



# Parallel Programming

## Homework 1

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## Contents

1. Principle .....	1
2. Goal .....	1
3. Software used .....	1
4. Building Linux Cluster.....	1
4.1 Linux Cluster Structure.....	2
4.2 Oracle VM VirtualBox Manager .....	2
4.3 Downloading Ubuntu 22.04.3 .....	3
4.4 Creating Workmachine .....	3
4.5 Adding User In System .....	5
4.6 Giving Permission To Other User .....	5
5. Basic configurations and services for a Linux Cluster .....	6
5.1 Downloading Ubuntu Server.....	6
5.2 Install Ubuntu Server For Linux Cluster .....	6
5.3 Node 1 and Node 2 Created.....	9
5.4 sudo apt install net-tools .....	9
5.5 Checking Network Setting.....	10
5.6 Creating Nat Network .....	10
5.7 Setting Nat Network For Work Machine.....	12
5.8 Setting Nat Network For Node1.....	13
5.9 Setting Nat Network For Node 2.....	13
5.10 Demonstration of Linux Cluster .....	14
5.11 Creating enp0s8 .....	15
5.12 Setting Up enp0s8 Network.....	15
5.13 sudo apt install ifupdown.....	16
5.14 ifconfig node1 .....	16
5.15 ifconfig node1 Default .....	17
5.16 ifconfig node1 Updated .....	17
5.17 Node2.....	18
5.18 Work-machine sudo vim /etc/hosts .....	19
5.19 sudo hostnamectl set-hostname workmachine.cluster.local.....	20
5.20 Node 1.....	20
5.21 Node 2 .....	22

5.22 Work-machine's Entry Point .....	23
5.23 Workmachine Ping Result .....	24
5.24 Node 1 Ping Result .....	24
5.25 Node 2 Ping Result .....	25
6. SSH .....	25
6.1 Enable SSH server.....	25
6.2 sudo systemctl status ssh.....	26
6.3 sudo systemctl enable ssh .....	26
6.4 Node 1.....	27
6.5 Node 2.....	28
6.6 Generate SSH key For WorkMachine.....	30
6.7 Public key .....	31
6.8 Connecting in node1 .....	31
6.9 Result of node1.....	32
6.10 Result of node2 .....	33
7. NIS .....	34
7.1 Problem Faced in NIS .....	34
7.2 Installation NIS system.....	35
7.3 On the server side .....	35
7.3.1 sudo vim /etc/default/nis .....	35
7.3.2 sudo vim /etc/ypserv.securenets.....	36
7.3.3 Makefile for the NIS databases.....	37
7.4 On the Server Side .....	37
7.4.1 /usr/lib/yp/ypinit -m .....	38
7.4.2 Adding user .....	38
7.4.3 Make .....	39
7.4.4 NIS Activate .....	39
7.4.5 Setting Up The NIS Server .....	40
7.5 sudo apt-get install portmap nis .....	40
7.6 Ping Testing Workmachine .....	41
7.7 apt-get install rpcbind and apt-get install portmap.....	41
7.8 vim /etc/yp.conf.....	42
7.9 vim /etc/nsswitch.conf .....	42

7.10 vi /etc/pam.d/common-session.....	43
7.11 Restarting systemctl.....	43
8. NFS .....	44
8.1 Install nfs server on master machine.....	44
8.2 Creating a directory .....	44
8.3 Install gedit.....	45
8.4 Checking Firewall Status .....	47
8.5 status nfs-kernel-server.service .....	48
8.6 Install nfs client as slave node 1 and node2 .....	49
9.MPI .....	51
9.1 sudo apt-get install openmpi-bin libopenmpi-dev .....	51
9.2 sudo apt-get install gcc .....	51
9.3 Connecting with Sharedfolder .....	52
9.4 sudo apt-get install mpich.....	52
9.5 Assigning 2 processor for each node .....	53
9.6 Node 1.....	54
9.7 Node 2 .....	56
9.8 Result .....	58
10. Conclusion.....	60
11.Acknowledgement .....	60
11. Reference .....	60

## **1. Principle**

In this experiment, you will learn how to build a Linux cluster for parallel programming and parallel computing using 2-3 physical machines or virtual machines. One of them is acting as a management node, the other nodes are computing nodes. The computing nodes should be accessed using SSH without requiring password. And you can install MPI and run MPI programs based on the basic services such as SSH, NFS and NIS.

## **2. Goal**

- Master virtualization technology , to create 2-3 virtual machines (optional) ;
- Master some common Linux commands, such as useradd etc.
- Master some basic configurations and services for a Linux cluster, such as SSH,NIS,NFS ;
- Master the installation and usage of gcc or Intel compilers (optional);
- Master the installation of MPI and running of MPI programs.

## **3. Software used**

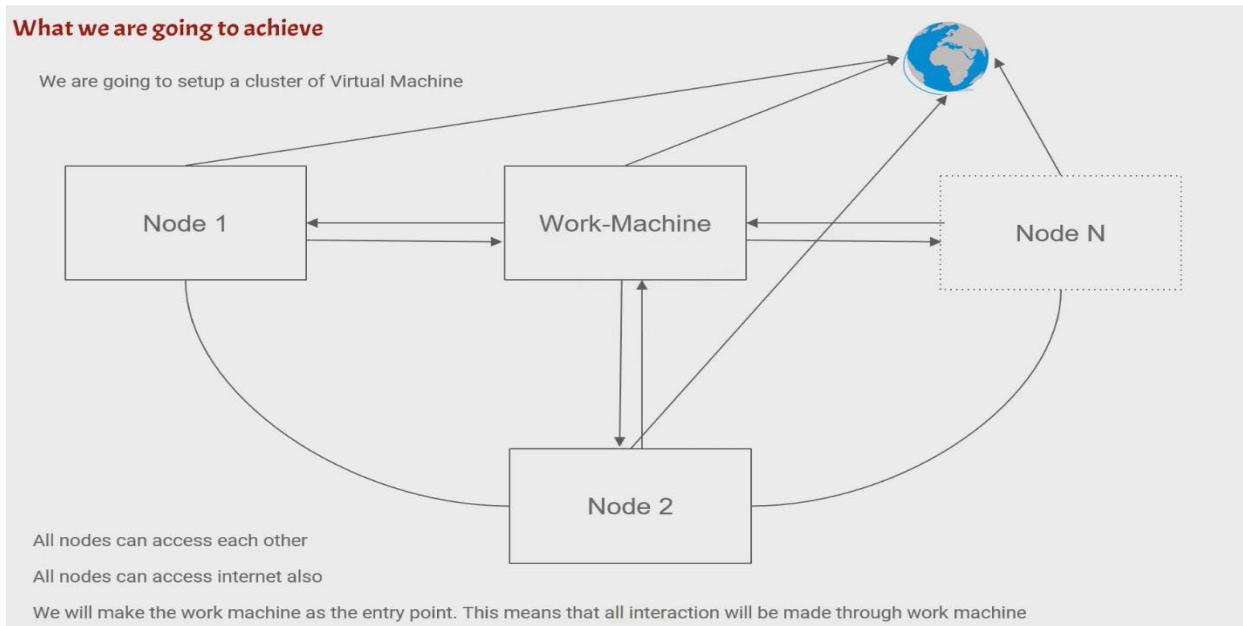
- (a) Virtual Box
- (b) Linux Ubuntu Distro -20.04.3-
- (c)

## **4. Building Linux Cluster**

### **#Structure:**

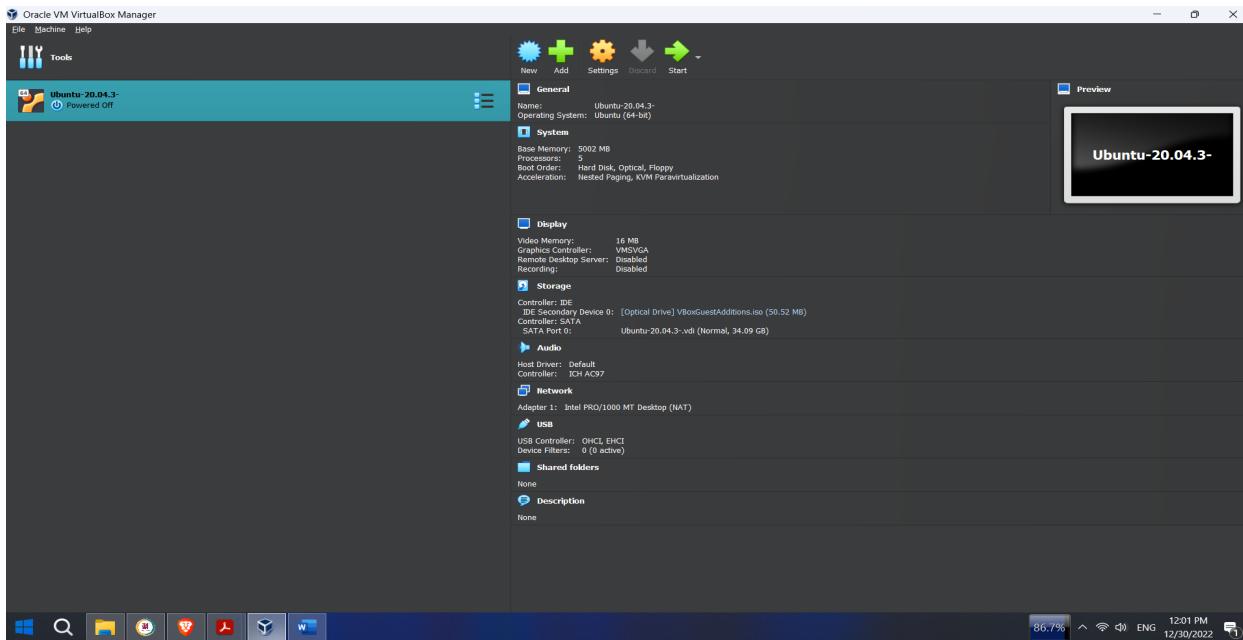
This is how our cluster will run. The work machine is our main machine(client) and can talk to both nodes while the nodes can talk to the work machine as well. Alongside the nodes will be able to contact each other and every machine can individually connect to internet.

## 4.1 Linux Cluster Structure



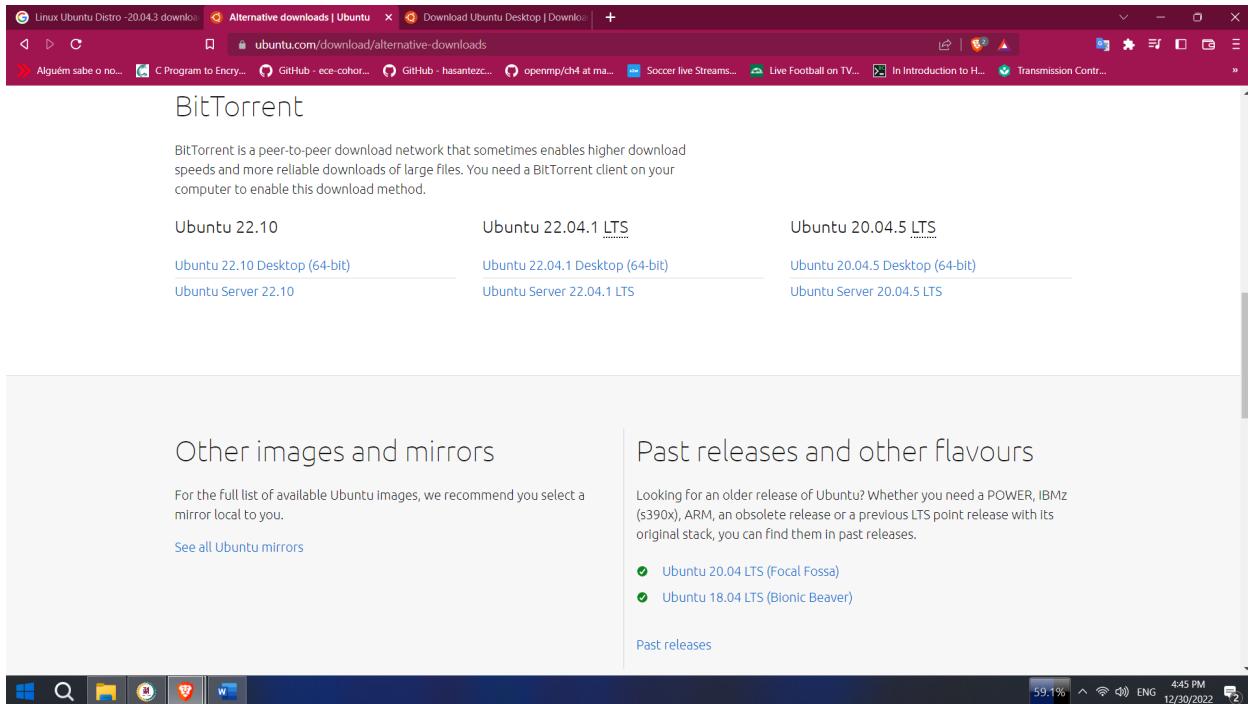
**Figure: Linux Cluster Structure**

## 4.2 Oracle VM VirtualBox Manager



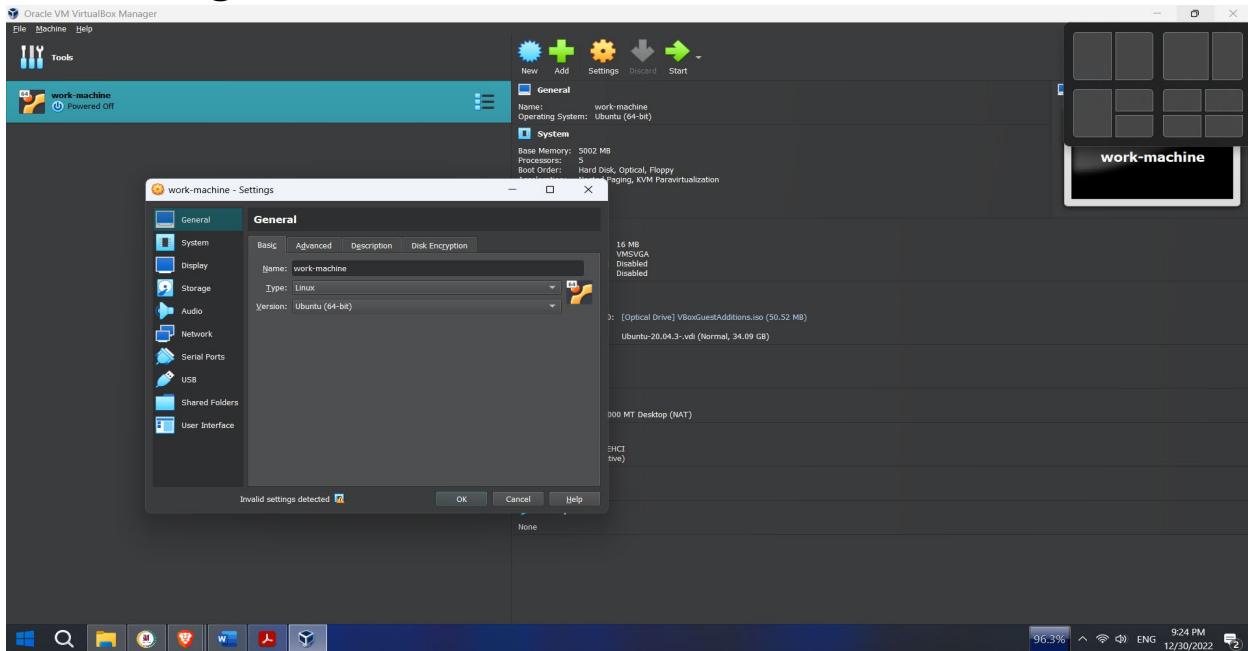
**Figure: Oracle VM VirtualBox Manager Interface**

## 4.3 Downloading Ubuntu 22.04.3

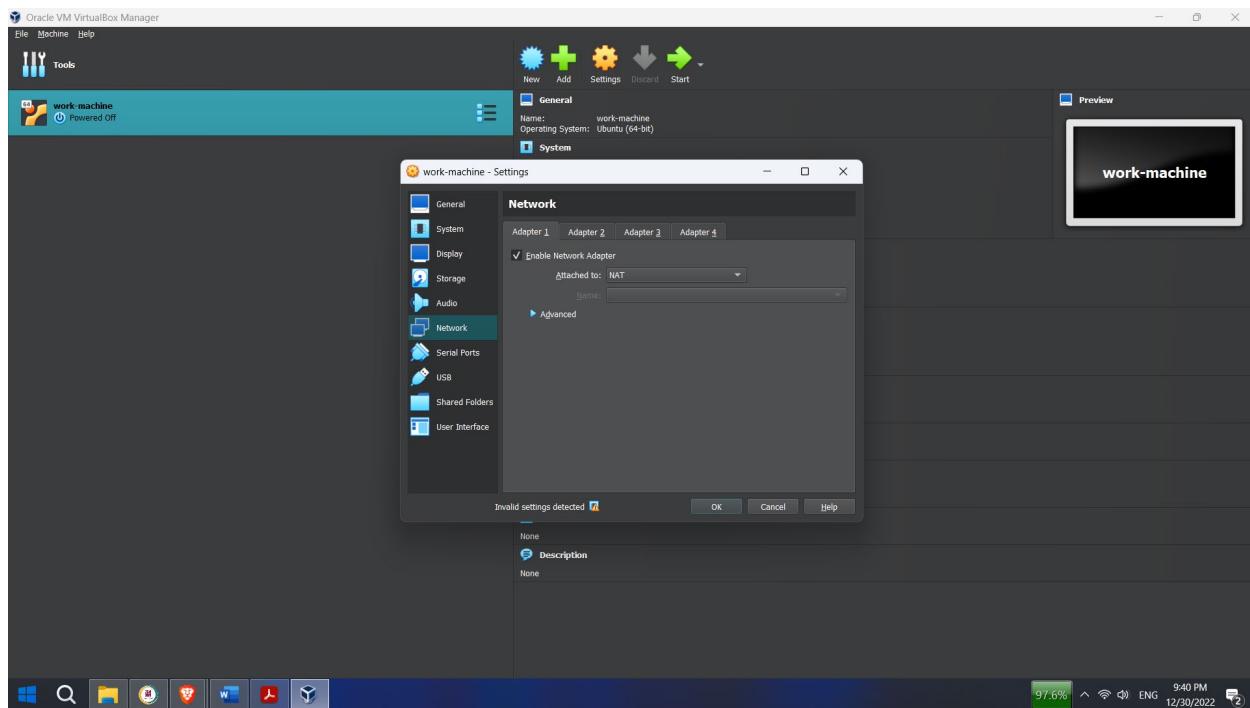


**Figure: Downloading Ubuntu 22.04.3**

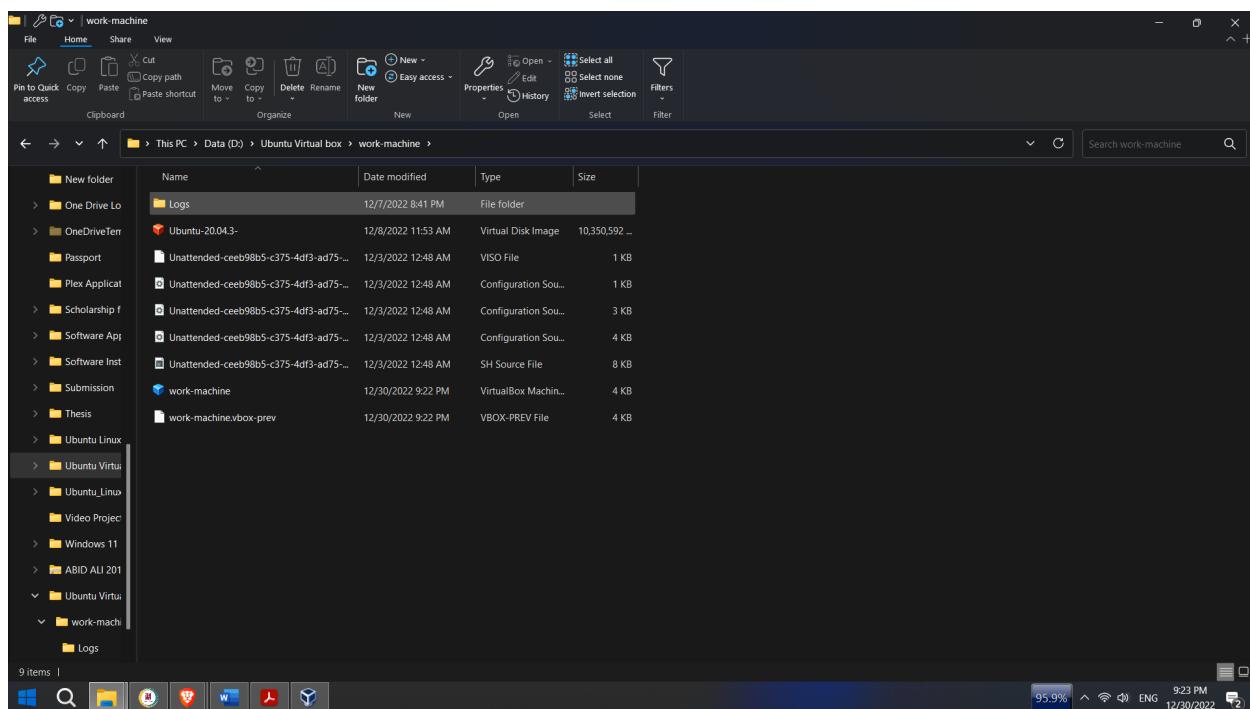
## 4.4 Creating Workmachine



**Figure: Created Workmachine**



## Figure: Created Workmachine (1)



## Figure: Created Workmachine (2)

## 4.5 Adding User In System

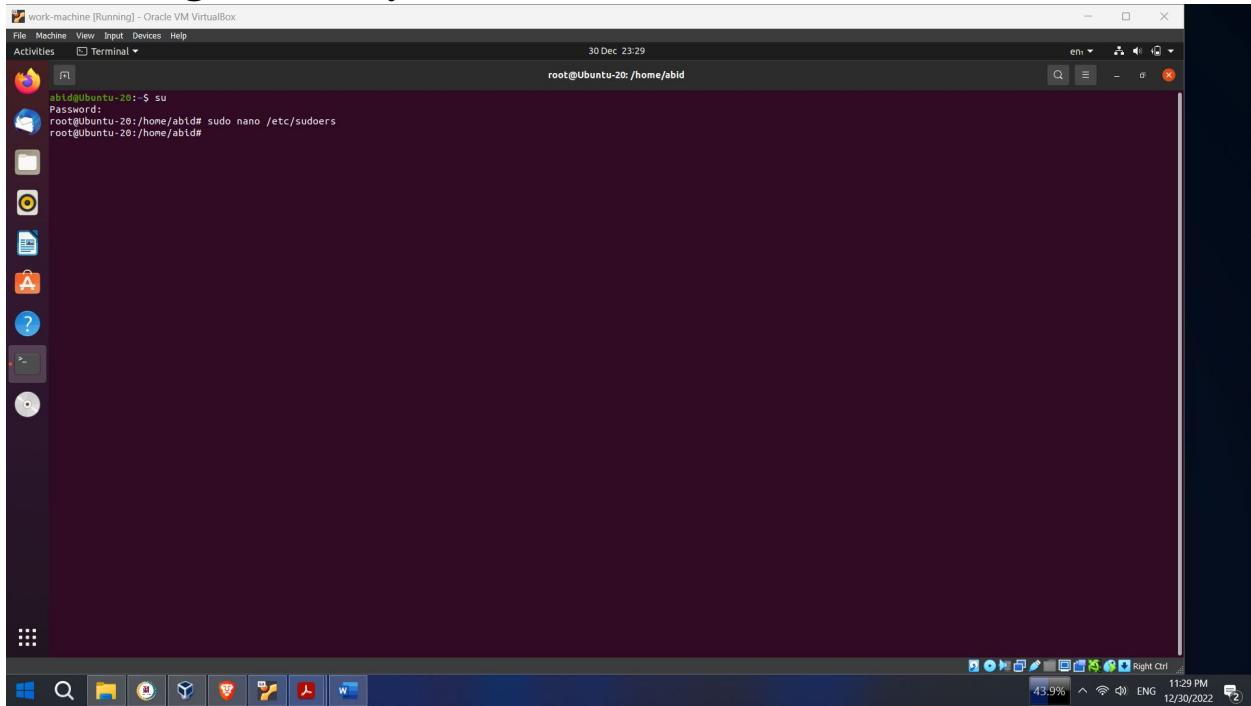


Figure: Added User In The System

## 4.6 Giving Permission To Other User

A screenshot of a Linux desktop environment, specifically Ubuntu, running in Oracle VM VirtualBox. The terminal window is open and shows the root user editing the '/etc/sudoers' file using 'nano'. The screen displays the configuration for granting sudo privileges to the 'abid' user. The terminal window title is 'Terminal' and the path is 'root@Ubuntu-20:/home/abid'. The desktop interface includes a dock with various icons at the bottom.

Figure: Permission To Other User

## 5. Basic configurations and services for a Linux Cluster

### 5.1 Downloading Ubuntu Server

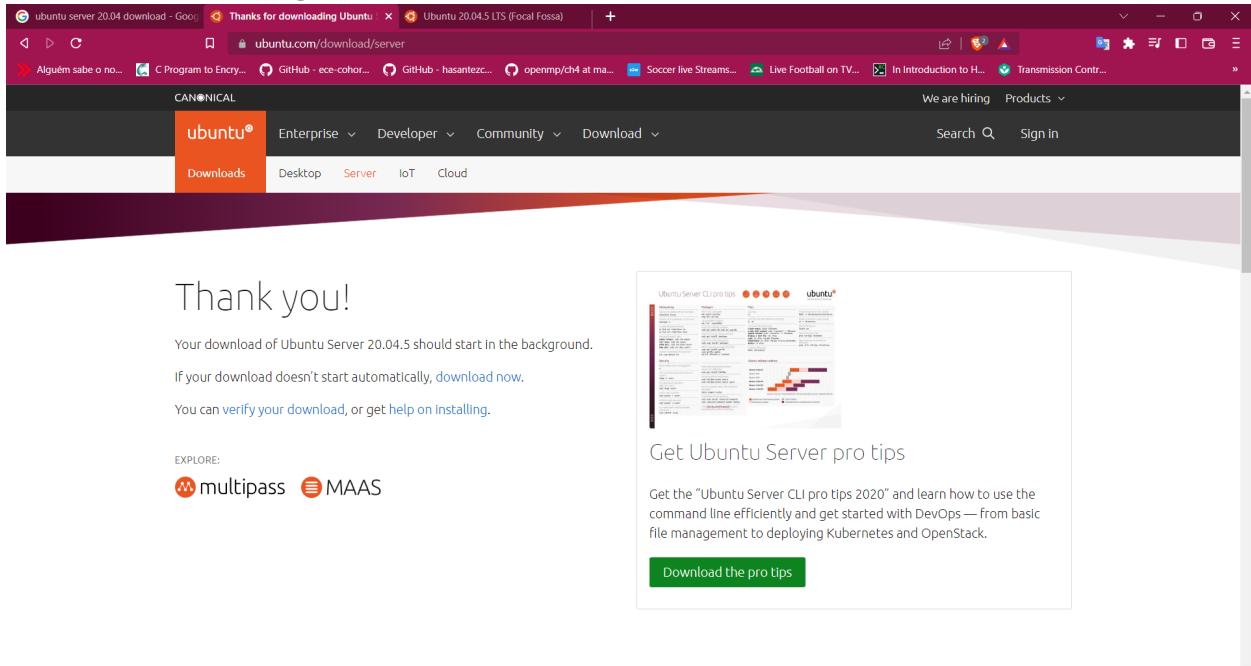


Figure: Downloading Ubuntu Server

### 5.2 Install Ubuntu Server For Linux Cluster

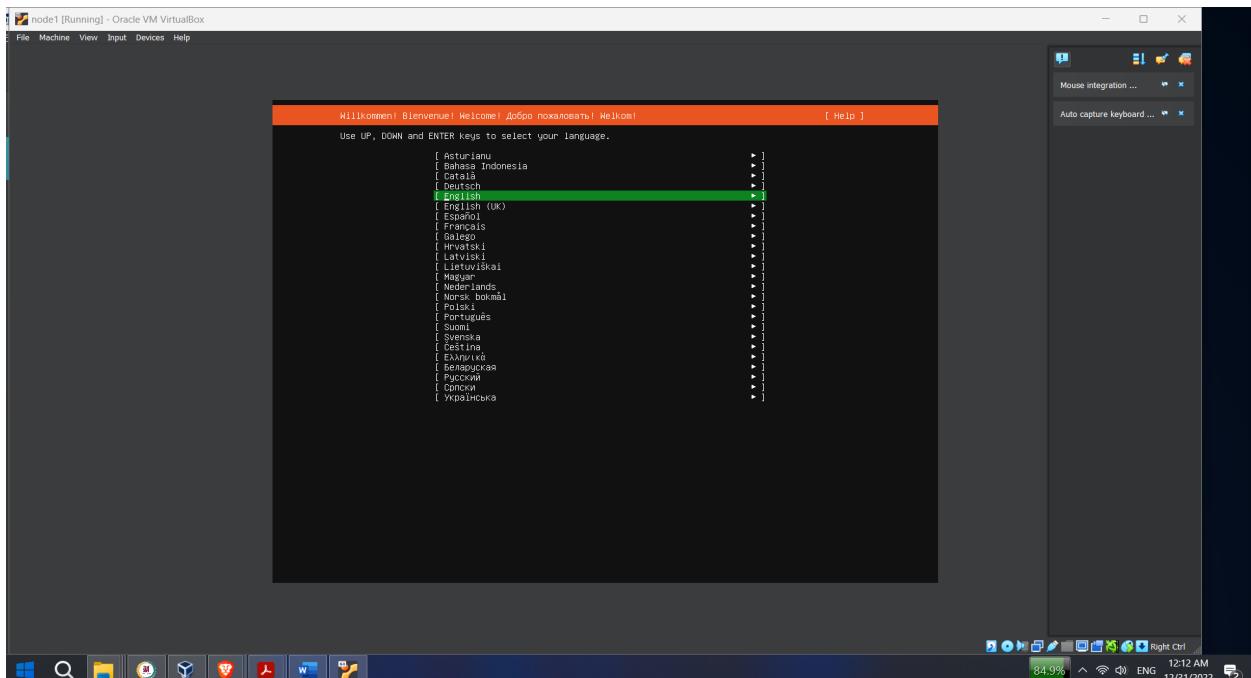
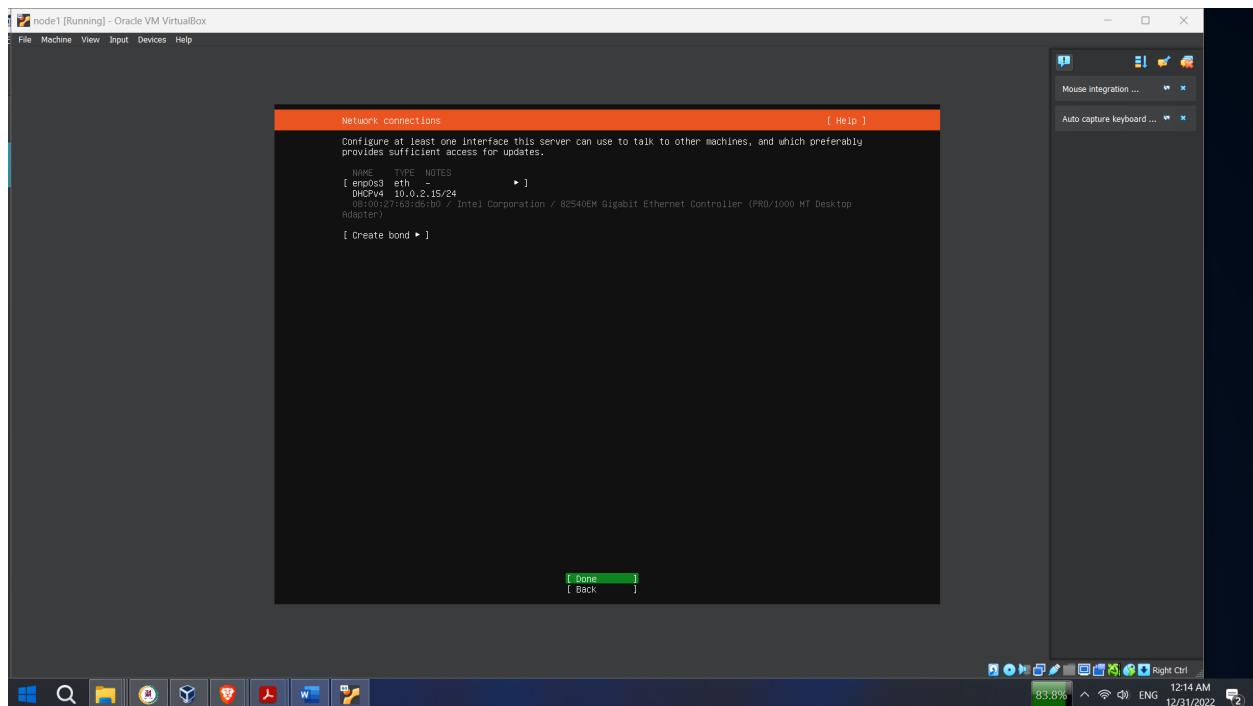
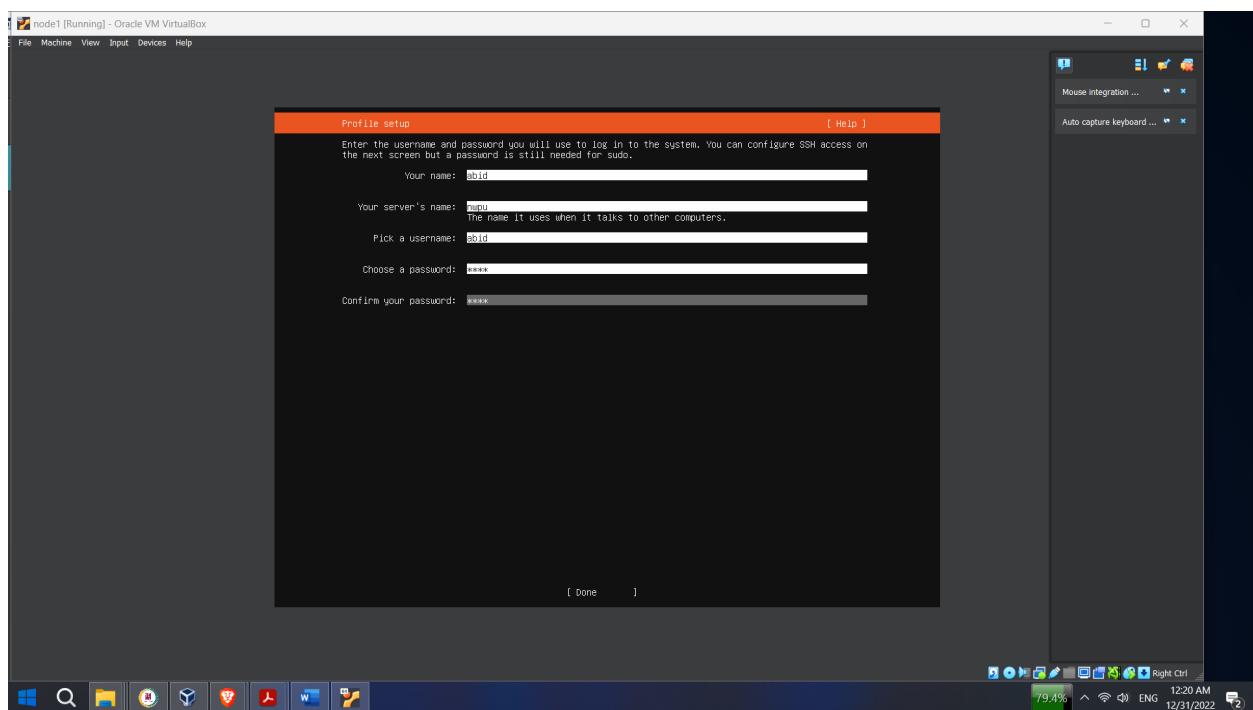


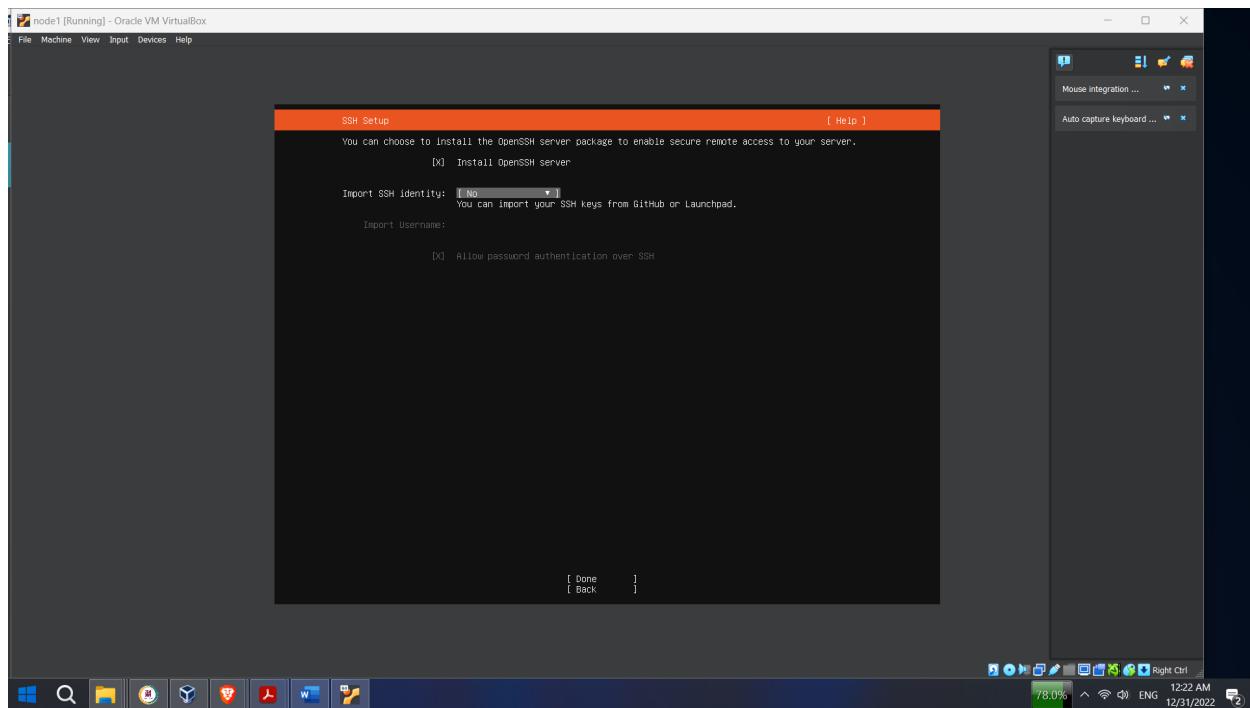
Figure: Installing Ubuntu Server For Linux Cluster



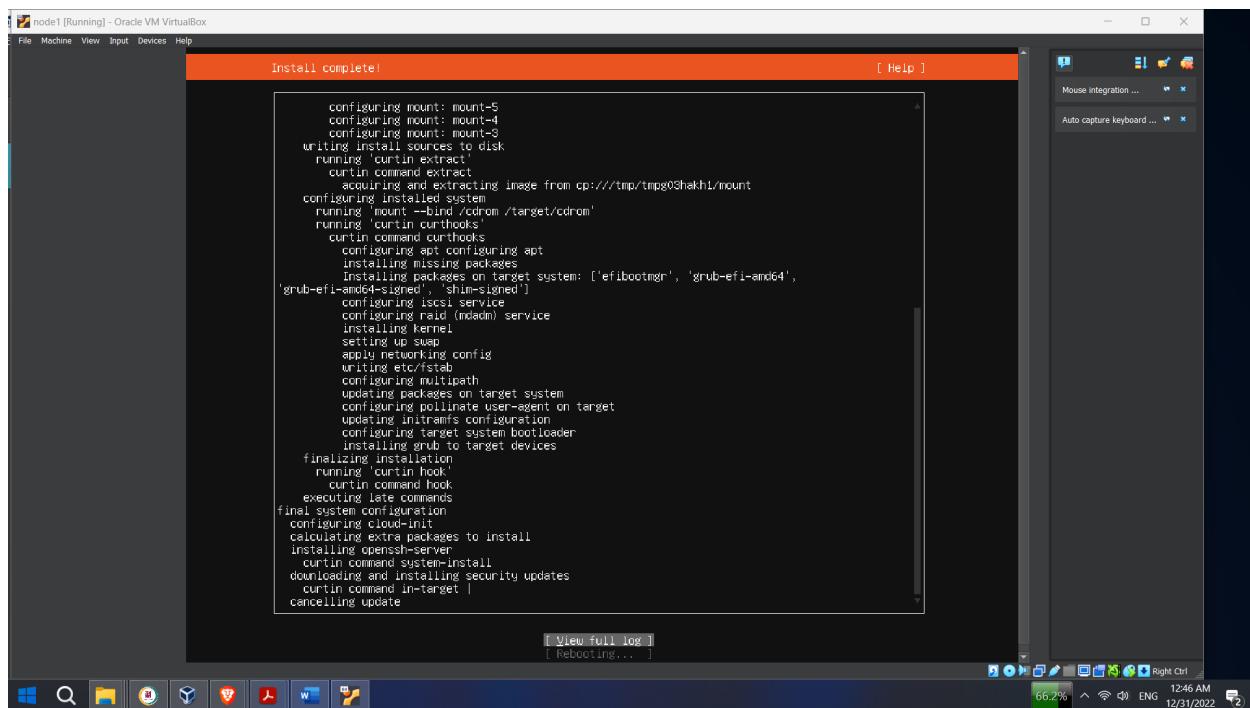
**Figure: Installing Ubuntu Server For Linux Cluster (1)**



