

Lecture P3: Unix



Overview

What is an OS?

Files

- Abstraction for storage (disks).
- File manipulation commands.

Processes.

- Abstraction for processor (CPU).
- Some useful commands.

Interactions.

- Between files and processes.
- I/O redirection and pipes.

Layers of Abstractions in Unix OS

Bare hardware.

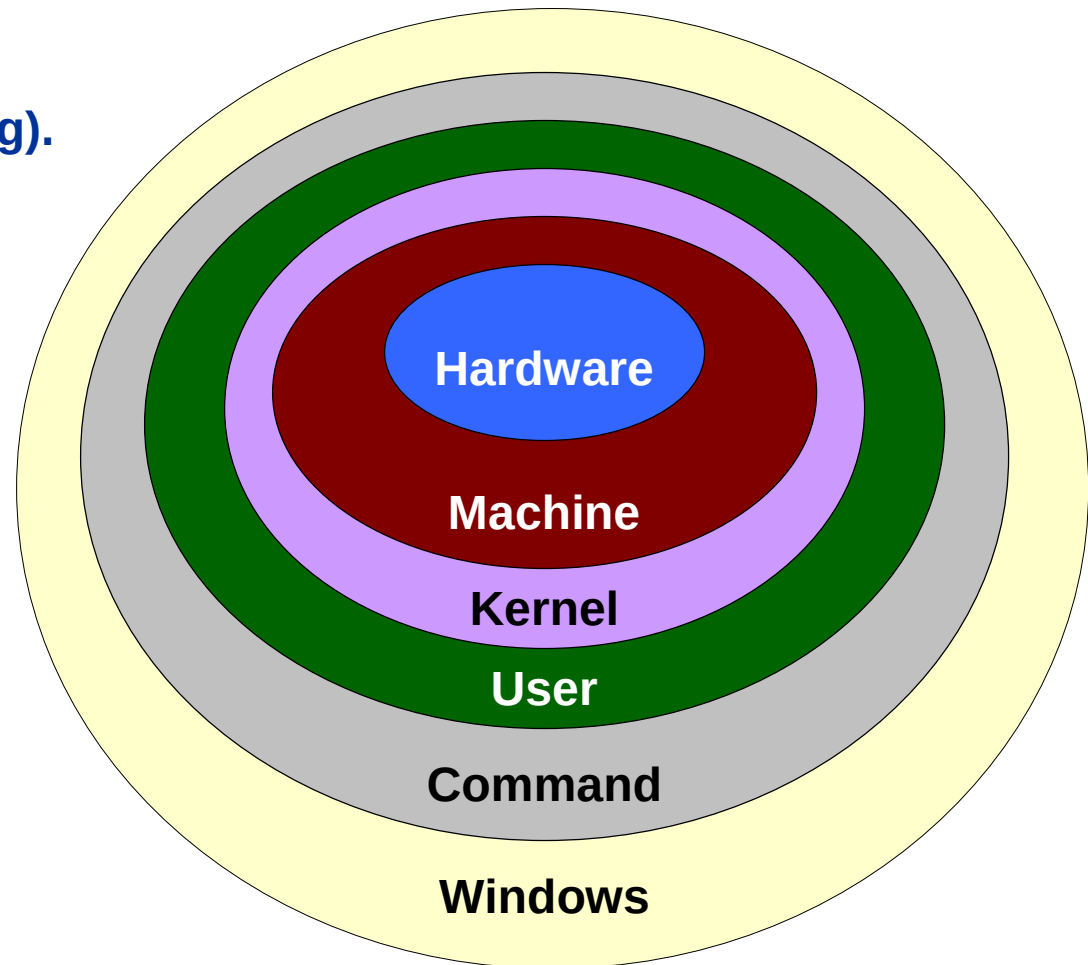
Machine language.

Kernel.

User level (C programming).

Command level (shell).

Window system.



Operating Systems

Multics (1965-1970)

- Ambitious OS project at MIT.
- Pioneered most of innovations in modern OS.
 - file system
 - protection
 - virtual machines
- A little ahead of its time.

Unix History

Multics (1965-1970).

Unix / Linux (Thompson and Ritchie 1969).

