Training course in Bioinformatic tools

Instituto de Microbiología
Centro de Bioinformática

Virtual training

Module 1: Introduction to Linux

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Repositorios

- https://github.com/BioinformaticaUSFQ1/Course_Bioinformatics
- http://korflab.ucdavis.edu/bootcamp.html
- http://linuxcommand.org/lc3_lts0010.php
- https://cocalc.com
- Google Colab - https://colab.research.google.com/

Unix - History

- Unix is an operating system developed by AT&T Bell labs (1969-1971)
- Collaborators worked on MULTICS (Multiplexed Information and Computing Service)
- Ken Thompson and others developed a much smaller OS called UNICS (Uniplexed Information Computing Service), later named to Unix
- Rewritten in C programming language in 1972 by Dennis Ritchie

Linux - History

- 1975 – Unix licensed to outside world (educational institutions, corporate companies, government agencies)
- Unix Version 5 – first distributed version as source code
- Linux – developed by Linus Benedict Torvalds, an open source Unix like OS in 1991
- Various Linux distributions include Ubuntu, openSUSE, Fedora, Red Hat etc.
- Mac OSX, mobile devices such as iOS, Android and Kindle use different variants of Unix

Terminal

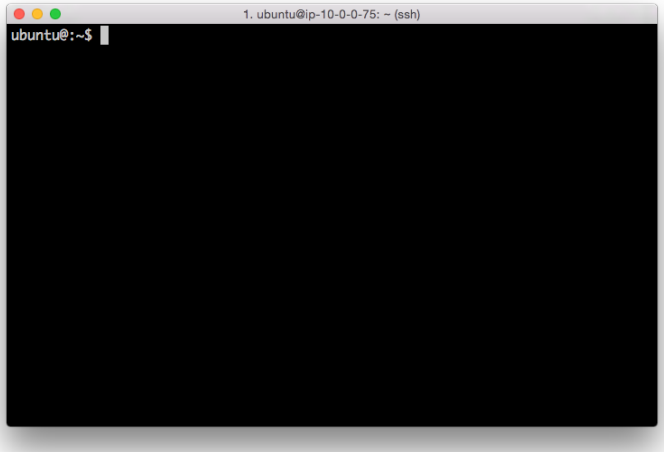
- Within Unix, you use the "Terminal" to give commands to your computer (eg run programs, move/view files, etc). Additionally, the terminal allows you to look at the results of your data after running a particular program.
- The command line gives you flexibility and allows you to control with just :

  -command (options) <input>

- The Unix shell is an “interpreter” that provides the user with an interface to interact with the computer via the command line.

Terminal

- A terminal is the common name for the program that does two main things. It allows you to type input to the computer (i.e. run programs, move/view files etc.) and it allows you to see output from those programs.
- All Unix machines will have a terminal program available.



Terminal

- VM – desktop edition of Ubuntu
- Open Terminal, which loads the command line interface (CLI) of the OS
- Terminal lets you interact with the shell

- username@computername:~$

  - username – name of the user
  - computername – name of the computer/host
  - : - separator
  - ~ - tilde symbol – shows that the user is working in the home directory
  - $ - dollar symbol – user is a regular user (root user has a # symbol displayed)

Shell

- OS shell uses a CLI/GUI (graphical user interface) to access OS services
- Outermost layer surrounding the OS kernel and acts as an interface between the user and the system
- Common Shells
  - sh: Thompson shell (1971)
  - sh: Bourne shell (1977) (replaced previous shell)
  - csh: C shell (1979)
  - tcsh: Tabbed C shell (1979)
  - ksh: Korn shell (1982)
  - bash: Bourne-Again shell (1987)
  - zsh: Z shell (1990)

What are commands? Commands have turquoise background

- Commands are single words/words combined by “_” or “-” that are typed in CLI, received by the shell and processed by the OS

- Rules of command options and arguments
  - Commands are case sensitive
  - Options have to follow command
  - Options can start with a single hyphen and a character or a double hyphen and a word
  - Single character options can be combined
  - Some times options need a value (cut -f 1)
  - Argument can be one or more inputs
  - You can write more than one command separating with a semicolon (;)

ls -a (or) ls - -all

ls -a course_data/

Copy text – Ctrl + Shift + c

Paste text – Ctrl + Shift + v

Help!

