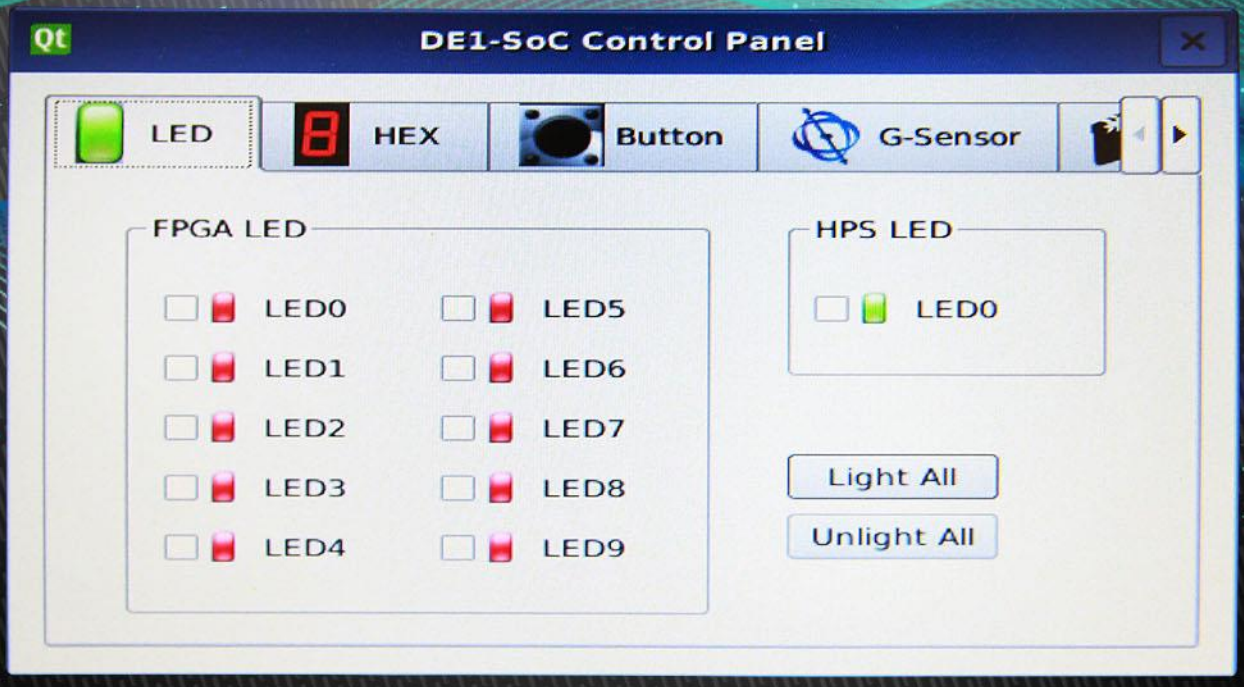
DE1-SoC

Control Panel



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ALTERA UNIVERSITY PROGRAM

CONTENTS

Chapter 1

Overview

The Altera Cyclone V SoC Development Kit (DE1-SoC), a robust platform that is built around Altera System-on-Chip (SoC) FPGA which combines the dual-core Cortex-A9 embedded cores with industry leading programmable logic for ultimate design flexibility. Altera's SoC FPGA integrates Hard Processor System (HPS) consisting of processor, peripherals and memory interfaces tied seamlessly with the FPGA fabric using a high-bandwidth interconnect backbone. Other than having the Altera SoC FPGA, DE1-SoC FPGA development board is equipped with hardware, such as DDR3 memory, video and audio capabilities, Ethernet networking, and much more that promise many exciting applications.

To demonstrate the power of the SoC FPGA on the DE1-SoC FPGA development board, we have created a "Control Panel" program, a board utility software that uses ARM to access various peripherals that belong both to the Hard Processor System (HPS) and the FPGA. This demo is particularly useful for anyone who is interested in the SoC FPGA structure and development of future SoC applications.

This scope of this tutorial is to help users understand and learn how to build the board utility "Control Panel" on the DE1-SoC FPGA development board in a step-by-step fashion. To boost user confidence while following the instructions, we provide screenshots of steps needed to be followed. This helps users debug if they encounter any problems during the learning process. Users should have basic concepts toward building their own applications once they have finished working with the whole tutorial. Also, users should find this tutorial self-explanatory and self-contained as we hope that lots of creative projects can be inspired as a result of this.

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.

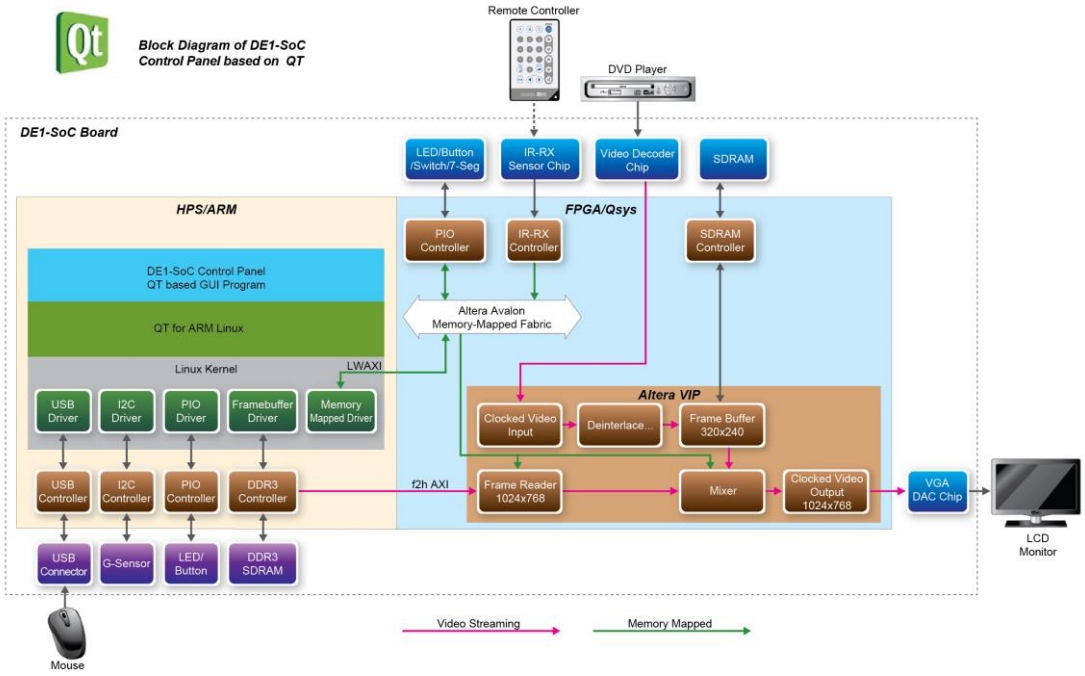

Figure 1-1 Block Diagram of the Control Panel

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 on Windows Host
- Install a Linux x86 under virtual machine
- Install QT Designer on Linux x86
- Create and build a QT hello program for Linux x86
- Cross-compile to build QT library for Altera SoC ARM
- Cross-compile to build QT Application for Altera SoC ARM
- Create and build a Quartus Project for Altera SoC FPGA
- Launch QT application on Altera 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 x86 PC
- Altera DE1-SoC FPGA board
- Linux Ubuntu 12.04 x32 Installer
- Options if Windows Host is preferred
  - MS Windows Installer
  - VMware Player Installer
- QT 5.2.0 Designer Installer
- QT 4.8.5 open source
- Quartus 13.0 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 x86 on Windows Host
2. Install QT 5.2.0 Creator
3. Install Altera SoC Tool-Chain
4. Build QT 4.8.5 Library for Altera SoC ARM
5. Build QT App for Altera SoC FPGA Board
6. Build Quartus Project
7. Execute QT App on Altera SoC FPGA Board

1.5 Set up the Control Panel Demo

This section describes how to set up the Control Panel program on the Altera DE1-SoC Development Kit. There are five steps involved. Please carefully follow the instructions below:

1. Download microSD card writer utility – **Win32 Disk Imager**
2. Decompress the ControlPanel image file, and write the file into a 4GB microSD card with an ImageWriter Utility
3. Insert the microSD card intro Altera DE1-SoC FPGA Development Board, connect a USB keyboard and mouse to the USB host port, connect a LCD monitor to the VGA port, then power on the board to boot Linux System.
4. Login in Linux with 'root' user name
5. Type "./ControlPanel –qws" to launch Control Panel.

■ 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-v0.9-binary.zip".

Figure 1-2 Download Web Page of Win32 Disk Imager

Decompress the file and execute Win32DiskImage.exe to launch the tool as shown in **Figure 1-3**.

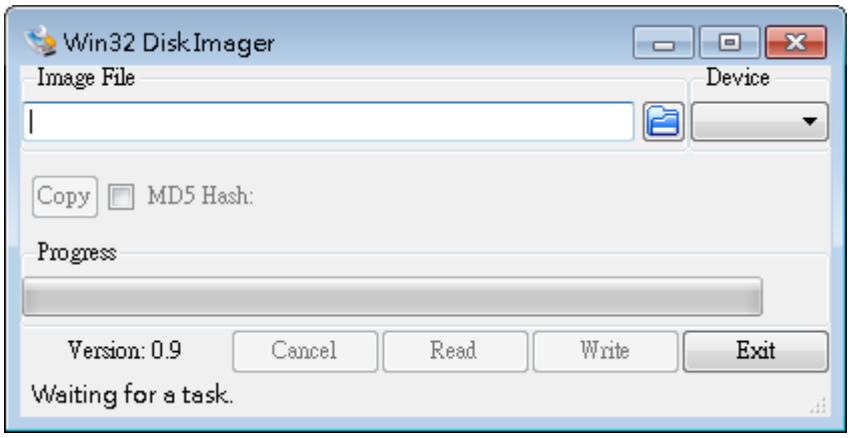

Figure 1-3 Win32 Disk Imager

■ Create Linux Booting microSD card

The "Control Panel" microSD card image is available from the website:

http://cd-de1-soc.terasic.com

Please download the microSD card image "Linux Console with framebuffer" under the Linux BSP section. The filename is DE1_SoC_FB.zip. The archive needs to be decompressed to extract the image named DE1_SoC_FB.img.

Then, insert a 4GB microSD card 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 DE1_SoC_FB.img. Click "Write" to start writing the image file into the microSD card as shown in **Figure 1-4.**

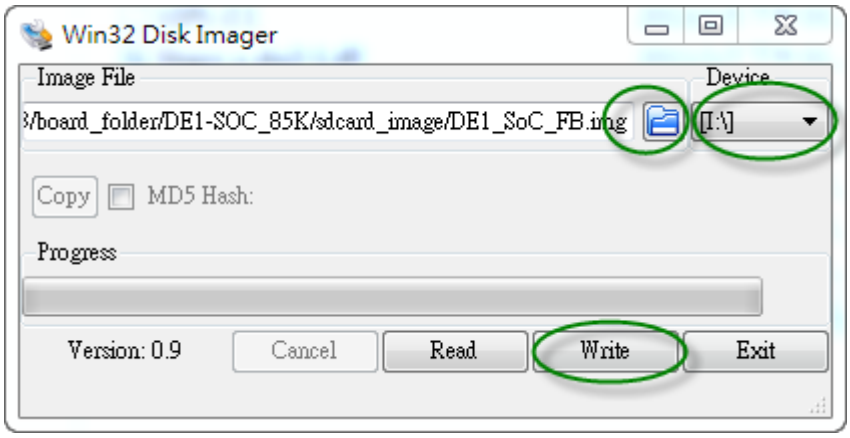

Figure 1-4 Write microSD card with a Given Image File

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.

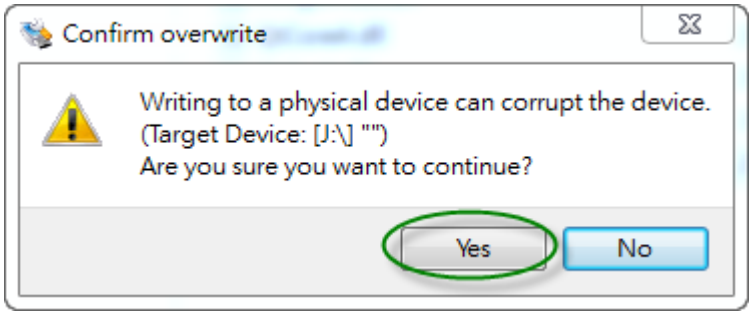

Figure 1-5 Confirm to Continue

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

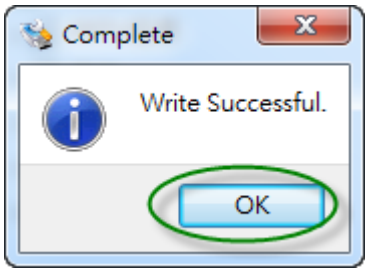

Figure 1-6 Write SD-card Complete

■ Set up Hardware and Boot Linux

Connect the following items to the Altera DE1-SoC FPGA development board as shown in **Figure 1-7**.

- USB mouse and keyboard
- LCD monitor
- Control Panel microSD Card
- DC Power

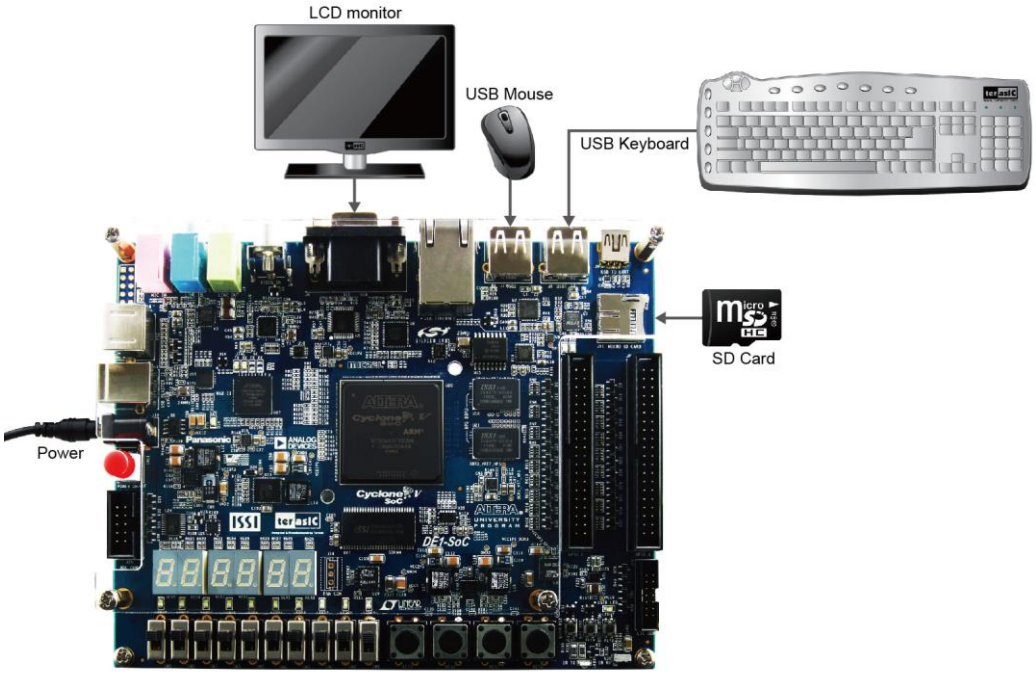

Figure 1-7 Altera DE1-SoC FGPA Development Board Setup

Please also make sure that MSEL[4:0]=00000 located on the back of the Altera DE1-SoC FPGA development board as shown in **Figure 1-8.**

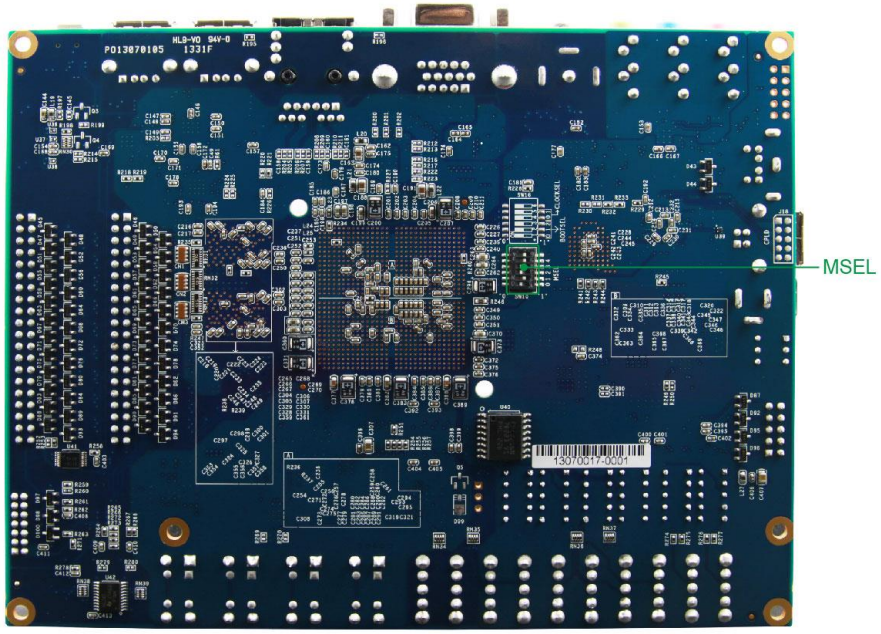

Figure 1-8 MSEL[4:0] on the Altera DE1-SoC FPGA Development Board

After connecting the above peripherals, power on the Altera DE1-SoC FPGA board. The LCD monitor will now display Linux booting message as shown in **Figure 1-9**.

Figure 1-9 Linux Booting Using Root Account

When the Linux boot process is complete, a login prompt will appear as shown in **Figure 1-10**. Type in “root” and press ENTER to login Linux.

■ Launch Control Panel

After successful login as root, the current directory is now set at "/home/root". The Control Panel execution file "ControlPanel" is pre-built in this directory. Please type in "./ControlPanel –qws" 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.

Figure 1-10 Launch the Control Panel

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.

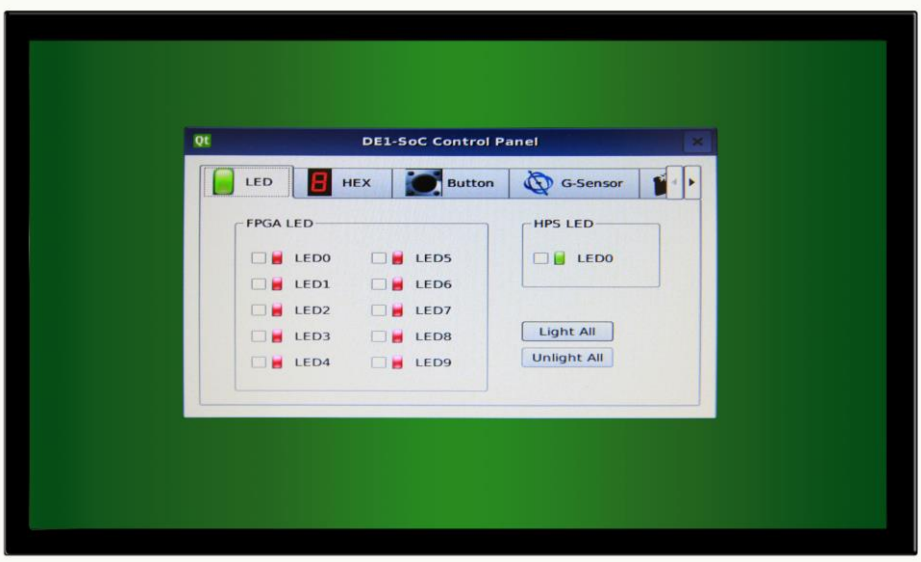

Figure 1-11 Screenshot of DE1-SoC Control Panel

Chapter 2

Linux Installation

The Control Panel program runs on Linux in the Altera SOC ARM as shown in the block diagram in Chapter 1. In Chapter 2, we begin by installing Linux as a first step toward completing the Control Panel project. The Linux system can be installed on a x86 PC directly or on a virtual machine running on Microsoft Windows. This chapter also describes how to install an Ubuntu OS, a Linux system, on a virtual machine VMware Player running on Microsoft Windows. The VMware Player is first installed on a Windows host, and subsequently Ubuntu Linux is installed on the VMware 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 Ubuntu on VMware Player running on Microsoft Windows. Note that QT Creator, a software meant for GUI-based programs, can't be successfully installed on Cygwin Linux in Microsoft Windows.

Running Ubuntu on VMware 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 Microsoft Windows installed
- VMware Player installer (shareware)
- Linux Ubuntu 12.04 x32 .iso image file

2.2 Install VMware Player

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

■ Download VMware Player Installer

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

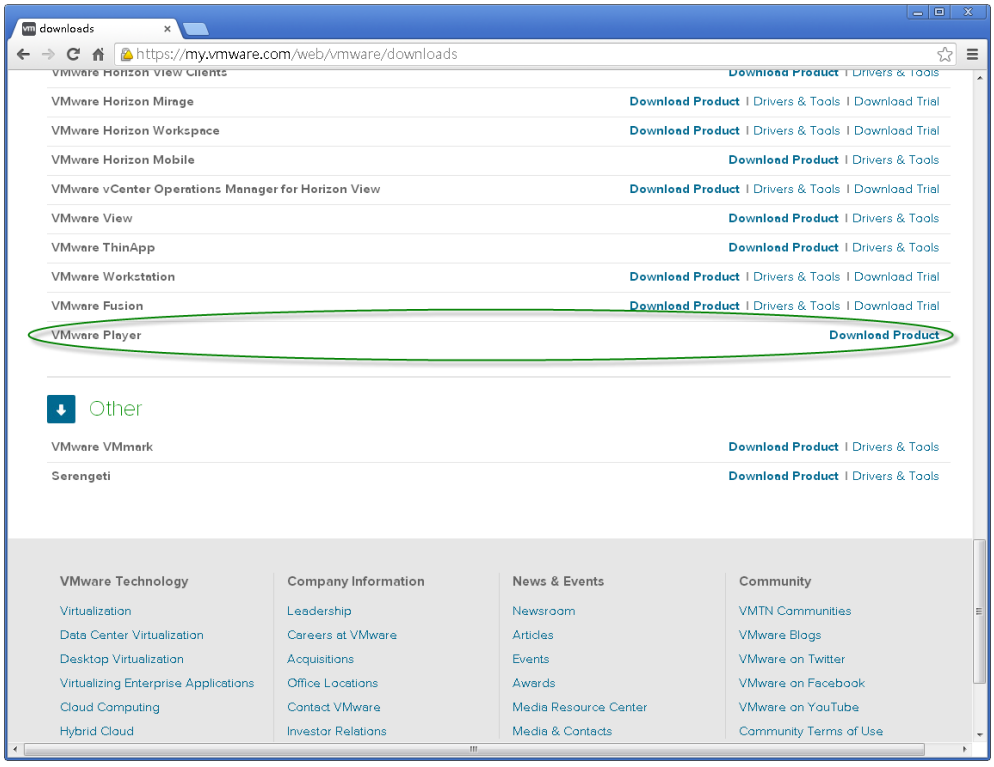

Figure 2-1 Download Web Page of VMware

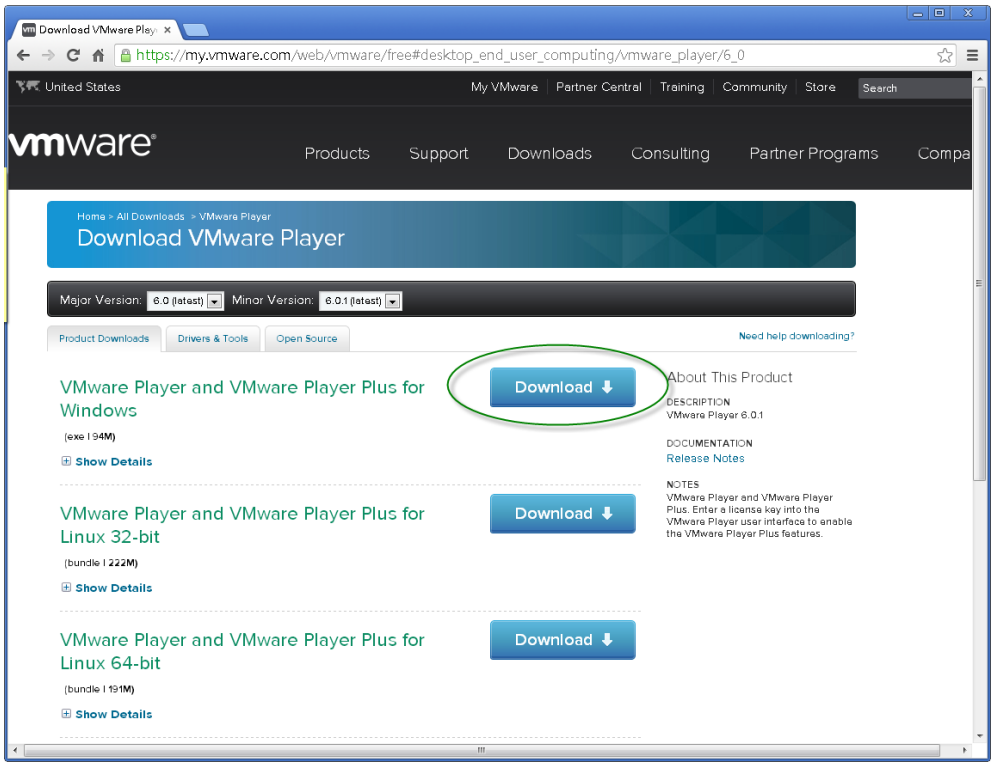

Figure 2-2 VMware Player Download Web Page

■ Install VMware

Under the Windows host, execute the downloaded installer "VMware-player-6.0.1-1379776.exe" to start the setup process. **Figure 2-3** shows the screenshot of the installer. Click “Next >” button to go to the next step.

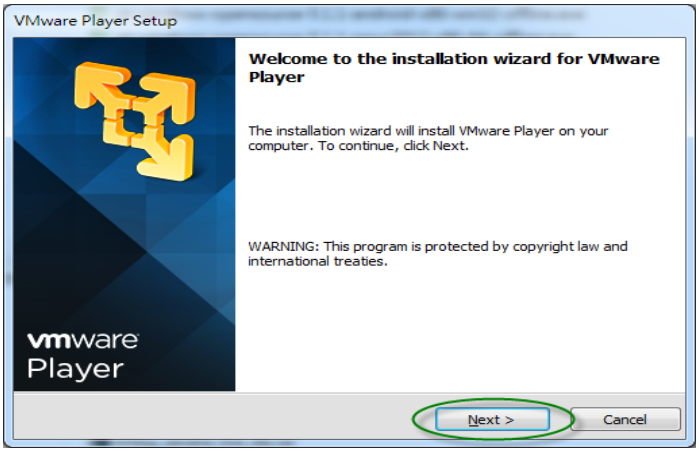

Figure 2-3 Welcome Dialog

In the **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.

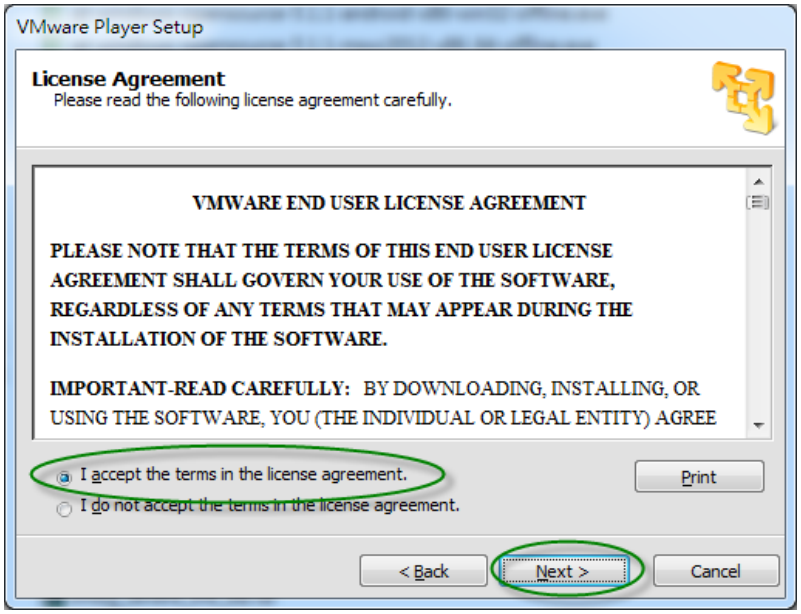

Figure 2-4 License Agreement Dialog

In the **Destination Folder** 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.

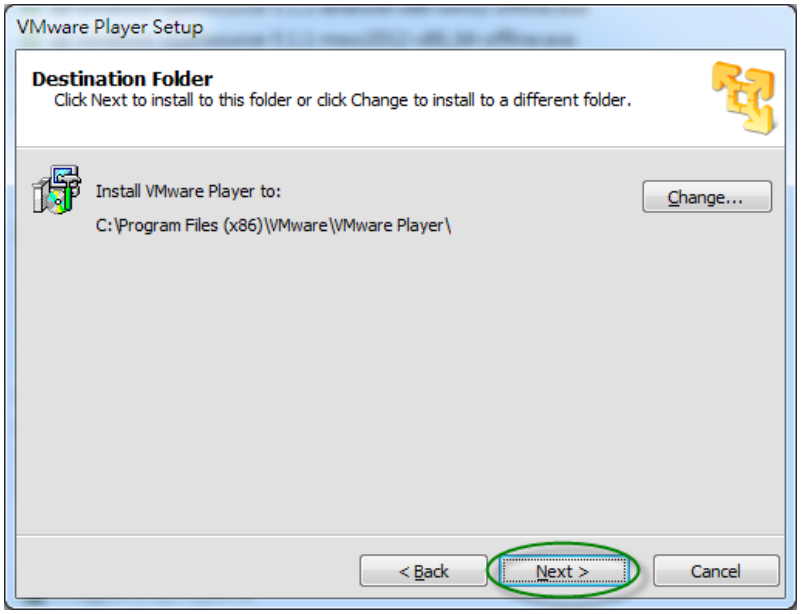

Figure 2-5 Destination Folder Dialog

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

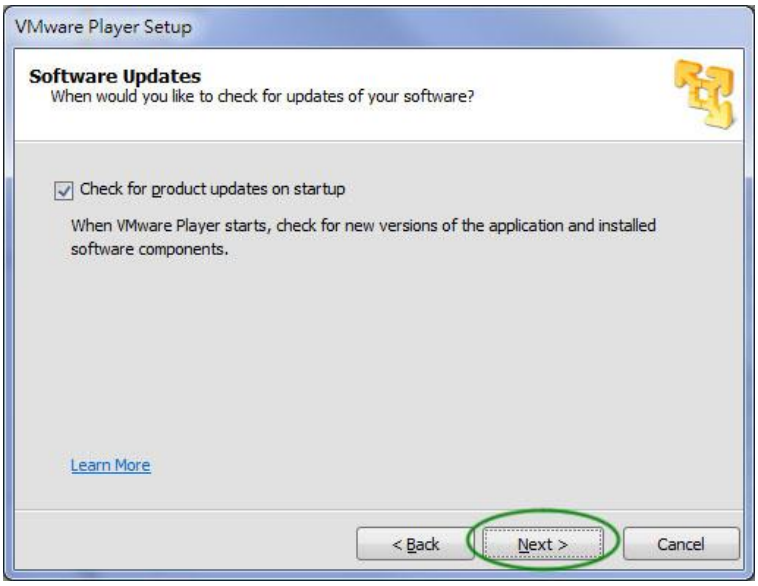

Figure 2-6 Software Updates Dialog

Next, you should see a "**User Experience Improvement Program**" dialog as shown in **Figure 2-7.** Check on "Help improved VMware Player" and click "Next" to continue.

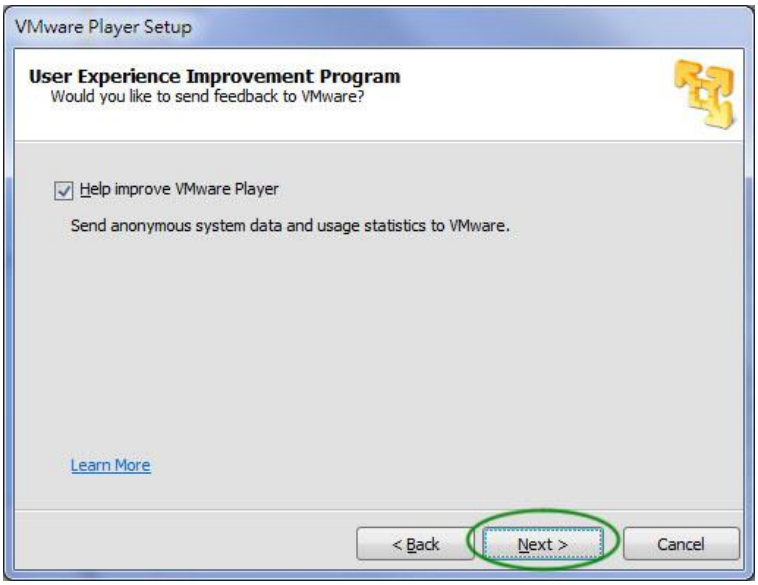

Figure 2-7

In the **Shortcuts** dialog as shown in **Figure 2-8**, keep the default setting, then click "Next >" button to go to the next step

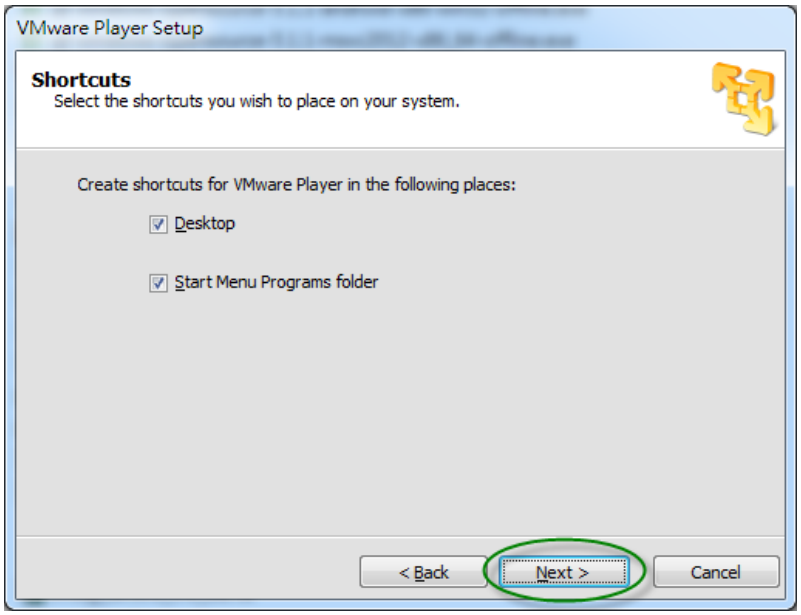

Figure 2-8 Shortcuts Dialog

In the **Ready to Perform the Requested Operations** dialog as shown in **Figure 2-9**, click "Next >" button to go to the next step

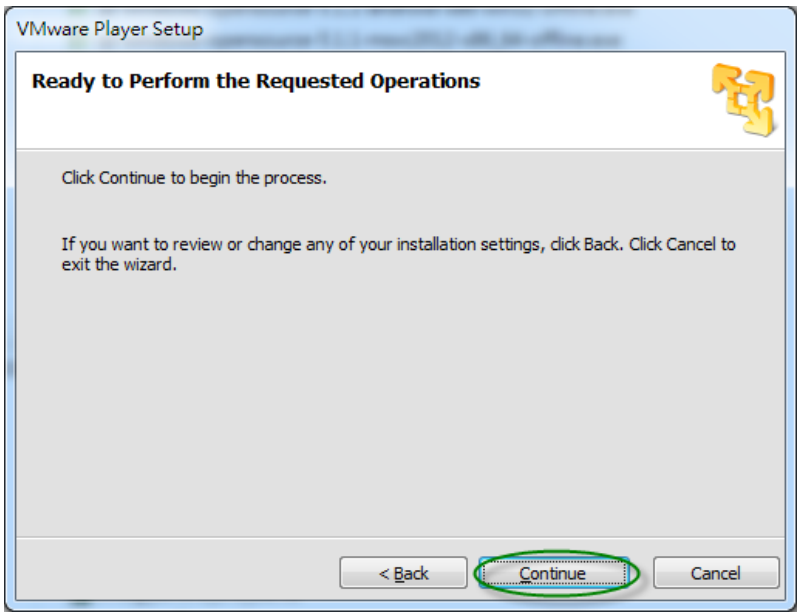

Figure 2-9 Ready to Perform the Requested Operation Dialog

When the installation is complete, **Setup Wizard Complete** dialog appears as shown in **Figure 2-10**. Click "Finished" button to finish the setup process.