**Figure: Installing Ubuntu Server For Linux Cluster (2)**



**Figure: Installing Ubuntu Server For Linux Cluster (3)**



**Figure: Installing Ubuntu Server For Linux Cluster (4)**

## 5.3 Node 1 and Node 2 Created

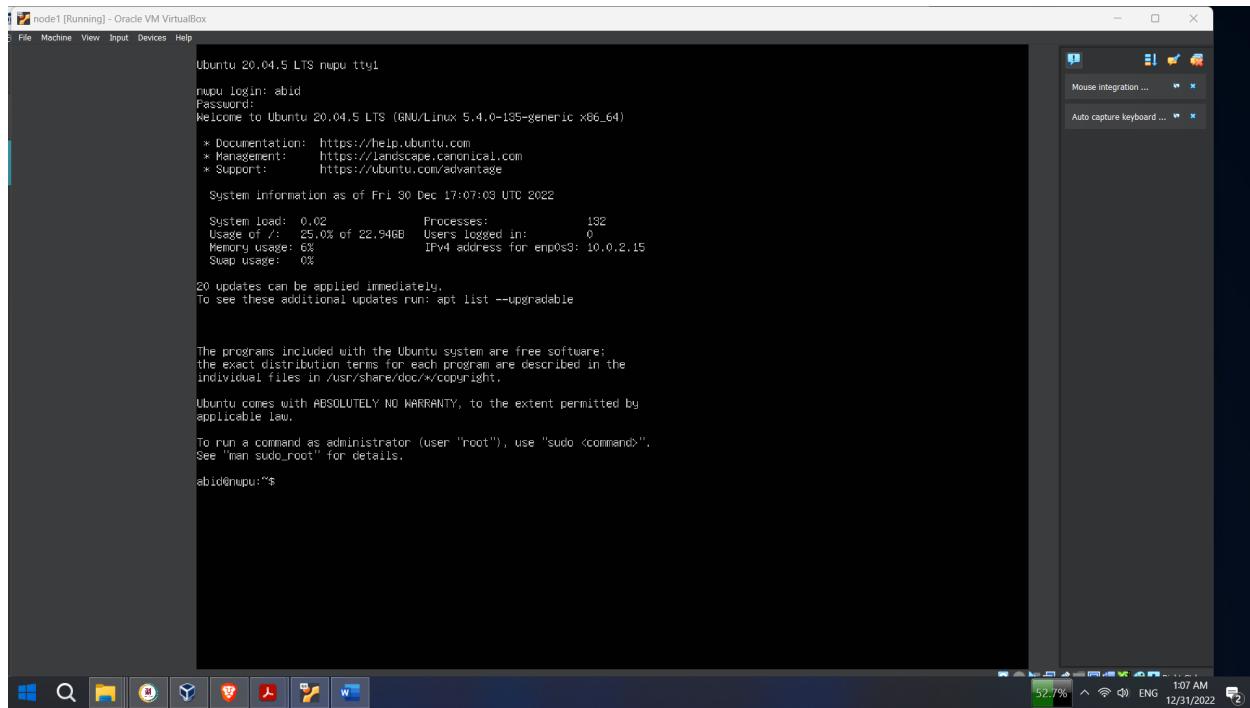
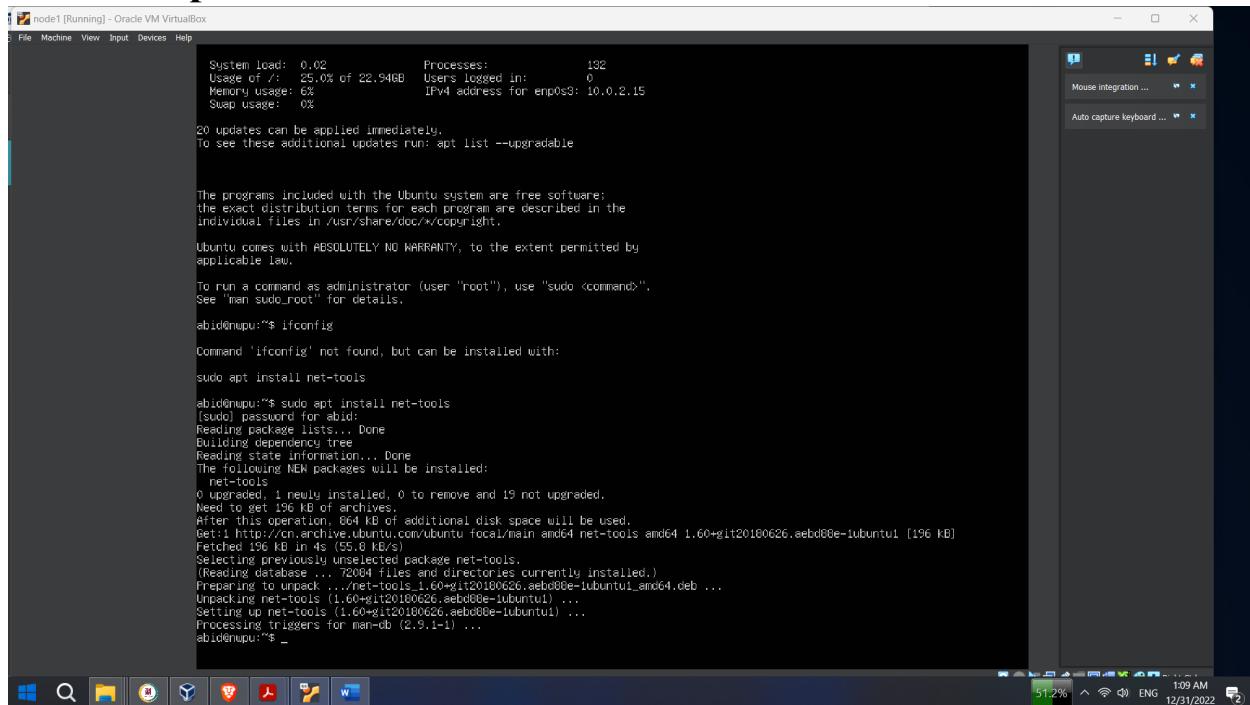


Figure: Node 1 and Node 2

## 5.4 sudo apt install net-tools



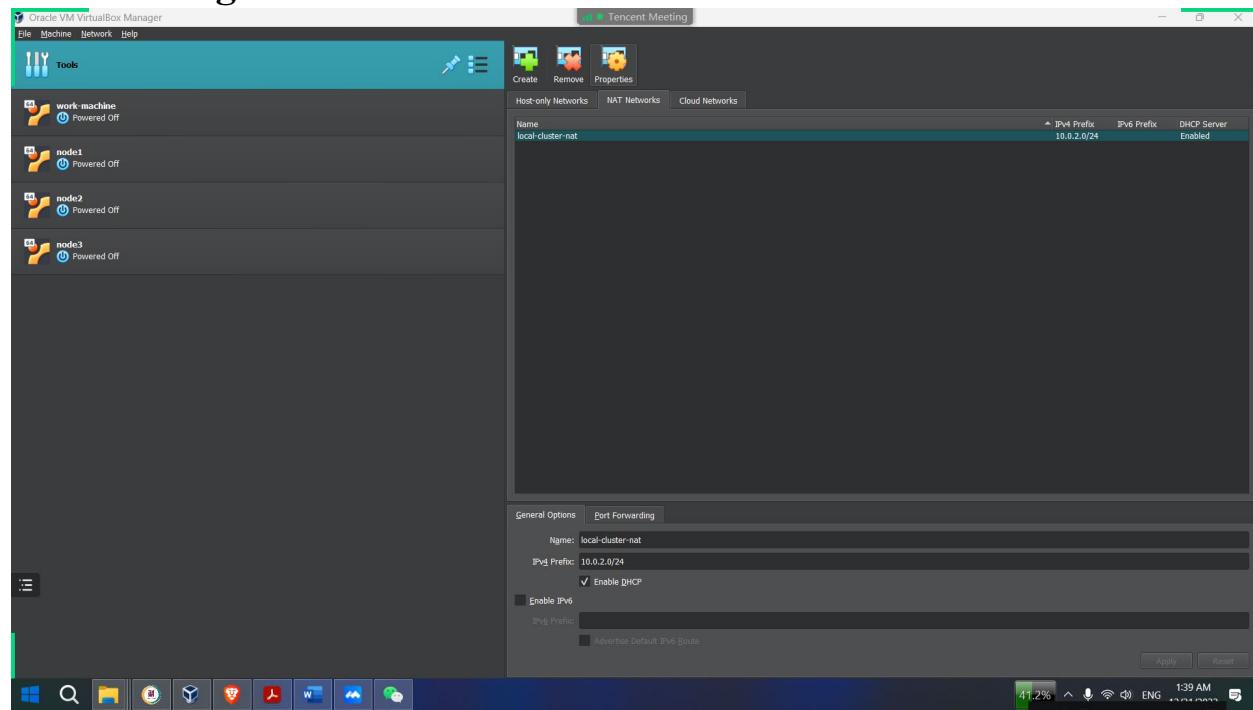
sudo apt install net-tools

## 5.5 Checking Network Setting

```
abi@npu:~$ ifconfig
enp0s9: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
                inet6 fe80::a00:27ff:fe69:d6b0 prefixlen 64 scopeid 0x20<link>
                    ether 08:00:27:69:d6:b0 txqueuelen 1000 (Ethernet)
                    RX packets 414 bytes 479622 (479.6 KB)
                    RX errors 0 dropped 0 overruns 0 frame 0
                    TX packets 172 bytes 19916 (19.9 KB)
                    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

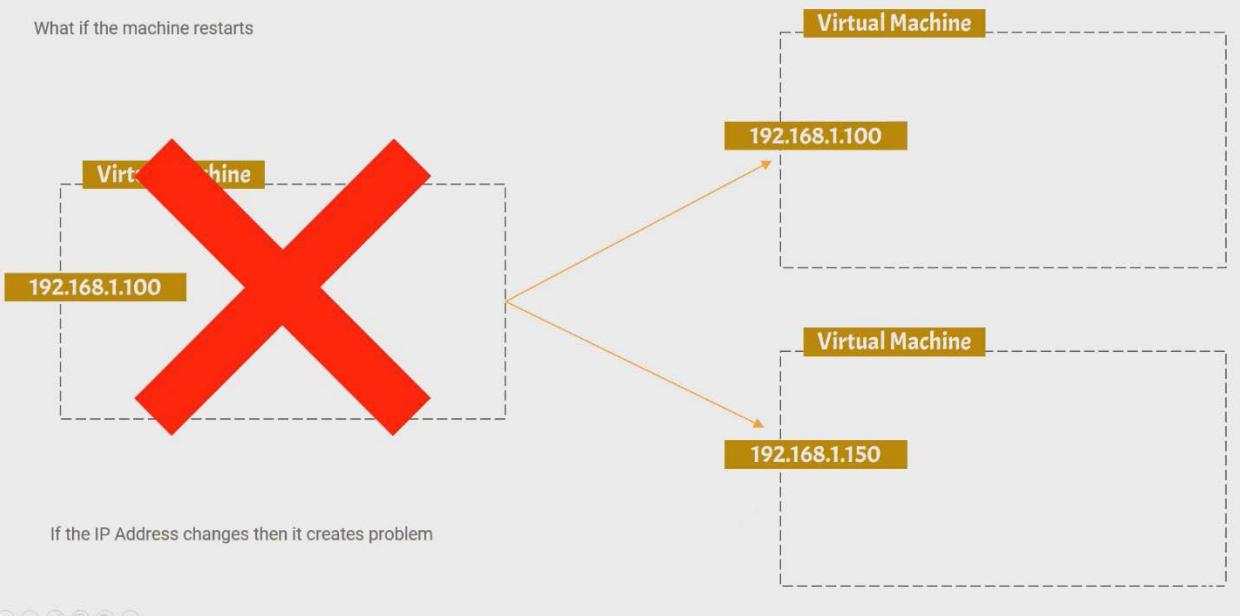
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
        inet 127.0.0.1 netmask 255.0.0.0
                inet6 ::1 prefixlen 128 scopeid 0x10<host>
                    loop txqueuelen 1000 (Local Loopback)
                    RX packets 114 bytes 9224 (9.2 KB)
                    RX errors 0 dropped 0 overruns 0 frame 0
                    TX packets 114 bytes 9224 (9.2 KB)
                    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

## 5.6 Creating Nat Network



If the machine is running then it will have an IP Address

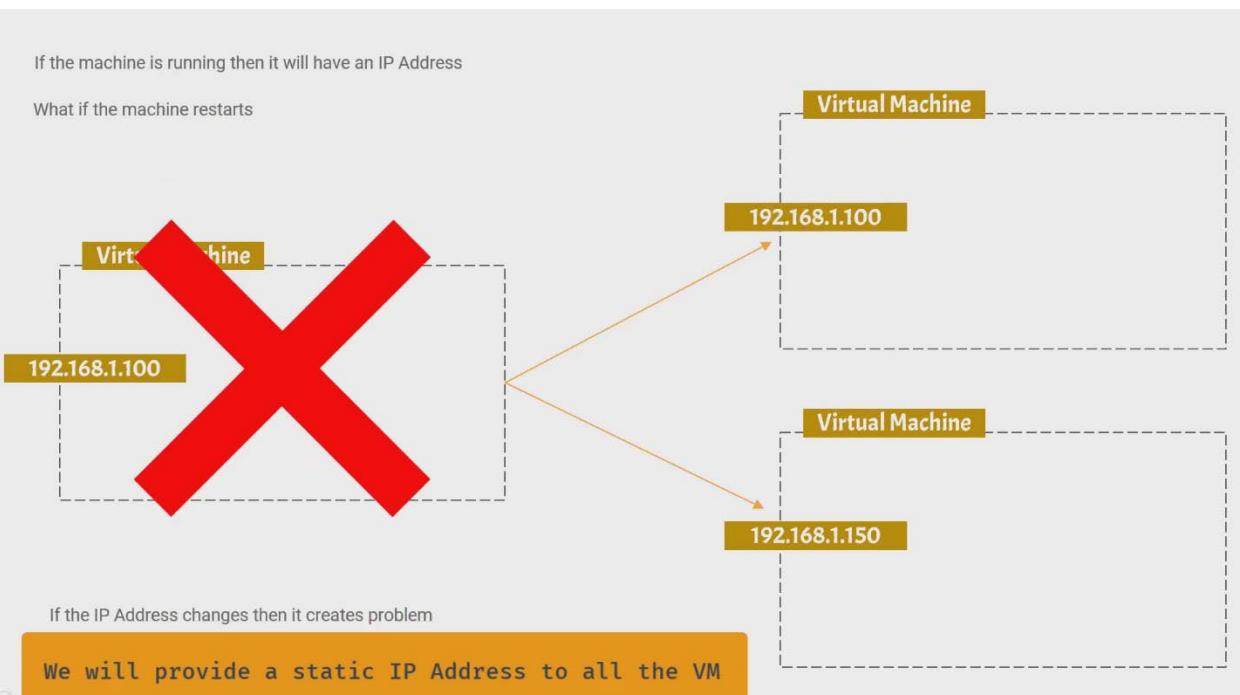
What if the machine restarts



If the IP Address changes then it creates problem

If the machine is running then it will have an IP Address

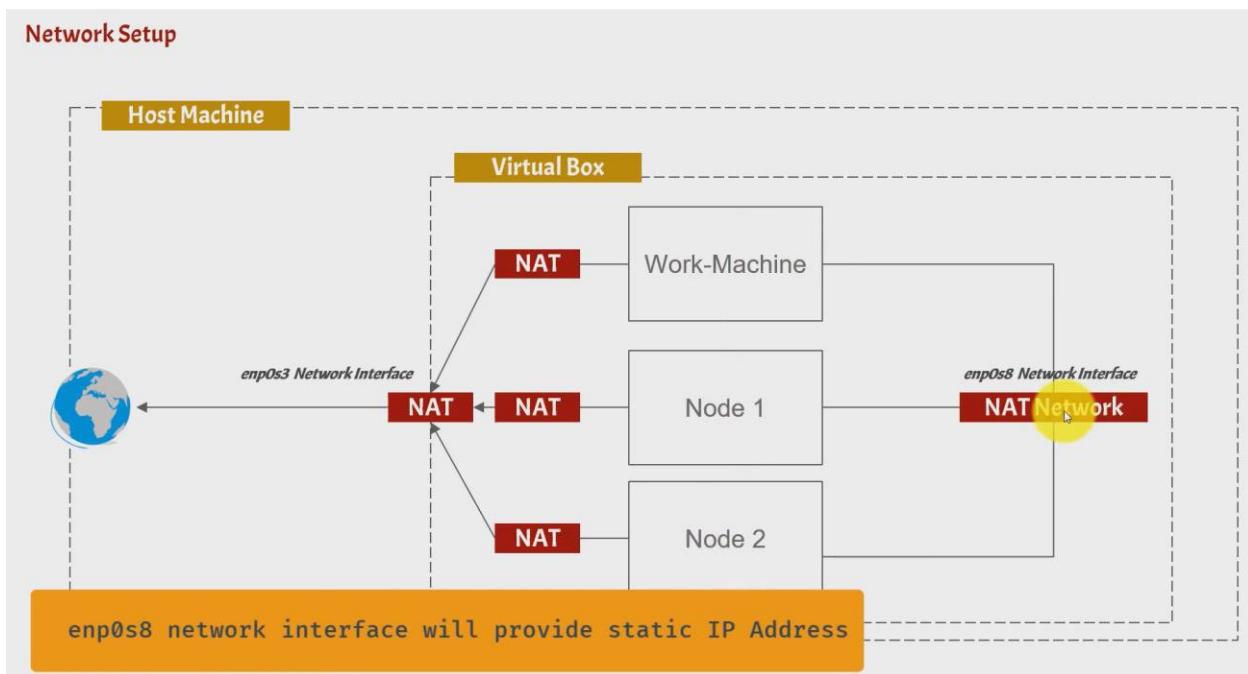
What if the machine restarts



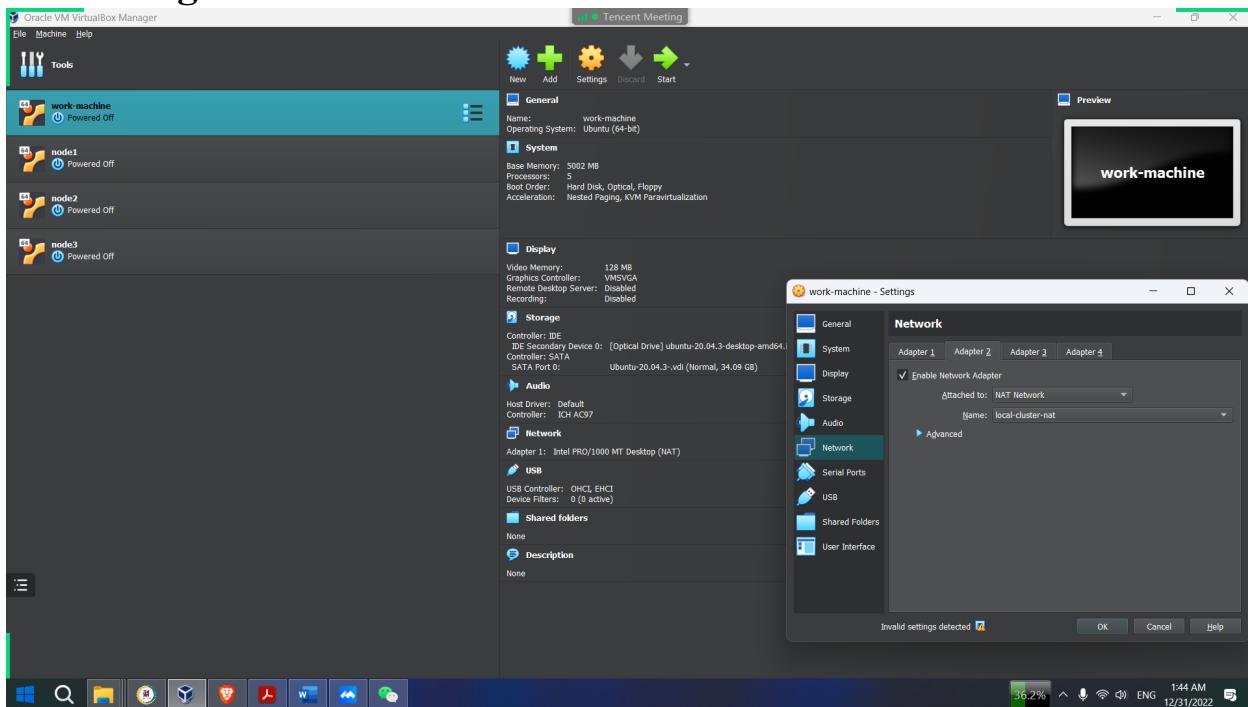
If the IP Address changes then it creates problem

We will provide a static IP Address to all the VM

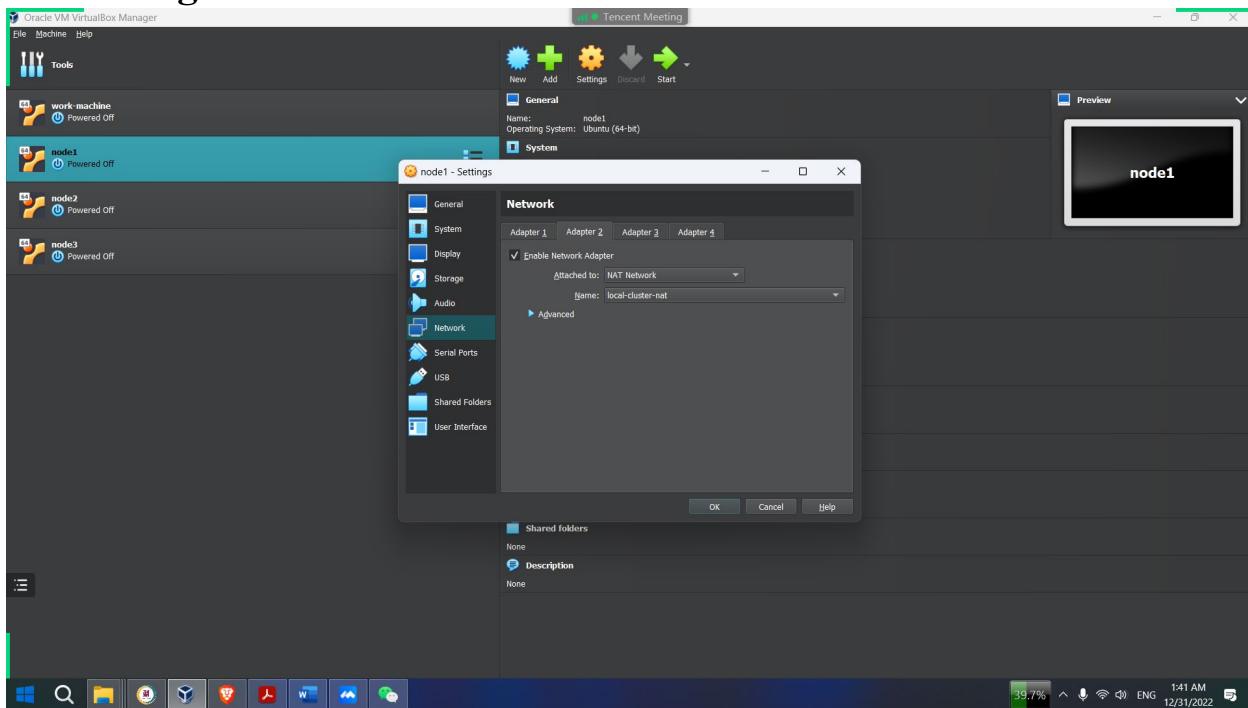
## Network Setup



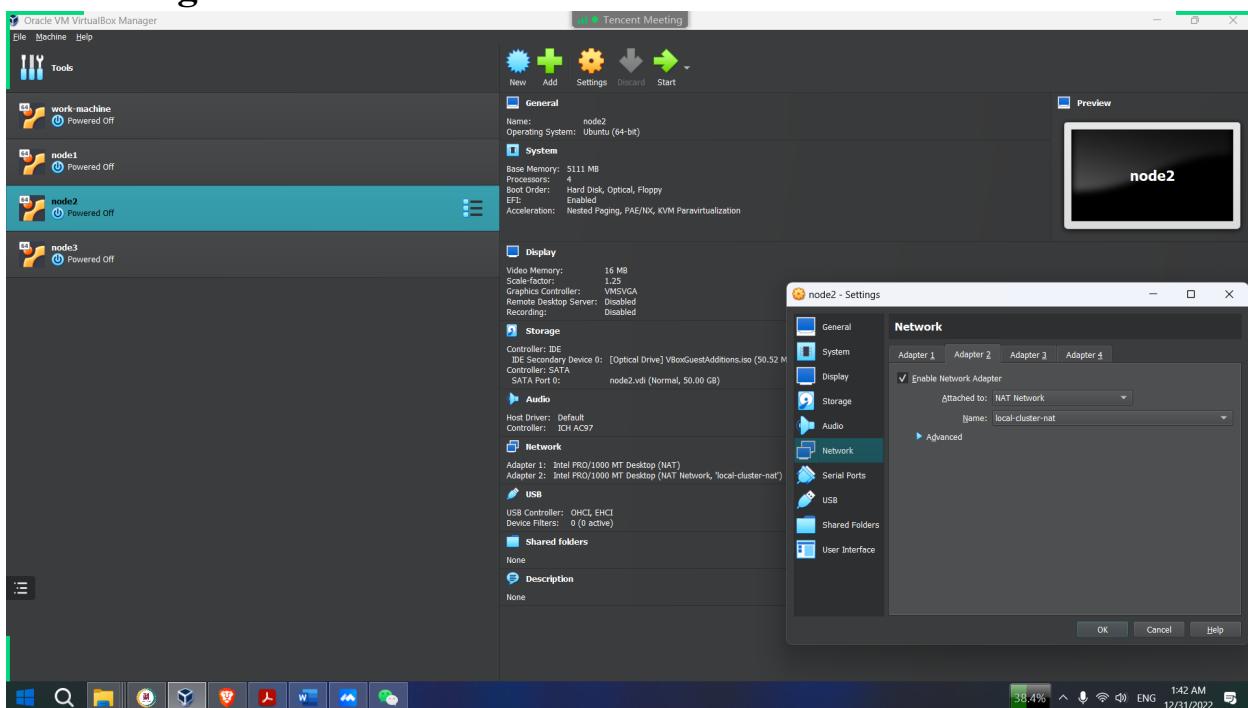
## 5.7 Setting Nat Network For Work Machine

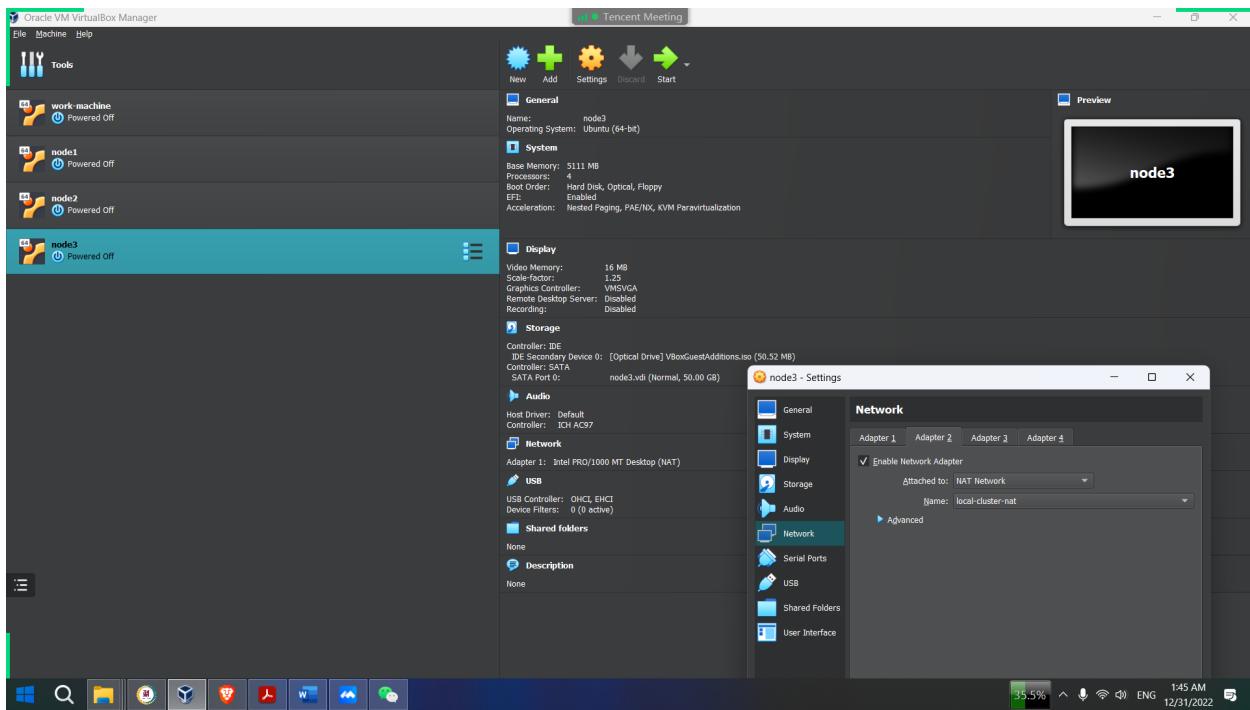


## 5.8 Setting Nat Network For Node1

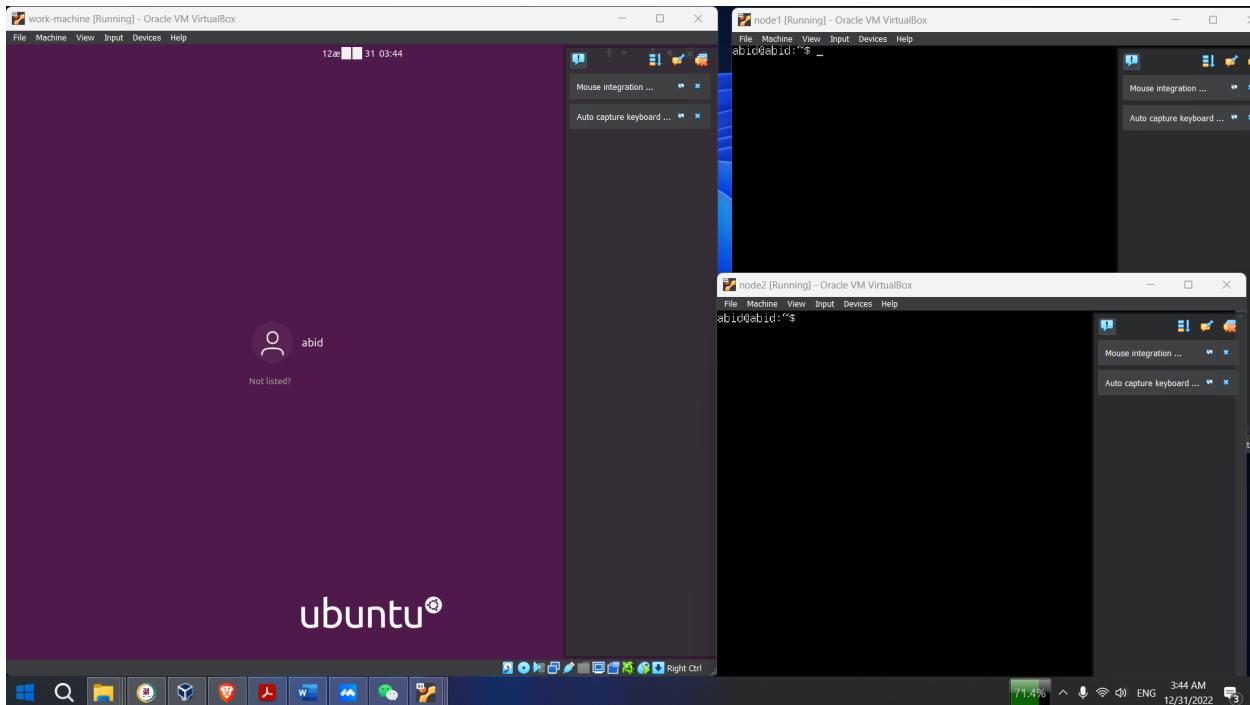


## 5.9 Setting Nat Network For Node 2





## 5.10 Demonstration of Linux Cluster



**Figure: Demonstration of Linux Cluster**

## 5.11 Creating enp0s8

The screenshot shows a Linux desktop environment with a terminal window open. The terminal window title is "Activities Terminal" and the date and time are "31 Dec 04:37". The user is "abid@Ubuntu-20: ~". The terminal displays the output of the command "sudo ifup enp0s8", which brings up the interface and shows its configuration and statistics. The interface has an MTU of 1500, an IP address of 10.0.2.15, and is connected via an Ethernet card (ether). RX and TX statistics are shown for the interface. Below this, the terminal shows the configuration for the loopback interface (lo) with an MTU of 65536 and an IP address of 127.0.0.1. The desktop environment includes a dock with various icons and a system tray at the bottom right.

## Figure: Creating enp0s8

## 5.12 Setting Up `enp0s8` Network

The screenshot shows a desktop environment within a virtual machine. The desktop has a dark red background. On the left is a vertical dock containing icons for various applications: a browser, file manager, terminal, calendar, notes, dash, and system settings. The main workspace is mostly empty. In the top right corner, there is a system tray with icons for battery (64.0%), signal strength, and system status. The bottom of the screen features a dock with icons for the Dash, Home, Task View, and several application icons.

Activities Terminal 31 Dec 04:37 abid@Ubuntu-20: ~

```
auto enp0s8
iface enp0s8 inet static
    address 192.168.1.110
    netmask 255.255.255.0
    network 192.168.1.0
    broadcast 192.168.1.255
```

/etc/network/interfaces 6L, 145C 6.28 All

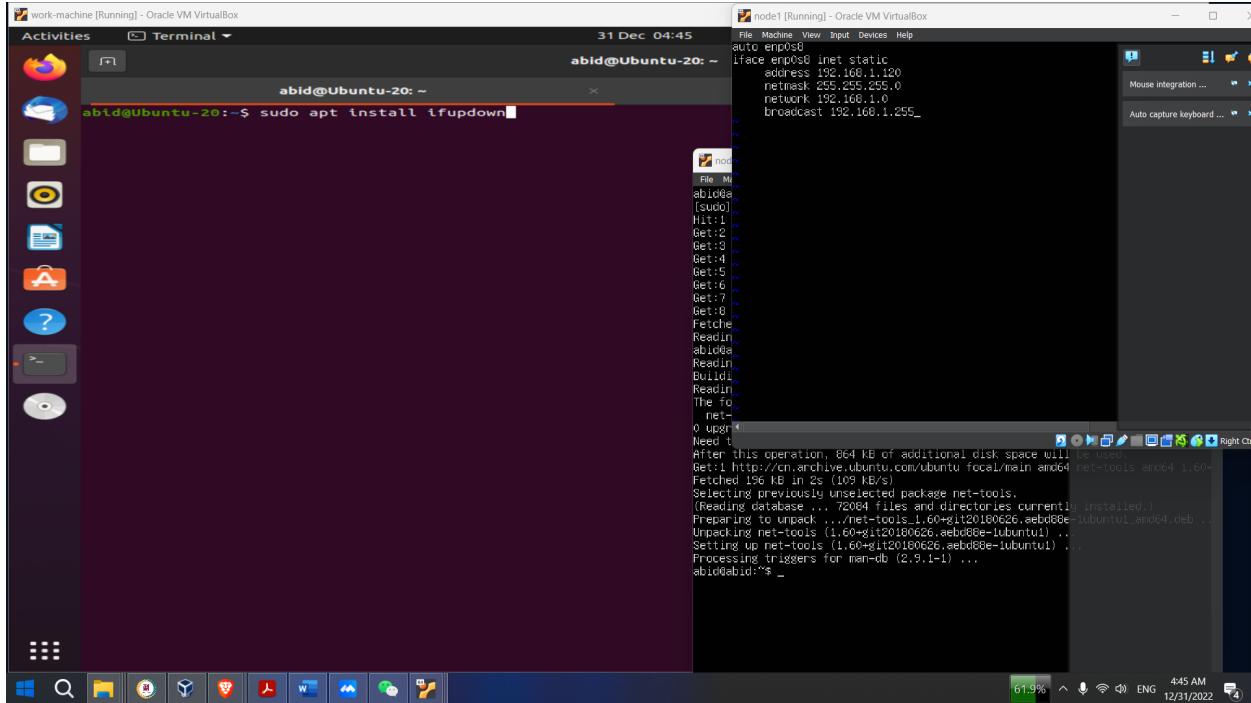
en: Mouse integration ...  
Auto capture keyboard ...

64.0% 437 AM 12/31/2022

## Figure: Setting Up enp0s8 Network

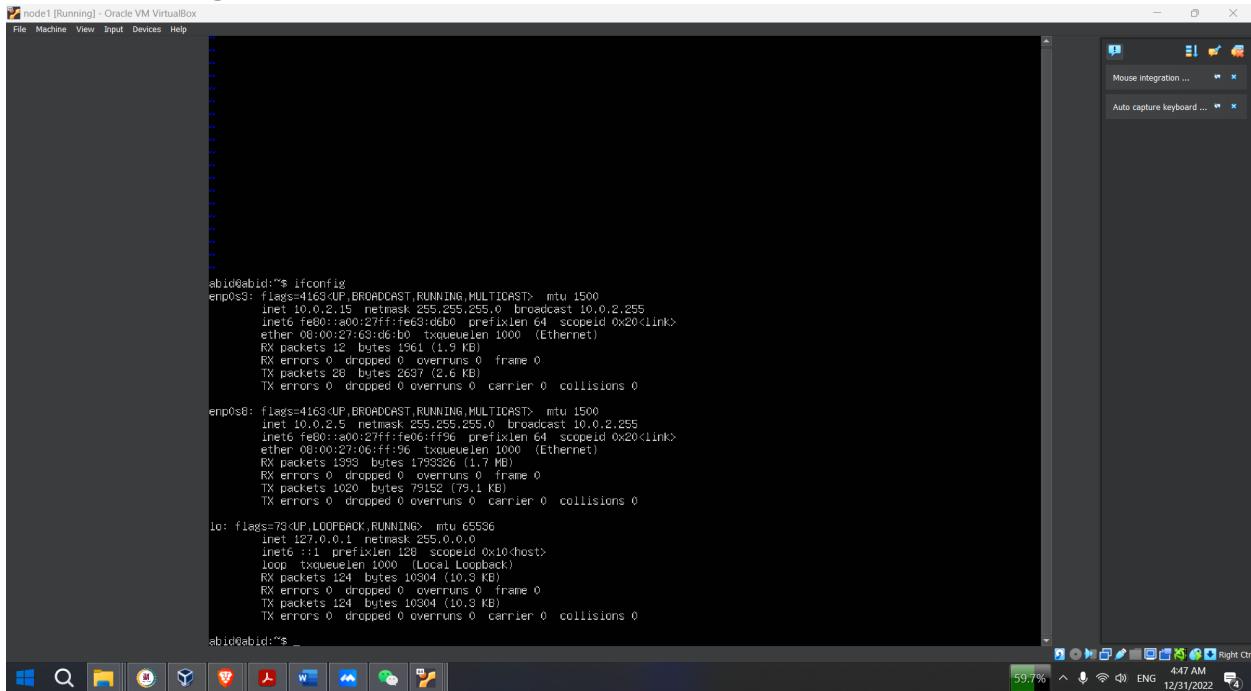
## 5.13 sudo apt install ifupdown

workmachine



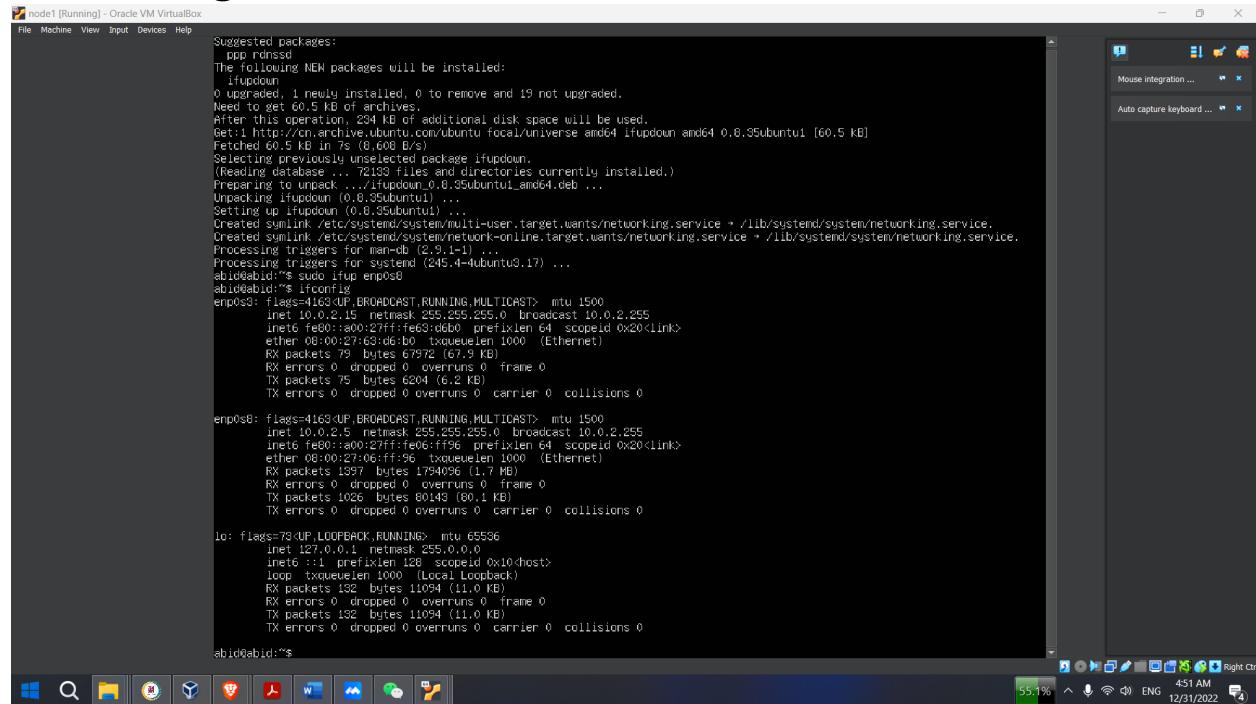
`sudo apt install ifupdown`

## 5.14 ifconfig node1



`ifconfig`

## 5.15 ifconfig node1 Default



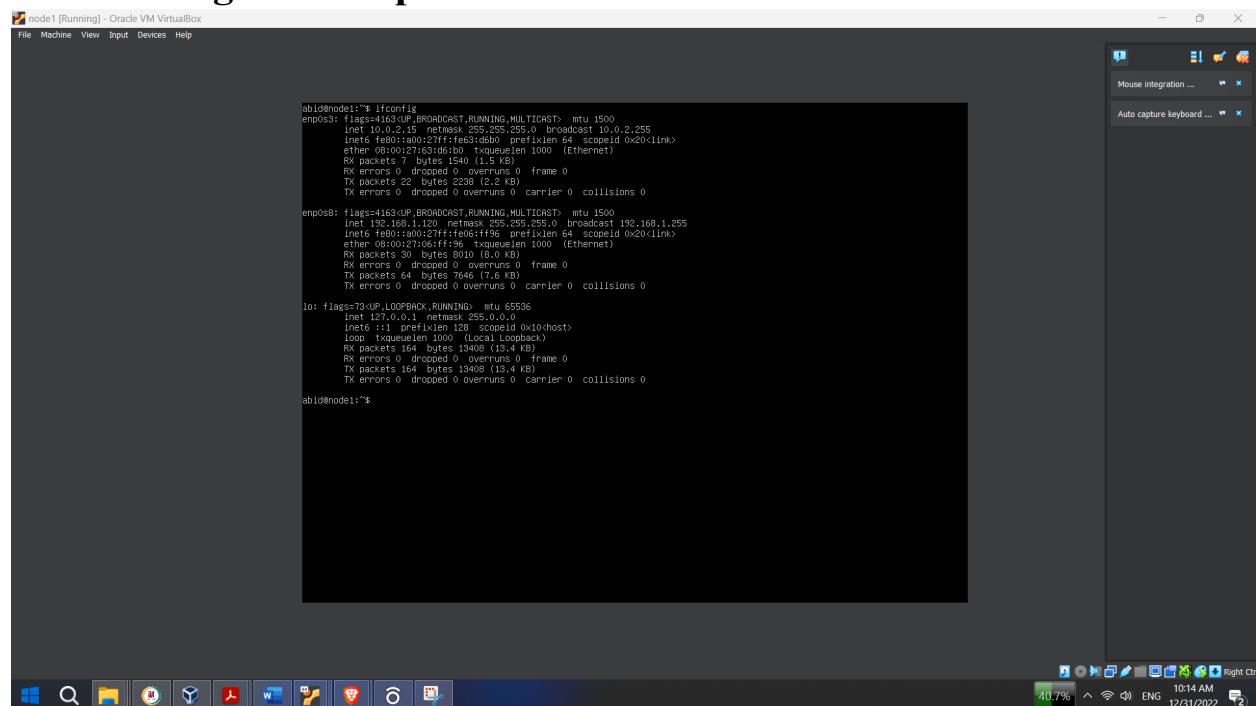
```
Suggested packages:
  sppr rmonrd
The following NEW packages will be installed:
  ifupdown
0 upgraded, 1 newly installed, 0 to remove and 19 not upgraded.
Need to get 60.5 kB of additional disk space will be used.
Get:1 http://cn.archive.ubuntu.com/ubuntu focal/universe amd64 ifupdown amd64 0.8.35ubuntu1 [60.5 kB]
Fetched 60.5 kB in 7s (8.600 B/s)
Selecting previously unselected package ifupdown.
(Reading database ... 72193 files and directories currently installed.)
Preparing to unpack .../ifupdown_0.8.35ubuntu1_amd64.deb ...
Unpacking ifupdown (0.8.35ubuntu1) ...
Setting up ifupdown (0.8.35ubuntu1) ...
Created symlink /etc/systemd/system/multi-user.target.wants/networking.service → /lib/systemd/system/networking.service.
Created symlink /etc/systemd/system/network-online.target.wants/networking.service → /lib/systemd/system/networking.service.
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for systemd (245.4-ubuntu0.17) ...
abid@abid:~$ sudo ifup enp0s8
abid@abid:~$ ifconfig
enp0s8: flags=4163 UP BROADCAST RUNNING MULTICAST  mtu 1500
      inet 10.0.2.15  brd 255.255.255.0  broadcast 10.0.2.255
        netmask 255.255.255.0  broadcast 10.0.2.255
        ether fe:00:a0:27:ff:fe63:6b00  txqueuelen 1000  (Ethernet)
          RX packets 79  bytes 67972 (67.9 KB)
          RX errors 0  dropped 0  overruns 0  frame 0
          TX packets 75  bytes 6204 (6.2 KB)
          TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

