

Sistemas Informáticos (Computer Systems)

Unit 05. Linux - Part 1



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Nomenclatura

A lo largo de este tema se utilizarán diferentes símbolos para distinguir elementos importantes dentro del contenido. Estos símbolos son:

Important

Attention

Interesting

INDEX

1. What is Linux?	3
1.1 GNU/Linux	3
1.2 What is a distribution?	4
1.3 Where do we find Linux?	4
2. Software Licences	4
3. Installation	5
3.1 Download	5
3.2 Installation	5
3.3 The hard disk	8
3.4 The partitions	9
3.5 The boot sector	11
3.6 Creating admin username	12
4. Applications	12
4.1 Basic applications	12
4.1.1 File Explorer	12
4.1.2 Text editor	13
4.1.3 The terminal	14
4.2 How to install programs on Linux	14
4.2.1 Installing using packages	14
4.2.2 Installing using complete packages	16
5. Bibliography	16


UNIT 05. LINUX - PART 1

1. WHAT IS LINUX?

The simplest way to define Linux is that it is a Unix-style operating system. At this point, we already know that it is an operating system, but what is Unix?

Although not the first operating system, Unix is, undoubtedly, the first **GREAT** operating system. Its most important features were that it is portable (can run on different computer systems) multitasking and multi-user. In addition, architecturally speaking, it was created based on concepts such as simplicity and modularity so that the code was easily maintained and extended by other programmers.

Over the years, the creator company (the Bell Labs¹) was licensing the product to other companies that, in order to adapt it to more specific environments, were making modifications and creating different versions. Hence, products like Xenix (Microsoft), HP-UX (HP), IRIX (Silicon Graphics), SCO (Novell), AIX (IBM), etc. were born.


 **Interesting:** all systems in the UNIX family are often called *IX.


The problem with all of them is that they are proprietary versions so that the code is not available for study (apart from the large amount of money that a licence cost). That is why, with a purely educational objective, in the late 80s, a professor at the University of Amsterdam (Andrew Tanenbaum) decided to create “Minix”, an OS based on the UNIX philosophy but rewritten from scratch and open source. Due to its educational nature, the author decided not to allow modifications which would very likely complicate the code much more.

It is at this time that a Finnish computer science student decides, based on “Minix”, to create a free clone that works on PC systems. This student was Linus Torvalds¹, and he called his operating system “Linux”.

1.1 GNU/Linux

In the previous section, we commented that Linux was an operating system, but that is not exactly true. Every operating system consists of a kernel or core and a set of applications that help make possible the function of the operating system. In fact, a possible classification of the different programs that accompany the kernel in an operating system could be: the shell or the terminal (which allows interaction with the user text mode), services or daemons (which are programs that run in background), a graphical server (which allows you to draw elements on screen) or a desktop (which takes advantage of the functions of the graphical server to provide graphical access to the user).

 **Attention:** Linux is simply the kernel of the system, kernel that to form the OS is accompanied by many GNU3 utilities. That operating system is not called Linux, it's called GNU/Linux.

 **Attention:** every day, everyone simplifies and calls Linux the operating system (wrongly).

¹ <http://www.comunidadhosting.com/t/primer-mensaje-de-linus-torvals-y-comienzo-de-linux.8904/>

1.2 What is a distribution?

The kernel and basic utilities make up the core operating system, but we know that today an operating system is gone with by a lot of software not necessary for the computer itself (drawing programs, text editors, etc.). The fact that the kernel and the basic utilities are freely distributed allows anyone to take these elements and accompany them with other utilities (whether basic or not) according to the way they like it or their needs. This is how distributions of Linux or, more commonly, distros arise.

There are hundreds of them in the market, but to mention some of the best known: "Ubuntu" (and its different "flavours" like "Lubuntu", "Xubuntu", "Kubuntu", "Ubuntu Server", etc.), "Open Suse", "Arch", "Fedora", "Debian", "Red Hat", "Mint", "LLiurex".

We will use "Lubuntu" throughout this course. "Lubuntu" is, a distribution based on Ubuntu that aims to be lightweight, and it is the main reason to choose it, because it is easier to virtualize.

1.3 Where do we find Linux?

One of the most widespread ideas is that Unix is an operating system that is only used in academic environments or of a high technical level, and nothing is further from reality. The systems based on free versions of Unix are implanted in many computer systems. Although possibly in desktop environments Microsoft systems are still the ones that dominate most of the market, in mobile devices as in servers the reality is quite different.

For example, the two mobile operating systems par excellence (Android and iOS), are systems derived from Linux or FreeBSD (as well as systems such as macOS).

2. SOFTWARE LICENCES

Several times throughout the previous sections, we have commented that one of the fundamental features of Linux is the fact that it is free. **But what does it mean to be free?**

Because of the use of the same word in English, many people think that being free (at liberty) implies being free (not charge). The price of the software has nothing to do with the type of licence to which you submit.

The software licence is a contract that defines all the rules that govern the use of a particular program. The contract is made between the owner of the program and the user of the application.

Its clauses determine issues such as the term of assignment of rights, the geographical scope of validity of the contract, limits of responsibility for failures, number of allowable copies, possibility or not of transferring the software to third parties, etc.

There are several types of licences, but in general all could be included in one of these types:

- **Proprietary licence:** use of software on one or more machines for a certain cost. It is not usually included in the program code, only the executable file.
- **Shareware licence:** use of software with limited functionalities for a time (or even of a definitive way) and need for payment to extend them.
- **Freeware licence:** unlimited use and copying at zero cost.
- **Free software:** it allows the use, copy, modification and free distribution with access to the source code. Within the latter, we can find two types:
 - **Permissive licences:** those that give the user total freedom, so that with the modified code he can do what he wants. That is, although the original is free code, the modification can be private. A licence of this type is BSD.

