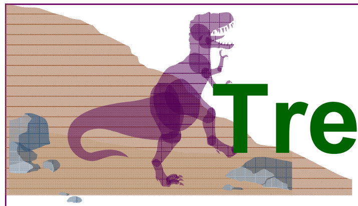


- Path name
- Can have the same file name for different user
- Efficient searching
- No grouping capability



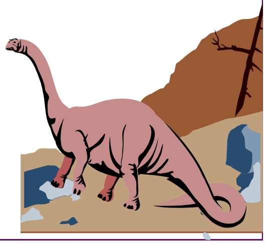
Tree-Structured Directories

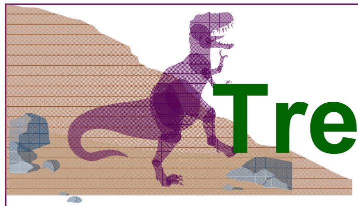




Tree-Structured Directories (cont.)

- Efficient searching
- Grouping Capability
- Current directory (working directory)
  - **cd** /spell/mail/prog
  - **type** list

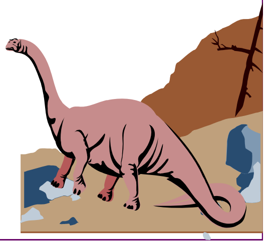




Tree-Structured Directories (cont.)

- **Absolute** or **relative** path name
- Creating a new file is done in current directory.
- Delete a file

  rm <file-name>



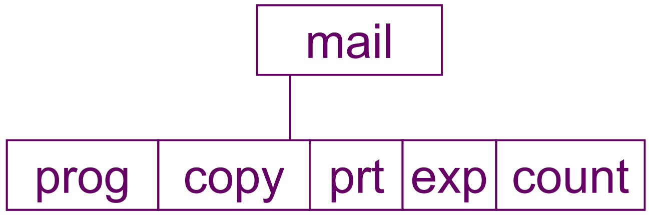
Tree-Structured Directories (cont.)

- Creating a new subdirectory is done in current directory.

