

Assignment No 2

Open MPI Cluster Configuration

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

□ Group Members:

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❖ 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 22:01
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ sudo apt update
[sudo] password for ubuntu
Get:1 http://security.ubuntu.com/ubuntu jammy InRelease
Get:2 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:3 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:4 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Get:5 http://security.ubuntu.com/ubuntu jammy-security/main l386 Packages [681 kB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [2,559 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main i386 Packages [1,548 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [379 kB]
Get:9 http://in.archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [2,082 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/main amd64 DEP-11 Metadata [54.6 kB]
Get:11 http://in.archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [144 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1,013 kB]
Get:13 http://in.archive.ubuntu.com/ubuntu jammy-updates/main amd64 DEP-11 Metadata [112 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [729 kB]
Get:15 http://in.archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 DEP-11 Metadata [212 kB]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 DEP-11 Metadata [208 kB]
Get:17 http://in.archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [125 kB]
Get:18 http://in.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1,226 kB]
Get:19 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [993 kB]
Get:20 http://in.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 DEP-11 Metadata [359 kB]
Get:21 http://in.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 DEP-11 Metadata [940 kB]
Get:22 http://in.archive.ubuntu.com/ubuntu jammy-backports/main DEP-11 Metadata [7,096 kB]
Get:23 http://in.archive.ubuntu.com/ubuntu jammy-backports/main l386 Packages [671 kB]
Get:24 http://in.archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 DEP-11 Metadata [212 kB]
Get:25 http://in.archive.ubuntu.com/ubuntu jammy-security/universe amd64 DEP-11 Metadata [125 kB]
Get:26 http://in.archive.ubuntu.com/ubuntu jammy-backports/universe amd64 DEP-11 Metadata [140 kB]
Get:27 http://in.archive.ubuntu.com/ubuntu jammy-security/multiverse amd64 DEP-11 Metadata [208 kB]
Get:28 http://in.archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 DEP-11 Metadata [212 kB]
Fetched 17.2 MB in 7s (2,031 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
0 upgraded, 0 newly installed, 0 to remove and 4 not upgraded.
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 4 not upgraded.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/ubuntu/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter passphrase again:
Your identification has been saved in /home/ubuntu/.ssh/id_rsa
Your public key has been saved in /home/ubuntu/.ssh/id_rsa.pub
The key's fingerprint is:
SHA256:lnf0Qm3fz1z561/N4ru0xt0BNsnC4MuH2bORPIe9o ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC
The key's randomart image is:
+---[RSA 3072]---+
|          . |
|          . |
|          . |
|          = o ..o.o +|
| + =o5o.o. ooo| .
| . =...o. .|= |
| . . o . . . |
| . o o . +|| |
| . E o++..o++|| |
+---[SHA256]---+
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id user@172.25.6.37
Generating public/private rsa key pair.
Enter file in which to save the key (/home/ubuntu/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/ubuntu/.ssh/id_rsa
Your public key has been saved in /home/ubuntu/.ssh/id_rsa.pub
The key's randomart image is:
+---[RSA 3072]---+
|          . |
|          . |
|          . |
|          = o ..o.o +|
| + =o5o.o. ooo| .
| . =...o. .|= |
| . . o . . . |
| . o o . +|| |
| . E o++..o++|| |
+---[SHA256]---+
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id user@172.25.6.37
* /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: 183: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_tmp_id': Directory nonexistent
* /usr/bin/ssh-copy-id: 189: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': Directory nonexistent
grep: /home/ubuntu/.ssh/ssh-copy_id: 202: cannot open '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': No such file or directory
cat: /home/ubuntu/.ssh/ssh-copy_id.popids_tmp_id: No such file or directory
/usr/bin/ssh-copy-id: WARNING: All keys were skipped because they already exist on the remote system.
(if you think this is a mistake, you may want to use -f option)

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id user@172.25.6.37
ssh-copy-id user@172.25.6.37: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: 183: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_tmp_id': Directory nonexistent
/usr/bin/ssh-copy-id: 189: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': Directory nonexistent
/usr/bin/ssh-copy-id: 202: cannot open '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': No such file or directory
cat: /home/ubuntu/.ssh/ssh-copy_id.popids_tmp_id: No such file or directory
/usr/bin/ssh-copy-id: ERROR: ssh: connect to host 172.25.6.37 port 22: Connection timed out
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=0.166 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
...
--- 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

```

Step 2: Generate SSH Key (if not done already)

`ssh-keygen -t rsa`

Generated SSH key for secure communication.

