Lecture 34 - File Systems

CprE 308

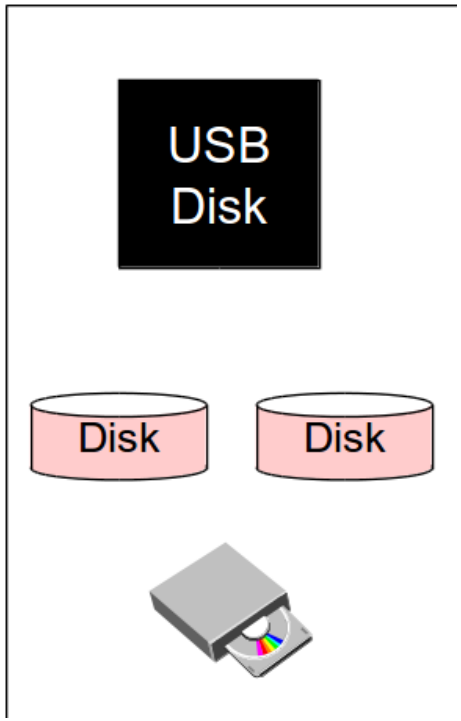
April 7, 2014

Intro

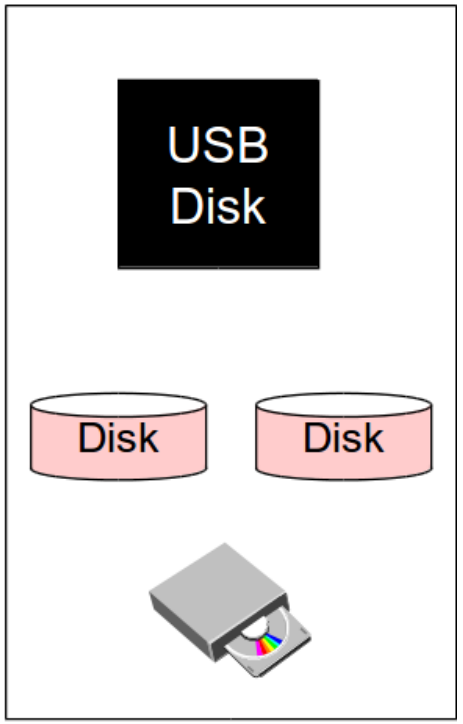
File System

- User View
- Programming Interface
- File System Implementation

Permanent Storage

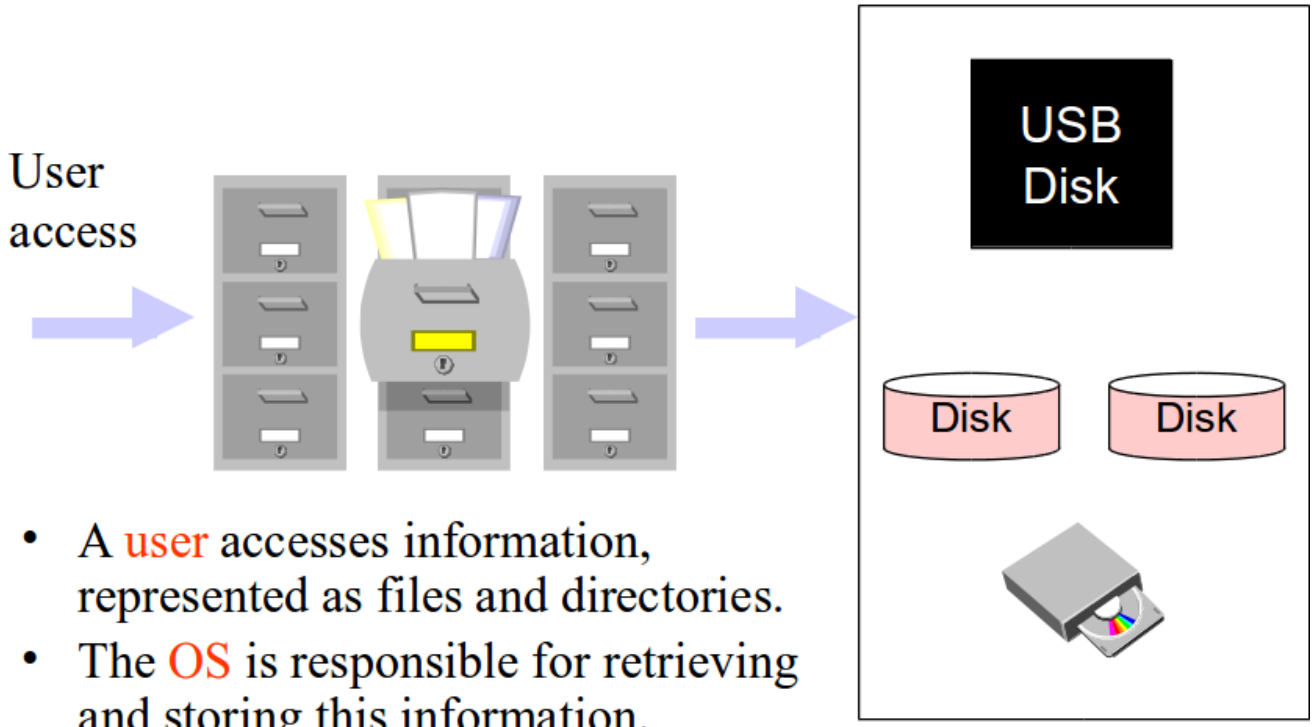


Files



- File system provides a simple abstraction of permanent storage

File System



- A user accesses information, represented as files and directories.
- The OS is responsible for retrieving and storing this information.

Roles of OS

Two important tasks of an operating system

1. Provides easy interface to hardware
2. Manages resources

Requirements

- Permanent storage (usually)
  - resides on disk (or alternatives)
  - survives software and hardware crashes
- User access
  - Regular users
  - Programmers (convenient programming interface)

File

User View of a File System

File Naming

- Usually ASCII characters, with extensions. E.g. myprog.c

Unix:

- Case is important "abc" different from "aBc"
