Curs 2019-2020

Computer Systems
Linux I

IES Jaume II El Just
Tavernes de la Valldigna

Contents

1 Linux

1.1 History

Linux is a family of open source operating systems. These families of operating systems were born from UNIX. Linux is called GNU/LINUX because Linux is a mix of several projects where GNU is the most prominent.

The GNU Project is a collaborative project of free software. This free software can be changed and used for any purpose. This movement was born in 1985. Richard Stallman lead this movement in order to defend the freedom of the user. Free software can be confused by freeware (not monetary cost). Free software could be paid through distributions. To sum up, free software doesn't mean that it goes against making money on some software.

On the other hand, open source is not considered as a free software, but most of the time it is considered synonymous.

But, what about UNIX? UNIX was the first operating system. It was born in Bell Laboratories and General Electric and the MIT (Technological Institute of Massachusetts). They worked together on a project to develop Multics. They were looking for a multi-tasting and sharing time operating system. Bell Laboratories would therefore be separated from the Project. Ken Thompson and Dennis Ritchie carried on with the Project for themselves and in 1970 the first version of UNIX was born.

UNIX was forbidden for educational issues in 1979, and Andrew S. Tanembaum wrote a UNIX clone in order to use it at the university.

In the early nineties, Linus Torvards, a Finnish student of Helsinki University, started to improve MINIX in order to exploit the 80386 processor. On October 5th of 1991, Linux was born with the intention that everyone could get Linux and improve it; thus, developing the kernel.

> 🔧 **Try it 1**
> Investigate about the following concepts concerned in software license: public-domain software, copyleft, GPL license, freeware and shareware.

1.2 Distributions

A Linux Distribution is a set of software which complements the Linux Kernel. The main target of it is to satisfy a group of specific necessities. For instance, distributions for companies, servers, homes, etc. Each distribution can provide software, even installation software that makes the process of setting it up easier. This software and the tools for making up the distributions is received from free software projects like GNU, GNOME, KDE.

Ubuntu is well known, but there are a lot more like Lliurex, Red Hat, Manjaro, Arch Linux, Open Suse, Debian ... Besides others which include distributions based on Ubuntu like: lUbuntu, Ubuntu Mate, KUbuntu, Xubuntu, etc.

1.3 Main features of Linux

Due to Linux, there is a version of UNIX. They share the most of both technical and functionalities. The most important features are:

- Linux is a multi-tasking and multi-user operating system. This means that several users can work simultaneously, and each one can run several programs at the same time.

- Cross-platform software (multi-platform software): it is possible to run Linux in different CPUs.

- Memory protected between processes.

- Virtual memory using pagination.

- Protocol stack of TCP/IP

- Linux supports several file systems.

