

07 – Your shell, jobs, and proc

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As always: Everybody! ssh to wash.cs.cornell.edu

- Quiz time! Everybody! run **quiz-02-06-19**
- You can just explain a concept from last class, doesn't have to be a command this time.

Processes Overview

What is a Process?

- A process is just an instance of a running program.
- Not just a “program” - it is being *executed*.
- Not just a “running program”, as you can execute the same program multiple times.
 - These would be multiple processes running an instance of the same program.
- Example: if you open more than one terminal (windows or tabs), you are running multiple processes of your shell.
- You can execute **echo \$\$** to see the process of the current running shell.

Identification

- Processes have a unique “Process ID” (PID) when created.
- The PID allows you to distinguish between multiple instances of the same program.
- There are countless ways to discover the PID, as well as what processes are running.
- These methods often depend on how much information you want, as well as what your user privileges are.

Identification: **ps**

Process Snapshot

ps [options]

- Reports a snapshot of the current running processes, including PIDs.
- By default, only the processes started by the user.
- Use **-e** to list every process currently running on the system.
- Use **-ely** to get more information than you can handle.
- Use **-u <username>** to list all processes for user **username**.
- Use **-C <processname>** to list all processes matching a name
- Use **ps aux** for “BSD” style ps, works on macOS/*nix

Display and Update **top** CPU Processes

top [flags]

- Displays the amount of resources in percentages each process is using.
- Use **-d <seconds>** to control the update frequency.
 - The act of monitoring resources usage uses resources!
- Use **-u <user>** to show only the processes owned by **user**.
- Use **-p <PID>** to show only the statistics on process with id number **PID**.

- Can be a very powerful analysis tool.

Better Resource Usage

Display and Update **htop** CPU Processes

htop [flags]

- Displays the amount of resources in percentages each process is using.
 - Use **-d <seconds>** to control the update frequency.
 - The act of monitoring resources usage uses resources!
 - Use **-u <user>** to show only the processes owned by **user**.
 - Use **-p <PID>** to show only the statistics on process with id number **PID**.
-
- Just a lot better than **top**, but not on all systems
 - use F6 (the function key) to change sort order

Example: Resource Monitoring

- First, use **ps** to find the PID for **firefox**:

```
$ ps -C firefox
12975 ? 00:01:45 firefox
```

- Now that we have the PID of **firefox**, monitor using **htop**:

```
$ htop -p 12795
```

- See **man htop** to understand what all is being reported.
- Some great top examples in [3].

Modifying Processes

Priority

- Suppose you want to run some long calculation that might take days, but would consume 100% of your CPU.
- Can we tell the server to give your process less priority in terms of CPU time?
- Recall that although Unix seems to run tens or hundreds of processes at once, one CPU can only run “one process” at a time.
- Quick switching back and forth between processes makes it seem as though they are all running simultaneously.
- In Unix, each process is given a **priority** when it starts.
 - This priority determines how frequently the process gets CPU time.

Execute Process with Non-default Priority

`nice [options] command`

- Runs **command** with specified “*nice*ness” value (default: **10**).
- *Nice*ness values range from **-20** (highest priority) to **19** (lowest priority).
- Only **root** can give a process a *negative nice*ness value.
- Commands run without **nice** have priority **0**.
- Example: **nice -n 10 deluge**
 - Prevent torrents from hogging the CPU.
 - ... don't pirate stuff folks

Adjusting Priority

Change the Priority of a Running Process

`renice <priority> -p <PID>`

- Change *nice*ness of process with id **PID** to **<priority>**.
- Remember: only **root** can assign *negative* values.
- You can only **renice** a process *you* started.
 - Of course, **root** can **renice** *anything*.
- `renice 5 -p 10275`
 - Set the *nice*ness of the process with PID **10275** to **5**.
 - Slightly lower than normal *nice*ness (default: **0**).
- `renice 19 -u username`
 - Set *nice*ness of **all** processes owned by **username** to **19**.

Ending Processes: I

Kill or Signal a Process

```
kill [-signal] <PID>
```

- Sends the specified **signal** to the process with id **PID**.
- By default (no **signal** given), it terminates execution.
 - `kill <PID>` same as `kill -15 <PID>`
 - Signal **15** is **SIGTERM** (signal terminate).

