

Capture in a single file (archive) metadata and contents of files and directories, e.g.:

```
# capture files in sheeple directory tree
# -c create an archive
# -f archive filename
# -z compress with gzip
$ tar -zcf sheeple.tar.gz sheeple
$ cp sheeple.tar.gz /tmp
$ cd /tmp
# extract files from archive
# -x create an archive
# -v (verbose) - print filenames when extracting
# -f archive filename
$ tar -xvf sheeple.tar.gz
...
```

1

curl lets you interact from command line with web and other servers

```
# fetch a file
$ curl -O https://cgi.cse.unsw.edu.au/~cs2041/examples.zip
# get other info
$ curl I https://unsw.edu.au
HTTP/1.1 200 OK
Server: Apache/2.4.34 (Red Hat) OpenSSL/1.0.1e-fips PHP/5.6.25
X-Powered-By: PHP/5.6.25
# send data to web server
$ curl -X PUT -H 'content-type: txt/plain' https://google.com
# send cookies to web server
$ curl -b 'id=42' https://google.com
....
```

many other options

2

- ssh was written by Finnish university student Tatu Ylönen
- quickly adopted as an internet standard

```
$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/andrewt/.ssh/id_rsa):
# leaves private key in $HOME/.ssh/id_rsa
# leaves public key in $HOME/.ssh/id_rsa.pub
$ cat $HOME/.ssh/id_rsa.pub
ssh-rsa AAAAB3NzaC1yc2EAAAABIwAAAQEaxL+t ....
```

Add public key to `$HOME/.ssh/authorized_keys` to allow for access without password.

Can also run commands remotely:

```
$ ssh z1234567@login.cse.unsw.edu.au ls -las
```

3

rsync efficiently copies files & directories locally or between machines (using ssh)

```
# mirror a directory tree in your CSE account
# -a preserves metadata & copies recursively
# -P shows progress
$ rsync -aP sheeple/ login.cse.unsw.edu.au:sheeple_backup/
```

If you run rsync command again it will only copy files which have changed.

If only a part of large file changed, will copy only the change (delta).

Many options, see `man rsync`

4

```

# create a 100mb file
$ dd if=/dev/random bs=1M count=100 of=100_mb_file
# takes 25 seconds to copy it to CSE (40Mbps NBN)
$ time rsync 100_mb_file login.cse.unsw.edu.au:100_mb_file
real    0m24.943s
# repeat the rsync without changing the file - very fast
$ time rsync 100_mb_file login.cse.unsw.edu.au:100_mb_file
real    0m0.782s
# change a few bytes of the file
$ echo hello andrew >>100_mb_file
# rsync still fast
$ time rsync 100_mb_file login.cse.unsw.edu.au:100_mb_file
real    0m0.846s

```

Unix provides a range of tools for manipulating processes

Commands:

- ps ... show process information
- top ... show high-cpu-usage process information
- kill ... send a signal to a process
- killall ... send a signal to a process with particular names

5

6

Linux Filesystem Layout

/home - home directories for users on the system

/bin - important system programs (scripts and binaries)

/usr/ - system programs and associated files

- **/usr/bin** system programs
- **/usr/local/bin** custom installed local programs
- **/usr/lib** - libraries (linked with programs)
- **/usr/include** - header files for C programs.

/etc - holds configuration for system programs

/opt - multi-operating system packages sometimes install here

/var - system files that regularly change, e.g.: log files, database files.

/tmp - directory for temporary files - removed on reboot

Linux Filesystem Layout

/root - home directory for root user

/boot - files need to boot operating system

/dev - pathnames for hardware devices.

/media - mount-point for removable device

/proc - special filesystem with information about processes

/sys - special filesystem with information about system

7

8

Devices manipulated by special files in /dev e.g a disk might appear as /dev/sda

```
$ ls -l /dev
...
brw-rw---- 1 root disk      8,  0 May 21 08:38 sda
brw-rw---- 1 root disk      8,  1 May 21 08:38 sda1
...
crw-rw-rw- 1 root root      1,  3 May 21 08:38 null
...
crw-rw-rw- 1 root root      1,  8 May 21 08:38 random
...
crw--w---- 1 root tty       4,  0 May 21 08:38 tty0
...
rw-rw-rw- 1 root root      1,  5 May 21 08:38 zero
```

9

Disks can be separated into separate regions called partitions.

This allows parts of disk to be used for different purposes

fdisk is a simple program to view or change partitions, see also **gparted**.

```
$ fdisk -l /dev/sdg
Disk /dev/sdg: 28.66 GiB, 30752636928 bytes, 60063744 sectors
Disk model: Ultra
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x00000000
```

Device	Boot	Start	End	Sectors	Size	Id	Type
/dev/sdg1		32	60063743	60063712	28.7G	c	W95 FAT32 (LBA)

Beware: dangerous operation - have backups!