- **Non-permissive licences:** those that require that the copy, modification and subsequent distribution is carried out under the same conditions as the original. That is, if the original is free code, the copy must remain so. A licence of this type is the GPL, which is used by GNU products.

3. INSTALLATION

3.1 Download

The first step is to get and to burn and ISO of “Lubuntu”. You can download it from:

<https://lubuntu.me/>

After the download, the next step is to burn the ISO image to a CD/DVD (with a burning program like Brasero, Nero, Toast, ISO Burner, etc.) or in a USB stick (with UltraISO, Rufus, etc.).

3.2 Installation

Restart the computer with the burned DVD with “Lubuntu” in the DVD reader or, if, you use a USB, with the stick connected. If we let the system start up, it will end up starting a version of “Lubuntu” in graphic mode with options to install it in a hard disk.

! Attention: to boot from DVD or USB, it is necessary to have this option activated and/or modify the system boot order. These options can be configured from SETUP.

To arrive to it, in boot menu we choose Try or *Install Lubuntu*” option and later, when Live USB has started, we select “Install Lubuntu” tool as seen in next two figures:

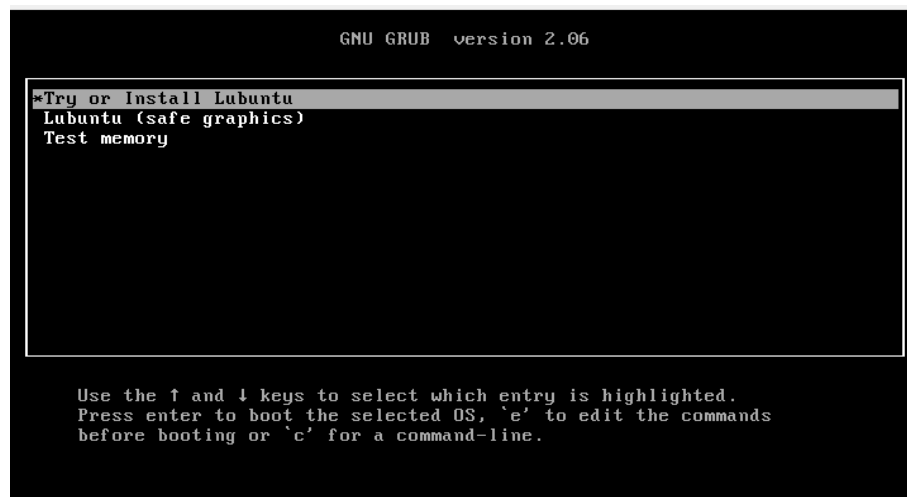


Figure 1. Lubuntu Live USB/DVD Boot menu

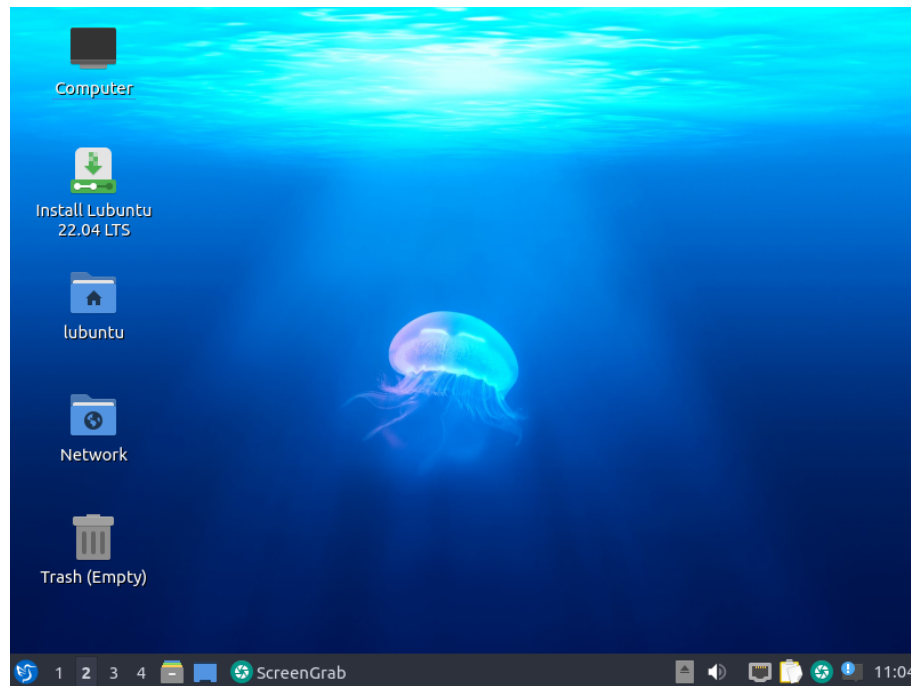


Figure 2. Ubuntu Live USB/DVD Desktop with “Install Ubuntu” tool.

When we have done those steps, installation will start. Today, the installation of Linux is very simple. In fact, in the vast majority of cases accepting the default options and assigning a user, the system is installed correctly.

But in order to make the installation more flexible and better adapted to the needs of the user, it is worthwhile to go into detail in the installation types window.