Kill all Processes by Name

```
killall [-signal] <name>
```

- Kills processes by **name**.
- By default (no **signal** given), it terminates execution.
 - `killall firefox` same as `kill -15 firefox`
 - Signal **15** is **SIGTERM** (signal terminate).

Useful Kill Signals

- Kill signals can be used by number or name.
- **TERM** or **15**: terminates execution (default signal sent with `kill` and `killall`).
- **HUP** or **1**: hang-up (restarts the program).
- **KILL** or **9**: like bleach, can kill anything.
- Some examples:

```
# Terminates process with PID 9009.
```

```
$ kill 9009
```

```
# REALLY kills the process with PID 3223.
```

```
$ kill -9 3223
```

```
# Restarts the process with PID 12221.
```

```
# Particularly useful for servers / daemon processes.
```

```
$ kill -HUP 12221
```

- Remember **top** and **htop**? They can both *renice* and *kill*

Jobs

What are Jobs?

- A job is a process running *under the influence* of a job control facility.
- Job control is a built-in feature of most shells, allowing the user to pause and resume tasks.
- The user can also run them in the background.
- Not covered here: **crontab**. For future sys admins, read the article in [1].

Intermission: An Infinite Command

- Let's use **ping** as an example.

Send Request Packets to Network Host

ping <server>

- Measure network response time (latency) to <server> and back.
 - Sends short bursts to <server>, measures time until return.
 - Example: **ping google.com**
 - Use **ctrl+c** to kill the process (**ping** runs until killed).
- The **ping** command will keep running indefinitely until stopped.

Why we Need Job Control

- As long as **ping** runs, we lose control of our shell.
- This happens with many other applications:
 - Moving / copying large quantities of files.
 - Compiling source code.
 - Playing multimedia.
 - Scientific computing.
 - **cat** with no arguments
- We need ways to control this while still being able to continue to use our terminal!

Starting a Job in the Background

Operator `&`

`<command> [arguments] &`

- Runs the specified `command` as a background job.
- Unless told otherwise, will send output to the terminal!
- Example: `mplayer best_song_ever.flac &`

- If you already started the job, use `ctrl+z` to pause it.

`tee`: split command output

`tee <filename>`

- Redirects output to `<filename>` *and* still prints it
- good for logging within a pipeline!

Sending a Job to the Background

Discovering your jobs

jobs

- Prints the running, paused, or recently stopped jobs.
- Prints jobs with their **JOB** IDs.

Background

bg <JOB ID>

- Resumes the job with id **JOB ID** in the *background*.
- Without **JOB ID**, resumes last job placed in background.

Foreground

fg <JOB ID>

- Resumes the job with id **JOB ID** in the *foreground*.
- Without **JOB ID**, resumes last job placed in the background.

Detaching Jobs

No Hangup

`nohup <command> [args]`

- *Background* jobs (started with `&`) end when terminal closed.
- `nohup` launches `command` so it will ignore `SIGHUP` signals.
- `nohup mplayer best_song_ever.flac >/dev/null 2>&1 &`

Disown a job

`disown [flags] jobspec`

- The `-h` flag prevents `jobspec` from `SIGHUP` killing it.
 - Use if you forgot to launch with `nohup`, for example.
- `jobspec` is the job number (e.g., execute `jobs` to find it).
- E.g., if `mplayer` has `jobID 1`, then `disown -h %1`

The **/proc** filesystem

- Everything in Linux is represented by a file
 - this includes your processes

```
$ ls /proc | head -3  
1  
10  
10377
```

- These are all running processes!

what's in a process?

```
$ ls /proc/1
```

attr	coredump_filter	gid_map	mountinfo	...
autogroup	cpuset	io	mounts	...
auxv	cwd	limits	mountstats	...
cgroup	environ	loginuid	net	...
clear_refs	exe	map_files	ns	...
cmdline	fd	maps	numa_maps	...
comm	fdinfo	mem	oom_adj	...

zooming in on that output

- `/proc/N/cwd` is the process's working directory
 - you can CD into it!
- `/proc/N/exe` is the program
- `/proc/N/fd` contains open files
 - Fun trick: open a file with `less`, then remove it, then look in `/proc/N/fd`
- `/proc/mem` is the live process memory!
- `man proc` for a lot more information!