- Sharing Libraries

Furthermore, Linux is the most used operating system in servers and in mobile phones. Everyone knows android. Android comes from Linux as well. And in educational environments, Linux is often used since a lot of communities have their own Linux distribution.
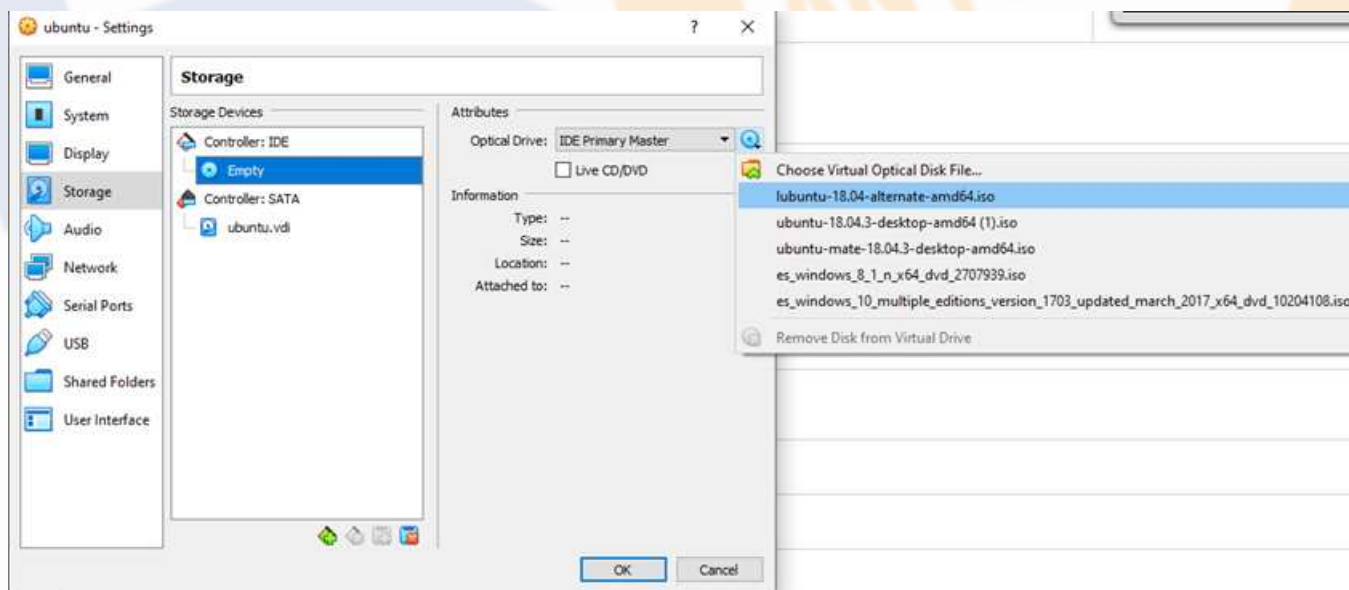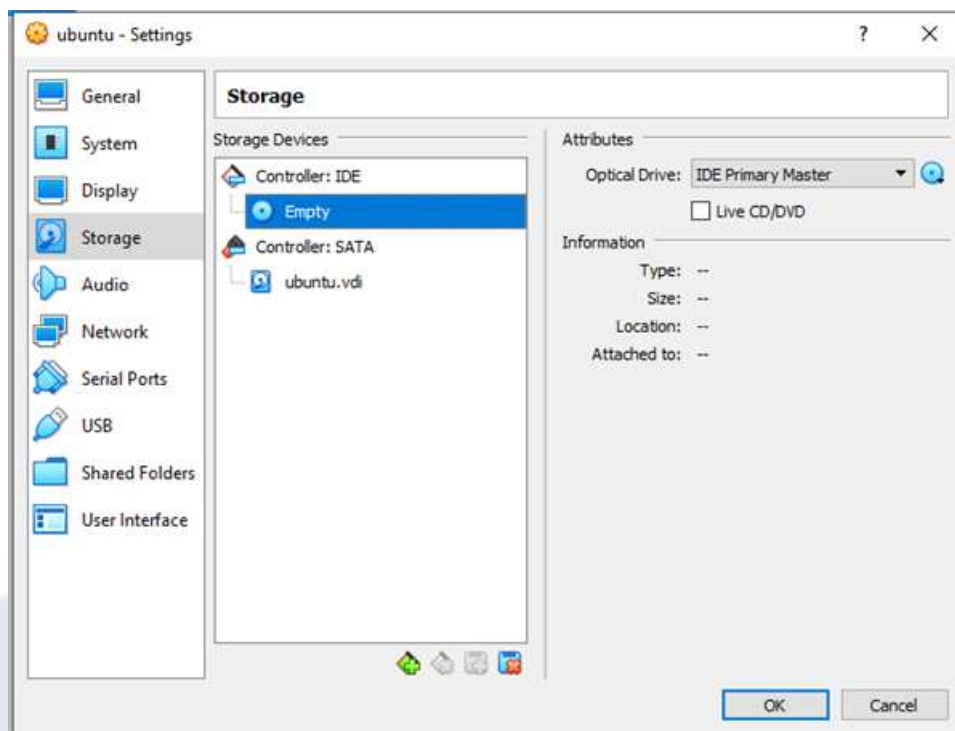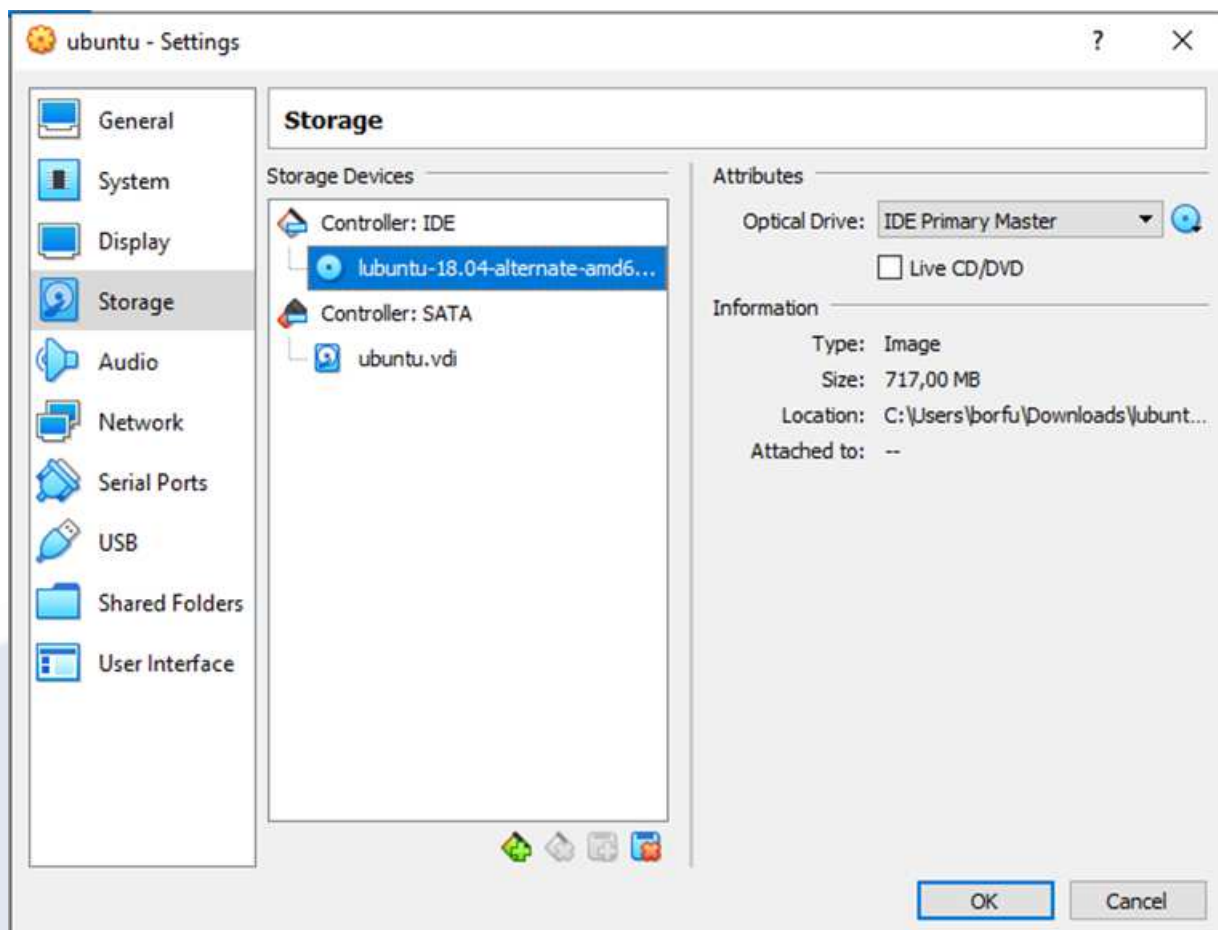
2   Installation

