Hands-on Lab Description

ThoTh Lab

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CS-SYS-00101 –
Virtual Network Setup in VirtualBox

Category:

```
   CS-SYS: Computer System
```

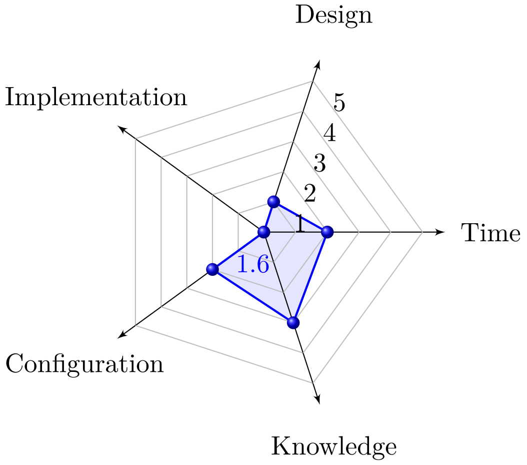
Objectives:

```
Learn how to install VirtualBox
Learn how to create virtual machine in VirtualBox
Learn how to configure virtual machine in VirtualBox
```

Estimated Lab Duration:

```
Expert: 20 minutes
Novice: 100 minutes
```

Difficulty Diagram:



Difficulty Table.

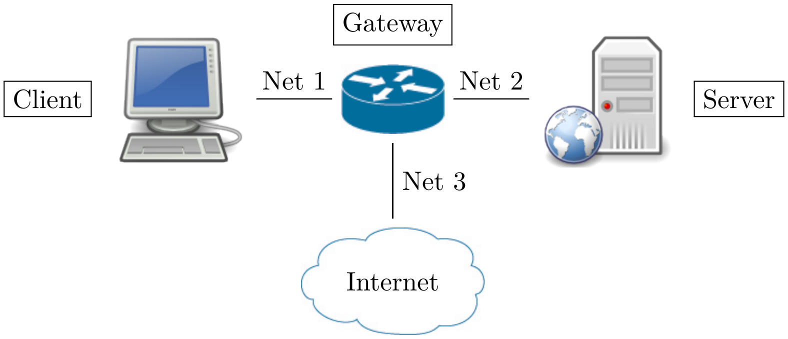
Measurements	Values (0-5)
Time	2
Design	1
Implementation	0
Configuration	2
Knowledge	3
Score (Average)	1.6

Required OS:

```
   Host: Windows, MAC, or Linux; VM: Ubuntu 18.04 LTS
```

Lab Running Environment:

```
   VirtualBox https://www.virtualbox.org/
```



```
Computer OS: Windows 10, Mac OS 10 or Linux 64-bit verison
Network Setup:
Internet: Accessible
```

Lab Preparations:

```
     Initial setup: At least 6GB of RAM and 20GB of hard disk space is required for
         this lab.
     lab-cs-sys-00001 (A short Linux Tutorial), lab-cs-net-00001 (Network setup),
         lab-cs-net-00002 (Gateway setup)
```

Task 1 Download and Install VirtualBox

Oracle VM VirtualBox is a cross-platform virtualization application. It can run on existing Intel or AMD-based computers, whether Windows, Mac OS X, Linux, or Oracle Solaris operating systems (OSes). Secondly, it extends the capabilities by running multiple OSes inside multiple virtual machines at the same time. For example, you can run Windows and Linux on your Mac, run Windows on your Linux server, and so on, all alongside existing applications. When dealing with virtualization, and also for understanding the following descriptions of this lab, it helps to acquaint oneself with a bit of crucial terminology, especially the following terms:

Host operating system (host OS). This is the OS of the physical computer on which Oracle VM VirtualBox was installed. Oracle VM VirtualBox versions are for Windows, Mac OS X, Linux, and Oracle Solaris hosts.

Guest operating system (guest OS). This is the OS that is running inside the virtual machine. Theoretically, Oracle VM VirtualBox can run any x86 OS such as DOS, Windows, OS/2, FreeBSD, and OpenBSD.

Go to `https://www.virtualbox.org/wiki/Downloads` to download the newest version of VirtualBox, which is 6.1.26 as this manual is being created. Using the link for Windows hosts if your host OS is Windows, and OS X link if your host OS is Mac OS, so on so forth.

Click on the link to download VirtualBox. After the download process is finished, you should get a .exe file for Windows or a .dmg file for Mac OS; double click it to start the installation process. The installer has a step-by-step interface for you to follow, keep everything by default if possible, and only change settings when you understand what's you change and what you want.
(Note: If you're using Ubuntu or other types of Linux OS as Host OS, please use apt install or other command lines to install Virtualbox.)

Task 2 Install provided VM on VirtualBox

Pre-built Ubuntu 18.04 VirtualBox images can be downloaded using the following links.

```
VM image with GUI:
https://drive.google.com/file/d/11apPTNLj5gGY-DzKyQYs5JyiA3Ulppfb/view?usp=sharing

VM image with CLI:
https://drive.google.com/file/d/1sMnd4f4tk5vckgPTonyynF_bWIF-ALfq/view?usp=sharing
```

Account information for all VMs:

```
Username: ubuntu
Password: 123456
```

Step 1: Create a New VM in VirtualBox

First, use *New* to create a new virtual machine. In the virtualBox window, Go to Machine − > New to create a new VM., as shown in fig CS-SYS-00101.1.