enp0s8: flags=4163 UP BROADCAST RUNNING MULTICAST  mtu 1500
      inet 10.0.2.5  brd 255.255.255.0  broadcast 10.0.2.255
        netmask 255.255.255.0  broadcast 10.0.2.255
        ether fe:00:a0:27:ff:fe63:6b96  txqueuelen 1000  (Ethernet)
          RX packets 1597  bytes 1754096 (1.7 MB)
          RX errors 0  dropped 0  overruns 0  frame 0
          TX packets 1026  bytes 80143 (80.1 KB)
          TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

lo: flags=73 UP LOOPBACK RUNNING  mtu 65536
      inet 127.0.0.1  brd 127.0.0.1  netmask 255.0.0.0
        netmask 255.0.0.0  broadcast 127.0.0.1
        ether 00:0c:29:1e:01:00  txqueuelen 1000  (Local Loopback)
          RX packets 132  bytes 11094 (11.0 KB)
          RX errors 0  dropped 0  overruns 0  frame 0
          TX packets 132  bytes 11094 (11.0 KB)
          TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

abid@abid:~$
```

## 5.16 ifconfig node1 Updated



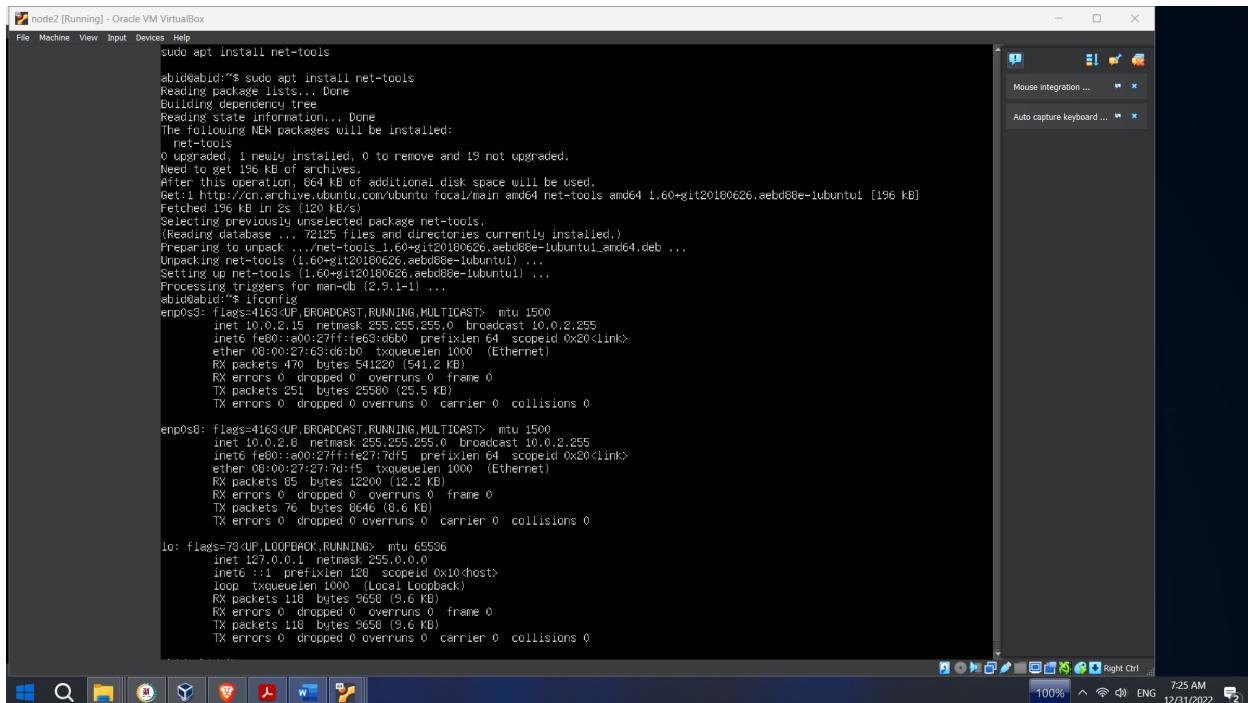
```
Suggested packages:
  sppr rmonrd
The following NEW packages will be installed:
  ifupdown
0 upgraded, 1 newly installed, 0 to remove and 19 not upgraded.
Need to get 60.5 kB of additional disk space will be used.
Get:1 http://cn.archive.ubuntu.com/ubuntu focal/universe amd64 ifupdown amd64 0.8.35ubuntu1 [60.5 kB]
Fetched 60.5 kB in 7s (8.600 B/s)
Selecting previously unselected package ifupdown.
(Reading database ... 72193 files and directories currently installed.)
Preparing to unpack .../ifupdown_0.8.35ubuntu1_amd64.deb ...
Unpacking ifupdown (0.8.35ubuntu1) ...
Setting up ifupdown (0.8.35ubuntu1) ...
Created symlink /etc/systemd/system/multi-user.target.wants/networking.service → /lib/systemd/system/networking.service.
Created symlink /etc/systemd/system/network-online.target.wants/networking.service → /lib/systemd/system/networking.service.
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for systemd (245.4-ubuntu0.17) ...
abid@node1:~$ ifconfig
enp0s8: flags=4163 UP BROADCAST RUNNING MULTICAST  mtu 1500
      inet 192.168.1.120  brd 255.255.255.0  broadcast 192.168.1.255
        netmask 255.255.255.0  broadcast 192.168.1.255
        ether fe:00:a0:27:ff:fe63:6b00  txqueuelen 1000  (Ethernet)
          RX packets 7  bytes 1540 (1.5 KB)
          RX errors 0  dropped 0  overruns 0  frame 0
          TX packets 7  bytes 1540 (1.5 KB)
          TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

enp0s8: flags=4163 UP BROADCAST RUNNING MULTICAST  mtu 1500
      inet 192.168.1.120  brd 255.255.255.0  broadcast 192.168.1.255
        netmask 255.255.255.0  broadcast 192.168.1.255
        ether fe:00:a0:27:ff:fe63:6b96  txqueuelen 1000  (Ethernet)
          RX packets 30  bytes 30408 (30.4 KB)
          RX errors 0  dropped 0  overruns 0  frame 0
          TX packets 64  bytes 7648 (7.6 KB)
          TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

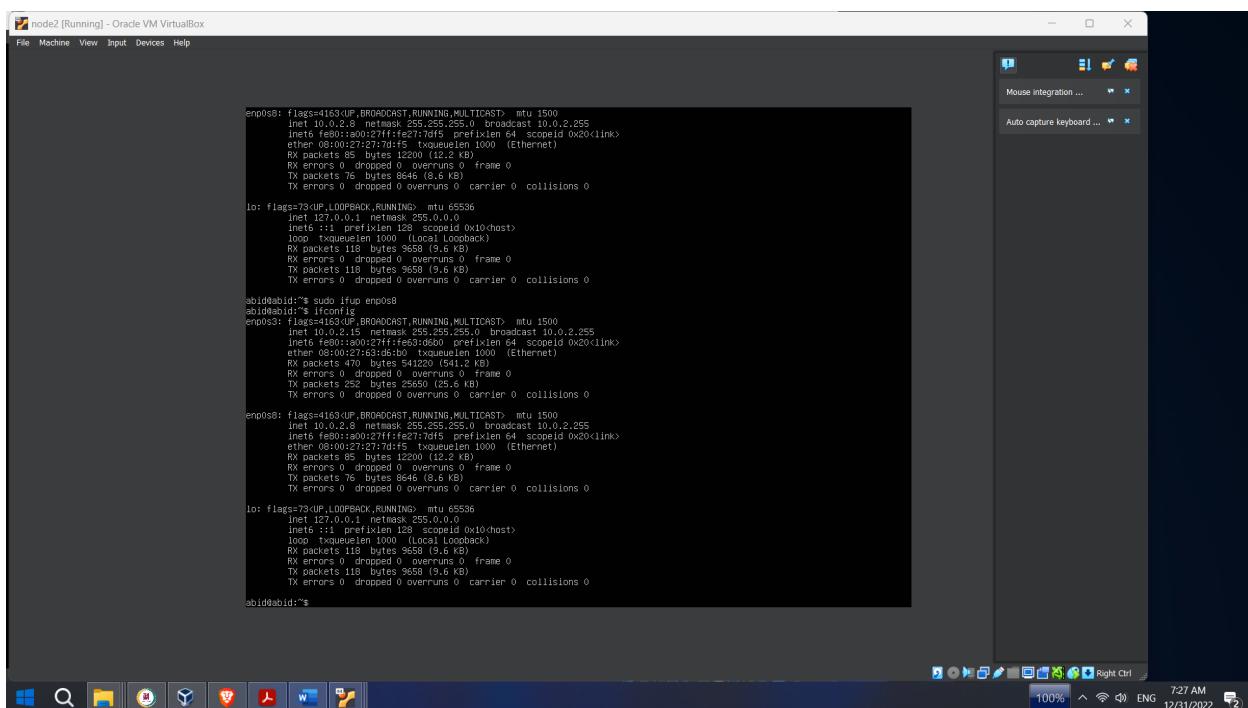
lo: flags=73 UP LOOPBACK RUNNING  mtu 65536
      inet 127.0.0.1  brd 127.0.0.1  netmask 255.0.0.0
        netmask 255.0.0.0  broadcast 127.0.0.1
        ether 00:0c:29:1e:01:00  txqueuelen 1000  (Local Loopback)
          RX packets 164  bytes 13408 (13.4 KB)
          RX errors 0  dropped 0  overruns 0  frame 0
          TX packets 164  bytes 13408 (13.4 KB)
          TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

abid@node1:~$
```

## 5.17 Node2



```
File Machine View Input Devices Help
File Machine View Input Devices Help
sudo apt install net-tools
abid@abid:~$ sudo apt install net-tools
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
net-tools
0 upgraded, 1 newly installed, 0 to remove and 19 not upgraded.
Need to get 196 kB of archives.
After this operation, 864 kB of additional disk space will be used.
Get:1 http://cn.archive.ubuntu.com/ubuntu focal/main amd64 net-tools amd64 1.60+git20180626.aebd88e-1ubuntu1 [196 kB]
Fetched 196 kB in 2s (120 kB/s)
Selecting previously unselected package net-tools.
(Reading database ... 72125 files and directories currently installed.)
Preparing to unpack .../net-tools_1.60+git20180626.aebd88e-1ubuntu1_amd64.deb ...
Unpacking net-tools (1.60+git20180626.aebd88e-1ubuntu1) ...
Setting up net-tools (1.60+git20180626.aebd88e-1ubuntu1) ...
Processing triggers for man-db (2.9.1-1) ...
abid@abid:~$ lsof | grep net
abid@abid:~$ ifconfig
enp0s0: flags=4163 mtu 1500
inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe80::a00:2ff:fe80:15%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:63:6b txqueuelen 1000 (Ethernet)
RX packets 470 bytes 541220 (541.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 251 bytes 25590 (25.5 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s0: flags=4163 mtu 1500
inet 10.0.2.8 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe00::a00:2ff:fe80:8%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:7d:f5 txqueuelen 1000 (Ethernet)
RX packets 65 bytes 12200 (12.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 76 bytes 8646 (8.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 110 bytes 9698 (9.6 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 110 bytes 9698 (9.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 110 bytes 9698 (9.6 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 110 bytes 9698 (9.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@abid:~$ ifconfig
abid@abid:~$ ifconfig
enp0s0: flags=4163 mtu 1500
inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe80::a00:2ff:fe80:15%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:63:6b txqueuelen 1000 (Ethernet)
RX packets 470 bytes 541220 (541.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 251 bytes 25590 (25.5 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s0: flags=4163 mtu 1500
inet 10.0.2.8 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe00::a00:2ff:fe80:8%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:7d:f5 txqueuelen 1000 (Ethernet)
RX packets 65 bytes 12200 (12.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 76 bytes 8646 (8.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 110 bytes 9698 (9.6 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 110 bytes 9698 (9.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@abid:~$
```



```
File Machine View Input Devices Help
File Machine View Input Devices Help
sudo ifup eno08
abid@abid:~$ ifconfig
enp0s0: flags=4163 mtu 1500
inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe80::a00:2ff:fe80:15%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:63:6b txqueuelen 1000 (Ethernet)
RX packets 470 bytes 541220 (541.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 251 bytes 25590 (25.5 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s0: flags=4163 mtu 1500
inet 10.0.2.8 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe00::a00:2ff:fe80:8%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:7d:f5 txqueuelen 1000 (Ethernet)
RX packets 65 bytes 12200 (12.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 76 bytes 8646 (8.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 110 bytes 9698 (9.6 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 110 bytes 9698 (9.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@abid:~$ ifconfig
abid@abid:~$ ifconfig
enp0s0: flags=4163 mtu 1500
inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe80::a00:2ff:fe80:15%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:63:6b txqueuelen 1000 (Ethernet)
RX packets 470 bytes 541220 (541.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 251 bytes 25590 (25.5 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s0: flags=4163 mtu 1500
inet 10.0.2.8 netmask 255.255.255.0 broadcast 10.0.2.255
inet6 fe00::a00:2ff:fe80:8%enp0s0 prefixlen 64 scopeid 0x20<link>
ether 08:00:00:27:7d:f5 txqueuelen 1000 (Ethernet)
RX packets 65 bytes 12200 (12.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 76 bytes 8646 (8.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 110 bytes 9698 (9.6 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 110 bytes 9698 (9.6 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@abid:~$
```

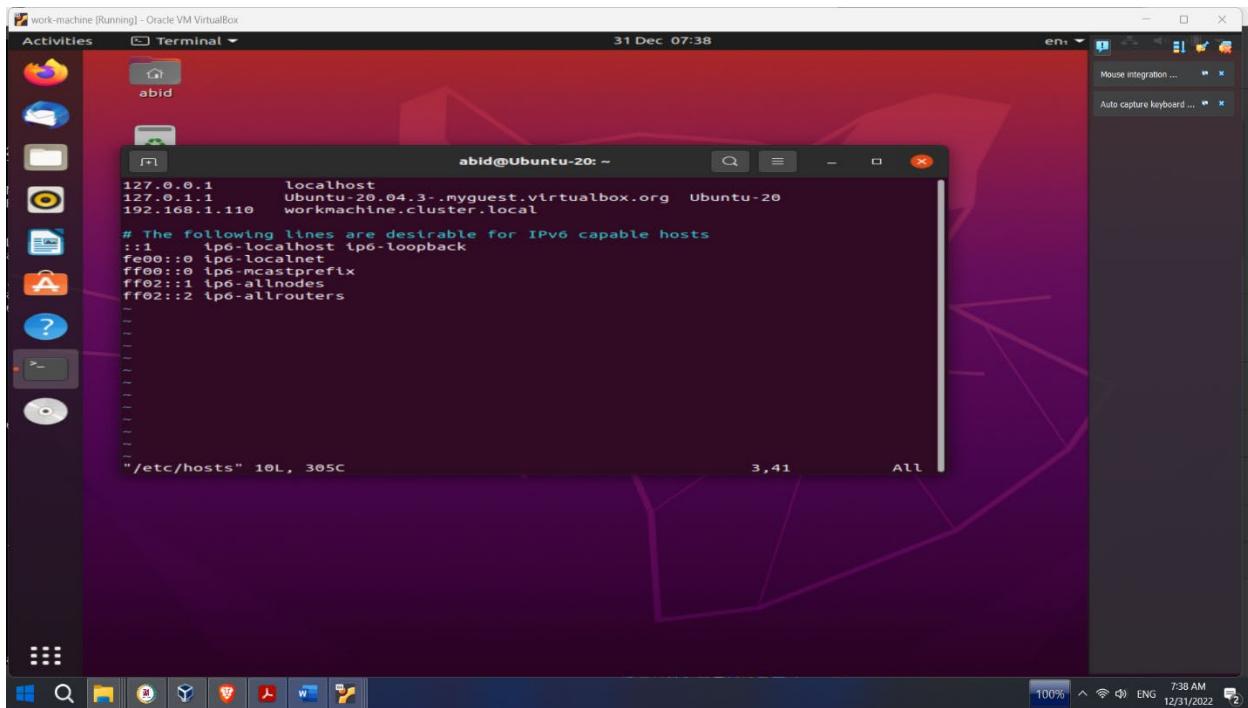
abid@node2:~\$ sudo service network-manager force-reload  
[sudo] password for abid:  
Failed to start networkmanager-services: Unit network-manager.service not found.  
abid@node2:~\$ systemctl restart networking.service  
Authentication is required to restart 'networking.service'.  
Authenticating as: abid  
Password:  
==== AUTHENTICATION COMPLETE ====  
abid@node2:~\$ sudo ifup enp0s8  
Iface dev enp0s8 already configured  
abid@node2:~\$ ifconfig  
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST mtu 1500  
inet 10.0.2.12 brd 10.0.2.255 netmask 255.255.255.0 broadcast 10.0.2.255  
inet 169.254.10.1 brd 169.254.10.255 scope 0x0c0::link  
ether 08:00:27:63:d6:b0 txqueuelen 1000 (Ethernet)  
Rx packets 34493 bytes 50574097 (50.5 MB)  
Tx packets 13946 bytes 593560 (582.6 KB)  
Tx errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
enp0s8: flags=4163<UP,BROADCAST,RUNNING,MULTICAST mtu 1500  
inet 192.168.1.130 brd 192.168.1.255 netmask 255.255.255.0 broadcast 192.168.1.255  
inet fe80::a00:27ff:fe27:7df5 brd fe80::ff:fe27:7df5 txqueuelen 1000 (Ethernet)  
ether 08:00:27:7d:f5 txqueuelen 1000 (Ethernet)  
Rx packets 68860 bytes 108860 (18.8 KB)  
Rx errors 0 dropped 0 overruns 0 frame 0  
Tx packets 5935 bytes 383560 (388.5 KB)  
Tx errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
lo: flags=73<UP,LOOPBACK,RUNNING mtu 65536  
inet 127.0.0.1 brd 127.0.0.0 netmask 255.0.0.0  
inets : brd 0.0.0.0 scope 0x0<host>  
loop0: flags=4096<NOARP,BROADCAST> mtu 1500  
Rx packets 224 bytes 108860 (18.8 KB)  
Rx errors 0 dropped 0 overruns 0 frame 0  
Tx packets 224 bytes 108860 (18.8 KB)  
Tx errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
abid@node2:~\$

## 5.18 Work-machine sudo vim /etc/hosts

abid@Ubuntu-20:~\$ sudo hostnamectl set-hostname workmachine.cluster.local  
abid@Ubuntu-20:~\$ sudo vim /etc/hosts  
abid@Ubuntu-20:~\$ hostname  
workmachine.cluster.local  
abid@Ubuntu-20:~\$

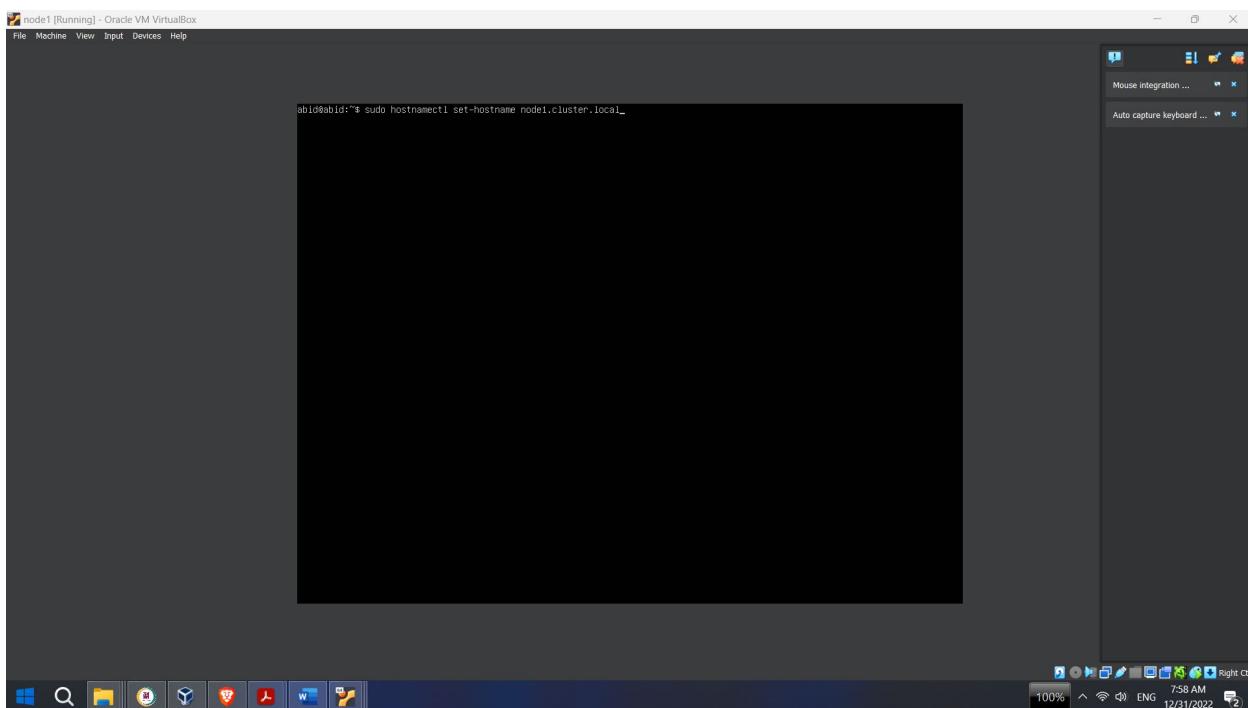
sudo vim /etc/hosts

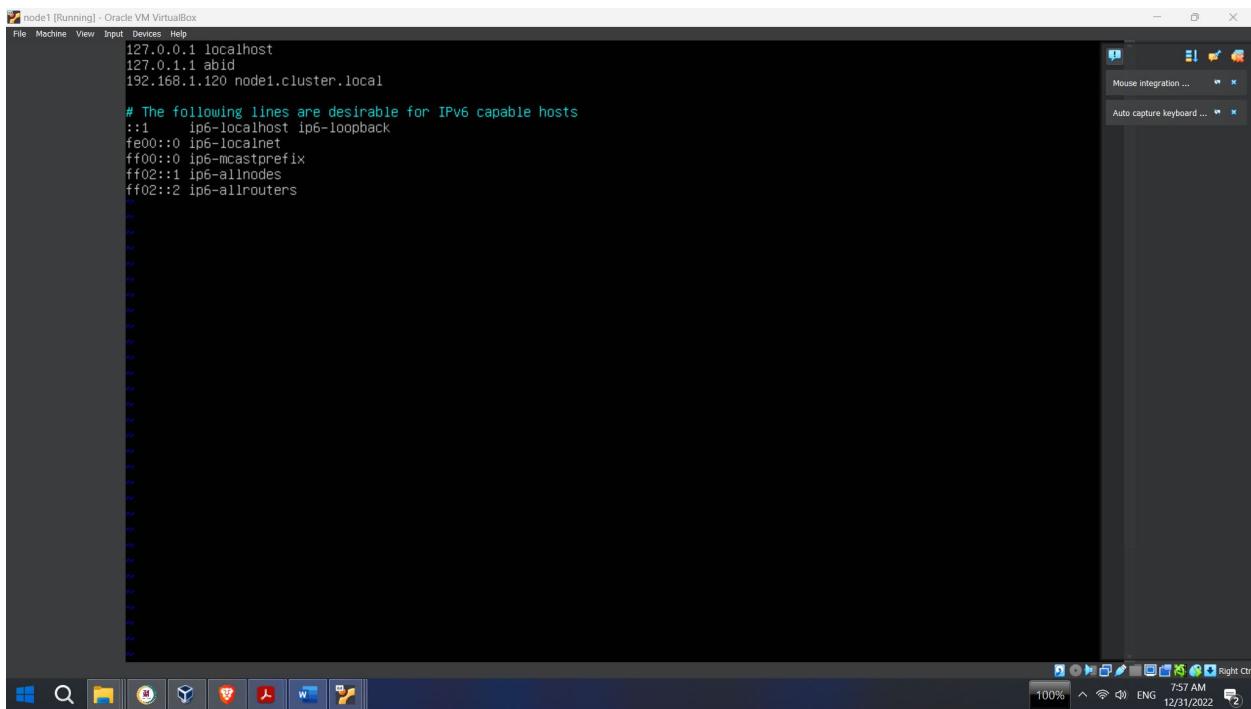
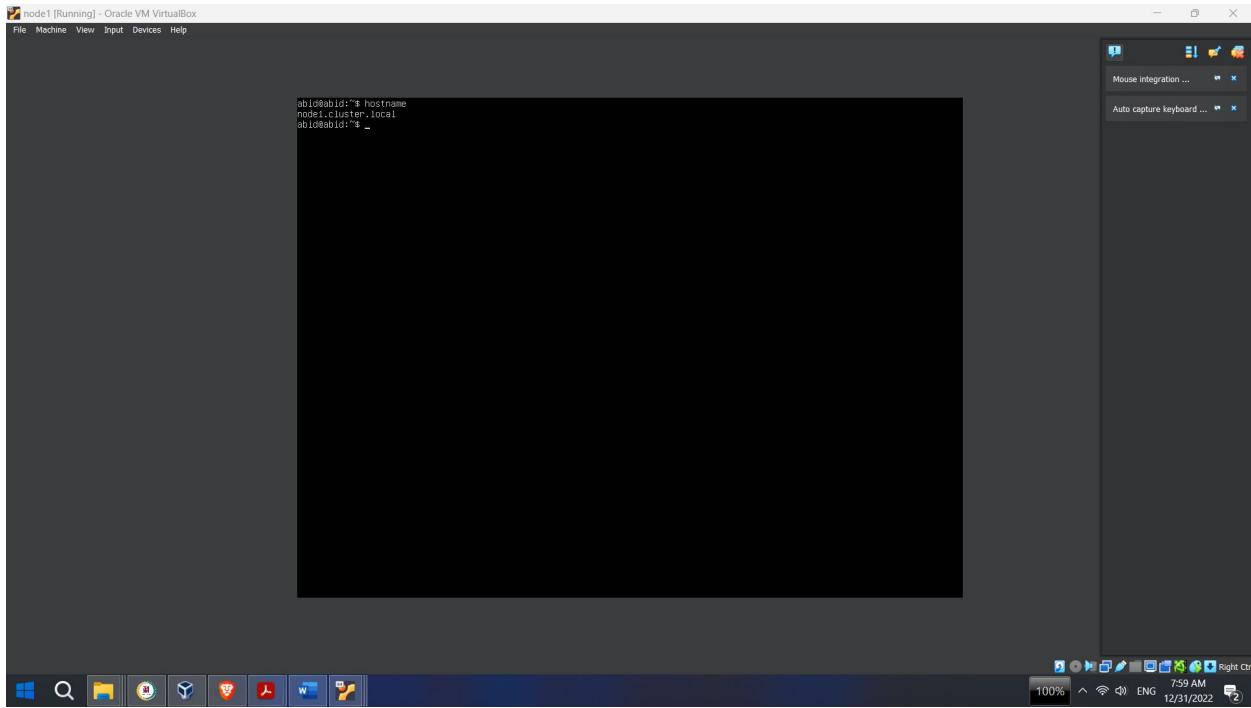
## 5.19 sudo hostnamectl set-hostname workmachine.cluster.local



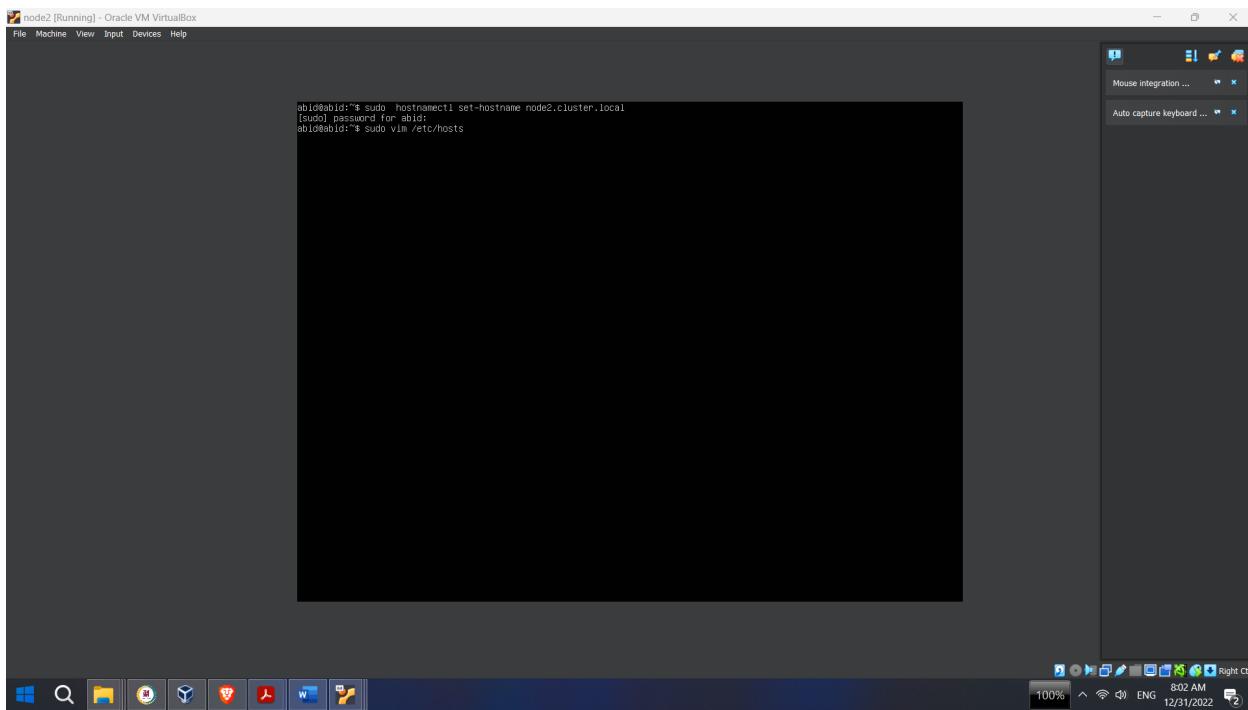
sudo hostnamectl set-hostname workmachine.cluster.local

## 5.20 Node 1

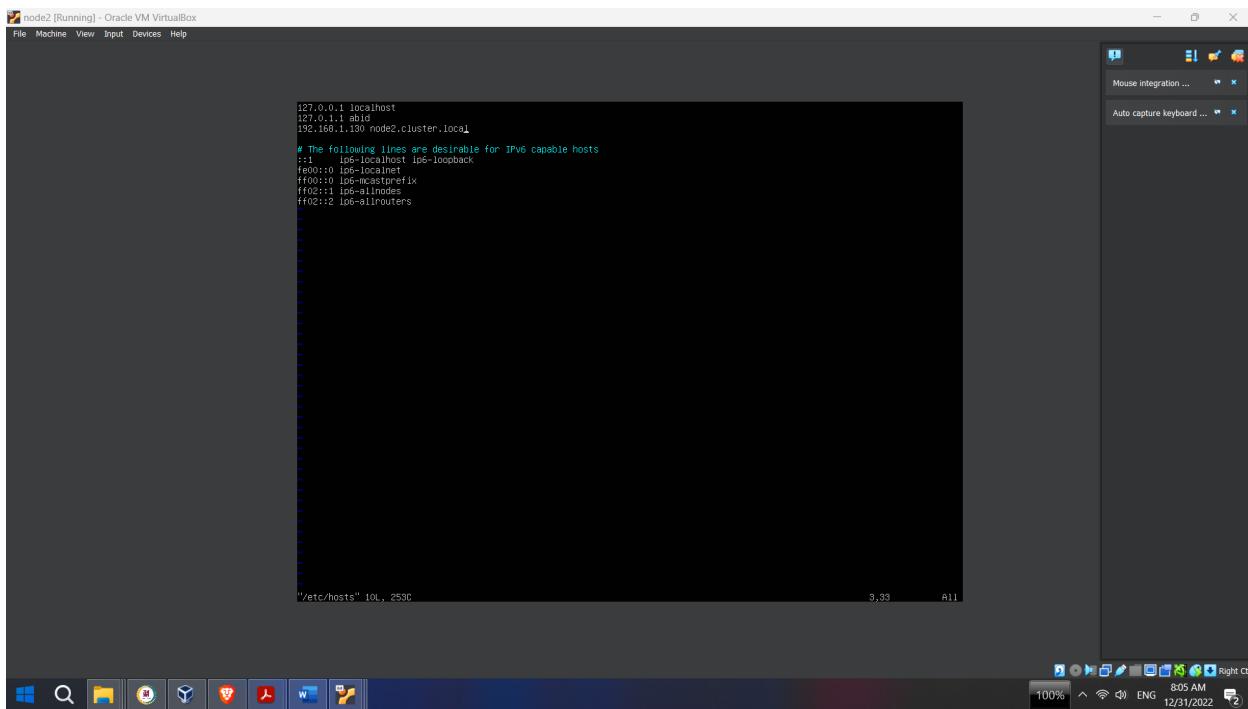




## 5.21 Node 2



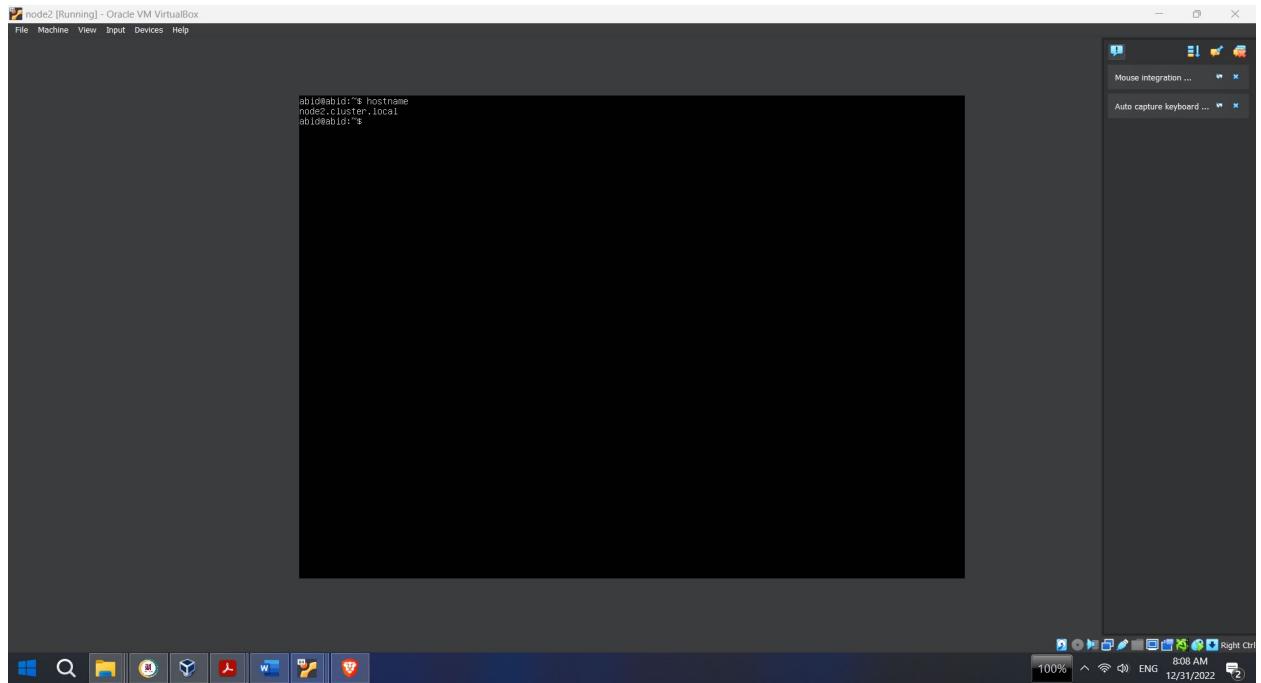
```
abid@abid:~$ sudo hostnamectl set-hostname node2.cluster.local
[sudo] password for abid:
abid@abid:~$ sudo vim /etc/hosts
```



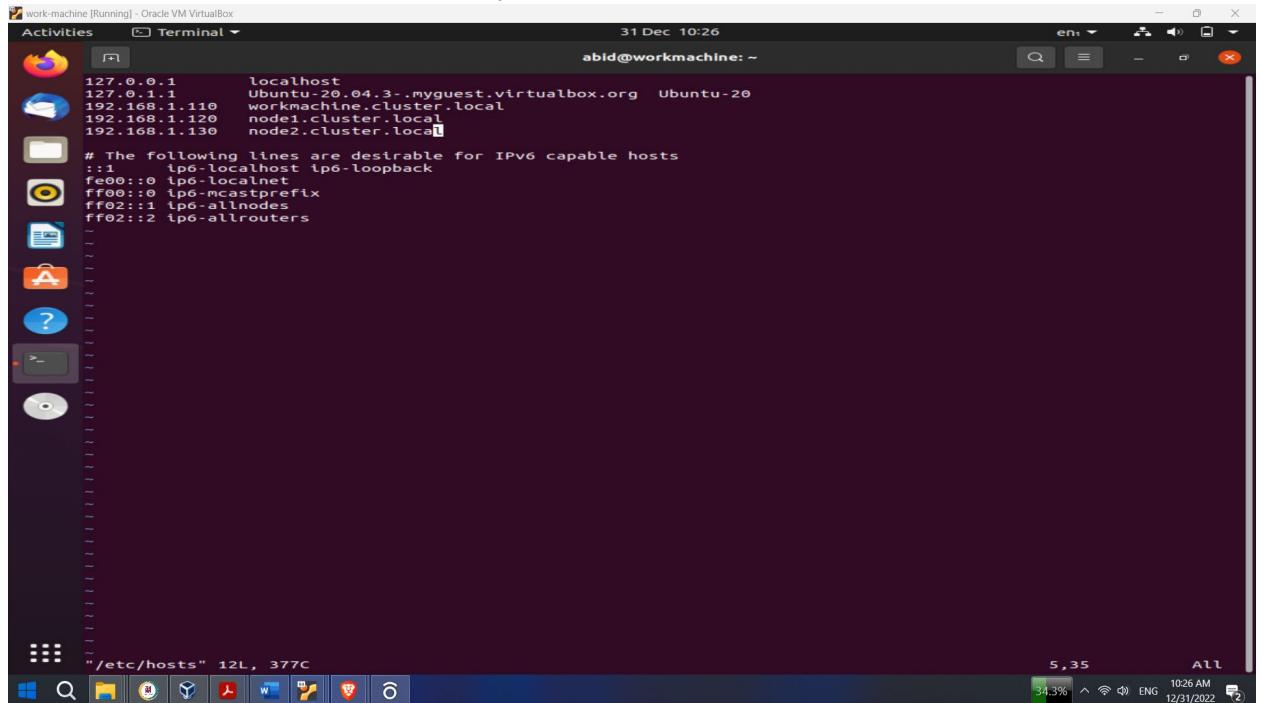
```
127.0.0.1 localhost
127.0.1.1 abid
192.168.1.130 node2.cluster.local

# The following lines are desirable for IPv6 capable hosts
::1 ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastrefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

"/etc/hosts" 10L, 253C
```



## 5.22 Work-machine's Entry Point



**Figure:** Work-machine's the entry point

## 5.23 Workmachine Ping Result

```
31 Dec 10:23
abid@workmachine: ~
ping node1.cluster.local (192.168.1.120): 64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=76 ttl=64 time=2.23 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=77 ttl=64 time=1.08 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=78 ttl=64 time=1.32 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=79 ttl=64 time=2.99 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=80 ttl=64 time=2.16 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=81 ttl=64 time=2.28 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=82 ttl=64 time=1.19 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=83 ttl=64 time=0.742 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=84 ttl=64 time=2.91 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=85 ttl=64 time=0.678 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=86 ttl=64 time=2.43 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=87 ttl=64 time=2.97 ms
^C
-- node1.cluster.local ping statistics --
87 packets transmitted, 87 received, 0% packet loss, time 86261ms
rtt min/avg/max/mdev = 0.677/2.268/16.962/2.234 ms
abid@workmachine: $ ping workmachine.cluster.local
PING workmachine.cluster.local (192.168.1.110) 56(84) bytes of data.
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=1 ttl=64 time=0.041 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=2 ttl=64 time=0.042 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=3 ttl=64 time=0.044 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=4 ttl=64 time=0.037 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=5 ttl=64 time=0.050 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=6 ttl=64 time=0.039 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=7 ttl=64 time=0.037 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=8 ttl=64 time=0.049 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=9 ttl=64 time=0.042 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=10 ttl=64 time=0.060 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=11 ttl=64 time=0.049 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=12 ttl=64 time=0.046 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=13 ttl=64 time=0.050 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=14 ttl=64 time=0.047 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=15 ttl=64 time=0.053 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=16 ttl=64 time=0.049 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=17 ttl=64 time=0.044 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=18 ttl=64 time=0.064 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=19 ttl=64 time=0.057 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=20 ttl=64 time=0.059 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=21 ttl=64 time=0.058 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=22 ttl=64 time=0.062 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=23 ttl=64 time=0.058 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=24 ttl=64 time=0.028 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=25 ttl=64 time=0.035 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=26 ttl=64 time=0.027 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=27 ttl=64 time=0.030 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=28 ttl=64 time=0.033 ms
64 bytes from workmachine.cluster.local (192.168.1.110): icmp_seq=29 ttl=64 time=0.035 ms
^C
36.4% ^ ⌂ ENG 10:23 AM 12/31/2022
```

## 5.24 Node 1 Ping Result