- Manual pages: man (man ssh)
  - Most of the commands have manual pages
  - Gives summary of a command
  - Gives all available options
  - Gives examples
  - Gives developer information
- Information: info
  - More detailed information than man
  - Available in newer versions

To remember

- Directories
  - Directories in Unix – equivalent to folders on a PC/Mac
  - Organised in a hierarchy

- Tab completion
  - Bash shell on most Linux distros supports tab completion
  - For example, to run the firefox command, type “fir”/”fire” and press tab for auto-completion
  - Double tapping tab provides options to choose; type fi and double tap to see all available options

Working directory

- Type

cd course_data/
cd Introduction_to_Linux_Unix_Text_processing/

- Avoid errors by using tab completion as follows:

cd cou (Press ‘tab’ once)
cd Int (Press ‘tab’ once)
cd Introduction_to_L (Press ‘tab’ once)

Working directory and changing directory commands

- pwd
  - Print working directory (pwd)
  - This command returns the path of the current working directory
- cd
  - Changing directories
  - From present working directory to the specified directory
  - Example :
    - cd Exercises/ – changes the working directory to the specified directory
    - pwd
    - cd .. – changes to the parent directory from which the previous cd command was typed in (to navigate up one directory level)
    - cd / - changes to the root directory
    - cd – changes to the home directory (specified by ~ symbol in the terminal)
    - cd course_data/Introduction_to_Linux_Unix_Text_processing

Listing files

- ls
  - Listing files
  - Directories – blue; files – white;
  - ls -l – long list files/directories
    - Information (from left to right):

      File permissions, number of links, owner's name, group's name, number of bytes, last modified time, file/directory name
  - ls -R – recursive listing
  - ls -a – include hidden files

Creating/removing files and directories

- mkdir
  - Make directory – creates a directory in the working directory
  - mkdir Practice – creates a directory named Practice
  - ls -l – list all files/directories
- rmdir
  - Removes the specified directory
  - rmdir Practice – removes the Practice directory
- touch
  - Updates the access time of the specified file to the current time
  - Creates one if the file does not exist
  - touch temp-file – creates a file named temp-file; if the file exists, changes the access time to the current time
  - ls -l – check if the file is created/check the time

Alert:
Please remember once a file or directory is deleted, it will not go to "Recycle bin" in Linux and there is no way you can recover it.

Creating/removing files and directories

- rm
  - Removes files from the system
  - rm temp-file – removes the file temp-file
  - -r removes directories recursively
  - -f never prompt
- cp
  - touch temp1 – creates a file named temp1
  - cp temp1 temp2 – make a copy of temp1 as temp2
  - -R – recursive copy in case of copying directories

Moving and renaming files/directories

- mv – move/rename a file or a directory
  - mkdir temp – creates a directory named temp
  - mv temp1 temp/. – moves the file temp1 into the temp directory
  - mv temp2 temp3 – renames temp2 to temp3

Create symbolic links to files

- ln – create links to a file or a directory
  - ln -s temp/temp1 . – creates a link to the specified file in the current directory
  - Useful in saving disk space

Helpful commands

- history
  - history – shows all the commands used in the current terminal session
- clear
  - clear – clears the terminal and provides a clean window to work on

Viewing files

- cat
  - Concatenate command combines files and prints onto standard output
  - cat SARS-CoV-2.fa – prints the file onto the screen
- more/less
  - Commands to view files
  - more SARS-CoV-2.fa– shows the contents of the file
  - Press Enter to view the file further
  - q to quit

