

Assignment No 2

Open MPI Cluster Configuration

Creating one Master Node, Two Slave Node and using matrix multiplication program execution.

□ Group Members:

Sr. no	Name	Roll no.	PRN
1.	Tanvi Gopinath Patil	73	2324010078
2.	Aarti Pandurang Chavre	81	2324010107
3.	Payal Hanmant Gavade	82	2324010109

❖ Introduction:

We are setting up an **Open MPI Cluster** using **Ubuntu systems** to perform parallel computing tasks. The cluster consists of:

1. **Master Node (PC1)**
 - Ubuntu system
 - Configured with **Open MPI** and **NFS server**
 - Distributes jobs to slave nodes
 - Provides **SSH key-based authentication** for passwordless access
2. **Slave Node 1 (PC2)**
 - Ubuntu system
 - Configured with **Open MPI client**
 - Mounts shared directory from Master using **NFS**
 - Executes MPI jobs assigned by Master
3. **Slave Node 2 (PC3)**
 - Ubuntu system
 - Same configuration as Slave Node 1
 - Participates in parallel computation via Open MPI

❖ Working of MPI Cluster

1. **User Request**
 - The user runs an **MPI program** (matrix multiplication) from the Master node.

2. SSH Authentication

- The Master uses **RSA key-based authentication** to log in to Slave nodes without password.

3. NFS Data Sharing

- Source code and input files are stored in /mnt/shared on the Master.
- Slaves access the same directory via **NFS mount**.

4. MPI Execution

- Master executes:
- `mpirun -np 6 -host master,slave1,slave2 ./matrix_mpi`
- Open MPI distributes processes among the Master and Slaves.

5. Program Output

- The **matrix multiplication result** is computed collaboratively.
- Output is stored in /mnt/shared/output.txt.

❖ Implementation Steps

We are using **three Ubuntu systems** in the same LAN.

PC1 (Master Node)

- **IP Address:** 172.25.6.41
- Installed: Open MPI, NFS Server
- Configured SSH key for passwordless login to slaves
- Exports /mnt/shared directory via NFS

PC2 (Slave Node 1)

- **IP Address:** 172.25.6.42
- Installed: Open MPI, NFS Client
- Mounts /mnt/shared from Master

PC3 (Slave Node 2)

- **IP Address:** 172.25.6.43
- Installed: Open MPI, NFS Client
- Mounts /mnt/shared from Master

❖ Configuration Steps

Master Node Setup for Clustering (NFS Server)

Step 1: SSH into Master Node

Open a terminal and connect to the master node using SSH.

`ssh ubuntu@<master-node-ip>`

You connected to the master node via SSH.


```
Activities Terminal Aug 6 22:02
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ping 172.25.6.38
PING 172.25.6.38 (172.25.6.38) 56(84) bytes of data:
64 bytes from 172.25.6.38: icmp_seq=1 ttl=64 time=0.160 ms
64 bytes from 172.25.6.38: icmp_seq=2 ttl=64 time=0.157 ms
64 bytes from 172.25.6.38: icmp_seq=3 ttl=64 time=0.150 ms
^C
--- 172.25.6.38 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2043ms
rtt min/avg/max/mdev = 0.150/0.155/0.160/0.004 ms
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ping 172.25.6.37
PING 172.25.6.37 (172.25.6.37) 56(84) bytes of data:
64 bytes from 172.25.6.37: icmp_seq=1 ttl=64 time=0.153 ms
64 bytes from 172.25.6.37: icmp_seq=2 ttl=64 time=0.178 ms
64 bytes from 172.25.6.37: icmp_seq=3 ttl=64 time=0.138 ms
64 bytes from 172.25.6.37: icmp_seq=4 ttl=64 time=0.129 ms
^C
--- 172.25.6.37 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3079ms
rtt min/avg/max/mdev = 0.129/0.149/0.178/0.018 ms
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ssh-copy-id user@172.25.6.38
The authenticity of host '172.25.6.38 (172.25.6.38)' can't be established.
ED25519 key fingerprint is SHA256:esGdnnuMLCFPTU+ELG4sq00kxHL5uA4b0K086At4.
This key is not known by any other names.
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
user@172.25.6.38's password:
Permission denied, please try again.
user@172.25.6.38's password:
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ssh-copy-id ubuntu@172.25.6.38
/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
ubuntu@172.25.6.38's password:
Number of key(s) added: 1
Now try logging into the machine, with: "ssh 'ubuntu@172.25.6.38'"
and check to make sure that only the key(s) you wanted were added.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ssh-copy-id ubuntu@172.25.6.37
The authenticity of host '172.25.6.37 (172.25.6.37)' can't be established.
ED25519 key fingerprint is SHA256:MRabusPFSXl1WVA7NBU5YK7JAKDBRJo8hzSGVd0ktw8.
This key is not known by any other names.
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
ubuntu@172.25.6.37's password:
Number of key(s) added: 1
Now try logging into the machine, with: "ssh 'ubuntu@172.25.6.37'"
and check to make sure that only the key(s) you wanted were added.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ssh ubuntu@172.25.6.38
Welcome to ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)
```

```
Activities Terminal Aug 6 22:02
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ssh ubuntu@172.25.6.38
Welcome to ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)

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

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.
To see these additional updates run: apt list --upgradable
Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ ssh ubuntu@172.25.6.37
The authenticity of host '172.25.6.37 (172.25.6.37)' can't be established.
ED25519 key fingerprint is SHA256:MRabusPFSXl1WVA7NBU5YK7JAKDBRJo8hzSGVd0ktw8.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '172.25.6.37' (ED25519) to the list of known hosts.
ubuntu@172.25.6.37's password:
Welcome to Ubuntu 22.04.2 LTS (GNU/Linux 6.8.0-65-generic x86_64)

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

1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.

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  Receive updates to over 25,000 software packages with your
  Ubuntu Pro subscription. Free for personal use.
  https://ubuntu.com/pro

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.
Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

1 device has a firmware upgrade available.
```

