Hacker Tools: Shell & Scripting

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10 September 2019

Where are we?

NUS Hackers

NUS HACKERS

http://nushackers.org

hackerschool

Friday **Hacks**

Hack & Roll

Hacker Tools

About Me

Hi! I'm Julius. My GitHub is `https://github.com/indocomsoft`

A Year 3 Computer Science Undergraduate who loves hacking and building systems.

I also enjoy Space Exploration, Music Theory and History.

(my favourite games are KSP and EU4 hit me up if you play those too)

What you will learn today

How to hack on a Unix-like environment:

- How to use the shell
- How to create scripts for automation

Required Software

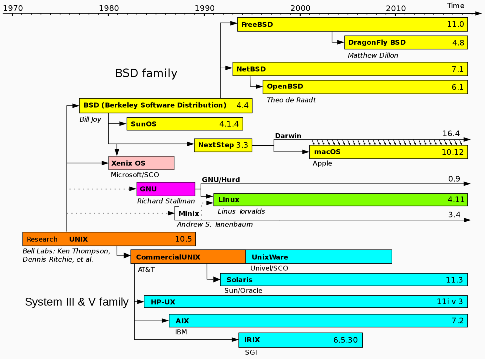
Unix-like environment, either one of these:

- Linux (you're good if you attended and installed Linux during our Linux Install Fest last week)
- macOS[1]
- BSD
- Other Unix-like OS'es (Minix, Solaris, AIX, HP-UX, etc.)
- WSL (Windows Subsystem for Linux) should also be alright, but no guarantee

[1]Open Terminal, and run `xcode-select --install` first

Unix? Can I eat that?

- A family of multitasking, multiuser OS'es.
- First developed in the 1970's.
- Popularised the use of interactive command line.



The Unix Philosophy

1. Write programs that do one thing and do it well.
2. Write programs to work together.
3. Write programs to handle text streams, because that is a universal interface.

Where are we?

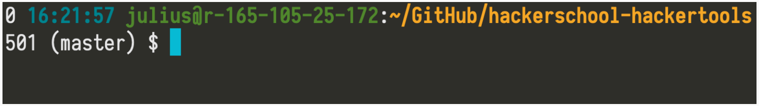
Introduction to Shell

- An efficient, textual interface to your computer.
- Provides an interactive programming language ("scripting").
- Many shells to choose from:
  - Standard ones: `sh` or `bash`
  - Shells that match languages: `csh`
  - "Better" shells: `fish`, `zsh`
- For this workshop, the focus is on the ubiquitous `sh` and `bash`.[2]

[2] Feel free to explore other shells. On macOS, many people prefer `fish` or `zsh`

The Shell Prompt

- What greets you when you open a terminal.



```
0 16:21:57 julius@r-165-105-25-172:~/GitHub/hackerschool-hackertools
501 (master) $ 
```

- Lets your run programmes and commands.

Common Commands

- `man` to get the **man**ual pages of a command
- `cd` to **c**hange **d**irectory
- `ls` to **l**i**s**t files and directories
- `mkdir` to **m**a**k**e **dir**ectory
- `rm` to **r**e**m**ove files and directories
- `cp` to **c**o**p**y file
- `mv` to **m**o**v**e file

Command Editing Shortcuts

`bash` has shortcuts based on `emacs` keybindings:

- Ctrl + a: beginning of line
- Ctrl + e: end of line
- Alt + b: move back one word
- Alt + f: move forward one word
- Ctrl + k: delete from cursor to the end of line

And some special ones:

- Ctrl + u: delete from cursor to the start of line
- Ctrl + w: delete from cursor to start of word

Command Control Shortcuts

- Ctrl + c: terminates the command
- Ctrl + z: suspends the command (`fg` to continue)
- Ctrl + l: clears the screen
- Ctrl + s: stops the output to the screen
- Ctrl + q: allows output to the screen

Where are we?

Script (1/2)

You can write programs directly at the prompt, or write into a file (writing scripts)

```
#!/bin/sh
echo something
```

- Open an editor (for beginner, `nano` is recommended), save the script as `example-script`
- On your shell, run `chmod +x example-script`
- You can run your script as `./example-script`

Script (2/2)

```
#!/bin/sh
echo something
```

Magic?