The first thing to bear in mind is reviewing the requirements of the operating system in order to make sure that it can be installed in your computer. Besides knowing the requirements, it allows you to build the proper virtual machines in case the operating system will be installed in one of them.
It is known that there are a lot of different distributions. In this chapter we are going to use an Ubuntu distribution. Even though there are a lot of distributions based on Ubuntu. For example, LUbuntu which is a fast and lightweight distribution of an operating system.
Any distribution of Ubuntu can be downloaded from the Internet for free.

2.1   First Step

In order to install the operating system in your computer, you must build a bootable USB or burn a DVD. In addition, you should go into BIOS in order to change the boot sequence. Once there you will choose boot from USB or DVD depending on your situation.
On the other hand, is installing Linux in a Virtual Machine. Once your virtual machine is built, it should be linked to the image so that the virtual machine will start loading it.

2.2 Second Step

Once the virtual machine is set up, it can be turned on. Choose language and the proper option to install the operating System.

Afterwards, a series of options appear. For instance, it is possible to install a minimal installation or normal installation and updates while it is installing the operating system.

2.3 Third Step

Besides this, one of the most important steps is choosing the installation type:

- The first one, Ubuntu is installed erasing everything. It is not possible to take part in how Ubunut distributes the hard disk.

- The following two options are about LVM and encryption, and their installation. LVM is a device mapper target that provides logical volume management. It is used in order to resize partitions if the space of some of them is full, and there is space in other. Bear in mind that the system files should support ReiserFS.

- The last option (something else) can be used in order to manipulate the partition and make the decision about the partitions for yourself.
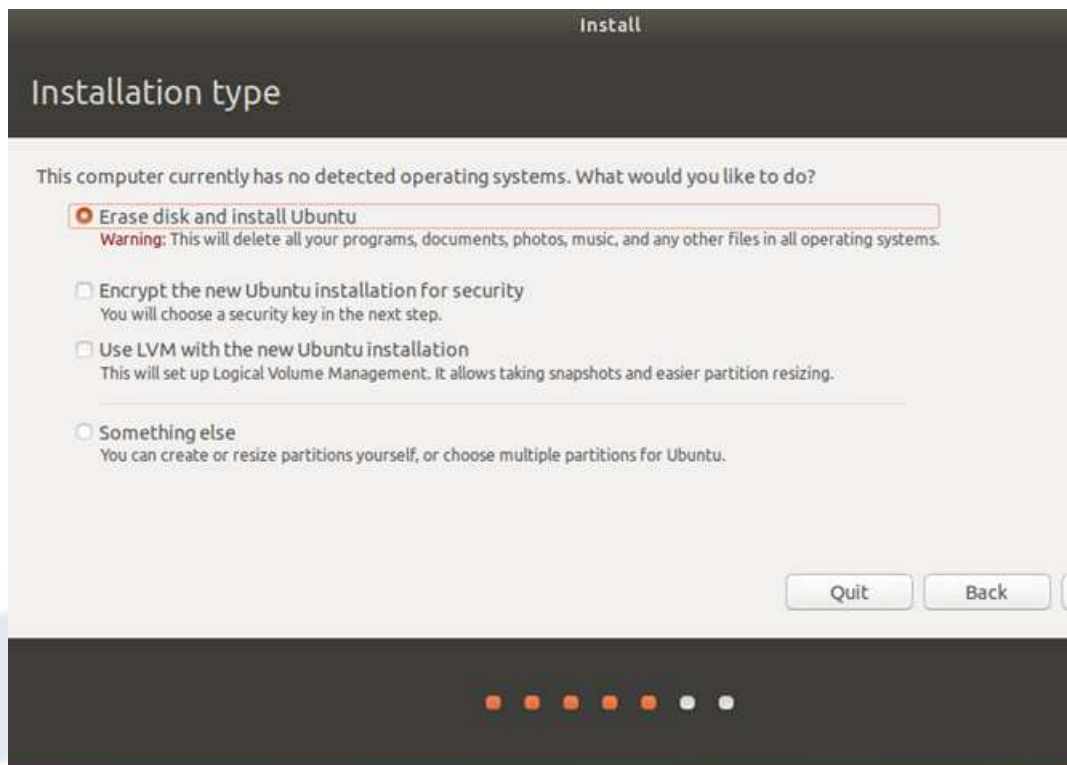
If the last option is chosen, the following steps show a window in order to establish the partitions. In Linux, the hard disk is storage in dev directory. Hard disks are considered files. In the following picture, it is possible to see that there is a hard disk called sda in /dev directory.

