

## 03 – UNIX Permissions and find

CS 2043: Unix Tools and Scripting, Spring 2019 [2]

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

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# You and 188 of your closest friends

- Welcome back to WASH!
- Wash is a *multi-user* machine
  - there are multiple users on here
  - how to solve conflicts?
- You're going to be working on wash..
- Security is *kinda* important

# Users. Users EVERYWHERE

- There are **217** users on wash.
- Even on a personal Linux computer, there are usually *at least* 30 different user account
- why so many users?
  - security
  - separation of concerns
  - principle of least privilege
- **EXAMPLE:** The **lp** user owns printing-related files

## So, the security model is...?

- \*NIX security model is *access control*-based
- Define who is *allowed* to use what resources
- What do users control?
  - file ownership and permissions
  - processes
- Most things are [represented by] a file
- **EXAMPLE:** The file `/dev/ttyS0` represents the serial port
  - early USB predecessor
  - ...what, I'm not **that** old.

So, if a special user owns printing stuff and serial ports... How to I print?

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# Groups

- Users can belong to [lots of] *groups*

List **groups** to which a user belongs

**groups** [**user name**]

- Lists groups to which [argument] belongs.
  - With no argument, lists your groups
- All files are owned by *both* a **user** and a **group**
  - Groups grant *permissions* on certain files and actions
    - **Example:** the **lp** group allows printing
    - **Example:** the **uucp** group allows serial port access



## Let's see what groups we're in!

### Groups with **groups**

```
$ groups  
mpm288 cs2043student student_only
```

- the **netID** group is just for you (you're the only one in it)
- the **cs2043student** group is for the entire class — everyone is in it!
- the **student\_only** group is for security; defines “student” as your *maximum privilege*
  - not getting into what that means this lecture ;) )

# File Ownership

- You can discern who owns a file many ways, the most immediate being `ls -l`

## Permissions with `ls`

```
$ ls -l README
-rwxrw---- 1 milano cs2043tas 20 Jan 26 15:48 README
#           milano           <-- the user
#           cs2043tas        <-- the group
```

- Third column is the *user*, fourth column is the *group*.
- Other columns are the *link count* and *size*
  - we'll talk about like count in .... 5 lectures?

# What is this RWX Nonsense?

- **r** = read, **w** = write, **x** = execute.

- <b>rwX</b> - - - - -	<b>User</b> permissions
- - - - <b>rwX</b> - - -	<b>Group</b> permissions
- - - - - - - <b>rwX</b>	<b>Other</b> permissions

- Directory permissions begin with a **d** instead of a -
- *Other*: “neither the owner, nor a member of the group”.

## An example

- What would the permissions `-rwxr-----` mean?
  - It is a file.
  - User can read and write to the file, as well as execute it.
  - Group members can read the file
  - Group members **cannot** write to or execute the file.
  - Other cannot do *anything* with it.

## Hold on... *execute* the file?

- Programs are just files!
- Most programs contain a special format of *binary data*, called ELF
- Some programs are *scripts*, which means they're just text!
- try to **cat** out the **handin** command, for example
  - (the path to it is: `/course/cs2043/bin/handin`)

## Ok but... execute the *directory*?

- This one is a bit counter-intuitive
- **Reading** a directory means listing its contents
- **Writing** a directory means removing or creating
- **Executing** a directory means *interacting* with its contents
  - editing, printing, etc.
  - **drw**- - - - - means you can create, remove, and list contents, but *cannot* print, edit, or execute anything *inside* the directory
  - **d-wx**- - - - - means you can create, remove, and use contents, but *cannot* list them.
- Execute without read means you have to know the name of the contents in order to access them!
  - no other way to discover the contents.
  - kinda like a password...

# Changing Permissions

## Change Mode

`chmod <mode> <file>`

- Changes file or directory permissions to **<mode>**.
- The format of **<mode>** is a combination of three fields:
  - Who is affected: a combination of **u**, **g**, **o**, or **a** (all).
  - Use a **+** to add permissions, and a **-** to remove.
  - Specify type of permission: any combination of **r**, **w**, **x**.
    - # Add read, write, & execute for user, group, & other  
\$ `chmod ugo+rwx <file>` # or `chmod a+rwx <file>`
    - # Remove read and write for other  
\$ `chmod o-rw <file>`
- Can specify mode in octal: user, then group, then other.
  - E.g., **750** means **user=7**, **group=5**, **other=0** permissions.

