CHAPTER 1

Getting Started with Ubuntu Linux for Robotics

Let's start our journey of programming robots by using the Robot Operating System (ROS). In order to get started with ROS, there are some prerequisites to be satisfied. The prerequisites are to have a good understanding of Linux, especially Ubuntu; a good understanding of Linux shell commands; and Python and C++programming knowledge.

This book discusses all the prerequisite technologies required for robot programming using ROS. This first chapter introduces the Ubuntu operating system, installation, important shell commands, and the important tools for programming robots. If you already work with Ubuntu, you should still go through this chapter. It will refresh your existing understanding of Ubuntu Linux.

Getting Started with GNU/Linux

Linux is an operating system like Windows 10 or Mac OS. Similar to other operating systems, it has capabilities such as communicating and receiving instructions from users, reading/writing data to the disk drive

L. Joseph, *Robot Operating System for Absolute Beginners*,
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and executing software applications. The important part of any operating system is the *kernel*. In GNU/Linux system, Linux (www.linux.org) is the kernel component. The rest of the components are applications developed by the GNU Project (www.gnu.org/home.en.html).

The Linux based OS are inspired from the Unix operating system. The Linux kernel is capable of multitasking in multiuser systems. The good thing is that GNU/Linux is free to use and open source. Users have full control on the operating system, which makes Linux ideal for computer hackers and geeks. Linux is vastly used in servers. The popular Android operating system runs in a Linux kernel. There are many distributions, or flavors, of Linux, which basically uses the Linux kernel as the core component; there are differences in the graphical interface. Some of the most popular Linux distributions are Ubuntu, Debian, and Fedora (see Figure 1-1). The Linux-based operating systems are among the most popular in the world.

Figure 1-1. *Logos of various popular Linux distributions*

What Is Ubuntu?

Ubuntu (www.ubuntu.com) is a popular Linux distribution based on the Debian architecture (https://en.wikipedia.org/wiki/Debian). It is freely available for use, and it is open source, so it can be modified according to your application. Ubuntu comes with more than 1,000 pieces of software, including the Linux kernel, a GNOME/KDE desktop

environment, and standard desktop applications (word processing, a web browser, spreadsheets, a web server, programming languages, integrated development environment (IDE), and several PC games). Ubuntu can run on desktops and servers. It supports architectures such as Intel x86, AMD-64, ARMv7, and ARMv8 (ARM64). Ubuntu is backed by Canonical Ltd. (www.canonical.com), a UK-based company.

Why Ubuntu for Robotics?

The software is the heart of any robot. A robot application can be run on an operating system that provide functionalities to communicate with robot actuators and sensors. A Linux-based operating system can provide great flexibility to interact with low-level hardware and provide provision to customize the operating system according to the robot application. The advantages of Ubuntu in this context are its responsiveness, lightweight nature, and high degree of security. Beyond these factors, Ubuntu has great community support and there are frequent releases, which makes Ubuntu an updated operating system. Ubuntu also has long-term support (LTS) releases, which provides user support for up to five years. These factors have led the ROS developers to stick to Ubuntu, and it is the only operating that is fully supported by ROS.

The Ubuntu-ROS combination is an ideal choice for programming robots.

Installing Ubuntu

This section discusses how to install Ubuntu 16.04 LTS. The procedure for installing any Ubuntu version is almost the same. Like any other operating system, a PC should have the recommended system requirements to install Ubuntu. Here are the recommended requirements needed for your PC. After that you can see the detailed procedure of Ubuntu installation.

Recommended PC Requirements

- 2GHz dual core processor or better
- 2GB system memory
- 25GB of free hard drive space
- a DVD drive or a USB port for the installer media
- Internet access is helpful

Downloading Ubuntu

The first step is to download the DVD/CD ISO image. To download an Ubuntu image, go to www.ubuntu.com/download/desktop.

You can take a look at all Ubuntu releases at http://releases.ubuntu.com.

The DVD image is less than 1GB. It is named ubuntu-16.04.X-desktop-amd64.iso. By default, the ISO image is 64-bit architecture; if your PC RAM size is less than 4GB, you can use 32-bit architecture.

After downloading the desired Ubuntu image, there are two options for installing Ubuntu.

- Install on a real PC. This can be done using one of two methods. You can burn the image to a DVD or to a USB drive.
- Install in VirtualBox (www.virtualbox.org) or VMWare Workstation (https://my.vmware.com/web/vmware/downloads). With this method, you have to first install VirtualBox software, and then install Ubuntu on top of it. In this book, we prefer this method because it is safe to work with VirtualBox. Installing on a real PC may cause data loss if you don't do it properly. As a beginner, you can experiment with Ubuntu inside VirtualBox.

Installing VirtualBox

VirtualBox (www.virtualbox.org) is a virtualization software that allows an unmodified operating system (with all of its installed software) to run in a special environment on top of your existing operating system. This environment, called a *virtual machine*, is created by the virtualization software by intercepting access to certain hardware components and certain features. The physical computer is called the *host*, and the virtual machine is called the *guest*. The guest can run on the host computer, which thinks that it's running on a real machine.

You can install VirtualBox on a host PC running Windows, Linux, OS X, or Solaris (www.virtualbox.org/wiki/Downloads). In this chapter, we install it on a Windows PC. You can choose the Windows platform from a list and install it on your Windows PC (see Figure 1-2). The installation of VirtualBox is easy; you may not have any confusing issues. During installation, you are asked to install virtual drivers. You can accept the driver installation.

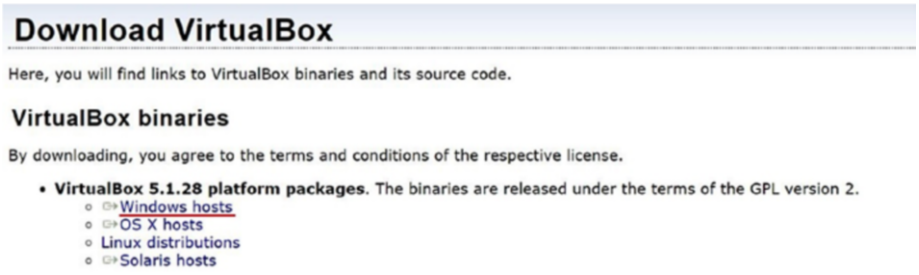

Figure 1-2. *Downloading the virtual box for Windows host*

If you are working in OS X or Linux, choose the platform accordingly. The installation instructions can be found at www.virtualbox.org/manual/ch02.html.

Creating a VirtualBox Machine

The first step in installing Ubuntu in VirtualBox is to create a new virtual machine. If you already installed VirtualBox on your system, you can create the virtual machine by going through the following steps.

Step 1: Adding a New Virtual Machine

After installing VirtualBox on your PC, open it. You see the window shown in Figure 1-3.

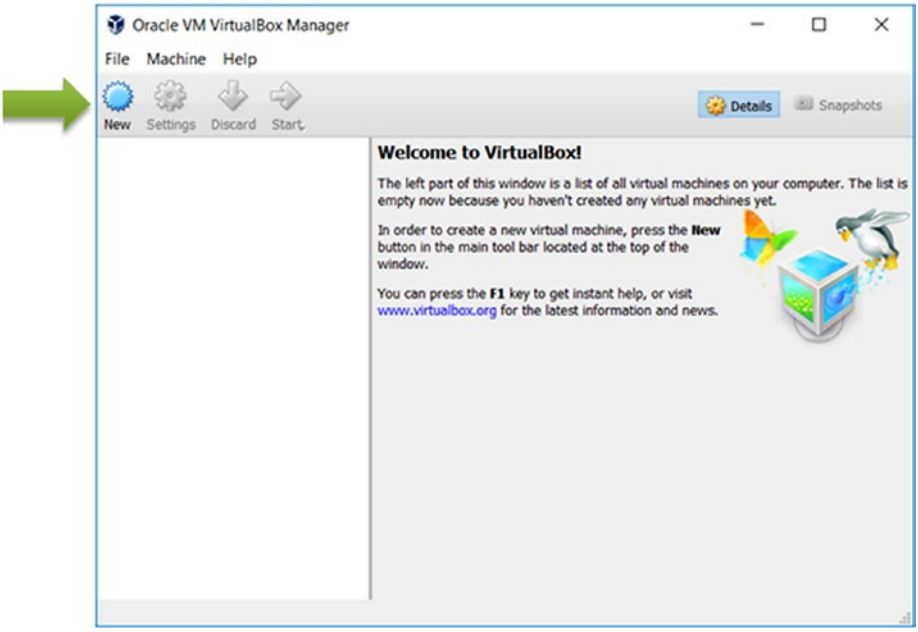

Figure 1-3. *Adding a new virtual machine in virtual box*

You can click the Add button to create a new virtual machine.