Hard disks are named with vowels, and after sd if the interface of the hard disks is SATA. On the other hand, Linux calls hard disks with PATA interface as hd followed by vowels. For instance, a hard disk with PATA would be called /dev/hda.
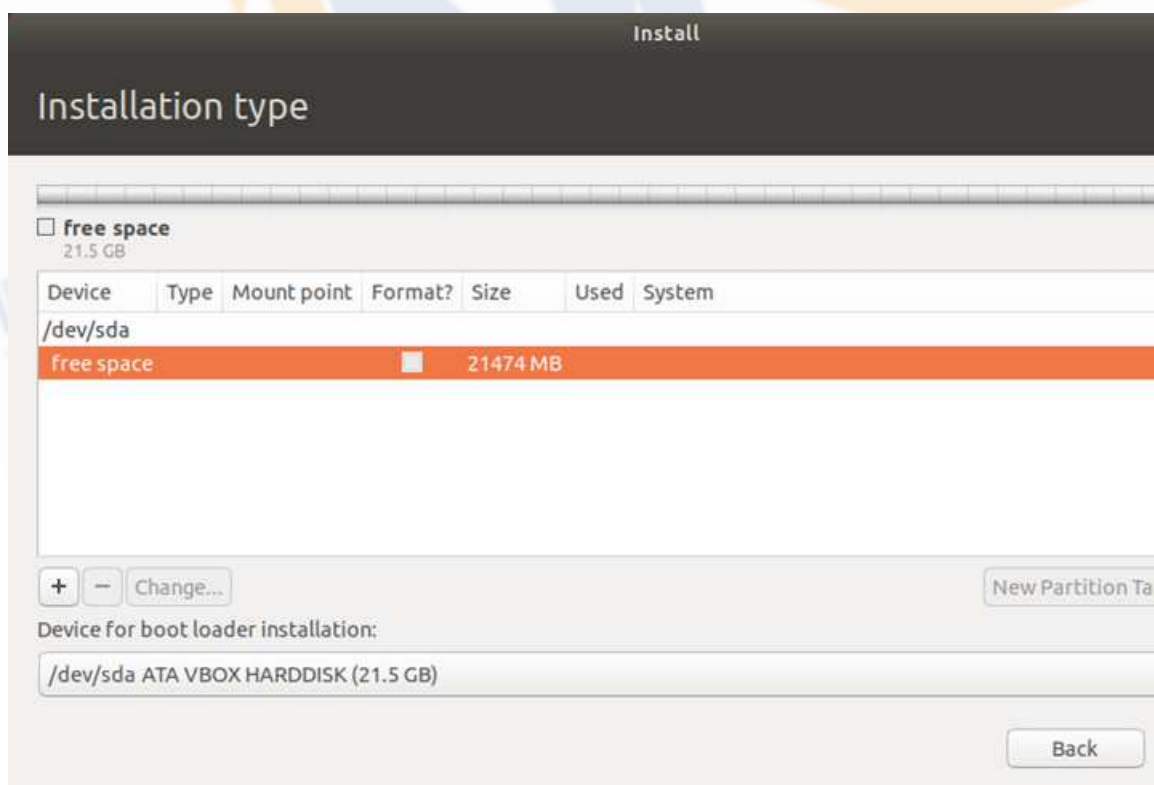
✏ Partitions

Partitions are needed because:

- Some file systems support maximum sizes shorter than the size of the hard disk.

- One of the benefits of partitions is that it is possible to keep a backup on it.

- More than a partition is needed in order to work. For instance, Linux, with swap space.

Types of partitions:

- Primary partition: actually, a formatted, hard disk is a primary partition, but it is possible to have more. It is allowed 4 primary partitions.

- Extended: it is a partition in order to allow more than 4 partitions on a hard disk. Extended partitions are a container to keep logical partitions.

- Logical partition: it is a partition in order to use extended partition. It is possible to have 32 logical partitions, although Linux allows just 15 including the primaries.