  mkdir <dir-name>

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

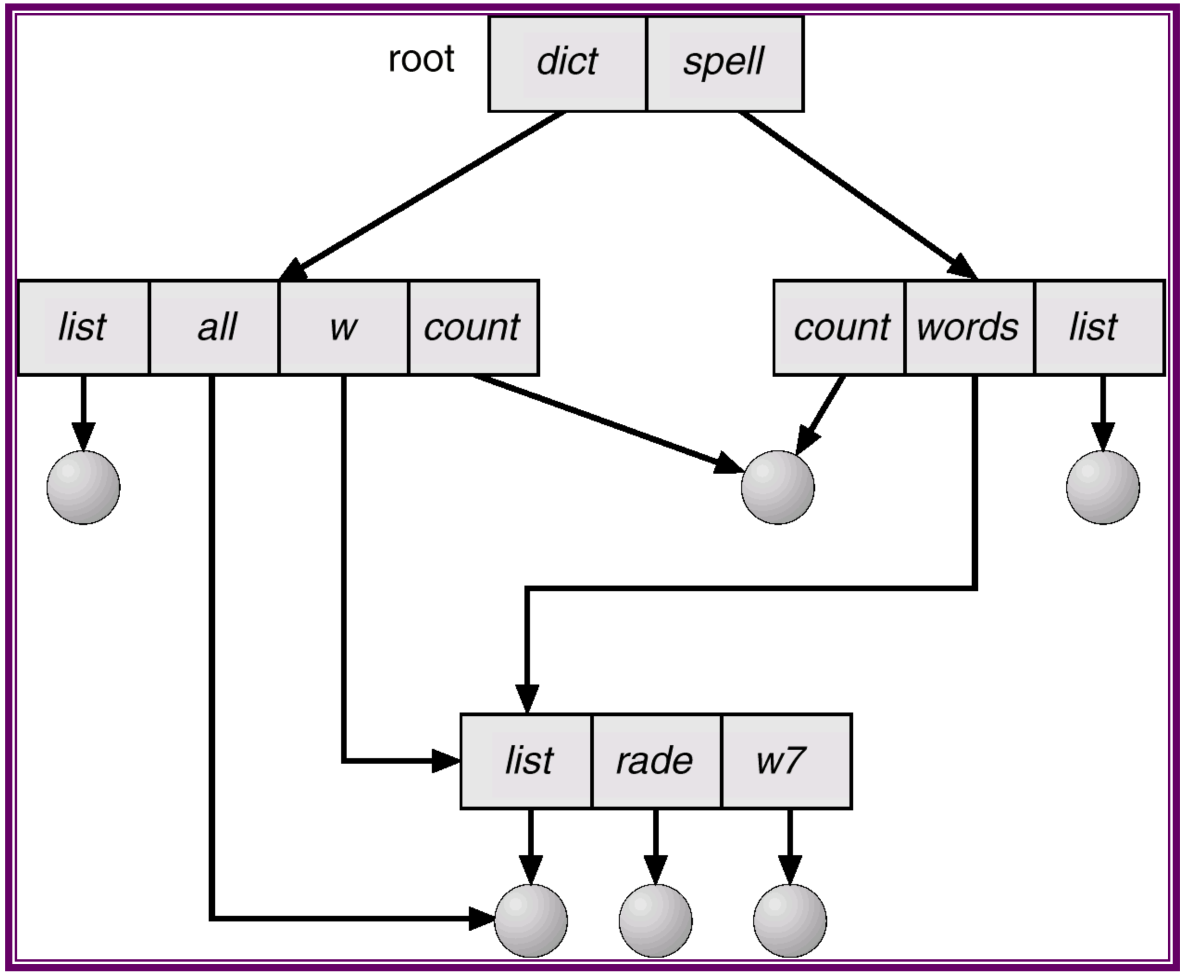
  mkdir count

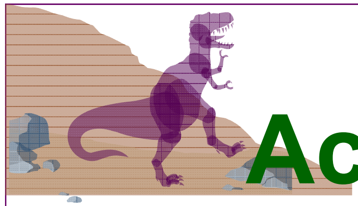


Deleting “mail” ⇒ deleting the entire subtree rooted by “mail”.

Acyclic-Graph Directories

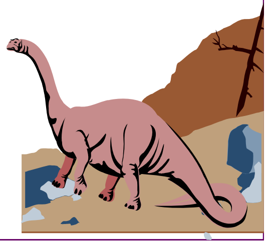
- Have shared subdirectories and files.



