NANYANG TECHNOLOGICAL UNIVERSITY
SINGAPORE

Laboratory Manual
for
CE/CZ1003
Introduction to Computational Thinking

Practical Exercise #2:
Network Access of Raspberry Pi
and Cloud9 IDE

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING
NANYANG TECHNOLOGICAL UNIVERSITY

Ex. #2 – Network Access of RPi

Learning Objectives

This practical exercise is to let the students learn how the Raspberry Pi (RPi) can be accessed by a desktop computer (or Notebook) through its Ethernet network connection, and the various software tools that can be used to code programs for the RPi through the remote desktop and execute them on the Raspberry Pi.

Intended Learning Outcomes

At the end of this exercise, you should

- know the setup required to enable remote computer connection to the Raspberry Pi through its Ethernet interface.
- be able to access the Raspberry Pi board using software tools such as PuTTY and VNC Viewer.
- Know how to develop Python programs using the Cloud9 online IDE.

Equipment and accessories required

i) Raspberry Pi 3 Model B (RPi3) board with Sense HAT add-on display module/board.
ii) A USB power source to power the RPi3 board (E.g. Power Bank, Adaptor or USB port of a desktop computer).
iii) A computer (desktop PC or notebook) with Ethernet port and cable for remote access of RPi3. Software (open source) to be installed on the computer – PuTTY, VNC Viewer and WinSCP

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1. Introduction

While the RPi can be used as a standalone computer by connecting it with keyboard/mouse/monitor as in Practical Exercise #1, this setup is rather cumbersome due to the connections required. An alternative way to use the RPi is to operate it in a 'headless' setup, i.e. without connecting it with keyboard/mouse/monitor. Instead, it is connected via one of its network interfaces to a computer/notebook. In this course, the setup is to have the RPi connects to the desktop computer in the laboratory using its wired Ethernet interface as shown in Figure 1 (and powered by one of the USB port on the computer).

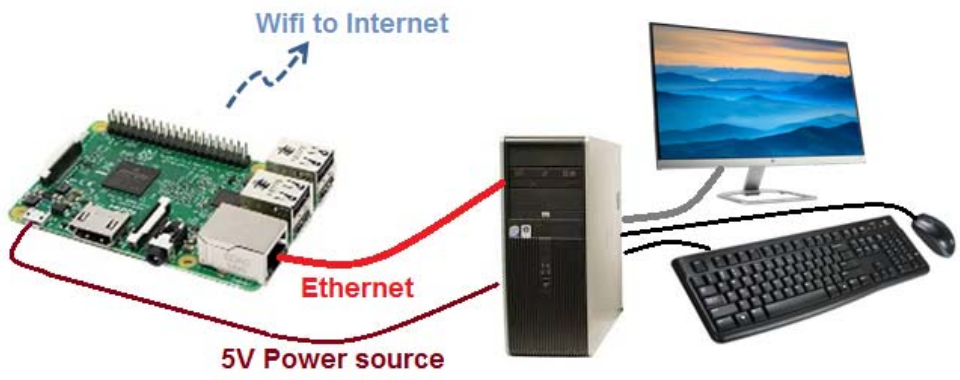


Fig.1 - Raspberry Pi in Headless mode

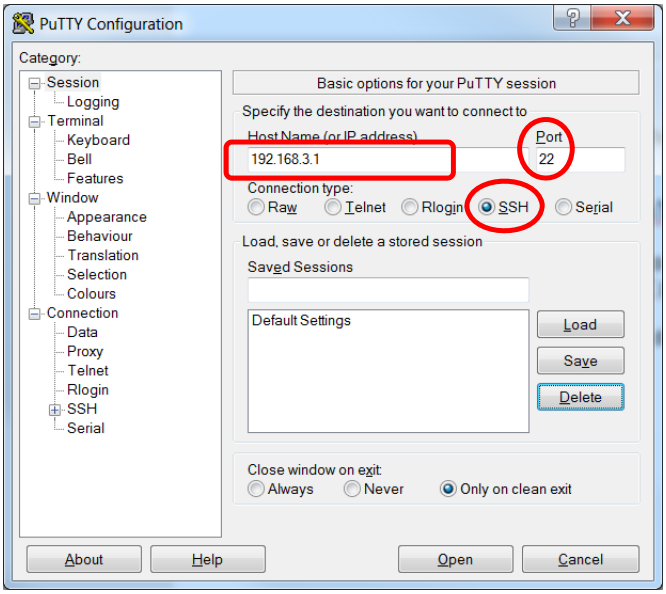
(In practice, it is much more convenient to have the RPi wirelessly connects to a notebook through its Wifi interface.)