- **Simplicity and elegance.**
 - **C language, bootstrapped implementation**
 - **integrated command structure**
 - **simplified, integrated file system**
 - **used by most programmers**
- **Continued development at AT&T (1970's) and "shepherding it out."**
- **Berkeley "BSD" (1978-1993): TCP/IP.**
- **Various flavors of commercial Unix (1980-1990).**
- **Linux gave it new life (1991 - present).**

Operating Systems

Multics (1965-1970).

Unix / Linux (Thompson and Ritchie 1969).

DOS.

Macintosh.

Windows.

- **OS definition under litigation.**

Files

File.

- Sequence of bits.
- A simple and powerful abstraction for permanent storage (disks).
- Extended for things beyond disks.

"Everything in Unix is a file."

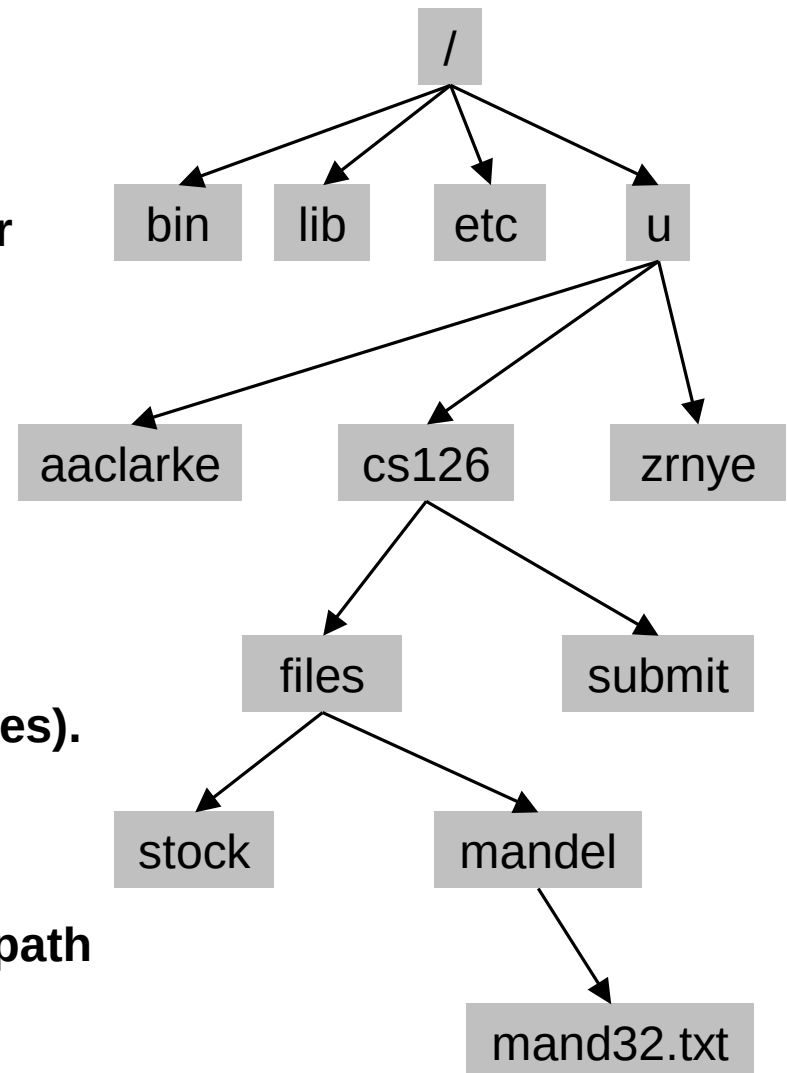
Directory.

- Sequence of files (and other directories).

Filename.

- Sequence of directory names on the path from "/" to the file.