Firstly, installation will ask our language, our region and our keyboard layout, as you can see in next figures:

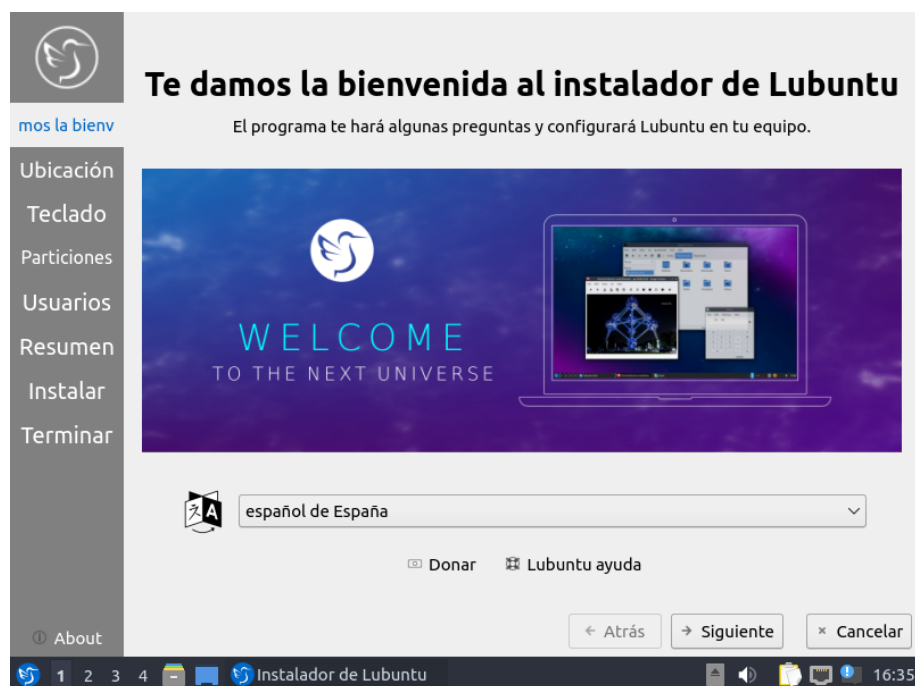


Figure 3. Ubuntu asking for our language.

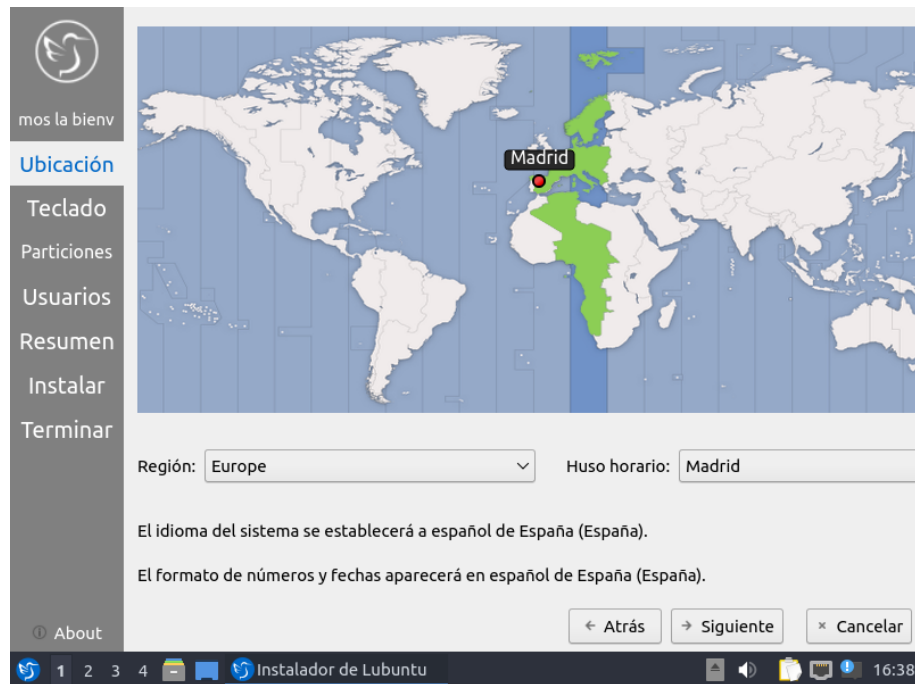


Figure 4. Ubuntu asking for our region.

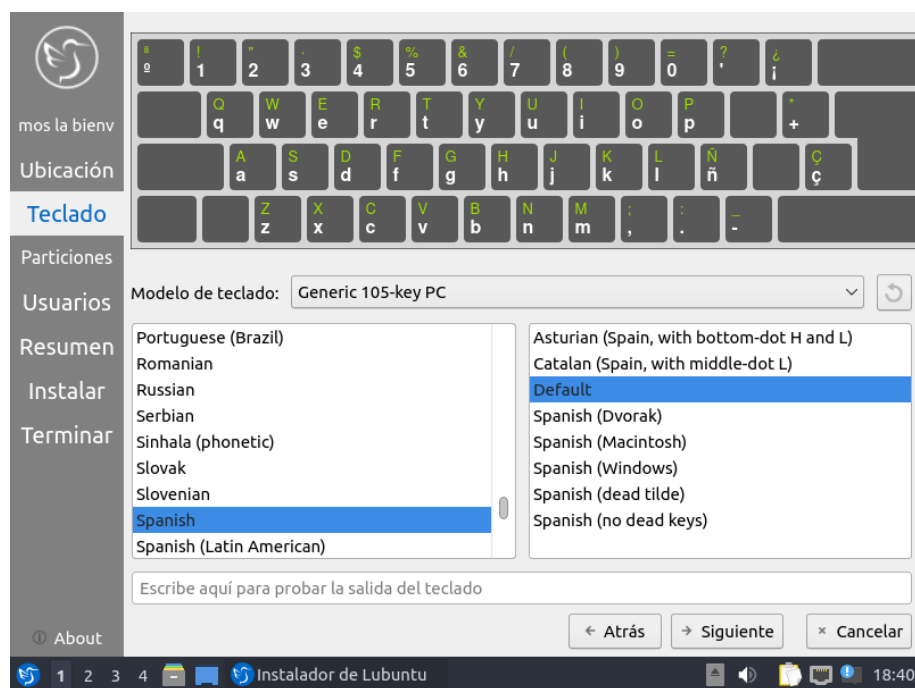


Figure 5. Ubuntu asking for our keyboard layout.