2 Network Access of RPi - PuTTY

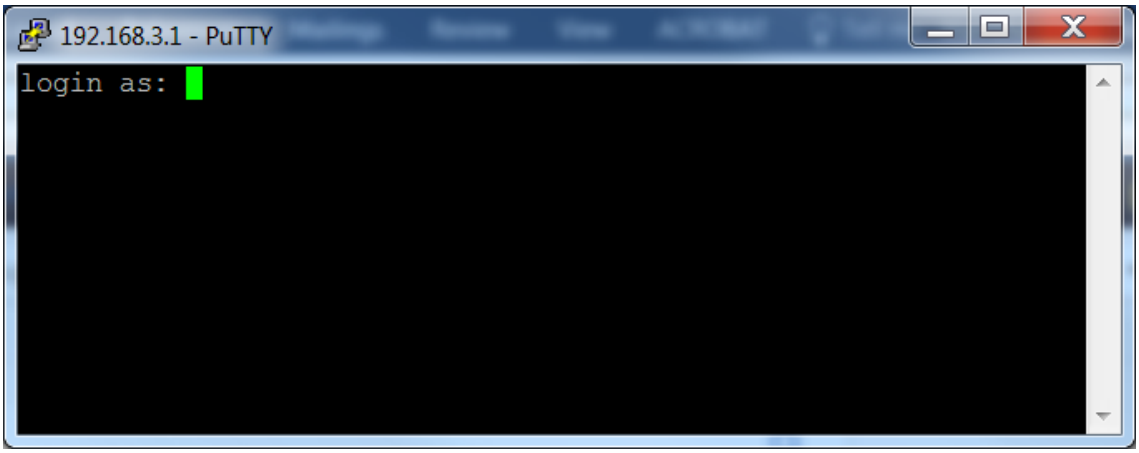
Several programs will be used in this course to access the RPi through the network. To start with, you will use the **PuTTY** program running the Secure Shell (SSH) network protocol.

- Run the PuTTY program on the desktop (which should be already install on the computer)

- A pop up window will be shown. Key in the IP address of the RPi, which is pre-set with the value 192.168.3.1. Make sure that port 22 is selected, and SSH is selected as the connection type.



- Click 'Open', and a console interface will appear if the connection is successful. (Otherwise, check the IP address and other settings that you key in.)



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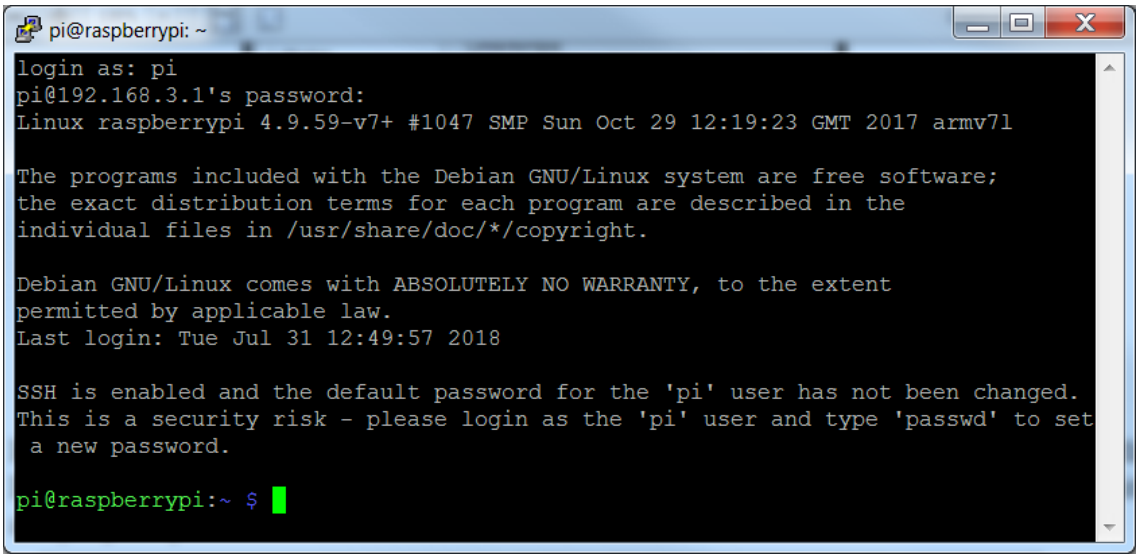
- The default login ID is "**pi**" and the password is "**raspberry**".

- If the remote login is successful, the console interface display in the PuTTY program will be as shown below, which is essentially identical to the Terminal interface that you used during Practical Exercise #1.



As such, you can now remotely operate the RPi as if you are running the Terminal program directly on the RPi. All the commands that you had used before can be similarly executed through the PuTTY console.

Things to try:

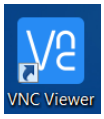
- Write the Python code to print the 'Hello world' message.
- Open another PuTTY console terminal and code the program to display a message on the Sense Hat module (refers to manual of Lab Ex #1 for detail).

