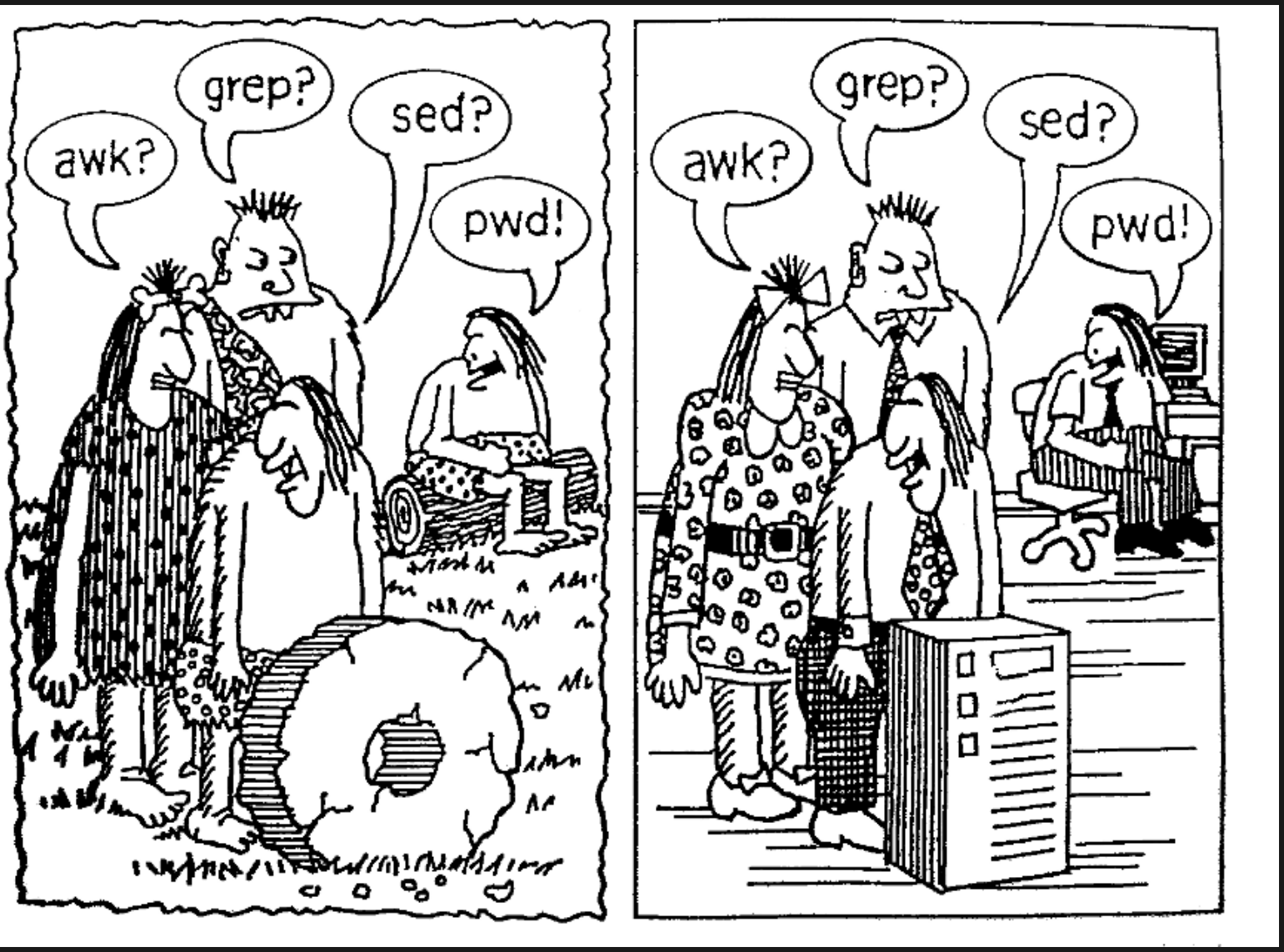
GNU/LINUX TUTORIAL

PART I: BASICS

§1: GNU, LINUX, AND DISTRIBUTIONS

WHY LINUX AND COMMAND LINE? 🤔

- One of the best operating systems.
- Efficient work flow from the terminal.
- Remote access is via command line.
- Linux is everywhere: servers, containers, IoT.


awk?
grep?
sed?
pwd!
awk?
grep?
sed?
pwd!

