

ECE 471 – Embedded Systems

Lecture 6

Vince Weaver

`https://web.eece.maine.edu/~vweaver`

`vincent.weaver@maine.edu`

11 September 2023

Announcements

- HW#2 was posted
- People doing OK getting Pis setup?
Can turn into almost a sysadmin task rather than embedded systems



Connecting Remotely to Pi

- Plain text, via ssh (or serial terminal)
Things like “screen” and “tmux” can even hold connections open
- Graphical over network
 - VNC
 - Remote Desktop
 - X11 forwarding. Over ssh, use `ssh -Y` when connecting
After many years X11 being discontinued for Wayland



which does not have built in display forwarding



Using the Linux Command-Line

- You can interact fully with Linux at a text-based command line (a shell prompt)
- Even in a GUI you can bring up a terminal emulator to do this
- The way we did things in the old days.
Some of us still prefer the command line.
- Good to know as in some situations (server, sysadmin, HPC, embedded systems) you might only get command line access to a machine



Files and the Filesystem

- On Linux/UNIX “everything is a file”
- A file is a collection of bytes that you can randomly access
- They are usually stored in a filesystem
 - Gives a name and directory (folder) hierarchy so you can easily find the files (rather than having to remember the block offset on disk where it lives)
 - Various types of filesystems available
 - Yet another Operating System abstraction



- Do people even use filesystems anymore?
 - There's worry that on modern interfaces (like phones) files are just magically on the cloud and you find them by search, essentially magic
 - At least currently the files still actually live on a filesystem somewhere (unless they're in a database which is another story for another time)



Steps for doing the homework via command line

- Login
- Use `pwd` to print current working directory
- Use `mkdir` to create a directory for 471 files
- Use `cd` to enter the new directory
- Use `ls` to list files
- Use `wget` to download assignment file
- Use `tar` to decompress/unpack assignment
- Use `cd` again to enter directory



- Edit the file using an editor `nano` or similar
- Run `make` to build assignment
Aside: look at contents of `Makefile`
- Run `./hello_world` to test what we built
Aside: why do you need the `./`?
As with lots of weird things, for security reasons
- Run `env` to look at the environment variables
- Run `shutdown` to shut down when done
Does it require `sudo` privileges?



The Linux Shell

- The command prompt is just a program called a “shell”
- Default is bash, the “Bourne Again Shell” (more computer person humor).
- There are various shells available (bash, sh, zsh, csh, tcsh, ksh)
- You can select via `chfn`
- It’s just another program in C, started by `login`
- When you run a program it runs as a separate process, but when done it returns to the shell



Root Filesystem Layout

- Executables in `/bin`, `/usr/bin`
Describe the on-going merge of `/usr/bin` with `/bin`
- System executables under `/sbin`, `/usr/sbin`
- Device nodes under `/dev`
- Config files under `/etc`
- Home directories under `/home`, also `/root`
- Temp Files under `/tmp`. Often wiped at reboot.
- Magic dirs under `/proc`, `/sys`
- Libraries under `/lib`, `/usr/lib`, sometimes `lib64` too



- Boot files under `/boot`
- `/usr` historically was where user files lived (now that's `/home`). A long time ago when low on disk space sysadmins put extra stuff in `/usr` and it stuck.
- `/opt` often commercial software installed there
- `/srv`, `/run`, `/var` these are where server programs store data
- `/media`, `/mnt` places to mount external disks like memory keys and CD roms
- `/lost+found` where the disk checker may store lost files it finds when fixing a disk after unclean shutdown



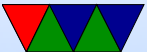
Interesting Config Files in /etc

- /etc/fstab – the filesystems to mount at boot time
- /etc/passwd – list of all users, world readable
- /etc/shadow – passwords stored here for security reasons
- /etc/hostname – name of the machine
- /etc/hosts – list of local machines, usually searched before resorting to DNS lookup over network
- /etc/resolv.conf – where your nameserver address is put
- /etc/sudoers – list of users allowed to use “sudo”
- /etc/network/interfaces – on Debian the network



settings are stored here

- `/etc/rc*` – what gets run at boot (prior to systemd)



Running things on Boot

- Useful for 471 projects
- Official solution is to write a systemd startup file (TODO: look up official name)
- In the old days you just stuck a shell script in `/etc/rc*`
- You can still do that with `rc.local` but not sure if that will keep working



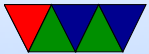
Devices

Block vs Char devices

- `/dev/sd*` – SCSI (hard disks)
- `/dev/mmc*` – SD cards
- `/dev/tty*` – tty (teletype, logins, serial ports)
- `/dev/zero`
- `/dev/full`
- `/dev/random` , `/dev/urandom`
- `/dev/loop`



Network devices are an exception.



Interesting /proc Files

These files are not on disk, but “virtual” and created on-the-fly by the operating system when you request them.