If we compare Windows and Linux, the installation is quite different. On the one hand, for Windows, a letter is assigned to each hard disk. And to install the operating system, it is necessary that one of the partitions by default. On the other hand, in Linux 2 partitions by default are needed:

- Swap: this partition is used for virtual memory. The size of this partition is normally double that of RAM memory. But what about if your RAM memory is 8 GB? Do we need 16 GB? That would be a wasting memory. The proper size is an unsolved issue because the distributions don't get an agreement. For instance:

✏ Swap size

Ubuntu says that:

– If it is needed to hibernate in your computer, swap size would be equal to the size of RAM memory plus the squared root of the size of RAM memory

– Else:

* If the RAM memory is less than 1 GB, the swap size should be at least the size of RAM memory and at most double the RAM size

* If the RAM memory is greater than 1 GB, the swap size should be at least the squared root of the RAM size or at most double the size of RAM memory.

Ubuntu made a table in order to make the swap size selection easier:

| Ram Size	Swap Size (without Hibernation)	Swap Size (with Hibernation)
256 MB	256 MB	512 MB
512 MB	512 MB	1 GB
1 GB	1 GB	2 GB
2 GB	1 GB	3 GB
3 GB	2 GB	5 GB
4 GB	2 GB	6 GB
6 GB	2 GB	8 GB
8 GB	3 GB	11 GB
12 GB	3 GB	15 GB
16 GB	4 GB	20 GB
24 GB	5 GB	29 GB
32 GB	6 GB	38 GB
64 GB	8 GB	72 GB
128 GB	11 GB	139 GB

- "/" (slash or root directory). The system will be installed from here. And it is possible to know the organization of the operating system:

  - /boot: this directory contains the setting files of the boot management.

  - /bin: this folder contains all the programs which can be run for every user.

  - /dev: it is possible to find the hardware files of the system.

  - /etc: settings files.

  - /home: user's folder.

  - /lib: common libraries for all programs.

  - /media: devices which are mounted live as hard-disks, DVD drives, pen drives...

  - /mnt: folder where are mounted temporary drives.

  - /opt: in order to install programs which cannot be installed automatically.

  - /root: It contains system administrator (superuser) programs.

  - /usr: general purpose programs for all users.

  - /tmp: temporary files

  - /var: variable files such as registers, databases...

2.4   Fourth Step

A good way in order to organize the partitions would be to create 3 partitions:

- "/" : a primary partition for the slash

- /home: a partition for user's folder in order to make easy reinstallation. That partition will be logical partition.

- Swap partition

First of all, you need to select "New partition table":
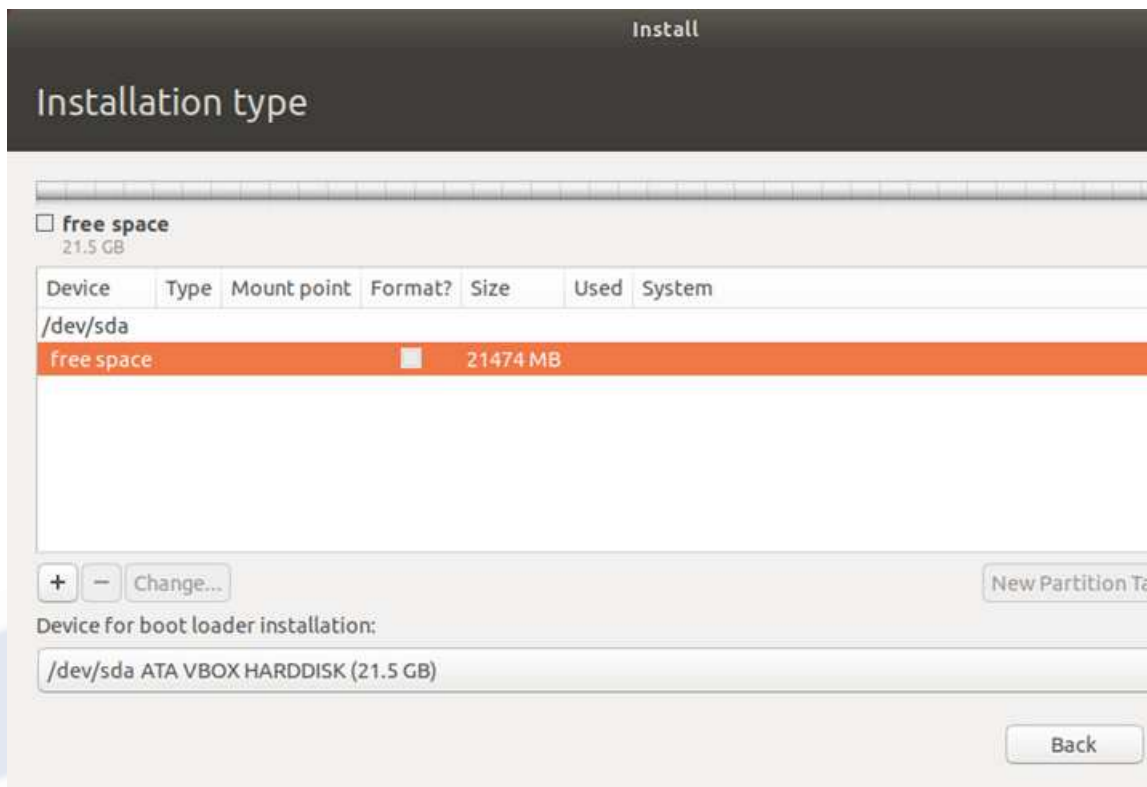
Later, "free space" is selected and the button "+" is pushed in order to define a new partition. A new window appears:

- Size option: to establish the size of the partition

- Type for the new partition option

- The location option.