`/u/cs126/files/mandel/mand32.txt`



File Manipulation Commands

cat, more

% more xx

show the contents of a file

cp, rm, mv

% cp xx yy

% rm xx

% rm *

% mv xx yy

copy, remove, move

copy file xx to yy

delete file xx

delete all files in current directory!

rename file xx to yy

ls

% ls

% ls *.c

% ls -tr

% ls -l

list file names

list all files in current directory

list all files ending in .c

list all files, reverse-sorted by date

list all file details (permissions, size)

File Manipulation Commands

mkdir, rmdir
% mkdir hello

make or remove directory
make a new directory named hello

pwd

print name of current (working) directory

cd
% cd ..
% cd ~
% cd ~xx

change directory
to parent directory
to my home directory
to xx's home directory

chmod

change read/write permissions

% chmod 600 hello.c **only you can read/write file hello.c**
% chmod 700 mandel **for all files in directory mandel**
% chmod 644 index.html **all Princeton students can read it**

Processes

Process.

- An abstraction for the processor (CPU).
- Almost every command is a process.

Over 2,500 standard commands.

- Thousand more available.
- EXTENSIBLE: can even add your own.

Unix Commands

lpr

% lpr hello.c

send file to printer

print file hello.c

man, apropos

% man ls

online documentation

get help on using ls command

cal, date, xclock

% cal 9 2000

% date

time utilities

display calendar for September, 2000

display current date

bc, xcalc

% xcalc

calculators

graphical version of scientific calculator

maple, matlab

scientific computing

Unix Commands: Text Processing

grep, awk, perl **pattern matching**

sort **sort the lines of a file**

diff **print out any lines where two files differ**

emacs, latex **text processing**
% emacs hello.c **edit file hello.c**

ispell **text processing**
% ispell readme **spell-checker**

Unix Commands: Programming

emacs, xemacs

% emacs hello.c

text processing

edit file hello.c

cc, lcc, gcc,

g++, javac

% gcc hello.c

C compilers

C++, Java compilers

compile C program hello.c

gdb, jdb

C and Java debuggers

Unix Commands: Specialized for COS 126

emacs126, xemacs126

% xemacs hello.c &

use our customizations as default

enscript126

% enscript126 hello.c

pretty-print C code

gcc126

% gcc126 hello.c

compile with warnings

submit126

% submit126 0 hello.c

submit COS 126 assignment for grading

Unix Commands: Multimedia

acroread, ghostview

% ghostview xx.ps

% acroread yy.pdf

display documents

display PostScript file xx.ps

display Acrobat file yy.pdf

xv, gs

% xv giraffe.gif

% gs mand.ps

display graphics

display graphics file giraffe.gif

display graphics mand.ps

xfig

create figures

audiotool

play or record music

soffice

StarOffice: free Office clone

Unix Commands: Communication

mail, pine

email

rn

read newsgroups

netscape

browse web

telnet, rlogin, ssh

login to remote computer

ftp, sftp

download files

Multiprocessing

Abstraction provided by operating system.

- MULTIPLE "virtual" machines for your use.
- Outgrowth of 1960s "time-sharing."

For COS126.

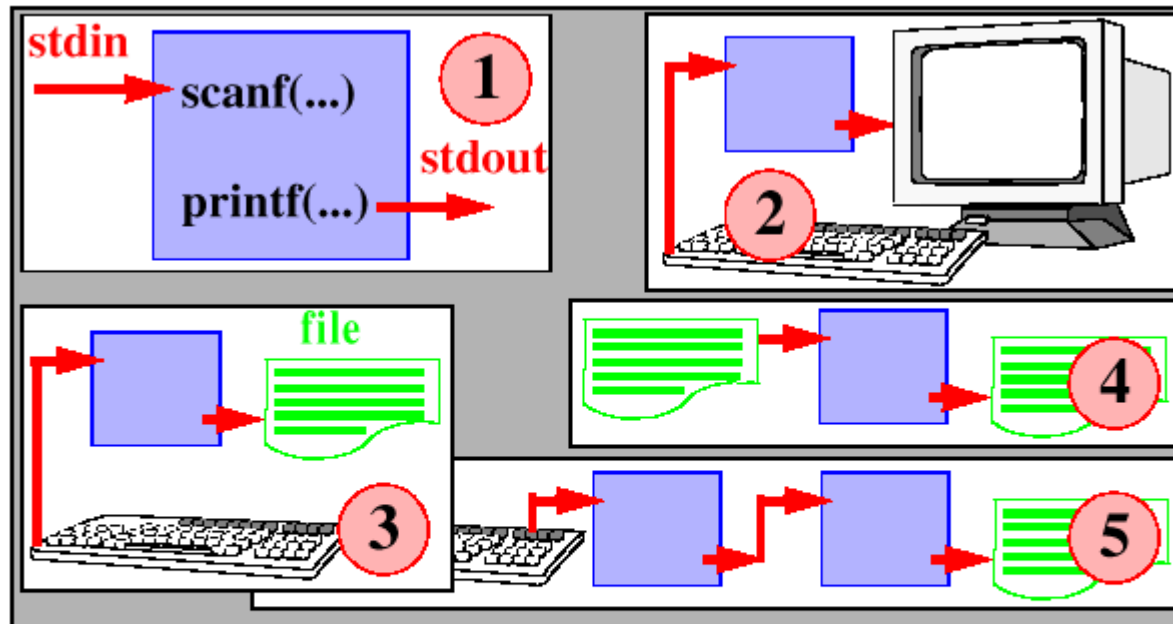
- One window for editor.
- One window for UNIX commands.