```

Activities Terminal Aug 6 22:02
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id user@172.25.6.37
Generating public/private rsa key pair.
Enter file in which to save the key (/home/ubuntu/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/ubuntu/.ssh/id_rsa
Your public key has been saved in /home/ubuntu/.ssh/id_rsa.pub
The key's randomart image is:
+---[RSA 3072]---+
|          . |
|          . |
|          . |
|          = o ..o.o +|
| + =o5o.o. ooo| .
| . =...o. .|= |
| . . o . . . |
| . o o . +|| |
| . E o++..o++|| |
+---[SHA256]---+
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id user@172.25.6.37
* /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: 183: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_tmp_id': Directory nonexistent
* /usr/bin/ssh-copy-id: 189: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': Directory nonexistent
grep: /home/ubuntu/.ssh/ssh-copy_id: 202: cannot open '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': No such file or directory
cat: /home/ubuntu/.ssh/ssh-copy_id.popids_tmp_id: No such file or directory
/usr/bin/ssh-copy-id: WARNING: All keys were skipped because they already exist on the remote system.
(if you think this is a mistake, you may want to use -f option)

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id user@172.25.6.37
ssh-copy-id user@172.25.6.37: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: 183: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_tmp_id': Directory nonexistent
/usr/bin/ssh-copy-id: 189: cannot create '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': Directory nonexistent
/usr/bin/ssh-copy-id: 202: cannot open '/home/ubuntu/.ssh/ssh-copy_id.o3wNzTBk/popids_output': No such file or directory
cat: /home/ubuntu/.ssh/ssh-copy_id.popids_tmp_id: No such file or directory
/usr/bin/ssh-copy-id: ERROR: ssh: connect to host 172.25.6.37 port 22: Connection timed out
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=0.166 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
...
--- 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

```

Step 3: Copy SSH Key to Slave Nodes

`ssh-copy-id ubuntu@<slave-node-ip>`

Repeat for each slave.

```

Activities Terminal ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
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 ---
3 packets transmitted, 3 received, 0% packet loss, time 3075ms
rtt min/avg/max/mdev = 0.150/0.149/0.178/0.010 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:resGdRnUMLCPTFU+EL04sqhOKKML5vA48okKo86l4.
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.
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
user@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:MRabuSpF5x1WmATnbUSYk73ak0BRJ08h25Gvd6ktw8.
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@172.25.6.37'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)

 * 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.

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:MRabuSpF5x1WmATnbUSYk73ak0BRJ08h25Gvd6ktw8.
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.
user@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/adventure

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

SSU

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  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.

```

```

Activities Terminal ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
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.

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.

ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~ ssh-copy-id user@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:MRabuSpF5x1WmATnbUSYk73ak0BRJ08h25Gvd6ktw8.
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.
user@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/adventure

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

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  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

