Practical Bioinformatics

Basic Linux

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URPP Evolution in Action

Why Linux?

In Genomics/Bioinformatics

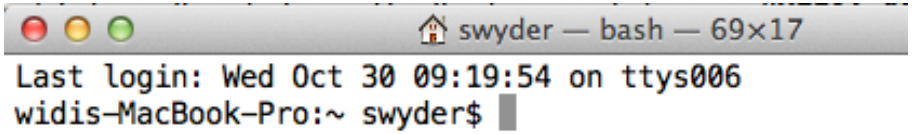
- Many tools are Linux only and are optimized to run on Linux
- Very powerful with text files, even large (GBs)

In general

- Linux users can work more efficiently and more quickly
- Multi-user
- Lots of control and customization possibilities
- 0$
- ....

Why command line / shell?

- for most bioinformatics software, you have to use it
- you can automate repetitive tasks
- reproducible (script = log file)
- to interact with high-performance remote computers
- offers handy tools to work for text manipulation



- The shell is an interactive interpreter: it reads commands, finds the corresponding programs, runs them, and displays output
- Today we use the **Bash shell** (default shell of most Linux distributions and Mac OS X)

The prompt

Prompt

```
eiger-uzh:~ swyder$
```

Hostname

User

Normal user

```
eiger-uzh:~ swyder$
```

Current path
(abbreviated)

Commands

- small programs to accomplish a particular task instead of trying to develop large monolithic programs to do a large number of tasks.

- "Designed to operate together"
  To accomplish more complex tasks, tools can simply be connected together.

- The shell comprises hundreds of commands, but if you know 25 you can achieve many things

- Commands are abbreviations to type less (ls:list, cp:copy, mv:move)

- Common structure:
  Command -Option(s) Parameter(s)
  ls -l /home/swyder/tmp

Setting options

Command -Option(s) Parameter(s)

ls -l

ls -l -r -h

ls -l -r -h

ls -rlh

ls --reverse --human-readable long options !only GNU tools!

The order of options does not matter
unless they override each other (e.g. sorting)

Options, grep as an example

more fruitlist.txt

```
apple
banana
pineapple
pear
peach
```

- $ grep apple fruitlist.txt
  apple
  pineapple
- $ grep -w apple fruitlist.txt (or grep -x)
  apple
- $ grep -v apple fruitlist.txt
  banana
  pear
  peach
- $ grep apple *.txt
  fruitlist.txt:apple
  fruitlist.txt:pineapple
  recipeFruitSalad.txt:1 pineapple
  recipePinaColada.txt:2oz fresh pineapple juice
- $ grep apple fruitlist.txt recipeFruitSalad.txt

Also options to color, to show context, search with compl patterns

Getting help

man <command>

```
man cp

CP(1)            BSD General Commands Manual            CP(1)

NAME
    cp -- copy files

SYNOPSIS
    cp [-R [-H | -L | -P]] [-fi | -n] [-apvX] source_file target_file
    cp [-R [-H | -L | -P]] [-fi | -n] [-apvX] source_file ... target_directory

DESCRIPTION
    In the first synopsis form, the cp utility copies the contents of the source_file to the targe
    contents of each named source_file is copied to the destination target_directory.  The na
    If cp detects an attempt to copy a file to itself, the copy will fail.

    The following options are available:

    -a    Same as -pPR options. Preserves structure and attributes of files but not directory st

    -f    If the destination file cannot be opened, remove it and create a new file, without pro
          permissions.  (The -f option overrides any previous -n option.)
...
```