Step 4: SSH into Slaves to Verify Access

ssh ubuntu@<slave-node-ip>

```
Activities Terminal Aug 6 22:03
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: -

1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ nano ~/.ssh/config
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh slave1
The authenticity of host '172.25.6.37 (172.25.6.37)' can't be established.
ED25519 key fingerprint is SHA256:MRabu5PF5Xl1WVA7NBUSYK7JAKDBR308hzSGVdektw8.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '172.25.6.37' (ED25519) to the list of known hosts.
ubuntu@172.25.6.37:~$ password:
Welcome to Ubuntu 22.04.2 LTS (GNU/Linux 6.8.0-65-generic x86_64)

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

1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.

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  https://ubuntu.com/pro

Expanded Security Maintenance for Applications is not enabled.
0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.

Last login: Wed Aug 6 15:48:29 2025 from 172.25.6.38
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ssh slave2
The authenticity of host '172.25.6.38 (172.25.6.38)' can't be established.
ED25519 key fingerprint is SHA256:esGdRUMlCFPTU+ELG4sqh00k8ML5vA48oK86A14.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '172.25.6.38' (ED25519) to the list of known hosts.
ubuntu@172.25.6.38:~$ password:
Welcome to Ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)

 * Documentation:  https://help.ubuntu.com
```

Step 5: Verify SSH Key File and SSH Config

In this step, the user checks the SSH configuration and key files. This is useful to ensure that:

- The SSH key has been generated.
- Paths like `~/.ssh/id_rsa.pub` and `~/.ssh/config` exist and are correctly configured

```
Activities Terminal Aug 6 22:03
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: -

ED25519 key fingerprint is SHA256:esGdRUMlCFPTU+ELG4sqh00k8ML5vA48oK86A14.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '172.25.6.38' (ED25519) to the list of known hosts.
ubuntu@172.25.6.38:~$ password:
Welcome to Ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)

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

Expanded Security Maintenance for Applications is not enabled.
0 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

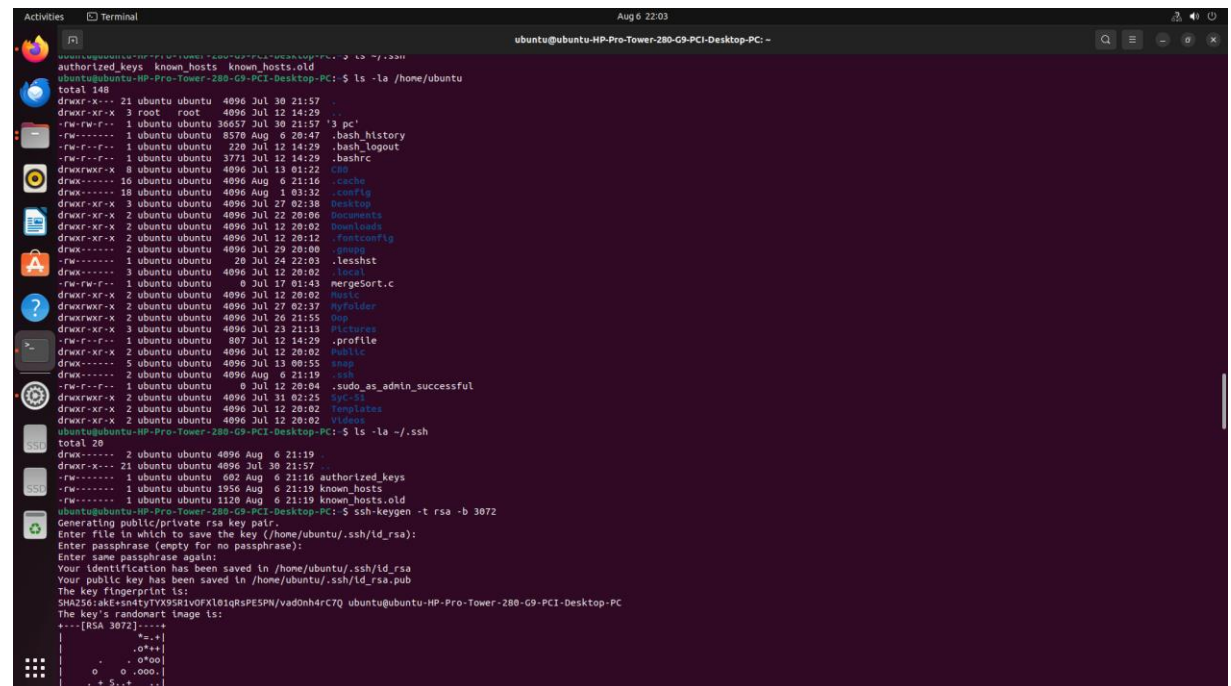
Last login: Wed Aug 6 21:17:55 2025 from 172.25.6.39
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ssh-copy-id ubuntu@172.25.6.37
/usr/bin/ssh-copy-id: ERROR: No identities found
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ssh-copy-id ubuntu@172.25.6.38
/usr/bin/ssh-copy-id: ERROR: No identities found
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ls -l ~/.ssh
total 12
-rw-r----- 1 ubuntu ubuntu 602 Aug 6 21:16 authorized_keys
-rw-r----- 1 ubuntu ubuntu 1956 Aug 6 21:19 known_hosts
-rw-r----- 1 ubuntu ubuntu 1120 Aug 6 21:19 known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ /home/ubuntu/.ssh/
-bash: /home/ubuntu/.ssh/: Is a directory
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ /home/ubuntu/.ssh/id_rsa
-bash: /home/ubuntu/.ssh/id_rsa: No such file or directory
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ssh-add ~/.ssh/id_rsa
Could not open a connection to your authentication agent.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ eval "$(ssh-agent -s)"
Agent pid 7995
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ssh-add ~/.ssh/id_rsa
/home/ubuntu/.ssh/id_rsa: No such file or directory
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ eval "$(ssh-agent -s)"
Agent pid 8125
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ssh-add ~/.ssh/id_rsa
/home/ubuntu/.ssh/id_rsa: No such file or directory
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ls -l ~/.ssh
total 12
-rw-r----- 1 ubuntu ubuntu 602 Aug 6 21:16 authorized_keys
-rw-r----- 1 ubuntu ubuntu 1956 Aug 6 21:19 known_hosts
-rw-r----- 1 ubuntu ubuntu 1120 Aug 6 21:19 known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ls -la ~/.ssh
authorized_keys  known_hosts  known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ls -la /home/ubuntu
total 148
drwxr-xr-x 21 ubuntu ubuntu 4096 Jul 30 21:57
```


Step 6: Login to Slave Node 1 Using SSH

SSH is used to log into the first slave node (Slave1) from the master node.