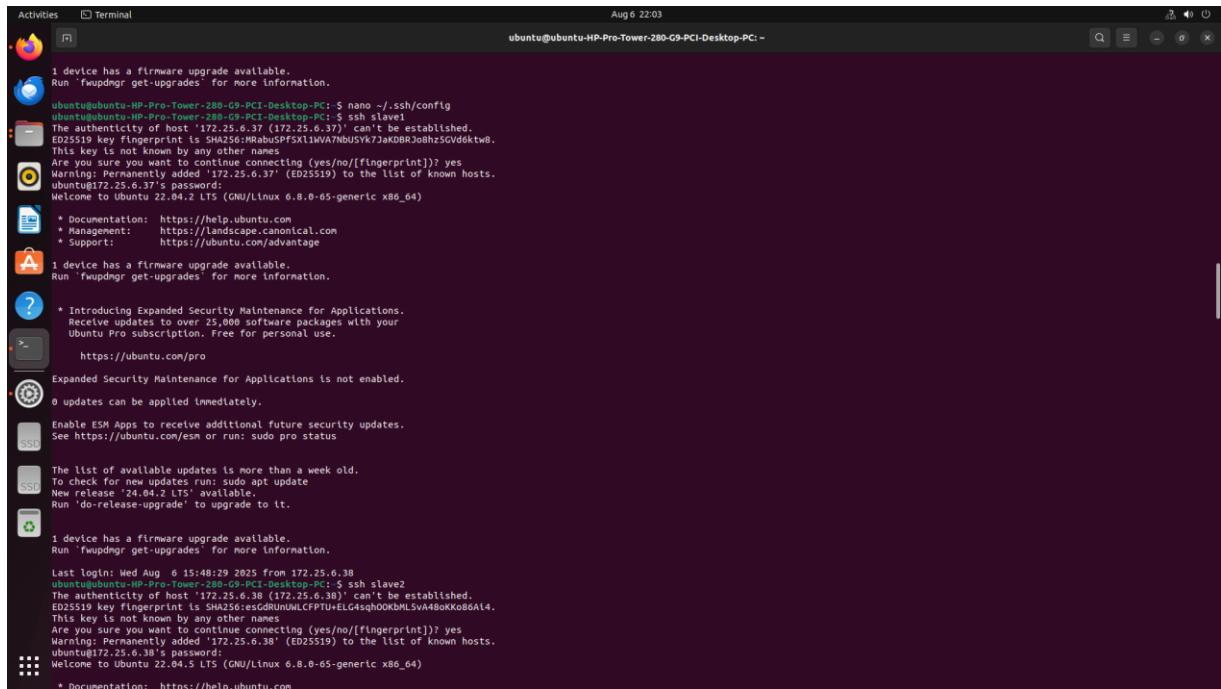
The list of available updates is more than a week old.
To check for new updates run: sudo apt update
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

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 'fwupdmgr 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:MRabuSpFSXlIWATnbUSyK7jakDRj0BzSGd6ktw8.
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

A 1 device has a firmware upgrade available.
Run 'fwupdmgr 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.

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

  SSD 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 'fwupdmgr 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:esGdRUnUMLCFPTU+ELG4sqh0OKbML5vA4BokKo86Al4.
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's password:
Welcome to Ubuntu 22.04.5 LTS (GNU/Linux 6.8.0-65-generic x86_64)