When we have finished those easy steps, we have to select “manual partitioning” in order to create partitions on the disk in which we are going to make the installation, as well as to realize an optimal distribution of the partitions to create. **This is an important step.**

! Attention: in most installations, you can use all the disk (for example, an installation alone in a virtual machine) but in some situations, like a dual boot with Windows, you have to be careful and doesn't destroy Windows partition.

In order to do manual changes in partition table, we have to select last item, like in next figure:

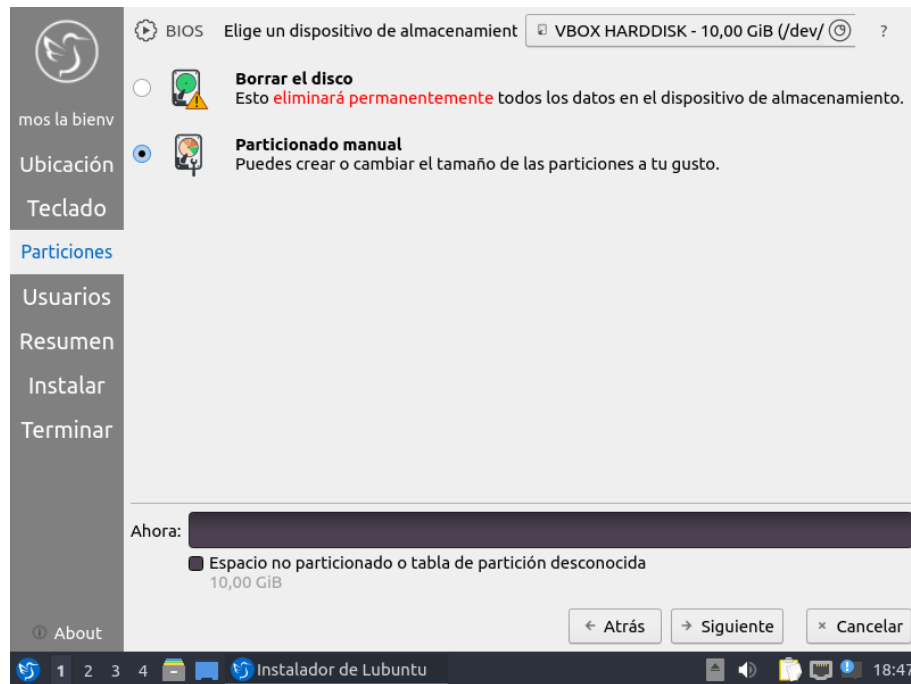


Figure 6. Ubuntu selection manual partitioning

3.3 The hard disk

When we have selected “manual partitioning” we should follow several steps.

The first step is to choose on which disk we want to perform the installation. On Linux, the devices are simulated using files that are in the dev directory. There are many types¹, but in terms of connected elements in the PATA or SATA connectors, the way to call them is: type + order + partition. The types are “**hd**” for PATA devices and “**sd**” for SATA devices. The order refers to the port number element in which they are connected. To do this, letters are used starting by the “a” letter. The partition are numbered with numbers, starting for the number 1. For instance, “**sdb1**” refers to the first partition in a device connected to the second SATA port.

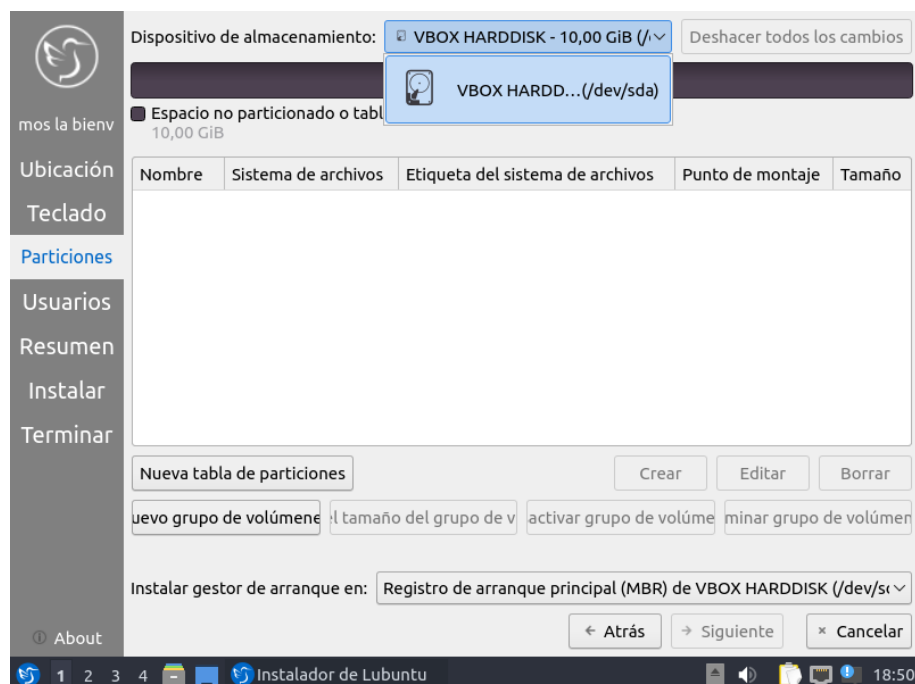


Figure 7. Ubuntu with hard disk in /dev/sda

In the last figure, you can see that the computer has only a SATA ("**sda**") hard disk connected, which is therefore the only one that can be used to perform the installation.

In case there were more ("**sdb**", "**sdc**", "**sde**", etc.), these would appear in the list so that we could choose in which one of them we want to install.

3.4 The partitions

Usually, we have associated the idea that a program is installed on a hard disk. In fact, in the previous section we have hinted that it is the first step to perform the installation of an OS. However, an operating system is special software and can be spread over different partitions of a hard disk or even in different hard disks.

In fact, this possibility is an obligation for any user with average knowledge. Apart from the security provided by the fact of separate contents (limited if the installation is performed on different partitions of a single hard disk, since if the hard disk fails all partitions fail), has the great advantage that the re-installation of the system in case of error (for example by restoring an image) is very fast and not dramatic.