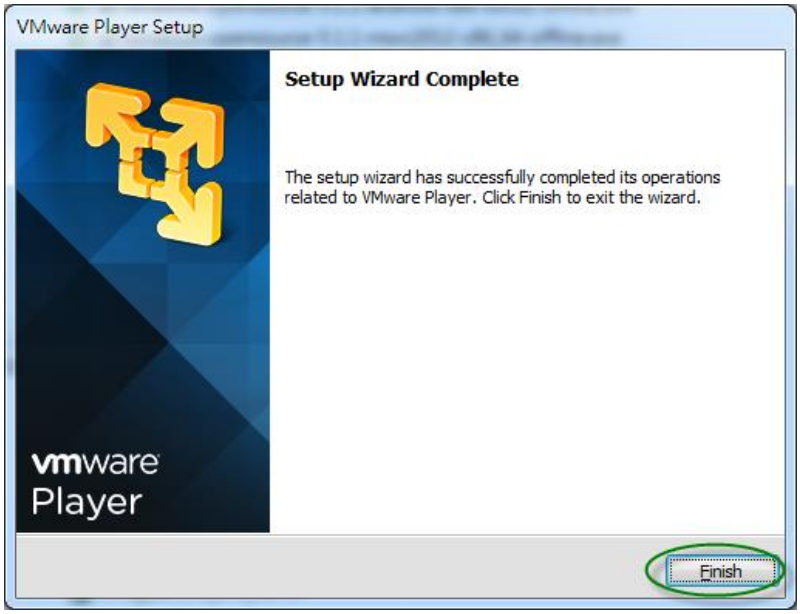

Figure 2-10 Setup Wizard Complete Dialog

2.3 Launch VMware

Once VMware Player is completely installed, a program shortcut icon will appear on the desktop in Windows, as shown in **Figure 2-11**. Double-click the shortcut icon will launch the VMware Player. **Figure 2-12** shows the main window of VMware Player.

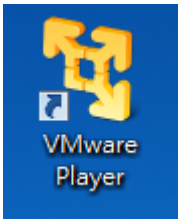

Figure 2-11 VMware Player Shortcut on Windows Desktop

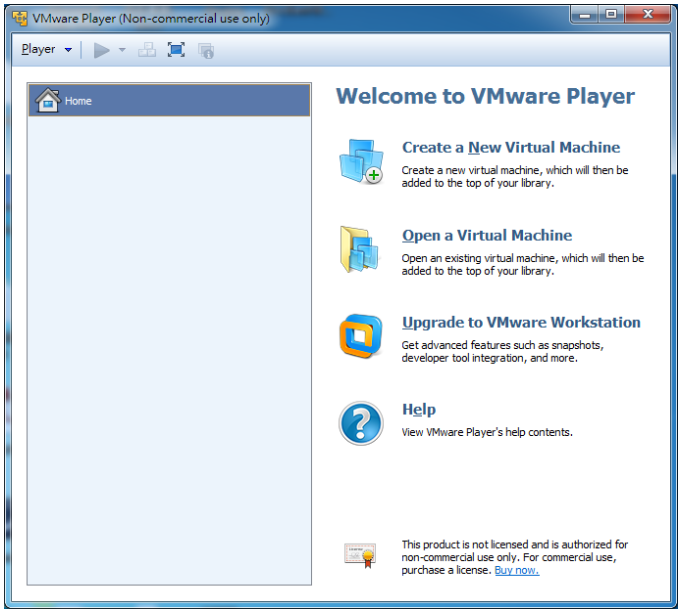

Figure 2-12 Main Window of VMware Player

2.4 Install Linux Ubuntu Desktop

Now we have downloaded and installed the VMware player, we are ready to download Ubuntu image file and install it on the VMware Player. Note that the “Easy Install” mode is automatically applied when VMware Player detects if the installed OS is Ubuntu 12.04.

■ Download Ubuntu Linux Image

The Ubuntu Desktop can be downloaded from the weblink provided below, as shown in **Figure 2-13**

http://www.ubuntu.com/download/desktop

On the download page, select “32-bit (for machines with less than 2GB)” and click "Ubuntu 12.04 LTS" button to start the download process.

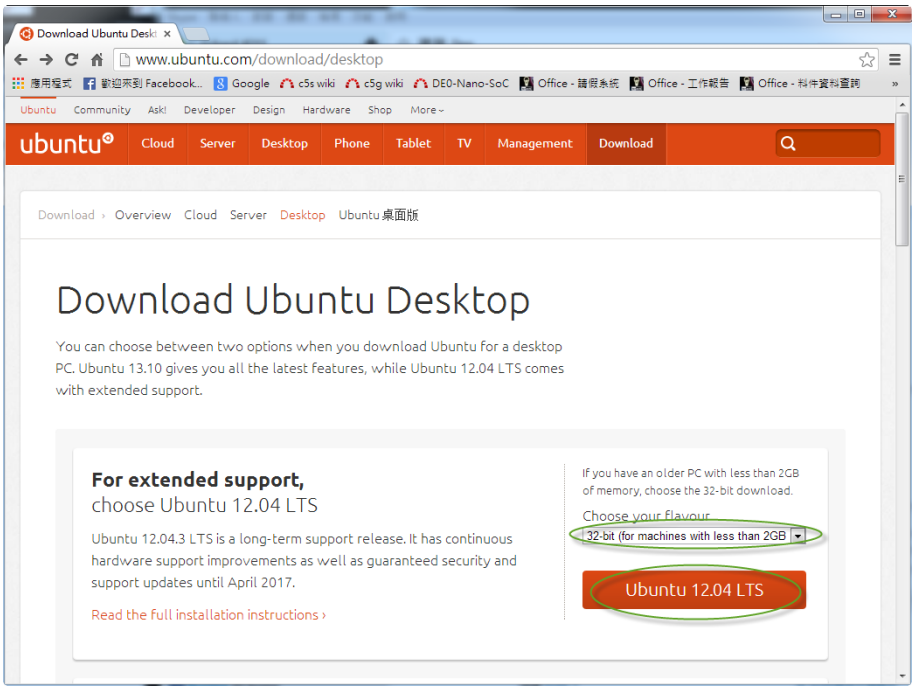

Figure 2-13 Download Page of Ubuntu Desktop

A **Contribution** page appears as shown in **Figure 2-14**. If you do not wish to contribute now, click "Not now, take me to the download >" to start the download process. The downloaded image filename is "**ubuntu-12.04.3-desktop-i386.iso**".

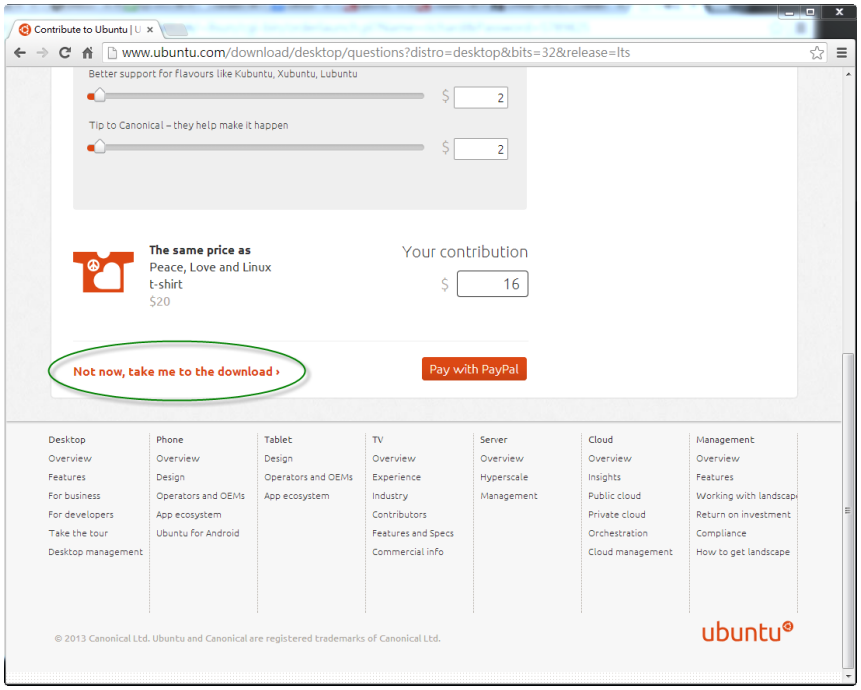

Figure 2-14 Download Page of Ubuntu Desktop

■ Create a Ubuntu Virtual Machine on the VMware Player

Launch the VMware Player as shown in **Figure 2-15**. Click the "Create a New Virtual Machine" Icon to create a virtual machine accordingly.

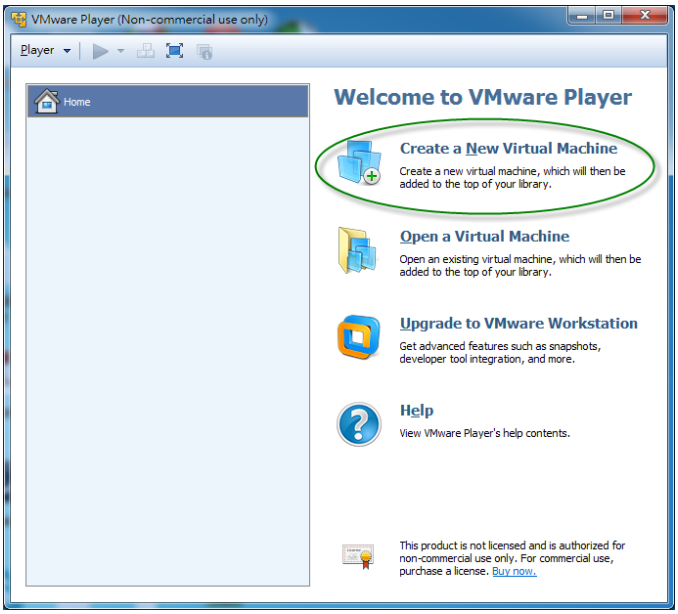

Figure 2-15 VMware Player Main Window

When the **Welcome to the New Virtual Machine Wizard** dialog appears as shown in **Figure 2-16**, select the "installer disk image file (iso):" radio button, and click "Browse" button to specify the location of the Ubuntu Linux image file "**ubuntu-12.04.3-desktop-i386.iso**" which has been downloaded in the previous step. Note that the "Easy Install" mode is enabled for Ubuntu 12.04. Click "Next >" to go to the next step.

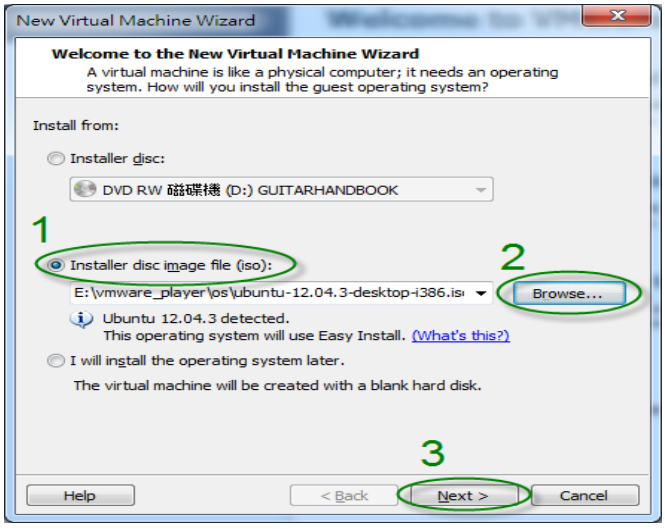

Figure 2-16 Install Dialog

When the **Easy Install Information** dialog appears as shown in **Figure 2-17**, 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.**

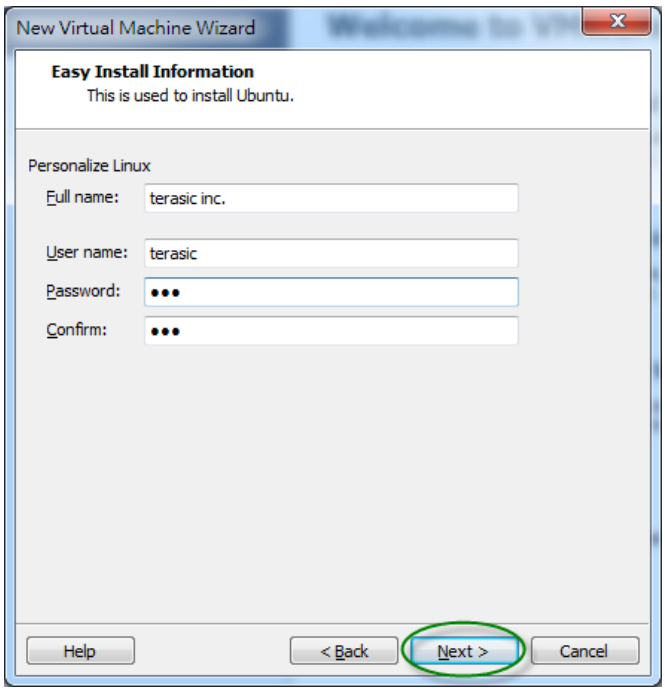

Figure 2-17 Easy Install Information Dialog

When the **Name the Virtual Machine** dialog appears as shown in **Figure 2-18**, you can change the virtual machine name as you wish. In this example, a machine name "Ubuntu 12.04 x32" 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.

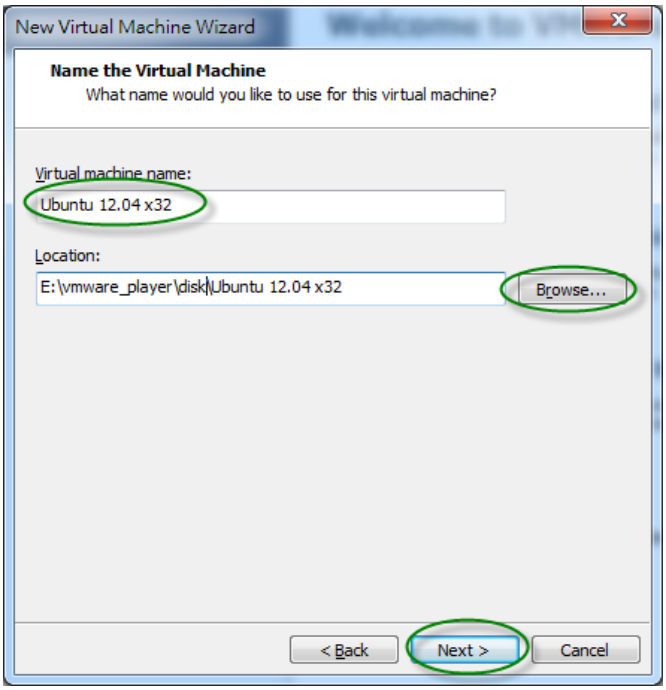

Figure 2-18 Name the Virtual Machine Dialog of New Virtual Machine Wizard

When the **Specify Disk Capacity** dialog appears as shown in **Figure 2-19**, please specify the maximum disk size and click "Next >" button to go to the next step.

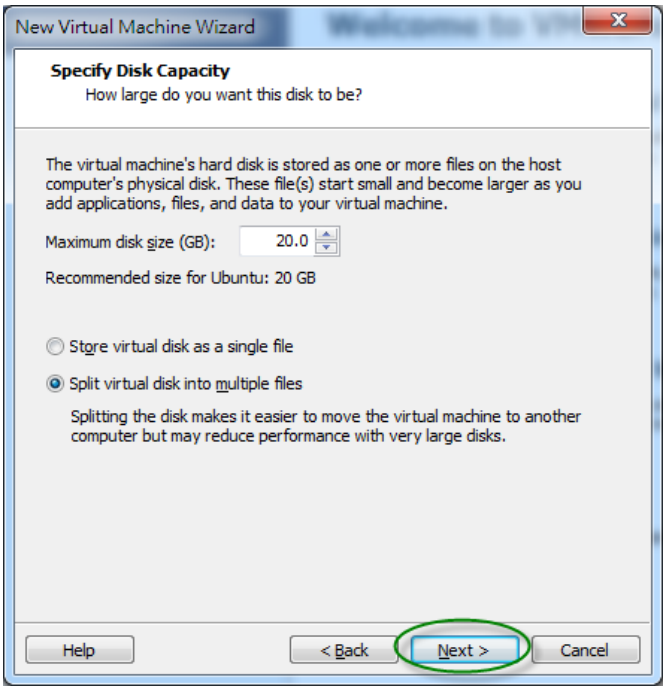

Figure 2-19 Specify Disk Capacity Dialog

Now, the **Ready to Create Virtual Machine** dialog appears as shown in **Figure 2-20**. Keep the default setting and click "Finish >" button to go to the next step.

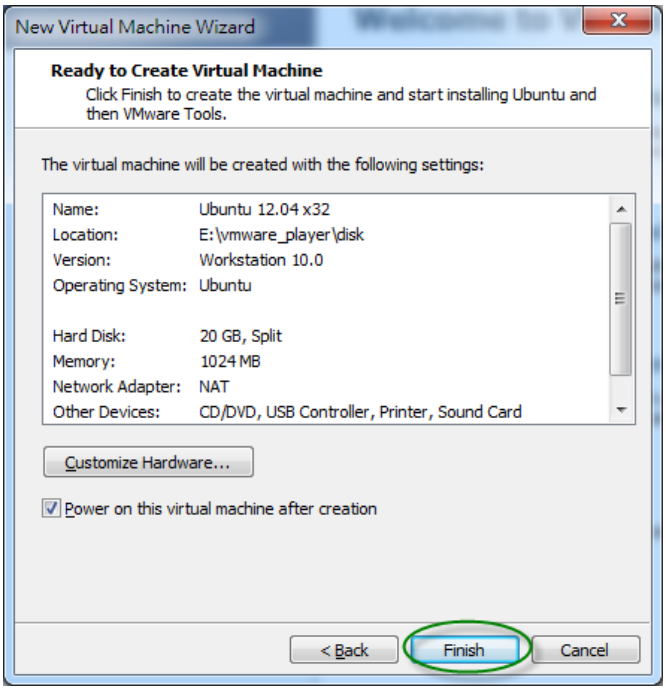

Figure 2-20 Ready to Create Virtual Machine Dialog

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

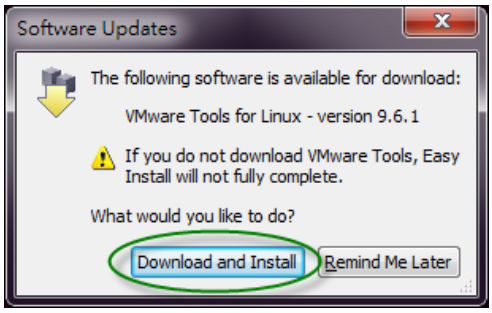

Figure 2-21 Software Updates Dialog

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

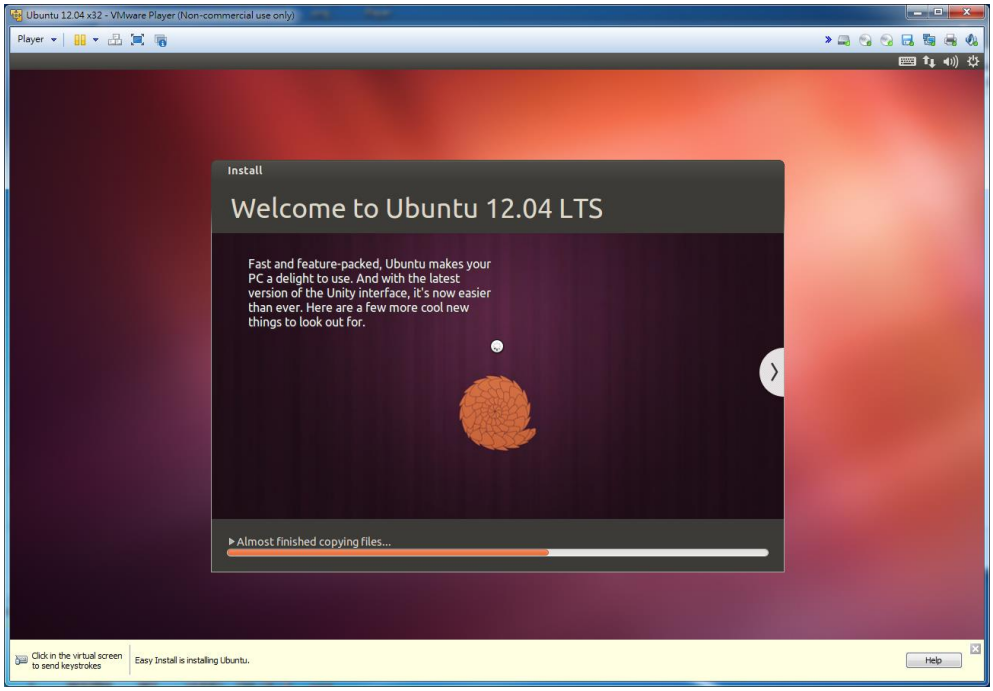

Figure 2-22 Installation Progress

When the installation is completed, a 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.

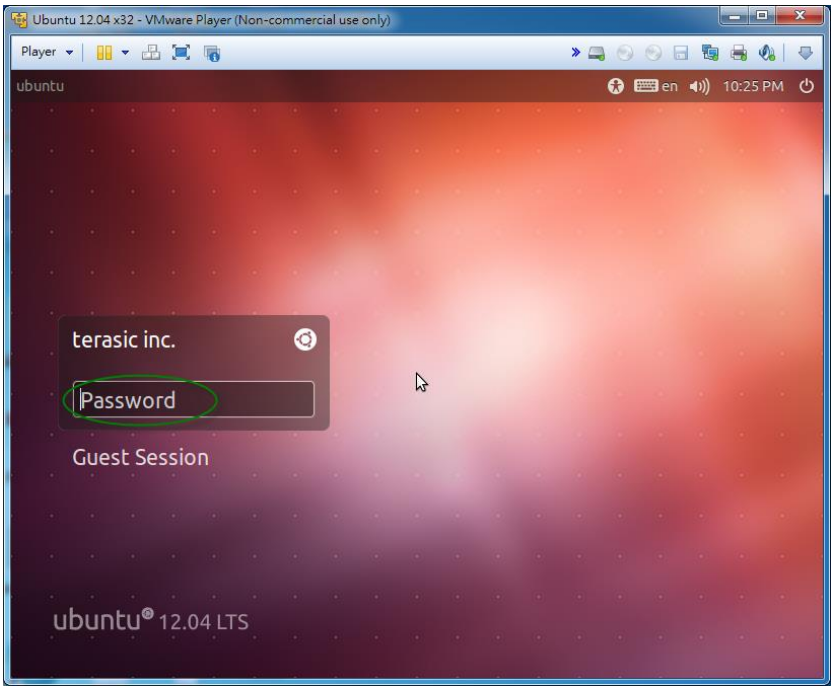

Figure 2-23 Ubuntu Login

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

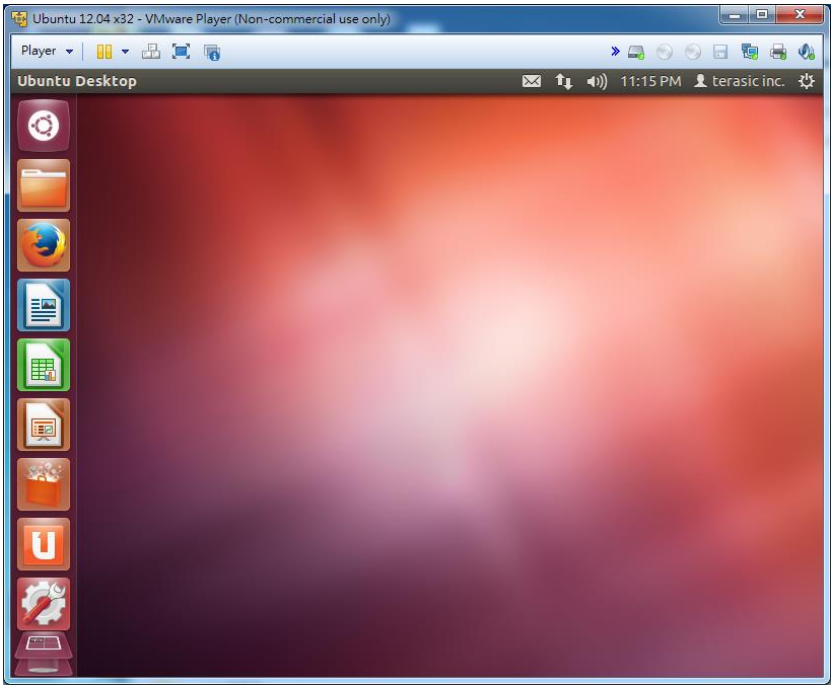

Figure 2-24 Ubuntu Desktop

Click the Power icon and select the "Shut Down…", as shown in **Figure 2-25** to turn off the Linux

system.

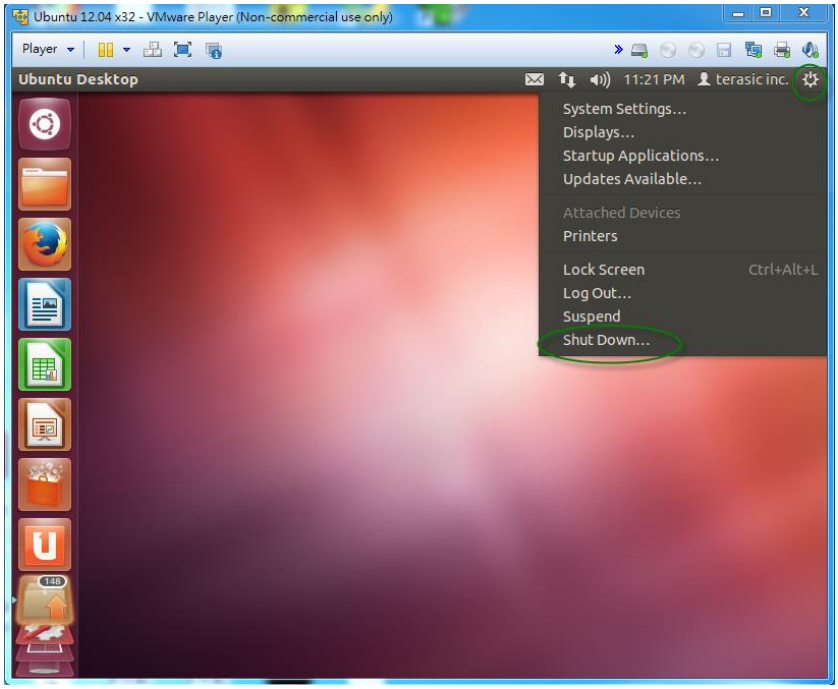

Figure 2-25 Shut Down Ubuntu Desktop

■ Restart Ubuntu

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

1. Launch VMware Player
2. Select the "Ubuntu 12.04 x32" item and click "Play virtual machine" button to start Ubuntu as shown in **Figure 2-26**.

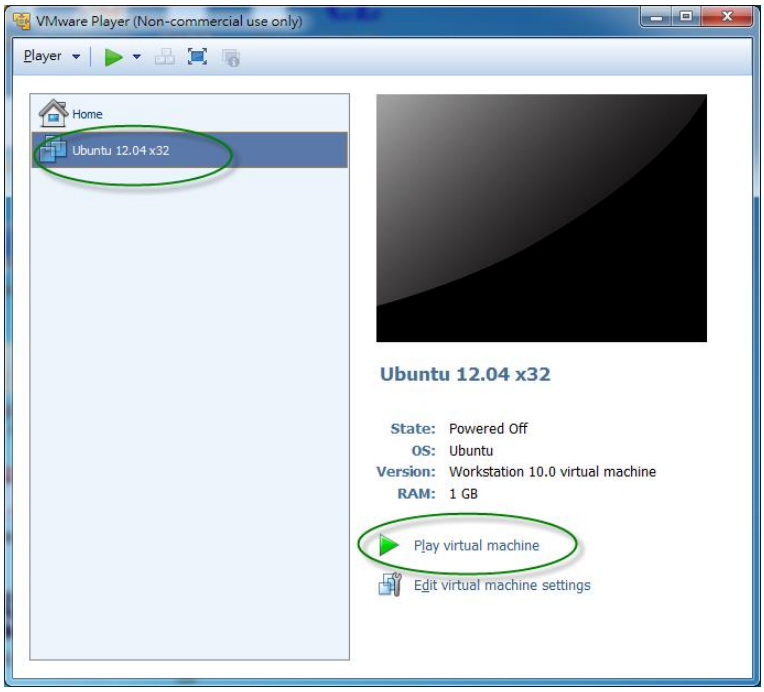

Figure 2-26 Start Ubuntu

2.5 Upgrade Linux Software Package

After Linux 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 2-27**.

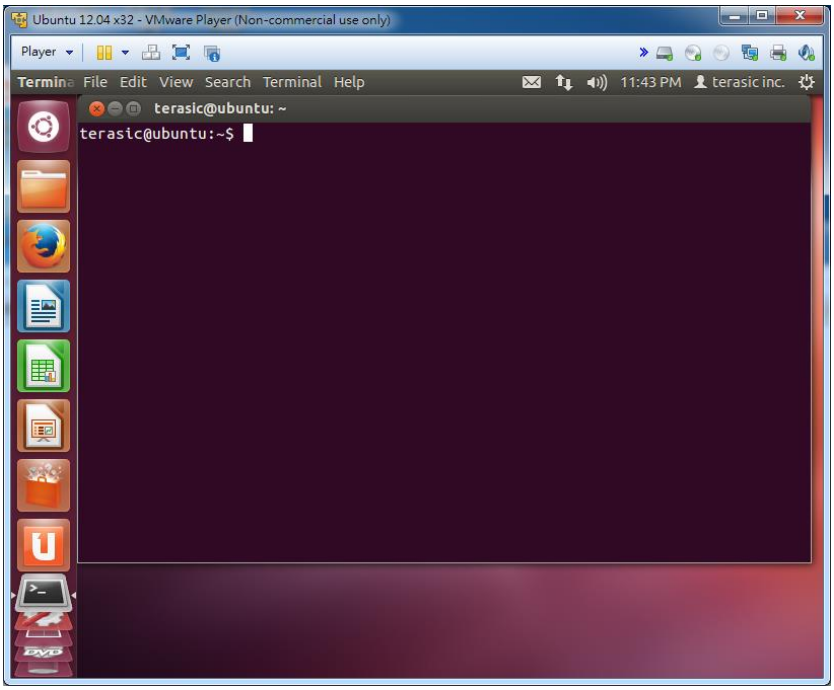

Figure 2-27 Linux Terminal

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

```
$sudo apt-get 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 2-28**.

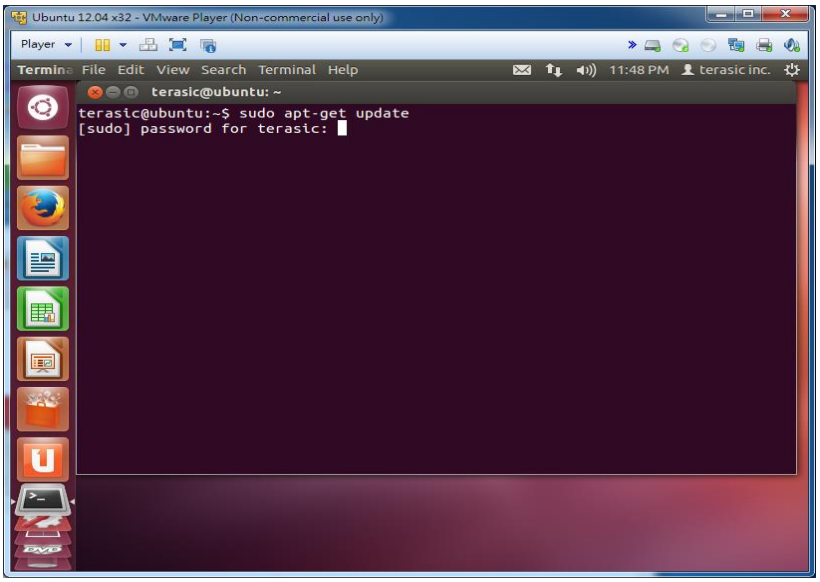

Figure 2-28 Input Password for Terasic

After finishing typing in "sudo apt-get update' and the password, now type in the following command and press ENTER, as shown in **Figure 2-29**.