# The Octal Version of `chmod`

- For the formula hungry, you can represent **r**, **w**, and **x** as binary variables (where 0 is off, and 1 is on). Then the formula for the modes is

## Octal Ownership Permissions

$$r \cdot 2^2 + w \cdot 2^1 + x \cdot 2^0$$

- Examples
  - `chmod 755: rwxr-xr-x`
  - `chmod 777: rwxrwxrwx`
  - `chmod 600: rw-----`
- If that makes less sense to you, feel free to ignore it.
  - Just use the **stat** command to help you convert :)
- The octal version can be confusing, but will save you time. Excellent resource in [1].



# Changing Ownership

- Changing the *group* of a file / directory

## Change Group

```
chgrp group <file>
```

- Changes the group ownership of <file> to **group**.
- The **-R** flag will recursively change permissions of a directory.

- Changing the *owner* of a file / directory

## Change Owner and Group

```
chown user:group <file>
```

- Changes the ownership of <file>.
- The **group** is optional (**chown user <file>**).
- The **-R** flag will recursively change permissions of a directory.

# The root user

- The special user **root** is the ultimate administrator on the system
- Gets the permissions of *any* user on the system
  - if anyone can read/write/exec it, **root** can too
- can change permissions any way it wants
  - can even set an owner/group combo where the owner's not in the group!
- can become root with the **su** or **sudo** comamnds
  - we won't be using these in this class...
  - you should **never** use **su** or **sudo** on wash!

# File Ownership, Alternate

- You will likely forget which column is which in `ls -l...`

## Status of a File or Filesystem

`stat [opts] <filename>`

- Gives you a wealth of useful information.
- **Uid** (%U) is the user, **Gid** (%G) is the group.
  - BSD/OSX: `stat -x <filename>` for “standard” behavior.
- Can be useful to mimic file permissions you don't know.
  - Human readable: `--format=%A`, e.g. `-rw-rw-r--`
    - BSD/OSX: `-f %Sp` is used instead.
  - Octal: `--format=%a` (great for `chmod`), e.g. **664**
    - BSD/OSX: `-f %A` is used instead.

# Types of Files and Usages

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- Plain text files are human-readable, used for things such as:
  - Documentation,
  - Application settings,
  - Source code,
  - Logs, and
  - Anything you may want to read via the terminal
    - README
    - INSTALL
    - etc.

# Binary Files

- Binary files are not human-readable. They are written in the language your computer prefers.
  - Executables,
  - Libraries,
  - Media files,
  - Archives (.zip, etc), and many more.

# Special Files

- Special Files represent things which ought not be files!
  - Sockets (connections)
  - Devices (hard disk, keyboard, etc)
  - Raw Memory (RAM)
  - The (software-emulated) terminal you're using now!
  - A lot of really random other stuff
- The UNIX philosophy: represent *everything you possibly can* as a file

# Default Permissions on Creation

## User Mask

`umask <mode>`

- Remove **mode** from the file's permissions.
- Similar syntax to **chmod**:
  - `umask 077`: +rwx for *owner*, - for all others.
  - `umask g+w`: enables group write permissions.
- `umask -S`: display the current mask.
- Just a bit mask with **0o777** and your *mode*.

Full permissions	0o777
Sample User Mask	0o002
Logical & Gives	0o002

- Changing `umask` only applies for the remainder of the session.
  - Permanent if put in your `~/.bashrc` or `~/.bash_profile`.



# Reading Files Without Opening

- Using your terminal to examine a file is very convenient!

## File Perusal Filter for (crt) Viewing

**more** <filename>

- Scroll through one page at a time.
- Program **exits** when end is reached.

## As the saying goes...

**less** <filename>

- Scroll pages or lines (mouse wheel, space bar, and arrows).
- Program does **not** exit when end is reached.

# Beginning and End

- Long files can be a pain with the previous tools.

## Print the Beginning (**head**) or End (**tail**) of a File

```
head -[numlines] <filename>
```

```
tail -[numlines] <filename>
```

- Prints the first / last **numlines** of the file.
- First 5 lines: **head -5 file.txt** *or* **head -n5 file.txt**
- Last 5 lines: **tail -5 file.txt** *or* **tail -n5 file.txt**
- Default is 10 lines.

# Not Really a File...YET

- You can talk to yourself in the terminal too!

## Display a Line of Text

`echo <text>`

- Prints the input string to the standard output (the terminal).
- We will soon learn how to use `echo` to put things into files, append to files, etc.
- Show off to your friends how cool you are:

```
$ echo 'I can have a conversation with my computer!'
```

```
$ echo 'But it always copies me. RUDE.'
```

## Flags & Command Clarification

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# Flags and Options

- Most commands take flags and optional arguments.
- These come in two general forms:
  - Switches (no argument required), and
  - Argument specifiers (for lack of a better name).
- When specifying flags for a given command, keep in mind:
  - Flags modify the behavior of the command / how it executes.
  - Some flags take precedence over others, and some flags you specify can implicitly pass additional flags to the command.
- There is no absolute rule here: research the command.