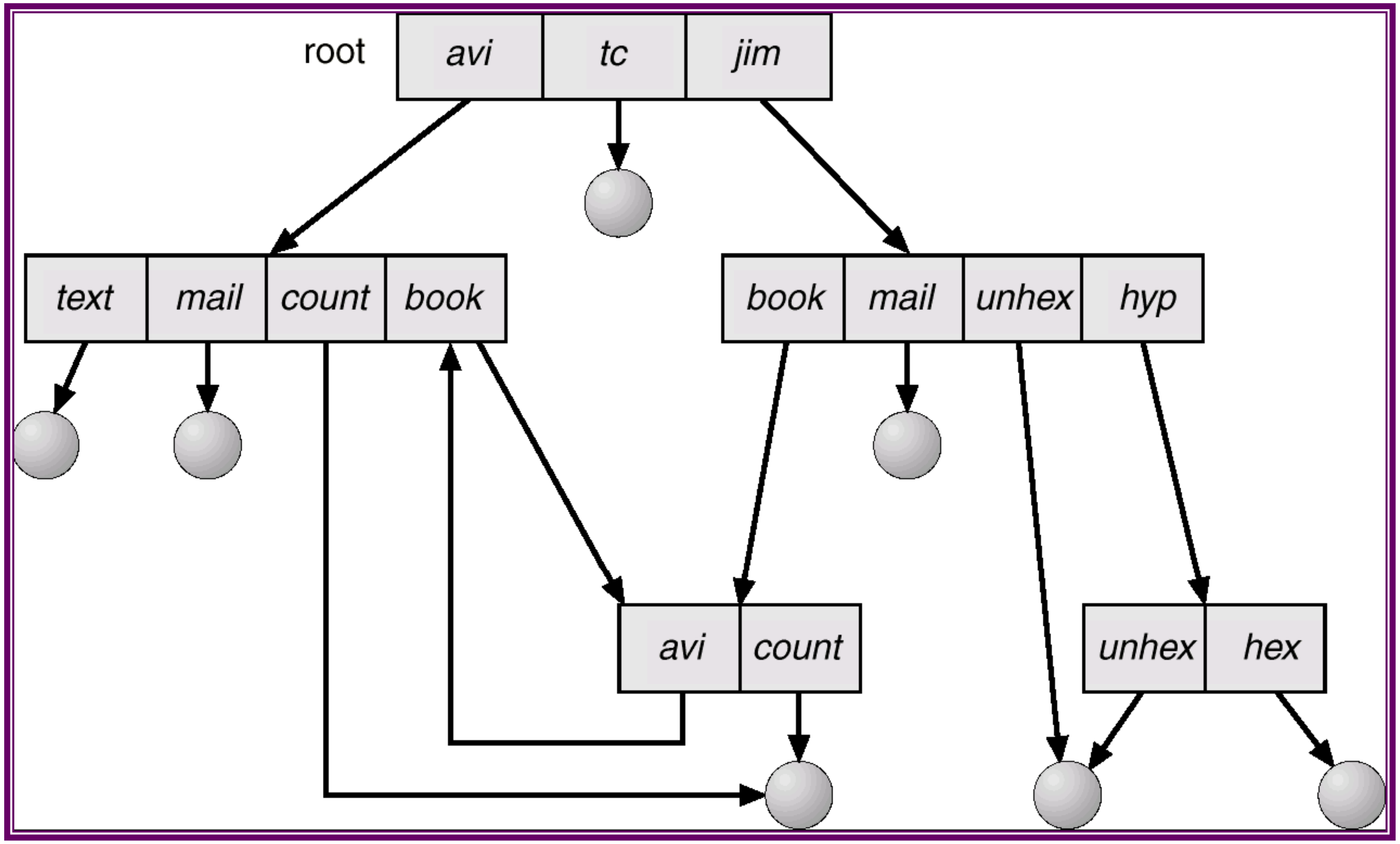


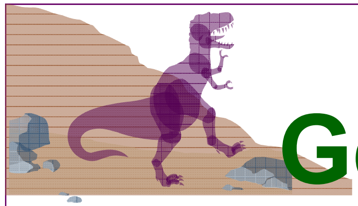
Acyclic-Graph Directories (cont.)

- Two different names (aliasing)
- If *dict* deletes *count* ⇒ dangling pointer.
  Solutions:
  - Backpointers, so we can delete all pointers.
  - Entry-hold-count solution.



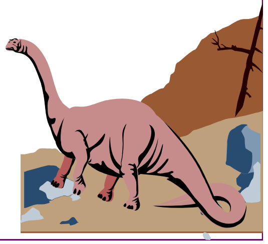
General Graph Directory

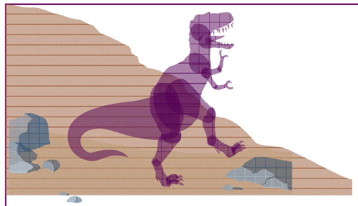




General Graph Directory (cont.)

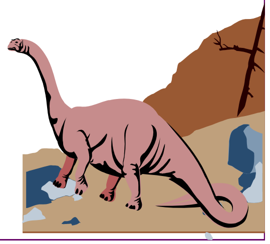
- How do we guarantee no cycles?
  - Allow only links to file not subdirectories.
  - Garbage collection.
  - Every time a new link is added use a cycle detection algorithm to determine whether it is OK.