ORIGINS 

- **UNIX**: operating system released in 1973. Written in C.
- Has inspired many **UNIX-like** operating systems.
- **POSIX**: a family of standards defining UNIX-like systems.

GNU/LINUX = GNU + LINUX 

- **Linux**: free kernel written by Linus Torvalds. In collaborative development since 1991. Millions of lines of code in C.
- **GNU** (= *GNU's not a UNIX*) Project, founded by Richard Stallman in 1983: together with the kernel makes a UNIX-like operating system.
- **GNU/Linux** is sometimes abbreviated to **Linux**.

A FEW DISTRIBUTIONS 

- A **distribution** comes with
  - custom Linux kernel build,
  - GNU software,
  - additional software,
  - package manager.
- **Debian**, **Ubuntu**, **Raspberry Pi OS**;
- **Fedora**, **CentOS**; **Arch**; **Gentoo**;
- **Alpine**: often used in containers.

OUR CHOICE IS DEBIAN

- Versions

	Packages	Stability
Stable	😒 older	🙂 stable
Testing	😐	😐
Unstable	🙂 latest	😒 not tested

- Current stable:

  Version 11 "Bullseye" (2021)

§2: FIRST PRACTICE

- Run our `debian-playground` image in Docker.
- You will see the **Bash** prompt:

```
user@cosmos:~$ ▌
```

  - `user` : user
  - `cosmos` : host
  - `~` : abbreviation for home directory
  - `$` : invitation to type commands

```
user@cosmos:~$ echo 'Hello, World!'
Hello, World!
user@cosmos:~$ echo "Hello, $(whoami)!"
Hello, user!
```

USEFUL COMMANDS 

Command	Action
`reset`	reset console
`clear`	clear screen
`history`	command history
`exit`	exit the shell
`logout`	log out of the shell

Command history is stored in `.bash_history` in your home dir.

BUILTINS VS. EXTERNAL COMMANDS

- `type <command>` : command type.
- `which <name>`, `whereis <name>` : find binary by name.

```
user@cosmos:~$ type cd
cd is a shell builtin
user@cosmos:~$ whereis cd
cd:
```

```
user@cosmos:~$ type --all ls
ls is aliased to `ls --color=auto'
ls is /bin/ls
user@cosmos:~$ whereis ls
ls: /bin/ls /usr/share/man/man1/ls.1.gz
```

```
user@cosmos:~$ which ls
/bin/ls
```

USEFUL KEYS (`C=Ctrl`, `M=Alt`)

Key	Action
`Tab`	completion
`C-a/e`	cursor to line start/**end**
`M-b/f`	previous/next word (**back**/**forward**)
`C-k`	delete everything till line end (**kill**)
`C-w`	delete previous **word**
`C-y`	paste what we cut (**yank**)
`C-r`	**reverse** history search (`C-r` for more)

MORE KEYS ⌨️

Key	Action
`C-c`	sends `SIGINT` to the running process
`C-d`	sends end-of-file symbol to console
`C-z`	stops running process (use `fg` to resume)

CAT (CONCATENATE) 📃

```
cat file1.txt [file2.txt ...]
```

Will print to standard output files `file1.txt`, `file2.txt`, etc. concatenated.

SEE SOMETHING WITH CAT

```
user@cosmos:~$ cat /etc/issue
Debian GNU/Linux 11 \n \l
```

```
user@cosmos:~$ cat /etc/debian_version
11.4
```

```
user@cosmos:~$ cat /etc/os-release
PRETTY_NAME="Debian GNU/Linux 11 (bullseye)"
NAME="Debian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
ID=debian
HOME_URL="https://www.debian.org/"
```

§3: GETTING HELP WITH MAN AND INSTALLING PACKAGES WITH APT

- We have a very basic system at hand.
- Let's install some software.
- `apt` = Advanced Package Tool.
- Specific to Debian-based distributions.
- Other systems come with their own package managers.