Command used:

```
ssh ubuntu@172.25.6.38
```



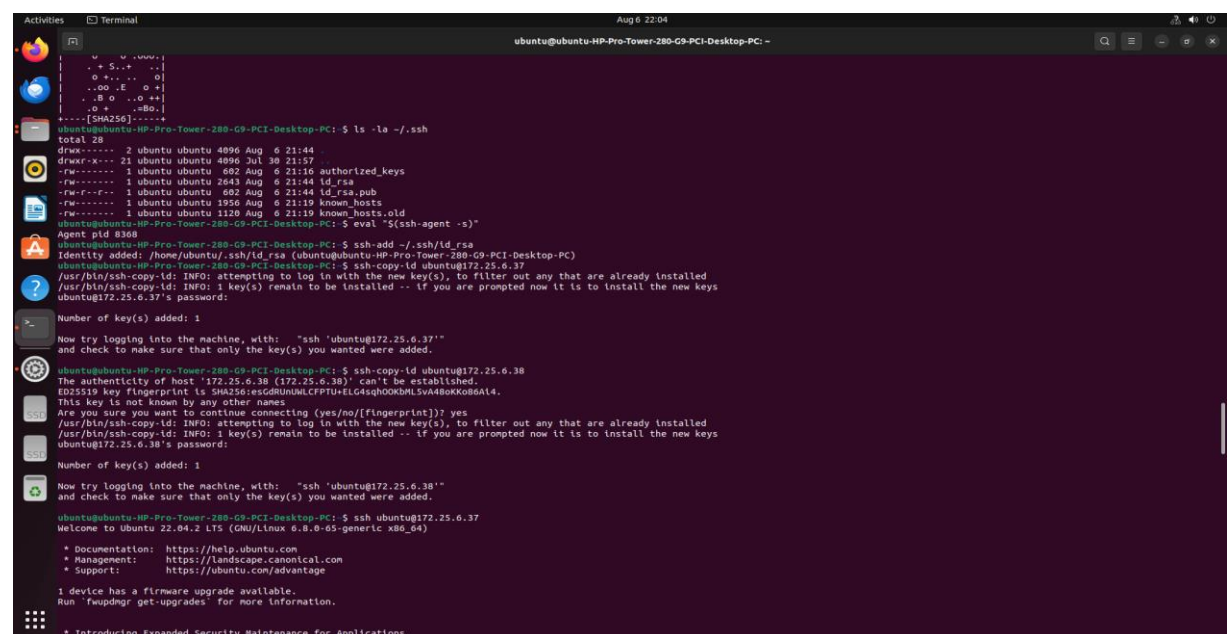
A terminal window titled 'ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~' showing the execution of 'ls -la /home/ubuntu'. It lists files like 'authorized_keys', 'known_hosts', and 'known_hosts.old'. Then, it runs 'ssh-keygen -t rsa -b 3072', which generates a new RSA key pair. The user is prompted to enter a passphrase (empty) and confirm it. The terminal shows the key's fingerprint and the random image used for the key.

Step 7: Login to Slave Node 2 Using SSH

This step is similar to Step 7 but for the second slave node (Slave2). It confirms that SSH access is also established here.

Command used:

```
ssh ubuntu@172.25.6.37
```



A terminal window titled 'ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~' showing the execution of 'ls -la ~/.ssh'. It lists files like 'authorized_keys', 'id_rsa', 'id_rsa.pub', and 'known_hosts'. Then, it runs 'ssh-add ~/.ssh/id_rsa', which adds the key to the agent. The terminal shows the key's fingerprint and the random image used for the key. Finally, it runs 'ssh ubuntu@172.25.6.37', which logs into the second slave node. The terminal shows the SSH banner and the user's login details.

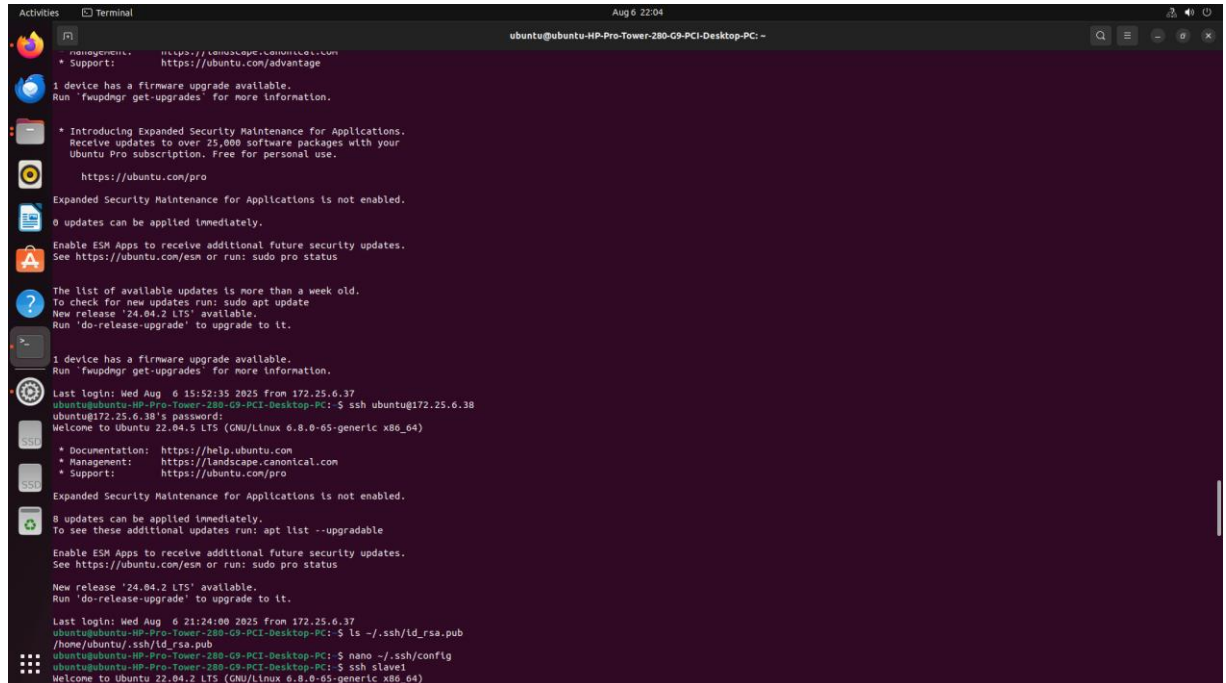
Step 8: Additional Verification + View Config Paths

