
CSE 374

Programming Concepts & Tools

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Lecture 2 – Processes, Programs, the Shell
(& emacs)

News

- HW0 due tomorrow tonight **11 pm** if not already done
- HW1 out by end of week, due next Thursday night, **11 pm**
 - Linux commands, files, editing
- Ed postings (public or private): please provide enough context so reader can understand what you're asking – especially if it might depend on your host computer (windows, mac), browser, or other details.

Where we are

- It's like we started over using the computer from scratch
- All we can do is run dinky programs at the command-line
- But we are learning a model (a system is files, processes, and users) and a powerful way to control it (the shell)
- If we get the model right, hopefully we can learn lots of details quickly
- Today:
 - More of the model briefly: Processes and Users
 - More programs (ps, chmod, kill, . . .)
 - Special shell characters (*, ~, . . .)
 - Text editing (particularly emacs)

Model of a computer

- Computer hardware: single system with processor(s), memory, I/O devices, ...
- Operating System (OS): program that controls the hardware and allows multiple programs (processes) to run simultaneously. Linux, Window, MacOS, iOS, Android, ...
 - OS manages memory, processor, files, devices, networks, ...
 - OS allows multiple users to access the system
 - OS isolates individual programs and users from each other – provides security, privacy, ...
- Shell: a program that reads user “input” (text, mouse clicks, trackpad gestures) and executes commands (runs processes) as requested by user actions
 - Bash running in a Linux terminal window for example

Users

- There is one file-system, one operating system, one or more CPUs, and multiple users (even on a laptop!)
- `whoami`
- `ls -l` and `chmod` (permissions), quota (limits)
 - Make your homework unreadable by others!
- `/etc/passwd` (originally) or user database (now) guides the login program:
 - Correct username and (originally) password – actual encrypted password is elsewhere now for security
 - Home directory
 - Which shell to open (pass it the home directory)
 - The shell then takes over, with startup scripts (e.g., `.bash_profile`, `.bashrc`). (`ls -a`)
- One “superuser” a.k.a. `root`. (Change passwords, halt machine, change system directories, add/remove user accounts, . . .)

Programs & the Shell

- A program is a file that can be executed
- Almost all system commands are programs
- The shell is itself a program
 - Reads lines you type in & carries them out
 - Normally finds the named program and runs it
 - A few commands are shell “built-ins” that the shell executes itself because they change the state of the shell. Obvious example: `cd`
 - After the named program runs it exits and the shell reads the next command
 - More to this story to come...

Processes

- A running program is called a process. An application (e.g., emacs), may be running as 0, 1, or 57 processes at any time
- The shell runs a program by “launching a process” waiting for it to finish, and giving you your prompt back
 - What you want for ls, but not for emacs or vim or gimp or web browsers or ...
 - &, jobs, fg, bg, kill — job control
 - ps, top
- Each process has private memory and I/O streams
- A running shell is just a process that kills itself when interpreting the exit command
- (Apologies for aggressive vocabulary, but we should learn to use the proper words properly.)

Standard I/O streams

- Every process has 3 standard streams: stdin (input), stdout (output), stderr (error messages)
- Default is keyboard (stdin), terminal window (stdout, stderr)
- Default behavior is to read from stdin, write normal output to stdout, write diagnostic output to stderr
 - Many programs accept command-line arguments naming files to read
 - If not supplied, just read stdin
 - Also ways to redirect stdin, stdout, stderr. Later...

That's most of a running system

- File-system, users, processes
- The operating system manages these
- Processes can do I/O, change files, launch other processes.
- Other things: Input/Output devices (monitor, keyboard, network)
- GUIs don't change any of this, but they do hide it a bit
- Now: Back to the shell. . .

