Lecture 10

File-System Interface & File System Implementation I

Lecture Information

Ceng328 *Operating Systems* at May 04, 2010

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Contents

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- Also includes tools outside the kernel; formatting, recovery, defrag, consistency, backup utilities (system administration).

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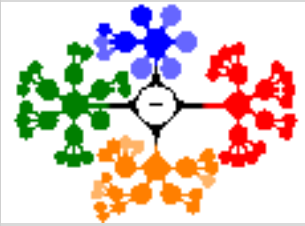

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  - How do you keep one user from reading another's data?
  - How do you know which blocks are free?

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  - An *executable file* is a series of code sections that the loader can bring into memory and execute.

File Attributes I

When a file is named, it becomes independent of the process, the user, and even the system that created it.

Attribute	Meaning
Protection	Who can access the file and in what way
Password	Password needed to access the file
Creator	ID of the person who created the file
Owner	Current owner
Read-only flag	0 for read/write; 1 for read only
Hidden flag	0 for normal; 1 for do not display in listings
System flag	0 for normal files; 1 for system file
Archive flag	0 for has been backed up; 1 for needs to be backed up
ASCII/binary flag	0 for ASCII file; 1 for binary file
Random access flag	0 for sequential access only; 1 for random access
Temporary flag	0 for normal; 1 for delete file on process exit
Lock flags	0 for unlocked; nonzero for locked
Record length	Number of bytes in a record
Key position	Offset of the key within each record
Key length	Number of bytes in the key field
Creation time	Date and time the file was created
Time of last access	Date and time the file was last accessed
Time of last change	Date and time the file was last changed
Current size	Number of bytes in the file
Maximum size	Number of bytes the file may grow to

Figure: Some possible file attributes.

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    - Both the read and write operations use this same pointer, saving space and reducing system complexity.

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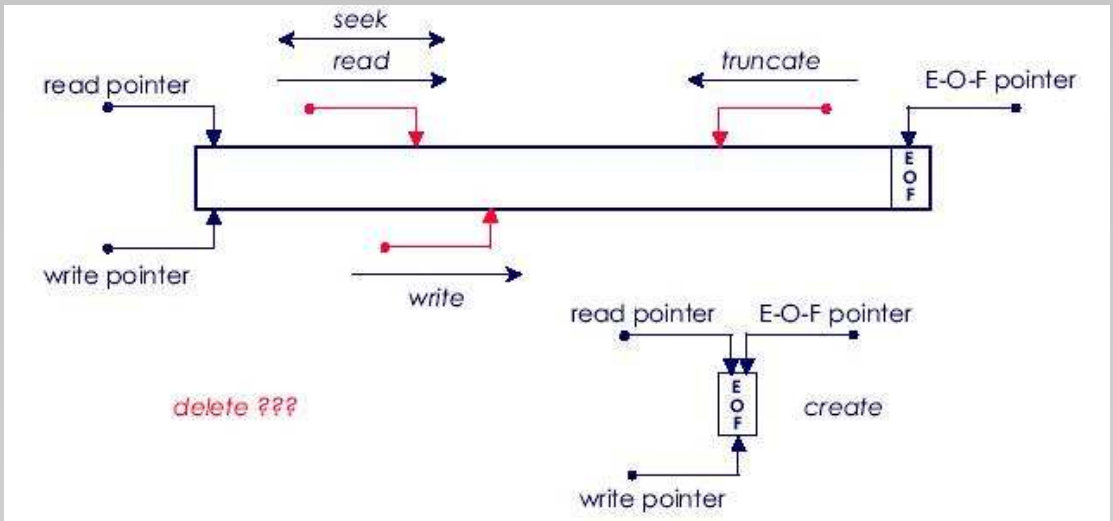
- **Repositioning within a file**. The directory is searched for the appropriate entry, and the current-file-position pointer is repositioned to a given value (file seek).



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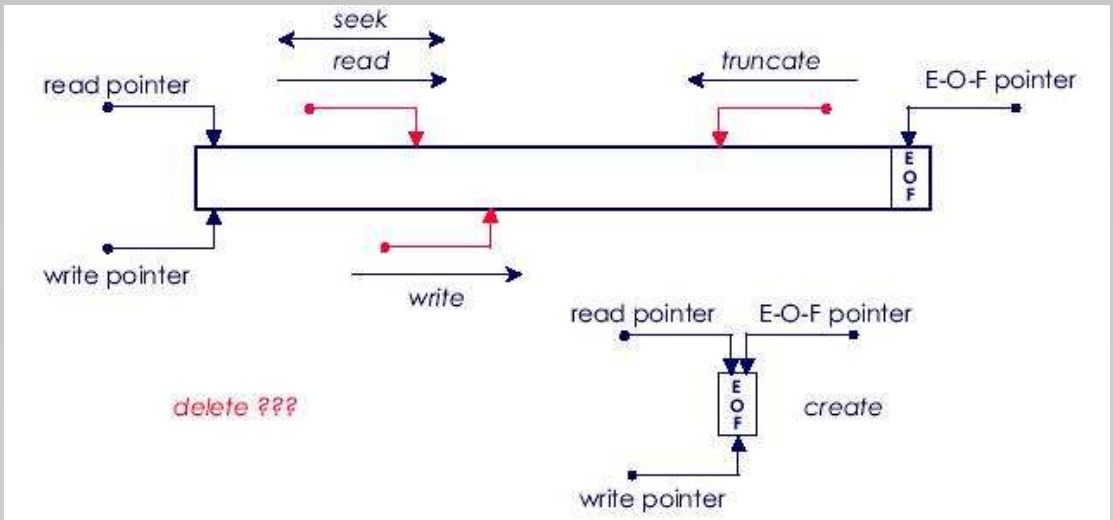

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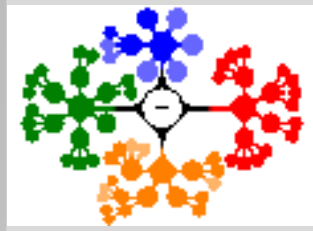