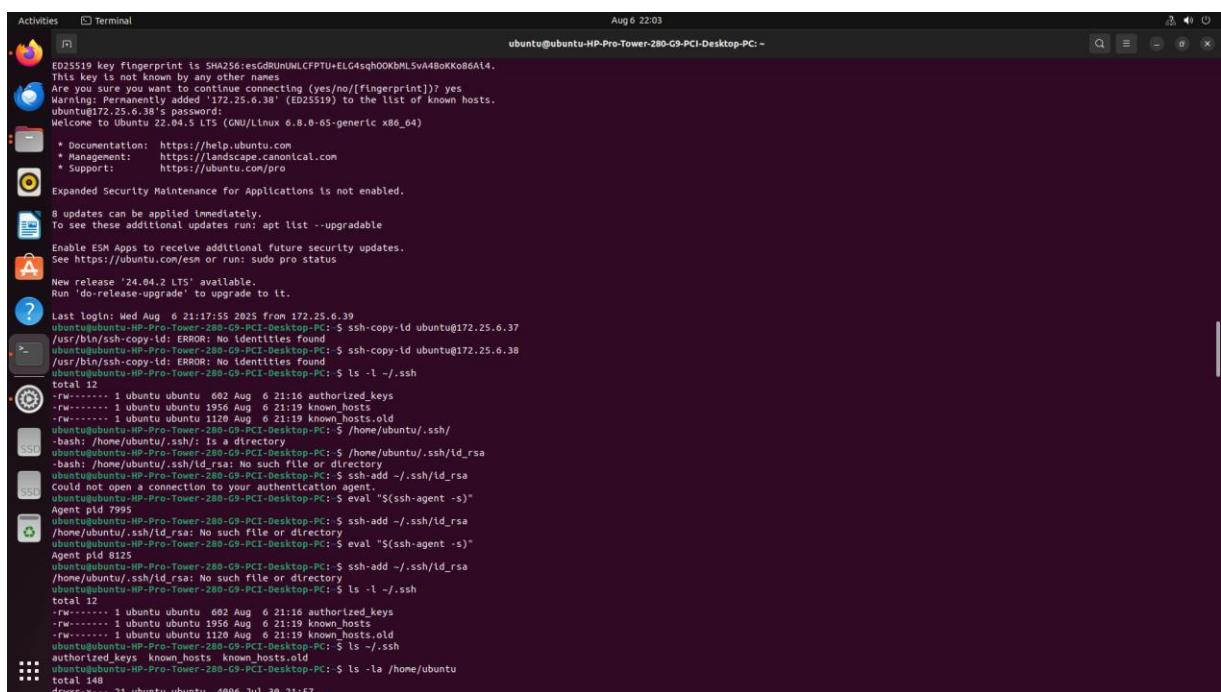
 * Documentation: https://help.ubuntu.com

```

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:esGdRUnUMLCFPTU+ELG4sqh0OKbML5vA4BokKo86Al4.
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'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

  A 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 identity 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 identity found
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ls -l ~/.ssh
total 12
-rw----- 1 ubuntu ubuntu 602 Aug 6 21:16 authorized_keys
-rw----- 1 ubuntu ubuntu 1956 Aug 6 21:16 known_hosts
-rw----- 1 ubuntu ubuntu 1128 Aug 6 21:16 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 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----- 1 ubuntu ubuntu 602 Aug 6 21:16 authorized_keys
-rw----- 1 ubuntu ubuntu 1956 Aug 6 21:19 known_hosts
-rw----- 1 ubuntu ubuntu 1128 Aug 6 21:19 known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ls -./ssh
authorized_keys known_hosts known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ls -la /home/ubuntu
total 146
drwxr-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
```

```
Activities Terminal Aug 6 22:03
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~ ls -la /home/ubuntu
total 148
drwxr-x-- 21 ubuntu ubuntu 4096 Jul 30 21:57 .
drwxr-x-- 3 root root 4096 Jul 12 14:29 ..
-rw-rw-f-- 1 ubuntu ubuntu 36657 Jul 30 21:57 .3_pc*
-rw-r--r-- 1 ubuntu ubuntu 857 Jul 12 14:29 .bash_history
-rw-r--r-- 1 ubuntu ubuntu 378 Jul 12 14:29 .bash_logout
-rw-r--r-- 1 ubuntu ubuntu 3771 Jul 12 14:29 .bashrc
drwxrwxr-x 8 ubuntu ubuntu 4096 Jul 13 01:22 .SSH
drwxr-x-- 16 ubuntu ubuntu 4096 Aug 6 21:16 .cache
drwxr-x-- 18 ubuntu ubuntu 4096 Aug 6 21:16 .config
drwxr-x-- 21 ubuntu ubuntu 4096 Jul 30 21:57 .dropbox
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:06 Documents
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:02 Downloads
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:12 .fontconfig
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 13 00:59 .gnome
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:03 .lessht
drwxr-x-- 3 ubuntu ubuntu 4096 Jul 12 20:02 .local
-rw-rw-r-- 1 ubuntu ubuntu 6 Jul 17 01:43 .mergeSort.c
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:02 Music
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 27 02:37 MyFolder
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:02 Pictures
drwxr-x-- 3 ubuntu ubuntu 4096 Jul 23 21:13 Pictures
-rw-r--r-- 1 ubuntu ubuntu 807 Jul 12 14:29 .profile
drwxr-x-- 2 ubuntu ubuntu 4096 Jul 12 20:02 Public
drwxr-x-- 5 ubuntu ubuntu 4096 Jul 13 00:55 snap
drwxr-x-- 2 ubuntu ubuntu 4096 Aug 6 21:16 .snap
-rw-r--r-- 1 ubuntu ubuntu 692 Aug 6 21:16 authorized_keys
-rw-r--r-- 1 ubuntu ubuntu 1956 Aug 6 21:19 known_hosts
-rw-r--r-- 1 ubuntu ubuntu 1120 Aug 6 21:19 known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-keygen -t rsa -b 3072
Generating public/private rsa key pair.
Enter file in which to save the key (/home/ubuntu/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter empty passphrase:
Your identification has been saved in /home/ubuntu/.ssh/id_rsa
Your public key has been saved in /home/ubuntu/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:akE=sn0tyTX95R1v0Fxl01qRsPE5PN/vad0nh4rC7Q ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC
The key's randomart image is:
+---[RSA 3072]---
|          *+.
|         .o+.
|        . o+o.
|       . o .oo.
|      o   o .oo.
|     . + 5. + ..|
```