Step 2: Naming the Guest Operating System

After adding the virtual machine, the next step is to name the guest operating system that we are going to create. As shown in Figure 1-4, you can name it Ubuntu, set the type as Linux, and the version as 32/64 bit. The naming is just for the information; it is not associated with any settings. After entering the name, press the Next button to continue to the next step.

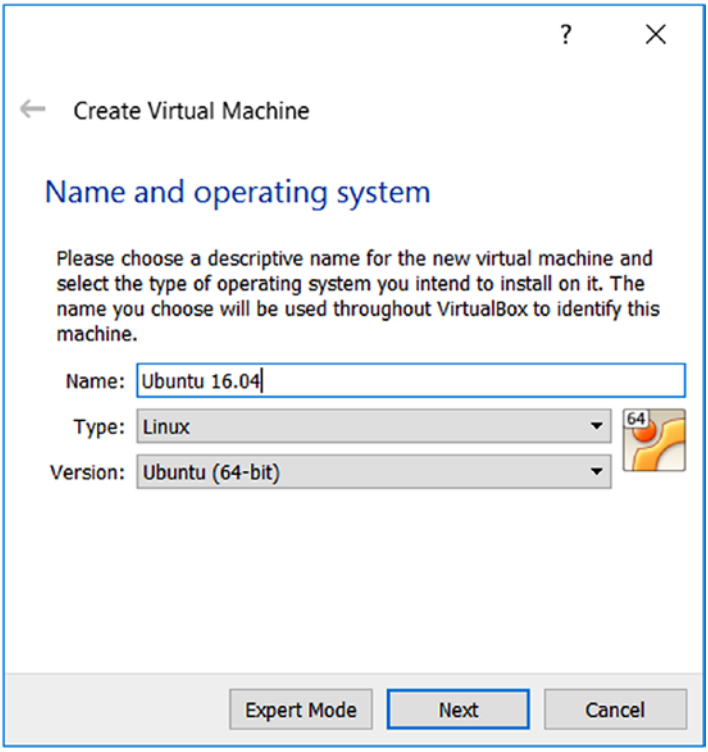

Figure 1-4. *Naming the guest operating system*

Step 3: Allocating RAM for the Guest OS

In this step, we allocate the RAM for the guest OS (see Figure 1-5). This step is important because if the RAM allocation is too low, the guest OS may take a lot of time to boot, and if the allocation is too high, the RAM for the host OS will also allocate for the guest OS, which may slow down the host OS. So, the RAM allocation should be optimized so that both operating systems get better performance. Based on the RAM size of your host PC, the wizard will show the safety limits of RAM size for the virtual OS in green. The RAM allocation of the guest should be within the safety limits.

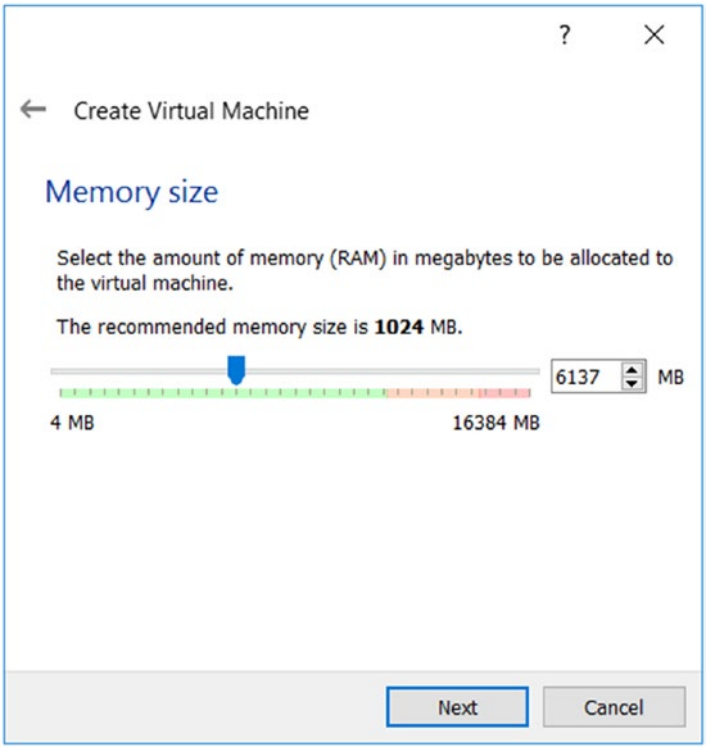

Figure 1-5. *Allocating RAM for the guest OS*

Step 4: Creating a Virtual Hard Disk

After allocating the RAM, the next step is to create a virtual hard disk for the guest OS. In this step, you can use an existing virtual hard disk file or create a new one. These virtual hard disk files are portable, so you can copy the virtual hard disk to any PC and set up the same virtual machine on that PC.

In this step, you can select the type of virtual hard disk that you want to create (see Figure 1-6). The default option is VDI (VirtualBox disk image), which is the native virtual hard disk of VirtualBox. VHD (virtual hard disk) is developed by VMWare, which is also supported in VirtualBox. The third option is VMDK (virtual machine disk) , which is the Microsoft Virtual PC virtual hard disk type. You can get more information from `www.virtualbox.org/manual/ch05.html`. In this chapter, we are selecting the native hard disk format, or VDI.

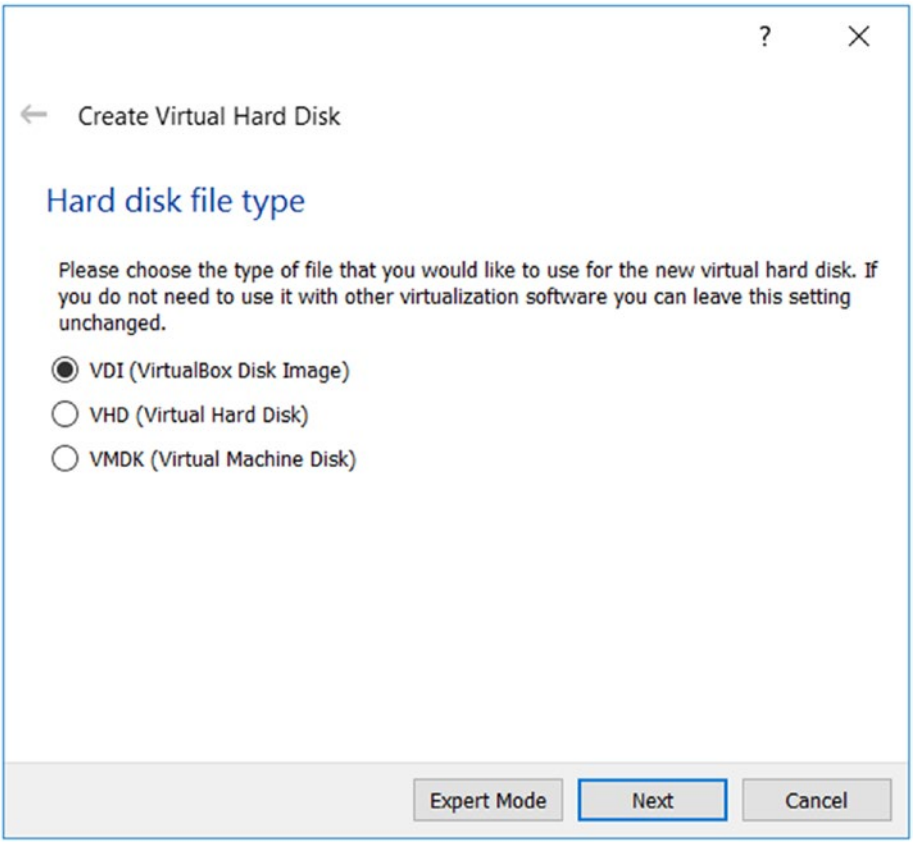

Figure 1-6. *Choosing the type of hard disk for the virtual machine*

Step 5: Configuring the Type of Virtual Disk

In this step, we have to configure the mode of storage. There are two modes: *dynamically allocated* and *fixed size* (see Figure 1-7). If we select fixed size, a virtual hard disk is created with a fixed size. That size can be set in the next step. After creating this virtual hard disk, it will consume that much physical disk size. With a dynamically allocated disk, you can use the maximum hard disk size, and it will only use the physical hard disk space when it fills up. The time taken to create a fixed hard disk is higher than

dynamically allocated, but once it is created, it can perform much better than a dynamically allocated mode. In this chapter, we are going to use a fixed size with a maximum size of 20GB.