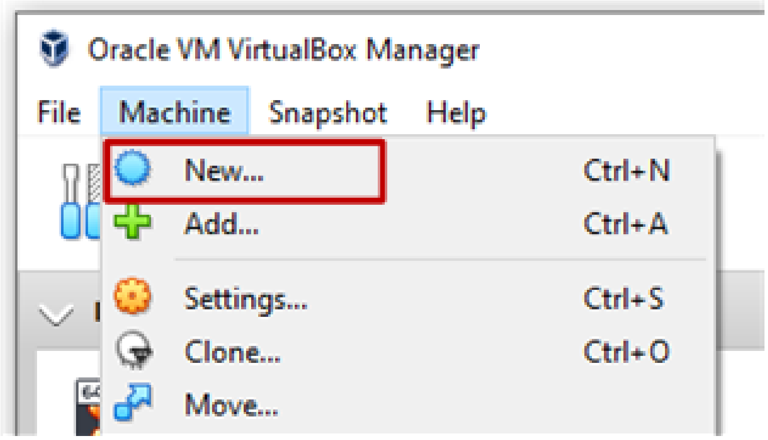
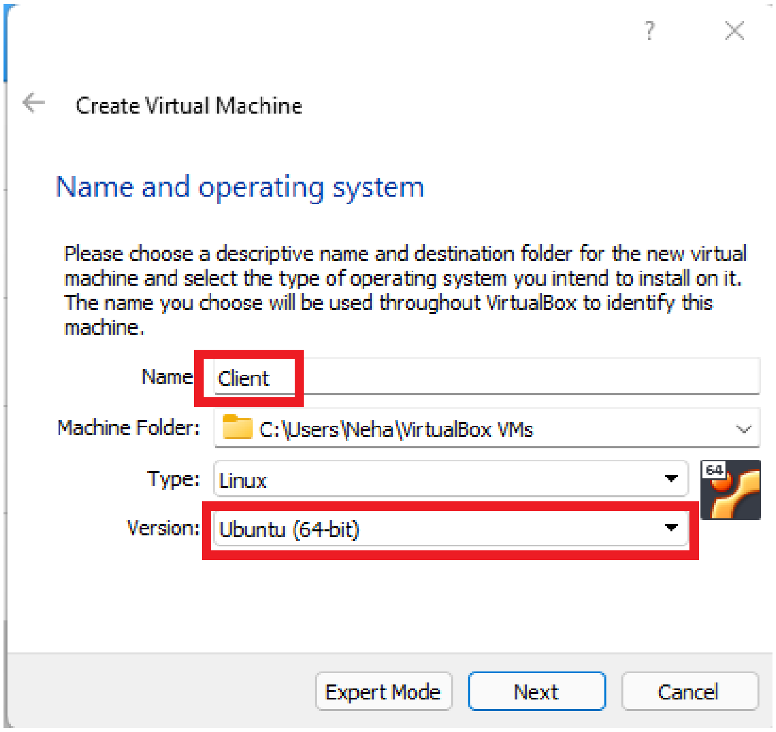


Figure CS-SYS-00101.1
Creating a new VM in VirtualBox.

Step 2: Provide a Name and Select the OS Type and Version

Write preferred name to your VM in the first text box. Keep the Machine folder same as default. Type and Version of OS should be "Linux" and "Ubuntu (64 bit), since our pre-built Ubuntu 18.04 VM is 64-bit, so pick Ubuntu (64-bit). The VM details are also provided in fig. CS-SYS-00101.2.



Create Virtual Machine

Name and operating system

Please choose a descriptive name and destination folder for the new virtual machine and select the type of operating system you intend to install on it. The name you choose will be used throughout VirtualBox to identify this machine.

Name: Client

Machine Folder: C:\Users\Neha\VirtualBox VMs

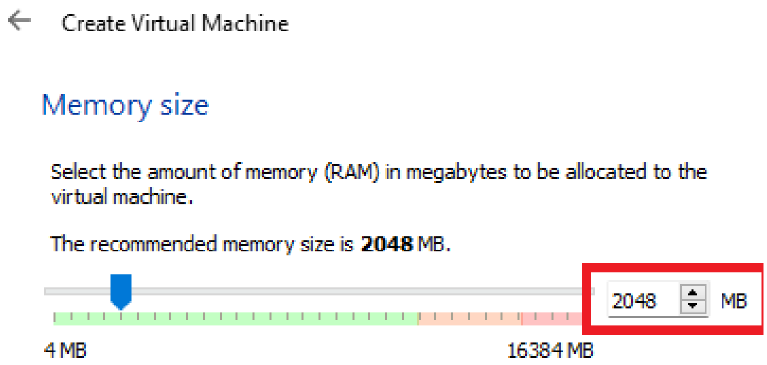
Type: Linux

Version: Ubuntu (64-bit)

Figure CS-SYS-00101.2
Creating a new VM - Name and Operating system

Step 3: Set memory size

It is recommended at least 2GB for the GUI version of the Linux VM, and you can use 1GB for CLI version of the Linux VM. If your computer has more RAM, you can increase it accordingly. The more memory you give to the VM, the better the performance you will get. But notice that you need to keep some memory for your Host OS, so, say if your total memory is 8GB, you should allocate not more than 6GB memory to the VM.