- `#!/bin/sh` is also known as the **shebang**, specifies the interpreter[3]
- `echo` is a command that prints its arguments to the standard output.

[3] You can use other interpreters too, e.g. `#!/usr/bin/env python` for a python script.

Flags (1/3)

- Most command line utilities take parameters using **flags**.
- They come in short form (`-h`) and long form (`--help`)
- Usually, running `COMMAND -h` or `man COMMAND` will give you a list of the flags the program takes.
- Short flags can be combined: `rm -r -f` is equivalent to `rm -rf` or `rm -fr`

Flags (2/3)

- A double dash `--` is used in to signify the end of command options, after which only positional parameters are accepted.
  - For example, to create a file called `-v`, Use `touch -- -v` instead of `touch -v`
  - For example, to grep a file called `-v`, `grep pattern -- -v` will work while `grep pattern -v` will not.

Flags (3/3)

Some common flags are a de facto standard:

- `-a` commonly refers to all files (i.e. also including those that start with a period[4])
- `-f` usually refers to forcing something, e.g. `rm -f`
- `-h` displays the help for most commands
- `-v` usually enables a verbose output
- `-V` usually prints the version of the command

[4] In Unix, by convention files whose names begin with a period is hidden

Unix Directory Structure

Unix has a different directory structure from Windows.

There is no concept of drives.

Everything is files and directories. The root directory is /

We use forward slash / instead of backward slash \

Important Unix Directories

- `/bin`, `/sbin`, `/usr/bin`, `/usr/local/bin`, `/opt` = executables
- On Linux: `/home` = user home directories
- On macOS: `/Users` = user home directories
- `/var/log` = log files
- `/tmp` = temporary files

Where are we?

Running a command

```
echo Hello
```

- `COMMAND ARG1 ARG2 ARG3`

Variables (1/3)

```
echo location
name=Julius
echo $name
```

- Used to store text
- `name=value` to set variable
- `$name` to access variable

Variables (2/3)

There are also a number of special variables:

- `$?`: get exit code of the previous command
- `$1` to `$9`: arguments to a script
- `$0`: name of the script itself
- `$#`: number of arguments
- `$$`: process ID of current shell

Variables (3/3)

Create a script `variable-example` containing the code below, then try running it with various arguments.

```
#!/bin/sh
echo $0
echo $1
echo $2
echo $#
```

Loop (1/4)

Loop is used to run a command a bunch of times.

For example:

```
for i in $(seq 1 5); do echo hello; done
```

Loop (2/4)

```
for i in $(seq 1 5); do echo hello; done
```

Let's unpack this!

```
for x in list; do BODY; done
```

- `;` terminates a command – equivalent to newline
- Split `list`, assign each to `x`, and run `BODY`
- Split by "whitespace" – we will get into it later
- Compared to C, no curly braces, instead `do` and `done`

Loop (3/4)

```
for i in $(seq 1 5); do echo hello; done
```

Let’s unpack this!

`$(seq 1 5)`

- Run the program `seq` with arguments `1` and `5`
- Substitute the `$(...)` block with the output of the program
- Equivalent to
  `for i in 1 2 3 4 5; do echo hello; done`

Loop (4/4)

```
for i in $(seq 1 5); do echo hello; done
```

Let’s unpack this!

```
echo hello
```

- Everything in a shell script is a command
- Here, it means run the `echo` command, with argument `hello`.
- All commands are searched in `$PATH` (colon-separated)
- Find out where a command is located by running `which COMMAND`, e.g. `which ls`

Conditionals (1/2)

```
if test -d /bin; then echo true; else echo
↪  false; fi;
```

Let's unpack this!

```
if CONDITION; then BODY; fi
```

- `CONDITION` is a command.
- If its exit code is `0` (success), then `BODY` is run.
- Optionally, you can also hook in an **`else`** or **`elif`**

Conditionals (2/2)

```
if test -d /bin; then echo true; else echo
↪  false; fi;
```

Let's unpack this!

```
test -d /bin
```

- `test` is a program that provides various checks and comparison which exits with exit code `0` if the condition is true[5].
- Alternate syntax: `[ condition ]`, e.g. `[ -d /bin ]`

[5]Remember, you can check exit code using `$?`

Everything Together

Let's create a command like `ls` that only prints directories:

```sh
#!/bin/sh
for f in $(ls)
do
  if test -d $f
  then
    echo dir $f
  fi
done
```

Bug!