```
31 Dec 10:21
abid@workmachine: ~
ping node2.cluster.local (192.168.1.130): 64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=73 ttl=64 time=2.78 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=74 ttl=64 time=1.22 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=75 ttl=64 time=1.50 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=76 ttl=64 time=1.73 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=77 ttl=64 time=2.07 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=78 ttl=64 time=2.34 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=79 ttl=64 time=1.19 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=80 ttl=64 time=1.41 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=81 ttl=64 time=1.47 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=82 ttl=64 time=1.06 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=83 ttl=64 time=3.29 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=84 ttl=64 time=2.30 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=85 ttl=64 time=1.35 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=86 ttl=64 time=1.22 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=87 ttl=64 time=4.19 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=88 ttl=64 time=0.774 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=89 ttl=64 time=3.47 ms
^C
-- node2.cluster.local ping statistics --
89 packets transmitted, 89 received, 0% packet loss, time 88409ms
rtt min/avg/max/mdev = 0.692/1.915/11.286/1.325 ms
abid@workmachine: $ ping node1.cluster.local
PING node1.cluster.local (192.168.1.120) 56(84) bytes of data.
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=1 ttl=64 time=11.8 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=2 ttl=64 time=1.11 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=3 ttl=64 time=2.42 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=4 ttl=64 time=1.22 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=5 ttl=64 time=4.56 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=6 ttl=64 time=3.77 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=7 ttl=64 time=4.03 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=8 ttl=64 time=2.64 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=9 ttl=64 time=1.33 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=10 ttl=64 time=2.49 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=11 ttl=64 time=1.61 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=12 ttl=64 time=0.88 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=13 ttl=64 time=2.4 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=14 ttl=64 time=3.15 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=15 ttl=64 time=1.19 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=16 ttl=64 time=1.16 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=17 ttl=64 time=1.94 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=18 ttl=64 time=1.78 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=19 ttl=64 time=1.87 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=20 ttl=64 time=0.851 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=21 ttl=64 time=2.69 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=22 ttl=64 time=4.15 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=23 ttl=64 time=2.29 ms
64 bytes from node1.cluster.local (192.168.1.120): icmp_seq=24 ttl=64 time=2.27 ms
^C
37.2% ^ ⌂ ENG 10:21 AM 12/31/2022
```

## 5.25 Node 2 Ping Result

The screenshot shows a terminal window titled "work-machine [Running] - Oracle VM VirtualBox". The terminal displays the output of several commands:

```
abid@workmachine:~$ sudo ifup enp0s8
ifup: interface enp0s8 already configured
abid@workmachine:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
        inet6 fe80::ccab:ae5a:2928:1560 prefixlen 64 scopcid 0x20<link>
            ether 08:00:27:7A:00:00 brd ff:ff:ff:ff:ff:ff
                RX packets 669 bytes 54523d (545.2 KB)
                RX errors 0 dropped 0 overruns 0 frame 0
                TX packets 554 bytes 50458 (50.4 KB)
                TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s8: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.110 netmask 255.255.255.0 broadcast 192.168.1.255
        inet6 fe80::a00:ff:fe19:dedd brd ff:ff:ff:ff:ff:ff
            ether 08:00:27:19:de:dd brd ff:ff:ff:ff:ff:ff
                RX packets 34 bytes 9474 (9.4 KB)
                RX errors 0 dropped 0 overruns 0 frame 0
                TX packets 249 bytes 20547 (20.5 KB)
                TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
        loop txqueuelen 1000 (Local Loopback)
            RX packets 513 bytes 49700 (49.7 KB)
            RX errors 0 dropped 0 overruns 0 frame 0
            TX packets 513 bytes 49700 (49.7 KB)
            TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@workmachine:~$ ping node2.cluster.local
PING node2.cluster.local (192.168.1.130) 56(84) bytes of data:
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=1 ttl=64 time=3.25 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=2 ttl=64 time=1.82 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=3 ttl=64 time=2.65 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=4 ttl=64 time=1.89 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=5 ttl=64 time=1.67 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=6 ttl=64 time=1.88 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=7 ttl=64 time=2.74 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=8 ttl=64 time=1.87 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=9 ttl=64 time=1.77 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=10 ttl=64 time=1.32 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=11 ttl=64 time=3.24 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=12 ttl=64 time=1.02 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=13 ttl=64 time=1.86 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=14 ttl=64 time=0.873 ms
64 bytes from node2.cluster.local (192.168.1.130): icmp_seq=15 ttl=64 time=1.66 ms
```

## 6. SSH

### 6.1 Enable SSH server

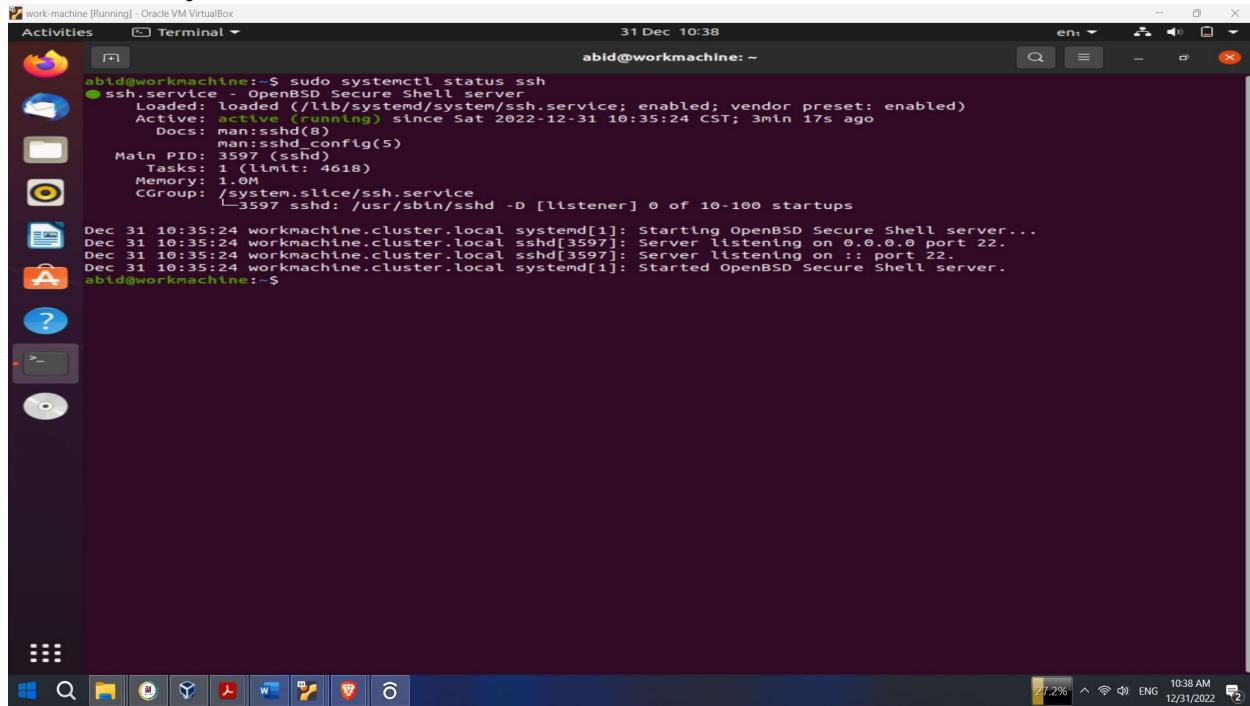
The screenshot shows a terminal window titled "work-machine [Running] - Oracle VM VirtualBox". The terminal displays the output of the command `sudo apt install openssh-server`:

```
abid@workmachine:~$ sudo apt install openssh-server
Reading package lists... Done
Building dependency tree...
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
Suggested packages:
  molly-guard monkeysphere ssh-askpass
The following NEW packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
0 to upgrade, 4 to newly install, 0 to remove and 1 not to upgrade.
Need to get 688 kB of newly archives.
After this operation, 6,010 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://us.archive.ubuntu.com/ubuntu focal/main amd64 ncurses-term all 6.2-0ubuntu2 [249 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 openssh-sftp-server amd64 1:8.2p1-4ubuntu0.5 [51.5 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 openssh-server amd64 1:8.2p1-4ubuntu0.5 [377 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal/main amd64 ssh-import-id all 5.10-0ubuntu1 [10.0 kB]
Fetched 688 kB in 4s (170 kB/s)
Preconfiguring packages...
Selecting previously unselected package ncurses-term.
(Reading database ... 189028 files and directories currently installed.)
Preparing to unpack .../ncurses-term_6.2-0ubuntu2_all.deb ...
Unpacking ncurses-term (6.2-0ubuntu2) ...
Selecting previously unselected package openssh-sftp-server.
Preparing to unpack .../openssh-sftp-server_1%3a8.2p1-4ubuntu0.5_amd64.deb ...
Unpacking openssh-sftp-server (1:8.2p1-4ubuntu0.5) ...
Selecting previously unselected package openssh-server.
Preparing to unpack .../openssh-server_1%3a8.2p1-4ubuntu0.5_amd64.deb ...
Unpacking openssh-server (1:8.2p1-4ubuntu0.5) ...
Selecting previously unselected package ssh-import-id.
Preparing to unpack .../ssh-import-id_5.10-0ubuntu1_all.deb ...
Unpacking ssh-import-id (5.10-0ubuntu1) ...
Setting up openssh-sftp-server (1:8.2p1-4ubuntu0.5) ...
Setting up openssh-server (1:8.2p1-4ubuntu0.5) ...

Creating config file /etc/ssh/sshd_config with new version
Creating SSH2 RSA key; this may take some time ...
3072 SHA256:B01Y2Fvw0IXxDGza+JeR4jPQMF4CP+zBcOR1mZcUP0 root@workmachine.cluster.local (RSA)
Creating SSH2 ECDSA key; this may take some time ...
256 SHA256:RY053BLFmc7eqwGEmrwOL4SEVvXDwWjzrCB16zzu9YM root@workmachine.cluster.local (ED25519)
Created symlink /etc/systemd/system/sshd.service → /lib/systemd/system/sshd.service.
Created symlink /etc/systemd/system/multi-user.target.wants/sshd.service → /lib/systemd/system/sshd.service.
rescue-ssh.target is a disabled or a static unit, not starting it.
```

`sudo apt install openssh-server`

## 6.2 sudo systemctl status ssh

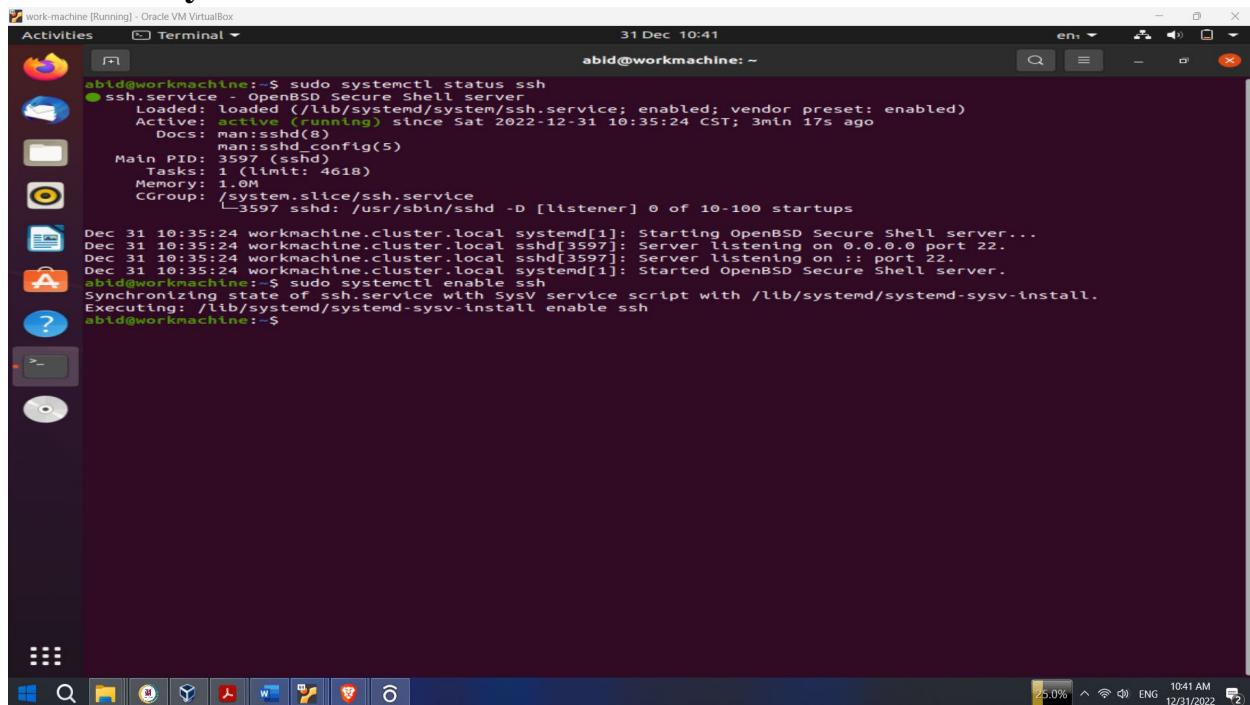


```
abtd@workmachine:~$ sudo systemctl status ssh
● ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
  Active: active (running) since Sat 2022-12-31 10:35:24 CST; 3min 17s ago
    Docs: man:sshd(8)
           man:sshd_config(5)
  Main PID: 3597 (sshd)
     Tasks: 1 (limit: 4618)
    Memory: 1.0M
       CGroup: /system.slice/ssh.service
               └─3597 sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups

Dec 31 10:35:24 workmachine.cluster.local systemd[1]: Starting OpenBSD Secure Shell server...
Dec 31 10:35:24 workmachine.cluster.local sshd[3597]: Server listening on 0.0.0.0 port 22.
Dec 31 10:35:24 workmachine.cluster.local sshd[3597]: Server listening on :: port 22.
Dec 31 10:35:24 workmachine.cluster.local systemd[1]: Started OpenBSD Secure Shell server.
abtd@workmachine:~$
```

sudo systemctl status ssh

## 6.3 sudo systemctl enable ssh

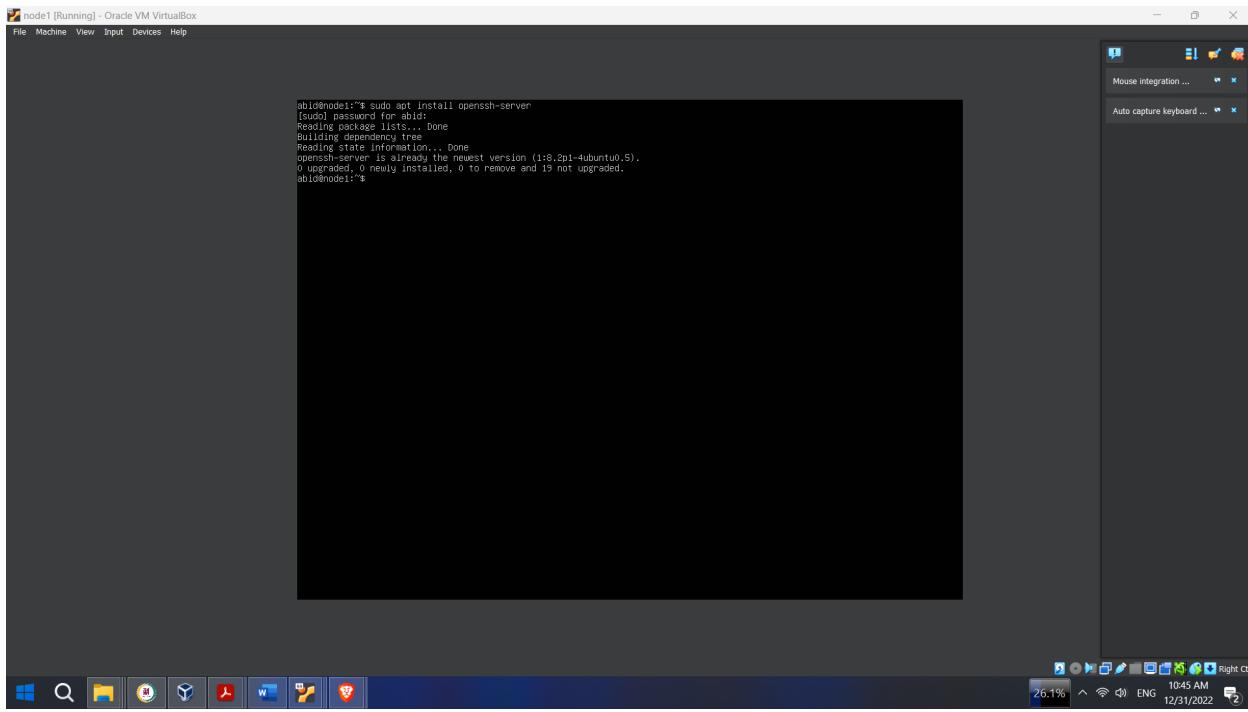


```
abtd@workmachine:~$ sudo systemctl status ssh
● ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
  Active: active (running) since Sat 2022-12-31 10:35:24 CST; 3min 17s ago
    Docs: man:sshd(8)
           man:sshd_config(5)
  Main PID: 3597 (sshd)
     Tasks: 1 (limit: 4618)
    Memory: 1.0M
       CGroup: /system.slice/ssh.service
               └─3597 sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups

Dec 31 10:35:24 workmachine.cluster.local systemd[1]: Starting OpenBSD Secure Shell server...
Dec 31 10:35:24 workmachine.cluster.local sshd[3597]: Server listening on 0.0.0.0 port 22.
Dec 31 10:35:24 workmachine.cluster.local sshd[3597]: Server listening on :: port 22.
Dec 31 10:35:24 workmachine.cluster.local systemd[1]: Started OpenBSD Secure Shell server.
abtd@workmachine:~$ sudo systemctl enable ssh
Synchronizing state of ssh.service with SysV service script with /lib/systemd/systemd-sysv-install.
Executing: /lib/systemd/systemd-sysv-install enable ssh
abtd@workmachine:~$
```

sudo systemctl enable ssh

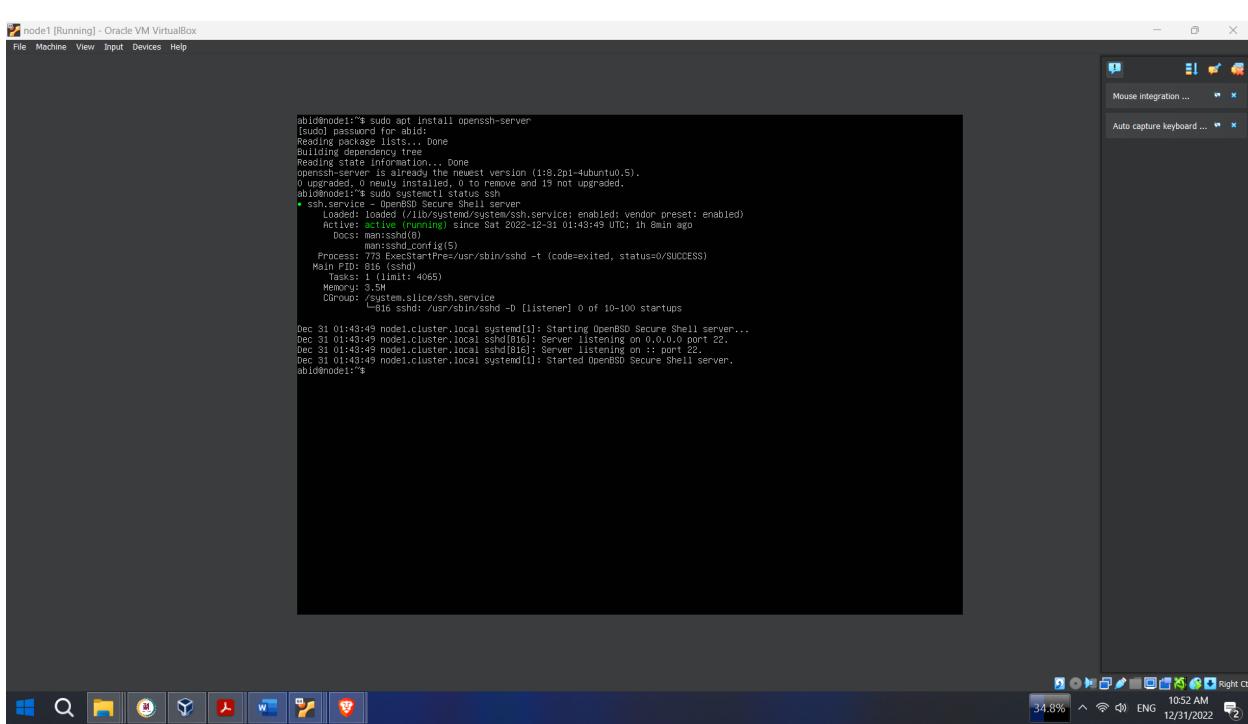
## 6.4 Node 1



node1 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

```
abid@node1:~$ sudo apt install openssh-server
[sudo] password for abid:
Reading package lists... Done
Building dependency tree...
Reading state information... Done
openssh-server is already the newest version (1:8.2p1-4ubuntu0.5).
0 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
abid@node1:~$
```



node1 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

```
abid@node1:~$ sudo apt install openssh-server
[sudo] password for abid:
Reading package lists... Done
Building dependency tree...
Reading state information... Done
openssh-server is already the newest version (1:8.2p1-4ubuntu0.5).
0 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
abid@node1:~$ sudo systemctl status ssh
● ssh.service - OpenBSD Secure Shell server
   Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
   Active: active (running) since Sat 2022-12-31 01:43:49 UTC; 1h 8min ago
     Docs: man:sshd(8)
           man:sshd_config(5)
   Main PID: 816 (sshd)
      Tasks: 3 (limit: 4065)
     Memory: 3.1M
        CPU: 0.000 CPU(s)
       CGroup: /system.slice/ssh.service
               └─816 sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups

Dec 31 01:43:49 node1.cluster.local systemd[1]: Starting OpenBSD Secure Shell server...
Dec 31 01:43:49 node1.cluster.local sshd[816]: Server listening on 0.0.0.0 port 22.
Dec 31 01:43:49 node1.cluster.local sshd[816]: Server listening on :: port 22.
Dec 31 01:43:49 node1.cluster.local systemd[1]: Started OpenBSD Secure Shell server.
abid@node1:~$
```

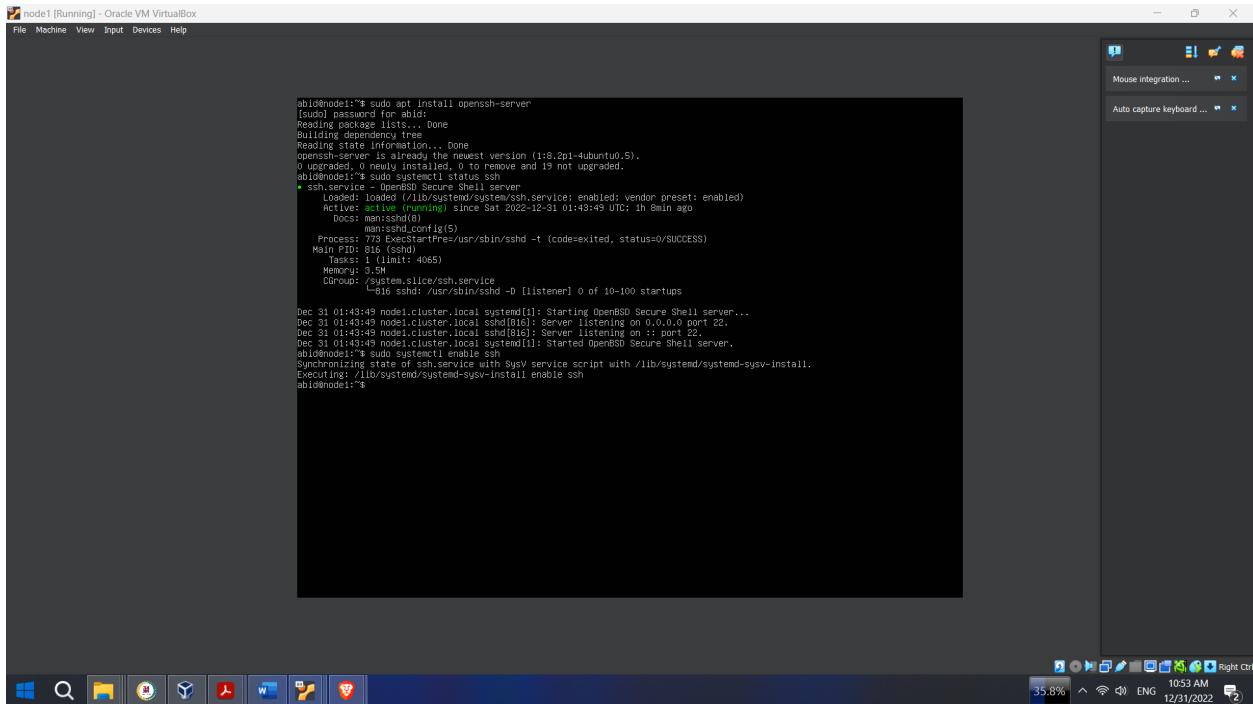
Mouse integration ...  
Auto capture keyboard ...

10:45 AM 12/31/2022

26.1% ENG

Right Ctrl

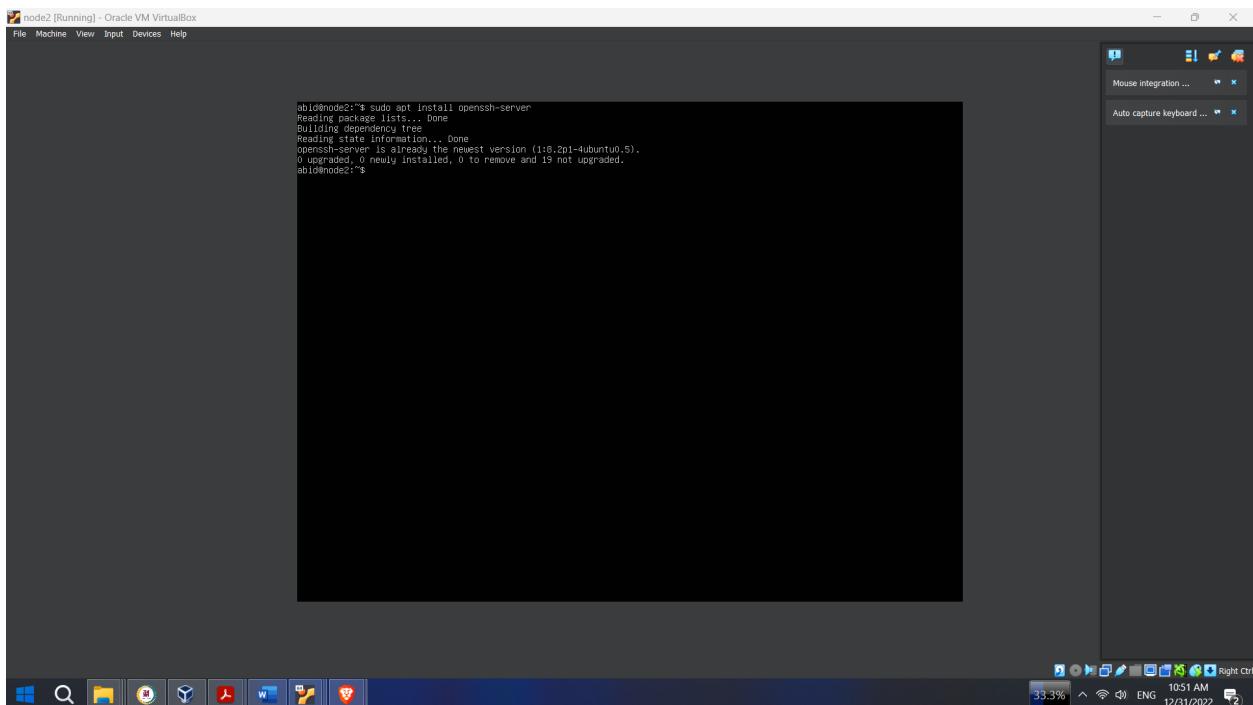
Windows Start button, Taskbar icons, System tray icons.



```
abid@node1:~$ sudo apt install openssh-server
[sudo] password for abid:
Reading package lists... done
Building dependency tree...
Reading state information... done
openSSH-server is already the newest version (1:8.2p1-ubuntu0.5).
0 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
abid@node1:~$ sudo systemctl status ssh
● ssh.service - OpenBSD Secure Shell server
   Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
     Active: active (running) since Sat 2022-12-31 01:43:49 UTC; 8min ago
       Docs: man:sshd(8)
             man:sshd_config(5)
             PREREQ: 773 ExecStartPre=/usr/sbin/sshd -t (code=exited, status=0/SUCCESS)
   Main PID: 773 (sshd)
      Tasks: 1 (limit: 4065)
        Memory: 3.5M
        CGroup: /system.slice/ssh.service
              └─ 773 sshd /usr/sbin/sshd -D [listener] 0 of 10-100 startups

Dec 31 01:43:49 node1.cluster.local systemd[1]: Starting OpenBSD Secure Shell server...
Dec 31 01:43:49 node1.cluster.local sshd[773]: Server listening on 0.0.0.0 port 22.
Dec 31 01:43:49 node1.cluster.local sshd[773]: Server listening on :: port 22.
Dec 31 01:43:49 node1.cluster.local systemd[1]: Started OpenBSD Secure Shell server.
abid@node1:~$ sudo systemctl enable ssh
Synchronizing state of ssh.service with SysV service script with /lib/systemd/system-sysv-install.
Expects control of ssh from /lib/systemd/system-sysv-install enable ssh.
abid@node1:~$
```

## 6.5 Node 2



```
abid@node2:~$ sudo apt install openssh-server
Reading package lists... done
Building dependency tree...
Reading state information... done
openSSH-server is already the newest version (1:8.2p1-ubuntu0.5).
0 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
abid@node2:~$
```

node2 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Mouse integration ...

Auto capture keyboard ...

```
abid@node2:~$ sudo ifup enp0s8
ifup: interface enp0s8 already configured
abid@node2:~$ ifconfig
enp0s3: flags=4163 mtu 1500
        inet 10.0.2.15 brd 255.255.255.0 broadcast 10.0.2.255
                netmask 255.255.255.0 broadcast 10.0.2.255
                inet6 fe80::20ff:fe02:15%enp0s3 brd fe80::fddc:15ff:fe02:15 scopeid 0x20<link>
                      ether 08:00:27:ff:fe:03 brd ff:ff:ff:ff:ff:ff link-layer [Ethernet]
                      RX packets 34498 bytes 50574097 (50.5 MB)
                      RX errors 0 dropped 0 overruns 0 frame 0
                      TX packets 9401 bytes 582566 (582.6 kB)
                      TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s8: flags=4163 mtu 1500
        inet 192.168.1.130 brd 255.255.255.0 broadcast 192.168.1.255
                netmask 255.255.255.0 broadcast 192.168.1.255
                inet6 fe80::20ff:fe01:130%enp0s8 brd fe80::fddc:13ff:fe01:130 scopeid 0x20<link>
                      ether 08:00:27:ff:fe:01 link-layer [Ethernet]
                      RX packets 66665 bytes 103092470 (103.0 MB)
                      RX errors 0 dropped 0 overruns 0 frame 0
                      TX packets 224 bytes 18860 (18.8 kB)
                      TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
        inet 127.0.0.1 brd 255.0.0.0
                netmask 255.0.0.0
                loop txqueuelen 1000 link-layer [Local Loopback]
                RX packets 224 bytes 18860 (18.8 kB)
                RX errors 0 dropped 0 overruns 0 frame 0
                TX packets 224 bytes 18860 (18.8 kB)
                TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@node2:~$ sudo systemctl status ssh
[sudo] password for abid:
● ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
  Active: active (running) since Sat 2022-12-31 01:07:47 UTC; in 38min ago
    Docs: man:sshd(8)
          man:sshd_config(5)
      Main PID: 797 (sshd)
         Tasks: 1 (limit: 4065)
        Memory: 3.5M
       CGroup: /system.slice/ssh.service
              └─797 sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups

Dec 31 01:07:47 node2.cluster.local systemd[1]: Starting OpenBSD Secure Shell server...
Dec 31 01:07:47 node2.cluster.local sshd[797]: Server listening on 0.0.0.0 port 22.
Dec 31 01:07:47 node2.cluster.local sshd[797]: Server listening on :: port 22.
Dec 31 01:07:47 node2.cluster.local sshd[797]: Started OpenBSD Secure Shell Server.
abid@node2:~$
```

File Machine View Input Devices Help

Mouse integration ...

Auto capture keyboard ...

```
abid@node2:~$ sudo ifup enp0s8
ifup: interface enp0s8 already configured
abid@node2:~$ ifconfig
enp0s3: flags=4163 mtu 1500
        inet 10.0.2.15 brd 255.255.255.0 broadcast 10.0.2.255
                netmask 255.255.255.0 broadcast 10.0.2.255
                inet6 fe80::20ff:fe02:15%enp0s3 brd fe80::fddc:15ff:fe02:15 scopeid 0x20<link>
                      ether 08:00:27:ff:fe:03 brd ff:ff:ff:ff:ff:ff link-layer [Ethernet]
                      RX packets 34498 bytes 50574097 (50.5 MB)
                      RX errors 0 dropped 0 overruns 0 frame 0
                      TX packets 9401 bytes 582566 (582.6 kB)
                      TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
enp0s8: flags=4163 mtu 1500
        inet 192.168.1.130 brd 255.255.255.0 broadcast 192.168.1.255
                netmask 255.255.255.0 broadcast 192.168.1.255
                inet6 fe80::20ff:fe01:130%enp0s8 brd fe80::fddc:13ff:fe01:130 scopeid 0x20<link>
                      ether 08:00:27:ff:fe:01 link-layer [Ethernet]
                      RX packets 66665 bytes 103092470 (103.0 MB)
                      RX errors 0 dropped 0 overruns 0 frame 0
                      TX packets 224 bytes 18860 (18.8 kB)
                      TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73 mtu 65536
        inet 127.0.0.1 brd 255.0.0.0
                netmask 255.0.0.0
                loop txqueuelen 1000 link-layer [Local Loopback]
                RX packets 224 bytes 18860 (18.8 kB)
                RX errors 0 dropped 0 overruns 0 frame 0
                TX packets 224 bytes 18860 (18.8 kB)
                TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
abid@node2:~$ sudo systemctl status ssh
[sudo] password for abid:
● ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
  Active: active (running) since Sat 2022-12-31 01:07:47 UTC; in 38min ago
    Docs: man:sshd(8)
          man:sshd_config(5)
      Main PID: 797 (sshd)
         Tasks: 1 (limit: 4065)
        Memory: 3.5M
       CGroup: /system.slice/ssh.service
              └─797 sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups

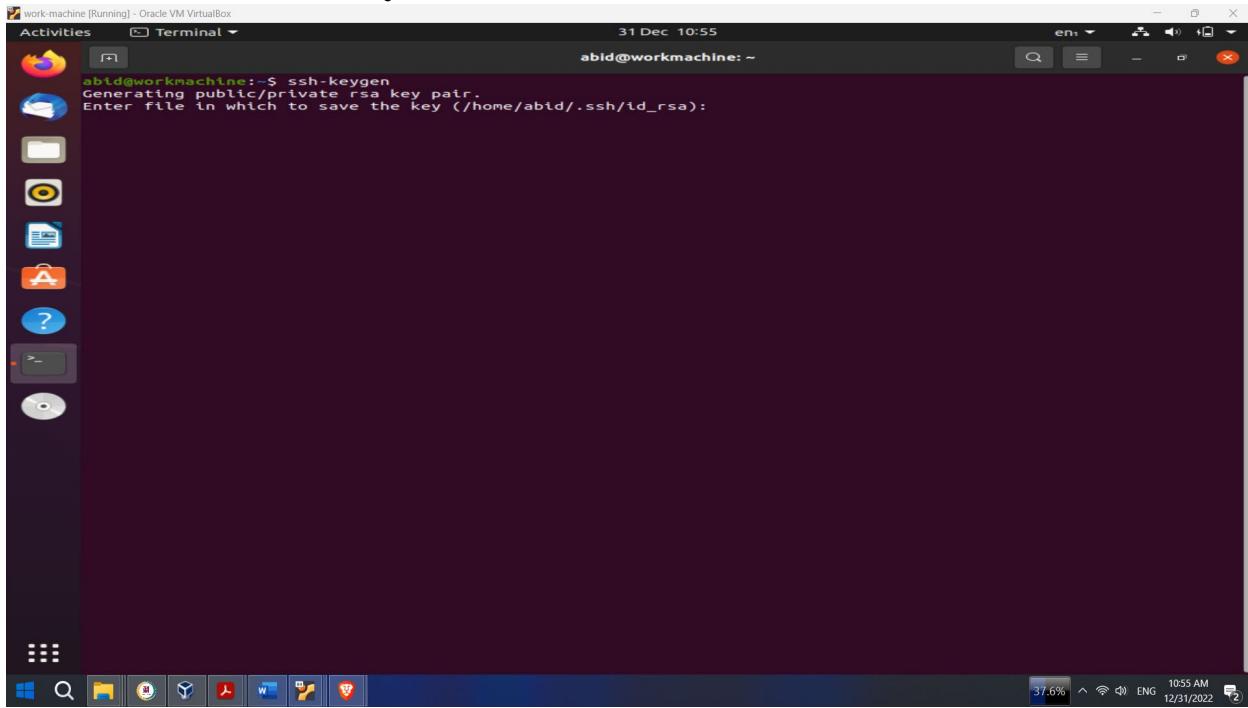
Dec 31 01:07:47 node2.cluster.local systemd[1]: Starting OpenBSD Secure Shell server...
Dec 31 01:07:47 node2.cluster.local sshd[797]: Server listening on 0.0.0.0 port 22.
Dec 31 01:07:47 node2.cluster.local sshd[797]: Server listening on :: port 22.
Dec 31 01:07:47 node2.cluster.local sshd[797]: Started OpenBSD Secure Shell Server.
abid@node2:~$ sudo systemctl enable ssh
Synchronizing state of ssh.service with SysV service script with /lib/systemd/systemctl-sysv-install.
Executing: /lib/systemd/systemctl-sysv-install enable ssh
abid@node2:~$
```

File Machine View Input Devices Help

Mouse integration ...

Auto capture keyboard ...

## 6.6 Generate SSH key For WorkMachine



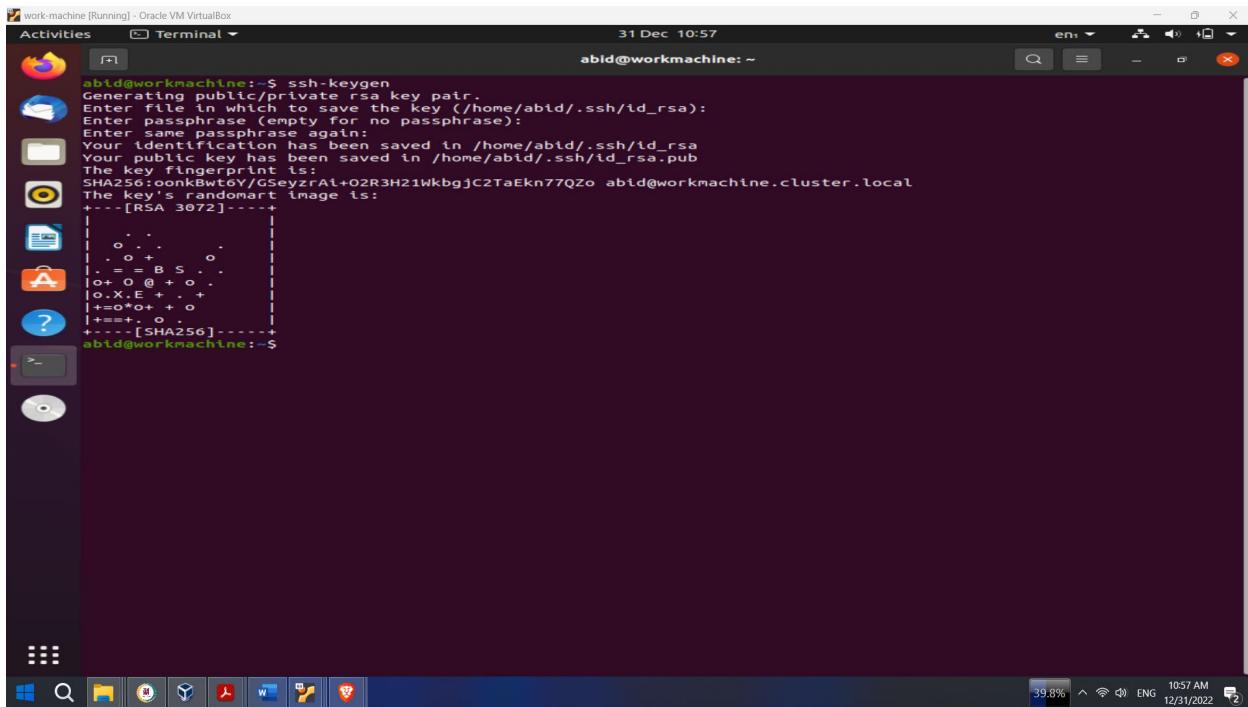
work-machine [Running] - Oracle VM VirtualBox

Activities Terminal 31 Dec 10:55 abid@workmachine: ~

```
abid@workmachine:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/abid/.ssh/id_rsa):

```

The screenshot shows a standard Ubuntu desktop interface with a dark theme. A terminal window is open at the bottom of the screen. The terminal title is "Terminal" and the command being run is "ssh-keygen". The user is prompted to enter a file name to save the key pair, but has not yet done so.



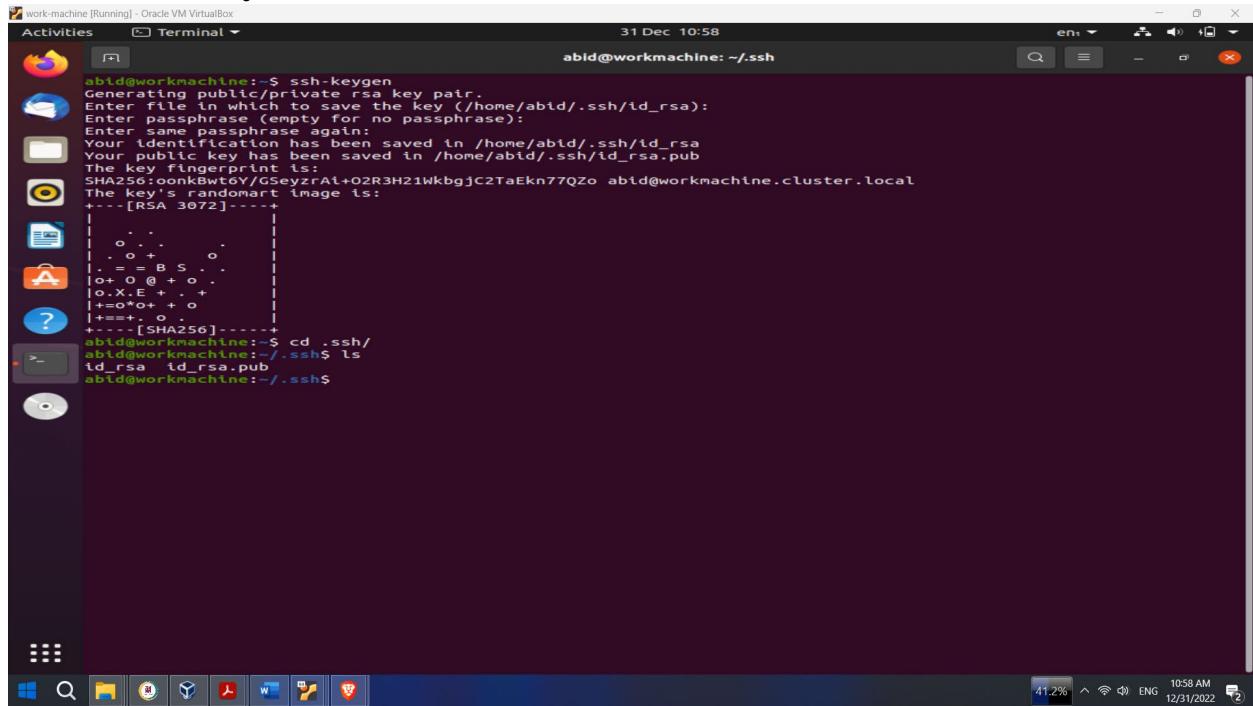
work-machine [Running] - Oracle VM VirtualBox

Activities Terminal 31 Dec 10:57 abid@workmachine: ~