BASIC USE 

`apt` command	Action
`list`	list available packages
`list --installed`	list installed packages
`update`	download list of packages
`upgrade`	install package upgrades
`search <pkg>`	package lookup
`info <pkg>`	package info
`install <pkg>`	install a package
`remove <pkg>`	remove a package
`autoremove`	remove no needed dependencies

SUDO 🦸

- Package management requires `root` privileges.
- Use `sudo` command

```
user@cosmos:~$ apt update
Reading package lists... Done
E: Could not open lock file /var/lib/apt/lists/lock - open (13: Perr
E: Unable to lock directory /var/lib/apt/lists/
user@cosmos:~$ sudo apt update
. . . . .
```

INSTALL MAN 📖

We'll install some documentation.

```
user@cosmos:~$ sudo apt update
. . . . .
user@cosmos:~$ sudo apt install man-db manpages
. . . . .
```

--HELP 🆘

```
user@cosmos:~$ tar --help
Usage: tar [OPTION...] [FILE]...
GNU 'tar' saves many files together into a
single tape or disk archive, and can restore
individual files from the archive.

. . . . .
```

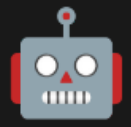
MAN 📖

```
user@cosmos:~$ man tar
TAR(1)                    GNU TAR Manual                    TAR(1)

NAME
       tar - an archiving utility

SYNOPSIS
   Traditional usage
       tar {A|c|d|r|t|u|x}[GnSkUWOmpsMBiajJzZhPlRvwo] [ARG...]

   UNIX-style usage
```

Command	Action
`whatis cat`	short summary
`man cat`	show manual page
`apropos <keyword>`	search for `<keyword>` in descriptions
`man -k <keyword>`	same as `apropos`

CALENDAR 


```
user@cosmos:~$ sudo apt install ncal
user@cosmos:~$ cal
    August 2022
Su Mo Tu We Th Fr Sa
    1  2  3  4  5  6
 7  8  9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
28 29 30 31
```

UUID 

```
user@cosmos:~$ sudo apt install uuid-runtime
user@cosmos:~$ uuidgen
050ff192-3dbf-4d32-b64a-e4a3f2bb8e72
```

CURL 🌍

```
user@cosmos:~$ sudo apt install curl
. . . . .
user@cosmos:~$ curl wttr.in
Weather report: Guanajuato City, Mexico

      \   /     Sunny
       .-.      19 °C
    ― (   ) ―   ↙ 8 km/h
       `-’      10 km
      /   \     0.0 mm
```

POSSIBILITIES OF CURL ⭐

- Various protocols.
- Inspection of headers (`-i` and `-v`).
- Sending extra headers (`-H`).
- GET, HEAD, POST, PUT, DELETE (`-X`).
- Sending file contents in POST (`-d`).
- Read `man curl`.
- No need to always use Postman.

WGET 💾

```
user@cosmos:~$ sudo apt install wget lzip
. . . . .

user@cosmos:~$ wget https://data.iana.org/time-zones/releases/tzdb-2
. . . . .

user@cosmos:~$ tar -xvf tzdb-2022a.tar.lz
. . . . .
```

OLD SOFTWARE

- Don't expect latest software versions in "stable" packages.
- Especially if the Debian release cycle is slower.
- Latest versions are in "unstable".

```
user@cosmos:~$ apt info nodejs
Package: nodejs
Version: 12.22.12~dfsg-1~deb11u1

# 18.x: current Node.js version,
# 12.x: old, not supported anymore.
```

INSTALLING FROM .DEB FILES 📦

- Packages are stored in `.deb` files.
- Can be installed directly.
- Prefix file name with `./`:

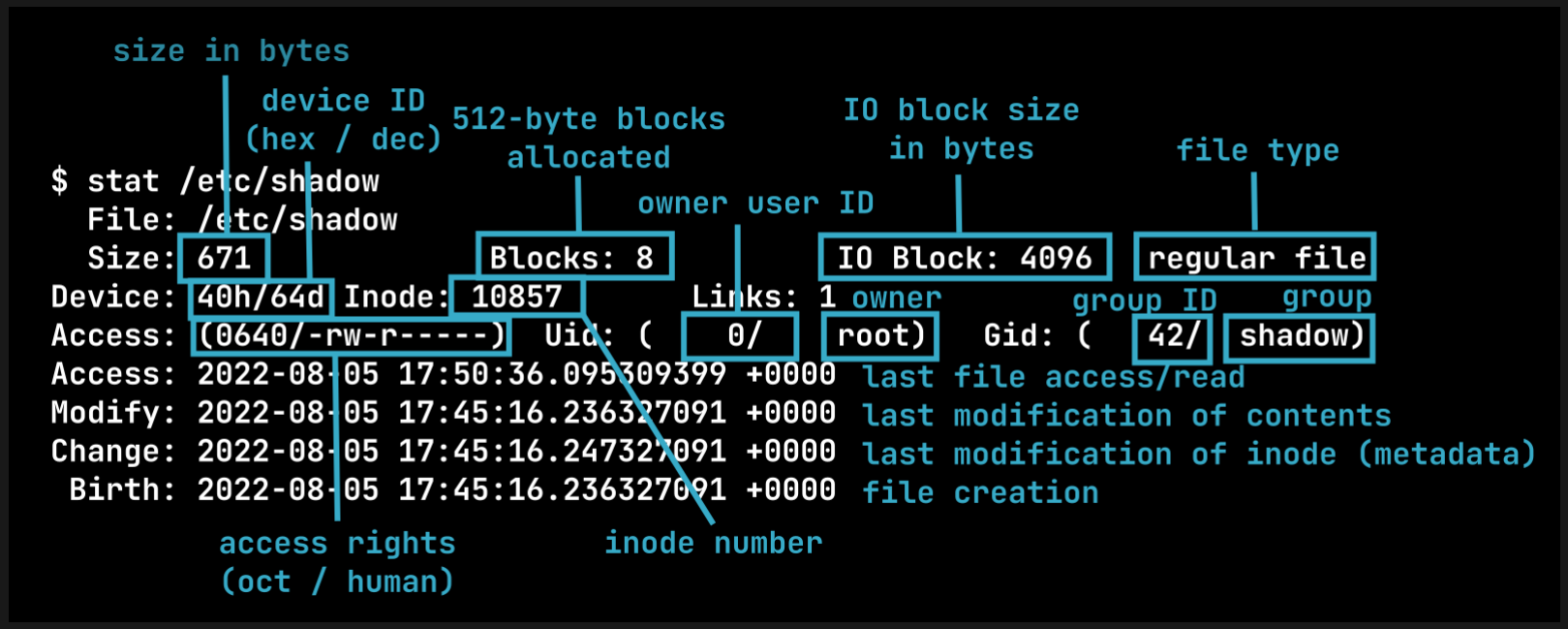
```
$ sudo apt install ./code_1.70.0-1659589288_amd64.deb
$ apt info code
Package: code
Version: 1.70.0-1659589288
Priority: optional
Section: devel
Maintainer: Microsoft Corporation <vscode-linux@microsoft.com>
Installed-Size: 359 MB
Provides: visual-studio-code
. . . . .
```

§4: WORKING WITH FILES

- Everything is a file, e.g. a directory or device.
- Common file systems: **ext4**, **Btrfs**.
- **Inode**: data structure representing contents and metadata.
- **Symbolic links**: pointers to files.
- File names: 255 bytes max, case-sensitive.
- Path separator is `/`.
- `.` is the current directory and `..` is the parent directory.

STAT 🔬

```
user@cosmos:~$ stat /etc/shadow
  File: /etc/shadow
  Size: 671             Blocks: 8          IO Block: 4096   regular
Device: 40h/64d Inode: 10857       Links: 1
Access: (0640/-rw-r-----)  Uid: (    0/    root)   Gid: (   42/  sha
Access: 2022-08-05 17:50:36.095309399 +0000
Modify: 2022-08-05 17:45:16.236327091 +0000
Change: 2022-08-05 17:45:16.247327091 +0000
 Birth: 2022-08-05 17:45:16.236327091 +0000
```


size in bytes
device ID
(hex / dec)
512-byte blocks
allocated
IO block size
in bytes
file type
owner user ID
$ stat /etc/shadow
File: /etc/shadow
Size: 671
Blocks: 8
IO Block: 4096
regular file
Device: 40h/64d Inode: 10857
Links: 1 owner
group ID
group
Access: (0640/-rw-r-----) Uid: (0/ root) Gid: (42/ shadow)
Access: 2022-08-05 17:50:36.095309399 +0000 last file access/read
Modify: 2022-08-05 17:45:16.236327091 +0000 last modification of contents
Change: 2022-08-05 17:45:16.247327091 +0000 last modification of inode (metadata)
Birth: 2022-08-05 17:45:16.236327091 +0000 file creation
access rights
(oct / human)
inode number

```
user@cosmos:~$ stat --format=%F /etc/passwd
regular file
user@cosmos:~$ stat --format=%F /home
directory
user@cosmos:~$ stat --format=%F /proc/1/exe
symbolic link
user@cosmos:~$ stat --format=%F /dev/tty
character special file
```

As you see,

`/etc/passwd`, `/home`, `/proc/1/exe`, `/dev/tty`

are all files, but of different kind.

