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Duration	:	3 HOURS
Experiment Date	:	21ST OCTOBER 2022
Submission Date	:	17TH NOVEMBER 2022

LAB 2 [REPORT]

NETWORK SIMULATOR AND EMULATOR INSTALLATION AND CONFIGURATION

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1.0 Introduction

An improperly configured network application can be costly in terms of time and money. Therefore, to prevent such incidents and accidents, routine efficient testing is required. In brief, a simulator is able to perform abstract tasks to demonstrate the behaviour of a network and the components connected to it whilst an emulator can replicate the behaviour of a network to functionally replace it [8]. Consequently, a network simulator and emulator are alternatives and faster platforms in order to understand, test, and configure computer network setups.

Simulators use mathematical formulas to create a theoretically and entirely virtual representation of a network [8][24]. They are software solutions and are available for different applications. They are used mainly for educational and research purposes however they also serve as crucial tools in testing the design and development of networks. There are a number of available network simulators such as; Qualnet, OPNET and ns-2/ns-3 [24]. Discrete event simulation is used in network simulators that chronically queues and processes events like data flow. This allows the building and evaluation of an experimental model of a network [8]. Since the model built was purely virtual, numerous scenarios can be tested without any consequences as it would if it were implemented in the real world. However despite the 'costless' testing, simulators cannot model the unanticipated events that may occur in real life [24].

Network emulators are used to test the performance of a real network and are used by professionals to accurately gauge the responsiveness, throughput, and end-user experience quality of a network application prior to making changes or additions [24]. Unlike simulators real work instances can be recreated on an emulator. Network emulators are available in both hardware and software solutions. Physically placing a network emulator between LAN segments can accurately replicate a client-server WAN connection by replacing a router, modem or live traffic. With emulation, there is a guarantee of continuous validation tests which increases defect detection and decreases resolution time [24]. There are many available network emulators available; NetEm, GNS3, and many more.

For this laboratory experiment, network simulation and emulation were to be carried out using GNS3. There were three main stages; simulation of different network configurations in a LAN using Ethernet switches, emulation of a LAN network using LISA (Linux Switching Appliance) from a virtual disk and finally the emulation involving two subnets using a Quagga router from a virtual disk. The LISA switch and Quagga router were virtual machines (VMs) that required a hypervisor in order to carry out the emulation. In this experiment Oracle VM Virtualbox was used.

2.0 Objectives

- Installation of the network simulator GNS3 and familiarisation of the settings and configurations.
- Configuration of switch and router emulators in GNS3 and familiarisation of testing methods.
- Design and configuration of simple Local Area Network (LAN) connection.

3.0 List of Equipment

No.	Equipment	Quantity
1	GNS3	1
2	VirtualBox	1
3	Linux Switch Application (LISA) Image	1
4	Quagga (Router) Image	1
5	Desktop computer	1

4.0 Procedures

1) *Software installation of GNS3 and VirtualBox*

a. An account was registered at the website https://www.gns3.com/software and the GNS3 software was downloaded. Figure 1 below shows the setup window after the GNS3.exe file was run.

Figure 1: GNS3 setup window

b. GNS3 was installed with the default settings. Figure 2 below shows the installation window.

c. The server was set up in GNS3 to 'Run appliances on my local computer', by going to Help > Setup Wizard in order to set up for using LISA and the Quagga router later in the laboratory experiment.

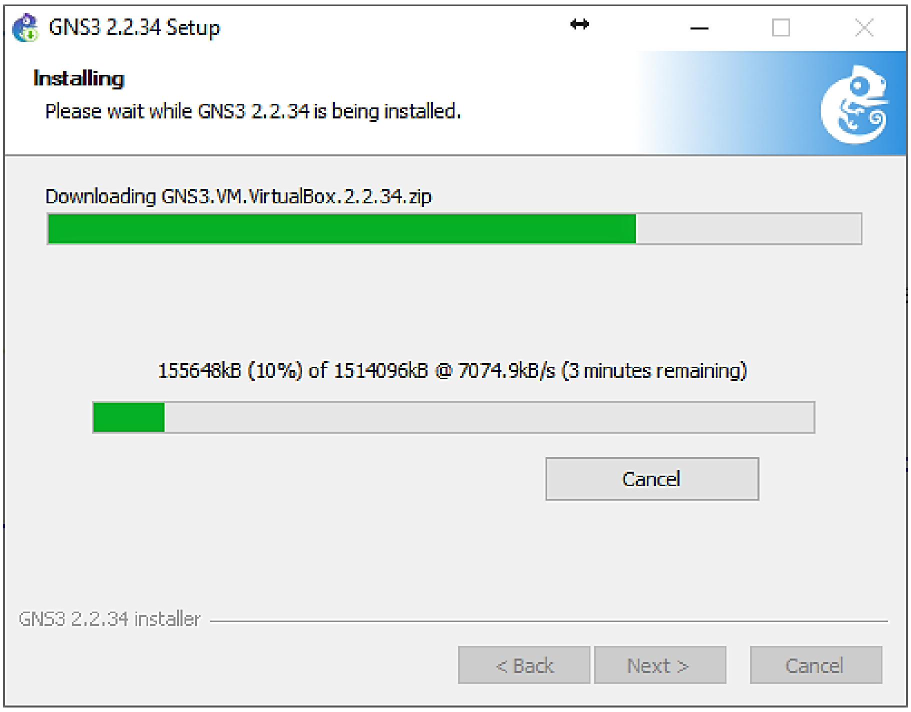


Figure 2: Installation of GNS3 with default settings

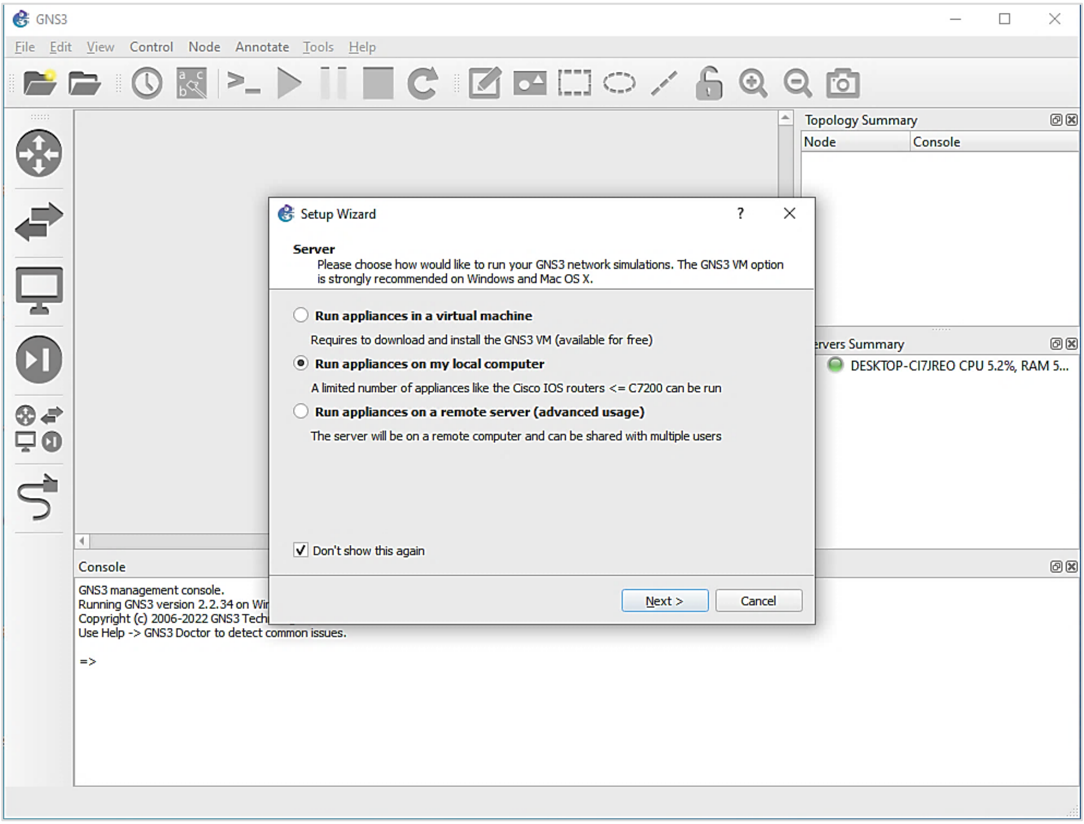


Figure 3: Setting up GNS3 server

d. Figure 4 below shows the server setup summary which shows the completion of the installation of GNS3.

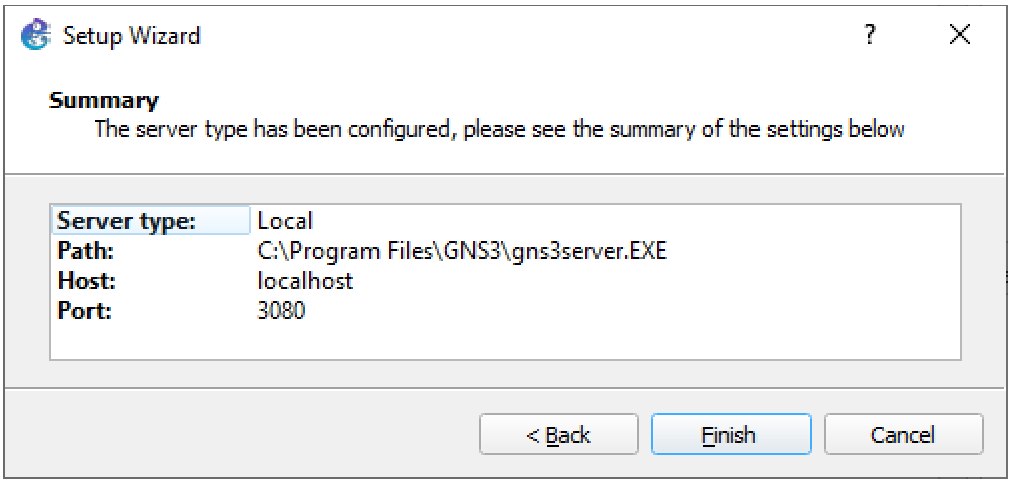


Figure 4: Completion of setup in GNS3

e. Oracle VM Virtualbox was installed with the default settings. Figure 5 below shows the setup window after running the executable file.

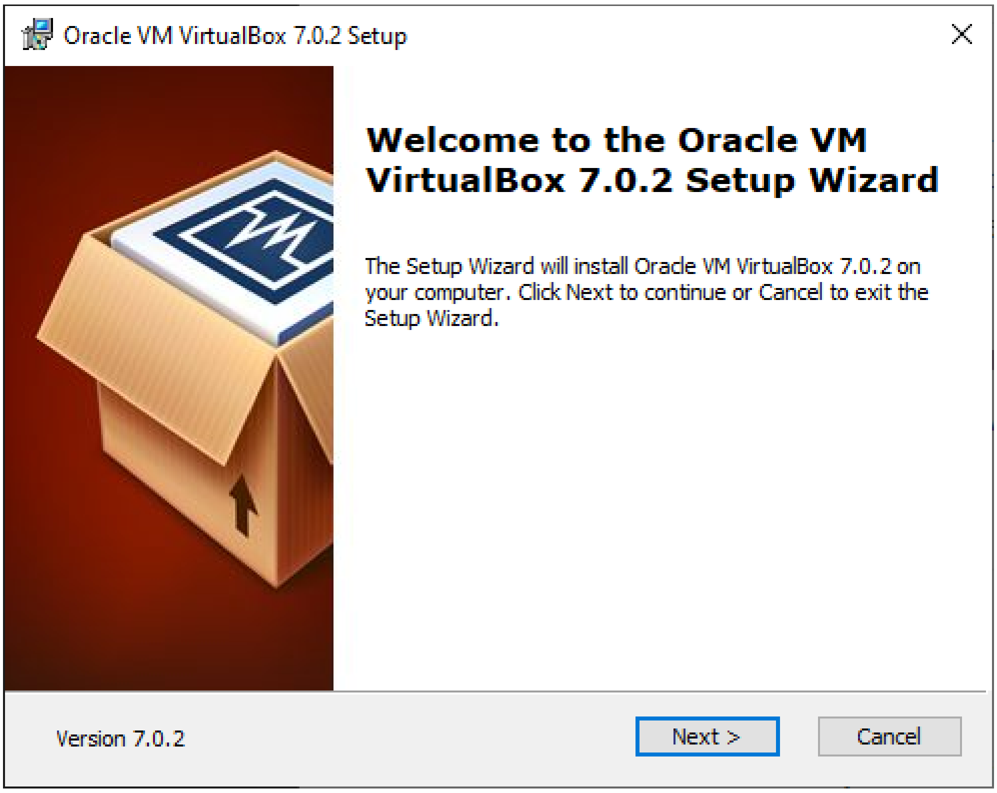


Figure 5: Running the VM Virtualbox.exe program

2) GNS3 Simulation

a. The static IP address LAN connection was simulated on GNS3. Figure 6 below shows the star topology configuration with straight-through cables between a switch and VPCSs (Virtual PC Simulator). Figure 7 below shows a peer-to-peer configuration between two VPCSs using crossover cable.

b. After constructing the networks, the simulation was run, and then the console was opened.

c. The IP addresses for each VPCS was set up on the console and then the Ping command was carried out to test the connections of the simulated devices.