3 Network Access of RPi – VNC Viewer

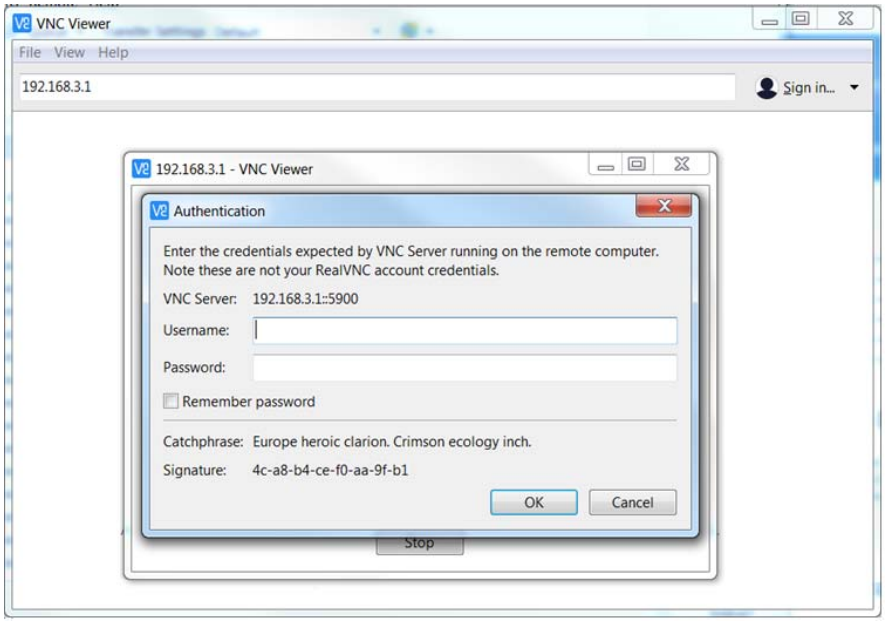
There may be time that you will need to access the RPi through its GUI, such as to launch a web browser to access the internet. For such situation, you can also remotely access the RPI's GUI through the network, using the VNC Viewer program.

3.1 We will first launch the GUI through the VNC Viewer

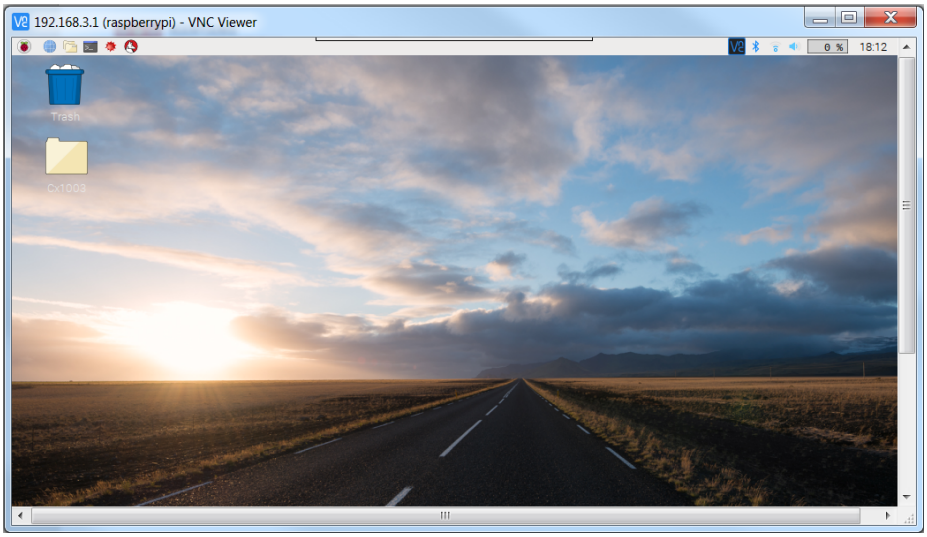
- Run the VNC Viewer program on the computer (it should be already installed).



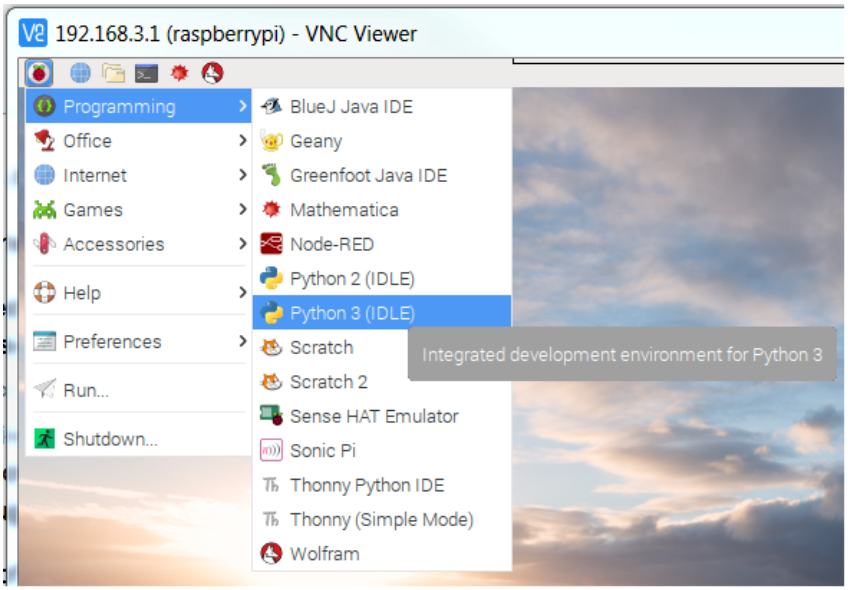
- Key in the IP address of the RPi (which is …). If this is the first time the RPi is accessed by the VNC Viewer program, an Authenticating pop up dialog will appear to request for the User's ID and password (which are ..)



