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Introduction to the Linux terminal:

Useful tools and commands for bioinformatic analyses

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03/06/2024

IJC Bioinformatics

The IJC Bioinformatics Unit

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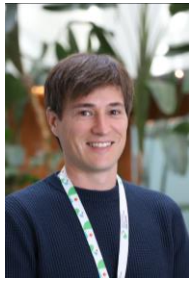

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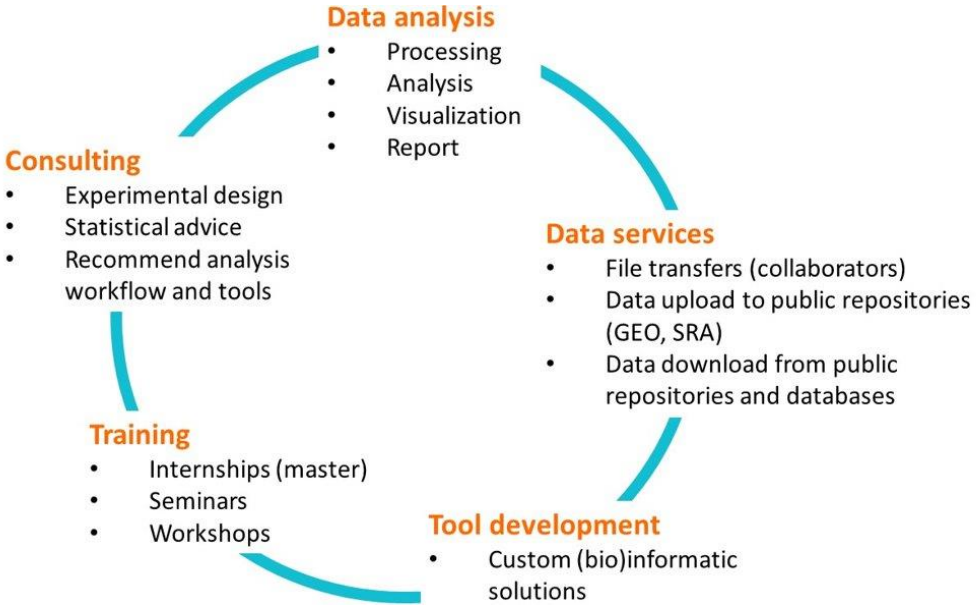


Office: 1st floor; phone: 4300
https://ijcbit.eu
https://www.carrerasresearch.org/en/bioinformatics-unit

Workshops

Introduction to the IJC computing infrastructure

Linux

- Introduction to the Linux terminal (Beginner) (2 days)
- Advancing with the Shell (Intermediate)

R

- Introduction to (base) R programming (Beginner)(2 days)
- Data visualization in R (Beginner)

Tools for reproducible research

- Introduction to git and github (Intermediate)
- Introduction to working with software containers (Intermediate)

Materials available at:

https://ijcbit.github.io/Workshops/

Introduction to the Linux terminal: Workshop overview

Day 1:

- Introduction to Linux
- Practical session I:

  Linux & the Shell (basics and commands)

Day 2:

- Practical session II:

  Shell programming & vim (CLI text editor)

What is Linux?

= free-open source computer software environment (operating system)

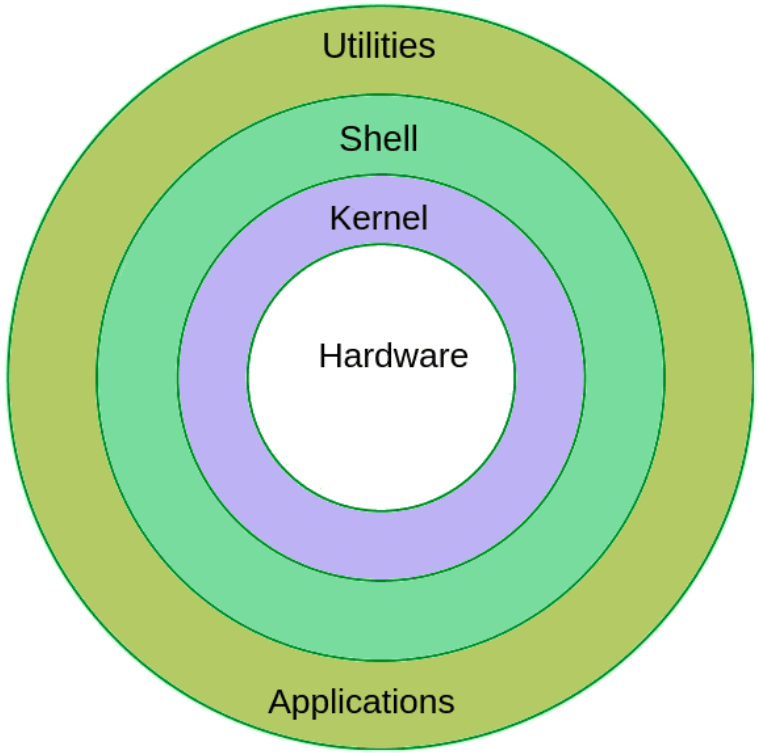
Free Software license:

- Freedom to run the program for any purpose
- Freedom to study and change the program; access to underlying source code
- Freedom to share copies to help your neighbor
- Freedom to distribute copies of modified versions for others

More than 300 Linux distributions!

https://upload.wikimedia.org/wikipedia/commons/6/6f/Linux_distros_tree.png

The Linux system



https://www.instructables.com/Linux-Presentation-in-PDF/

outer

core

Utilities & applications	programs
X	graphical system that provides windows, menus, icons, mouse support (KDE, GNOME)
Shell	user interface for typing commands, executing them and displaying the results
Kernel	low-level operating system for handling files, disks, networking, etc.

Terminology

Shell = a command line interface: CLI (as supposed to graphical user interface: GUI)
multiple shells: *bsh, bash, zsh*

Bash = Bourne Again SHell (enhanced version of the original Unix shell program, bsh written by Steve Bourne)

Terminal = a program called *terminal emulator,* opens a window and lets you interact with the shell (konsole, xterm, gnome-terminal, etc)

Let's get started..

Connect to the course server:

1. Open web browser
   `https://vpn.carrerasresearch.org/ > Login >> Linux_course`
2. Open terminal
   `ssh username@intercept`

First steps

1. The prompt
   `username@host:currentdirectory$`

2. A typical command *ls*
   `program` [*options*] *arguments*

```
ls                  # list files
ls --help           #   help option
ls -a               #  list all files (including)
ls -a mydirectory   # list all files in mydirectory
ls -l               # use a long listing format
```

3. File types:
   - directories (blue),
   - regular files (white),
   - executables (green),
   - compressed files (red),
   - softlinks (lightblue)

*colors depend on bash configuration

File attributes

ls : list information about files, default current directory

```
-l                          # use a long listing format
-h, --human-readable        # with -l and -s, print sizes like 1K 234M 2G etc.
-t                          # sort by modification time, newest first
```

```
amerkel@INTERCEPT:/home$ ls -lth
total 44K
drwx------  6 amerkel       isilon_merkel_group    4,0K nov 28 11:04 amerkel
drwxrwxrwt  2 super         root                   4,0K nov 28 10:39 shared
drwx------  5 idevillasante isilon_merkel_group    4,0K nov 28 10:10 idevillasante
drwx------  5 jalcantara    isilon_admins          4,0K nov 28 09:41 jalcantara
drwxr-xr-x 19 super         super                  4,0K nov 28 09:40 super
```

permissions

Number of linked hard-links

File owner

Group membership

File size (byte)

Modification/ creation date and time

File/directory name

File permissions

```
amerkel@INTERCEPT:/home$ ls -lth
total 44K
drwx------  6 amerkel       isilon_merkel_group    4,0K nov 28 11:04 amerkel
drwxrwxrwt  2 super         root                   4,0K nov 28 10:39 shared
drwx------  5 idevillasante isilon_merkel_group    4,0K nov 28 10:10 idevillasante
drwx------  5 jalcantara    isilon_admins          4,0K nov 28 09:41 jalcantara
drwxr-xr-x 19 super         super                  4,0K nov 28 09:40 super
```

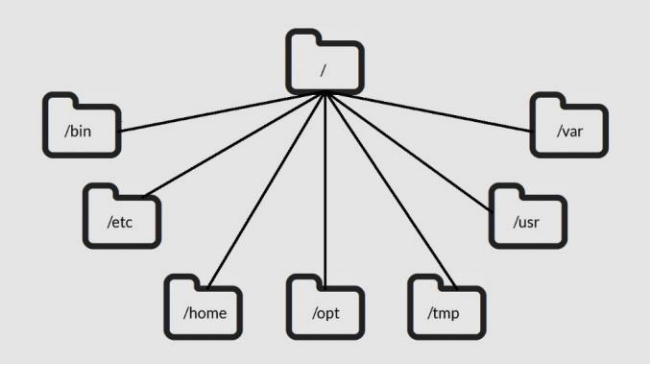
o,g,a = owner, group, all
r,w,x = read, write, execute # basic file permissions

chmod # change permissions of a file or directory

```
$ chmod a+rx myfile
```
add read and execute permissions for all for file