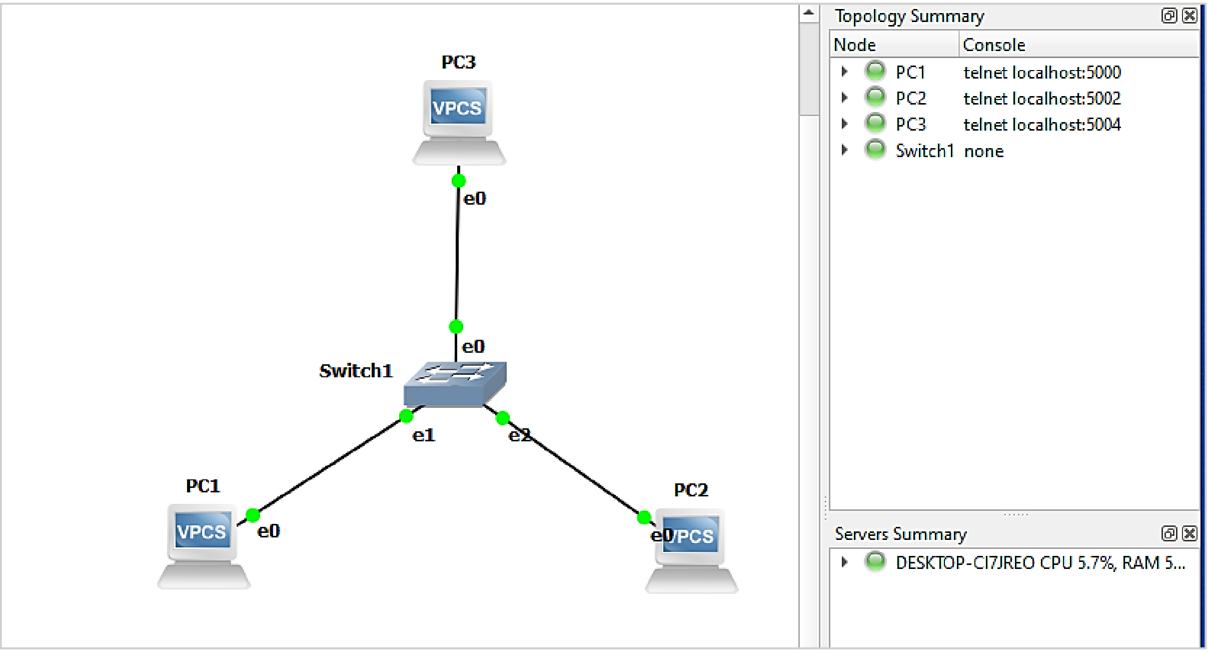


Figure 6: Simulation network of star-topology configuration with a switch on GNS3

Figure 7: Simulation network of peer-to-peer configuration on GNS3

3) *Configuration of Oracle VM VirtualBox (LISA) in GNS3*

a. A LISA switch emulator was created on VM Virtualbox, using an existing LISA virtual hard disk that was downloaded prior. The network adapter setting was set to 'not attached'. *[Note: Figure 8 below shows an erroneous version of the LISA switch however, it was corrected later from Windows 10 operating system to Linux]*

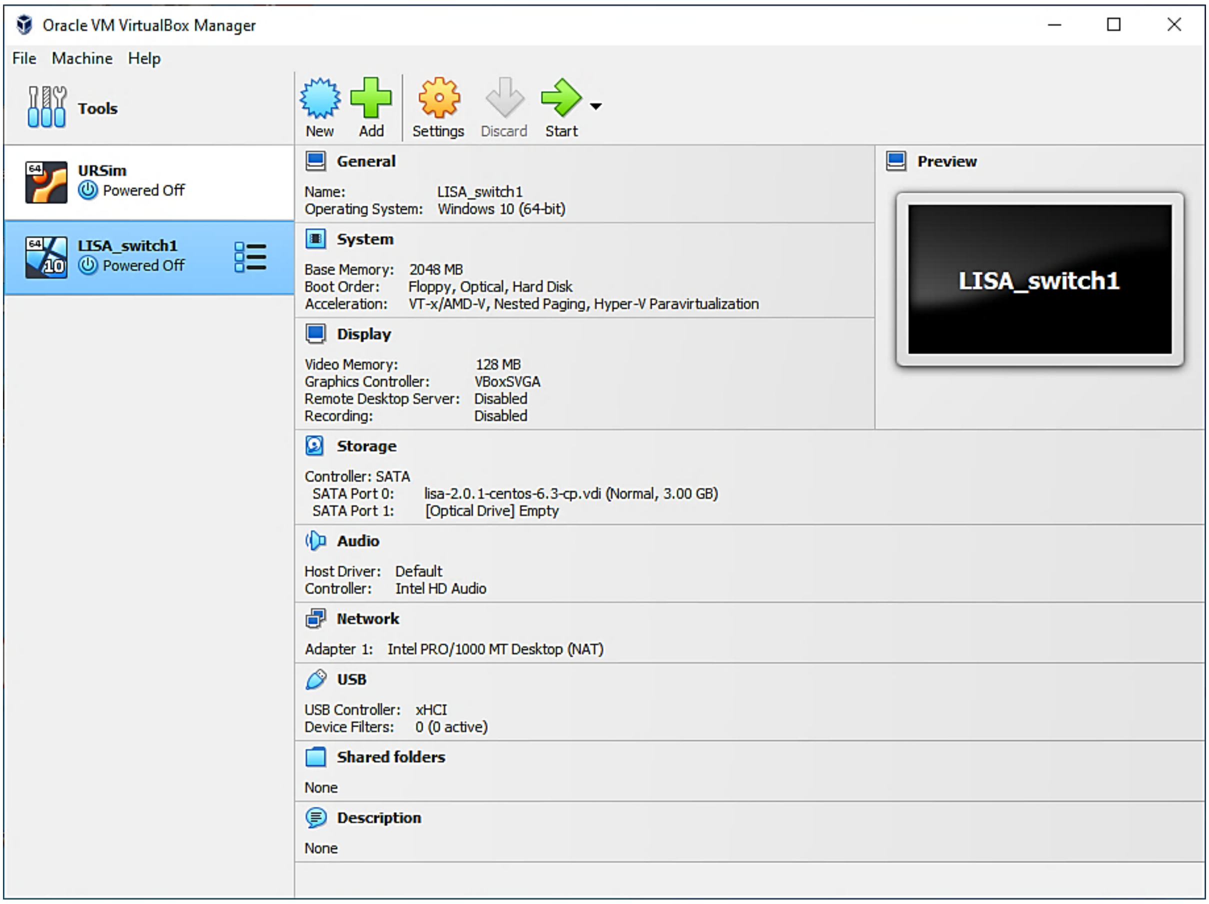


Figure 8: Configuration of LISA switch on Oracle VM Virtualbox

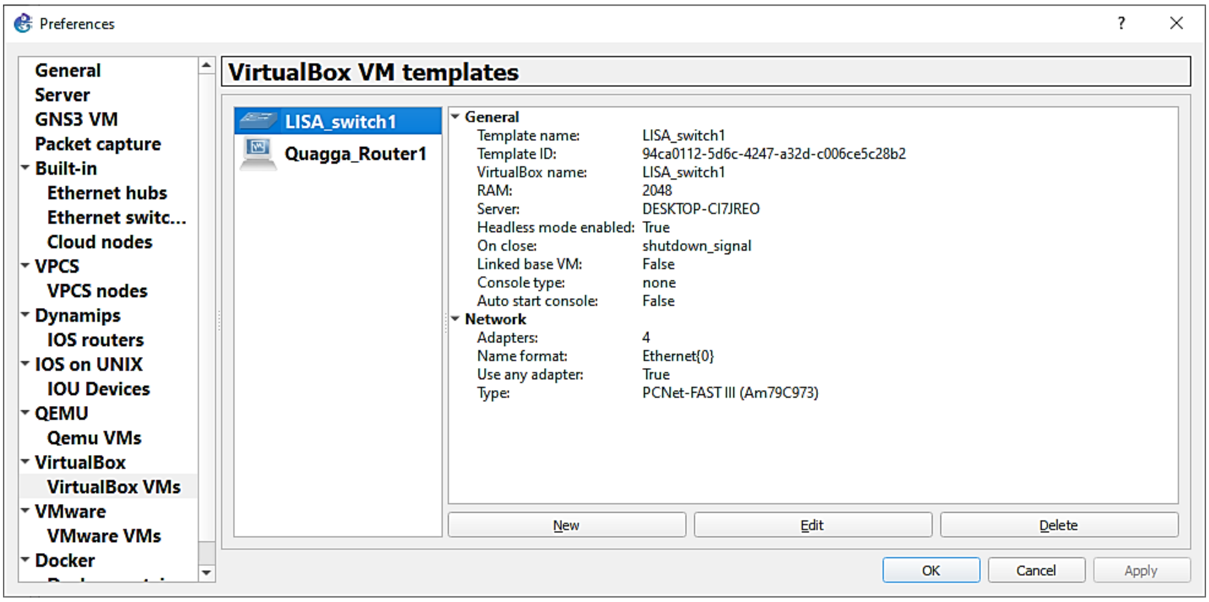


Figure 9: Creating a Virtualbox VM template of a LISA switch on GNS3

b. In GNS3, a new LISA VM Virtualbox template was created as shown in Figure 9 above. The network adapter value was set to 4.
c. Figure 10 below shows the star-topology network configuration of the emulation on GNS3 using the LISA switch.
d. Figure 11 below shows the configuration that was carried out on the LISA emulator after running. The port connections were configured to the switch. This needed to be carried out in order to allow proper functionality of the 'Ping' command after.

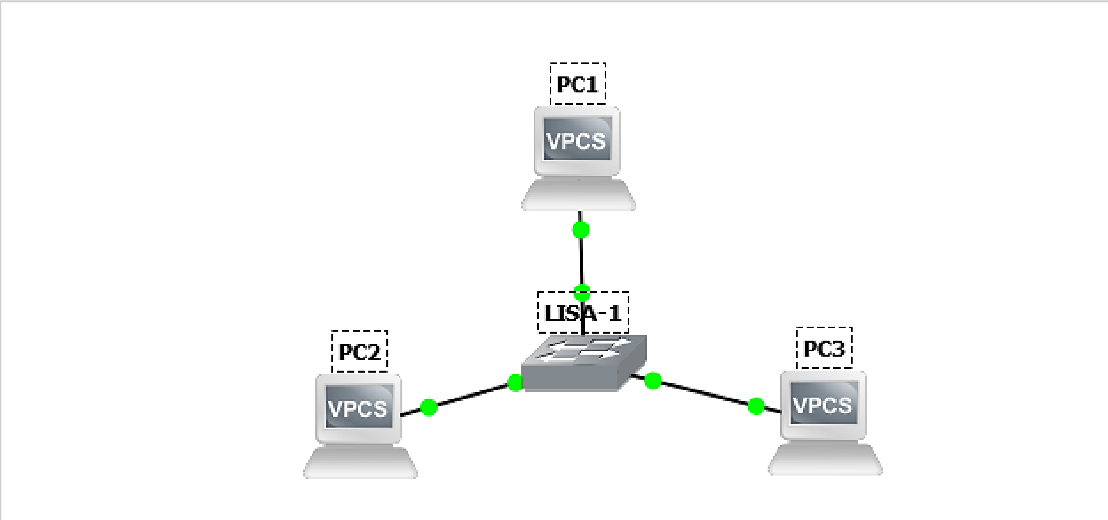


Figure 10: Emulation network of star-topology configuration with a LISA switch on GNS3

Figure 11: Configuration of LISA switch on GNS3 console with 3 port connections set up

4) *Configuration of Quagga in GNS3*

a. A Quagga router emulator was created on VM Virtualbox, using an existing Quagga virtual hard disk that was downloaded prior, shown in Figure 12 below. The network adapter setting was set to 'not attached'.

b. In GNS3, a new Quagga router VM Virtualbox template was created as shown in Figure 13 below. The network adapter value was set to 4.