Create Virtual Machine

Memory size

Select the amount of memory (RAM) in megabytes to be allocated to the virtual machine.

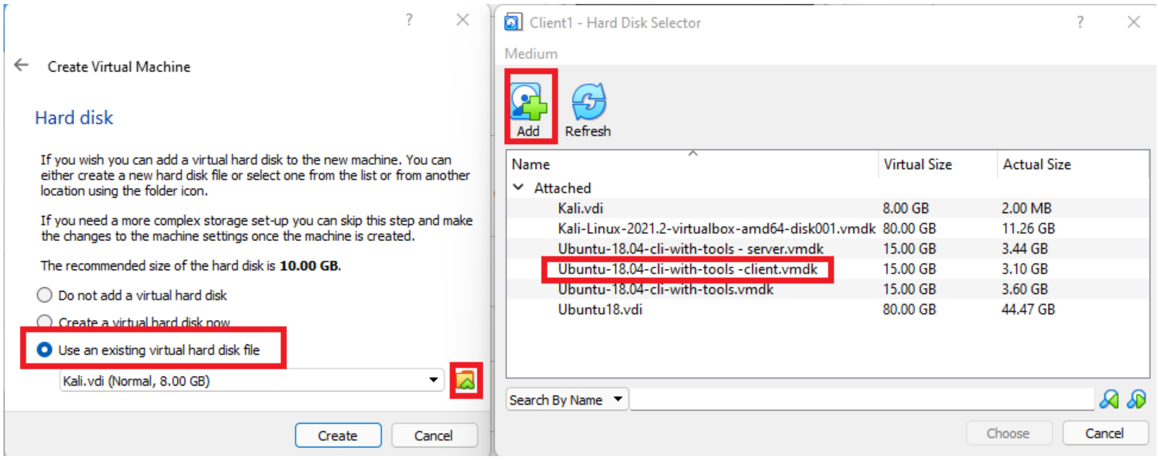
The recommended memory size is **2048** MB.

2048 MB

Figure CS-SYS-00101.3
Set the memory as 2048 MB for each VM.

Step 4: Select the Pre-built VM File Provided by Us

Pick “Using existing virtual disk file,” then click the folder image. Use the Add button to search and select the .vdi file downloaded from the google drive link on the popup window.



Create Virtual Machine

Hard disk

If you wish you can add a virtual hard disk to the new machine. You can either create a new hard disk file or select one from the list or from another location using the folder icon.

If you need a more complex storage set-up you can skip this step and make the changes to the machine settings once the machine is created.

The recommended size of the hard disk is **10.00 GB.**

○ Do not add a virtual hard disk
○ Create a virtual hard disk now
● Use an existing virtual hard disk file

Kali.vdi (Normal, 8.00 GB)

Client1 - Hard Disk Selector

Medium

Name	Virtual Size	Actual Size
Attached		
Kali.vdi	8.00 GB	2.00 MB
Kali-Linux-2021.2-virtualbox-amd64-disk001.vmdk	80.00 GB	11.26 GB
Ubuntu-18.04-cli-with-tools - server.vmdk	15.00 GB	3.44 GB
Ubuntu-18.04-cli-with-tools -client.vmdk	15.00 GB	3.10 GB
Ubuntu-18.04-cli-with-tools.vmdk	15.00 GB	3.60 GB
Ubuntu18.vdi	80.00 GB	44.47 GB

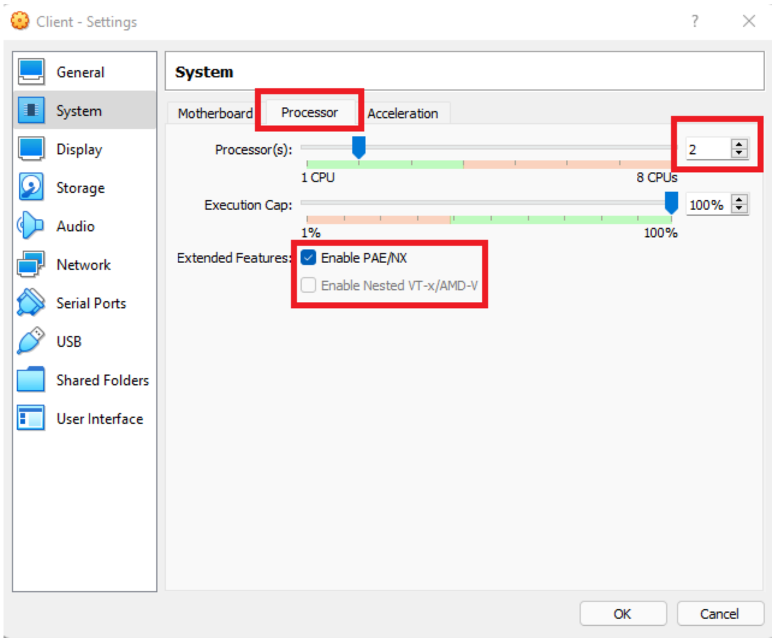
Figure CS-SYS-00101.4
Assign VirtualBox image provided to you for the VM

Task 3 Configure the VM

After the previous step, your VM will be created, and you will see it on VirtualBox's VM panel. We need to do some further configuration. Right-click the VM, click the Settings option, and we will see the Settings window.