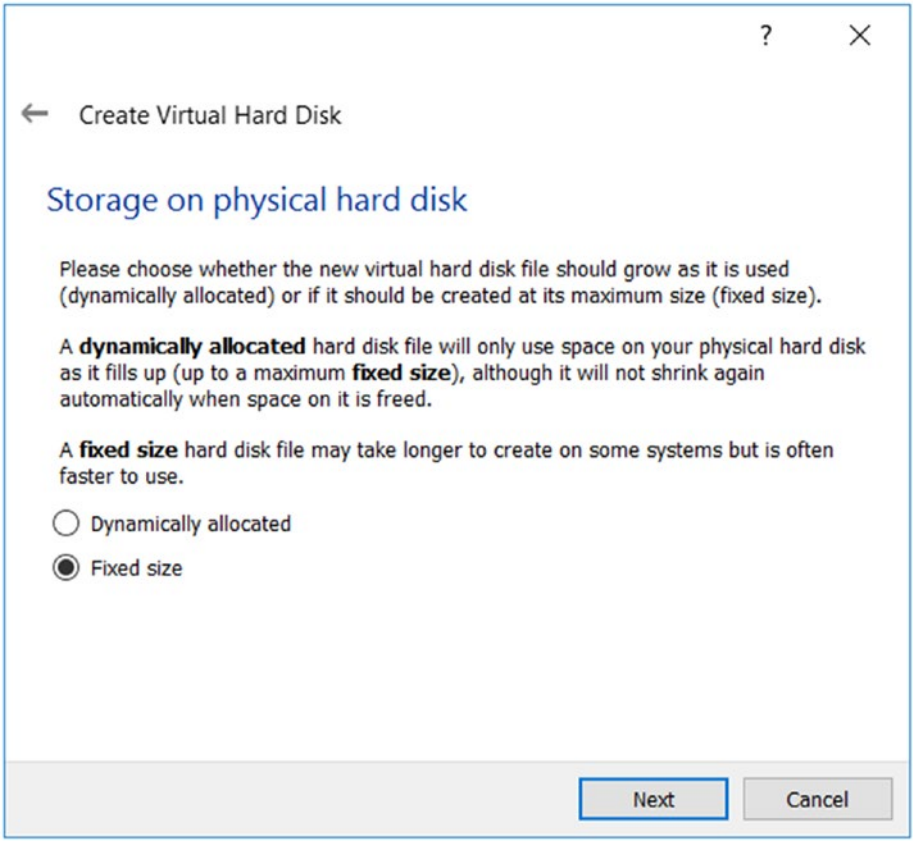

Figure 1-7. *Choosing the mode of storage in the virtual hard disk*

You can also browse the location to save the virtual hard disk file. When you finish the virtual disk configuration, it will take some time to build those configurations (see Figure 1-8).

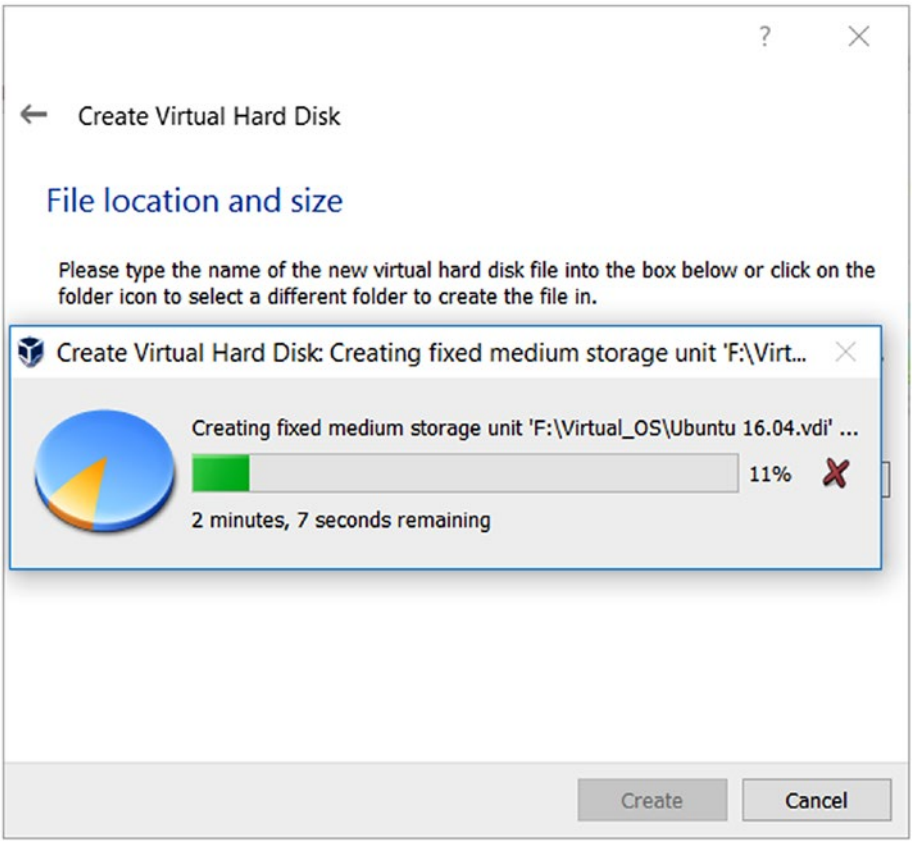

Figure 1-8. *Creating the fixed-size virtual hard disk*

After creating the virtual hard disk, you can see the newly created virtual machine. But where do we put the Ubuntu image in the virtual machine? Well, that is the next step that we are going to do.

Step 6: Choosing Ubuntu DVD Image

Figure 1-9 shows the newly created virtual machine. We have to select the Settings button to configure the virtual machine.

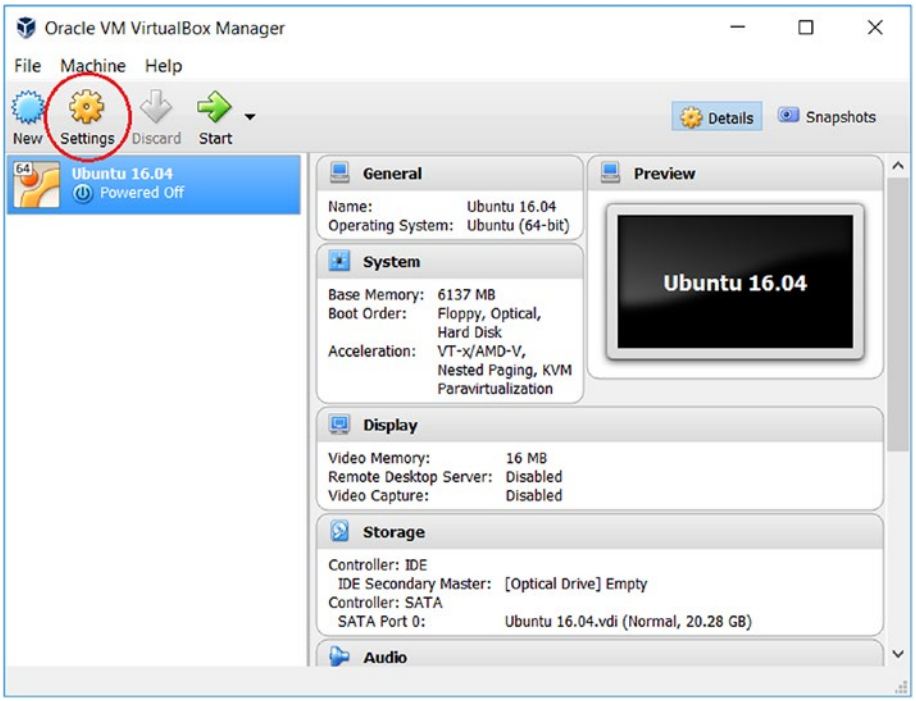

Figure 1-9. *Configuring the virtual machine*

In the Settings window, navigate to the Storage option on the left (see Figure 1-10).

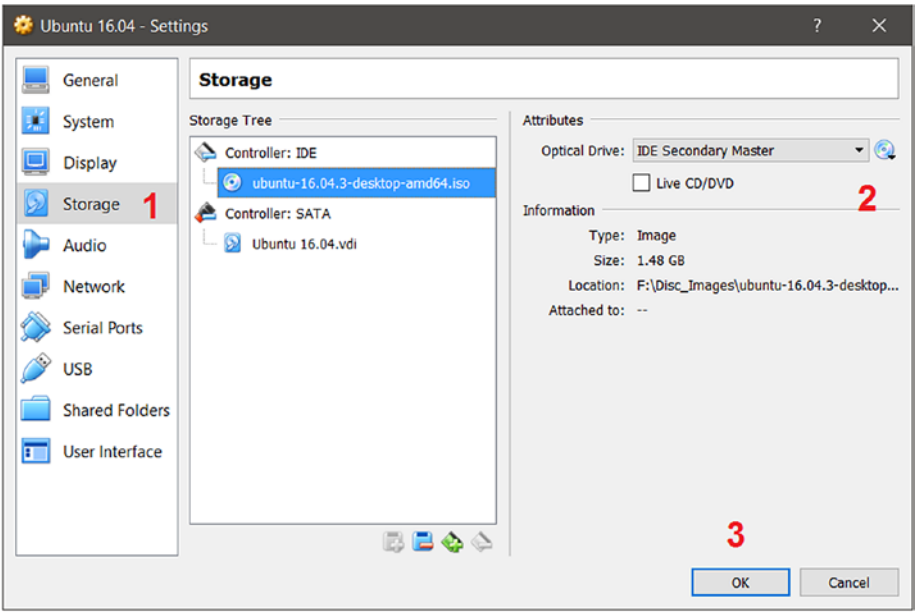

Figure 1-10. *Inserting Ubuntu DVD image in the optical drive*

After inserting the Ubuntu image, configure the video configuration. In this setting, you can allocate the video memory of the guest OS (see Figure 1-11).