```
$sudo apt-get upgrade
```

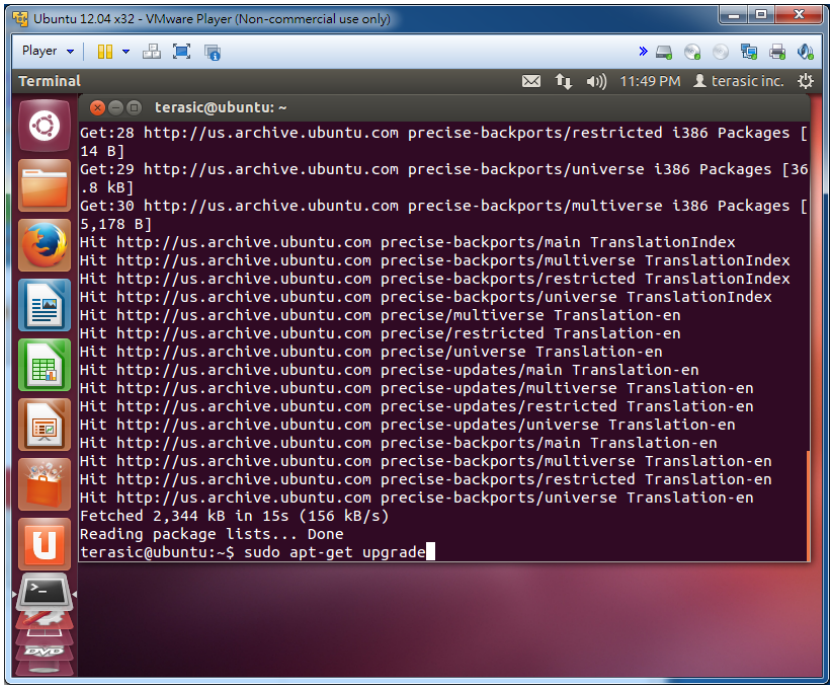

Figure 2-29 Typing in the Command "sudo apt-get upgrade"

System will prompt user to confirm the upgrade process. Please type "y" and press ENTER as shown in **Figure 2-30**. The upgrade process will take about 10~15 minutes.

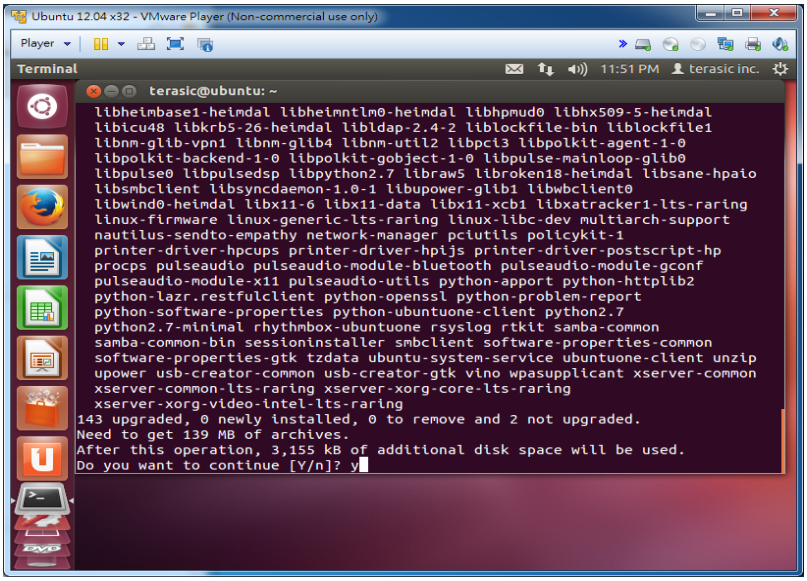

Figure 2-30 Type 'y' to Continue the Upgrade Process

Figure 2-31 shows the screenshot after the upgrade process has been complete.

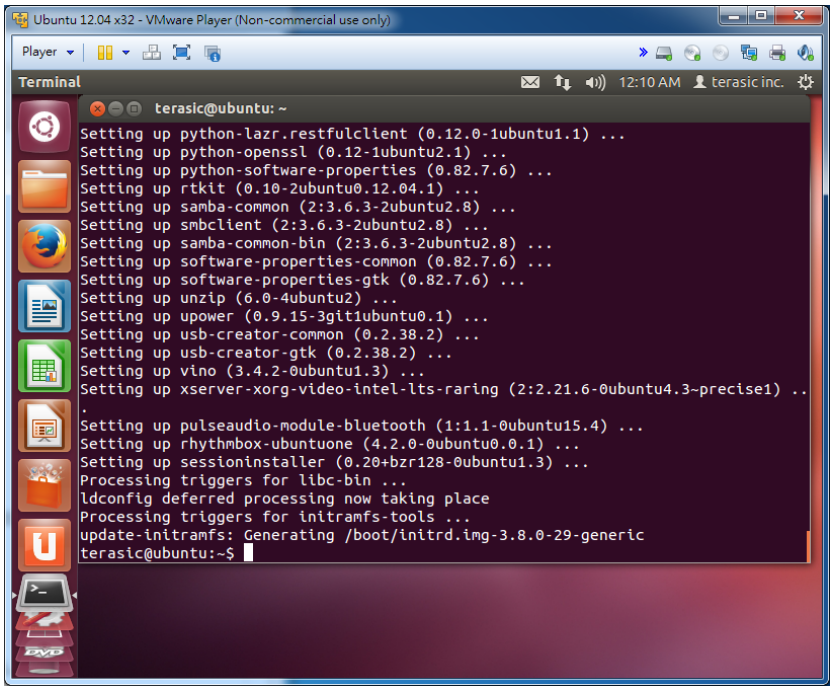

Figure 2-31 Upgrade Process Complete

Type "exit" to close the terminal, as shown in Figure 2-32.

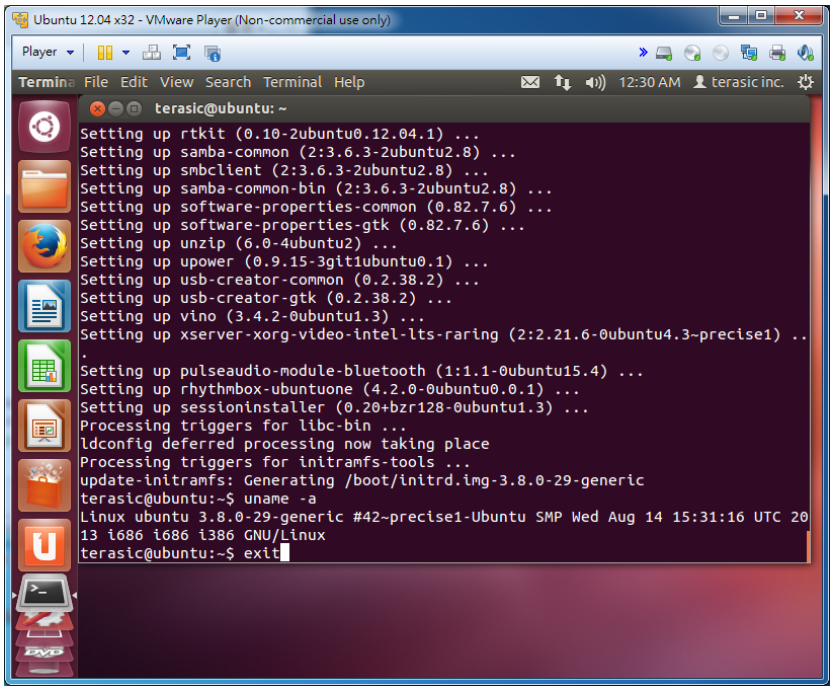

Figure 2-32 Type ‘exit’ to Close the Terminal

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 Desktop Ubuntu which has been installed in previous chapter. Also, we will show how to create, compile, and build a hello program running on Ubuntu. In order for QT Creator to be able to build a project correctly, we also provide steps of installing necessary x86 GCC tool-chain needed for the QT Creator.

3.1 Install Tool-Chain for Linux x86

In order for the QT Creator to be able to build a project correctly, a proper tool-chain is required. Use the following command to install the required tool-chain:

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

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

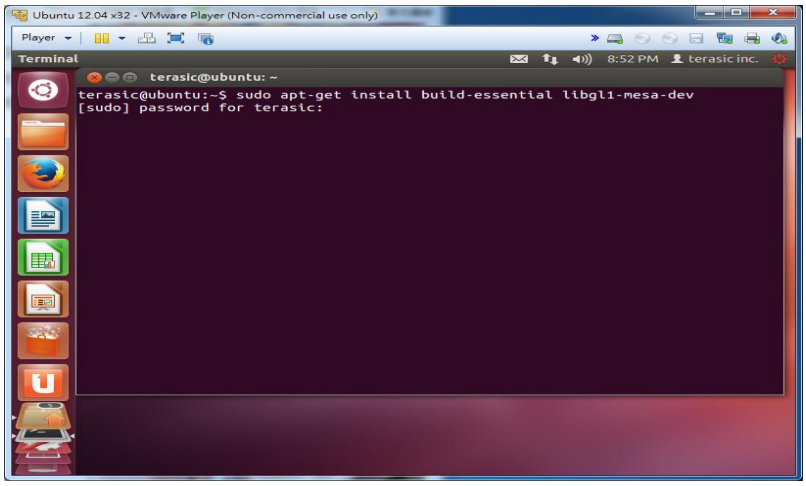

Figure 3-1 Install Software Package

Now system also prompts users to confirm to continue the installation process, as shown in **Figure 3-2**. Please type "y" and press ENTER to continue.

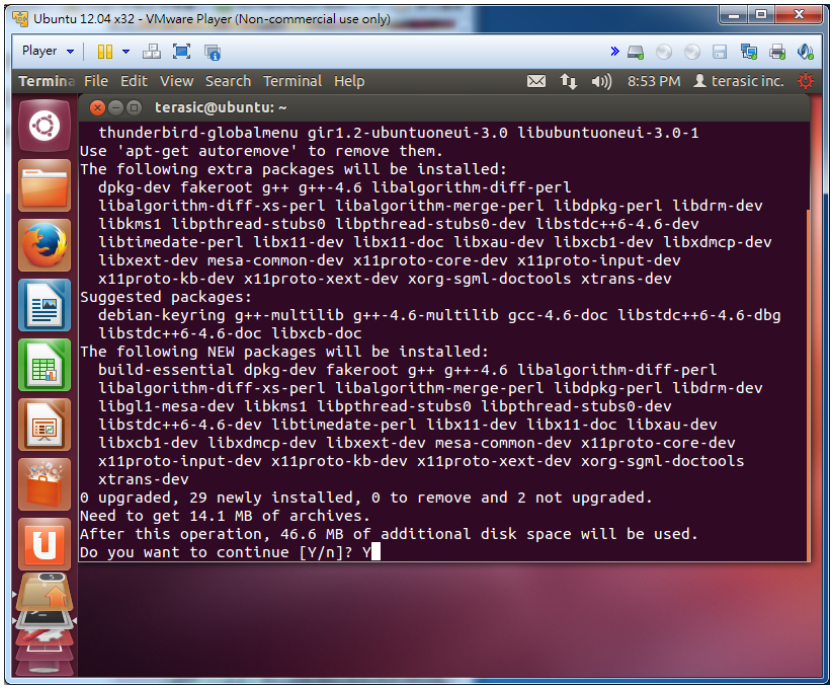

Figure 3-2 Confirm to Continue with the Software Package Installation

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

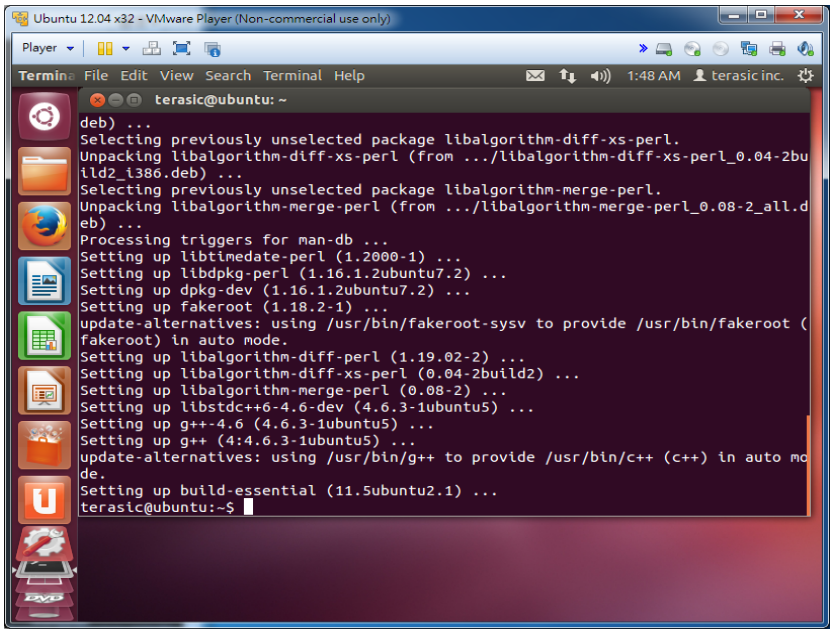

Figure 3-3 Software Package Installation is Now Complete

3.2 Download and Install QT Installer

■ Download QT Installer

As shown in **Figure 3-4**, click the Firefox web browser to open the web page http://download.qt-project.org/official_releases/qt/5.2/5.2.0/, then click “qt-linux-opensource-5.2.0-x86offline.run” to download the QT installer.

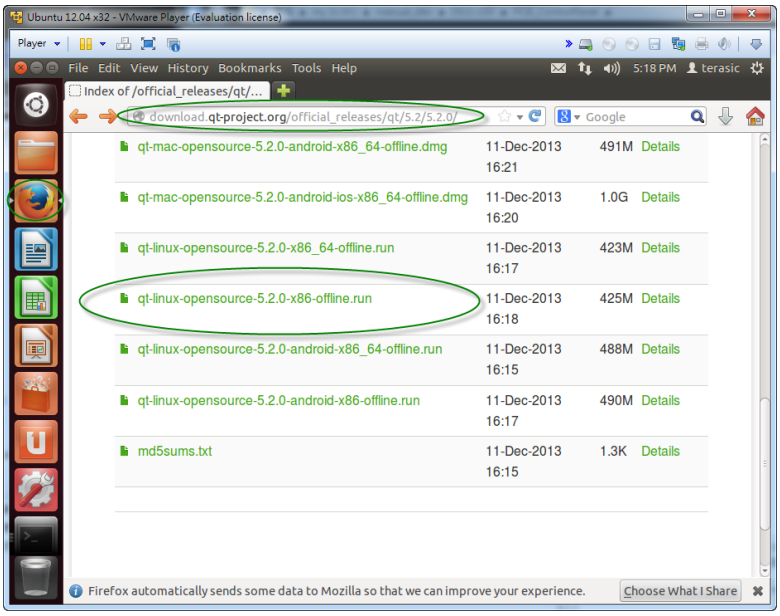

Figure 3-4 Web Page to Download QT

When an Opening dialog appears as shown in **Figure 3-5**, select "Save File" radio button, and click "OK".

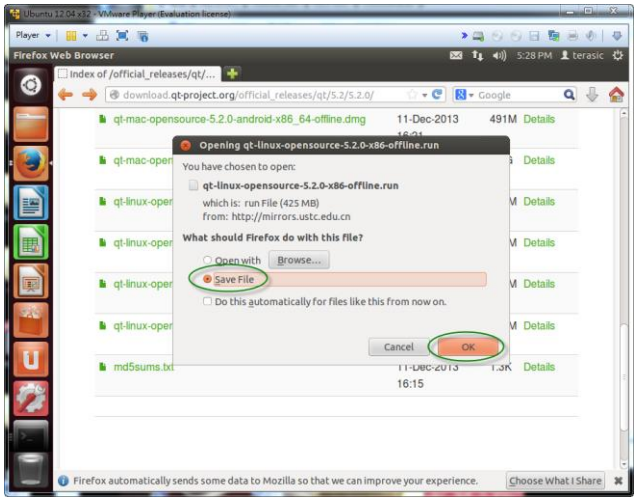

Figure 3-5 Opening Dialog

Figure 3-6 shows the download progress.

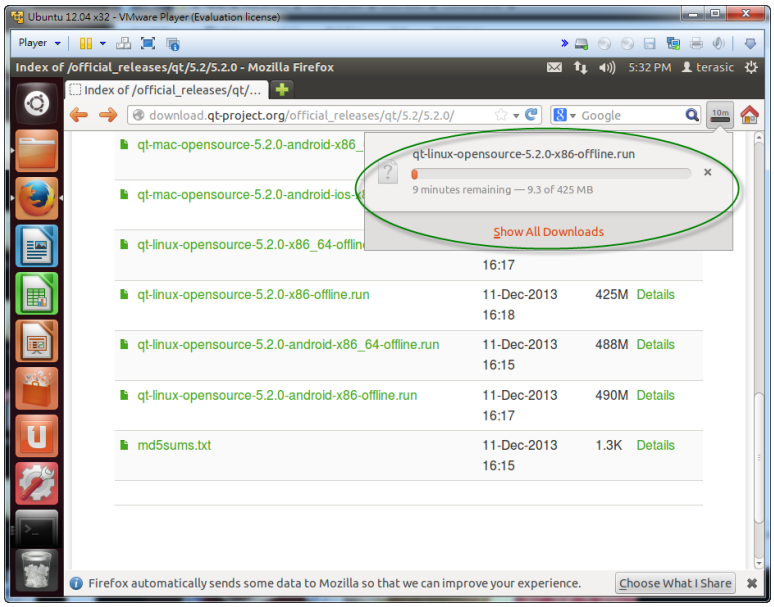

Figure 3-6 Download Process of qt-linux-opensource-5.2.0-x86-offline.run

The file is saved as "**qt-linux-opensource-5.2.0-x86-offline.run**", and saved under the folder "~/Download". When download is completed, click the Close icon, located on the left-top corner as shown in **Figure 3-7**, to close the Firefox web browser.

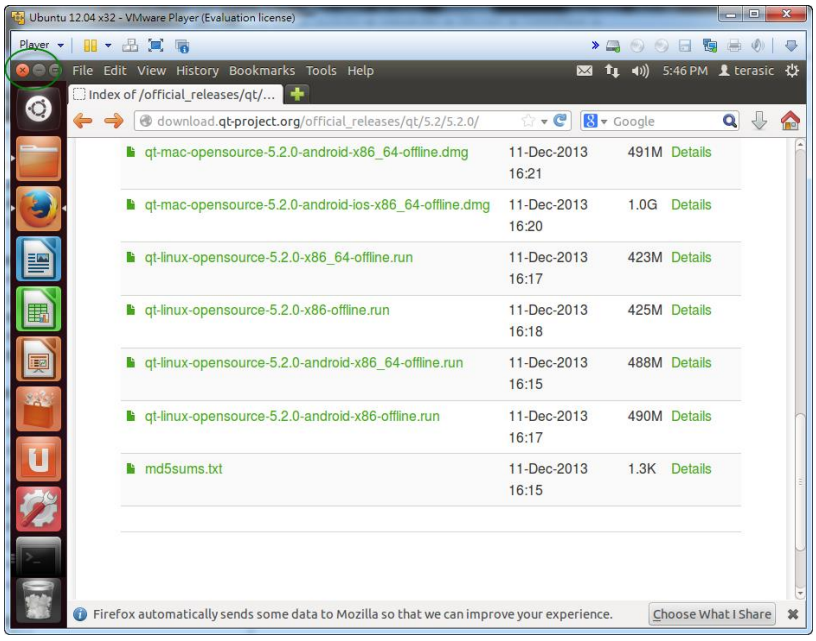

Figure 3-7 Click 'Close' Icon to Close Firefox Web Browser

■ Install QT

Type in the following commands to locate and launch the QT Installer, as shown in **Figure 3-8**.