Step 1: CPU Setup

Go to the System category and select the Processor tab. Assign the number of CPUs to this VM if you prefer. Although 2 may be sufficient, if the performance seems to be an issue, increase the number. And remember to keep some CPU for your Host OS! Select both options from Extended features.



Processor(s): 2

Execution Cap: 100%

Extended Features: ☑ Enable PAE/NX

□ Enable Nested VT-x/AMD-V

Figure CS-SYS-00101.5
Configure 2 processors for each VM.

Step 1: Display Setup

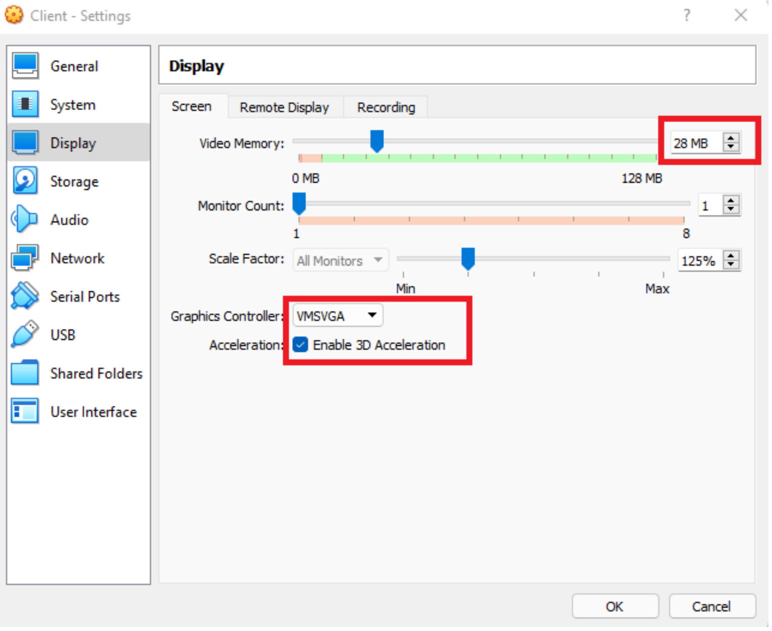
Go to the Display category, and select the Screen tab. If the display does not seem to work properly, try to increase the amount of video memory. In our testing, 28 MB seems to be sufficient. Select VMSVGA, and 3D acceleration enabled.

Note 1: Make sure to select VMSVGA, as choosing other graphic controllers may lead to the crash of the provided Ubuntu 18.04 VM.

Note 2: If your computer's screen resolution is too high, the VM may not be able to match the high resolution. As a result, your VM will be very small on your screen. To make it bigger, adjust the Scale Factor in this setting.

Step 3: Network Setup

As required for this project, you need to set up a virtual network environment shown in Figure CS-SYS-00101.7. For Gateway VM, you need to create three networks (Net1, Net2, and Net3). In the example, the



Client - Settings

Display

Video Memory: 28 MB

Monitor Count: 1

Scale Factor: All Monitors 125%

Graphics Controller: VMSVGA

Acceleration: ☑ Enable 3D Acceleration

Figure CS-SYS-00101.6
Configure display as per your requirement for each VM.

Net3 network is the one that you need to set up and connect to the local host allowing your Gateway traffic to the public domain through the host's network interface. It is considered as your virtual system's network interface connecting to the Internet. To set up this network, you need to go to the VirtualBox's *Preference* (shown in Figure CS-SYS-00101.8) and then choose the *Network* category, and you can create a NatNetwork. Note that this NatNetwork will serve as your entire VirtualBox's outgoing traffic network interface. Technically, you can create multiple NatNetworks. However, to fulfill the network setup requirements, you only need to create one NatNetworks and make it connects to your Gateway's virtual network interface. To this end, go back to your virtual Box's main menu, and select your Gateway's network setting, and then choose one unassigned adapter. From the *Attach to* dropdown menu, choose *NAT Network*, and then select the created NatNetwork. In this way, you attach your Gateway's virtual interfaces to the environment's outgoing interface.

Net 1 (Client network) and Net 2 (Server network) do not have direct connections to external networks. Thus, they need to be set up as internal networks, and their generated network traffic needs to pass through

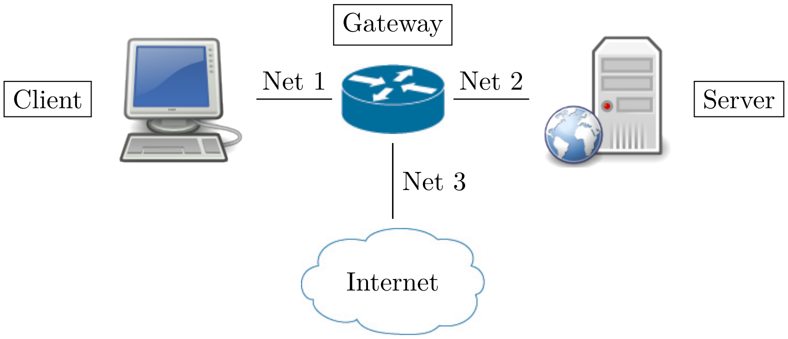


Figure CS-SYS-00101.7
Network Setup.