How can we distribute the partitions? What can we include in each of them?

Linux always creates by default at least 2 partitions: one for the system and another, called swap, for use the virtual memory. At the moment that we decide to perform the custom installation, we must remember that we must create a swap partition. Its recommended size is double of the memory RAM of the machine, although thinking about possible extensions of the same and taking into account that the capacity of hard drives today is great, a good option is to assign four times more.

To see how we can distribute the rest of the system, it is necessary to understand how the Linux file system works. Unlike Microsoft systems, in which each partition is assigned a drive (each of which is called using a letter of the alphabet, "**a:**", "**b:**", "**c:**", "**d:**", "**e:**", etc.) in Unix systems the user has a single unit called "/" (slash or root directory) from which to connect (to mount) in different directories the information of all the partitions of hard disks existing in the computer,

Obviously, all this information is organized in such a way as to make it simple of its location.

For example:

- **/boot**: this folder has files for the boot management.
- **/root**: It contains system administrator (superuser) programs.
- **/var**: It contains variable files, such as registers, databases, mail queues...
- **/tmp**: temporary files.
- **/usr**: programs and system data that can be shared by multiple users.
- **/home**: user's folders.
- **/dev**: files that encapsulate different physical devices connected to the system. For example, **/dev/lp** is a printer.
- **/opt**: third-party applications (similar to Windows Programs files)
- **/lib**: libraries common to all applications
- **/etc**: applications configuration files.
- **/mnt**: in this folder are located directories by each of the rest of the partitions of all the hard disks in the computer. For example, if I had a hard drive with a partition with Windows, its location would be **/mnt/windows** (the name of the folder could be any).
- **/media**: similar to the previous one but with devices that are mounted live (USB or SD card)

The distribution of partitions may be made following this structure. So for example, if one partition has assigned "/", in that partition we will install the entire system (which is what is done in a default installation).

A more consistent distribution is to create a partition for the whole system and another where the user's folders are stored (/home). In this way, the system is separated from the data, facilitating the re-installation. Another interesting option is, in addition to these two, create a partition where to store /var, thinking about separating other data types such as databases.

Interesting: previously indicated folders are just a few of them. And not all of them are allowed to be isolated in a partition. For example, **"/mnt"** and **"/media"** does not make any sense that they are in a separate partition since they are already in themselves a site where other partitions are going to be incorporated.

Each of these partitions can be on the hard drive that we want. In our case we will use a single hard disk and will create 3 partitions: **"/"**, **"/home"** and, of course, **"swap"**.

To do this, simply select the empty space on the hard drive where you want to create the partition and press the + button. This opens a window where you can assign a size (in MB), the type, file system type (usually ext4) and the mount point you want to include in that partition.

Interesting: the act of including a partition in our general file system is called mount. So for example, when we connect a USB, the system what it does is that it automatically mounts that unit in the **"/media"** folder.

Although the type of partition is a topic that today is not as important as a few years ago, it is at least interesting to know that there are two types of partitions: the primary and the extended. A hard disk can only contain 4 primary partitions. Formerly it was more than enough, since the size of the hard drives was not enough for much more, but with the increasing capacity there arose the need to create more partitions.

Faced with the impossibility of increasing the number of primaries, the concept of partition extended was created in such a way that a hard disk can create a maximum 3 primary and one extended. The great advantage of the extended one is that inside it could exist as many as partitions as desired. These partitions included within the extended partition are called logical partitions. For practical purposes the type of partition does not have much importance, although it is usually advisable that the main partitions and the boot system are in primary partitions.

In the rest of the figures, you can see how the new partitions are distributed on our hard disk.

! Attention: take note of the file system to swap partition. If you want to know more about how it works and why it is important to have a swap partition, you can check:

<https://haydenjames.io/linux-performance-almost-always-add-swap-space/>

<https://haydenjames.io/linux-performance-almost-always-add-swap-part2-zram/>

! Attention: obviously, we have to note that when we accept the distribution, all the information that has previously stored on that hard disk will be destroyed.