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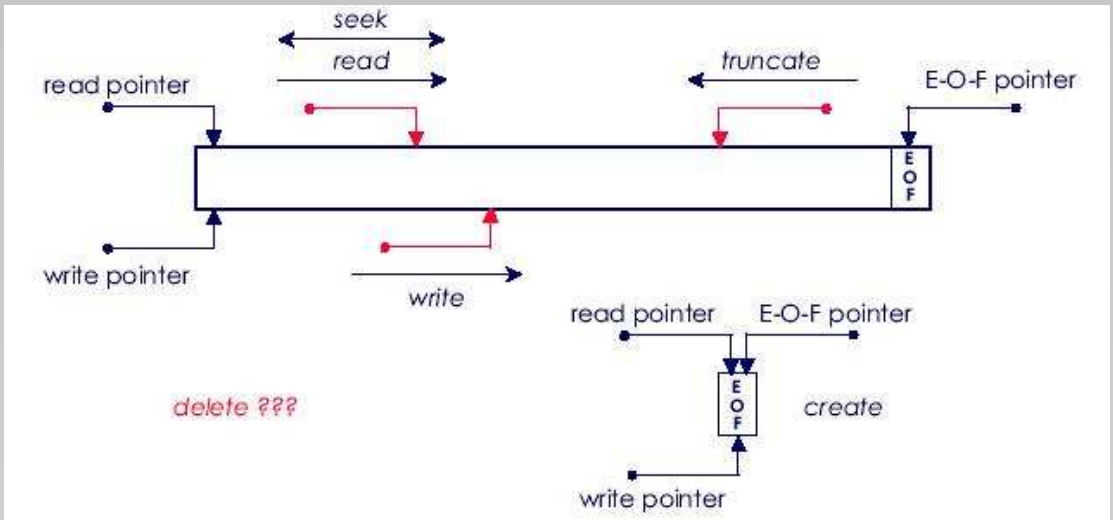
- **Truncating a file**. The user may want to erase the contents of a file but keep its attributes. The file be reset to length zero and its file space released.



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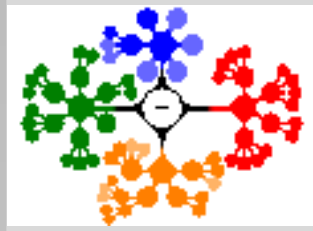

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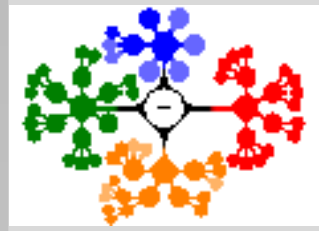

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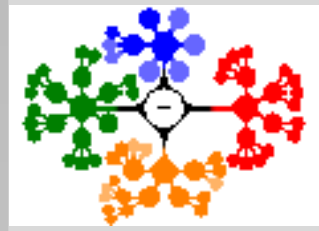

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  - Each *close*() decreases this open count, and when the open count reaches zero, the file is no longer in use, and the file's entry is removed from the open-file table.

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- Some OSs provide facilities for locking an open file (or sections of a file).
- File locks are useful for files that are shared by several processes.

An Example Program Using File System Calls I

- A simple UNIX program that copies one file from its source file to a destination file (see Fig. 3). The program has minimal functionality and even worse error reporting.

```
copyfile abc xyz
```


An Example Program Using File System Calls II

```
/* File copy program. Error checking and reporting is minimal. */

#include <sys/types.h>                  /* include necessary header files */
#include <fcntl.h>
#include <stdlib.h>
#include <unistd.h>

int main(int argc, char *argv[]);       /* ANSI prototype */

#define BUF_SIZE 4096                   /* use a buffer size of 4096 bytes */
#define OUTPUT_MODE 0700                /* protection bits for output file */

int main(int argc, char *argv[])
{
    int in_fd, out_fd, rd_count, wt_count;
    char buffer[BUF_SIZE];

    if (argc != 3) exit(1);             /* syntax error if argc is not 3 */

    /* Open the input file and create the output file */
    in_fd = open(argv[1], O_RDONLY);    /* open the source file */
    if (in_fd < 0) exit(2);             /* if it cannot be opened, exit */
    out_fd = creat(argv[2], OUTPUT_MODE);  /* create the destination file */
    if (out_fd < 0) exit(3);            /* if it cannot be created, exit */

    /* Copy loop */
    while (TRUE) {
        rd_count = read(in_fd, buffer, BUF_SIZE); /* read a block of data */
    if (rd_count <= 0) break;           /* if end of file or error, exit loop */
        wt_count = write(out_fd, buffer, rd_count); /* write data */
        if (wt_count <= 0) exit(4);     /* wt_count <= 0 is an error */
    }

    /* Close the files */
    close(in_fd);
    close(out_fd);
    if (rd_count == 0)                  /* no error on last read */
        exit(0);
    else
        exit(5);                        /* error on last read */
}
```

Figure: A simple program to copy a file.

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- Windows NT and Windows 2000 support the MS-DOS file system and thus also inherit its properties. However, these OSs also have a native file system (NTFS) that has different properties.

File Types II

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

Figure: Common file types.

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- Usually, they have some internal structure known to programs that use them (see Fig. 5).

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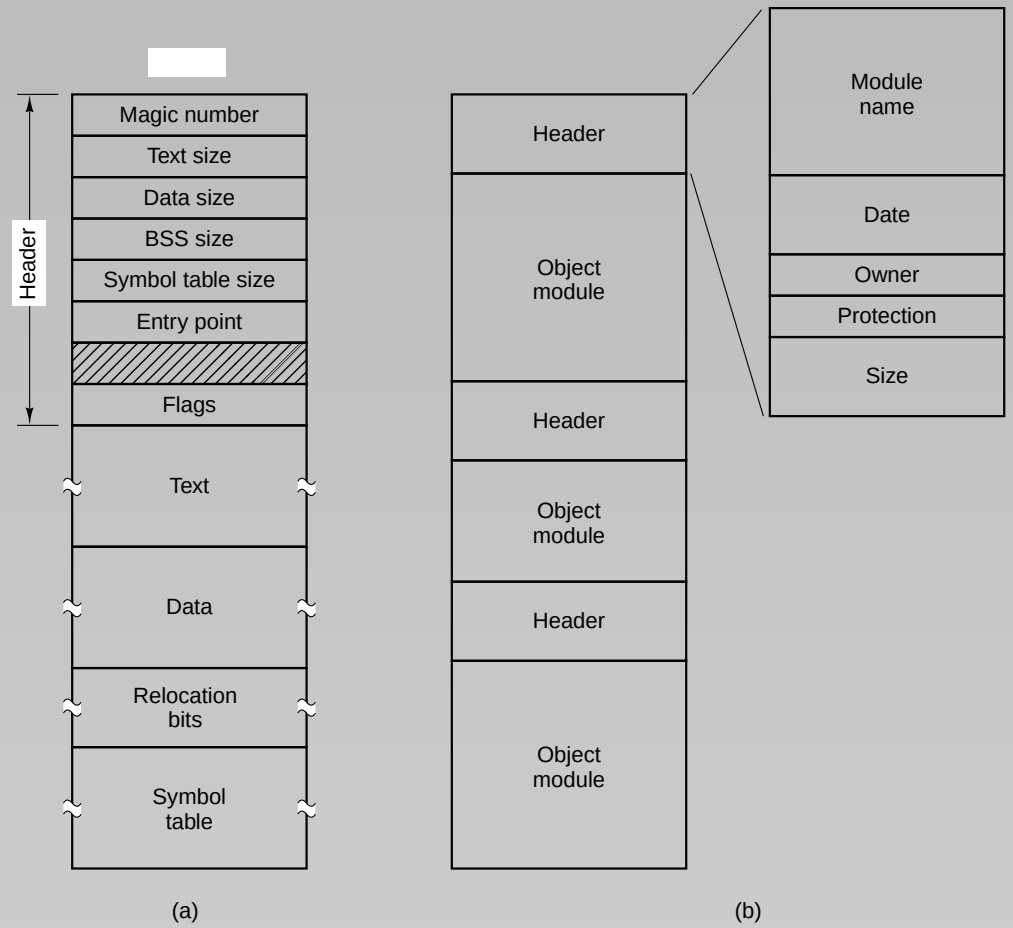
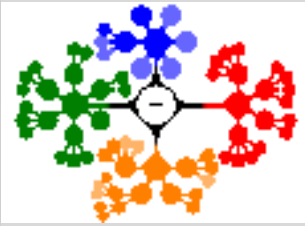