space: scroll down a page
b: scroll up
q: quit man

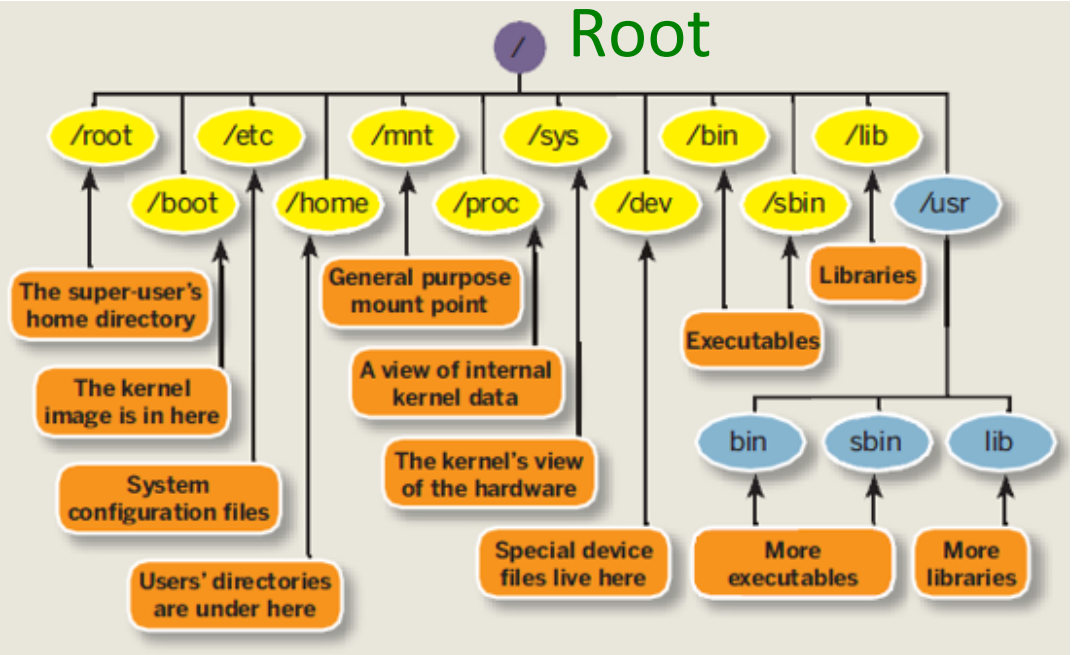
<command> --help
cp --help

a less verbose help
(not working on Mac OS)

The web
http://linuxconfig.org/linux-commands

Working with files and directories

Directory structure



http://www.tuxradar.com/

- Everything the system uses is located somewhere under root '/'.
- Every user has his home directory, e.g. /home/swyder
- Do your work in your home directory
- The system folders can only be modified by the administrator

File and Directory names

- Upper- and lower-case matter
- up to 256 characters long
- Every character except / is allowed. But by convention special characters like $äéÜ*? and quotes are not used.
- Don't use white spaces. Use underscores (_), hashes (-) and dots (.) to separate words
  Oct2013_RNAseq
  ~~Oct2013\ RNAseq~~

Main commands

Command	Meaning
ls	Content of current directory
cd *dir_name*	Change to directory
cd	Change to home directory
cd ~	Change to home directory
mkdir	Make a directory
cp	Copy a file/directory
rm	Delete a file/directory

Working with text files

Main text commands

UNIX has an extensive toolkit for text extraction, reporting and manipulation

Task	Commands
Show	**less**, more, head, tail, cat
Search/Extract	**grep**, **cut**, awk, uniq
Manipulate	**sort**, tr, sed, join, paste
Replace	**tr**, sed
Count	**wc, uniq -c**
Compare	comm, diff

Piping

Piping

Philosophy

"filters“: simple programs which only do 1 thing

the output of a filter is the input of the next

```
grep "mRNA" test.gff | less
```

```
grep -w "gene" test.gff | cut -f 1 | sort | uniq -c
```

Redirection

> Writing the output to a file

>> Appending the output to a file

```
ls > output.txt
grep -w "gene" test.gff | cut -f 1 | sort | uniq -c > output.txt
ls >> output.txt
```

< Reading from file

```
wc < hello.txt > hello_counts.txt
```

What we learned in Part 1

- Command -Option(s) Parameter(s)
  ls -rlh ~/data

- Working with files / directories
  ls, cd, mkdir, cp, mv, rm

- Directory structure
  everything is under the root: /

- Working with text files
  head, less, grep, cut, sort, tr, wc, uniq

- Tools can be connected by "|"

- The Mac OS X Shell differs from the typical Linux shell

Sources & Links

Acknowledgements

- Some exercises are from von Mering group (IMLS, UZH)

Material

- SIB course http://edu.isb-sib.ch/course/view.php?id=41
- O'reilly Books http://oreilly.com/linux/
- Video tutorials (~100 min) http://software-carpentry.org/v4/shell/index.html
- Cheatsheet http://www.embnet.org/sites/default/files/quickguides/guideUNIX.pdf

Additional topics

- Connecting with Unix/Linux servers
- File/Dir Compression&Extraction

- Installing and running software
- Permissions

- Differences in the shell Mac OS - Linux
- Command line on Windows 10

File/Dir compression

	Command	Meaning
1 file	**gzip** *filename*	compress file with gzip (adds .gz extension)
	gunzip *filename.gz*	decompress file with gzip (removes .gz extension)
Many files/ Directories	**tar xfz** *filename.tar.gz*	extract/decompress files from tar.gz archive
	tar zcvf *archive.tar.gz folder_to_compress*	creates archive.tar.gz
	unzip *filename.zip*	unzip archive

zmore, zless, zgrep, ...

Running programs

- Programs are executable files (permissions!)