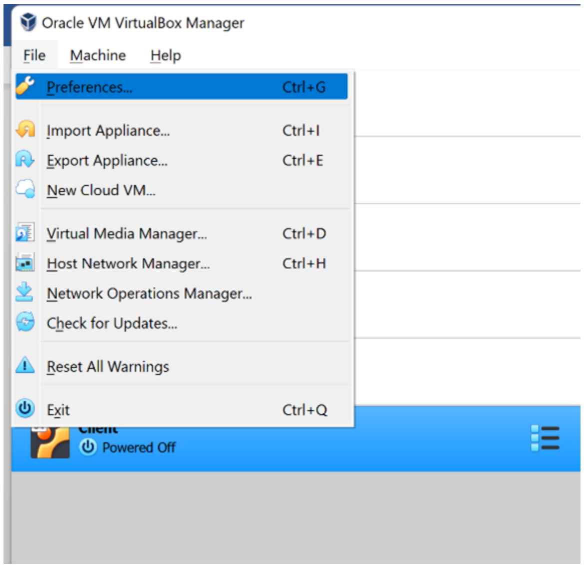
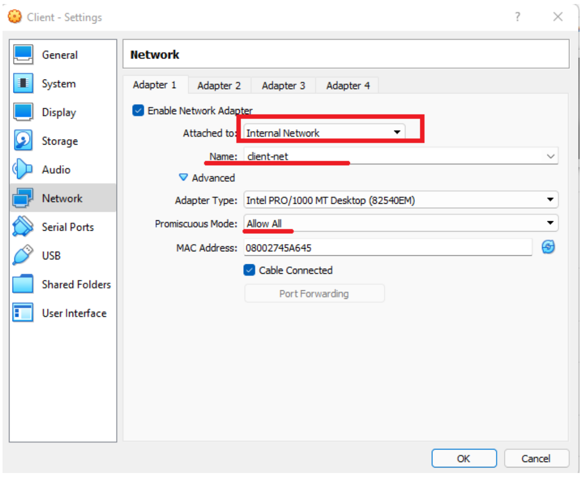

Oracle VM VirtualBox Manager
File
Machine
Help
Preferences... Ctrl+G
Import Appliance... Ctrl+I
Export Appliance... Ctrl+E
New Cloud VM...
Virtual Media Manager... Ctrl+D
Host Network Manager... Ctrl+H
Network Operations Manager...
Check for Updates...
Reset All Warnings
Exit Ctrl+Q
Client
Powered Off

Figure CS-SYS-00101.8
Setup virtual networks for gllobal virtual-Box setting preferences.



☑ Enable Network Adapter
Attached to: Internal Network
Name: client-net
Adapter Type: Intel PRO/1000 MT Desktop (82540EM)
Promiscuous Mode: Allow All
MAC Address: 08002745A645
☑ Cable Connected

Figure CS-SYS-00101.9
Configure network a NAT network for gateway VM, internal network for client and server VMs.

the Gateway to the public domain. To this end, you need to choose a different adapter on the Gateway and set it as *Internal Network* from the Attach to the dropdown menu, which is shown in Figure CS-SYS-00101.9. Repeat this procedure for both Net 1 and Net 2. Then you had established and enabled a Gateway that connects to three different networks.

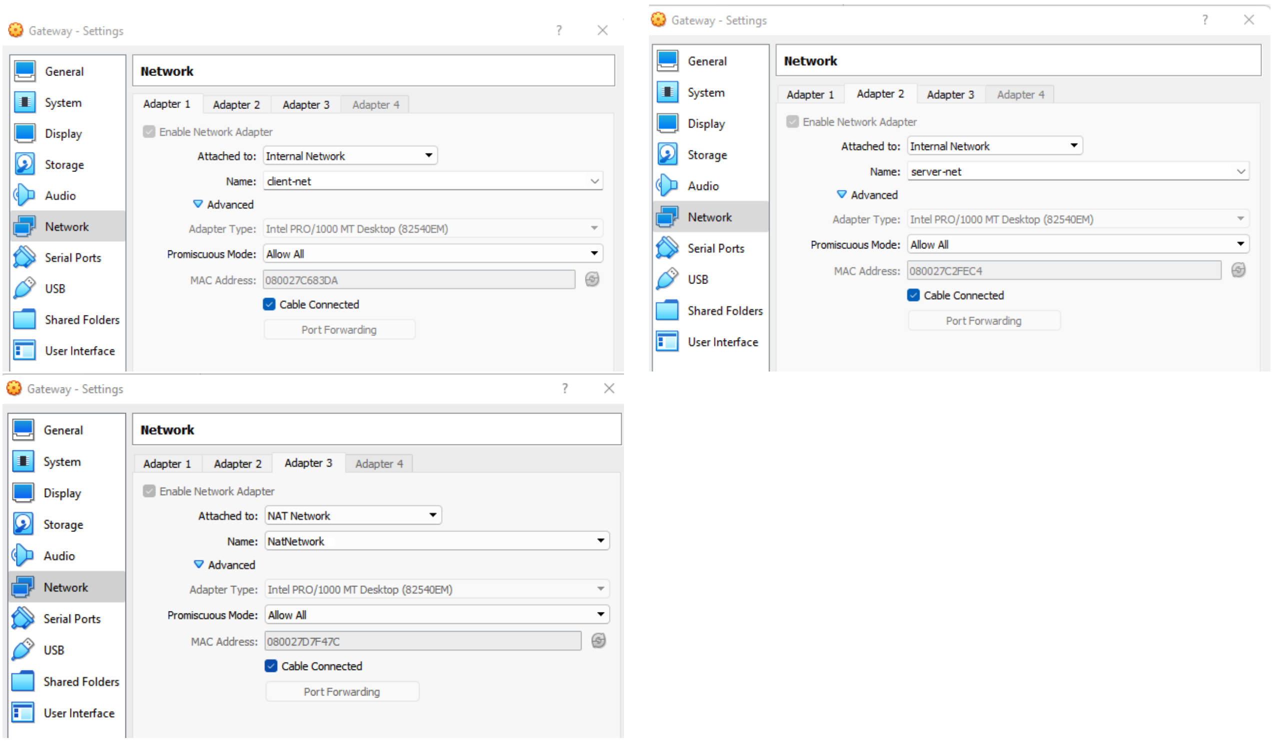
Client and server VMs only have one internal network interface. You need to follow the same procedure as for the Gateway to set up *Internal Network* and assign one of their virtual network interfaces to Net 1 (Client network) and Net 2 (Server network), respectively. The configuration example is shown in Figure CS-SYS-00101.10. Then, your VirtualBox network setup is done (here we ignore the demonstration on how to set up the server's network interfaces).