This shows SSH access verification again and displays config file locations such as:

/home/ubuntu/.ssh/id_rsa.pub

/home/ubuntu/.ssh/config

Additionally, shows successful login to both Slave1 and Slave2, ensuring both are accessible.



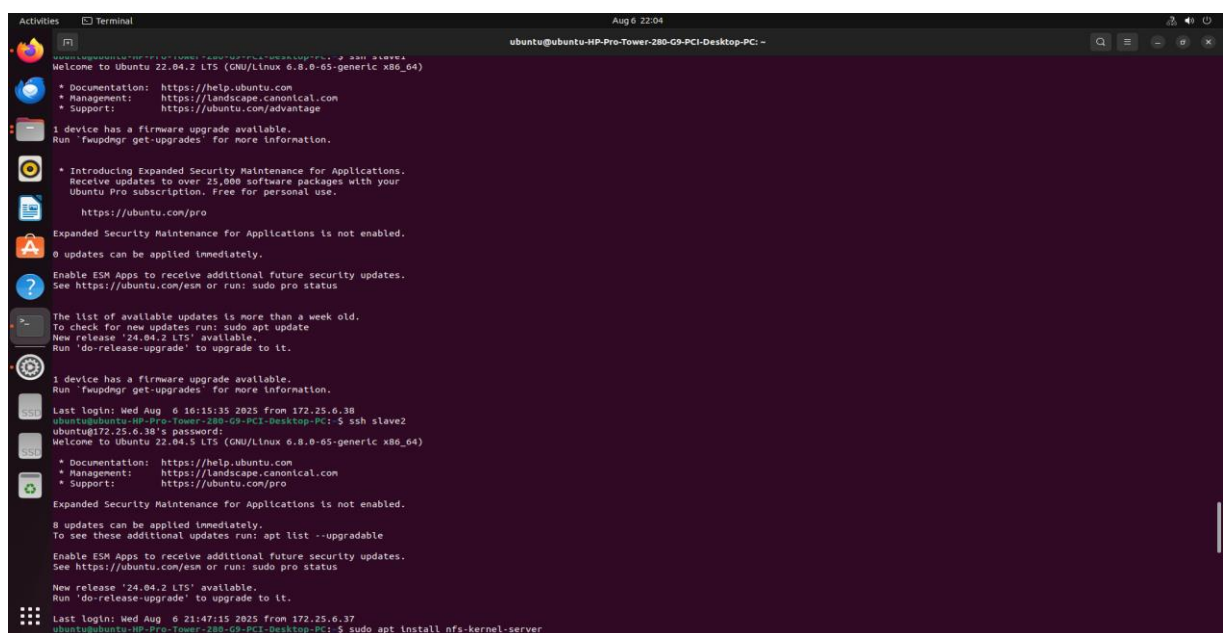
A terminal window on an Ubuntu system showing various system messages and commands. The messages include notifications about firmware upgrades, security maintenance, and available updates. The user runs the command `ls -l ~/.ssh/id_rsa.pub`, which shows the file's permissions and location. Then, the user runs `ssh slave1` and `ssh slave2`, both of which result in successful logins to the respective slave nodes.

```
Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
* Support: https://ubuntu.com/advantage
1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.
* Introducing Expanded Security Maintenance for Applications.
Receive updates to over 25,000 software packages with your
Ubuntu Pro subscription. Free for personal use.
https://ubuntu.com/pro
Expanded Security Maintenance for Applications is not enabled.
0 updates can be applied immediately.
Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status
The list of available updates is more than a week old.
To check for new updates run: sudo apt update
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.
1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.
Last login: Wed Aug 6 15:52:35 2025 from 172.25.6.37
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh ubuntu@172.25.6.38
ubuntu@172.25.6.38's password:
Welcome to Ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)
* Documentation: https://help.ubuntu.com
* Management: https://landscape.canonical.com
* Support: https://ubuntu.com/pro
Expanded Security Maintenance for Applications is not enabled.
8 updates can be applied immediately.
To see these additional updates run: apt list --upgradable
Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.
Last login: Wed Aug 6 21:24:08 2025 from 172.25.6.37
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ls -l ~/.ssh/id_rsa.pub
-rw-r--r-- 1 ubuntu ubuntu 459 Aug 6 21:24 /home/ubuntu/.ssh/id_rsa.pub
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ nano -f .ssh/config
Welcome to Ubuntu 22.04.2 LTS (GNU/Linux 6.8.0-65-generic x86_64)
```