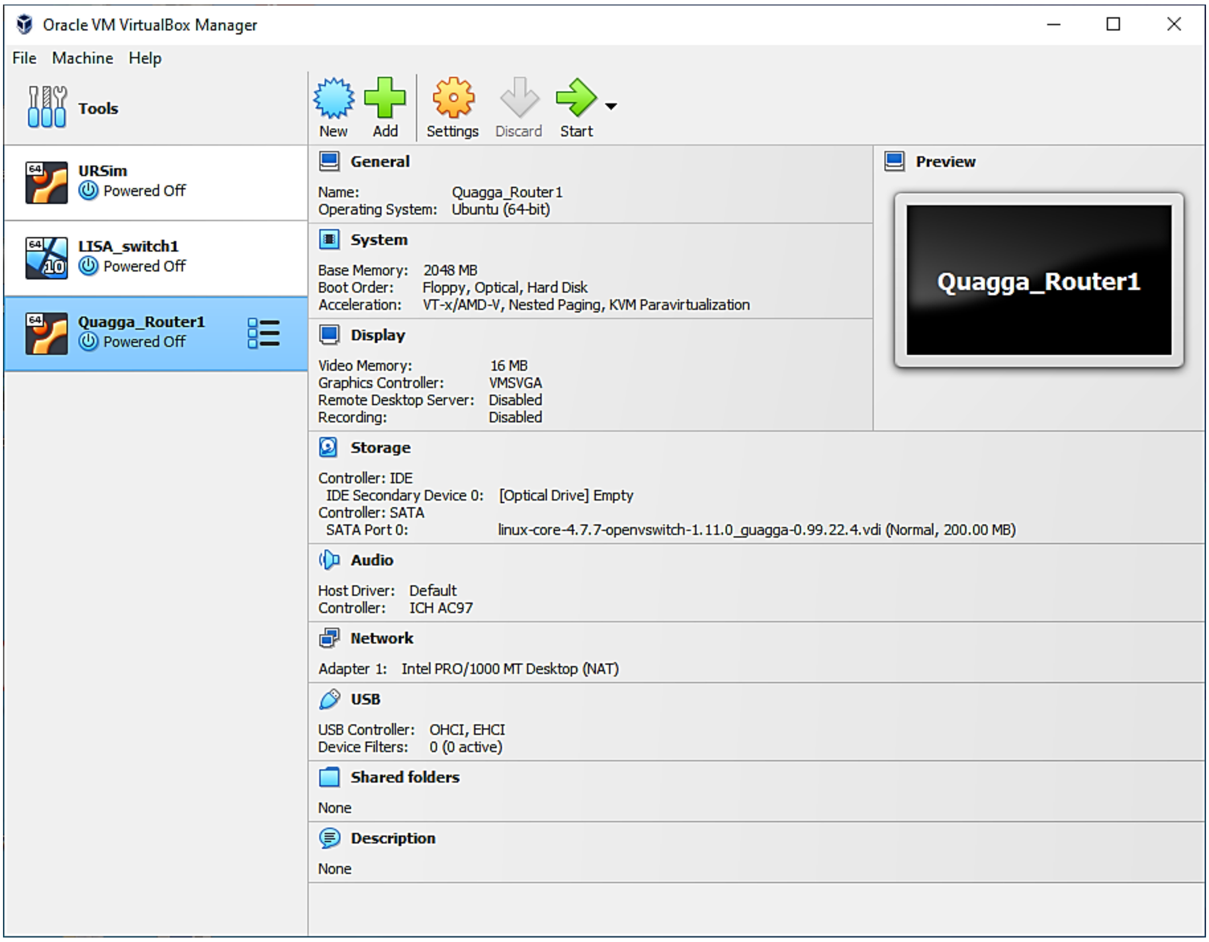


Figure 12: Configuration of Quagga router on Oracle VM Virtualbox

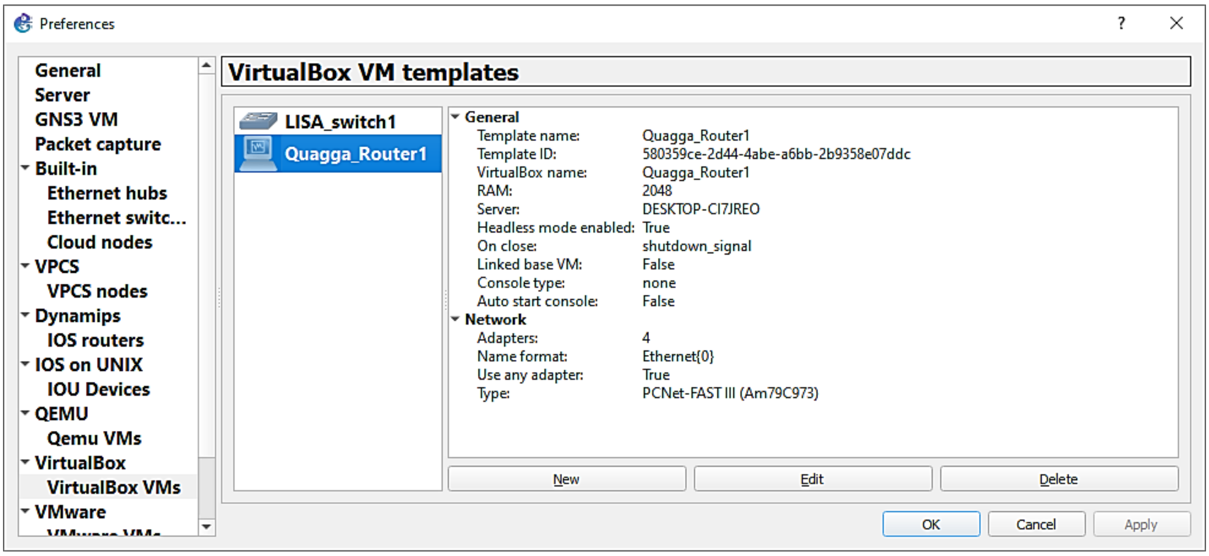


Figure 13: Creating a Virtualbox VM template of a Quagga router on GNS3

c. A network configuration was made such that the router would be connect two subnets as shown in Figure 14 below. Figure 15 below shows the configuration that was carried out on the Quagga router emulator after running. The port connections were configured to the router. This needed to be carried out in order to allow proper functionality of the 'Ping' command after.

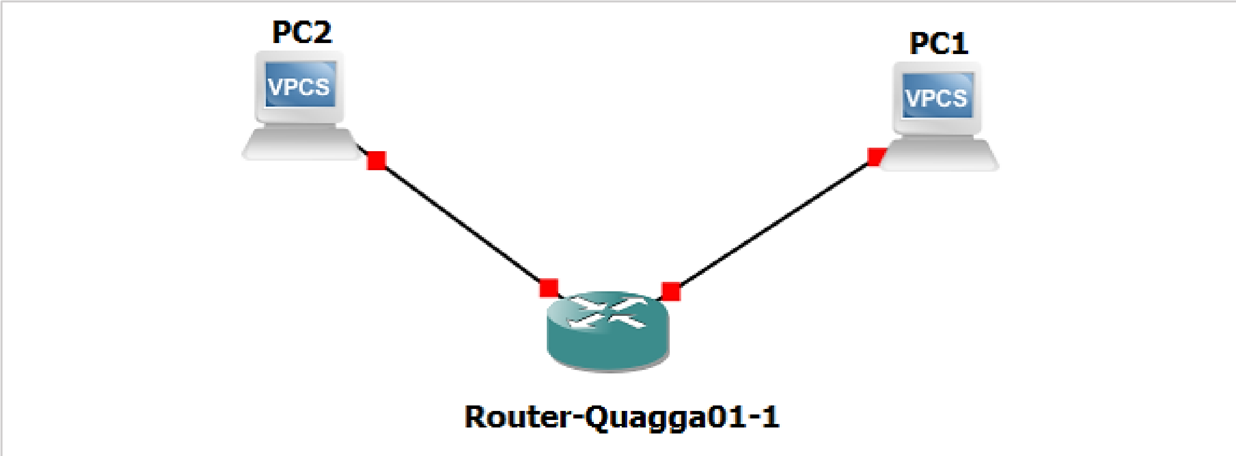


Figure 14: Emulation of configuration with Quagga router two different subnets on GNS3