```
$cd ~/Downloads/
$ls
$chmod +x qt-linux-opensource-5.2.0-x86-offline.run
$./qt-linux-opensource-5.2.0-x86-offline.run
```

The 2nd command line **ls** is used to check whether the qt-linux-opensource-5.2.0-x86-offline.run existed or not while the 3rd command line **chmod +x** is used to add "execution" attribute to the file such that it can be executed.

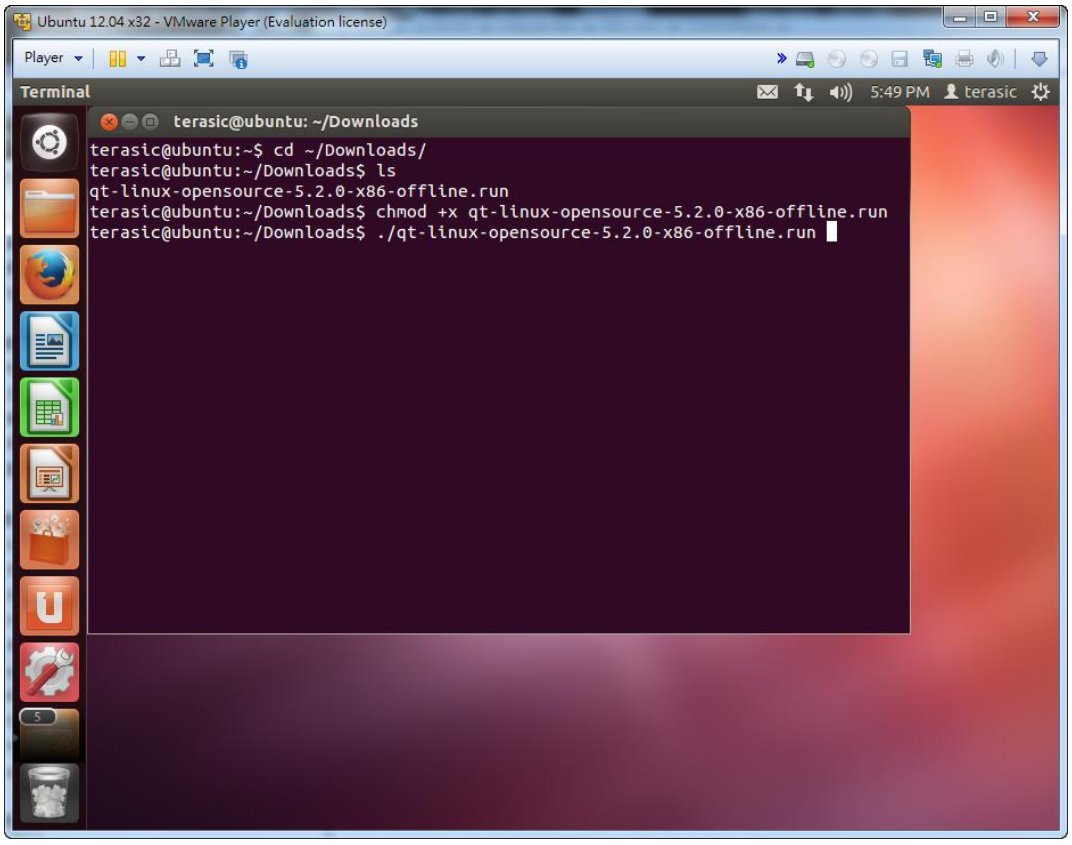

Figure 3-8 Locate and Launch the QT Installer

Figure 3-9 shows the **Welcome** dialog of the QT Installer.

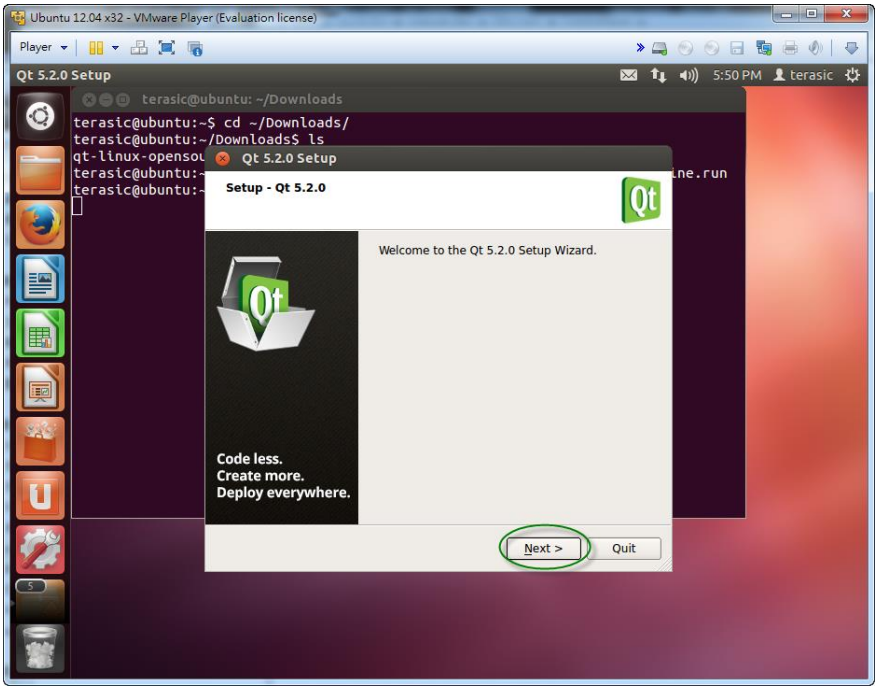

Figure 3-9 Welcome Dialog

In the **Installation Folder** dialog, please specify the folder where you wish to install Qt 5.2.0 and click “Next>” to go to the next step, as shown in **Figure 3-10**.

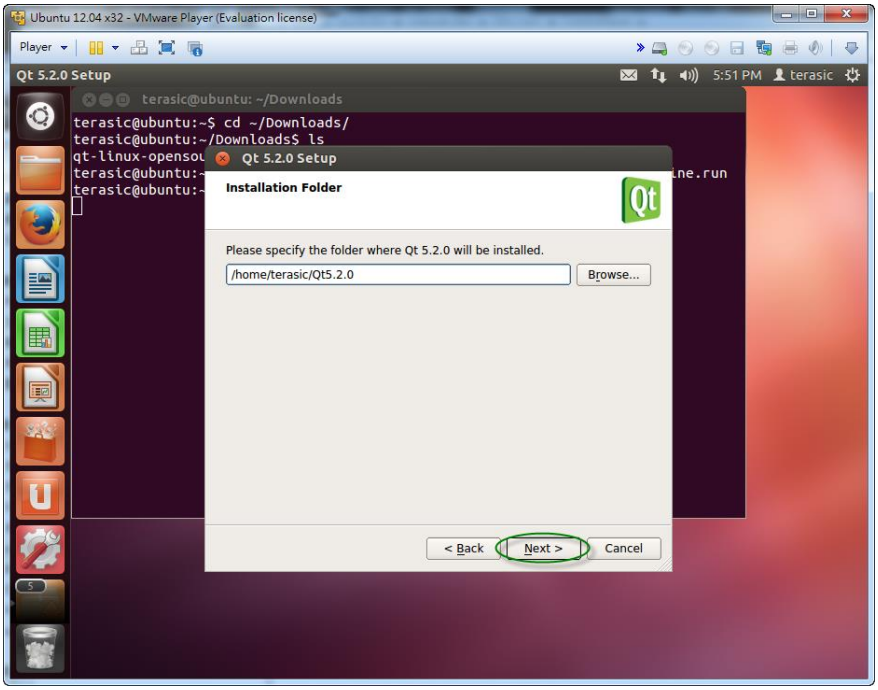

Figure 3-10 Specify the Folder to Install QT

In the **Select Components** dialog, keep default settings and click “Next >” to go to the next step, as shown in **Figure 3-11**

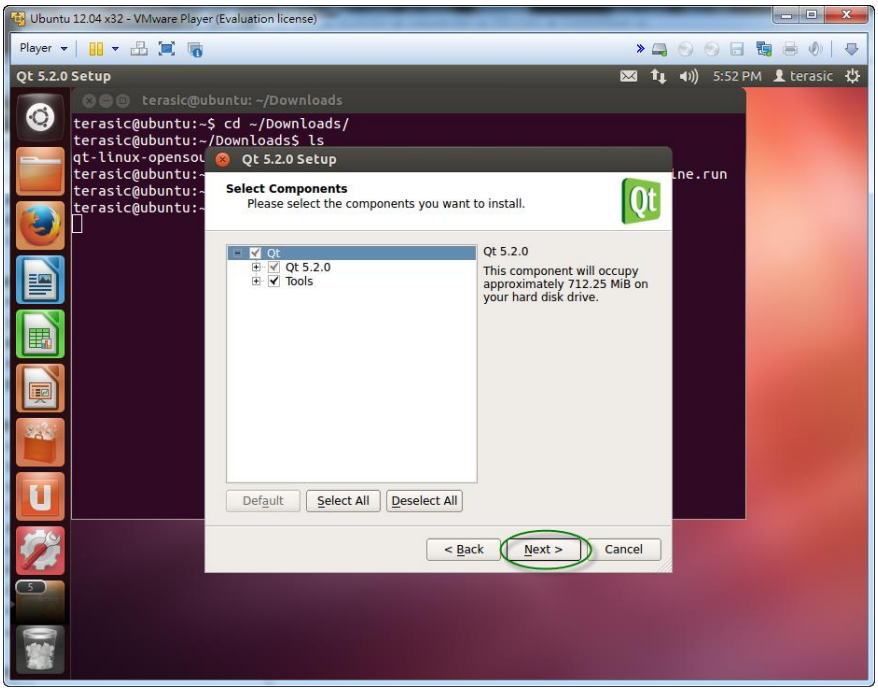

Figure 3-11 Select Components Dialog

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 3-12**

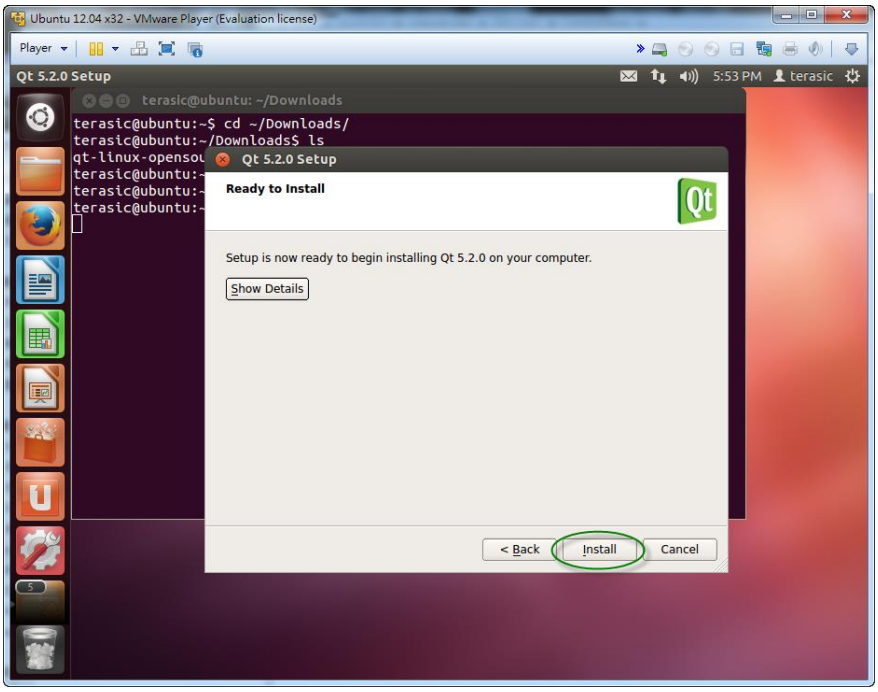

Figure 3-12 License agreement dialog of the QT installer

In the **Ready to Install** dialog, as shown in **Figure 3-13,** click "Install" to go to the next step.

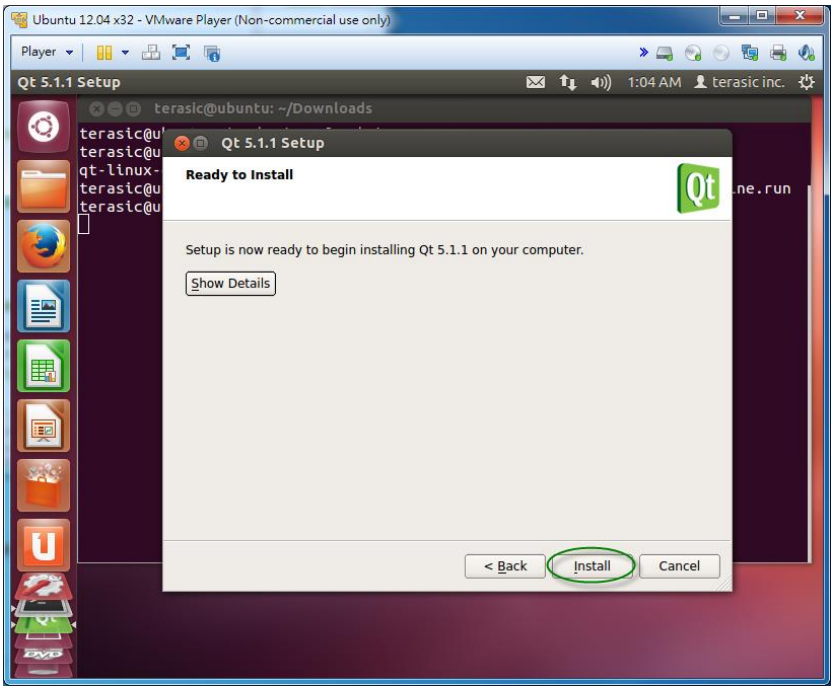

Figure 3-13 Ready to Install Dialog of QT Installer

In the **Completing the Qt 5.2.0 Wizard** dialog, as shown in **Figure 3-14,** click "Finish" to close the window.

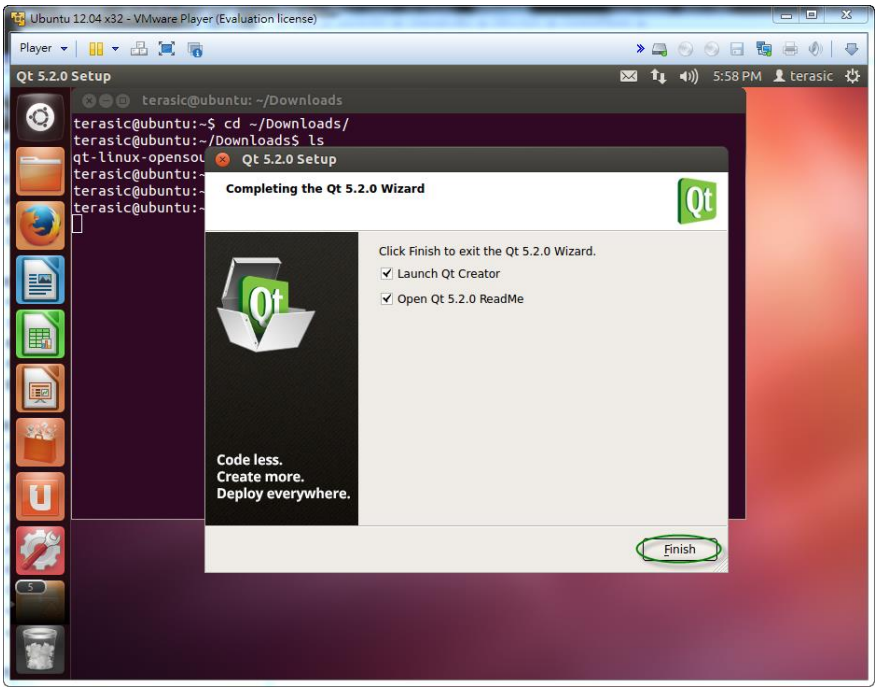

Figure 3-14 Completing Dialog of QT Installer

After installation has been completed, QT Creator is automatically launched as shown in **Figure 3-15**.

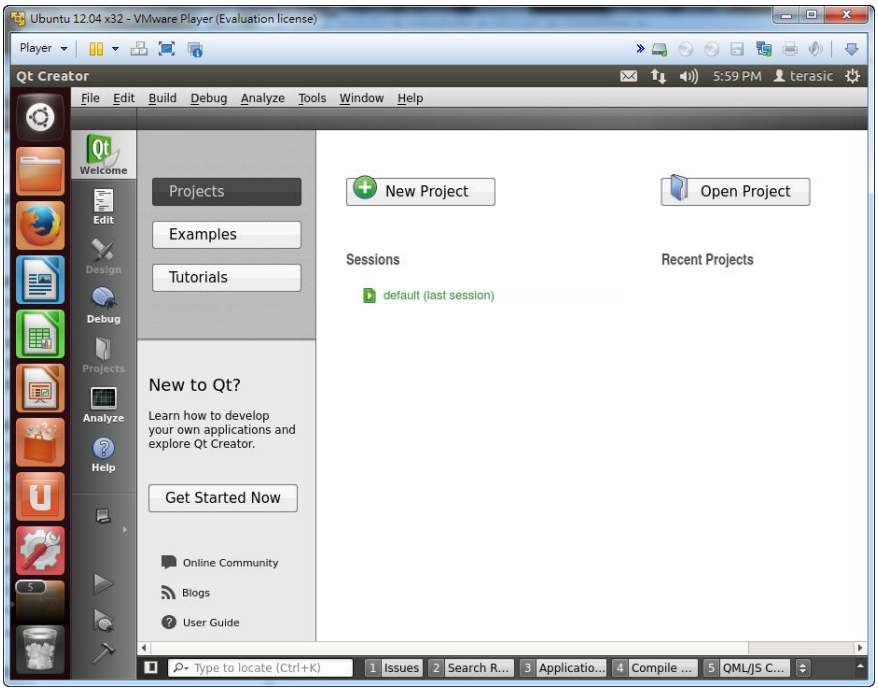

Figure 3-15 QT Creator GUI

Select the menu item "File→Exit", as shown in **Figure 3-16,** to close the QT Creator.

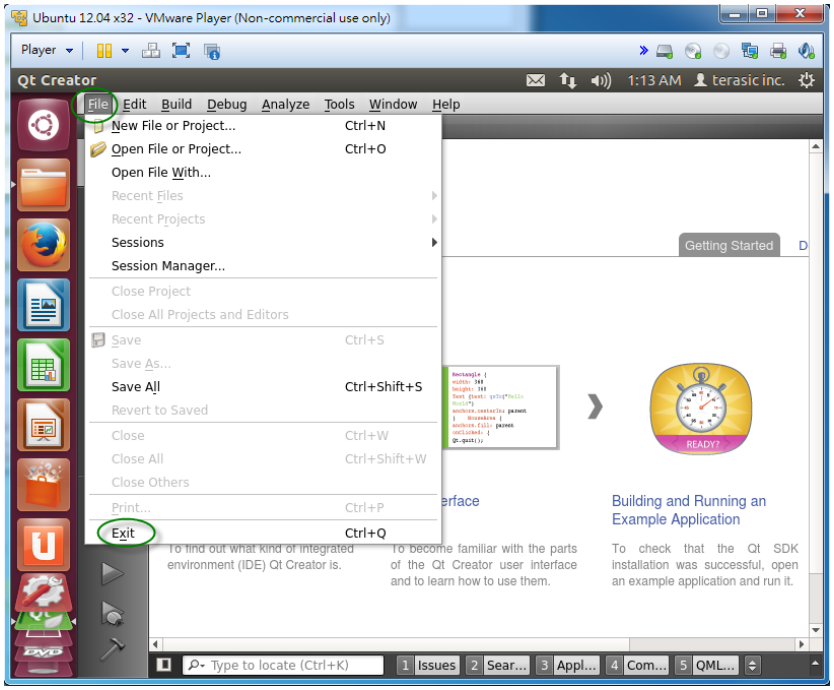

Figure 3-16 Exit QT Creator

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\Qt5.2.0\Tools\QtCreator\bin as shown in **Figure 3-17**. To launch QT creator, simply double click "qtcreator" program icon.

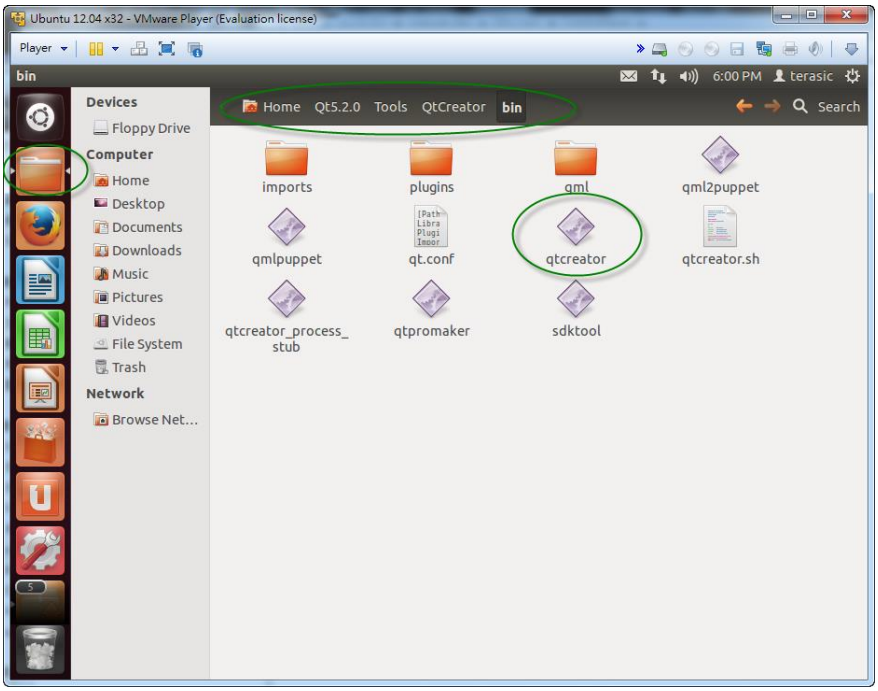

Figure 3-17 Launch QT Creator

■ Check Build & Run Configuration Settings

When QT Creator is launched, browse the menu and click "Tools→Options...", as shown in **Figure 3-18,** to open the Option dialog.

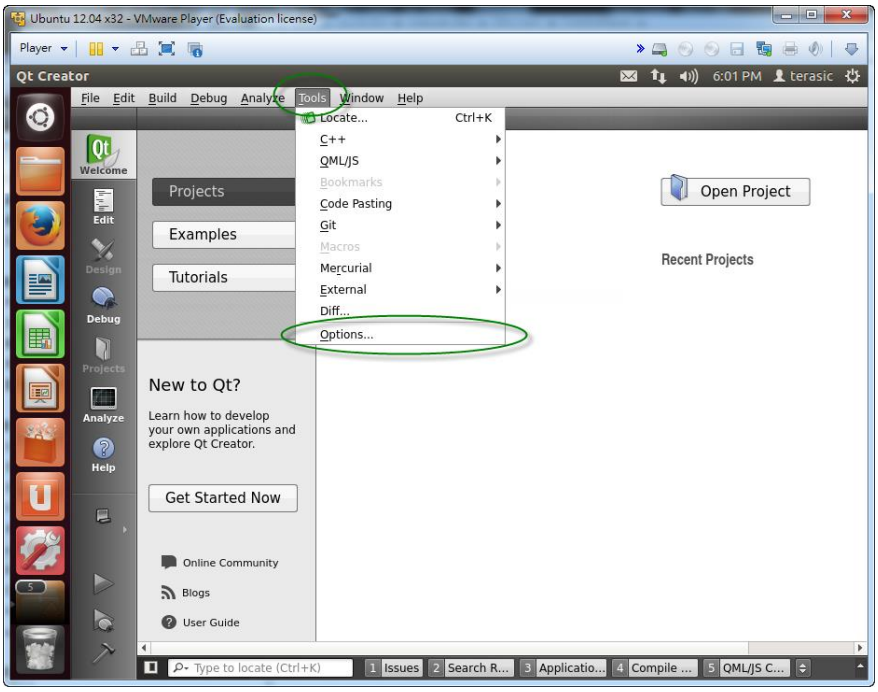

Figure 3-18 Open Option Dialog

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 3-19**.

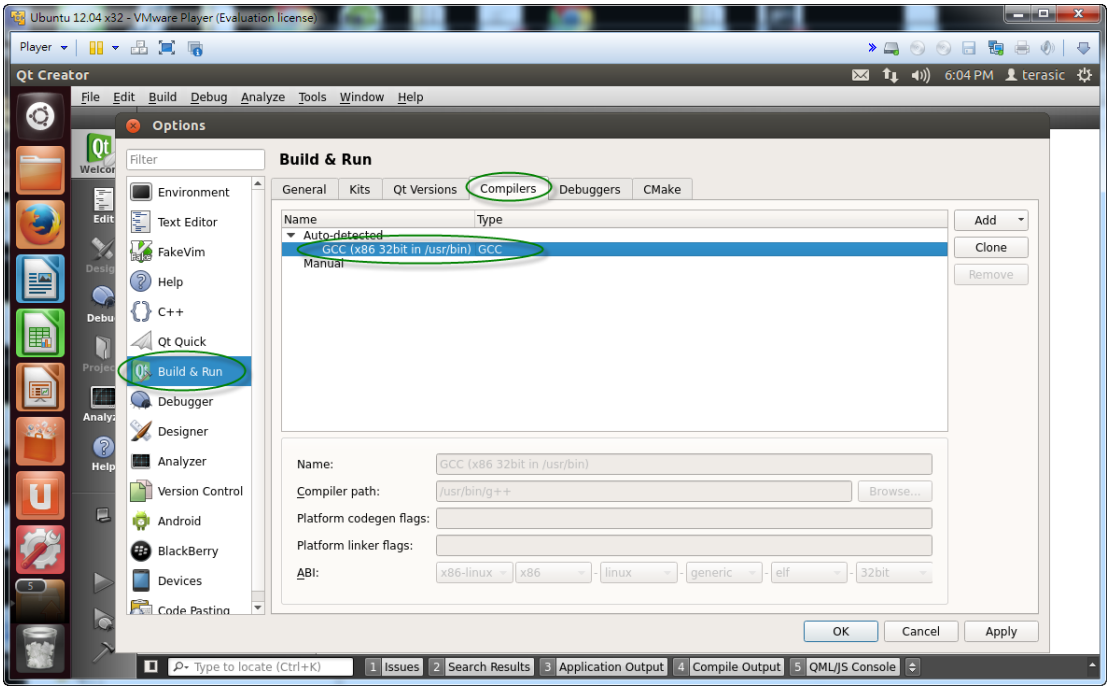

Figure 3-19 Compilers Options in QT Creator

Next, select “Qt Versions” tab (to the left of the “Compilers” tab) to check if the “Qt 5.2.0 GCC 32bit” is detected as shown in **Figure 3-20**.

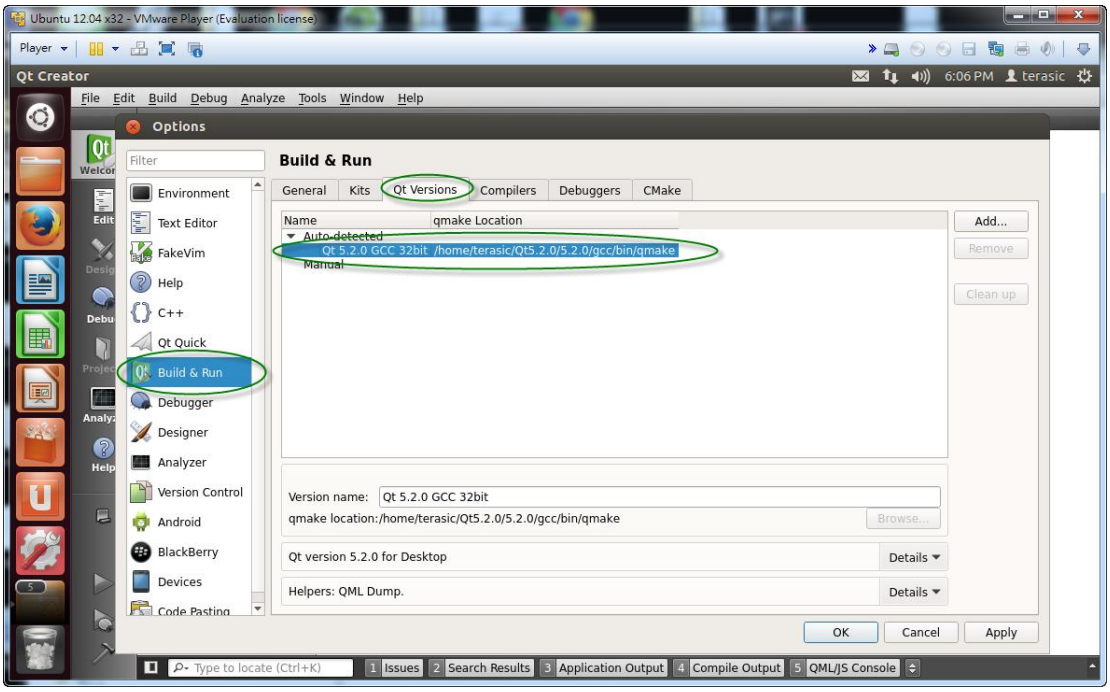

Figure 3-20 QT Version Option in QT Creator

Similarly, select “Kits” tab to check if the “Desktop Qt 5.2.0 GCC 32bit” is detected as shown in **Figure 3-21**.

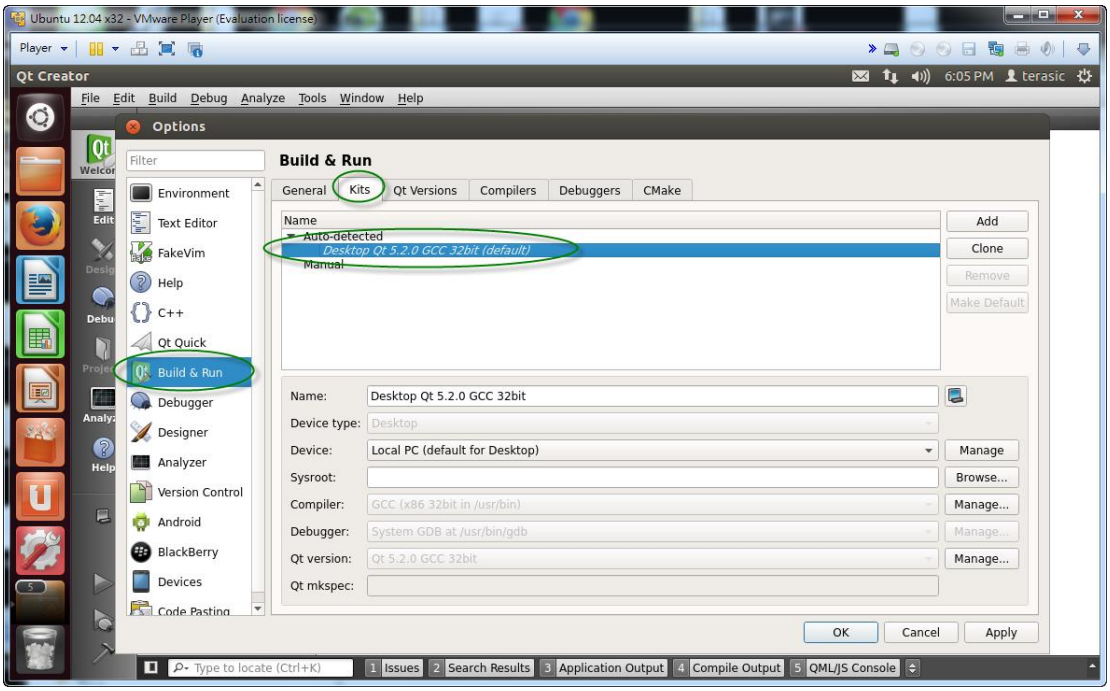

Figure 3-21 Kits Option in QT Creator

Finally, click "OK" to close the dialog as shown in Figure 3-22.

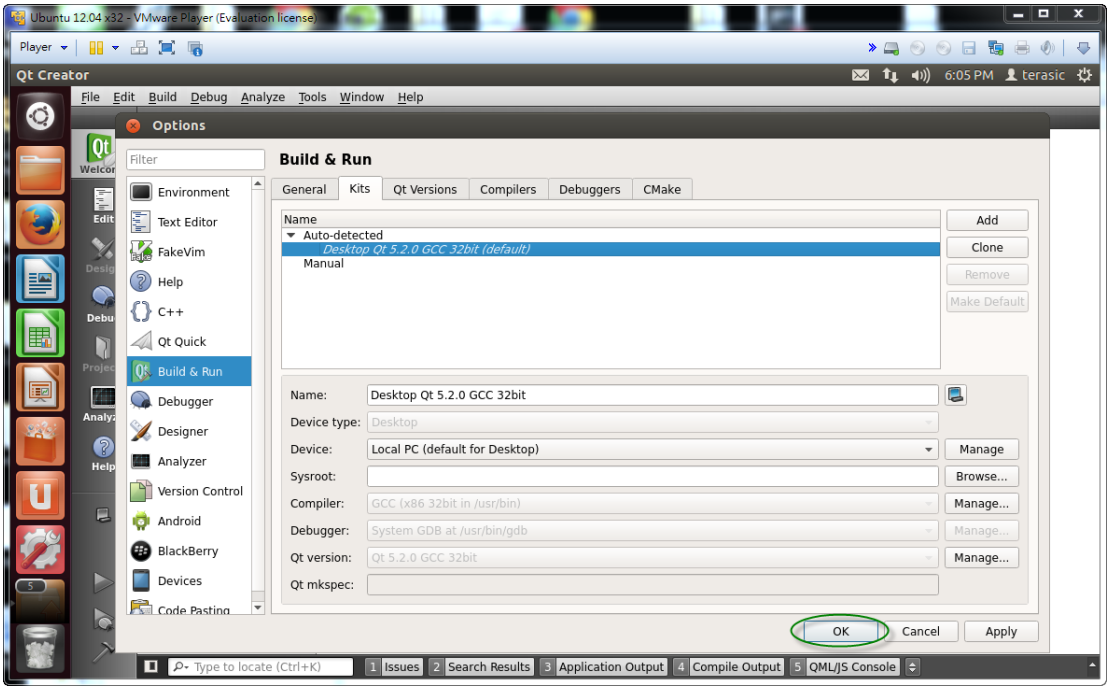

Figure 3-22 Click "OK" to Close Options Dialog

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 3-23** to open a new dialog.

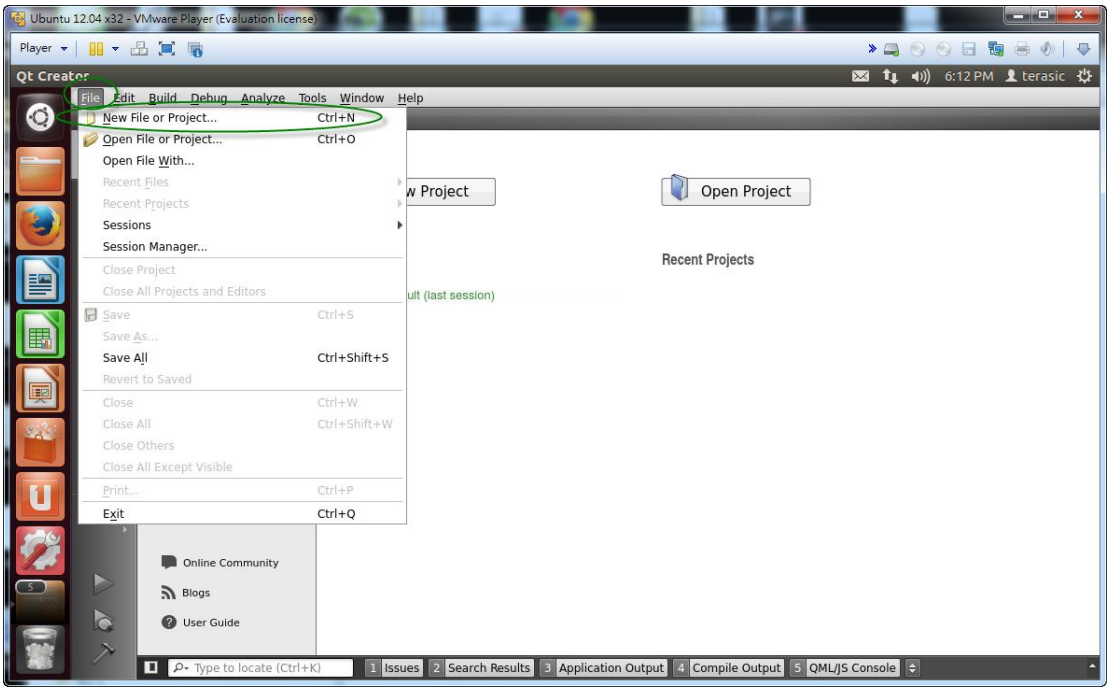

Figure 3-23 Open a New Project Dialog

In the **New** dialog, select “Applications” under Projects, and choose “Qt Gui Application” as shown in **Figure 3-24**. Click “Choose…” to go to the next step.

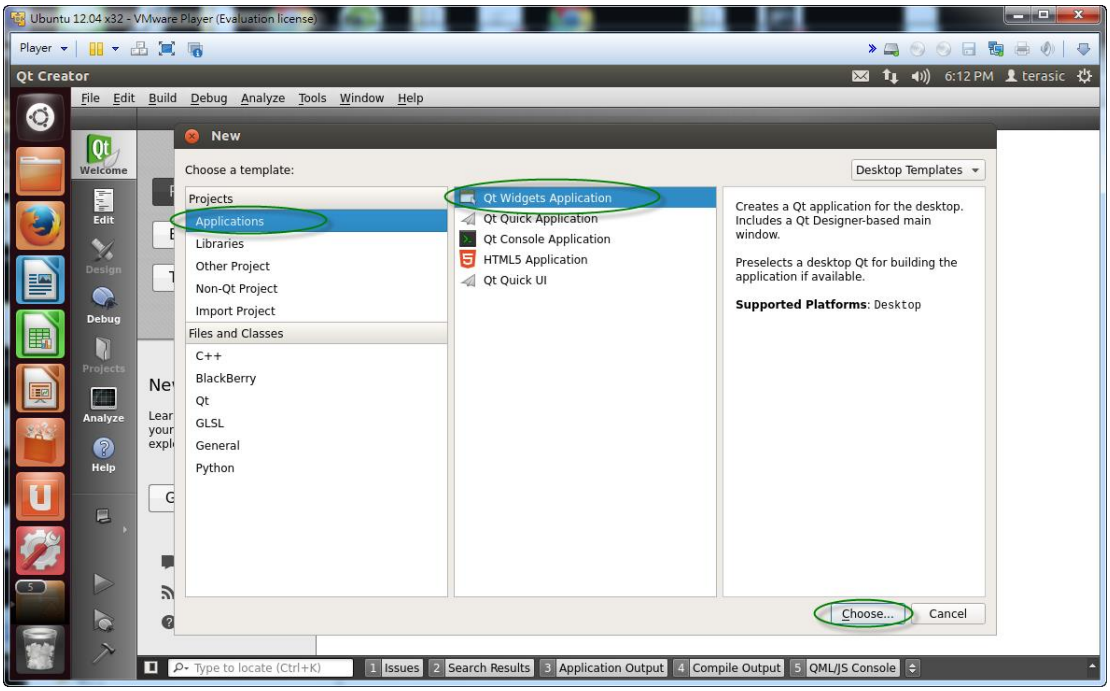

Figure 3-24 Dialog of Creating a New Project

In the **Qt Gui Applicaton** Dialog, specify the project name and project location, then click "Next >" as shown in **Figure 3-25**.

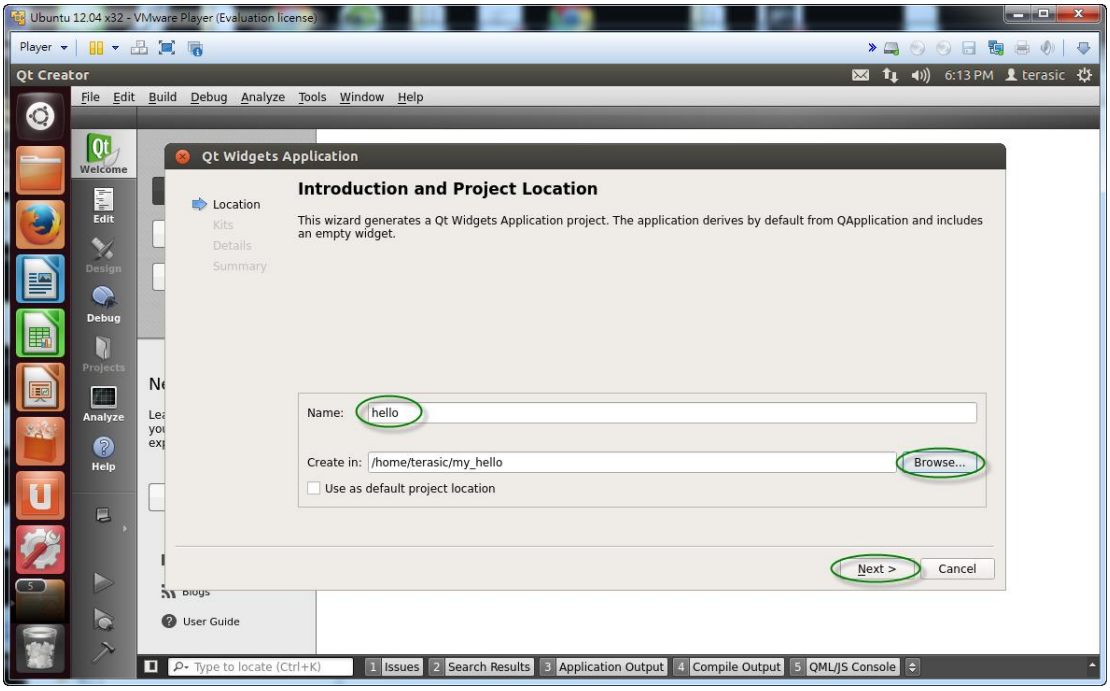

Figure 3-25 Project Name and Location Dialog

In the **Kit Selection** dialog, keep default settings and click “Next >” to go to next step as shown in **Figure 3-26**.

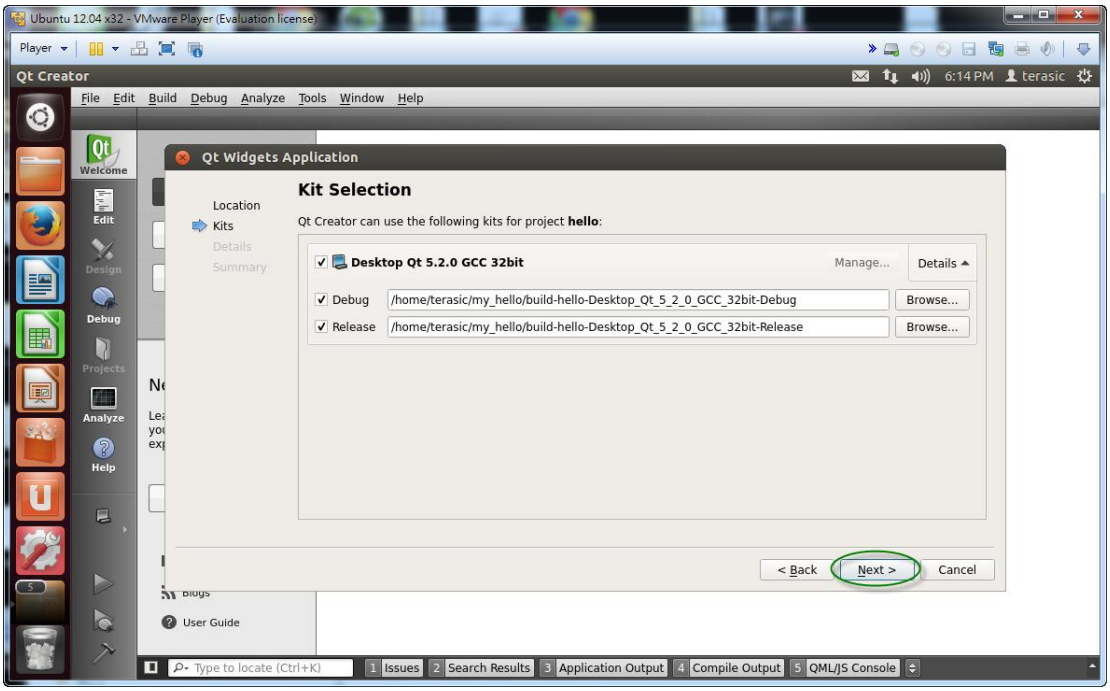

Figure 3-26 Kit Selection Dialog

In the **Class Information** dialog, click “Next >” as shown in **Figure 3-27** to proceed.

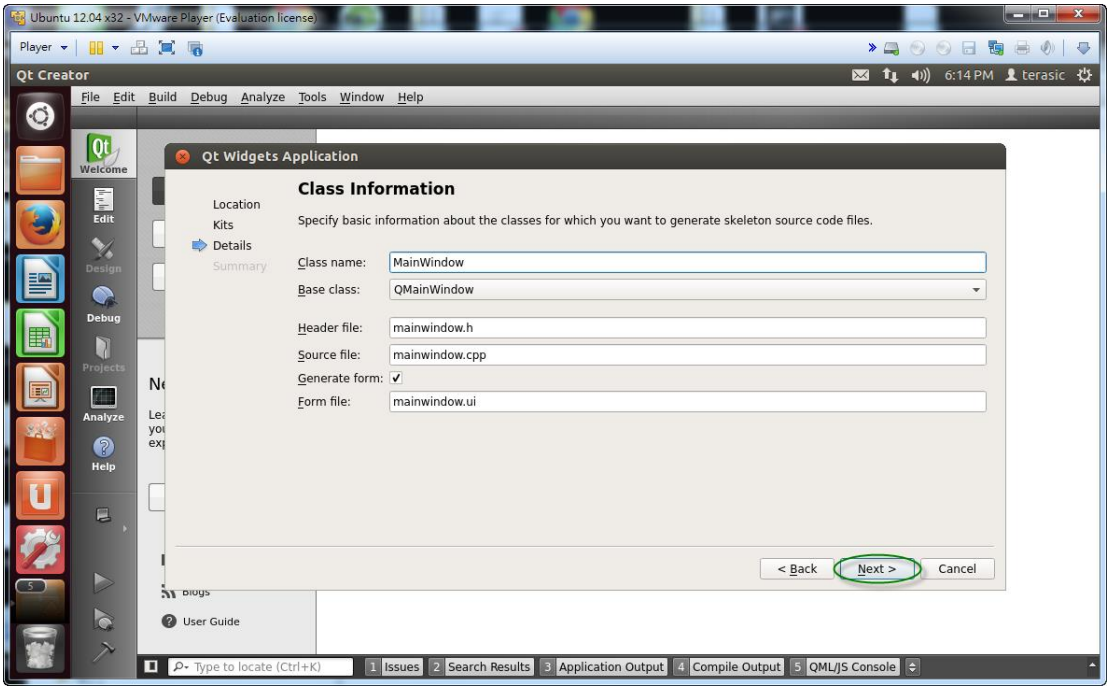

Figure 3-27 Class Information Dialog

In the **Project Management** dialog, click "Finish" as shown in **Figure 3-28** to proceed.

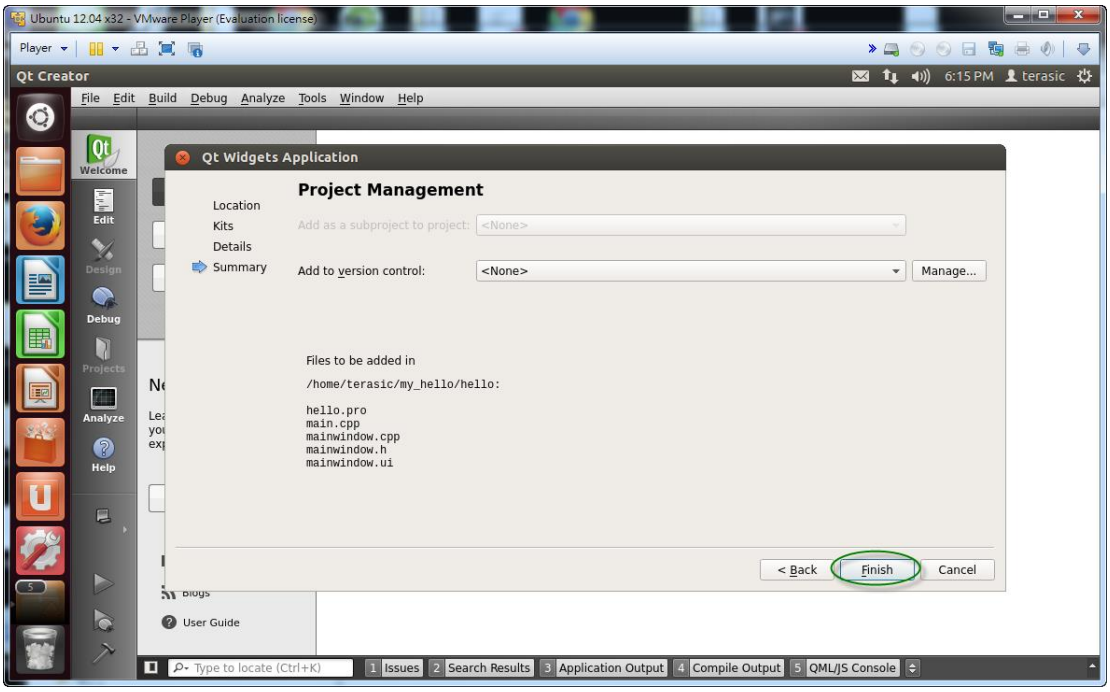

Figure 3-28 Final Dialog of Qt Gui Application

Figure 3-29 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.

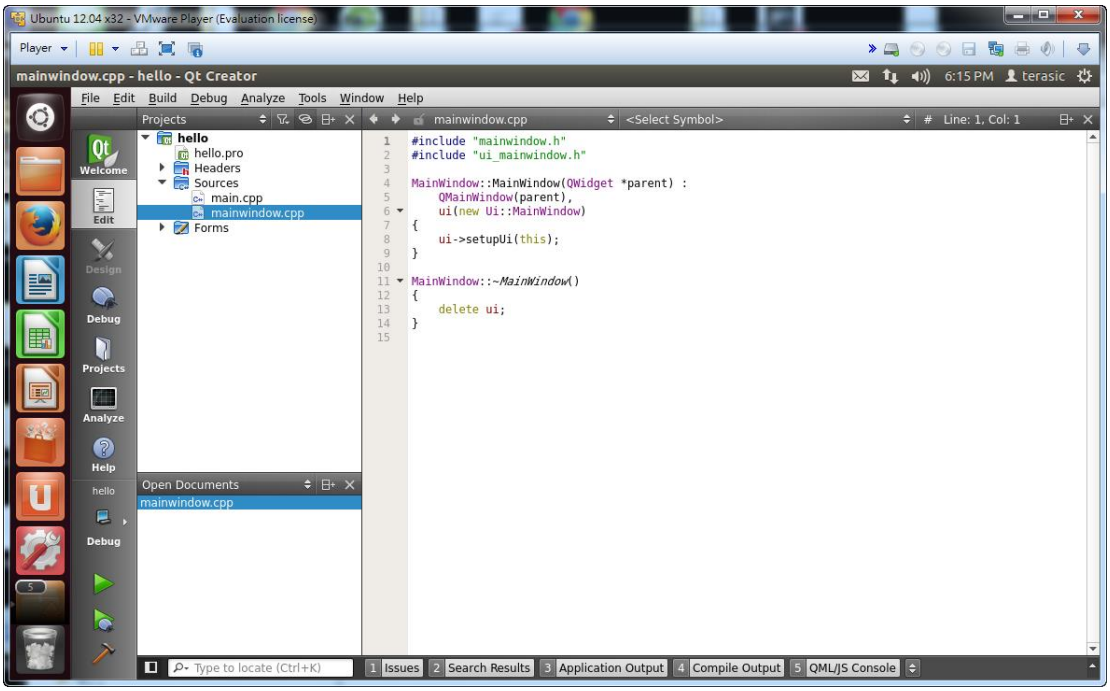

Figure 3-29 Mainwindow.cpp of the Hello project

■ Build & Run

Click on the "Run" icon to build and run the Hello program. The GUI program should appear as shown in **Figure 3-30**.

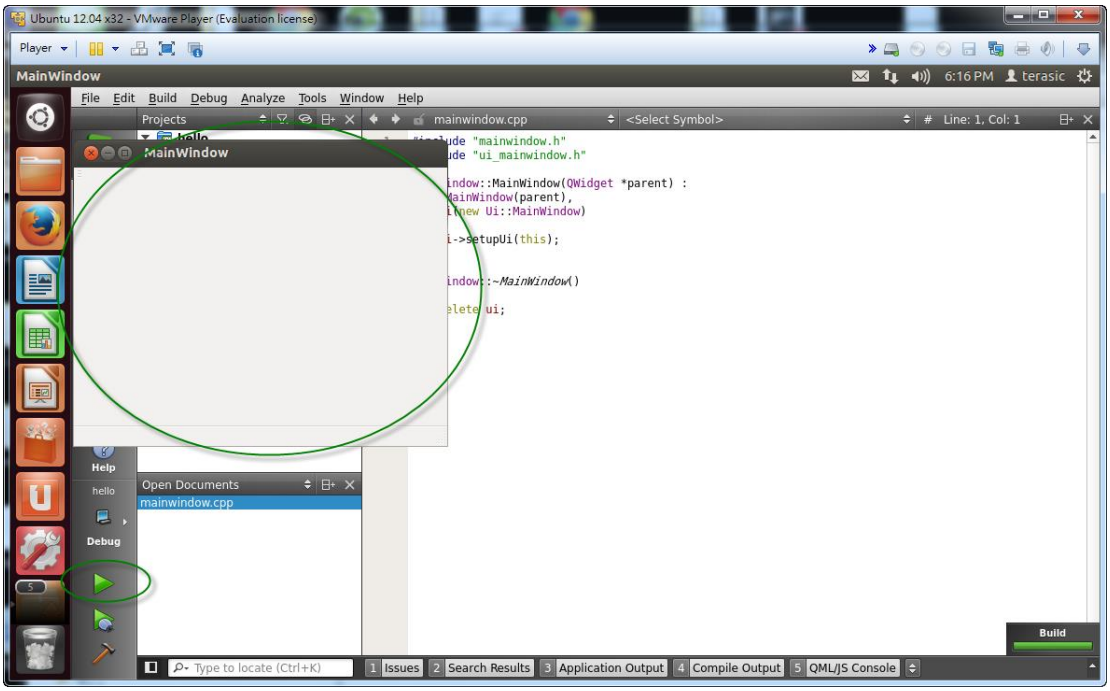

Figure 3-30 Run Hello Program

Chapter 4

Altera SoC Tool-Chain Installation

Altera SoC tool-chain is required while building the QT library for the Altera SoC ARM. In this chapter, we show the users steps needed to install the Altera SoC tool-chain. Here is a quick look of the 2 simple steps:

- Download the Altera SoC Tool-Chain and extract the file
- Include Tool chain path into the system environment variable $PATH

4.1 Download and Install Tool-Chain

Launch Linux terminal (CTRL+ALT+T) and execute the following commands to download and extract the Altera SoC tool-chain,

