CSCI 4061: Unix Basics

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Logistics

Reading: Stevens and Rago

- Ch 1: Unix Overview
- Ch 2: Unix Standards (skim)
- Ch 7: Processes (Up Next)

Goals Today

- Finish C review
- Unix Basics
- Process Sys Calls

Assignments

- HW01/Lab01 up
- Due Mon 2/1
- Project 1 is coming

Lab01 Today

- Comments?
- Discord work alright?

Wrap up C Programming Exercises

- Finish Reviewing C programs from last time
- Answer any pressing questions
- Reminder: C programming links on Canvas Homepage

Access to Unix Machines

Several options described in a class tutorial getting access to Unix

https://www.cs.umn.edu/~kauffman/tutorials/unix-environment

- CSE Labs
  - Via SSH
  - Via http://vole.cse.umn.edu
- Windows: Maybe Windows Subsystem for Linux (WSL)
- Mac OS X: No native environment, use a Virtual Machine
- Any: Install VirtualBox to host a Unix you like
- Install Native Linux or BSD: *"Now you're playing with power!"*

Unix Standards: POSIX

POSIX defines what you an plausibly expect on unix-like systems like Linux/BSD. Includes

- C libraries for system calls, standard libraries
- Basic layout of file system and naming conventions
- Some Devices such as `/dev/null`
- Presence of a shell and certain utilities like `cat`, `grep`, `...`

Distinction: C Standard vs Unix Library

- Lots of systems have a C compiler which has the C standard library: `printf()`, `fopen()`, `pow()` etc.
- Unix systems have additional, separate libraries for Unix-specific stuff like `read()`, `fork()`, `kill()`
- Some branches of Unix have their own special, special versions of these like Linux `clone()`

Brief Tour of Unix Utilities

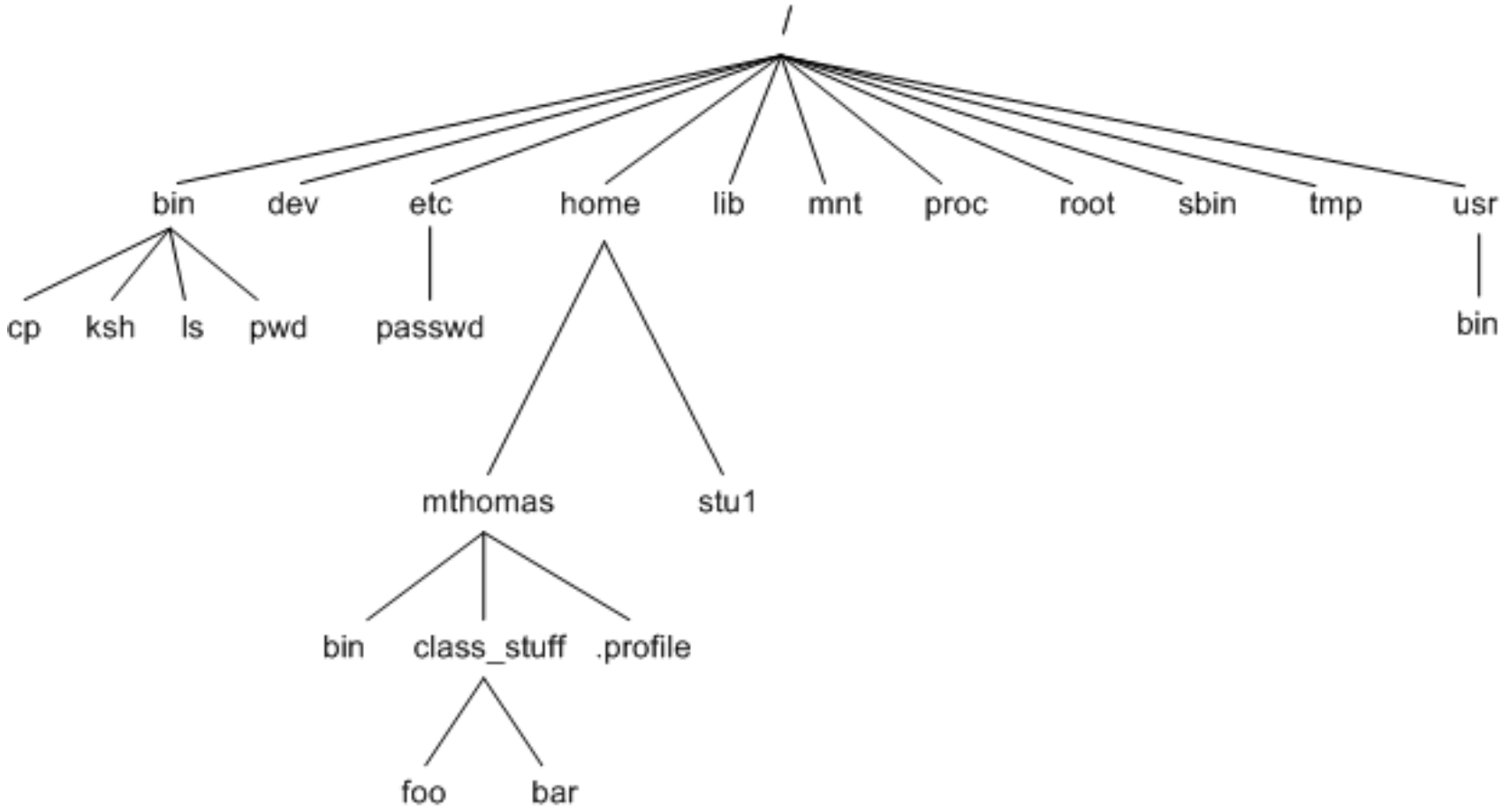
- Will discuss briefly tools that are useful for interacting with Unix in a "command shell"
- Shell / Terminal / Command Line / Non-graphical login, etc.
- Most of the discussion is widely applicable to any Unix system
- A few parts are specific to the **Bash** shell specifically (alternatives exist but Bash is default on many systems)