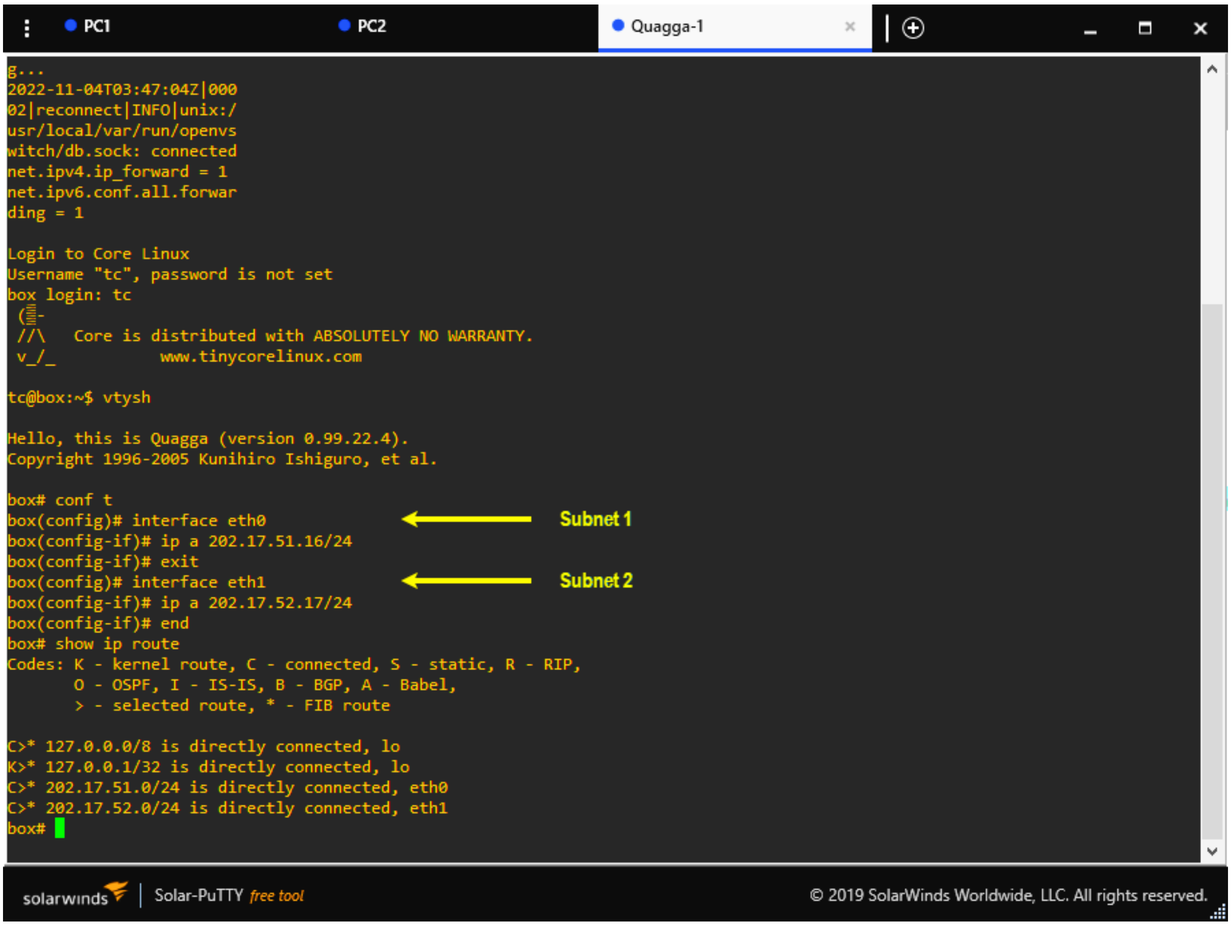
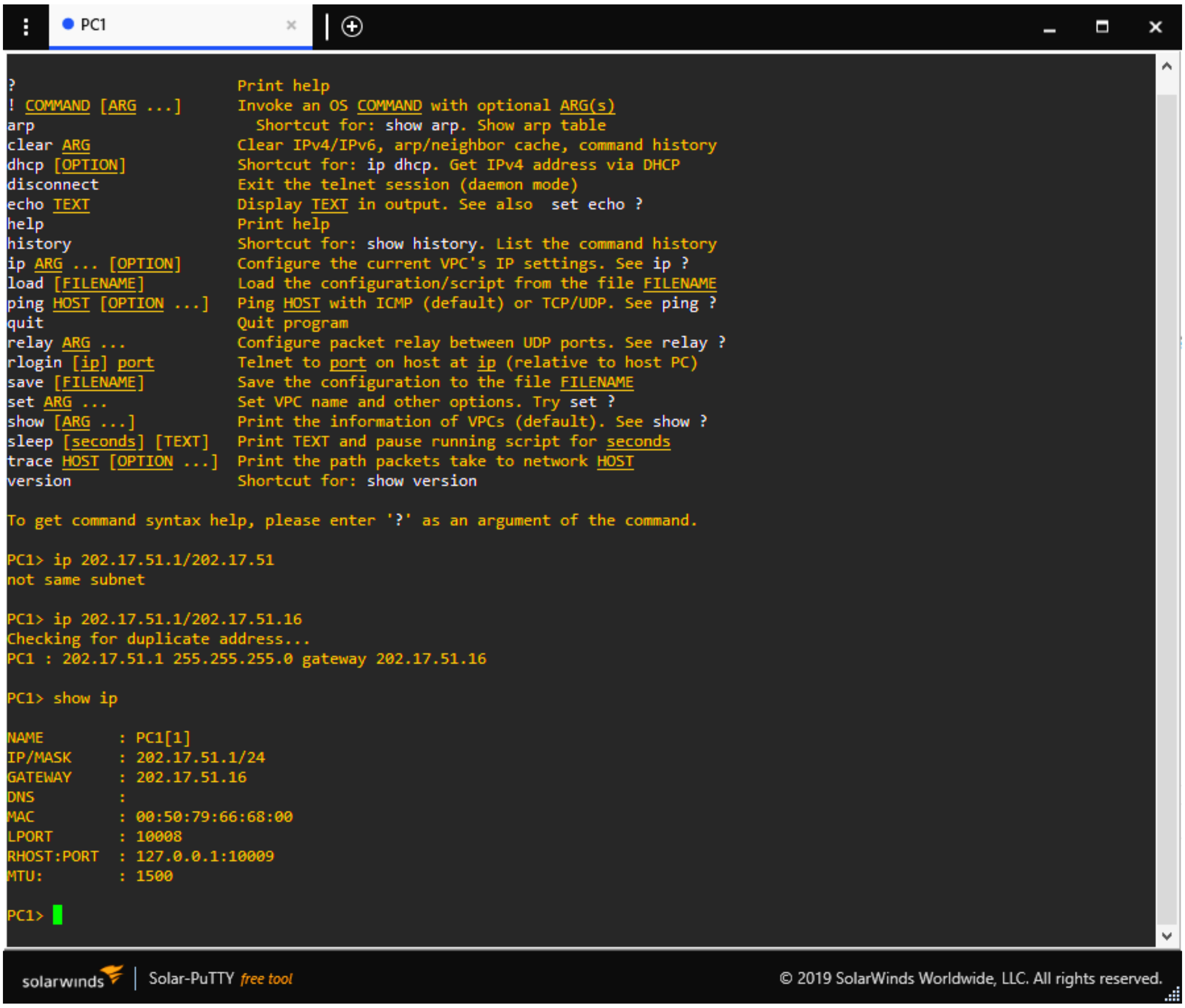


Figure 15: Configuration of Quagga router on GNS3 console with setup of two subnets

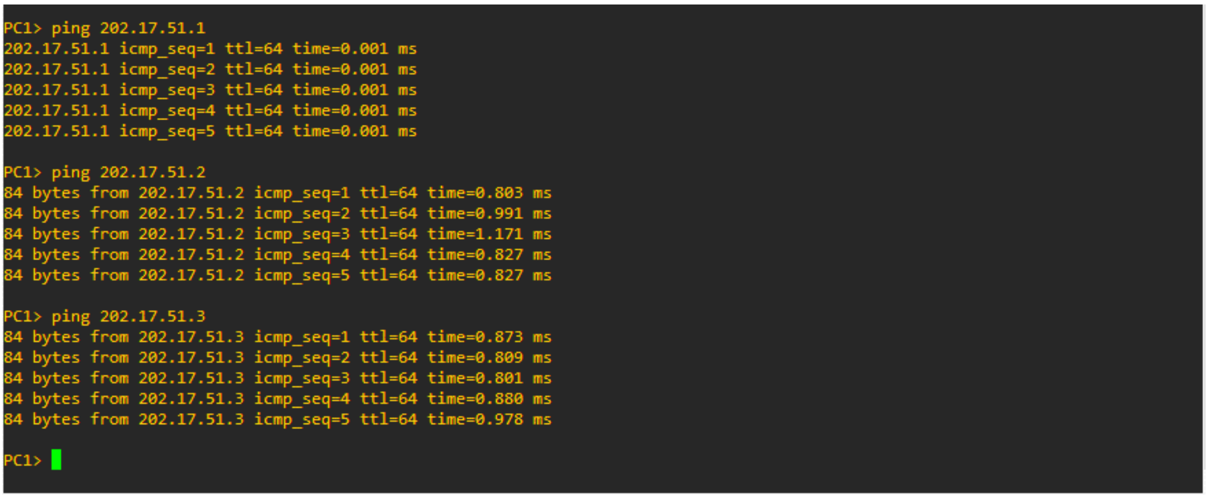
5.0 Results and Observations

1) GNS3 Simulation



```
PC1

?                          Print help
! COMMAND [ARG ...]        Invoke an OS COMMAND with optional ARG(s)
arp                          Shortcut for: show arp. Show arp table
clear ARG                  Clear IPv4/IPv6, arp/neighbor cache, command history
dhcp [OPTION]              Shortcut for: ip dhcp. Get IPv4 address via DHCP
disconnect                 Exit the telnet session (daemon mode)
echo TEXT                  Display TEXT in output. See also  set echo ?
help                       Print help
history                    Shortcut for: show history. List the command history
ip ARG ... [OPTION]        Configure the current VPC's IP settings. See ip ?
load [FILENAME]            Load the configuration/script from the file FILENAME
ping HOST [OPTION ...]     Ping HOST with ICMP (default) or TCP/UDP. See ping ?
quit                       Quit program
relay ARG ...              Configure packet relay between UDP ports. See relay ?
rlogin [ip] port           Telnet to port on host at ip (relative to host PC)
save [FILENAME]            Save the configuration to the file FILENAME
set ARG ...                Set VPC name and other options. Try set ?
show [ARG ...]             Print the information of VPCs (default). See show ?
sleep [seconds] [TEXT]     Print TEXT and pause running script for seconds
trace HOST [OPTION ...]    Print the path packets take to network HOST
version                    Shortcut for: show version

To get command syntax help, please enter '?' as an argument of the command.

PC1> ip 202.17.51.1/202.17.51
not same subnet

PC1> ip 202.17.51.1/202.17.51.16
Checking for duplicate address...
PC1 : 202.17.51.1 255.255.255.0 gateway 202.17.51.16

PC1> show ip

NAME        : PC1[1]
IP/MASK     : 202.17.51.1/24
GATEWAY     : 202.17.51.16
DNS         :
MAC         : 00:50:79:66:68:00
LPORT       : 10008
RHOST:PORT  : 127.0.0.1:10009
MTU:        : 1500

PC1>

solarwinds | Solar-PuTTY free tool        © 2019 SolarWinds Worldwide, LLC. All rights reserved.
```

Figure 16: Setting up static IP address for VPCS 1 for star-topology configuration simulation on GNS3 using switch.



```
PC1> ping 202.17.51.1
202.17.51.1 icmp_seq=1 ttl=64 time=0.001 ms
202.17.51.1 icmp_seq=2 ttl=64 time=0.001 ms
202.17.51.1 icmp_seq=3 ttl=64 time=0.001 ms
202.17.51.1 icmp_seq=4 ttl=64 time=0.001 ms
202.17.51.1 icmp_seq=5 ttl=64 time=0.001 ms

PC1> ping 202.17.51.2
84 bytes from 202.17.51.2 icmp_seq=1 ttl=64 time=0.803 ms
84 bytes from 202.17.51.2 icmp_seq=2 ttl=64 time=0.991 ms
84 bytes from 202.17.51.2 icmp_seq=3 ttl=64 time=1.171 ms
84 bytes from 202.17.51.2 icmp_seq=4 ttl=64 time=0.827 ms
84 bytes from 202.17.51.2 icmp_seq=5 ttl=64 time=0.827 ms

PC1> ping 202.17.51.3
84 bytes from 202.17.51.3 icmp_seq=1 ttl=64 time=0.873 ms
84 bytes from 202.17.51.3 icmp_seq=2 ttl=64 time=0.809 ms
84 bytes from 202.17.51.3 icmp_seq=3 ttl=64 time=0.801 ms
84 bytes from 202.17.51.3 icmp_seq=4 ttl=64 time=0.880 ms
84 bytes from 202.17.51.3 icmp_seq=5 ttl=64 time=0.978 ms

PC1>
```

Figure 17: Using 'ping' command for VPCS 1 to VPCS 2 and VCPS 3 for star-topology configuration simulation on GNS3 using switch.

Figure 18: Setting up static IP address for VPCS 2 for star-topology configuration simulation on GNS3 using switch.

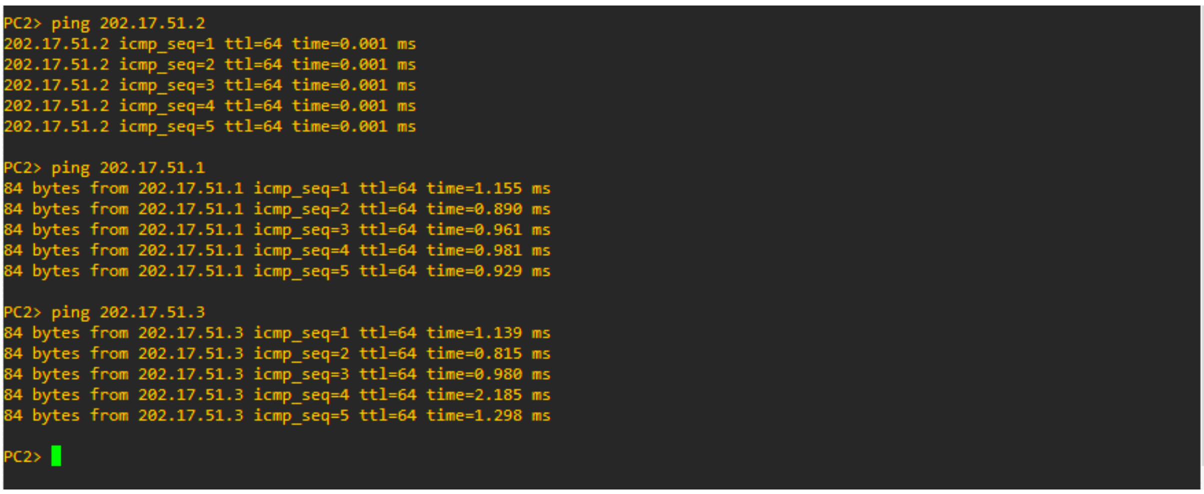


Figure 19: Using 'ping' command for VPCS 2 to VPCS 1 and VCPS 3 for star-topology configuration simulation on GNS3 using switch.

```
?

?                             Print help
! COMMAND [ARG ...]           Invoke an OS COMMAND with optional ARG(s)
arp                             Shortcut for: show arp. Show arp table
clear ARG                     Clear IPv4/IPv6, arp/neighbor cache, command history
dhcp [OPTION]                 Shortcut for: ip dhcp. Get IPv4 address via DHCP
disconnect                    Exit the telnet session (daemon mode)
echo TEXT                     Display TEXT in output. See also  set echo ?
help                          Print help
history                       Shortcut for: show history. List the command history
ip ARG ... [OPTION]           Configure the current VPC's IP settings. See ip ?
load [FILENAME]               Load the configuration/script from the file FILENAME
ping HOST [OPTION ...]        Ping HOST with ICMP (default) or TCP/UDP. See ping ?
quit                          Quit program
relay ARG ...                 Configure packet relay between UDP ports. See relay ?
rlogin [ip] port              Telnet to port on host at ip (relative to host PC)
save [FILENAME]               Save the configuration to the file FILENAME
set ARG ...                   Set VPC name and other options. Try set ?
show [ARG ...]                Print the information of VPCs (default). See show ?
sleep [seconds] [TEXT]        Print TEXT and pause running script for seconds
trace HOST [OPTION ...]       Print the path packets take to network HOST
version                       Shortcut for: show version

To get command syntax help, please enter '?' as an argument of the command.

PC3> ip 202.17.51.3/202.17.51.16
Checking for duplicate address...
PC1 : 202.17.51.3 255.255.255.0 gateway 202.17.51.16

PC3> show ip

NAME        : PC3[1]
IP/MASK     : 202.17.51.3/24
GATEWAY     : 202.17.51.16
DNS         :
MAC         : 00:50:79:66:68:02
LPORT       : 10006
RHOST:PORT  : 127.0.0.1:10007
MTU:        : 1500

PC3>
```