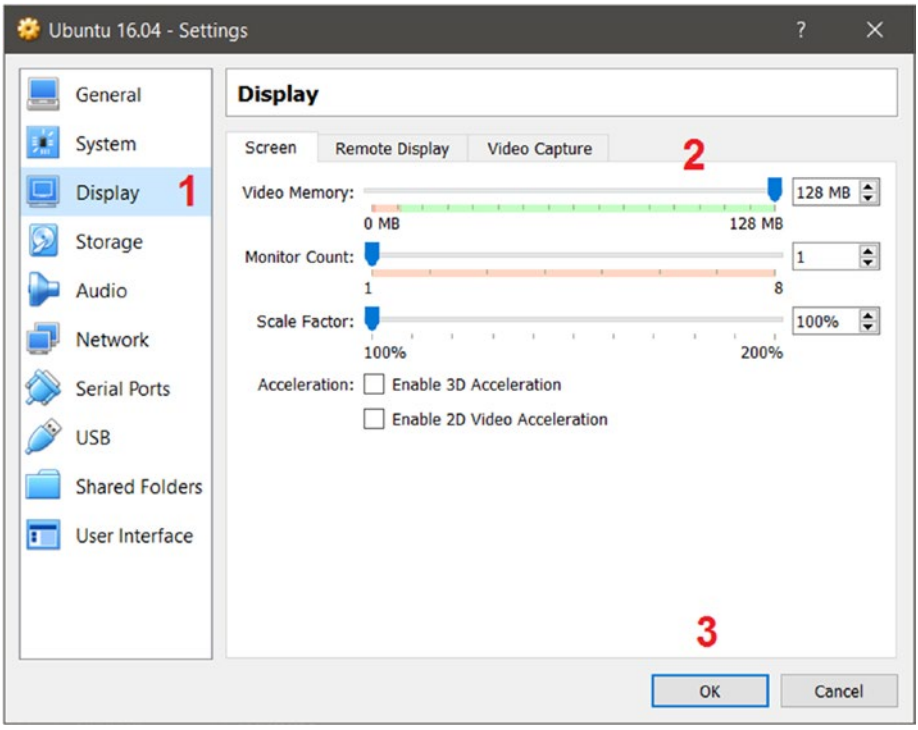

Figure 1-11. *Display settings of the guest OS*

After configuring the Display settings, we have to configure the System settings. In the System settings, you can allocate the number of CPUs for the guest OS. Figure 1-12 shows the safest settings for CPU allocation.

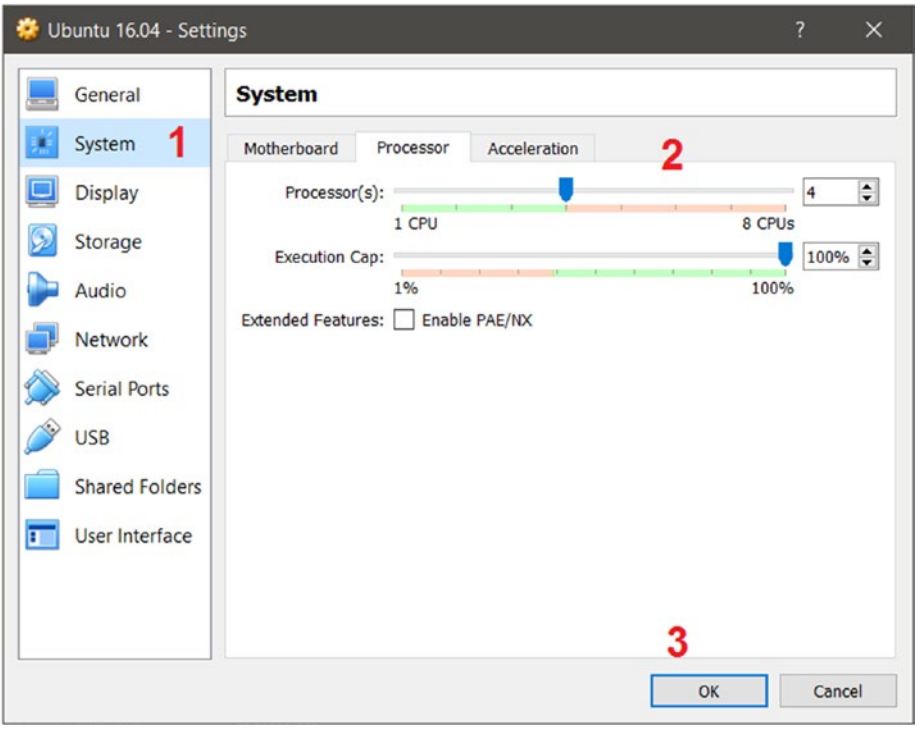

Figure 1-12. *The System settings for the guest OS*

The Shared Folders settings may be useful when working with Ubuntu (see Figure 1-13). Using this option, you can share the host operating system folder inside the guest operating system. This option is useful for accessing files and folders from the host operating system.

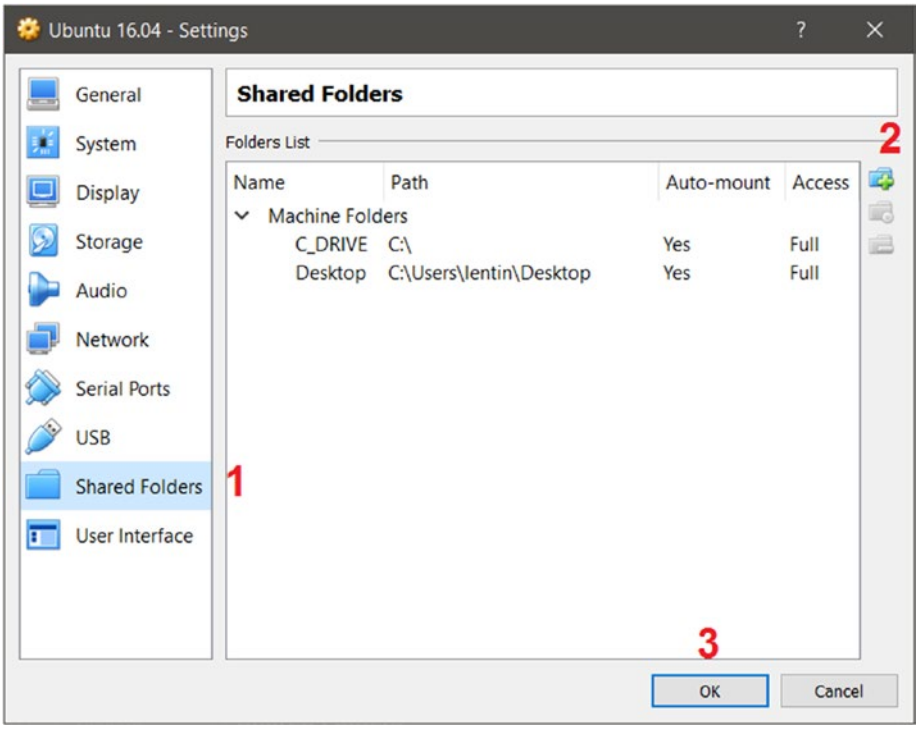

Figure 1-13. *The Shared Folders settings*

After completing these settings, you can start the virtual machine.

Step 7: Starting Virtual Machine

As shown in Figure 1-14, you can launch the virtual machine by pressing the Start button. This will boot the virtual machine and bring you to the Ubuntu live desktop.