Linux directory structure

Tree hierarchy



Tip: Display directory structure with `'tree'` command

Dir	Description
/	The directory called "root." It is the starting point for the file system hierarchy. Note that this is not related to the root, or superuser, account.
/bin	Binaries and other executable programs.
/etc	System configuration files.
/home	Home directories.
/opt	Optional or third party software.
/tmp	Temporary space, typically cleared on reboot.
/usr	User related programs.
/var	Variable data, most notably log files.

*E1

Finding your way around

1. Where am I ?

```
pwd  # print current working directory
```

2. What is a path ?

/directory/directory/directory

3. Change directory 'cd'

```
cd somedirectory          # go to some directory
cd . ;                    # go to current directory
cd ..;                    # go one level up
cd ../..                  # go two levels up
cd -                      # go to previous
cd [~]                    # go /home/username
```

Basic file and directory operations

```
mkdir mydirectory                    # create a directory

cp file newfile                      # copy file
cp -r mydirectory newdirectory       # copy directory (recursively)

mv filename newfilename              # move (rename) file or directory to new

mv file directory                    # move file into directory

rm file                              # remove (delete) file
rm -r directory                      # remove (delete) directory (recursively)
```

Softlinks

```
ln -s file -n softLink   # create a soft link to a file

rm softLink              # remove the softlink (not the original file)
```

*E2

Handy short cuts

1. Command history:

   history

   use ↑↓ to go back and forward

2. 

   autocomplete filenames and commands

Wildcard substitution '*' = substitute for anything

```
ls *.bed    # list all filenames starting with anything and ending with '.bed'
ls les*     # list all filenames starting with 'les' and ending with anything
```

*E2

File compression and archiving

Compression decreases file size

```
gzip, gunzip        # compress or uncompress files in GNU zip format (.gz)
bzip2, bunzip2      # compress or uncompress files in Burrows-Wheeler format (.bz2)
zip, unzip          # compress or uncompress file in Windows zip format (.zip)
```

```
*gzip myfile  # produces myfile.gz and the original file is deleted
 zcat myfile  # uncompress to standard output
```

Archiving packs directories and files into a single package preserving hirarchy

```
tar -tf archive.tar              # list contents of archive
tar -xf archive.tar              # unpack archive
tar -cf archive.tar dir1 dir2    # create archive from directory 1 and directory 2
tar –xzf archive.tar.gz          # unpack and extract gzipped archive
```

*E3

File viewing and info

```
cat  myfile                 # print myfile content
less (more) myfile          # view myfile by page (use spacebar)
head -10 myfile             # view the first 10 lines of myfile
tail -10 myfile             # view the last 10 lines of myfile
wc -cwl myfile              # count characters, words, lines in myfile
```

Shell input/output and error

Default input device = keyboard, Default output device = screen

- Command output can be re-directed to a file:

```
$  mycommand > outfile  # create/overwrite outfile
$  mycommand >> outfile # append output to outfile
```

- Standard error are system messages written standard output

```
$ ls lala
 ls: cannot access 'lala': No such file or directory
```

- Standard error can be directed to a file as well:

```
$ mycommand  1>  outfile
$ mycommand 2> errorlog
```

Merging files

```
Cat file1 file2 > newfile     # concatenate two file into a new file
Cat file1 >> newfile          # append a file to another

paste file1 file2             # combine two text files side by side
```

*E4

File text manipulations

```
Sort      # print lines of text file in specified order
            (default: alphabetical)
    -n          # sort numerically
    -r          # reverse order
    -k f        # sort by field f
    -c          # don’t sort, only check if it is sorted
```

Example:

```
   $ sort –k 5n myfile    # sort by 5th field numerically
```

File text manipulations

```
Cut             # extract columns of a text file

     -f 1,3      # extract columns 1 and 3
                  (ranges: 1-3 = 1 to 3; 5- = 5 to last; -16 = first to 16 )

     -d,         #  field separator  (default: tab seperator)



Uniq            # filter matching line from input

    -c            # count number of unique lines
    -u            # print only unique lines
    -d            # print only duplicated lines
```