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
```

```
Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~ ls -la ~/.ssh
total 28
drwxr----- 2 ubuntu ubuntu 4096 Aug 6 21:44 .
drwxr-x-- 21 ubuntu ubuntu 4096 Jul 30 21:57 ..
-rw-r--r-- 1 ubuntu ubuntu 689 Aug 6 21:44 authorized_keys
-rw-r--r-- 1 ubuntu ubuntu 1120 Aug 6 21:44 id_rsa
-rw-r--r-- 1 ubuntu ubuntu 692 Aug 6 21:44 id_rsa.pub
-rw-r--r-- 1 ubuntu ubuntu 1956 Aug 6 21:19 known_hosts
-rw-r--r-- 1 ubuntu ubuntu 1120 Aug 6 21:19 known_hosts.old
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ eval `ssh-agent -s`
Agent pid 3868
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-add - /ssh/id_rsa
Identity added: /home/ubuntu/.ssh/id_rsa (ubuntu@172.25.6.37)
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: $ ssh-copy-id ubuntu@172.25.6.37
/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-copy-id ubuntu@172.25.6.38
Warning: Identity file /home/ubuntu/.ssh/id_rsa (for user ubuntu@172.25.6.38 (172.25.6.38)) can't be established.
ED25519 key fingerprint is SHA256:iesGdRUnUMLCPFTUfL0L4sqh0OKmHLSv44okK0m0A14.
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@172.25.6.38'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 ubuntu@172.25.6.37
Welcome to Ubuntu 22.04.2 LTS (GNU/Linux 6.8.0-6-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 'fwupdmgmt get-upgrades' for more information.