- /proc/cpuinfo – info on cpu
- /proc/meminfo – memory info
- Each process (running program) has its own directory that has info about it



Processes

- Each program assigned its own number, a process id, often called a “pid”
- Can list processes with `ps -efa`
- Also can get real-time view of what’s going on in a system with `top`
- `htop` is a more advanced `top`



Common Commands

- `ls` : list files
 - `ls -la` : list long output, show all (hidden) files. on Linux any file starting with `.` is hidden
 - `ls -la /etc` : list all in `/etc` directory
 - `ls *.gz` : show all ending in `gz`. `*` and `?` are wildcards and can be used as regular expressions.
- `cd DIR` : change directories (folders)
 - `cd ..` : go to parent directory
 - `cd .` : go to current directory



`cd /` : go to root directory

`cd ~` : go to home directory

- `cat FILE` – dump file to screen (originally used to conCATenate files together but more commonly used to list files)
- `more` / `less` – list contents of file but lets you scroll through them. `less` more advanced version of `more`
- `exit` / `logout` / `control-D` – log out of the machine
- `df` / `du` – show disk space



`df -h` pretty-prints it

- `man command` – show documentation (manual) for a command. For example `man ls`
- `rm` remove file. CAREFUL! Especially famous `rm -rf`. In general on Linux you cannot undo a remove.
- `cp` copy file. CAREFUL! By default will overwrite the destination without prompting you.
- `mv` move file. CAREFUL! Can overwrite!
`mv -i` will prompt before overwrite



- `tar` create archive file `tar cvf output.tar dir`
`tar xzvf output.tar.gz` uncompresses a `.tar.gz` file
- `gzip` / `gunzip` / `bzip2` / `bunzip2` compress/uncompress a file. `gzip` and `bzip2` are two common formats, many more exist



Compiler / Devel Commands

- `make` – build a file based on list of dependencies in Makefile
- `gcc` – C compiler. Simplest something like this: `gcc -O2 -Wall -o hello hello.c`
- `g++` C++ `gfortran` Fortran
- `as`, `ld` – assembler and linker
- `gdb` – debugger



- `strace` – list system calls
- `git` – source code management



Other Commands

- `shutdown` – used to shutdown / reboot
- `last` – list last people to log in
- `su` / `sudo` – switch to root, run command as root
- `uptime` – how long machine has been up
- `date` – show the date
as root you can use `date -s` to set the date



- `whoami` – who are you
- `write` / `wall` / `talk` – write to other users
- `finger` – get info on other users
- `w` / `who` – see who is logged in
- `wc` – count words/bytes/lines in a file
- `dmesg` – print system and boot messages (might need `sudo`)



- `ln` – link files together, sort of like a shortcut
`ln -s goodbye.c hello.c` – symbolic link. also hard links
- `dd` – move disk blocks around, often used for creating disk images
- `mount` / `umount` – mount or unmount filesystems
- `mkfs.ext3` – make new filesystem
- `e2fsck` – filesystem check



- `ifconfig / route` – show and setup network config being replaced by `ip` tool
- `dpkg / apt-get update/upgrade/install` – Debian only package management
- `ssh / scp` – log into other machines, copy files remotely
- `lynx` – text-based web browser
- `reset` – clear the screen and reset settings (useful if you accidentally `cat` a binary file and end up with a screenful of garbage). `Control-L` also refreshes the screen



- `linux_logo` – my program
Try `linux_logo -L 9 | less`



Editing files

Linux and UNIX have many, many editors available. Most famous are vi and emacs. On our board using nano might be easiest.

- nano – a simple text editor.

`nano FILENAME` – edit a filename

It shows the commands you can do at the bottom. `^O`

means press control-O

control-O : writes

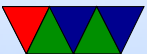
control-X : exits



control-W : searches

control-\ : search and replace

control-C : prints line number



Redirection and Pipes

- redirect to a file : `ls > output`
- redirect from a file : `wc < output`
- pipe from one command to another : `ls | wc, dmesg | less`
- re-direct stderr : `strace 2> output`



Suspend/Resume

- Press control-C to kill a job
- Press control-Z to suspend a job
- Type `bg` to continue it in the background
- Type `fg` to resume it (bring to foreground)
- Run with `&` to put in background to start with. (ie, `mpg123 music.mp3 &`).



Permissions

- user, group – use chgrp
- read/write/execute – use chmod



Shell Scripts

- Create a list of files in a dir
- Start with the shell, `#!/bin/sh` (or perl, etc)
- Make executable `chmod +x myfile`



Command Line History

- Can press “tab” to auto-complete a command
- Can press “up arrow” to re-use previous commands
- Can use “control-R” to search for previous commands



Environment Variables

- `env`
- Varies from shell to shell.
- `export TERM=vt102`
- `PATH`, and why “.” isn’t in it. This is why you have to run self-compiled binaries as `./blah`