Note: can use ctrl-Z
and bg instead of &

Unix	
% emacs hello.c &	
[1] 18439	
% netscape &	
[2] 18434	
% jobs	
[1] + Running	emacs hello.c
[2] - Running	netscape

Ampersand
indicates "do this
in the background"

I/O Redirection and Pipes



- 1: "Standard I/O", 2: default attachment, 3: redirect output
- 4: redirect both input and output, 5: pipes

Filters and Pipes

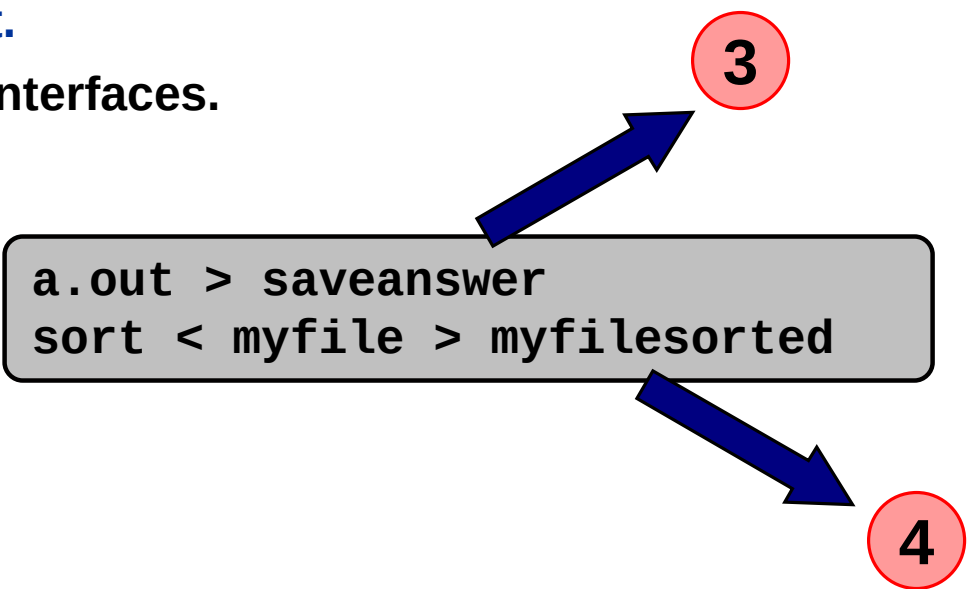
Standard input, standard output.

- Abstract files for command interfaces.

Redirection:

- Standard input from file.
- Standard output to file.