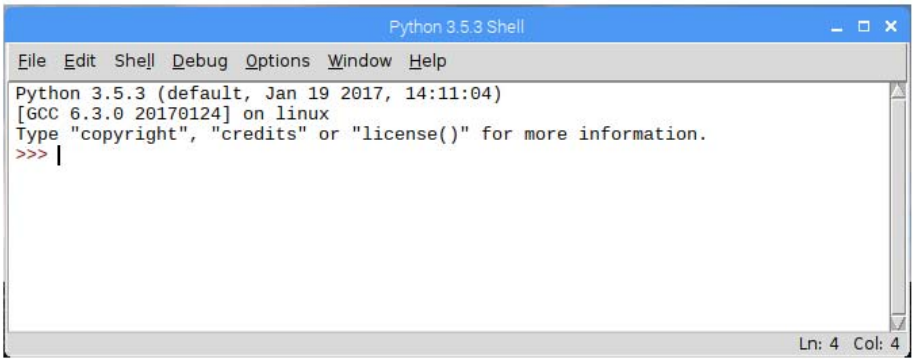
- The GUI of the RPi will then appear in the window, which you can then use to access and operate the RPi as in Practical Exercise #1.



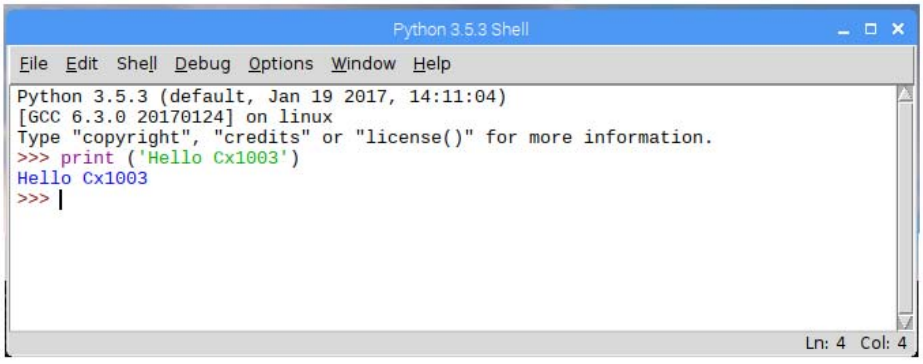
3.2 You will now try using a simple Python IDE (Integrated Development Environment) software with build-in Python interpreter for Python programs development. This is the IDLE program (use the Python 3 version) available under the Application menu.



- It looks the same to the Python3 interpreter running in a terminal, and obviously will behave exactly the same way.



- Try the Hello message code like as shown below. Note that the interface is now displayed in colour to provide better interface to the user.



- Close the VNC Viewer program before you proceed to the next part.

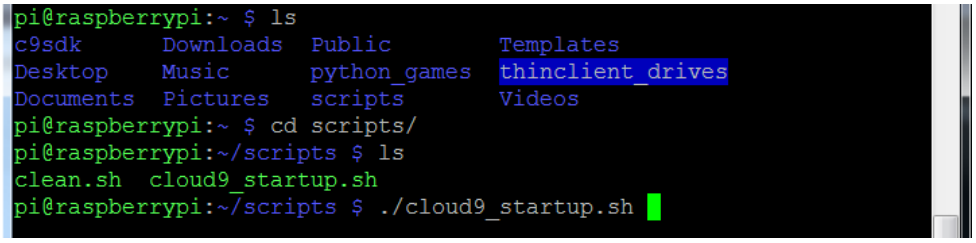
4 Cloud9 IDE

As can be observed, the features provided by the IDLE Python IDE is rather rudimentary, and will not be user friendly once your program grows and becomes more complex. In this course, we will be using a more sophisticated IDE, the Cloud9 IDE for you to practice developing the various programming exercises in subsequent practical sessions.

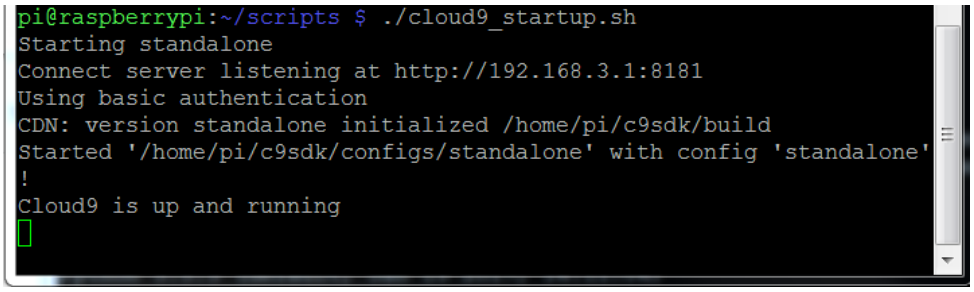
Cloud9 is a 'cloud-based' IDE that lets you write, run, and debug your code with just a web browser. This means that Cloud9 is a web server program that runs remotely on another computer (somewhere behind a 'cloud'), and allows the user to remotely access it using web browser through a network connection. In our case, you will run the Cloud9 Web server on the RPi, and then access it using a web browser on the desktop.

