hackerschool
by NUS Hackers

Hacker Tools: Part 1

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Where are we?

Introduction

Shell and Scripting

Data Wrangling

Automation

Conclusion

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Friday **Hacks**

Hack & Roll

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About Me

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

A Year 2 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)

About This Workshop

- No prior knowledge assumed
- Learning how to make the most of tools that productive programmers use.
- How to hack on Unix-like environment.

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Required Software

Unix-like environment, either one of these:

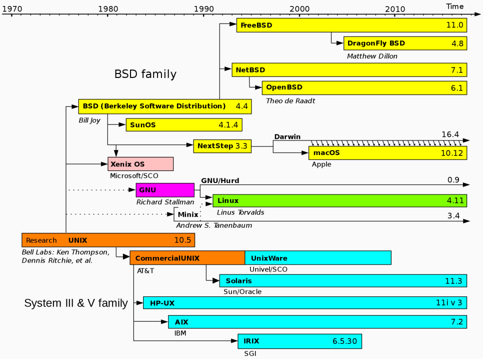
- Linux[1]
- macOS[2]
- BSD
- Other Unix-like OS'es (Minix, Solaris, AIX, HP-UX, etc.)

[1] For beginners, Ubuntu is recommended. Either dual-boot or install as virtual machine using VirtualBox

[2] 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.

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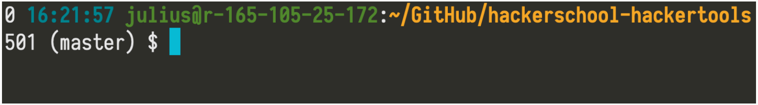
Introduction to Shell

- 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`, `ksh`
- For this workshop, the focus is on the ubiquitous `sh` and `bash`.[3]

[3] 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.
- Determined by the variable `PS1`. For example,

```
export PS1='> '
```

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

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[4]
- `echo` is a command that prints its arguments to the standard output.

[4] 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[5])
- `-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

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

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Running a command

```
echo Hello
```

- `COMMAND ARG1 ARG2 ARG3`

Variables (1/3)

```
PS1='> '
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[6].
- Alternate syntax: `[ condition ]`, e.g. `[ -d /bin ]`

[6] 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)

You can make advanced patterns

- `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/`

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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 Mar 23 | tail
```

- `cat /var/log/sys*log` prints the system log
- This output is fed into `grep Mar 23`, 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?

Stream Redirection (2/2)

So why is this useful?

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`[7]
- For example: `(echo qwe; echo asd; echo zxc) | tac`

[7] `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.

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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`[8], 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.

[8] 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[9]:
        - `SIGKILL` (`-9` or `-KILL`): tell it to exit *right now* (equivalent to `^\`)
        - `SIGTERM` (`-15` or `-TERM`): tell it to exit gracefully (equivalent to `^C`)

[9] 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[10].
- For a more in-depth introduction, The Linux Command Line[11] is a good resource.

[10] http://mywiki.wooledge.org/BashGuide

[11] http://linuxcommand.org/tlcl.php

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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 >>?

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What is Data Wrangling?

- Have you ever had a bunch of text and wanted to do something with it?
- Great! That's **Data Wrangling**
- Adapting data from one format to another, until you end up with exactly what you wanted.

Basic Data Wrangling (1/2)

Linux:

```
journalctl | grep -i intel
```

- This is an example of basic data wrangling: finding all system log entries that mentions Intel
- Most of data wrangling is just about knowing what tools you have, and how to combine them.
- Remember **The Unix Philosophy**!

Basic Data Wrangling (2/2)

- Let's start from the beginning:
  1. We need a data source
  2. Something to do with it.
- A good use case is for logs, because you often want to investigate them, but reading the whole thing is not feasible.

Data Wrangling Example (1/)

Let's try to figure out who is trying to log into my server.

- First, I try to look into my server's log:

```
cat log
```

- That's far too much stuffs!
- Let's limit it to `ssh` stuffs:

```
cat log | grep sshd
```

- That is still way more stuffs than what we wanted, and it's pretty hard to read.

Data Wrangling Example (2/)

We can do better!

```
cat log
| grep sshd
| grep "Accepted publickey for"
```

There’s still a lot of noise here.

There are *a lot* of ways to get rid of that, but let’s look at one of the most powerful tools in your toolkit: `sed`.

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sed? Isn’t that the adjective to describe my life?

- `sed` is a stream editor that builds on top of the old `ed`[12] editor
- In it, you basically give short commands for how to modify the file.
- If you use `vim`, you should be familiar with some of the commands (`ed` -> `vi` -> `vim`)
- There are tonnes of commands, but the most common one is `s` for substitution.

[12] If you’re into lame computing jokes, here’s a joke about `ed`: `https://www.gnu.org/fun/jokes/ed-msg.html`

Back to Our Example

```
cat log
| grep sshd
| grep "Accepted publickey for"
| sed 's/.*Accepted publickey for //'
```

- Wow! It’s a lot cleaner.
- What we just wrote was a simple **Regular Expression**

The s Command in sed

Syntax: `s/REGEX/SUBSTITUTION/`

- `REGEX` is the regular expression you want to search for.
- `SUBSTITUTION` is the text you want to substitute matching text with.

What is Regular Expression

- It’s a powerful construct that lets you match text against patterns.
- They are common and useful enough that it’s worthwhile to take some time to understand how they work.
- Usually (though not always) surrounded by /
- Most ASCII characters just carry their normal meaning, but some characters have special matching behaviour.
- Exactly which characters do what vary somewhat between different implementations of regular expressions, which is a source of great frustration.

List of Regex Special Characters

Character	Meaning
`.`	Any single character except newline
`*`	Zero or more of the preceding match
`?`	One or more of the preceding match
`[abc]`	Any one character of `a`, `b`, and `c`
`(RX1|RX2)`	Either something that matches `RX1` or `RX2`
`^`	The start of the line
`$`	The end of the line

Obsolete vs Modern Regex

- Note that `sed`'s regex is somewhat weird and will require you to put a `\` before most of these to give them special meaning.
- This is because by default `sed` is using the *obsolete* regex format.
- You can avoid this problem by passing `-E` flag to `sed`, which tells it to switch to the *modern* regex format.
- You can explore the differences by running `man re_format`

Looking at our regex just now

```
/.*Accepted publickey for /
```

- It means any text that starts with any number of characters, followed by the literal string `"Accepted publickey for "`
- However, regexes are tricky.
- What if the username is also ”Accepted publickey for”?
- Why? By default, `*` and `+` are “greedy” – they will match as much text as they can

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Talk to us!

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- Upcoming hackerschool:
  - Hackertools Part Two