```
abid@workmachine:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/abid/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/abid/.ssh/id_rsa
Your public key has been saved in /home/abid/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:oonkBwt6Y/GseyzrAt+O2R3H21WkbgjC2TaEkn77QZo abid@workmachine.cluster.local
The key's randomart image is:
+---[RSA 3072]----+
|   . . .
|   . o +   o .
|   . = B S . .
|o+ O @ + o .
|o.X.E + . +
|+=o*o+ + o
|+=+=+ + o
+---[SHA256]----+
abid@workmachine:~$
```

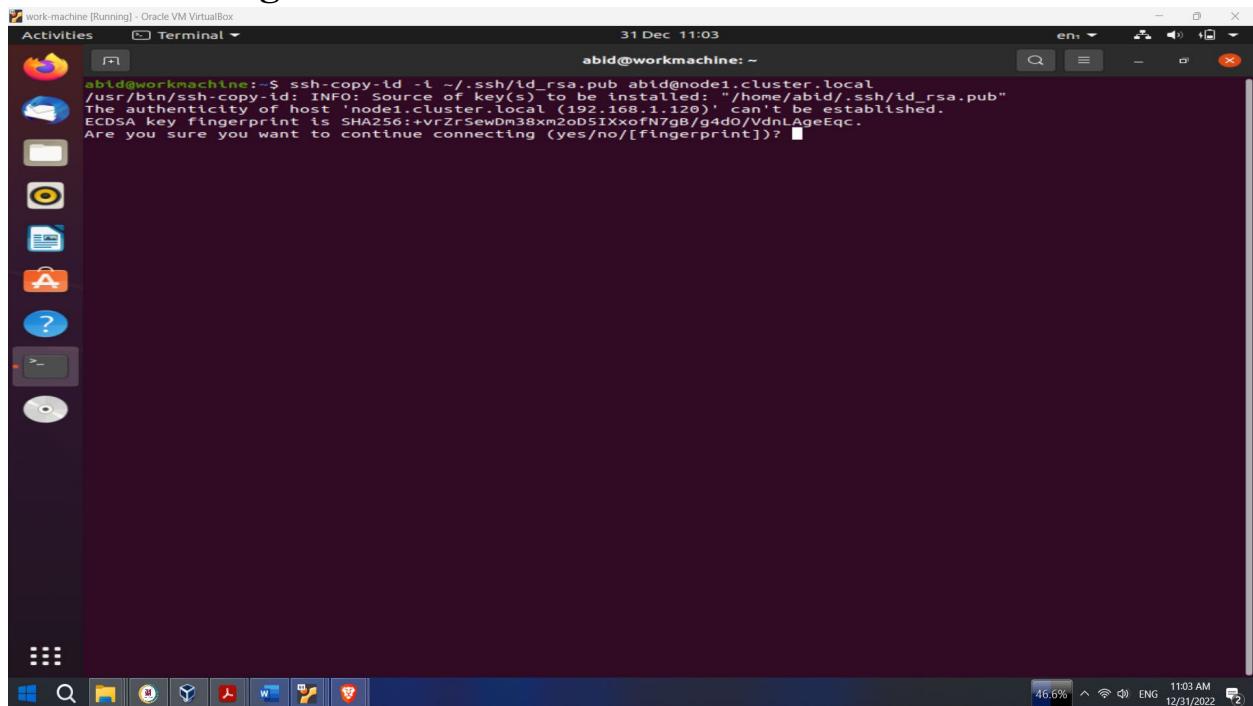
The screenshot shows the same desktop environment after the key generation process has completed. The terminal window now displays the generated key details, including the SHA256 fingerprint and the randomart image. The desktop icons and status bar are visible at the bottom.

## 6.7 Public key



abid@workmachine:~\$ ssh-keygen  
Generating public/private rsa key pair.  
Enter file in which to save the key (/home/abid/.ssh/id\_rsa):  
Enter passphrase (empty for no passphrase):  
Enter same passphrase again:  
Your identification has been saved in /home/abid/.ssh/id\_rsa  
Your public key has been saved in /home/abid/.ssh/id\_rsa.pub  
The key's randomart image is:  
+---[RSA 3072]---+  
| . . . . |  
| . o + o . |  
| = B S . . |  
|o+ O @ + o . |  
|o.X,E + ..+ |  
|+o\*o+ + o |  
+=+=+. o .  
+---[SHA256]---+  
abid@workmachine:~\$ cd .ssh/  
abid@workmachine:~/ssh\$ ls  
id\_rsa id\_rsa.pub  
abid@workmachine:~/ssh\$

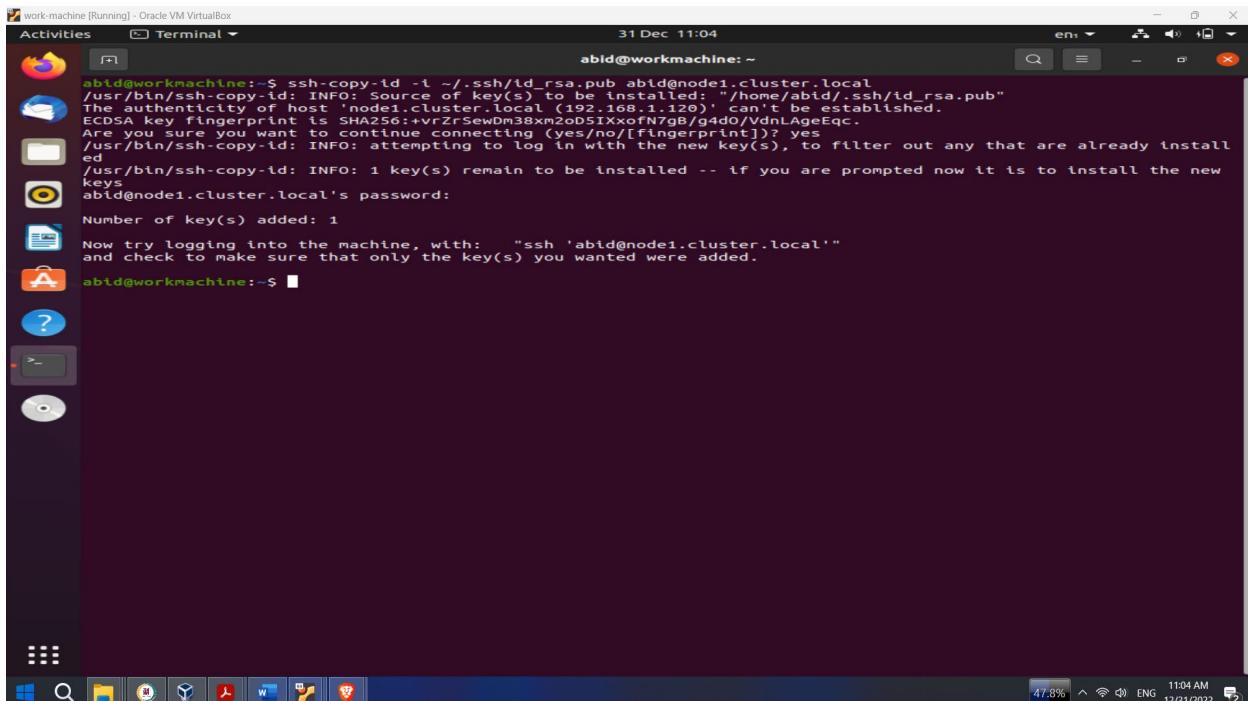
## 6.8 Connecting in node1



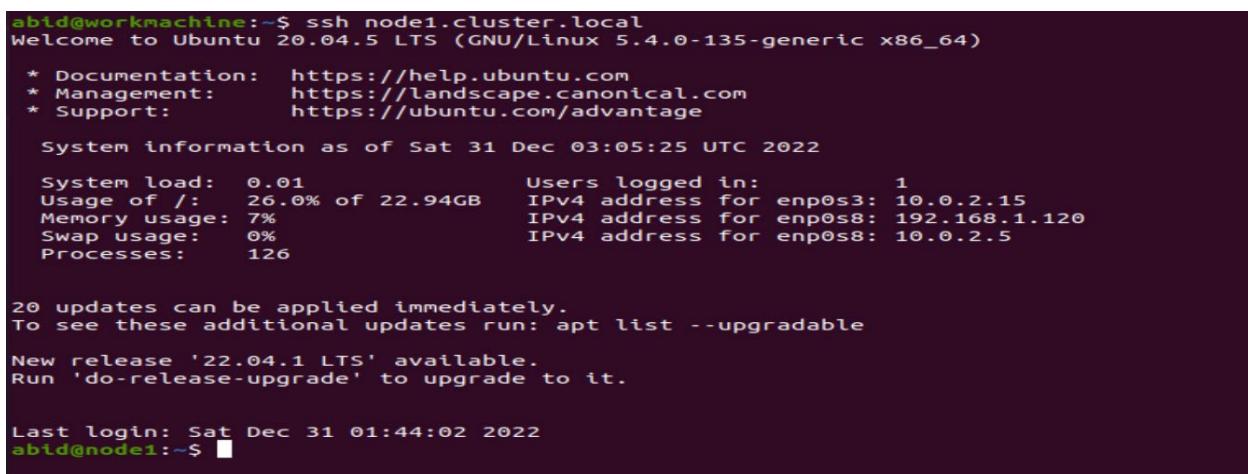
abid@workmachine:~\$ ssh-copy-id -i ~/ssh/id\_rsa.pub abid@node1.cluster.local  
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/abid/.ssh/id\_rsa.pub"  
The authenticity of host 'node1.cluster.local (192.168.1.120)' can't be established.  
ECDSA key fingerprint is SHA256:+vrZrSewDm38xm2oDS1XxofN7qB/g4d0/VdnLAgeEqc.  
Are you sure you want to continue connecting (yes/no/[fingerprint])? █

[ssh-copy-id -i ~/ssh/id\\_rsa.pub abid@node1.cluster.local](ssh-copy-id -i ~/ssh/id_rsa.pub abid@node1.cluster.local)

## 6.9 Result of node1

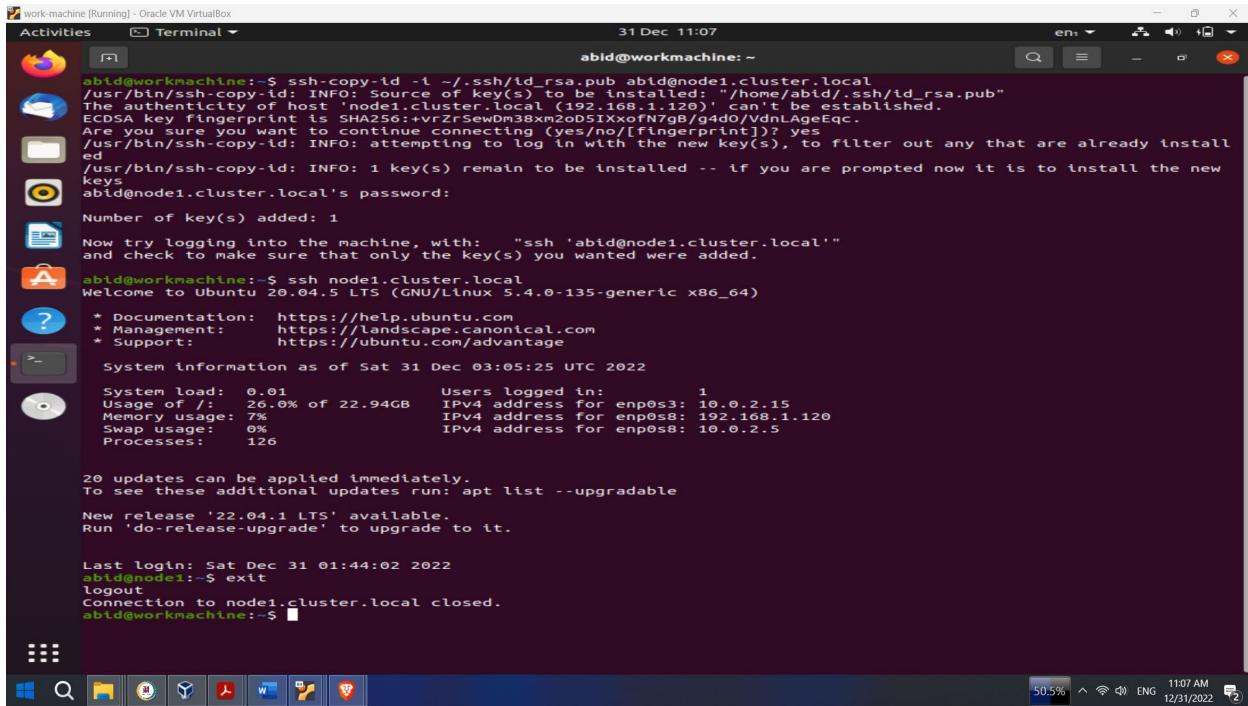


The screenshot shows a Linux desktop environment with a dark theme. A terminal window is open in the center, displaying the command `ssh-copy-id -i ~/ssh/id_rsa.pub abid@node1.cluster.local`. The output shows the key being copied and a confirmation message: "Number of key(s) added: 1". It also includes instructions to log in again. Below the terminal, the desktop environment is visible with icons for various applications like Dash, Home, and System.

The terminal window now shows a successful login to the Ubuntu 20.04.5 LTS system. The prompt is `abid@workmachine:`. The user runs the command `ssh node1.cluster.local`, which connects to the remote host. The remote host's welcome message and system information are displayed, including the system load (0.01), memory usage (7%), swap usage (0%), and process count (126). It also indicates 20 updates available and provides upgrade instructions. The terminal ends with the prompt `abid@node1:`.

Logout



work-machine [Running] - Oracle VM VirtualBox

Activities Terminal 31 Dec 11:07 abid@workmachine:~

```
abid@workmachine:~$ ssh-copy-id -i ~/.ssh/id_rsa.pub abid@node1.cluster.local
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/abid/.ssh/id_rsa.pub"
The authenticity of host 'node1.cluster.local (192.168.1.120)' can't be established.
ECDSA key fingerprint is SHA256:vvrZrSewBm38xm2oD5IXxofN7QB/g4d0/VdnLAgeEqc.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
abid@node1.cluster.local's password:
Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'abid@node1.cluster.local'"
and check to make sure that only the key(s) you wanted were added.

abid@workmachine:~$ ssh node1.cluster.local
Welcome to Ubuntu 20.04.5 LTS (GNU/Linux 5.4.0-135-generic x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage

System information as of Sat 31 Dec 03:05:25 UTC 2022

System load: 0.01           Users logged in: 1
Usage of /: 26.0% of 22.94GB  IPv4 address for enp0s3: 10.0.2.15
Memory usage: 7%            IPv4 address for enp0s8: 192.168.1.120
Swap usage: 0%              IPv4 address for enp0s8: 10.0.2.5
Processes: 126

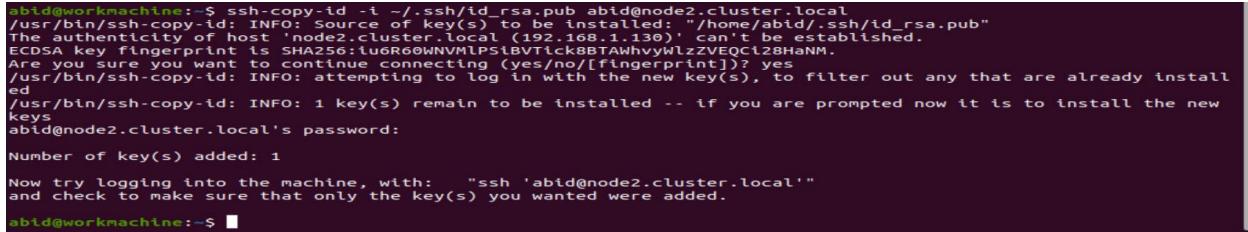
20 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

New release '22.04.1 LTS' available,
Run 'do-release-upgrade' to upgrade to it.

Last login: Sat Dec 31 01:44:02 2022
abid@node1:~$ exit
logout
Connection to node1.cluster.local closed.
abid@workmachine:~$
```

50.5% 11:07 AM ENG 12/31/2022

## 6.10 Result of node2

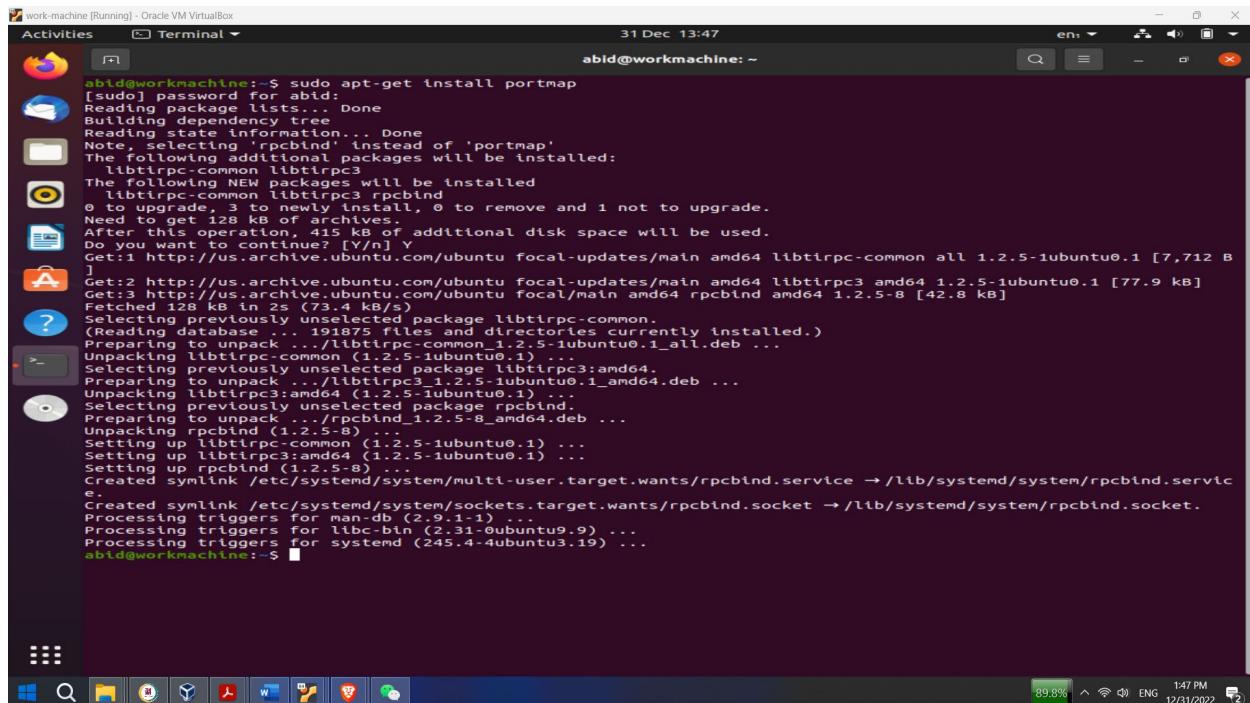


```
abid@workmachine:~$ ssh-copy-id -i ~/.ssh/id_rsa.pub abid@node2.cluster.local
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/abid/.ssh/id_rsa.pub"
The authenticity of host 'node2.cluster.local (192.168.1.130)' can't be established.
ECDSA key fingerprint is SHA256:tu6R60WNVmlPSlBVTick8BTAWhvyWlzZVEQC128HaNM.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
abid@node2.cluster.local's password:
Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'abid@node2.cluster.local'"
and check to make sure that only the key(s) you wanted were added.

abid@workmachine:~$
```

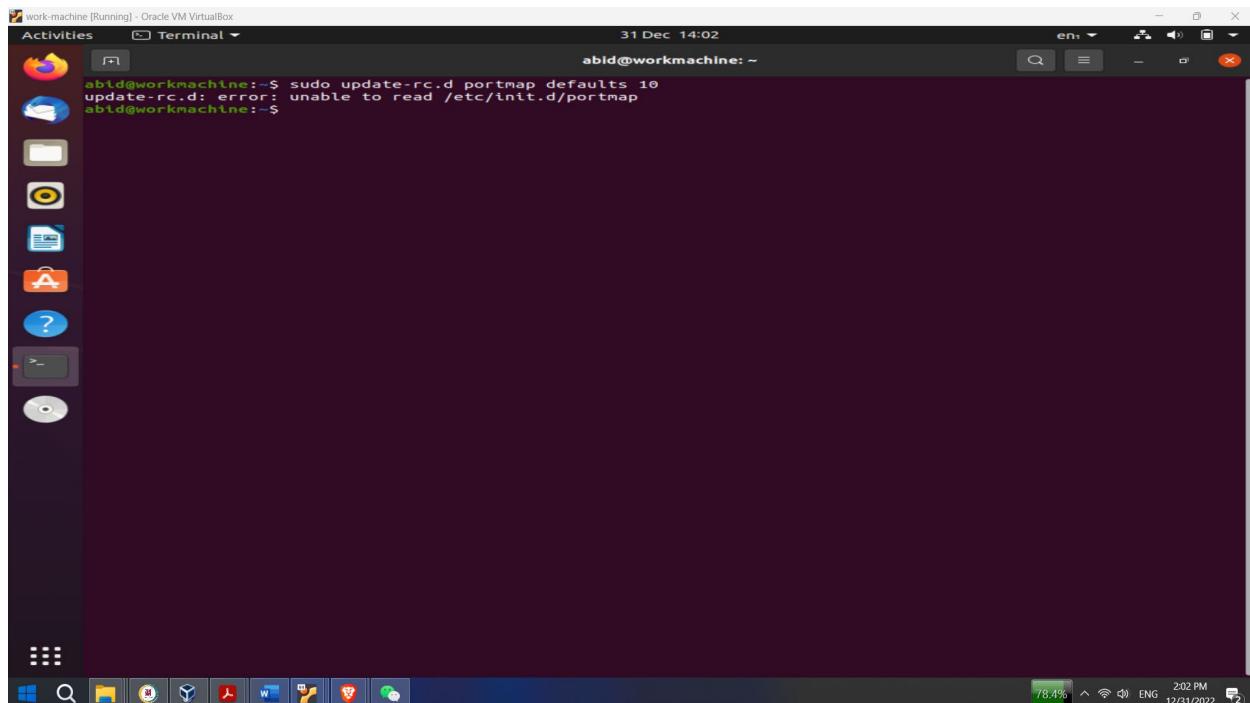
## 7. NIS



```
abid@workmachine:~$ sudo apt-get install portmap
[sudo] password for abid:
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'rpcbind' instead of 'portmap'
The following NEW packages will be installed:
  libtirpc-common libtirpc3
The following NEW packages will be installed:
  libtirpc-common libtirpc3 rpcbind
0 to upgrade, 3 to newly install, 0 to remove and 1 not to upgrade.
Need to get 128 kB of archives.
After this operation, 415 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtirpc-common all 1.2.5-1ubuntu0.1 [7,712 B]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtirpc3 amd64 1.2.5-1ubuntu0.1 [77.9 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/main amd64 rpcbind amd64 1.2.5-8 [42.8 kB]
Fetched 128 kB in 2s (73.4 kB/s)
Selecting previously unselected package libtirpc-common.
(Reading database ... 191875 files and directories currently installed.)
Preparing to unpack .../libtirpc-common_1.2.5-1ubuntu0.1_all.deb ...
Unpacking libtirpc-common (1.2.5-1ubuntu0.1) ...
Selecting previously unselected package libtirpc3:amd64.
Preparing to unpack .../libtirpc3_1.2.5-1ubuntu0.1_amd64.deb ...
Unpacking libtirpc3:amd64 (1.2.5-1ubuntu0.1) ...
Selecting previously unselected package rpcbind.
Preparing to unpack .../rpcbind_1.2.5-8_amd64.deb ...
Unpacking rpcbind (1.2.5-8) ...
Setting up libtirpc-common (1.2.5-1ubuntu0.1) ...
Setting up libtirpc3:amd64 (1.2.5-1ubuntu0.1) ...
Setting up rpcbind (1.2.5-8) ...
Created symlink /etc/systemd/system/multi-user.target.wants/rpcbind.service → /lib/systemd/system/rpcbind.service.
Created symlink /etc/systemd/system/sockets.target.wants/rpcbind.socket → /lib/systemd/system/rpcbind.socket.
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.9) ...
Processing triggers for systemd (245.4-4ubuntu3.19) ...
abid@workmachine:~$
```

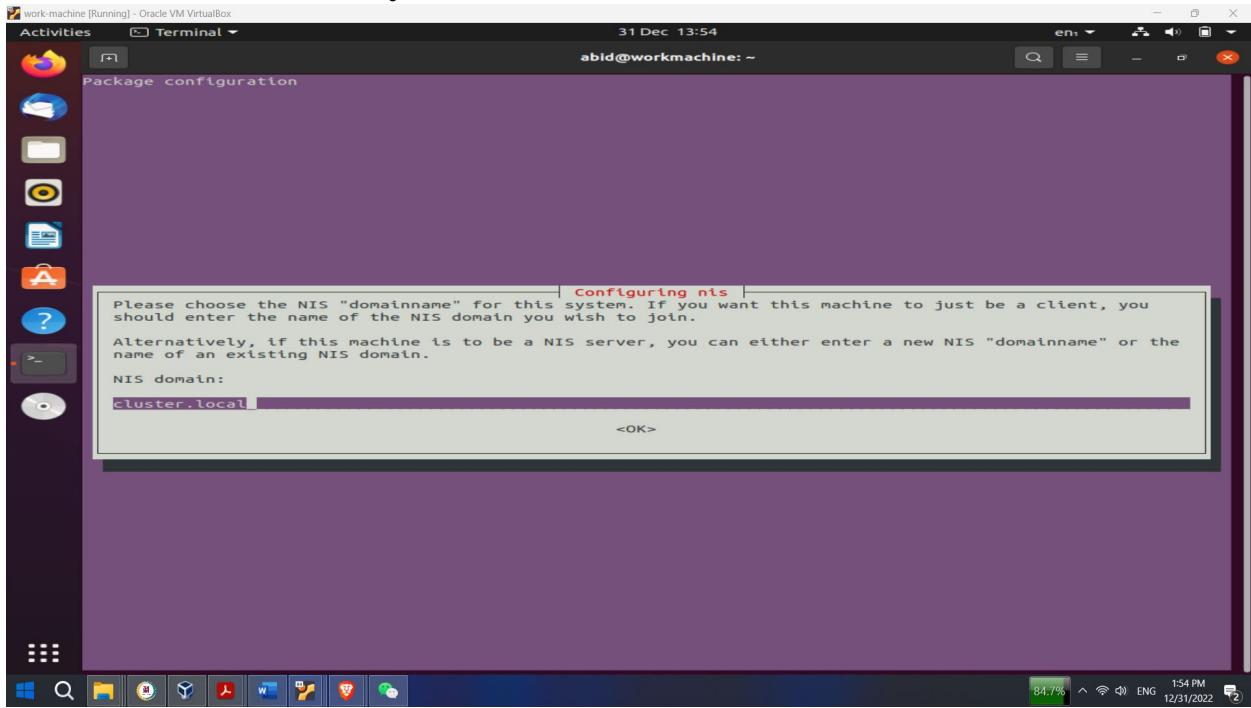
sudo apt-get install portmap

### 7.1 Problem Faced in NIS



```
abid@workmachine:~$ sudo update-rc.d portmap defaults 10
update-rc.d: error: unable to read /etc/init.d/portmap
abid@workmachine:~$
```

## 7.2 Installation NIS system



```
sudo apt -y install nis
```

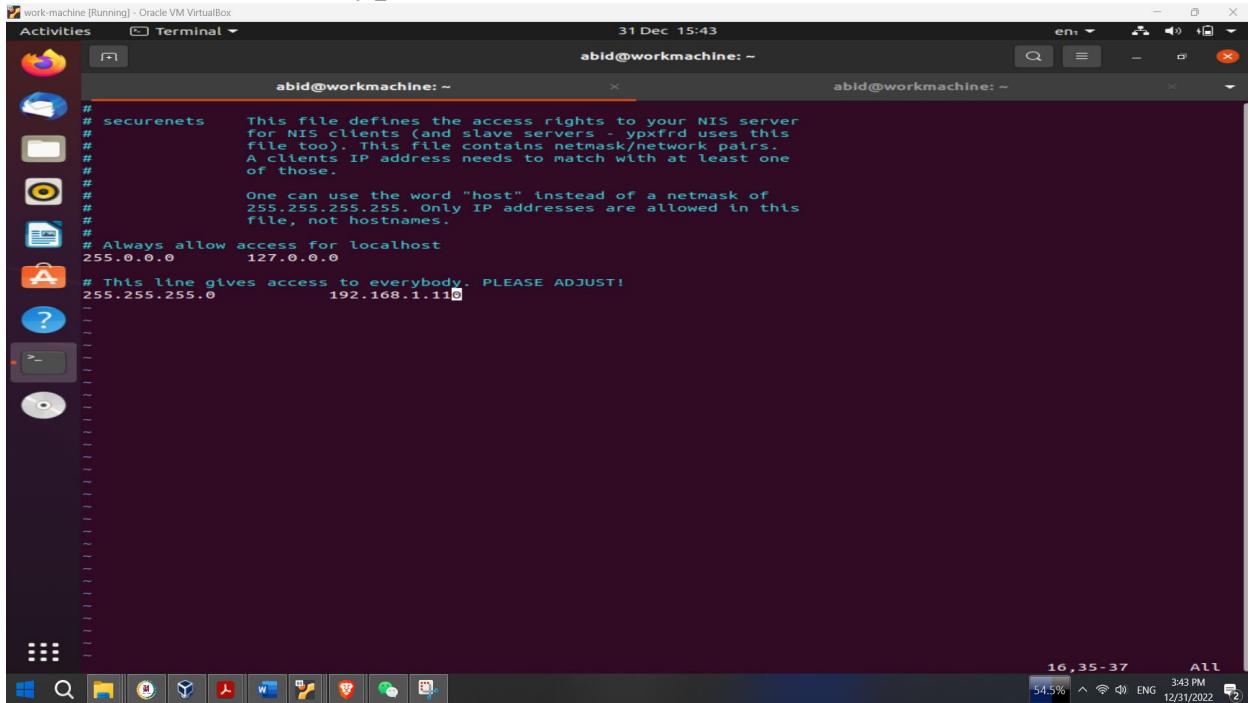
## 7.3 On the server side

### 7.3.1 sudo vim /etc/default/nis

A screenshot of a Linux terminal window showing the contents of the file '/etc/default/nis'. The terminal title is 'Terminal'. The file is a configuration script for NIS daemons. It contains several commented-out lines starting with '#'. Some of the visible variables include: NISERVERMASTER, NISCLIENT=false, YPPWDDIR=/etc, YPCHANGEOK=chsh, YPSERVARGS=, YPBINDARGS=no-dbu, YPPASSWDARGS=, and YPXFRDARGS=. The file ends with the message: '/etc/default/nis' 35L, 1045C written. The terminal window also shows the date and time: '31 Dec 15:32'.

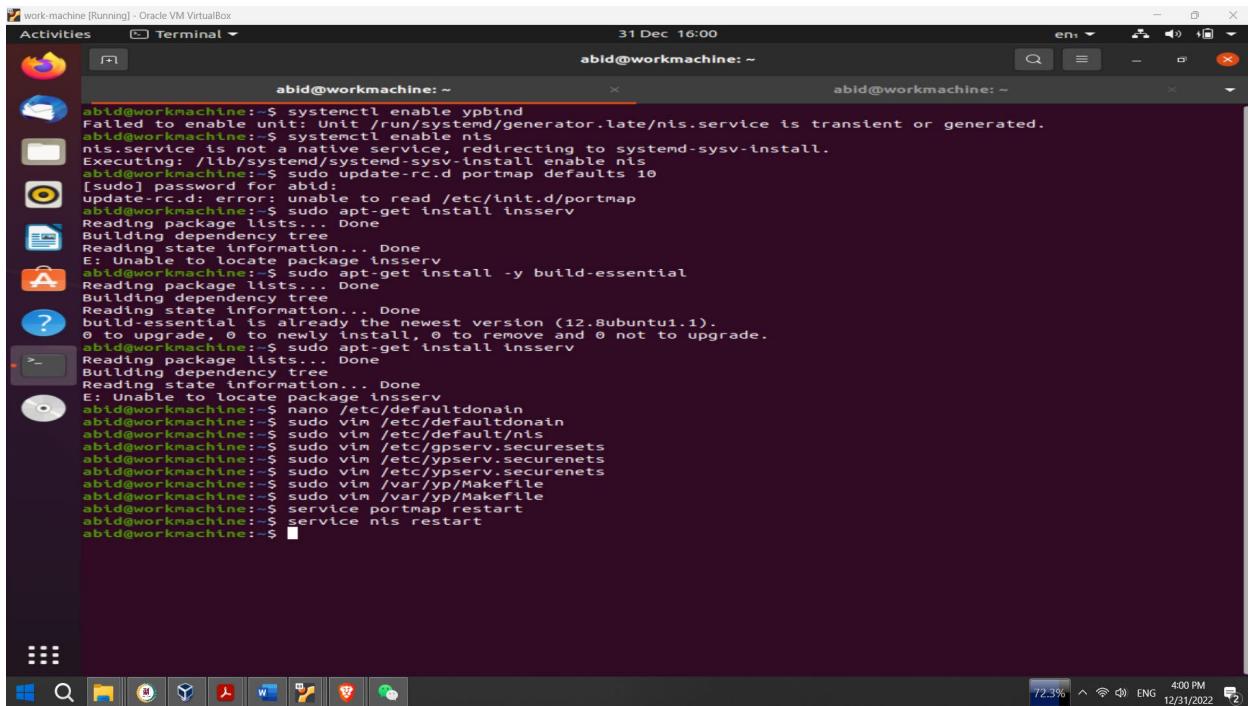
```
sudo vim /etc/default/nis
```

### 7.3.2 sudo vim /etc/ypserv.securenets



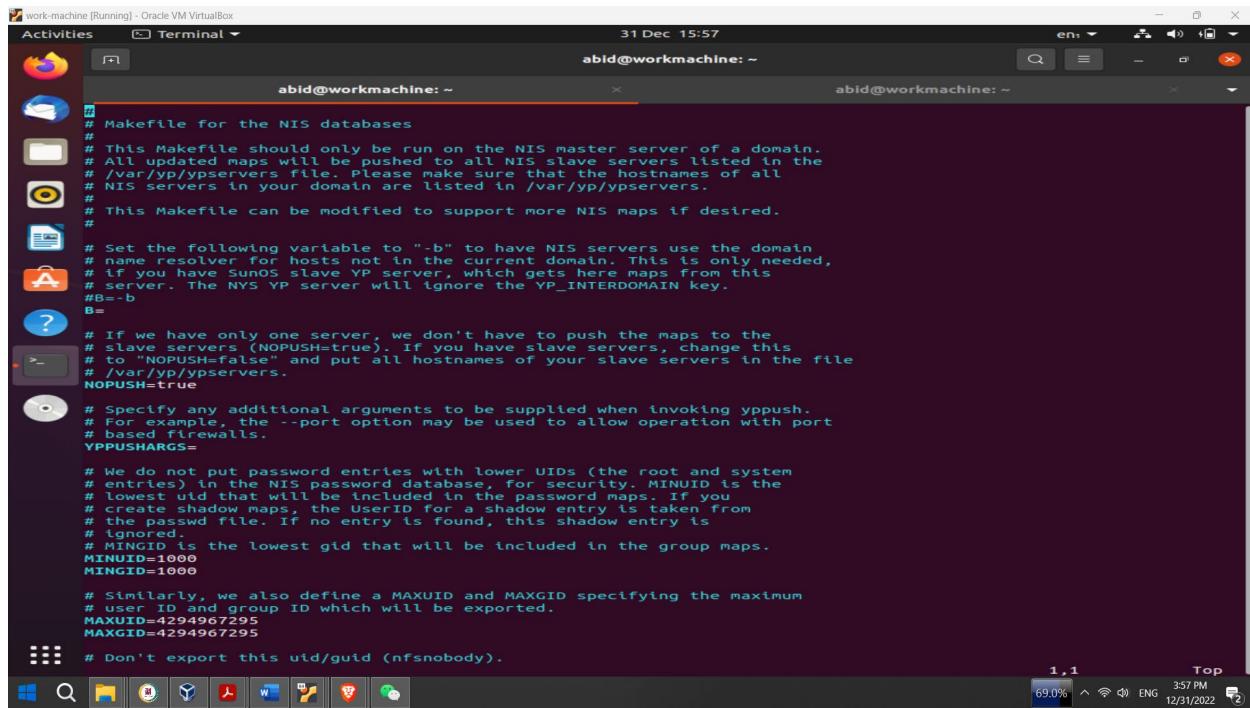
```
# securenets  This file defines the access rights to your NIS server
# for NIS clients (and slave servers - ypxfrd uses this
# file too). This file contains netmask/network pairs.
# A clients IP address needs to match with at least one
# of those.
#
# One can use the word "host" instead of a netmask of
# 255.255.255.255. Only IP addresses are allowed in this
# file, not hostnames.
#
# Always allow access for localhost
255.0.0.0      127.0.0.0
# This line gives access to everybody. PLEASE ADJUST!
255.255.255.0  192.168.1.110
```

sudo vim /etc/ypserv.securenets



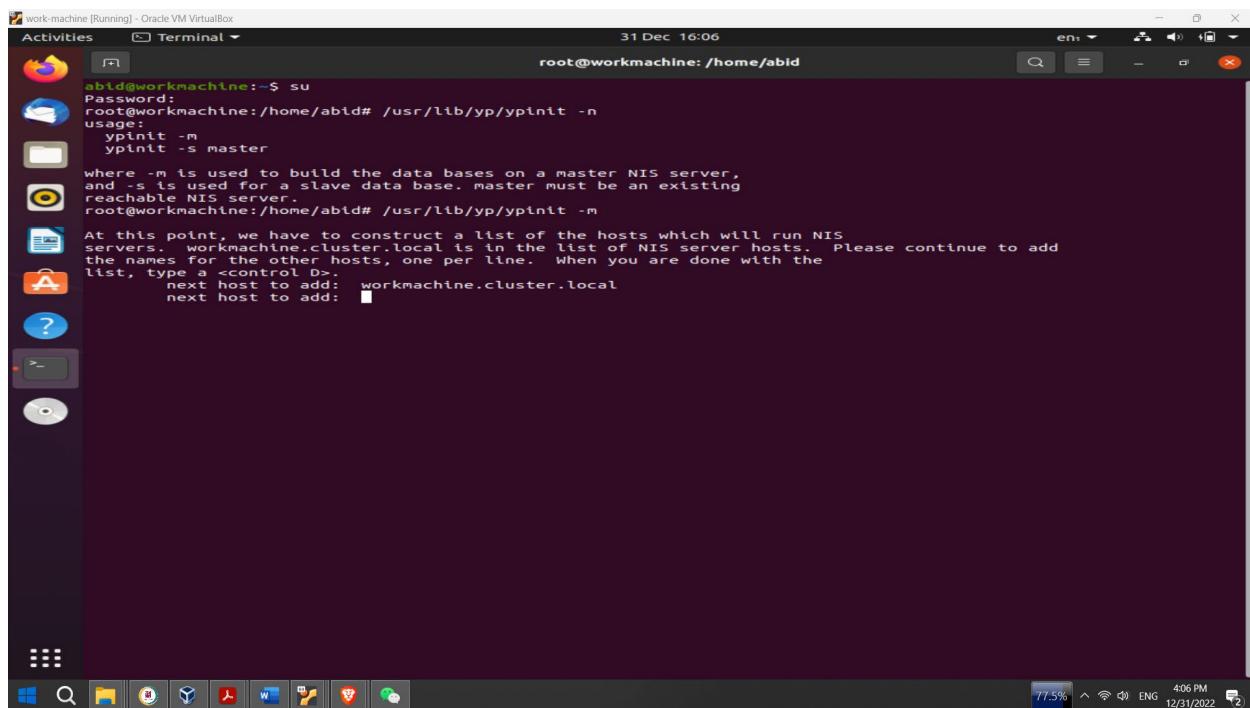
```
abid@workmachine:~$ systemctl enable ypbind
Failed to enable unit: Unit /run/systemd/generator.late/nis.service is transient or generated.
abid@workmachine:~$ systemctl enable nis
nis.service is not a native service, redirecting to systemd-sysv-install.
Executing: /lib/systemd/systemd-sysv-install enable nis
abid@workmachine:~$ sudo update-rc.d portmap defaults 10
[sudo] password for abid:
update-rc.d: error: unable to read /etc/init.d/portmap
abid@workmachine:~$ sudo apt-get install insserv
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package insserv
abid@workmachine:~$ sudo apt-get install -y build-essential
Reading package lists... Done
Building dependency tree
Reading state information... Done
build-essential is already the newest version (12.8ubuntu1.1).
0 to upgrade, 0 to newly install, 0 to remove and 0 not to upgrade.
abid@workmachine:~$ sudo apt-get install insserv
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package insserv
abid@workmachine:~$ nano /etc/defaultdomain
abid@workmachine:~$ sudo vim /etc/defaultdomain
abid@workmachine:~$ sudo vim /etc/default.nis
abid@workmachine:~$ sudo vim /etc/ypserv.securenets
abid@workmachine:~$ sudo vim /etc/ypserv.securenets
abid@workmachine:~$ sudo vim /etc/ypserv.securenets
abid@workmachine:~$ sudo vim /var/yp/Makefile
abid@workmachine:~$ sudo vim /var/yp/Makefile
abid@workmachine:~$ service portmap restart
abid@workmachine:~$ service nis restart
abid@workmachine:~$
```

### 7.3.3 Makefile for the NIS databases



```
# Makefile for the NIS databases
#
# This Makefile should only be run on the NIS master server of a domain.
# All updated maps will be pushed to all NIS slave servers listed in the
# /var/yp/ypservers file. Please make sure that the hostnames of all
# NIS servers in your domain are listed in /var/yp/ypservers.
#
# This Makefile can be modified to support more NIS maps if desired.
#
# Set the following variable to "-b" to have NIS servers use the domain
# name resolver for hosts not in the current domain. This is only needed,
# if you have SunOS slave YP server, which gets here maps from this
# server. The NYS YP server will ignore the YP_INTERDOMAIN key.
#B=-b
#
# If we have only one server, we don't have to push the maps to the
# slave servers (NOPUSH=true). If you have slave servers, change this
# to "NOPUSH=false" and put all hostnames of your slave servers in the file
# /var/yp/ypservers.
#NOPUSH=true
#
# Specify any additional arguments to be supplied when invoking yppush.
# For example, the --port option may be used to allow operation with port
# based firewalls.
YPPUSHARGS=
#
# We do not put password entries with lower UIDs (the root and system
# entries) in the NIS password database, for security. MINUID is the
# lowest uid that will be included in the password maps. If you
# need shadow maps, the UserID for a shadow entry is taken from
# the passwd file. If no entry is found, this shadow entry is
# ignored.
# MINGID is the lowest gid that will be included in the group maps.
MINUID=1000
MINGID=1000
#
# Similarly, we also define a MAXUID and MAXGID specifying the maximum
# user ID and group ID which will be exported.
MAXUID=4294967295
MAXGID=4294967295
#
# Don't export this uid/guid (nfsnobody).
1,1 Top
69.0% ^ ⚡ ENG 3:57 PM 12/31/2022
```

### 7.4 On the Server Side