Hold on! What if the directory is called ”`My Documents`”?

- `for f in $(ls)` expands to
  `for f in My Documents`
- Will first perform the test on `My`, then on `Documents`
- Not what we wanted!

Argument Splitting

- Bash splits arguments by whitespace (tab, newline, space)
- Same problem somewhere else: `test -d $f`
- If `$f` contains whitespace, `test` will error!
- Need to use quote to handle spaces in arguments
  `for f in "My Documents"`
- How do we fix our script?
- What do you think `for f in "$(ls)"` does?

Globbing (1/2)

- `bash` knows how to look for files using patterns:
    - `*`: any string of characters
    - `?`: any single character
    - `{a,b,c}`: any of these characters
- Thus, `for f in *` means all files in this directory
- When globbing, each matching file becomes its own argument
- However, still need to make sure to quote, e.g. `test -d "$f"`

Globbing (2/2)

You can make advanced patterns

- `for f in a*:`

Globbing (2/2)

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- `for f in a*`: all files starting with `a` in the current directory
- `for f in foo/*.txt`:

Globbing (2/2)

You can make advanced patterns

- `for f in a*`: all files starting with `a` in the current directory
- `for f in foo/*.txt`: all `.txt` files in `foo`
- `for f in foo/*/p??.txt`:

Globbing (2/2)

You can make advanced patterns

- `for f in a*`: all files starting with `a` in the current directory
- `for f in foo/*.txt`: all `.txt` files in `foo`
- `for f in foo/*/p??.txt`: all three-letter text files, starting with p, in subdirectories of `foo`

Other whitespace issues

- `if [ $foo = "bar" ]; then`: What’s the issue?

Other whitespace issues

- `if [ $foo = "bar" ]; then`: What’s the issue?
- What if `$foo` is empty? arguments to `[` are `=` and `bar`
- Possible workaround: `[ x$foo = "xbar" ]`, but very hacky

Other whitespace issues

- `if [ $foo = "bar" ]; then`: What's the issue?
- What if `$foo` is empty? arguments to `[` are `=` and `bar`
- Possible workaround: `[ x$foo = "xbar" ]`, but very hacky
- Instead, use `[[ CONDITION ]]`: `bash` built-in comparator that has special parsing
- Good news: it also allows `&&` instead of `-a`, `||` instead of `-o`, etc.

shellcheck

- The mentioned problems are the most common bugs in shell scripts.
- A good tool to check for these kinds of possible bugs in your shell script: `https://www.shellcheck.net/`

Where are we?

Composability

- Shell is powerful, in part because of **Composability**
- You can chain multiple programs together, rather than one program that does everything
- Remember **The Unix Philosophy**:
    1. Write programs that do one thing and do it well.
    2. Write programs to work together.
    3. Write programs to handle text streams, because that is a universal interface.

Pipe (1/2)

```
dmesg | tail
```

Let's unpack this!

```
a | b
```

- Means run both `a` and `b`, but send all the output of `a` as input to `b`, and then print the output of `b`

Pipe (2/2)

You can chain this even longer!

```
cat /var/log/sys*log | grep Sep 10 | tail
```

- `cat /var/log/sys*log` prints the system log
- This output is fed into `grep Sep 10`, which looks for all entries from today.
- This output is then further fed into `tail`, which prints only the last 10 lines.

Streams

- All programs launched have 3 streams:
    - `STDIN`: the program reads input from here
    - `STDOUT`: the program prints to here
    - `STDERR`: a second output that the program can choose to use.
- By default, `STDIN` is your keyboard, `STDOUT` and `STDERR` are both your terminal

Stream Redirection (1/2)

- However, this can be changed!
- `a | b`: makes `STDOUT` of `a` the `STDIN` of `b`.
- `a > foo`: `STDOUT` of `a` goes to the file `foo`
- `a 2> foo`: `STDERR` of `a` goes to the file `foo`
- `a < foo`: `STDIN` of `a` is read from the file `foo`
- `a <<< some text`: `STDIN` of `a` is read from what comes after `<<<`

Stream Redirection (2/2)

So why is this useful?