Customizing your Terminal

What is it and Why?

- You will spend a **lot** of time in your terminal.
- It's worth spending a little time to configure it how you want.
- Customizations allow you to be
 1. More effective.
 2. Perform common operations more quickly.
 3. Make your terminal appear more comfortable *for you*.
 4. A super all-star-hacker-pro with l33t skillz.
- Think of it this way: it's like buying a new house. Paint the walls, build a tool shed, meet your neighbors, throw some parties. Why buy it if you weren't going to make it yours?
 - Why use the default terminal just because it came that way?

What are Dotfiles?

- “Dotfiles” change, add, or enhance existing functionality.
 - The files reside in your home (~) directory.
 - They are hidden files: their names start with a `.`
- Some common dotfiles you’ll hear about:

<code>~/.bashrc</code>	Controls bash terminal behavior*
<code>~/.bash_profile</code>	Controls bash environment variables*
<code>~/.profile</code>	Controls shell environment variables*
<code>~/.vimrc</code>	Controls the behavior of vim
<code>~/.emacs</code>	Controls the behavior of emacs
<code>~/.gitconfig</code>	Controls the behavior of git
<code>~/.tmux.conf</code>	Controls the behavior of tmux (covered later)

- There are **many** possible dotfiles to customize.
- We will focus on configuring our shell (**bash**).

* What these *do* depends on what **you** write in them! [See lecture demo.](#)

A Reminder: common environment variables

- **\$PATH**: where your shell looks to find programs
- **\$EDITOR**: your preferred editor (defaults to nano)
- **\$LANG**: your language and file encoding
- **\$LD_LIBRARY_PATH**: where your dynamic libraries are (not always set)
- **\$USER**: who you are
- **\$HOME**: your home directory
- **\$TERM**: how fancy your terminal can be
- **\$MANPATH**: places to find man pages

The Source of All Things

- So we now know a little bit about how a script is structured.
- It just executes from the top to the bottom.
- The shebang says how to run it. But...

Execute **source** in Current Shell

source <filename> [**arguments**]

- *Executing* script **B** from script **A** runs **B** in a *subshell*.
- *Sourcing* script **B** from script **A** executes in *current shell*.
 - If script **B** **exits**, then script **A** **exits**!
- Think of it like copy-pasting **B** into **A** at the line where **source B** is written in **A**.
- Just like **#include <header.h>** in **C** if you know it.
- Fundamental to the initial shell setup process:
 - All dotfiles related to your **shell** are *sourced*.

What Happens When

- There is a **lot** going on with dotfiles; no “standard” protocol.
- What happens when depends on:
 1. Your operating system.
 2. The shell you are using.
 3. For graphical logins, what your desktop / window manager is.
- There is an important difference between types of shells:
 - There is a “login” shell, and a “interactive” shell.
 - “Login” shell: takes place *once*, when you login.
 - `~/.profile`, `~/.bash_profile`, `~/.zprofile`, depending on what your shell is.
 - “Interactive” shell: takes *every time* you spawn a new shell.
 - E.g. `ctrl+shift+n` on Linux, `cmd+n` on Mac.
 - Inherits all actions that took place at *login*.
 - `~/.bashrc`, `~/.zshrc` depending on what your shell is.

Login Actions: Precursor

- There is even still an important distinction:
 - A graphical login (logging in through the GUI).
 - A login shell (disabled GUI, or used **ssh** or something).
- Graphical logins:
 - I will not cover this. There is **way** too much going on.
 - Depends on what your GUI (Gnome, KDE, etc) is.
 - A **fantastic** explanation in [4].
 - Hey! Look around the rest of the site!
 - Lots of other *great* information available!!!
- Login shells:
 - For simplicity, assume that when you login through your GUI, it triggers a login shell to be called.
 - This is mostly true, but not exactly.
 - Discussion to come: Bourne shells (**bash**, **ksh**, ...) vs **zsh**
 - Only because Bourne shells and **zsh** are “incompatible”.