```
abtd@workmachine:~$ su
Password:
root@workmachine:/home/abtd# /usr/lib/yp/ypinit -n
usage:
    ypinit -m
    ypinit -s master
where -m is used to build the data bases on a master NIS server,
and -s is used for a slave data base. master must be an existing
reachable NIS server.
root@workmachine:/home/abtd# /usr/lib/yp/ypinit -m
At this point, we have to construct a list of the hosts which will run NIS
servers. workmachine.cluster.local is in the list of NIS server hosts. Please continue to add
the names for the other hosts, one per line. When you are done with the
list, type a <control D>.
    next host to add: workmachine.cluster.local
    next host to add: █
406 PM 77.5% ^ ⚡ ENG 12/31/2022
```

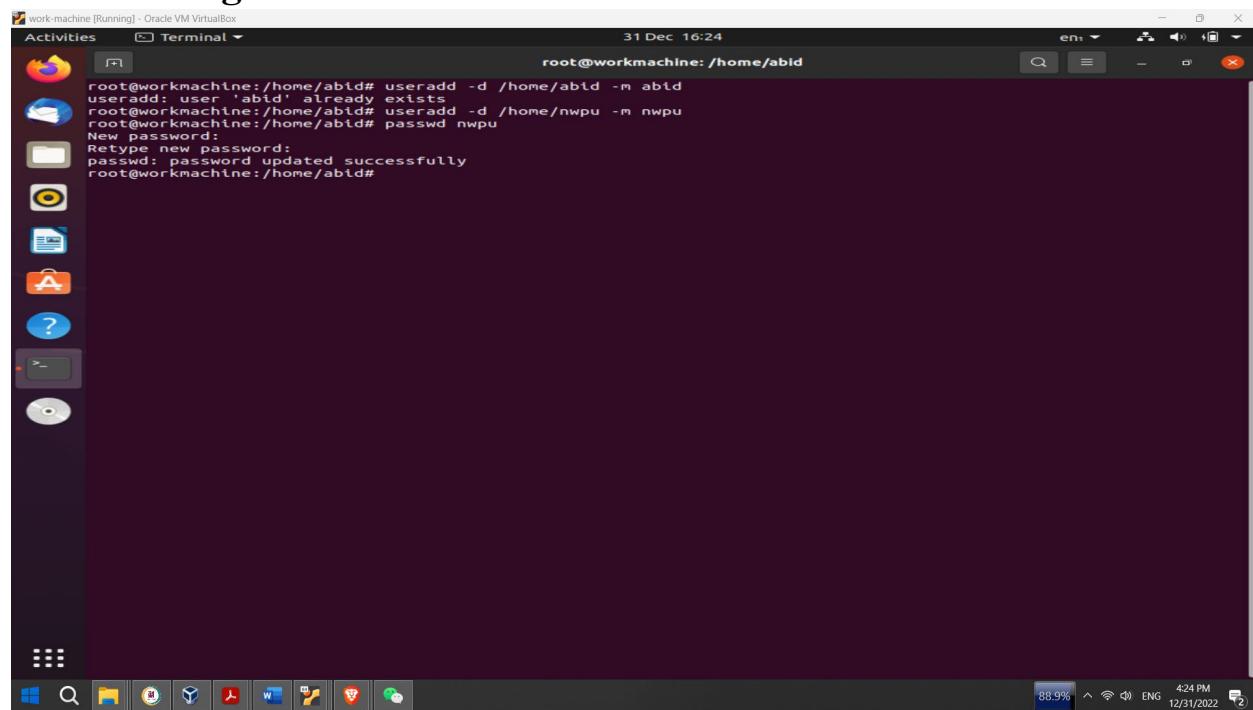
## 7.4.1 /usr/lib/yp/ypinit -m

```
At this point, we have to construct a list of the hosts which will run NIS servers. workmachine.cluster.local is in the list of NIS server hosts. Please continue to add the names of the other hosts, one per line. When you are done with the list, type a <control-D>:
next host to add: workmachine.cluster.local
next host to add:
The current list of NIS servers looks like this:
workmachine.cluster.local

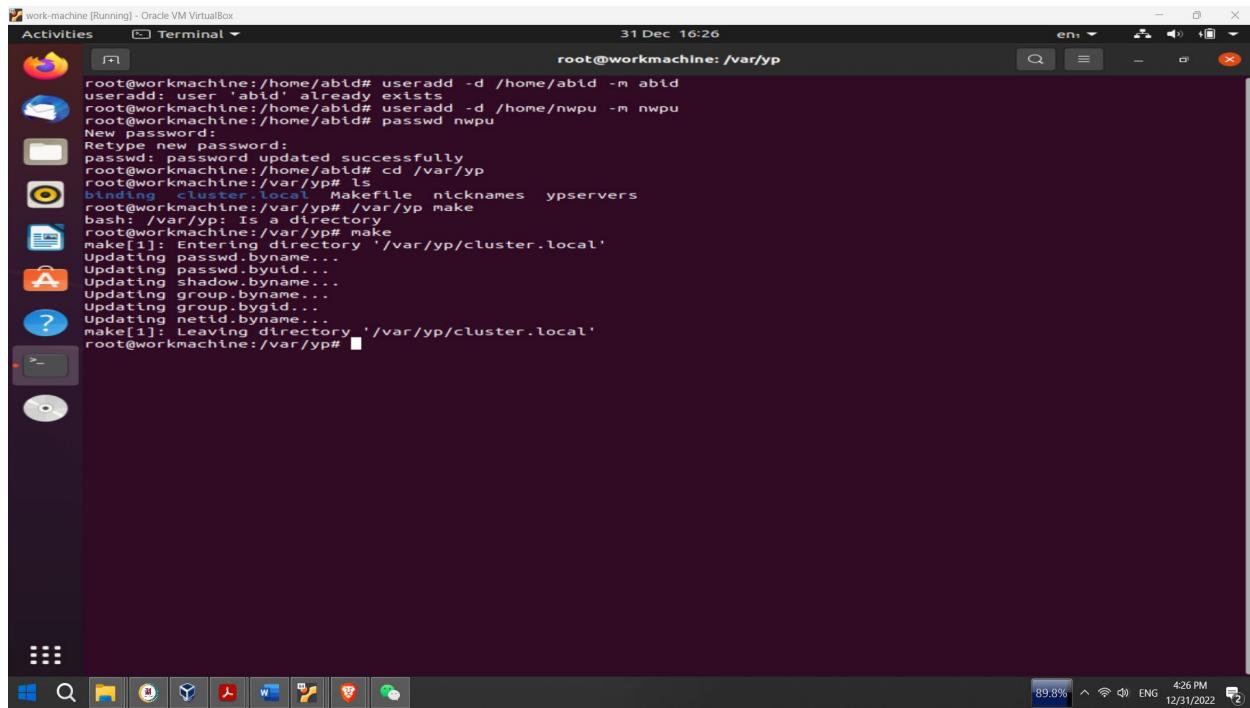
Is this correct? [y/n: y] y
We need a few minutes to build the databases...
Building /var/yp/cluster.local/yservers...
Running /var/yp/Makefile...
make[1]: Entering directory '/var/yp/cluster.local'
Updating passwd.byname...
Updating passwd.byuid...
Updating shadow.byname...
Updating groupbyname...
Updating group.bygid...
Updating hosts.byname...
Updating hosts.byaddr...
Updating rpc.byname...
Updating rpc.bynumber...
Updating services.byname...
Updating services.byserVICENAME...
Updating netid.byname...
Updating protocols.bynumber...
Updating protocols.byname...
Updating netgroup...
Updating netgroup.byhost...
Updating netgroup.byuser...
make[1]: Leaving directory '/var/yp/cluster.local'
workmachine.cluster.local has been set up as a NIS master server.
Now you can run ypinit -s workmachine.cluster.local on all slave server.
root@workmachine:/home/abid#
```

/usr/lib/yp/ypinit -m

## 7.4.2 Adding user

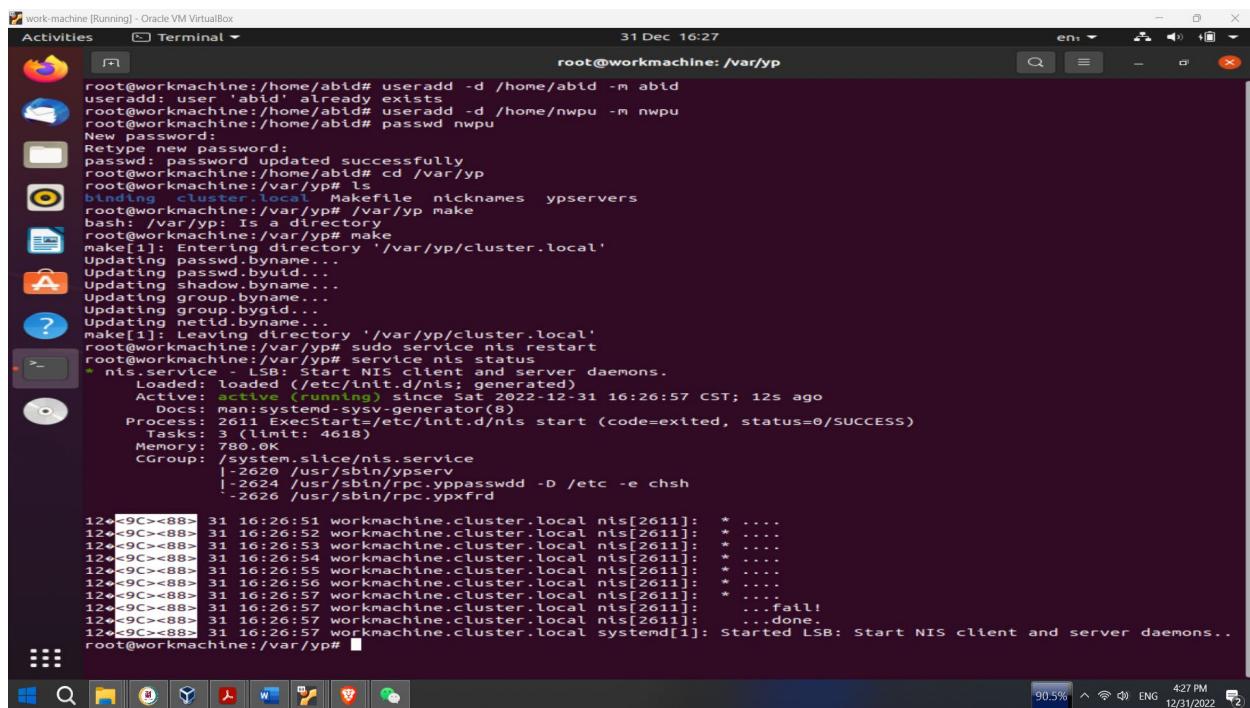


### 7.4.3 Make



```
root@workmachine:/home/abid# useradd -d /home/abid -m abid
useradd: user 'abid' already exists
root@workmachine:/home/abid# useradd -d /home/nwpw -m nwpw
root@workmachine:/home/abid# passwd nwpw
New password:
Retype new password:
passwd: password updated successfully
root@workmachine:/home/abid# cd /var/yp
root@workmachine:/var/yp# ls
binding cluster.local Makefile nicknames ypservers
root@workmachine:/var/yp# /var/yp make
bash: /var/yp: Is a directory
root@workmachine:/var/yp# make
make[1]: Entering directory '/var/yp/cluster.local'
Updating passwd.byname...
Updating shadow.byname...
Updating groupbyname...
Updating groupbygid...
Updating netidbyname...
make[1]: Leaving directory '/var/yp/cluster.local'
root@workmachine:/var/yp#
```

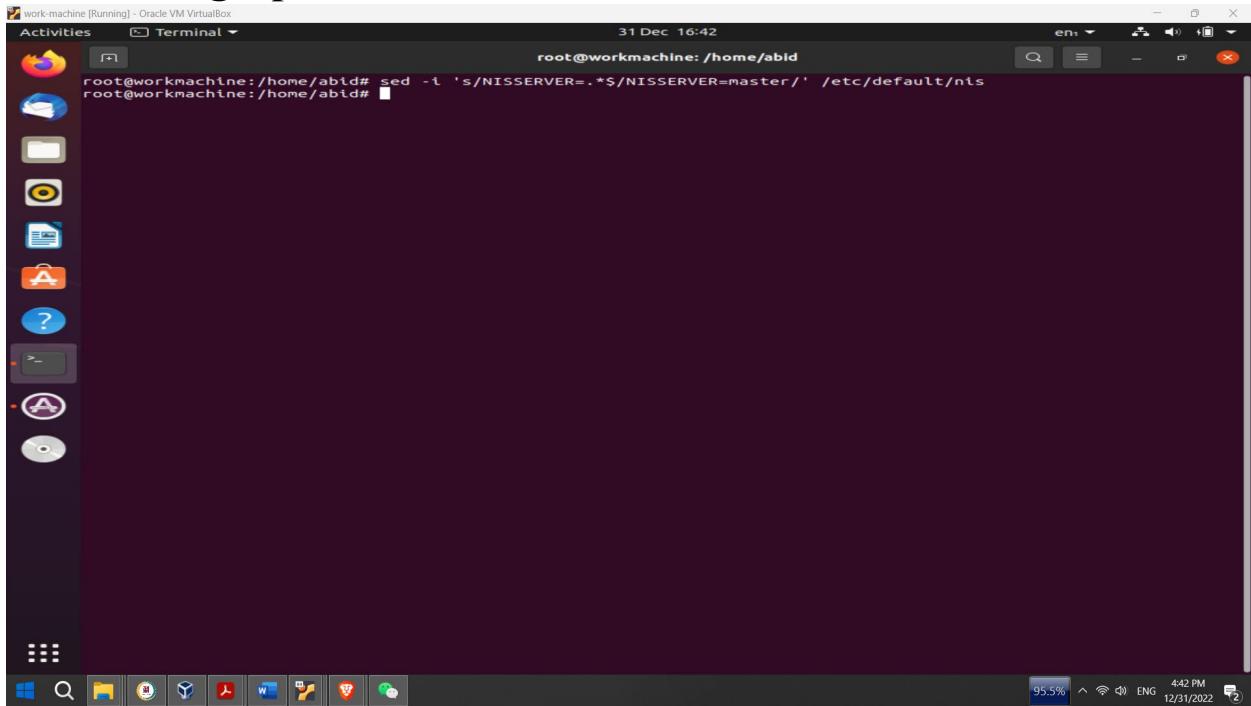
### 7.4.4 NIS Activate



```
root@workmachine:/home/abid# useradd -d /home/abid -m abid
useradd: user 'abid' already exists
root@workmachine:/home/abid# useradd -d /home/nwpw -m nwpw
root@workmachine:/home/abid# passwd nwpw
New password:
Retype new password:
passwd: password updated successfully
root@workmachine:/home/abid# cd /var/yp
root@workmachine:/var/yp# ls
binding cluster.local Makefile nicknames ypservers
root@workmachine:/var/yp# /var/yp make
bash: /var/yp: Is a directory
root@workmachine:/var/yp# make
make[1]: Entering directory '/var/yp/cluster.local'
Updating passwd.byname...
Updating shadow.byname...
Updating groupbyname...
Updating groupbygid...
Updating netidbyname...
make[1]: Leaving directory '/var/yp/cluster.local'
root@workmachine:/var/yp# sudo service nts restart
root@workmachine:/var/yp# service nts status
* nis.service - LSB: Start NIS client and server daemons.
  Loaded: loaded (/etc/init.d/nts; generated)
  Active: active (running) since Sat 2022-12-31 16:26:57 CST; 12s ago
    Docs: man:systemd-sysv-generator(8)
  Process: 2611 ExecStart=/etc/init.d/nts start (code=exited, status=0/SUCCESS)
   Tasks: 3 (limit: 4018)
  Memory: 780.BK
   CGroup: /system.slice/nts.service
           |-2620 /usr/sbin/ypserv
           |-2624 /usr/sbin/rpc.ypassword -D /etc -e chsh
           |-2626 /usr/sbin/rpc.ypxfrd

12<9C><8B> 31 16:26:51 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:52 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:53 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:54 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:55 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:56 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:57 workmachine.cluster.local nts[2611]: * ....
12<9C><8B> 31 16:26:57 workmachine.cluster.local nts[2611]: ...fail!
12<9C><8B> 31 16:26:57 workmachine.cluster.local nts[2611]: ...done.
root@workmachine:/var/yp#
```

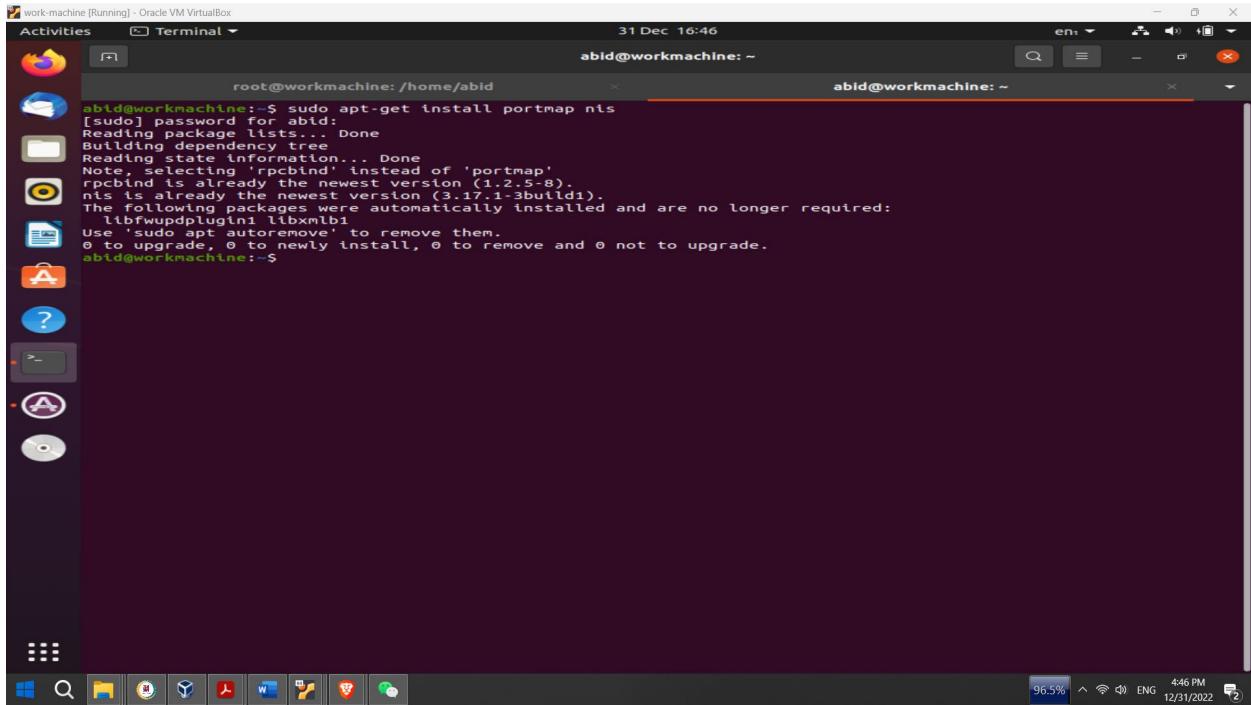
## 7.4.5 Setting Up The NIS Server



```
root@workmachine:/home/abid# sed -i 's/NISERVER=.*$/NISERVER=master/' /etc/default/nis
root@workmachine:/home/abid#
```

sed -i 's/NISERVER=.\*\$/NISERVER=master/' /etc/default/nis

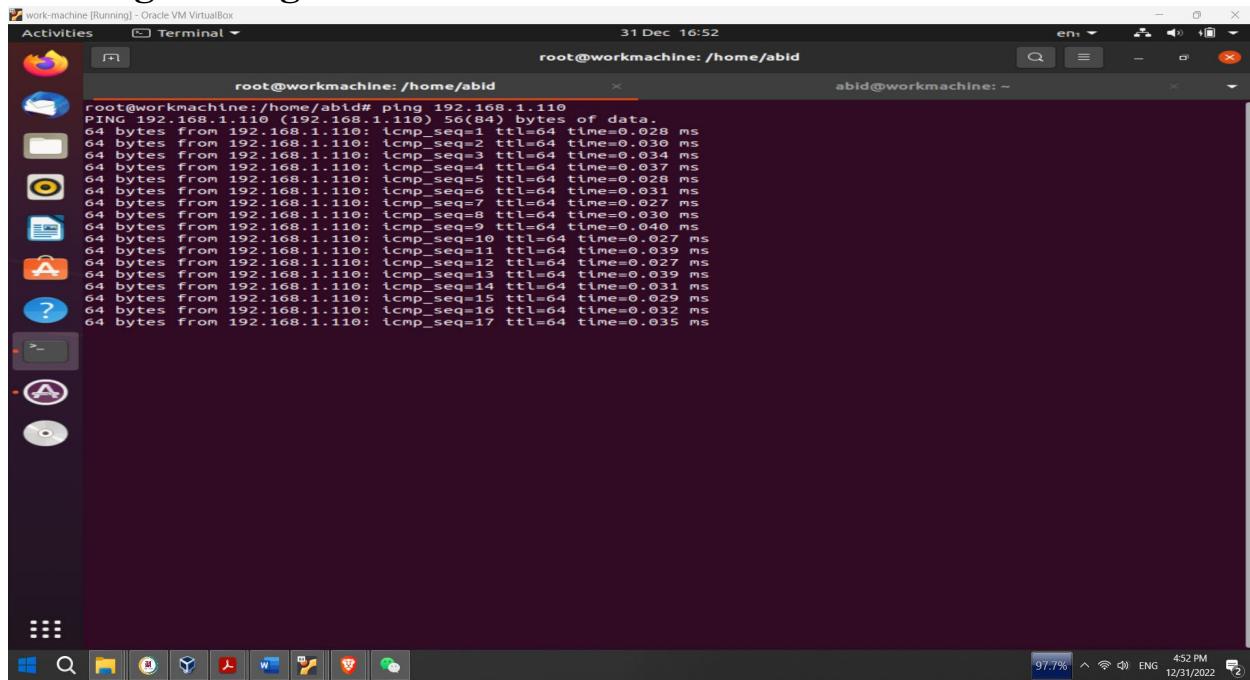
## 7.5 sudo apt-get install portmap nis



```
root@workmachine:/home/abid# sudo apt-get install portmap nis
[sudo] password for abid:
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'rpcbind' instead of 'portmap'
rpcbind is already the newest version (1.2.5-8).
nis is already the newest version (3.17.1-3build1).
The following packages were automatically installed and are no longer required:
  libfwupdplugin libxmlmb1
Use 'sudo apt autoremove' to remove them.
0 to upgrade, 0 to newly install, 0 to remove and 0 not to upgrade.
abid@workmachine:$
```

sudo apt-get install portmap nis

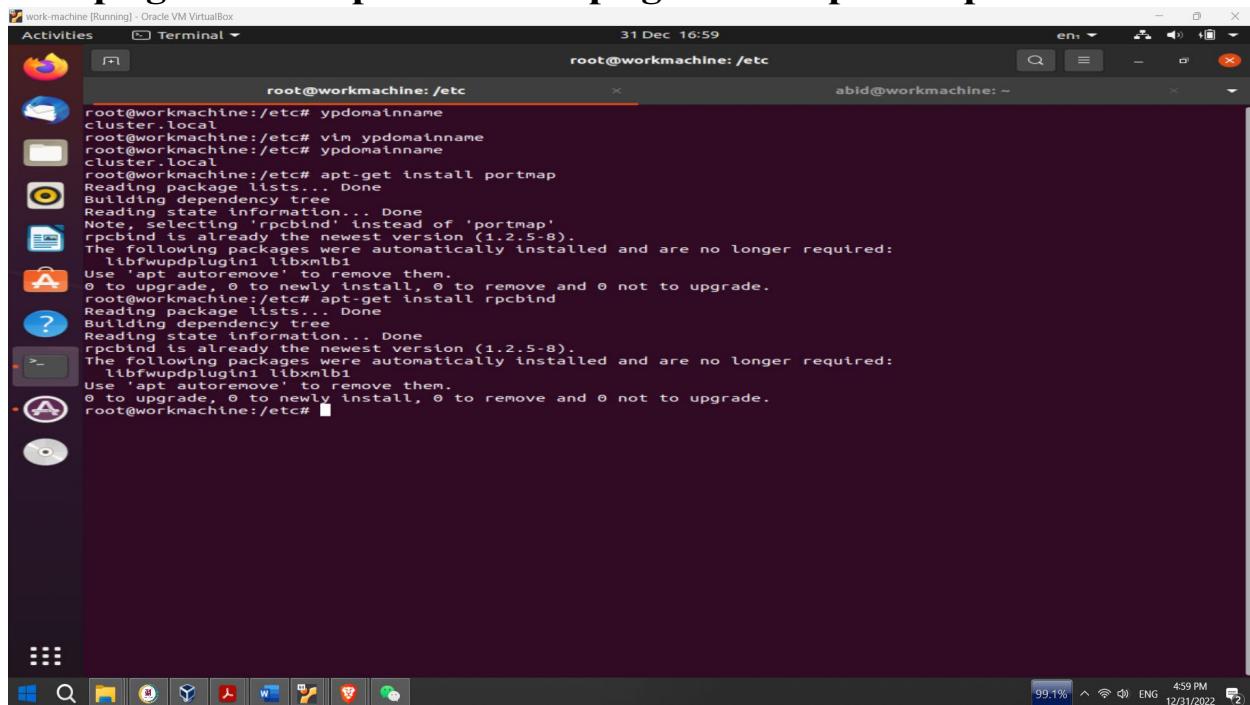
## 7.6 Ping Testing Workmachine



A screenshot of a Linux desktop environment (Ubuntu) running in Oracle VM VirtualBox. The desktop has a dark theme with icons for various applications like a browser, file manager, and terminal. A terminal window titled 'root@workmachine: /home/abid' is open, showing the output of a 'ping' command to 192.168.1.110. The output shows 64 bytes being sent from 192.168.1.110 to 192.168.1.110, with TTL=64 and times ranging from 0.028 ms to 0.035 ms. The terminal window is part of a larger windowed interface.

```
root@workmachine:/home/abid$ ping 192.168.1.110
PING 192.168.1.110 (192.168.1.110) 56(84) bytes of data.
64 bytes from 192.168.1.110: icmp_seq=1 ttl=64 time=0.028 ms
64 bytes from 192.168.1.110: icmp_seq=2 ttl=64 time=0.030 ms
64 bytes from 192.168.1.110: icmp_seq=3 ttl=64 time=0.034 ms
64 bytes from 192.168.1.110: icmp_seq=4 ttl=64 time=0.037 ms
64 bytes from 192.168.1.110: icmp_seq=5 ttl=64 time=0.028 ms
64 bytes from 192.168.1.110: icmp_seq=6 ttl=64 time=0.031 ms
64 bytes from 192.168.1.110: icmp_seq=7 ttl=64 time=0.027 ms
64 bytes from 192.168.1.110: icmp_seq=8 ttl=64 time=0.030 ms
64 bytes from 192.168.1.110: icmp_seq=9 ttl=64 time=0.040 ms
64 bytes from 192.168.1.110: icmp_seq=10 ttl=64 time=0.027 ms
64 bytes from 192.168.1.110: icmp_seq=11 ttl=64 time=0.039 ms
64 bytes from 192.168.1.110: icmp_seq=12 ttl=64 time=0.027 ms
64 bytes from 192.168.1.110: icmp_seq=13 ttl=64 time=0.039 ms
64 bytes from 192.168.1.110: icmp_seq=14 ttl=64 time=0.031 ms
64 bytes from 192.168.1.110: icmp_seq=15 ttl=64 time=0.030 ms
64 bytes from 192.168.1.110: icmp_seq=16 ttl=64 time=0.032 ms
64 bytes from 192.168.1.110: icmp_seq=17 ttl=64 time=0.035 ms
```

## 7.7 apt-get install rpcbind and apt-get install portmap



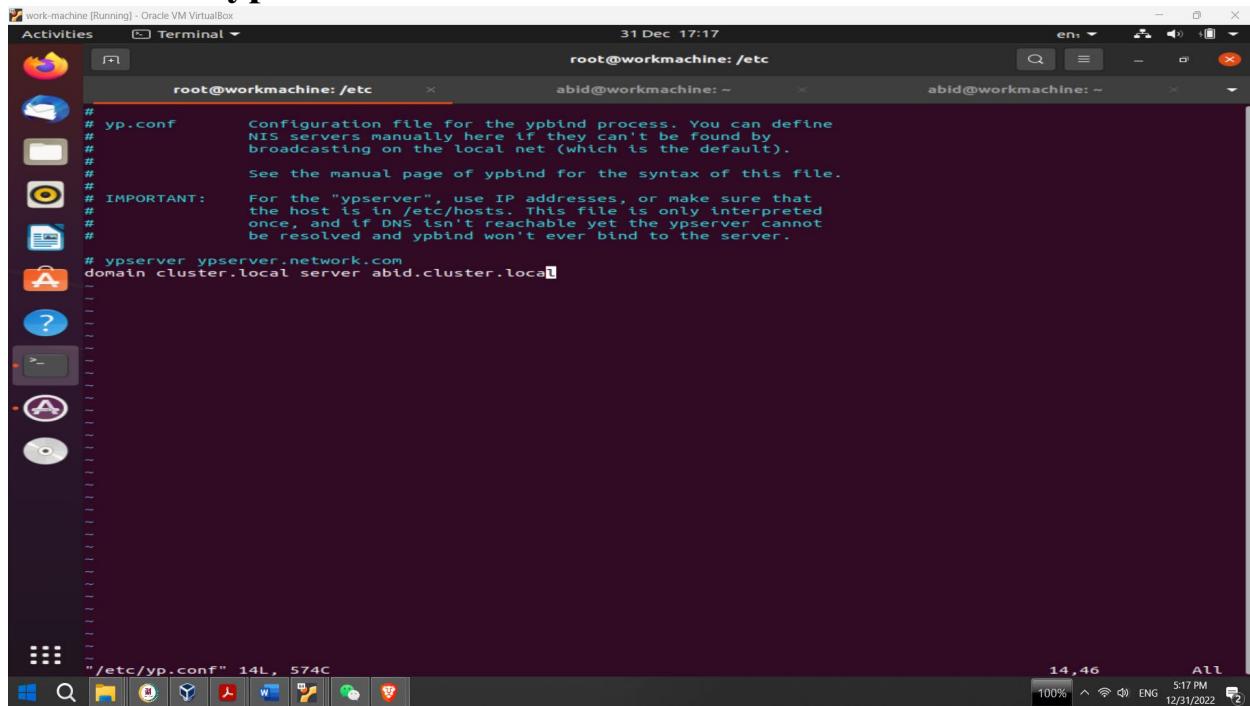
A screenshot of a Linux desktop environment (Ubuntu) running in Oracle VM VirtualBox. The desktop has a dark theme with icons for various applications like a browser, file manager, and terminal. Two terminal windows are open: one titled 'root@workmachine: /etc' and another titled 'abid@workmachine: ~'. The root terminal shows the command 'apt-get install rpcbind' being run, which outputs that rpcbind is already the newest version (1.2.5-8). The user terminal shows the command 'apt-get install portmap' being run, which outputs that portmap is already the newest version (1.2.5-8).

```
root@workmachine:/etc# ypmdomainname
cluster.local
root@workmachine:/etc# vim ypmdomainname
root@workmachine:/etc# ypmdomainname
cluster.local
root@workmachine:/etc# apt-get install portmap
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'rpcbind' instead of 'portmap'
rpcbind is already the newest version (1.2.5-8).
The following packages were automatically installed and are no longer required:
  libfwupdplugin1 libxml2
Use 'apt autoremove' to remove them.
0 to upgrade, 0 to newly install, 0 to remove and 0 not to upgrade.
root@workmachine:/etc# apt-get install rpcbind
Reading package lists... Done
Building dependency tree
Reading state information... Done
rpcbind is already the newest version (1.2.5-8).
The following packages were automatically installed and are no longer required:
  libfwupdplugin1 libxml2
Use 'apt autoremove' to remove them.
0 to upgrade, 0 to newly install, 0 to remove and 0 not to upgrade.
root@workmachine:/etc#
```

apt-get install rpcbind

apt-get install portmap

## 7.8 vim /etc/yp.conf

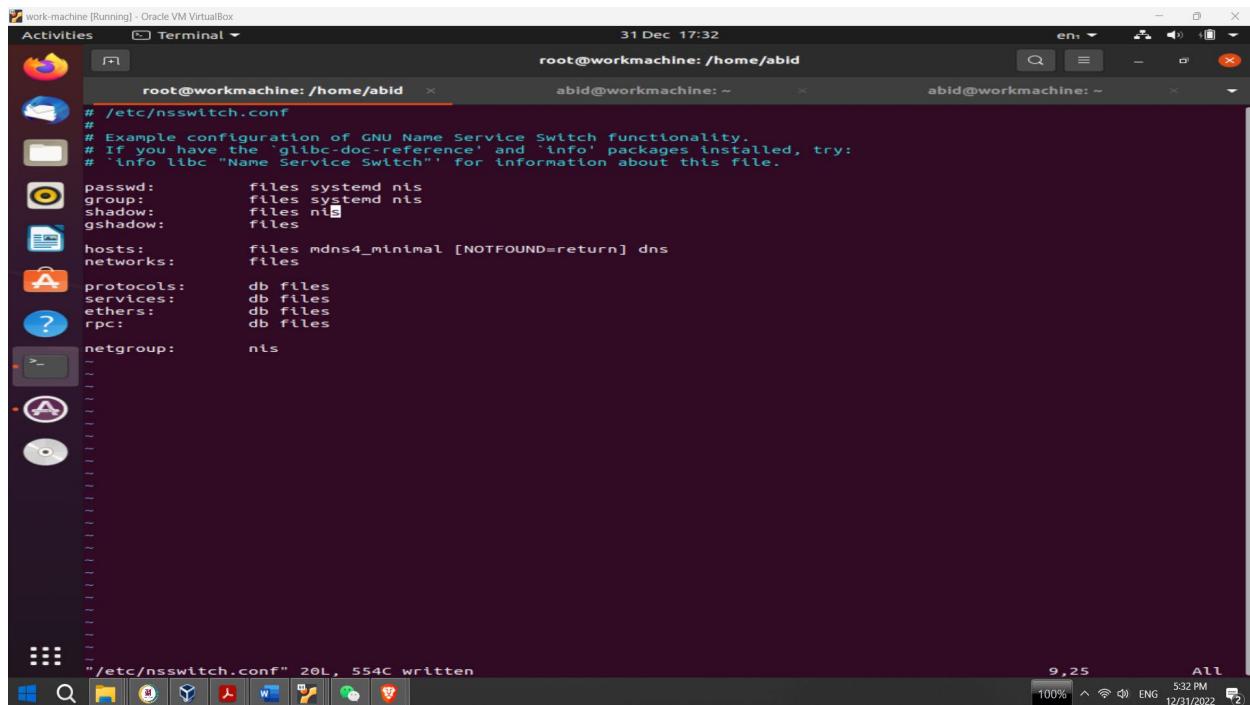


A screenshot of a Linux desktop environment. In the center is a terminal window titled "root@workmachine: /etc". The terminal shows the contents of the /etc/yp.conf file. The file contains configuration for the ypbind process, including sections for ypserver and domain settings. The terminal window is part of a Unity interface, with the Activities overview visible on the left and a dock of icons at the bottom.

```
# yp.conf      Configuration file for the ypbind process. You can define
# NIS servers manually here if they can't be found by
# broadcasting on the local net (which is the default).
#
# See the manual page of ypbind for the syntax of this file.
#
# IMPORTANT: For the "ypserver", use IP addresses, or make sure that
# the host is in /etc/hosts. This file is only interpreted
# once, and if DNS isn't reachable yet the ypserver cannot
# be resolved and ypbind won't ever bind to the server.
#
# ypserver ypserver.network.com
domain cluster.local server abid.cluster.local
```

vim /etc/yp.conf

## 7.9 vim /etc/nsswitch.conf



A screenshot of a Linux desktop environment. In the center is a terminal window titled "root@workmachine: /home/abid". The terminal shows the contents of the /etc/nsswitch.conf file. The file defines how various system services (like passwd, group, shadow, hosts, networks, protocols, services, ethers, rpc, and netgroup) should be resolved. The terminal window is part of a Unity interface, with the Activities overview visible on the left and a dock of icons at the bottom.