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Figure 20: Setting up static IP address for VPCS 3 for star-topology configuration simulation on GNS3 using switch.

```
PC3> ping 202.17.51.3
202.17.51.3 icmp_seq=1 ttl=64 time=0.001 ms
202.17.51.3 icmp_seq=2 ttl=64 time=0.001 ms
202.17.51.3 icmp_seq=3 ttl=64 time=0.001 ms
202.17.51.3 icmp_seq=4 ttl=64 time=0.001 ms
202.17.51.3 icmp_seq=5 ttl=64 time=0.001 ms

PC3> ping 202.17.51.1
84 bytes from 202.17.51.1 icmp_seq=1 ttl=64 time=0.916 ms
84 bytes from 202.17.51.1 icmp_seq=2 ttl=64 time=0.941 ms
84 bytes from 202.17.51.1 icmp_seq=3 ttl=64 time=0.972 ms
84 bytes from 202.17.51.1 icmp_seq=4 ttl=64 time=1.218 ms
84 bytes from 202.17.51.1 icmp_seq=5 ttl=64 time=1.143 ms

PC3> ping 202.17.51.2
84 bytes from 202.17.51.2 icmp_seq=1 ttl=64 time=0.994 ms
84 bytes from 202.17.51.2 icmp_seq=2 ttl=64 time=1.119 ms
84 bytes from 202.17.51.2 icmp_seq=3 ttl=64 time=0.897 ms
84 bytes from 202.17.51.2 icmp_seq=4 ttl=64 time=1.580 ms
84 bytes from 202.17.51.2 icmp_seq=5 ttl=64 time=1.662 ms

PC3>
```

Figure 21: Using 'ping' command for VPCS 3 to VPCS 1 and VCPS 2 for star-topology configuration simulation on GNS3 using switch.

Figure 16 to Figure 18 above show the screengrabs of the console window of the network simulation of the star-topology configuration on GNS3 whereby the VPCSs were configured to each have static LAN addresses. Figure 19 to 21 show the 'ping' command being carried out between the VPCS. Table 1 below shows the LAN address configurations.

Table 1: LAN address configuration for star-topology configuration simulation on GNS3

Computer	IP Address	Gateway Address	Netmask Address
PC1	202.17.51.1	202.17.51.16	255.255.255.0
PC2	202.17.51.2	202.17.51.16	255.255.255.0
PC3	202.17.51.3	202.17.51.16	255.255.255.0

Figure 22: Setting up static IP address for VPCS 4 for peer-to-peer configuration simulation and using 'ping' command for VPCS 4 to VPCS 5 on GNS3 using switch.

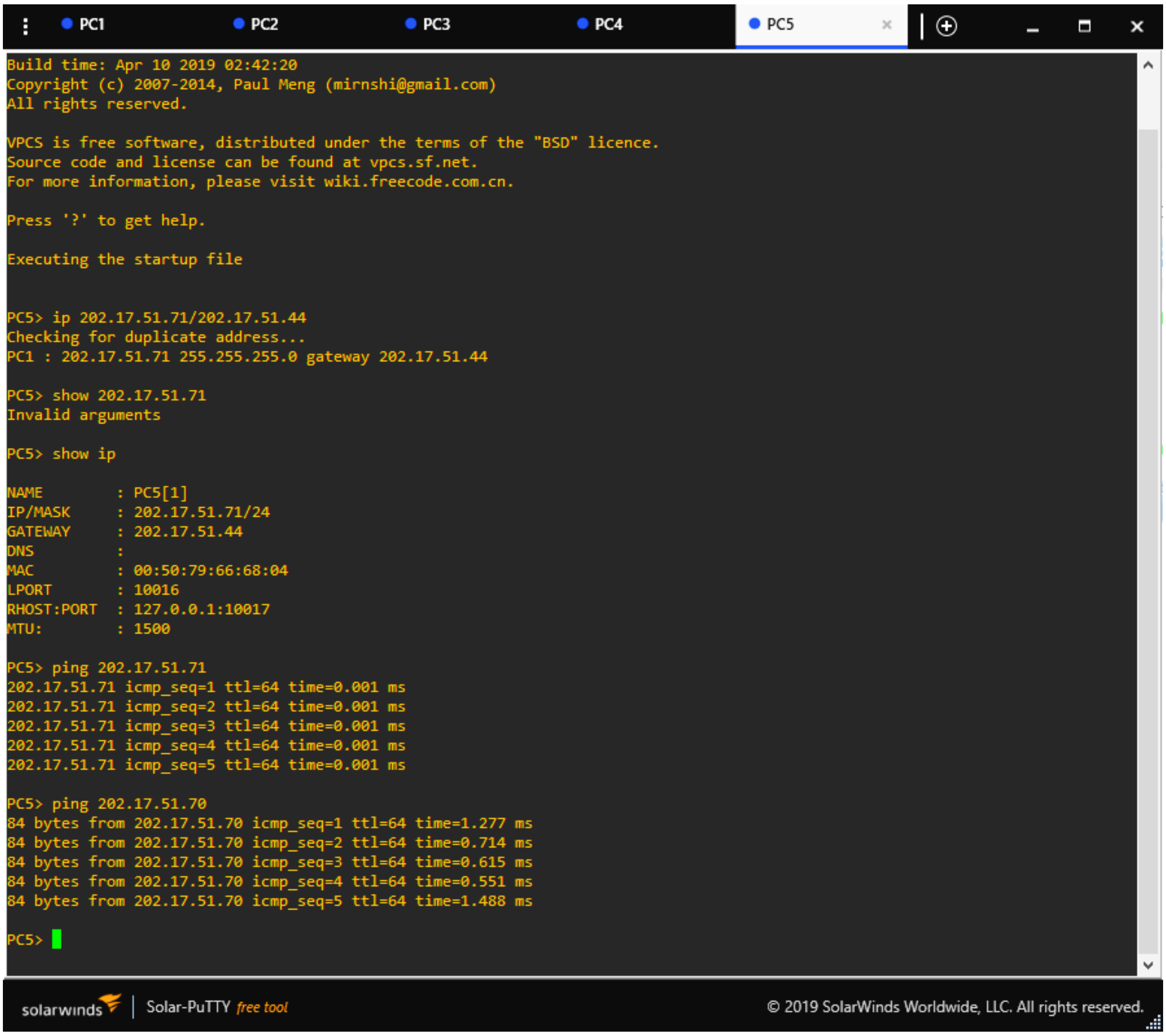

Figure 23: Setting up static IP address for VPCS 5 for peer-to-peer configuration simulation and using 'ping' command for VPCS 5 to VPCS 4 on GNS3 using switch.

Figure 22 and Figure 23 above show the screengrabs of the console window of the network simulation of the peer-to-peer configuration on GNS3 whereby the VPCSs were configured to each have static LAN addresses as well as using the 'ping' command being carried out between the VPCS. Table 2 below shows the LAN address configurations.

Table 2: LAN address configuration for peer-to-peer configuration simulation on GNS3

Computer	IP Address	Gateway Address	Netmask Address
PC4	202.17.51.70	202.17.51.44	255.255.255.0
PC5	202.17.51.71	202.17.51.44	255.255.255.0

2) Configuration of Oracle VM VirtualBox (LISA) in GNS3

Figure 24 to Figure 26 below show the screengrabs of the console window of the network emulation of the star-topology configuration on GNS3 using the LISA switch whereby the VPCSs were configured to each have static LAN addresses. They show the ‘ping’ command being carried out between the VPCS. Table 3 below shows the LAN address configurations.

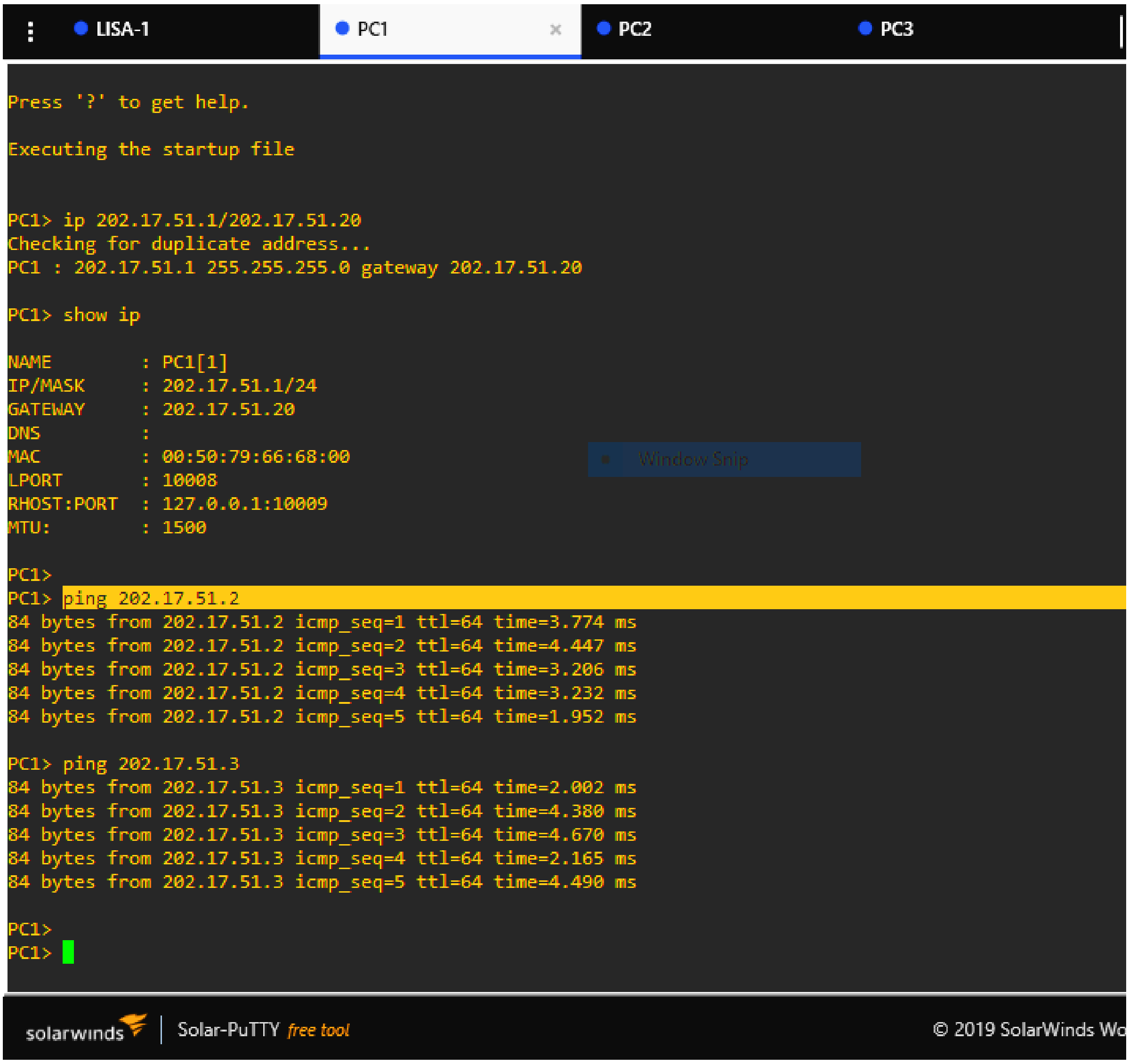

Figure 24: Setting up static IP address for VPCS 1 for peer-to-peer configuration emulation and using ‘ping’ command for VPCS 2 to VPCS 3 on GNS3 using LISA switch.