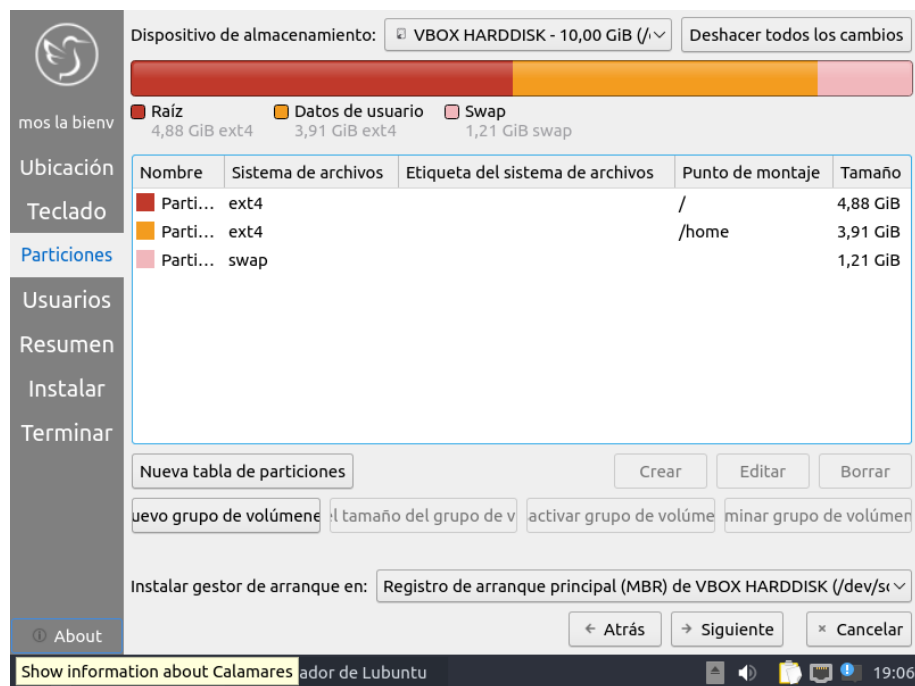


Figure 8. Disk `/dev/sda` partitioned in `/`, `/home` and swap partition

3.5 The boot sector

The last step is to select on which hard drive we want to install the bootloader. As we saw in previous lessons, in the BIOS there is configured an order in which to search, in the different storage systems, a sector (MBR) that allows to run the load of an operating system. The BIOS program, in charge of that task, looks for that list of devices until finding one that allows to boot. That is why each operating system has to install and configure that sector, regardless of the installation of the operating system itself. This is easily achieved when there is only one operating system on the computer, but what happens when more than one is going to be installed?

With the first system to install there will be no problem, but when we install the rest, each one will install the boot sector overwriting the previous one. In this way, even if the operating systems are installed, you will only be able to boot the one that was last installed. Fortunately, Linux distributions are usually very respectful in that aspect, so if when they install their boot sector, they detect the existence of another, do not overwrite it, but modify a small program (usually called grub) to display a menu that allows to select the OS from that which you want to boot.

Interesting: however, if the system installed later is one of the Microsoft family, it only takes into account systems that belong to the same family. So if you want to have multiple operating systems on the same computer, install those from the Microsoft family first.

Interesting: If you have problems with the boot sector, remember that **the operating system is there, the only problem is to access to it**. For that there are several utilities to make a backup, restore or repair it in case of problems. For example, "Rescatux" is a good "Live DVD/USB" to help with that kind of problem <https://www.supergrubdisk.org/rescatux/>

3.6 Creating admin username

The last important step, before starting to copy files in disk, is to create a user with administrator profile. It is very easy, as you can see in the next figure:

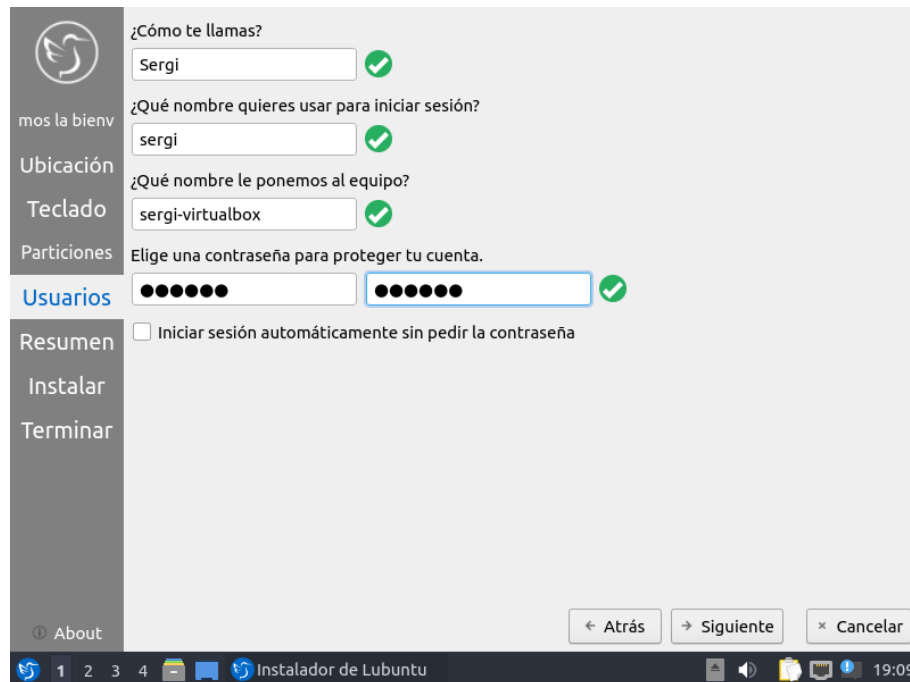


Figure 9. Creating user with administrator profile

When we have finished this step, we can start copying operating system to disk and when installation finishes, our Lubuntu system will be ready to work :)

4. APPLICATIONS

4.1 Basic applications

Although each distribution includes the applications they consider accomplishing their goals, there are three that are very common and can help you in almost any desktop distribution.

4.1.1 File Explorer

It comes to be the like “Windows File Explorer” or the “macOS Finder”. You can run it from Accessories or search the system search bar, but the most common way is to run it from the icon that exists in the toolbar. The great advantage of Linux is its heterogeneity, because does not exist a single file explorer. Depending on the desktop you installed, the options may vary. One of the best known file explorer for Linux is Nautilus. In “Lubuntu” we can use “PCManFM”.