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It lets you manipulate output of a program!

Stream Redirection (2/2)

So why is this useful?

It lets you manipulate output of a program!

- `ls | grep foo`: all files that contain the word `foo`
- `ps | grep foo`: all processes that contain the word `foo`
- On Linux: `journalctl | grep -i intel | tail -n 5`: last 5 system log messages with the word `intel` (case-insensitive)
- Note that this forms the basis for **data-wrangling**, which will be covered later.

Grouping Commands

```
(a; b) | tac
```

- Run `a`, then `b`, and send all their output to `tac`[6]
- For example: `(echo qwe; echo asd; echo zxc) | tac`

[6] `tac` print in reverse

Process Substitution

`b <(a)`

- Run `a`, generate a temporary file name for its output stream, and pass that filename to `b`
- To demonstrate: `echo <(echo a) <(echo b)`
- On Linux: `diff <(journalctl -b -1 | head -n20) <(journalctl -b -2 | head -n20)`
- This shows the difference between the first 20 lines of the last boot log and the one before that.

Where are we?

Job (1/2)

Used to run longer-term things in the background.

- Use the `&` suffix
  - It will give back your prompt immediately.
  - For example: `(for i in $(seq 1 100); do echo hi; sleep 1; done) &`
  - Note that the running program still has your terminal as `STDOUT`. Instead, can redirect `STDOUT` to file.
  - Handy especially to run 2 programs at the same time like a server and client: `server & client`
  - For example: `nc -l 1234 & nc localhost 1234 <<< test`

Job (2/2)

- `jobs`: see all jobs
- `fg %JOBS`: bring the job corresponding to the id to the foreground (with no argument, bring the latest job to foreground)
- You can also background the current program: ^Z[7], then run `bg`
  - ^Z stops the current process and makes it a job.
  - `bg` runs the last job in the background.
- `$!` is the PID of the last background process.

[7] Ctrl is usually denoted as ^, thus Ctrl + z is denoted as ^Z

Process Control (1/2)

- `ps`: lists running processes
  - `ps -A`: lists processes from all users
  - Check out the man page for other arguments.
- `pgrep`: find processes by searching (like `ps -A | grep`)
  - `pgrep -f`: find processes with arguments
- `kill`: send a *signal* to a process by ID (`pkill` to search and run `kill`)
  - Signal tells a process to do something
  - `SIGKILL` (`-9` or `-KILL`): tell it to exit *right now* (equivalent to `^\`)
  - `SIGTERM` (`-15` or `-TERM`): tell it to exit gracefully (equivalent to `^C`)

Process Control (2/2)

- `kill`: send a *signal* to a process by ID (`pkill` to search and run `kill`)
  - Signal tells a process to do something
  - Most common[8]:
    - `SIGKILL` (`-9` or `-KILL`): tell it to exit *right now* (equivalent to `^\`)
    - `SIGTERM` (`-15` or `-TERM`): tell it to exit gracefully (equivalent to `^C`)

[8] Prefer `SIGTERM` over `SIGKILL`: `https://turnoff.us/geek/dont-sigkill/`

More Resources

- If you are completely new to the shell, you might want to read a comprehensive guide, such as BashGuide[9].
- For a more in-depth introduction, The Linux Command Line[10] is a good resource.

[9] `http://mywiki.wooledge.org/BashGuide`
[10] `http://linuxcommand.org/tlcl.php`

Where are we?

xargs

- Sometimes piping doesn't quite work because the command being piped into does not expect the newline separated format.
- For example, `file` command tells you properties of the file.
- Try running `ls | file` and `ls | xargs file`
- What is `xargs` doing?

Other Exercises

- Try running `touch {a,b}{a,b}`, then `ls`. What appeared?
- Sometimes you want to keep `STDIN` and still output to a file. Try running `echo HELLO | tee hello.txt`
- Run `echo HELLO > hello.txt`, then `echo WORLD >> hello.txt`. What are the contents of `hello.txt`? How is `>` different from `>>`?

Where are we?

Talk to us!

- Feedback form: `https://is.gd/2019ht5`
- Upcoming Hacker Tools:
  Data Wrangling, SR1, 17th September 2019, 7pm