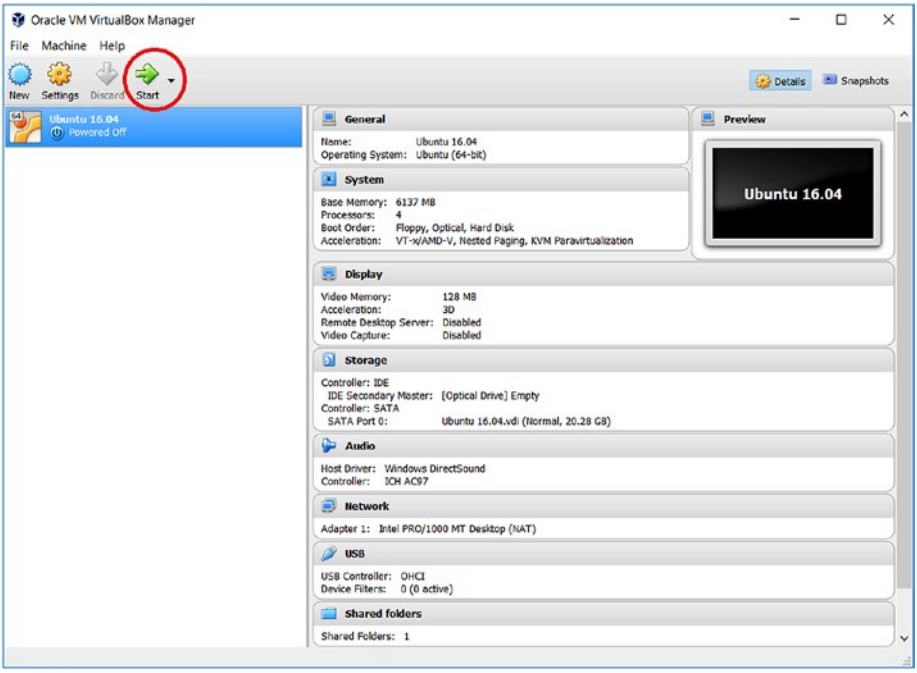

Figure 1-14. *Launching the virtual machine*

On the live desktop, you can explore the Ubuntu features without installing it. You also have the option to install Ubuntu in the live mode. In the next section, we will see how to install Ubuntu in VirtualBox. The steps are the same if you install it on a real PC.

Installing Ubuntu on VirtualBox

When the virtual machine boots up, you get the window shown in Figure 1-15, which asks you to Try Ubuntu or Install Ubuntu. If you want to use Ubuntu before installing it, select Try Ubuntu, but if you want to directly install Ubuntu, select Install Ubuntu. Here we choose the Install Ubuntu option.

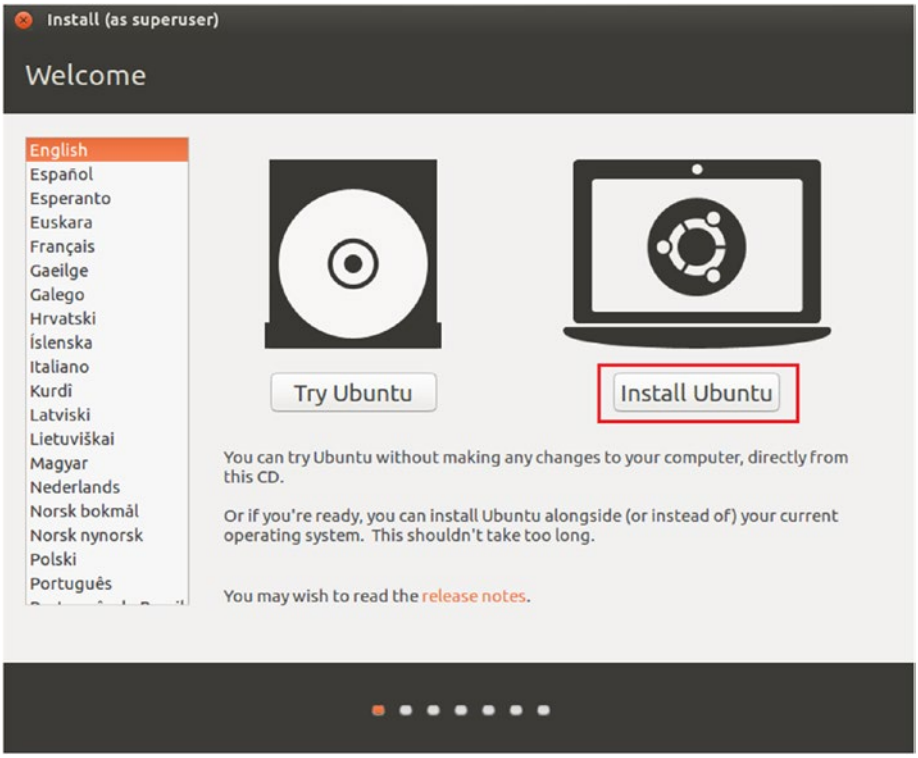

Figure 1-15. *The first window after booting from Ubuntu DVD image*

After selecting the Install Ubuntu option, the next window (see Figure 1-16) allows you to select options such as updating Ubuntu during installation and updating third-party applications and drivers. If you are working in VirtualBox, you can ignore this, but if you are installing on a real PC that has graphics cards like NVDIA or ATi Raedon, you can select these options. It can search for an appropriate graphics driver and install it during the Ubuntu installation; otherwise, you may need to manually install it. However, there is no guarantee that we will get a proper drive for our graphics card.

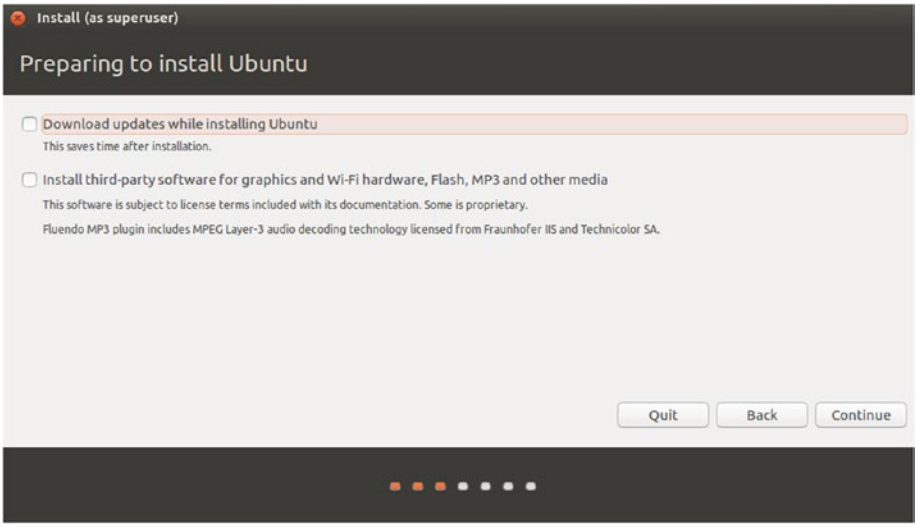

Figure 1-16. *Updating Ubuntu and installing third-party software*

After configuring, press Continue to move onto the next step. This step is very important because we are going to partition the hard disk to install Ubuntu on it (see Figure 1-17). You have to be careful when selecting the partition option. The first option, *Erase disk and install Ubuntu*, erases all the drives on the hard disk and installs Ubuntu. If you are willing to do this, you can proceed with that option. If you installed Ubuntu in VirtualBox, this option will be fine, but if you are planning to install Ubuntu along with Windows, select the *Something else* option.

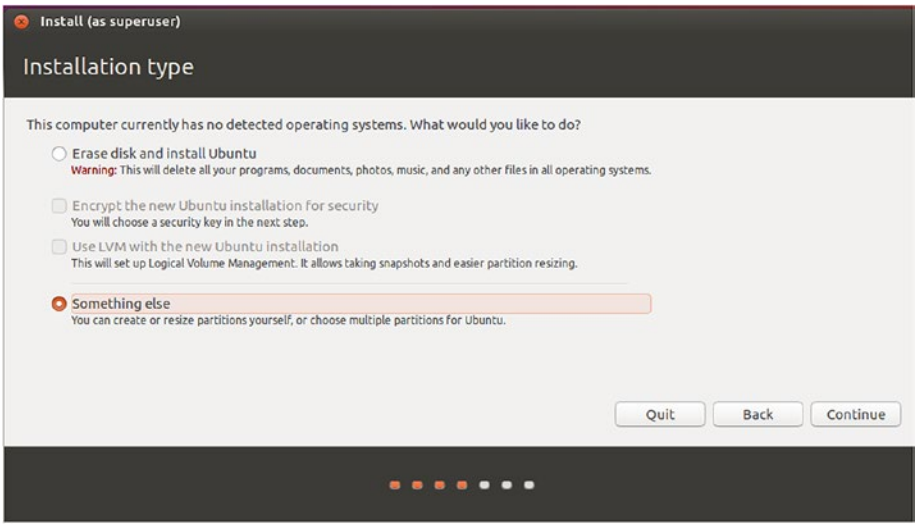

Figure 1-17. *Choosing the installation type*

The *Something else* option gives us the option to format the desired drive and install Ubuntu on it. If you are installing Ubuntu in VirtualBox, you don't need to worry much about this because there is only one hard disk. If you are going to install on your real PC, you have to find a partition for installing Ubuntu before booting into Ubuntu. In the partition manager, you can identify the drive by checking the size of the partition. If the disk is not formatted, you see the disk drive as `/dev/sda`. The first option is to create a partition table, which you do by clicking the New Partition Table button. After doing this, the disk drive shows free space, as shown in Figure 1-18.