* Introducing Expanded Security Maintenance for Applications.
```

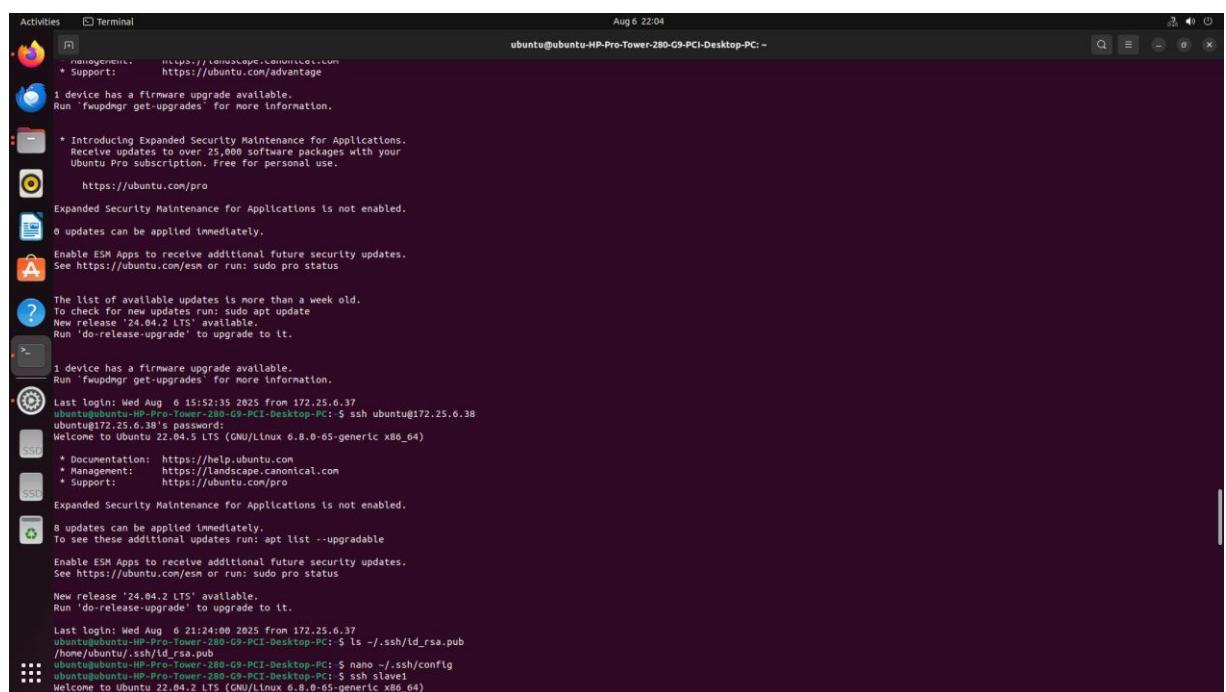
Step 8: Additional Verification + View Config Paths

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 screenshot of a Linux desktop environment showing a terminal window titled "Terminal". The terminal output is as follows:

```
Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~

noimage[1]: https://coinscope.com/microlot
Support: https://ubuntu.com/advantage

1 device has a firmware upgrade available.
Run fwupdmgr 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

A ? 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 fwupdmgr get-upgrades for more information.

>Last login: Wed Aug  6 15:53:35 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