```
# /etc/nsswitch.conf
#
# Example configuration of GNU Name Service Switch functionality.
# If you have the "glibc-doc-reference" and "info" packages installed, try:
#   info libc "Name Service Switch"
#
passwd:      files      systemd nis
group:       files      systemd nis
shadow:      files      nis
gshadow:     files
hosts:        files      mdns4_minimal [NOTFOUND=return] dns
networks:    files
protocols:   db      files
services:    db      files
ethers:      db      files
rpc:         db      files
netgroup:    nis
```

vim /etc/nsswitch.conf

## 7.10 vi /etc/pam.d/common-session

```
# /etc/pam.d/common-session - session-related modules common to all services
## This file is included from other service-specific PAM config files,
## and should contain a list of modules that define tasks to be performed
## at the start and end of sessions of *any* kind (both interactive and
## non-interactive).
## As of pam 1.0.1-6, this file is managed by pam-auth-update by default.
## To take advantage of this, it is recommended that you configure any
## local modules either before or after the "auth" block, and use
## pam-auth-update to manage selection of other modules. See
## pam-auth-update(8) for details.
# here are the per-package modules (the "Primary" block)
session [default]=1          pam_permit.so
# here's the fallback if no module succeeds
session requisite           pam_deny.so
# include auth with a positive return value if there isn't one already;
# this avoids us returning an error just because nothing sets a success code
# since the modules above will each just jump around
session required             pam_permit.so
# pam_permit module will set the umask to the system default in
# /etc/login.defs and user settings, solving the problem of different
# umask settings with different shells, display managers, remote sessions etc.
# See man pam_permit.
session optional             pam_umask.so
# and here are more per-package modules (the "Additional" block)
session required             pam_unix.so
session optional             pam_systemd.so
# end of pam-auth-update config
session optional             pam_mkhomedir.so skel=/etc/skel umask=077
```

### Note

vi /etc/pam.d/common-session

# adding to the end

```
session optional     pam_mkhomedir.so skel=/etc/skel umask=077
```

## 7.11 Restarting systemctl

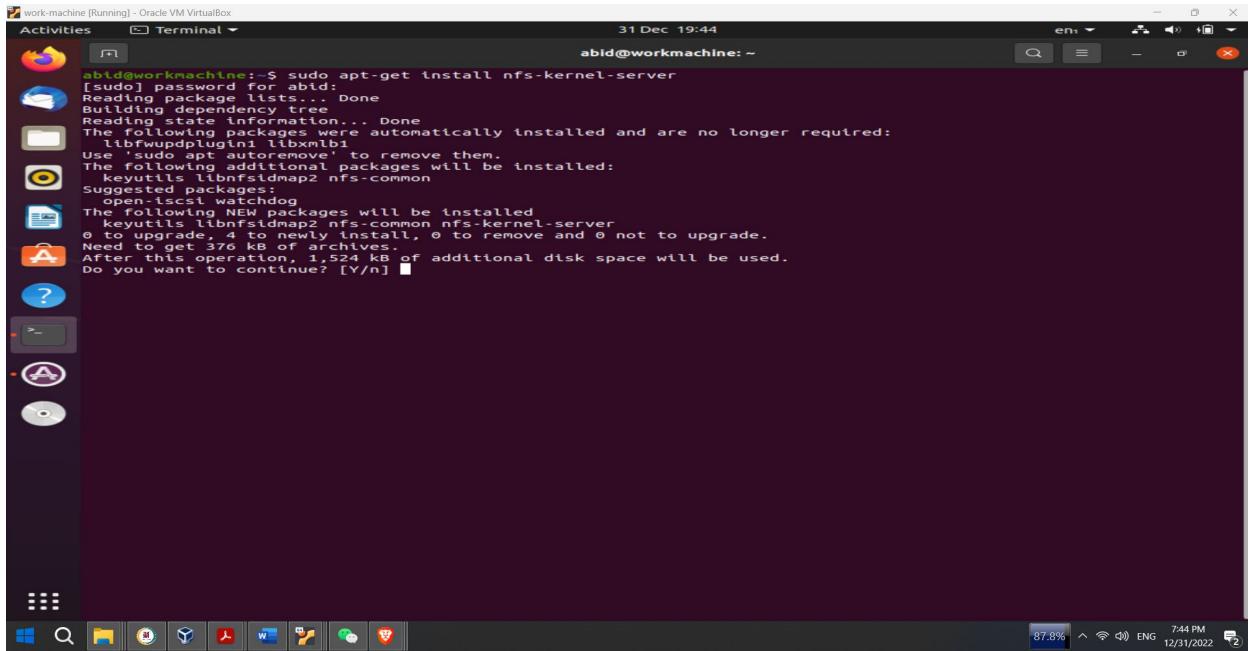
```
root@workmachine: /home/abid  ypcat passwd
No such domain.
root@workmachine: /home/abid# Reboot can't bind to server which serves this domain
root@workmachine: /home/abid# vi /etc/nsswitch.conf
root@workmachine: /home/abid# vi /etc/pam.d/common-session
root@workmachine: /home/abid# systemctl restart rpcbind nis
root@workmachine: /home/abid#
```

Restarting systemctl

systemctl restart rpcbind nis

## 8. NFS

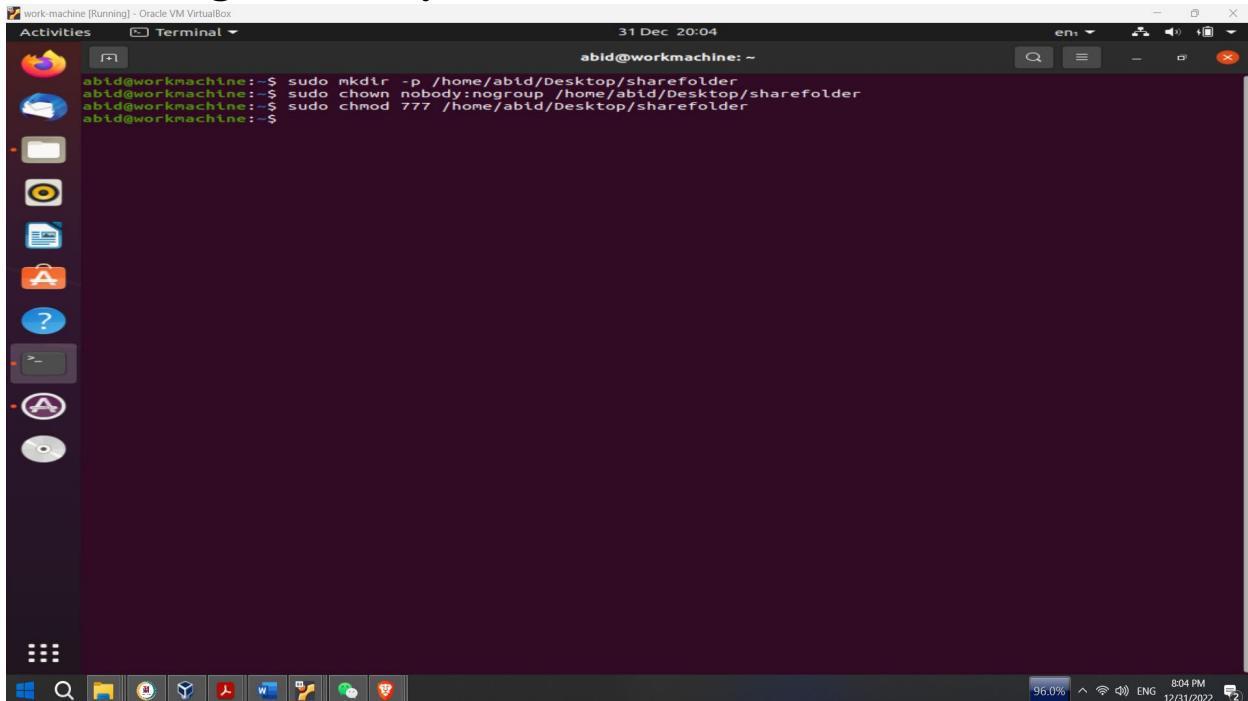
### 8.1 Install nfs server on master machine



```
work-machine [Running] - Oracle VM VirtualBox
Activities Terminal 31 Dec 19:44 abid@workmachine: ~
abid@workmachine:~$ sudo apt-get install nfs-kernel-server
[sudo] password for abid:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libfwupdplugin1 libxml2
Use 'sudo apt autoremove' to remove them.
The following NEW packages will be installed:
  keyutils libnfsidnmap2 nfs-common
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed
  keyutils libnfsidnmap2 nfs-common nfs-kernel-server
0 to upgrade, 4 to newly install, 0 to remove and 0 not to upgrade.
Need to get 376 kB of archives.
After this operation, 1,524 kB of additional disk space will be used.
Do you want to continue? [Y/n] ■
```

sudo apt-get install nfs-kernel-server

### 8.2 Creating a directory



```
work-machine [Running] - Oracle VM VirtualBox
Activities Terminal 31 Dec 20:04 abid@workmachine: ~
abid@workmachine:~$ sudo mkdir -p /home/abid/Desktop/sharefolder
abid@workmachine:~$ sudo chown nobody:nogroup /home/abid/Desktop/sharefolder
abid@workmachine:~$ sudo chmod 777 /home/abid/Desktop/sharefolder
abid@workmachine:~$
```

sudo mkdir -p /home/abid/Desktop/sharefolder

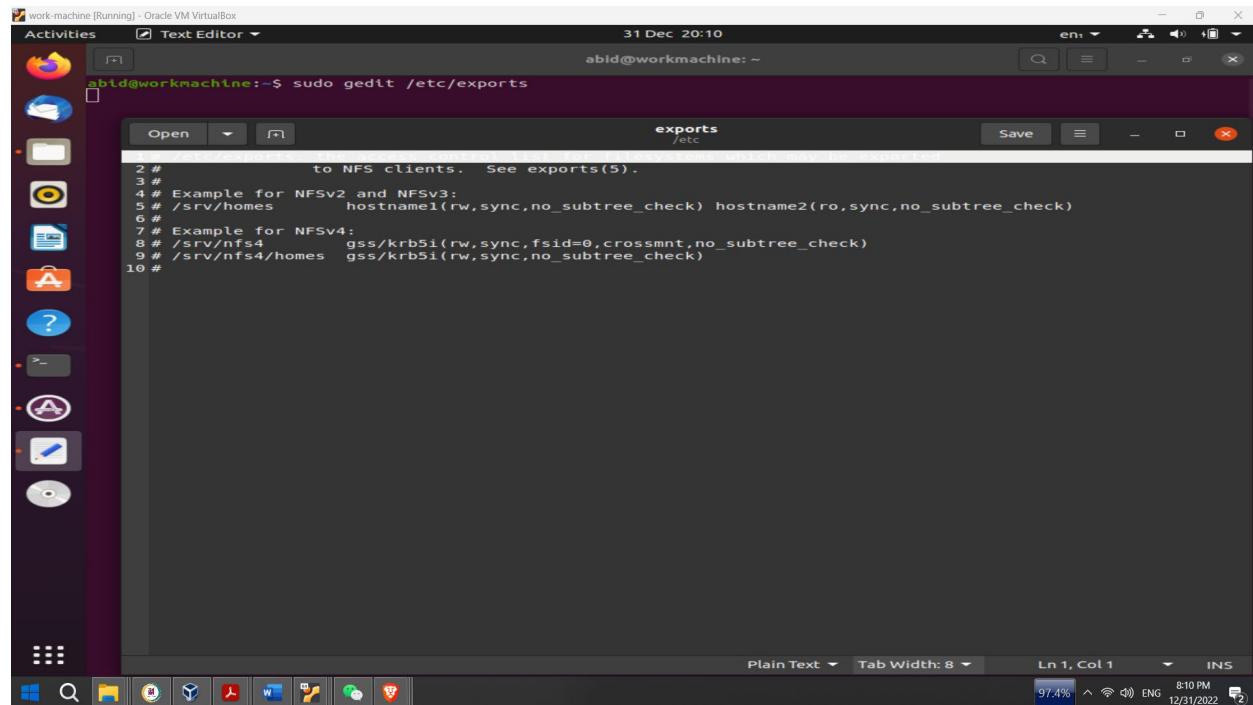
sudo chown nobody:nogroup /home/abid/Desktop/sharefolderS

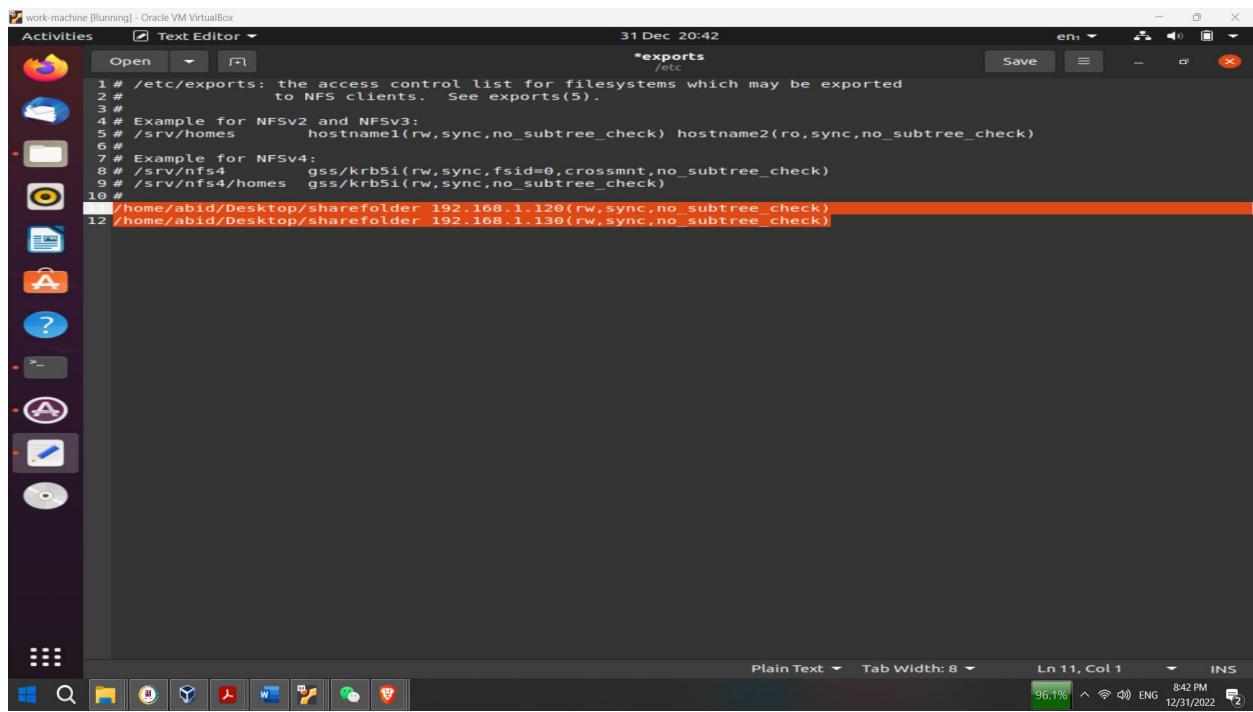
```
sudo chmod 777 /home/abid/Desktop/sharefolder
```

## 8.3 Install gedit

```
abid@workmachine:~$ sudo apt-get install gedit
Reading package lists... Done
Building dependency tree
Reading state information... Done
gedit is already the newest version (3.36.2-0ubuntu1).
gedit set to manually installed.
The following packages were automatically installed and are no longer required:
  libfwupdplugin1 libxml2
Use 'sudo apt autoremove' to remove them.
0 to upgrade, 0 to newly install, 0 to remove and 0 not to upgrade.
abid@workmachine:~$
```

```
sudo apt-get install gedit
```





```
1 # /etc/exports: the access control list for filesystems which may be exported
2 #           to NFS clients. See exports(5).
3 #
4 # Example for NFSv2 and NFSv3:
5 # /srv/homes      hostname1(rw,sync,no_subtree_check) hostname2(ro,sync,no_subtree_check)
6 #
7 # Example for NFSv4:
8 # /srv/nfs4       gss/krb5i(rw,sync,fsid=0,crossmnt,no_subtree_check)
9 # /srv/nfs4/homes gss/krb5i(rw,sync,no_subtree_check)
10 #
11 # /home/abid/Desktop/sharefolder 192.168.1.120(rw, sync, no_subtree_check)
12 # /home/abid/Desktop/sharefolder 192.168.1.130(rw, sync, no_subtree_check)
```

Adding those two lines

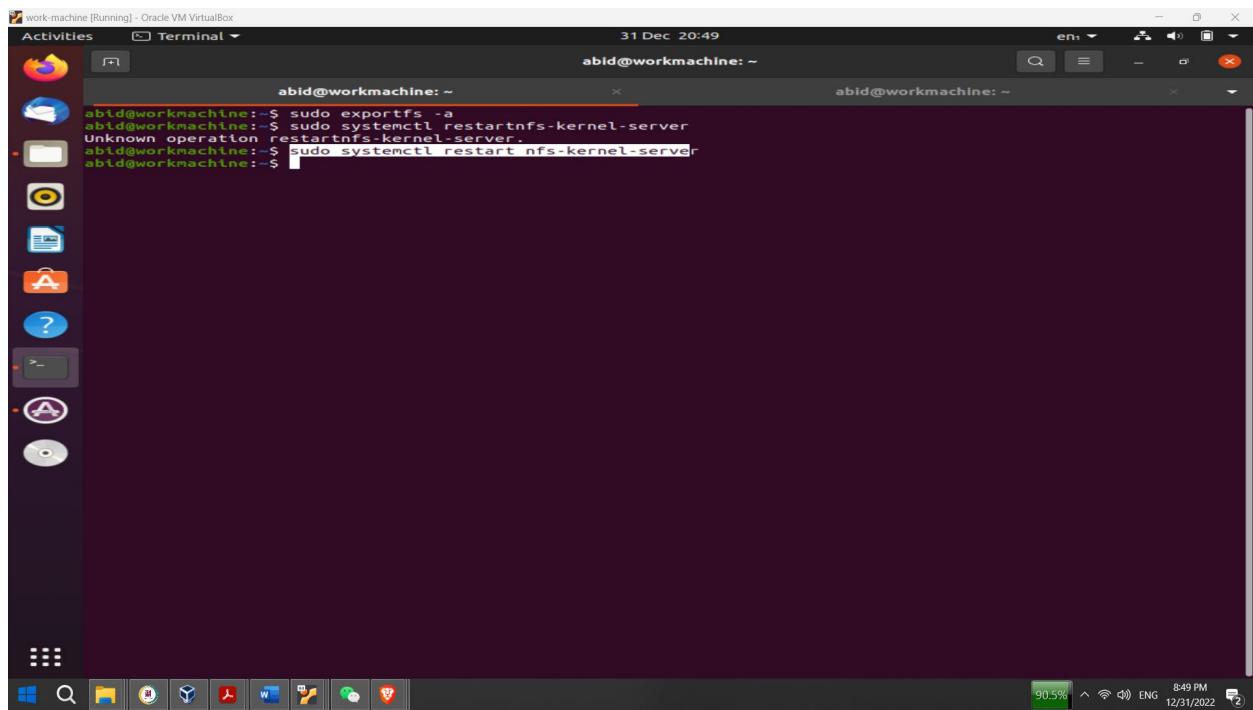
/home/abid/Desktop/sharefolder 192.168.1.120(rw, sync, no\_subtree\_check)

/home/abid/Desktop/sharefolder 192.168.1.130(rw, sync, no\_subtree\_check)

## Export shared directory and restart server

sudo exportfs -a

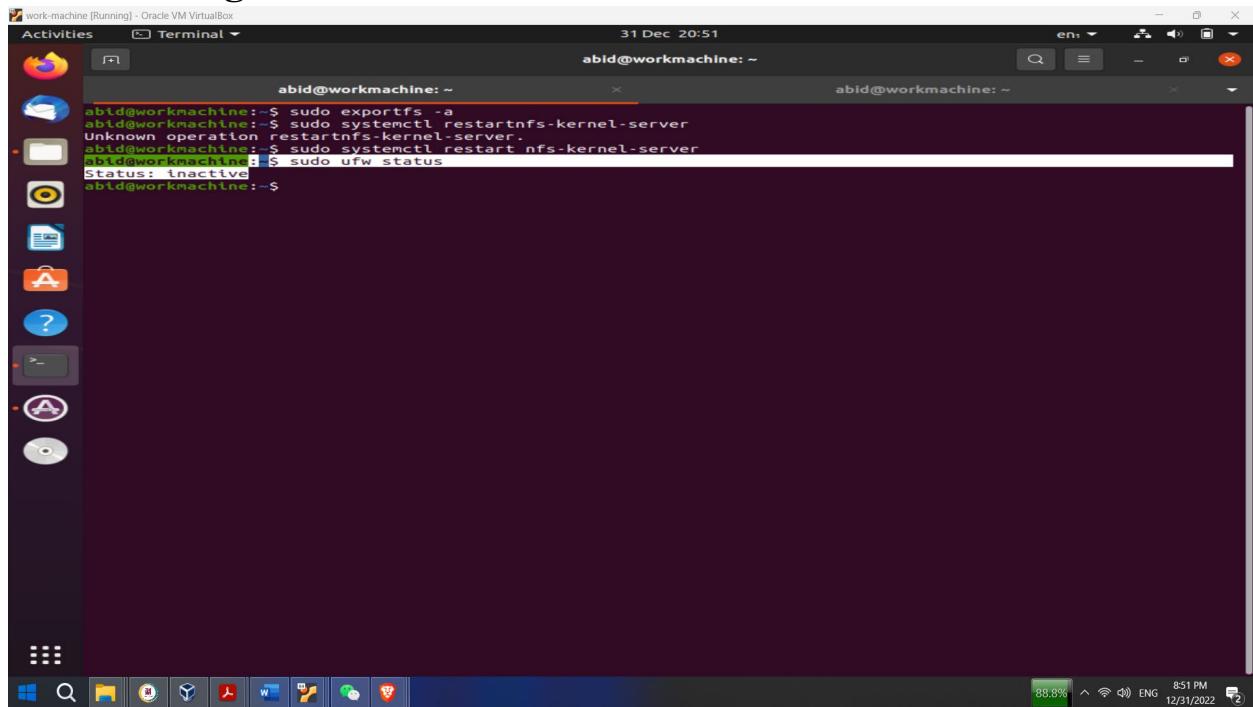
sudo systemctl restart nfs-kernel-server



A screenshot of an Ubuntu desktop environment. On the left is a dock with various icons. In the center is a terminal window titled 'Terminal' with the command line 'abid@workmachine: ~'. The terminal shows the following commands being run:

```
abid@workmachine:~$ sudo exportfs -a
abid@workmachine:~$ sudo systemctl restartnfs-kernel-server
Unknown operation restartnfs-kernel-server.
abid@workmachine:~$ sudo systemctl restart nfs-kernel-server
```

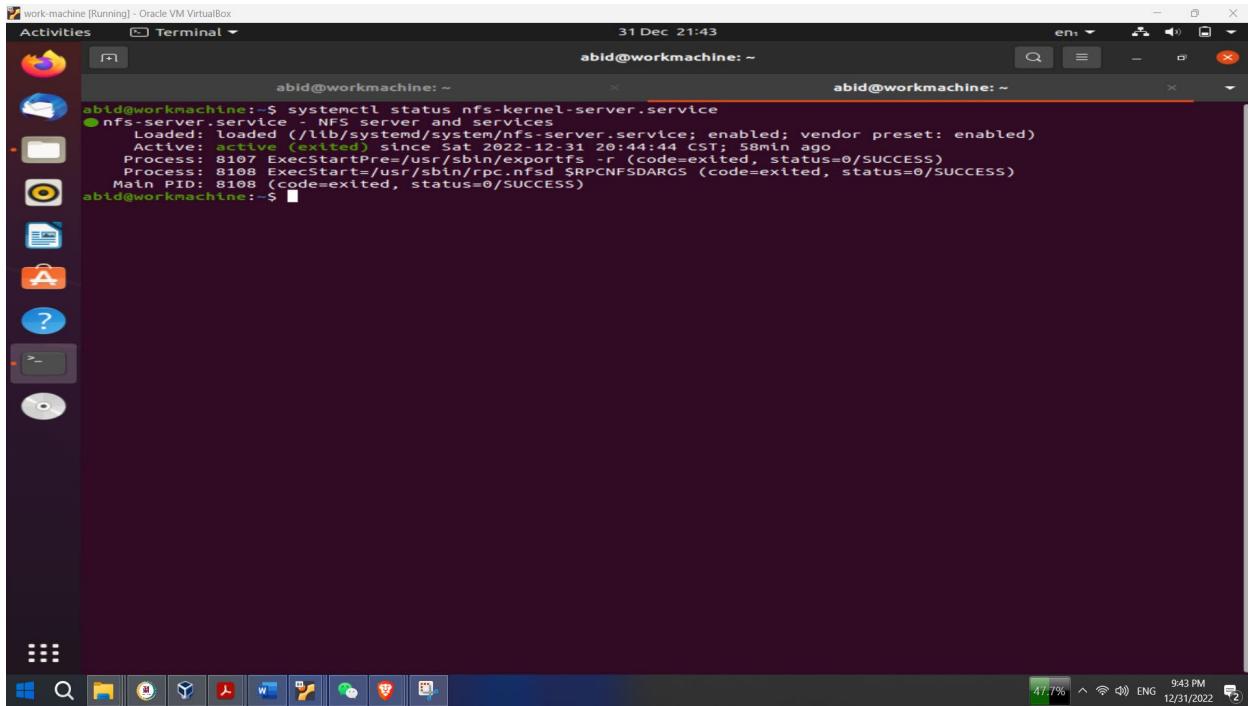
## 8.4 Checking Firewall Status



A screenshot of an Ubuntu desktop environment. On the left is a dock with various icons. In the center is a terminal window titled 'Terminal' with the command line 'abid@workmachine: ~'. The terminal shows the following commands being run:

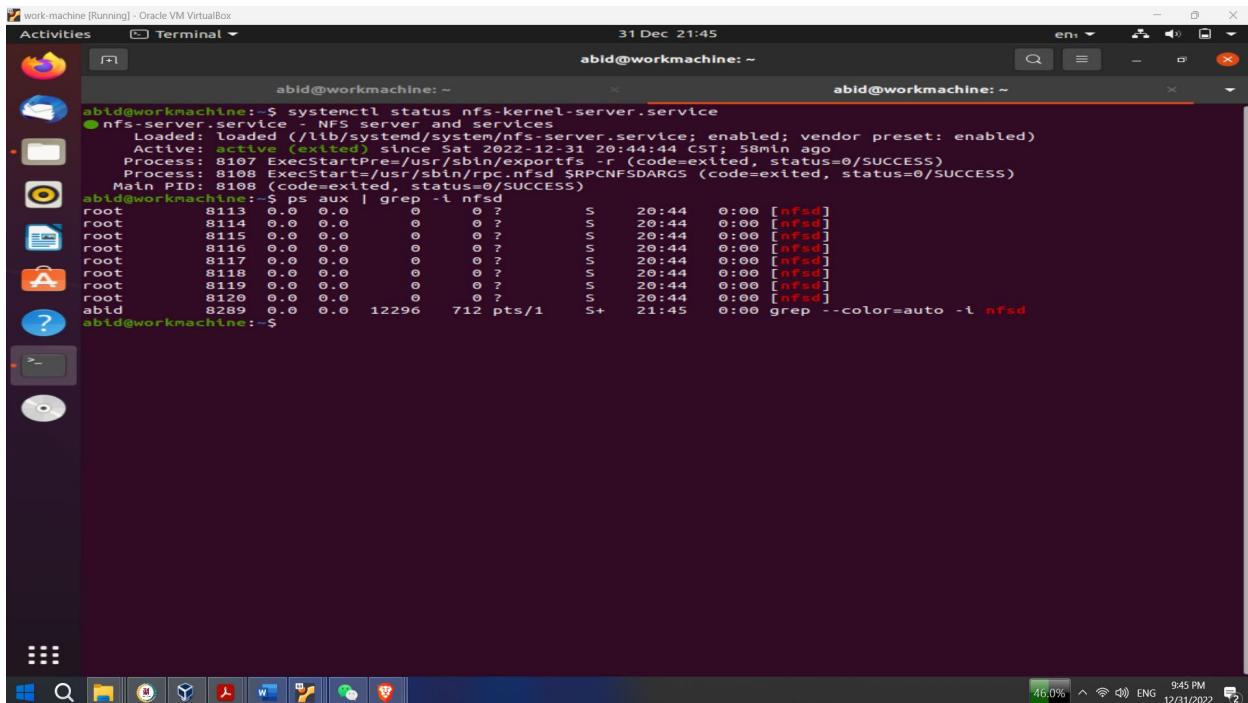
```
abid@workmachine:~$ sudo exportfs -a
abid@workmachine:~$ sudo systemctl restartnfs-kernel-server
Unknown operation restartnfs-kernel-server.
abid@workmachine:~$ sudo systemctl restart nfs-kernel-server
abid@workmachine:~$ sudo ufw status
Status: inactive
abid@workmachine:~$
```

## 8.5 status nfs-kernel-server.service



```
abid@workmachine:~$ systemctl status nfs-kernel-server.service
● nfs-server.service - NFS server and services
   Loaded: loaded (/lib/systemd/system/nfs-server.service; enabled; vendor preset: enabled)
   Active: active (exited) since Sat 2022-12-31 20:44:44 CST; 58min ago
     Process: 8107 ExecStartPre=/usr/sbin/exportfs -r (code=exited, status=0/SUCCESS)
    Process: 8108 ExecStart=/usr/sbin/rpc.nfsd $RPCNFSDARGS (code=exited, status=0/SUCCESS)
      Main PID: 8108 (code=exited, status=0/SUCCESS)
```

systemctl status nfs-kernel-server.service



```
abid@workmachine:~$ systemctl status nfs-kernel-server.service
● nfs-server.service - NFS server and services
   Loaded: loaded (/lib/systemd/system/nfs-server.service; enabled; vendor preset: enabled)
   Active: active (exited) since Sat 2022-12-31 20:44:44 CST; 58min ago
     Process: 8107 ExecStartPre=/usr/sbin/exportfs -r (code=exited, status=0/SUCCESS)
    Process: 8108 ExecStart=/usr/sbin/rpc.nfsd $RPCNFSDARGS (code=exited, status=0/SUCCESS)
      Main PID: 8108 (code=exited, status=0/SUCCESS)

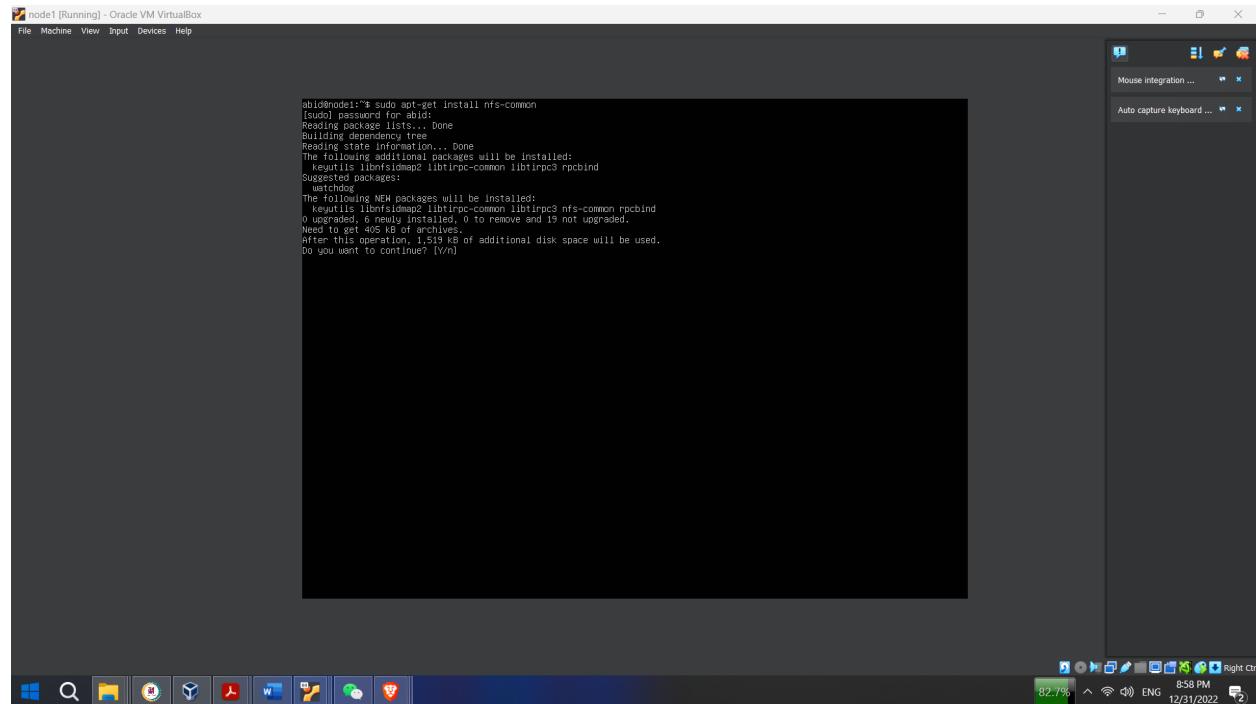
abid@workmachine:~$ ps aux | grep -i nfsd
root     8113  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8114  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8115  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8116  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8117  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8118  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8119  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
root     8120  0.0  0.0    0    0 ?        S     20:44  0:00 [nfsd]
abid    8289  0.0  0.0 12296  712 pts/1   S+   21:45  0:00 grep --color=auto -i nfsd
```

ps aux | grep -i nfsd

## 8.6 Install nfs client as slave node 1 and node2

### Installing nfs client, run:

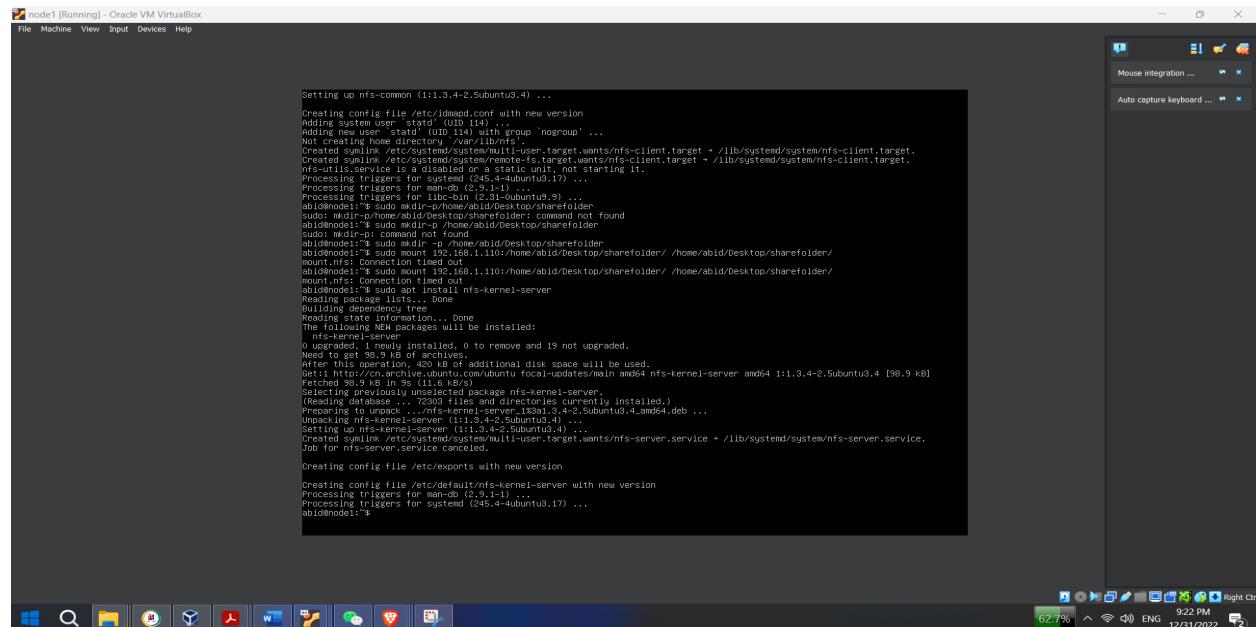
#### Node1



```
node1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

abidnode1:~$ sudo apt-get install nfs-common
[sudo] password for abid:
Reading package lists...
Building dependency tree
Resolving dependencies...
The following additional packages will be installed:
  keyutils libnfsidmap2 libtirpc-common libtirpc3 rpcbind
Suggested packages:
  autofs
The following NEW packages will be installed:
  keyutils libnfsidmap2 libtirpc-common libtirpc3 nfs-common rpcbind
0 upgraded, 6 newly installed, 0 to remove and 19 not upgraded.
Need to get 1,519 kB of additional disk space.
After this operation, 1,519 kB of additional disk space will be used.
Do you want to continue? [Y/n]
```

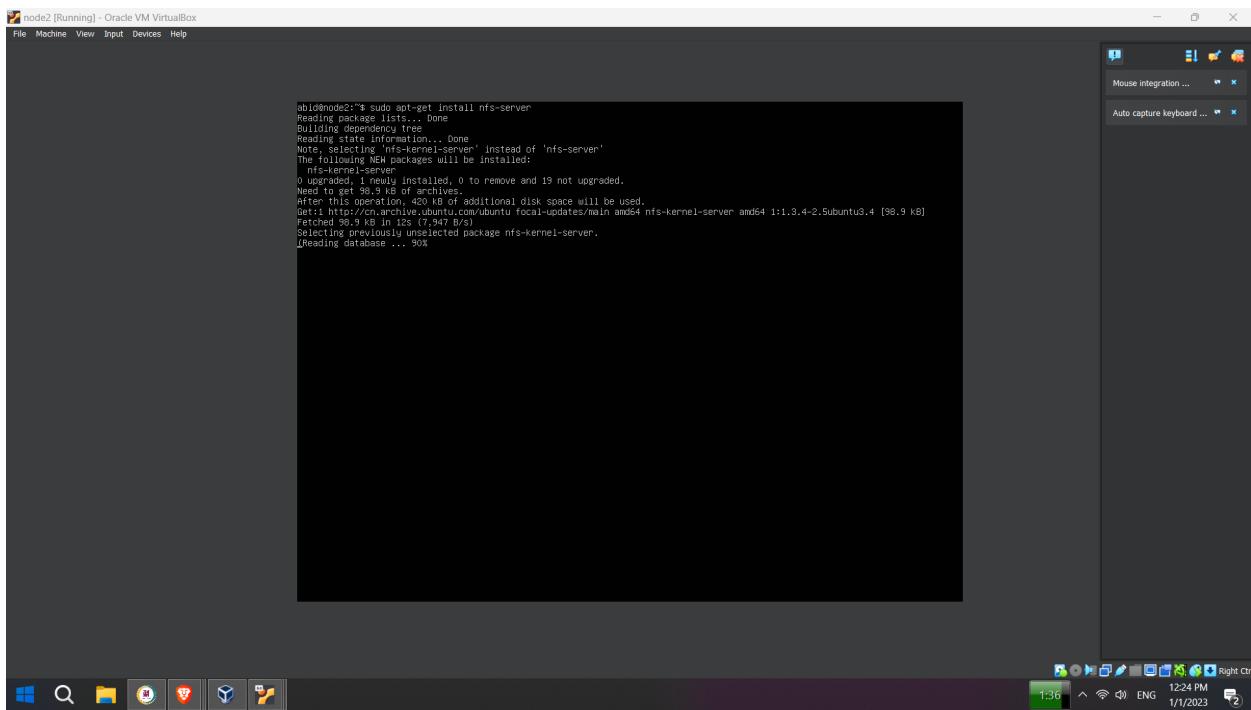
sudo apt-get install nfs-common



```
node1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

Setting up nfs-common (1:1.3.4-2.5ubuntu0.4) ...
Creating config file /etc/idmapd.conf with new version
Adding system user `nfsnobody' (UID 114) with group `nogroup' ...
Not creating home directory '/var/lib/nfs'.
Created symlink /etc/systemd/system/multi-user.target.wants/nfs-client.target → /lib/systemd/system/nfs-client.target.
Created symlink /etc/systemd/system/multi-user.target.wants/nfs-client.target → /lib/systemd/system/nfs-client.target.
nfs-utils.service is a static or a static unit, not starting it.
Processing triggers for systemd (245.4-4ubuntu0.17) ...
Processing triggers for libc-bin (2.31-0ubuntu9.3)
Unpacking nfs-kernel-server (1:2.6.0-1ubuntu1.1) ...
abidnode1:~$ sudo mkdir -p /home/abid/Desktop/sharefolder
sudo: mkdir: directory '/home/abid/Desktop/sharefolder' already exists
abidnode1:~$ sudo mount 192.168.1.110:/home/abid/Desktop/sharefolder /home/abid/Desktop/sharefolder/
mount: mounting 192.168.1.110:/home/abid/Desktop/sharefolder onto /home/abid/Desktop/sharefolder failed: Connection timed out
abidnode1:~$ sudo mount 192.168.1.110:/home/abid/Desktop/sharefolder /home/abid/Desktop/sharefolder
mount.nfs: Connection timed out
Job for nfs-server.service canceled.
Reading package lists... done
Building dependency tree
Resolving dependencies...
The following NEW packages will be installed:
  nfs-kernel-server
0 upgraded, 1 newly installed, 0 to remove and 19 not upgraded.
Need to get 38.9 kB of archives.
After this operation, 420 kB of additional disk space will be used.
On the server side, run 'sudo apt update; sudo apt upgrade; sudo apt install nfs-kernel-server amd64 1:1.3.4-2.5ubuntu0.4 [98.9 kB]
Fetched 38.9 kB in 9s (11.6 kB/s)
Selecting previously unselected package nfs-kernel-server.
Reading package lists... done
Preparing to unpack .../nfs-kernel-server_1:2.6.0-1ubuntu1.1_amd64.deb ...
Preparing to unpack .../nfs-kernel-server_1:1.3.4-2.5ubuntu0.4_amd64.deb ...
Unpacking nfs-kernel-server (1:1.3.4-2.5ubuntu0.4) ...
Setting up nfs-kernel-server (1:1.3.4-2.5ubuntu0.4) ...
Created symlink /etc/systemd/system/multi-user.target.wants/nfs-server.service → /lib/systemd/system/nfs-server.service.
Job for nfs-server.service canceled.
Creating config file /etc/exports with new version
Creating config file /etc/default/nfs-kernel-server with new version
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for systemd (245.4-4ubuntu0.17) ...
abidnode1:~$
```

sudo apt install nfs-kernel-server



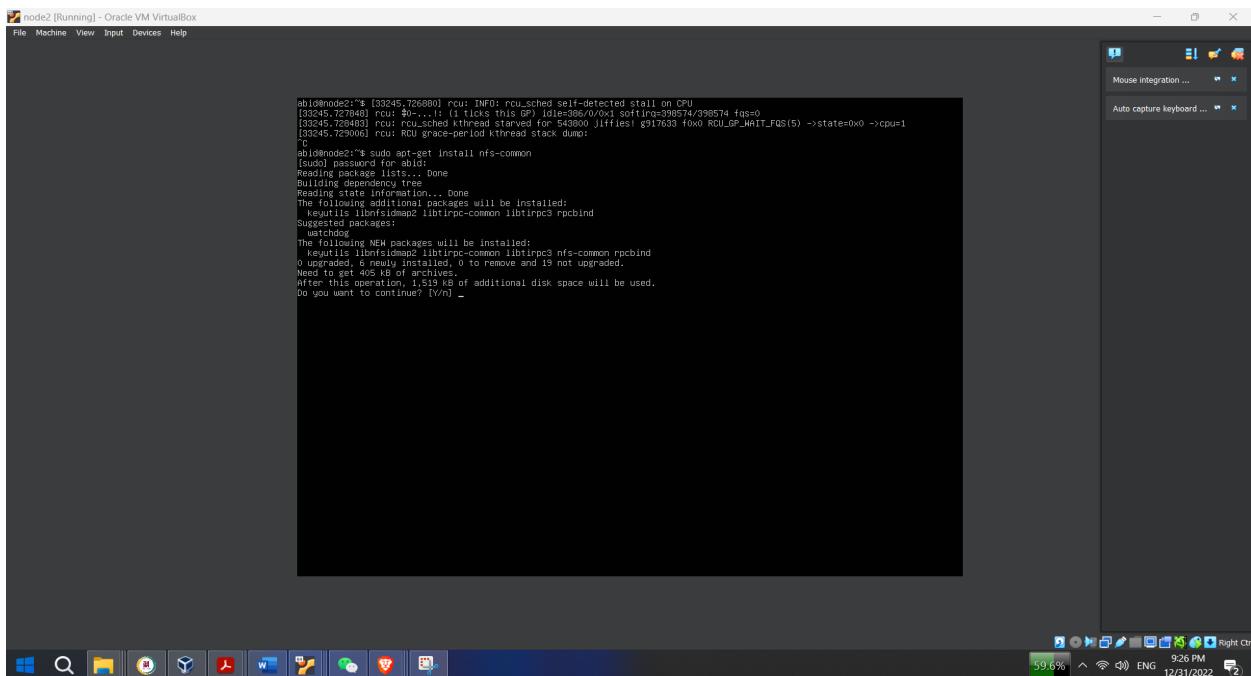
```
abid@node2:~$ sudo apt-get install nfs-server
Reading package lists... Done
Building dependency tree...
Reading state information... Done
Note, selecting 'nfs-kernel-server' instead of 'nfs-server'
The following NEW packages will be installed:
  nfs-kernel-server
0 upgraded, 1 newly installed, 0 to remove and 19 not upgraded.
Need to get 38.9 kB of archives.
After this operation, 420 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu/focal-updates/main amd64 nfs-kernel-server amd64 1:1.3.4-2.5ubuntu3.4 [98.9 kB]
Fetched 98.9 kB in 12s (7,947 B/s)
Selecting previously unselected package nfs-kernel-server.
Reading database ... 90%
```

Sudo apt-get install nfs server

### Installing nfs client,run:

## Node2

### Installing nfs client,run:



```
abid@node2:~$ [33245.726880] rcu: INFO: rcu_sched self-detected stall on CPU
[33245.727040] rcu: $0-...: (i ticks this GP) idle=306/0/x1 softirq=398574/fqs=0
[33245.728480] rcu: rcu_sched kthread starved for 543800 jiffies g91763 fwo:RCU_GP_WAIT_FQS(5) ->state=0x0 ->cpu=1
[33245.729160] rcu: rcu grace-period kthread stack dump:
'C
abid@node2:~$ sudo apt-get install nfs-common
[sudo] password for abid:
Reading package lists... Done
Building dependency tree...
Reading state information... Done
The following additional packages will be installed:
  keyutils libnfsidmap2 libtirpc-common libtirpc3 rpcbind
Suggested packages:
  libtirpc3
The following NEW packages will be installed:
  keyutils libnfsidmap2 libtirpc-common libtirpc3 nfs-common rpcbind
0 upgraded, 1 newly installed, 0 to remove and 19 not upgraded.
Need to get 405 kB of archives.
After this operation, 1,519 kB of additional disk space will be used.
Do you want to continue? [y/n] _
```

sudo apt-get install nfs-common

9.MPI

## 9.1 sudo apt-get install openmpi-bin libopenmpi-dev

