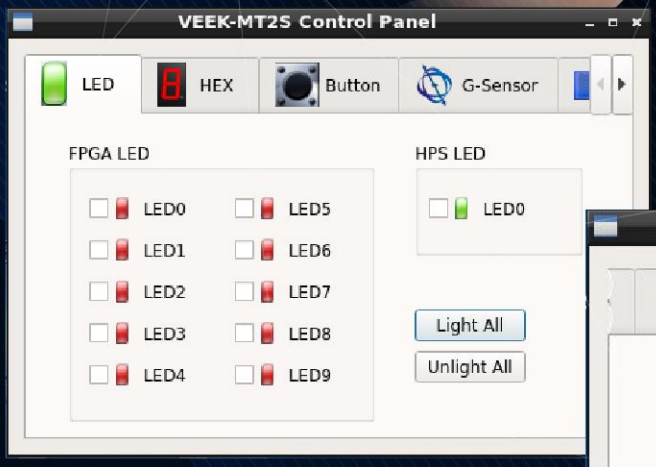
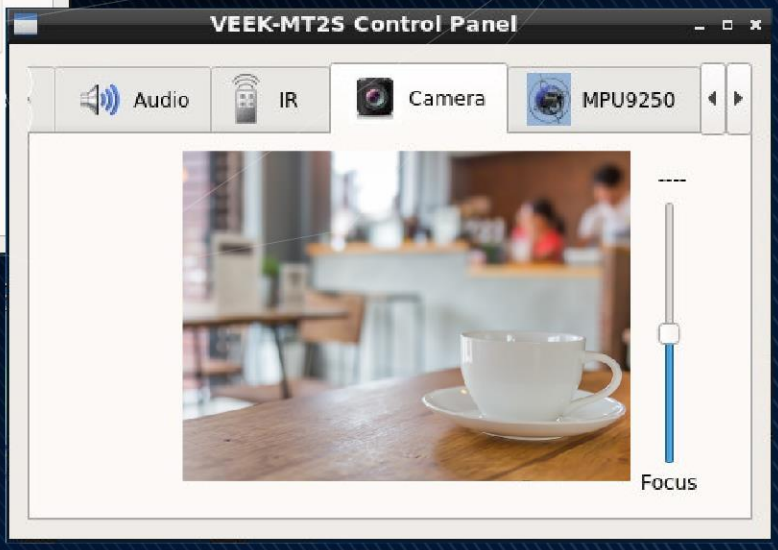
VEEK-MT2S

Control Panel User Manual





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CONTENTS

Chapter 1

Overview

The purpose of this document is to develop a QT based GUI application running on DE1-SoC-MTL2 LXDE Linux. The control panel is a QT based GUI utility running on Linux and communicating with peripherals connected to the FPGA side. This document describes how to rebuild its Quartus project and QT project. Users will learn how to setup the environment of QT development on Linux and develop their GUI software base on the control panel example given.

1.1 System Block Diagram

Figure 1-1 shows the block diagram of the Control Panel where user can see the Control Panel program is running on Linux on the left-hand side. The program GUI is built based on Qt library and it can access the FPGA resources through the AXI bus. The Linux Frame Buffer Display hardware is implemented based on Altera VIP suite and HPS DDR3 SDRAM memory is used as frame buffer. The Nios II processor is implemented to configure the VIP when the system is booted. The Nios II program runs on the on-chip memory.

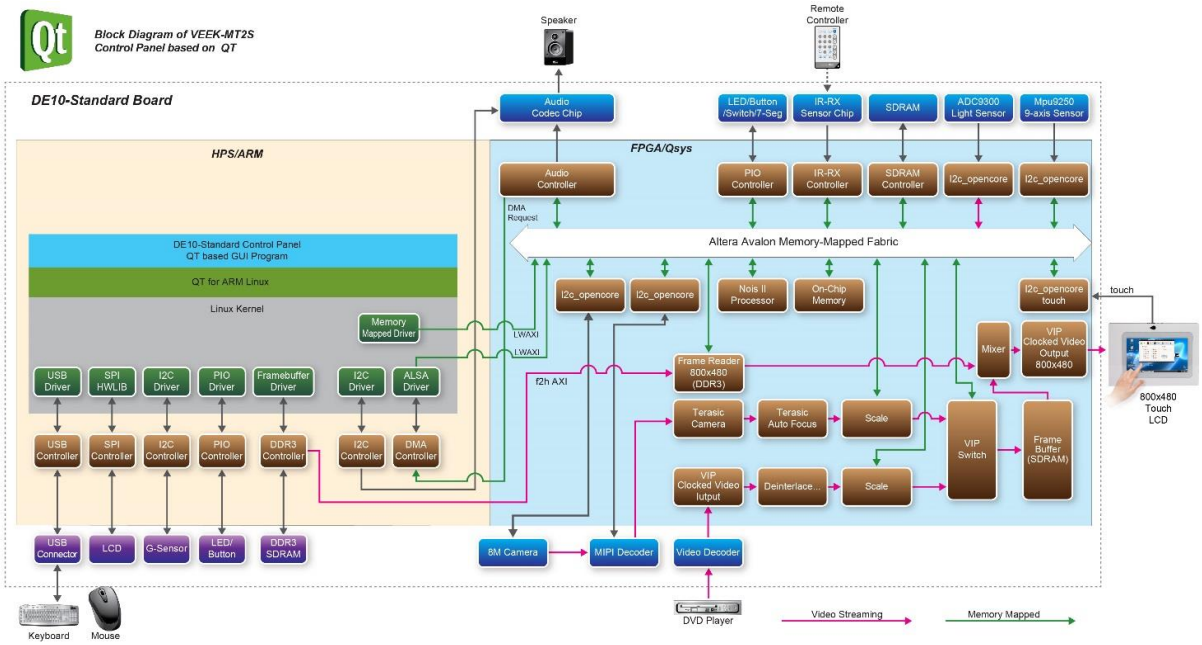

Figure 1-1 Block Diagram of the Control Panel

1.2 Learning Topics

To give users an outline what they will learn in this manual, here we provide a list of topics that will be covered and explained:

- Install a virtual machine VMware on 64-bit Windows Host
- Install a Linux x64 under virtual machine VMware
- Install Qt Creator on Linux x64
- Create and build a Qt hello program for Linux x64
- Install Linaro ARM cross compiler toolchain for Intel SoC ARM
- Install prebuild Qt Library for Intel SoC ARM
- Cross-compile to build Qt Application for Intel SoC ARM
- Create and build a Quartus Project for Intel SoC FPGA
- Launch Qt Application on Intel SoC FPGA board

1.3 System Requirements

Before starting this tutorial, please note that the following items are required to complete the Control Panel project:

- A x64 PC
- VEEK-MT2S FPGA board
- Linux Ubuntu 16.04 x64 Installer
- Options if Windows Host is preferred
  - MS Windows Installer
  - VMware Workstation Player Installer
- Qt 5.7.0 for Linux 64-bit Installer
- Qt 5.5.1 open source
- Quartus Prime 16.1 or later installer

1.4 Development Flow

Our Control Panel program GUI is built using the Qt library. Considering that most users might not be familiar with the Qt library, we believe it would be most helpful to first list all the steps required to complete the control panel project in the following:

1. Install Linux x64 on VMware running under Windows Host
2. Install Qt Creator 5.7.0 on Linux x64
3. Install Intel SoC Toolchain on Linux x64
4. Install Qt 5.5.1 Library for Intel SoC on Linux x64
5. Build Qt App for Intel SoC FPGA Board on Linux x64
6. Build Quartus Project on Windows Host
7. Execute Qt App on Intel SoC FPGA Board

1.5 Set up the Control Panel Demo

This section describes how to set up the Control Panel program on the VEEK-MT2S Development Kit. There are five major steps involved. Please carefully follow the instructions below. If you already have the MicroSD card for LXDE Desktop, skip first two steps.

1. Download microSD card writer utility – **Win32 Disk Imager**
2. Download the compressed LXDE Desktop image file. Then, decompress the compressed image file, and write the file into a microSD card (at least 4GB) with an ImageWriter Utility
3. Insert the microSD card intro VEEK-MT2S FPGA Development Board, connect a USB keyboard and mouse to the USB host port, connect a LCD monitor to the VGA-output port, then power on the board to boot Linux System.
4. Boot LXDE Desktop.
5. Double click "ControlPanel" icon on LXDE Desktop to launch the Control Panel Utility. If a confirm dialog appears, please click the "Execute" button.

■ Download Win32 Disk Imager

To write the microSD card image into a microSD card, a writing tool is required. In this tutorial, **Win32 Disk Imager** utility is used. This utility is a shareware, users can download it from the web: (http://sourceforge.net/projects/win32diskimager/)

On the download page as shown in **Figure 1-2**, click "Download" to start the download process. The downloaded filename is "Win32DiskImager-0.9.5-install.exe".

Figure 1-2 Download Web Page of Win32 Disk Imager

Install the Win32DiskImage by executing the installer and execute Win32DiskImage.exe to launch the tool as shown in **Figure 1-3**.

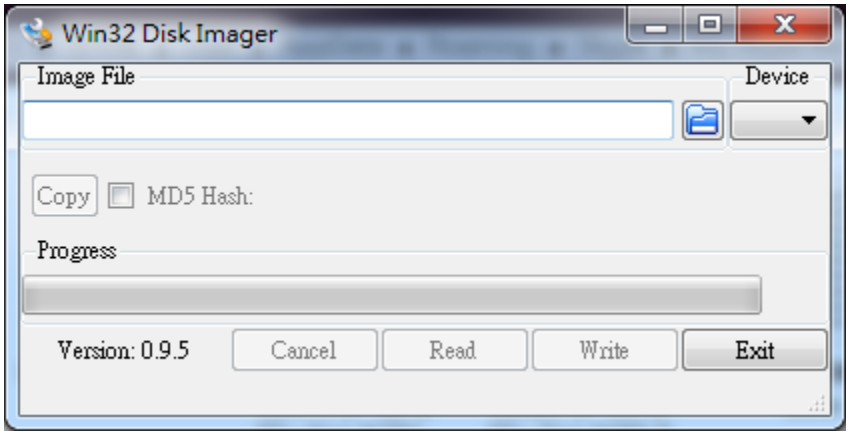

Figure 1-3 Win32 Disk Imager

■ Create Linux Booting microSD card

The "LXDE Desktop" microSD card image is available from the website:

http://veek-mt2s.terasic.com/cd

Please download the microSD card image "Linux LXDE Desktop" under the Linux BSP section. The filename is VEEK_MT2S_LXDE.zip. The archive needs to be decompressed to extract the image named VEEK_MT2S_LXDE.img.

Then, insert a microSD card (at least 8GB) into the host Windows. Launch Win32 Disk Imager, select the inserted microSD card in the Device list box and click on the Folder icon to select the image file **VEEK_MT2S_LXDE.img**. Click "Write" to start writing the image file into the microSD card as shown in **Figure 1-4.**

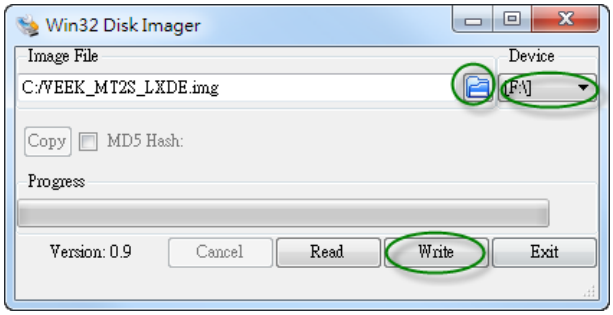

Figure 1-4 Write microSD card with a Given Image File

Before writing, a "Confirm overwrite" dialog appears as shown in **Figure 1-5**. Make sure the device is the microSD card, and click "Yes" to close the window.

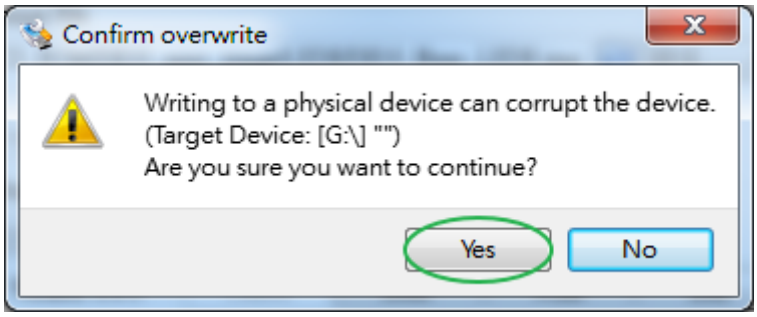

Figure 1-5 Confirm to Continue

When the writing process is complete, a "Complete" dialog appears as shown in **Figure 1-6**. Click "OK" to close the window.

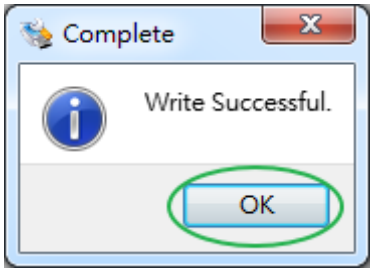

Figure 1-6 Write SD-card Complete

■ Set up Hardware and Boot Linux

Connect the following items to the VEEK-MT2S development board as shown in **Figure 1-7**.

- Linux LXDE Desktop microSD Card
- PAL/NTSC video signal from a Media Player
- Speaker
- Ethernet (option, only needed on Section **6.3** and Section **8.4**)
- DC Power for VEEK-MT2S

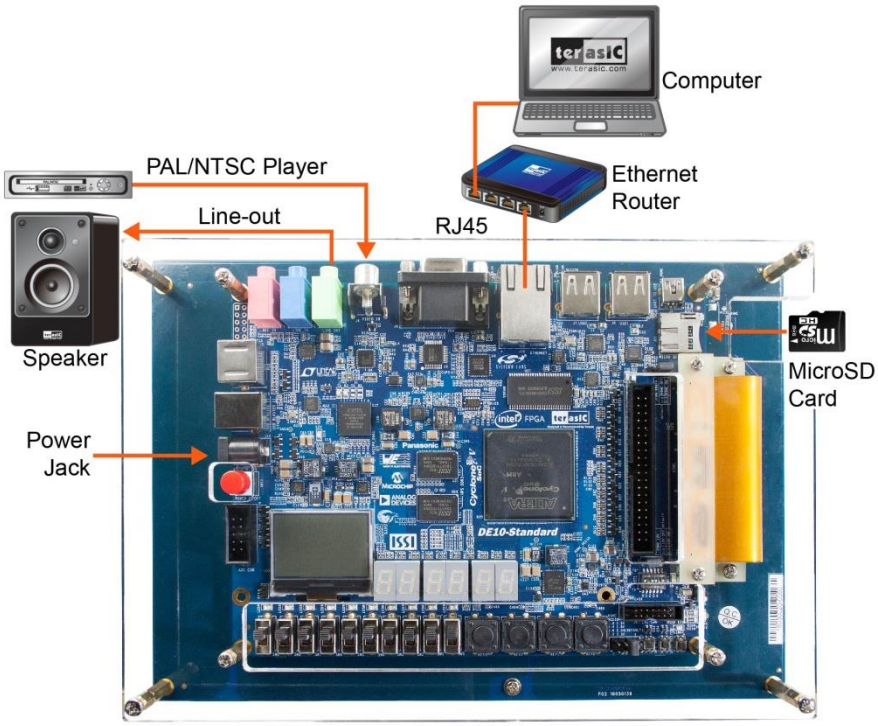

Figure 1-7 VEEK-MT2S Development Board Setup

Please also make sure that MSEL[4:0]=01010 located on the back of the VEEK-MT2S FPGA development board as shown in

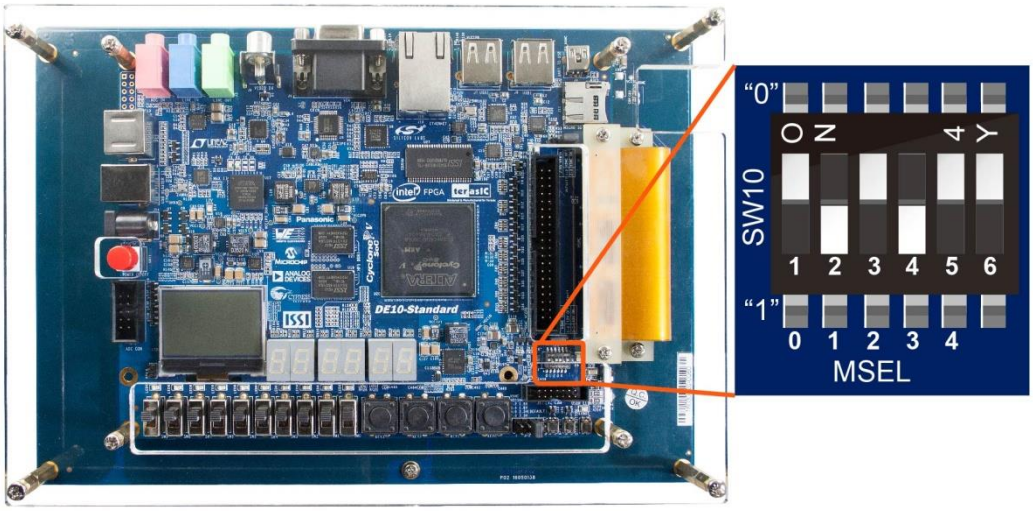

Figure 1-8.

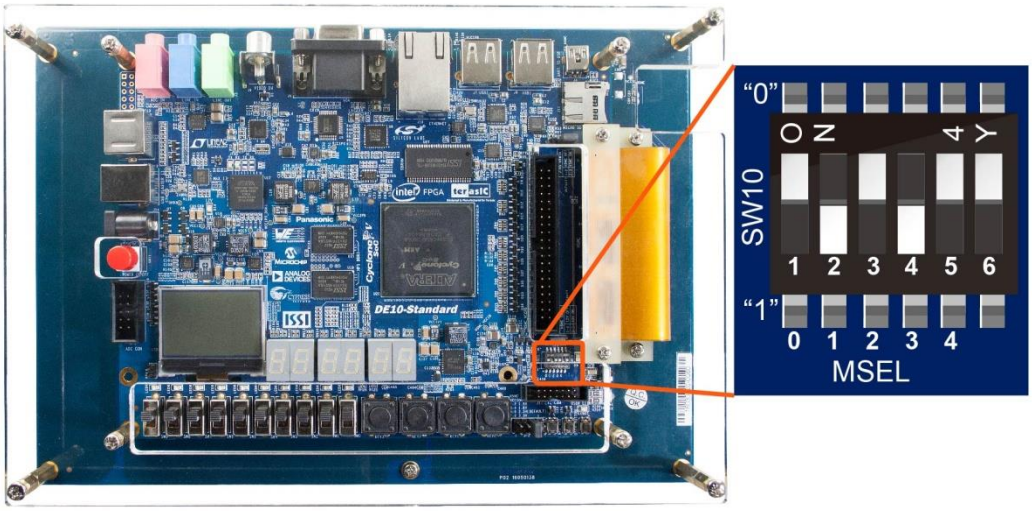

Figure 1-8 MSEL[4:0] on the VEEK-MT2S FPGA Development Board

After connecting the above peripherals, power on the VEEK-MT2S board. The LCD monitor will now display Penguin Linux Logo as shown in **Figure 1-9**.

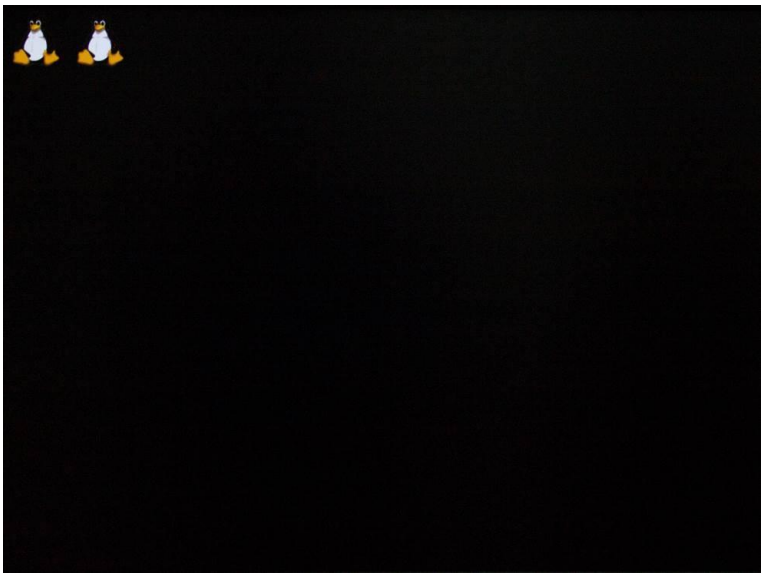

Figure 1-9 Linux Booting Using Root Account

When the Linux boot process is complete, LXDE Desktop will appear as shown in **Figure 1-10**.

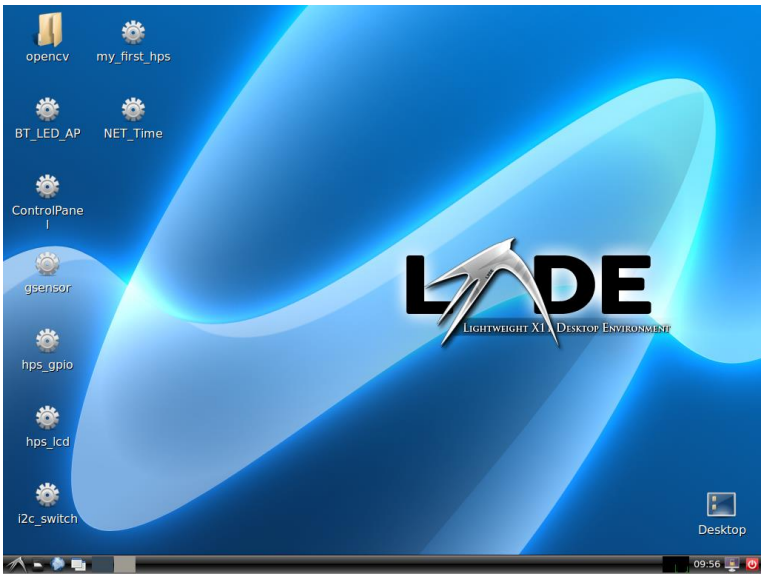

Figure 1-10 Launch the Control Panel

■ Launch Control Panel

After successful boot, the Control Panel execution file "ControlPanel" is pre-built in the desktop. Please double click "ControlPanel" icon and click "Execute" button to launch the Control Panel as shown in **Figure 1-11**. Note that Qt library has been preinstalled in the microSD card image therefore users can simply launch the Control Panel without installing the Qt library.

The Control Panel window will appear on the LCD monitor as shown **Figure 1-11**. Now, you can use the USB mouse to operate the Control Panel.

Figure 1-11 Screenshot of VEEK-MT2S Control Panel

Choosing the **LED** tab leads to the window in **Figure 1-12**. Here, you can directly turn the LEDs on or off individually or by clicking “Light All” or “Unlight All”.

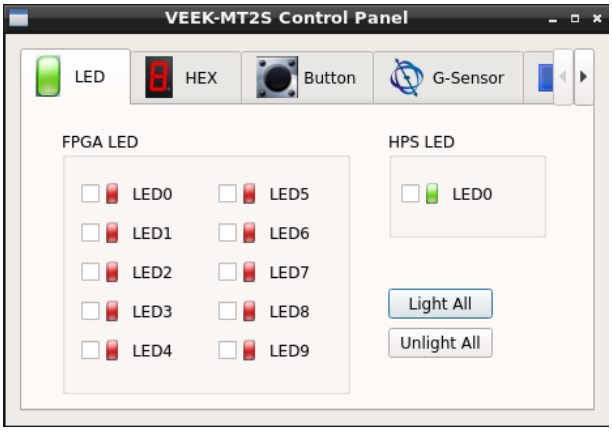

Figure 1-12 Controlling LED

Choosing the 7-SEG tab leads to the window shown in **Figure 1-13**. From the window, directly use the up-down arrows to control the 7-SEG patterns on the VEEK-MT2S board which are updated immediately. Note that the dots of the 7-SEGs are not enabled on VEEK-MT2S board.

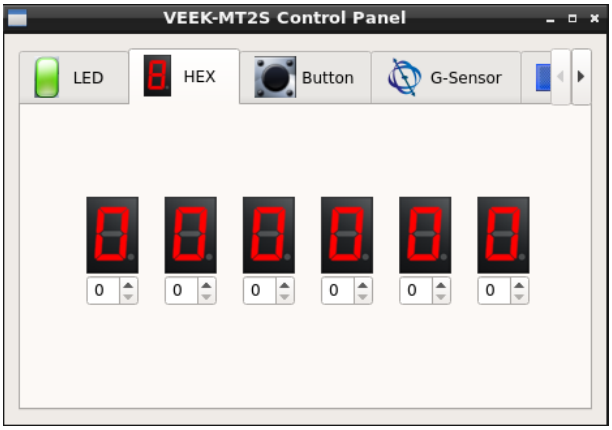

Figure 1-13 Controlling 7-Segment Display

Choosing the Switches tab leads to the window in **Figure 1-14**. The function is designed to monitor the status of slide switches and push-buttons in real time and show the status in a graphical user interface. It can be used to verify the functionality of the slide switches and push-buttons.

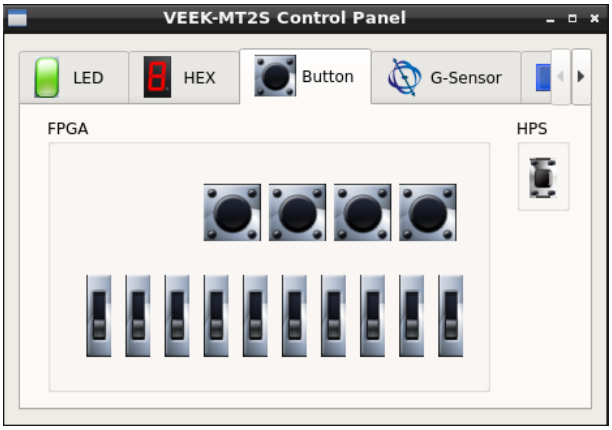

Figure 1-14 Monitoring switches and buttons

Choosing the G-Sensor tab leads to the window in **Figure 1-15**. The function is designed to monitor the status of G-Sensor in real time and show the status graphically. It can be used to verify the functionality of the G-Sensor chip.

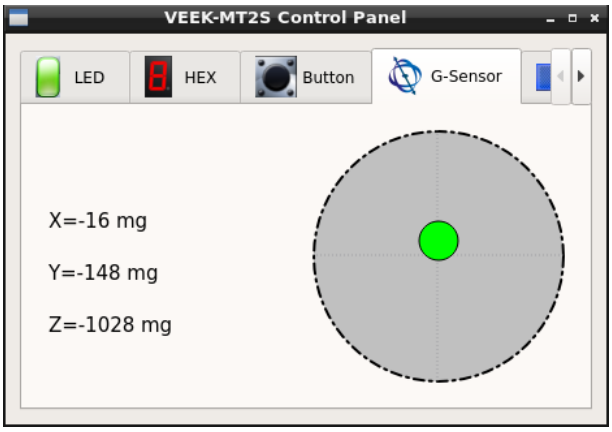

Figure 1-15 Monitoring G-sensor measured value

Choosing the LCD tab leads to the window in **Figure 1-16**. The LCD backlight can be turned on or off by checking or unchecking the LCD Backlight checkbox from this window. The display on the LCD can be updated immediately according to the demo pattern form the pull-down list. .

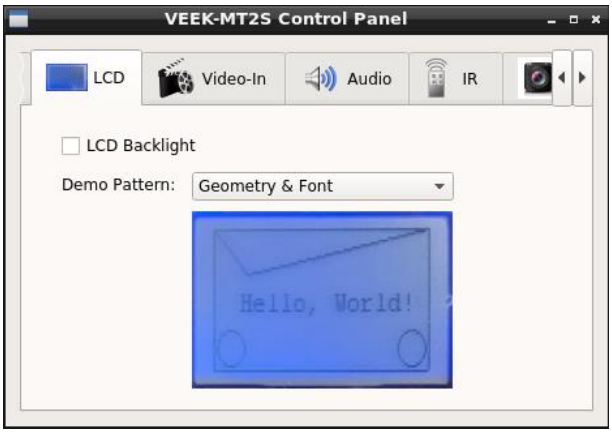

Figure 1-16 Controlling Graphic LCD

Choosing the Video-In tab leads to the window in **Figure 1-17**. This demonstration requires connect PAL/NTSC video signal to the RCA-in port on the VEEK-MT2S. The decoded PAL/NTSC video will display on the Control Panel in real time.

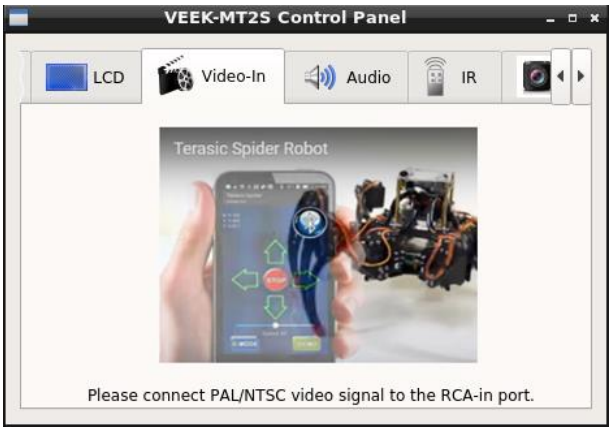

Figure 1-17 Testing the video-on of TV decoder

Choosing the Audio-In tab leads to the window in **Figure 1-18.** This demonstration requires connect speaker to the line-out port on the VEEK-MT2S board. Then, click the tone buttons on the dialog, the speaker will play an associated tone sound immediately.

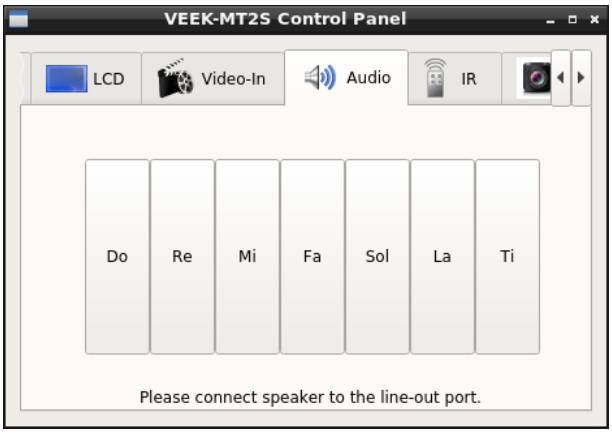

Figure 1-18 Testing the line-out of audio decoder

From the control panel, we can test the IR receiver on the VEEK-MT2S by sending scan code from a remote controller. **Figure 1-19** depicts the IR receiver window when the IR tab is pressed. When the scan code is received, the information will be displayed on the IR Receiver window represented in hexadecimal. The "press button" on the remote controller on the IR receiver window. Note that there are several encoding forms among different brands of remote controllers. Only the remote controller included with the kit is confirmed to be compatible with this software.

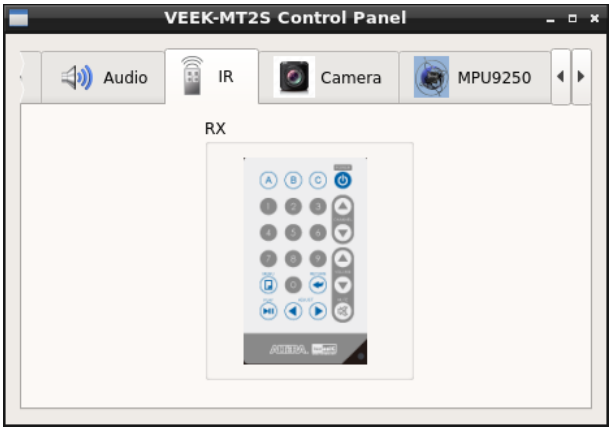

Figure 1-19 Testing the IR receiver using remote controller

From the control panel, we can test the 8 Mega Pixel Camera on the VEEK-MT2S. **Figure 1-20** depicts the Camera display window with Focus control. The display window will display the captured camera image in real time. The Focus control can be used to control the Focus Distance in the camera module.

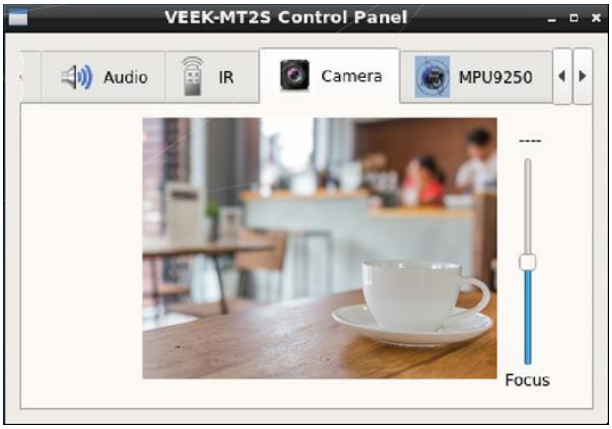

Figure 1-20 Testing the Camera

Choosing the MPU9250 tab leads to the window in **Figure 1-21**. The function is designed to monitor the status of MPU9250 9-axis sensor in real time. It can be used to verify the functionality of the MPU9250 sensor chip.

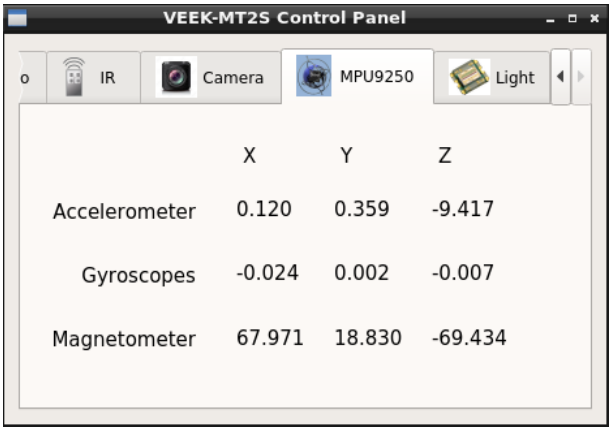

Figure 1-21 Monitoring MPU9250 9-axi sensor measured value

Choosing the Light tab leads to the window in **Figure 1-22**. The function is designed to monitor the status of ADC9300 light sensor in real time. It can be used to verify the functionality of the ADC9300 light sensor chip.

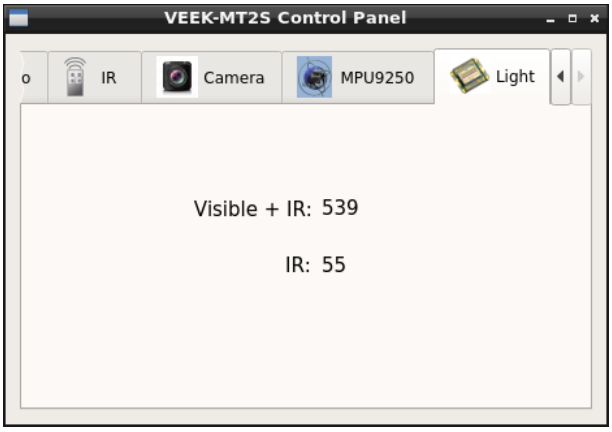

Figure 1-22 Monitoring light sensor measured value

Chapter 2

Linux x64 Installation

The Control Panel program runs on Linux in the Intel SoC ARM as shown in the block diagram in Chapter 1. In Chapter 2, we begin by installing Linux x64 as a first step toward completing the Control Panel project. The Linux x64 system can be installed on a x64 PC directly or on a virtual machine running on 64-bit Microsoft Windows. This chapter also describes how to install an Ubuntu OS, a Linux x64 system, on a virtual machine VMware Workstation Player running on Microsoft Windows. The VMware Workstation Player is first installed on a Windows host, and subsequently Ubuntu Linux is installed on the VMware Workstation Player with an Easy Install mode.

The Control Panel is a GUI-based program and Qt Creator is a convenient tool to help create such GUI-based programs. Regarding the Linux installation, users might ask if it is possible to install Cygwin Linux in Microsoft Windows instead of installing Linux x64 on VMware Workstation Player running on Microsoft Windows. Note that Qt Creator, software meant for GUI-based programs, can't be successfully installed on Cygwin in Microsoft Windows.

Running Linux x64 on VMware Workstation Player in Microsoft Windows is an easier way when users wish to create a GUI application, such as oscilloscopes or logic analyzers, without the need to have a Desktop Linux. Users can simply follow our GUI application development method explained in this tutorial for more user-based GUI applications.

2.1 System Requirements

Before starting the Linux installation on a virtual machine, please make sure and check if these following items are in place:

- a PC with 64-bits Microsoft Windows installed
- VMware Workstation Player installer (shareware)
- Linux Ubuntu 16.04 x64 .iso image file

2.2 Install VMware Workstation Player

Now, we proceed to install the virtual machine under Microsoft Windows. This section shows (1) where to download VMware Workstation Player and (2) how to install it under Microsoft Windows.

■ Download VMware Workstation Player Installer

Go to VMware download web page: https://my.vmware.com/web/vmware/downloads, find the VMware Workstation Player item and click "Download Product" as shown in **Figure 2-1**. In the VMware Workstation Player download page, click the "Downloads" button to download VMware Workstation Player, as shown **Figure 2-2** .

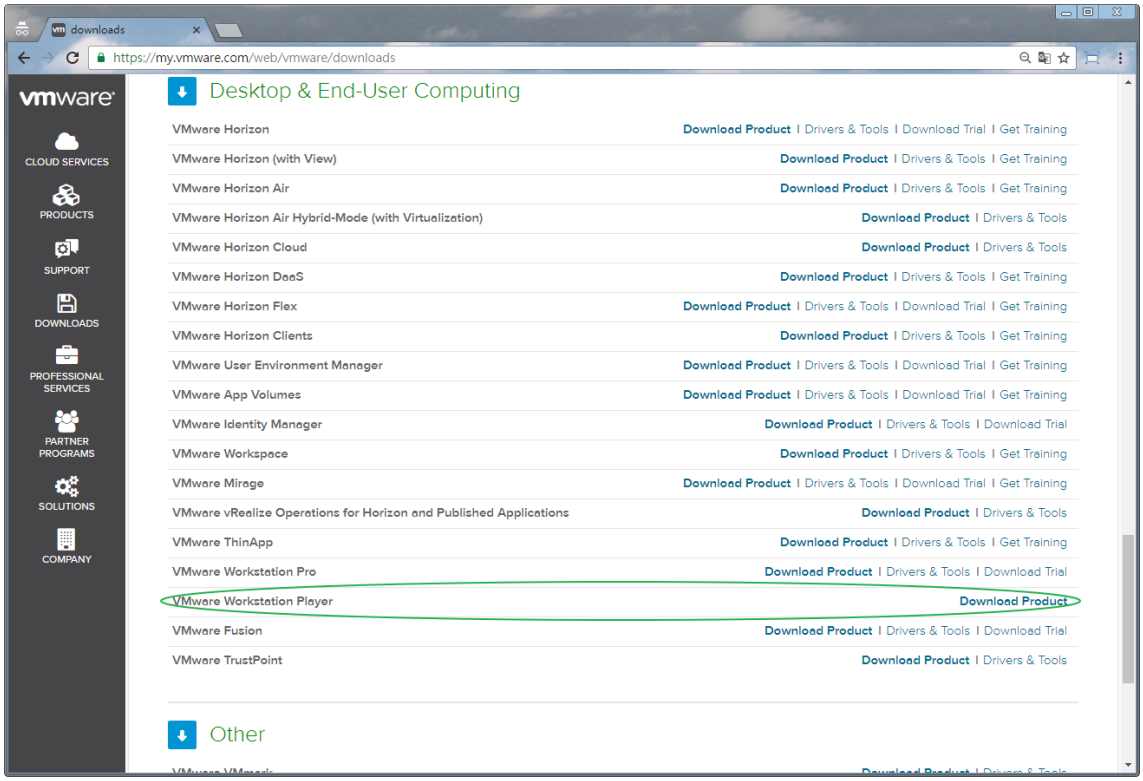

Figure 2-1 Download Web Page of VMware

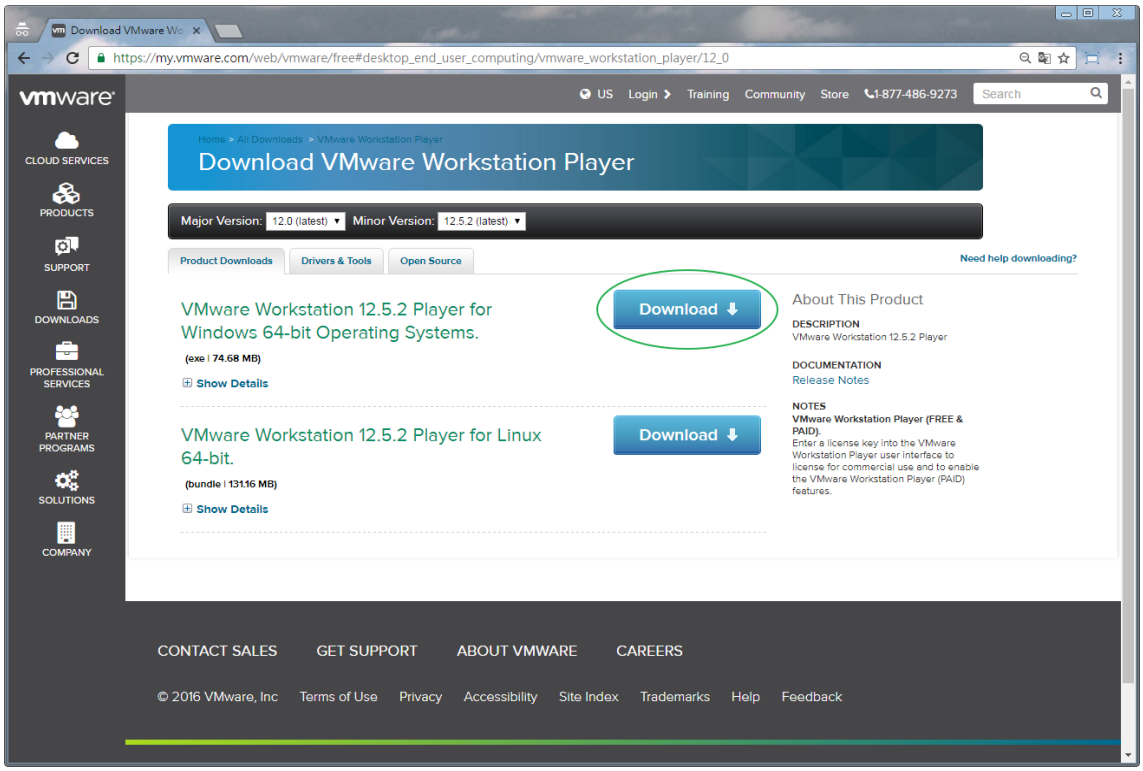

Figure 2-2 VMware Workstation Player Download Web Page

■ Install VMware

Under the Windows host, execute the downloaded installer "VMware-player-12.5.2-4638234.exe" to start the setup process. Figure 2-3 shows the screenshot of the installer. Click "Next >" button to go to the next step.

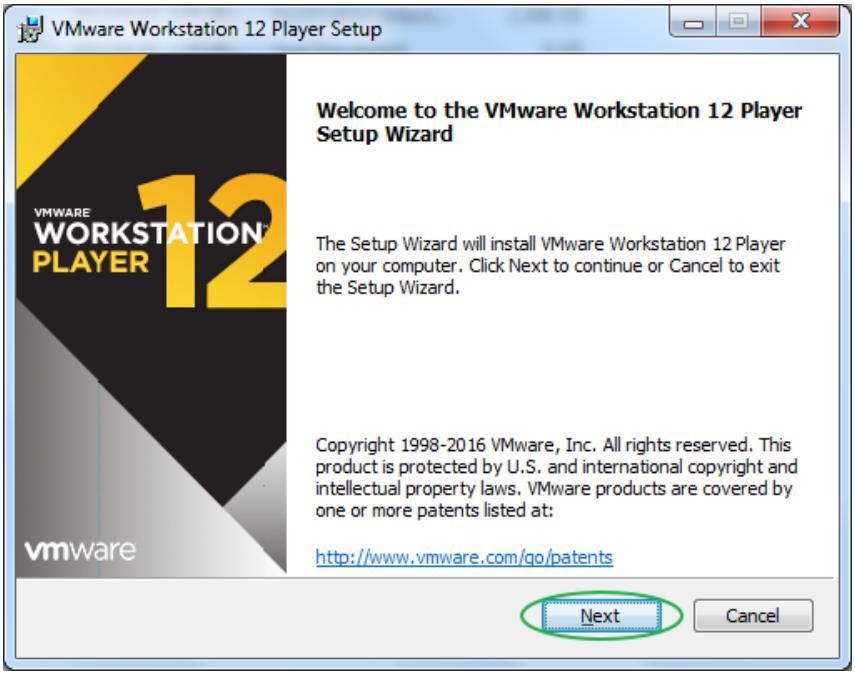

Figure 2-3 Welcome Dialog

In the **End-User License Agreement** dialog as shown in **Figure 2-4**, check "I accept the terms in the license agreement" and click "Next >" button to go to the next step.

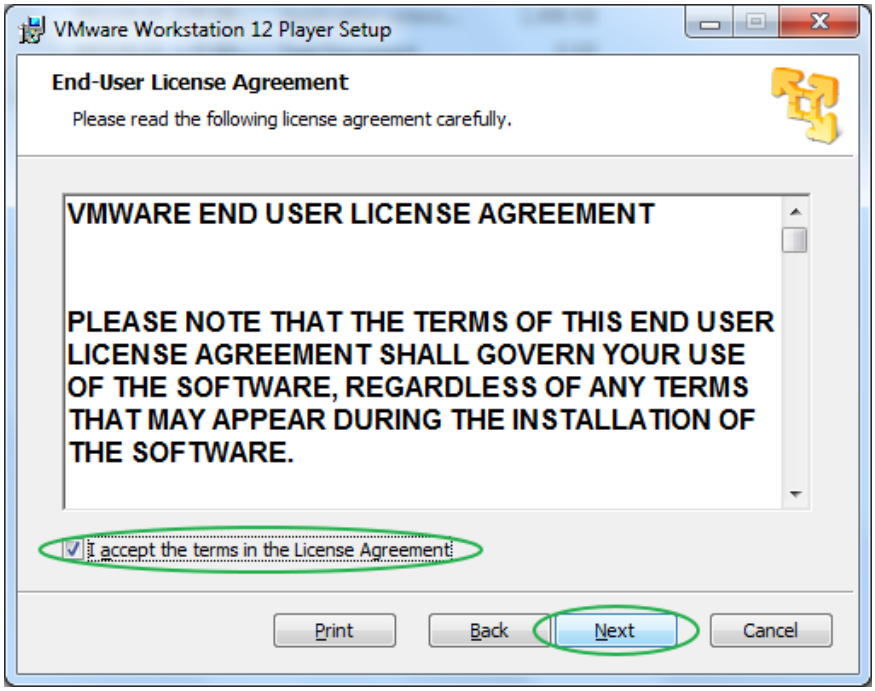

Figure 2-4 End-User License Agreement Dialog

In the **Custom Setup** dialog as shown in **Figure 2-5**, keep the default destination or specify desired installation folder, then click "Next >" button to go to the next step.

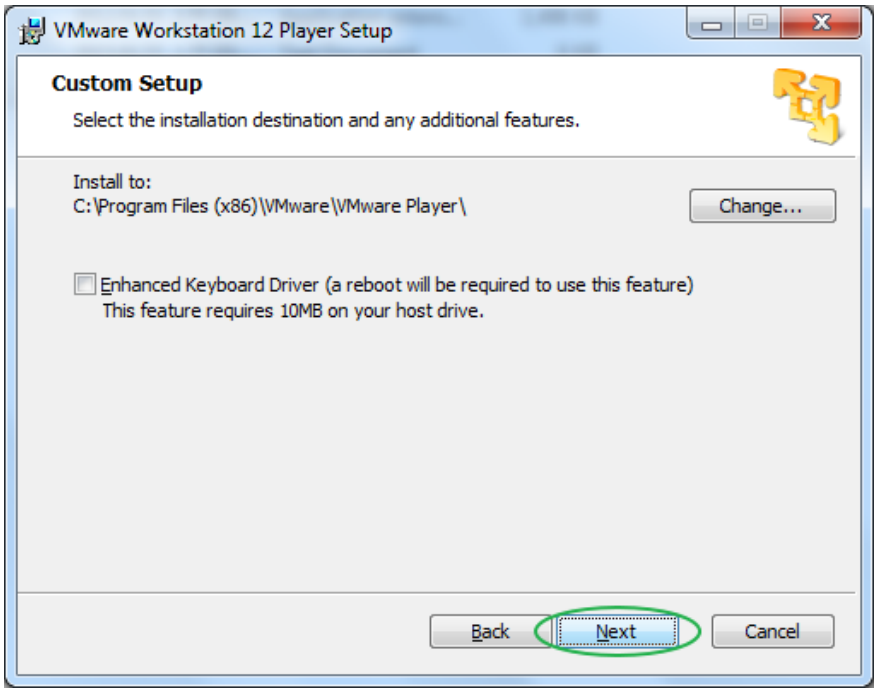

Figure 2-5 Custom Setup Dialog

In the **User Experience Settings** dialog as shown in **Figure 2-6**, check on the "Check for product updates on startup" and click "Next" to continue.