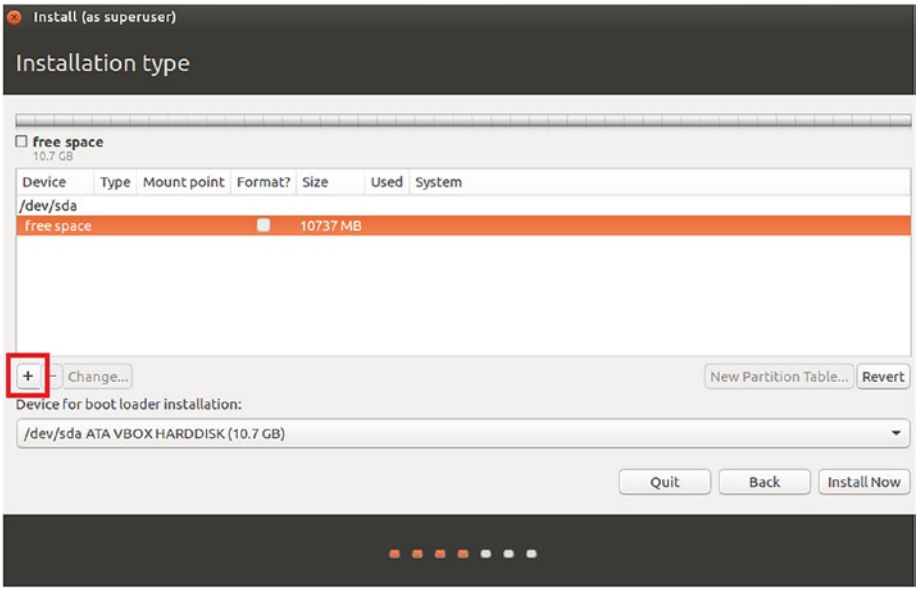

Figure 1-18. *Free space on the hard disk*

You can modify the existing partition with the button on the left. There are three buttons. The button with the + symbol is for creating a new partition from a free space; the button with the – symbol is for deleting an existing partition; and the Change button is for converting an existing partition into another format or changing its size. Here we are going to create a new partition, so click the + button. You see another window (as shown in Figure 1-19), which asks for information about the new partition.

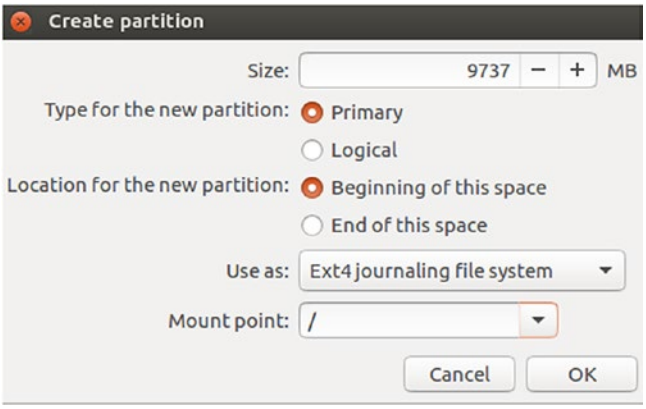

Figure 1-19. *Creating a new root partition*

Basically, to install Ubuntu, we need to set up two partitions. One is a root partition and the other is a swap partition. The Ubuntu OS is installed in the root partition. As shown in Figure 1-19, *primary* is the type for the root partition, and the format of the file system is Ext4Journaling. You have to set the mount point of root partition as /.

The swap partition is a special kind of partition that is used for storing inactive pages when your physical memory (RAM) is approaching maximum usage. If your RAM is large enough, let's say greater than 4GB, the swap partition can be ignored; otherwise, it is a good idea to have a swap partition. You can allocate 1GB or 2GB to the swap partition (see Figure 1-20).

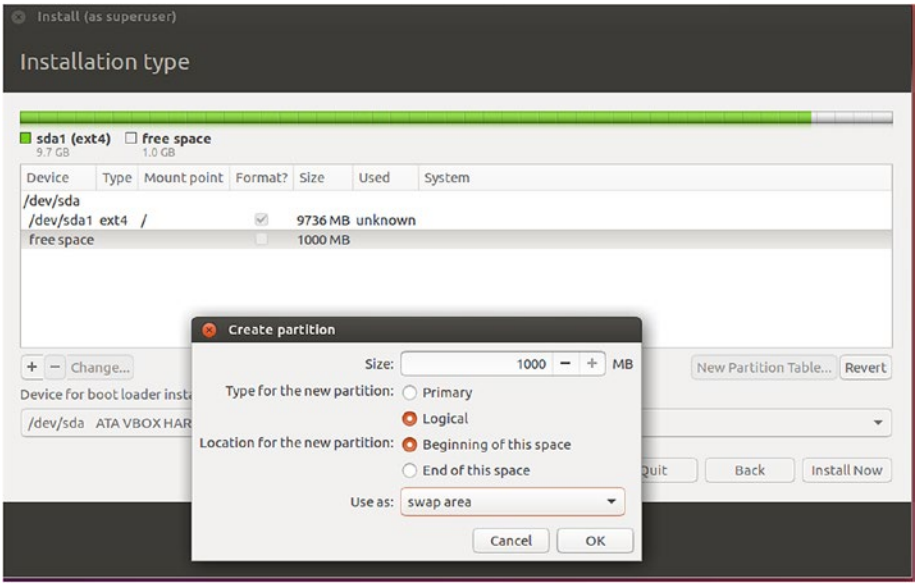

Figure 1-20. *Creating a new swap partition*

After creating both partitions, click the Install Now button, which installs Ubuntu to the selected partition. During installation, you can set the time zone, keyboard layout, and username and password (see Figure 1-21).

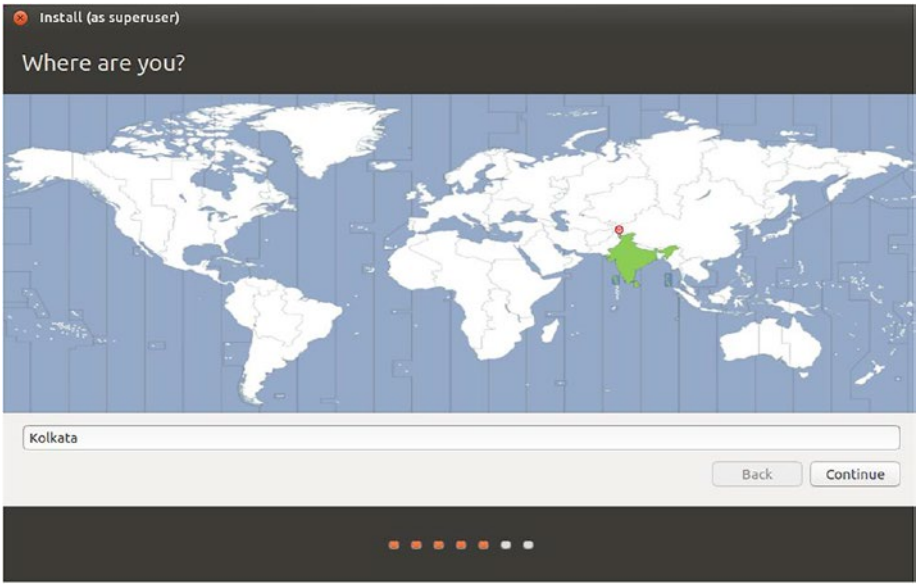

Figure 1-21. *Setting the time zone*

You can click your country to set the time zone. The country name will be visible when you click the map. After setting the time, the next step is to set up the keyboard layout (see Figure 1-22). Use the default keyboard layout (i.e., English (US)).

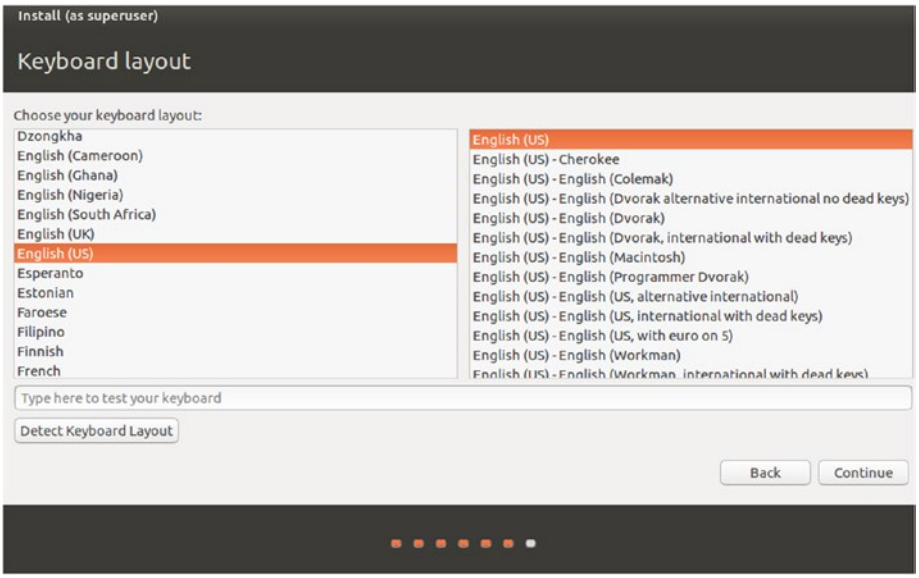

Figure 1-22. *Setting the keyboard layout*

Next, enter the Ubuntu login information (see Figure 1-23).