```
$cd ~
$wget https://launchpad.net/linaro-toolchain-binaries/trunk/2012.11/\
+download/gcc-linaro-arm-linux-gnueabihf-4.7-2012.11-20121123_linux.tar.bz2
$tar xjf gcc-linaro-arm-linux-gnueabihf-4.7-2012.11-20121123_linux.tar.bz2
```

Figure 4-1 shows the screenshot of tool-chain download progress after typing in the wget command. It will take about 5 minutes to download the file.

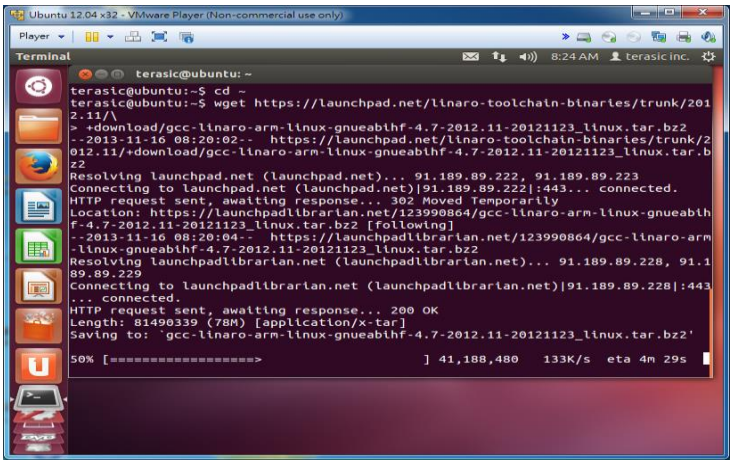

Figure 4-1 Altera SoC Tool-Chain Download Progress

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 tool-chain download has been finished and has been extracted by the **tar** command. After extraction, the tool-chain is located in the folder "~/gcc-linaro-arm-linux-gnueabihf-4.7-2012.11-20121123_linux"

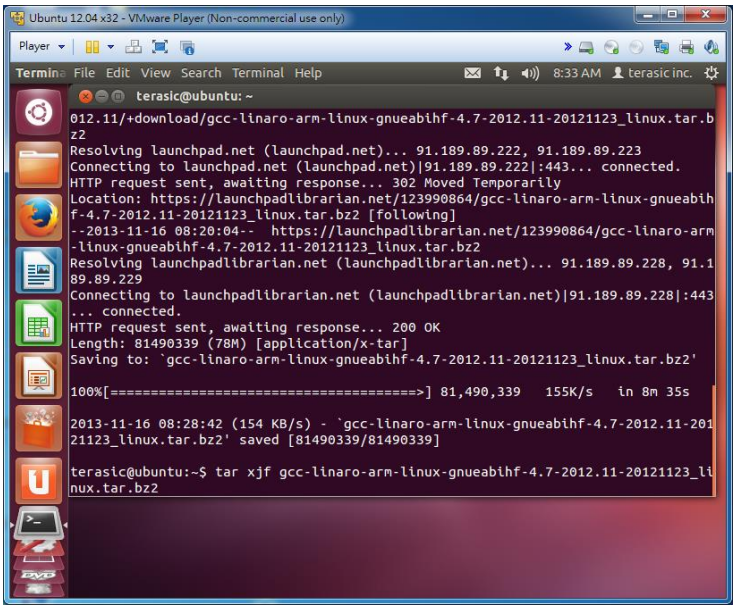

Figure 4-2 Altera SoC Tool-Chain Download Finished and Extracted by the Tar Command

4.2 Set up Tool-Chain Path

Now, the tool-chain 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 tool-chain path.

Launch terminal (CTRL+ALT+T) and type in the following command to open the batch file "~./profile"

```
$gedit ~/.profile
```

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

```
export PATH=/home/terasic/gcc-linaro-arm-linux-gnueabihf-4.7-2012.11-20121123_linux/bin:$PATH
```

to the **end** of the batch file. Note, in the path string, you should replace "teraisc" with your linux user name. 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.

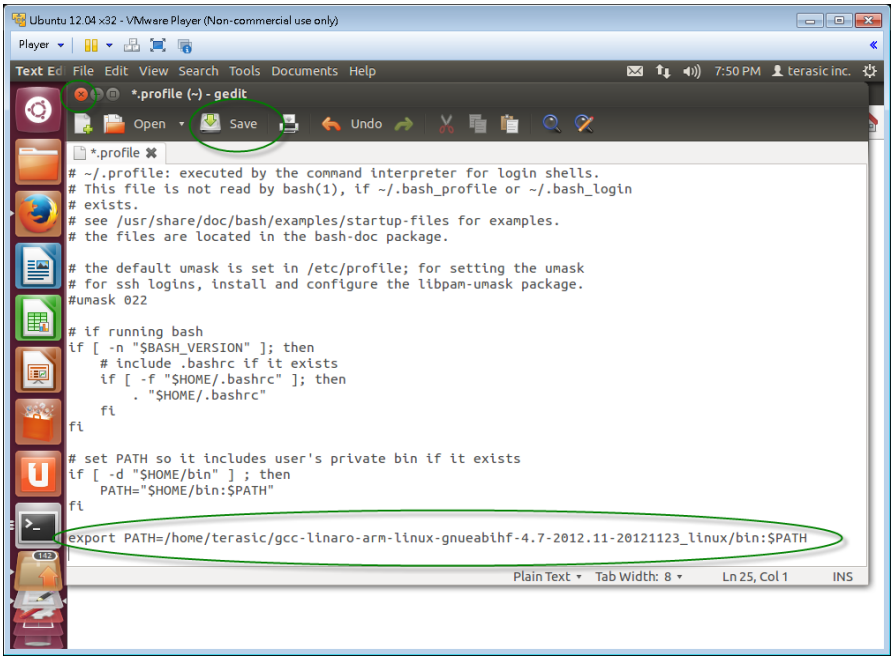

Figure 4-3 ./Profile Opened by gedit

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

Chapter 5

Build QT Library for Altera SoC

Up to now, you should have successfully installed the Altera SoC tool-chain in the Ubuntu system. Now we start building QT library for Altera SoC ARM on the Ubuntu Linux.

Here is a quick look of the 3 simple steps:

- Download and extract the QT source code
- Create a make configuration folder 'mkspecs' for Altera SoC
- Configure, build and install QT Library

5.1 Download the QT source code

■ Download Compressed Source File

Go to the QT libraries download home page http://qt-project.org/downloads as shown in **Figure 5-1**. Then, click "Qt libraries 4.8.5 for embedded Linux" to download the source code.

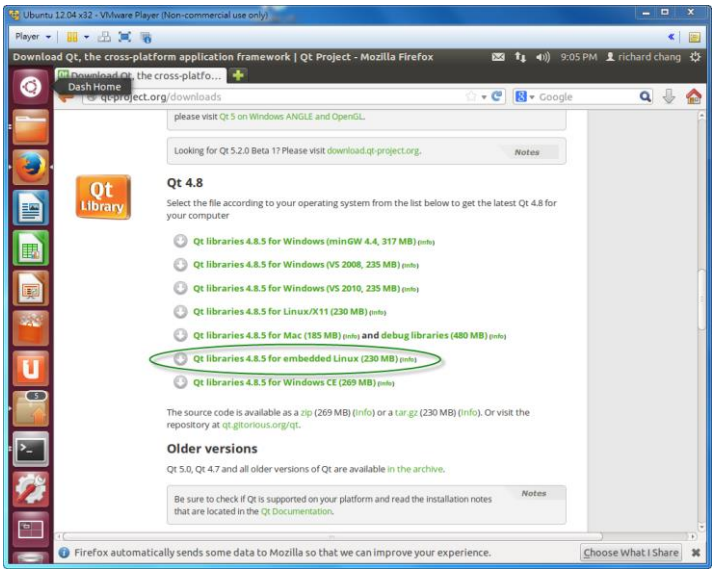

Figure 5-1 QT Source Code Download Web Page

When an **Opening** dialog appears as shown in **Figure 5-2**, please select "Save File" radio button and click "OK". The file is saved as "~/Downloads/qt-everywhere-opensource-src-4.8.5.tar.gz".

Figure 5-2 Save QT File

■ Extract the Compressed Source File

The download source file is a compressed file. Again we need to extract the file before we can use it. Please launch a terminal (CTRL+ALT+T) and use the following commands to extract the file:

```
$cd ~/Downloads
$ls
$tar -zxvf qt-everywhere-opensource-src-4.8.5.tar.gz
```

Note the 2nd command line 'ls" checks if the source file exists and the 3rd command line is used to extract the source file, as shown in **Figure 5-3.** The source will be extracted to the folder "~\Download\ qt-everywhere-opensource-src-4.8.5".

5.2 Create a new 'mkspecs' for Altera SoC

In order to perform cross-compile for the QT library, a new make configuration file should be defined first. What we will do is to first to copy existing make configuration file and then to modify the file accordingly.

■ Copy existing make configuration files

Copy the entire make configuration folder "linux-arm-gnueabi-g++" and rename it (simply add "hf" at the end of "gnueabi") as "linux-arm-gnueabihf-g++" with the following command:

```
$cd ~/Downloads/qt-everywhere-opensource-src-4.8.5/mkspecs/qws
$cp -r linux-arm-gnueabi-g++ linux-arm-gnueabihf-g++
```

Where the 2nd command line is to browse the folder where the folder "linux-arm-gnueabi-g++" exists and the 3rd command line is to duplicate the "linux-arm-gnueabi-g++" folder and rename it as "linux-arm-gnueabi**hf**-g++" s shown in **Figure 5-3**

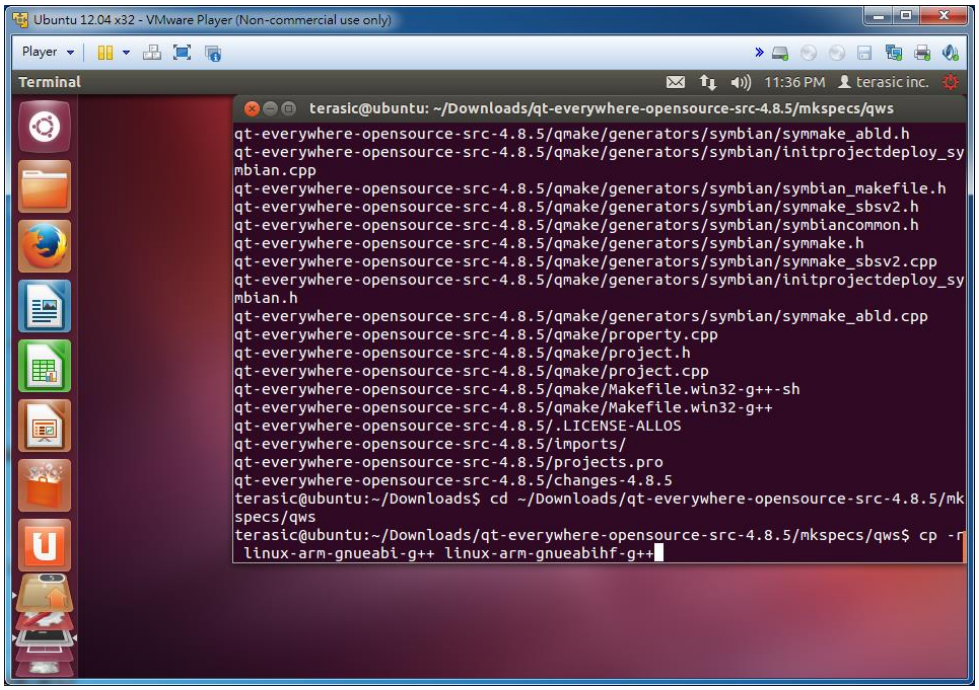

Figure 5-3 Duplicate Configuration Folder

■ Modify the Configuration File

Simply follow the below procedures to modify the configuration file in the terminal:

1. Type “cd ~/Downloads/qt-everywhere-opensource-src-4.8.5/mkspecs/qws”
2. Type “cd linux-arm-gnueabihf-g++”
3. Type “gedit qmake.conf”. The file is opened by gedit as shown in **Figure 5-4**
4. In gedit, replace all “arm-none-linux-gnueabi” with “arm-linux-gnueabihf” as shown in **Figure 5-4**. Click “Save” icon followed by clicking “Close” icon to terminate gedit.

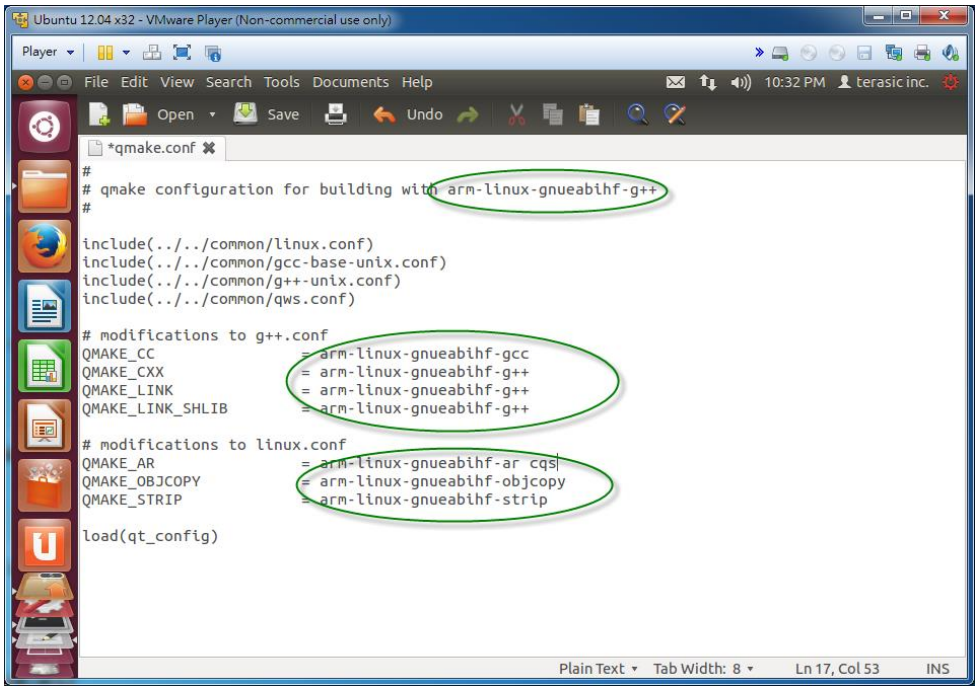

Figure 5-4 qmake.conf File

5.3 Configure, build, and install QT library

After we have modified the make configuration files, now we are ready to configure, build, and install the QT library. Here is a list of the commands that will be used toward building and installing the QT library.

```
$source ~/.profile
$cd ~/Downloads/qt-everywhere-opensource-src-4.8.5
$ ./configure -prefix /usr/local/qt-4.8.5-altera-soc -release -shared \
-nomake examples -nomake tools -nomake docs -make demos \
-xplatform qws/linux-arm-gnueabihf-g++ -embedded arm -little-endian \
-no-pch -v
$make
$sudo make install
```

■ Configure

The command line

```
$source ~/.profile
```

is used to make sure the $PATH$ includes the correct Altera SoC tool-chain path.

To go to the source code folder, type

```
$cd ~/Downloads/qt-everywhere-opensource-src-4.8.5
```

To execute the configure batch to create makefile, type

```
$ ./configure -prefix /usr/local/qt-4.8.5-altera-soc -release -shared \
-nomake examples -nomake tools -nomake docs -make demos \
-xplatform qws/linux-arm-gnueabihf-g++ -embedded arm -little-endian \
-no-pch -v
```

Before executing the configure batch, system will prompt to ask license type as shown in **Figure 5-5**, type in "o" and press ENTER.

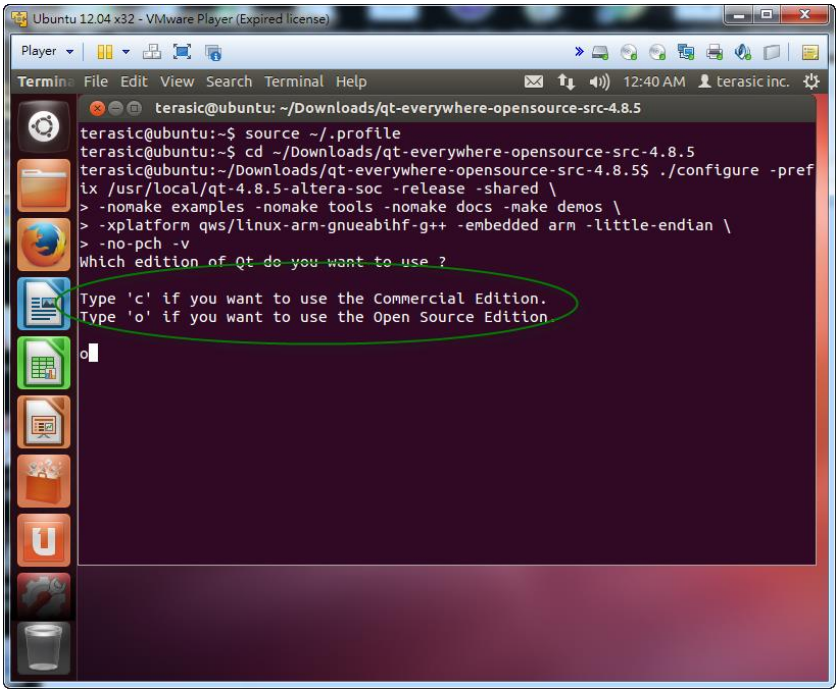

Figure 5-5 Ask License Type

After selecting the license type, system prompts to ask whether to accept the license term or not as

shown in **Figure 5-6**. Type “yes” and press ENTER.

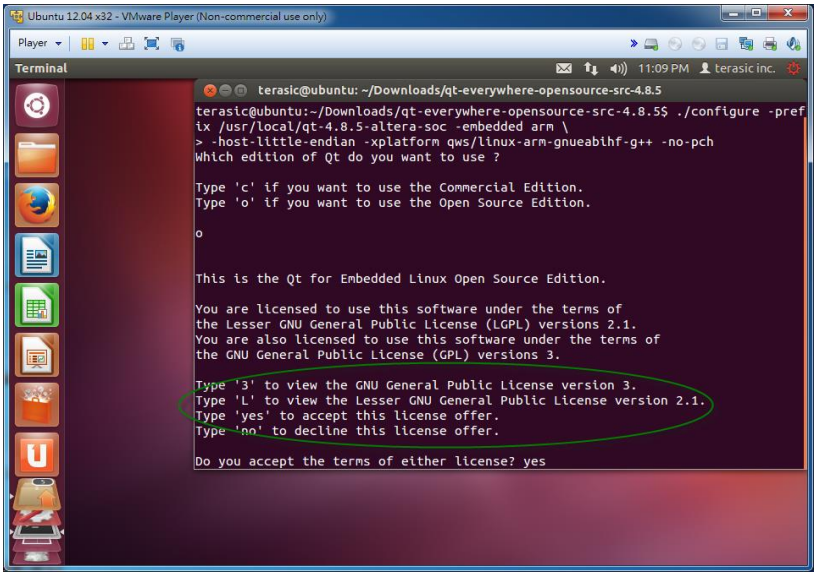

Figure 5-6 Type Yes to Accept This License Offer

When configuration is completed successfully, your will see the message “Qt is now configured for building. Just run ‘make’” as shown in **Figure 5-7**.

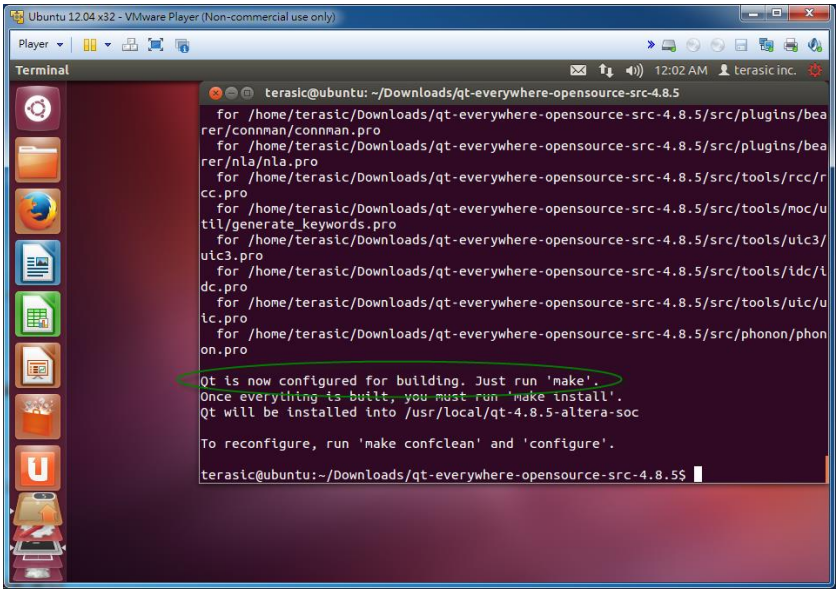

Figure 5-7 Qt Now Configured for Building

■ Make

In the terminal simply type:

```
$make
```

to build the QT library as shown in **Figure 5-8**. The build process will take several hours to complete.

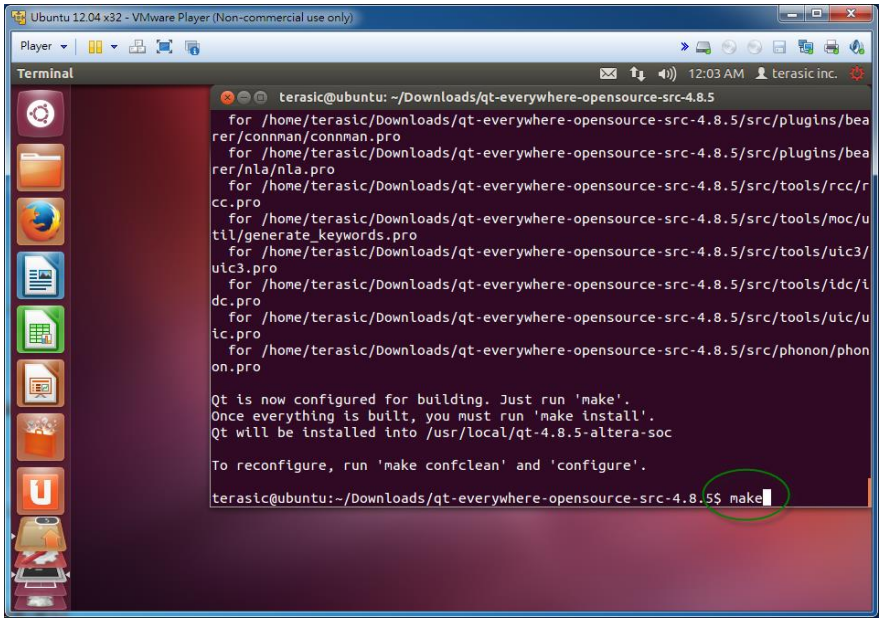

Figure 5-8 Type Make to Start the Build Process

Figure 5-9 shows the screenshot when the make process is completed.

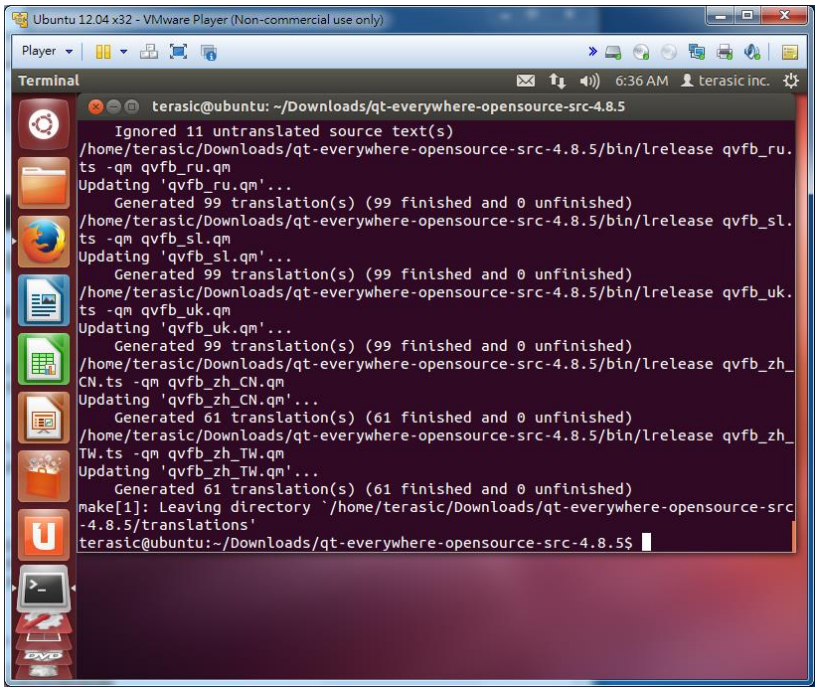

Figure 5-9 Make Process Now Complete

■ Install

Finally, to install the QT package please type in