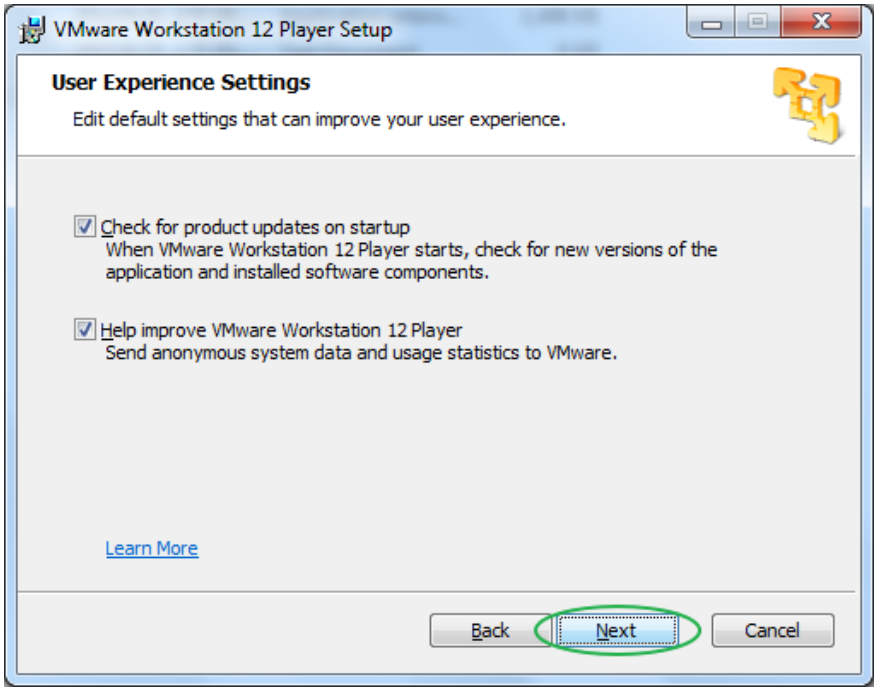

Figure 2-6 User Experience Settings Dialog

In the **Shortcuts** dialog as shown in **Figure 2-7**, keep the default setting, then click "Next >" button to go to the next step

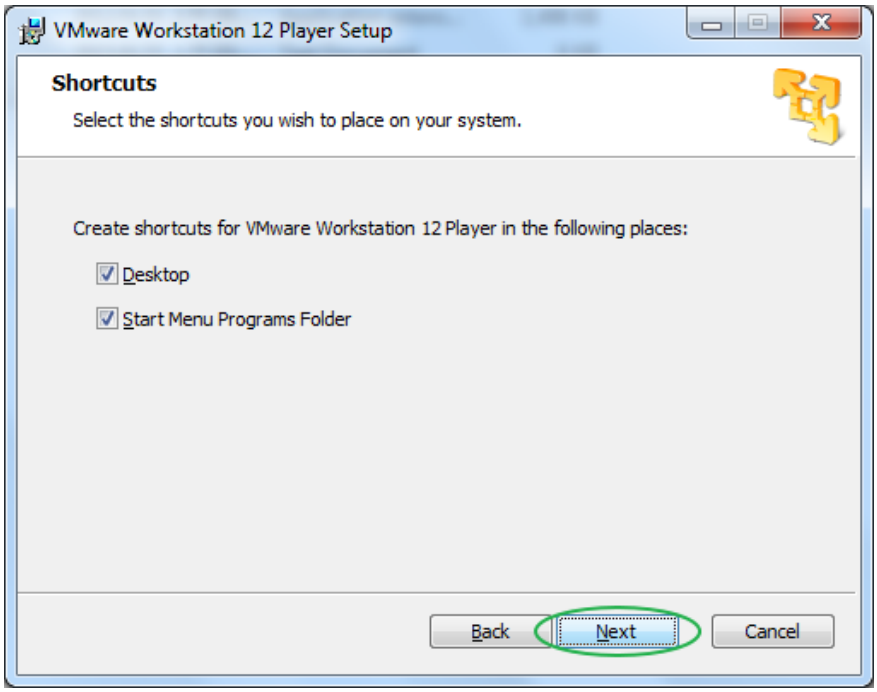

Figure 2-7 Shortcuts Dialog

In the **Ready to install VMware Workstation 12 Player** dialog as shown in **Figure 2-8**, click "Next >" button to go to the next step

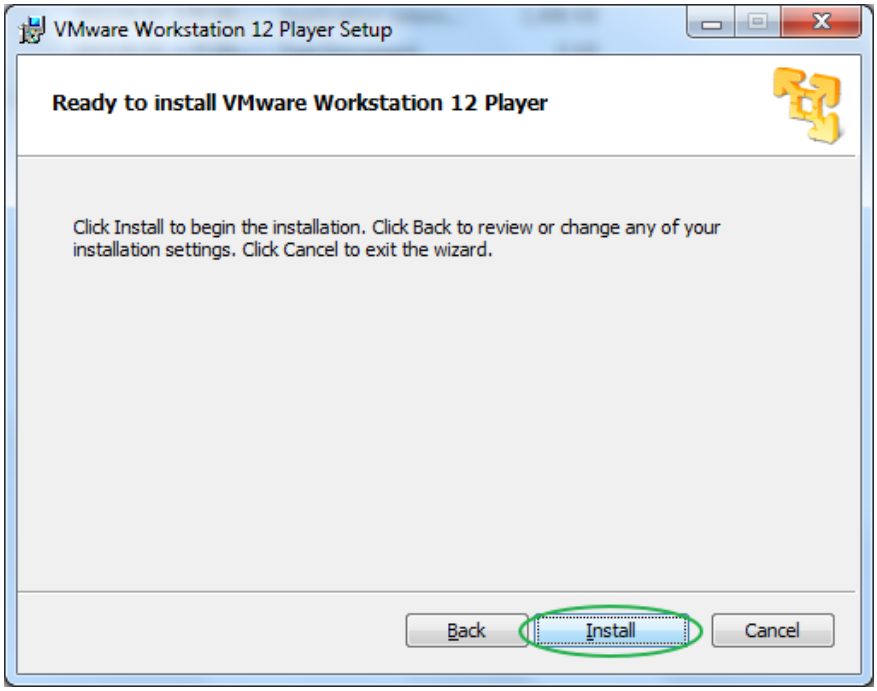

Figure 2-8 Ready to install VMware Workstation 12 Player Dialog

When the installation is complete, **Completed the VMware Workstation 12 Player Setup Wizard** dialog appears as shown in **Figure 2-9**. Click "Finished" button to finish the setup process.

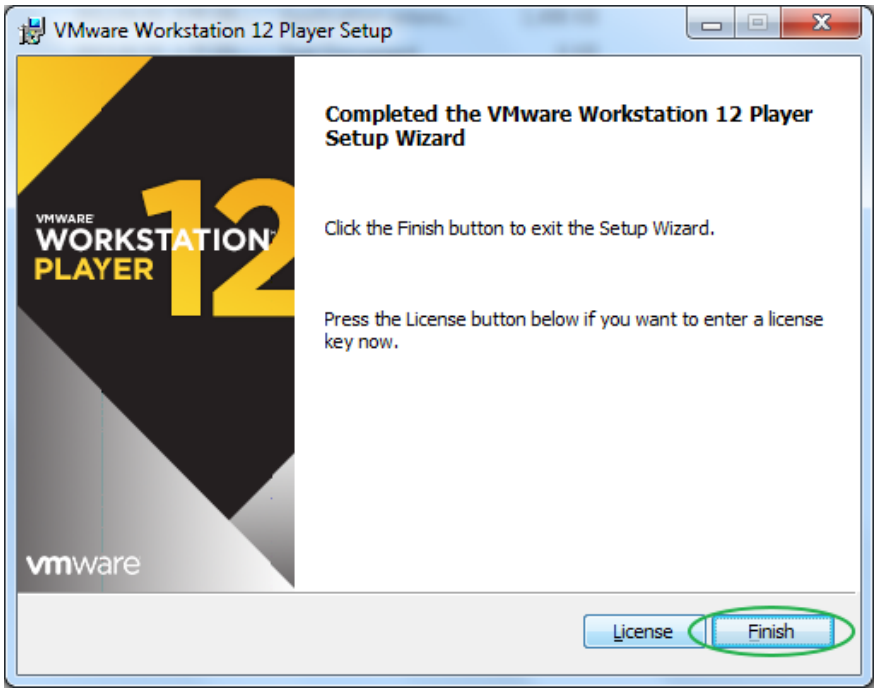

Figure 2-9 Completed the VMware Workstation 12 Player Setup Wizard Dialog

2.3 Launch VMware

Once VMware Workstation Player is completely installed, a program shortcut icon will appear on the desktop in Windows, as shown in Figure 2-10. Double-click the shortcut icon to launch the VMware Workstation Player. Figure 2-11 shows the main window of VMware Workstation Player.

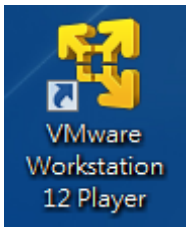

Figure 2-10 VMware Workstation Player Shortcut on Windows Desktop

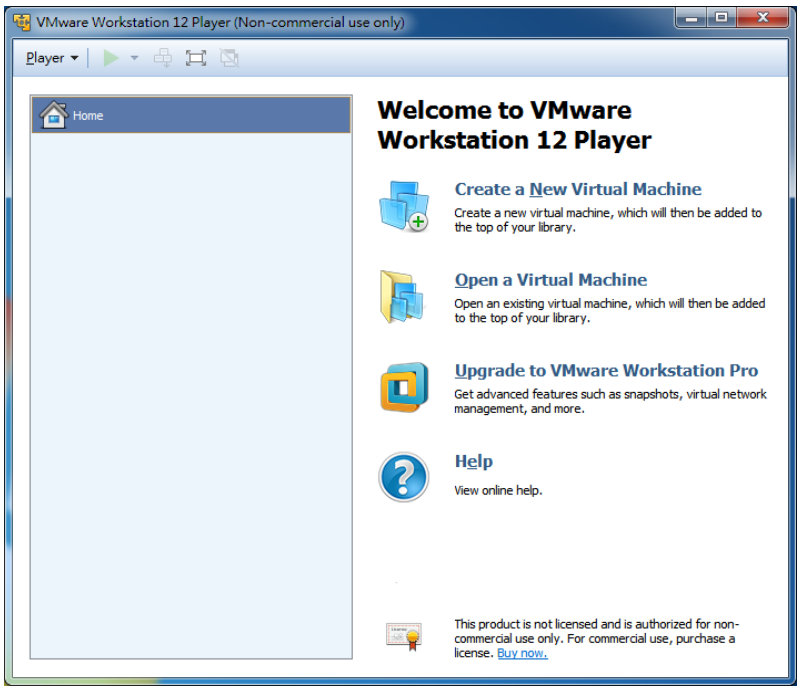

Figure 2-11 Main Window of VMware Workstation Player

2.4 Install Linux Ubuntu Desktop

Now we have downloaded and installed the VMware Workstation Player, we are ready to download Ubuntu image file and install it on the VMware Workstation Player. Note that the "Easy Install" mode is automatically applied when VMware Workstation Player detects if the installed OS is Ubuntu 16.04.

■ Download Ubuntu Linux Image

The Ubuntu Desktop can be downloaded from the web link provided below, as shown in **Figure 2-12**

http://releases.ubuntu.com/16.04/

On the download page, click "64-bit PC (AMD64) desktop image" link to start the download process. The downloaded image filename is "**ubuntu-16.04.1-desktop-amd64.iso**".

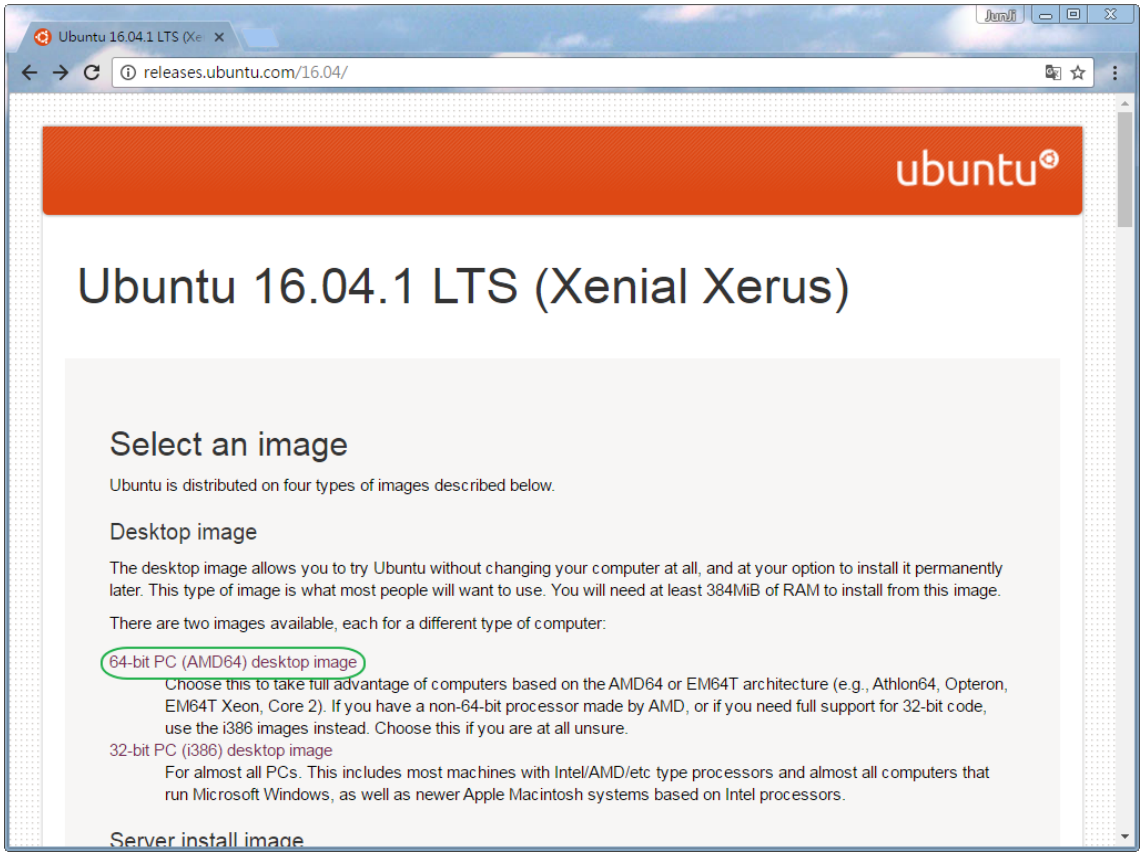

Figure 2-12 Download Page of Ubuntu Desktop

■ Create a Ubuntu Virtual Machine on the VMware Workstation Player

Launch the VMware Workstation Player as shown in **Figure 2-13**. Click the "Create a New Virtual Machine" icon to create a virtual machine accordingly.

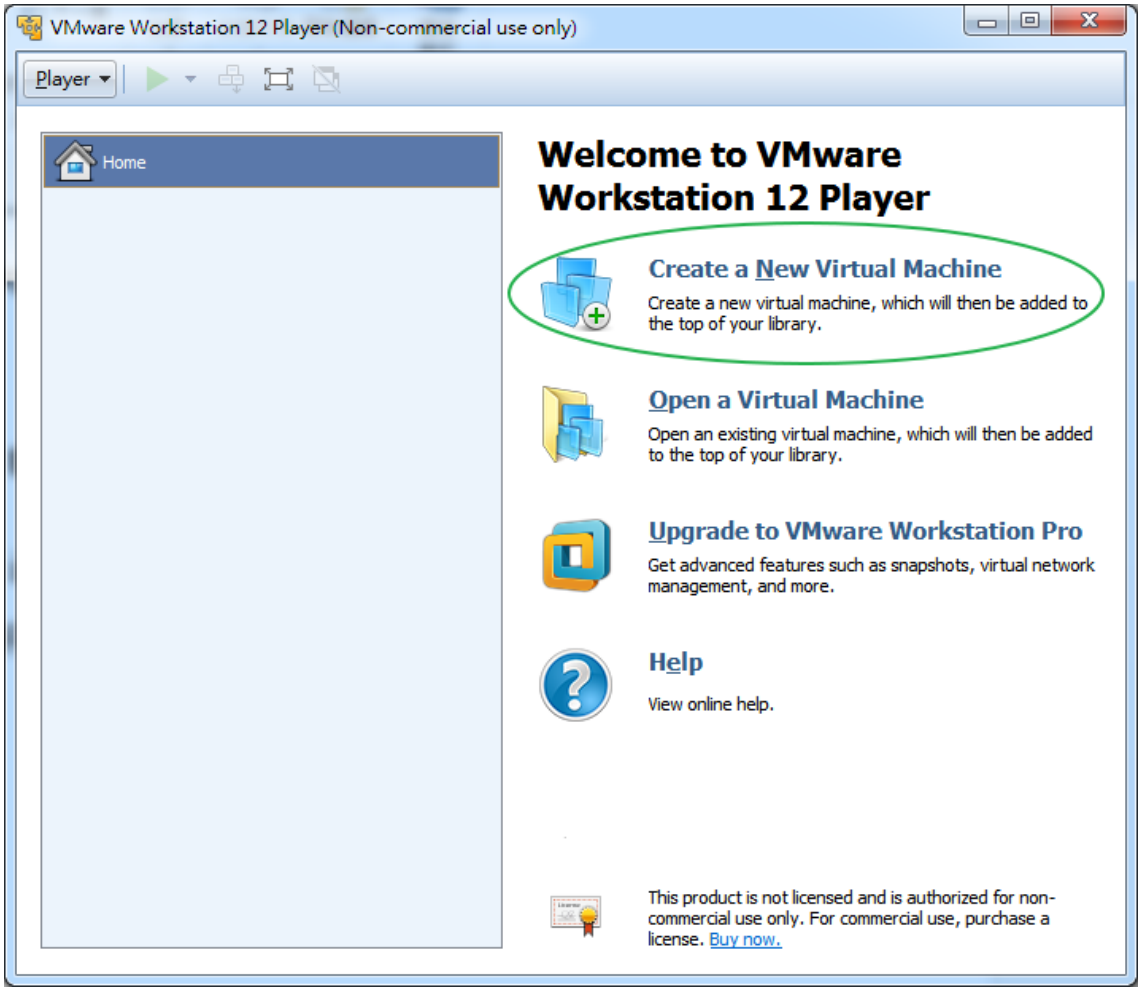

Figure 2-13 VMware Workstation Player Main Window

When the **Welcome to the New Virtual Machine Wizard** dialog appears as shown in **Figure 2-14**, select the "installer disk image file (iso):" radio button, and click "Browse" button to specify the location of the Ubuntu Linux image file "**ubuntu-16.04.1-desktop-amd64.iso**" which has been downloaded in the previous step. Note that the "Easy Install" mode is enabled for Ubuntu 16.04.1. Click "Next >" to go to the next step.

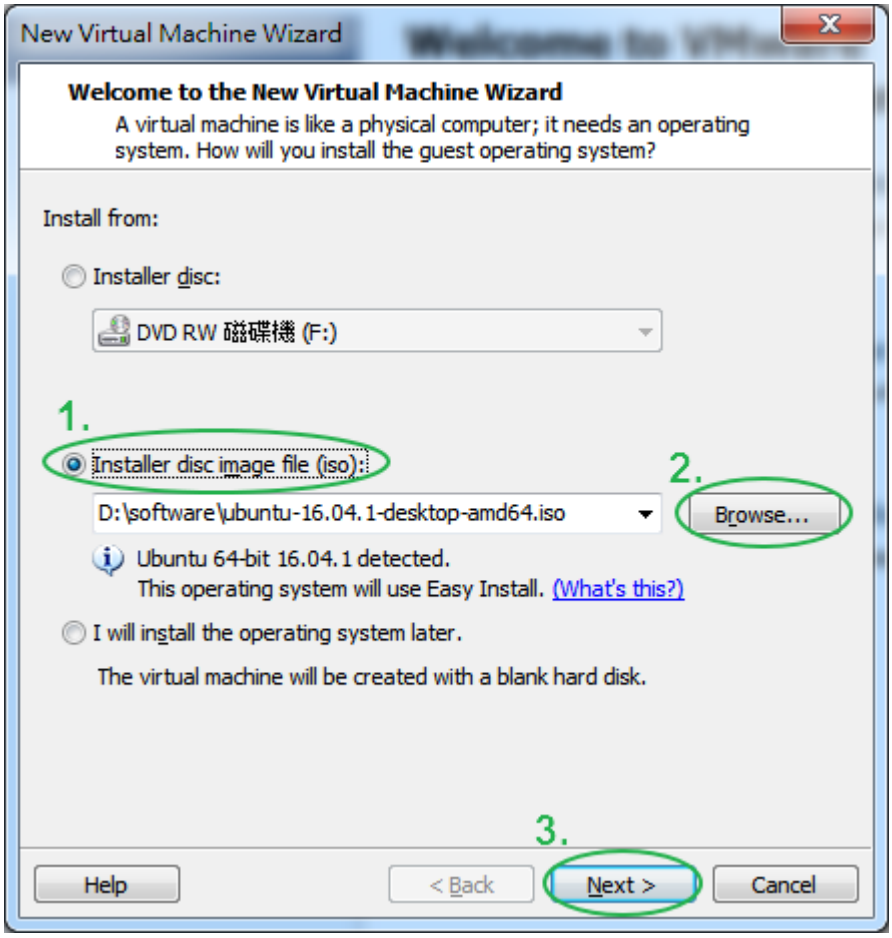

Figure 2-14 Install Dialog

When the **Easy Install Information** dialog appears as shown in **Figure 2-15**, please specify your username and password. In this tutorial, the user name "terasic" and the password "123" are used. Click "Next >" button to go to the next step. **Please remember your username and password, as they will be frequently used throughout the tutorial.**

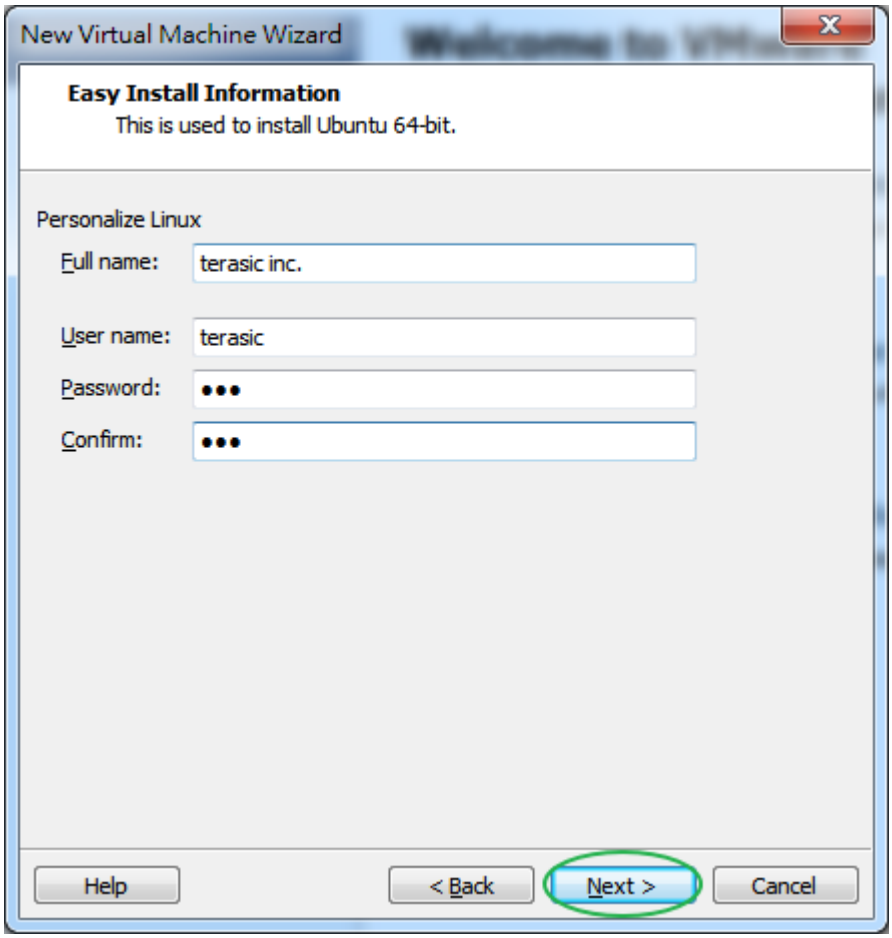

Figure 2-15 Easy Install Information Dialog

When the **Name the Virtual Machine** dialog appears as shown in **Figure 2-16**, you can change the virtual machine name as you wish. In this example, a machine name "Ubuntu 64-bit" is used. Click the "Browse" button to specify a folder location for the virtual disk of the virtual machine. Finally, click "Next > " button to go to the next step.

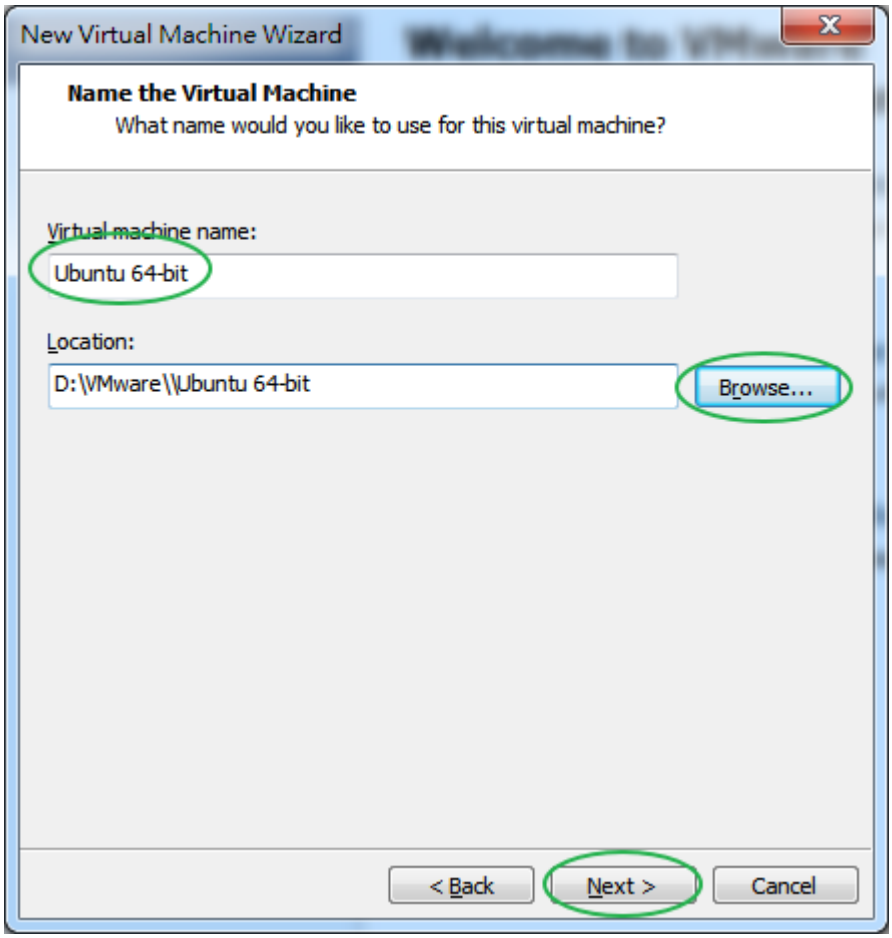

Figure 2-16 Name the Virtual Machine Dialog of the New Virtual Machine Wizard

When the **Specify Disk Capacity** dialog appears as shown in **Figure 2-17**, please specify the maximum disk size and click "Next >" button to go to the next step.

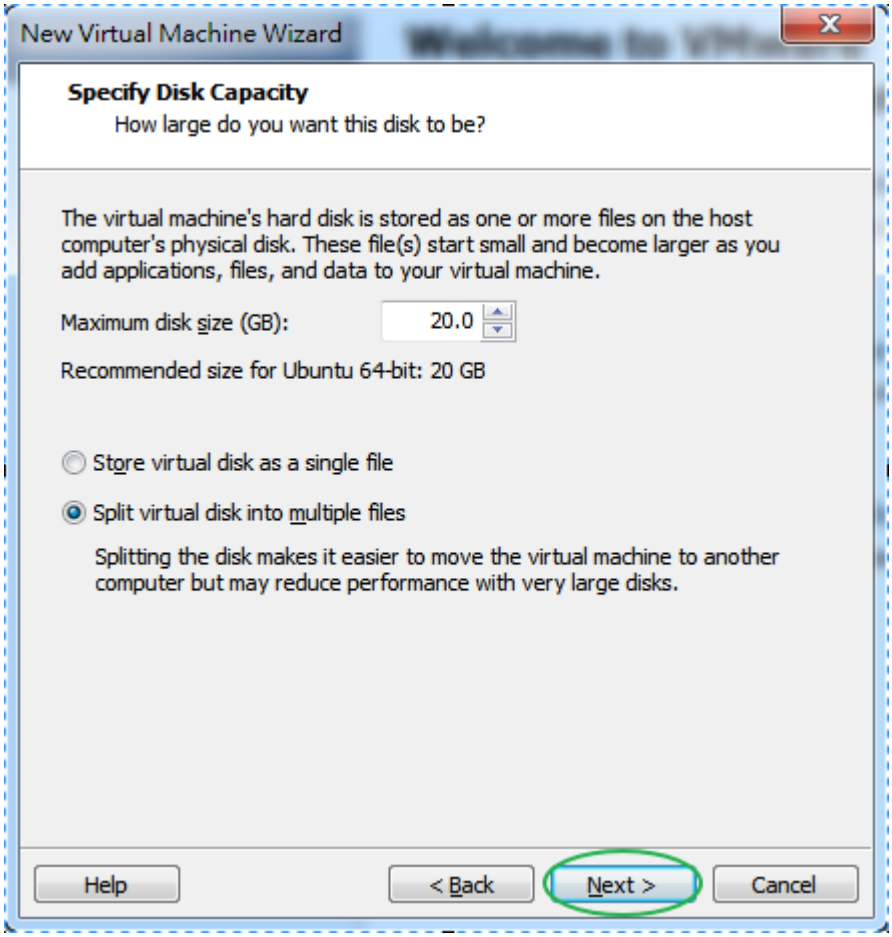

Figure 2-17 Specify Disk Capacity Dialog

When the **Ready to Create Virtual Machine** dialog appears as shown in **Figure 2-18**. Click the "Customize Hardware …" button to modify memory allocated to the virtual machine.

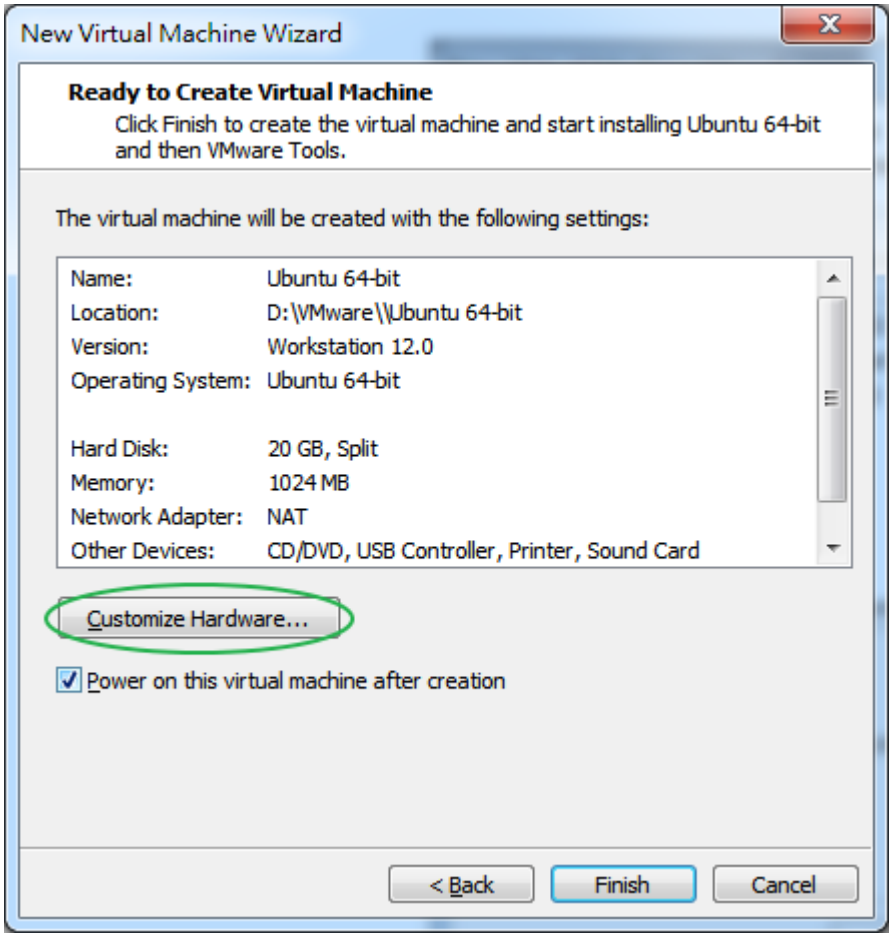

Figure 2-18 Ready to Create Virtual Machine Dialog

The **Hardware** dialog appears as shown in **Figure 2-19**. Modify memory for this virtual machine to 2048MB or more. Then, click "Close " button to return to the **Ready to Create Virtual Machine** dialog.

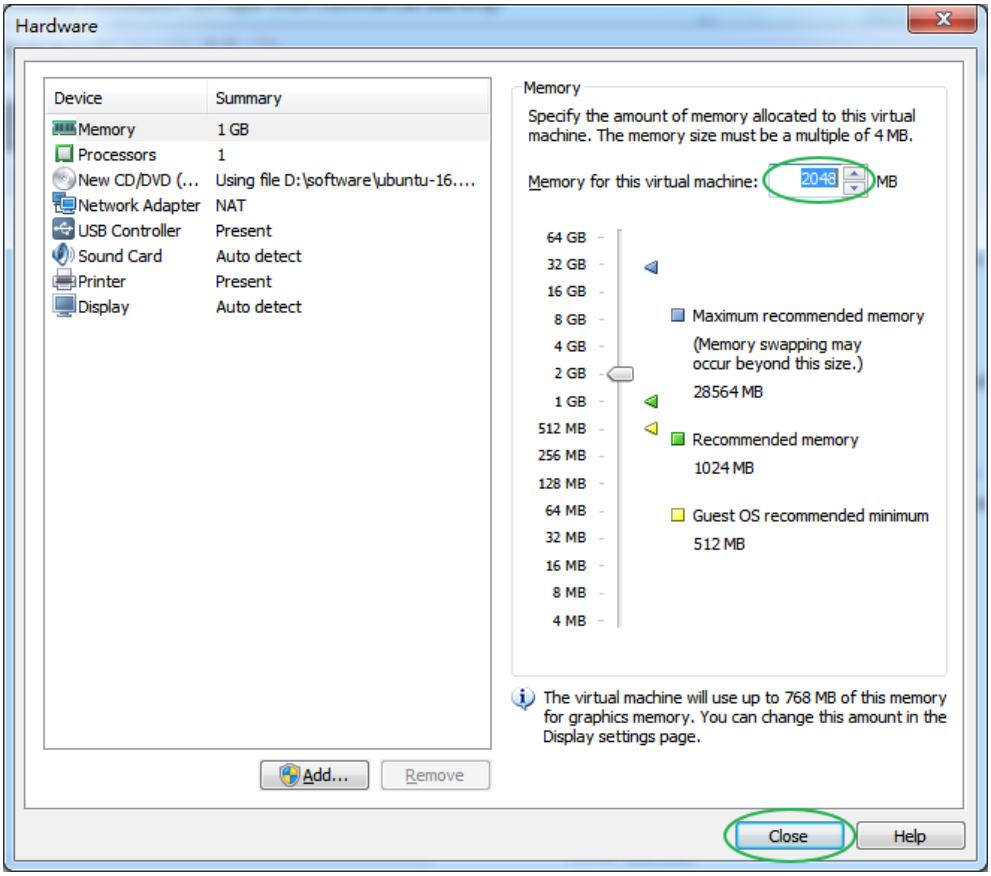

Figure 2-19 Hardware Dialog

Finally, the **Ready to Create Virtual Machine** dialog appears as shown in **Figure 2-20**. Click the "Finish" button to start installation progress.

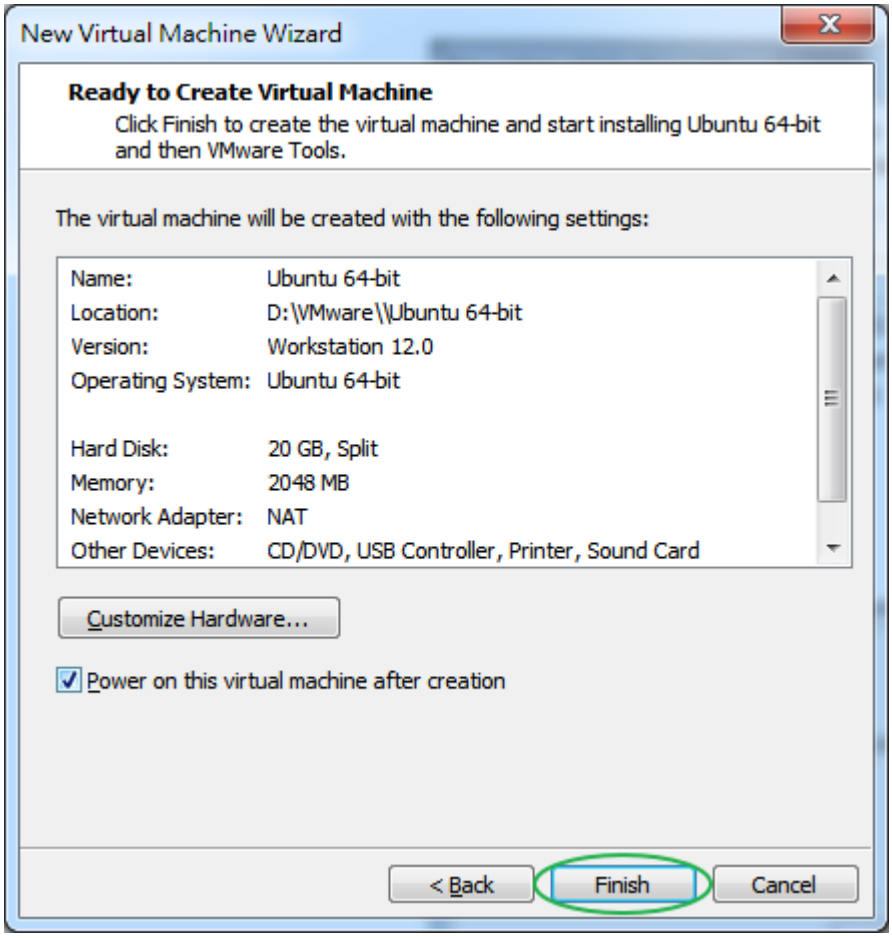

Figure 2-20 Ready to Create Virtual Machine Dialog - Modify Memory

While installing, the **Software Updates** dialog appears as shown in **Figure 2-21**. Click the "Download and Install" button to proceed.

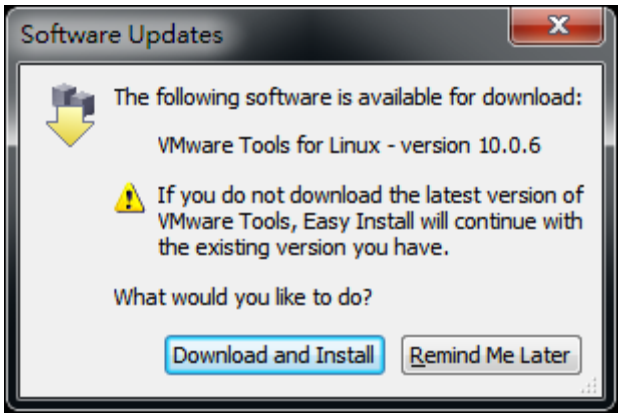

Figure 2-21 Software Updates Dialog

Figure 2-22 shows a screenshot of the installation progress.

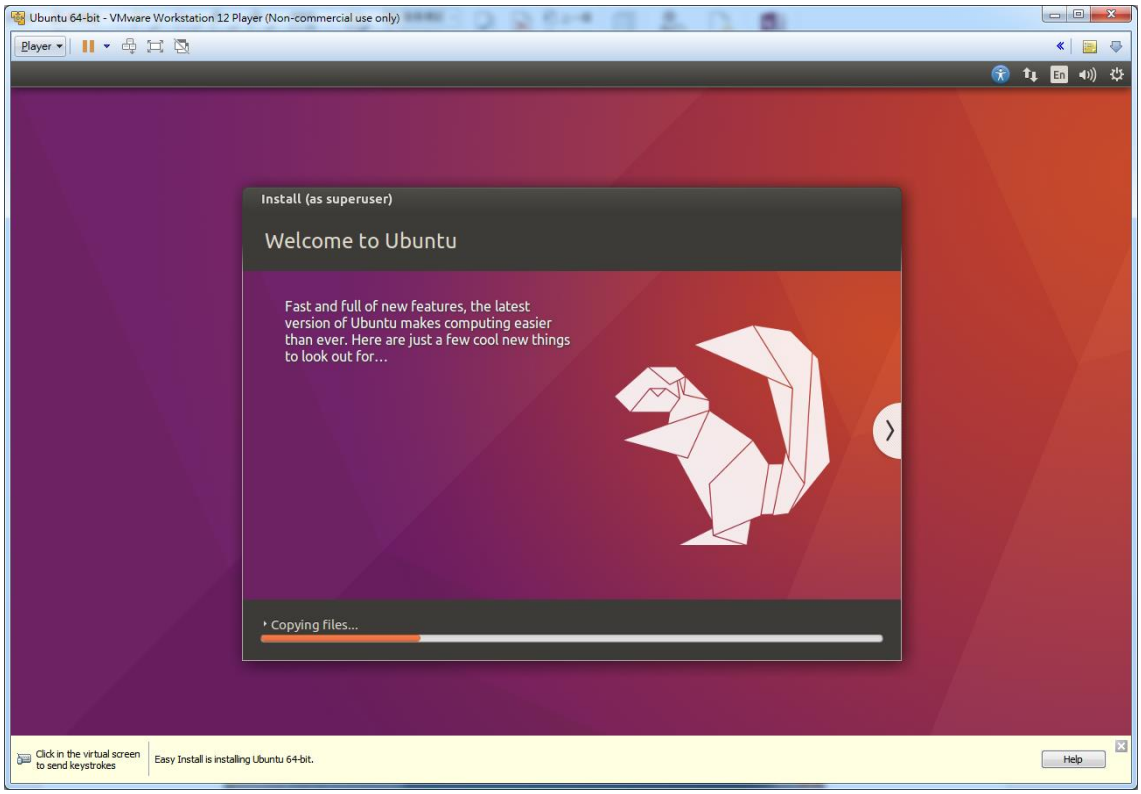

Figure 2-22 Installation Progress

When the installation is completed, Ubuntu login dialog appears as shown in **Figure 2-23**. In the Password edit box, key in the password specified in the previous step (in this tutorial, password is "123"), and press "ENTER" on the keyboard.

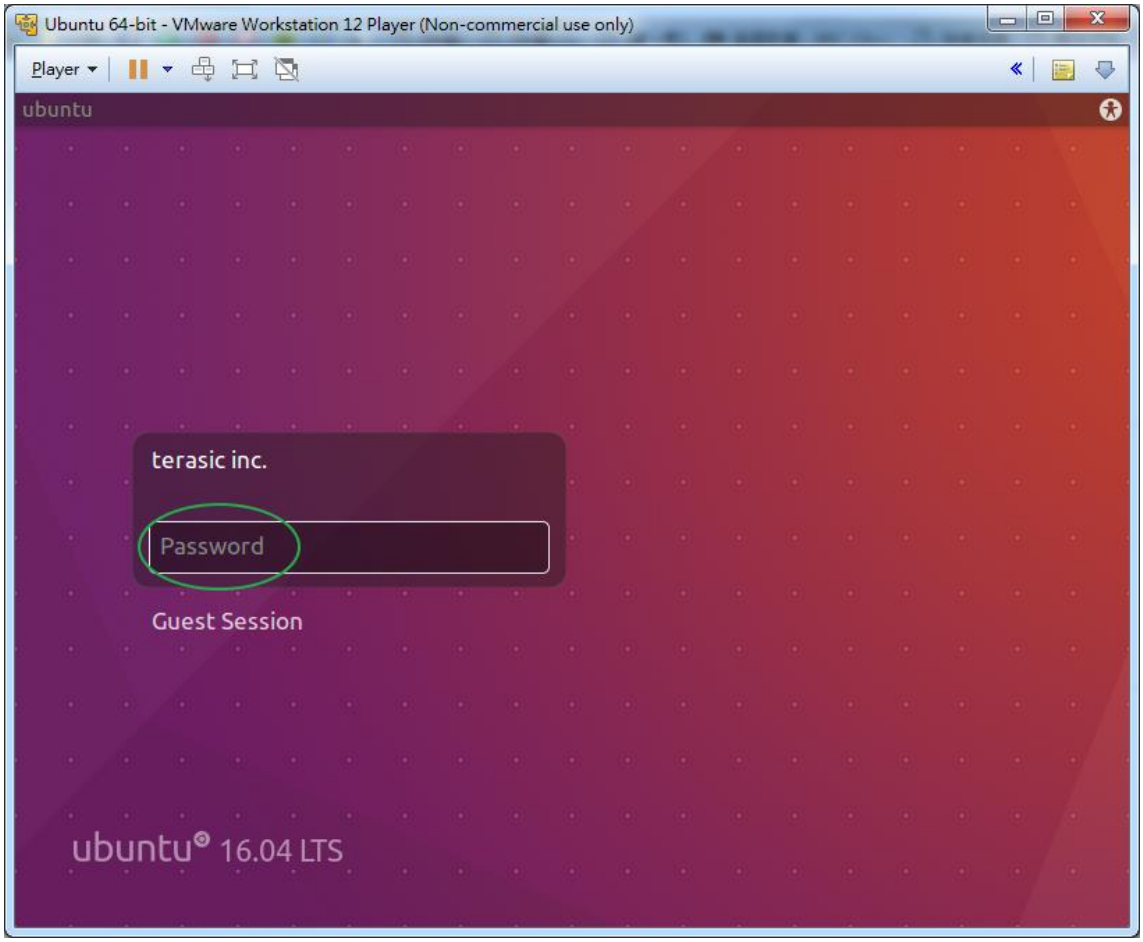

Figure 2-23 Ubuntu Login

After successful login, Ubuntu Desktop appears as shown in **Figure 2-24**.

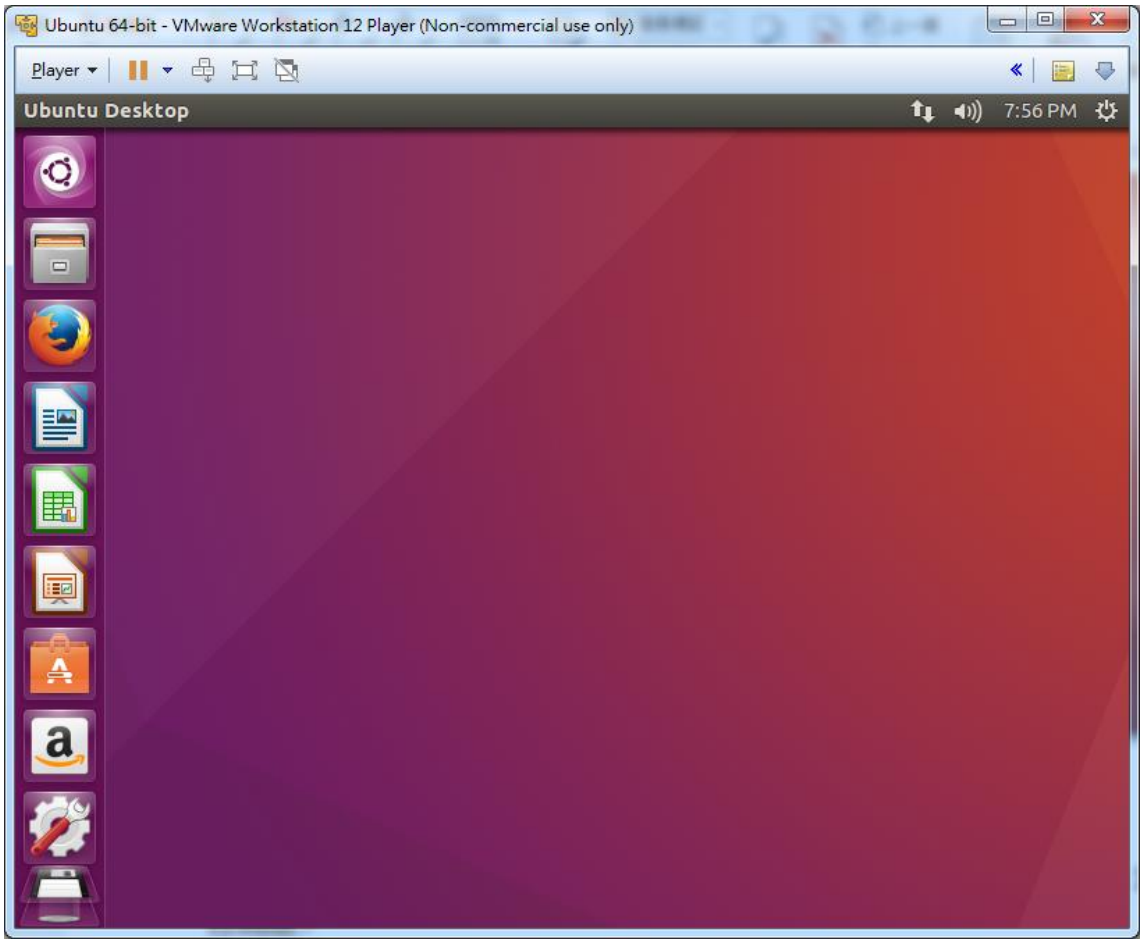

Figure 2-24 Ubuntu Desktop

■ Shut Down Linux System

Click the Power icon and select the "Shut Down…" as shown in **Figure 2-25.**

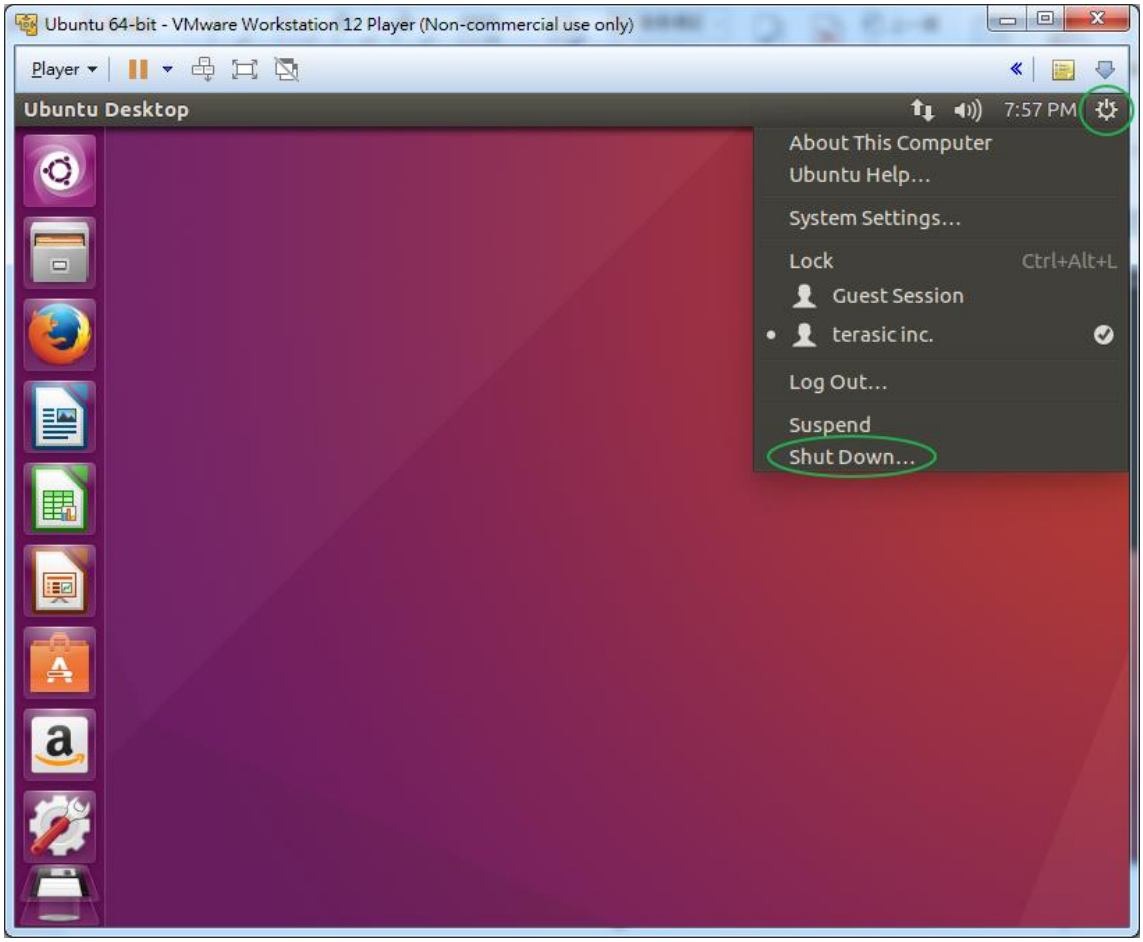

Figure 2-25 Shut Down Ubuntu Desktop - 1

Then, select "Shut Down" as shown in **Figure 2-26** to turn off the Linux system.