*E5

The pipe '|' operator

Using the shell, you can redirect standard of one command to be the standard input of another:

```
$ cut -f1 peaks.bed | uniq –c| sort -nr
```

File text manipulations with 'grep'

```
Grep  # print all lines matching a regular expression

  -v   # print lines that do not match the regular expression
  -w   # match only complete words
  -c   # print a count of matching lines
  -A N # after each matching line, print the next N lines from this file
  -B N # before each matching line, print the next N lines from this file
```

– E # or egrep for extended regular expression

Example:

```
$ grep chr1 peaks.bed
```

*E6

Online tutorials Linux

https://ryanstutorials.net/linuxtutorial/

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Introduction to the Linux terminal

Day 2: Programming with the shell

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04/06/2024

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Vim command line text editor

```
~
~                                   VIM - Vi IMproved
~
~                                   version 8.0.1763
~                                by Bram Moolenaar et al.
~                           Modified by <bugzilla@redhat.com>
~                     Vim is open source and freely distributable
```

Vim shellscript.sh # opens a new file 'shellscript.sh' with vim

Basic vim:

```
[esc]  # switch mode
  i        # enter edit mode

  :        # enter command mode

   wq       # when in command modes: save and exit vim
   q!       # when in command mode: exit without saving
```

For more on vim, check here

Shell script

1. create shellscript.sh

```
#! /bin/bash


### Author:

### Date:

### Description:
### My first shell script



# do something

echo "Hello world!"
```

2. execute

make the script executable

```
$ chmod a+x shellscript.sh
```

run the script

```
./shellscript.sh
```

Shell variables: $

Variables

```
MYVAR="Hello world!" # assign a variable
echo $MYVAR          # return variable
printf $MYVAR        # print variable formatted
MYVAR=$( ls *bed )   # assign the output of a command to a variable
MYVAR=`ls *bed`
```

Build-in variables

```
$PWD        # current working directory;
$PATH       # default path to executables
```

```
./shellscript.sh arg1 arg2  # Any string after a script is passed to the script as a build-in variable
```

```
$1=arg1
```

```
$2=arg2
```

Control structures: if-else

If-else

```
if [condition]
 then
   statement1
 else
   statement2
fi
```

example

```
#! /bin/bash

N=$1
M=$2
if [ $N -eq $M ]
 then
   echo "Hello world!"
 else
   echo "Good bye world!"
fi
```

test command = '[' = '[['

Statement	Description
test EXPRESSION	Test if an expression is true
[EXPRESSION]	Short hand for test, used on all POSIX shells
[[EXPRESSION]]	Short hand for test, available with newer shells like bash, ksh, zsh

Expression	Meaning
&&	Logical AND
||	Logical OR
-eq	Equality check
-ne	Inequality check
-lt	Less Than
-le	Less Than or Equal
-gt	Greater Than
-ge	Greater Than or Equal

File checks

Example: Test if a file exists

```
#! /bin/bash

FILE=$1

if [ -e $FILE ]
 then
  echo "$FILE exists."
 else
  echo "$FILE doesn't exist."
fi
```

```
# run

$ Shellscript.sh /etc/config
```

```
# Check if a file exists
[ -e $FILE  ]

# Check if a file is a regular file
[ -f $FILE ]

# Check if a file is a directory
[ -d $FILE ]

# Check if a file is empty
[ -z $FILE ]

# Check if a file is not empty
[ -n $FILE ]
```

Control structure: for-loop

for loop

```
for iteration
 do
  something
done
```

example

```
#!/bin/bash


for i in {1..10..1}
 do
   echo "Hello $i world!"
done
```

Looping over a list of files

Example: Iteration over a list of files ending with '*bed

```
#!/bin/bash


for i in $(ls *bed)
 do
   wc -l $i
done
```

* $( ) command substitution/ content is evaluated

Control structure: while-loop

While loop

```
while [condition]
 do
  something
done
```

example

```
#! /bin/bash

COUNTER=0
while [ $COUNTER -le 5 ]
do
  echo "Welcome $COUNTER times"
  COUNTER=$(( $COUNTER + 1 ))
done
```

* $(( )) content is evaluated in numeric context

Operating on a file line-by-line

Example: Substract and add 200 to a set of fields

```
#! /bin/bash

FILE=$1

Cut –f 1-3 $FILE | while read CHR START END
 do
  echo $CHR $(( $START – 200)) $(( $END + 200 ))
done
```

More on shell scripting

https://ryanstutorials.net/bash-scripting-tutorial/

Thank you!

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