- OS does not use filename extensions
  - Programmers might use them

Windows:

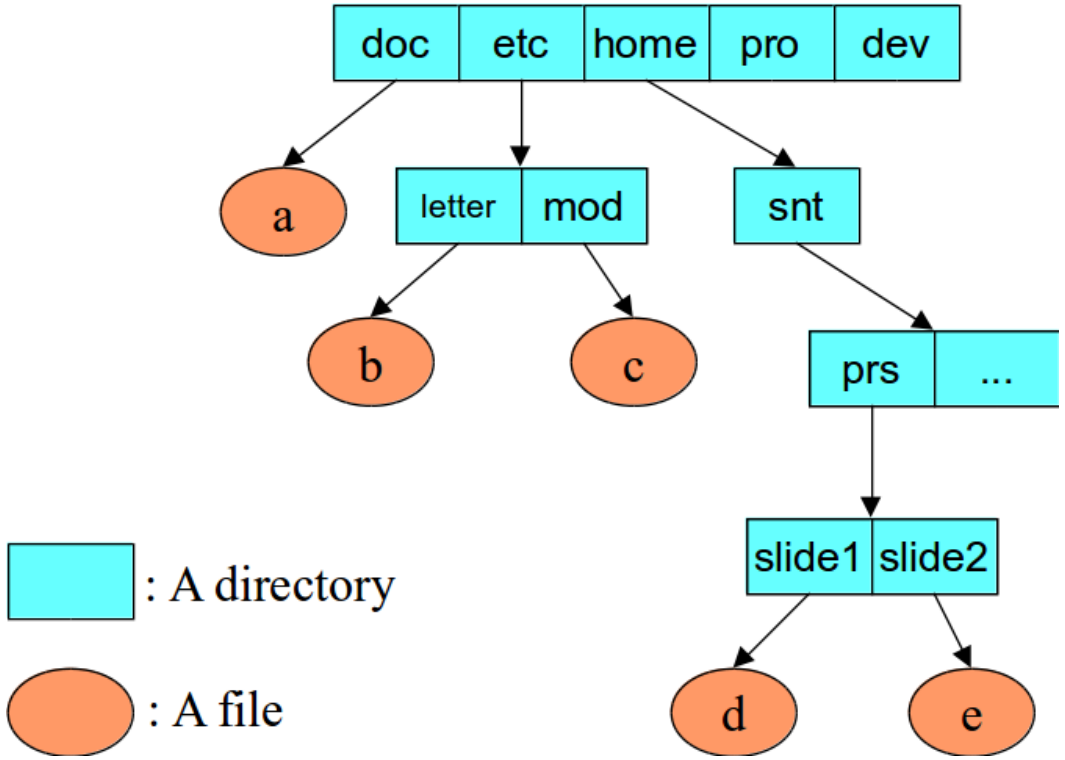
- Case insensitive names
- OS uses extensions to determine which programs to use to open the file
  - Ex: Clicking on "myfile.doc" opens up Microsoft word

File Naming

Extension	Meaning
file.bak	Backup file
file.c	C source program
file.gif	Compuserve Graphical Interchange Format image
file.hlp	Help file
file.html	World Wide Web HyperText Markup Language document
file.jpg	Still picture encoded with the JPEG standard
file.mp3	Music encoded in MPEG layer 3 audio format
file.mpg	Movie encoded with the MPEG standard
file.o	Object file (compiler output, not yet linked)
file.pdf	Portable Document Format file
file.ps	PostScript file
file.tex	Input for the TEX formatting program
file.txt	General text file
file.zip	Compressed archive

Typical file extensions

Hierarchical directory structure



- What about user interface for this structure?