Command Line: Basic File System Navigation

Command	Effect
`pwd`	print the current directory
`cd folder`	change directory / folder
`ls`	list files in directory
`cd ~`	change to home directory

```
> pwd
/home/kauffman
> ls
1103-F2017  aurs     Downloads  Hello.class  Hello.java~  PathClassLoader.txt
4061-F2017  Desktop  Dropbox    Hello.java   misc         public_html
> cd 4061-F2017
> ls
exams  lectures  Makefile~  projects       schedule.html~  schedule.org~  textbook
labs   Makefile  misc       schedule.html  schedule.org    syllabus
> pwd
/home/kauffman/4061-F2017
> cd lectures
> pwd
/home/kauffman/4061-F2017/lectures
> ls
00-course-mechanics.org   00-course-mechanics.tex   01-introduction.org   01-introduction.tex
00-course-mechanics.org~  01-introduction-code      01-introduction.org~  02-unix-basic.c
00-course-mechanics.pdf   01-introduction-code.zip  01-introduction.pdf   02-unix-basics.org
> cd ~
> pwd
/home/kauffman
> ls
1103-F2017  aurs     Downloads  Hello.class  Hello.java~  PathClassLoader.txt
4061-F2017  Desktop  Dropbox    Hello.java   misc         public_html
```

Typical Unix Directory Structure



Source: The Unix File System by Mark Thomas

- rooted at /, reachable via 'cd /'
- user directories such as `/home/kauffman/`

Determining File Types

Command	Effect
`file something.ext`	try to determine the type of given file

```
> file xxx
xxx: UTF-8 Unicode text, with very long lines
> file test.txt
test.txt: ASCII text
> file www
www: directory
> file 4061-F2017
4061-F2017: symbolic link to /home/kauffman/Dropbox/teaching/4061-F2017
> file 4061-F2017/
4061-F2017/: directory
> cd 4061-F2017/lectures/
> file 01-introduction-code.zip
01-introduction-code.zip: Zip archive data, at least v1.0 to extract

> file 02-unix-basics-code/no_interruptions.c
02-unix-basics-code/no_interruptions.c: C source, ASCII text

> file 02-unix-basics-code/no_interruptions.o
02-unix-basics-code/no_interruptions.o: ELF 64-bit LSB relocatable, x86-64, version 1 (SYSV),
not stripped

> file 02-unix-basics-code/a.out
02-unix-basics-code/a.out: ELF 64-bit LSB shared object, x86-64, version 1 (SYSV),
dynamically linked, interpreter /lib64/ld-linux-x86-64.so.2, for GNU/Linux 2.6.32,
BuildID[sha1]=ffb87934737b0e48b891d27573ae8a2e5687c46a, not stripped
>
```