4.1 First you need to start the Cloud9 web server program on the RPi. This is to be done by running a (shell script) file that contain the instructions to launch the Cloud9 server program.

- Start a PuTTY terminal program and change to the scripts directory as shown below.



- Execute the cloud9_startup.sh shell script file, and if everything is in order, a message will indicate that the Cloud9 server program is up and running, waiting for user to connect over the network.

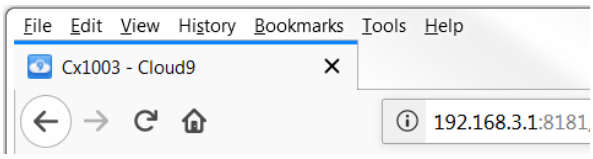


- Note that the program indicates that it is "listening at http://192.168.3.1:8181", in which the 8181 is the port number it is listening to.

- We will leave this server program running on the RPi, and now try to access it through our desktop computer's browser.

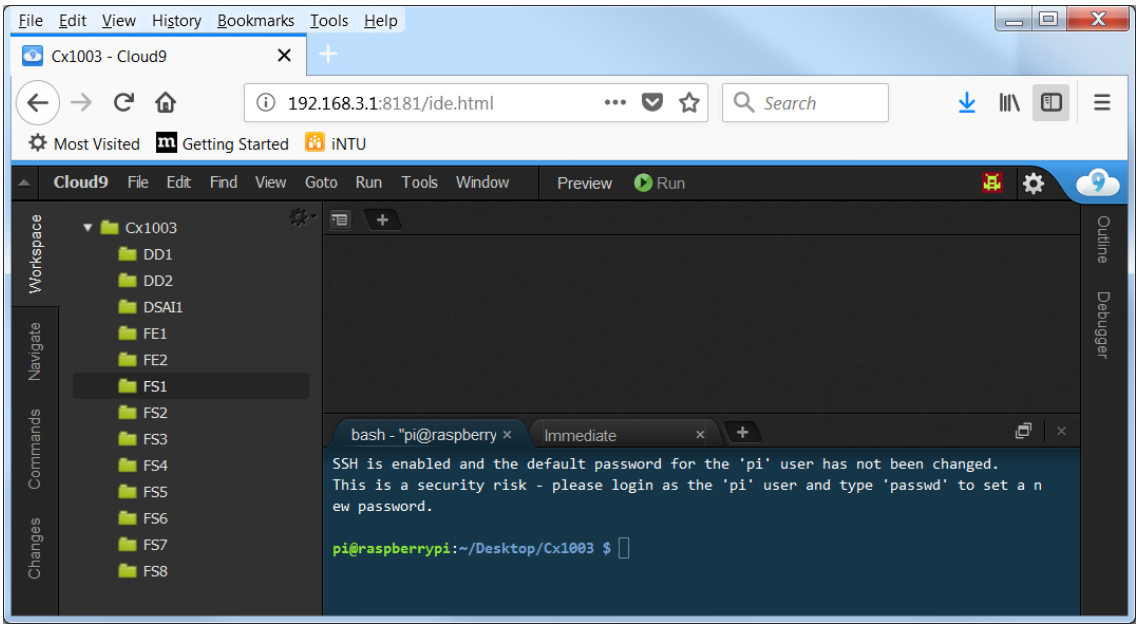
4.2 We will now run a Web browser program on the desktop computer, such as the Firefox (or IE, or Chrome).

- Open a web browser on the desktop computer, key in the IP address and port number indicated by the server program

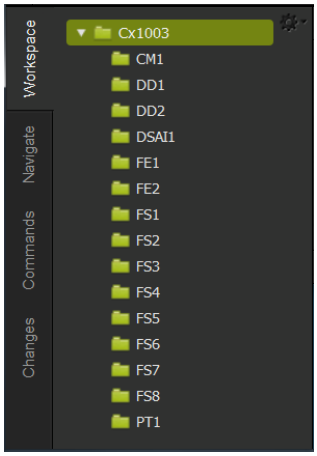


- The Cloud9 screen will appear briefly.