Figure: (a) An executable file. (b) An archive.

Every OS must recognize at least one file type; its own executable file.

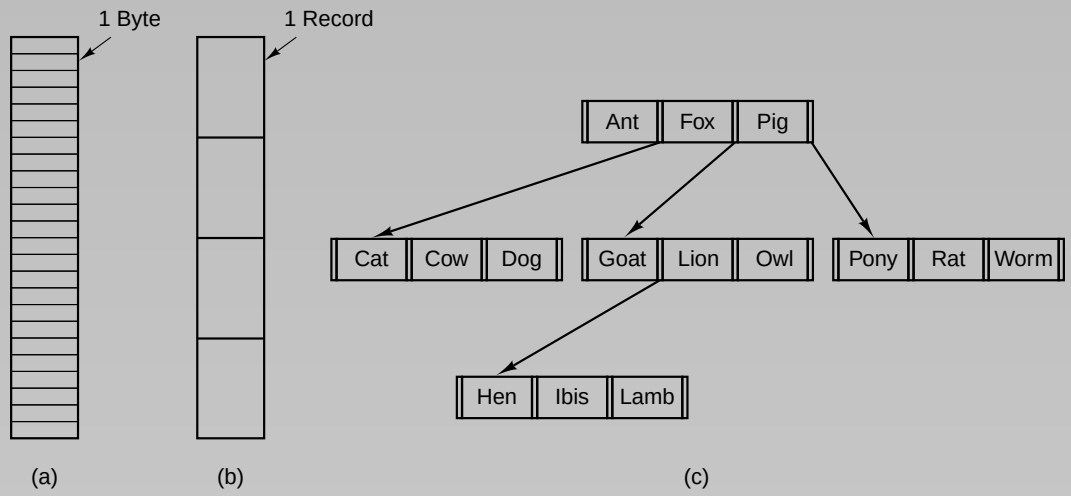


File Types V

- A simple executable binary file taken from a version of UNIX is seen in Fig. 5a .

Internal File Structure I

- Three common possibilities for structuring are depicted in Fig. 6.



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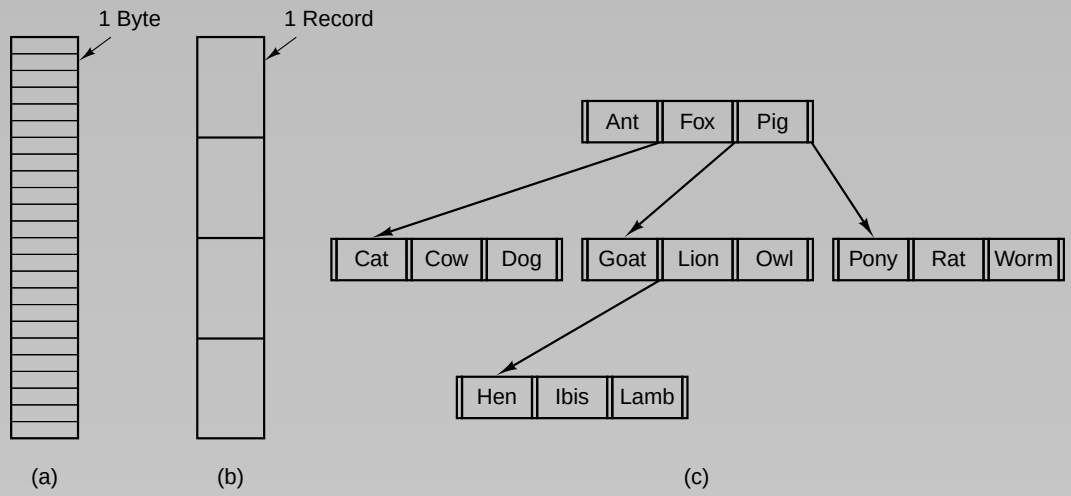

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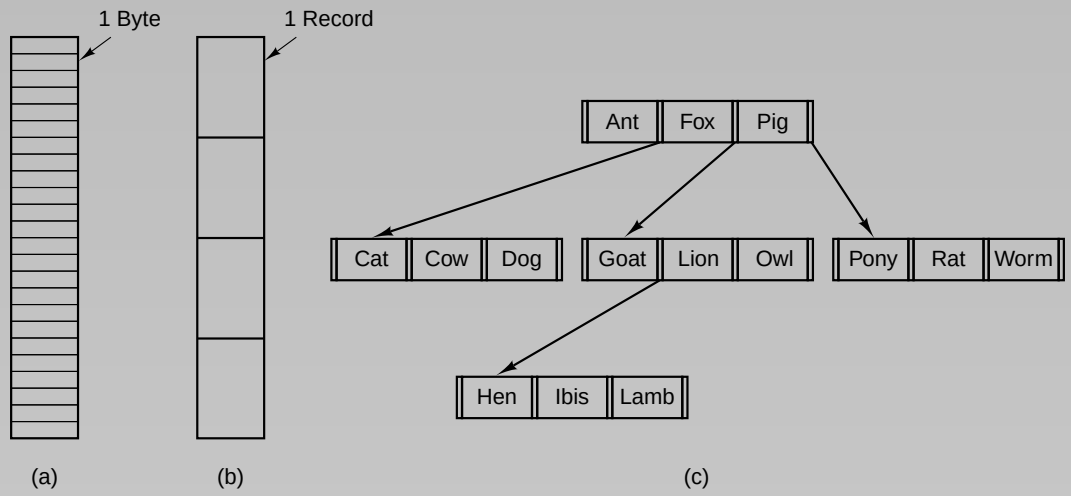