Login Shells

- Where do the environment variables like **\$PATH** come from?
- For Bourne Shells:
 1. System level configuration files are sourced. Same for all users.
 - The file **/etc/profile** is sourced.
 - Do **NOT** edit this file directly. It sources *anything* found in **/etc/profile.d/*.sh**. Put additional resources there.
 - This is where **PATH** among many other variables is getting set!
 2. User-level configuration files are sourced (if found).
 - **bash** looks for **~/.bash_profile** first. If it sees it, it sources it.
 - Only if **bash** does not find **~/.bash_profile**, it looks for **~/.bash_login** next and then **~/.profile** last.
 - **ksh**, on the other hand, only looks for **~/.profile**.
- For **zsh**, the same pattern occurs:
 1. System level configuration: **/etc/zprofile**.
 - Typically, it *emulates* **ksh** and sources **/etc/profile**!
 2. Look for **~/.zprofile**.

Know Your Shell

- `$SHELL` reports *your* default shell (`echo $SHELL`).
- How do I know what my shell looks for and in what order?
 - `man <shell>` and search for **INVOCATION** as well as **FILES**.
 - Or cruise the Arch Wiki – they're great! E.g. [Arch on zsh](#).

Change your Login Shell

```
chsh -s /absolute/path/to/new/shell username
```

- GNU and BSD `chsh` are slightly different, read the **man** page!
- Example usage to change `$SHELL` for `username`:

```
$ sudo chsh -s /bin/zsh username
```
- **Warning:** do **not** change the `$SHELL` of the **root** user!
- Typically, `chsh` will modify `/etc/passwd`
 - `grep` your `username` and read last field.

Aliases

Creating Aliases

`alias <new-name> <old-name>`

- Aliases `new-name` to be `old-name`, e.g. `alias ..='cd ..'`
 - Can now type `..` to go up one directory.
- Should not ever be used in scripts.
 - Disabled by default, battle to use them — **very** bad practice.
 - I don't have your aliases, so now I can't run your script.
- Usually stored in `~/.<shell>rc` file, though `~/.<shell>_aliases` is slowly gaining traction.
 - Make sure you `source ~/.<shell>_aliases` from `~/.<shell>rc` or else they won't be available!!!
 - E.g. `bash`: `~/.bashrc` sources `~/.bash_aliases`, or
 - `zsh`: `~/.zshrc` sources `~/.zsh_aliases`

Modifying your Terminal Prompt

- The **\$PS1** variable controls what shows up when you type in your terminal.
 - In **zsh** this is **\$PROMPT**.
- List of all options [here](#).
- Common: **export PS1="\u@\h:\w> "**
 - **usr@hostname:current/working/directory>**
- Try changing your **\$PS1** using **export** right now to see how you can modify it.
- Play with colors after, since they are tedious to type in the format needed.

Storing Customizations

- There are many such places that people put things, but generally speaking...
- Your **bashrc** should have things like aliases and functions. Limit the **export** calls to just things related to coloring the terminal.
- Your **bash_profile** should contain any special environment variables you need to define.
 - Typically when you are exporting things like **\$PATH** or **\$LD_LIBRARY_PATH** for something you have installed on your own.
- You should source your **bash_profile** from your **profile**, and you should source your **bashrc** from your **bash_profile**.

- [1] Computer Hope. *Linux and UNIX crontab command help and examples*. 2017. URL: <http://www.computerhope.com/unix/ucrontab.htm>.
- [2] Stephen McDowell, Bruno Abrahao, Hussam Abu-Libdeh, Nicolas Savva, David Slater, and others over the years. “Previous Cornell CS 2043 Course Slides”.
- [3] Ramesh Natarajan. *Can You Top This? 15 Practical Linux Top Command Examples*. 2010. URL: <http://www.thegeekstuff.com/2010/01/15-practical-unix-linux-top-command-examples/>.

- [4] Greg Woledge. *Configuring your login sessions with dot files*. 2015. URL: <http://mywiki.woledge.org/DotFiles>.