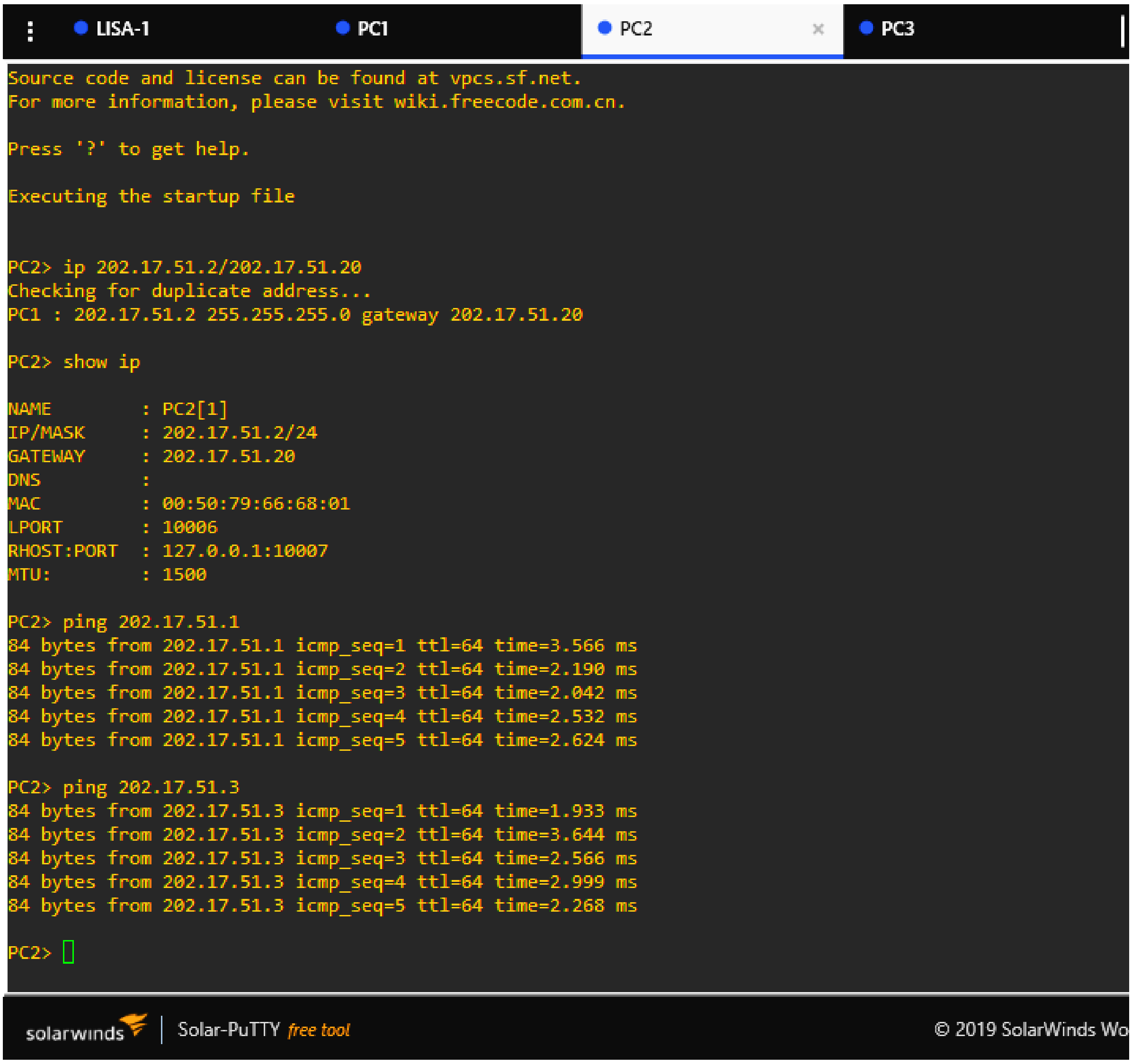

Figure 25: Setting up static IP address for VPCS 2 for peer-to-peer configuration emulation and using 'ping' command for VPCS 1 to VPCS 3 on GNS3 using LISA switch.

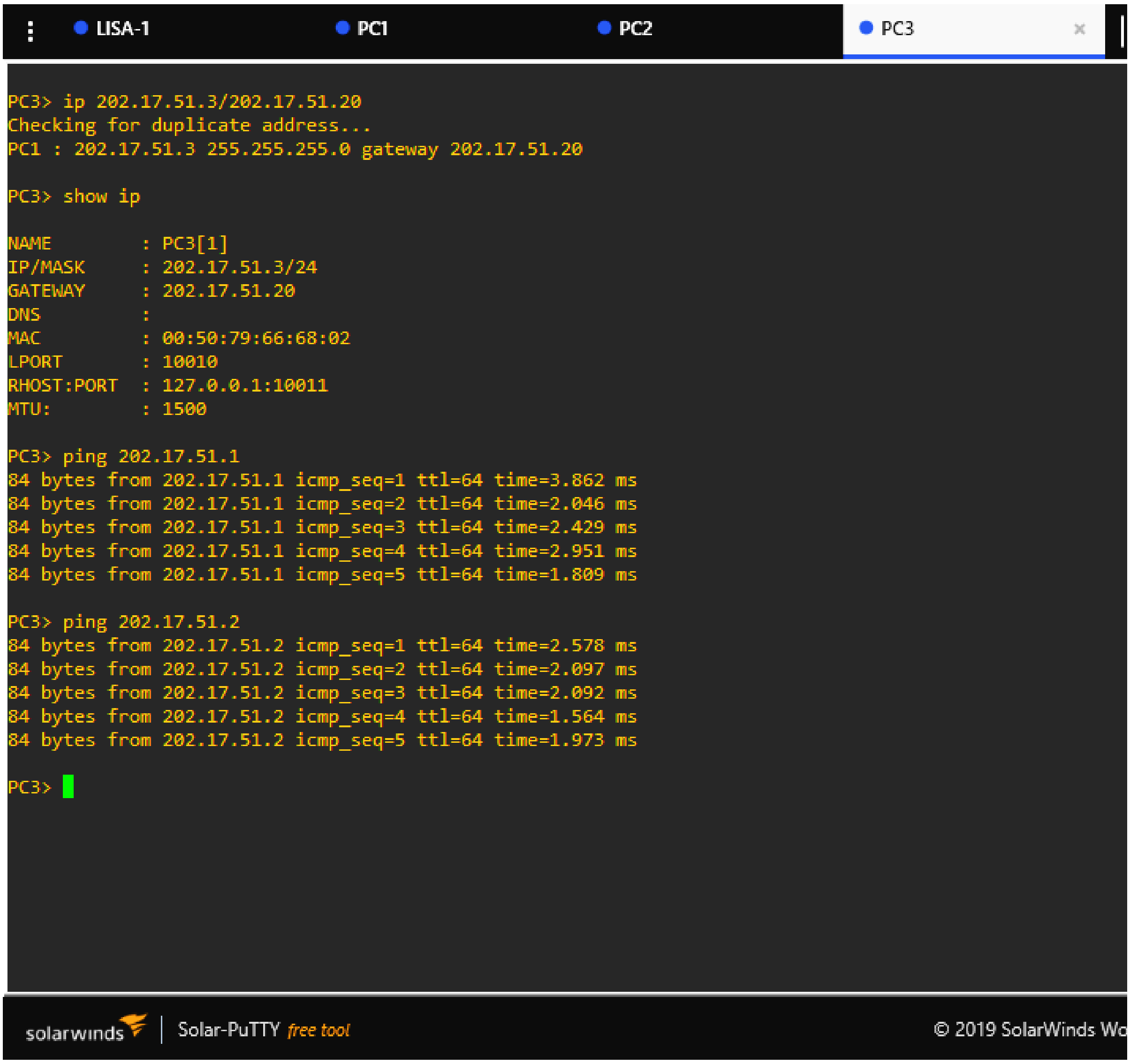

Figure 26: Setting up static IP address for VPCS 3 for peer-to-peer configuration emulation and using 'ping' command for VPCS 1 to VPCS 2 on GNS3 using LISA switch.

Table 3: LAN address configuration for star-topology configuration emulation on GNS3 using LISA switch

Computer	IP Address	Gateway Address	Netmask Address
PC1	202.17.51.1	202.17.51.20	255.255.255.0
PC2	202.17.51.2	202.17.51.20	255.255.255.0
PC3	202.17.51.3	202.17.51.20	255.255.255.0

3) Configuration of Quagga in GNS3

Figure 27 and Figure 28 show the screengrabs of the console window of the network emulation using the Quagga router whereby the VPCSs were configured to each have static LAN addresses. They show the 'ping' command being carried out between the VPCS. Table 4 below shows the LAN address configurations.

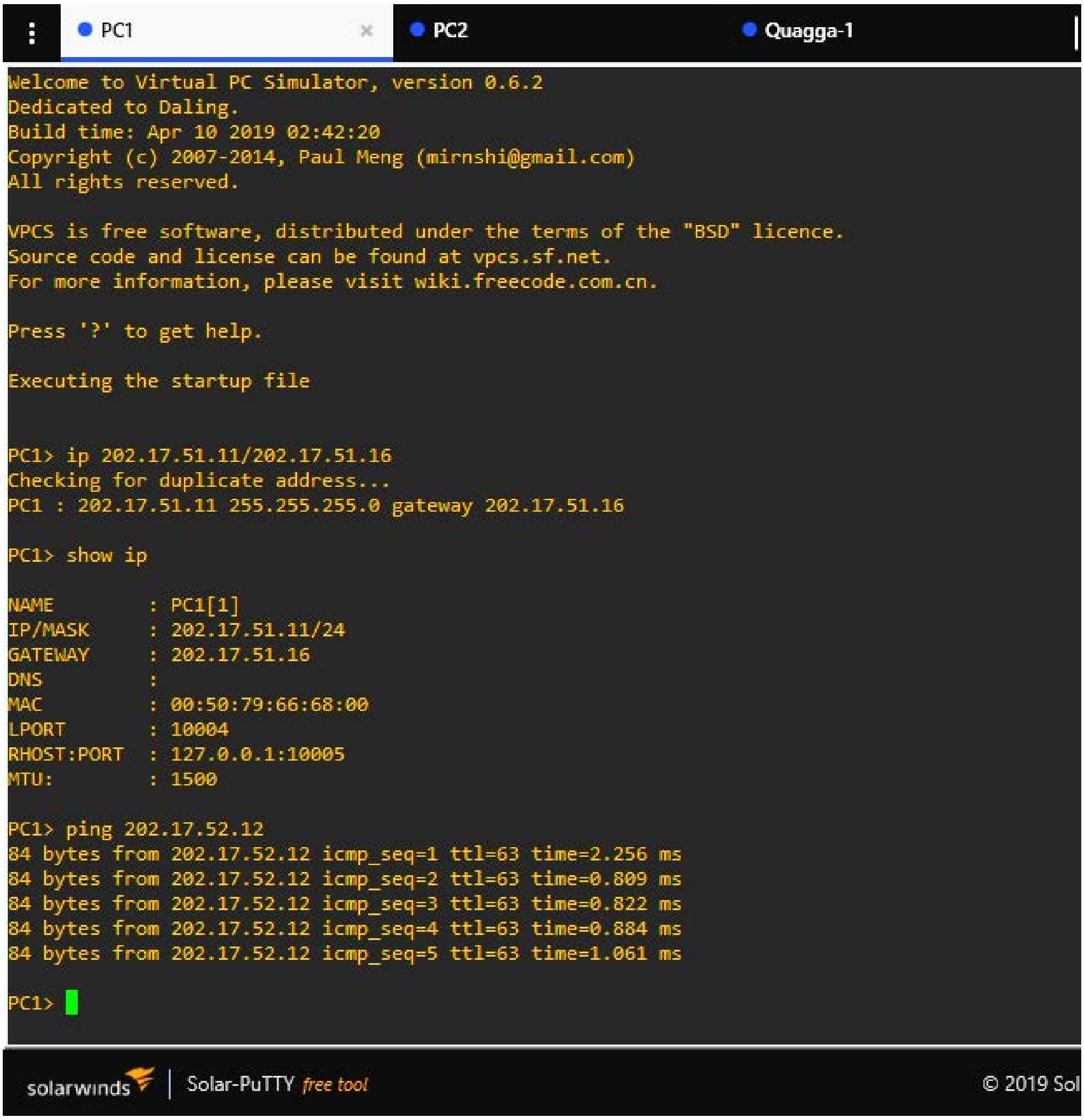

Figure 27: Setting up static IP address for VPCS 1 for configuration of Quagga router with two different subnets and using 'ping' command for VPCS 1 to VPCS 2 on GNS3