- And eventually the cloud9 IDE interface is launched

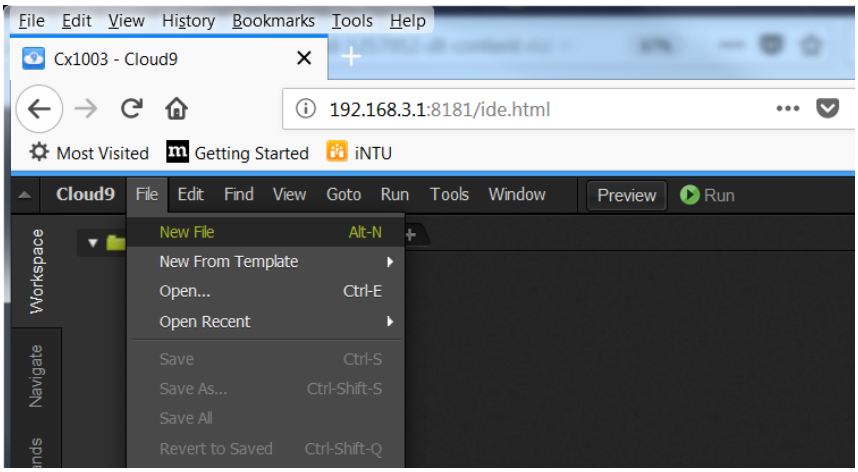


4.3 On the left side of the IDE is the workspace, where you will store the program files you are going to create. The workspace has already been created with various sub-folders, corresponding to the different lab groups that you belong to. You should hence store your program files in the appropriate folder.



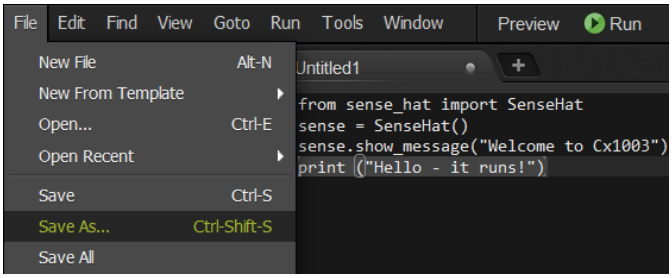
The top right window pane is for you to create your program code.

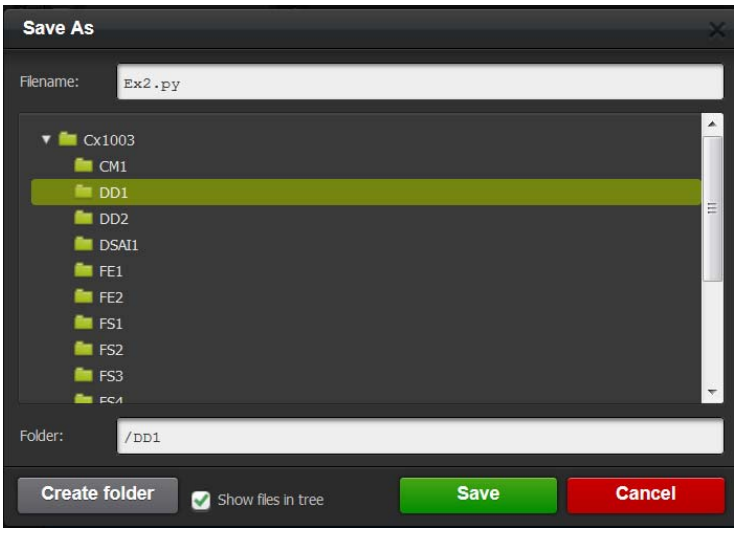
- Click on File→New File option to open a new file for coding

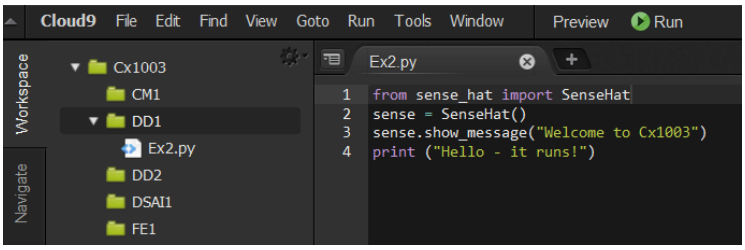


- Type the code such as the following

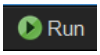
- Save the file as “Ex2.py” in your folder (e.g. DD1 folder here)





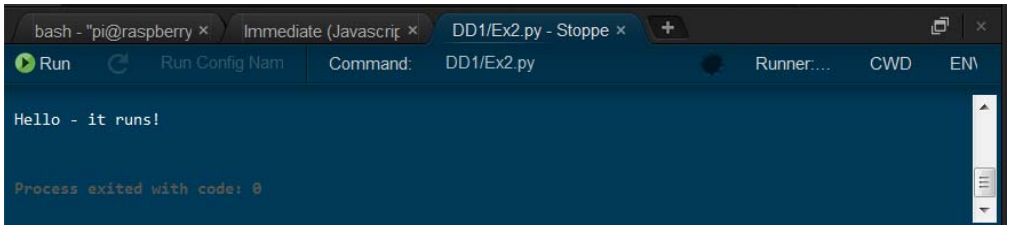


Notice that the IDE now highlights the code in different colours once it knows that this is a Python program. (Q. How does it know that?)

Next you can run the program by clicking the Run icon, 

on the top panel.