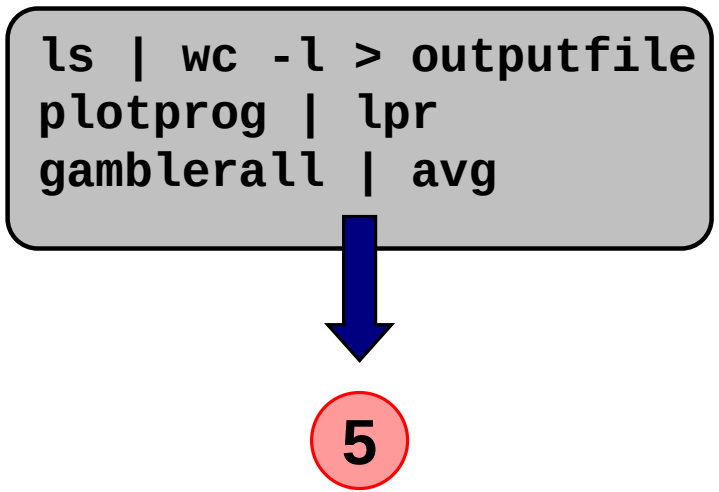
```
a.out > saveanswer  
sort < myfile > myfilesorted
```



Piping:

- Connect standard output of one command to standard input of the next.

```
ls | wc -l > outputfile  
plotprog | lpr  
gamblerall | avg
```



Don't confuse redirection and piping.

```
plotprog > lpr
```

Shell

Command interface to UNIX.

Just another programming language.

- sequence of instructions
- variables
- branches, loops

```
mv file1 tmp;  
mv file2 file1;  
mv tmp file2
```

Shell program to annoy Steve with email

repeat 5 times

email Shapiro

wait 1 minute

```
#!/bin/csh -f  
@ n = 0  
while ($n < 5)  
    printf "Goodbye.\n" |  
        mail -s "yo Hal!" hts@princeton.edu  
    @ n = ($n + 1)  
    sleep 60  
end
```

Shell

EXTENSIBLE: add another command.

- rename a.out
- or chmod 700 a file containing shell commands

Unix

```
% gcc avg.c  
% mv a.out avg  
% gamblerall | avg | lpr
```

Primary use.

- low overhead "programming" to manipulate files and invoke commands

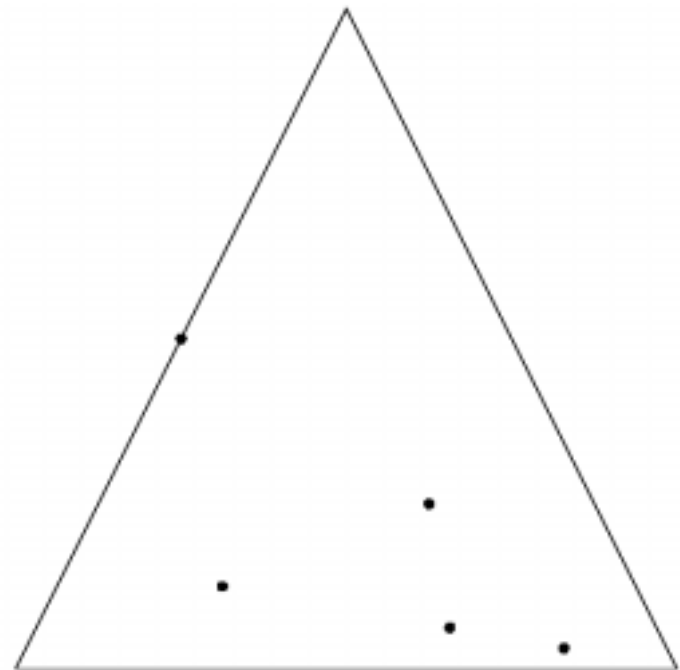
Graphics

ANSI C does not directly support graphical output.

- Need help from operating system.
- In this course we use "PostScript" to get cool pictures.
- Don't worry about details yet.

