Introduction to Linux

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1 Operating system

Linux is an operating system, i.e. the software that enables a computer to run and execute programs. It acts as an intermediary between hardware (processor, memory, hard disk, etc.) and software (web browser, text editor, etc.).

Warning: Do not confuse Unix and Linux: Unix is a proprietary operating system, while Linux is open source.

Note: There are various Linux distributions (Ubuntu, Debian, Fedora, etc.), adapted to different uses: personal computers, servers, embedded systems, supercomputers...

Linux is mainly used in web servers, supercomputers and by developers, because it's stable, secure and efficient.

The three layers of Linux:

- **The kernel**: close to the metal. Launches the machine, manages the graphics card, network, etc.
- **The shell**: a program for executing utilities and interacting (via windows or terminal).
- **Utilities** (ls, firefox...): programs run through the shell.

Two modes of use:

- Graphical user interface (**GUI**)
- Command line interface (**CLI**)

You're familiar with the first, as it corresponds to clickable windows, and the second to a terminal.

2 Shell

2.1 Terminal

Whatever your Linux version, you will find a "terminal" application that you can launch, and the default command interpreter is **Bash** (Bourne Again Shell), the most common command interpreter under Linux.

The terminal executes a **REPL** (read, eval, print, loop):

1. **Read**: The user types a command which is read by the interpreter,
2. **Eval**: This command is executed and returns a character string,
3. **Print**: The string is displayed on the screen,
4. **Loop**: Repeat.

Tip: In a code extract, a shell command is symbolized by a $ (often called prompt).

Notes: A terminal can be accessed physically (in front of the machine) by running a program, or remotely via the ssh (secured shell) network service.

2.2 Basic commands

All these commands accept various options, the documentation for which can be consulted by typing: `man` followed by the command you want. Example:

```
$ man ls
```

Example of file and directory management basic commands:

- `cd`: Change Directory Move around the directory tree
- `ls`: List Displays contents of current directory
- `cp`: Copy files or directories
- `mv`: Move or rename files or directories
- `rm`: Delete files or directories
- `cat`: View file contents
- `echo`: Display a message or the contents of a variable
- `touch`: Create an empty file or reset a file's timestamp
- `mkdir`: Creates a new directory
- `grep`: Searches for a string in a file
- `wc`: Counts the number of lines, words and characters in a file
- `find`: Searches for files or directories according to criteria
- `awk`: A text and file processing language

Notes: For a larger albeit non-exhaustive list of commands, see the following documentation: https://doc.ubuntu-fr.org/tutoriel/console_commandes_de_base.

2.2.1 Different ways to create, read and modify a file

Select the terminal on your laucher. It is time to start with some simple file manipulations!

```
$ touch myfile
```

```
$ echo "Adding some content to the file" > echo_file
```

```
$ echo "Appending a 2nd line" >> echo_file
```

```
$ cat echo_file
Adding some content to the file
Appending a 2nd line
```

```
$ cat echo_file > cat_file
```

A way to use `cat` command to add content to a file:

```
$ cat << EOF >> filename
> typing a first line
> typing a 2nd line
> EOF
$ cat filename
typing a first line
typing a 2nd line
```

It can be used as a copy-paste method to show the content of a file you are providing your audience. Copy-paste, as an example, the following lines on your terminal and execute:

```
cat << EOF >> filename
1st line of the script
2nd line of the script
3rd line...
EOF
```

With file editors such as **Vi** (*Vim*) and **Emacs**, creation and editing are all in the same command line:

```
$ vi my_vi-file
```

- To edit type `i` *(allows you to enter the INSERT mode)*
- To quit the file:
  - [ESC] *(quits the INSERT mode)* then type:
    - `:wq` *if you want to save your modifications,*
    - `:q!` *if you want to discard your modifications.*
- **Vim** cheatsheet: https://cheatsheets.zip/vim

```
$ emacs my_emacs-file
```

- You may edit immediately the file
- To quit: CTRL-x CTRL-c
  - *You will be asked if you want to save or discard your modifications*
- **Emacs** cheatsheet: https://cheatsheets.zip/emacs

2.3 Access rights and permissions

There are three categories of rights: **user**, **group**, **rest of the world**.

2.3.1 Representing permissions with letters

Example:

```
$ ls -l fichier.txt
-rwxr-xr-- 1 utilisateur groupe 1234 fév 18 12:34 fichier.txt
```

Let's decompose the first part `-rwxr-xr--`.

Generally the first character represents:

- `-` : a file
- `d` : a folder
- `l` : a symbolic link

In our example, it is a `-`, so it is a file.