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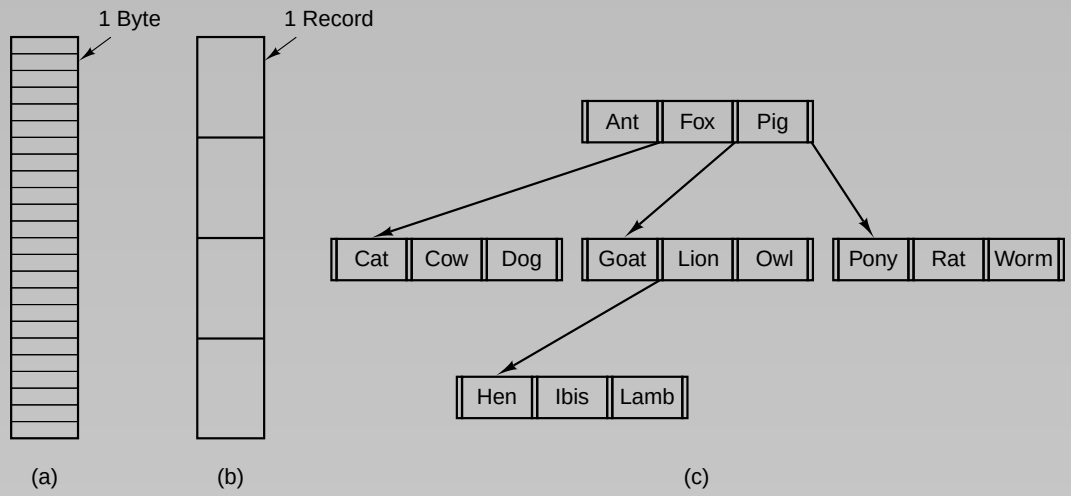

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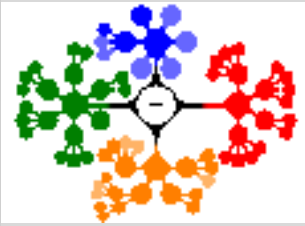

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- All file systems suffer from internal fragmentation; the larger the block size, the greater the internal fragmentation.

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  - Similarly, the write operation *write next* appends to the end of the file and advances to the end of the newly written material (the new end of file).

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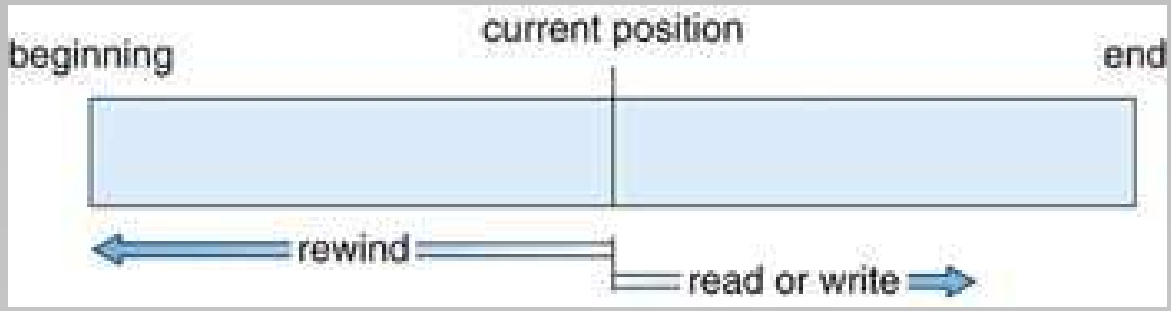
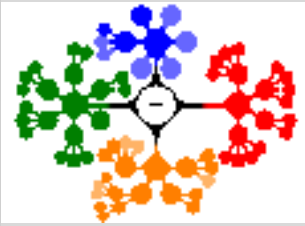


Figure: Sequential-access file.

Sequential access, which is depicted in Fig. 7, is based on a tape model of a file and works as well on sequential-access devices as it does on random-access ones.



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- The direct-access method is based on a disk model of a file, since disks allow random access to any file block.

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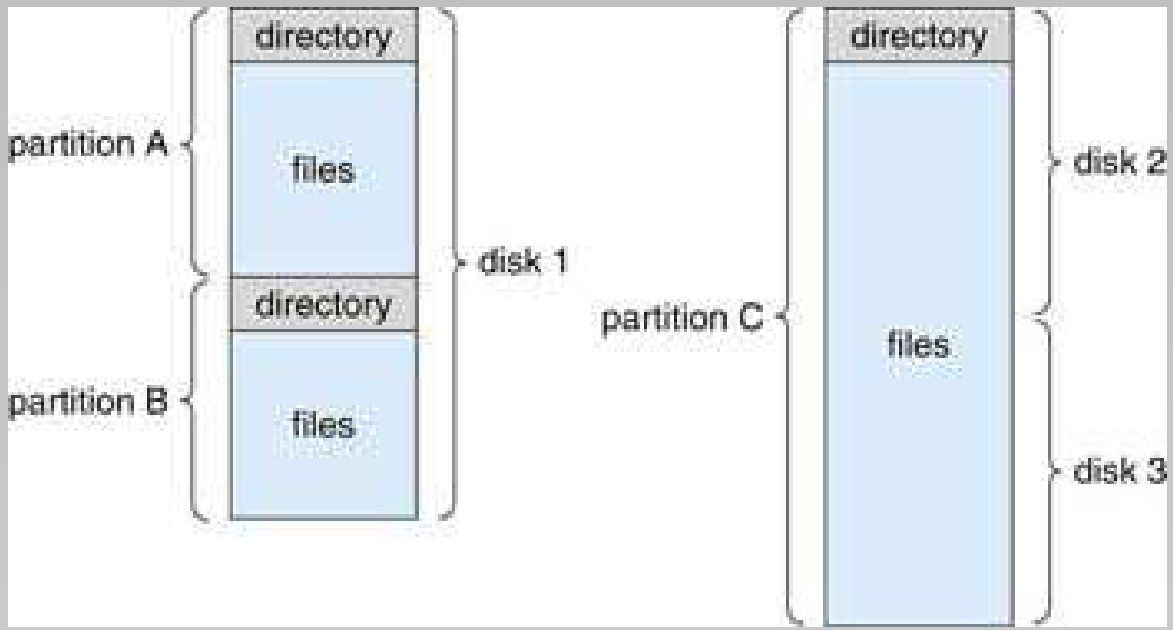
Storage Structure II

Figure 8 shows a typical file-system organization.