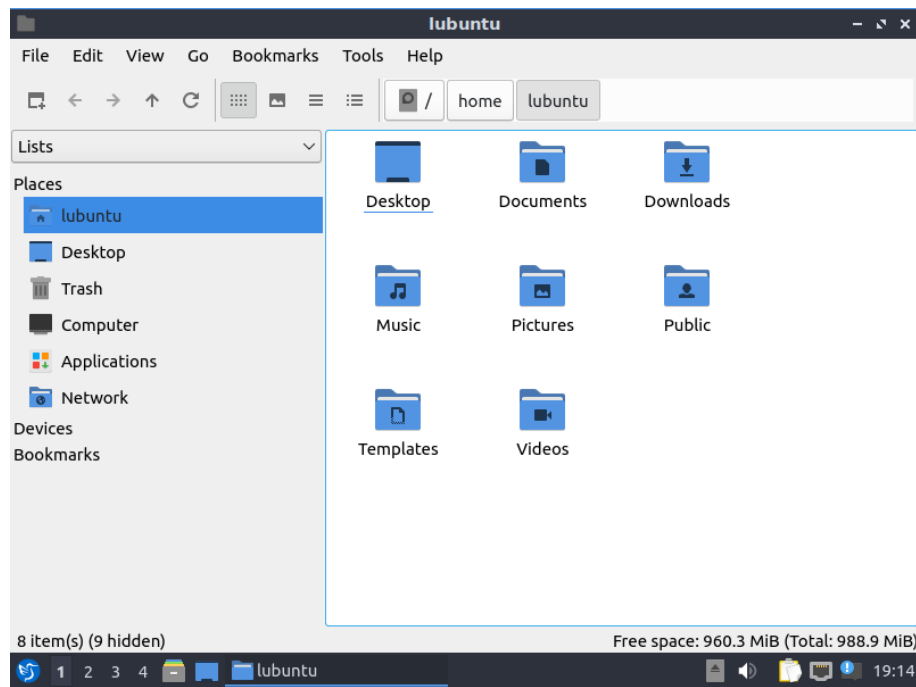


Figure 10. Ubuntu with “PCManFM” file explorer

4.1.2 Text editor

It is similar to tools like “Notepad” in Windows operating system. As always, the options are multiple, but the most used and comes standard on most of the desktops is “Gedit”. In “Ubuntu” we can use “FeatherPad”. It can be accessed from Accessories.

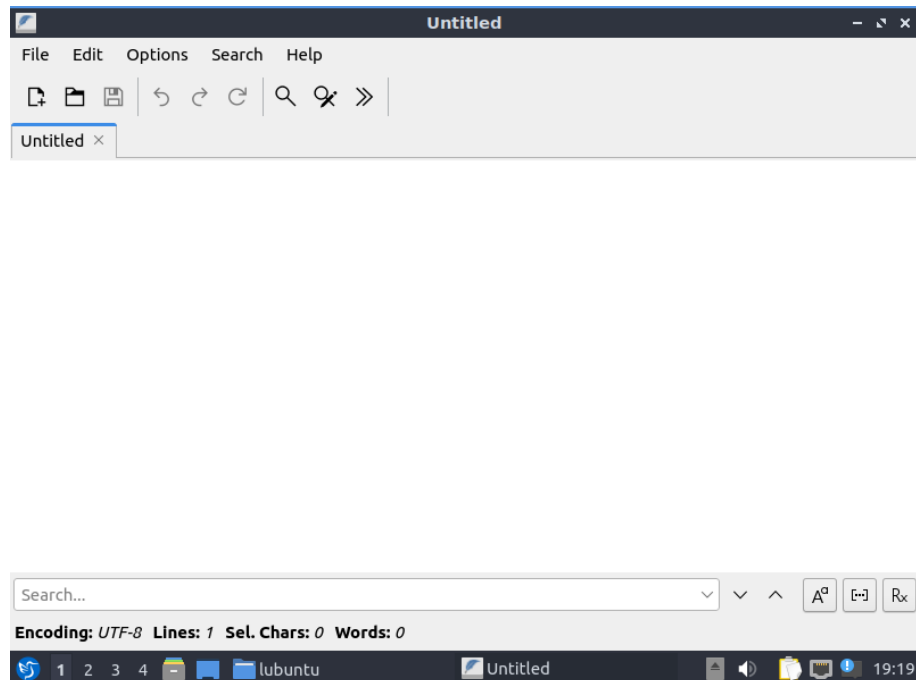


Figure 11. Ubuntu with “FeatherPad” as notepad application

Interesting: on Linux, in order to help you to program or simply to edit text files, Visual Studio Code is a great option. You can install it from <https://code.visualstudio.com/>.

4.1.3 The terminal

Perhaps the most hated app by the basic users, but the best friend of those who want to get the most out of the system. Through it, we can iterate with the operating system in text mode. We will develop all our work from it. We can access to the default terminal application on “Lubuntu” accessing through “System Tools” and then “QTerminal”.

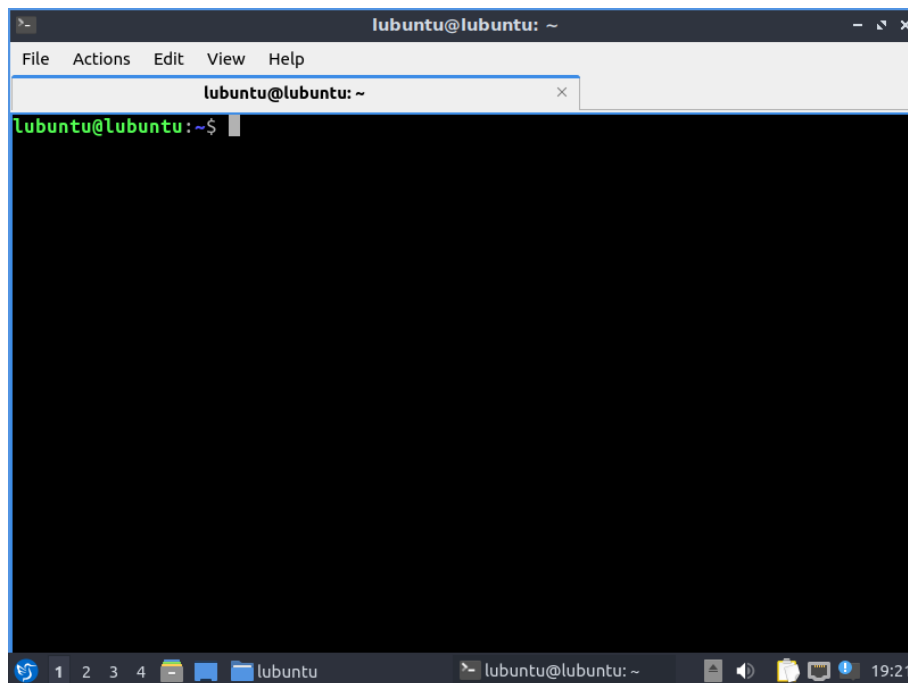


Figure 11. Lubuntu with “QTerminal” as terminal application

4.2 How to install programs on Linux

4.2.1 Installing using packages

There are three fundamental ways to install programs on Linux:

- From a package.
- From a compressed file.
- From the source code.