The following nine characters are in groups of three. In our example we have:

- `-rwxr-xr--` (owner) : The user who owns the file
- `-rwxr-xr--` (group) : Users in the same group
- `-rwxr-xr--` (others) : All other users

Each letter means :

- `r` (read) : Can read the file
- `w` (write) : Can modify the file
- `x` (execute) : Can execute the file (if it's a program or script)

In our example:

- The owner `rwx` can do everything
- The group `r-x` can read and execute, but not write
- Others `r--` can only read

2.3.2 Representation with numbers (octal notation)

Each permission is associated with a number:

`r` = 4
`w` = 2
`x` = 1

These values are added together for each group:

`rwx` = 7 (4+2+1)
`r-x` = 5 (4+0+1)
`r--` = 4 (4+0+0)

Thus, our `-rwxr-xr--` file has `754` permissions.

2.3.3 Modify permissions

Allow execution also to the rest of the world (with numbers):

```
$ chmod 755 fichier.txt
$ ls -l fichier.txt
-rwxr-xr-x 1 utilisateur groupe 1234 fév 18 13:24 fichier.txt
```

Examples with letters

- `chmod u+w fichier.txt` ↪ Add (`+`) write (`w`) to owner (`u`)
- `chmod g-x fichier.txt` ↪ Remove (`-`) execution (`x`) from group (`g`)
- `chmod o-r fichier.txt` ↪ Remove (`-`) read (`r`) from other (`o`)

2.4 SSH key configuration

SSH (secure shell) is an encrypted protocol used to administer and communicate with servers. SSH key pairs are two encrypted keys that can be used to authenticate a client to an SSH server. Each key pair consists of a public and a private key. The public key will be used to encrypt messages that only the private key can decrypt.

To connect to an interactive server in the CC-IN2P3 (`cca` machine), you need to use the SSH command.

```
$ ssh user@cca.in2p3.fr
```

then enter the password you have been given.

If you need to generate an SSH key, run:

```
$ ssh-keygen -t rsa -b 4096 -C "user@example.com"
```

- `-t rsa`: Uses the RSA algorithm (most common).
- `-b 4096`: Sets key length to 4096 bits (more secure).
- `-C "user@example.com"`: Adds a comment to the key (useful for identifying it).

When asked where to save the key, press Enter to accept the default location (`~/.ssh/id_ed25519`). If a key already exists, choose another name or save the old one before continuing.

You can also set a password to secure the key.

Then copy the public key to the `cca`.

```
$ ssh-copy-id user@adresse_cca
```

Connect to `cca` with SSH key:

```
$ ssh -i ~/.ssh/id_rsa user@cca.in2p3.fr
```

Note: `@cca.in2p3.fr` is the address of the `cca` machine. You can connect to a specific machine, for example: `@cca013.in2p3.fr`. If you wish to connect to another center, the address will obviously change.

2.5 Public key for Gitlab

Open a shell and execute the following command:

```
$ ssh-keygen -t ed25519 -C "user@example.com"
```

Note: Why `ed25519`?
It's more secure and faster than RSA. But if your system does not support it, use :
`$ ssh-keygen -t rsa -b 4096 -C "user@example.com"`

When asked where to save the key, press Enter to accept the default location (`~/.ssh/id_ed25519`). If a key already exists, choose another name or save the old one before continuing.

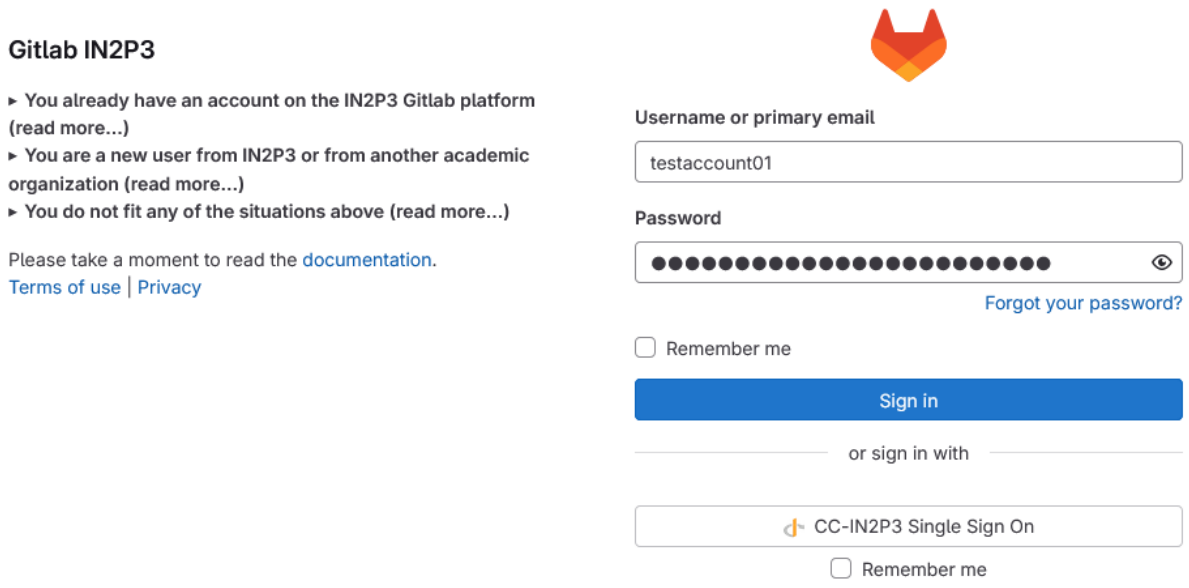
You can also set a password to secure the key.