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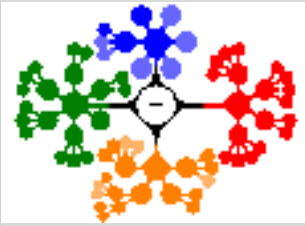

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  - **Traverse the file system**. We may wish to access every directory and every file within a directory structure. For reliability, it is a good idea to save the contents and structure of the entire file system at regular intervals (backup copy).

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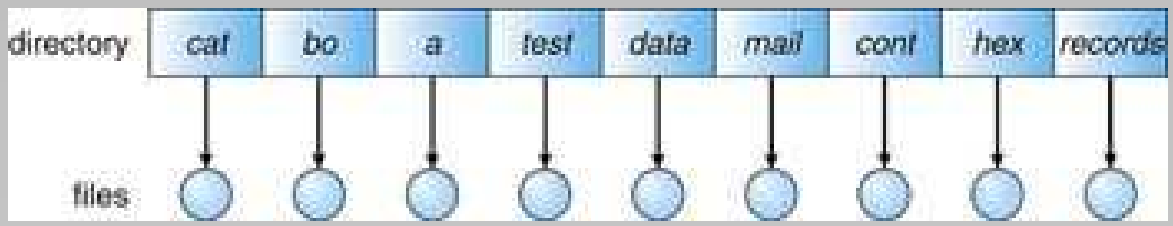

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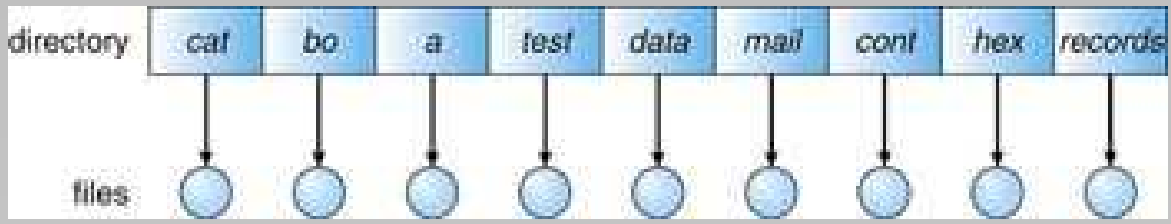

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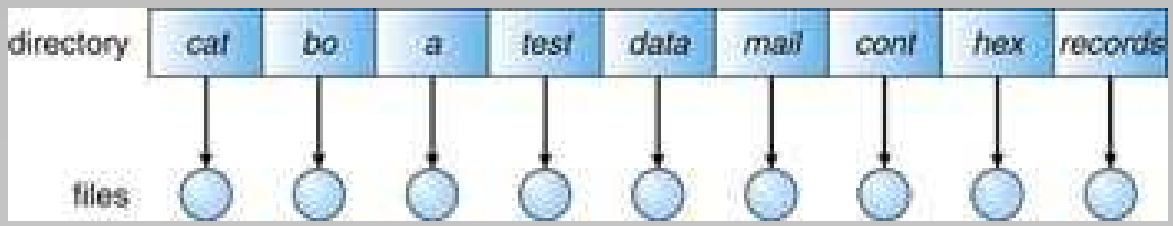

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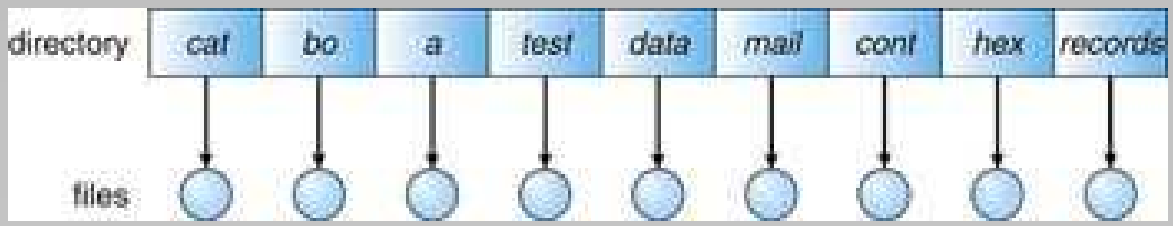

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- Even a single user on a single-level directory may find it difficult to remember the names of all the files as the number of files increases.

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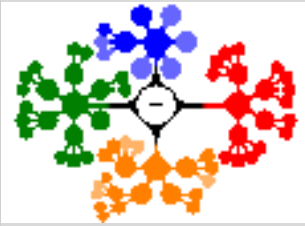

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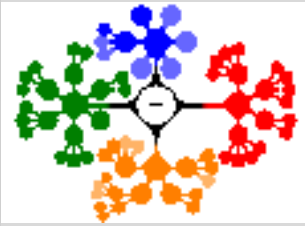

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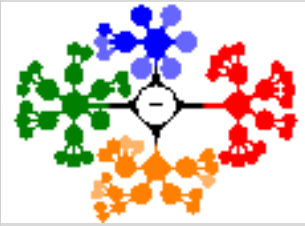

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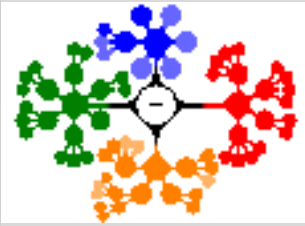

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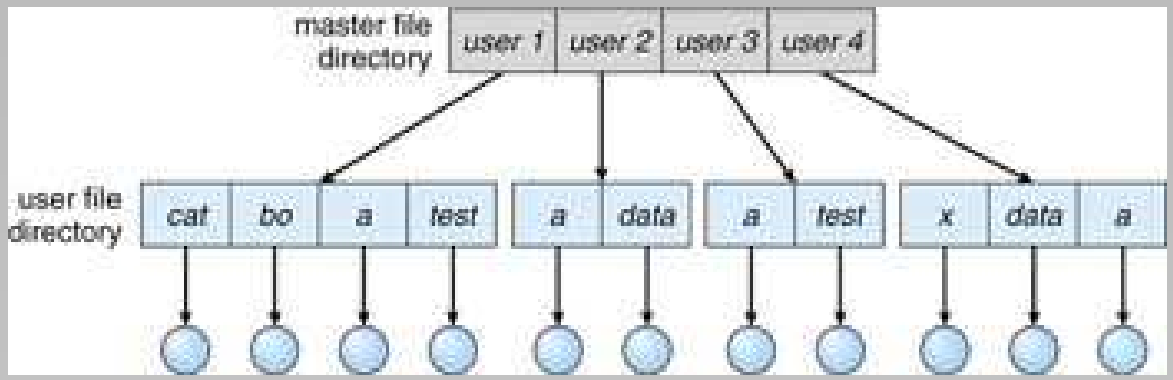