Searching and Manipulating Text

Command	Effect
`cat file.txt`	show contents of file in terminal
`less file.txt`	"page" text file, press "q" to quit
`grep 'expression' file.txt`	show lines matching expression in file
`grep 'expression' *.txt`	search every `.txt` file for lines
`find .`	show all files recursively from current directory
`find . -name '*.c'`	find all C source files recursively

These are very handy, worth knowing about, but won't be covered in detail during our course. Try the relevant session in Tool Time Lectures if curious.

Editing Files

- There are fancy text editors like Atom (free, GUI, on lab machines)
- Then there are the old-school terminal editors like these:

Command	Effect
`vi`	modal editing, terse, powerful, ALWAYS present
`emacs`	modes for editing, extensible, mostly available, ♡
`nano`	simple, podunky, usually available

- Learn some vi or emacs: long-term worthwhile investment
- Comes in real handy when you need to edit but there is no graphical login

File Permissions / Modes

- Unix enforces file security via *modes*: permissions as to who can read / write / execute each file
- See permissions/modes with `ls -l`
- Look for series of 9 permissions

```
> ls -l
total 140K
-rwx--x--- 2 kauffman faculty  8.6K Oct  2 17:39  a.out
-rw-r--r-- 1 kauffman devel    1.1K Sep 28 13:52  files.txt
-rw-rw---- 1 kauffman faculty  1.5K Sep 26 10:58  gettysburg.txt
-rwx--x--- 2 kauffman faculty  8.6K Oct  2 17:39  my_exec
---------- 1 kauffman kauffman  128 Oct  2 17:39  unreadable.txt
-rw-rw-r-x 1 root     root     1.2K Sep 26 12:21  scripty.sh
 U  G  O     O        G        S    M T           N
 S  R  T     W        R        I    O I           A
 E  O  H     N        O        Z    D M           M
 R  U  E     E        U        E      E           E
    P  R     R        P
^^^^^^^^^^
PERMISSIONS
```

- Every file has permissions set from somewhere on creation

Changing File Permissions

Command	Effect
`ls -l`	long listing of files, shows permissions
`chmod u+x file.abc`	make file executable by user
`chmod o-rwx file.abc`	remove permissions from other users
`chmod 777 file.abc`	everyone can do anything to file

```
> ls
a.out  no_interruptions.c  no_interruptions.c~  no_interruptions.o
> ls -l
total 40K
-rwxrwx--- 1 kauffman kauffman 8.5K Sep  7 09:55 a.out
-rw-r--r-- 1 kauffman kauffman  955 Sep  7 09:55 no_interruptions.c
-rw-r--r-- 1 kauffman kauffman  883 Sep  7 09:54 no_interruptions.c~
-rw-rw---- 1 kauffman kauffman 2.4K Sep  7 11:59 no_interruptions.o
> chmod u-x a.out
> ls -l
total 40K
-rw-rwx--- 1 kauffman kauffman 8.5K Sep  7 09:55 a.out
-rw-r--r-- 1 kauffman kauffman  955 Sep  7 09:55 no_interruptions.c
-rw-r--r-- 1 kauffman kauffman  883 Sep  7 09:54 no_interruptions.c~
-rw-rw---- 1 kauffman kauffman 2.4K Sep  7 11:59 no_interruptions.o
> ./a.out
bash: ./a.out: Permission denied
> chmod u+x a.out
> ./a.out
Ma-na na-na!
```

Manual Pages

Command	Effect
`man ls`	Bring up the manual page for command `ls` 'space' scrolls down, 'q' quits

```
> man ls | cat
LS(1)                          User Commands                          LS(1)

NAME
       ls - list directory contents

SYNOPSIS
       ls [OPTION]... [FILE]...

DESCRIPTION

       List information about the FILEs (the current directory by
       default).  Sort entries alphabetically if none of -cftuvSUX nor
       --sort is specified.

       Mandatory arguments to long options are mandatory for short
       options too.

       -a, --all
              do not ignore entries starting with .

       -A, --almost-all
              do not list implied . and ..
...
```