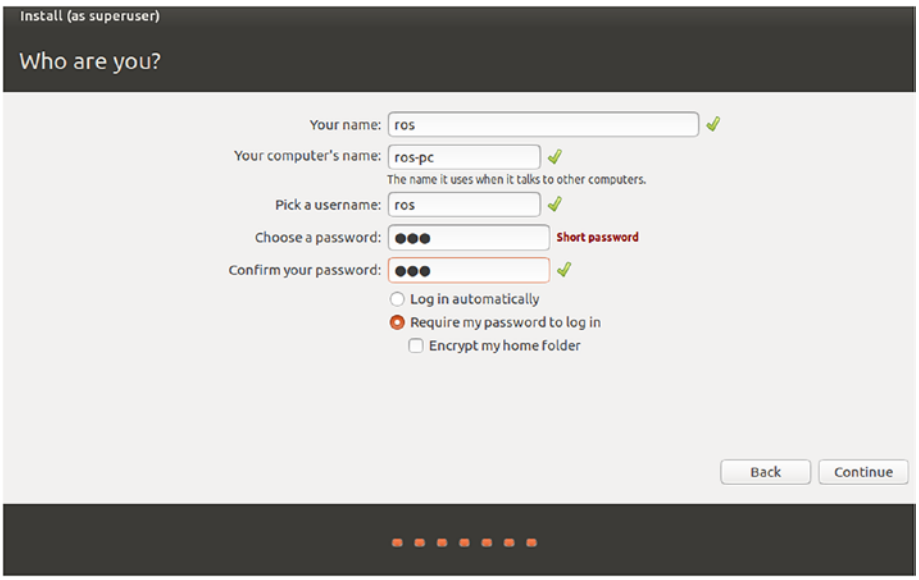

Figure 1-23. *Setting login information*

In this step, we set the PC name, login name, and password. If you don't want to log in using a username and password, you can enable the *Log in automatically* feature. This logs in directly to the Ubuntu screen without prompting for a username and password.

After assigning the login information, the installation procedure is almost over. After installing the files, you need to reboot (see Figure 1-24). Press Reboot to restart the virtual machine/PC. During this time, you can remove the DVD image from the VirtualBox menu. Select Devices ➤ Optical Drives ➤ Remove disk from the VirtualBox drop-down menu.

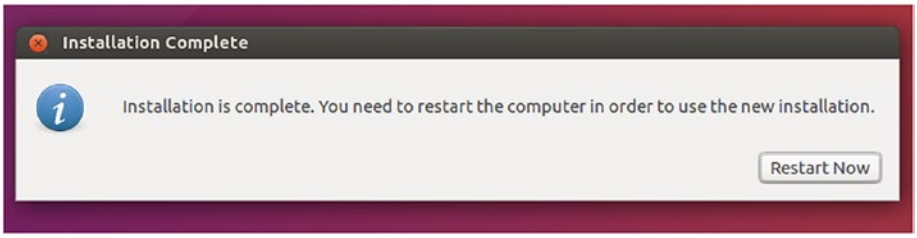

Figure 1-24. *Restarting Ubuntu*

After rebooting, you see the Ubuntu desktop shown in Figure 1-25.

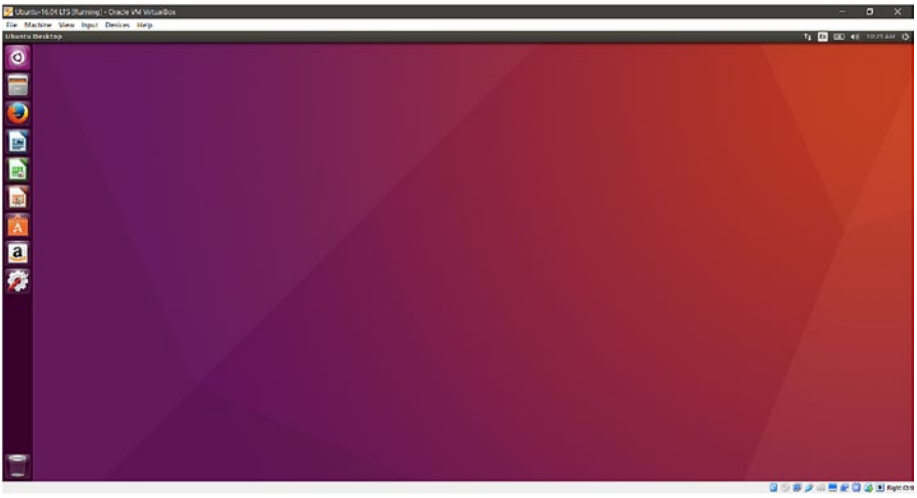

Figure 1-25. *Ubuntu desktop*

Congratulations. You have successfully installed Ubuntu on VirtualBox. If you are planning to install it on a real PC, you may need to know the following things to boot Ubuntu on a PC.

Installing Ubuntu on a PC

Basically, there are two ways to boot Ubuntu on a PC. The first method is direct: burn the DVD image you downloaded to a DVD, and then boot it from the DVD. The other method is to boot from a USB drive, which is easier and faster than a DVD installation.

A tool called UNetbootin burns the DVD image to a USB drive. It can be downloaded from `https://sourceforge.net/projects/unetbootin/`. You can browse the DVD image from this tool. Press OK to start the copying process (see Figure 1-26).

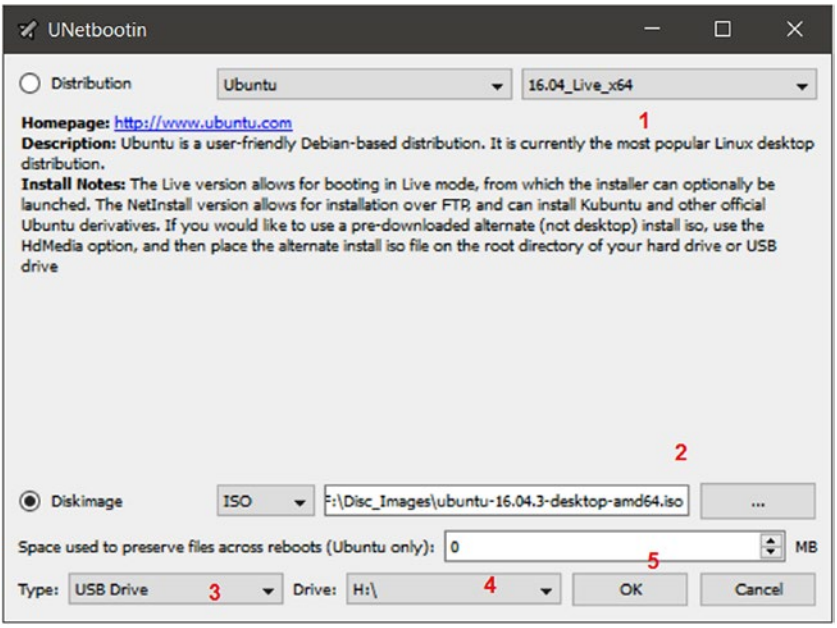

Figure 1-26. *UNetbootin setup*

You can select the Linux distribution and browse the DVD image. After selecting the DVD image, select the type of drive, which is *USB Drive*. Next, select the drive letter. Then, press the OK button. It takes time to copy the DVD image to the drive. When it is complete, reboot the PC and set the first boot device as USB drive. Now it will boot from the USB drive. You can follow the installation procedures described earlier. More instructions are at https://unetbootin.github.io/.

If you have any trouble installing the OS using UNetbootin, try Rufus (https://rufus.akeo.ie/), which is another application for the same purpose.

Playing with the Ubuntu Graphical User Interface

On the Ubuntu desktop, there is a panel on the left of the screen called Unity, which is a graphical shell built on the top of GNOME (www.gnome.org), the default desktop environment of Ubuntu. It is a free, open source application. The other desktop environments are KDE and LXDE.

Figure 1-27 shows the Unity Launcher, which helps to quickly launch and search Ubuntu applications. Click each app to make it pop up. You can also search by application name. These GUI tools can save your time in finding an application. On the right side of the Unity panel, there are options to adjust the volume and power off the system. The launcher is called the Unity Launcher. The search utility in the launcher is called the Dash. There is an indicator panel to show the network connection, volume, and other notifications.