Now we need to send the public key to GitLab. Retrieve the public key with this command:

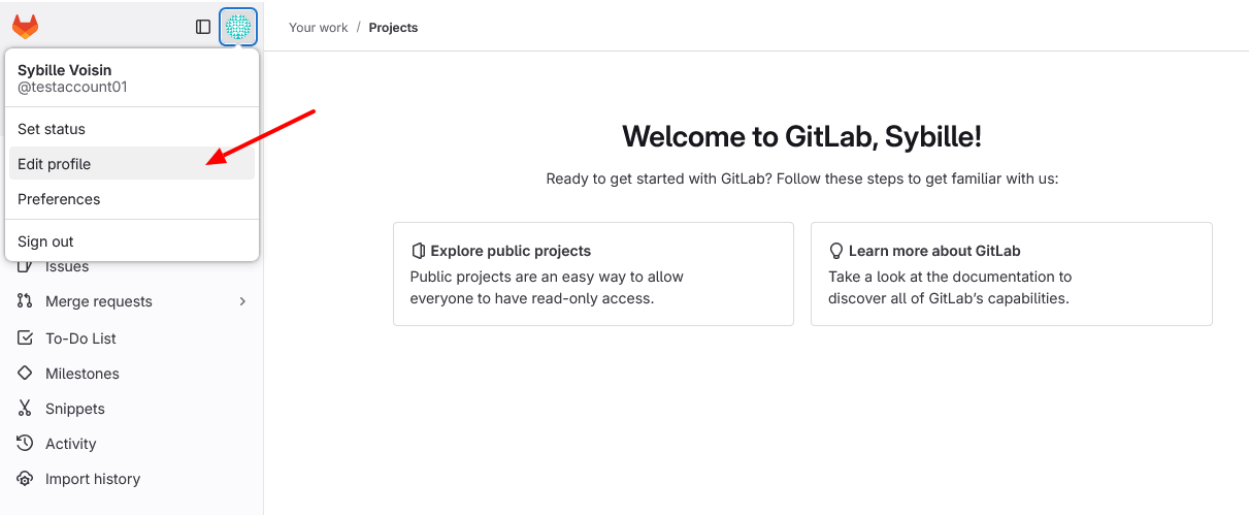
```
$ cat ~/.ssh/id_ed25519.pub
```

2.5.1 Connect to your GitLab account and edit your profile

On https://gitlab.in2p3.fr/

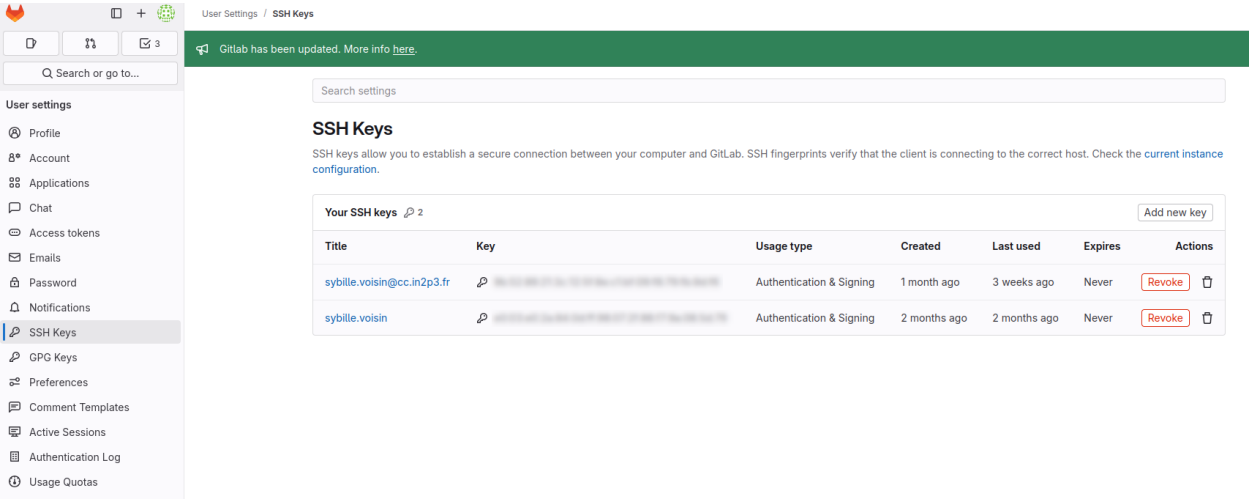


To **login**, use the password you were given.

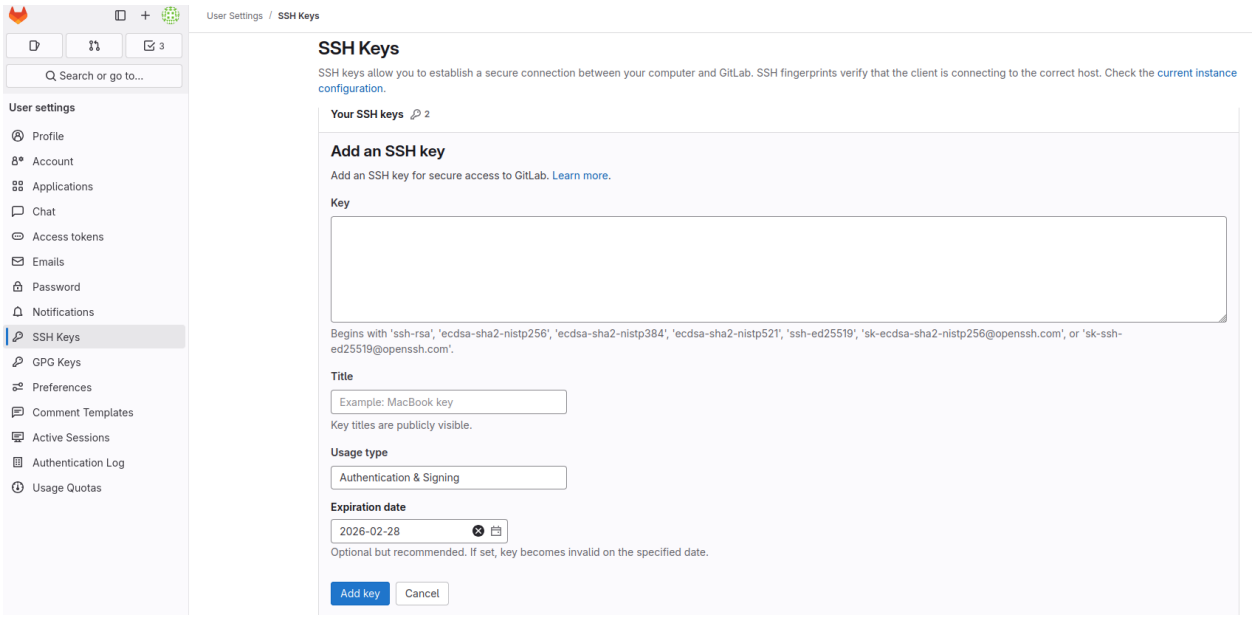


2.5.2 Add SSH key to your profile

Copy the contents of the key and connect to your gitlab account. Go to **User settings** -> **SSH Keys** and **Add new key**.



Paste the key into the field, enter a title, a date (you can leave the date blank) and click on **Add Key**.



To test that the connection is working properly, run the command :

```
$ ssh -T git@gitlab.in2p3.fr
```

If everything is set up correctly, you'll see a message like:

"Welcome to GitLab, @user!"

3 BASH scripts

A sequence of commands allows the administrator to automate certain tasks, known as **scripts**, stored in a file with the extension `.sh`.

Script arguments can be invoked with 1,2 etc., their number with `$#` and their list with `$*`.

Here, for example, is a `delete.sh` script which, instead of deleting the file passed as an argument, moves it to a "trash" folder on the user's HOME.

The first line indicates the interpreter used.

```
#! /bin/bash
# This script has one argument: a filename
#  -   if necessary, creates a trash directory in the user's HOME directory
#  - moves the file given as argument into this directory trash

# first check whether this folder exists in ~/ :
if [ -d ~/trash ]
then
    echo "The trash directory already exists in your Home."
else # if it doesn't, we create it
    mkdir ~/trash
    echo "Trash directory does not exist. It has been created."
fi
# Move the file given as an argument to trash.
mv $1 ~/trash
```