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Dr. Cem Özdoğan

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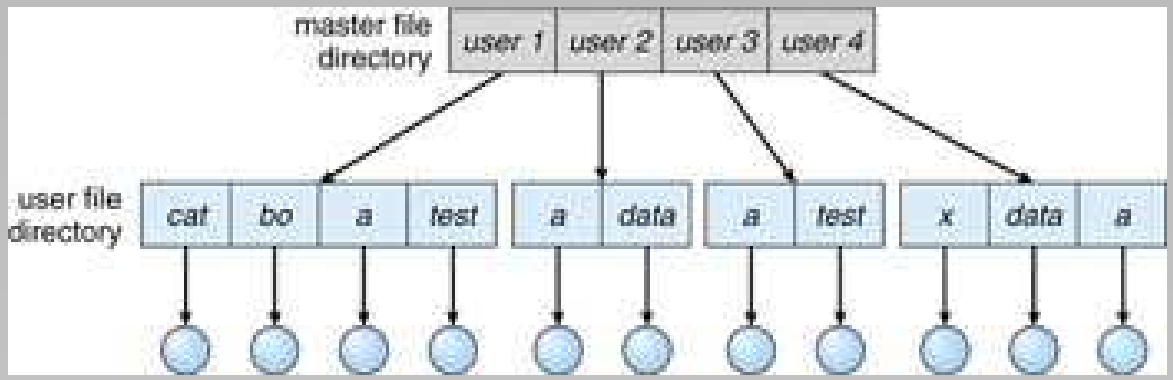

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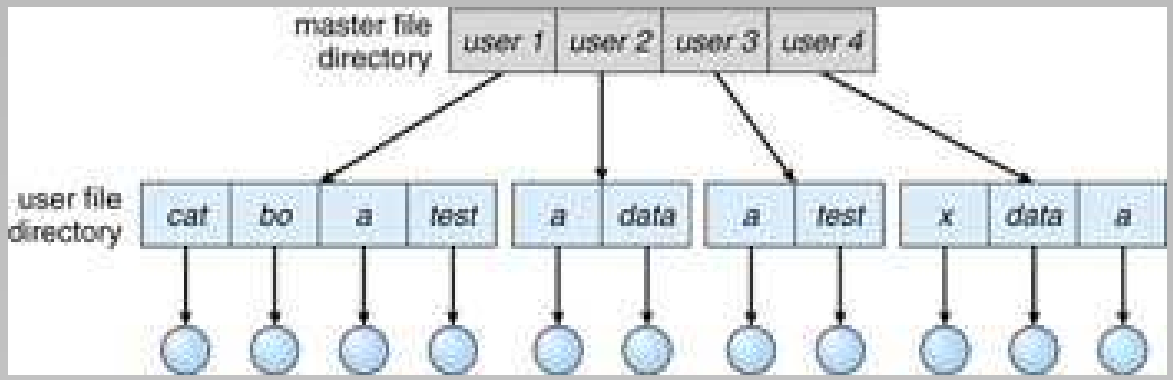

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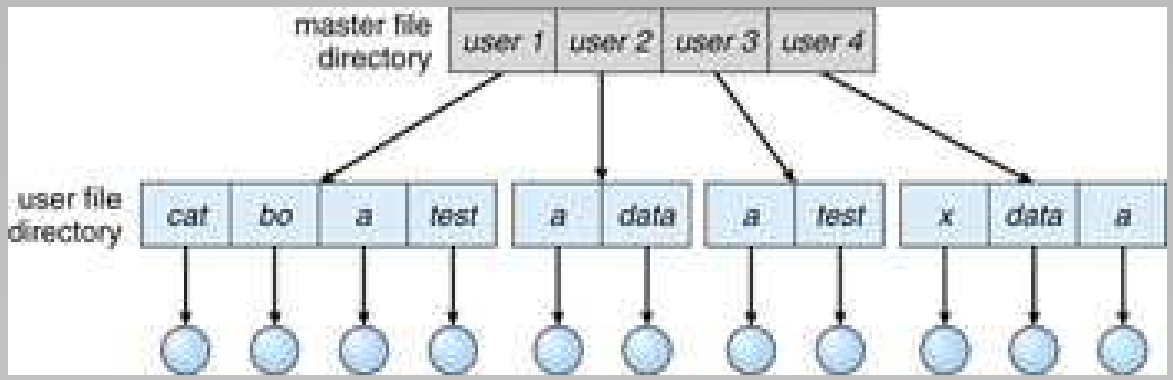

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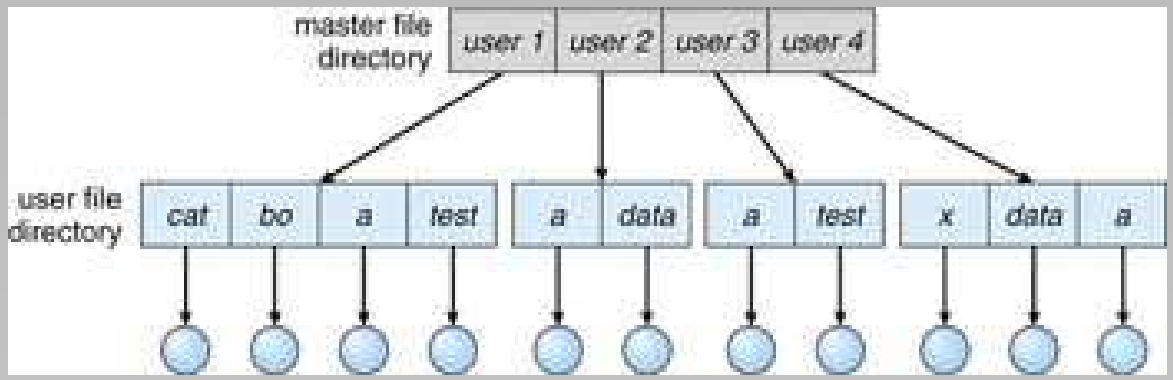