Step 9: Install NFS Server on Master Node

`sudo apt update`

`sudo apt install nfs-kernel-server`



A terminal window on an Ubuntu system showing the installation of the NFS kernel server. The user runs `sudo apt update` and then `sudo apt install nfs-kernel-server`. The terminal output shows the progress of the installation, including the download of the package and its dependencies.

```
Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
Welcome to Ubuntu 22.04.2 LTS (GNU/Linux 6.8.0-65-generic x86_64)
* Documentation: https://help.ubuntu.com
* Management: https://landscape.canonical.com
* Support: https://ubuntu.com/pro
1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.
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Expanded Security Maintenance for Applications is not enabled.
0 updates can be applied immediately.
Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status
The list of available updates is more than a week old.
To check for new updates run: sudo apt update
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.
1 device has a firmware upgrade available.
Run 'fwupdgr get-upgrades' for more information.
Last login: Wed Aug 6 16:15:35 2025 from 172.25.6.38
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh slave2
ubuntu@172.25.6.38's password:
Welcome to Ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)
* Documentation: https://help.ubuntu.com
* Management: https://landscape.canonical.com
* Support: https://ubuntu.com/pro
Expanded Security Maintenance for Applications is not enabled.
8 updates can be applied immediately.
To see these additional updates run: apt list --upgradable
Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.
Last login: Wed Aug 6 21:47:15 2025 from 172.25.6.37
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ sudo apt install nfs-kernel-server
```

```
Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo apt install nfs-kernel-server
[sudo] password for ubuntu:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common nfs-kernel-server rpcbind
0 upgraded, 6 newly installed, 0 to remove and 8 not upgraded.
Need to get 615 kB of archives.
After this operation, 2,235 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://ft.archive.ubuntu.com/ubuntu jammy/main amd64 libevent-core-2.1-7 amd64 2.1.12-stable-1build3 [93.9 kB]
Get:2 http://ft.archive.ubuntu.com/ubuntu jammy-updates/main amd64 libnfsidmap1 amd64 1:2.6.1-1ubuntu1.2 [42.9 kB]
Get:3 http://ft.archive.ubuntu.com/ubuntu jammy/main amd64 rpcbind amd64 1:2.6-2build1 [46.6 kB]
Get:4 http://ft.archive.ubuntu.com/ubuntu jammy/main amd64 keyutils amd64 1.6.1-2ubuntu3 [50.4 kB]
Get:5 http://ft.archive.ubuntu.com/ubuntu jammy-updates/main amd64 nfs-common amd64 1:2.6.1-1ubuntu1.2 [241 kB]
Get:6 http://ft.archive.ubuntu.com/ubuntu jammy-updates/main amd64 nfs-kernel-server amd64 1:2.6.1-1ubuntu1.2 [140 kB]
Fetched 615 kB in 0s (27.6 MB/s)
Selecting previously unselected package libevent-core-2.1-7:amd64.
(Reading database ... 21468 files and directories currently installed.)
Preparing to unpack .../9-libevent-core-2.1-7-2.1.12-stable-1build3_amd64.deb ...
Unpacking libevent-core-2.1-7:amd64 (2.1.12-stable-1build3) ...
Selecting previously unselected package libnfsidmap1:amd64.
Preparing to unpack .../1-libnfsidmap1_1k3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
Selecting previously unselected package rpcbind.
Preparing to unpack .../2-rpcbind_1:2.6-2build1_amd64.deb ...
Unpacking rpcbind (1:2.6-2build1) ...
Selecting previously unselected package keyutils.
Preparing to unpack .../3-keyutils_1.6.1-2ubuntu3_amd64.deb ...
Unpacking keyutils (1.6.1-2ubuntu3) ...
Selecting previously unselected package nfs-common.
Preparing to unpack .../4-nfs-common_1k3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-common (1:2.6.1-1ubuntu1.2) ...
Selecting previously unselected package nfs-kernel-server.
Preparing to unpack .../5-nfs-kernel-server_1k3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-kernel-server (1:2.6.1-1ubuntu1.2) ...
Setting up libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
Setting up rpcbind (1:2.6-2build1) ...
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 libevent-core-2.1-7:amd64 (2.1.12-stable-1build3) ...
Setting up keyutils (1.6.1-2ubuntu3) ...
Setting up nfs-common (1:2.6.1-1ubuntu1.2) ...
Creating config file /etc/ldmapd.conf with new version
Creating config file /etc/nfs.conf with new version
Adding system user `statd' (UID 134) ...
Adding new user `statd' (UID 134) with group `nogroup' ...
Not creating home directory /var/lib/nfs/
```