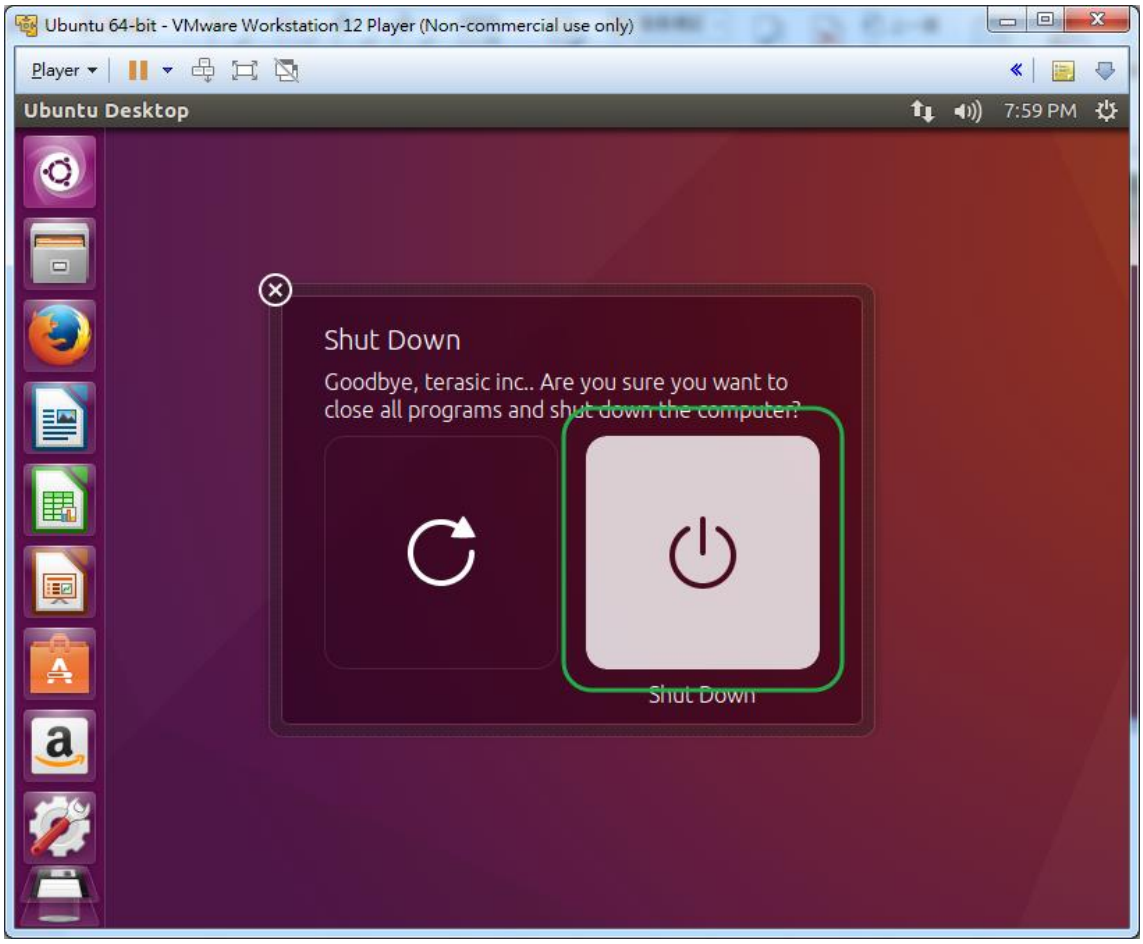

Figure 2-26 Shut Down Ubuntu Desktop - 2

■ Restart Ubuntu

To restart Ubuntu after it has been shut down, here is the step-by-step instruction:

1. Launch VMware Workstation Player
2. Select the "Ubuntu 64-bit" item and click "Play virtual machine" button to start Ubuntu as shown in **Figure 2-27**.

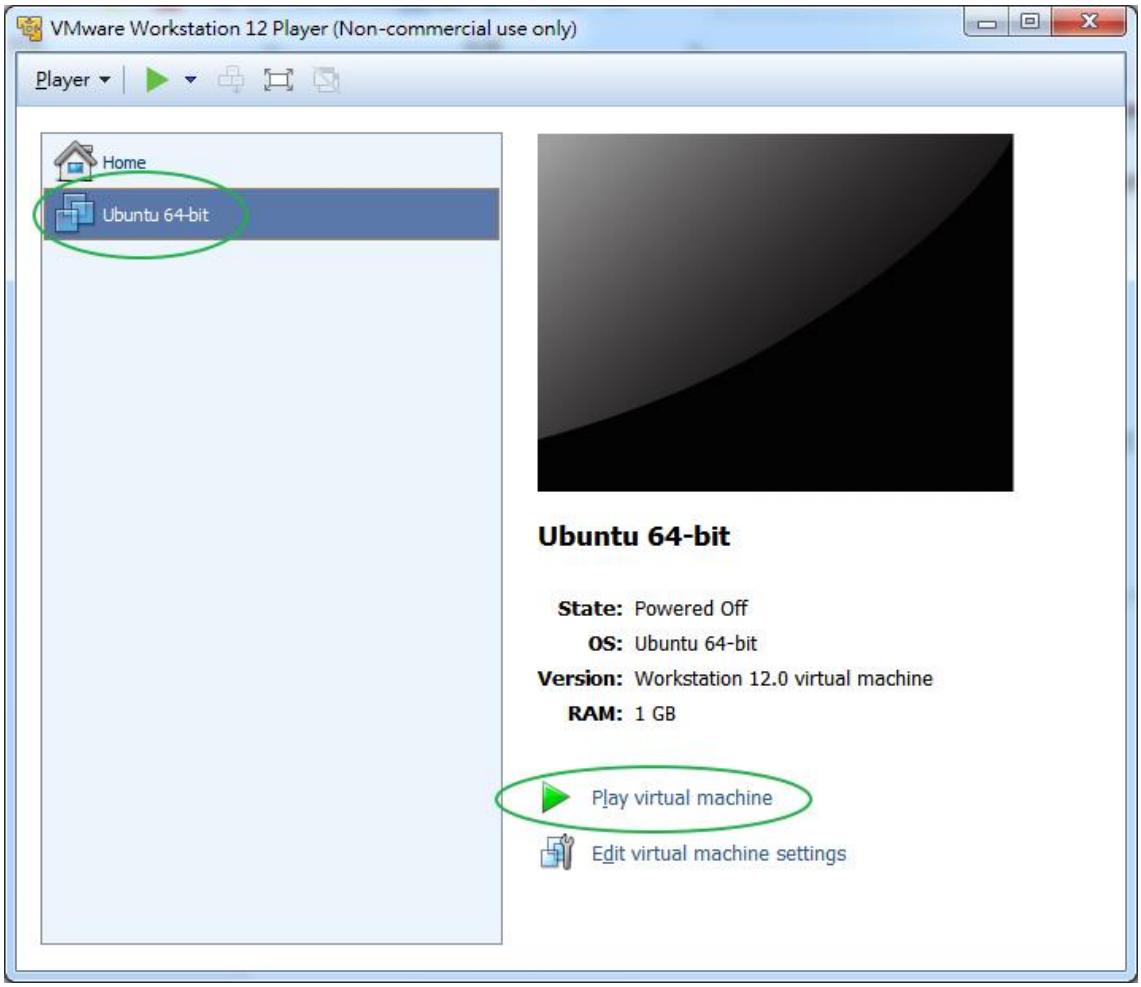

Figure 2-27 Start Ubuntu

2.5 Upgrade Linux x64 Software Package

After Linux x64 has been completely installed, we also need to upgrade the system to make sure the system is the most up-to-date.

Please follow carefully with the installation procedures in this section. First, press "CTRL+ALT+T" on keyboard to launch a terminal as show in **Figure 2-28**.

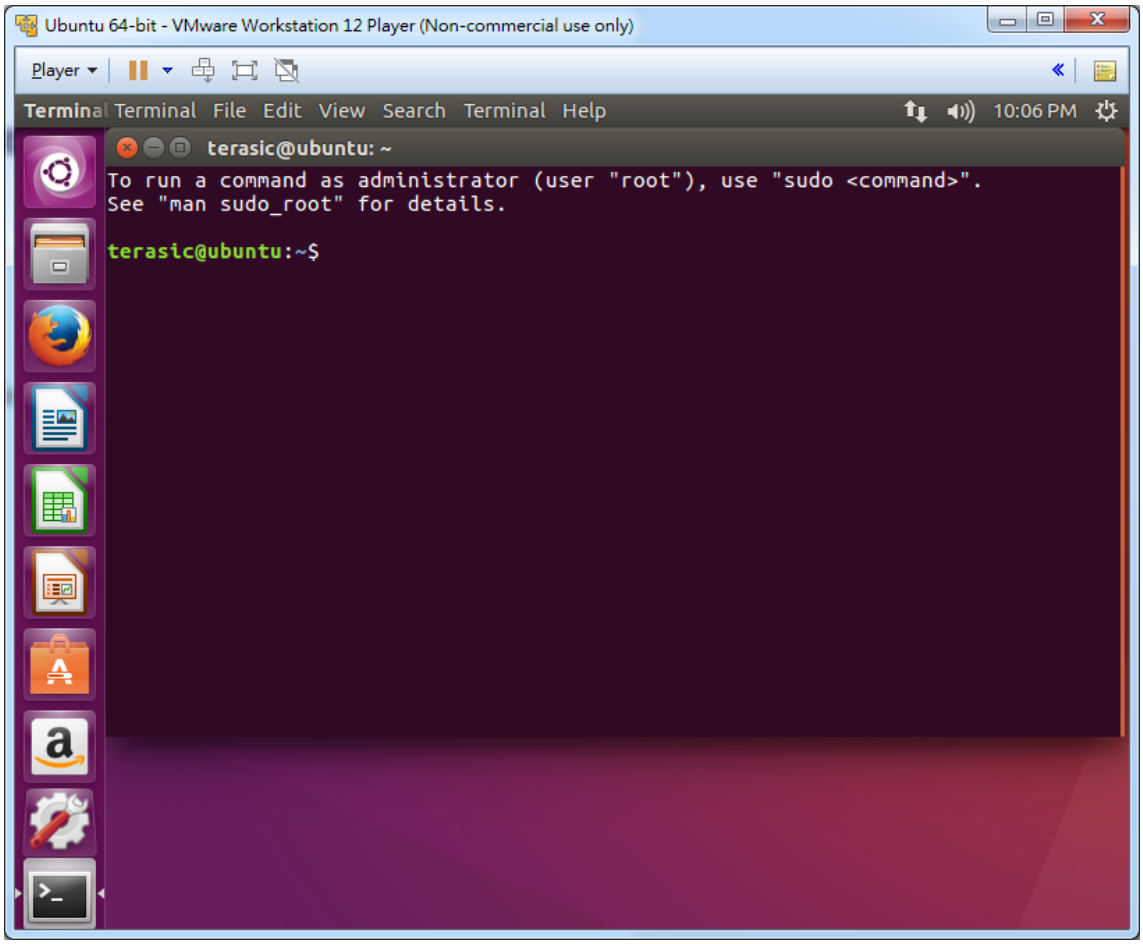

Figure 2-28 Linux Terminal

In the terminal, type the following command and press ENTER.

```
$ sudo apt update
```

The system will prompt users to input a password. Please input your password (in this tutorial, the password is "123") and press ENTER as shown in **Figure 2-29**.

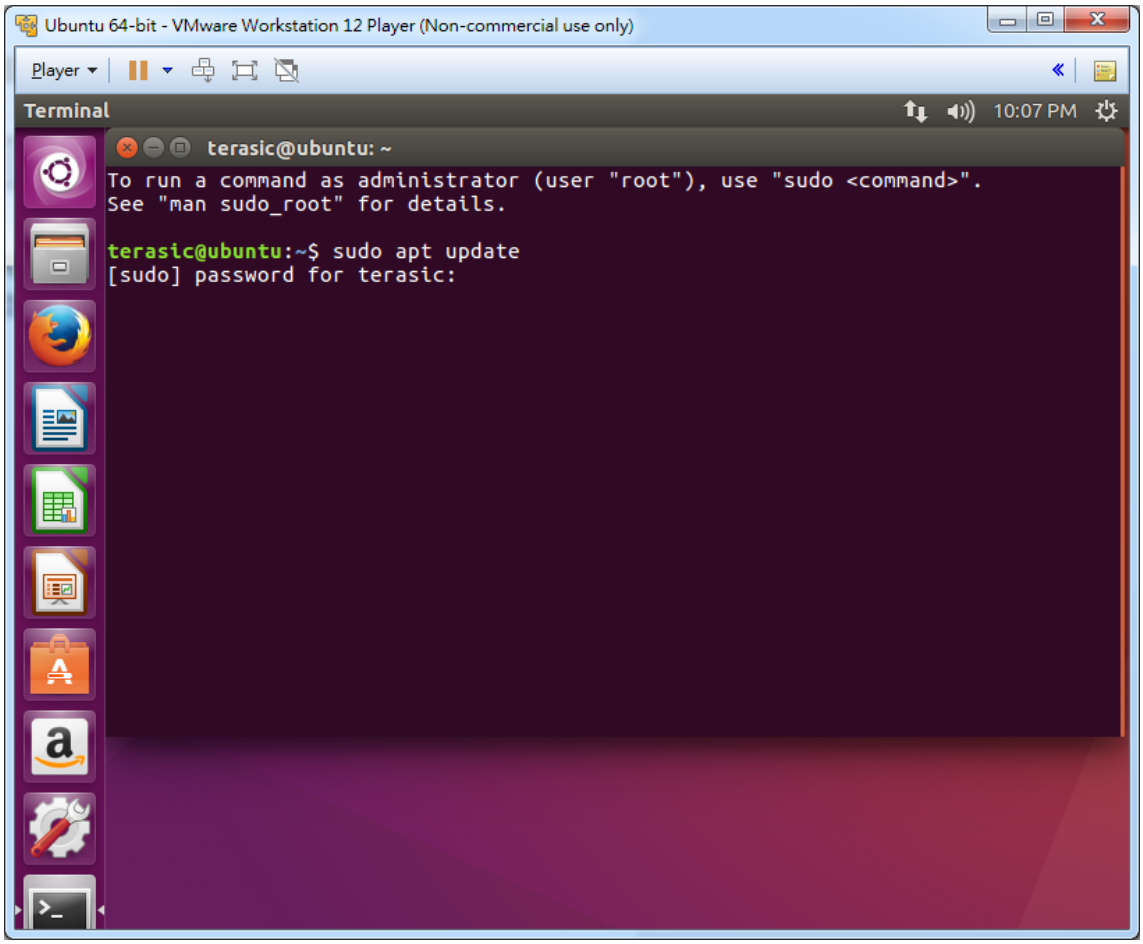

Figure 2-29 Input password for terasic

After finishing typing in "sudo apt update' and the password, now type in the following command and press ENTER, as shown in **Figure 2-30**. The upgrade process will take about 10~15 minutes.

```
$ sudo apt dist-upgrade -y
```

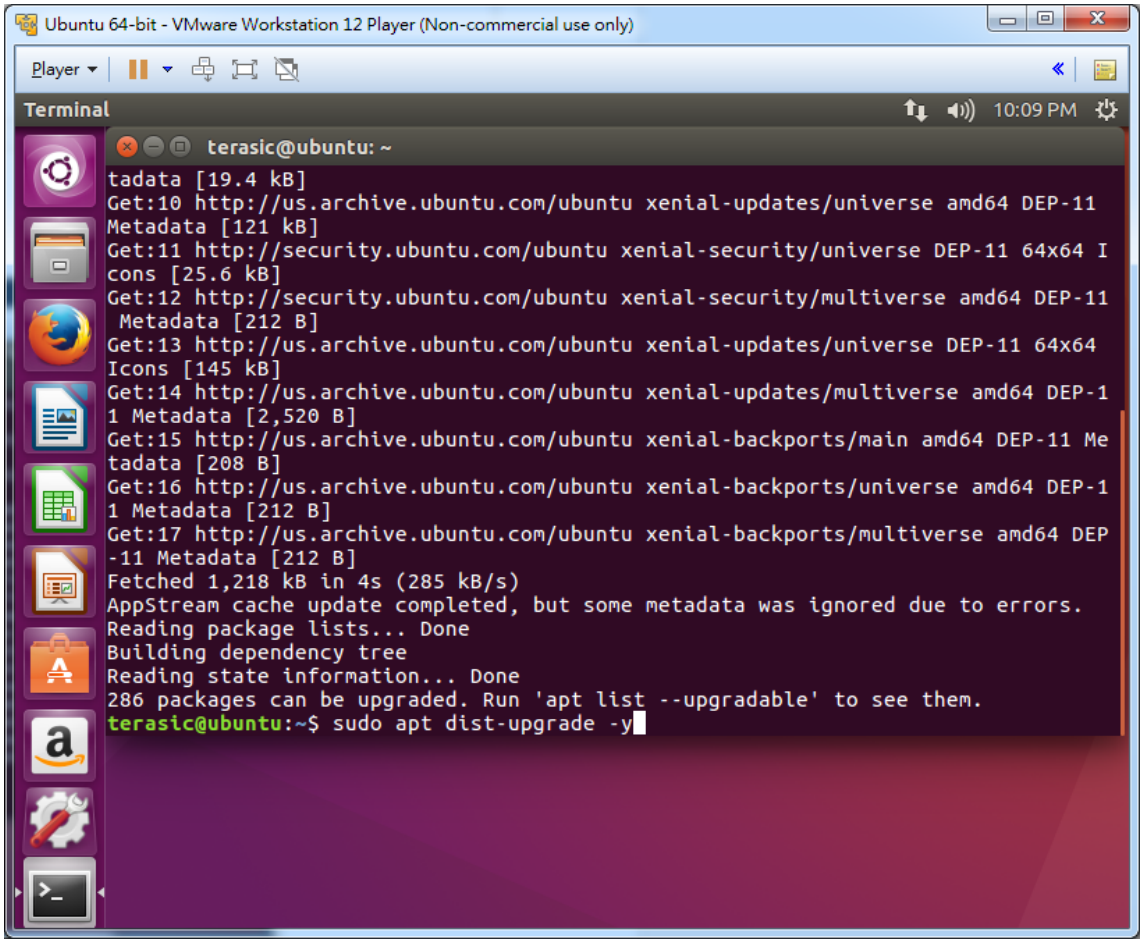

Figure 2-30 Typing in the Command "sudo apt dist-upgrade -y"

Figure 2-31 shows the screenshot after the upgrade process has been complete. Type "exit" to close the terminal.

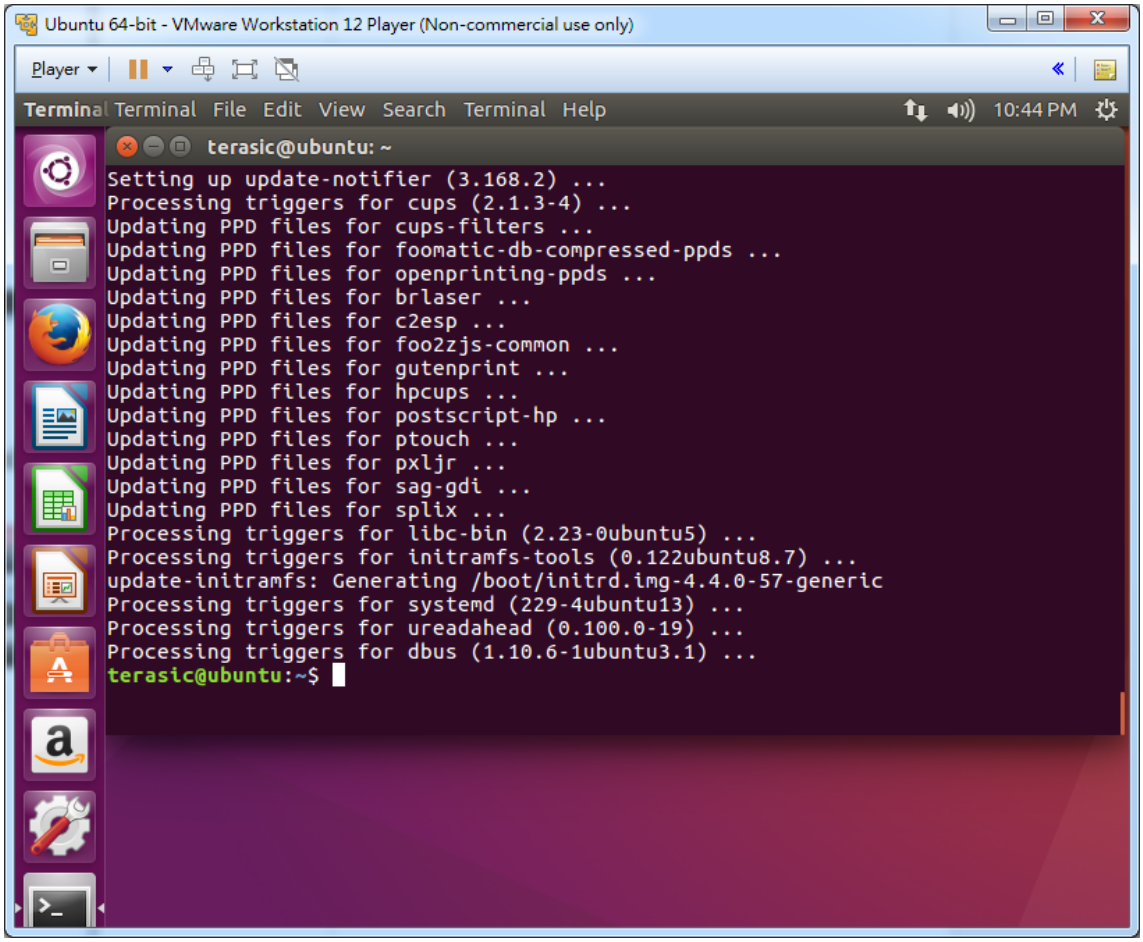

Figure 2-31 Upgrade Process Complete

2.6 Enable VMware Share Folder

After Linux system has been upgraded, we also need to copy files from Windows host by using VMware Workstation Player's **Shared Folder** features. Note, a software patch is applied to fix known bugs.

■ Fix and Enable VMware Workstation Player's Shared Folder features

Please follow carefully with the installation procedures in this section. First, press "CTRL+ALT+T" on keyboard to launch a terminal as show in Figure 2-32.

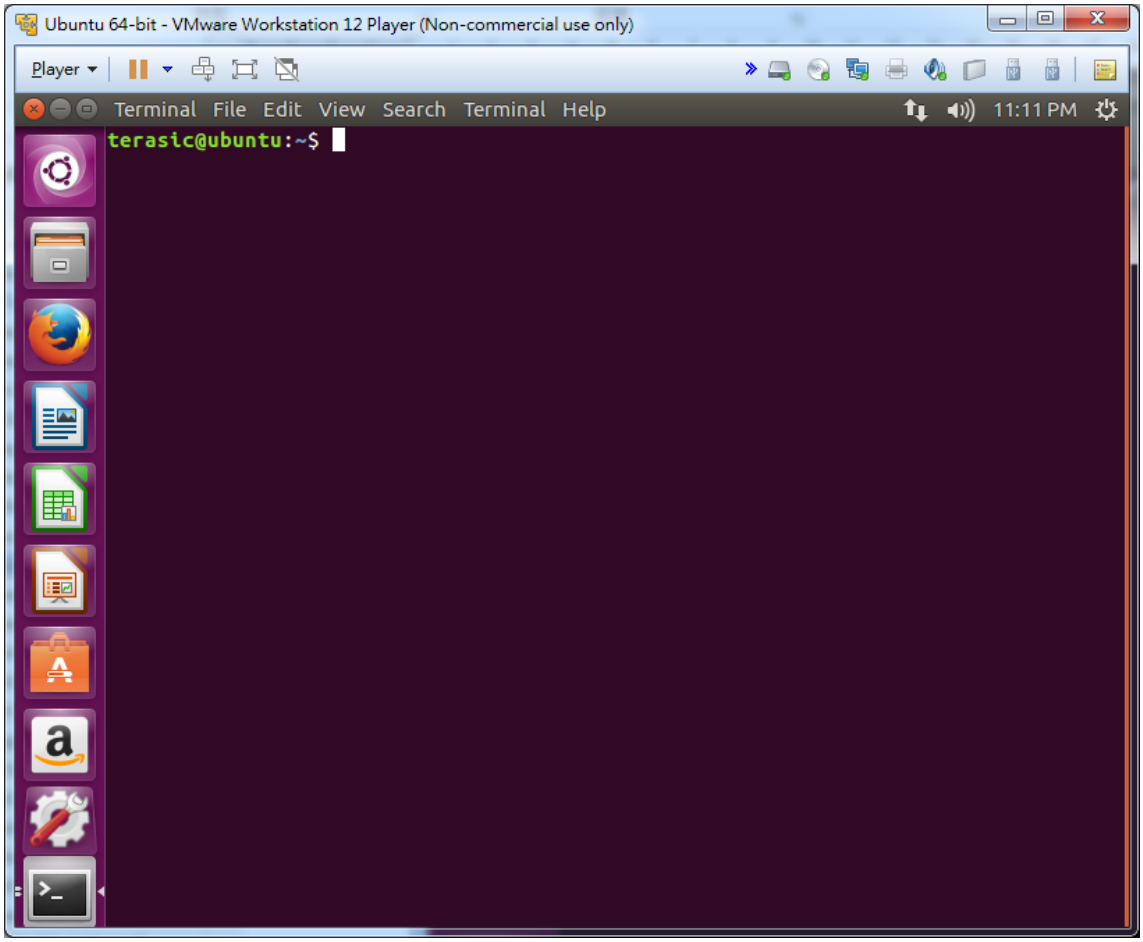

Figure 2-32 Linux Terminal

In the terminal, execute the following commands to download and install VMware Tools Patches.

```
$ wget https://codeload.github.com/rasa/vmware-tools-patches/zip/master \
-O vmware-tools-patches.zip
$ unzip vmware-tools-patches.zip
$ cd vmware-tools-patches-master/
$ sudo ./patched-open-vm-tools.sh
```

Figure 2-33 shows the screenshot of patches download finish after typing in the wget command.

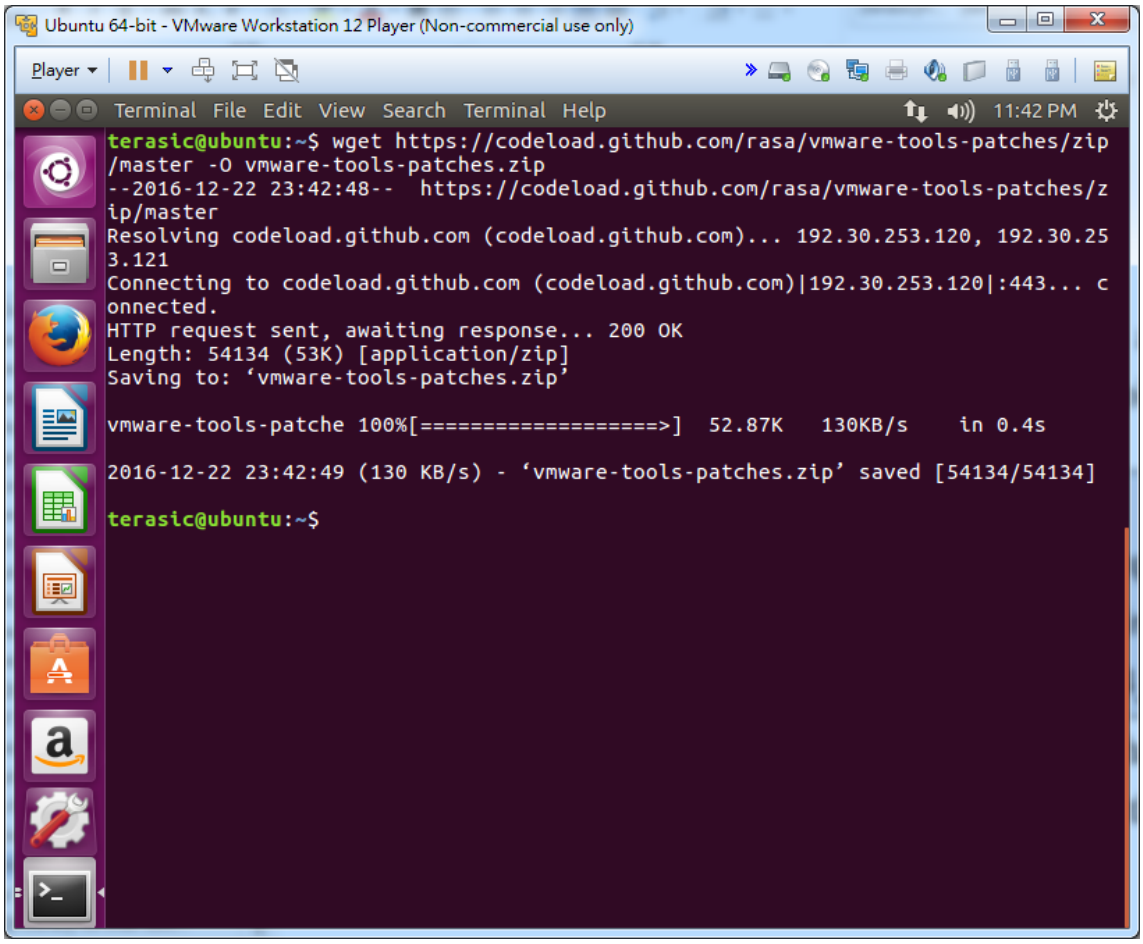

Figure 2-33 VMware Tools Patches Download Finished

The downloaded file is in the compressed format, so we need to decompress it before we can use it. Figure 4-2 shows the screenshot after patches download has been finished and has been extracted by the **unzip** command. After extraction, the patches is located in the folder "~/vmware-tools-patches-master"

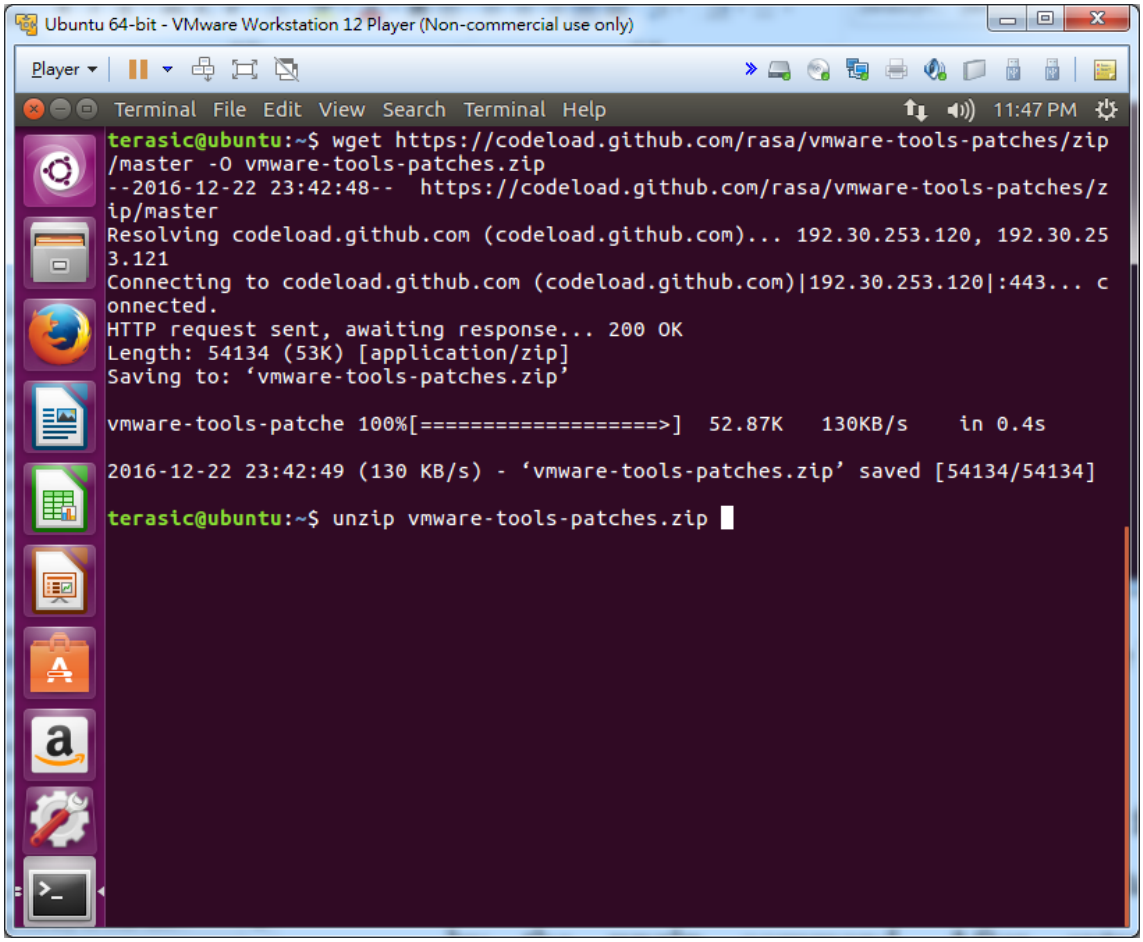

Figure 2-34 VMware Tools Patches Extracted by the unzip Command

In order to fix VMware Tools bug, installing patches is required. **Figure 2-35** shows the screenshot of installing the patches. The system will prompt users to input a password. Please input your password (in this tutorial, the password is "123") and press ENTER.

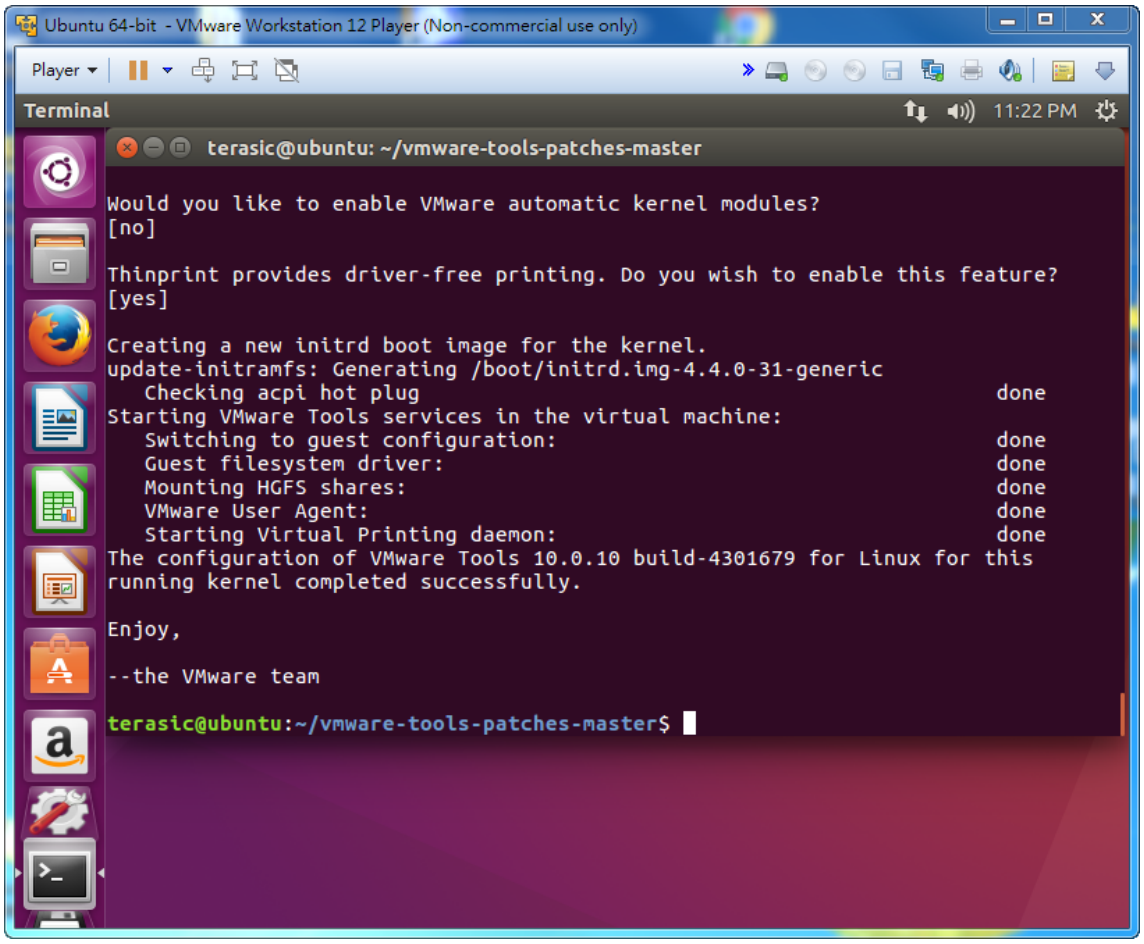

Figure 2-35 VMware Tools Patches Installation

■ Shared Folder Setup

In order to modify virtual machine setting. First, shut down Linux system. Launch the VMware Workstation Player, select the "Ubuntu 64-bit", and click "Edit virtual machine settings", as shown in **Figure 2-36.**

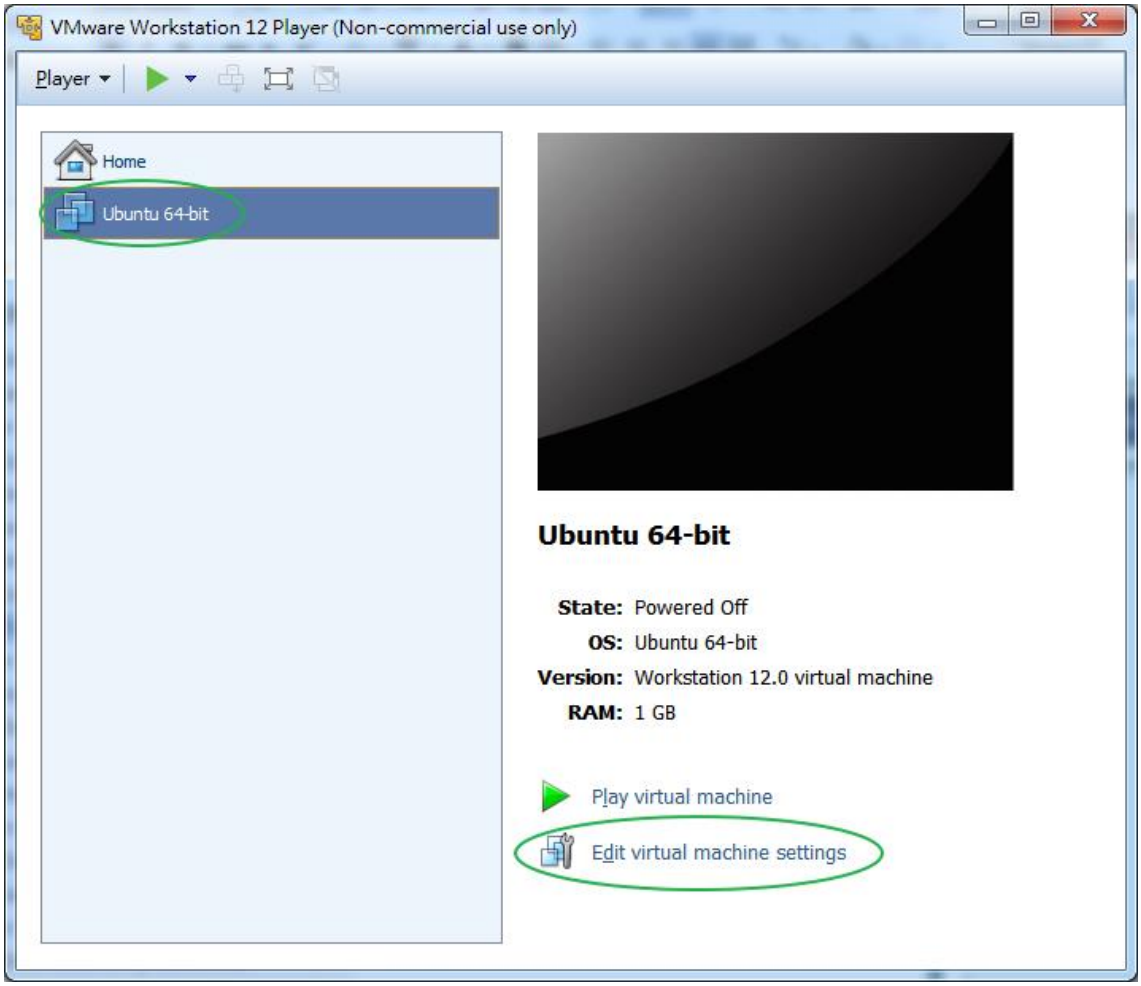

Figure 2-36 Launch Edit Virtual Machine Settings

When the **Virtual Machine Settings** dialog appears as shown in **Figure 2-37**, please select "Options" tab, click "Shared Folders" icons, check "Always enabled" radio button, and then click "Add…".

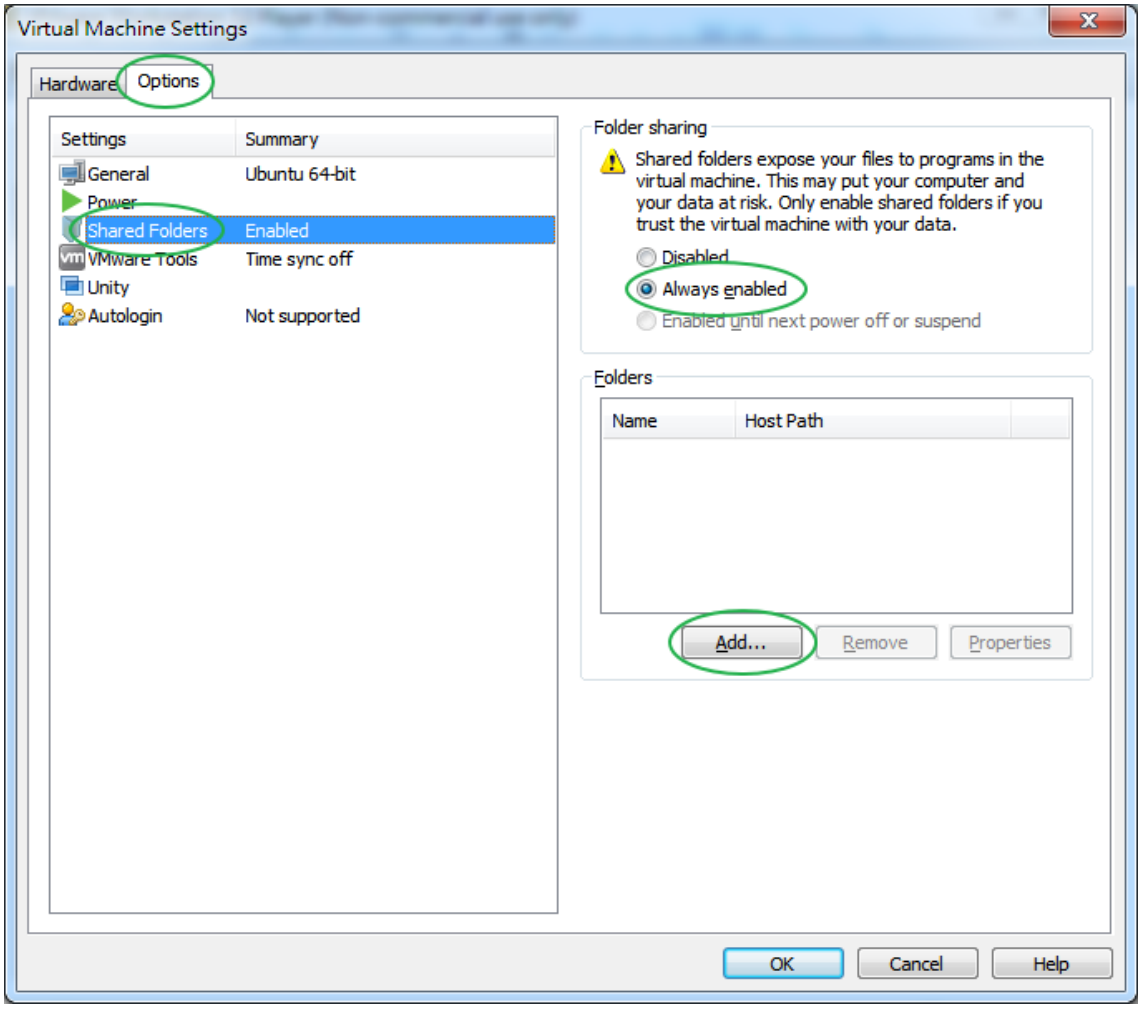

Figure 2-37 Add Shared Folders

Add Shared Folder Wizard is launched for shared folder settings. A Welcome dialog appears as shown in **Figure 2-38**, please click "Next >" to go to the next step.

Figure 2-38 Welcome Dialog of Add Shared Folder Wizard

When the **Name the Shared Folder** dialog appears as shown in **Figure 2-39**, click "Browse…" to select a folder as the shared folder, gives a name to the shared folder(in this tutorial, **shared** is used), and click "Next >" to proceed.

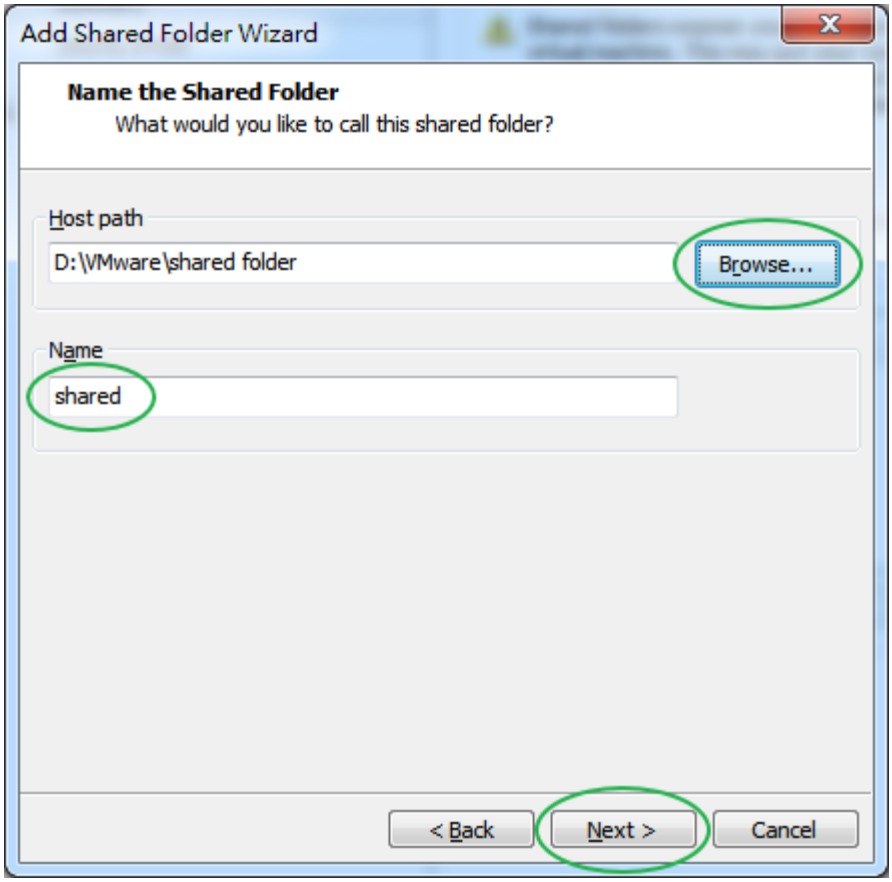

Figure 2-39 Specify Shared Folder Location and Name

When the **Specify Shared Folder Attributes** dialog appears as shown in **Figure 2-40**, check "Enable this share" checkbox and click "Finish".

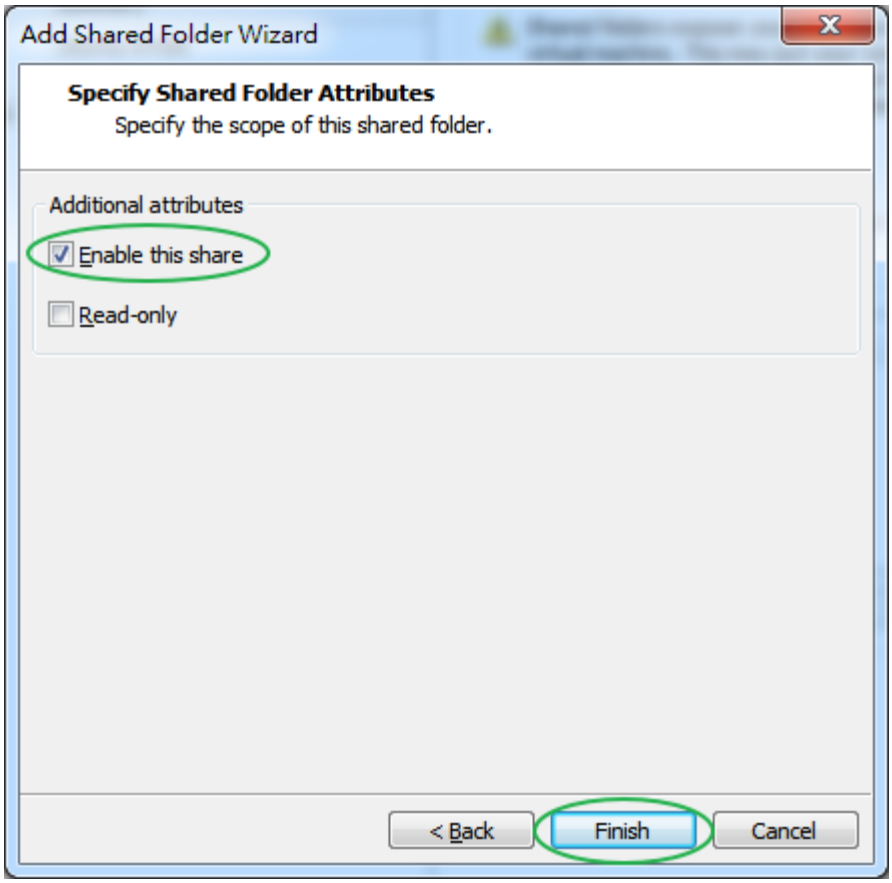

Figure 2-40 Finish Shared Folder Setup

When going back to the **Virtual Machine Settings** dialog as shown in **Figure 2-41**, check "OK" to complete the settings. Now the Shared Folder feature is applied.