Viewing files

- head/tail
  - Shows first and last 10 lines respectively
  - head SARS-CoV-2.gb
  - tail SARS-CoV-2.gb

File editors

- Non-graphical text editors
  - ed
  - emacs
  - vi
  - nano

nano

- nano
  - Graphical editor
  - Commands executed through keyboard
  - Modifier is the Ctrl key
  - nano – opens a standard blank nano window
  - Options
    - Ctrl + X – exits nano; returns to command line
    - Ctrl + O – writes the contents of the text buffer to file
    - Ctrl + R - reads file
    - Ctrl + T – opens the file navigator

Text processing in Linux

- cut
  - Command line utility to cut sections from a file
  - cut -c1-10 SARS-CoV-2.fa – cut 10 characters from each line of the file
  - -d – based on the delimiter
  - -f – based on the field number
- head human_viruses.txt – viruses that have human hosts, genbank ids and genome length.
  - cut -d"|" -f2 human_viruses.txt – cuts the file by delimiter "|" and prints 2nd column onto standard output

Text processing in Linux

- sort
  - Sorts the input
- Few options:
  - -t: field separator
  - -n: numeric sort
  - -k: sort with a key (field)
  - -r: reverse sort
  - -u: print unique entries
- sort -t"|" -nrk6 human_viruses.txt – sorts the human viruses by the genome length field, delimited by "|" symbol

Text processing in Linux

- grep
  - Searches the input for a given pattern/text
- Few options:
  - -A: after context
  - -B: before context
  - -C: before and after context
  - -c: count
  - -l: file with match
  - -i: ignore case
  - -o: only match
  - -v: invert match
  - -w: word match

Text processing in Linux

- grep “Hepatitis” human_viruses.txt
- grep -v “Hepatitis” human_viruses.txt

- Linux commands support BRE - special characters - pattern in data

- grep “Torque teno midi virus . DNA” human_viruses.txt
- ls -l temp?
- ls -l temp*

“.”- dot character that matches any single character at a given position

“?”- question mark character that matches one occurrence

“*”- asterisk matches zero or more occurrences of the preceding character

Text processing in Linux

- Pipes
  - Powerful and efficient way to combine commands.
  - “|” in Linux acts as a link between commands, redirects output of first command as an input to the next
  - Nest as many commands as we would like to
  - sort -t”|” -nk6 human_viruses.txt | head -10 – prints smallest 10 human viruses

Exercise: print largest 10 human viruses

Text processing in Linux

- wc
  - Word count – counts lines, words or characters
  - wc -l outbreak.csv
  - cat outbreak.csv | wc -l
- uniq
  - Extracts unique lines from the input
  - Used in combination with sort command
  - cut d”,” -f3 outbreak.csv | sort | uniq – prints the unique list of countries that has had an outbreak in 2022
  - -c - gives a count of the values

Exercise: Count the number of countries that has had an outbreak in 2022

I/O control in Linux

- Output of a command – sent to standard output i.e terminal
- To redirect to a file, use the “>”
  - ls > list – creates a file named “list” with all the file names in the directory; if exists, overwrites it; >> to append
  - cat list – prints the contents of the file “list”
- To redirect standard error, use “2>”
- To redirect both stdout and stderr, use “&>”

Process control

- Commands that take longer – put to background by appending the command with “&”
- Completion indicated by “Done”
- gzip list & - compresses the file “list” in the background
- jobs – list of currently running jobs in the terminal

Command line shortcuts

- Up/Down arrows: Previous commands
- !!: Reruns previous command
- Tab: Auto complete
- Tab+Tab: All available options
- Ctrl+a: Move cursor to start of line
- Ctrl+e: Move cursor to end of line
- Alt+: Alternates between terminals
- Ctrl+l: Clear screen ((or Command+k on Mac)
- Ctrl+c: Terminates the running program
- Ctrl+z: Suspends the running program
- Ctrl+w: Removes a previous word
- Ctrl+d: Logout
- Ctrl+u: Removes till the beginning