Note that at this moment, you only set up the network connections (like you connect a computer to a physical network cable), you still need to log into your computers (i.e., VMs) to set up appropriate network configurations to allow VMs to "talk" to each other; especially, enable the Gateway to forward the client and server's network traffic to the public Internet. This will be discussed shortly.

Task 4 VM Operations: Start the VM, Take Snapshot, and Stop the VM

We can now start the VM. You can also use the Take button to take a snapshot of your VM, which is shown in Figure CS-SYS-00101.11. This way, if something goes wrong, you can roll back the state of your VM using the saved snapshots.

A running VM will consume a lot of computing resources from your computer, so you may want to close it when it is not being used. There are many ways to stop the VM. The best way is to use the *Save State*. This is different from shutting down the VM. It saves the current VM state, so the state will be recovered next time you restart the VM. Moreover, the speed is also faster than booting up a VM.



Network

Adapter 1

☑ Enable Network Adapter

Attached to: Internal Network

Name: client-net

Advanced

Adapter Type: Intel PRO/1000 MT Desktop (82540EM)

Promiscuous Mode: Allow All

MAC Address: 080027C683DA

☑ Cable Connected

Network

Adapter 2

☑ Enable Network Adapter

Attached to: Internal Network

Name: server-net

Advanced

Adapter Type: Intel PRO/1000 MT Desktop (82540EM)

Promiscuous Mode: Allow All

MAC Address: 080027C2FEC4

☑ Cable Connected

Network

Adapter 3

☑ Enable Network Adapter

Attached to: NAT Network

Name: NatNetwork

Advanced

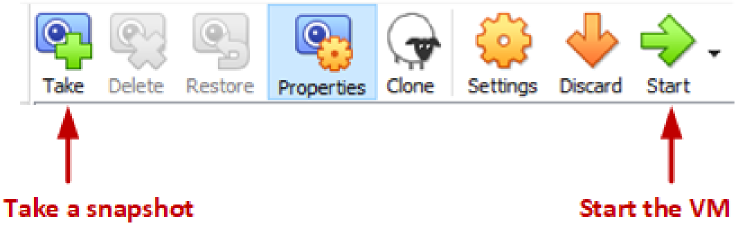
Adapter Type: Intel PRO/1000 MT Desktop (82540EM)

Promiscuous Mode: Allow All

MAC Address: 080027D7F47C

☑ Cable Connected

Figure CS-SYS-00101.10
Network configuration (netplan) settings for Gateway VM.



Take a snapshot

Start the VM

Figure CS-SYS-00101.11
Take a snapshot of your VM

Task 5 Set up VMs Networks

For our course project, you'll need to create three VMs images provided (downloaded from Google Drive with the link above) by repeat Task 2 steps for three-time with the image provided. You can name them Client VM, Gateway VM, and Server VM. As presented in previous tasks, you should configure Client VM with one internal network, Server VM with another internal network, and configure Gateway VM all three networks, client-internal network, server-internal network, and NatNetwork (connects to the Internet through the physical host machine as shown in Figure CS-SYS-00101.12). So that both Client VM and Gateway VM are connected to the client-internal network, both Server VM and Gateway VM are connected to the server-internal network, and only Gateway VM is connected to NatNetwork (i.e., the Internet).

In the following subtasks, we will need to log in to each VM and set up their network configuration to enable interconnections and packet forwarding.