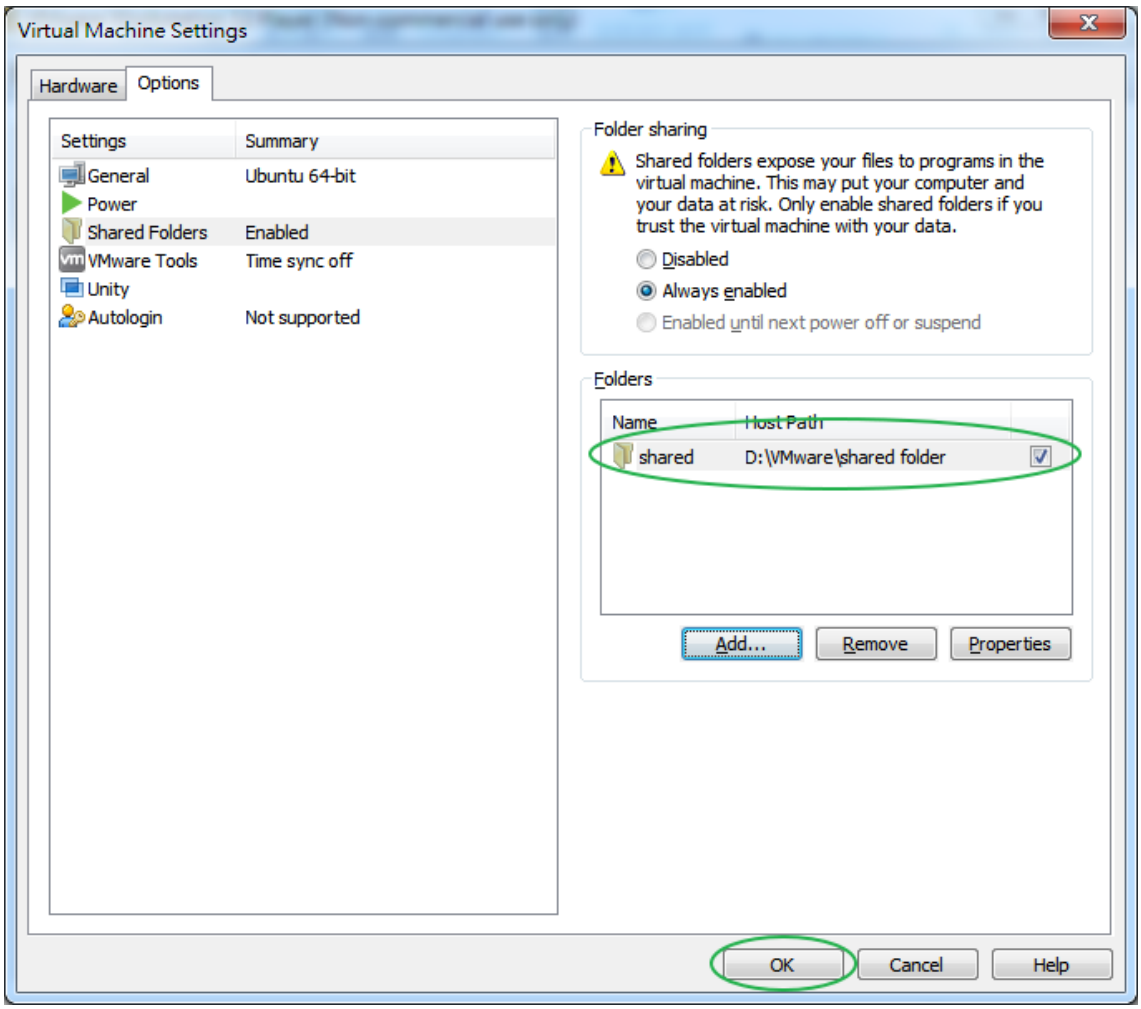

Figure 2-41 Complete Virtual Machine Setting

Chapter 3

Qt Creator Installation

The Control Panel is a GUI-based program and Qt Creator is a convenient tool to help create GUI-based programs. Users can simply follow our GUI application development explained in this tutorial to develop needed GUI applications.

Chapter 3 illustrates how to install Qt Creator on the Linux x64 which has been installed in previous chapters. Also, we will show how to create, compile, and build a hello program running on the Linux x64. In order for Qt Creator to be able to build a project correctly, we also provide steps of installing necessary x86_64 GCC toolchain needed for the Qt Creator.

3.1 Install Toolchain for Linux x64

In order for the Qt Creator to be able to build a project correctly, a proper toolchain is required. Use the following command to install the required toolchain:

```
$ sudo apt install build-essential libgl1-mesa-dev -y
```

System will prompt the user to input a password (in this tutorial, the password is "123") as shown in **Figure 3-1**.

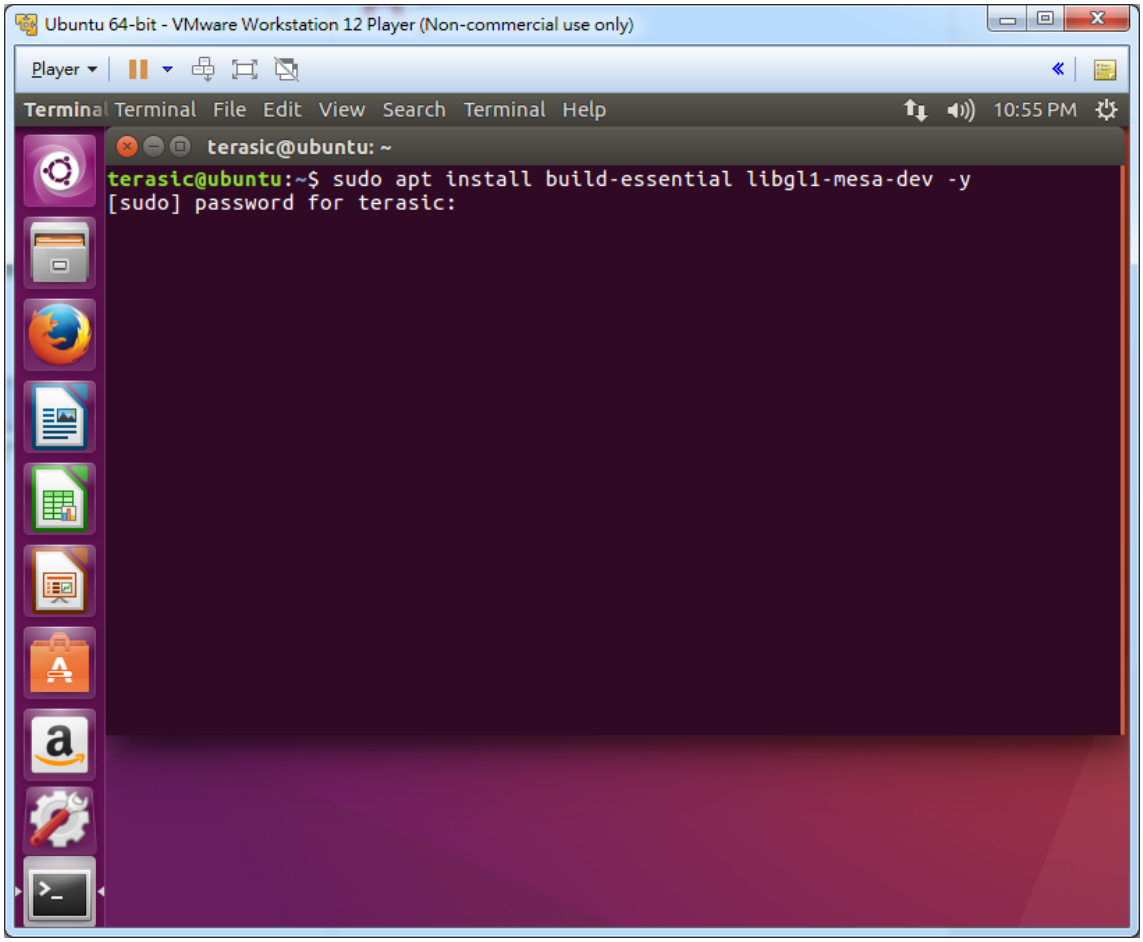

Figure 3-1 Install Software Package

Figure 3-2 shows the screenshot after the installation has been completed. Type "exit" to close the terminal.

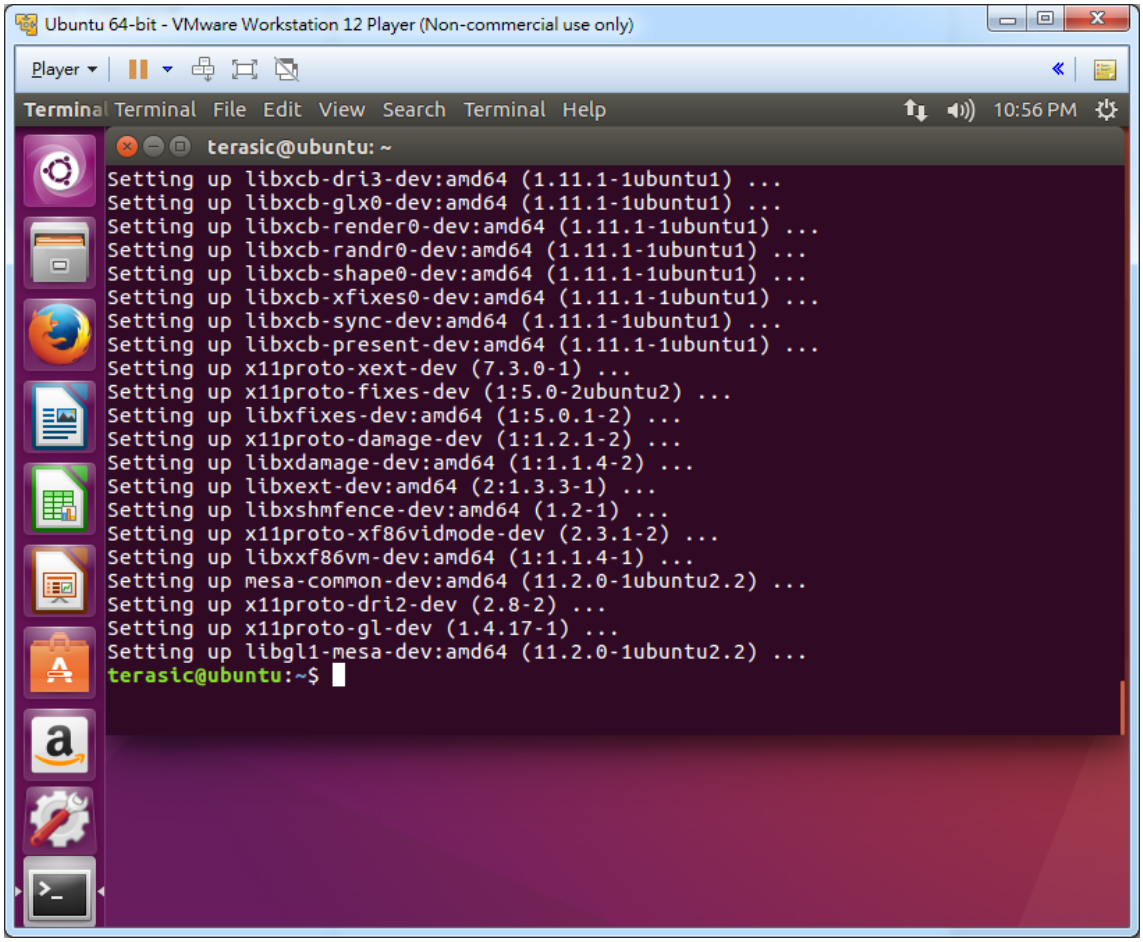

Figure 3-2 Software Package Installation is Now Complete

3.2 Download and Install Qt Installer

■ Download Qt Installer

As shown in **Figure 3-3**, click the Firefox web browser to open the web page

http://download.qt.io/archive/qt/5.7/5.7.0/

Then click "qt-opensource-linux-x64-5.7.0.run" to download the Qt installer.

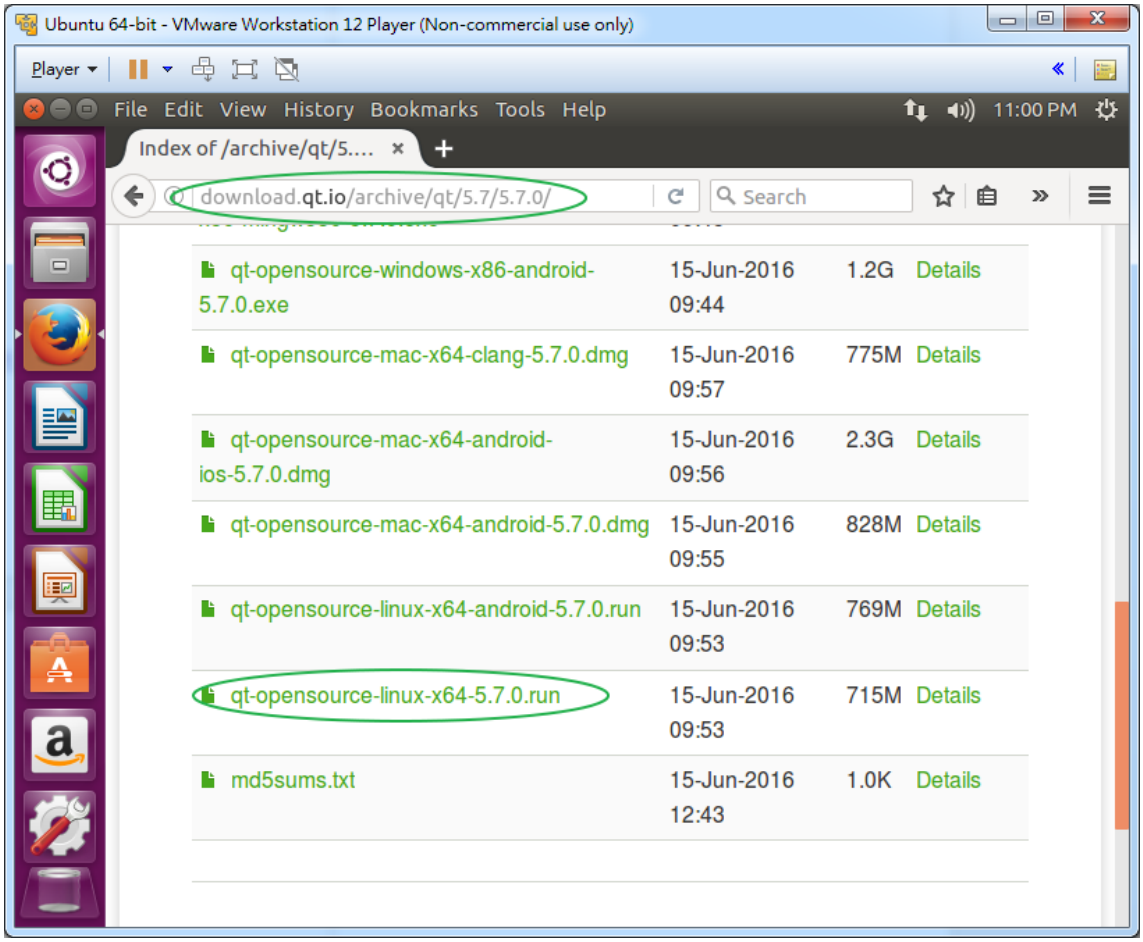

Figure 3-3 Web Page to Download Qt

When an Opening dialog appears as shown in **Figure 3-4**, click "Save File".

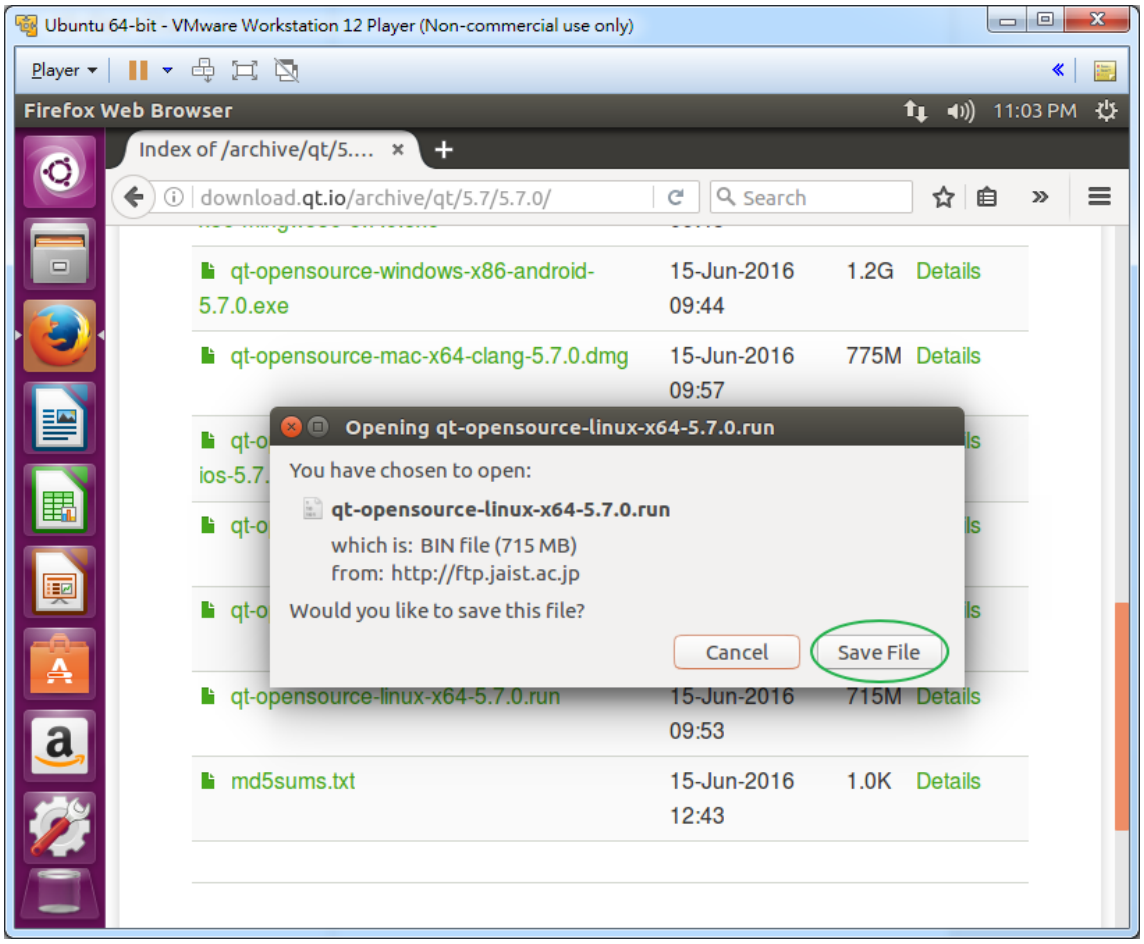

Figure 3-4 Opening Dialog

Figure 3-5 shows the download progress.

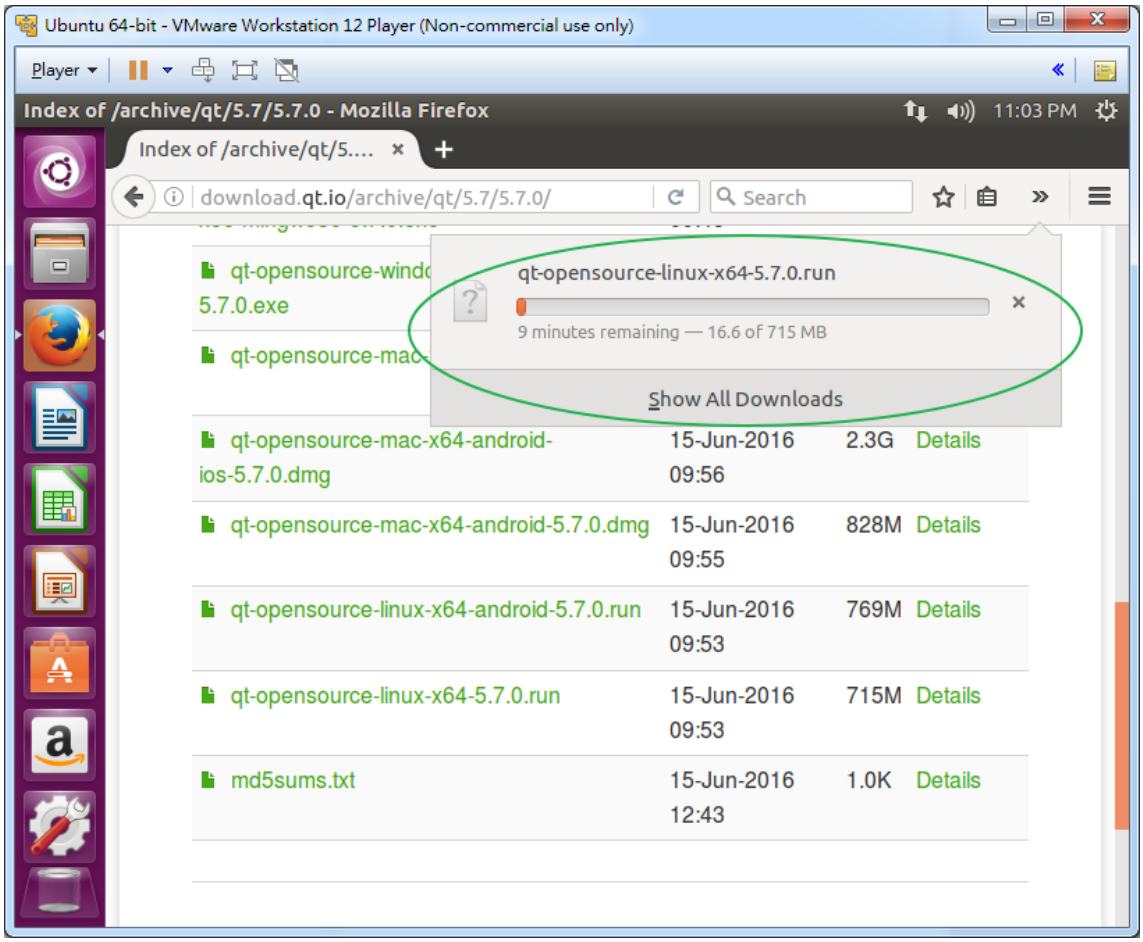

Figure 3-5 Download Process of qt-opensource-linux-x64-5.7.0.run

The file is saved as "**qt-opensource-linux-x64-5.7.0.run**", and saved under the folder "~/Download". When download is completed, click the Close icon, located on the top-left corner as shown in **Figure 3-6**, to close the Firefox web browser.

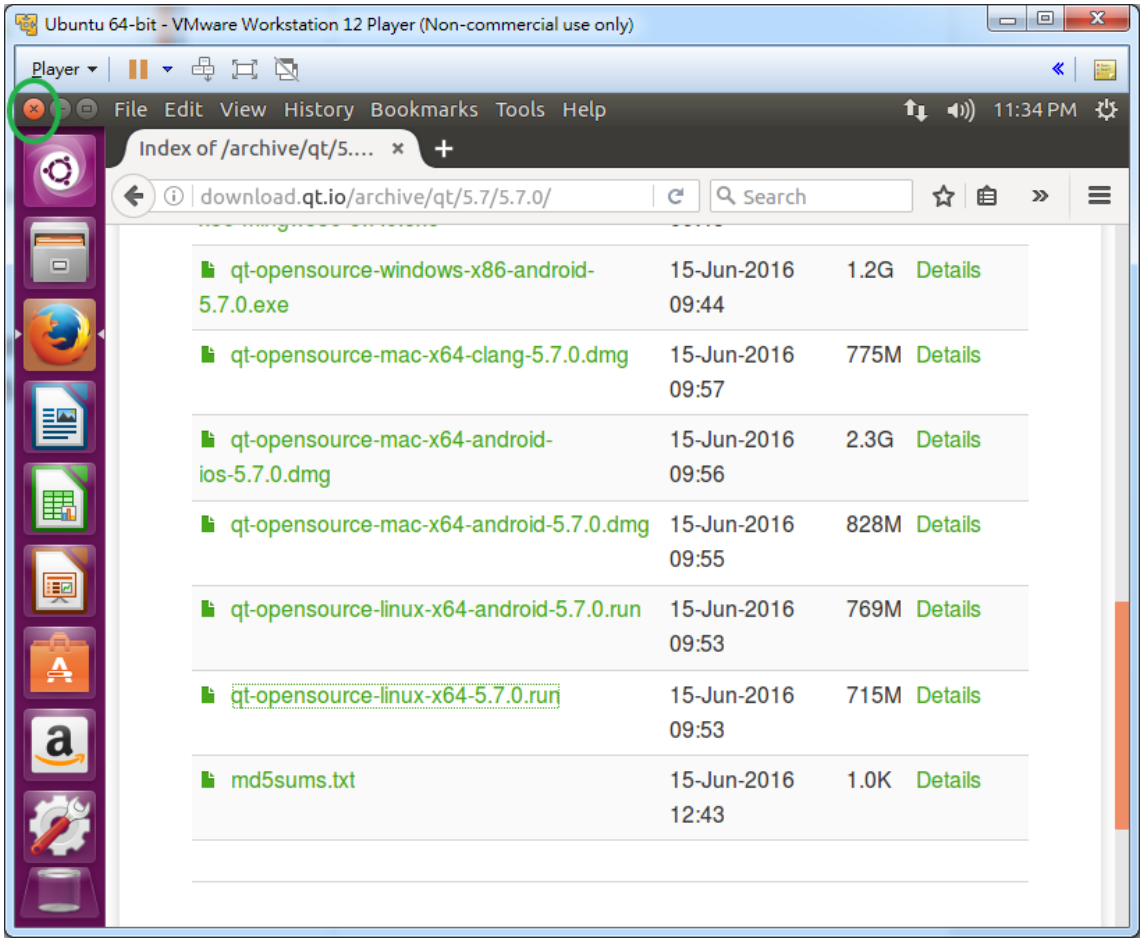

Figure 3-6 Click 'Close' Icon to Close Firefox Web Browser

■ Install Qt

Type in the following commands to locate and launch the Qt Installer, as shown in **Figure 3-7**.

```
$ cd ~/Downloads/
$ ls
$ chmod a+x qt-opensource-linux-x64-5.7.0.run
$ ./qt-opensource-linux-x64-5.7.0.run
```

The 2nd command line **ls** is used to check whether the qt-opensource-linux-x64-5.7.0.run existed or not while the 3rd command line **chmod a+x** is used to add "execution" attribute to the file such that it can be executed.

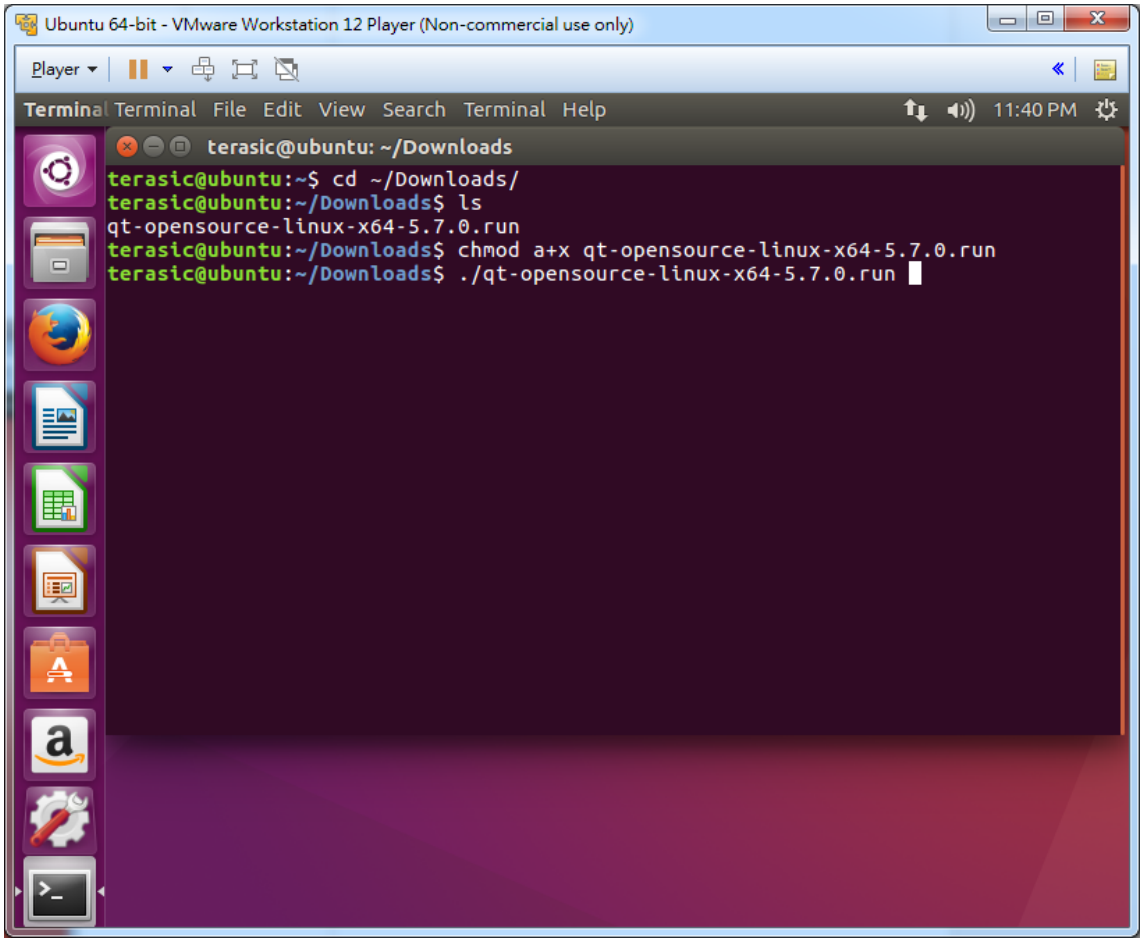

Figure 3-7 Locate and Launch the Qt Installer

Figure 3-8 shows the **Welcome** dialog of the Qt Installer.

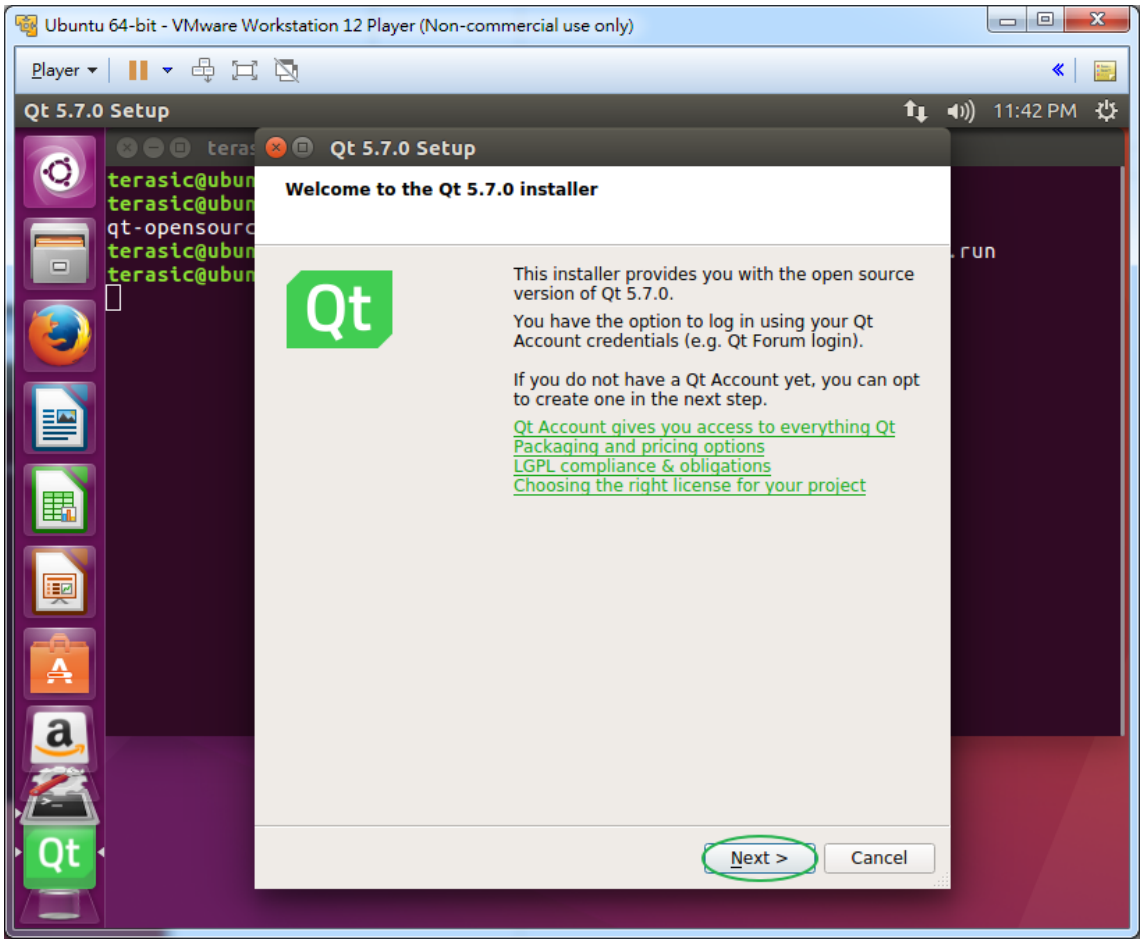

Figure 3-8 Welcome Dialog

In the **Qt Account – Your unified login to everything Qt** dialog, click "Skip" to skip Qt account log in and go to the next step, as shown in **Figure 3-9**.

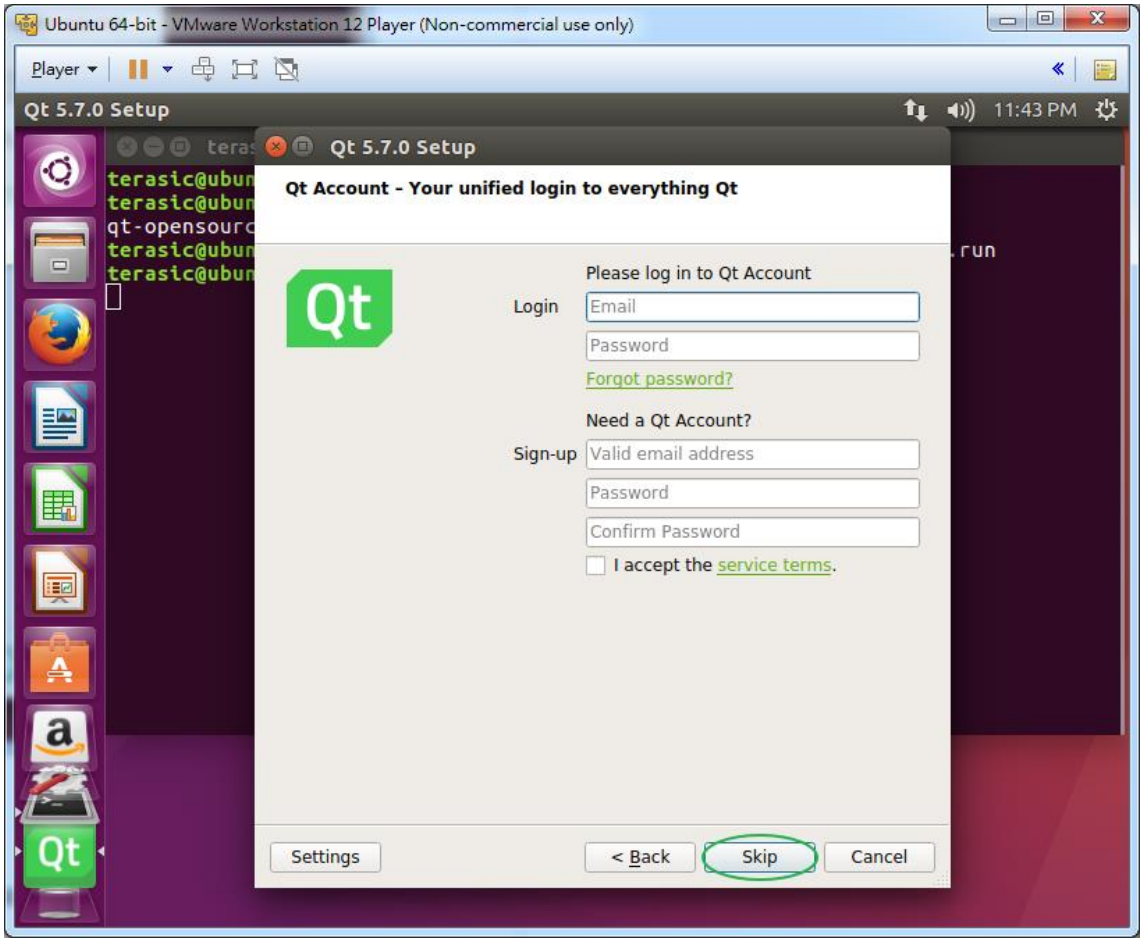

Figure 3-9 Skip Qt Account log in

In the **Setup – Qt 5.7.0** dialog, click "Next >" to go to the next step, as shown in **Figure 3-10**.

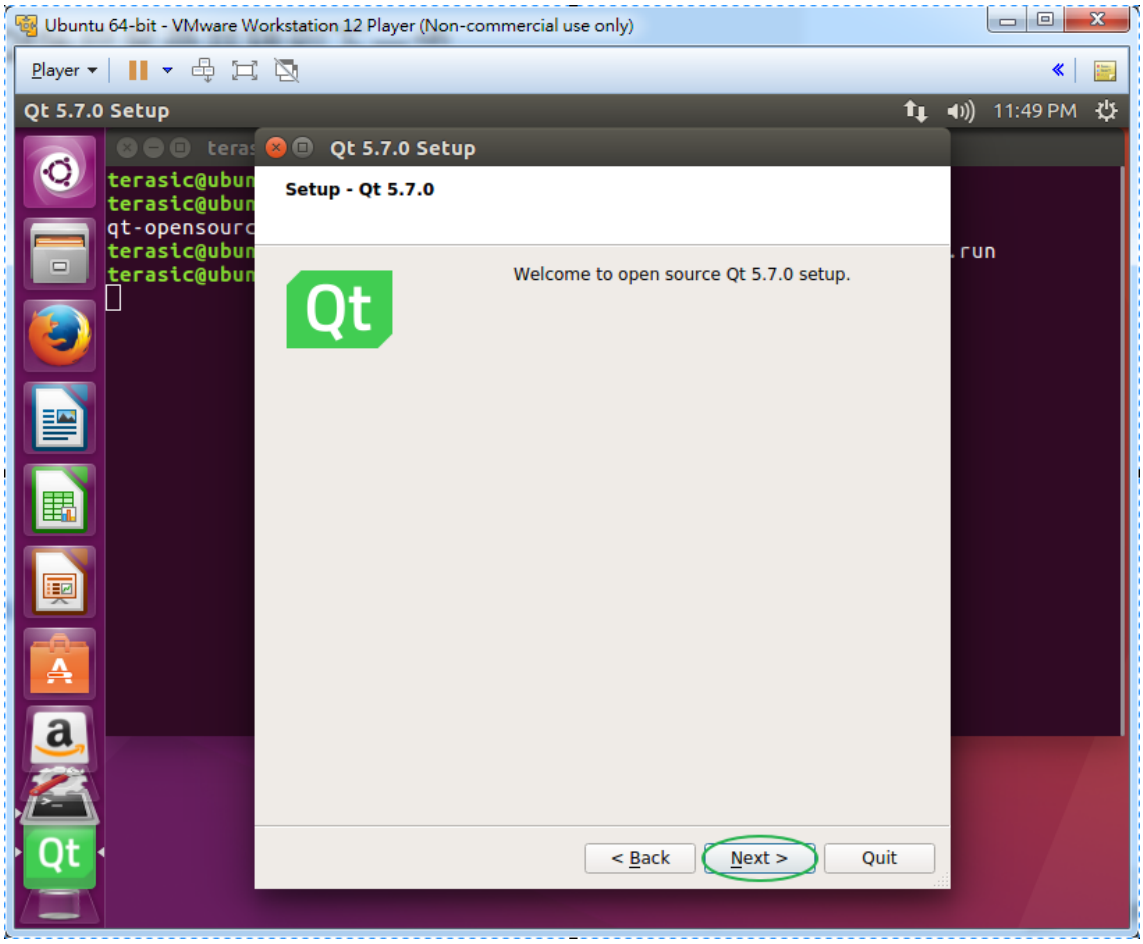

Figure 3-10 Qt Setup Dialog

In the **Installation Folder** dialog, please specify the folder where you wish to install Qt 5.7.0 and click "Next >" to go to the next step, as shown in **Figure 3-11**.

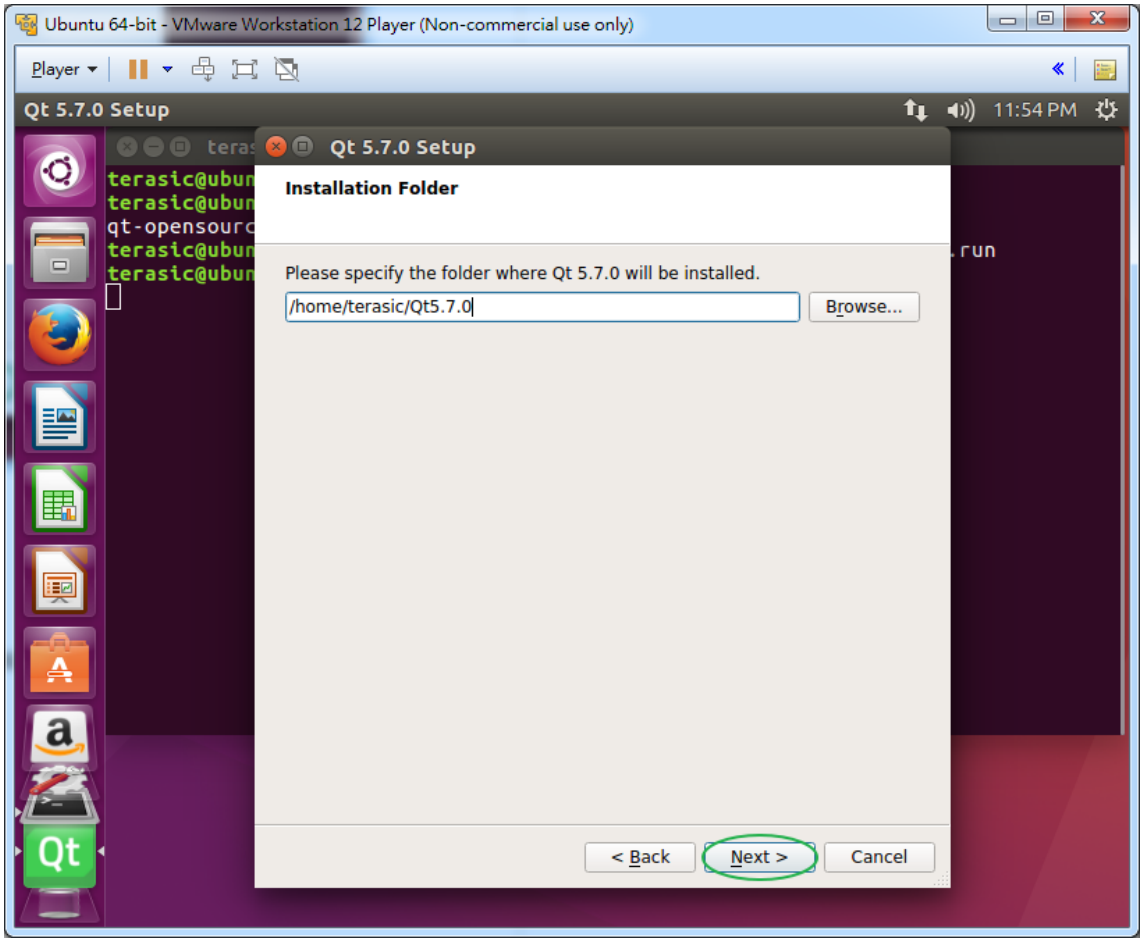

Figure 3-11 Specify the Folder to Install Qt

In the **Select Components** dialog, keep default settings and click "Next >" to go to the next step, as shown in **Figure 3-12**

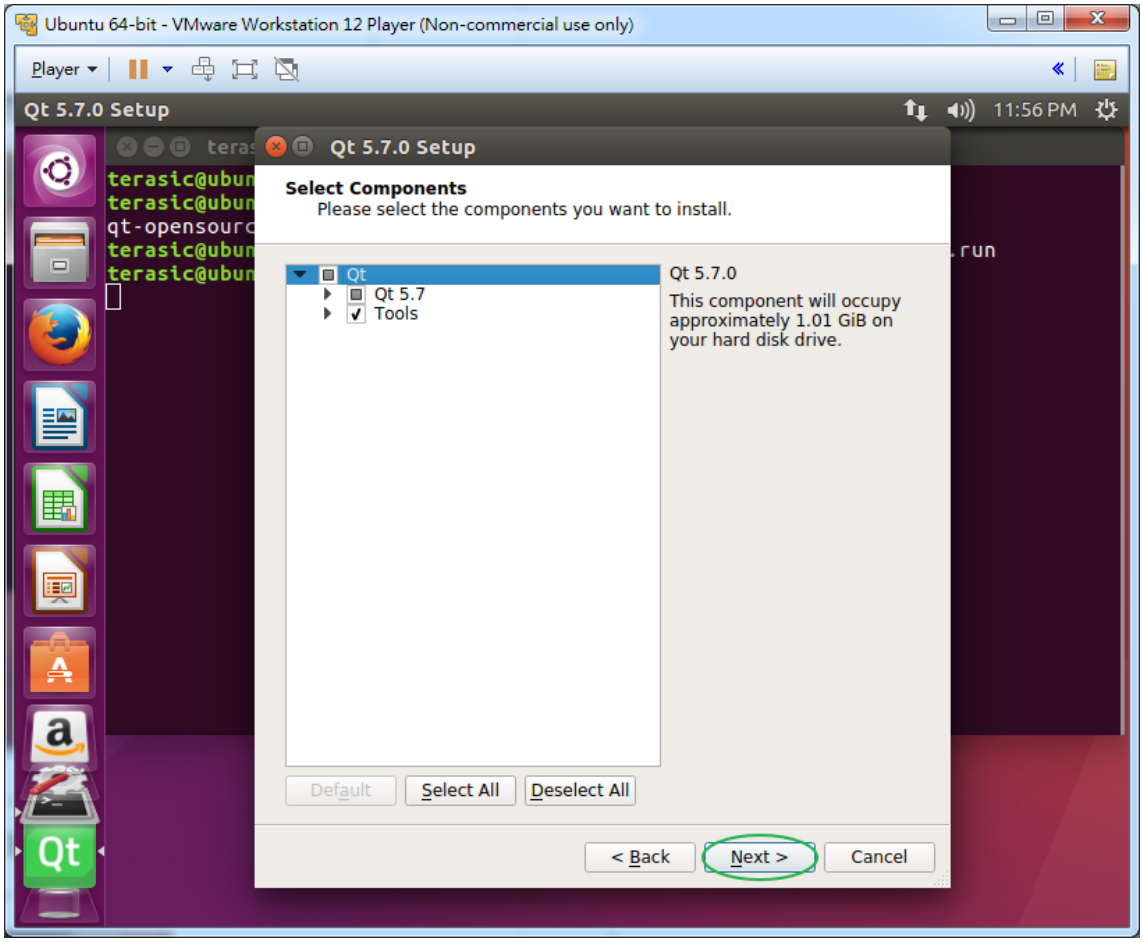

Figure 3-12 Select Components Dialog

In the **License Agreement** dialog, select a license and select the "I have read and agree ..." radio button. Click "Next >" to go to the next step, as shown in **Figure 3-13**

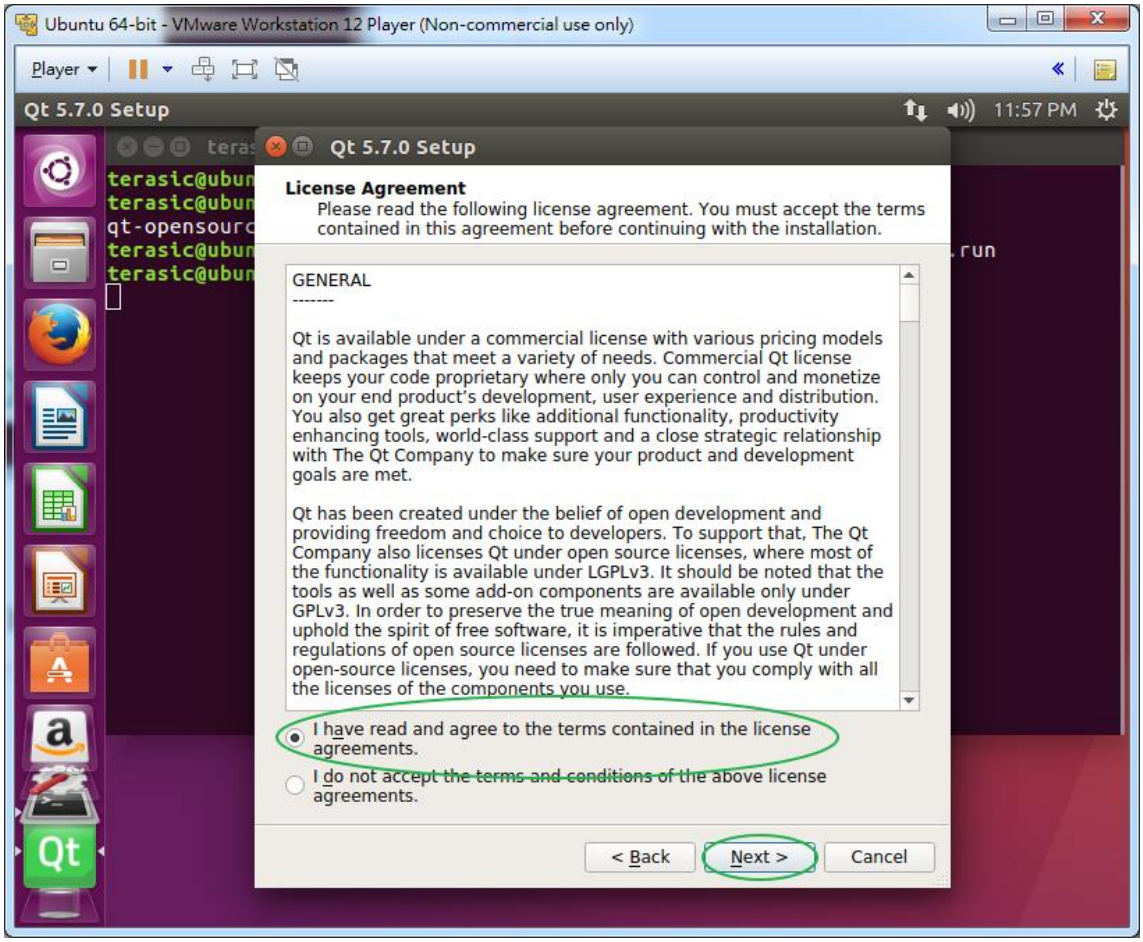

Figure 3-13 License agreement dialog of the Qt installer

In the **Ready to Install** dialog, as shown in **Figure 3-14,** click "Install" to go to the next step.

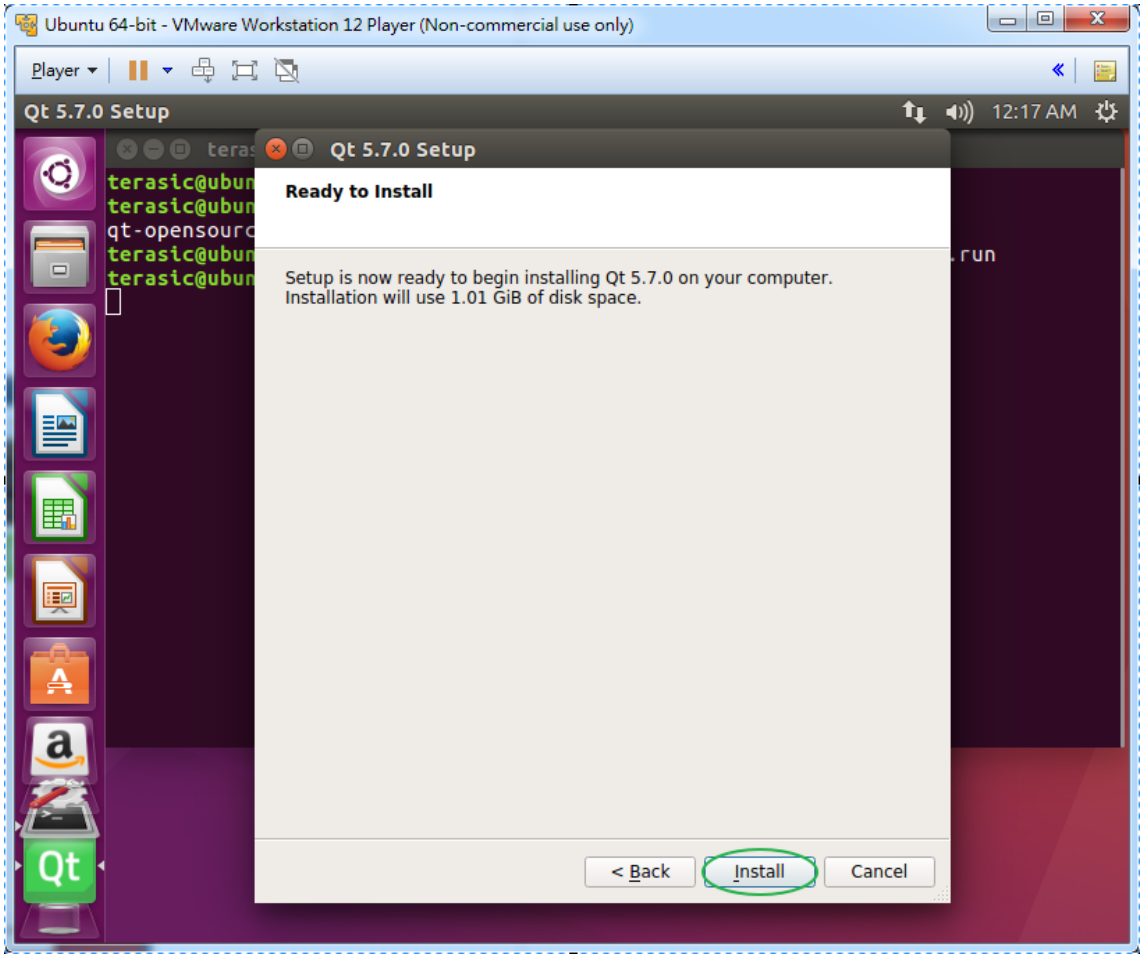

Figure 3-14 Ready to Install Dialog of Qt Installer

In the **Completing the Qt 5.7.0 Wizard** dialog, as shown in **Figure 3-15**, unselect "Launch Qt Creator" and click "Finish" to close the window.