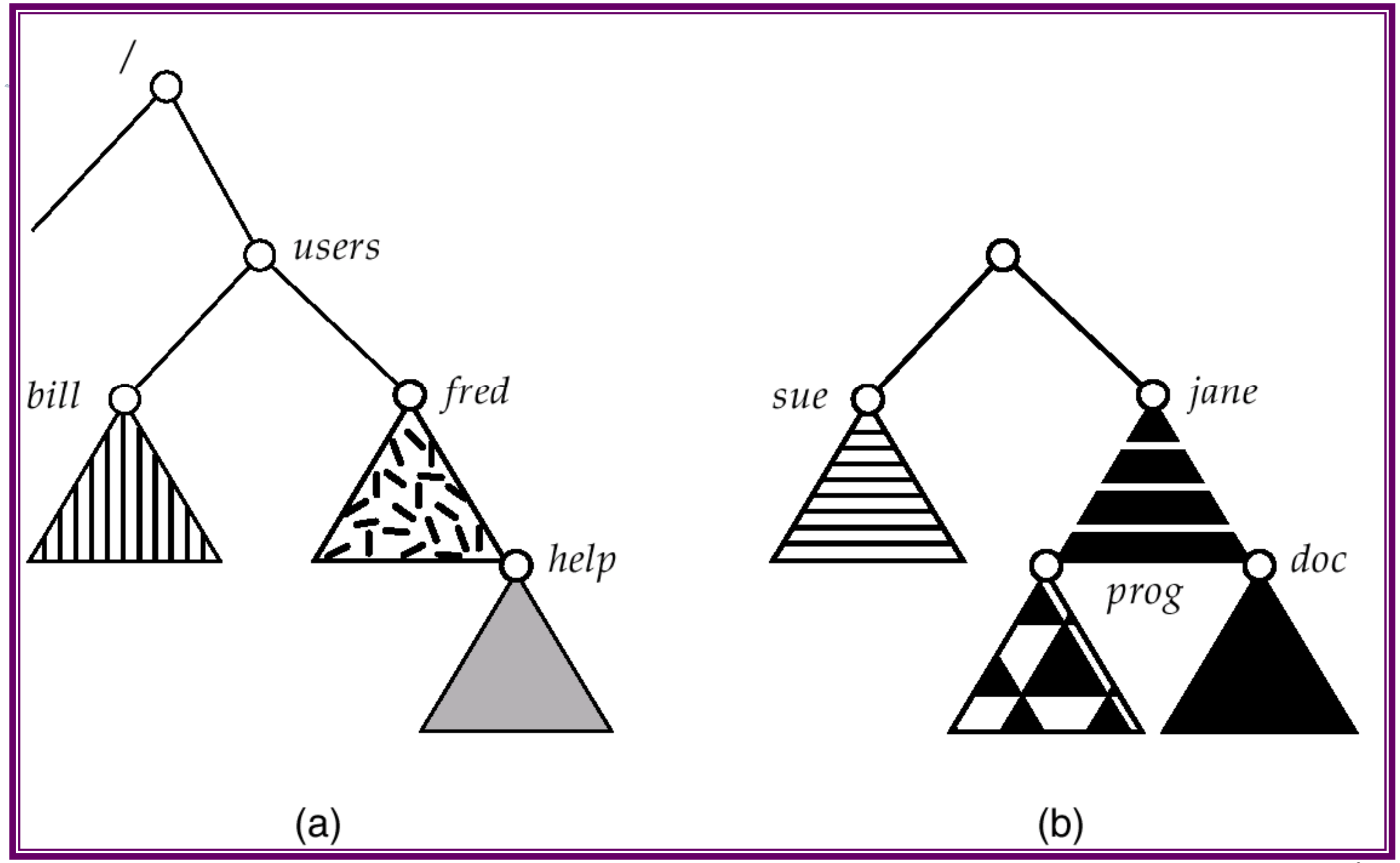


File System Mounting

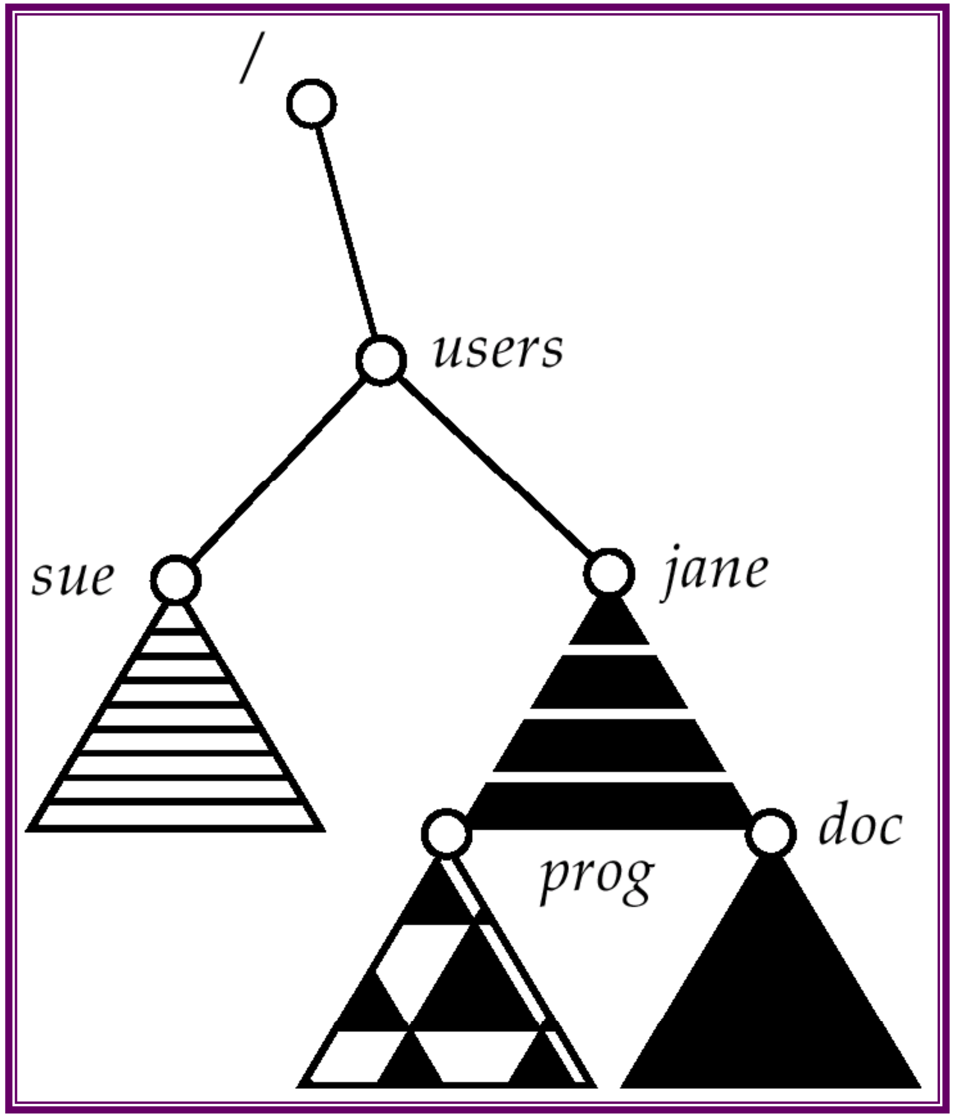
- A file system must be **mounted** before it can be accessed.
- An unmounted file system (I.e. Fig. 11-11(b)) is mounted at a **mount point**.

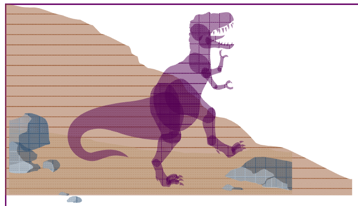


(a) Existing
(b) Unmounted Partition



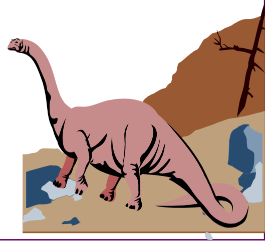
Mount Point

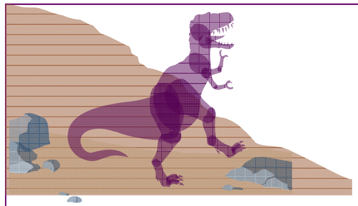




File Sharing

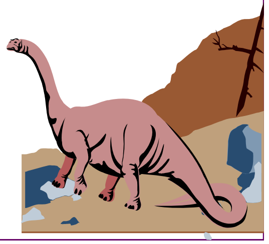
- Sharing of files on multi-user systems is desirable.
- Sharing may be done through a *protection* scheme.
- On distributed systems, files may be shared across a network.
- Network File System (NFS) is a common distributed file-sharing method.