Types of Unix Files

Data Files:

- ASCII files - lines of text
  - Special programs to handle these (`wc`, `grep`)
- Binary Files
  - Non ASCII characters (executable code, archive, .dvi, .pdf)

Directories:

- special files whose data contains a list of files

Special Files:

- Point to I/O devices

Special Files

ls -l /dev crw——— 1 root root 10, 3 Apr 11 2002 atimouse crw——— 1 root root 14, 4 Apr 11 2002 audio crw——— 1 root root 14, 20 Apr 11 2002 audio1 crw——— 1 root root 14, 7 Apr 11 2002 audioctl brw-rw—- 1 root disk 29, 0 Apr 11 2002 aztcd

1. Character Special Files (terminal, network device, etc.)
   - The device is abstracted by a stream of bytes that can only be accessed in sequential order.
2. Block Special Files (disks)
   - The device driver transfers chunks or blocks of data between the operating system and the device.

File Attributes

- Information about the file, but not a part of the file data
  - Protection (or permissions)
  - Owner
  - Time of creation
  - Current Size
  - Etc..
- Examples (in Unix)

```
-rw-r--r--  1 snt  users  443529 Sep 25 13:49 switching
drwxr-xr-x  4 snt  users      53 Oct  7 20:07 streams
```

Unix System Calls for Files

- `int open(const char *pathname, int flags, mode_t mode);`
  - Returns a file descriptor
- `ssize_t read(int fildes, void *buf, size_t count);`
  - Use the file descriptor
- `ssize_t write(int fildes, const void *buf, size_t count);`
  - Use file descriptor
- `off_t lseek(int fildes, off_t offset, int whence);`
  - Use file descriptor
- Delete, read attributes, set attributes, etc.

The open() call

```
#include <sys/tyles.h>
#include <sys/stat.h>
#include <fcntl.h>
int open (const char *path, int flags, [mode_t mode]);
```

- `char *path`: is a string that contains the *fully qualified filename* of the file to be opened
- `int flags`: specifies the method of access i.e. *read_only* (O_RDONLY), *write_only* (O_WRONLY), *read_and_write* (O_RDWR).
- `mode_t mode`: optional parameter used to set the access mode upon file creation (e.g. O_TRUNC, O_APPEND, . . .)

read() and write()

```
#include <fcntl.h>
ssize_t read(int filedes, void *buffer, size_t n);
ssize_t write(int filedes, const void *buffer, size_t n);
```

- `int filedes`: file descriptor that has been obtained though an `open()` or `create()` call.
- `void *buffer`: pointer to an array that will hold the data that is read or holds the data to be written.
- `size_t n`: the number of bytes that are to be read/written from/to the file.

An example

```
#include <fcntl.h>
#include <unistd.h>
main() {
    int fd;   /* a file descriptor */
    ssize_t nread;  /* # of bytes read */
    char buf[1024]; /* data buffer */
    /* open the file "data" for reading */
    fd = open("C:/mydata.dat", O_RDONLY);
    /* read in the data */
    nread = read(fd, buf, 1024);
    /* close the file */
     close(fd);
}
```

A `close()` call

- Although all open files are closed by the OS upon completion of the program, it is *good programming style* to "clean up" after you are done with any system resource.
- Please make it a habit to *close* all files that you program has used as soon as you don't need them anymore!

```
#include <fcntl.h>
int close(int filedes);
```

- Remember, closing resources timely can improve system performance and prevent deadlocks from happening (more later)

Random Access

```
#include <sys/types.h>
#include <unistd.h>
off_t lseek(int fd, off_t offset, int whence)
```

- sets the file pointer for fd:
  - if *whence* is SEEK_SET, the pointer is set to *offset* bytes;
  - if *whence* is SEEK_CUR, the pointer is set to its current value plus *offset* bytes;
  - if *whence* is SEEK_END, the pointer is set to the size of the file plus *offset* bytes
- it returns the (possibly) updated value of the file pointer relative to the beginning of the file. Thus, `n = lseek(fd, (off_t)0, SEEK_CUR);` returns the current value of the file pointer for fd

Standard File Descriptors

```
main( ) {
    char buf[100]; int n;
    const char* note = "Write failed\n";
    while ((n = read(0, buf, sizeof(buf))) > 0)
        if (write(1, buf, n) != n) {
            (void)write(2, note, strlen(note));
            exit(EXIT_FAILURE);
        }
    return(EXIT_SUCCESS);
}
```

- File descriptor 0: standard input
- File descriptor 1: standard output
- File descriptor 2: standard error output