```
$sudo make install
```

and type in “123” when asked for password for Terasic as shown in **Figure 5-10**.

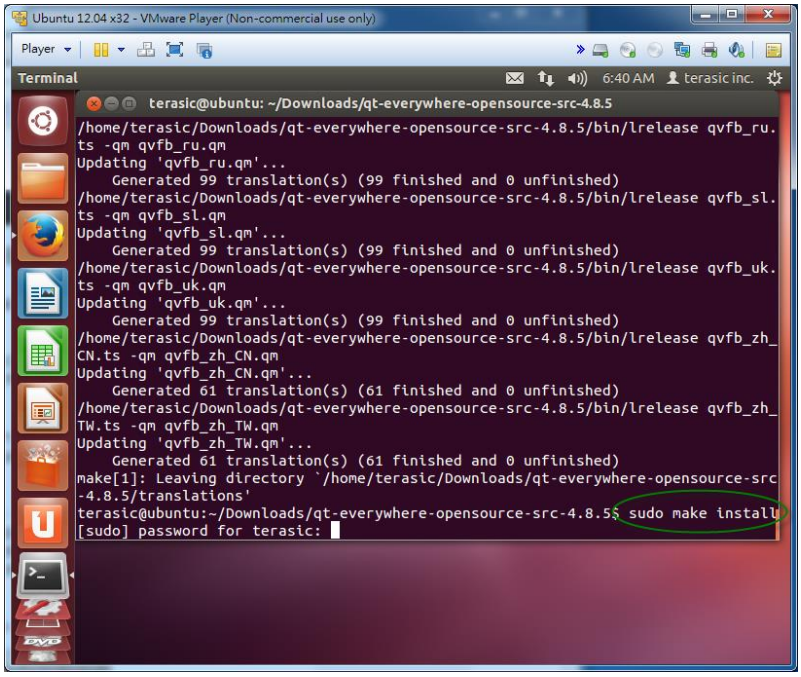

Figure 5-10 Input User Password to Continue the Installation

Figure 5-11 shows the screenshot when the installation is completed.

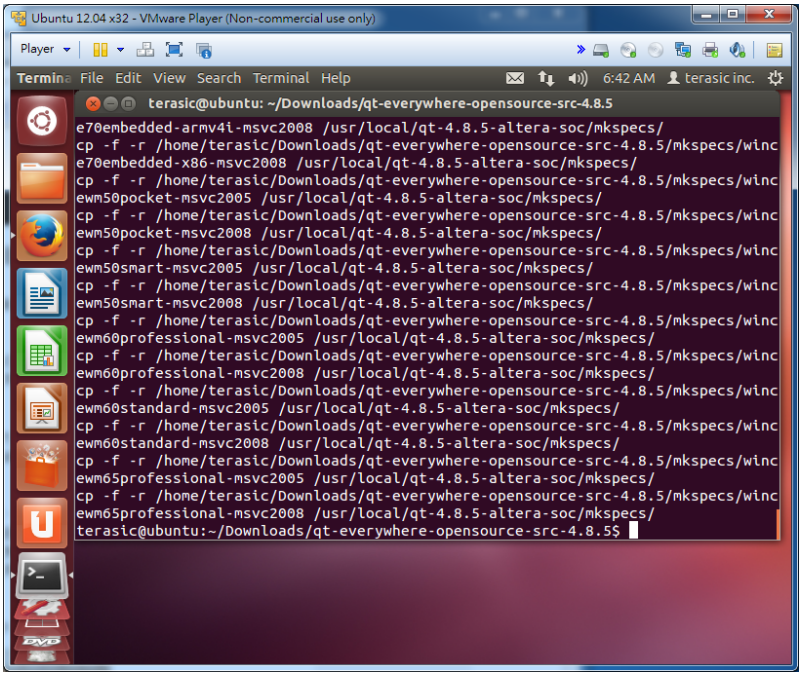

Figure 5-11 Installation is now complete

The QT package will be installed in the folder "/usr/local/qt-4.8.5-altera-soc" as shown in **Figure 5-12**.

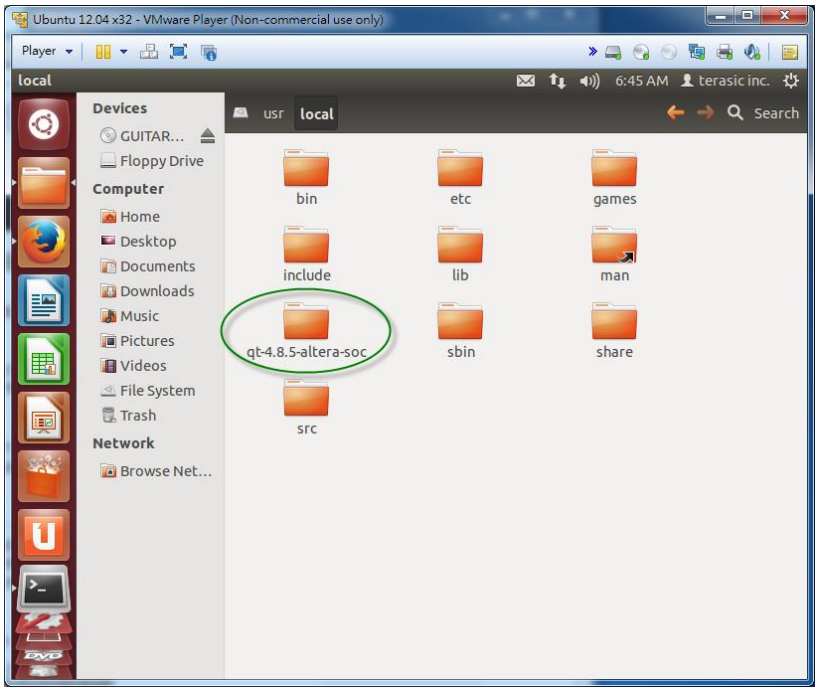

Figure 5-12 Installed Location of Altera SoC QT Package

Chapter 6

QT App for Altera 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 – Altera DE1-SoC FPGA development board in this tutorial. Here we assume that Altera SoC Tool-Chain and QT library for Altera 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.

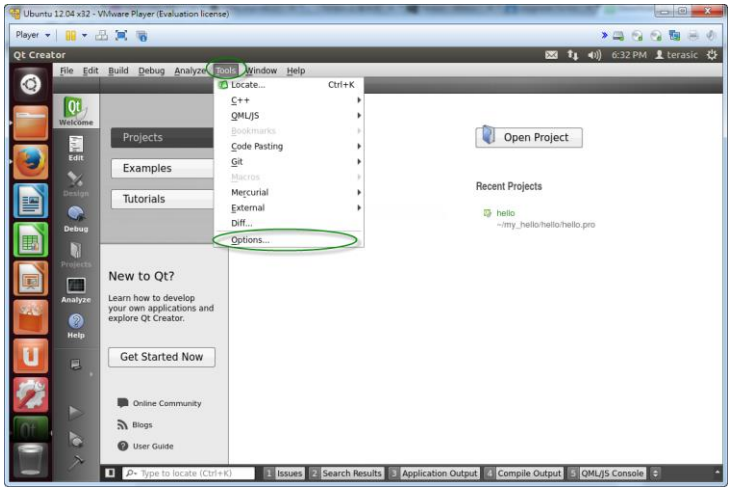

Figure 6-1 Open Option Dialog

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**.

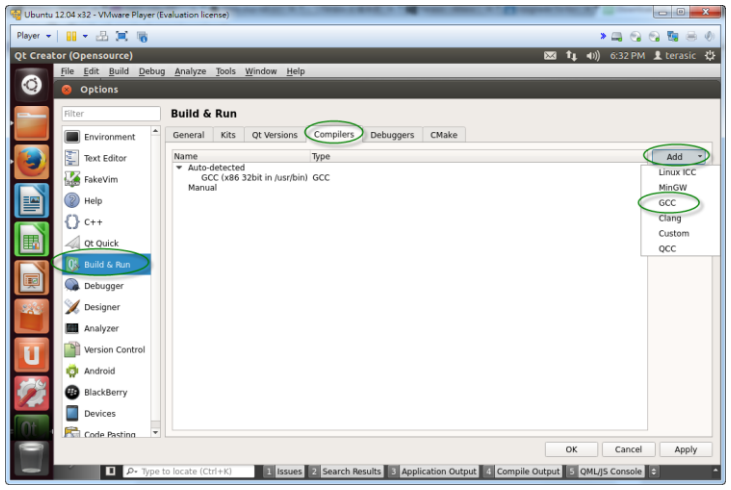

Figure 6-2 Add GCC Compiler

Next, you need to specify the GCC compiler details. First, please type in "GCC (Altera SoC)" in the Name option box and click "Browse…" to select the location of the compiler of Altera SoC ARM. The compiler is located at "/home/**terasic**/gcc-linaro-arm-linux-gnueabihf-4.7-2012.11-20121123_linux/ /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**.

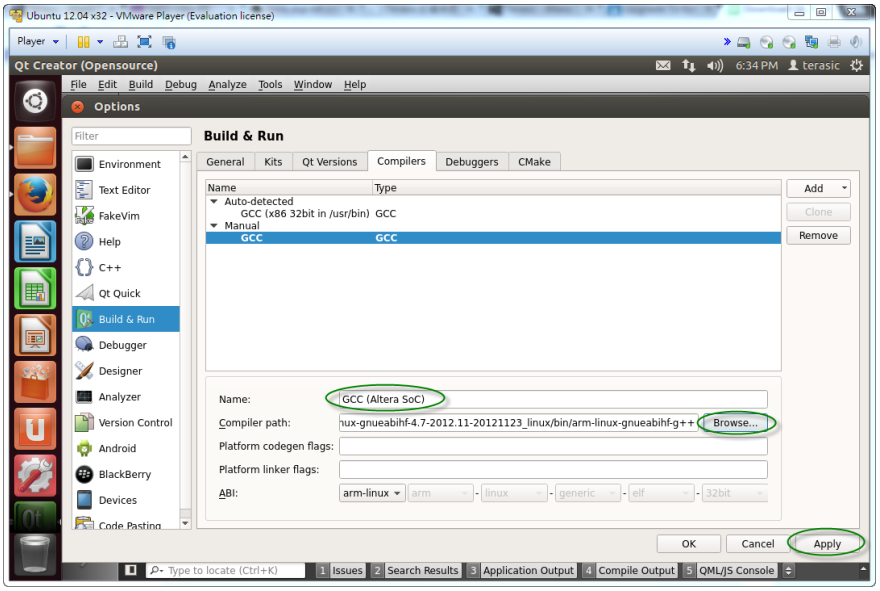

Figure 6-3 Specify Compiler Name and Path

■ 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: "**/usr/local/qt-4.8.5-altera-soc/bin/qmake**".

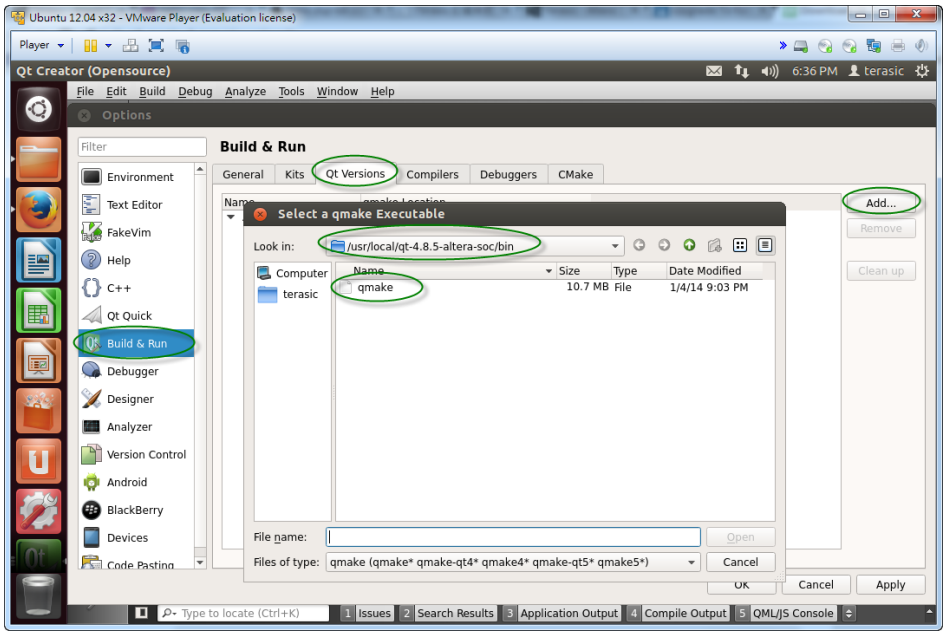

Figure 6-4 Add Qt Version

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

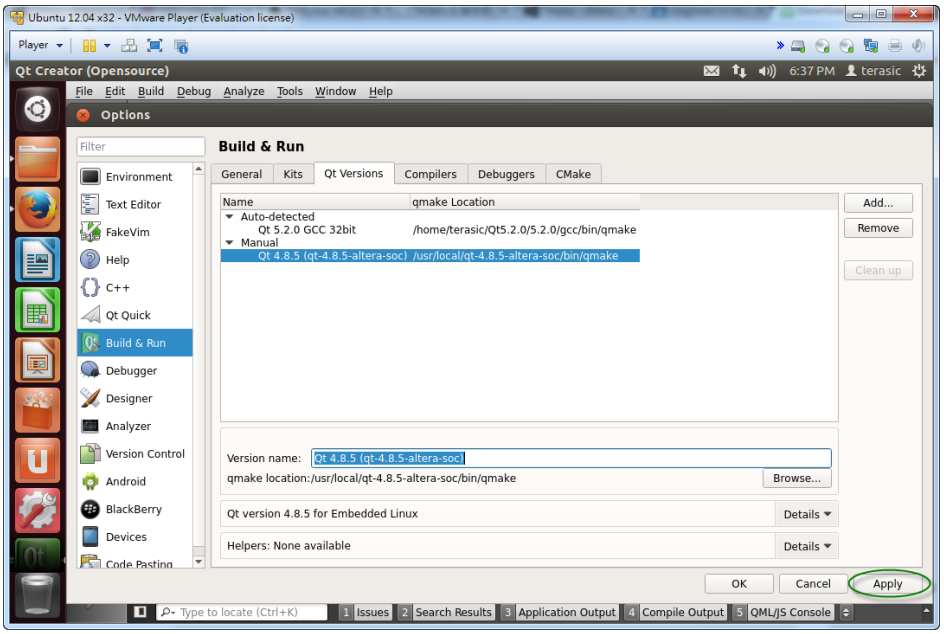

Figure 6-5 Apply the Qt Version

■ 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: Altera SoC FPGA Kit
- Device Type: Select "Generic Linux Device"
- Compiler: Select "GCC (Altera SoC)"
- Qt Version: Select "(Qt 4.8.5 (qt-4.8.5-atera-soc)"

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

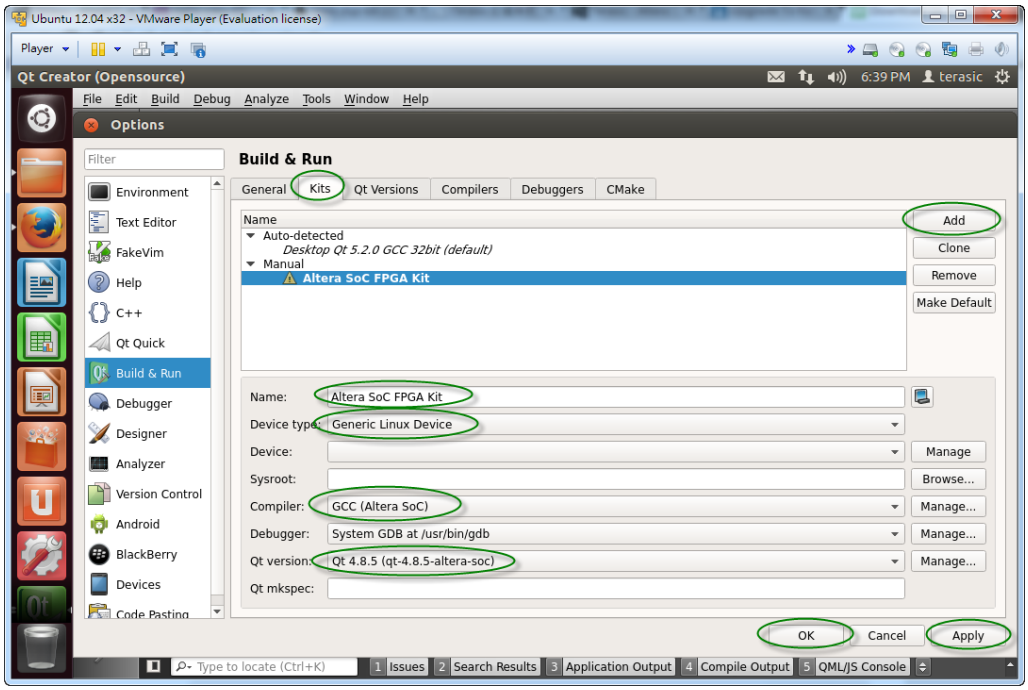

Figure 6-6 Add Altera SoC FPGA Kit

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**.

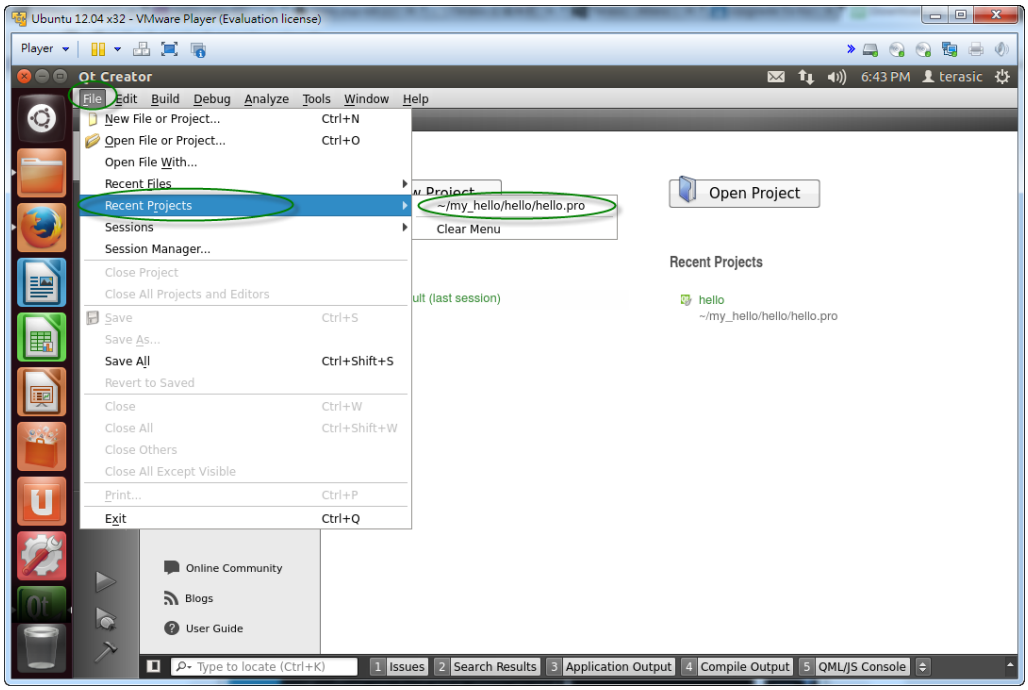

Figure 6-7 Open the Hello Project

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

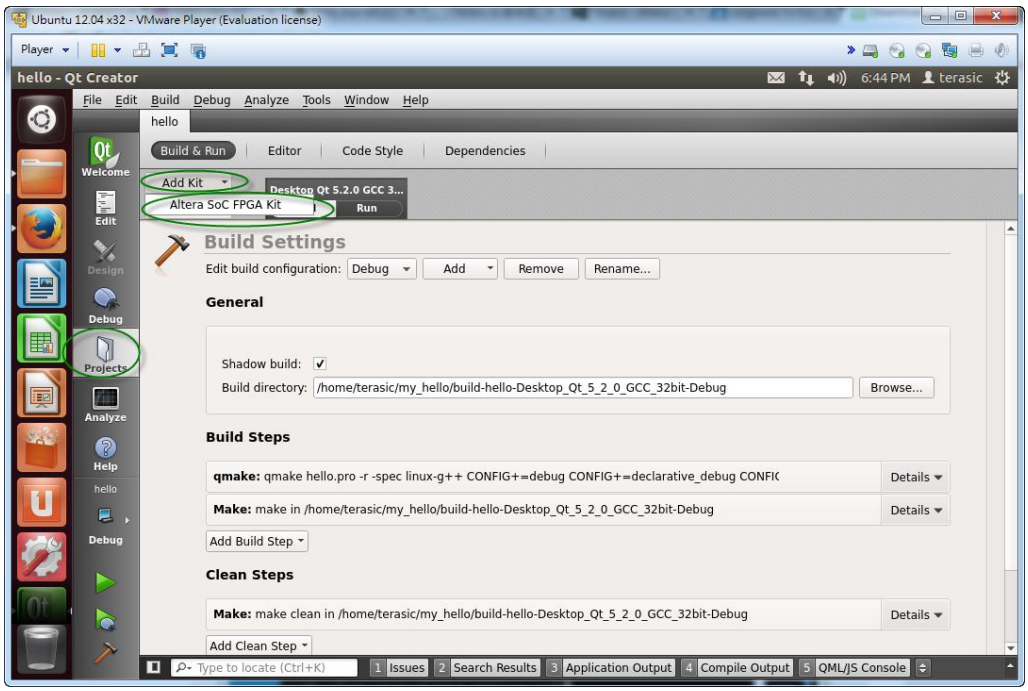

Figure 6-8 Add Altera SoC FPGA Kit into the Hello Project

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

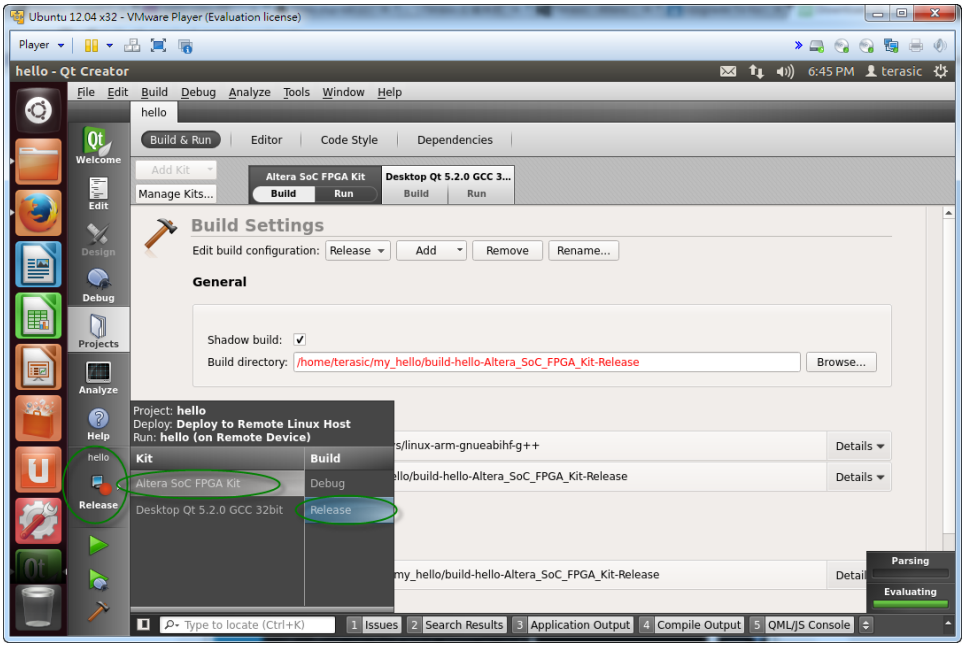

Figure 6-9 Specify Release Setting

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.

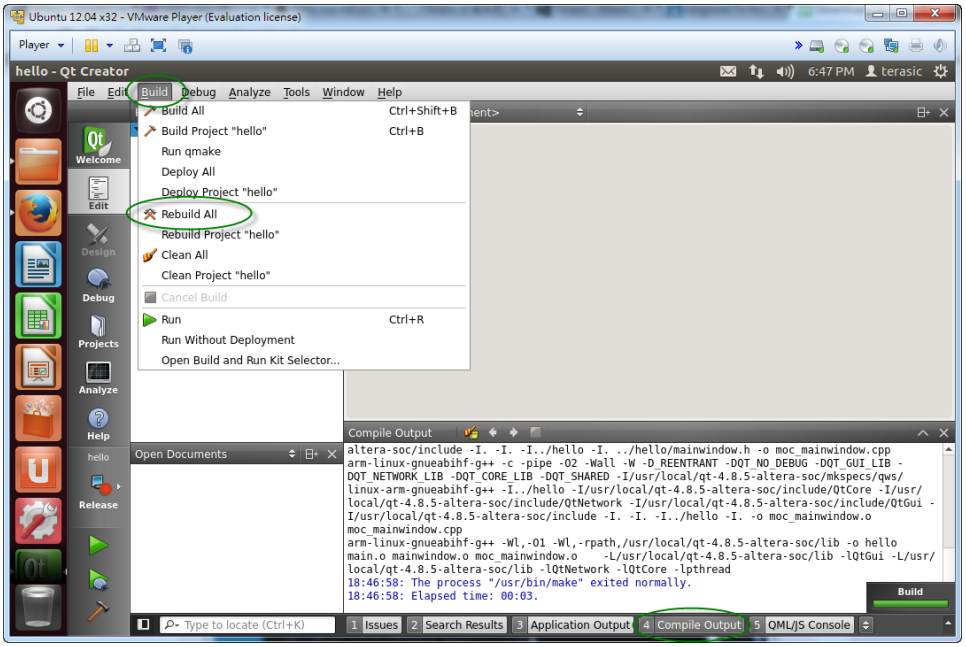

Figure 6-10 Build Hello Project

When the build process has been complete, the output execution file can be found under the folder "/home/**terasic**/my_hello/build-hello-Altera_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**.

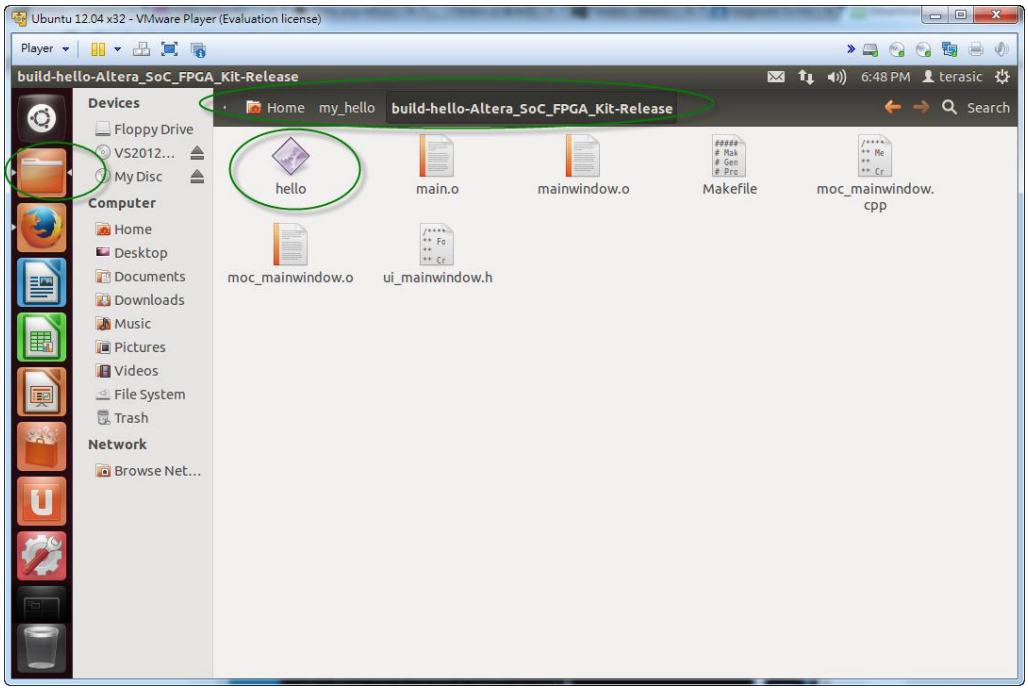

Figure 6-11 Location of the Output Hello Execution File

6.3 Execute Hello Program

To execute the Hello program on the Altera DE1-SoC FPGA board, we need to copy the **hello** execution file and **QT library for Altera SoC** to the Altera 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 Altera DE1-SoC FPGA development board.

■ Setup Network for Altera SoC FPGA Board

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

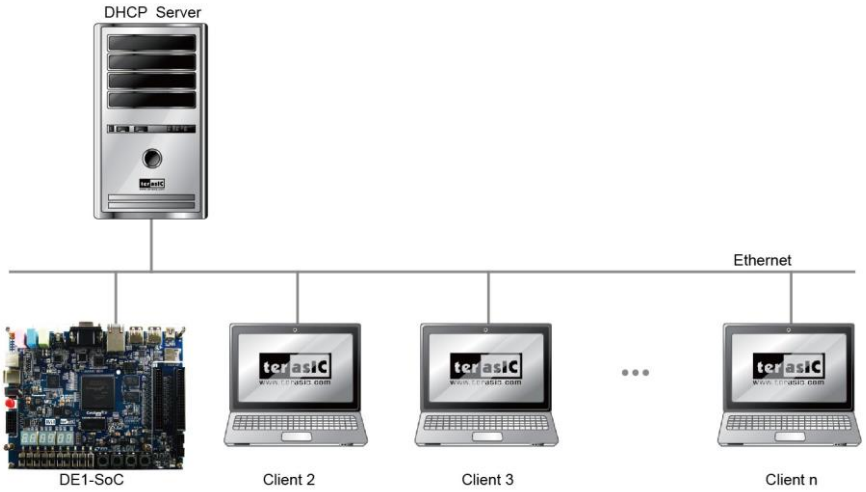

Figure 6-12 Connect Altera SoC FPGA Board To the Ethernet Network

Then, use the microSD card which Control Panel is written to, described in chapter one, to boot the Altera SoC FPGA development board. After logging into Linux, type in "udhcpc" command to request an Ethernet IP Address from the DHCP server as shown in **Figure 6-13**.

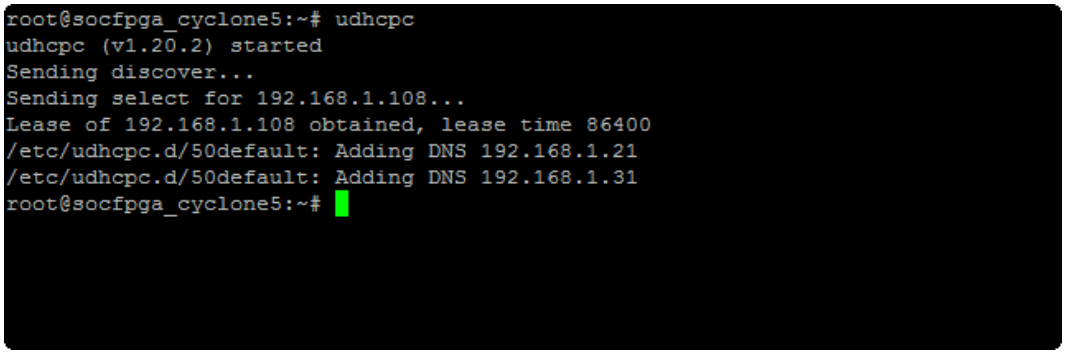

Figure 6-13 Linux UDHCPC Command

To get a IP address from the UDHC 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 "192.168.1.114".

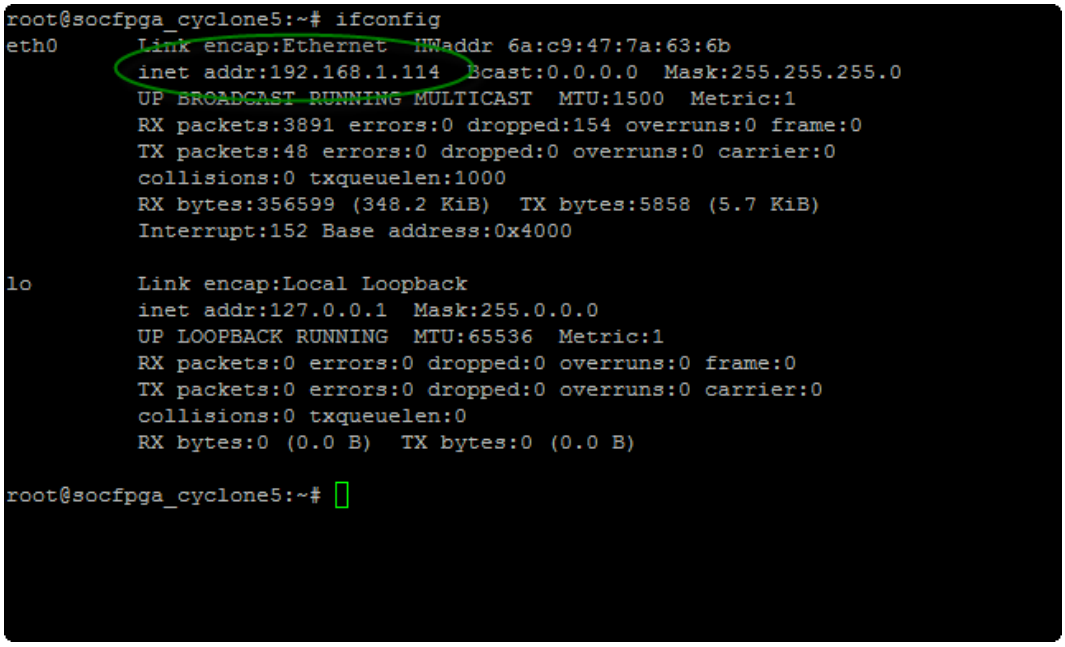

Figure 6-14 Use Linux ifconfig Command to Check Assigned Ethernet IP Address

■ Copy Files from PC Host to Altera SoC FPGA Board

Now, back to the host PC part. Please make sure the host PC is connected to the Ethernet which Altera DE1-SoC FPGA development board also is connected to. Launch a terminal, and type in:

```
$cd /home/terasic/my_hello/build-hello-Altera_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.

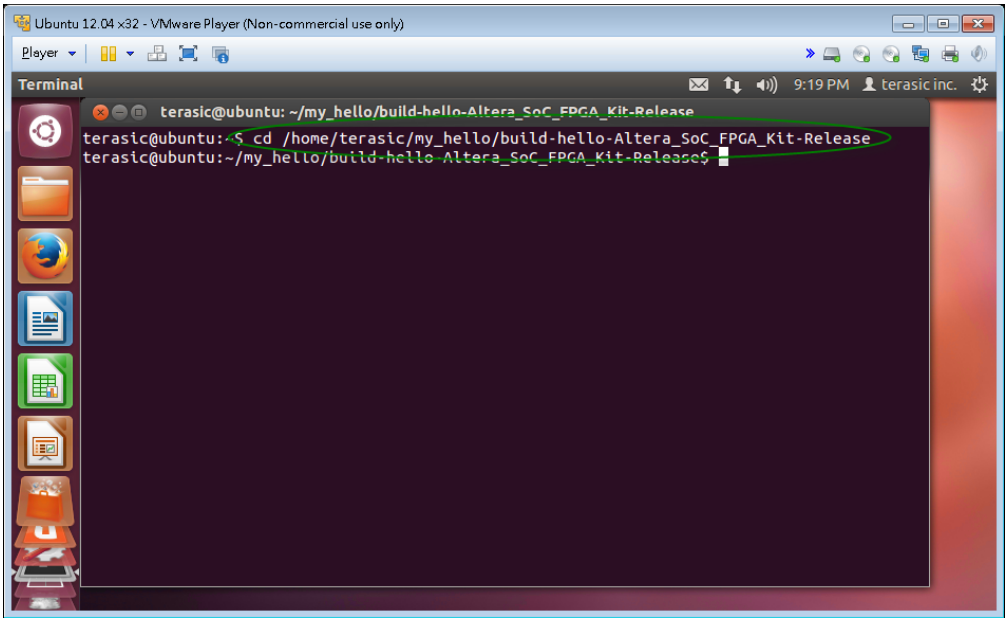

Figure 6-15 Go to the Hello Program Folder

Then, type:

```
$ scp hello root@192.168.1.114:/home/root
```

to remote copy the **hello** program to the /home/root directory of the file system of Altera DE1-SoC FPGA development board , as shown in **Figure 6-16**. Note that the IP address 192.168.1.114 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.

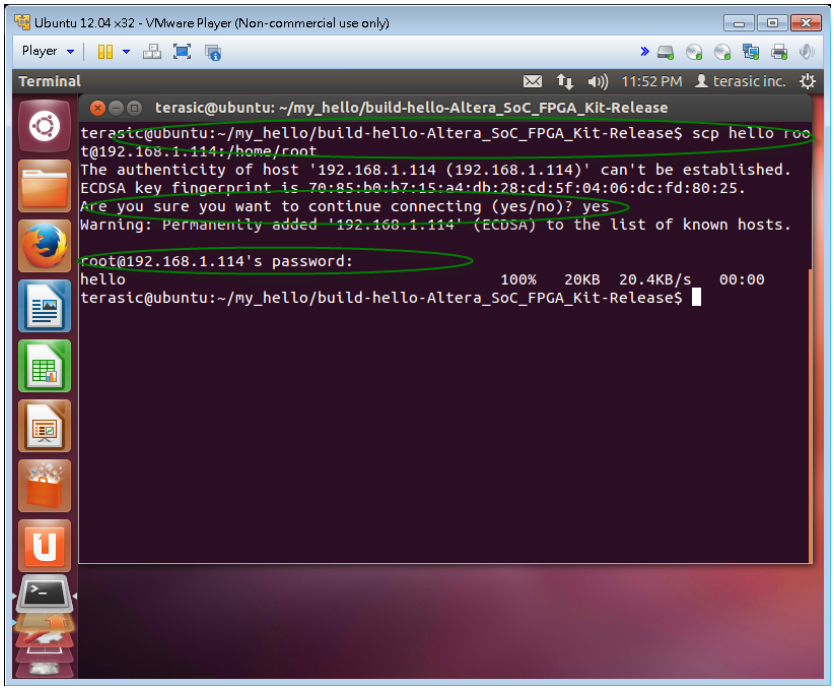

Figure 6-16 Remote Copy the Hello Program

Now, we are going to copy the QT library. Please type in:

```
$ cd /usr/local
```

to go to the directory where QT library is located, as shown in **Figure 6-17**.

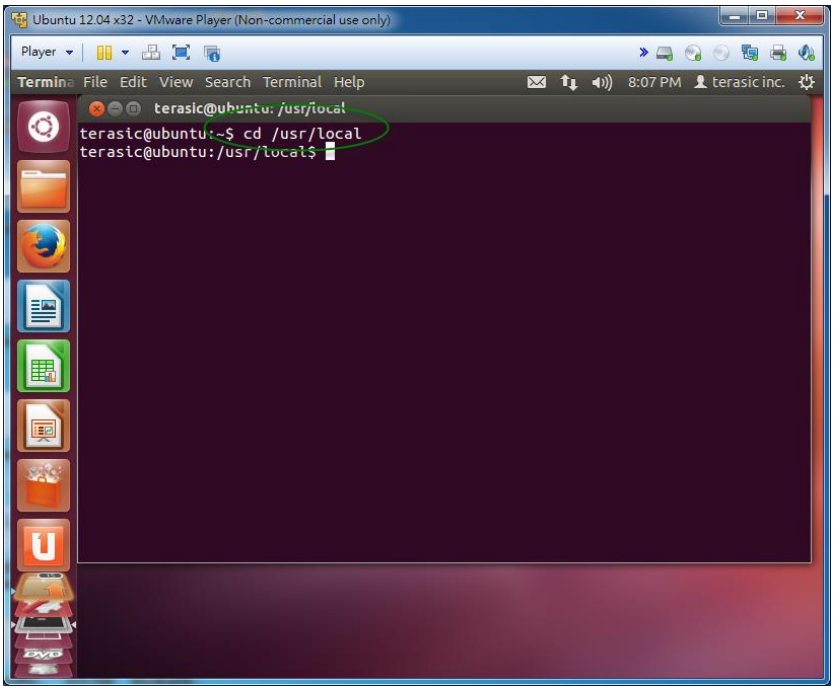

Figure 6-17 Go to the QT Library Directory

Please type in the following command to compress the QT library as shown in **Figure 6-18**.

```
$sudo tar -jcv -f qt-4.8.5-altera-soc.tar.bz2 qt-4.8.5-altera-soc
```

When system prompts to request your password, please input your password and press ENTER. (In this tutorial, the password is "123")

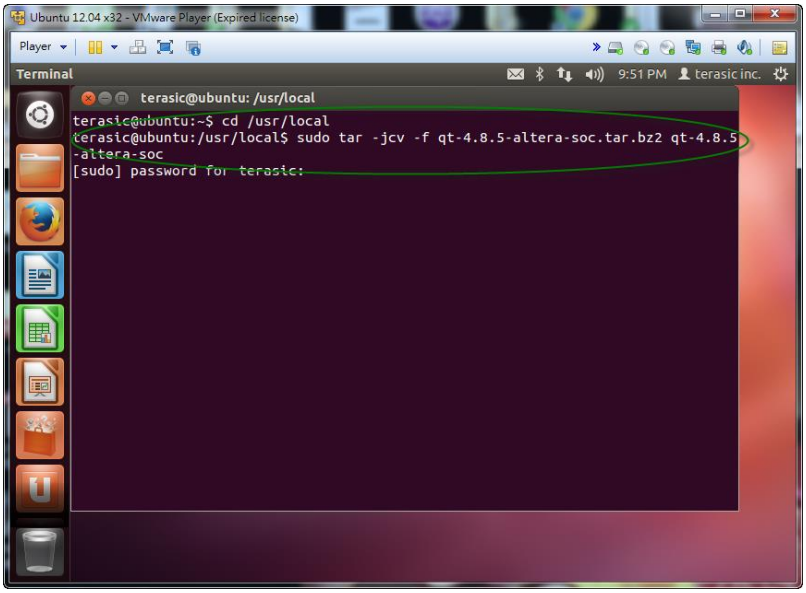

Figure 6-18 Compressing QT Library

Figure 6-19 shows the screenshot when the compressing process is complete.

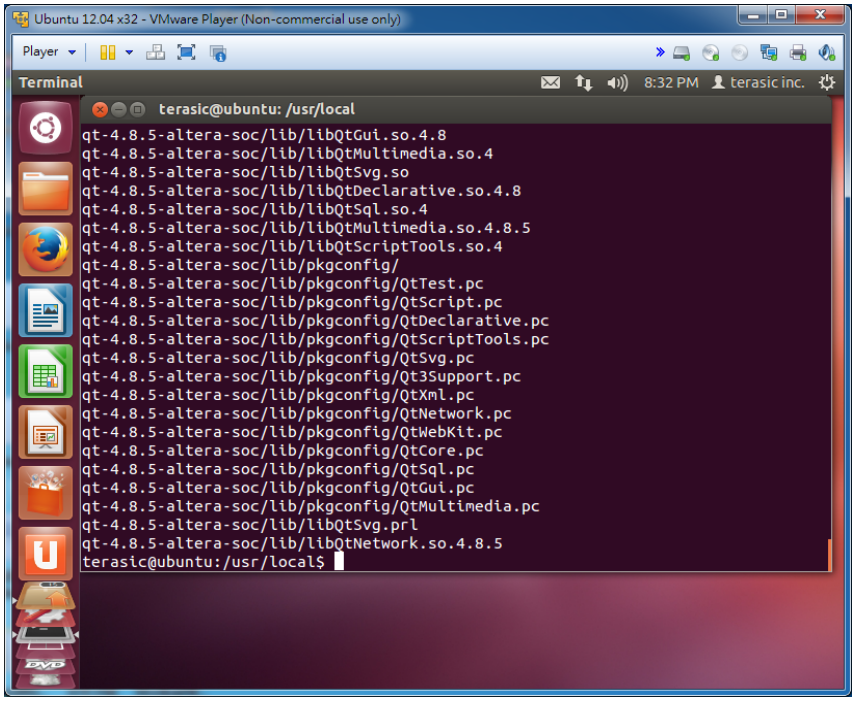

Figure 6-19 Compressing the QT Library

Type in the following command

```
$ scp qt-4.8.5-altera-soc.tar.bz2 root@192.168.1.114:/usr/local
```

to remote copy the compressed QT Library to the "/usr/local" directory of the file system of Altera SoC FPGA development board, as shown in **Figure 6-20.** Note that the ip address 192.168.1.108 should be changed to the ip address actually assigned. The system will ask you to provide the password of the remote machine, please type in "**terasic**" and press ENTER.