```
work-machine [Running] - Oracle VM VirtualBox
Activities Terminal 31 Dec 22:54 abid@workmachine: ~ abid@workmachine: ~ abid@workmachine: ~ abid@workmachine: ~
abid@workmachine:~$ sudo apt-get install openmpi-bin libopenmpi-dev
[sudo] password for abid:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libfwupdplugin1 libxmlmb1
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  autoconf automake autopoint cpp-8 gcc-8-base gfortran gfortran-8 gfortran-9 libverbs-providers
  libevent-core-2.1-7 libevent-dev libevent-pthreads-2.1-7 libfabric1 libgcc-8-dev
  libevent-extra-2.1-7 libevent-openssl-2.1-7 libibverbs1 liblbind1 liblbind-dev liblbind-libs  liblbind-libs-dev
  libibverbs1 liblbind1 liblbind-dev liblpx2 liblbnl-3-dev liblbnl-route-3-dev libnuma-dev libopenmpi3 libpmix2
  libpmix2 libpmix-infinipath1 libpsm2-2 librdmacm1 libsigsegv2 libtalloc libxnvctrl0 m4 ocl-icd-libopencl1 openmpi-common
Suggested packages:
  autoconf-archive gnu-standards autoconf-doc gettexte gcc-8-locales gcc-8-multilib gcc-8-doc gfortran-multilib
  gfortran-doc gfortran-8-multilib gfortran-8-doc gfortran-9-multilib gfortran-9-doc libhwloc-contrib-plugins
  libtalloc-doc openmpi-doc gcj-jdk m4-doc opencl-icd
The following NEW packages will be installed
autoconf automake autopoint cpp-8 gcc-8-base gfortran gfortran-8 gfortran-9 libverbs-providers
libevent-core-2.1-7 libevent-dev libevent-pthreads-2.1-7 libfabric1 libgcc-8-dev
libevent-extra-2.1-7 libevent-openssl-2.1-7 libibverbs1 liblbind1 liblbind-dev liblbind-libs  liblbind-libs-dev
libibverbs1 liblbind1 liblbind-dev liblpx2 liblbnl-3-dev liblbnl-route-3-dev libnuma-dev libopenmpi3 libpmix2
libpmix2 libpmix-infinipath1 libpsm2-2 librdmacm1 libsigsegv2 libtalloc libxnvctrl0 m4 ocl-icd-libopencl1 openmpi-common
0 upgraded, 40 newly installed, 0 to remove and 0 not to upgrade.
Need to get 49.1 MB of archives.
After this operation, 171 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 https://repo.huaweicloud.com/ubuntu focal/main amd64 libsigsegv2 amd64 2.12-2 [13.9 kB]
Get:2 https://repo.huaweicloud.com/ubuntu focal/main amd64 amd64 1.4-18-4 [199 kB]
Get:3 https://repo.huaweicloud.com/ubuntu focal/main amd64 autoconf all 2.67-1 [1.1 kB]
Get:4 https://repo.huaweicloud.com/ubuntu focal/main amd64 autopoint dev all 20180224.1 [39.6 kB]
Get:5 https://repo.huaweicloud.com/ubuntu focal/main amd64 autowake all 1:1.16.1-4ubuntu6 [522 kB]
Get:6 https://repo.huaweicloud.com/ubuntu focal/universe amd64 gcc-8-base amd64 8.4.0-3ubuntu2 [18.7 kB]
Get:7 https://repo.huaweicloud.com/ubuntu focal/universe amd64 cpp-8 amd64 8.4.0-3ubuntu2 [8,945 kB]
Get:8 https://repo.huaweicloud.com/ubuntu focal/universe amd64 liblpx2 amd64 8.4.0-3ubuntu2 [11.8 kB]
Get:9 https://repo.huaweicloud.com/ubuntu focal/universe amd64 libgcc-8-dev amd64 8.4.0-3ubuntu2 [2,313 kB]
Get:10 https://repo.huaweicloud.com/ubuntu focal/universe amd64 gcc-8 amd64 8.4.0-3ubuntu2 [9,833 kB]
Get:11 https://repo.huaweicloud.com/ubuntu focal-updates/main amd64 libgfortran5 amd64 10.3.0-1ubuntu1-20.04 [73.6 kB]
Get:12 https://repo.huaweicloud.com/ubuntu focal-updates/main amd64 libgfortran-9-dev amd64 9.4.0-1ubuntu1-20.04 .1 [685 kB]
Get:13 https://repo.huaweicloud.com/ubuntu focal-updates/main amd64 gfortran-9 amd64 9.4.0-1ubuntu1-20.04.1 [7,9
35.7% 1054 MB 12/21/2022
```

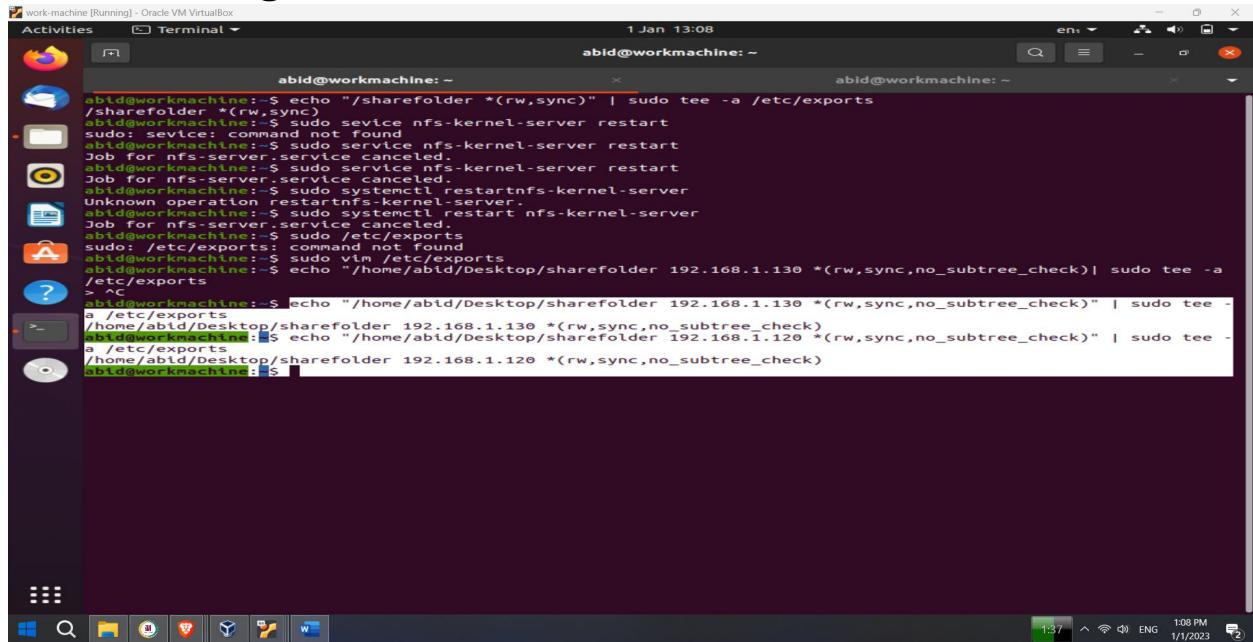
```
sudo apt-get install openmpi-bin libopenmpi-dev
```

## 9.2 sudo apt-get install gcc

```
sudo apt-get install gcc
```

```
sudo apt-get install openmpi-bin openmpi-common libopenmpi-dev libgtk2.0-dev
```

## 9.3 Connecting with Sharedfolder



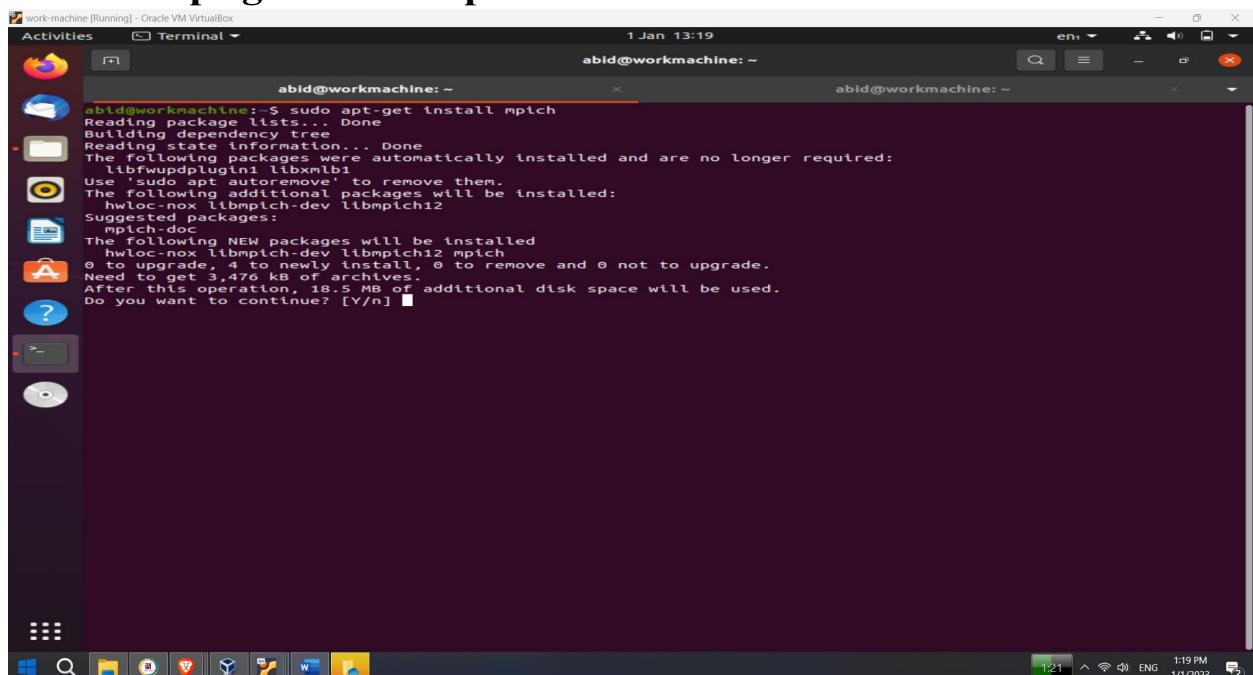
A screenshot of a Linux desktop environment (Ubuntu) showing a terminal window. The terminal window has two tabs: 'abid@workmachine: ~' and 'abid@workmachine: ~'. The user is running several commands to configure NFS sharing:

```
abid@workmachine:~$ echo "/sharefolder *(rw,sync)" | sudo tee -a /etc/exports
abid@workmachine:~$ sudo service nfs-kernel-server restart
sudo: service: command not found
abid@workmachine:~$ sudo service nfs-kernel-server restart
Job for nfs-kernel-server.service canceled.
abid@workmachine:~$ sudo service nfs-kernel-server restart
Job for nfs-kernel-server.service restarted.
abid@workmachine:~$ sudo systemctl restart nfs-kernel-server
Unknown operation restartnfs-kernel-server.
abid@workmachine:~$ sudo systemctl restart nfs-kernel-server
Job for nfs-kernel-server.service canceled.
abid@workmachine:~$ sudo /etc/exports
abid@workmachine:~$ sudo vim /etc/exports
abid@workmachine:~$ echo "/home/abid/Desktop/sharefolder 192.168.1.130 *(rw,sync,no_subtree_check)" | sudo tee -a /etc/exports
abid@workmachine:~$ echo "/home/abid/Desktop/sharefolder 192.168.1.130 *(rw,sync,no_subtree_check)" | sudo tee -a /etc/exports
abid@workmachine:~$ echo "/home/abid/Desktop/sharefolder 192.168.1.120 *(rw,sync,no_subtree_check)" | sudo tee -a /etc/exports
/home/abid/Desktop/sharefolder 192.168.1.120 *(rw,sync,no_subtree_check)
abid@workmachine:~$
```

```
echo "/home/abid/Desktop/sharefolder 192.168.1.130 *(rw,sync,no_subtree_check)" | sudo tee -a /etc/exports
```

```
echo "/home/abid/Desktop/sharefolder 192.168.1.120 *(rw,sync,no_subtree_check)" | sudo tee -a /etc/exports
```

## 9.4 sudo apt-get install mpich

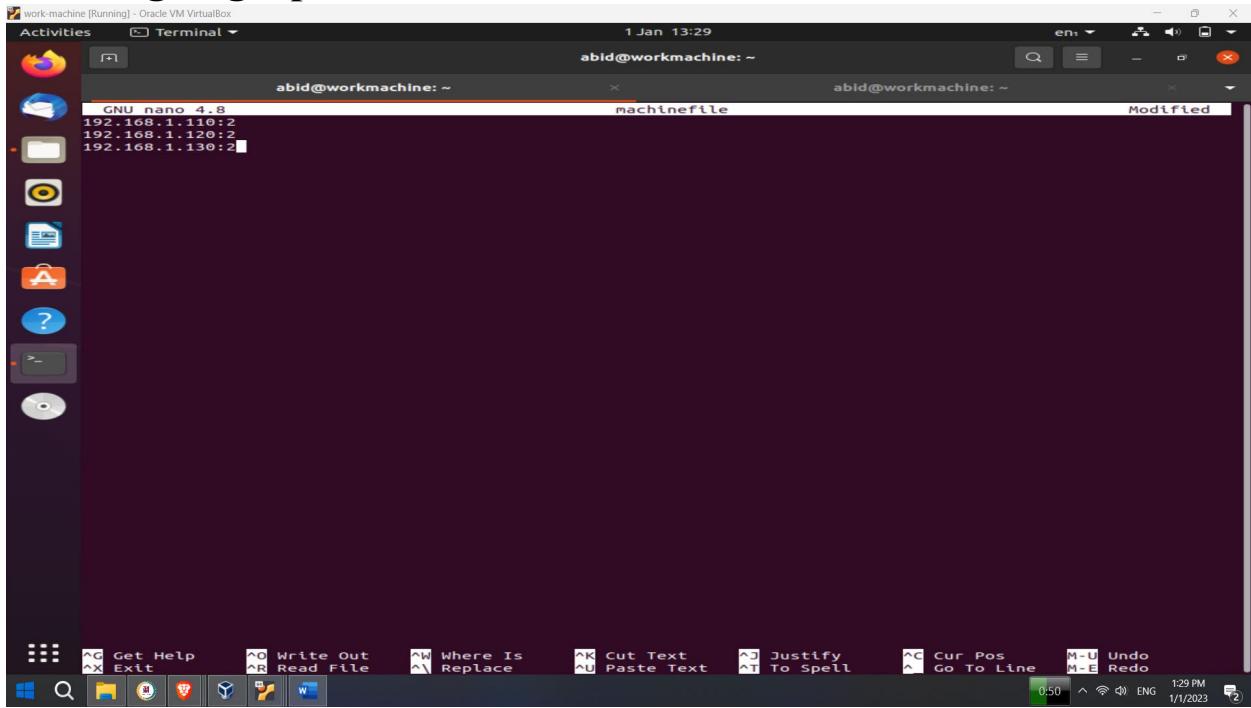


A screenshot of a Linux desktop environment (Ubuntu) showing a terminal window. The terminal window has two tabs: 'abid@workmachine: ~' and 'abid@workmachine: ~'. The user is running the command to install mpich:

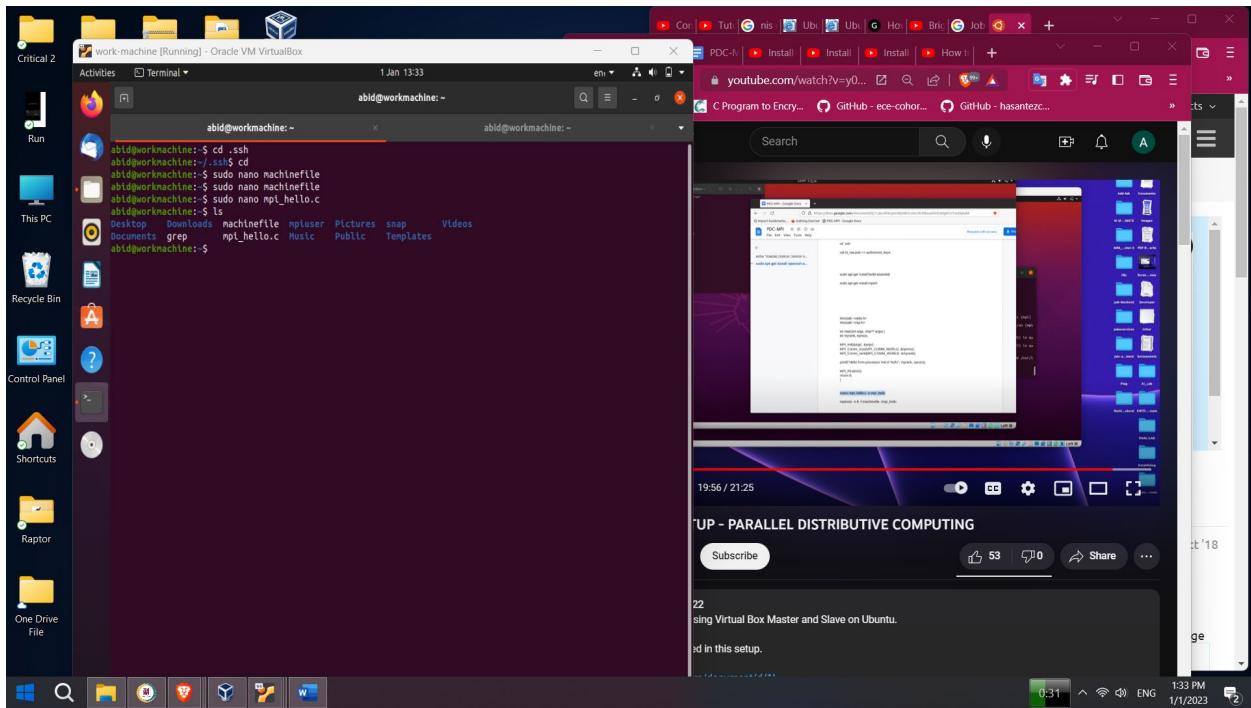
```
abid@workmachine:~$ sudo apt-get install mpich
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libfwupdplugin1 libxml2
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  hwloc-nox libmpich-dev libmpich12
Suggested packages:
  mpich-doc
The following NEW packages will be installed
  hwloc-nox libmpich-dev libmpich12 mpich
0 to upgrade, 4 to newly install, 0 to remove and 0 not to upgrade.
Need to get 3,476 kB of archives.
After this operation, 18.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] ■
```

```
sudo apt-get install mpich
```

## 9.5 Assigning 2 processor for each node



2 processor given

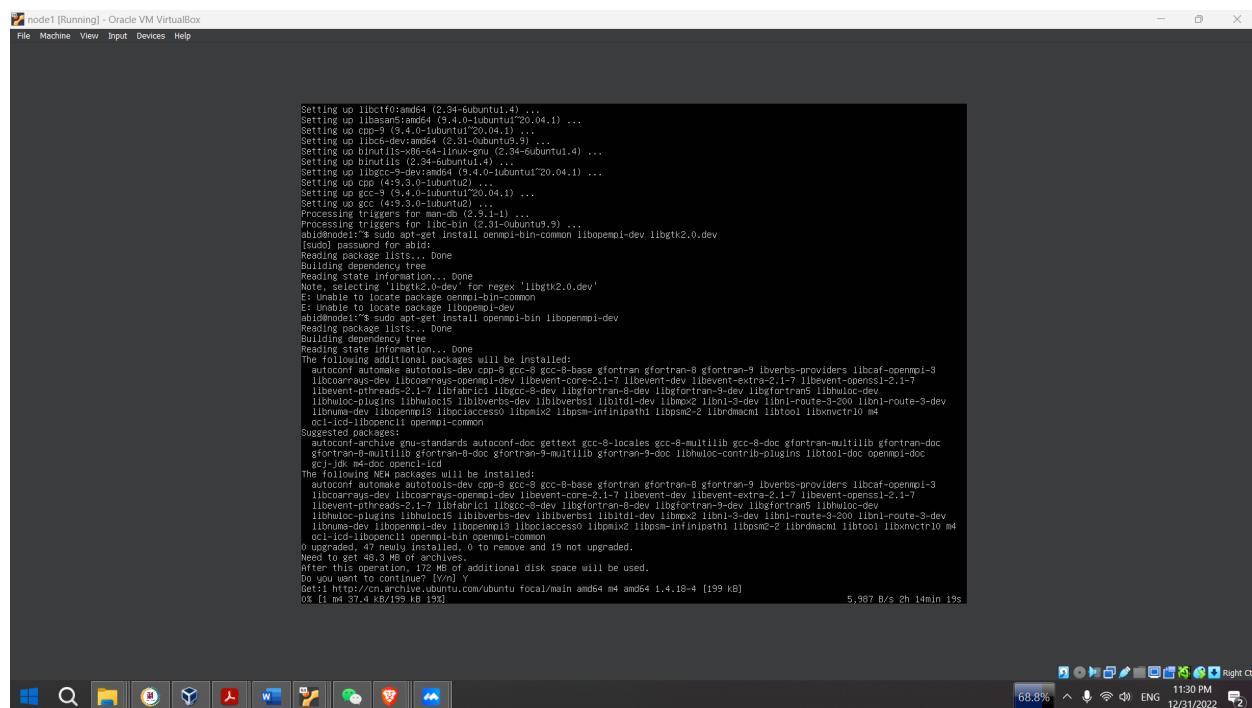


## 9.6 Node 1

```
abid@node1:~$ sudo apt-get install gcc
[sudo] password for abid:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
 binutils binutils-common binutils-x86-64-linux-gnu cpp cpp-9 gcc-9 gcc-9-base libasan5 libatomic1 libbinutils libc-dev-bin
 libc6-dev libgcc1-0 libcrypt-dev libctf-nobfd0 libctf0 libgcc-9-dev libgomp1 libis122 libitm1 liblsan0 libmpc3 libquadmath0
 libtsan0 libubsan1 linux-libc-dev manpages-dev
Suggested packages:
 binutils-doc cpp-doc gcc-9-locales gcc-multilib make autoconf automake libtool flex bison gdb gcc-doc gcc-9-multilib
 gcc-9-doc glibc-doc
The following NEW packages will be installed:
 binutils binutils-common binutils-x86-64-linux-gnu cpp cpp-9 gcc gcc-9 gcc-9-base libasan5 libatomic1 libbinutils
 libc-dev-bin libgcc1-0 libcrypt-dev libctf-nobfd0 libctf0 libgcc-9-dev libgomp1 libis122 libitm1 liblsan0 libmpc3
 libquadmath0 libtsan0 libubsan1 linux-libc-dev manpages-dev
0 upgraded, 28 newly installed, 0 to remove and 19 not upgraded.
Need to get 34.0 MB of archives.
After this operation, 150 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 binutils-common amd64 2.34-6ubuntu1.4 [207 KB]
Get:2 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libbinutils amd64 2.34-6ubuntu1.4 [474 KB]
Get:3 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libctf-nobfd0 amd64 2.34-6ubuntu1.4 [47.2 KB]
Get:4 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 libctf0 amd64 2.34-6ubuntu1.4 [46.6 KB]
Get:5 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 binutils-x86-64-linux-gnu amd64 2.34-6ubuntu1.4 [1,613 KB]
Get:6 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 binutils amd64 2.34-6ubuntu1.4 [3,380 B]
Get:7 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 gcc-9-base amd64 9.4.0-1ubuntu1~20.04.1 [19.4 KB]
Get:8 http://cn.archive.ubuntu.com/ubuntu focal/main amd64 libis122 amd64 0.22.1-1 [592 KB]
Get:9 http://cn.archive.ubuntu.com/ubuntu focal/main amd64 libmpc3 amd64 1.1.0-1 [40.8 KB]
Get:10 http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 cpp-9 amd64 9.4.0-1ubuntu1~20.04.1 [7,500 KB]
24% [10 cpp-9 4,236 KB/7,500 KB 56%] 22.2 kB/s 20min 1
```

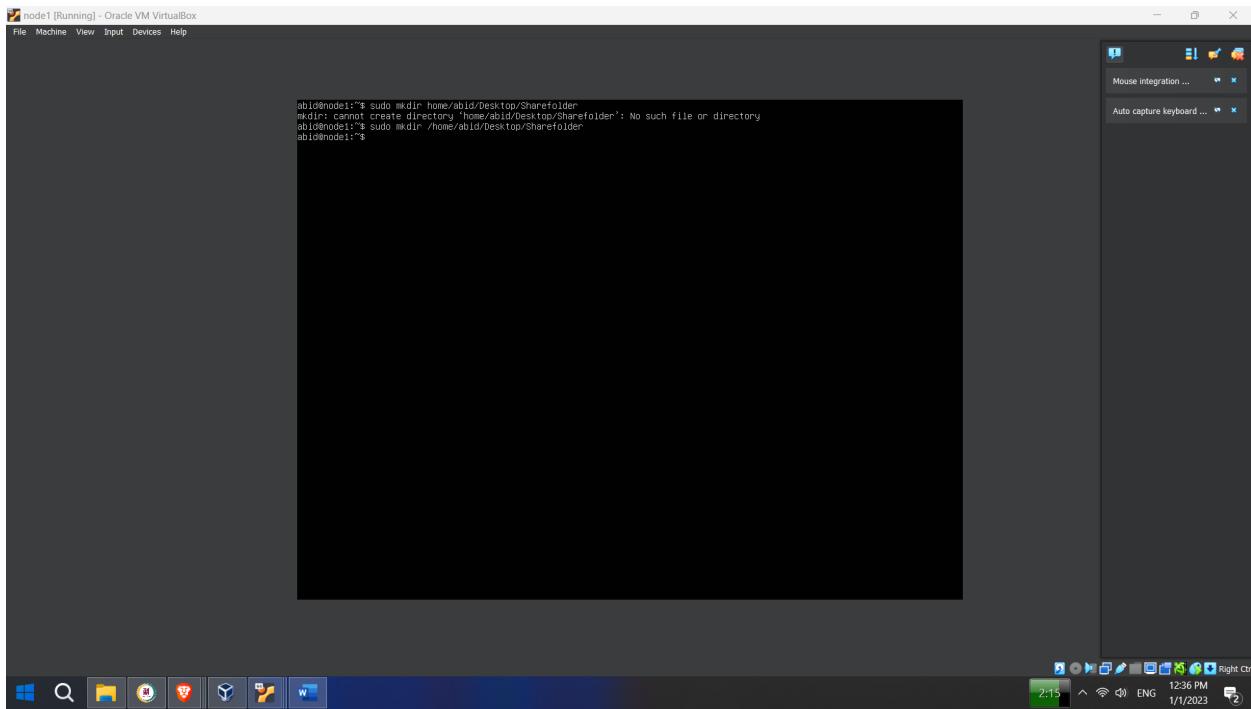
```
sudo apt-get install gcc
```

```
sudo apt-get install openmpi-bin openmpi-common libopenmpi-dev libgtk2.0-dev
```



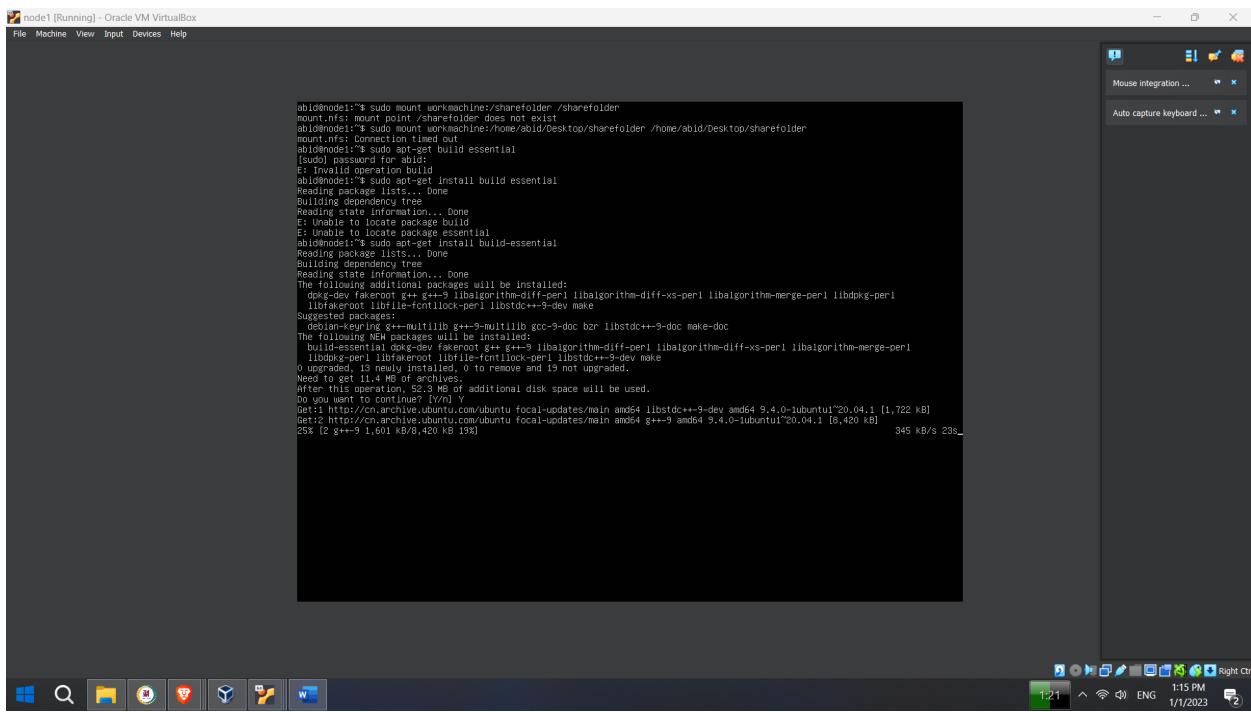
```
sudo apt-get install openmpi-bin libopenmpi-dev
```

## Make Folder



```
node1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

abid@node1:~$ sudo mkdir home/abid/Desktop/Sharefolder
mkdir: cannot create directory '/home/abid/Desktop/Sharefolder': No such file or directory
abid@node1:~$ sudo mkdir /home/abid/Desktop/Sharefolder
abid@node1:~$
```



```
node1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

abid@node1:~$ sudo mount workmachine:/sharefolder /sharefolder
mount.nfs: mount point /sharefolder does not exist
abid@node1:~$ sudo apt-get update
mount.nfs: Connection timed out
abid@node1:~$ sudo apt-get build-essential
[sudo] password for abid:
E: Incomplete archive
abid@node1:~$ sudo apt-get install build-essential
Reading package lists... Done
Building dependency tree...
Reading state information...
The following additional packages will be installed:
diff-dev libalgorithm-diff-perl libalgorithm-diff-xs-perl libalgorithm-merge-perl libdpkg-perl
libfakeroot libfile-fcntllock-perl libstdc++-9-dev make
Suggested packages:
  debhelper dh-autoreconf libutil0 libgcc-9-doc b2r libstdc++-9-doc make-doc
The following NEWER packages will be installed:
  build-essential dh-gcc dh-make dh-make-perl libalgorithm-diff-perl libalgorithm-diff-xs-perl libalgorithm-merge-perl
  libdpkg-perl libfakeroot libfile-fcntllock-perl libstdc++-9-dev make
0 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
Need to get 11.1 MB of archives.
After this operation, 52.3 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
http://deb.debian.org/debian focal-updates/main amd64 libstdc++-9-dev amd64 3.4.0-1ubuntu1~20.04.1 [1,722 kB]
http://cn.archive.ubuntu.com/ubuntu focal-updates/main amd64 g++-9 amd64 9.4.0-1ubuntu1~20.04.1 [8,420 kB]
25% [2 g++-9 1,601 kB/8,420 kB 19%]
```

sudo apt-get install build-essential

```

node1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Mouse integration ...
Auto capture keyboard ...

Selecting previously unselected package fakeroot.
Preparing to unpack .../08-fakeroot_1.24-1_amd64.deb ...
Unpacking fakeroot (1.24-1) ...
Selecting previously unselected package libalgorithm-diff-perl.
Preparing to unpack .../09-libalgorithm-diff-perl_1.19.03-2_all.deb ...
Unpacking libalgorithm-diff-perl (1.19.03-2) ...
Selecting previously unselected package libalgorithm-diff-xs-perl.
Preparing to unpack .../10-libalgorithm-diff-xs-perl_0.04-0_amd64.deb ...
Unpacking libalgorithm-diff-xs-perl (0.04-0) ...
Selecting previously unselected package libalgorithm-merge-perl.
Preparing to unpack .../11-libalgorithm-merge-perl_0.08-3_all.deb ...
Unpacking libalgorithm-merge-perl (0.08-3) ...
Selecting previously unselected package libfile-fcntllock-perl.
Preparing to unpack .../12-libfile-fcntllock-perl_1.0.22-2build4_amd64.deb ...
Unpacking libfile-fcntllock-perl (1.0.22-2build4) ...
Setting up libstdc++-9-devamdd (9.4.0-1ubuntu0.1) ...
Setting up libfile-fcntllock-perl (0.02-20ubu104) ...
Setting up libalgorithm-diff-perl (1.19.03-2) ...
Setting up libalgorithm-merge-perl (0.08-3) ...
Setting up fakeroot (1.24-1) ...
update-alternatives: using /usr/bin/fakeroot-sysv to provide /usr/bin/fakeroot (fakeroot) in auto mode
Setting up make (4.1-1) ...
Setting up libmpich-dev (3.4-1ubuntu0.1) ...
Setting up libbdk-perl (1.19.7ubuntu0.2) ...
Setting up g++ (4:9.3.0-0ubuntu0.2) ...
update-alternatives: using /usr/bin/g++ to provide /usr/bin/c++ (c++) in auto mode
Setting up libalgorithm-merge-perl (0.08-3) ...
Setting up libmpich-dev libmpich2 ...
Suggested packages:
  libmpich-doc
The following NEW packages will be installed:
  libmpich-dev libmpich2
0 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
Need to get 34.0 MB of archives.
After this operation, 18.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] 

```

`sudo apt-get install mpich`

## 9.7 Node 2

```

node2 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Mouse integration ...
Auto capture keyboard ...

Selecting previously unselected package keyutils.
Preparing to unpack .../01-keyutils_1.6-9ubuntu1_amd64.deb ...
Unpacking keyutils (1.6-9ubuntu1) ...
Selecting previously unselected package libnfsidmap2:amd64.
Preparing to unpack .../04-libnfsidmap2_2.0.25-5_tubuntu1_amd64.deb ...
Unpacking libnfsidmap2:amd64 (2.0.25-5_tubuntu1_amd64) ...
Selecting previously unselected package nfs-common.
Preparing to unpack .../05-nfs-common_1.32a1.3.4-2.5ubuntu0.4_amd64.deb ...
Unpacking nfs-common (1:1.3.4-2.5ubuntu0.4) ...
Setting up libnfsidmap2:amd64 (0.25-5_tubuntu0.1) ...
Setting up keyutils (1.6-9ubuntu1) ...
Setting up libnfsidmap2:amd64 (0.25-5_tubuntu0.1) ...
Setting up libnfsidmap2:amd64 (1.2.5-1ubuntu0.1) ...
Setting up libnfsidmap2:amd64 (1.2.5-1ubuntu0.1) ...
Created symlink /etc/systemd/system/multi-user.target.wants/rpcbind.service → /lib/systemd/system/rpcbind.service.
Created symlink /etc/systemd/system/sockets.target.wants/rpcbind.socket → /lib/systemd/system/rpcbind.socket.
Setting up nfs-common (1:1.3.4-2.5ubuntu0.4) ...
Creating config file /etc/ldmload.conf with new version
Adding new user 'statd' (UID 114)
Not adding /etc/ldmload.conf directly to /etc/ldm/
Created symlink /etc/systemd/system/multi-user.target.wants/nfs-client.target → /lib/systemd/system/nfs-client.target.
Created symlink /etc/systemd/system/remote-fs.target.wants/nfs-client.target → /lib/systemd/system/nfs-client.target.
nfs-client.service is a disabled static unit, not starting it.
Processing triggers for libtirpc (0.4.5-1ubuntu0.1) ...
Processing triggers for man-db (2.9.1-1)
Processing triggers for libc-bin (2.31-1ubuntu0.9) ...
[sudo] password for abuid:
[sudo] password for abuid:
Reading package lists... Done
Building dependency tree
Read no descriptions. Done
The following additional packages will be installed:
  binutils binutils-common libgcc-9-base libasan5 libatomic libbinutils libcc-dev-bin
  libgcc-dev-bin libgcc1 libcrypt-dev liblctc-nobfd0 liblctc0 libgcc-9-dev libomp1 libis22 libitm libisano libmc3 libquadmath0
  libquadmath0-dev libgcc1-dev libgcc1-nobfd0 libgcc1-nobfd0-dev libgcc1-nobfd0 libgcc1-nobfd0-dev libgcc1-nobfd0 libgcc1-nobfd0-dev
The following NEW packages will be installed:
  binutils binutils-common libgcc-9-base libasan5 libatomic libbinutils
  libgcc-dev-bin libgcc1 libcrypt-dev liblctc-nobfd0 liblctc0 libgcc-9-dev libomp1 libis22 libitm libisano libmc3
  libquadmath0 libquadmath0-dev libgcc1-dev libgcc1-nobfd0 libgcc1-nobfd0-dev libgcc1-nobfd0 libgcc1-nobfd0-dev libgcc1-nobfd0 libgcc1-nobfd0-dev
0 upgraded, 28 newly installed, 0 to remove and 19 not upgraded.
Need to get 34.0 MB of archives.
After this operation, 150 MB of additional disk space will be used.
Do you want to continue? [Y/n] 

```

`sudo apt-get install gcc`

`sudo apt-get install openmpi-bin openmpi-common libopenmpi-dev libgtk2.0-dev`

```
sudo apt-get install openmpi-bin libopenmpi-dev
```

```
abi@node2:~$ sudo apt-get install build-essential
[sudo] password for abi:
Sorry, try again.
[sudo] password for abi:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
dpkg-dev fakeroot g++-4.9 libalgorithm-diff-perl libalgorithm-merge-perl libdpkg-perl
libdpkg-dev libflock-perl libstdc++-3-dev make
Suggested packages:
  debhelper-re賴 g++-multilib g++-9-multilib gcc-9-doc bzip2 libstdc++-9-doc make-doc
The following NEW packages will be installed:
  build-essential libalgorithm-diff-perl libalgorithm-merge-perl libdpkg-perl
  libdpkg-dev libfakeroot libfile-fcntllock-perl libstdc++-9-dev make
0 upgraded, 13 newly installed, 0 to remove and 19 not upgraded.
Need to get 11.4 MB of archives.
After this operation, 55.3 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

```
sudo apt-get install build-essential
```

```
Preparing to unpack .../07-fakeroot_1.24-1_amd64.deb ...
Unpacking fakeroot (1.24-1) ...
Selecting previously unselected package fakeroot.
Preparing to unpack .../08-fakeroot_1.24-1_amd64.deb ...
Unpacking fakeroot (1.24-1) ...
Selecting previously unselected package libalgorithm-diff-perl.
Preparing to unpack .../09-libalgorithm-diff-perl_1.19.03-2_all.deb ...
Unpacking libalgorithm-diff-perl (1.19.03-2) ...
Selecting previously unselected package libalgorithm-diff-xs-perl.
Preparing to unpack .../10-libalgorithm-diff-xs-perl_0.04-6_amd64.deb ...
Unpacking libalgorithm-diff-xs-perl (0.04-6) ...
Selecting previously unselected package libalgorithm-merge-perl.
Preparing to unpack .../11-libalgorithm-merge-perl_0.08-3_all.deb ...
Unpacking libalgorithm-merge-perl (0.08-3) ...
Selecting previously unselected package libfile-fcntllock-perl.
Preparing to unpack .../12-libfile-fcntllock-perl_0.22-3build4_amd64.deb ...
Unpacking libfile-fcntllock-perl (0.22-3build4) ...
Setting up libfile-fcntllock-perl (0.22-3build4) ...
Setting up libalgorithm-diff-perl (1.19.03-2) ...
Setting up libalgorithm-merge-perl (0.08-3) ...
Setting up fakeroot (1.24-1) ...
Setting up fakeroot (1.24-1) ...
update-alternatives: using /usr/bin/fakeroot-sv to provide /usr/bin/fakeroot (fakeroot) in auto mode
Setting up make (4.2.1-1.2ubuntu1~16.04.1) ...
Setting up libbz2-0.9.2-1ubuntu1~20.04.1 ...
Setting up libblkdev-perl (1.19.1ubuntu3.2) ...
Setting up g++ (4:5.3.0-1ubuntu3.2) ...
update-alternatives: using /usr/bin/g++ to provide /usr/bin/c++ (c++) in auto mode
Setting up libalgorithm-merge-perl (0.08-3) ...
Setting up libalgorithm-merge-perl (0.08-3) ...
Setting up dpg-dep (1.19.1ubuntu3.2) ...
Setting up build-essential (12.1ubuntu1~1) ...
Processing triggers for libasan0 (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.9) ...
libcnode2@'s sudo apt-get install mpich
Reading Package Lists... Done
Building dependency tree...
Reading state information... Done
The following NEW packages will be installed:
  libmpich-dev libmpich2
Suggested packages:
  mpich-doc
The following NEW packages will be installed:
  libmpich-dev libmpich2
0 upgraded, 4 newly installed, 0 to remove and 19 not upgraded.
Need to get 3,476 kB of archives.
After this operation, 19.5 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

```
sudo apt-get install mpich
```

## 9.8 Result

```
File Edit View Search Terminal Help
abid@workmachine: ~$ mpicc sum_array_mpi.c -o obj
abid@workmachine: ~$ mpirun -np 4 ./obj
Enter number of elements: 20
sum calculated by root process: 15
Sum calculated by process 3: 90
Partial sum returned from process 3: 90
Sum calculated by process 2: 65
Sum calculated by process 1: 40
Partial sum returned from process 1: 40
Partial sum returned from process 2: 65
Sum of array is : 210
abid@workmachine: ~$
```

```
abid@workmachine:~$ sudo apt-get install openmpi-bin libopenmpi-dev
[sudo] password for amir:
Reading package lists... Done
Building dependency tree
Reading state information... Done
libopenmpi-dev is already the newest version (4.0.3-0ubuntu1).
openmpi-bin is already the newest version (4.0.3-0ubuntu1).
The following packages were automatically installed and are no longer required:
chromium-codecs-ffmpeg-extra gstreamer1.0-vaapi
libgstreamer-plugins-bad1.0-0 libva-wayland2
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 8 not upgraded.
abid@workmachine:~$ cd /home/amir/Desktop
abid@workmachine:~/Desktop$ cd /home/amir/Desktop
abid@workmachine:~/Desktop$ cd openmpi-4.1.1/
abid@workmachine:~/Desktop/openmpi-4.1.1$ ./configure --prefix="/home/amir/.openmpi"
checking for perl... perl
=====
== Configuring Open MPI
=====
*** Startup tests
checking build system type... x86_64-pc-linux-gnu
checking host system type... x86_64-pc-linux-gnu
checking target system type... x86_64-pc-linux-gnu
checking for gcc... gcc
checking whether the C compiler works... yes
checking for C compiler default output file name... a.out
checking for suffix of executables...
checking whether we are cross compiling... no
checking for suffix of object files... o
checking whether we are using the GNU C compiler... yes
checking whether gcc accepts -g... yes
checking for gcc option to accept ISO C89... none needed
checking whether gcc understands -c and -o together... yes
checking how to run the C preprocessor... gcc -E
checking for grep that handles long lines and -e... /usr/bin/grep
checking for egrep... /usr/bin/grep -E
checking for ANSI C header files... yes
checking for sys/types.h... yes
checking for sys/stat.h... yes
checking for stdlib.h... yes
```

The terminal window shows the execution of MPI programs. It starts with the compilation of MPIserver.c into MPIserver, followed by the execution of mpirun with one process. The server then outputs its port number. The user enters the string "AVINASH". Finally, the reversed string "HSANIVA" is displayed.

```
abid@workmachine:~/sharedfolder$ mpicc MPIserver.c -o MPIserver
abid@workmachine:~/sharedfolder$ mpirun -np 1 ./MPIserver
Server available at port: 2168455169.0:2560756268
Enter the string :
AVINASH

Reversed string is : HSANIVA
```

```
abid@workmachine:~/sharedfolder$ mpicc MPIclient.c -o MPIclient
abid@workmachine:~/sharedfolder$ mpirun -np 1 ./MPIclient 2166161409.0:162766861
0
```

## **10. Conclusion**

I have created virtual cluster in my computer and continued through the processes simultaneously. Being completely new to parallel computing, while creating virtual cluster we might run into complexities in the later stages that might require to start all over again. To eliminate the risk, I have done the complete processes in the computer and successfully completed all the tasks. Hence, I solved the project alone.

## **11. Acknowledgement**

During the process I have faced many obstacles and problems that took countless hours of searching and trials but at the end I was happy to learn the vital skills of parallel computing and thankful to our teacher who have taught us really well and provided us with the best possible resources.

## **11. Reference**

- (a) <https://ubuntu.com/download/server>
- (b) <https://releases.ubuntu.com/20.04/ubuntu-20.04.5-desktop-amd64.iso.torrent>
- (c) [https://www.server-world.info/en/note?os=Ubuntu\\_20.04&p=nis&f=2](https://www.server-world.info/en/note?os=Ubuntu_20.04&p=nis&f=2)
- (d) <https://www.thegeekdiary.com/how-to-configure-nis-network-information-system-master-and-slave-servers-in-centos-rhel/>
- (e) [https://www.server-world.info/en/note?os=Ubuntu\\_20.04&p=nis&f=2](https://www.server-world.info/en/note?os=Ubuntu_20.04&p=nis&f=2)
- (f) [https://www.youtube.com/watch?v=8DodjQ7QmsI&ab\\_channel=SelfTuts](https://www.youtube.com/watch?v=8DodjQ7QmsI&ab_channel=SelfTuts)
- (e) <https://youtu.be/-t4k6IwmtFI>