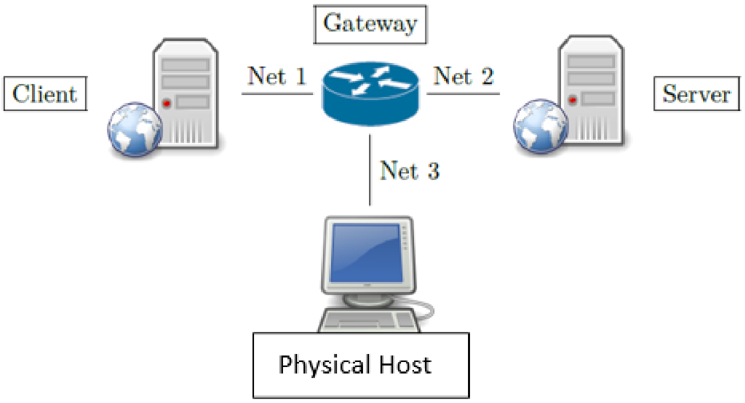


Figure CS-SYS-00101.12
Network Topology for project.

Task 5.1 CLIENT SETUP

From the command-line, you can use the following command to check your client's network interfaces:

```
$    ifconfig -a
```

Note that the option "-a" allows you to check hidden (or inactive network interfaces). At this moment, there should be no an IP address assigned to the only virtual network interface enabled for the client VM. Usually the enp0s3 is the first available interface for your Ubuntu VM. Different systems may have different names.

Then, you can use the following command to manually set the ip address:

```
$    sudo ifconfig enp0s3 192.168.0.10/24 netmask 255.255.255.0 up
```

Note *sudo* command is to enable the admin privilege to change your network system configurations. Use the provided password to authorize the command. Then, you can issue *ifconfig* to check if your network interface is configured properly.

Next, you need to configure the default Gateway for your client network. If the client wants to send a packet to another VM on the same network, e.g., the Gateway, it does not need to rely on the default gateway. However, when the client wants to send a packet to a remote host, the client needs to know the default gateway to forward its packet to the next hop. To add the default gateway on the client VM, issue the following command:

```
$    sudo route add default gw 192.168.0.100
```

Alternatively, you can also use the "ip" command:

```
$    sudo ip route add default via 192.168.0.100
```

In this example, 192.168.0.100 is the IP address that you will need to set up on the Gateway VM's interface that connects to the client network. To check if you set up your default gateway properly, you can use the following command:

```
$    route -n
```

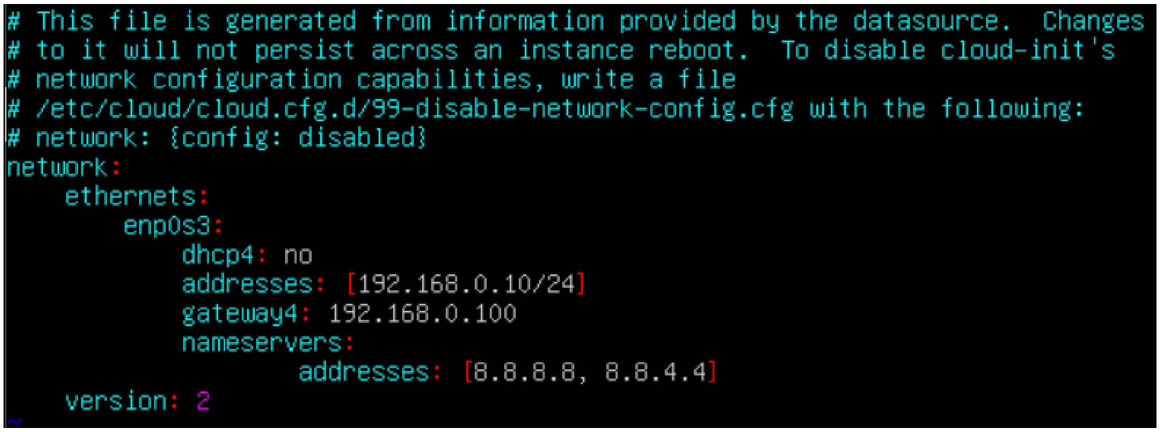
Using ifconfig/route/ip commands, you can set up the network, however if you restart your VM, the system will not keep the configuration. To permanently set up the network, you need to use *netplan* to configure your network. The default netplan configuration file is located in the "/etc/netplan" folder. You can use any editor to set up the configuration (e.g., vim):

```
$    sudo vim /etc/netplan/01-netcfg.yaml
```

For this client network example, you can setup the configuration as follows:

```
network:
  version: 2
  renderer: networkd
  ethernets:
    enp0s3:
      dhcp4: no
      addresses:
        - 192.168.0.10/24
      gateway4: 192.168.0.100
      nameservers:
        addresses: [8.8.8.8, 8.8.4.4]
```

In this example, you configured the client IP address as 192.168.0.10 with network mask 255.255.255.0. The default gateway is set as 192.168.0.1, and the DNS servers are 8.8.8.8 and 8.8.4.4, which are shown in Figure CS-SYS-00101.13.



```
# This file is generated from information provided by the datasource.  Changes
# to it will not persist across an instance reboot.  To disable cloud-init's
# network configuration capabilities, write a file
# /etc/cloud/cloud.cfg.d/99-disable-network-config.cfg with the following:
# network: {config: disabled}
network:
    ethernets:
        enp0s3:
            dhcp4: no
            addresses: [192.168.0.10/24]
            gateway4: 192.168.0.100
            nameservers:
                    addresses: [8.8.8.8, 8.8.4.4]
    version: 2
~
```

Figure CS-SYS-00101.13
Network configuration (netplan) settings for Client VM.