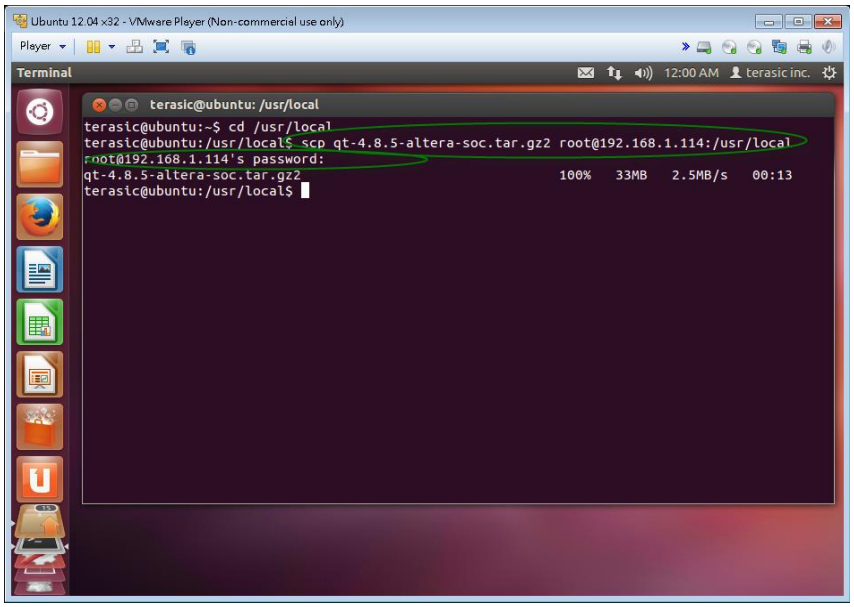

Figure 6-20 Remote Copy Compressed QT Library to Altera SoC FPGA Development Board

Once the copying process is done, we work in the Linux terminal on Altera SoC FPGA development board. Since the file sent earlier from host PC is in the compressed format, we need to decompress the QT Library before we can use it.

By typing the following command in the Linux terminal on Altera SoC FPGA development board

```
$ cd /usr/local
```

to go to the /usr/local directory, as shown in **Figure 6-21**.

Figure 6-21 Go to /usr/local Directory in Altera SoC FPGA Board

There is already a "qt-4.8.5-altea-soc" directory in /usr/local. We need to move(rename) that directory because we now need to decompress qt-4.8.5-altera-soc.tar.bz2. Please use the following command to rename " qt-4.8.5-altera-soc " directory name as " qt-4.8.5-altera-soc-org" as shown in **Figure 6-22.**

```
$ mv qt-4.8.5-altera-soc qt-4.8.5-altera-soc-org
```

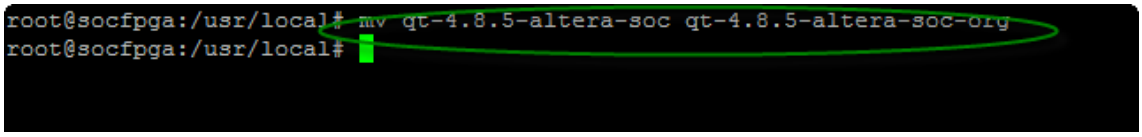

Figure 6-22 Rename Existing Qt Library Directory

After renaming, we can now decompress the QT Library by typing the following command:

```
$ tar -jxv -f qt-4.8.5-altera-soc.tar.bz2
```

as shown in **Figure 6-23**.

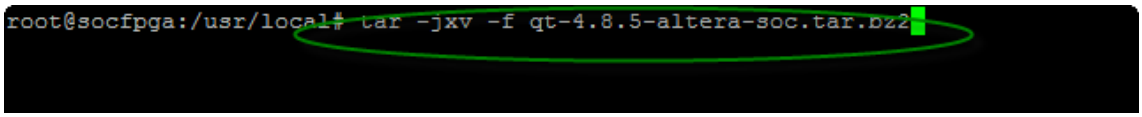

Figure 6-23 Decompress QT Library

■ Launch Hello Program

Before we launch the hello program, we first type in

```
$ cd /home/root
```

to go to the /home/root directory, as shown in **Figure 6-24**.

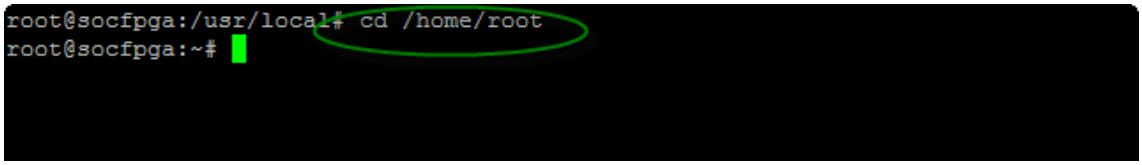

Figure 6-24 Go to /home/root Directory

Now launch hello program by typing in the following command:

```
$ ./hello -qws
```

as shown in **Figure 6-25**.

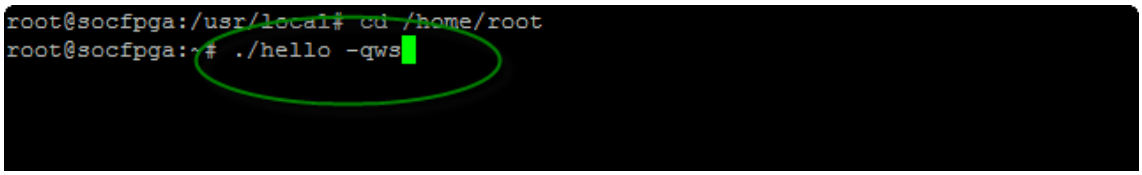

Figure 6-25 Launch Hello Program

If the Hello program is launched successfully, you should see the Hello windows as shown in

Figure 6-26.

Figure 6-26 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 Altera 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 13.0 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/download/sw/dnl-sw-index.jsp 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: "**Demonstration\ 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.

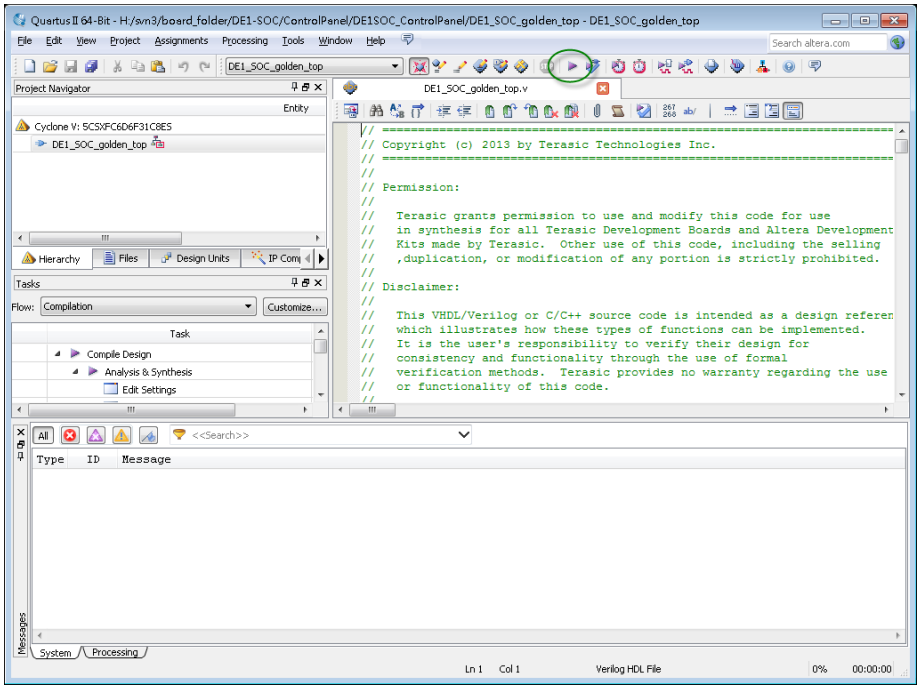

Figure 7-2 Quartus Project of the Control Panel

When finished compiling, **DE1_SOC_golden_top.sof** is generated under the Quartus project folder.

7.2 Test FPGA Configuration File

When Altera 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 DE1_SOC_golden_top.sof soc_system.rbf
```

We have provided the batch file "sof_to_rbf.bat" which implements the translation command for user's convenience. When the file translation is complete, **soc_system.rbf** file is generated in the folder where the Quartus project is located.

■ 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 Altera DE1-SoC FPGA development board with the updated microSD Card, login to Linux, and launch control panel with the command "./ControlPanel ./qws" to test if everything works well.

7.3 More on the Quartus Project of Control Panel

The Control Panel circuit is built by QSyS. The HPS Linux program accesses **Avalon Memory Mapped Bus** through the **HPS** component. Also, 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.

■ Linux Access FPGA Controller

The HPS Linux program accesses **Avalon Memory Mapped Slave** ports 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 addresses are not overlapped with each other. We strongly recommend

that developer properly defines the port addresses and lock port addresses in Qsys.

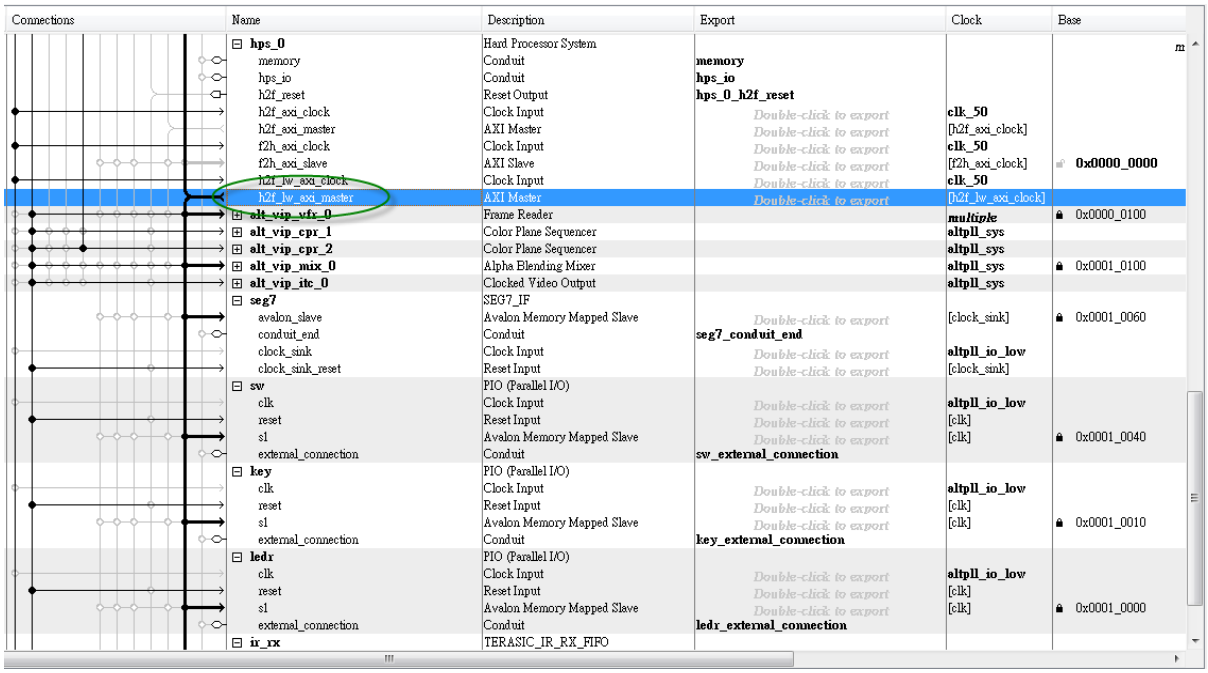

Figure 7-3 HPS AXI Master Port

In this tutorial, the slave port of LED, Button, Switch, IR, 7-segment, VIP frame reader, VIP clocked video input, and VIP alpha blending mixer controllers are connected to the **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**.

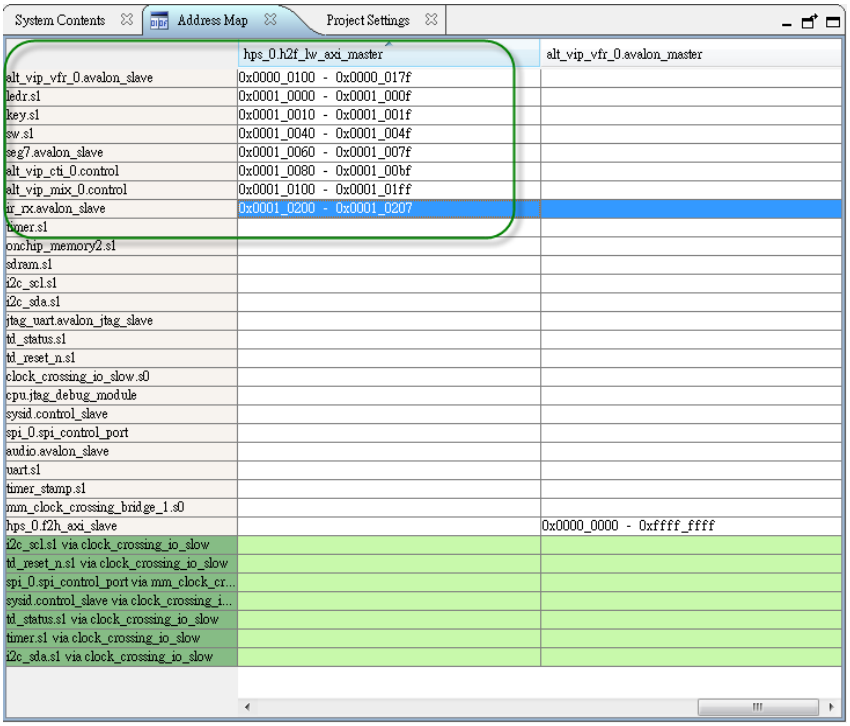

Figure 7-4 HPS h2f_lw_axi_master Connection and Address Map

■ 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 7-5**.

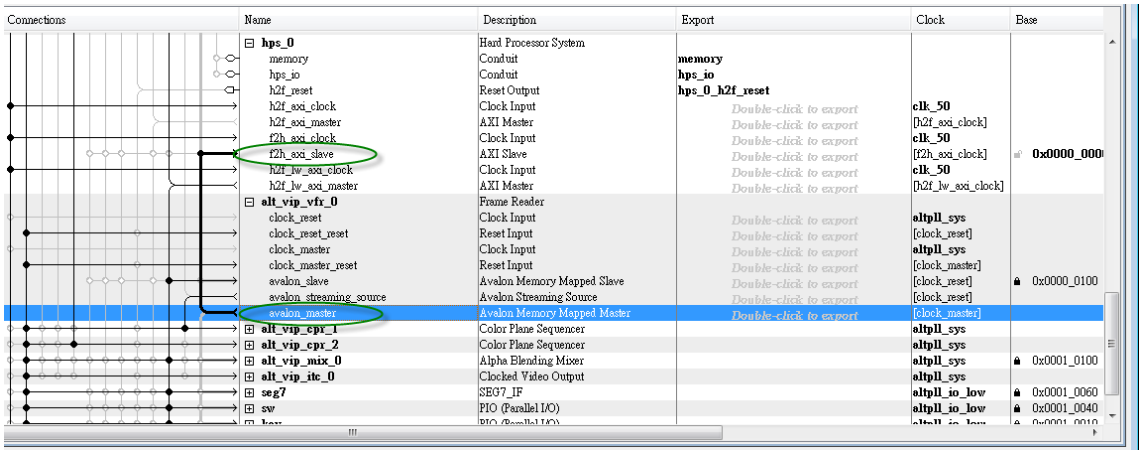

Figure 7-5 HPS AXI Master Port

Figure 7-6 shows Frame Reader instance setting. The display resolution is set as 1024x768.

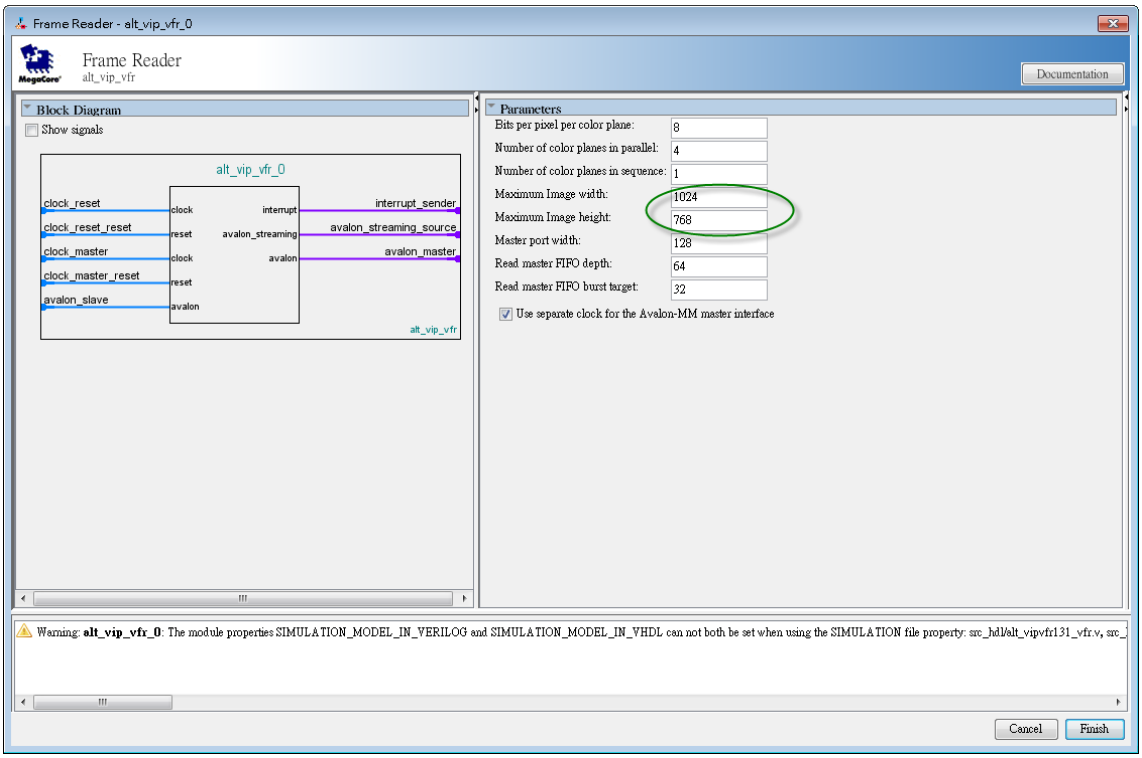

Figure 7-6 Frame Reader Setting

Chapter 8

Control Panel QT Project

Chapter 8 describes how to build the Control Panel QT project by the QT Creator on the Linux host. Here, we assume the QT library for Altera SoC ARM built in previous chapters is still in place. The **Shared Folder** feature of VMware Player is used so that the Control Panel QT project in the folder on the Windows host can be visible on the Linux host.

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

Altera SoC EDS can be downloaded from https://www.altera.com/download/sw/dnl-sw-index.jsp or the Altera Download Center by clicking on the **SoCEDS** icon as shown in **Figure 8-1**.

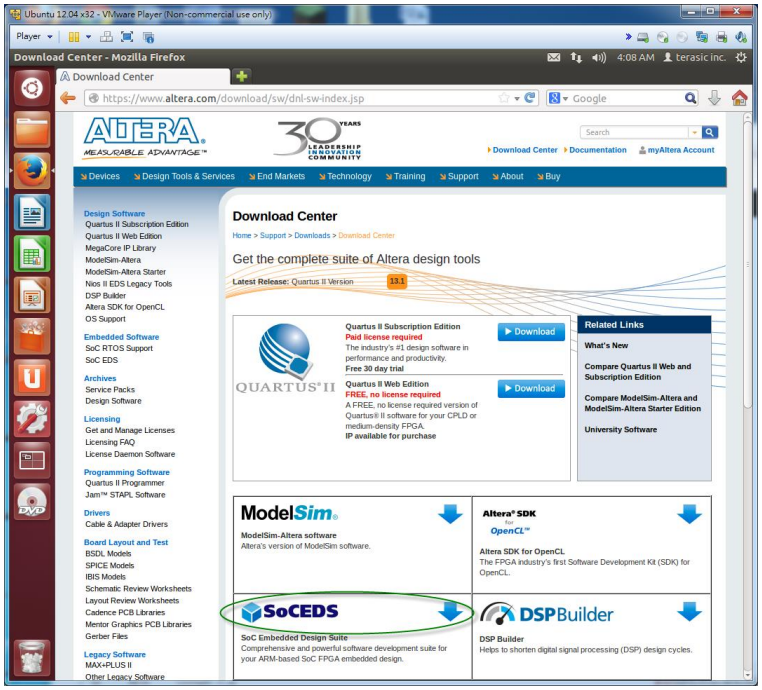

Figure 8-1 Altera SoC EDS Download Web Page

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

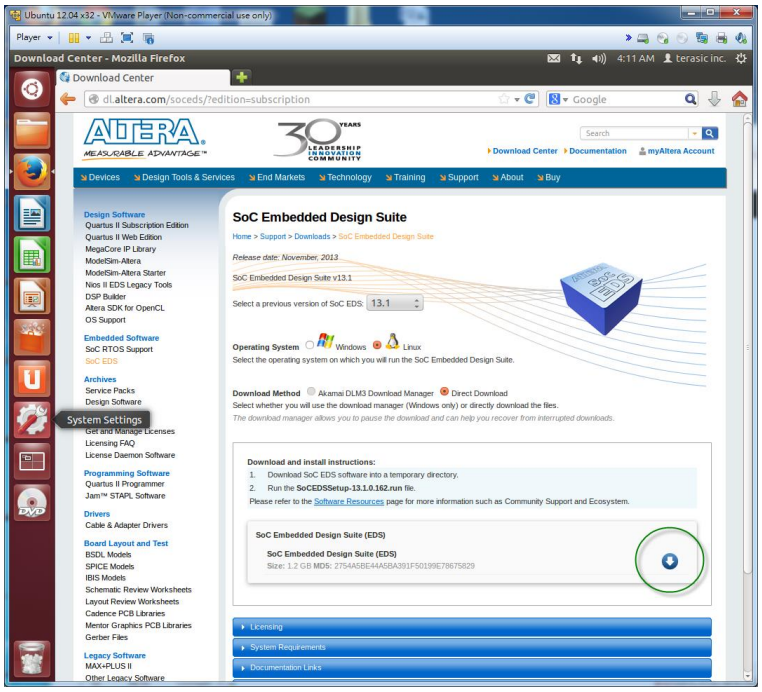

Figure 8-2 Altera SoC EDS Download Web Page

The downloaded SoC EDS installer "**SoCEDSSetup-13.1.0.162.run**" is located in the directory "~/Downloads". To launch the installer, first launch Linux terminal (CTRL+ALT+T), and type in:

```
$ cd ~/Downloads
```

to go to "~/Downloads" directory.

Then, type in:

```
$ chmod +x SoCEDSSetup-13.1.0.162.run
```

to add execution attribute to the installer.

Finally, type in:

```
$ ./SoCEDSSetup-13.1.0.162.run
```

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

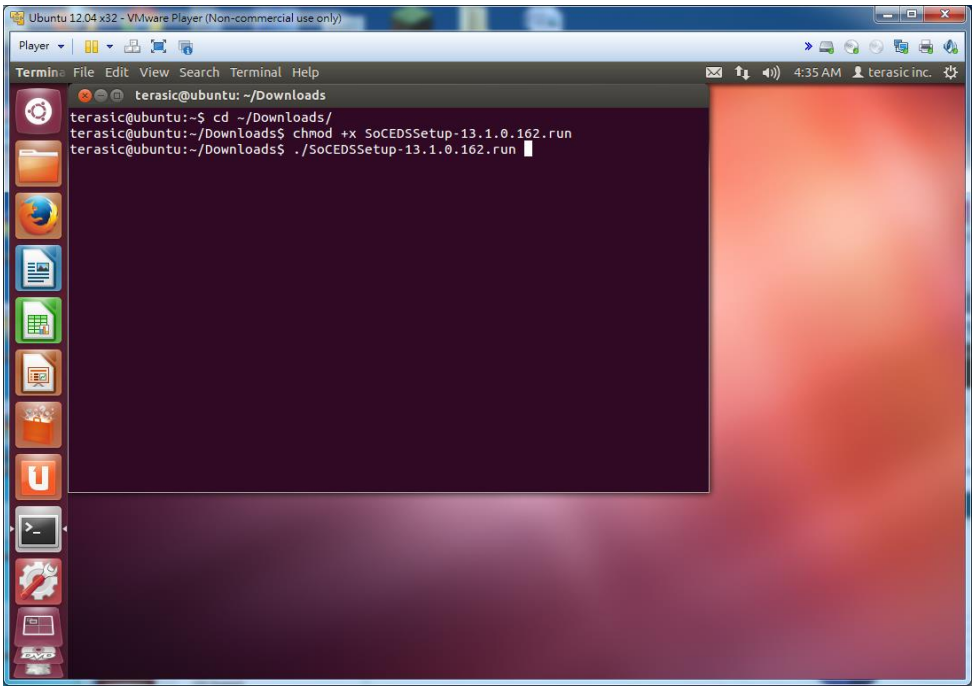

Figure 8-3 Launch SoC EDS Installer

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

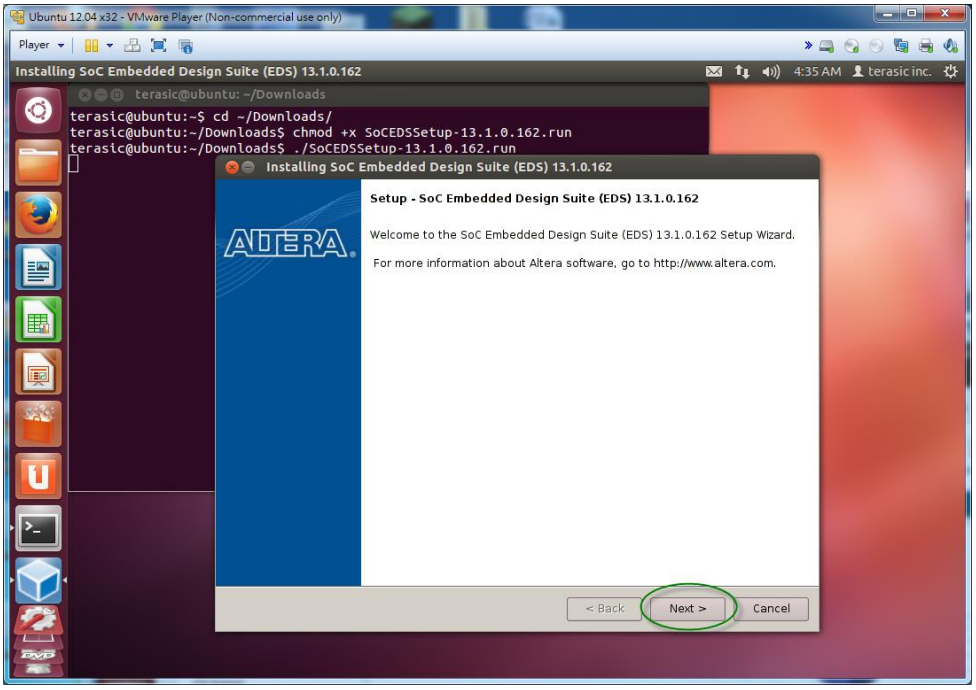

Figure 8-4 Welcome Dialog of SoC EDS Installer

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.

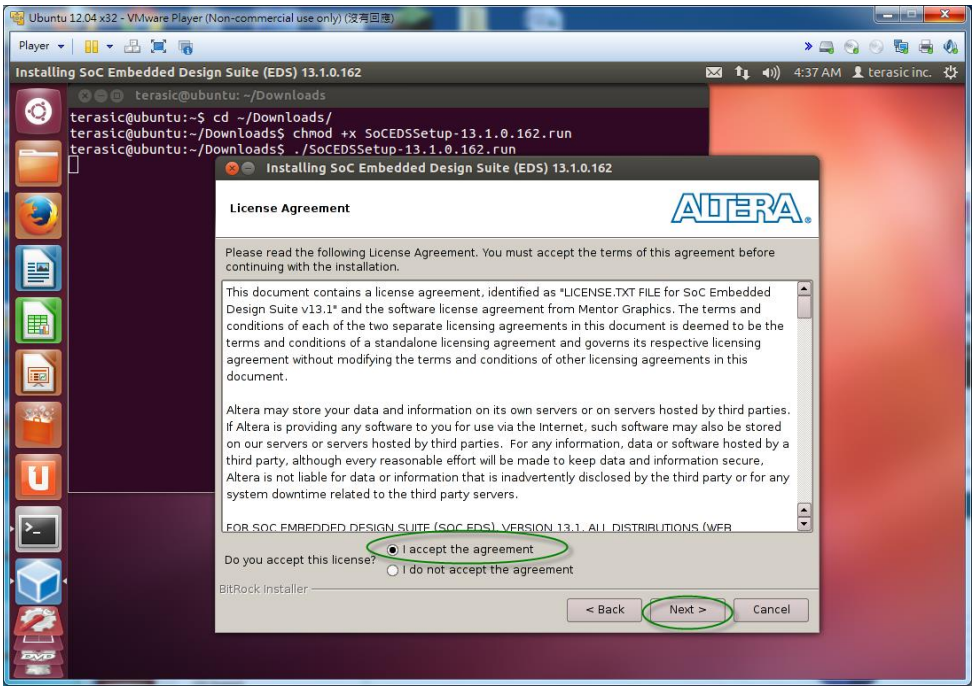

Figure 8-5 License Agreement Dialog of SoC EDS Installer

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.

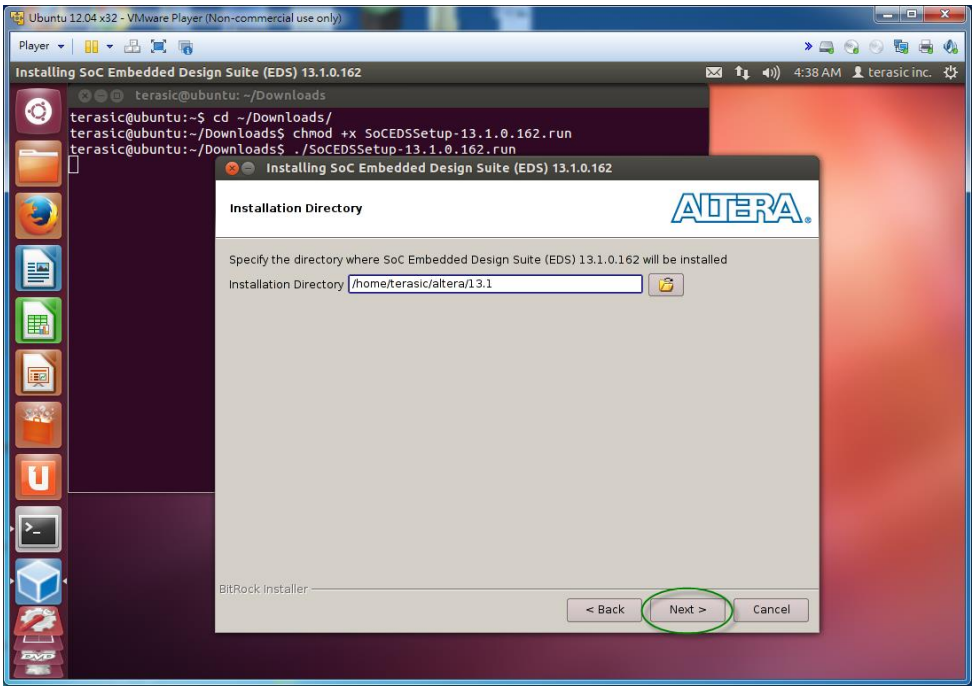

Figure 8-6 Installation Directory Dialog of SoC EDS Installer

When the **Select Components** dialog appears as shown in **Figure 8-7**, please **uncheck** the "Quartus II Programmer and SignalTap II(937.2MB)" checkbox and click "Next >" to go to the next step.

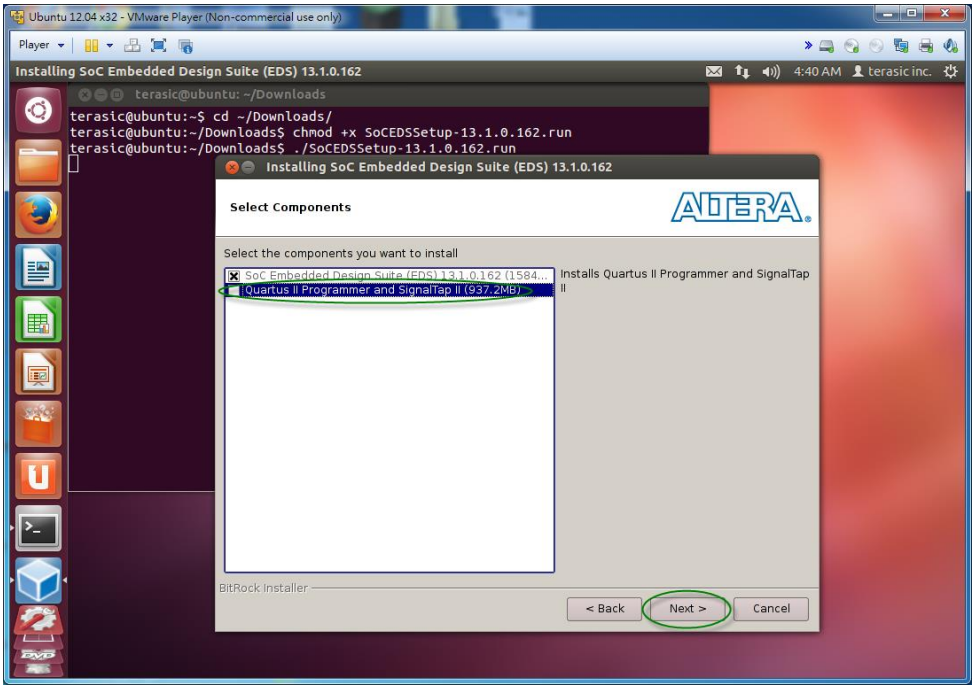

Figure 8-7 Select Components Dialog of SoC EDS Installer

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

the next step.

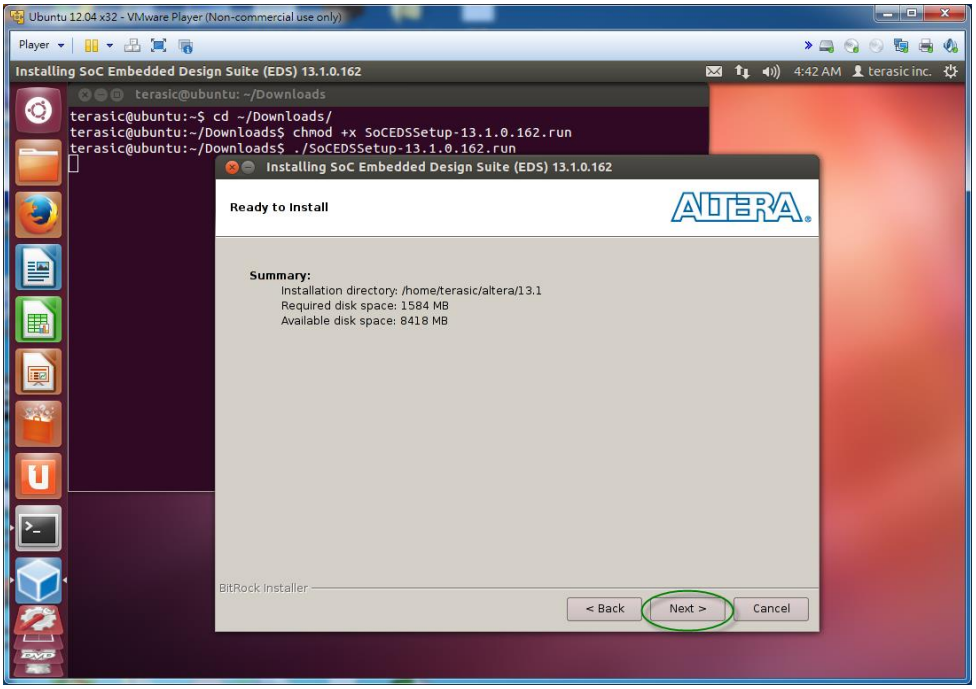

Figure 8-8 Ready to Install Dialog of SoC EDS Installer

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

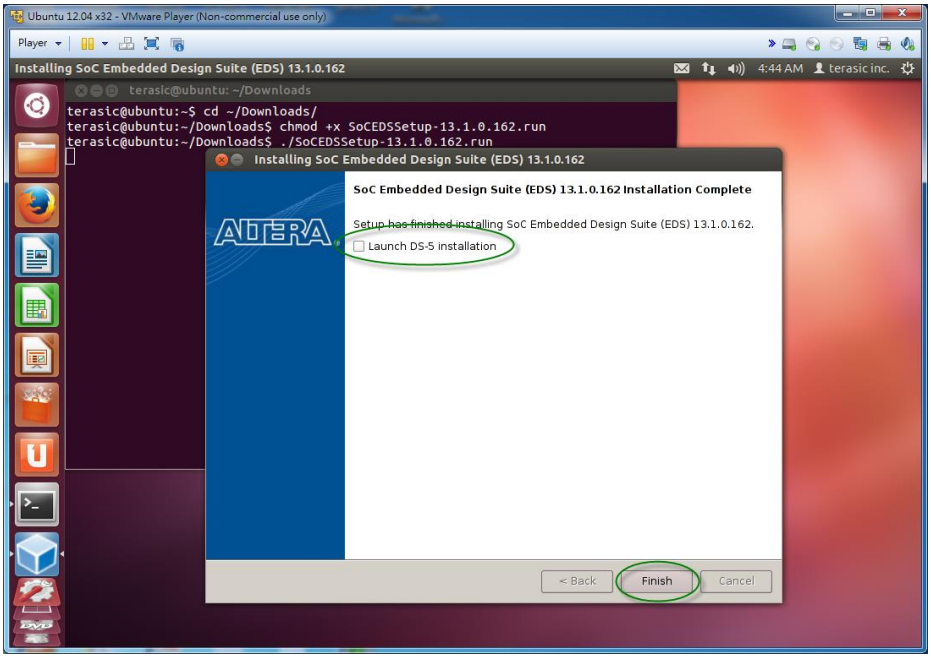

Figure 8-9 Finish Dialog of SoC EDS Installer

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

/home/**terasic/**altera/13.1/embedded/ip/altera/hps/altera_hps/hwlib

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

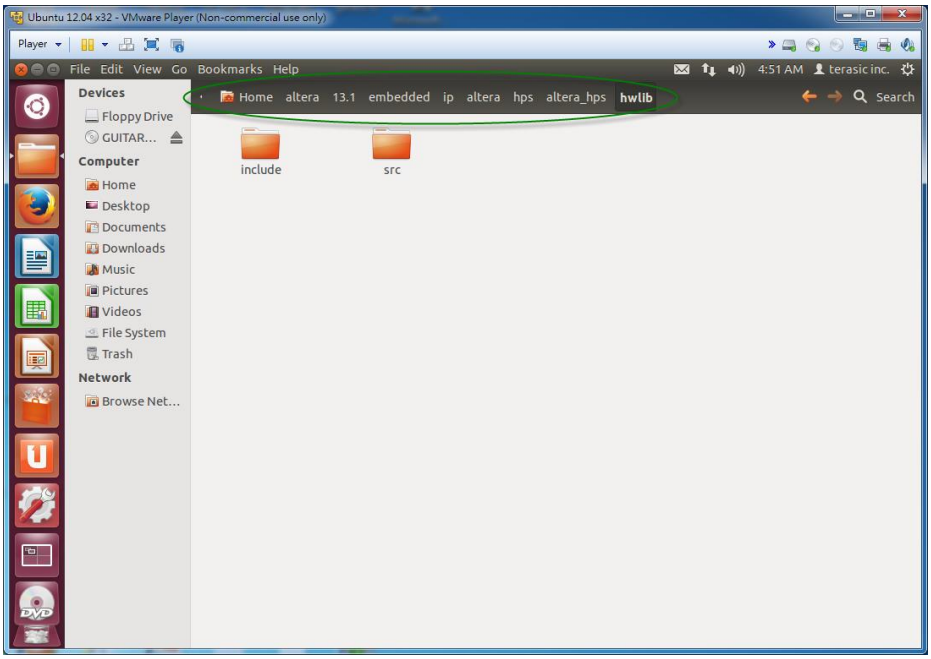

Figure 8-10 Directory Location of Altera 'hwlib' Library Source Code

8.1 Copy Control Panel QT Project

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

\Demonstration\ ControlPanel\ControlPanel_QT

Here we show how to make the project visible under the Linux host by using VMware Player's **Shared Folder** features.

■ Shared Folder Setup

Launch the VMware Player, select the "Ubuntu 12.04 x32", and click "Edit virtual machine settings", as shown in **Figure 8-11.**

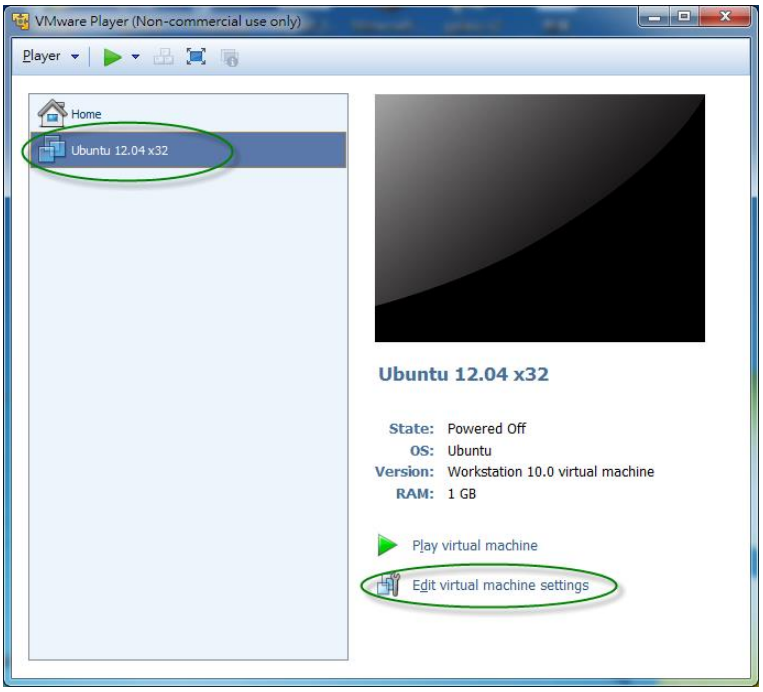

Figure 8-11 Launch Edit Virtual Machine Settings

When the **Virtual Machine Settings** dialog appears as shown in **Figure 8-12**, please select "Options" tab, click "Shared Folders" icons, check "Always enabled" radio button, and then click "Add…".

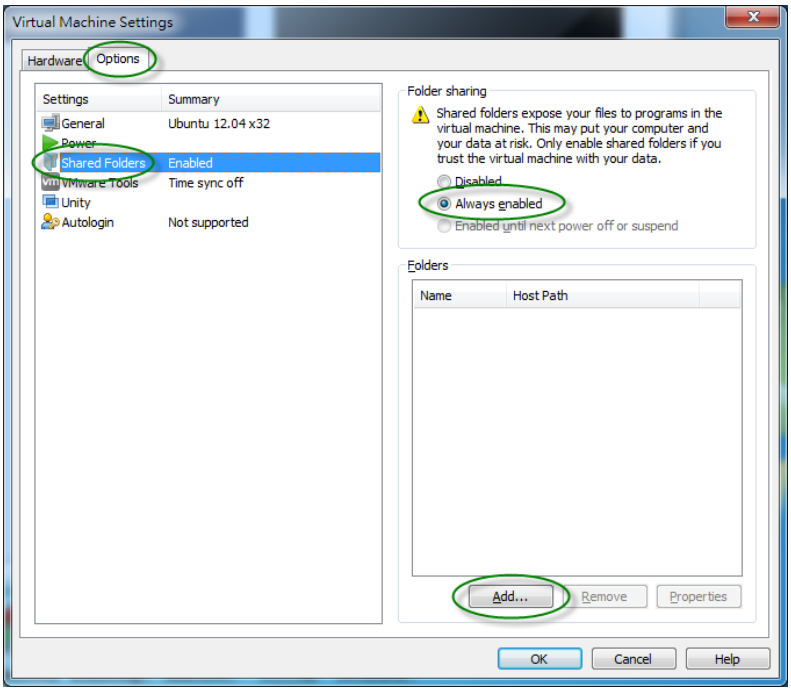

Figure 8-12 Add Shared Folders

Add Shared Folder Wizard is launched for shared folder settings. A Welcome dialog appears as shown in **Figure 8-13**, please click "Next >" to go to the next step.

Figure 8-13 Welcome Dialog of Add Shared Folder Wizard

When the **Name the Shared Folder** dialog appears as shown in **Figure 8-14**, click "Browse…" to select a folder as the shared folder, give a name to the shared folder(in this tutorial, **shared** is used), and click "Next >" to proceed.

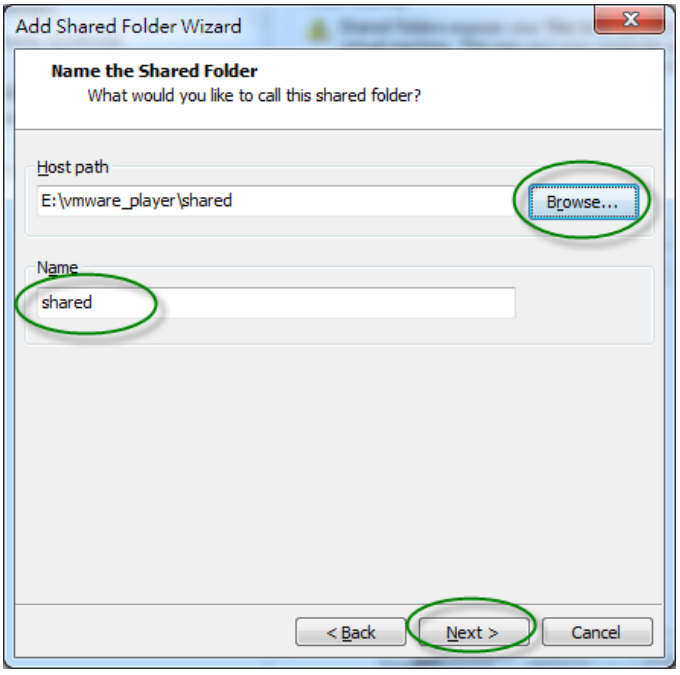

Figure 8-14 Specify Shared Folder Location and Name

When the **Specify Shared Folder Attributes** dialog appears as shown in **Figure 8-15**, check "Enable this share" checkbox and click "Finish".

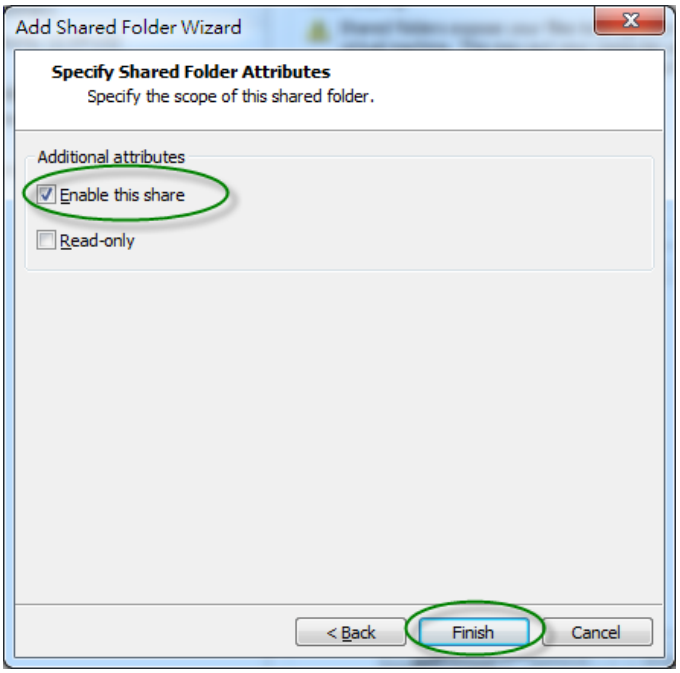

Figure 8-15 Finish Shared Folder Setup

When going back to the **Virtual Machine Settings** dialog as shown in **Figure 8-16**, check "OK" to complete the settings. Now the Shared Folder feature is applied.

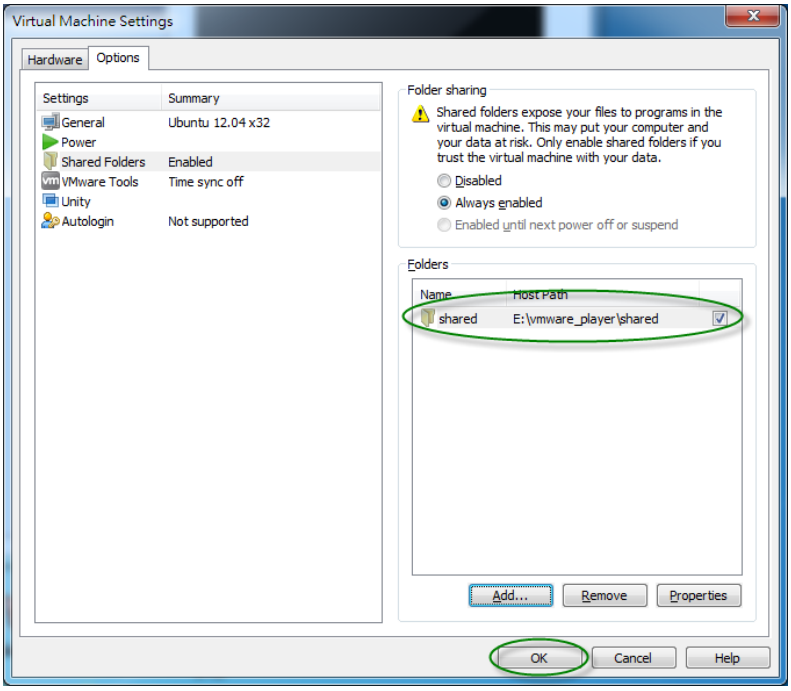

Figure 8-16 Complete Virtual Machine Setting

■ 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 the "Ubuntu 12.04 x32" virtual machine. After logging in Ubuntu, 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 8-17.**

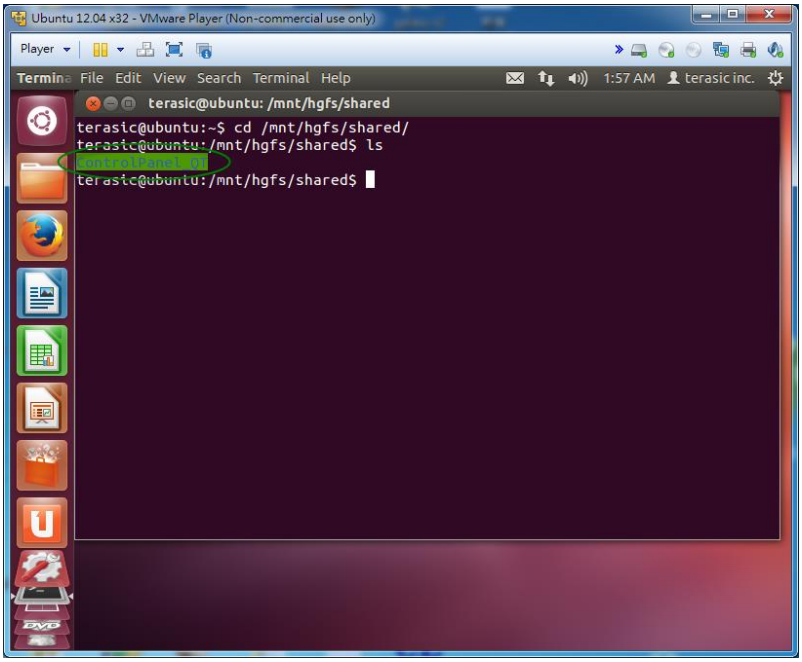

Figure 8-17 'ControlPanel_QT' Directory of Control Panel QT Project

8.2 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 8-18**.

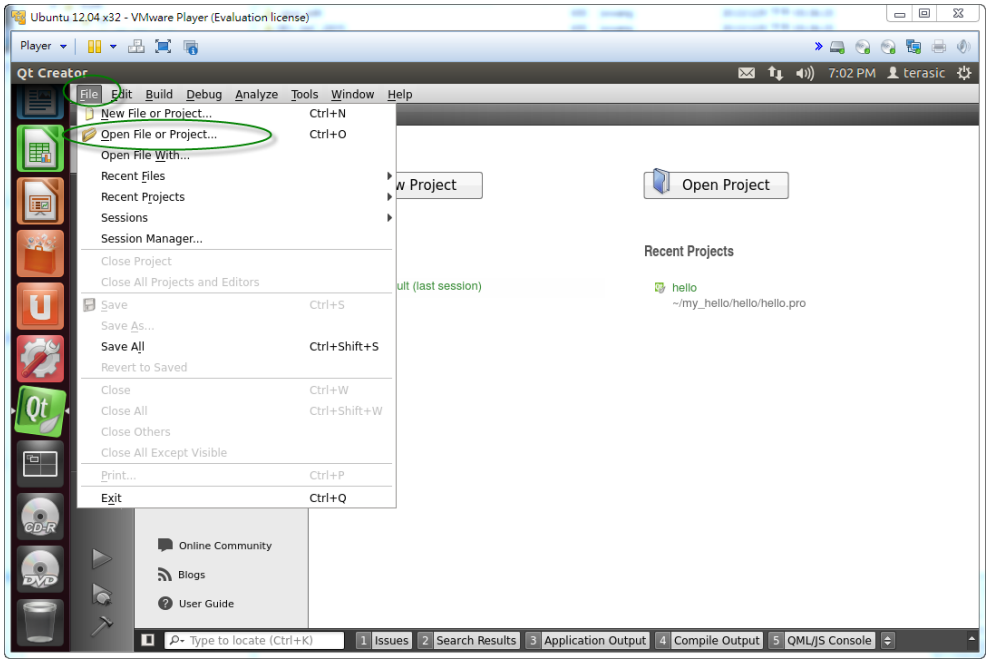

Figure 8-18 Launch Open Project Dialog

In the **Open File** dialog, go to the directory "/mnt/hgfs/shared/ControlPanel_QT", select "ControPanel.pro", and click "Open" as shown in **Figure 8-19**.

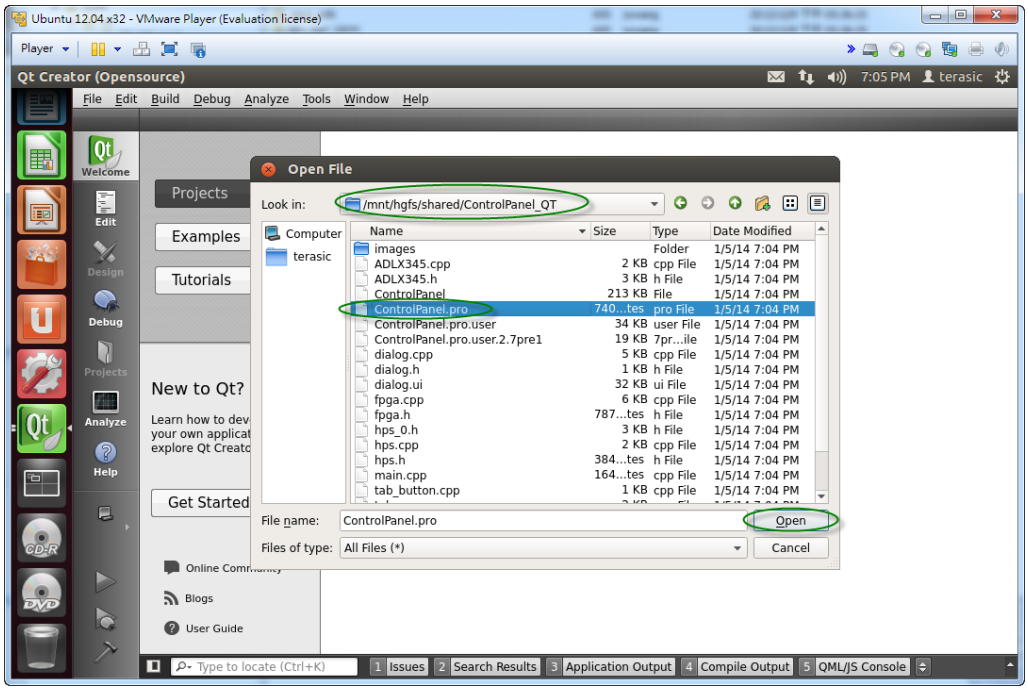

Figure 8-19 Select Control Panel Project – ControlPanel.pro

If the **Settings File** dialog appears as shown in **Figure 8-20**, please click "No" to proceed.

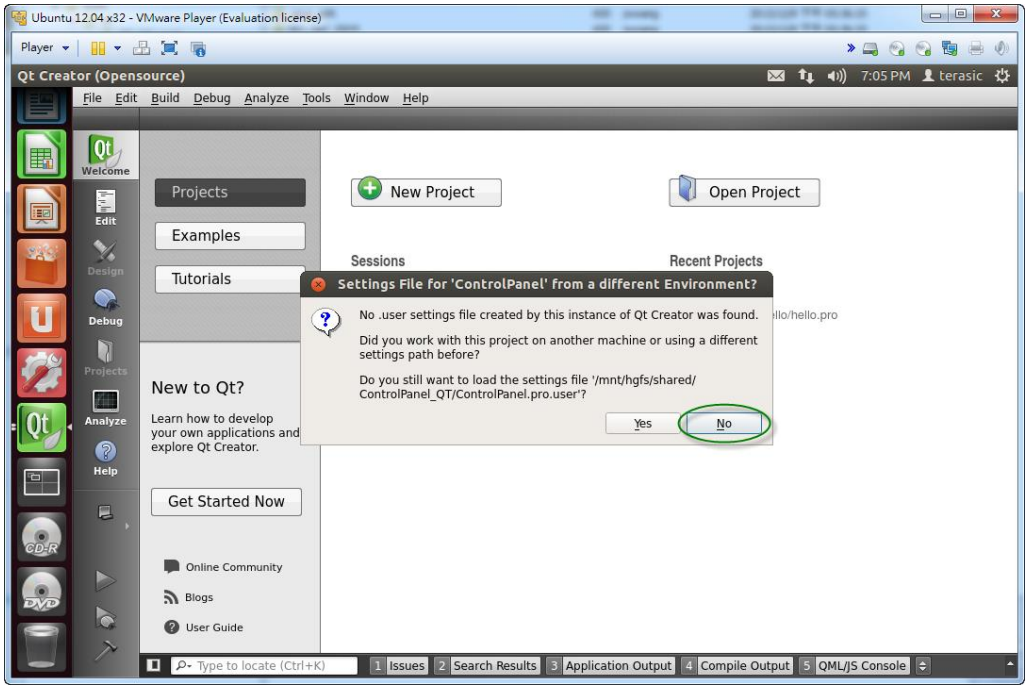

Figure 8-20 Query .user Setting

If Configure Project appears as shown in **Figure 8-21**, please check "Altera SoC FPGA Kit" and click "Configure Project".

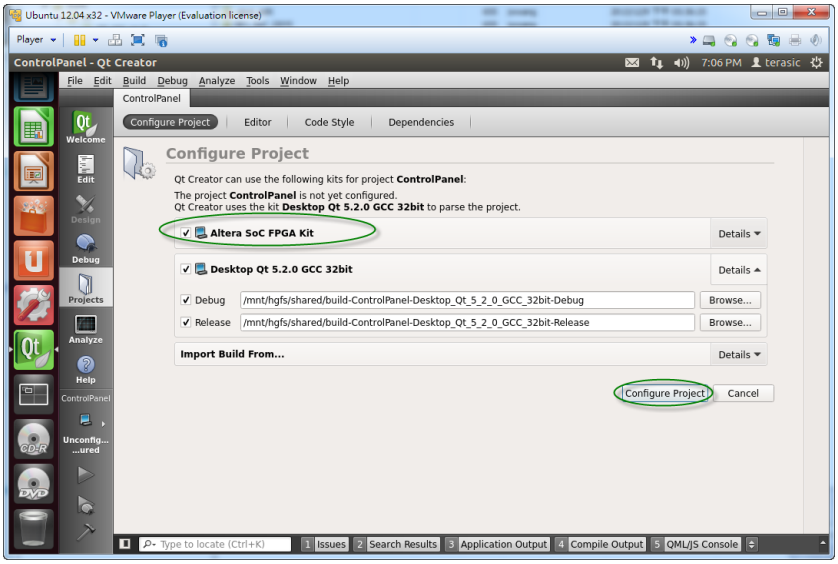

Figure 8-21 Configure Project

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 8-22**, please make sure the **INCLUDEPATH** includes the correct path:

/home/**terasic**/altera/13.1/embedded/ip/altera/hps/altera_hsp/hwlib/include

(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 8-23**.

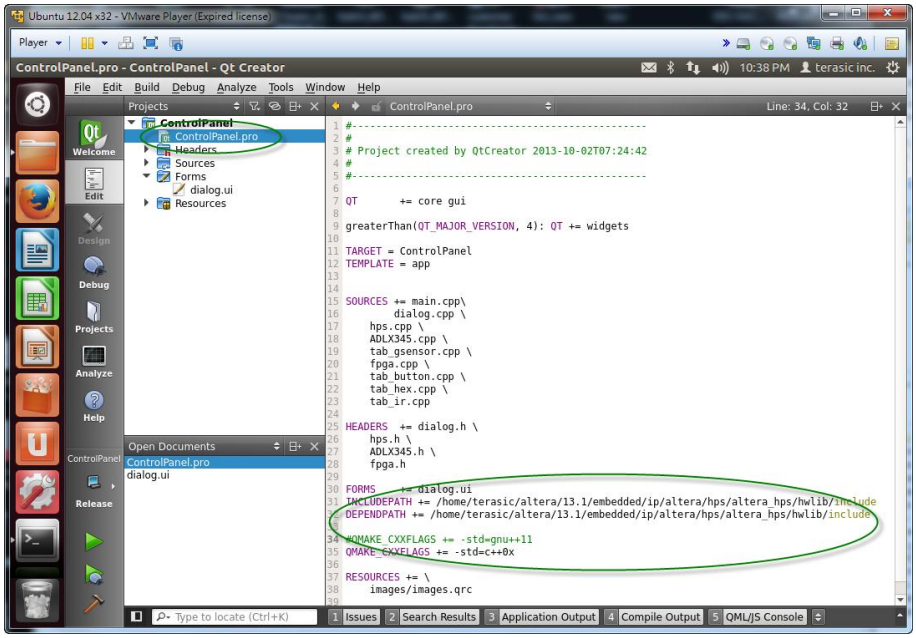

Figure 8-22 Check Include Path in ControlPanel.pro

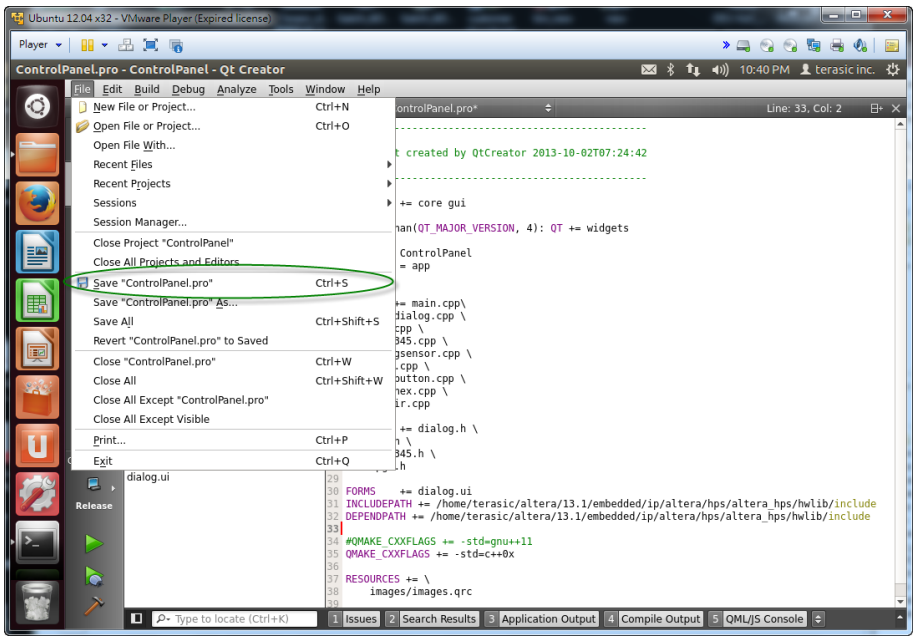

Figure 8-23 Save ControlPanel.pro

Click on the “Release” icon, and select “Altera Soc FPGA Kit” and “Release” Build as shown in Figure 8-24.

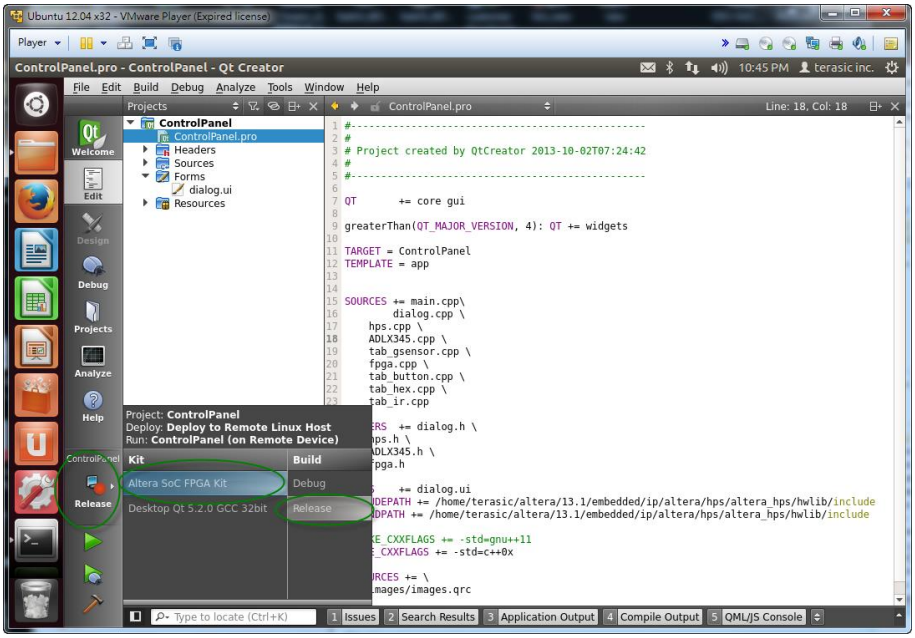

Figure 8-24 Setting Release Kit and Build

Then, select menu item “Build→Rebuild All”, as shown in Figure 8-25, to build the Control Panel Project.

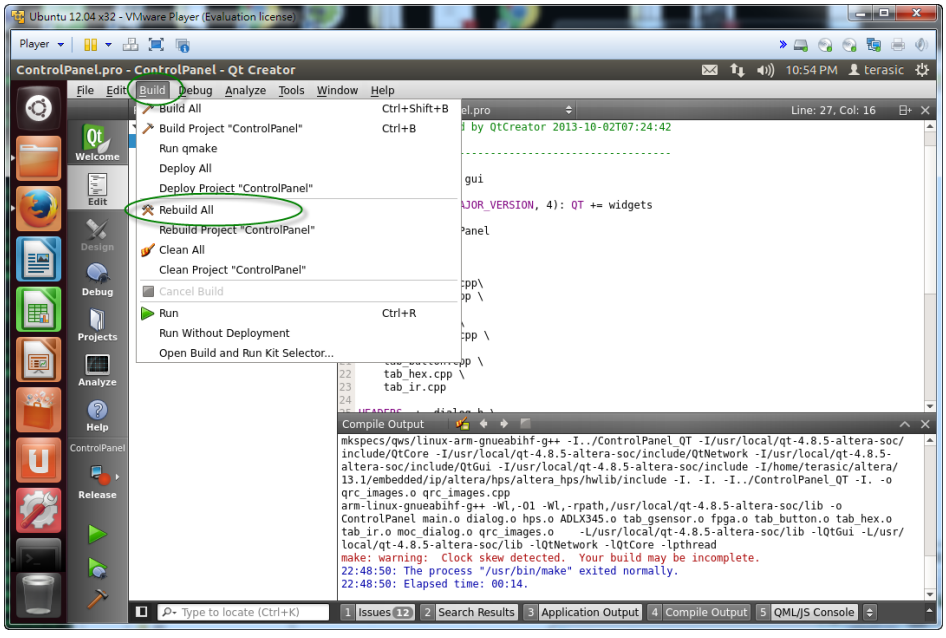

Figure 8-25 Build Control Panel

If the build is successful, the ControlPanel execution file is generated in the below folder as shown in **Figure 8-26**.

/mnt/hgfs/shared/build-ControlPanel-Altera_SoC_FPGA_Kit-Release

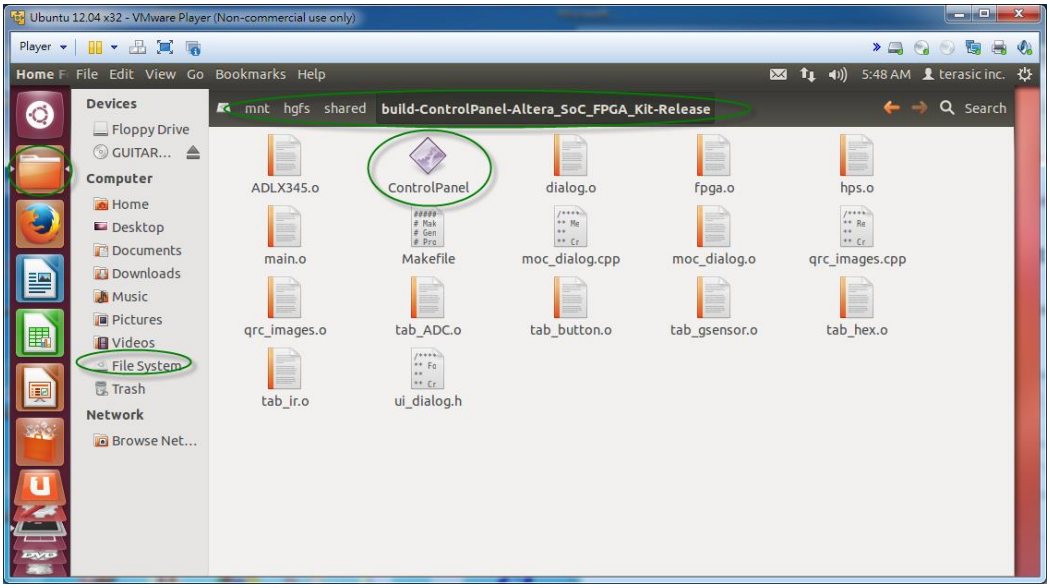

Figure 8-26 Generated Control Panel Execution File

8.3 Execute Control Panel Program

To run the "ControlPanel" execution file on the Altera DE1-SoC FPGA development board, we need to copy it to the Linux on Altera 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 Altera SoC FPGA Board, type "./ControlPanel –qws" to launch the Control Panel in the terminal of Altera SoC FPGA board. If you can see the ControlPanel windows as shown in **Figure 8-27**, it means you had successfully built the Control Panel QT Project.

Figure 8-27 Screenshot of Control Panel

8.4 More on the Control Module of Control Panel

■ 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 10 LEDs which is controlled by Qsys PIO Controller whose address is 0x10000 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. Const 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     0x10000

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. ConstALT_GPIO1_SWPORTA_DDR_ADDR is used to define the direction register address of GPIO1 Controller, and const USER_IO_DIR is used to define the direction pin bits-mask associated to the HPS LED. Const ALT_GPIO1_SWPORTA_DR_ADDR defines the data register address of GPIO1 Controller, and const 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 AdcRead(uint16_t szValue[8]);
    bool VideoEnable(bool bEnable);
    bool VideoMove(int x, int y);
    bool IsVideoEnabled();
    bool IrDataRead(uint32_t *scan_code);
    bool IrIsDataReady(void);
```

■ HPS Class

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);
```