Step 10: Create Shared Directory

```
sudo mkdir /mnt/shared
```

```
sudo chown nobody:nogroup /mnt/shared
```

Directory created and permission set for NFS sharing.

Restart NFS Server

```
sudo systemctl restart nfs-kernel-server
```

Restarted NFS service to apply changes.

```
Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo systemctl restart nfs-kernel-server
Restarting nfs-kernel-server (1:2.6.1-1ubuntu1.2) ...
Creating config file /etc/ldmapd.conf with new version
Creating config file /etc/nfs.conf with new version
Adding system user `statd' (UID 134) ...
Adding new user `statd' (UID 134) 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/remote-fs.target.wants/nfs-client.target → /lib/systemd/system/nfs-client.target.
auth-rpcgss-module.service is a disabled or a static unit, not starting it.
nfs-ldmapd.service is a disabled or a static unit, not starting it.
nfs-utils.service is a disabled or a static unit, not starting it.
proc-fs-nfsd.mount is a disabled or a static unit, not starting it.
rpc-gssd.service is a disabled or a static unit, not starting it.
rpc-statd.service is a disabled or a static unit, not starting it.
rpc-svcgssd.service is a disabled or a static unit, not starting it.
rpc-pipefs.target is a disabled or a static unit, not starting it.
var-lib-nfs-rpc-pipefs.mount is a disabled or a static unit, not starting it.
Setting up nfs-kernel-server (1:2.6.1-1ubuntu1.2) ...
Created symlink /etc/systemd/system/nfs-client.target.wants/nfs-blkmap.service → /lib/systemd/system/nfs-blkmap.service.
Created symlink /etc/systemd/system/multi-user.target.wants/nfs-server.service → /lib/systemd/system/nfs-server.service.
nfs-mountd.service is a disabled or a static unit, not starting it.
nfsdclld.service is a disabled or a static unit, not starting it.
Creating config file /etc/exports with new version
Creating config file /etc/default/nfs-kernel-server with new version
Processing triggers for man-db (2.10.2-1) ...
Processing triggers for libc-bin (2.35-0ubuntu3.4) ...
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo mkdir /mnt/shared
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo chown nobody:nogroup /mnt/shared
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo nano /etc/exports
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo exportfs -a
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$ sudo systemctl restart nfs-kernel-server
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~$
```