- It is possible to choose "use as" in the swap area

- In the "Mount point" option, it is possible to choose "/", "/home" or some other directory.

- If it should be done in 3 partitions, it will be necessary to repeat this step 3 times.
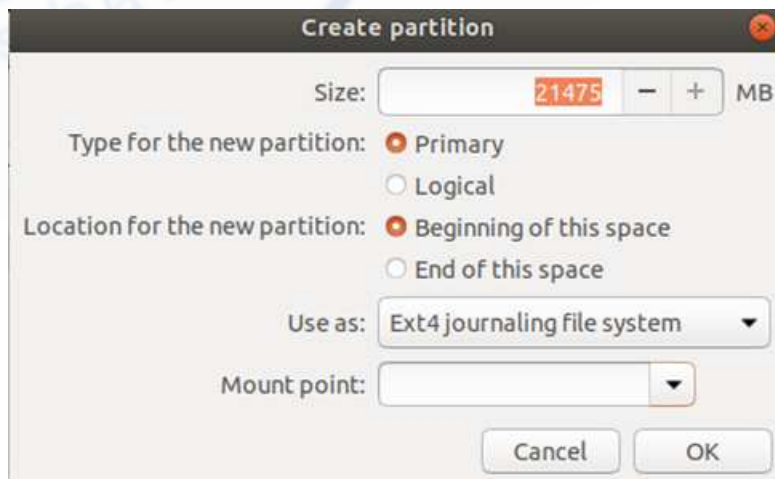
Eventually, the installation would look this way:
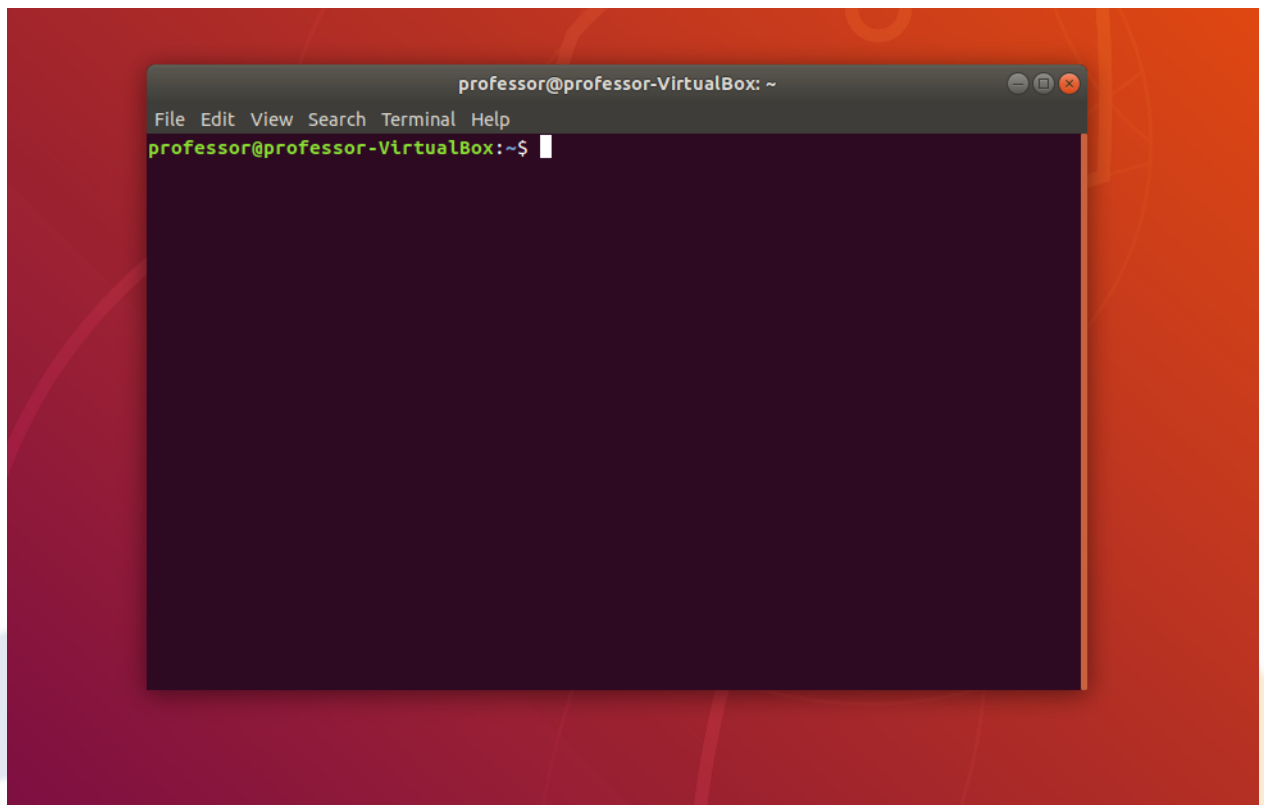
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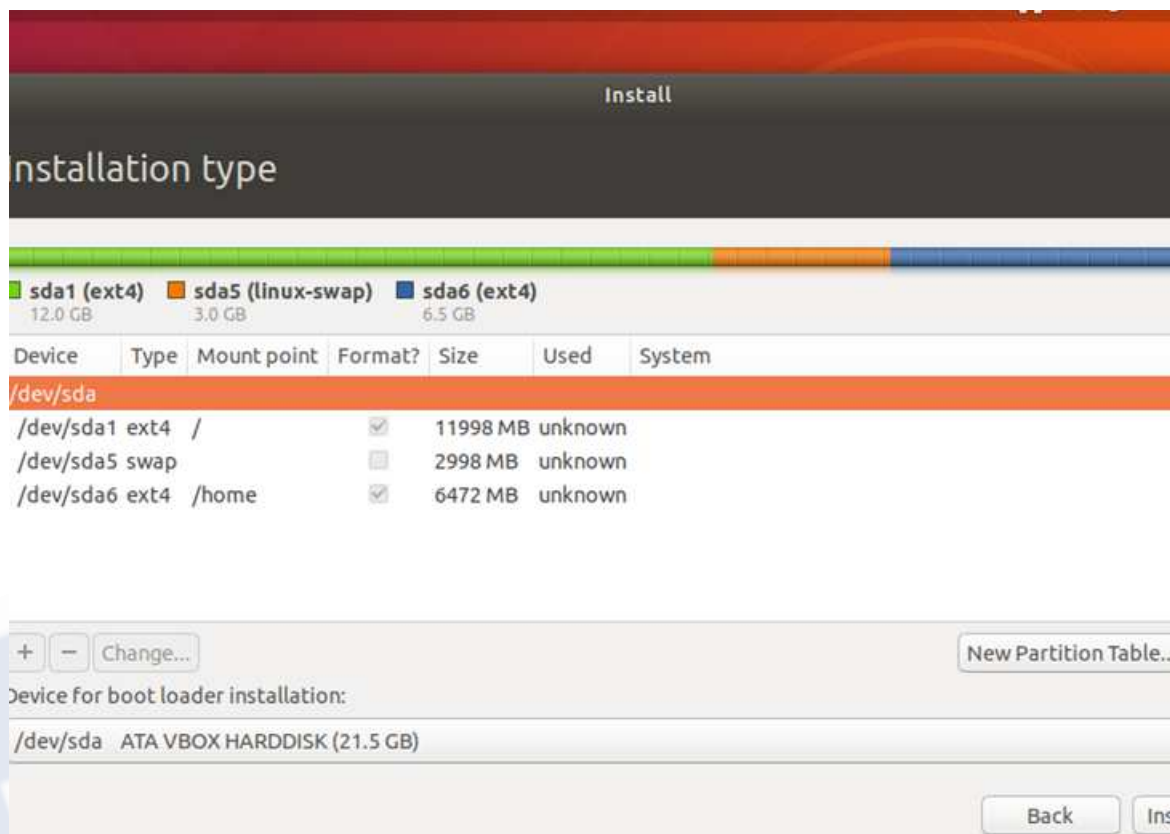
2.5   The boot Sector