- If everything is in order, you should see the message displays on the Sense Hat module, as well as the message in the output panel at the bottom of the IDE.



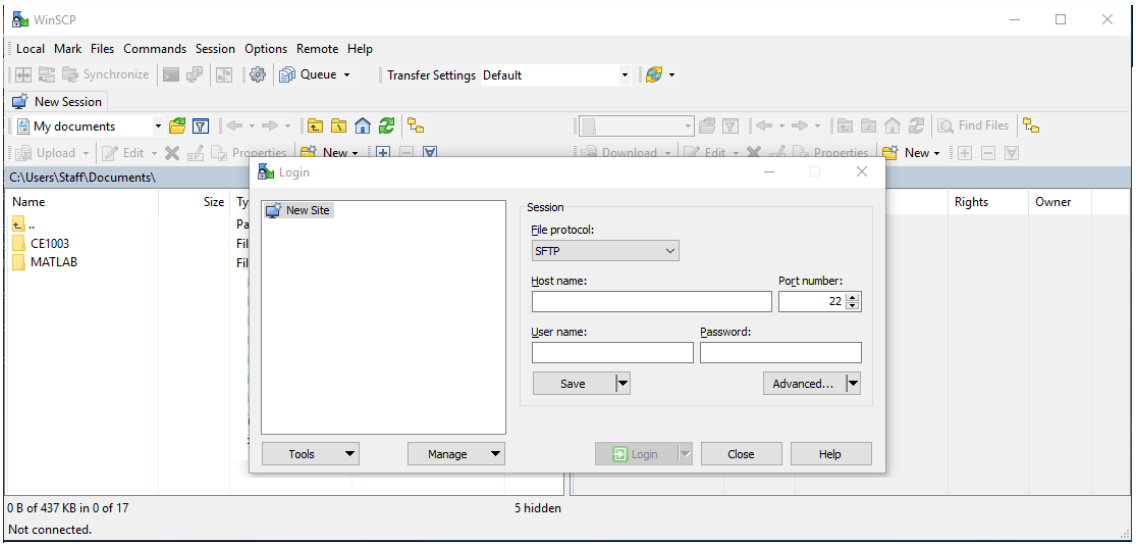
Q. Does the program execution exhibit certain behaviour expected of an interpreted language?

5. Back-up your program file

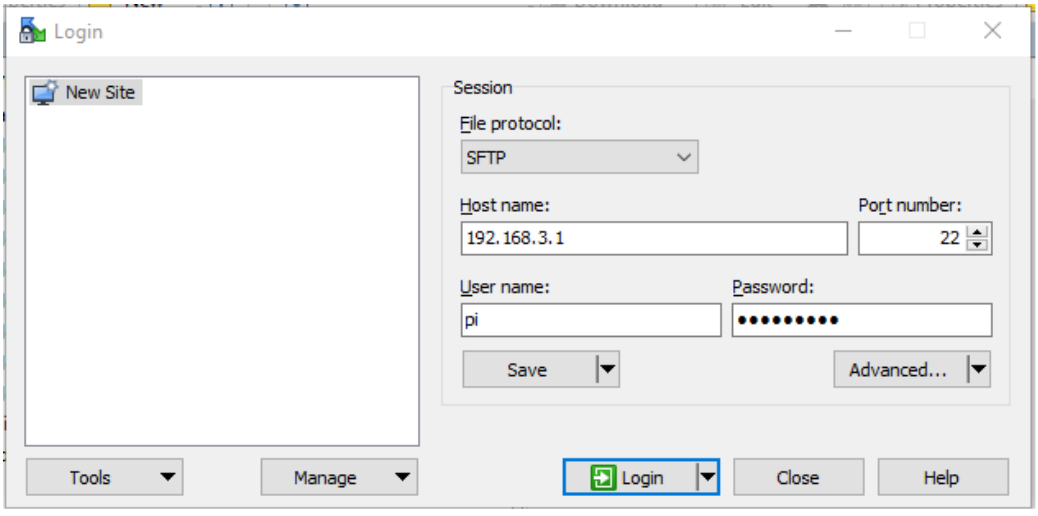
At the end of each practical session, you may want to copy your program files on the RPi to your own USB thumb drive. There are several ways to do this. For example, you can use the WinSCP program as describe here.

- Open the WinSCP program on the desktop computer.

- The program will run and prompt for the detail of the RPi board that you want it to connect to.