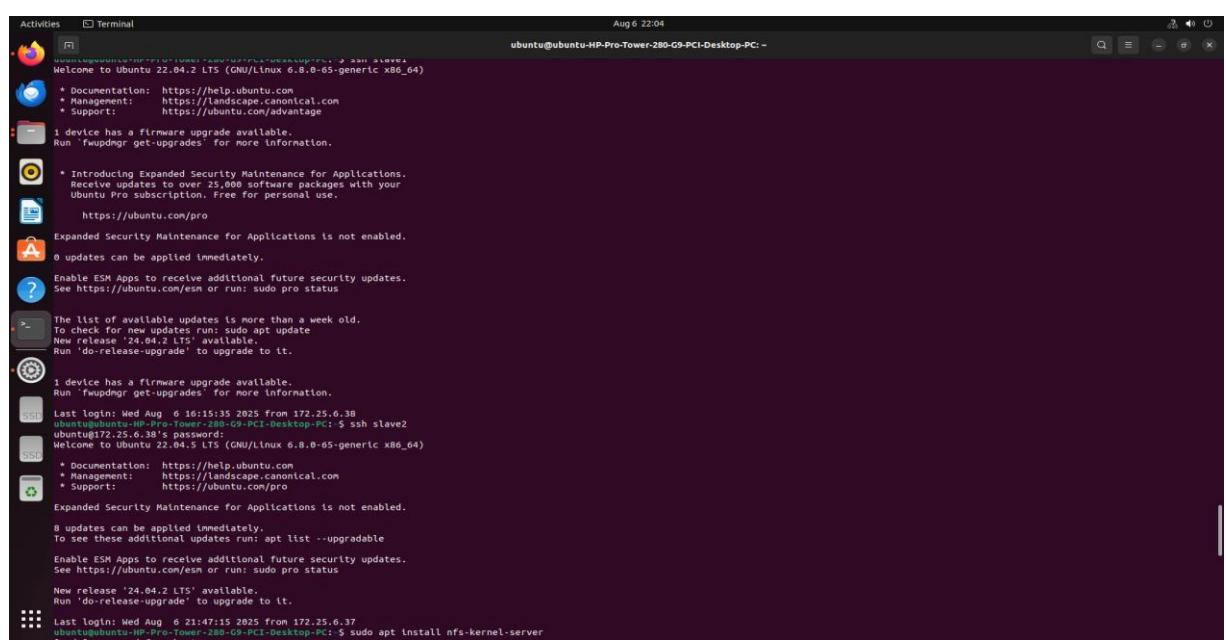
New release '24.04.2 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Wed Aug  6 21:24:00 2025 from 172.25.6.37
/home/ubuntu/.ssh/id_rsa.pub
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
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 screenshot of a Linux desktop environment showing a terminal window titled "Terminal". The terminal output is as follows:

```
Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~

noimage[1]: https://coinscope.com/microlot
Support: https://ubuntu.com/advantage

1 device has a firmware upgrade available.
Run fwupdmgr 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

A ? 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 fwupdmgr 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
```

```

Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
Loa...
Last logins: Mon Aug  6 22:04 2023 from 192.168.1.103
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 libnfsidmap nfs-common rpcbind
Suggested packages:
  open-isclt watchdog
The following previously unselected packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap nfs-common nfs-kernel-server rpcbind
0 upgraded, 6 newly installed, 0 to remove and 0 not upgraded.
Need to get 616 kB of archives.
After this operation, 1,270 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://in.archive.ubuntu.com/ubuntu jammy/main amd64 libevent-core-2.1-7 amd64 2.1.12-stable-1build3 [93.9 kB]
Get:2 http://in.archive.ubuntu.com/ubuntu jammy/main amd64 libevent-core-2.1-7 libnfsidmap1 amd64 [122.4 kB]
Get:3 http://in.archive.ubuntu.com/ubuntu jammy/main amd64 libevent-core-2.1-7 libnfsidmap1_1.6.1-1ubuntu1.2 [59.4 kB]
Get:4 http://in.archive.ubuntu.com/ubuntu jammy/main amd64 keyutils amd64 1.6.1-2ubuntu3 [59.4 kB]
Get:5 http://in.archive.ubuntu.com/ubuntu jammy-updates/main amd64 nfs-common amd64 4.1.2.6.1-1ubuntu1.2 [241 kB]
Get:6 http://in.archive.ubuntu.com/ubuntu jammy-updates/main amd64 nfs-kernel-server amd64 1:2.6.1-1ubuntu1.2 [140 kB]
Get:7 http://in.archive.ubuntu.com/ubuntu jammy-updates/main amd64 rpcbind amd64 1:2.6.2-2ubuntu1 [27.6 kB]
Selecting previously unselected package libevent-core-2.1-7:amd64.
(Reading database... 214908 files and directories currently installed.)
Preparing to unpack .../libevent-core-2.1-7:amd64_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 .../libnfsidmap1_1.6.1-1ubuntu1.2_amd64.deb ...
Unpacking libnfsidmap1:amd64 (1.6.1-1ubuntu1.2) ...
Selecting previously unselected package rpcbind.
Preparing to unpack .../rpcbind_1.2.6-2ubuntu1_amd64.deb ...
Unpacking rpcbind (1.2.6-2ubuntu1) ...
Selecting previously unselected package keyutils.
Preparing to unpack .../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_1:32.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-common (1:32.6.1-1ubuntu1.2) ...
Selecting previously unselected package nfs-kernel-server.
Preparing to unpack .../5-nfs-kernel-server_1:32.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-kernel-server (1:32.6.1-1ubuntu1.2) ...
Setting up libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
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 (1:32.6.1-1ubuntu1.2) ...
Setting up nfs-kernel-server (1:32.6.1-1ubuntu1.2) ...
Creating config file /etc/ldmap.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.