Command	Action
`pwd`	print working directory
`ls`	list files in the working directory
`tree`	print file tree (package `tree`)
`ls foo`	list files in `foo`
`cd foo`	go to `foo` directory
`cd ..`	go to the parent directory
`cd -`	go to the previous directory
`cd`	go to your home directory

SOME OPTIONS OF LS ⚙️

- `-1` : one file per line,
- `-a`, `--all` : show hidden files,
- `-h`, `--human-readable` : human-readable size,
- `-l` : long listing format,
- `-p` : append `/` to directories,
- `-R`, `--recursive` : recursive list,
- `-S` : sort by size, largest first,
- `-t` : sort by time, newest first,
- `-r`, `--reverse` : reverse sort.

```
user@cosmos:~$ ls -1ahlp /etc
```

HIDDEN FILES 🫣

- By convention, files starting with `.` are hidden.

```
user@cosmos:~$ ls -1
user@cosmos:~$ ls -1a
.
..
.bash_history
.bash_logout
.bashrc
.profile
```

HIDDEN FILES 🫣

- Used to store local settings and configuration.
- Bash will have these in your home dir: `.bash_history`, `.bash_logout`, `.bashrc`, `.profile` (second session).
- Familiar example: Git stores its local data in `.git`.
- Your IDE configuration is in `/home/user/.vscode`, `/home/user/.idea`, etc.

Command	Action
`mkdir foo`	create directory `foo`
`mkdir -p foo/bar/baz`	create together with parents
`mv foo bar`	move `foo` to `bar`
`cp foo bar`	copy `foo` to `bar`
`cp -r ./foo/ bar`	copy directories recursively
`rm foo.txt`	delete `foo.txt`
`rmdir foo`	delete empty directory
`rm -r foo`	delete directory recursively
`ln -s source target`	create symbolic link
`touch foo.txt`	modify / create file

SYMBOLIC LINKS 🔗

- **Hard links** share inode; point to a specific part of the file system.
- **Soft (symbolic) liks** are separate inodes refering to another path.
- Example use: if you install Java on Debian (package `default-jdk`), you'll have symbolic links

`/usr/bin/java` → `/etc/alternatives/java` → `/usr/lib/jvm/java-11-openjdk-amd64/bin/java`

DANGLING LINKS ⛔

```
user@cosmos:~$ touch foo.txt
user@cosmos:~$ ln -s foo.txt bar.txt
user@cosmos:~$ ls -1l
total 4
lrwxrwxrwx 1 user user 7 Aug  8 20:34 bar.txt -> foo.txt
-rw-r--r-- 1 user user 0 Aug  8 20:34 foo.txt
user@cosmos:~$ rm foo.txt
user@cosmos:~$ ls -1l
total 4
lrwxrwxrwx 1 user user 7 Aug  8 20:34 bar.txt -> foo.txt
user@cosmos:~$ cat bar.txt
```

VIEWING FILES 👀

Command	Action
`cat file ...`	concatenate files
`less foo.txt`	view interactively
`head foo.txt`	view first lines
`tail foo.txt`	view last lines
`tail -f log.txt`	watch for updates

* `sudo apt install less`

FINDING FILES 🔍

- `find` : finds files in a directory.
- Read `man find`.
- Finding file by name:

```
user@cosmos:~$ find /usr -name *.txt
/usr/share/doc/libdb5.3/build_signature_amd64.txt
/usr/share/doc/mount/mount.txt
/usr/share/doc/util-linux/00-about-docs.txt
/usr/share/doc/util-linux/PAM-configuration.txt
/usr/share/doc/util-linux/blkid.txt
. . . . .
```