- Key in the information requested



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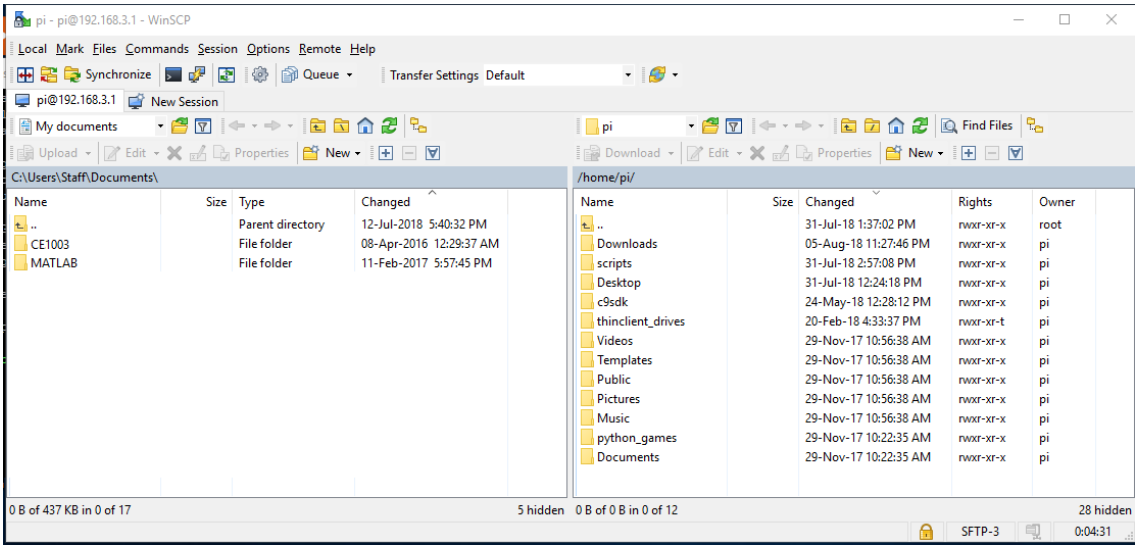
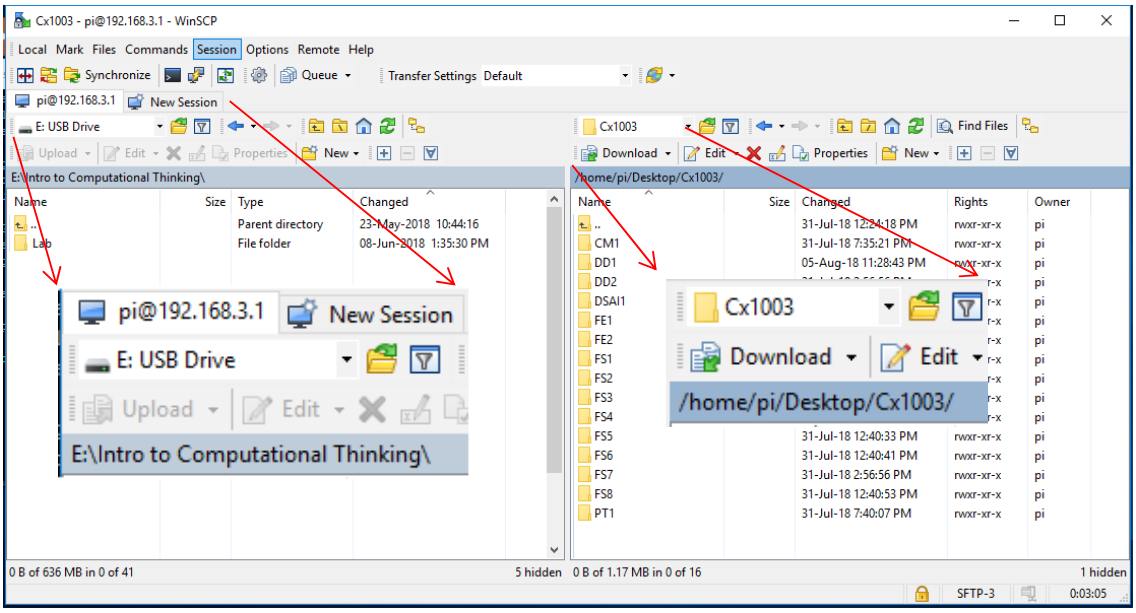
- Once the connection is established, the WinSCP program will display the default directories of both the desktop computer (on the left window pane) and RPi (on the right window pane).



- You can plug in your USB thumb drive to the desktop computer, and then select it for the left window pane. Similarly select the appropriate directory of the RPi on the right window pane.



- You can then copy your file on the RPi to your USB thumb drive by dragging it from the right window pane to the left window pane, and vice versa.

(Alternatively, you can copy your file on the RPi to the desktop computer, and then email it to yourself.)

6. Summary

In this practical exercise, you had seen how the RPi can be setup in a headless mode. You then learnt how it can be remotely accessed through the network using software programs such as PuTTY and VNC Viewer. You had also learnt how to use the Cloud9 IDE to develop simple Python program, and how to save your work to a USB thumb drive using the WinSCP program.

Lastly, issue the following commands in the PuTTY Terminal to properly shut down the RPi computer.

- Terminate the Cloud9 IDE – select the Terminal that you started the Cloud9 server (you would have observed several messages in the Terminal, correspond to what you had performed earlier in your browser Cloud9 IDE), press Crtl-C to stop the server program
- Delete the file that you have created by running the script file: `./clean.sh`
  Make sure that you have saved your work (if you want) to your thumb drive before you do this.
- Shutdown the RPi by issuing the command: `sudo shutdown –h 0`