```

Activities Terminal Aug 6 22:04
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC: ~
Selecting previously unselected package rpcbind.
Preparing to unpack .../2-rpcbind_1.2.6-2ubuntu1_amd64.deb ...
Unpacking rpcbind (1.2.6-2ubuntu1) ...
Selecting previously unselected package keyutils.
Preparing to unpack .../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_1:32.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-common (1:32.6.1-1ubuntu1.2) ...
Selecting previously unselected package nfs-kernel-server.
Preparing to unpack .../5-nfs-kernel-server_1:32.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-kernel-server (1:32.6.1-1ubuntu1.2) ...
Setting up libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
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 (1:32.6.1-1ubuntu1.2) ...
Setting up nfs-kernel-server (1:32.6.1-1ubuntu1.2) ...
Creating config file /etc/ldmap.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/sockets.target.wants/nfs-client.target → /lib/systemd/system/nfs-client.target.
nfs-tmdapd.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-n怠务er.service is a disabled or a static unit, not starting it.
rpcbind.service is a disabled or a static unit, not starting it.
rpc-statd-notify.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-svcsd.service is a disabled or a static unit, not starting it.
rpc-statd-notify.service is a disabled or a static unit, not starting it.
var-lib-nfs-rpc-pipes.mount is a disabled or a static unit, not starting it.
Setting up nfs-kernel-server (1:32.6.1-1ubuntu1.2) ...
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-mountservice is a disabled or a static unit, not starting it.
nfsdcd.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 liblbc-bl (2.35-0ubuntu3.10) ...
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 -r
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
[...]
Hit:1 http://in.archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:3 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Get:4 http://in.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [2,802 kB]
Get:5 http://in.archive.ubuntu.com/ubuntu jammy-updates/main i386 Packages [853 kB]
Get:6 http://in.archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [443 kB]
Get:7 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 DEP-11 Metadata [112 kB]
Get:8 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 DEP-11 Metadata [212 kB]
Get:9 http://archive.ubuntu.com/ubuntu jammy-updates/restricted i386 DEP-11 Metadata [781 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:11 http://in.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1,226 kB]
Get:12 http://in.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 DEP-11 Metadata [359 kB]
Get:13 http://in.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 DEP-11 Metadata [940 kB]
Get:14 http://in.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 DEP-11 Metadata [290 kB]
Get:15 http://in.archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 DEP-11 Metadata [212 kB]
Get:16 http://in.archive.ubuntu.com/ubuntu jammy-backports/universe amd64 DEP-11 Metadata [14,0 kB]
Get:17 http://in.archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 DEP-11 Metadata [212 kB]
Get:18 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [2,524 kB]
Get:19 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [379 kB]
Get:20 http://security.ubuntu.com/ubuntu jammy-security/main amd64 DEP-11 Metadata [54,6 kB]
Get:21 http://security.ubuntu.com/ubuntu jammy-security/main amd64 DEP-11 Metadata [4,013 kB]
Get:22 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [722 kB]
Get:23 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 DEP-11 Metadata [172 kB]
Get:24 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 DEP-11 Metadata [208 kB]
Get:25 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [993 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 kB]
Fetched 17.2 MB in 31s (562 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
1:2.6.0-0ubuntu12.1 can be upgraded. Use '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 (1:8.9p1-3ubuntu9.13).
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
ubuntu@ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC:~$ lp a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback brd 00:00:00:00:00:00 state UNKNOWN group default qlen 1000
        valid_lft forever preferred_lft forever
    inet 127.0.0.1/8 brd 0.0.0.0 scope host
        valid_lft forever preferred_lft forever
        inet6 fe80::1%lo brd fe80::ff:ff%lo scope link
            valid_lft forever preferred_lft forever
2: enp0s25: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 7c:57:58:37:29:92 brd ff:ff:ff:ff:ff:ff
        inet 172.25.6.38/16 brd 172.25.255.255 scope global noprefixroute enp0s25
            valid_lft forever preferred_lft forever
        inet6 fe80::1bfe:7f4d:8e51:4654%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 - OpenBSD 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; 4min 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 OpenBSD Secure Shell server...
Aug 06 20:27:31 ubuntu-HP-Pro-Tower-280-G9-PCI-Desktop-PC systemd[1]: Started OpenBSD 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.

```
root@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
```