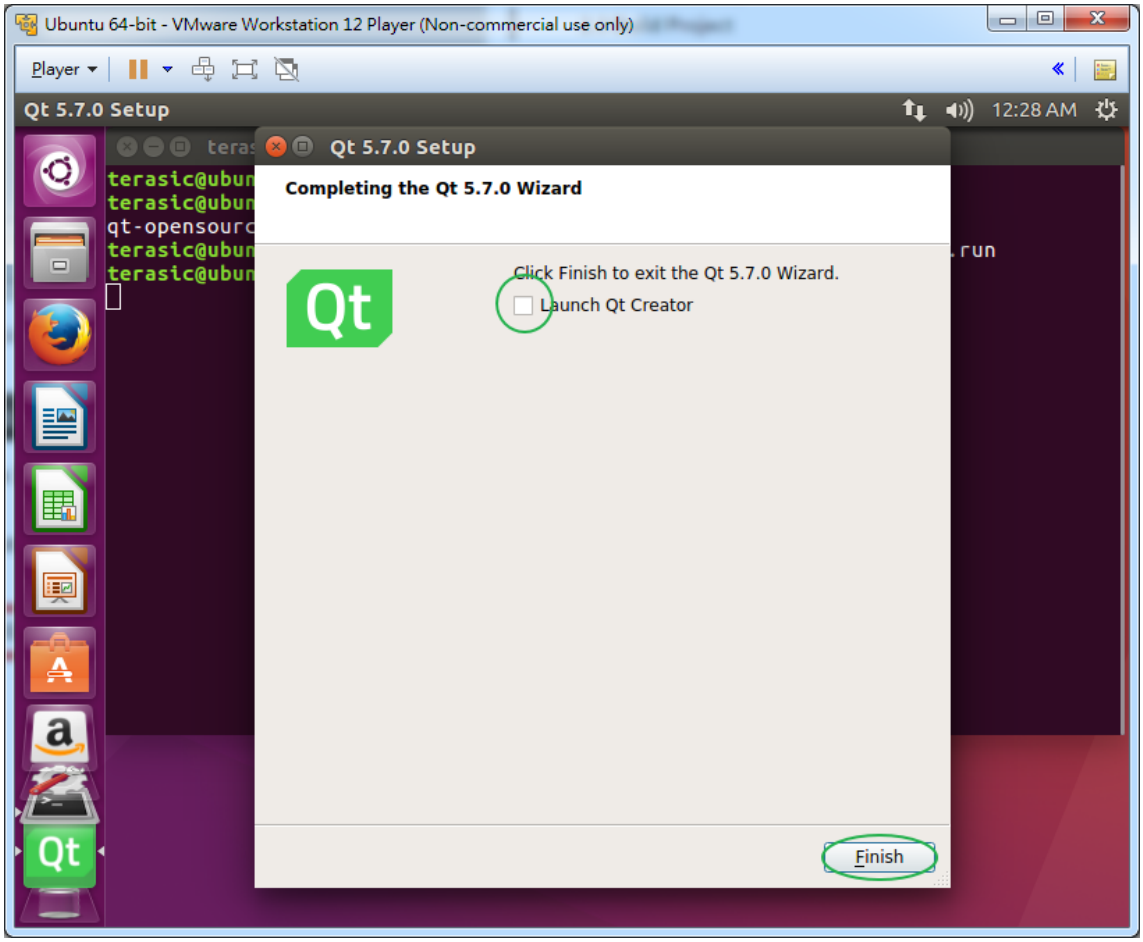

Figure 3-15 Completing Dialog of Qt Installer

3.3 Launch Qt Creator and Check Configure

This section describes how to launch Qt Creator in Linux and where to check its Build & Run configuration settings.

■ Launch Qt Creator

The Qt Creator program is located under \home\Qt5.7.0\Tools\QtCreator\bin as shown in **Figure 3-16**. To launch Qt creator, simply double click "qtcreator" program icon.

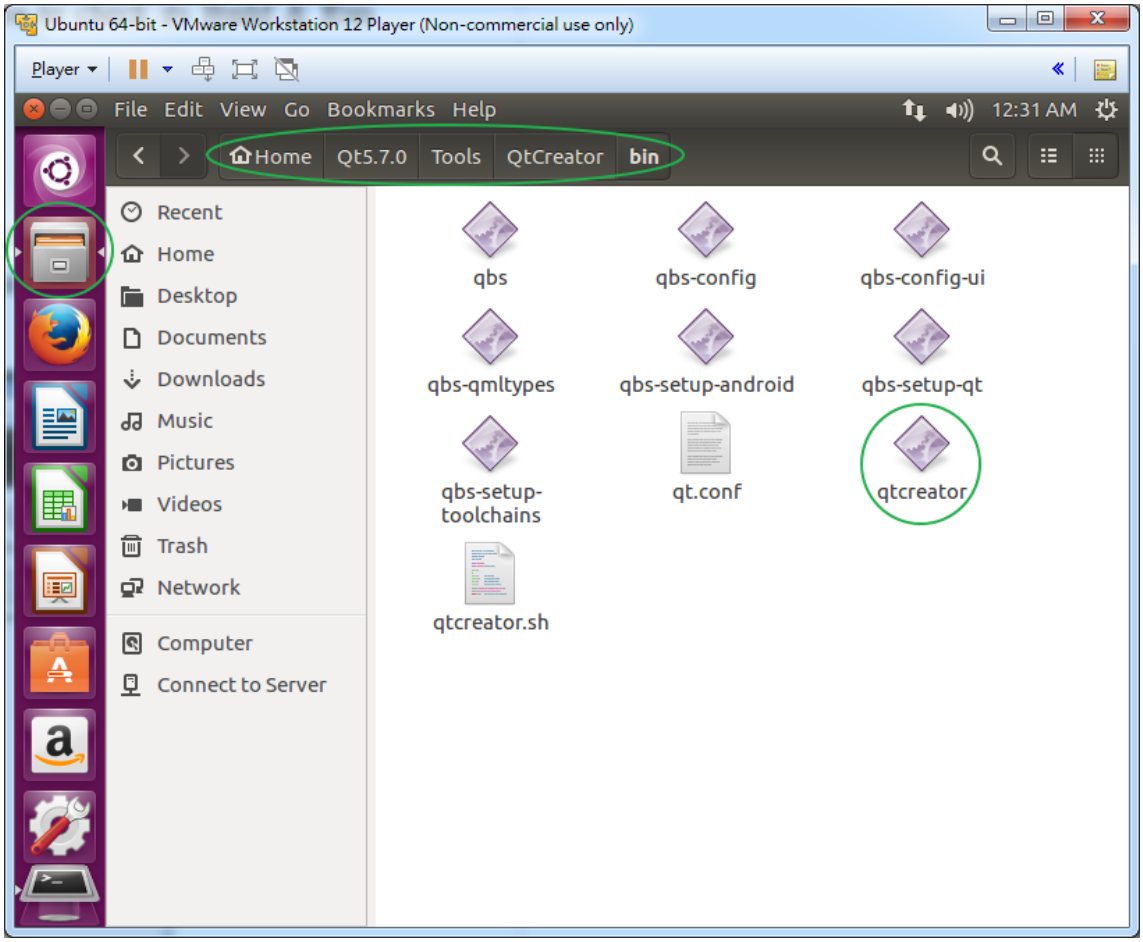

Figure 3-16 Launch Qt Creator

■ Check Build & Run Configuration Settings

When Qt Creator is launched, browse the menu and click "Tools→Options..." as shown in **Figure 3-17,** to open the Option dialog.

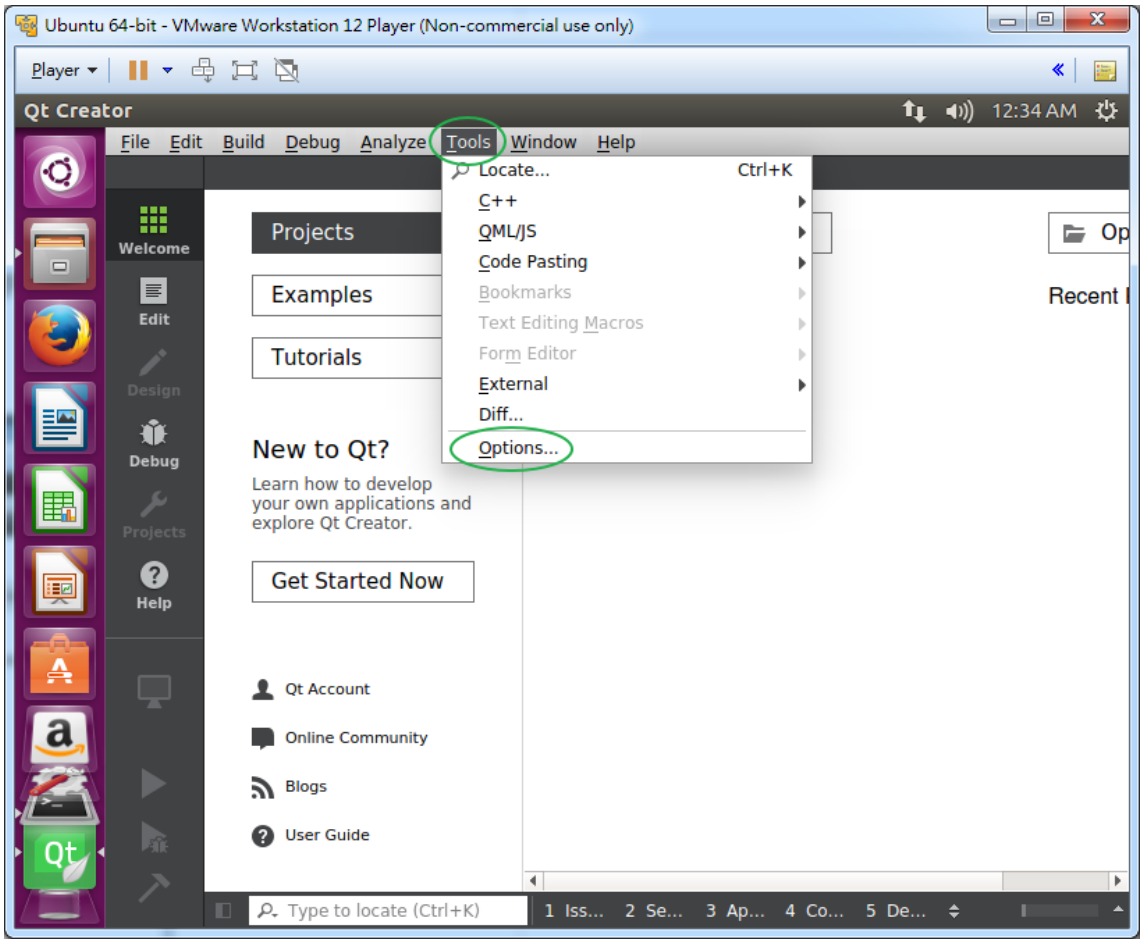

Figure 3-17 Open Option Dialog

In the **Options** dialog, first click "Build & Run" on the left and select the "Compilers" tab on the right to check if the "GCC" is detected as shown in **Figure 3-18**.

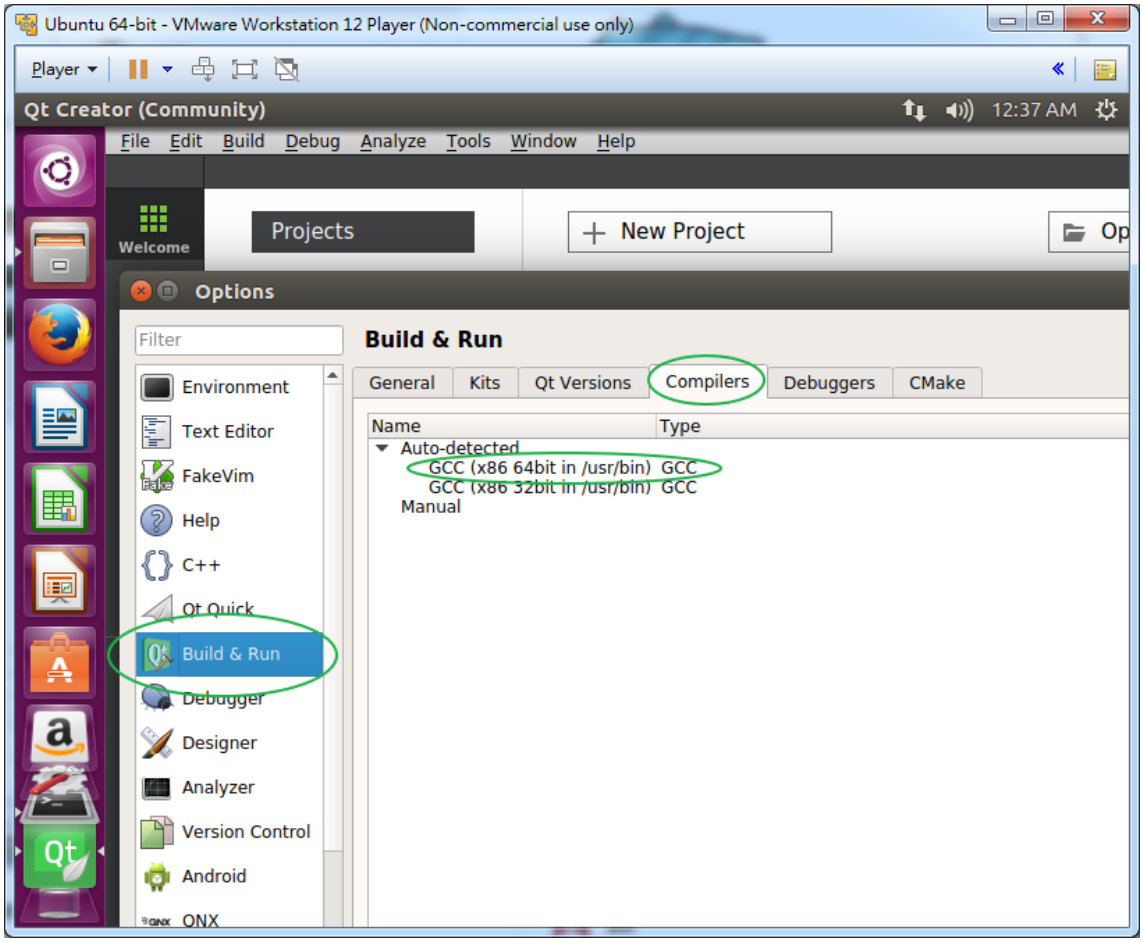

Figure 3-18 Compilers Options in Qt Creator

Next, select "Qt Versions" tab (to the left of the "Compilers" tab) to check if the "Qt 5.7.0 GCC 64bit" is detected as shown in **Figure 3-19**.

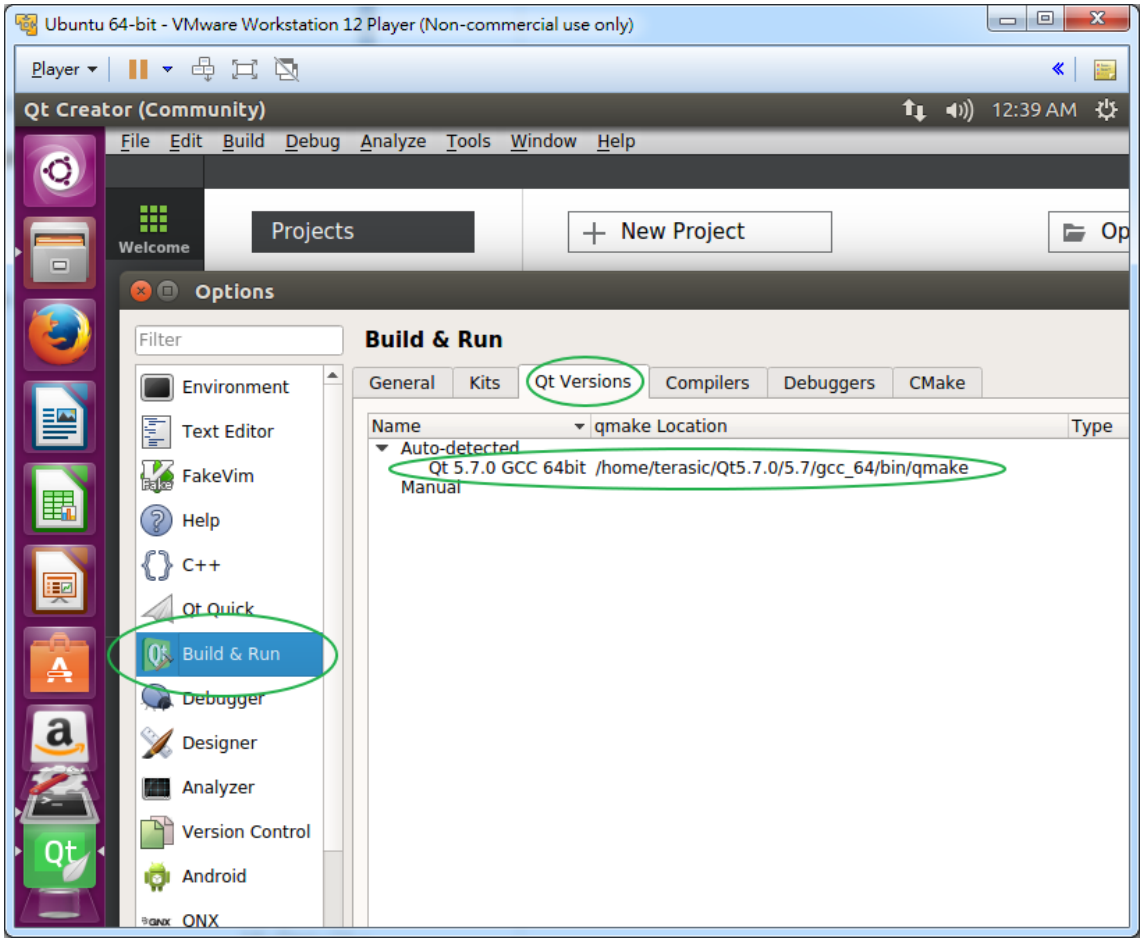

Figure 3-19 Qt Version Option in Qt Creator

Similarly, select "Kits" tab to check if the "Desktop Qt 5.7.0 GCC 64bit" is detected as shown in **Figure 3-20**.

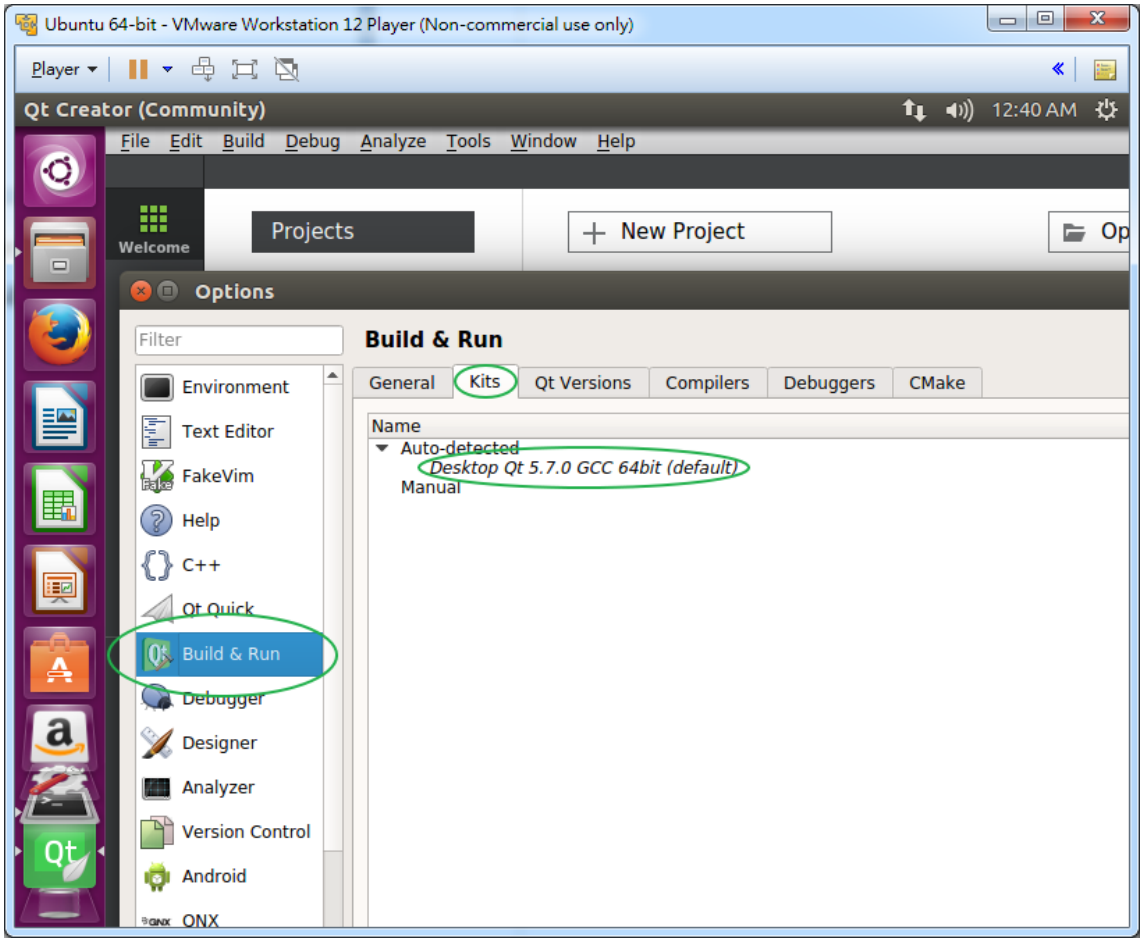

Figure 3-20 Kits Option in Qt Creator

Finally, click "OK" to close the dialog as shown in Figure 3-21.

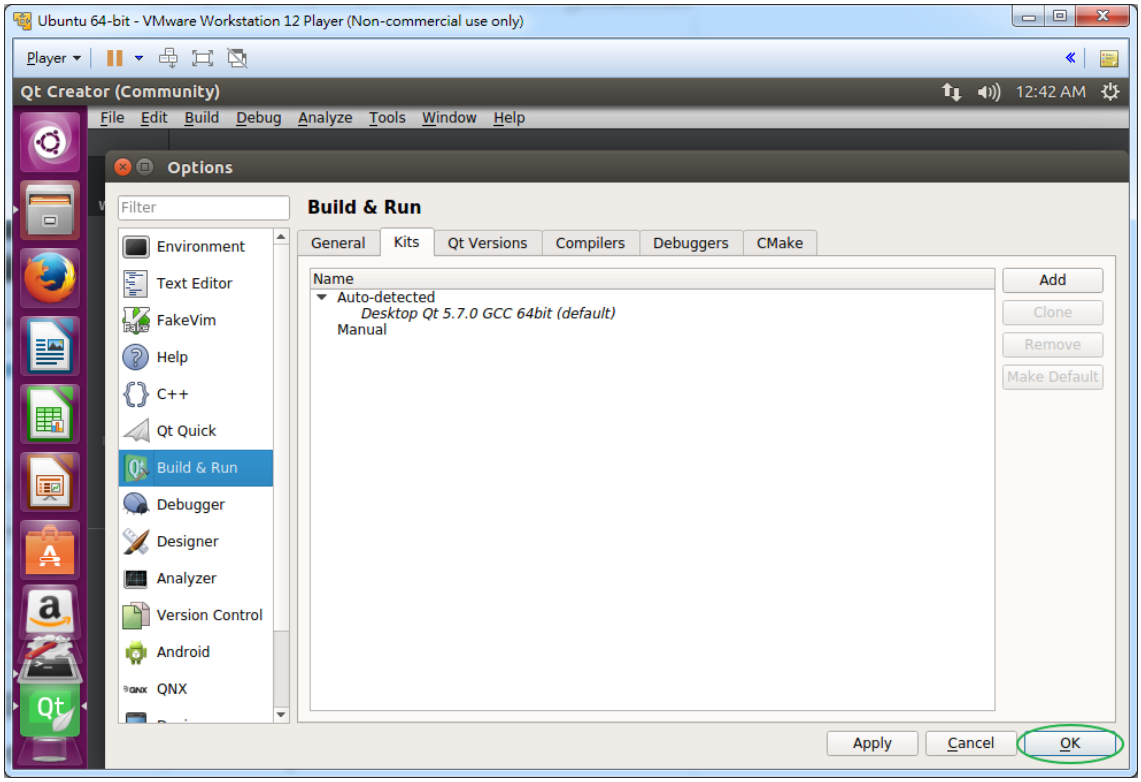

Figure 3-21 Click "OK" to Close Options Dialog

3.4 Hello Program

Now we are ready to create, build, and run our first program "Hello" in Qt Creator. Please follow carefully with the following instructions.

■ Create a New Project

After launching the Qt Creator, browse the menu and select item "File→New File or Project…" as shown in **Figure 3-22** to open a new dialog.

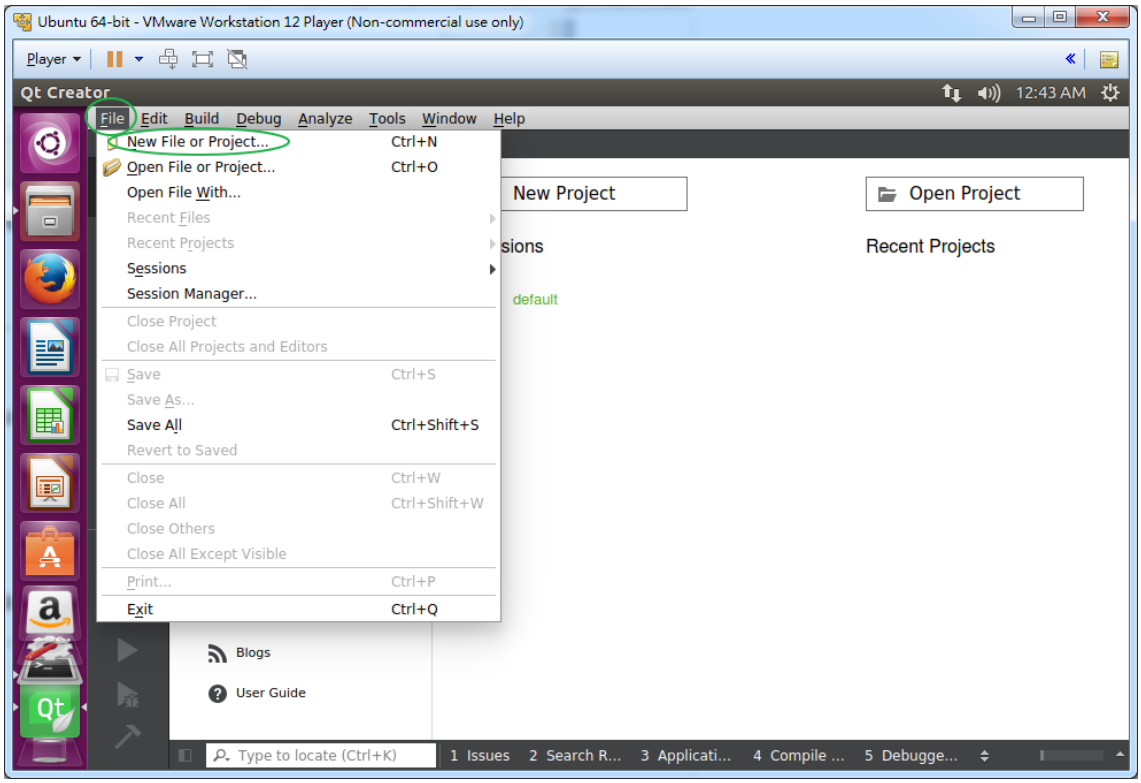

Figure 3-22 Open a New Project Dialog

In the **New** dialog, select "Applications" under Projects, and choose "Qt Widgets Application" as shown in **Figure 3-23**. Click "Choose…" to go to the next step.

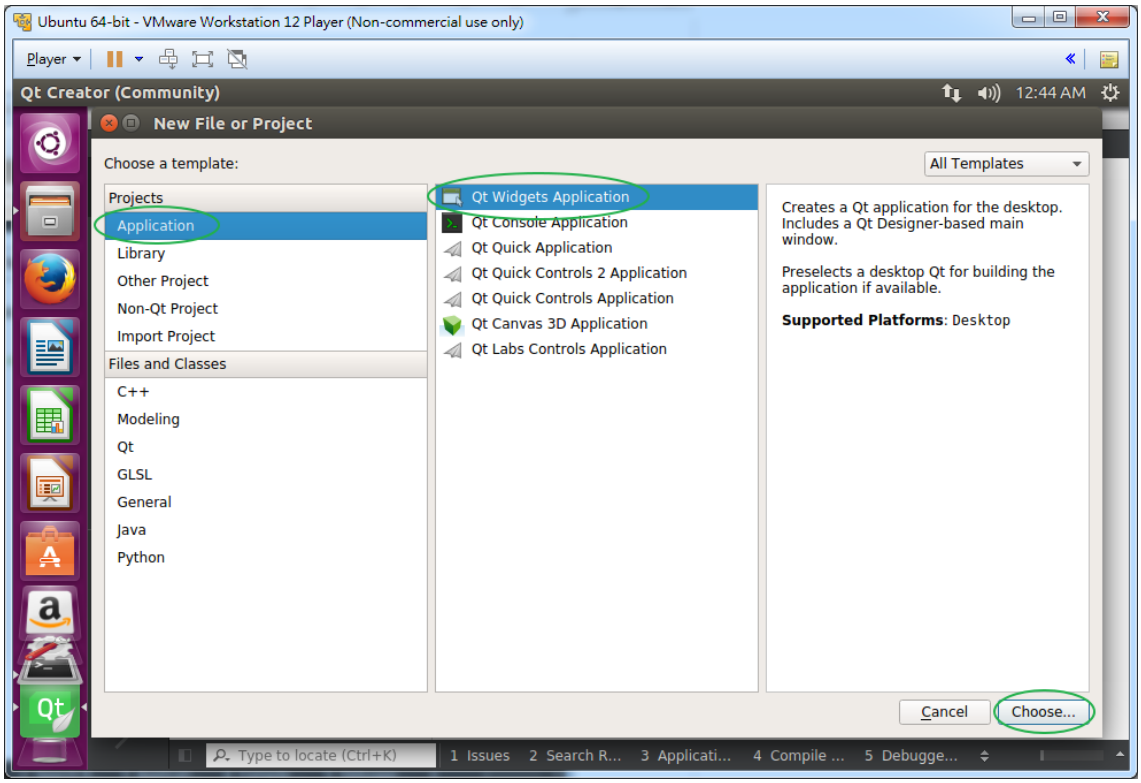

Figure 3-23 Dialog of Creating a New Project

In the **Qt Widgets Application** Dialog, specify the project name and project location, then click "Next >" as shown in **Figure 3-24**.

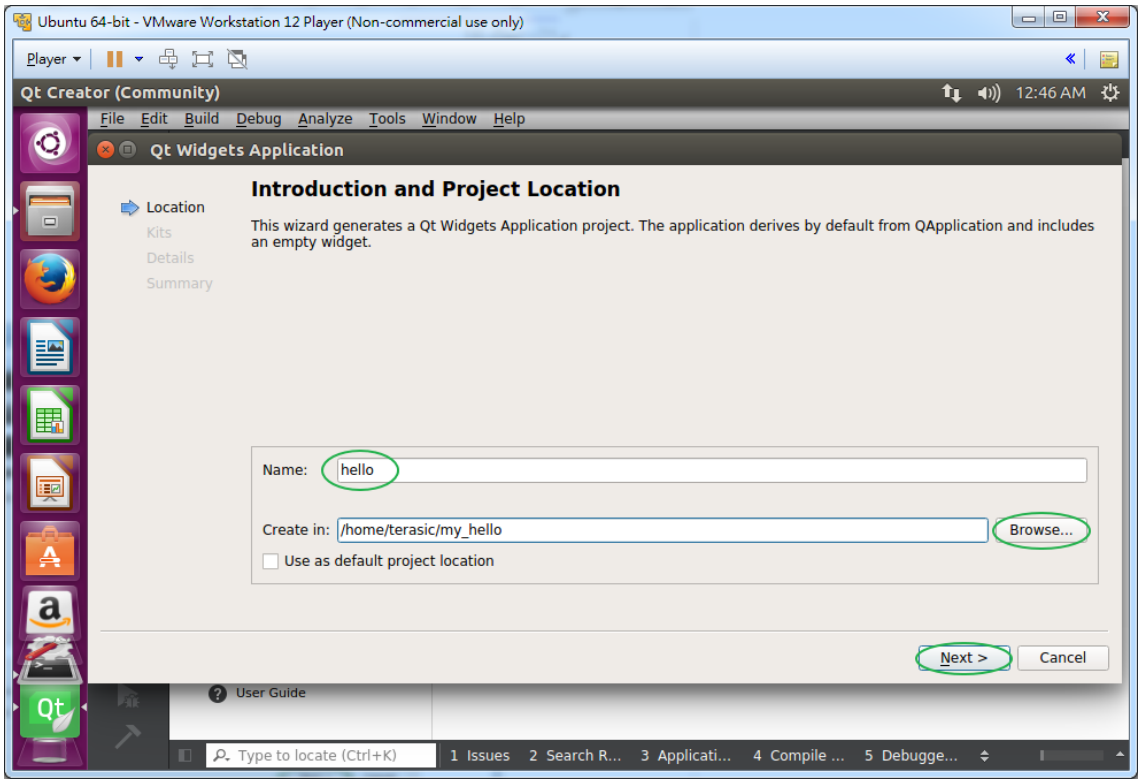

Figure 3-24 Project Name and Location Dialog

In the **Kit Selection** dialog, keep default settings and click "Next >" to go to next step as shown in Figure 3-25.

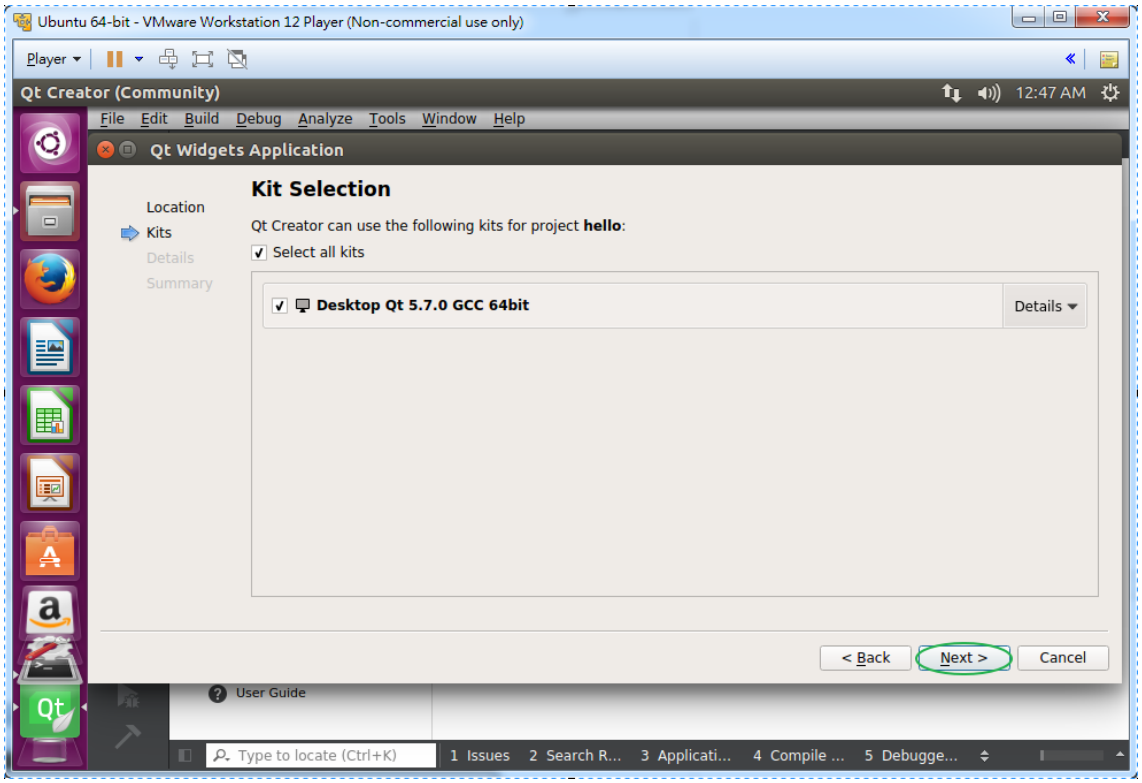

Figure 3-25 Kit Selection Dialog

In the **Class Information** dialog, click "Next >" as shown in **Figure 3-26** to proceed.

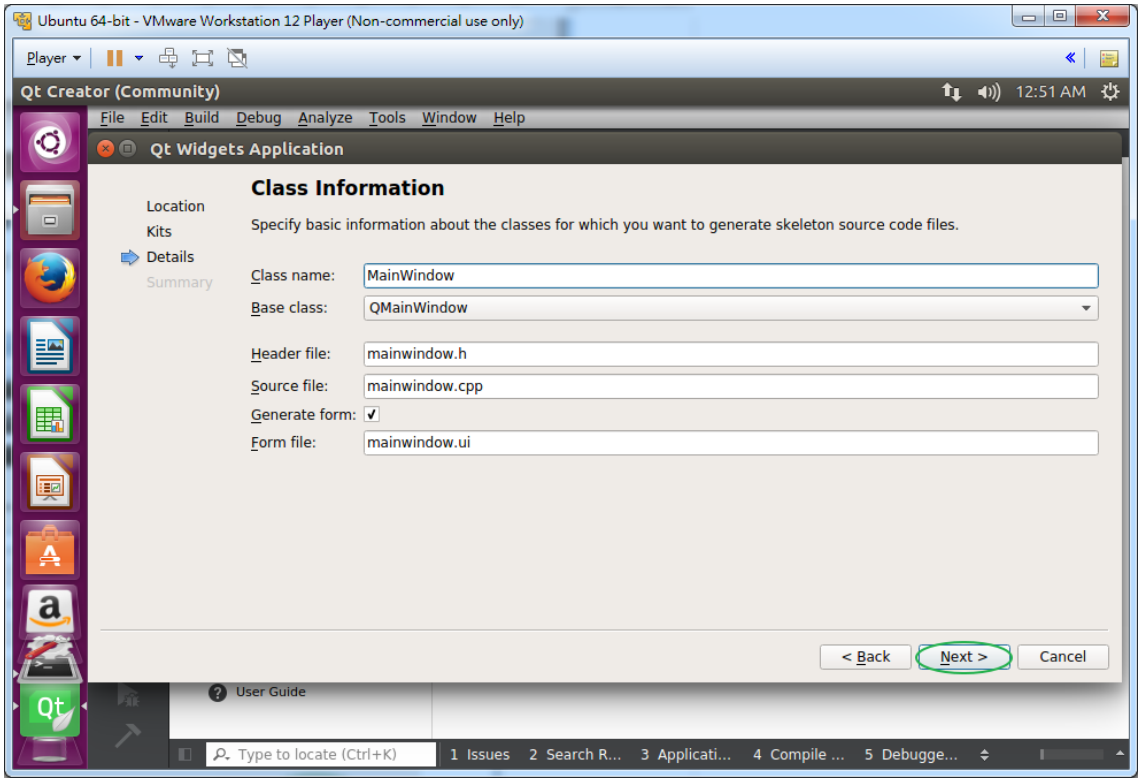

Figure 3-26 Class Information Dialog

In the **Project Management** dialog, click "Finish" as shown in **Figure 3-27** to proceed.

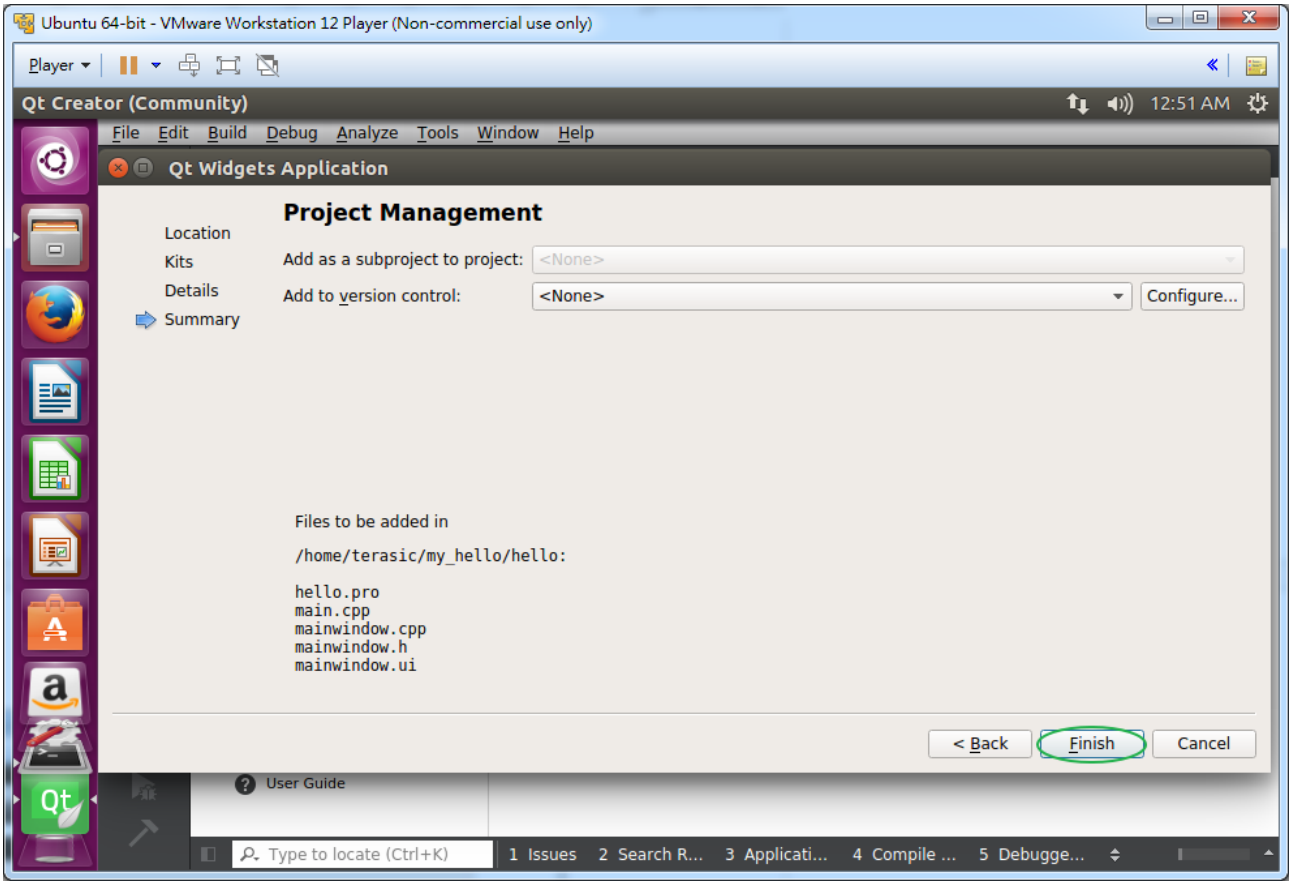

Figure 3-27 Final Dialog of Qt Widgets Application

Figure 3-28 shows the hello project now has been created and the mainwindow.cpp and main.cpp files are included in the Sources folder under the hello project.

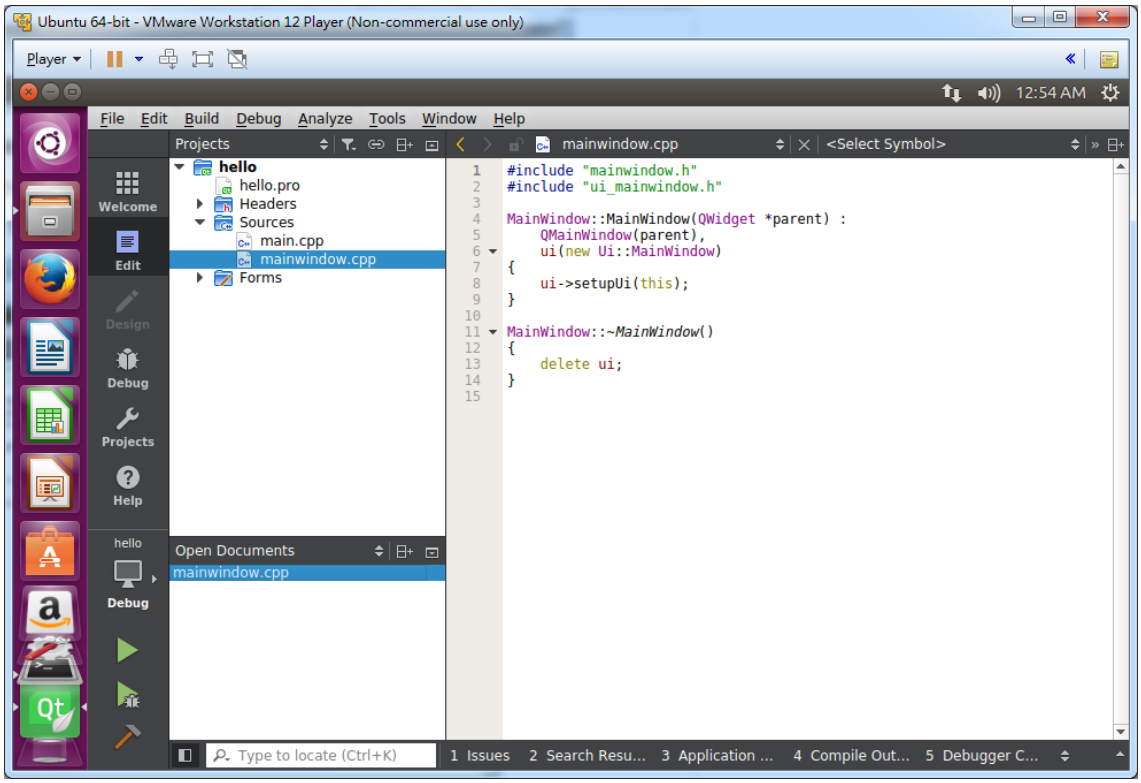

Figure 3-28 mainwindow.cpp of the Hello project

■ Build & Run

Click on the "Run" icon to build and run the Hello program. The GUI program should appear as shown in **Figure 3-29**.

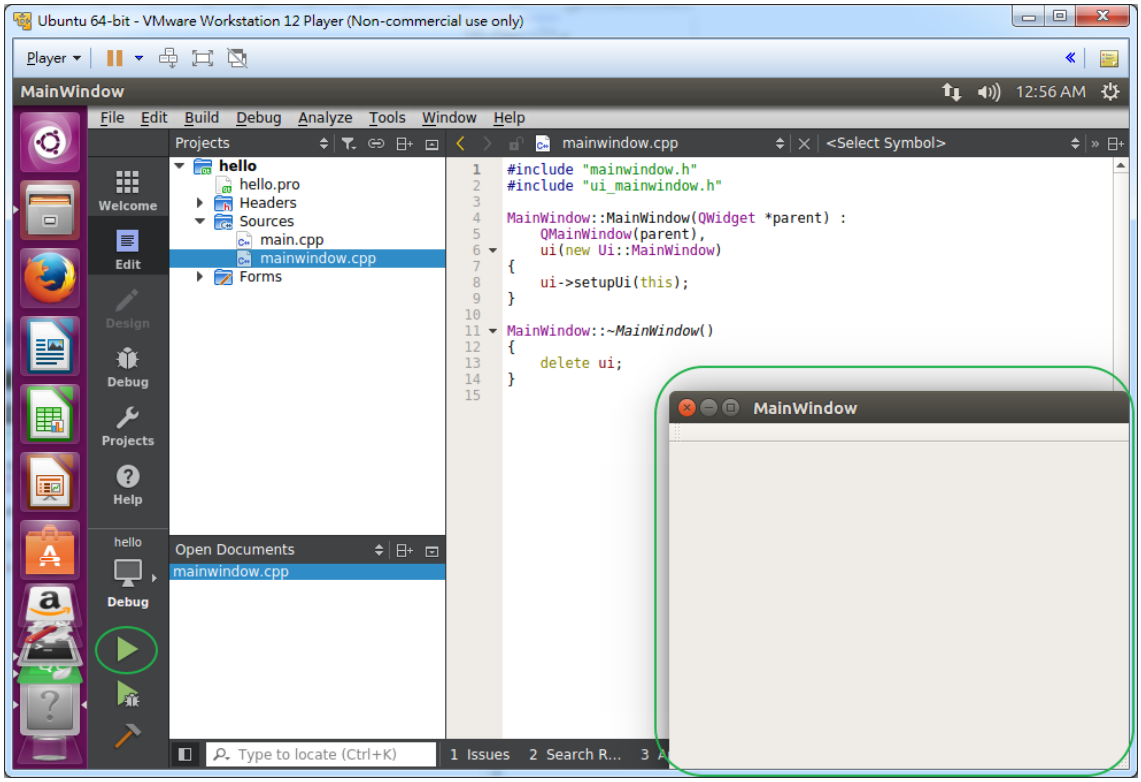

Figure 3-29 Run Hello Program

Chapter 4

Intel SoC Toolchain Installation

Linaro ARM cross compiler toolchain is required while building the Qt application for the Intel SoC ARM on the Linux x64. In this chapter, we show the users steps needed to install the Linaro ARM cross compiler toolchain. Here is a quick look of the 2 simple steps performed on Linux x64:

- Download the Linaro ARM cross compiler toolchain and extract the file
- Include Toolchain path into the system environment variable $PATH

4.1 Download and Install Toolchain

Launch Linux terminal on the Linux x64 (CTRL+ALT+T) and execute the following commands to download and extract the Linaro ARM cross compiler toolchain,

```
$ cd ~
$ wget -c https://releases.linaro.org/components/toolchain/binaries/\
5.2-2015.11-2/arm-linux-gnueabihf/gcc-linaro-5.2-2015.11-2-x86_64_arm-linux-gnueabihf.tar.xz
$ tar xvf gcc-linaro-5.2-2015.11-2-x86_64_arm-linux-gnueabihf.tar.xz
```

Figure 4-1 shows the screenshot of toolchain download progress after typing in the wget command. It will take about 10 minutes to download the file.