To enable the netplan configuration, issue the command:

```
$    sudo netplan try
```

or

```
$    sudo netplan apply
```

If it is successful, it will reply with a "configuration accept" message. If there is an error, you can try the debug to check syntax or setup error. Then, you can debug the error by the following command:

```
$    sudo netplan -d apply
```

Task 5.2 GATEWAY SETUP

You can use the command "ifconfig" to set up three network interfaces on the Gateway VM (refer to examples given in Task 5.2). First, you need to check available virtual interfaces for the VM by using "ifconfig -a" command. Suppose you client network interface and server network interfaces are enp0s3 and enp0s9, respectively. Then, to setup IP addresses for two internal networks, you can use the following ifconfig commands:

```
$    sudo ifconfig enp0s3 192.168.0.100 netmask 255.255.255.0 up
$    sudo ifconfig enp0s8 10.0.0.100 netmask 255.0.0.0 up
```

The special treatment is given on the NatNetwork since it connects to the host networking environment, which provides the DCHP and DNS service to the Gateway client. In the example, we assume the *enp0s8* interfaces is assigned to the NatNetwork, then you can use the following command to get a DHCP assigned IP address for that interface:

```
$    sudo dhclient enp0s9
```

Then, you can check the network set up by using "ifconfig" and "route -n" commands. They should show the assigned IP address and default gateway set up for this DHCP enabled network.

To permanently set up the configuration, you can create the following netplan configuration on the Gateway VM:

```
$    sudo vim /etc/netplan/01-netcfg.yaml
```

It should contain the following information.

```
  network:
    version: 2
    renderer: networkd
    ethernets:
      enp0s3:
       dhcp4: no
        addresses:
          - 192.168.0.100/24
        nameservers:
          addresses: [8.8.8.8, 8.8.4.4]
      enp0s9:
        dhcp4: yes
        nameservers:
          addresses: [8.8.8.8, 8.8.4.4]
      enp0s8:
        dhcp4: no
        addresses:
          - 10.0.0.100/8
        nameservers:
          addresses: [8.8.8.8, 8.8.4.4]
```

```
$    sudo netplan apply
```

To enable the Gateway forwarding traffic to external networks, you need to configure "iptables" and setup up POSTROUTING NAT rule:

```
$    iptables -t nat -A POSTROUTING -o enp0s9 -j MASQUERADE
```

This iptables rule allows the Gateway VM to forward the packet to external system using the host's IP address, which is routable in the public domain.

Finally, you need to enable IP forwarding on the Gateway VM, and you can just put the following line in /etc/sysctl.conf:

```
  net.ipv4.ip_forward = 1
```

And then run the follwing command to enable the configuration.

```
$    sudo sysctl -p
```

Alternatively, you can also run the following command directly in the command-line to enable the packet fowarding on the Gateway VM.

```
$    sudo sysctl -w net.ipv4.ip_forward=1
```

Task 5.3 SERVER SETUP

The server network setup is similar to the client network setup. First, check if the IP address shows up using command "ifconfig -a", if not, then try the following to manually set the ip:

```
$    sudo ifconfig enp0s3 10.0.0.10 netmask 255.0.0.0 up
```

Then, add default route: (Assume your gateway's network interface is set as 10.0.0.100)

```
$    sudo route add default gw 10.0.0.100
```

To set up the network permanently on the server VM, configure the IP addresses in the netplan configuration file:

```
$    sudo vim /etc/netplan/01-netcfg.yaml
```

```
network:
  version: 2
  renderer: networkd
  ethernets:
    enp0s3:
      dhcp4: no
      addresses:
        - 10.0.0.10/8
      gateway4: 10.0.0.100
      nameservers:
        addresses: [8.8.8.8, 8.8.4.4]
```

Finally, apply these settings:

```
$    sudo netplan -d apply
```

Troubleshooting

If all three VMs are not getting started due to the same VirtualBox image, try the following:

- On a Windows machine, you can do it by following :
  1. Open the Command Prompt
  2. Change the directory to where VirtualBox is installed ($Default : C : /ProgramFiles/Oracle/VirtualBox$)
  3. Type the following command:

```
$         VBOXMANAGE.EXE internalcommands sethduuid PathOfNewVMDK
```

Note that internal commands and *sethduuid* need to be lowercase.

- On a MAC machine, you can follow:
  The underlying logic is the same, as explained before. The different part is that Windows and MAC stores the VirtualBox manager in different locations, and the name of the manager is slightly different.

  1. Open the Command Prompt;
  2. Change to the Virtualbox.app directory (e.g. /Applications/VirtualBox.app/Contents/MacOS)
  3. Type the following command:

```
$         VBoxManage internal commands sethduuid PathOfYourVMDK
```

Related Information and Resource

```
[1] VirtualBox Download page:
https://www.virtualbox.org/wiki/Downloads
[2] VirtualBox User Manual:
https://www.virtualbox.org/manual/UserManual.html
```