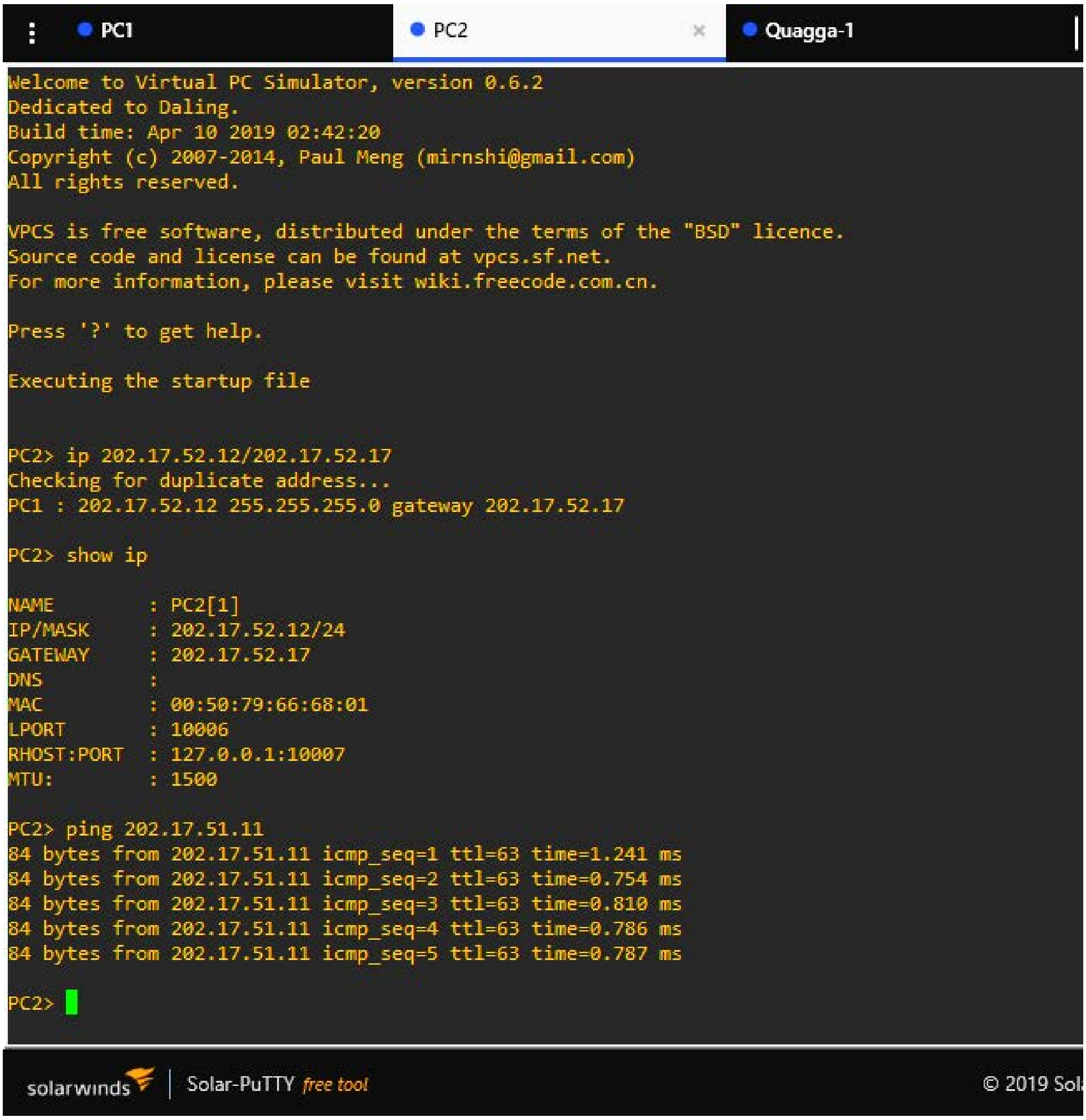

Figure 28: Setting up static IP address for VPCS 2 for configuration of Quagga router with two different subnets and using 'ping' command for VPCS 2 to VPCS 3 on GNS3

Table 4: LAN address configuration for emulation using two different subnets on GNS3 using Quagga router

Computer	IP Address	Gateway Address	Netmask Address
PC1	202.17.51.11	202.17.51.16	255.255.255.0
PC2	202.17.52.12	202.17.52.17	255.255.255.0
Interface	**IP Address**	**Default Gateway**	**Subnet Mask**
Router (eth0)	202.17.51.16	-	255.255.255.0
Router (eth1)	202.17.52.17	-	255.255.255.0

6.0 Discussion

a) What is the purpose of network simulation?

Network simulation is carried out to research computer networks by using a software program that mimics the performance of a network by analysing the relations between the various network components. Aspects of the computer network such as the performance, applications, services and supports can be monitored and different features in the surroundings can be altered in a controlled manner to observe the performance of the network or protocols in different conditions. [3]

b) Discuss on GNS3.

GNS3 (Graphical Network Simulator-3) is an open-source software that allows the emulation and simulation of complex network designs [4] as shown in Figure 29 below. It is used to emulate, configure, test, and troubleshoot virtual and real networks. It consists of two components; the graphical user interface and the virtual machine. The network topologies are created on the GUI which allows the user to visualise the connections between components easily. The devices used in the topology need to be hosted and run by a server process. The following are the options for the server of the software; local GNS3 server, local GNS3 VM and remote GNS3 VM. [10]

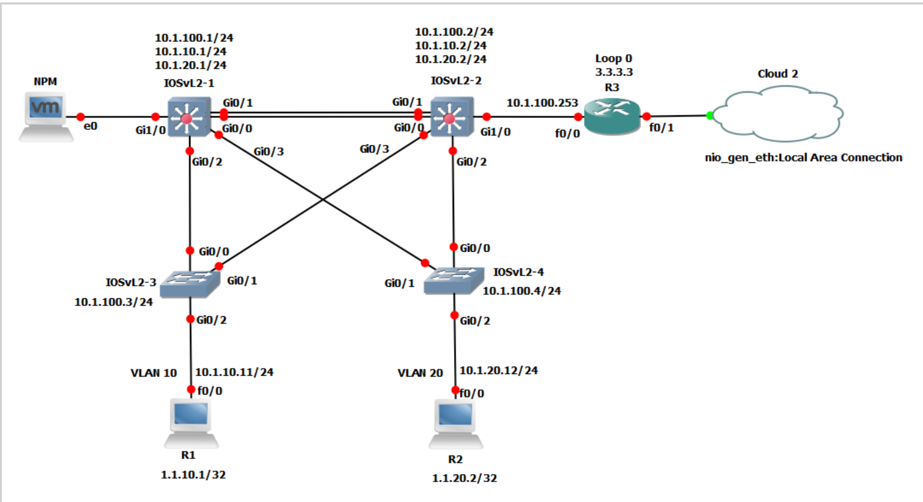

Figure 29: Sample of complex network design on the GUI interface on GNS3 [10]

c) Discuss on Wireshark.

Wireshark is a network protocol analyser or an application that captures packets from a network connection in other works it is a ‘packet-sniffer’. Wireshark is the most commonly used packet-sniffer application. It serves three purposes; capturing packets in real times on a network connection, filtering the live data to obtain the desired information and visualisation of a network packet. Wireshark is used in multiple occasions such as in troubleshooting networks and tracing connections by cybersecurity professionals. [5]

d) ***Discuss on VM (e.g. VirtualBox)***

A virtual machine (VM) is a virtual environment that functions as a virtual computer system with its own CPU, memory, network interface, and storage, created on a physical hardware system. Since the physical system is able to be shared with many isolated virtual environments, they do not interfere with the existing hardware of the computer therefore; VMs are useful for testing new applications or setting up a production environment [6].

Another use of VMs is in server consolidation whereby many virtual servers can be placed into a physical server to improve hardware utilisation. This allows the use of lesser resources such as; power, space and cooling systems. They also allow disaster recovery options by enabling failover and redundancy that which was only achievable by additional hardware prior [6]. An example of a VM software would be VirtualBox. It is open-source software that acts as a hypervisor that virtualises the x86 computing architecture so that the user can run another OS [7].

e) ***What is the difference between network simulation and network emulation?***

Simulators create an environment that contains all of the variables that would exist in the real environment. Typically, simulators are used for software testing scenarios [8]. Network simulators utilise mathematical formulas to create a purely theoretical and virtual model of a network and is typically used for research and educational purposes however they are crucial in network testing, design and development. The downside however is that simulators are unable to anticipate certain events that may occur in a physical network [9].

Emulators attempt to mimic the actual environment which could consist of both hardware and software configurations. They are suitable for testing how software interacts with the underlying hardware or a combination of both [8]. Network emulators are used to test the performance of an actual network. They allow testing, performance validation and trouble shooting and are available as both hardware or software solutions. A network emulator is able to accurately replicate a client-server connection without the need for an actual device such as a router or modem. ‘Problems’ like packet loss, delay and jitter can also be modelled [9] to account for the issues faced in networking in the real world.

f) ***In GNS3, what is the difference between VPCS and Host devices?***

VPCS (Virtual PC Simulator) on GNS3 allows the simulation of a lightweight PC that supports DHCP (Dynamic Host Configuration Protocol) and ping commands. It only consumes 2MB of RAM per instance and does not require an additional image [12].

A host device is any hardware device that can permit access to a network by a user interface, specialised software, network address, protocol stack or others [16]. On GNS3, a host device is similar to a ‘Cloud’ but with the Ethernet and TAP (Test Access Points) interfaces configured in the object [15].

g) ***In GNS3, what is the difference between Ethernet hub and Ethernet switch devices? [18]***
A hub is layer 1 device in the OSI model that connects signals to computers within a LAN through a process called 'flooding' [18] whereby once the hub receives data it is sent to all other ports that it is connected to the hub except from the port it arrived form.

A switch is a layer 2 device in the OSI model that 'learns' the connection topology and transmits data only to devices with known MAC addresses out of specific ports within the LAN. Unlike an Ethernet hub, a switch is an 'intelligent' device [18]. Figure 30 and Figure 31 show the icons of the Ethernet switch and Ethernet hub in GNS3.

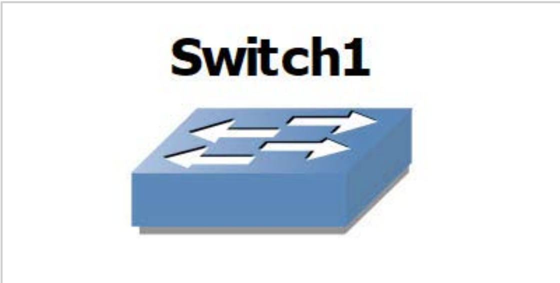

Figure 30: Icon of Ethernet Switch on GNS3

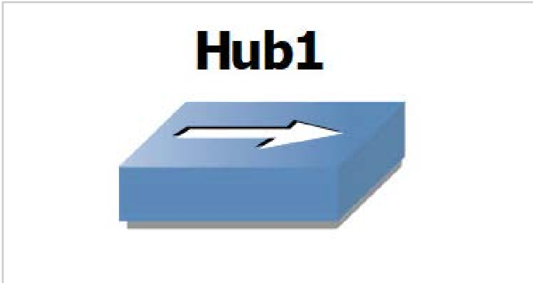

Figure 31: Icon of Ethernet Hub on GNS3

h) ***In GNS3, what is the difference between switch and router devices?***
A switch is a layer 2 device on the OSI model and forwards packets of data on the data link layer within the same LAN. A switch connects end devices within a single network. Meanwhile, a router is a layer 3 device on the OSI model and forwards packets of data on the network layer [19]. The purpose of a router is to connect two different networks as was observed above in the laboratory experiment involving the Quagga router emulator which connected two different sub-nets. Figure 32 below shows an icon of a router on GNS3.