# Flags and Options: Formats

- A flag that is
  - One letter is specified with a single dash (**-a**).
  - More than one letter is specified with two dashes (**--all**).
  - The reason is because of how switches can be combined.
- We generally use “flag” and “switch” interchangeably:
  - “flag” the command, telling it that “action X” should occur
  - specify to the command to “switch on/off action X”

# Flags and Options: Switches

- *Switches* take no arguments, and can be specified in a couple of different ways.
- Switches are usually one letter, and multiple letter switches usually have a one letter alias.
- One option:
  - `ls -a`
  - `ls --all`
- Two options:
  - `ls -l -Q`
  - `ls -lQ`
- *Usually* applied from left to right in terms of operator precedence, but not always:
  - This is up to the developer of the tool.
  - Prompts: `rm -fi <file>`
  - Does **not** prompt: `rm -if <file>`

# Flags and Options: Argument Specifiers

- The `--argument="value"` format, where the `=` and quotes are needed if `value` is more than one word.
  - Yes: `ls --hide="Desktop" ~/`
  - Yes: `ls --hide=Desktop ~/`
    - One word, no quotes necessary
  - No: `ls --hide = "Desktop" ~/`
    - Spaces by the `=` will be misinterpreted
    - It used `=` as the argument to `hide`
- The `--argument value` format (space after the `argument`).
  - Quote rules same as above.
  - `ls --hide "Desktop" ~/`
  - `ls --hide Desktop ~/`
- Usually, `--argument value` and `--argument=value` are interchangeable.
  - Not always!



# Flags and Options: Conventions, Warnings

- Generally, always specify the flags before the arguments.
- `ls -l ~/Desktop/` and `ls ~/Desktop/ -l` both work.
  - Sometimes flags after arguments **get ignored**.
  - Depends both on the command, and the flag(s).
- The special sequence `--` signals the end of the options.
  - Executes as expected: `ls -l -a ~/Desktop/`
  - Only uses `-l`: `ls -l -- -a ~/Desktop/`
    - `"ls: cannot access -a: No such file or directory`
    - The `-a` was treated as an **argument**, and there is no `-a` directory (for me)
- In this example:
  - `-l` and `-a` are the **flags**.
  - `~/Desktop/` is the **argument**.

## Flags and Options: Conventions, Warnings (cont)

- The special sequence `--` that signals the end of the options is often most useful if you need to do something special.
- Suppose I *wanted* to make the folder `-a` on my **Desktop**.

```
$ cd ~/Desktop # for demonstration purpose
$ mkdir -a      # fails: invalid option -- 'a'
$ mkdir -- -a   # success! (ls to confirm)
$ rmdir -a      # fails: invalid option -- 'a'
$ rmdir -- -a   # success! (ls to confirm)
```

- This trick can be useful in **many** scenarios, and generally arises when you need to work with special characters of some sort.

# Your new best friend

- How do I know what the flags / options for all of these commands are?

## The Manual Command

`man command_name`

- Loads the manual (manpage) for the specified command.
  - Unlike google, manpages are **system-specific**.
  - Usually very comprehensive. Sometimes *too* comprehensive.
  - Type **/keyword** to search for **keyword**, and hit **<enter>**.
  - The **n** key jumps to the next search result.
- Search example on next page if that was confusing. Intended for side-by-side follow-along.

# Man oh man

- The **man** command is really useful!

```
$ man man # you now have the manual loaded
$ /useful # type /useful, then hit enter
##### [[[ first result highlighted ]]]
$ n      # followed by enter
##### [[[ next result highlighted ]]]
# The default 'pager' is `less`, type `q`
# without backticks to exit.
```

- Subtle differences depending on distribution, e.g. **ls -B**
- BSD/OSX: Force printing of non-printable characters in file names as **\xxx**.
  - **xxx** is the numeric value of the character in **octal**.
- GNU (Fedora, Ubuntu): don't list implied entries ending with **~**
  - Files ending with **~** are *temporary* backup files that certain programs generate (e.g. some text-editors, your OS).

# References

- [1] Computer Hope. *Linux and Unix chmod command help and examples*. 2016. URL: <http://www.computerhope.com/unix/uchmod.htm>.
- [2] Stephen McDowell, Bruno Abrahao, Hussam Abu-Libdeh, Nicolas Savva, David Slater, and others over the years. “Previous Cornell CS 2043 Course Slides”.