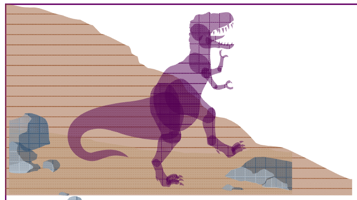




Protection

- 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 RWX

  a) **owner access** 7 $\Rightarrow$ 1 1 1

  b) **group access** 6 $\Rightarrow$ 1 1 0

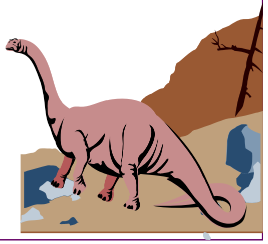
  c) **public access** 1 $\Rightarrow$ 0 0 1
- Ask manager to create a group (unique name), say G, and add some users to the group.
- For a particular file (say *game*) or subdirectory, define an appropriate access.

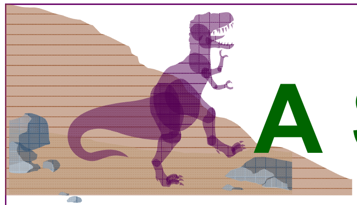
owner group public

chmod 761 game

Attach a group to a file

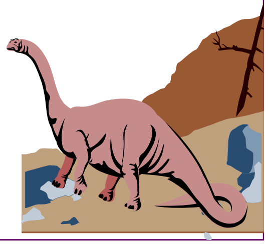
chgrp G game

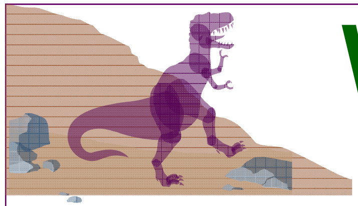




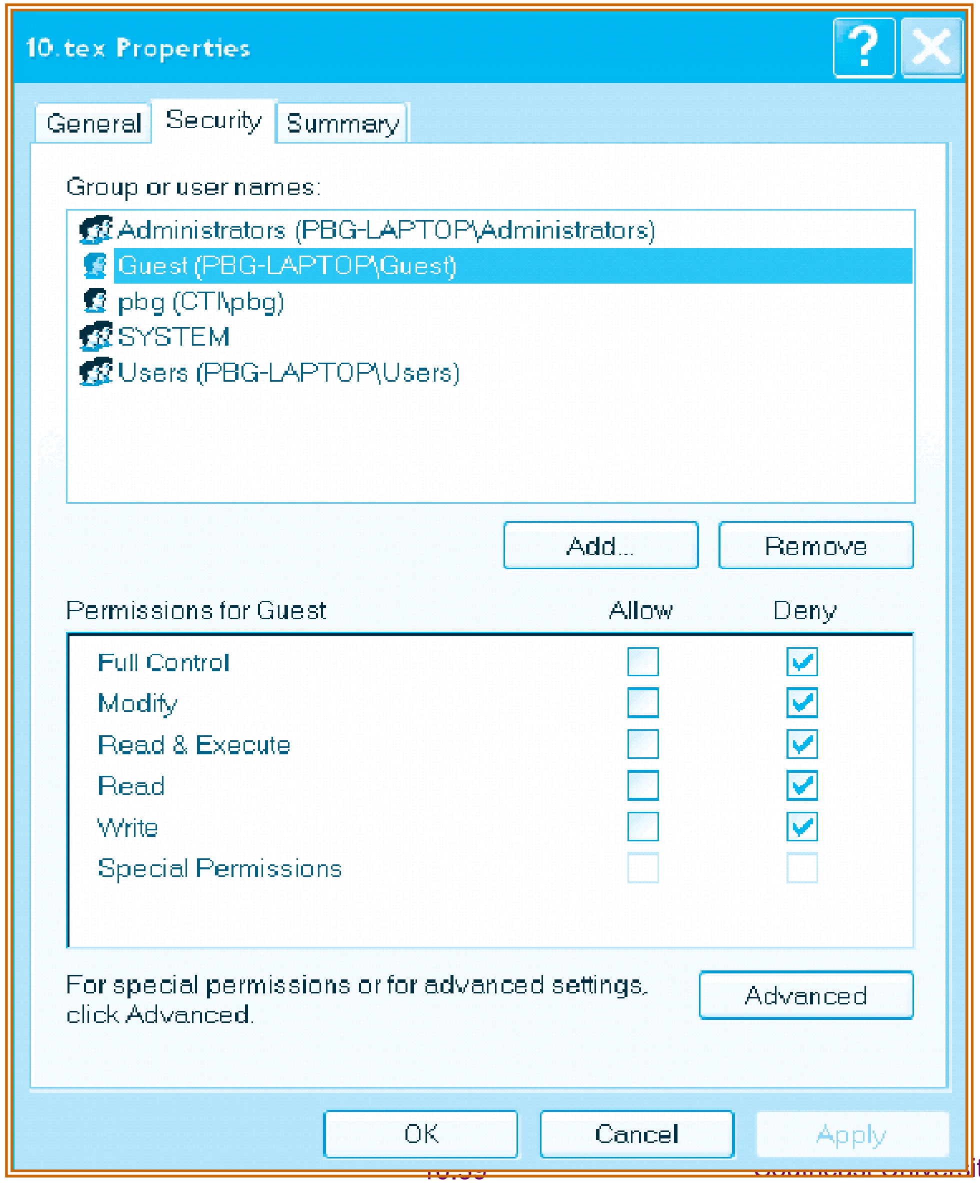
A Sample UNIX Directory Listing

```
-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/
```