Unix

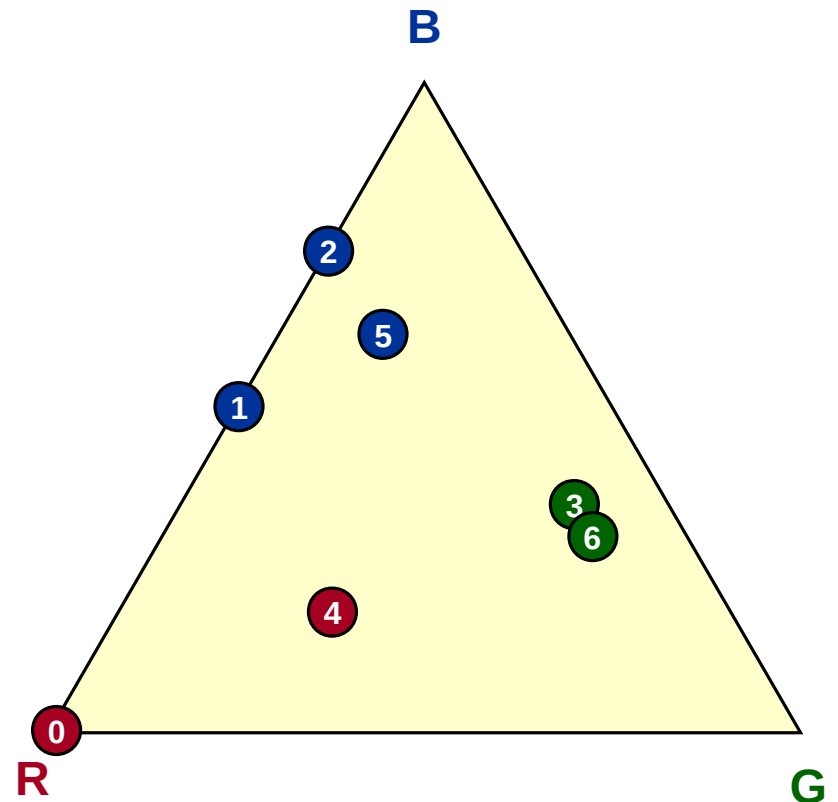
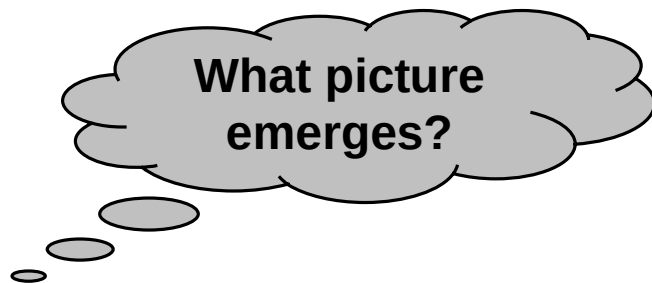
```
phoenix.Princeton.EDU% cat ifs.ps
%!
50 50 translate
0 0 moveto 512 0 lineto
256 512 lineto closepath stroke
/pt {0 360 arc fill} def
125.0 250.0 5.0 pt
312.5 125.0 5.0 pt
156.2 62.5 5.0 pt
328.1 31.2 5.0 pt
414.1 15.6 5.0 pt
showpage
phoenix.Princeton.EDU% gs ifs.ps
```



Graphics

Game played on equilateral triangle, with vertices R, G, B.

- Start at R.
- Repeat the following:
 - pick a random vertex
 - move halfway between current point and vertex
 - draw a "dot" in color of vertex



Graphics

ifs.c

```
#include <stdlib.h>
#include <stdio.h>
#define N 50000
int randomInteger(int n) { ... }

int main(void) {
    int i, r;
    double x = 0.0, y = 0.0, x0, y0;

    for (i = 0; i < N; i++) {
        r = randomInteger(3);
        if (r == 0)          { x0 = 0.0; y0 = 0.0; }
        else if (r == 1) { x0 = 512.0; y0 = 0.0; }
        else                  { x0 = 256.0; y0 = 512.0; }
        x = (x0 + x) / 2.0;
        y = (y0 + y) / 2.0;
        printf("%f %f\n", x, y);
    }
    return 0;
}
```


Graphics

Text output is boring.

- Replace and add `printf()` statements to create PostScript.
- Use `gs` to view PostScript file.

ifs.c

. . .

```
printf("%%!\n 50 50 translate\n");  
printf("/pt {0 360 arc fill} def\n");  
printf("0 0 moveto 512 0 lineto ");  
printf("256 512 lineto closepath stroke\n");
```

draw enclosing
triangle

```
for (i = 0; i < N; i++) {  
    . . .  
    printf("%f %f 1.0 pt\n", x, y);  
}
```

```
printf("showpage\n");
```