Figure 32: Icon of router on GNS3

i) ***Why, unlike a switch, the router device is not readily available in GNS3? How to enable it?***
A router is not available in the components in GNS3 by default therefore, a router needs to be manually configured from an external source. One method would be to use a VM and a virtual disk to emulate a router as was done using the virtual disk of the Quagga router and Virtualbox in the laboratory experiment above.

j) What is IP address? Discuss the difference between static and dynamic IP address.

IP stands for 'Internet Protocol'. The IP address gives each device connected to the internet or in other words, a host a unique address that identifies their location. IP addresses are assigned to users by ISPs (Internet Service Providers).

A static IP address is one that always stays the same and is used for instances where a 'permanent' address is needed such as web servers. Static IP addresses need to be configured manually. A dynamic address is one that is provided by an ISP for temporary use. When not in use, a dynamic IP address can simply be assigned to another user. They are assigned by one of two methods; DHCP (Dynamic Host Configuration Protocol) or PPPoE (Point-to-Point Protocol over Ethernet). [17]

k) What is DNS? Provide one example of DNS.

DNS is short for domain name system which is an application layer protocol that translates user-supplied hostnames into IP addresses that are machine readable.

An example would be taking the hostname www.instagram.com which upon carrying out a DNS lookup would show the IP address 179.60.192.174.

l) What is gateway address? Provide one example of gateway address.

A gateway address refers to a device on a network which sends local network traffic to other networks [20]. A 'default gateway' is the private IP address given to the router in a network which allows the sending of information from devices in one network to another. The traffic is first sent to the default gateway and then leaves to the destination LAN [11].

An example of finding the default gateway is shown in the steps below:

i) The following keys on the keyboard were pressed; ⊞ **Win + R**

ii) Then 'cmd' was entered and 'OK' was pressed as shown in Figure 33 below.

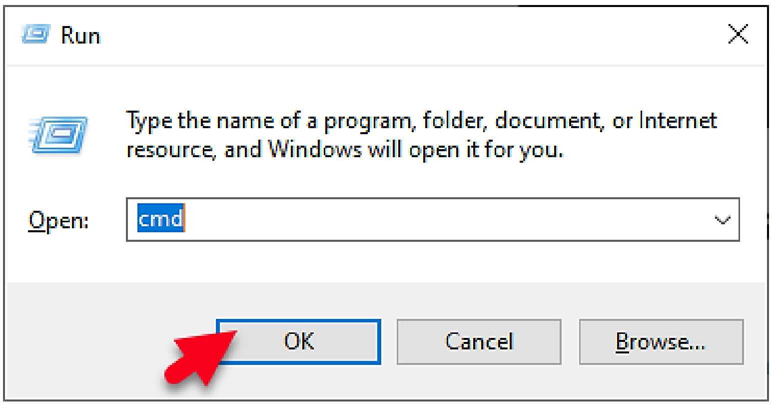

Figure 33. Window for running command prompt

iii) `ipconfig` was entered into the command prompt window and the gateway IP address was found next to Default Gateway. This is shown in Figure 34 below.

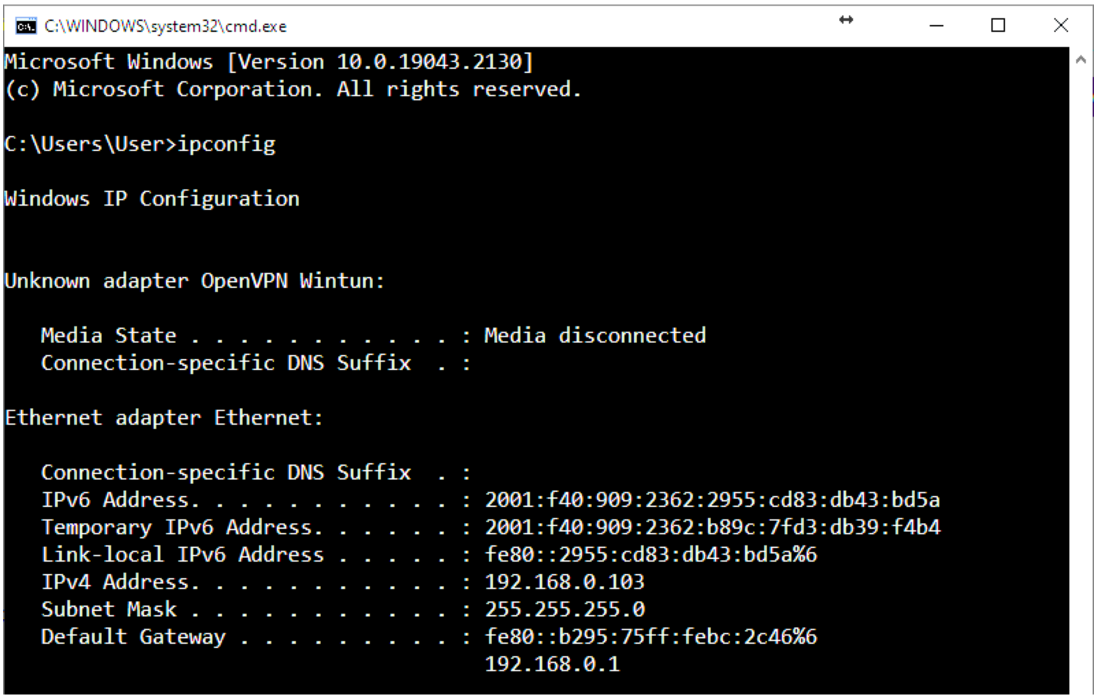

Figure 34. Command prompt window after `ipconfig` *command was entered*

The IPv4 gateway IP address that is seen from Figure 14 is `192.168.0.1` and the IPv6 gateway IP address is `fe80::b295:75ff:febc:2c46%6.`

m) What is netmask address? Provide one example of netmask address.

A netmask address consists of 32 bits and is used to divide an IP address and to specify the available hosts in a particular network [21]. The netmask defines how ‘large’ a network is. As an example, the netmask address from Figure 34 above is `255.255.255.0` which applies to IP addresses ranging from `192.168.55.0` to `192.168.55.255`.

n) Discuss about Ping command.

The ‘ping’ command is a command-line utility that is available on any operating system that is connected to a network. It tests to see if a ‘networked device’ is reachable. The command sends a request over the network to a particular device. When a ping is successful, a response is gotten from the computer that was pinged back to the originating computer. [22]

o) ***Discuss your achievements and problems encountered during the laboratory session.***

Overall, the laboratory session was successful. GNS3 and VirtualBox were installed successfully and VMs were successfully set up in VirtualBox using virtual disks. In the GNS3 simulation, the emulation using the LISA switch and the emulation using the Quagga router; the ping commands between the VPCS were carried out in the networks successfully.

There was namely one issue when using the VMs (LISA and Quagga) in VirtualBox; they would run in the background even after closing GNS3, so it was not possible to create a new network configuration using the VMs. In order to overcome this, the running of the VirtualBox program was terminated. The following steps were taken; Start > Task Manager > Processes > End Task for all VirtualBox processes. After terminating the programs, the VMs could be used again after waiting for a short period.

For the first experiment involving the simulation of two network configurations using Ethernet switches on GNS3, the desired results were obtained. For the star-topology configuration; the IP address of each VPCS was set and was connected to an Ethernet switch in the same subnet. This was done by ensuring the VPCSs all had the same gateway as observed from the console screengrabs in Figure 16, Figure 18, and Figure 20. The ping command was carried out between all three VPCSs and it was observed that if a VPCS was ‘pinged’ with itself, there would be no bytes transferred as a device cannot send itself any data whilst there were bytes transferred when ‘pinged’ with another device. This is observed from the screengrabs in Figure 17, Figure 19, and Figure 21. The same process was repeated for the peer-to-peer configuration involving PC4 and PC5. Successful results were obtained as seen from the console screengrabs in Figure 22 and Figure 23.

The second laboratory experiment involved the emulation of the LISA switch on GNS3 in the star-topology configuration. It was similar to the simulation using the GNS3 ethernet switch. The only difference was having to configure the LISA switch emulator as seen in Figure 11. From the screengrabs of the console in Figure 24, Figure 25, and Figure 26, the successful ping commands can be seen between the VPCSs.

The last laboratory experiment involved the configuration and testing of the Quagga router with two subnets. The emulation was successful because the ‘ping’ command was able to be carried out between PC1 and PC2 as seen in Figure 27 and Figure 28. As mentioned prior, routers are used to forward packets of data from one network to another. The network configuration illustrated in Figure 35 below shows that PC1 and PC2 were in two different subnets. Thus, a gateway was required for the forwarding of information between the subnets. Taking the instance of the ping command from PC1 to PC2; when PC1 `(202.17.51.11)` wants to ping to PC2 `(202.17.52.12)`, the data packets are first forwarded to the default gateway `(202.17.51.16)` in the router. The router then checks the routing table to see if there was a route available to PC2. Since the PC2 subnet `(202.17.52.0)` was connected directly to the router, the TTL is reduced by 1 then the gateway is changed to `202.17.52.17`. Then the data packets are forwarded to PC2 `(202.17.52.12)`.

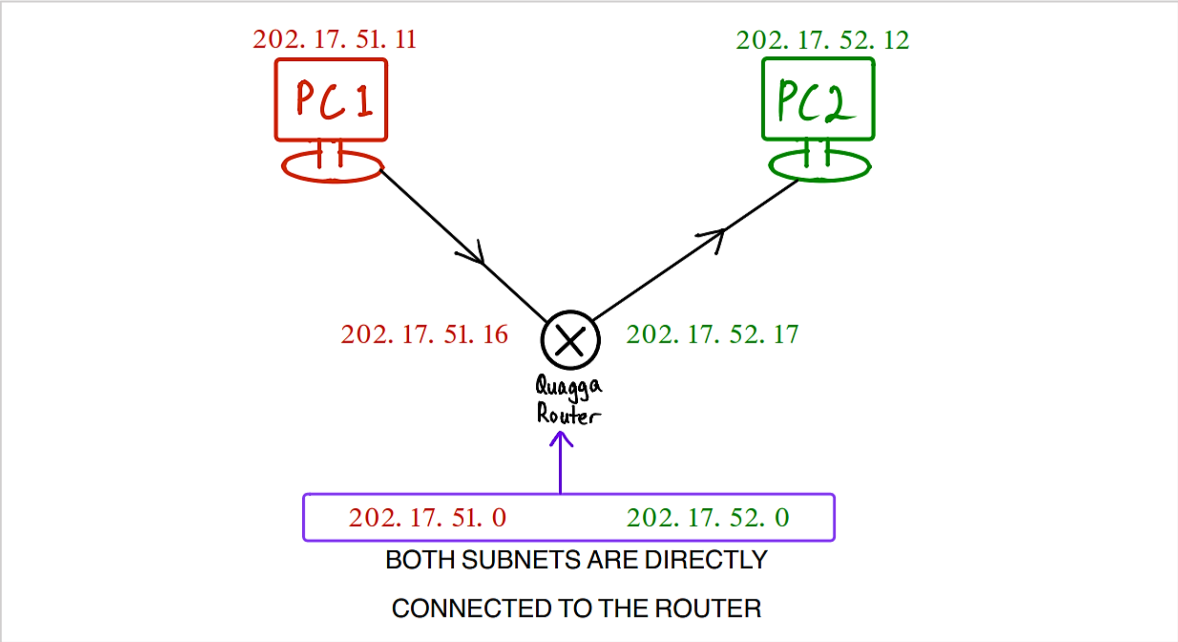

Figure 35: Diagram of network configuration with Quagga router two different subnets from emulation experiment.

7.0 Conclusion

The objectives of the laboratory session were fulfilled successfully as the desired results were obtained. The required software was installed without issues; the GNS3 software which allowed the simulation and emulation of networks and VirtualBox which was a hypervisor will enable the creation and running of the VMs (LISA switch and Quagga router) used. Then the GNS3 simulation of the two network configurations; star-topology configuration and peer-to-peer configuration was completed and the expected results were obtained from the ping commands. When carrying out the emulation using the LISA switch in the star-topology configuration similar results were obtained as the GNS3 simulation which was expected. Lastly, the emulation using the Quagga router with two subnets yielded successfully. It was observed that switches can only forward packets within the same subnet and have only one gateway whilst routers are used to forward packets between networks and use the different gateways for each subnet in order to accomplish so.

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