10

- **ext4** - mostly widely used Linux file-system
- **ext2/ext3** - older versions of ext4 - limited with less features
- **brtfs** - copy-on-write filesystem with interesting features
- **zfs** - filesystem which can span disks with interesting features
- **ntfs** default Windows file-system - can be accessed from Linux
- **vfat** - older Windows filesystem - widely used for removable devices such as SD cards and USB keys

11

```
$ ls -l /dev/sdg*
brw-rw---- 1 root disk 8, 96 Aug  4 12:47 /dev/sdg
brw-rw---- 1 root disk 8, 97 Aug  4 12:47 /dev/sdg1
$ mkfs /dev/sdg1
mke2fs 1.45.6 (20-Mar-2020)
Discarding device blocks: done
Creating filesystem with 262144 4k blocks and 100096 inodes
Filesystem UUID: 66028671-cece-47ff-804c-4a3b7f9f0ea5
Superblock backups stored on blocks:
    32768, 98304, 163840, 229376
```

```
Allocating group tables: done
Writing inode tables: done
Creating journal (8192 blocks): done
Writing superblocks and filesystem accounting information: done
```

Beware: dangerous operation - have backups!

12

mount makes a file-system available from a point in the file-system

umount reverses this.

```
$ mkdir /tmp/g
$ sudo mount /dev/sdb1 /tmp/g
$ ls -l /tmp/g
..
$ umount /tmp/g
```

Distributions usually have a helper program to mount/unmount removable devices.

Power failure or otehr unexpected events may leave a filesystem in inconsistent state.

fsck (file system check) checks and repairs a file-system.

```
$ sudo fsck /dev/sdg1
fsck from util-linux 2.34
fsck.fat 4.1 (2017-01-24)
/dev/sdg1: 5 files, 739/1876074 clusters
```

File system should not be in use (unmounted)

Beware: dangerous operation - have backups!

Configures file systems on device to be mounted when system starts.

```
$ cat /etc/fstab
# device  mount-point  fs-type  options  1 1
/dev/sda1  /            ext4     noatime,errors=remount-ro  1 1
/dev/sda2  none        swap     sw        0 0
```

Must include a root file-system on /

Usually includes a swap device.

Often use a unique label for device because device names can change if hardware reconfigured, e.g. more disks added.

```
$ cat /etc/fstab
UUID=36bcedb9-de07-4de0-82c6-509000029f0e / ext4 defaults 1 1
```

fsck - repair an (unmounted) file system

fdisk - print change disk partition tables

User information in `/etc/passwd`

Password hashes in `/etc/shadow`

Every user has unique number: `uid`

```
$ sed2q /etc/passwd
```

```
root:x:0:0:root:/root:/bin/bash
```

```
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
```

```
$ sudo sed2q /etc/passwd
```

```
root:$6$YiSiP7Pehz8aoe...../:18379:0:99999:7:::
```

```
daemon*:18362:0:99999:7:::
```

Manage users with `adduser` `deluser`

17

Group information in `/etc/group`

```
$ head /etc/group
```

```
root:x:0:
```

```
daemon:x:1:
```

```
bin:x:2:
```

```
sys:x:3:
```

```
adm:x:4:
```

```
tty:x:5:
```

Each group has unique number: `gid`

Do not edit `/etc/group` directly

Add users to groups with `adduser`

Also `addgroup` `delgroup`

18

Many system actions require root (`uid == 0`)

`su` allows you to switch to root or other user.

`sudo` allows command to be run as root

Use cautiously - easy to damage system with commands run as root.

Edit sudo config file `/etc/sudoers` with `visudo`

```
# Adding user to sudo group should allow them to run sudo
```

```
$ adduser andrewt sudo
```

19

A distribution is a Linux kernel packaged together with other programs

Many linux distributions, popular with CSE students are: Debian, Ubuntu, Mint, Arch, Red Hat

20

One of the oldest Linux distribution (1993)
Widely used and available for many platforms.
Stable - new release every 2 yrs.

21

A packages contains files that make up an application
And build scripts to install/remove application.
May contain metadata for managing the package.
Used to install new applications onto a system
Debian uses the .deb format

22

apt

```
# update database of packaes available
$ apt update
# install a package + dependencies
$ apt install <packagename>
# uninstall package
$ apt remove <packagename>
# update all packages
$ apt dist-upgrade
# search for a package
$ apt search <packagename>
# install a downloaded package file
$ apt install ./package.deb
```

23