- **Slave Node Configuration**

Step 1. Install NFS client

sudo apt install nfs-common -y

Installs tools needed to connect to Master's shared folder.

```
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo apt update
[sudo] password for ubuntu:
Hit:1 http://ln.archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://ln.archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:3 http://ln.archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Get:4 http://ln.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [2,802 kB]
Get:5 http://ln.archive.ubuntu.com/ubuntu jammy-updates/main i386 Packages [853 kB]
Get:6 http://ln.archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [443 kB]
Get:7 http://ln.archive.ubuntu.com/ubuntu jammy-updates/main amd64 DEP-11 Metadata [112 kB]
Get:8 http://ln.archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 DEP-11 Metadata [212 B]
Get:9 http://ln.archive.ubuntu.com/ubuntu jammy-updates/universe i386 Packages [781 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:11 http://ln.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1,226 kB]
Get:12 http://ln.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 DEP-11 Metadata [359 kB]
Get:13 http://ln.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 DEP-11 Metadata [940 B]
Get:14 http://ln.archive.ubuntu.com/ubuntu jammy-backports/main amd64 DEP-11 Metadata [7,096 B]
Get:15 http://security.ubuntu.com/ubuntu jammy-backports/restricted amd64 DEP-11 Metadata [212 B]
Get:16 http://ln.archive.ubuntu.com/ubuntu jammy-backports/universe amd64 DEP-11 Metadata [14.0 kB]
Get:17 http://ln.archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 DEP-11 Metadata [212 B]
Get:18 http://security.ubuntu.com/ubuntu jammy-security/main i386 Packages [681 kB]
Get:19 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [2,557 kB]
Get:20 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [379 kB]
Get:21 http://security.ubuntu.com/ubuntu jammy-security/main amd64 DEP-11 Metadata [54.0 kB]
Get:22 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [4,013 kB]
Get:23 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [729 kB]
Get:24 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 DEP-11 Metadata [208 B]
Get:25 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [593 kB]
Get:26 http://security.ubuntu.com/ubuntu jammy-security/universe i386 Packages [671 kB]
Get:27 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 DEP-11 Metadata [125 kB]
Get:28 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 DEP-11 Metadata [208 B]
Fetched 17.2 MB in 31s (562 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
12 packages can be upgraded. Run 'apt list --upgradable' to see them.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo apt install openssh-server
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
openssh-server is already the newest version (1:8.9p1-3ubuntu0.13).
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 7c:67:58:37:29:92 brd ff:ff:ff:ff:ff:ff
    inet 172.25.0.38/16 brd 172.25.255.255 scope global noprefixroute enp2s0
        valid_lft forever preferred_lft forever
    inet6 fe80::bbe7:f4d8:8e51:465d/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
```

Step 2. Create mount directory

sudo mkdir -p /mnt/shared

Creates a local folder where Master's shared files will appear.

```
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo systemctl status ssh
● ssh.service - OpenSSH Secure Shell server
   Loaded: loaded (/lib/systemd/system/ssh.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2025-08-06 20:27:31 IST; 41min ago
     Docs: man:sshd(8)
           man:sshd_config(5)
   Main PID: 898 (sshd)
     Tasks: 1 (Limit: 18711)
    Memory: 3.1M
       CPU: 13ms
   CGroup: /system.slice/ssh.service
           └─898 "sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups"

Aug 06 20:27:31 ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC sshd[898]: Server listening on 0.0.0.0 port 22.
Aug 06 20:27:31 ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC sshd[898]: Server listening on :: port 22.
Aug 06 20:27:31 ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC systemd[1]: Starting OpenSSH Secure Shell server...
Aug 06 20:27:31 ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC systemd[1]: Started OpenSSH Secure Shell server.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo ufw status
Status: active

To Action From
--
53 ALLOW Anywhere
80/tcp ALLOW Anywhere
443 ALLOW Anywhere
53 (v6) ALLOW Anywhere (v6)
80/tcp (v6) ALLOW Anywhere (v6)
443 (v6) ALLOW Anywhere (v6)

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo ufw allow ssh
Rule added
Rule added (v6)
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo ufw reload
Firewall reloaded
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo ufw status
Status: active

To Action From
--
53 ALLOW Anywhere
80/tcp ALLOW Anywhere
443 ALLOW Anywhere
22/tcp ALLOW Anywhere
53 (v6) ALLOW Anywhere (v6)
80/tcp (v6) ALLOW Anywhere (v6)
443 (v6) ALLOW Anywhere (v6)
22/tcp (v6) ALLOW Anywhere (v6)

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo passwd user
passwd: user 'user' does not exist
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ whoami
ubuntu
```

Step 3. Mount shared folder from Master

```
sudo mount 172.25.6.39:/mnt/shared /mnt/shared
```

Connects to Master (IP: 172.25.6.39) and mounts its shared folder on Slave.

```
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ whoami
ubuntu
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo apt install nfs-common
[sudo] password for ubuntu:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
nfs-common is already the newest version (1:2.6.1-1ubuntu1.2).
nfs-common set to manually installed.
0 upgraded, 0 newly installed, 0 to remove and 8 not upgraded.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo mkdir /mnt/shared
mkdir: cannot create directory '/mnt/shared': File exists
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ sudo mount 172.25.6.39:/mnt/shared /mnt/shared
mount.nfs: Connection timed out
```