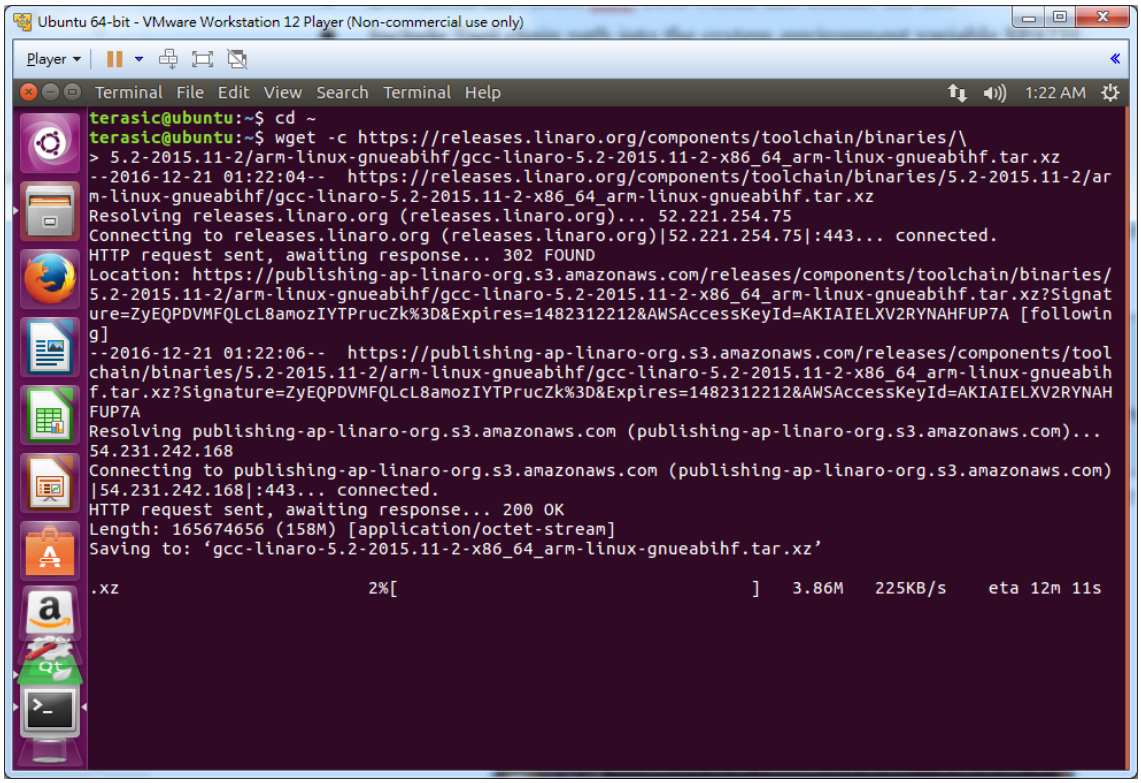

Figure 4-1 Linaro ARM cross compiler toolchain Download Progress

The downloaded file is in the compressed format, so we need to decompress it before we can use it. Figure 4-2 shows the screenshot after toolchain download has been finished and has been extracted by the **tar** command. After extraction, the toolchain is located in the folder "~/gcc-linaro-5.2-2015.11-2-x86_64_arm-linux-gnueabihf"

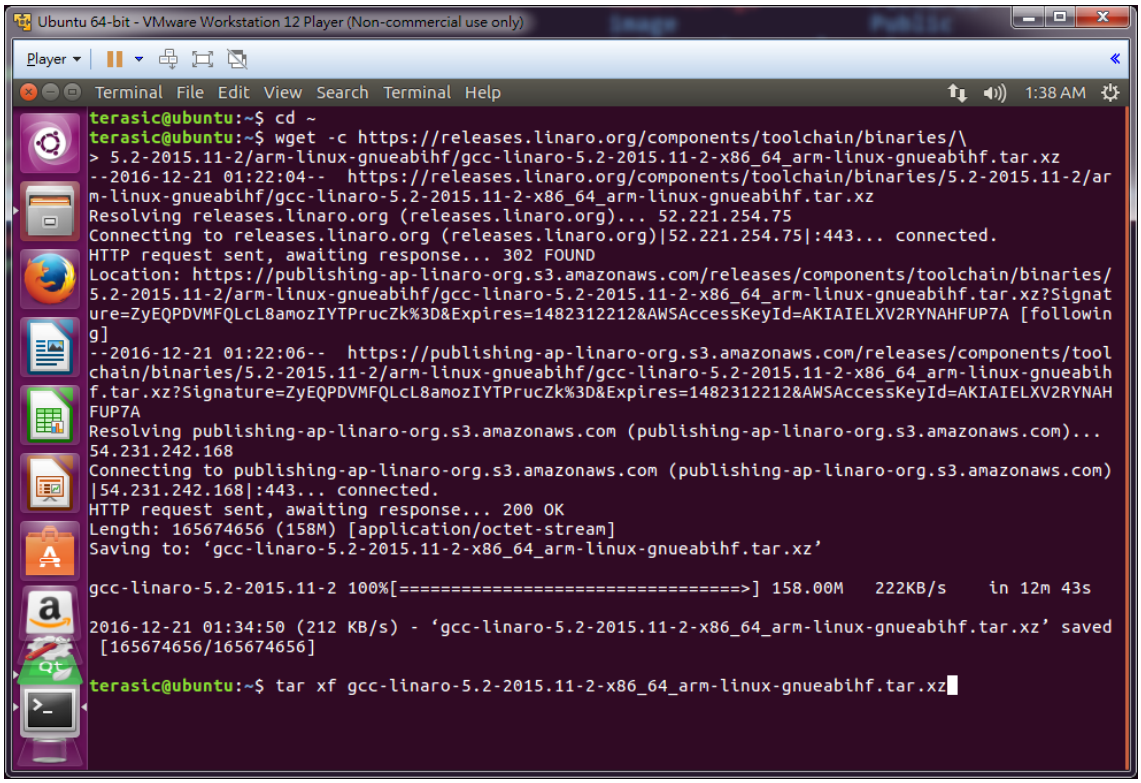

Figure 4-2 Toolchain Download Finished and Extracted by the Tar Command

4.2 Setup Toolchain Path

Now, the toolchain path needs to be defined and added into the system variable **$PATH**. We use the system editor tool **gedit** to add the path. Please refer to the following for more details to set up the toolchain path.

Launch terminal (CTRL+ALT+T) and type in the following command to edit the personal initialization file "~/.bashrc"

```
$gedit ~/.bashrc
```

Figure 4-3 shows the screenshot that the "~/.proifle" opened by gedit. Please add the following line,

```
export PATH=~/gcc-linaro-5.2-2015.11-2-x86_64_arm-linux-gnueabihf/bin:$PATH
```

to the **end** of the initialization file. Click "save" icon to save the file followed by clicking "close" icon (red circle with a x on the upper left corner) to terminate gedit tool.

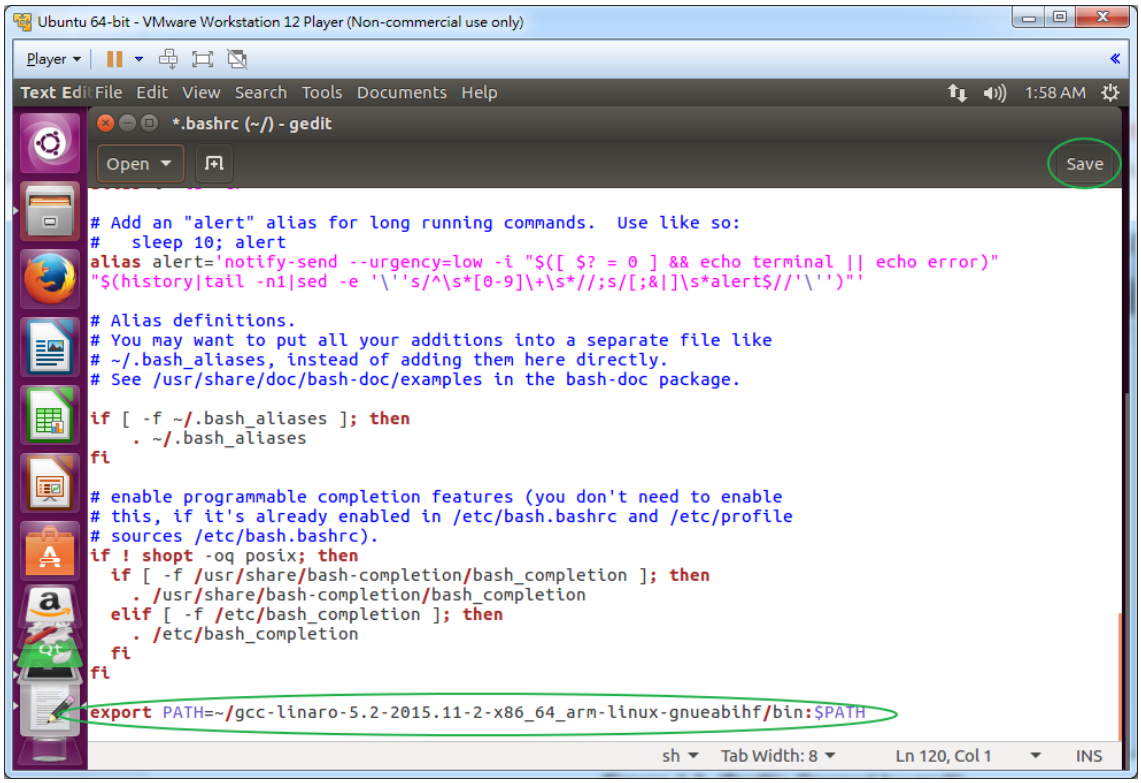

Figure 4-3 .bashrc Opened by gedit

In order for the path setting to take effect immediately, please type in "source ~/.bashrc" in the terminal or restart the OS.

Chapter 5

Qt Library Installation for Intel SoC

Up to now, you should have successfully installed the Linaro ARM cross compiler toolchain in the Linux x64 system. Now we install prebuilt Qt library for Intel SoC ARM on the Linux x64.

Here is a quick look at the 2 simple steps performed on Linux x64:

- Copy prebuilt Qt library from System CD
- Decompress prebuilt Qt library

5.1 Copy Prebuilt Qt Library from System CD

■ Copy prebuilt Qt library to Shared Folder

The prebuilt Qt library is located on the System CD:

```
\Demonstrations\SoC_FPGA\ControlPanel\bin\qt5.5.1_for_intel_soc.tar.gz
```

Copy the prebuilt Qt library compressed file from the System CD to the shared folder, which is specified as in **Figure 2-39**, on Windows host. on Windows host. Then, launch the "Ubuntu 64-bit" virtual machine. After logging in Linux x64, launch a terminal (CTRL+ALT+T) and type the following command to go to the shared folder on Linux x64:

```
$cd /mnt/hgfs/shared
```

to go to the shared directory on Linux.

Now type in

```
$ ls
```

To see the "qt5.5.1_for_intel_soc.tar.gz" file, as shown in **Figure 5-1.**

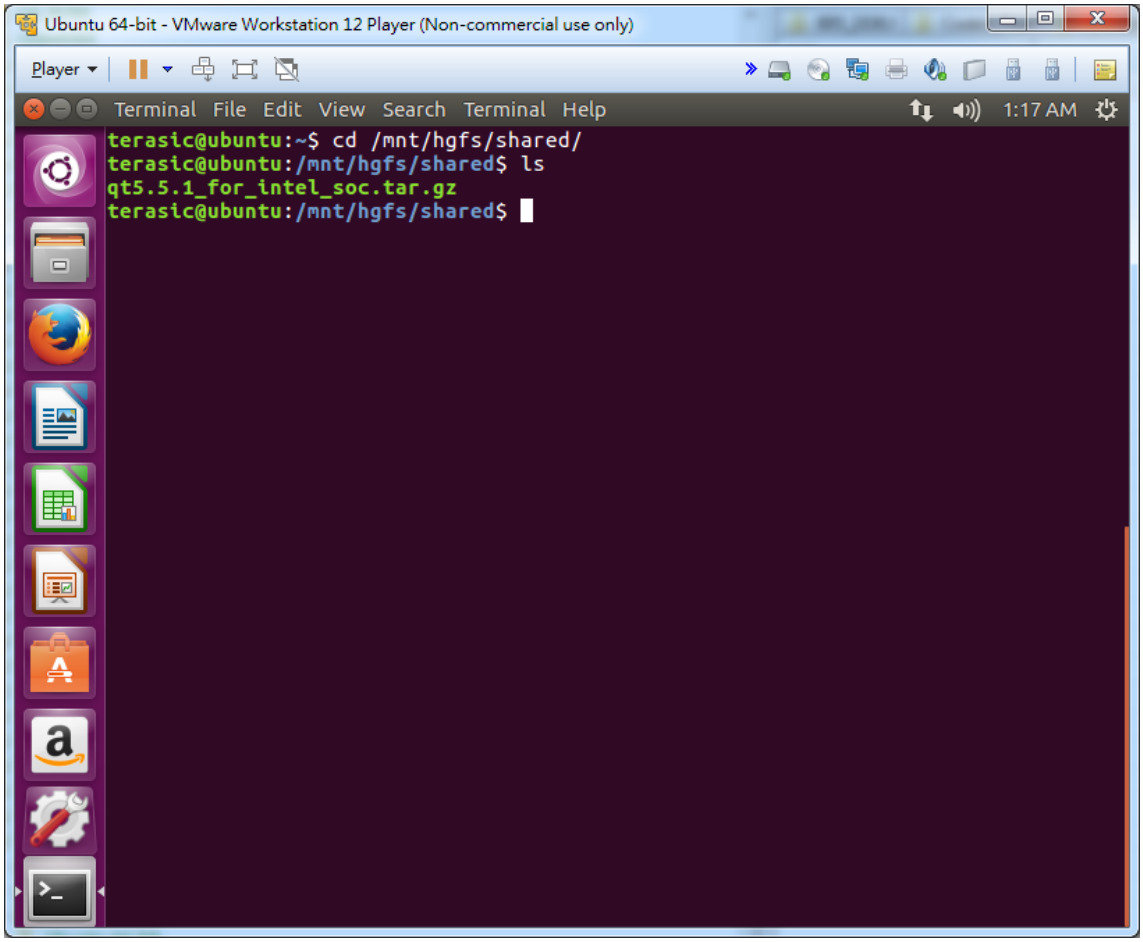

Figure 5-1 'qt5.5.1_for_intel_soc.tar.gz' File of Prebuilt Qt Library

5.2 Install Prebuilt Qt Library

■ Decompress Prebuilt Qt Library to System Path

After copy prebuilt Qt library to the shared folder, we need to install prebuilt Qt library to system path.

In the terminal, type the following command and press ENTER.

```
$ sudo tar zxvf qt5.5.1_for_intel_soc.tar.gz -C /opt
```

The system will prompt users to input a password. Please input your password (in this tutorial, the password is "123") and press ENTER as shown in **Figure 5-2**.

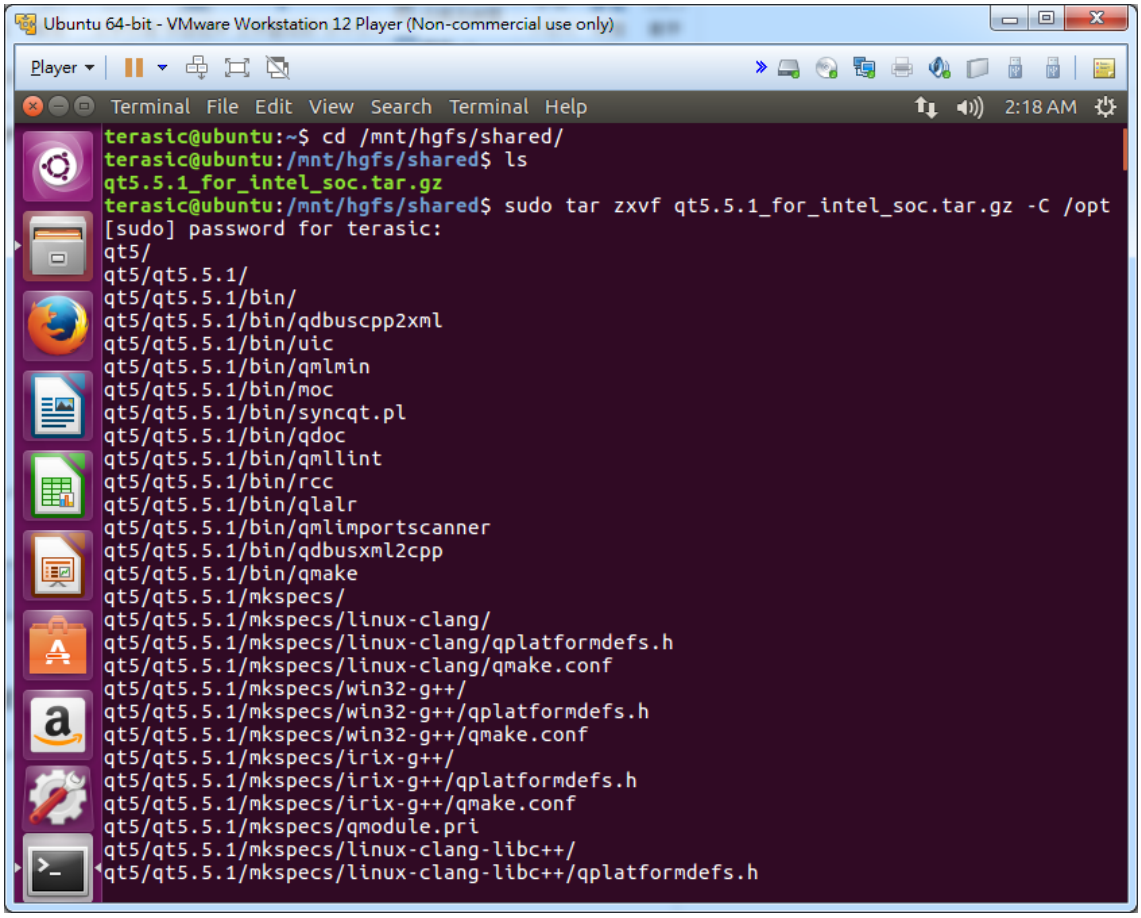

Figure 5-2 Decompress Prebuilt Qt Library

Chapter 6

Qt App for Intel SoC

Chapter 6 describes how to cross-compile the Hello project we created back in chapter 3, such that the hello program can run on the target platform –VEEK-MT2S FPGA development board in this tutorial. Here we assume that Intel SoC toolchain and Qt library for Intel SoC FPGA development board have been successfully installed and are now available on the system.

Here is a quick look of the 3 simple steps:

- Set up "Build & Run" in Qt Creator
- Cross-compile the Hello project
- Execute Hello program

6.1 Set up "Build & Run" in Qt Creator

■ Compiler Setup

First launch the Qt Creator, and select the menu item "Tools→Options…" as shown in **Figure 6-1** to open the **Option** dialog.

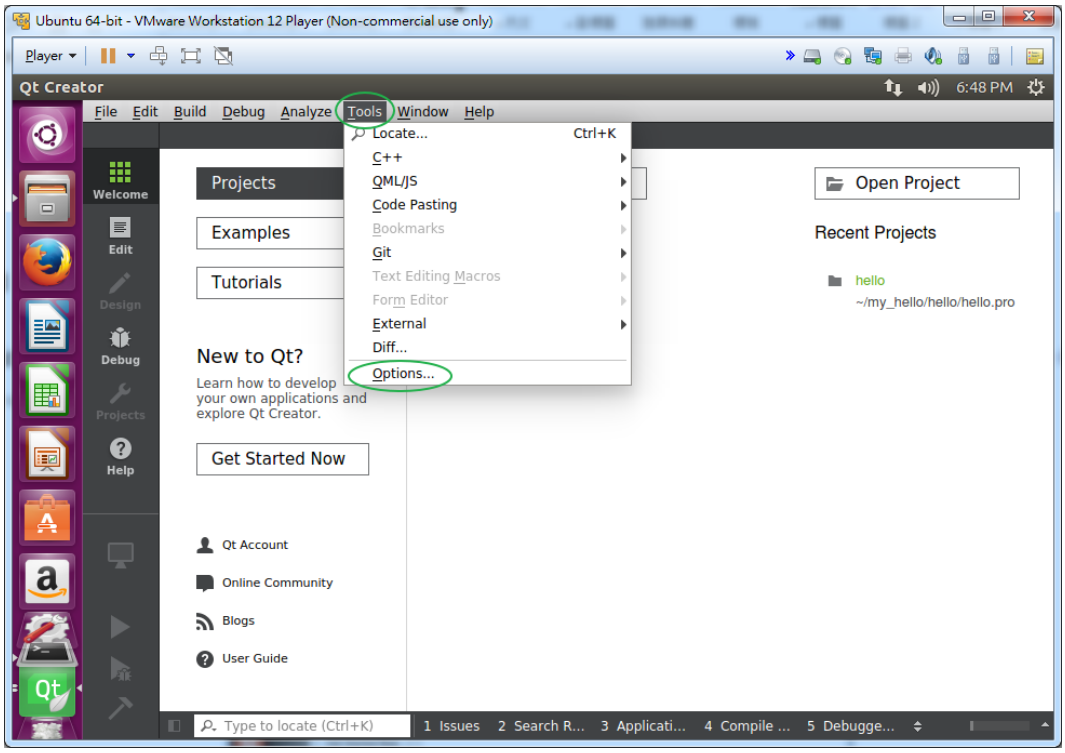

Figure 6-1 Open Option Dialog

To add the "GCC" compiler, in the Option dialog, select "Build & Run" item on the left and then select "Compilers" tab. Now you can select "GCC" item from the "Add" pull down menu as shown in **Figure 6-2**.

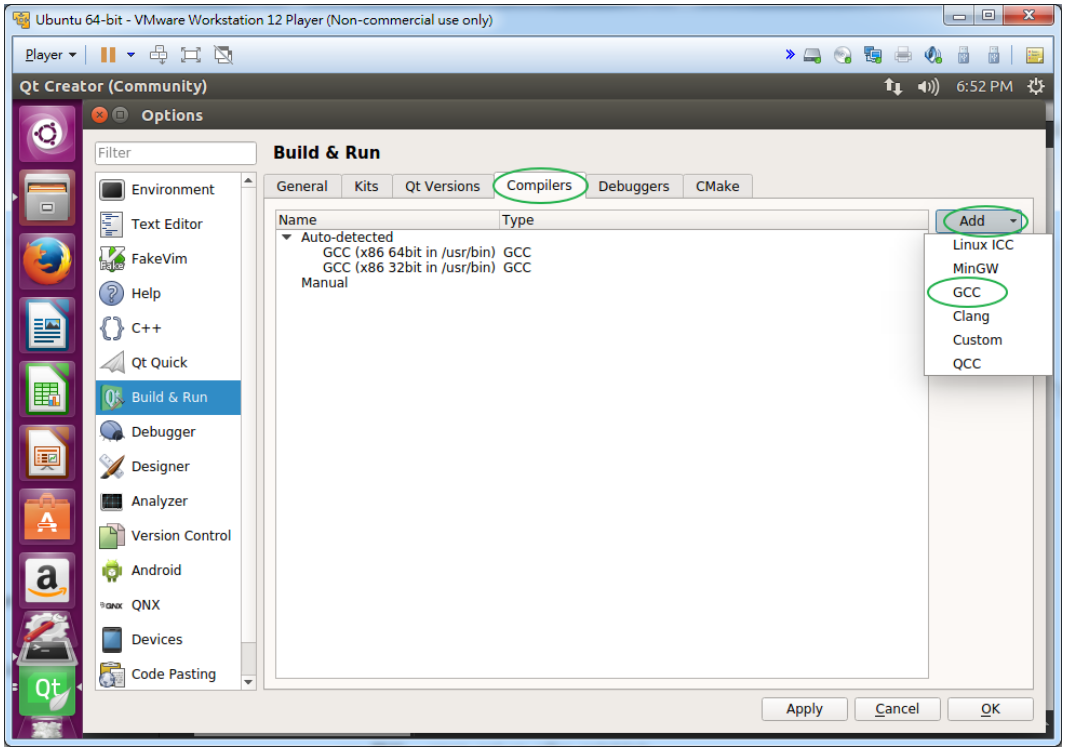

Figure 6-2 Add GCC Compiler

Next, you need to specify the GCC compiler details. First, please type in "GCC (Intel SoC)" in the Name option box and click "Browse…" to select the location of the compiler of Intel SoC ARM. The compiler is located at "/home/**terasic**/ gcc-linaro-5.2-2015.11-2-x86_64_arm-linux-gnueabihf/bin/arm-linux-gnueabihf-g++". Note that in the path string, you should replace "terasic" with your linux user name. Then click "Apply" to finish the **Compiler** setup as shown in **Figure 6-3**.

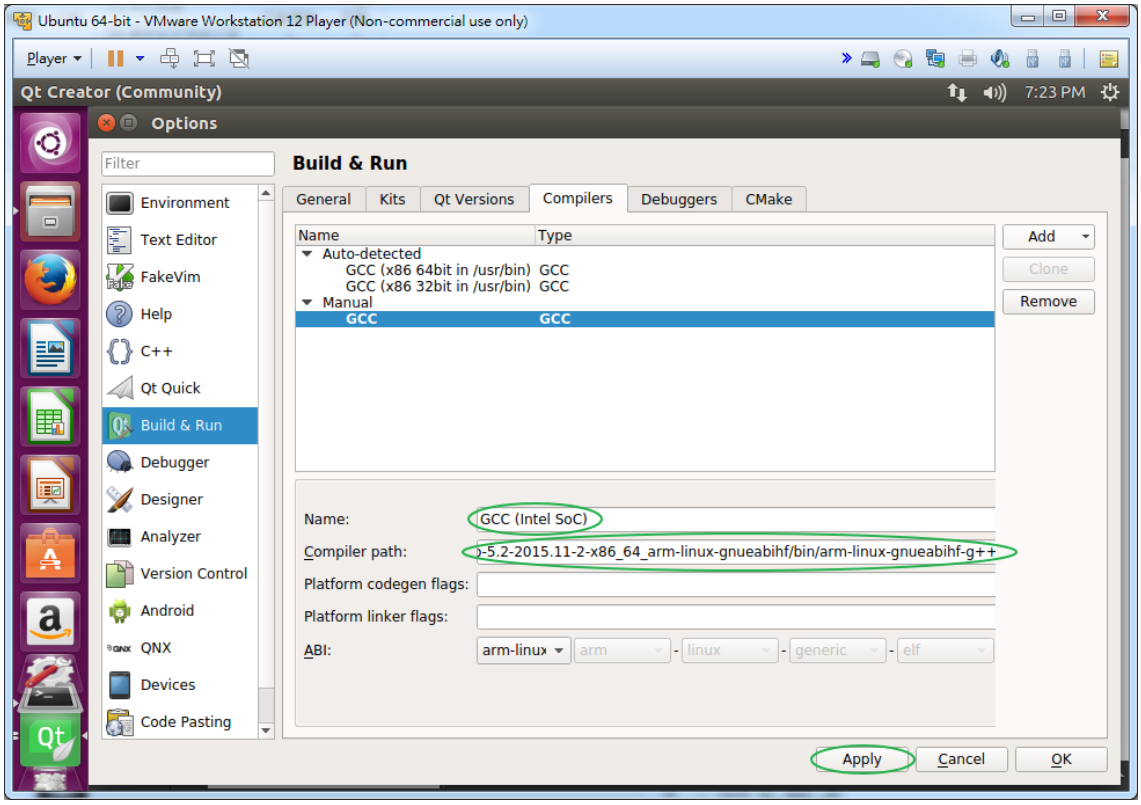

Figure 6-3 Specify Compiler Name and Path

■ Qt Verisons Setup

To add Qt Versions, first click on the "Qt Versions" tab and click "Add" as shown in **Figure 6-4**. When an **Open File** dialog appears to ask the location of qmake executable, please specify the location as: "**/opt/qt5/qt5.5.1/bin/qmake**".

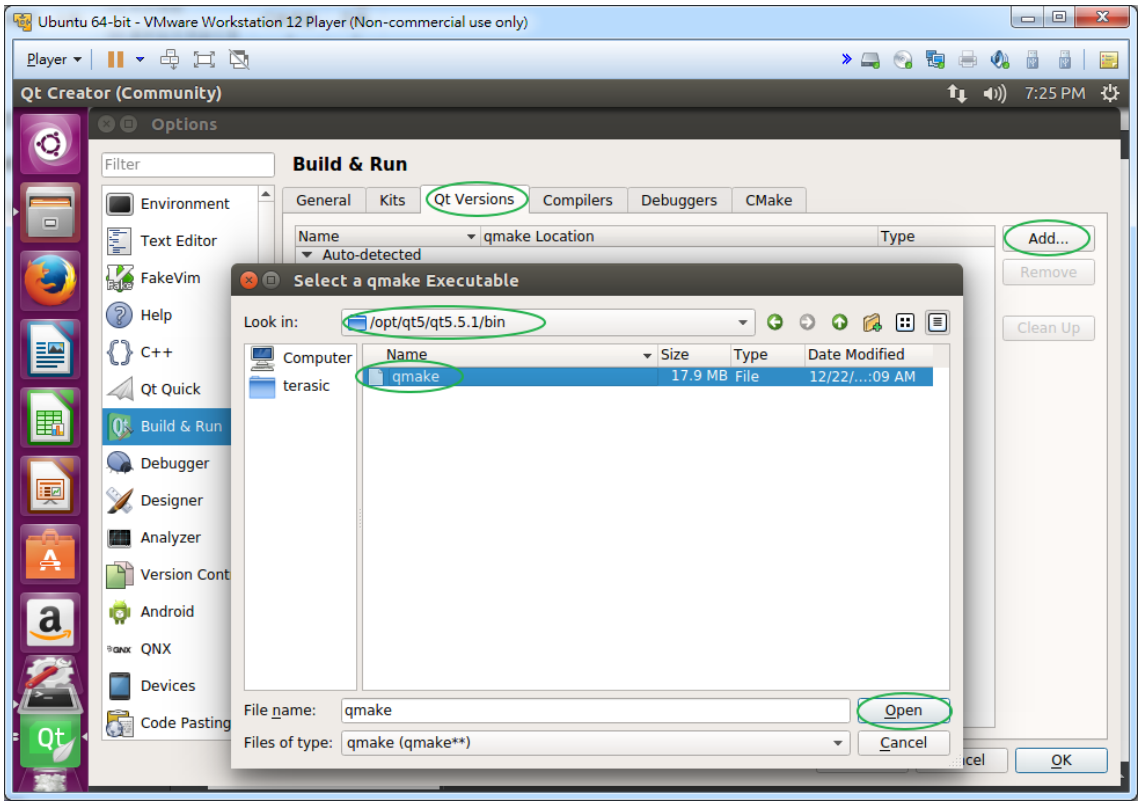

Figure 6-4 Add Qt Version

Finally, click "Apply" to complete the **Qt Versions** setup as shown in **Figure 6-5**.

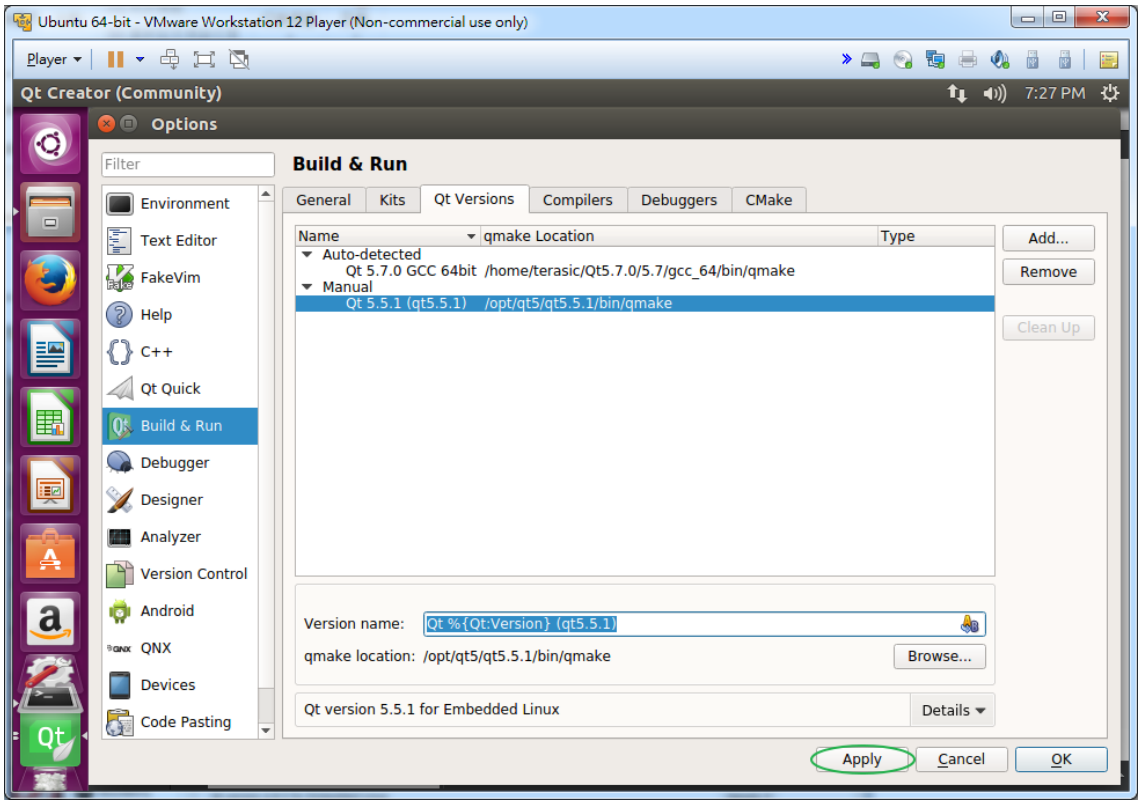

Figure 6-5 Apply the Qt Version

■ Kits Setup

To add Kits, first click on the "Kits" tab and click on "Add" as shown in **Figure 6-6**. Specify the kit detail as below:

- Name: Intel SoC FPGA Kit
- Device Type: Select "Generic Linux Device"
- Compiler: Select "GCC (Intel SoC)"
- Qt Version: Select "Qt 5.5.1 (qt5.5.1)"

Then, click "Apply" to finish **Kits** setup and click "OK" to finish Options setup.

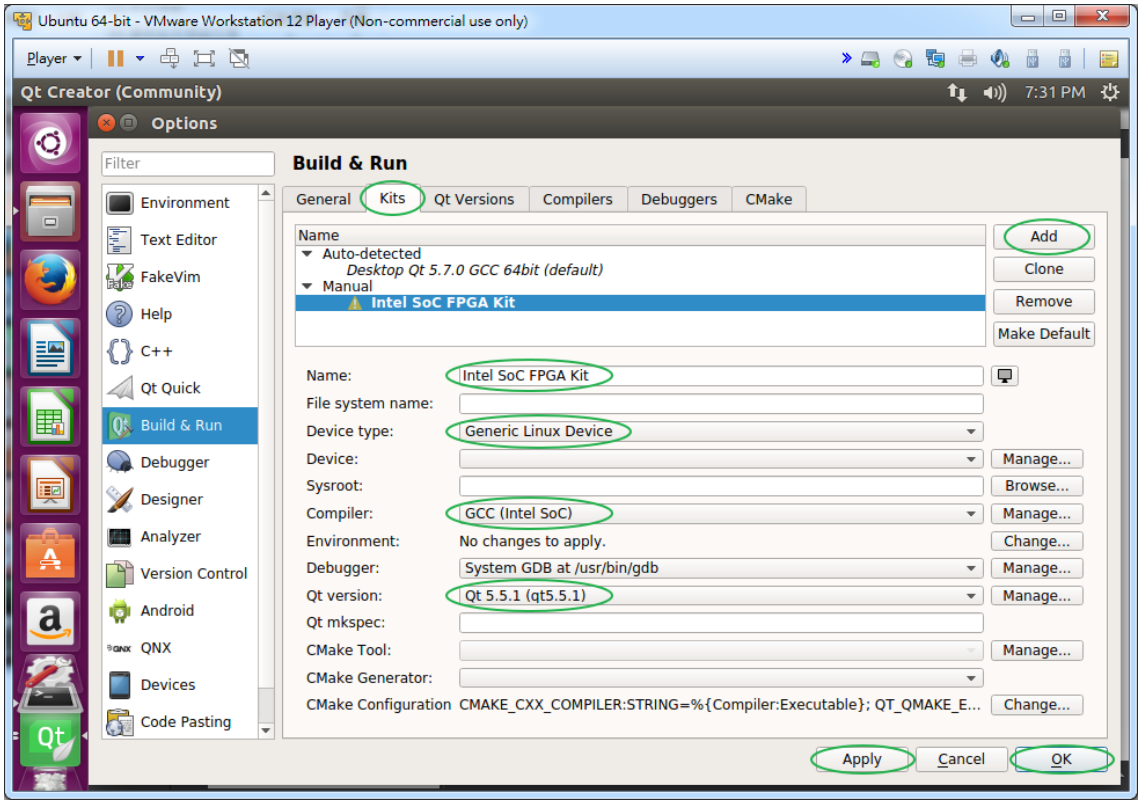

Figure 6-6 Add Intel SoC FPGA Kit

6.2 Cross-Compile the Hello Project

Now, after properly setting up "Build & Run" settings, we are ready to cross-compile the Hello project. First, please launch the Qt Creator, and select the menu item "File→Recent Projects" to open the hello project as shown in Figure 6-7.

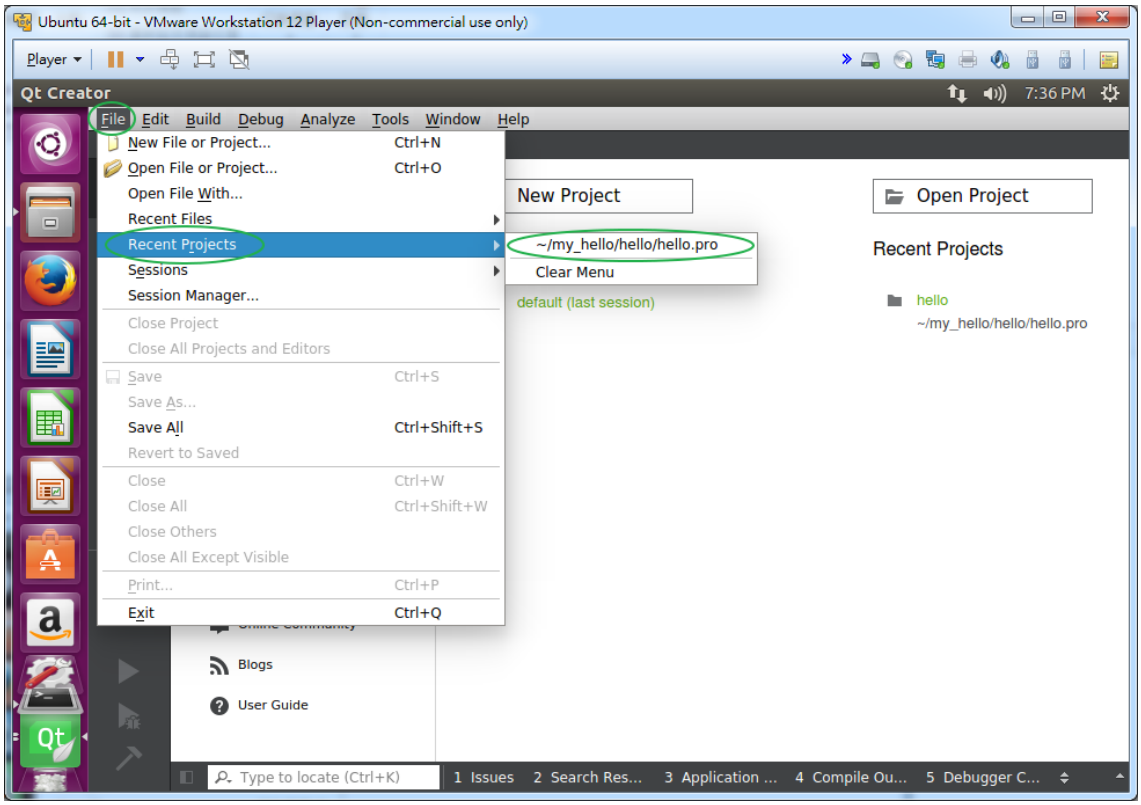

Figure 6-7 Open the Hello Project

To add "Intel SoC FPGA Kit" into the Hello project, click on the "Projects" icon and select "Intell SoC FPGA Kit" from the "Add Kit" pull-down menu, as shown in **Figure 6-8**.

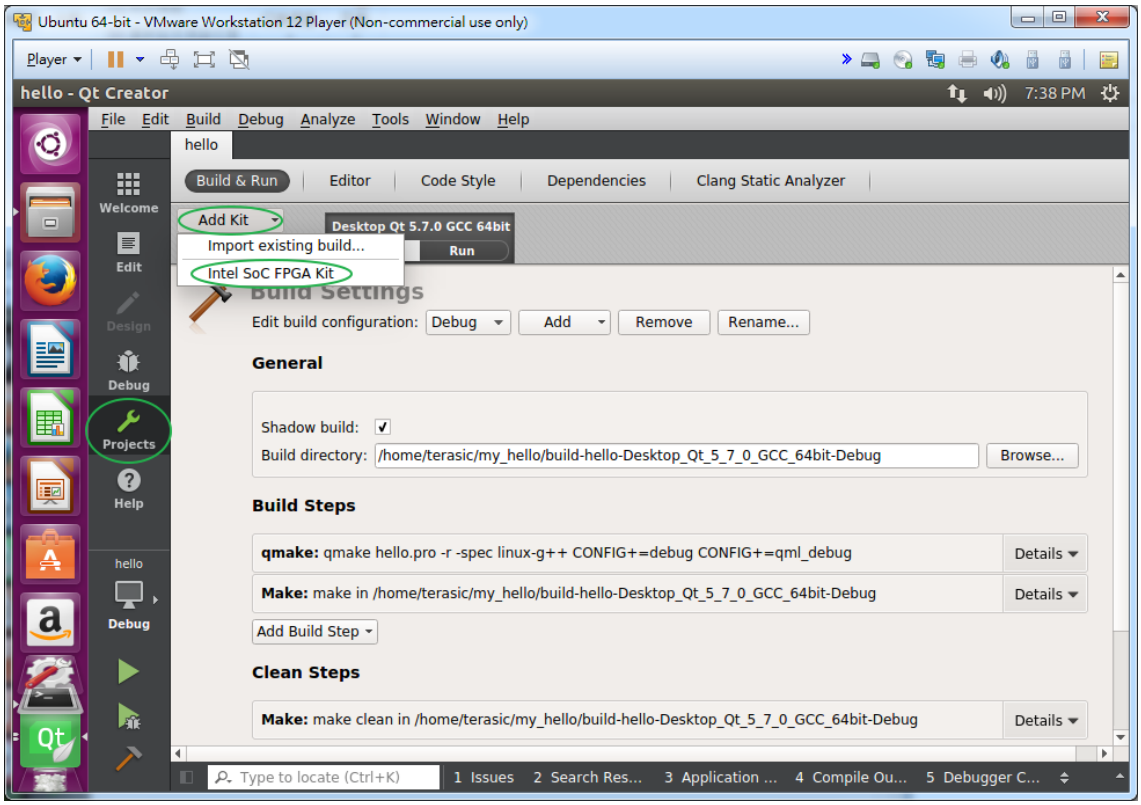

Figure 6-8 Add Intel SoC FPGA Kit into the Hello Project

To select **Release** type, click on "Release" icon and select "Intel SoC FPGA Kit" item under the **Kit** list menu and "Release" in **Build** list menu, as shown in **Figure 6-9**.

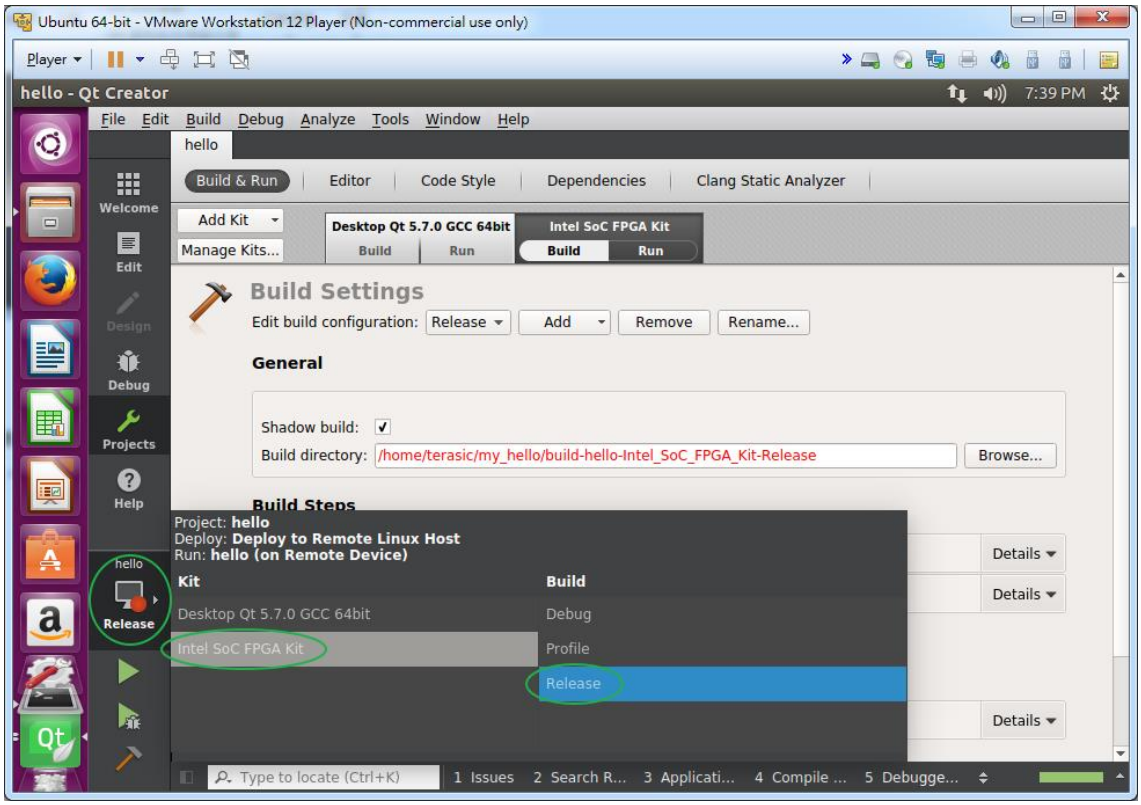

Figure 6-9 Specify Release Setting

To compile the hello project, click on "Compile Output" item on the bottom toolbar of the Qt Creator and select the menu item "Build→Rebuild All" as shown in **Figure 6-10**. While compiling, the system message will be simulaneously displayed on the "Compile Output" Windows.

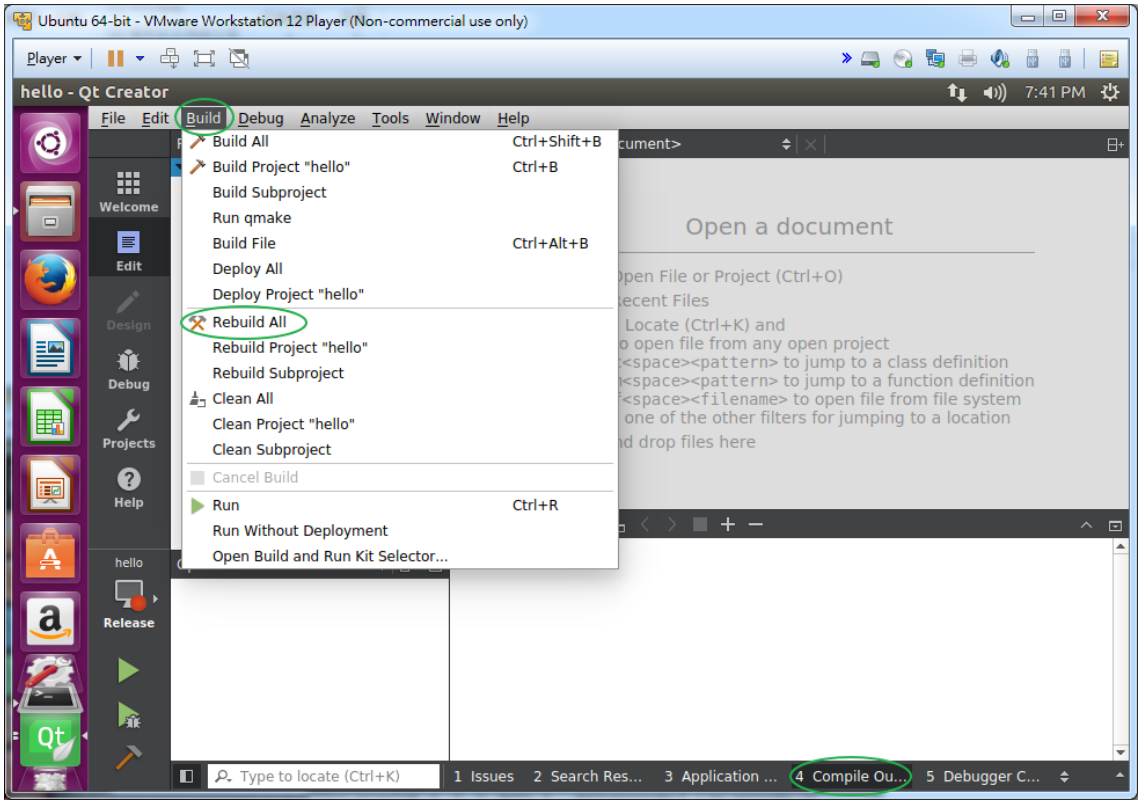

Figure 6-10 Build Hello Project

When the build process has been completed, the output execution file can be found under the folder "/home/**terasic**/my_hello/build-hello-Intel_SoC_FPGA_Kit-Release/hello". Note that in the path string, you should replace "terasic" with your linux user name as shown in **Figure 6-11**.

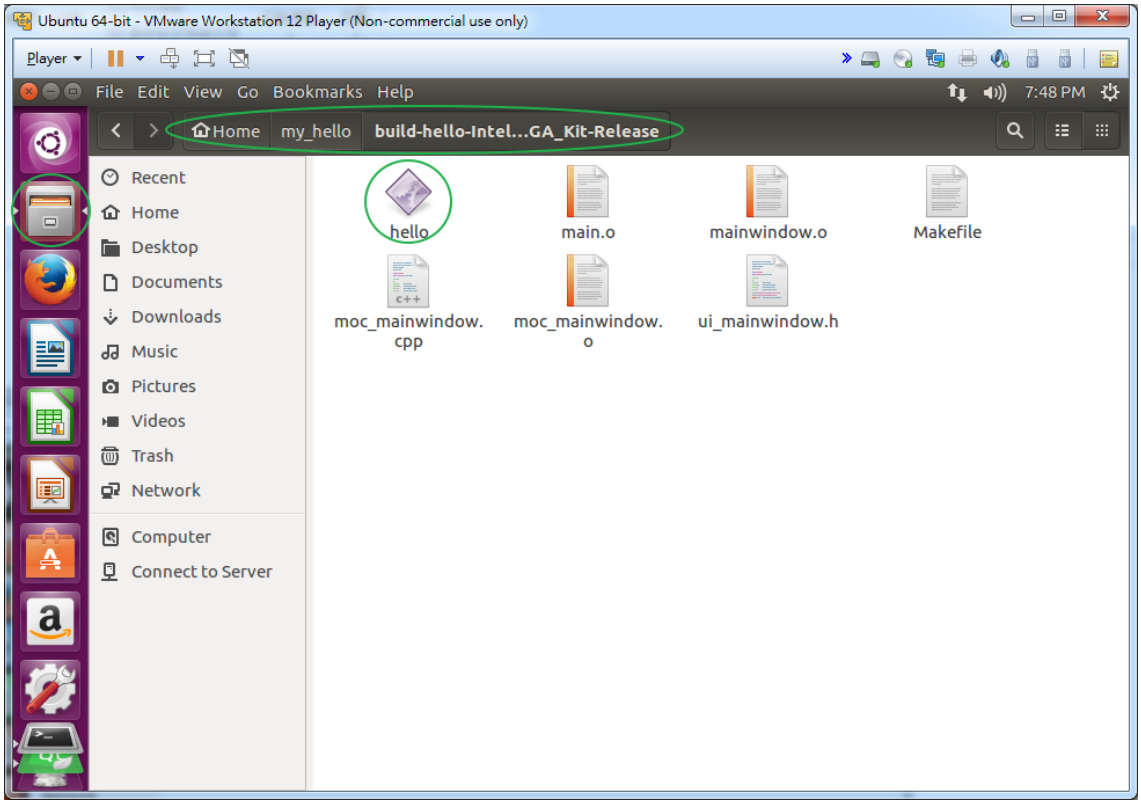

Figure 6-11 Location of the Output Hello Execution File

6.3 Execute Hello Program

To execute the Hello program on the VEEK-MT2S FPGA board, we need to copy the **hello** execution file to the Intel SoC FPGA Board which runs on Linux. In this demonstration, we use Linux "scp" command to remote copy these files from host PC to the VEEK-MT2S FPGA development board.