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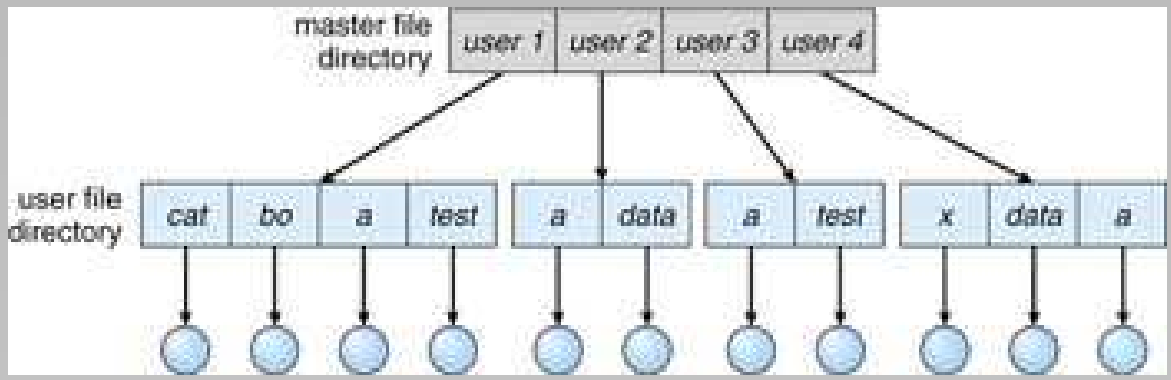

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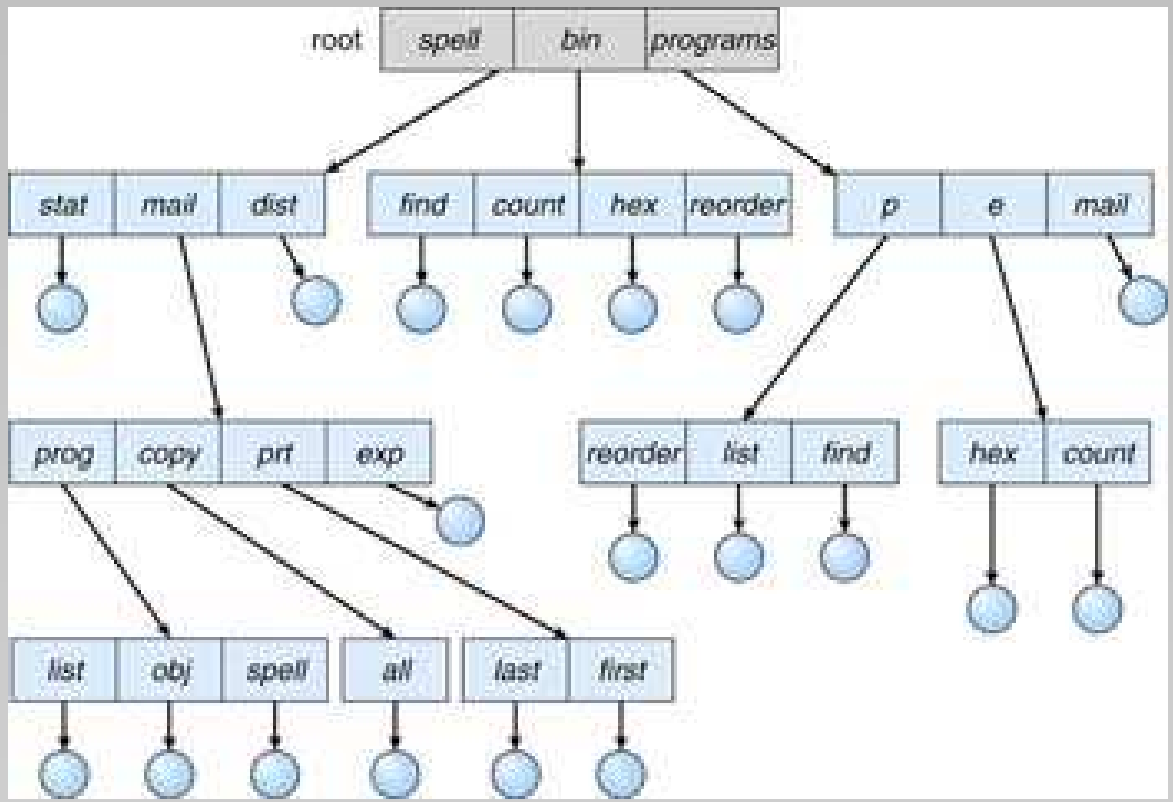
Two-Level Directory III

- Specifying a user name and a file name defines a path in the tree from the root (the MFD) to a leaf (the specified file).

Tree-Structured Directories I

- Once we have seen how to view a two-level directory as a two-level tree, the natural generalization is to extend the directory structure to a tree of arbitrary height (see Fig. 11).



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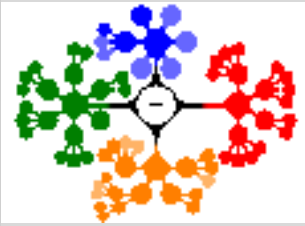

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- With a tree-structured directory system, users can be allowed to access, in addition to their files, the files of other users.
  - For example, user *B* can access a file of user *A* by specifying its path names.
  - User *B* can specify either an absolute or a relative path name.
  - Alternatively, user *B* can change her current directory to be user *A*'s directory and access the file by its file names.

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- An **acyclic graph** (a graph with no cycles) allows directories to share subdirectories and files (see Fig. 12).