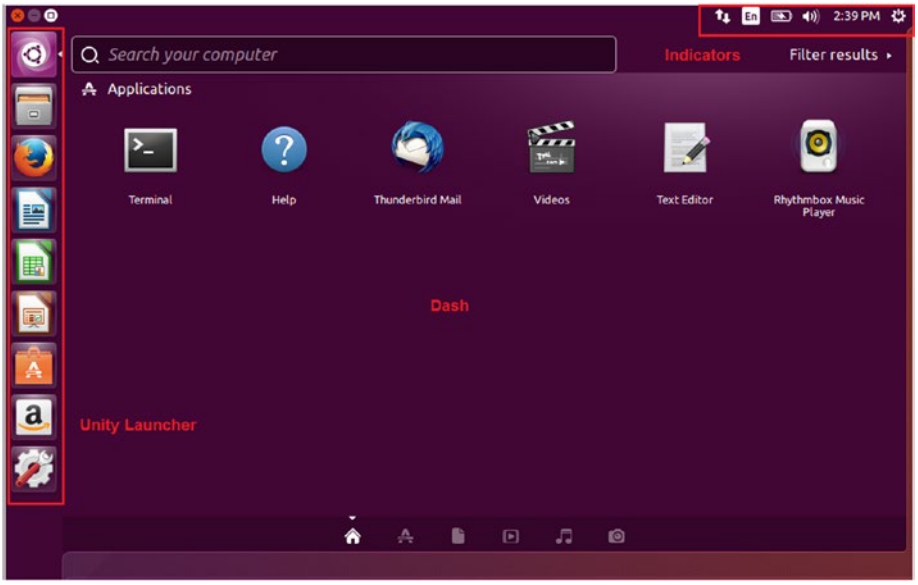

Figure 1-27. *The Unity Launcher panel*

Similar to Windows and OS X, there are many options in Ubuntu for customizing the desktop environment. If you are interested in configuring your Ubuntu desktop, refer to the Compiz Settings Manager at `https://help.ubuntu.com/community/CompositeManager#Compiz`.

To learn more about Ubuntu, download the PDF from `https://ubuntu-manual.org/downloads`.

The Ubuntu File System

Like the C drive in a Windows operating system, Linux has a special drive for storing system files. It is called the *root file system*, which we created during the installation of Ubuntu. We assigned / for the file system. Figure 1-28 shows the Ubuntu file system architecture.

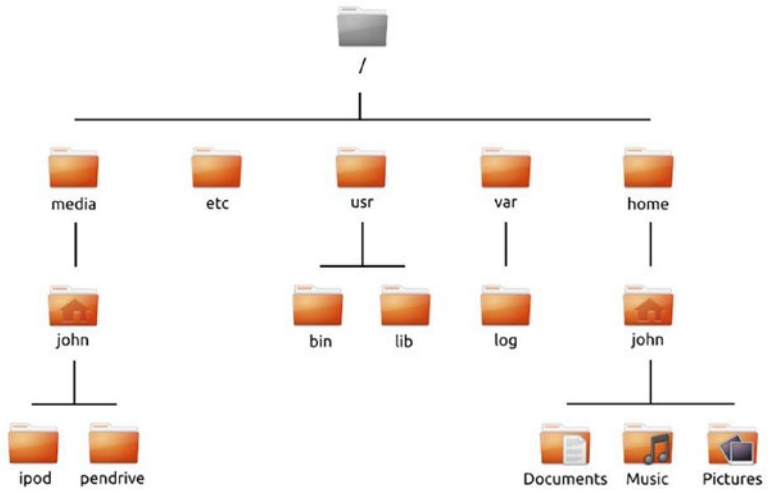

Figure 1-28. *Ubuntu file system structure*

You can explore the file system by choosing File Manager from the Unity Launcher, as shown in Figure 1-29.

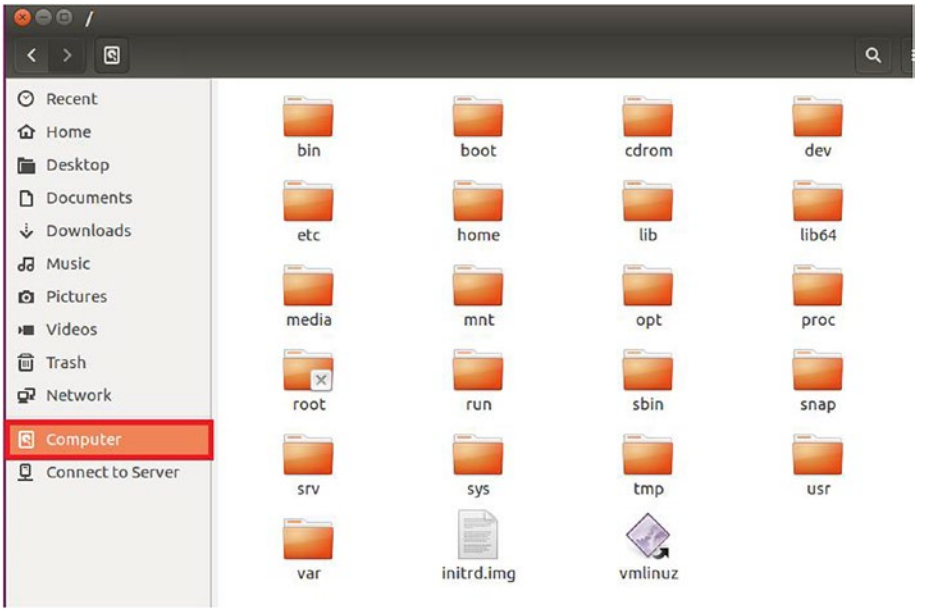

Figure 1-29. *Ubuntu file system structure*

The following describes the uses of each folder in the file system.

- `/bin` and `/sbin`: Contains system applications similar to the C:\ Windows folder
- `/etc`: Contains system configuration files
- `/home/`*`yourysername`*: This is equivalent to the C:\Users folder in Windows
- `/lib`: Contains library files similar to `.dll` files in Windows
- `/media`: Removable media is mounted in the directory
- `/root`: Contains root user files (not the root user file system; root user is the administrator of the Linux system)
- `/usr`: Pronounced *user*, it contains most of the program files (equivalent to C:\Program Files in Microsoft Windows)
- `/var/log`: Contains log files written by many applications
- `/home/yourusername/Desktop`: Contains Ubuntu desktop files
- `/mnt`: The mounted partitions are shown here
- `/boot`: Contains the files required to boot
- `/dev`: Contains Linux device files
- `/opt`: The location for optionally installed programs (ROS is installed to /opt)
- `/sys`: Holds the files containing information about the system

Useful Ubuntu Applications

If you want to install a popular software application in Ubuntu, use Ubuntu Software (see Figure 1-30), which is available in the Unity Launcher. It is a direct way to install applications in Ubuntu. In the coming sections, you see how to install Ubuntu packages using command lines.

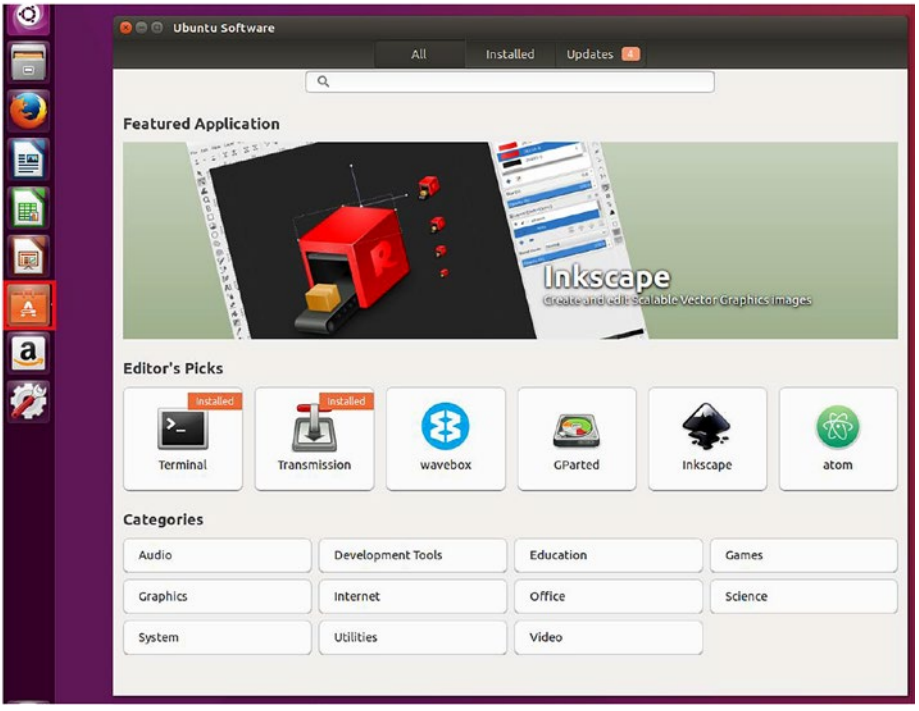

Figure 1-30. *The Ubuntu Software center*