Windows XP Access-Control List Management



10.tex Properties

General | Security | Summary

Group or user names:

- Administrators (PBG-LAPTOP\Administrators)
- Guest (PBG-LAPTOP\Guest)
- pbg (CTI\pbg)
- SYSTEM
- Users (PBG-LAPTOP\Users)

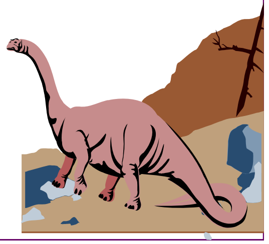
Add... | Remove

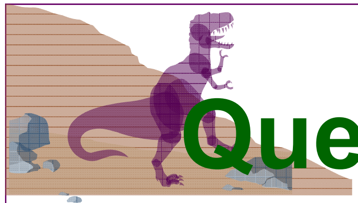
Permissions for Guest	Allow	Deny
Full Control	☐	✓
Modify	☐	✓
Read & Execute	☐	✓
Read	☐	✓
Write	☐	✓
Special Permissions	☐	☐

For special permissions or for advanced settings, click Advanced.

Advanced

OK | Cancel | Apply

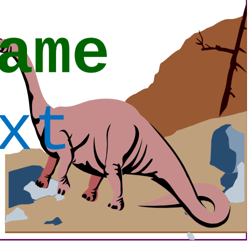


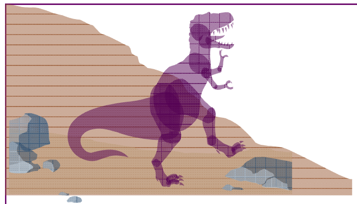


Question about File Access-Control

- Which of the following will generate a permission error?
  - cat foo.txt
  - cat dir/bar.txt
  - touch dir/new.txt

```
$ ls –l ./
Permission      user   group     ….    Filename
drw-r--r--      me     me              dir
-rw-r--r--      other  other           foo.txt

$ sudo ls –l dir
Permission      user   group     ….    Filename
-rw-r--r--      me     me              bar.txt
```





Another Question

- Which of the following will generate a permission error?
  - cat foo.txt
  - cat dir/bar.txt
  - touch dir/new.txt

```
$ ls –l ./
Permission      user  group    ….   Filename
d--xr--r--      me    me            dir
-rw-r--r--      other other         foo.txt

$ sudo ls –l dir
Permission      user  group    ….   Filename
-rw-r--r--      me    me            bar.txt
```