Program Search PATH

Command	Effect
`echo $PATH`	show where shell looks for programs
`PATH=$PATH:/home/kauffman/bin`	also look in my `bin` directory
`PATH=$PATH:.`	also look in current directory
`PATH=.`	ONLY look in the current directory

```
> echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/bin:/usr/lib/jvm/default/bin:
/usr/bin/site_perl:/usr/bin/vendor_perl:/usr/bin/core_perl:/home/kauffman/bin:
/home/kauffman/Dropbox/bin:/home/kauffman/code/bin:/home/kauffman/code/utils:.
```

Search directories are separated by colons in Unix

Note: `PATH` is a notable **Environment Variable.** We'll discuss these soon and how they relate to processes.

Exercise: Compilation

1. What command is typically used to compile C programs?
2. What is the default name of a compiled program on Unix and how can it be changed?
3. What function does a *runnable* C file need to have to make a program?
4. Must *every* C file have that special function? Can you compile C files without that special function?

Write down your answers as a team for screen sharing

Answers: Compilation

1. What command is typically used to compile C programs?

   ```
   > gcc myprog.c
   ```

2. What is the default name of a compiled program on Unix and how can it be changed?

   ```
   > ./a.out
   > gcc -o mprog mprog.c
   > ./myprog
   ```

3. What function does a *runnable* C file need to have to make a program?
   - `main()` must be present in at least one C file to make program

4. Must *every* C file have that special function? Can you compile C files without that special function?

   ```
   > gcc -c funcs1.c                    # produces funcs1.o
   > gcc -c funcs2.c                    # produces funcs2.o
   > gcc -o prog funcs1.o funcs2.o      # link object files
   # Either funcs1.c or funcs2.c had main(), not both
   > ./prog
   ```

`make` and Makefiles

- Example of a **build system**
- Very old system, many newer ones but a good starting point
- Discussed in `HW01` which is due soon
  - Get some experience creating a `Makefile`
  - Will be a required element for Projects

How `make` and `Makefile` Works

Build up dependencies recursively

- A tree-like structure (actually a DAG)
- Run commands for the lowest level
- Then go up a level
- Then up another . . .
- Can recurse to subdirectories to use other `Makefiles` as well
- `Makefile` describes dependencies between source/program files and commands to generate/compile

`Makefile` Format

```
target1 : dependecy1 dependency2
        do command 1
        then do command 2

target2 : target1 dependency3
        do command X
        then do command Y
```

Showing and Murdering Running Processes

Command	Effect
`ps`	show running processes associated with terminal
`ps a`	show ALL running processes
`ps u`	show all processes for me
`kill 1234`	send process 1234 the TERM signal
`kill -9 1234`	send process 1234 the KILL signal
`pkill a.out`	send process named a.out the TERM signal
`pkill -9 a.out`	send process named a.out the KILL signal
`top` or `htop`	interactive process monitoring / signaling

```
> ps
  PID TTY          TIME CMD
 8050 pts/1    00:00:00 bash
 8061 pts/1    00:00:00 ssh
11033 pts/1    00:00:00 ps
> ps u
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
kauffman   724  0.0  0.0 201092  5520 tty2     Ssl+ Sep06   0:00 /usr/lib/gdm/gdm-x-session --run-script
kauffman   726  0.1  0.5 691872 94388 tty2     Rl+  Sep06   2:08 /usr/lib/xorg-server/Xorg vt2 -displayfd
kauffman   737  0.0  0.3 603020 49496 tty2     Sl+  Sep06   0:00 cinnamon-session --session cinnamon
kauffman   784  0.0  0.1 565264 23008 tty2     Sl+  Sep06   0:00 /usr/lib/cinnamon-settings-daemon/csd-or
...
```

Exercise: Summarize the most important Unix Commands

1. Discuss what the most important Unix command line concepts and commands are for beginners
2. Explain these in your own words, how to use them, and why they are important
3. How do these commands interact with the operating system? What role does the OS play in the command?

Write down your answers as a team for screen sharing