■ Setup Network for Intel SoC FPGA Board

First, use a RJ45 cable to connect the Intel SoC FPGA development board to an Ethernet network with a DHCP server, like **Figure 6-12**.

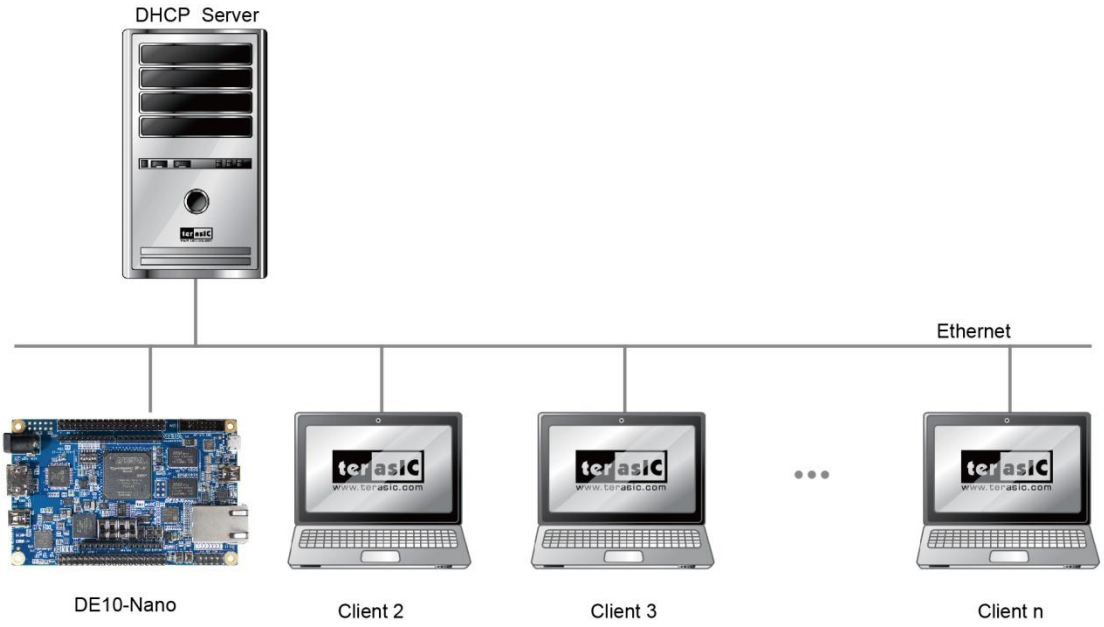

Figure 6-12 Connect Intel SoC FPGA Board To the Ethernet Network

Then, use the microSD card which Linux LXDE Desktop image is written to, described in chapter 1, to boot the Intel SoC FPGA development board. After booting LXDE Desktop, launch a terminal on the LXDE Desktop (CTRL+ALT+T) and type in "dhclient -v eth0" command to request an Ethernet IP Address from the DHCP server as shown in **Figure 6-13**.

```
root@DE10_NANO:/root# dhclient -v eth0
Internet Systems Consortium DHCP Client 4.3.3
Copyright 2004-2015 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/

Listening on LPF/eth0/fe:91:89:03:17:1b
Sending on   LPF/eth0/fe:91:89:03:17:1b
Sending on   Socket/fallback
DHCPDISCOVER on eth0 to 255.255.255.255 port 67 interval 3 (xid=0x78ceb156)
DHCPREQUEST of 192.168.1.191 on eth0 to 255.255.255.255 port 67 (xid=0x56b1ce78)
DHCPOFFER of 192.168.1.191 from 192.168.1.1
DHCPACK of 192.168.1.191 from 192.168.1.1
bound to 192.168.1.191 -- renewal in 1527 seconds.
root@DE10_NANO:/root#
```

Figure 6-13 Linux dhclinet Command

To get a IP address from the DHCP server, type Linux "ifconfig" command to find the assigned IP address, as shown in **Figure 6-14**. In this case, the assigned IP address is "192.168.1.191".

```
root@DE10_NANO:/root# ifconfig
eth0      Link encap:Ethernet  HWaddr fe:91:89:03:17:1b
          inet addr:192.168.1.191  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::9a34:b532:2ff6:8f8e/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:5227 errors:0 dropped:0 overruns:0 frame:0
          TX packets:846 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:579109 (579.1 KB)  TX bytes:1021798 (1.0 MB)
          Interrupt:37 Base address:0x4000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:240 errors:0 dropped:0 overruns:0 frame:0
          TX packets:240 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:17760 (17.7 KB)  TX bytes:17760 (17.7 KB)
```

Figure 6-14 Use Linux ifconfig Command to Check Assigned Ethernet IP Address

■ Copy Files from PC Host to Intel SoC FPGA Board

Now, back to the host PC part. Please make sure the host PC is connected to the Ethernet which VEEK-MT2S FPGA development board also is connected to. Launch a terminal on the Linux x64, and type in:

```
$ cd /home/terasic/my_hello/build-hello-Intel_SoC_FPGA_Kit-Release
```

to go to the directory where the hello execution file is located, as shown in **Figure 6-15**. Note, in the path string, you should replace "terasic" with your linux user name.

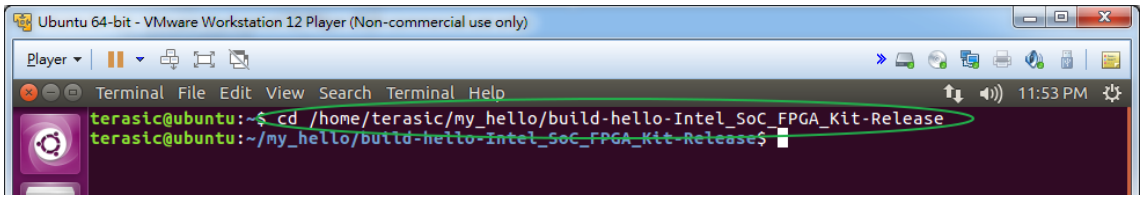

Figure 6-15 Go to the Hello Program Folder

Then, type:

```
$ scp hello root@192.168.1.191:/home/root
```

To remote copy the **hello** program to the /home/root directory of the file system of VEEK-MT2S FPGA development board, as shown in **Figure 6-16**. Note that the IP address 192.168.1.191 should be changed to the actual IP address assigned.

During the first time of the connection, system will ask "Are you sure you want to continue connecting (yes/no)?". Please type in "yes" and press ENTER. After confirming, the system will ask you to input password for the remote machine, please type "**terasic**" (the default setting with the microSD image) and press ENTER.

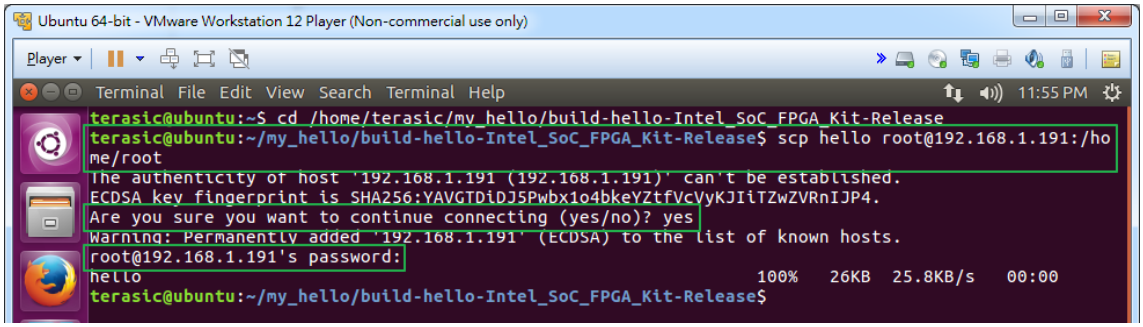

Figure 6-16 Remote Copy the Hello Program

■ Launch Hello Program

Please double click "hello" icon and click "Execute" button to launch the Control Panel as shown in Figure 6-17.

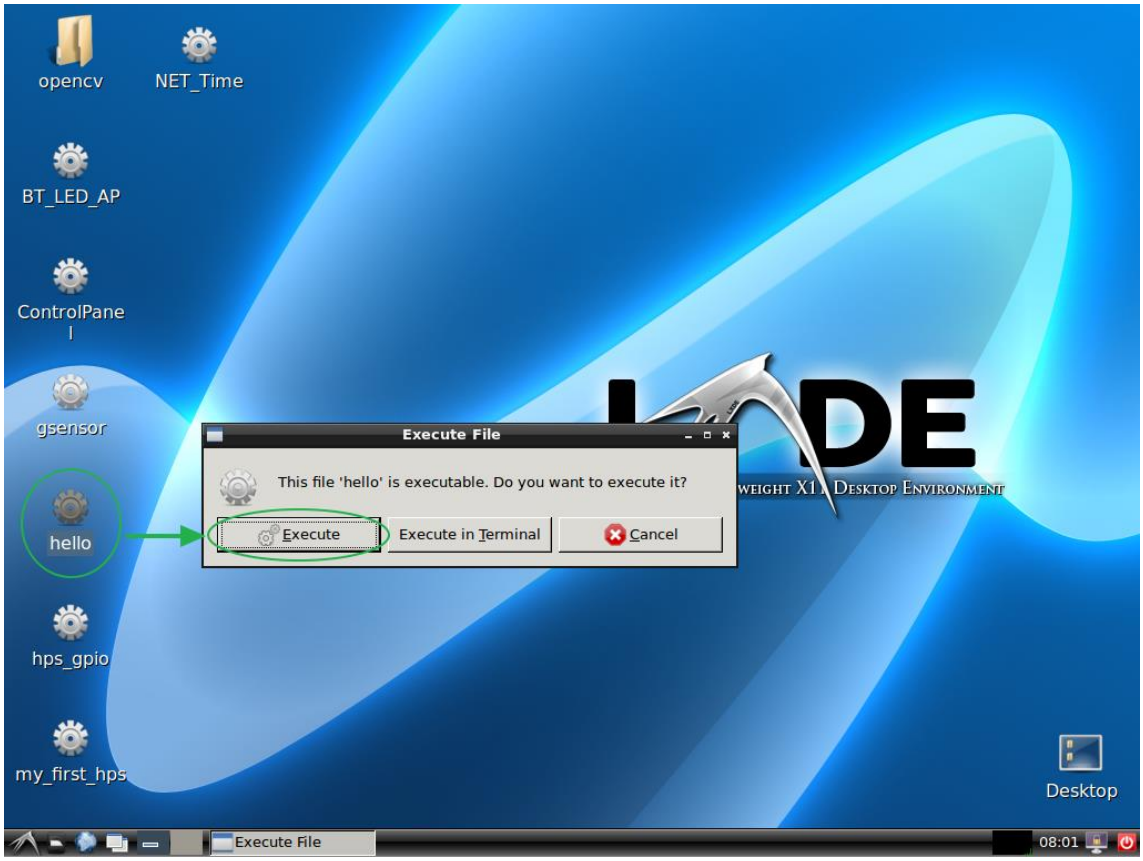

Figure 6-17 Screenshot of the Hello Program

If the Hello program is launched successfully, you should see the Hello windows as shown in Figure 6-18.

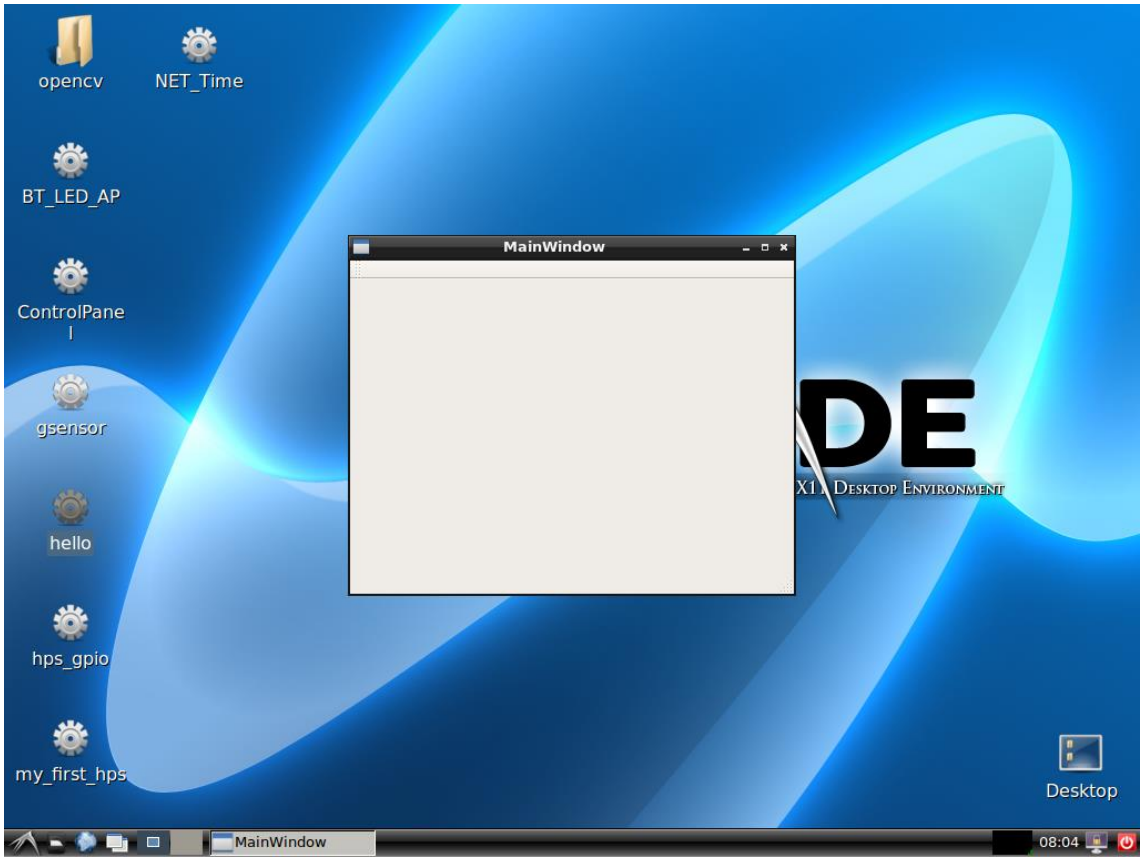

Figure 6-18 Screenshot of the Hello Program

Chapter 7

Control Panel Quartus Project

We have so far shown how to build and run hello program on the Intel SoC FPGA development board with Qt library. In Chapter 7, we show how to build the Quartus project "Control Panel" over on the Windows host, translate the .sof to .rbf, and copy the .rbf file to the microSD Card such that the FPGA can be configured while booting Linux. We also introduce how to use **HPS** component in Qsys in order for the Linux program to access Qsys Avalon Memory-Mapped bus through **HPS** component.

Quartus Prime 16.1 or later which supports Cyclone V Device on Windows is required in the Control Panel Quartus Project can be downloaded from https://www.altera.com/downloads/download-center.html or as shown in **Figure 7-1**.

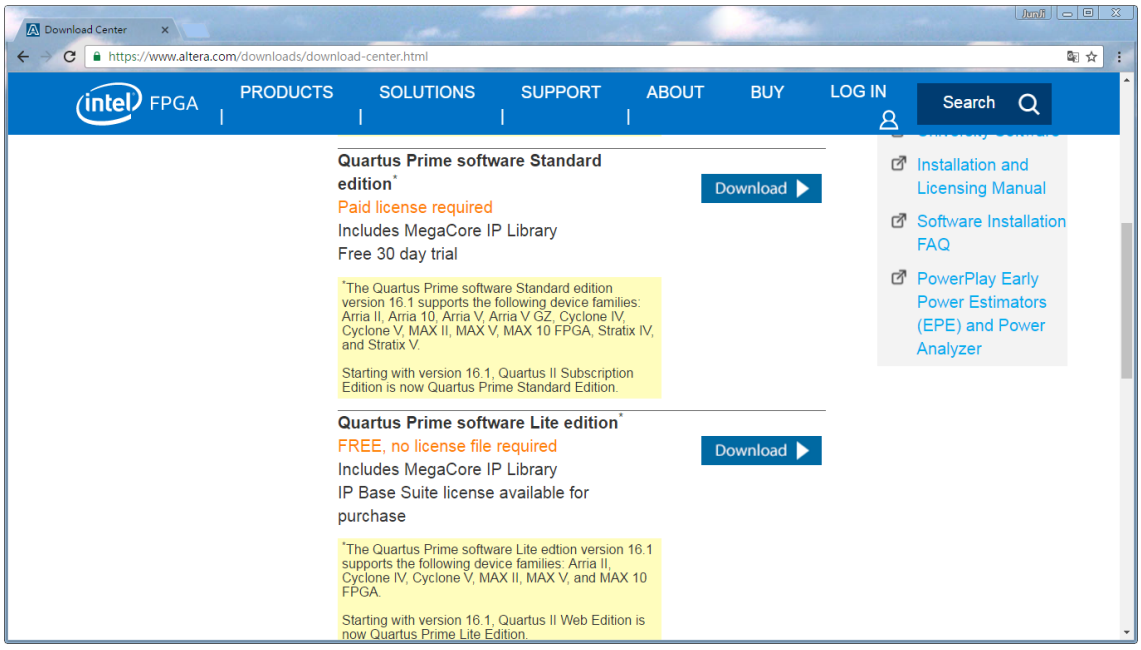

Figure 7-1 Quartus Download Web Page

7.1 Build Quartus Project of Control Panel

The Quartus project of Control Panel is located on the system CD: "**Demonstrations\SoC_FPGA\ControlPanel\Quartus**". Please copy the folder to the Windows host and open it with Quartus, as shown in **Figure 7-2**. Click "Start Compilation" icon to start to compile.

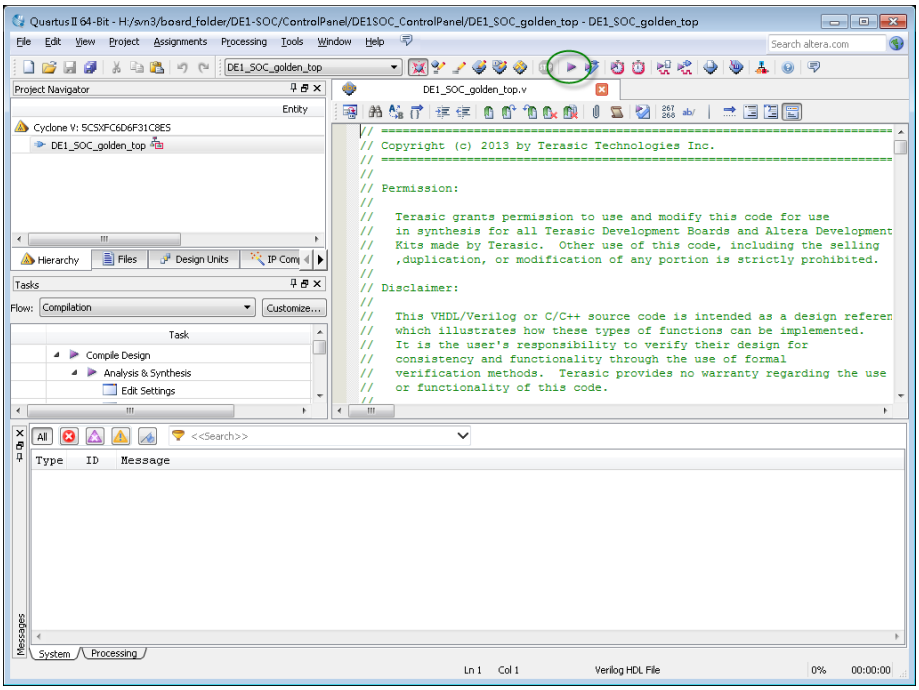

Figure 7-2 Quartus Project of the Control Panel

When finished compiling, **DE10_NANO_SOC_FB.sof** is generated under the **output_files** folder of Quartus project.

7.2 Test FPGA Configuration File

When Intel SoC FPGA boots from the microSD Card, it also reads soc_system.rbf in the microSD Card to configure the FPGA. Therefore, we now show how to translate the .sof to .rbf.

■ Generate soc_system.rbf

First, we need to translate the .sof to .rbf with the following command

```
$ quartus_cpf -c -o bitstream_compression=on \
DE10_Stabdard_FB.sof soc_system.rbf
```

We have provided the batch file "sof_to_rbf.bat" which implements the translation command for the users convenience. The batch file is located in the output_files folder of the Quartus project. Execute the batch file will start the translation. When the file translation is complete, soc_system.rbf will be generated on the same folder.

■ Update microSD card

Next, we need copy the **soc_system.rbf** to the microSD Card with the following procedures:

1. Insert the microSD Card in the Windows Host
2. Delete **soc_system.rbf** in the microSD Card if there is one
3. Copy your **soc_system.rbf** into the microSD Card

■ Test

Finally, boot the VEEK-MT2S FPGA development board with the updated microSD Card. When the Linux boot process is complete, Double click "ControlPanel" icon and click "Execute" button to test if everything works well.

7.3 More on the Quartus Project

The Control Panel circuit is built by Qsys. The HPS Linux program accesses **Avalon Memory Mapped Bus** through the **HPS** component. Also, the FPGA controller can use HPS resource, like DDR3 SDRAM, through the **HPS** component. The HPS configuration is board-peripheral-dependent, so users don't need to modify the HPS setting if the board has not been changed. The top Qsys is implement in soc_system.qsys. The TV decoder sub system is implement in the tv_decoder.qsys.

■ Linux Access FPGA Controller

The HPS Linux program accesses **Avalon Memory Mapped Slave** port through HPS **AXI Master** port as shown **Figure 7-3**. If you wish that Linux program can access a Qsys instance, just connect its **Avalon Memory Mapped Slave** port of the controller to HPS **AXI Master** port.

Linux program access specific **Avalon Memory Mapped Slave** port based on its port address, so please make sure the port address are not overlapped with each other. We strongly recommend that the developer properly defines the port addresses and lock port addresses in Qsys.

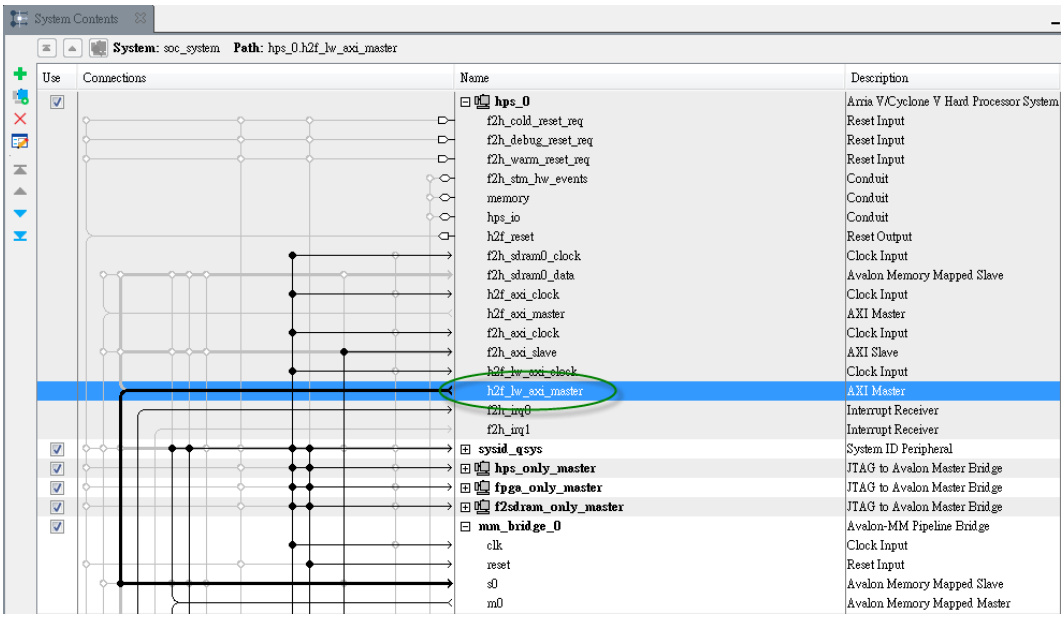

Figure 7-3 HPS AXI Master Port

In this tutorial, the slave port of LED, Button, Switch, IR, 7-segment, audio, VIP frame reader, VIP clocked video input, VIP Mixer II and tv_decoder are connected to the to the **mm_bridge_0 → HPS h2f_lw_axi_master AXI Master** port. Use Qsys "Address Map" tab can view the connection summary and associated address, as shown in **Figure 7-4**.

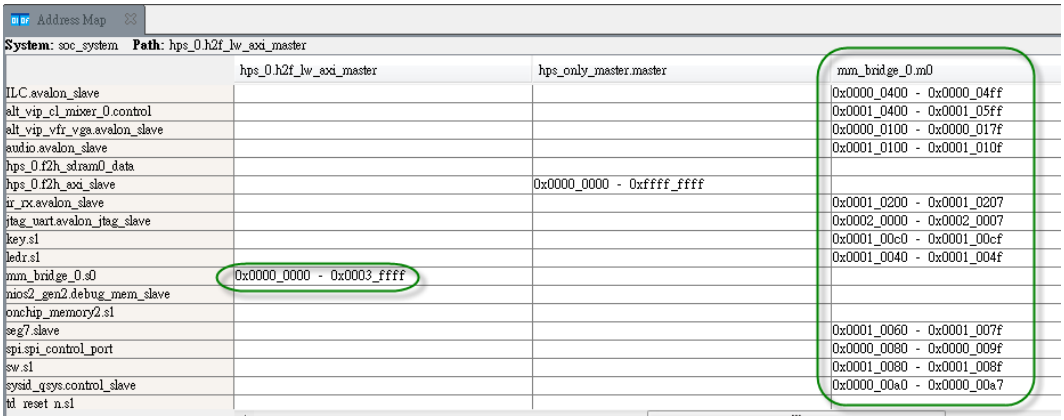

Figure 7-4 HPS h2f_lw_axi_master Connection and Address Map

The TV decoder is implemented in tv_decoder.qsys as shown in Figure 7-5 tv_decoder sub Qsys. The SRAM acts as video buffer for the VIP frame buffer.

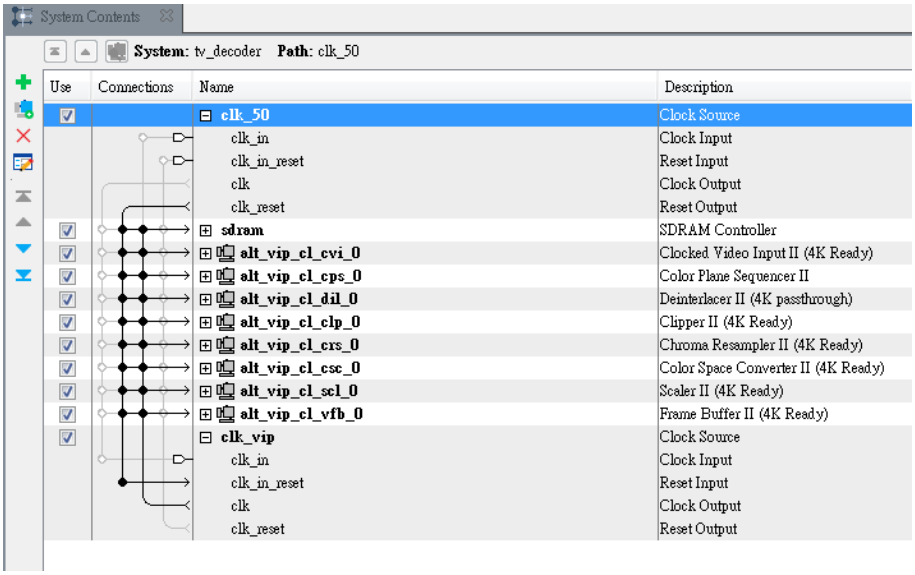

Figure 7-5 tv_decoder sub Qsys

■ Hardware of Linux Frame Buffer Display

VIP Frame Reader is used to implement the Frame Buffer Display of Linux. The Frame Reader uses HPS's DDR3 SDRAM as frame buffer, so we need to connect the **Avalon Memory Mapped Master** port of Frame Reader instance to the **AXI Slave** port of HPS instance, as shown in **Figure 7-6**.

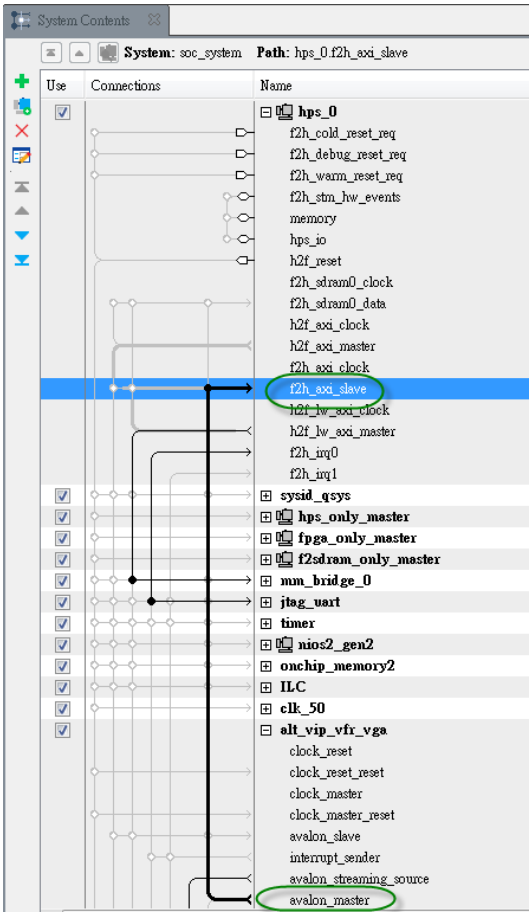

Figure 7-6 HPS AXI Master Port

Figure 7-7 shows Frame Reader instance setting. The display resolution is set as 1024x768.

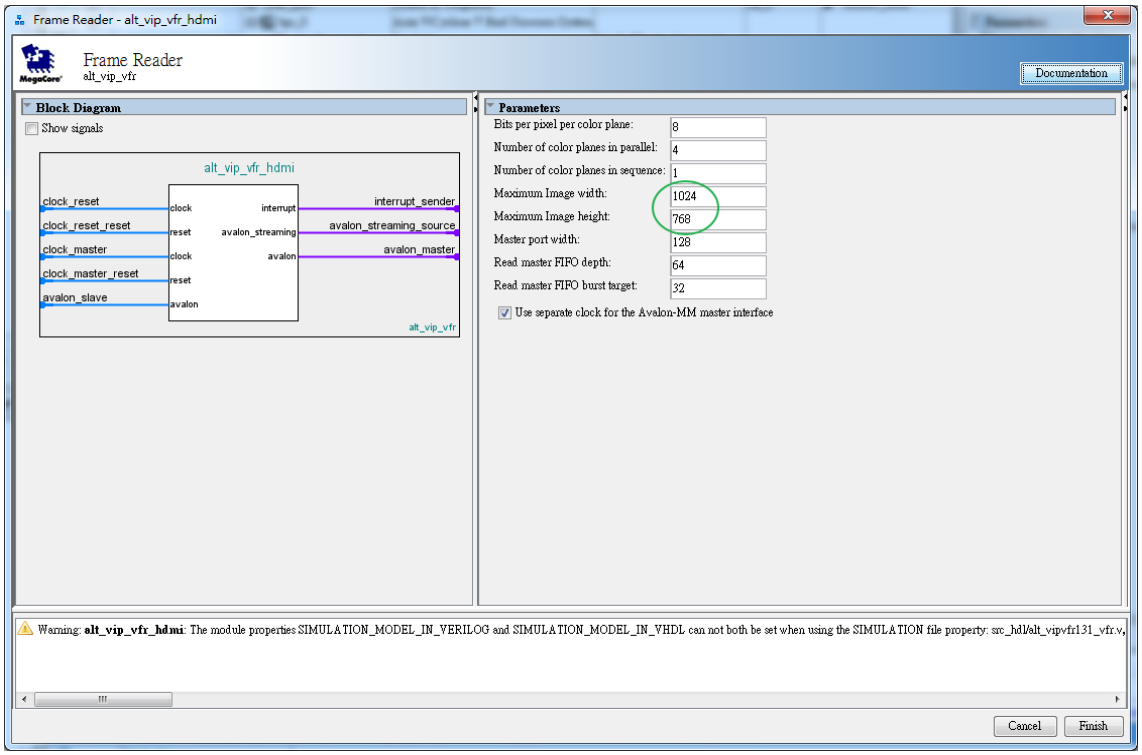

Figure 7-7 Frame Reader Setting

Chapter 8

Control Panel Qt Project

Chapter 8 describes how to build the Control Panel Qt project by the Qt Creator on the Linux x64. Here, we assume the Qt library for Intel SoC ARM built in previous chapters is still in place.

Control Panel Qt project uses Intel SoC FPGA hwlib library source code which is included in the Intel SoC EDS (Embedded Development Suite). Therefore make sure to install Intel SoC EDS before compiling the Qt Project.

8.1 Install Intel SoC EDS on Linux x64

Intel SoC EDS can be downloaded from http://dl.altera.com/soceds/16.1/?edition=standard or the Intel Download Center by clicking on the **Embedded Software** item and clicking on the **SoC EDS** item as shown in **Figure 8-1**.

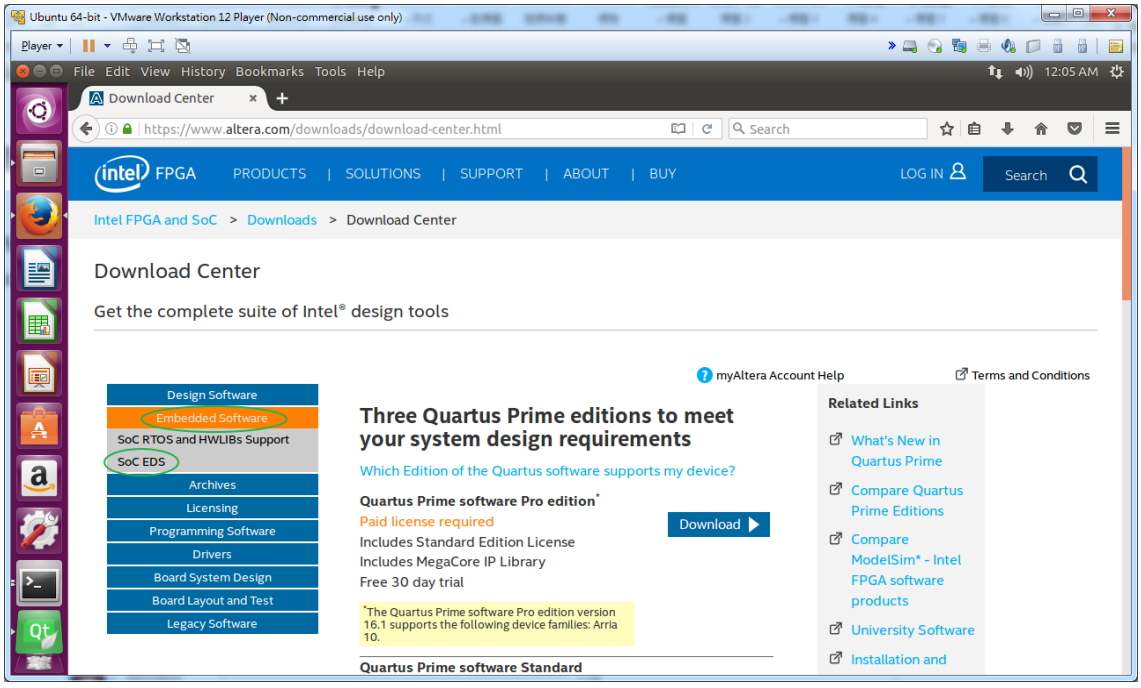

Figure 8-1 Intel SoC EDS Download Web Page

In the SoC Embedded Design Suite Download page, click the "Download" icon to download the SoC EDS installer as shown in **Figure 8-2**.

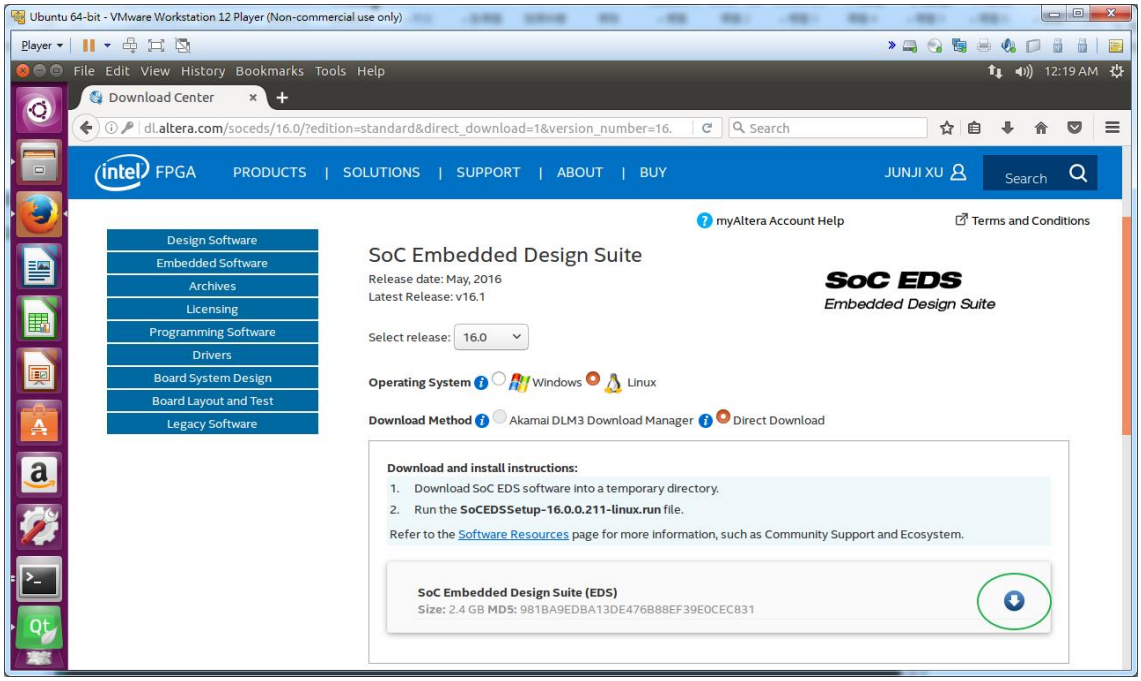

Figure 8-2 Intel SoC EDS Download Web Page

The downloaded SoC EDS installer "**SoCEDSSetup-16.1.0.196-linux.run**" is located in the directory "~/Downloads". To launch the installer, first launch Linux terminal on the Linux x64 (CTRL+ALT+T), and type in:

```
$ cd ~/Downloads
```

to go to "~/Downloads" directory.

Then, type in:

```
$ chmod +x SoCEDSSetup-16.1.0.196-linux.run
```

to add execution attribute to the installer.

Finally, type in:

```
$ ./SoCEDSSetup-16.1.0.196-linux.run
```

to launch SoC EDS installer as shown in **Figure 8-3**.

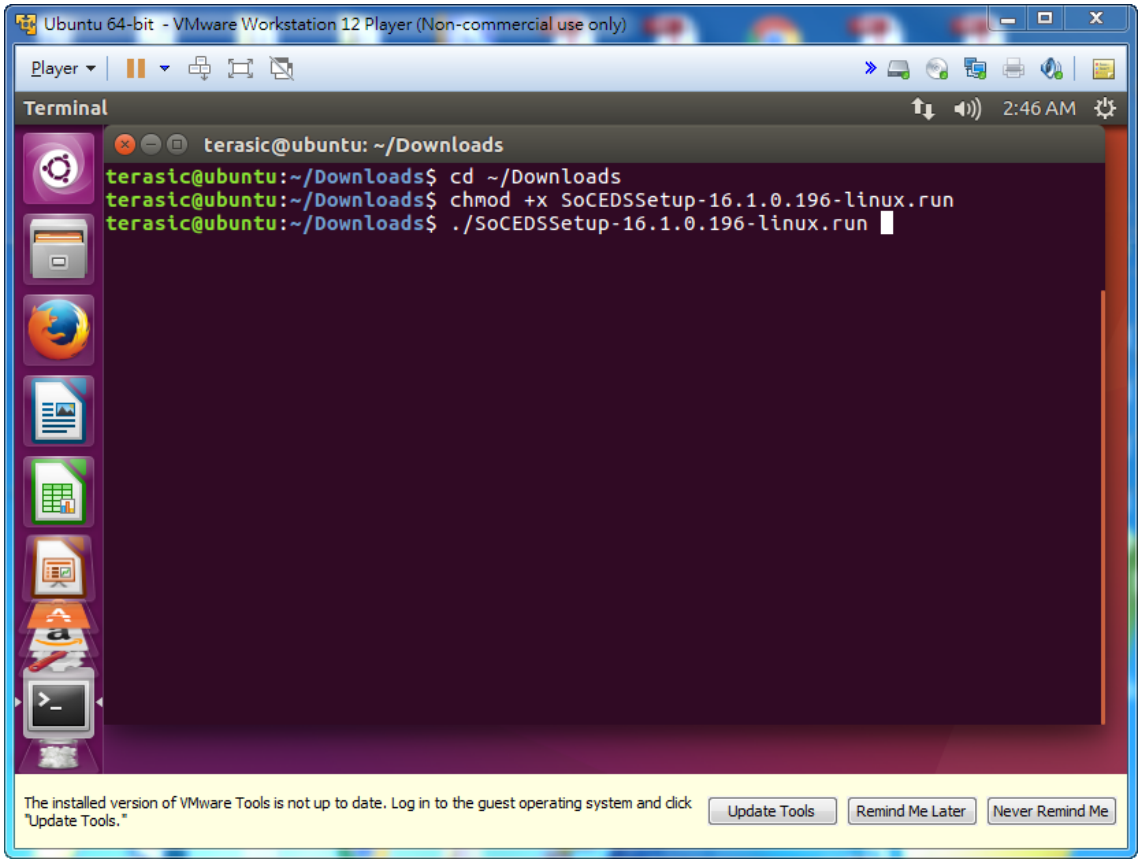

Figure 8-3 Launch SoC EDS Installer

When the installer is launched, a **Welcome** dialog appears as shown in **Figure 8-4**. Click "Next >" to go to the next step.

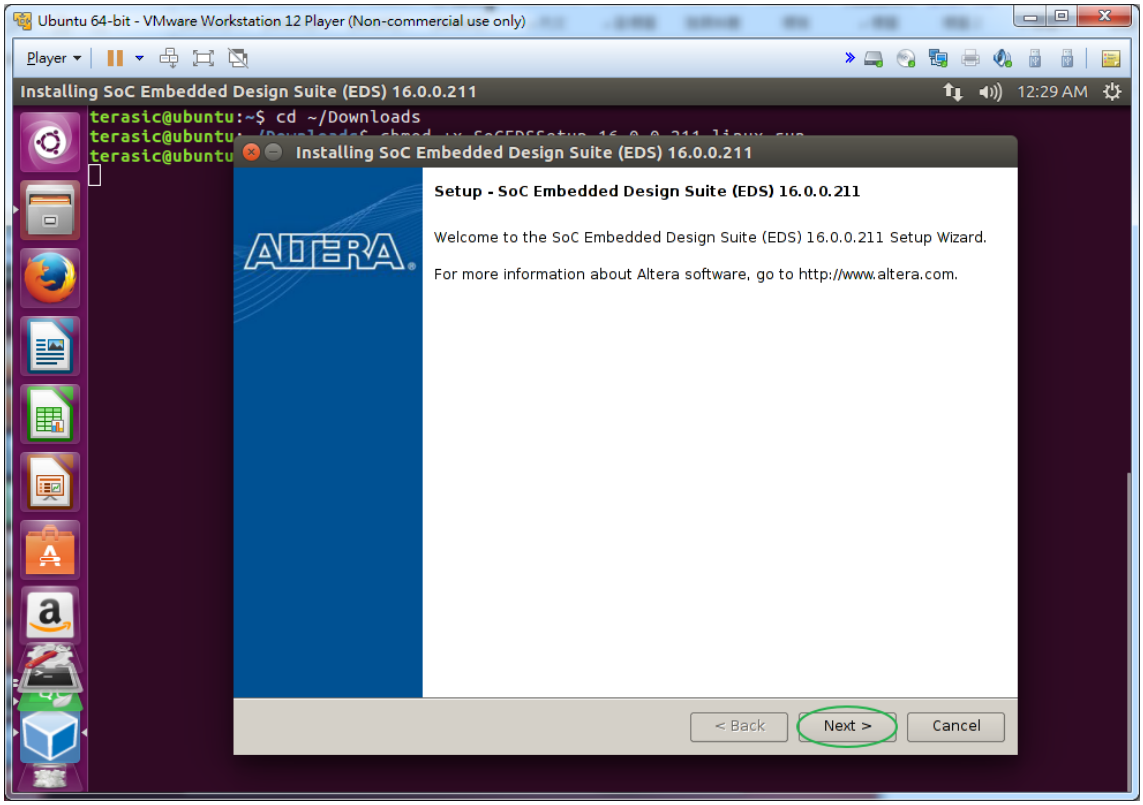

Figure 8-4 Welcome Dialog of SoC EDS Installer

When the **License Agreement** dialog appears as shown in **Figure 8-5**, please select the "I accept the agreement" radio button if you agree with the license and click "Next >" to go to the next step.

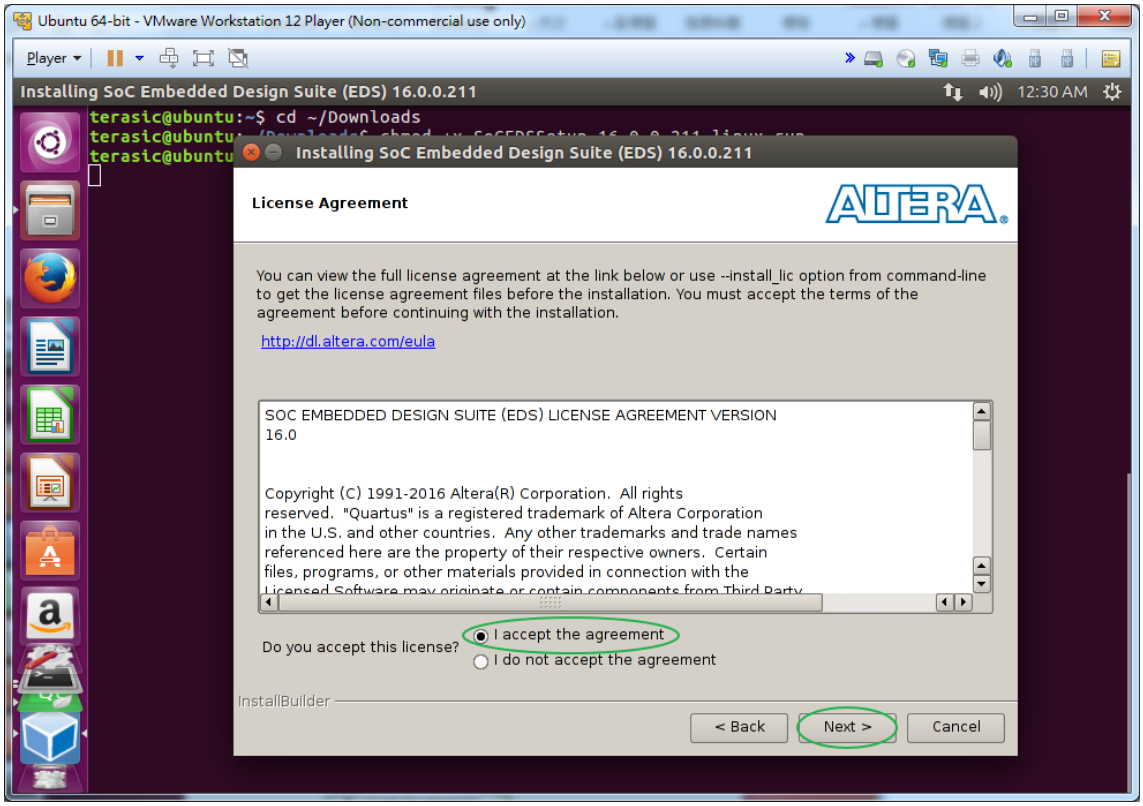

Figure 8-5 License Agreement Dialog of SoC EDS Installer

When the **Installation Directory** dialog appears as shown in **Figure 8-6**, we strongly recommend you keep the default directory and click "Next >" to proceed.

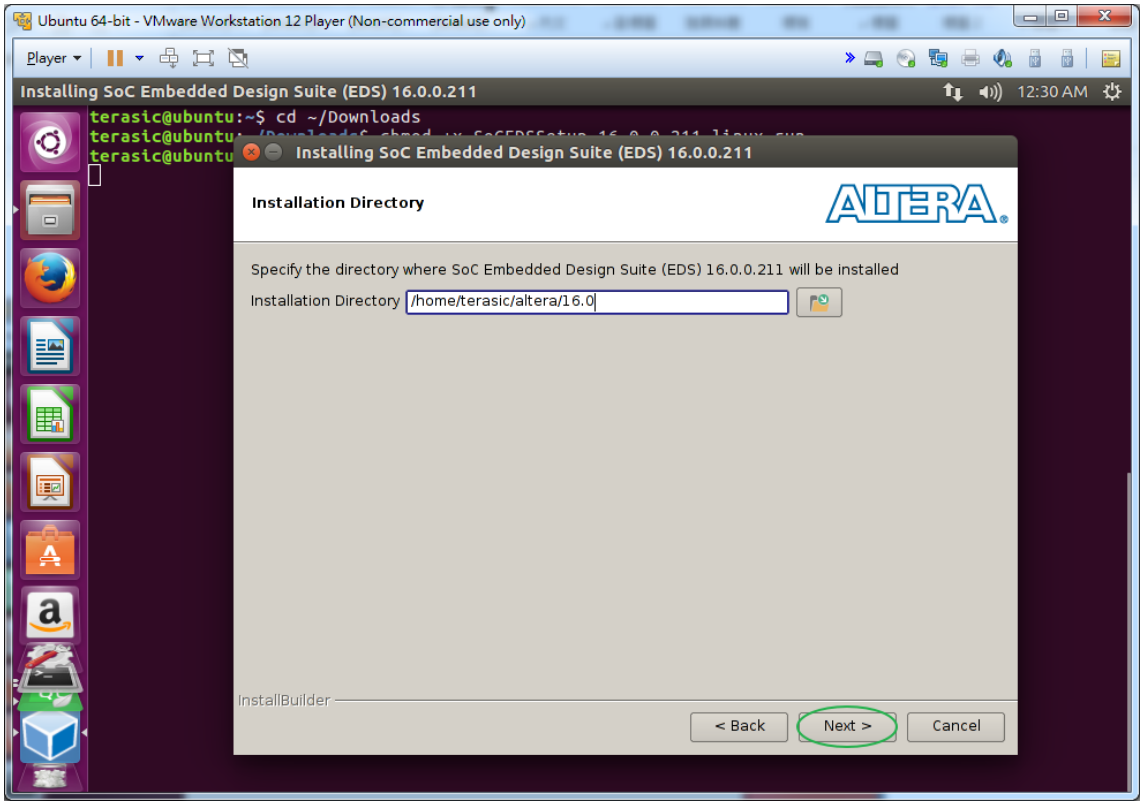

Figure 8-6 Installation Directory Dialog of SoC EDS Installer

When the **Select Components** dialog appears as shown in **Figure 8-7**, please **uncheck** the "Quartus Prime Programmer and Tools (1911.3MB)" checkbox and click "Next >" to go to the next step.