GREPPING THROUGH CONTENTS 🔍

- Read `man grep`.
- `-r`, `--recursive` for recursive search,
- `-i`, `--ignore-case` to ignore case.

```
user@cosmos:~$ grep -r -i torvalds /usr
/usr/share/doc/bsdutils/copyright:            1991, 1992 Linus Torva
/usr/share/doc/bsdutils/copyright:Copyright: 1991, 1992 Linus Torva
/usr/share/doc/libblkid1/copyright:            1991, 1992 Linus Torva
/usr/share/doc/libblkid1/copyright:Copyright: 1991, 1992 Linus Torva
/usr/share/doc/libmount1/copyright:            1991, 1992 Linus Torva
```

DU: DISK USAGE 📂

- Directory size reported by `ls` and `stat`: possibly not what you want.
- Actual recursive size of contents: `du` (disk usage).
  - `-h`, `--human-readable`,
  - `-s`, `--summarize` : display total size.

```
user@cosmos:~$ stat --format=%s /usr
84
user@cosmos:~$ du -sh /usr
136M    /usr
```

DF: DISK SPACE 💿

```
user@cosmos:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/vdb         50G   46G  4.2G  92% /
tmpfs            64M     0   64M   0% /dev
tmpfs           3.3G     0  3.3G   0% /sys/fs/cgroup
shm              64M     0   64M   0% /dev/shm
/dev/vdb         50G   46G  4.2G  92% /etc/hosts
devtmpfs        3.3G     0  3.3G   0% /dev/tty
tmpfs           3.3G     0  3.3G   0% /proc/asound
tmpfs           3.3G     0  3.3G   0% /proc/acpi
tmpfs           3.3G     0  3.3G   0% /proc/scsi
```

WORKING WITH ARCHIVES 📦

Command	Action
`zip -r files.zip files`	create `.zip` acrchive
`unzip files.zip -d /path/to/unzip`	extract `.zip` archive
`unzip -l files.zip`	list contents
`tar -czvf files.tar.gz files`	create `.tar.gz` archive
`tar -xvf files.tar.gz`	extract archive
`tar -tvf files.tar.gz`	list contents

WHAT IS `.tar.gz`? 

- An **archive** packages files together.

  `.tar` = "tape archive" format.
- **Compression** is applied to an archive.

  `.gz`, `.bz2`, `.lz`, `.xz`, ... = different compression algorithms.
- `tar` command is already aware of those formats applied to `.tar`.

OTHER USEFUL COMMANDS 🔮

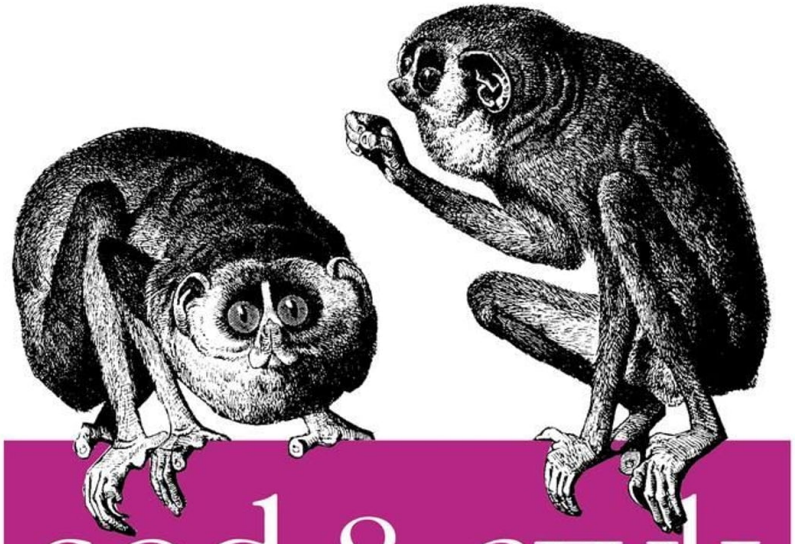
Command	Action
`sort foo.txt`	sort lines and print to stdout
`sort -u foo.txt`	sort lines, print unique entries
`diff foo.txt bar.txt`	compare files
`sed s/foo/bar/g text.txt`	pattern substitution
`wc`	count words, lines, bytes

Count installed packages:

```
user@cosmos:~$ apt list --installed | wc -l
```

UNIX Power Tools

2nd Edition



sed & awk

O'REILLY

Dale Dougherty & Arnold Robbins

NEXT TIME

- Users, groups, permissions.
- Processes (`ps`, `top`, `kill`, `killall`).
- Linux file system: what is `/bin`, `/dev`, `/boot`, `/etc`, and so on.