Obviously, this last option is the most complex and requires the knowledge necessary to compile the application, knowledge that is beyond the scope of this module.

The simplest way is to use packages, something similar to Windows “MSI”. These files include all the information for the installation and the configuration of the application, notifying to the system which dependencies are mandatory to be able to execute it correctly.

Interesting: the problem is that there is no single package format. In the market, there are two formats, “.deb” (used by distributions like Ubuntu or Debian) and “.rpm” (used by distributions like OpenSuse or Fedora). That makes the developers must generate the two types of packages to distribute their applications.

Actually the installation of these packages is very simple, they are simply downloaded, clicked on them and the installation program is automatically launched.

The problem is that Linux systems are very open and very dynamic systems. The versions of the applications happen really quickly and the places from which to download are very varied. This is

why it is convenient to use the names of application managers, an idea existing on Linux for many years and that comes as something like today's application stores (App Store, Google Play, etc.).

Of course, each type of package is associated with its own manager (working in terminal mode). Today the most common format is the store (in graphical mode), but possibly the most versatile is the classic (the ancestor of the store).

For example, in distributions with “.deb” packages, the manager is a console command called “apt-get”. Its classic desktop version is Synaptic, and the storage mode is called “Application Center”. In case of knowing the name of the package, the simplest method is the first one. For example, if we want to install the VLC player, the easiest way is to open the terminal and write:

```
sudo apt install vlc
```

Where:

- **sudo**: allows us to execute applications in superuser mode. Obviously, the installation of programs is not something that can do any user, so to be able to do this it is necessary to ask for superuser credentials.
- **apt**: name of the package manager application.
- **install**: option of the manager program that allows the installation. Obviously there are others for removal, updating, etc.
- **vlc**: package name

If we run, the system prompts us for the password and proceeds to the installation.

! Attention: Linux is case-sensitive, so it is not the same to write in uppercase (for example “Vlc”) than in lower case (for example “vlc”).

If we do not know the exact name of the package, it is better to use “Muon”. We can access from “System tools” menu. The application has a search engine to locate the package that interests us and then select it. The dependencies necessary for installation will be automatically selected.

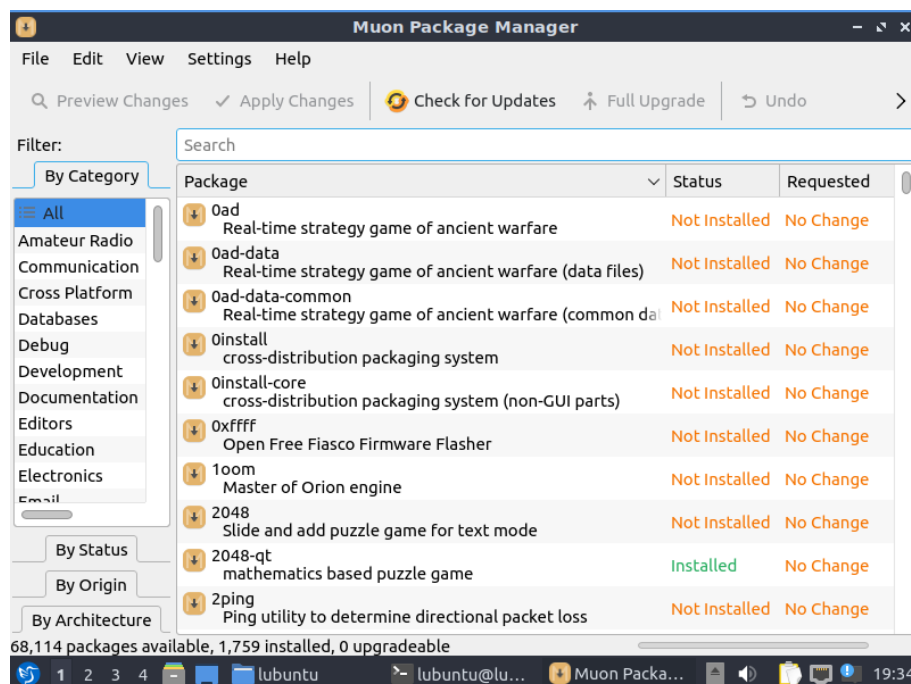


Figure 12. Ubuntu with “Muon” as package manager

These managers are configurable to be able to support any data source. In general, it is configured against the servers of the distribution that is responsible for keeping them as up to date as

possible. Even so, they do not contain all the programs nor the last versions, so in many cases it is usually convenient to add new sources that allow to be as up-to-date as possible.

You can manage those fonts from “Muon” in the option “Settings” and then pressing “Configure software sources”.

4.2.2 Installing using complete packages

There is a fourth way: complete packages (including in one package application + dependencies) like <https://snapcraft.io> or <https://flatpak.org/> . They are easier to set up, but consume a lot of disk space compared to normal packages, because they include not only the program, but all its dependences.

In order to use them, you have to install a special software manager. For example, to install “snap” to use packages from <https://snapcraft.io> you have to use this command:

```
apt install snapd
```

When you have installed “snapd”, you can install the program from <https://snapcraft.io> following instruction. For example, if you want to install “Visual Studio Code”, you can follow instructions from <https://snapcraft.io/code>. In this case, instructions say to run this command:

```
sudo snap install code --classic
```

5. BIBLIOGRAPHY

[1] Organización de los directorios en Linux

<http://www.linux-es.org/node/112>

[2] Install Lubuntu

<https://www.tecmint.com/install-lubuntu/>