- Run a bash script

```
#make file executable
chmod +x script.sh
#Run it
./script.sh
```

or

```
#no need for chmod
bash script.sh
```

- Its the same for any script (python, perl,...)

```
./script.py
```

or

```
python script.py
```

- Run a binary

```
chmod +x bowtie
./bowtie
```

Installing Software (binaries)

- Packages
  Using a package manager - takes also care of dependencies
  - Linux:
    Ubuntu: via .deb files (e.g. aptitude or apt-get)
    Fedora/SUSE: via .rpm files
  - Mac OS X: homebrew (my favourite), MacPorts, fink

- Compiling from source
  Typically open-source software is written in C/C++ -> GCC compiler
  - Linux: install gcc using the package manager (apt-get search gcc, then apt-get install *gcc-XXXX*)
  - Mac Os X: install gcc using homebrew (brew search gcc, ...) or via XCode

```
./configure
make
make install       # optional
make clean         # optional
```

To install an executable

Bash only looks at certain directories for commands/software/programs
$PATH is a variable

echo $PATH
/usr/bin:/bin:/usr/sbin:/sbin:/usr/local/bin:/opt/X11/bin:/usr/texbin

1. You copy it into one of the folders in $PATH
2. You add its directory to $PATH
   export PATH=$PATH:*directory*

3. You create a symbolic link to it into a folder contained in $PATH
   sudo ln -s executable directory

Summary: executables

- Come in two flavours: Scripts / Binaries
- Execute permissions must be set:

  `chmod +x programname`

- Scripts mostly start with the shebang line, telling the shell which interpreter to use. E.g.

  #!/usr/bin/perl

- Executing of executables

  ```
  ./prg
  ./prg.sh   (bash prg.sh)
  python prg.py
  perl prg.pl
  ```

Permissions

```
$ ls -l
```

```
-rw-r--r--   1 swyder  staff      6677 30 Okt 22:02 At.gff
-rw-r--r--@  1 swyder  staff   3723486 28 Okt 17:30 CheatSheetguideUNIX.pdf
drwxr-xr-x  11 swyder  staff       374 11 Nov 16:13 FASTAS
-rw-r--r--   1 swyder  staff        21 30 Okt 22:04 indA.txt
```

Permissions

Owner

Group

File size
(bytes)

Last modification

File type
d : directory
- : regular file

Changing Permissions

r: read
w: write
x: execute

```
$ chmod [ugo][+-][rwx] file
```

u: user
g: group
o: other/world

Make a file executable (for you)

```
$ chmod +x file
chmod ug+rx my_file
```

Setting exact permission (only reading, for you)

```
$ chmod =r file
```

Removing permissions (for you)

```
$ chmod -wx file
```

Permission code

Owner	Group	Other
r w x	r w x	r - x
4+2+1	4+2+1	4+0+1
7	7	5

r: read
w: write
x: execute

chmod 775 *file*

Server commands

Command	Task
ssh -X *user@hostname* (secure shell)	Connect to server
scp <what> <towhere>	Transfer file from/to server
sftp *user@hostname*	Transfer file from/to server (interactive)

Connect to remote computer

```
$ ssh username@mnf-44.uzh.ch
```

```
RSA key fingerprint is 71:ed:af:1f:d6:0a:43:05:8d:11:34:68:
2c:2d:79:01.
Are you sure you want to continue connecting (yes/no)?
```

Type "yes" and press ENTER.
Then you will be asked for your password.

```
$ bash          # we will use the bash shell
$ whoami        # what is my username on this host
$ uname -a      # show basic info of the host OS
$ df -h         # displays free disk space
```

Differences in the Shell

Linux - Mac OS

Differences Linux - Mac OS X

- Mac line breaks are '\r\n' (and Windows: '\r') instead of the standard Linux '\n'
  When working in the command line make sure the files have the right format
  perl -pi -e 's/\r\n?/\n/g' <filename>
  which you could alias and put in the .bashrc

- Mac has no GNU tools by default
  less options – less powerful
  for installation install homebrew
  then: brew install coreutils
  All GNU commands are then installed with the prefix 'g': gls, gcp, gsed,...

- Mac has non-standard folder structure
  e.g. home (~) is /Users/swyder

native Linux command line on Windows 10

Windows Subsystem for Linux (WSL)

- You can install your favourite Linux distribution
- Run command-line utilities and bash scripts
- use the distribution's package manager
- requires fewer resources than VM
- does not aim to support GUI desktops or applications (e.g. Gnome, KDE, etc.

see
https://msdn.microsoft.com/en-us/commandline/wsl/about
https://msdn.microsoft.com/en-us/commandline/wsl/faq