The shell so far

- So far, our view of the shell is the barest minimum:
 - builtins affect subsequent interpretations
 - New builtin: source
 - Otherwise, the first “word” on an input line is a program to run with the other “words” passed as arguments
 - Programs interpret arguments arbitrarily, but conventions exist

Complicating the shell

- But you want (and bash has) so much more:
 - Filename metacharacters
 - Pipes and Redirections (redirecting I/O from and to files)
 - Command-line editing and history access
 - Shell and environment variables
 - Programming constructs (ifs, loops, arrays, expressions, ...)
- All together, a very powerful feature set, but awfully inelegant

Filename metacharacters - globbing

- Much happens to a command-line to turn it into a “call program with arguments” (or “invoke builtin”)
- Certain characters can expand into (potentially) multiple filenames:
 - ~foo – home directory of user foo
 - ~ – current user’s home directory (same as ~\$user or `whoami`).
 - * (by itself) – all files in current directory
 - * – match 0 or more filename characters
 - ? – match 1 filename character
 - [abc], [a-E], [^a], . . .more matching
- Remember, this is done by the shell before the program sees the resulting arguments

Filename metacharacters: why

- Manually, you use them all the time to save typing.
- In scripts, you use them for flexibility. Example: You do not know what files will be in a directory, but you can still do: `cat *` (though a better script would skip directories)
- But what if it's not what you want? Use quoting ("`*`" or '`*`') or escaping (`*`)
- The rules on what needs escaping where are very arcane
- A way to experiment: `echo`
 - `echo args. . .` copies its arguments to standard output after expanding metacharacters

History

- The history builtin
- The ! special character
 - !!, !n, !abc, . . .
 - Can add, substitute, etc.
- This is really for fast manual use; not so useful in scripts
 - And most shells support up- and down-arrow keys to scroll through history and see previous commands before executing

Aliases

- Idea: Define a new command that expands to something else (not a full script)
- Shell builtin command:

```
alias repeat=echo
alias dir=ls
alias hello="echo hello"
alias rm="rm -i"           % for cautious users
alias                    % list existing aliases
```
- Often put in a file read by source or in a startup file read automatically
- Example: your `.bashrc` – feel free to change

Bash startup files

- Bash reads (sources) specific files when it starts up. Put commands here that you want to execute every time you run bash
- Which file gets read depends on whether bash is starting as a “login shell” or not
 - Login shell: `~/.bash_profile` (or others – see bash documentation)
 - Non-login shell: `~/.bashrc` (or others if not found)
- Suggestion: Include the following in your `.bash_profile` file so the commands in `.bashrc` will execute regardless of how the shell starts up

```
if [ -f ~/.bashrc ]; then source ~/.bashrc; fi
```


Where we are

Features of the bash “language”:

1. builtins
 2. program execution
 3. filename expansion (Pocket Guide 23-25, 1st ed 22-23)
 4. history & aliases
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5. command-line editing
6. shell and environment variables
7. programming constructs

But file editing is too useful to put off. . . so a detour to emacs (which shares some editing commands with bash)

What is emacs?

- A programmable, extensible text editor, with lots of goodies for programmers
- Not a full-blown IDE but much “heavier weight” than vi(m)
- Top-6 commands:
 - C-g
 - C-x C-f
 - C-x C-s, C-x C-w
 - C-x C-c
 - C-x b
 - C-k, C-w, C-y, . . .
- Take the emacs tutorial to get the hang of the basics
- Everyone should know this at least a little – emacs editing shortcuts are common in other Linux programs and beyond
- Customizable with elisp (starting with your .emacs)

Command-line editing

- Lots of control-characters for moving around and editing the command-line. (Pocket Guide “shell features” section, emacs-help, and Bash reference manual Sec. 8.4.)
- They make no sense in scripts
- Gotcha: C-s is a strange one (stops displaying output until C-q, but input does get executed)
- Good news: many of the control characters have the same meaning in emacs (and bash has a vi “mode” too)

vi(m) vs emacs

- You should learn one of these
 - Yes, there are many other editors out there, but you should learn one of these – they are standard and available on all Unix/Linux systems
 - VSCode is widely used and shares similar ideas
- Emacs keyboard shortcuts work in many other programs and situations like bash
 - Including vi(m) if you set the right mode!
 - Learn them – it will make you more efficient
- We won't try to dictate or settle the vi vs emacs wars
 - You're on your own for that!

Summary

As promised, we are flying through this stuff!

- Your computing environment has files, processes, users, a shell, and programs (including emacs)
- Lots of small programs for files, permissions, manuals, etc.
- The shell has strange rules for interpreting command-lines. So far:
 - Filename expansion
 - History expansion
- The shell has lots of ways to customize/automate. So far:
 - alias and source
 - run (i.e., automatically source) `.bash_profile` or `.bashrc` when shell starts

Next: I/O Redirection & stream details, Shell Programming