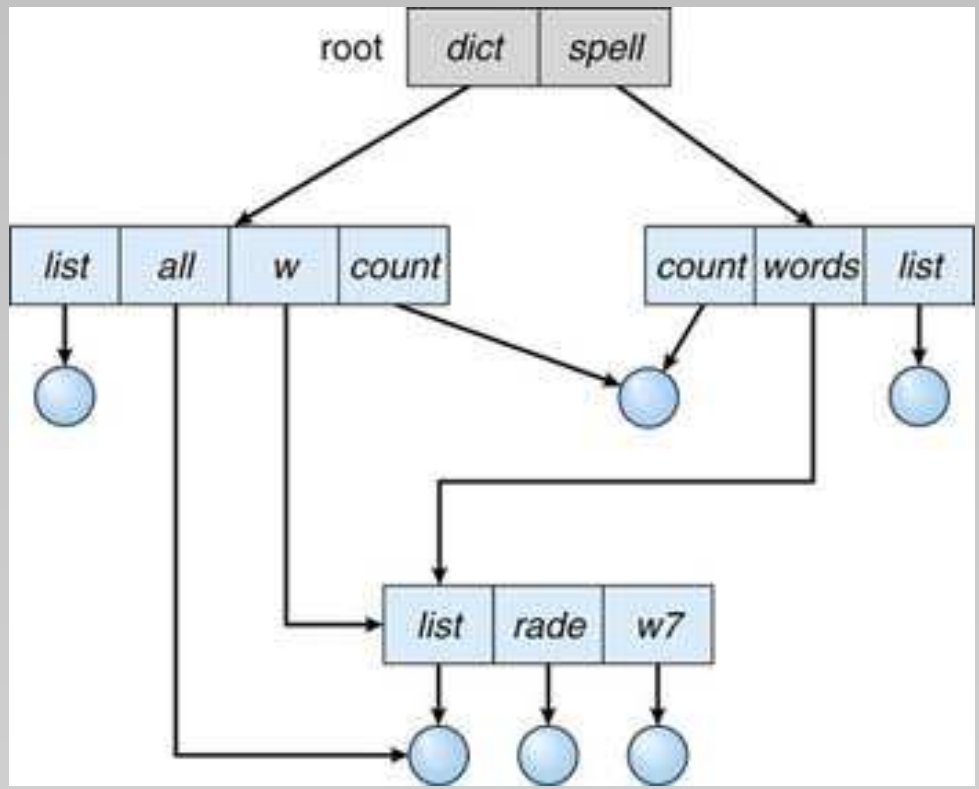

Figure: Acyclic-graph directory structure.

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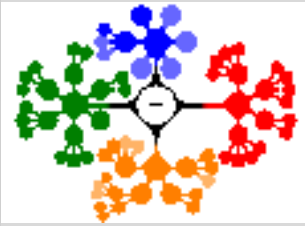

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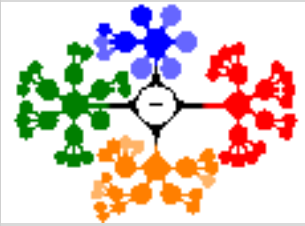

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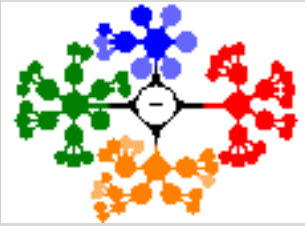

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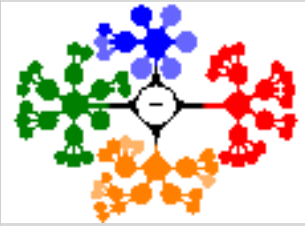

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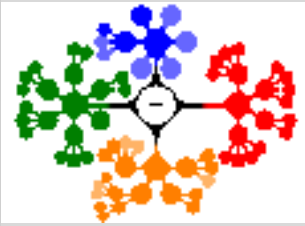

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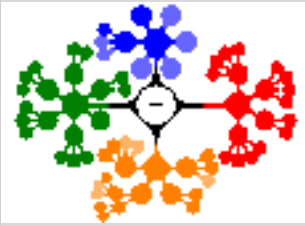

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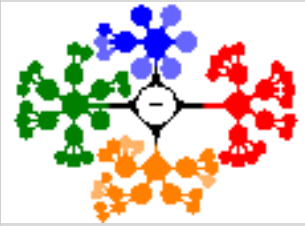

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- In the case of UNIX, symbolic links are left when a file is deleted. Microsoft Windows (all flavours) uses the same approach.

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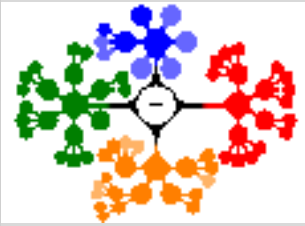

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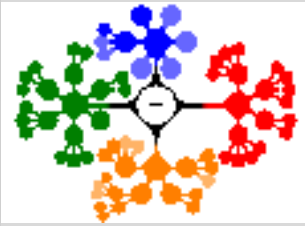

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- The UNIX OS uses this approach for non-symbolic links (or **hard links**), keeping a reference count in the file information block (or **inode**).

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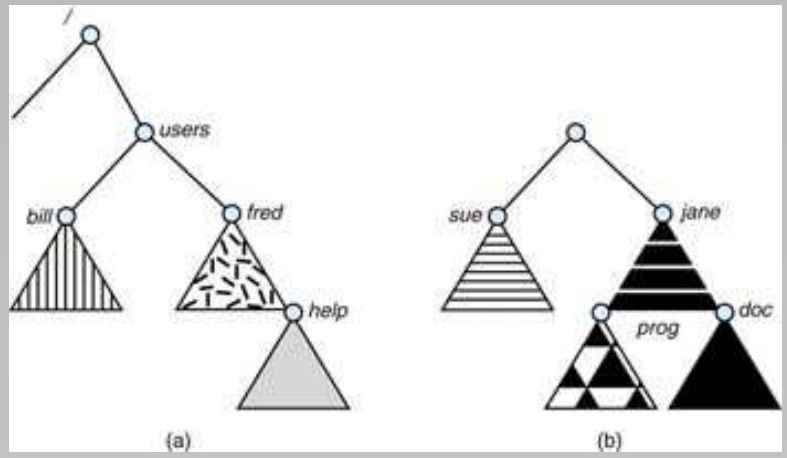


Figure: File system. (a) Existing system. (b) Unmounted volume.

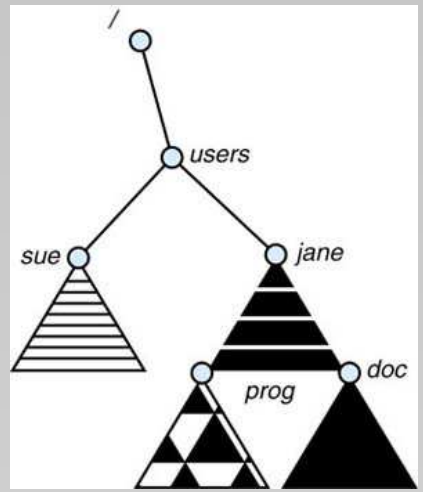
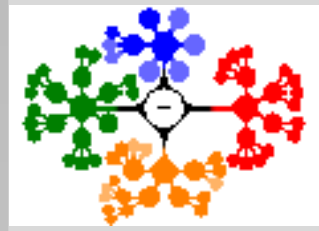


Figure: Mount point.



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- The result indicates which permissions are applicable.

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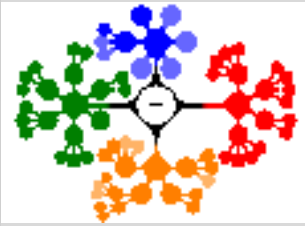

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- Bugs in the file-system software can also cause file contents to be lost.

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- These higher-level functions may be implemented by a system program that makes lower-level system calls.

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  - **Universe**. All other users in the system constitute the universe.

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- In this scheme, nine bits per file are needed to record protection information.