The BIOS is in charge of searching a sector (MBR) which lets the operating system to boot. Each operating system sets that sector when it is installed. When it is installed, there is another operating system in order to have a dual boot; the second one will install again. This way the last operating system installed will be the only one allowed to boot. Linux is respectful about that and does not overwrite it. It is possible to modify the boot program. The program which is normally used for this issue is grub.

3   Applications

There are 3 basics applications in Linux:

- File Explorer: if we take the example of Windows, It would be the File Explorer. We can find this in the icon in the toolbar, in Accesories or search the system bar. There are a lot of kinds of File explorer in Linux. Ubuntu uses Nautilus.

- Text editor: the text editor most used is gedit. It is possible to find it throught the applications or search the system bar.

- Terminal: this application is used to send command to the operating system.

4   Installing Programs

There are different ways in order to install programs in Linux. One of the easiest ways is from a package. Programs can be installed from the graphical mode, from the store, but there is another way. From the terminal by command. The command is used in order to install programs, such as:

```
sudo apt-get install package_name
```

Where:

- sudo: allows us to execute applications in superuser mode. To install programs, it is necessary to validate the credential permissions.

- apt-get: name of the package manager application.

- install: option of the manager program that allows the installation.

- package_name: programa which is required for installation.

Furthermore, it is possible installing packages from Synaptics (System→ Tools→ Menu), in case of an unknown name of the program. Dependencies will be selected automatically.

It is possible to search from several fonts managing in the Synaptic → Settings/Repositories menu in the other fonts tab.

5   File and Directories Management

The way the information is organized depends on the operating system, and Linux has its own way of organizing the information.

It is known that a file is a set of related information. All of this information is saved under a name. This name should have between 1 and 255 types. "/" is not allowed to use because this type is used in order to point out the root directory and to separate names and files when they are pointed out in a path.

Each element of a table is called i-node with a structure of data. Each structure of data keeps information about each file. This table is created when the system turns on.

The operating system identifies each file for the name and i-node number. This number is unique for each file. Each structure of data in the table has the following information:

- I-node number

- File type

- Owner and group

- File permissions

- Creation, access and modification date.

- Links

In addition to all this information, a pointer structure is saved. This structure will be used in order to save the memory on hard-disk blocks where the file is stored. This structure is composed by:

- Twelve pointers which point out the memory hard-disk blocks addresses

- An indirect simple pointer. This simple pointer points out to a memory hard-disk block. This block contains pointers to other addresses where the file is stored.

- An indirect double pointer which points out to a memory hard-disk block. This block contains another pointers block which contains pointers to other addresses.

- An indirect triple pointer which points out to a memory hard-disk block. This block contains another pointer block which in turn contains pointers to another pointers blocks which also contains pointers to other addresses.

As you can see, it is increasing in an exponential direction. The bigger the file, the more addresses and pointers will be needed.
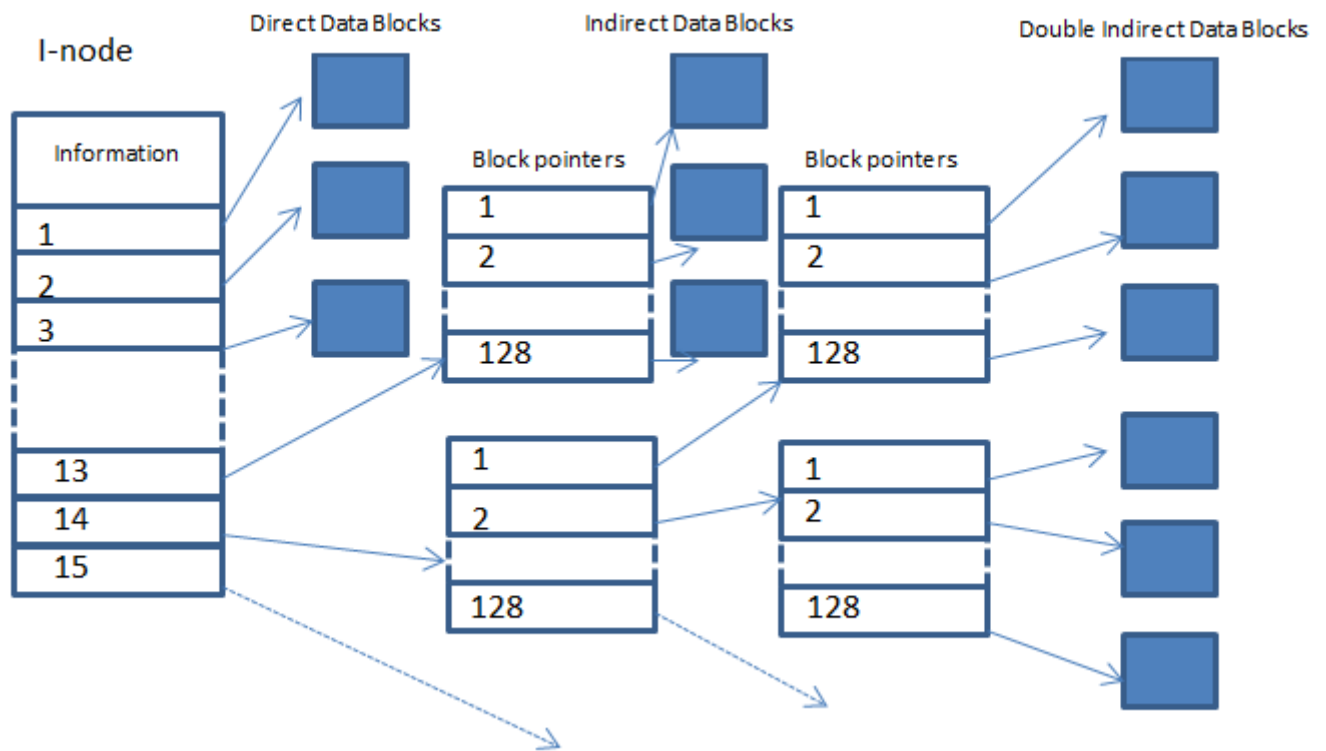
If some information is changed, the information is updated in the i-node table. Besides a copy of this, a table is saved in secondary storage. This secondary table is often updated.

> 🔧 **Try it 2**
> With all the information above, explain what would be the maximum file size which could be stored in this kind of file system if the size block is 4 kB?