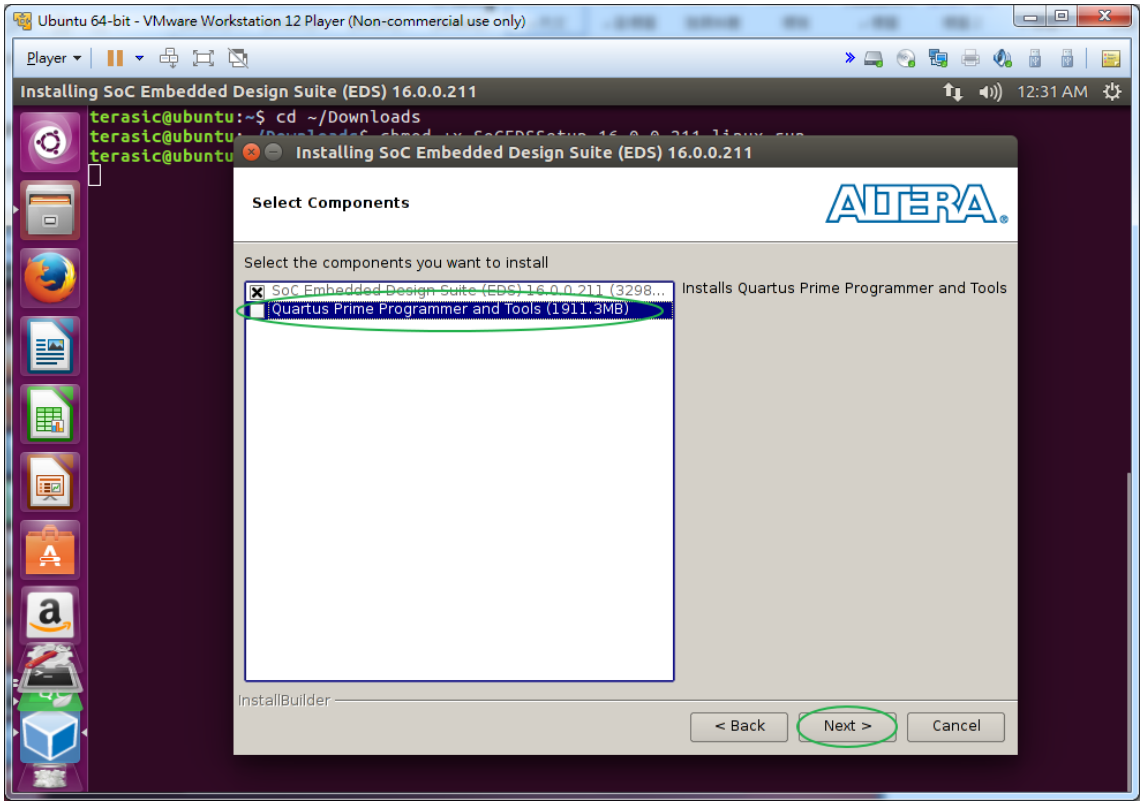

Figure 8-7 Select Components Dialog of SoC EDS Installer

When the **Ready to Install** dialog appears as shown in **Figure 8-8**, please click "Next >" to go to the next step.

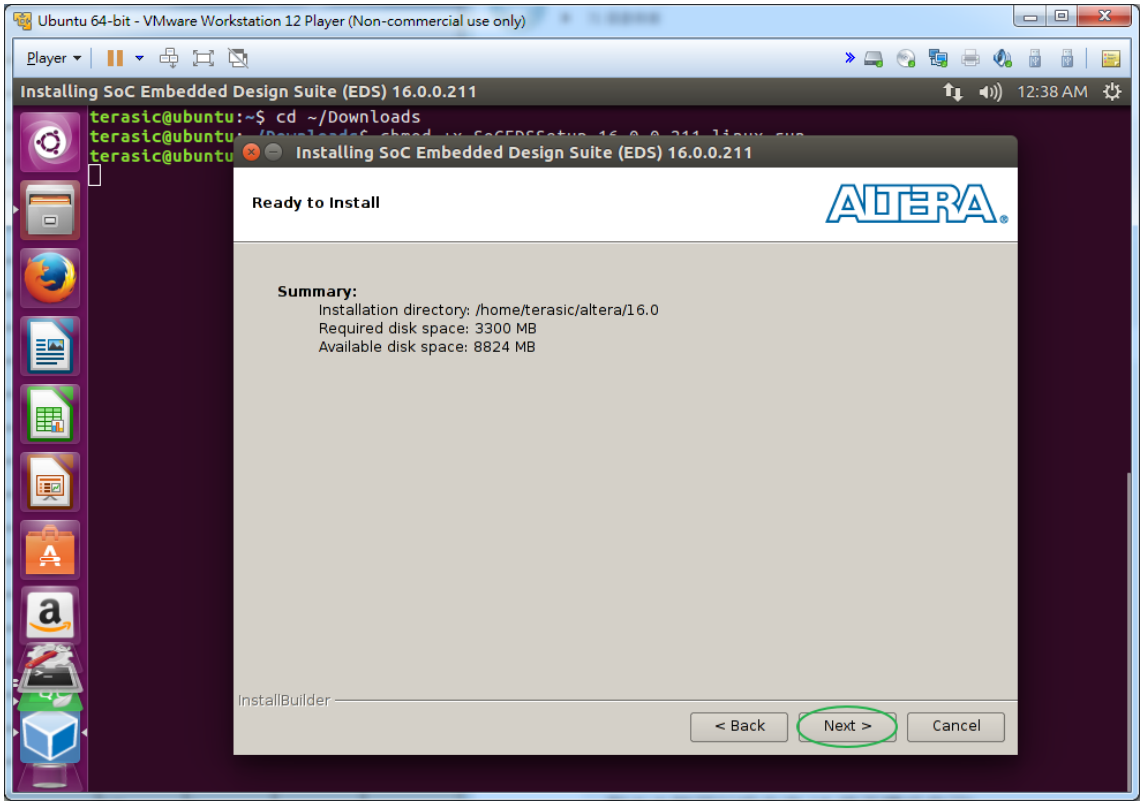

Figure 8-8 Ready to Install Dialog of SoC EDS Installer

When the installation is complete, please uncheck the "Launch DS-5 Installation" checkbox and click "Finish" as shown in **Figure 8-9** to finish.

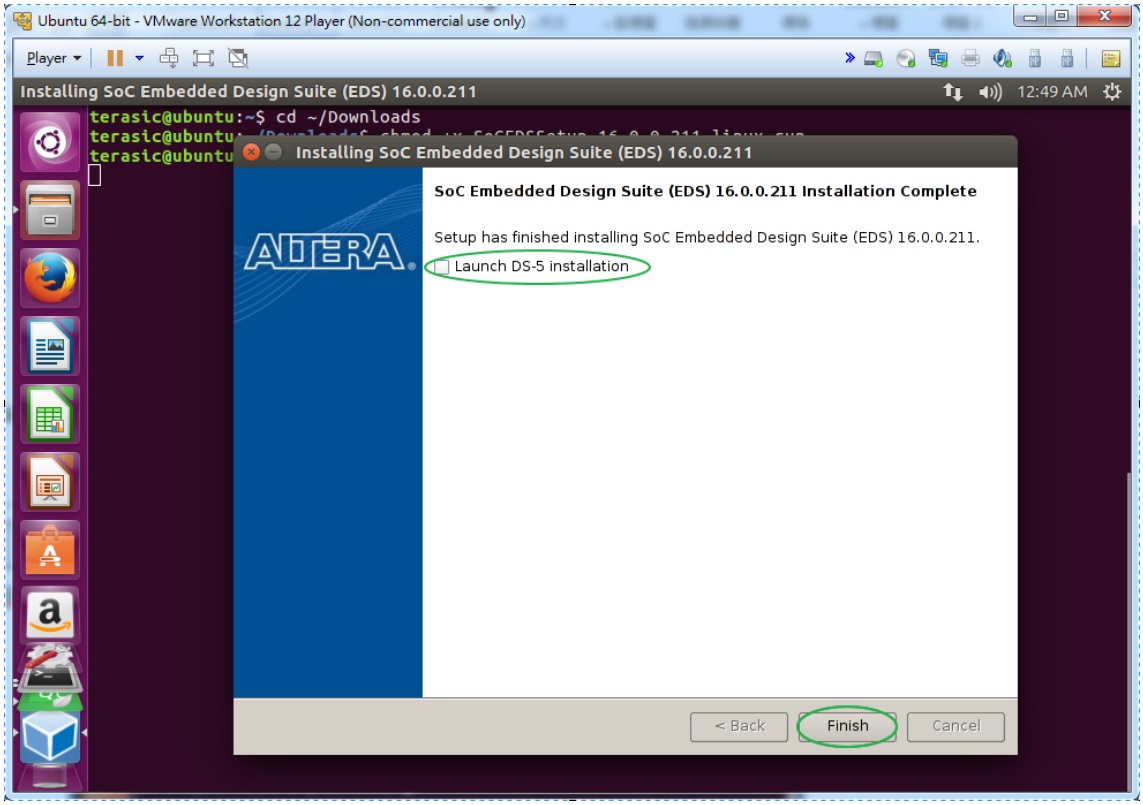

Figure 8-9 Finish Dialog of SoC EDS Installer

The source code of **hwlib** library can be found at the below location as shown in **Figure 8-10**.

/home/**terasic/**intelFPGA/16.1/embedded/ip/altera/hps/altera_hps/hwlib

(Note, in the path string, the "terasic" should be replaced with your linux user name.)

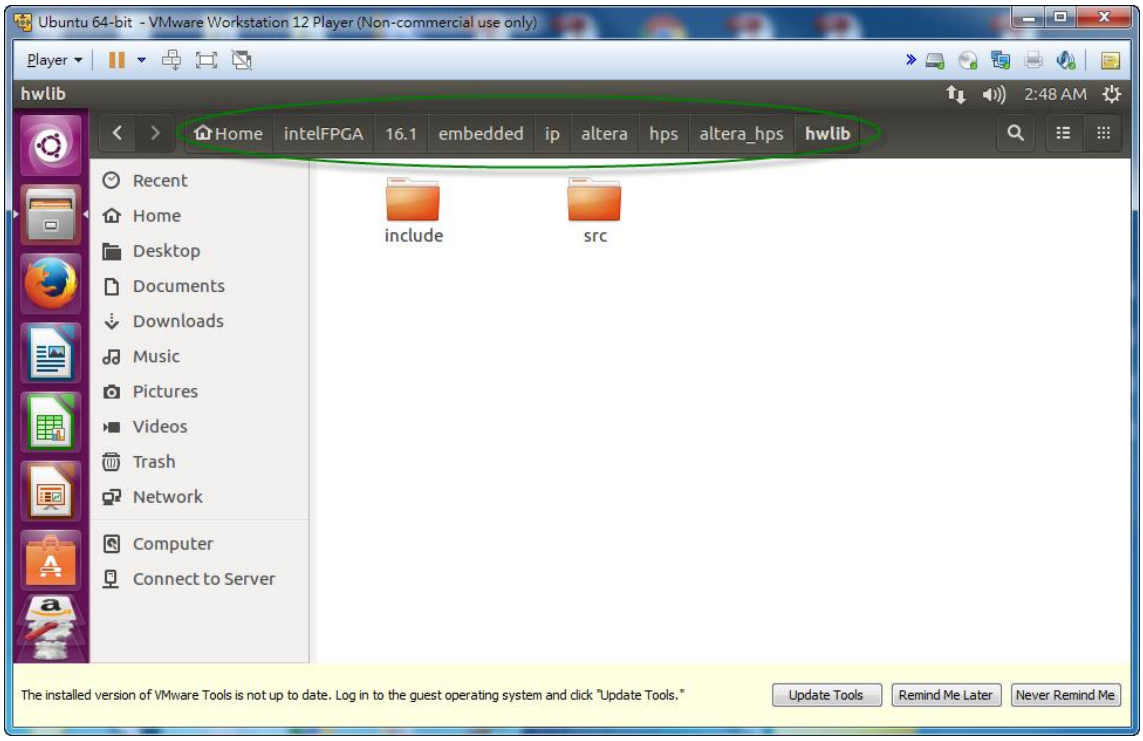

Figure 8-10 Directory Location of Altera 'hwlib' Library Source Code

8.2 Copy Control Panel Qt Project

The Control Panel Qt project is located on the System CD:

\Demonstrations\SoC_FPGA\ControlPanel\ControlPanel_QT

Here we copy the project from Windows host by using VMware Workstation Player's **Shared Folder** features, described in Chapter 2.6.

Copy the prebuilt Qt library compressed file from the System CD to the shared folder on Windows host. Then, launch the "Ubuntu 64-bit" virtual machine. After logging in Linux x64, launch a terminal (CTRL+ALT+T) and type the following command to go to the shared folder on Linux:

■ Copy Control Panel Qt Project to Shared Folder

Copy the Control Panel Qt project folder "ControlPanel_QT" from the System CD to the shared folder on Windows host. Then, launch a terminal (CTRL+ALT+T) and type the following command to go to the shared folder on Linux:

```
$ cd /mnt/hgfs/shared
```

to go to the shared directory on Linux.

Now type in

```
$ ls
```

To see the "ControlPanel_QT" directory of Control Panel Qt Project, as shown in **Figure 8-11.**

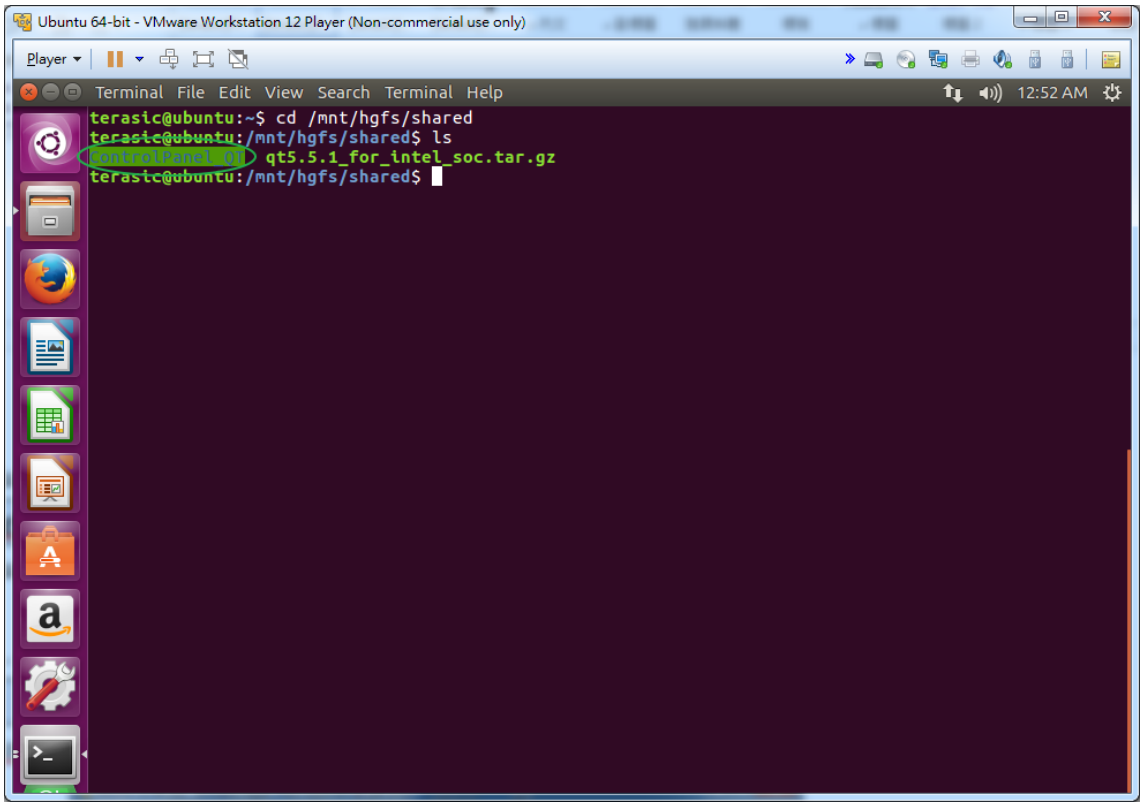

Figure 8-11 'ControlPanel_QT' Directory of Control Panel Qt Project

8.3 Build Control Panel Qt Project

Now, we can launch the Qt Creator, and select the menu item "Files→Open File or Project…" as shown in **Figure 8-12**.

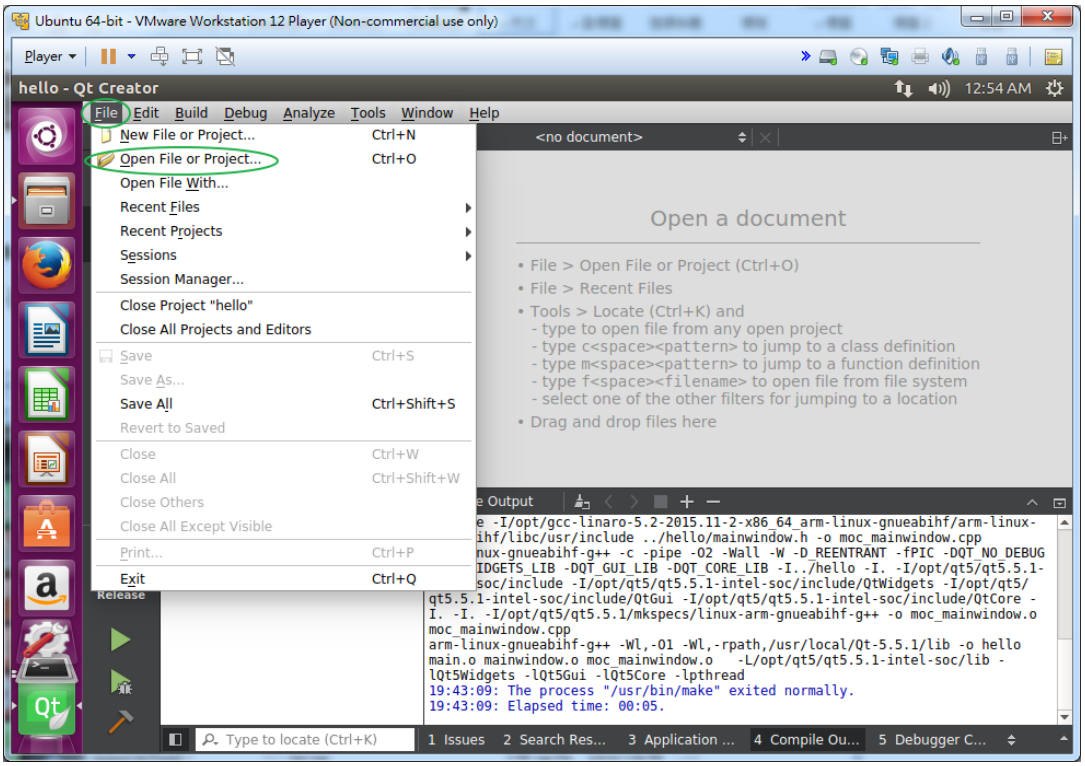

Figure 8-12 Launch Open Project Dialog

In the **Open File** dialog, go to the directory "/mnt/hgfs/shared/ControlPanel_QT", select "ControPanel.pro", and click "Open" as shown in **Figure 8-13**.

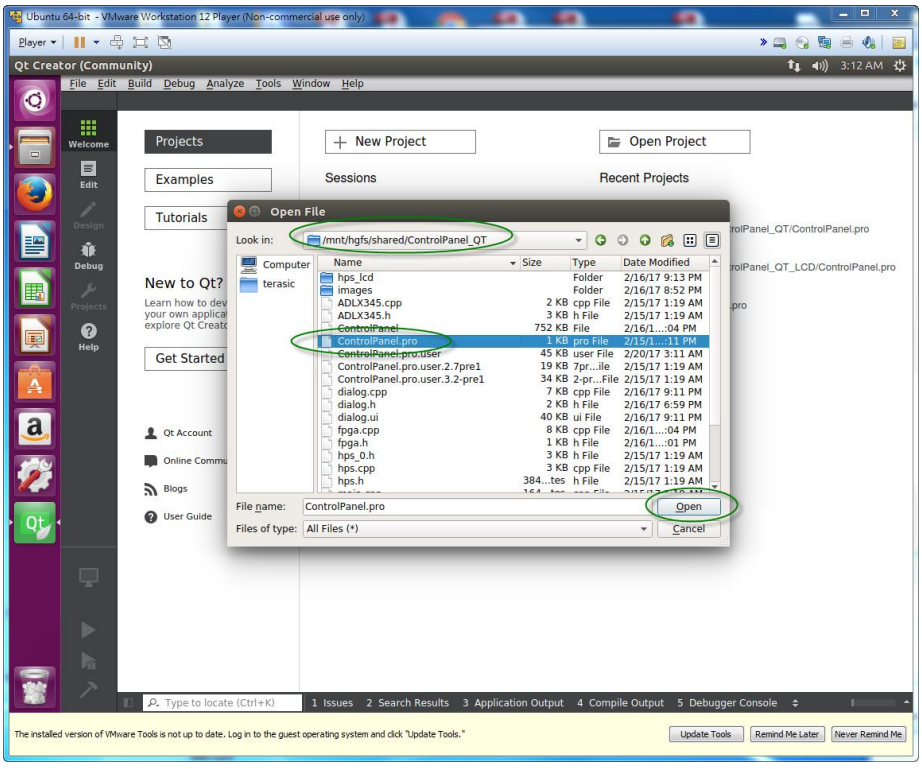

Figure 8-13 Select Control Panel Project – ControlPanel.pro

If the **Settings File** dialog appears as shown in Figure 8-14, please click "No" to proceed.

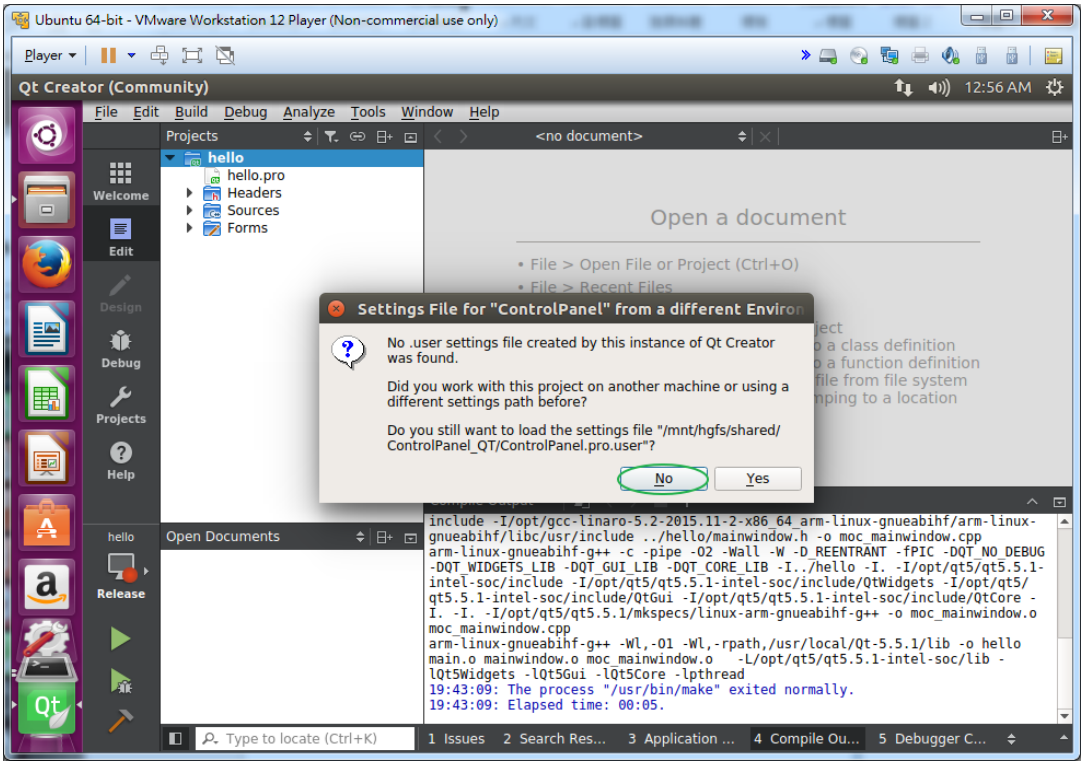

Figure 8-14 Query .user Setting

If Configure Project appears as shown in Figure 8-15, please check "Intel SoC FPGA Kit" and click "Configure Project".

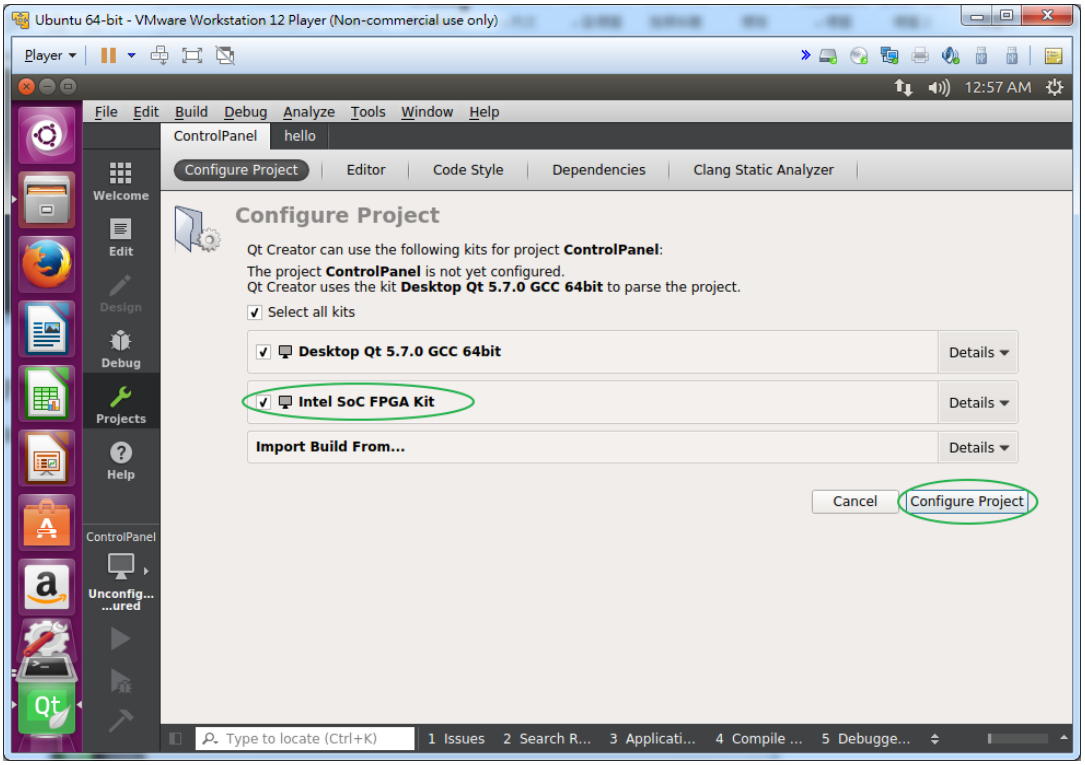

Figure 8-15 Configure Project

Now, to check if the include path is correct, please follow the instructions below:

First click on "Edit" icon on the left and double click "ControlPanel.pro" as shown in **Figure 8-16**, please make sure the **INCLUDEPATH** includes the correct path:

/home/**terasic**/intelFPGA/16.1/embedded/ip/altera/hps/altera_hps/hwlib/include
/home/**terasic**/intelFPGA/16.1/embedded/ip/altera/hps/altera_hps/hwlib/include/soc_cv_av

(Note, in the path string, the "terasic" should be replaced with your linux user name.)

If the file "ControlPanel.pro" is modified, please correct the path and select the menu item "File→Save "ControlPanel.pro" as shown in **Figure 8-17**.

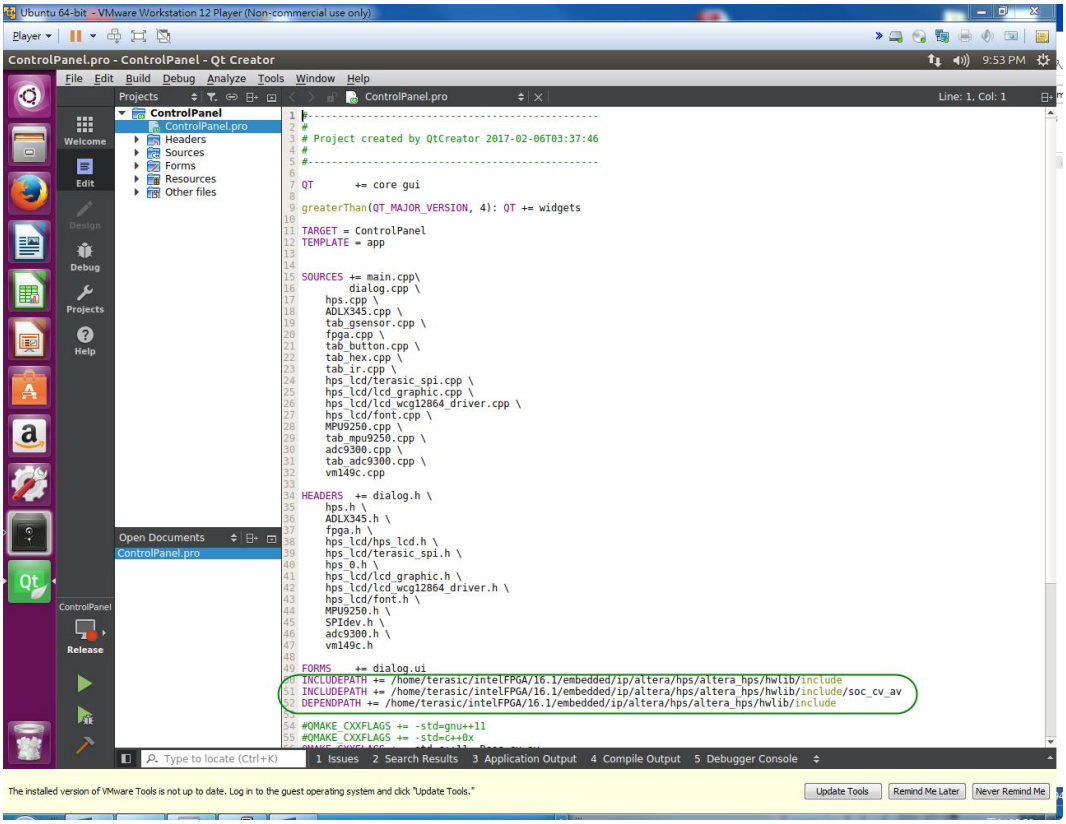

Figure 8-16 Check Include Path in ControlPanel.pro

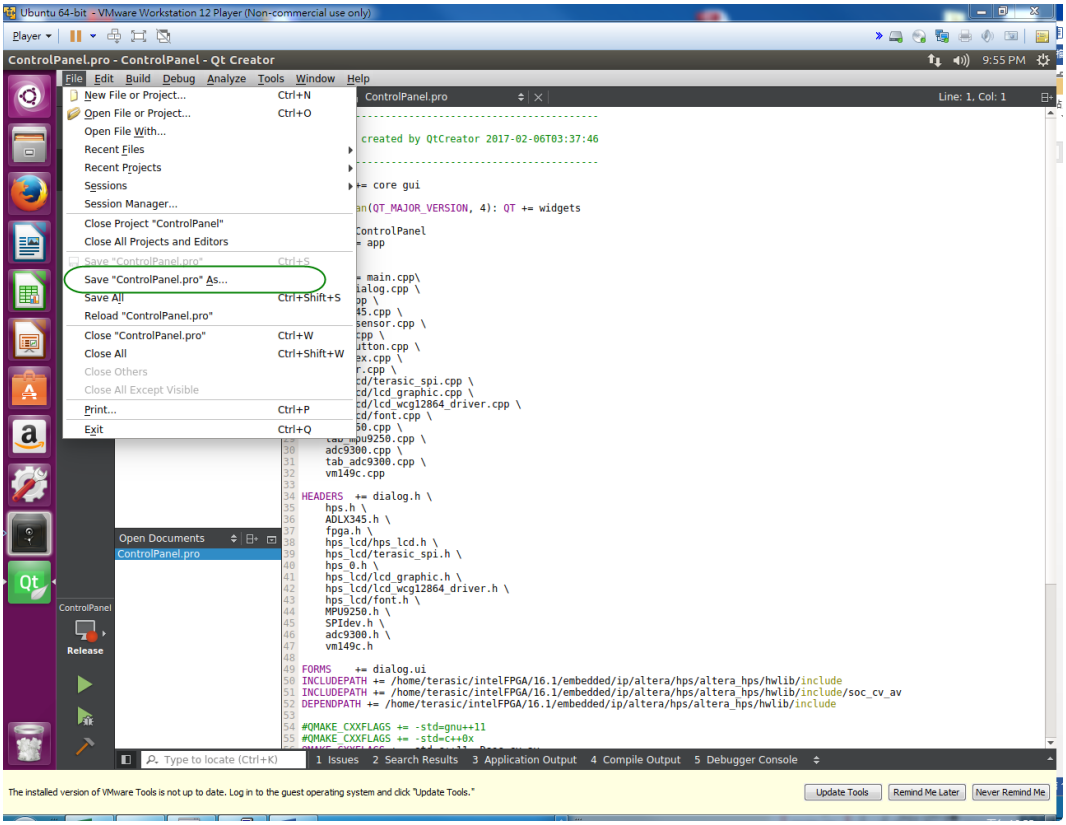

Figure 8-17 Save ControlPanel.pro

Click on the "Release" icon, and select "Intel Soc FPGA Kit" and "Release" Build as shown in **Figure 8-18**.

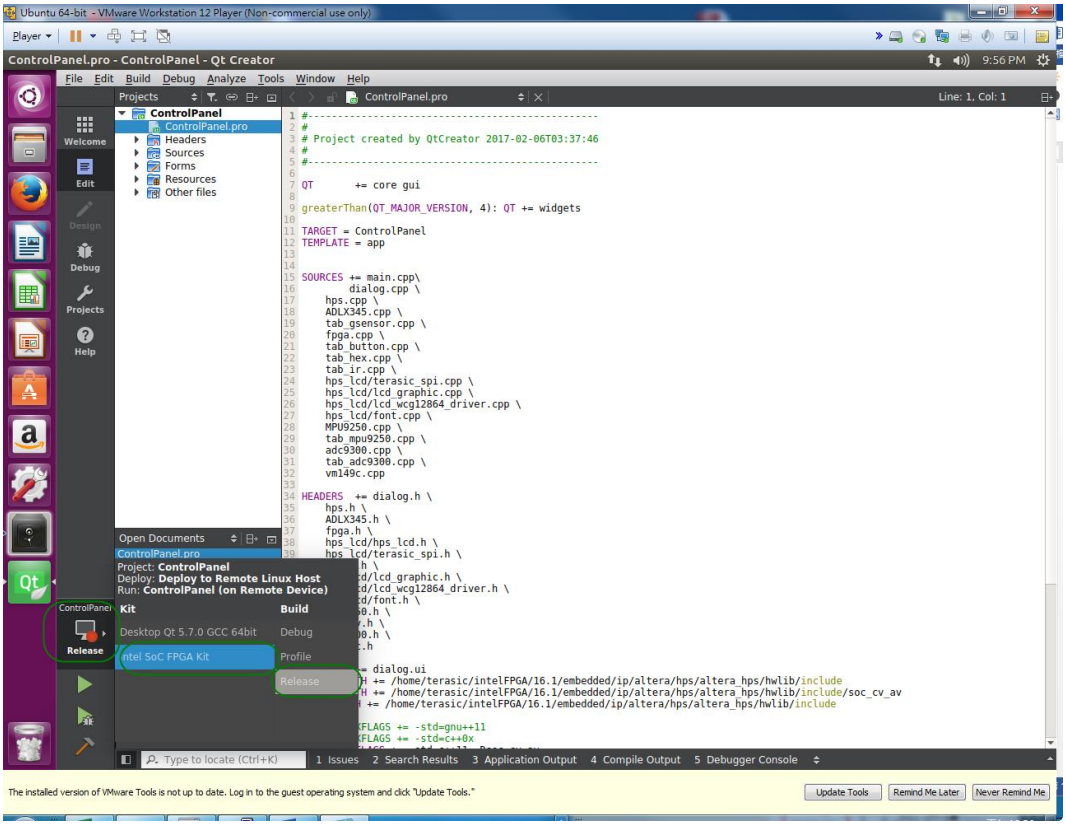

Figure 8-18 Setting Release Kit and Build

Then, select menu item "Build→Rebuild All", as shown in **Figure 8-19**, to build the Control Panel Project.

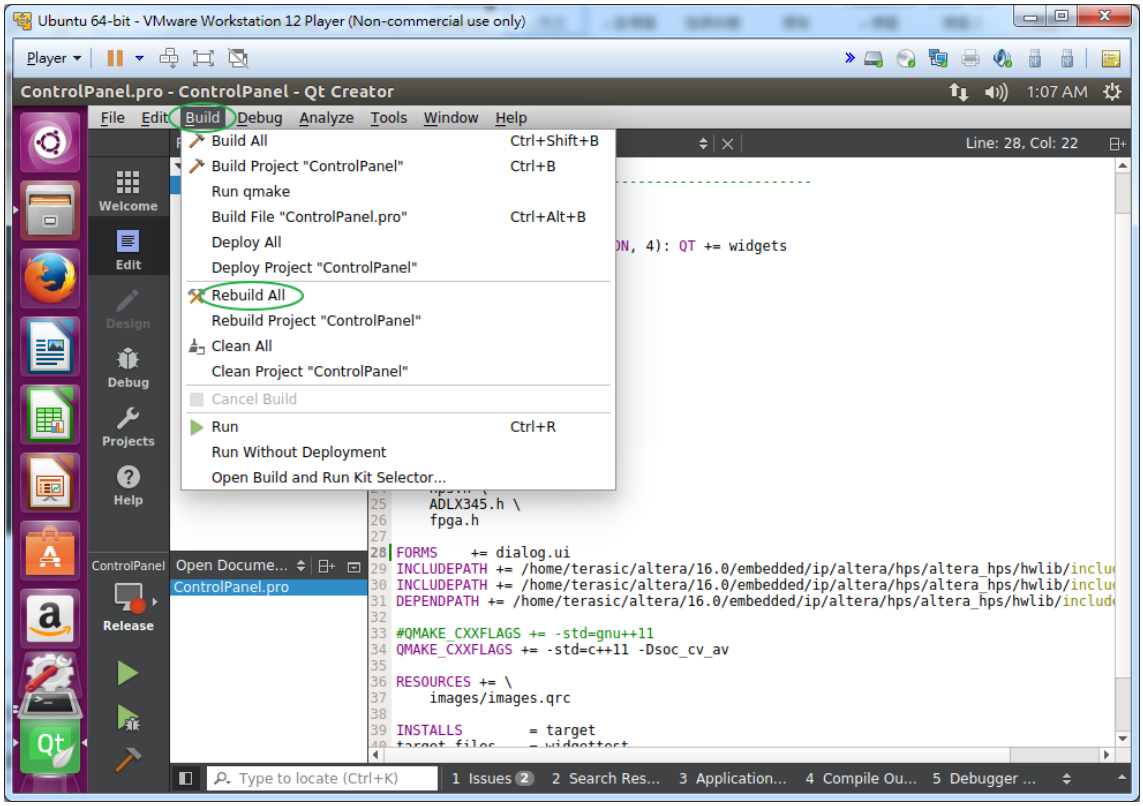

Figure 8-19 Build Control Panel

If the build is successful, the ControlPanel execution file is generated in the below folder as shown in **Figure 8-20**.

```
/mnt/hgfs/shared/build-ControlPanel-Intel_SoC_FPGA_Kit-Release
```

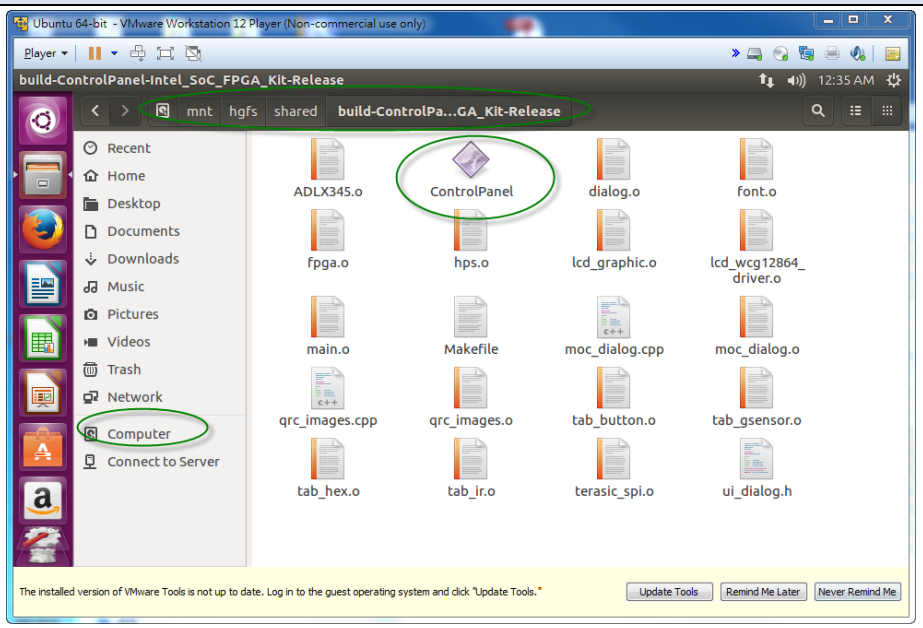

Figure 8-20 Generated Control Panel Execution File

8.4 Execute Control Panel Program

To run the "ControlPanel" execution file on the VEEK-MT2S FPGA development board, we need to copy it to the Linux on Intel SoC FPGA Board. This is similar to what we have done in Section 6.3 "Execute Hello Program" where we use Linux "scp" command to remote copy.

After "ControlPanel" execution file has been remotely copied to the "/home/root" directory of Linux running on Intel SoC FPGA Board, double click "ControlPanel" icon and click "Execute" button to launch the Control Panel in the LXDE Desktop of Intel SoC FPGA board. If you can see the ControlPanel windows as shown in **Figure 8-21**, it means you had successfully built the Control Panel Qt Project.

Figure 8-21 Screenshot of Control Panel

8.5 More on the Control Panel QT Project

■ Control FPGA LED

Control Panel controls the FPGA Qsys components through the memory-mapped method. The device driver "/dev/mem" is used to access the physical address space which is mapped to Qsys address space.

Below shows how to turn on the 10 LEDs, which is controlled by Qsys PIO Controller, whose address is 0x10040 in the Qsys system. Based on "/dev/mem" device driver and "mmap" function, we can calculate the LED address **led_base**. With the address, we can directly write the value of the address to control the PIO Controller. Constant ALT_LWFPGASLVS_OFST is defined "socal/hsp.h"

```
#include "socal/hps.h"

#define HW_REGS_BASE ( ALT_STM_OFST )
#define HW_REGS_SPAN ( 0x04000000 )
#define HW_REGS_MASK ( HW_REGS_SPAN - 1 )

// Controller Base Address in QSYS
#define FPGA_LED_PIO_BASE     0x10040
```

```
int file;
void *virtual_base;
uint8_t *led_base;

file = open( "/dev/mem", ( O_RDWR | O_SYNC ) );
virtual_base = mmap( NULL, HW_REGS_SPAN, ( PROT_READ | PROT_WRITE ), MAP_SHARED,
file, HW_REGS_BASE );
led_base= (uint8_t *)virtual_base + ( ( unsigned long  )( ALT_LWFPGASLVS_OFST +
FPGA_LED_PIO_BASE ) & ( unsigned long)( HW_REGS_MASK ) );

*(uint32_t *)m_led_base = 0x3FF; // turn on 10 led
```

■ Control HPS LED

The way to control HPS LEDs is similar to the way to control FPGA LED. The register files of both PIO controllers are different. Macro alt_setbits_word is used to set value to the specific address. The HPS LED is controlled by GPIO1 GPIO Controller.

Constant ALT_GPIO1_SWPORTA_DDR_ADDR is used to define the direction register address of GPIO1 Controller, and constant USER_IO_DIR is used to define the direction pin bits-mask associated to the HPS LED.

Constant ALT_GPIO1_SWPORTA_DR_ADDR defines the data register address of GPIO1 Controller, and constant BIT_LED is used to define the pin bits-mask associated to the HPS LED. Both ALT_GPIO1_SWPORTA_DDR_ADDR and ALT_GPIO1_SWPORTA_DR_ADDR are defined in "socal/hps.h". Macro alt_setbits_word is defined in "socal/socal.h"

```
#include "socal/socal.h"
#include "socal/hps.h"

#define HW_REGS_BASE ( ALT_STM_OFST )
#define HW_REGS_SPAN ( 0x04000000 )
#define HW_REGS_MASK ( HW_REGS_SPAN - 1 )

#define USER_IO_DIR         (0x01000000)
#define BIT_LED             (0x01000000)
```

```
int file
void *virtual_base;
uint8_t *led_base;

file = open( "/dev/mem", ( O_RDWR | O_SYNC ) );
virtual_base = mmap( NULL, HW_REGS_SPAN, ( PROT_READ | PROT_WRITE ), MAP_SHARED,
file, HW_REGS_BASE );
// configure LED as output pin
alt_setbits_word((void *) ( (char *)virtual_base +
( ( uint32_t )( ALT_GPIO1_SWPORTA_DDR_ADDR ) & ( uint32_t )( HW_REGS_MASK ) ) ),
USER_IO_DIR );
// turn on LED
alt_setbits_word((void *) ( (char *)virtual_base + ( ( uint32_t )( ALT_GPIO1_SWPORTA_DR_ADDR )
& ( uint32_t )( HW_REGS_MASK ) ) ), BIT_LED );
```

■ FPGA Class

All of FPGA control functions are encapsulated in the **FPGA** class and it is implemented in fpga.c and fpga.h. Below shows the public functions of this class.

```
bool LedSet(int mask);
bool HexSet(int index, int value);
bool KeyRead(uint32_t *mask);
bool SwitchRead(uint32_t *mask);
bool VideoEnable(bool bEnable);
bool VideoMove(int x, int y);
bool IsVideoEnabled();
bool IrDataRead(uint32_t *scan_code);
bool IrIsDataReady(void);
bool PlayTone(TONE_ID ToneID, uint32_t dur_ms=200 /* 0.2 second */);
bool CameraFocus(int nFocusPos /* 0 ~ 1023 */);
bool getMotion9(float *ax, float *ay, float *az, float *gx, float *gy, float *gz, float *mx, float *my, float *mz);
bool getLight(uint16_t *light0, uint16_t *light1);
```

■ HPS Class

Except for LCD, all of HPS control functions are encapsulated in the **HPS** class and it is implemented in hps.cpp and hps.h. Below shows the public functions of this class:

```
bool LedSet(bool bOn);
bool IsButtonPressed();
bool GsensorQuery(int16_t *X, int16_t *Y, int16_t *Z);
```

■ LCD_GRAPHIC Class

The **LCD_GRAPHIC** class is designed to provide graphic function for the LCD. It provides line, rectangle, and circle geometric drawing function, as well as font drawing function. It is implemented in lcd_graphic.cpp and hps.h. These two files are located in the hps_lcd folder. The code below shows the public functions of this class. The drawing result will not be displayed on the LCD until **Refresh** function is called. Below shows the public functions of this class:

```
void Clear(int Color=COLOR_WHITE);
void Line(int X1, int Y1, int X2, int Y2, int Color);
void Pixel(int X, int Y, int Color);
void Rect(int X1, int Y1, int X2, int Y2, int Color);
void Circle(int x0, int y0, int Radius, int Color);
void Refresh(void); // update to hardware
int FrameWidth(void);
int FrameHeight(void);
```

The **LCD_GRAPHIC** class is derived from the **LCD_WCG12864** class. The LCD_WCG12864 class is derived from the **TERASIC_SPI** class. The **TERASIC_SPI** class uses Altera hwlib to control the Master SPI controller in HPS(Hard Process System) directly. The font bitmap data is stored in the font.cpp.

■ MPU9250 Class

The **MPU9250** class is designed to configure the MPU9250 9-axis sensor and read the measured values through the SPI interface. The class is implement in the MPU9250.cpp and MPU9250.h. Developers can call the **initialize** function to initialize the MPU9250 chip, then call **getMotion9** or to **getMotion6** to read the measured values. Below shows the public functions of this class:

```
bool initialize(int sample_rate_div = 1, int low_pass_filter = 0x01);
bool testConnection();
```

```
unsigned int WriteReg( uint8_t WriteAddr, uint8_t WriteData );
unsigned int ReadReg( uint8_t WriteAddr, uint8_t WriteData );
void ReadRegs( uint8_t ReadAddr, uint8_t *ReadBuf, unsigned int Bytes );

unsigned int set_gyro_scale(int scale);
unsigned int set_acc_scale(int scale);

void calib_acc();
void calib_mag();

void read_temp();
void read_acc();
void read_gyro();
void read_mag();
void read_all();

unsigned int whoami();
uint8_t AK8963_whoami();
void getMotion9(float *ax, float *ay, float *az, float *gx, float *gy, float *gz, flo
    void getMotion6(float *ax, float *ay, float *az, float *gx, float *gy, float *gz);
```

The **MPU9250** class uses the **SPIdev** class to handle the low level data transmission with the MPU9250 chip. The **SPIdev** class is implemented in the SPIdev.h file.

■ ADC9300 Class

The **AD9300** class is designed to configure the ADC9300 light sensor and read the measured values through the I2C interface. The class is implemented in the ADC9300.cpp and ADC9300.h. Developers can call the **Set_PowerSwitch** function to power on the MPU9250 chip, then call **Get_ADCData0** and **Get_DCData1** to read the measured values. Below shows the public functions of this class:

```
bool IsReady(void);
bool Get_ADCData0(uint16_t *pData16
bool Get_ADCData1(uint16_t *pData16
```

```
bool Get_ID(uint8_t *pData8);
bool Set_PowerSwitch(bool bSwitch);
```

The **ADC9300** class use the I2C driver to handle the low level data transmission with the ADC9300 chip. In the VEEK-MT2 LXDE BSP, the ADC9300 I2C device is mapped to the file named "/dev/i2c-5".

■ HPS_AUDIO Class

The **HPS_AUDIO** class is designed to provide audio output function. The function is implemented in the hps_audio.cpp and hps_audio.h. The ALSA Audio API is used to perform audio relative function. Below shows the public functions of this class:

```
static bool PlayTone(TONE_ID ToneID, uint32_t dur_ms=200 /* 0.2 second */);
static bool PlayTone(float fToneFrequencyHz, uint32_t dur_ms);
```