Pemrosesan Paralel

MPI

Disusun Oleh :

Kelompok 3

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Universitas Sriwijaya

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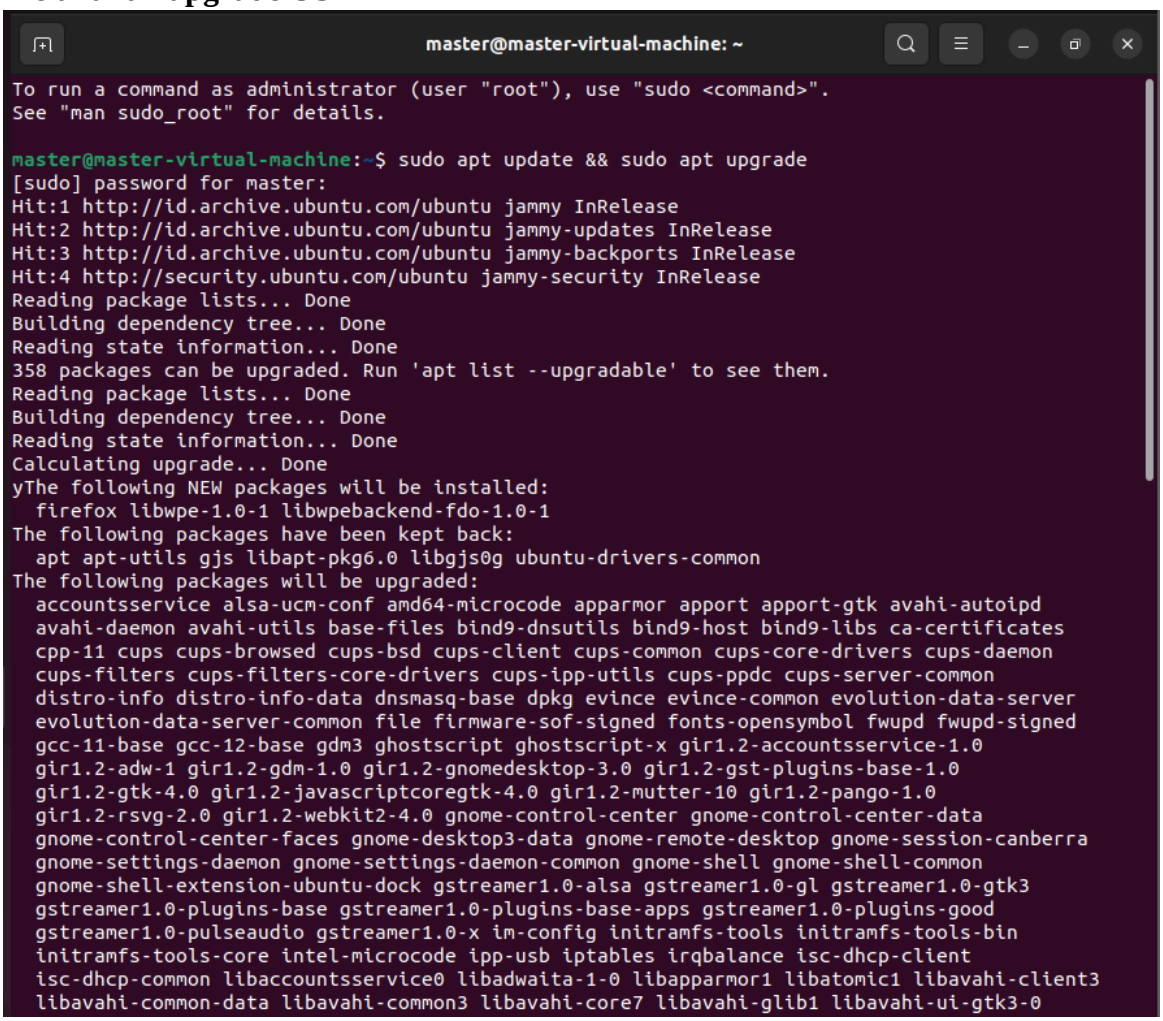
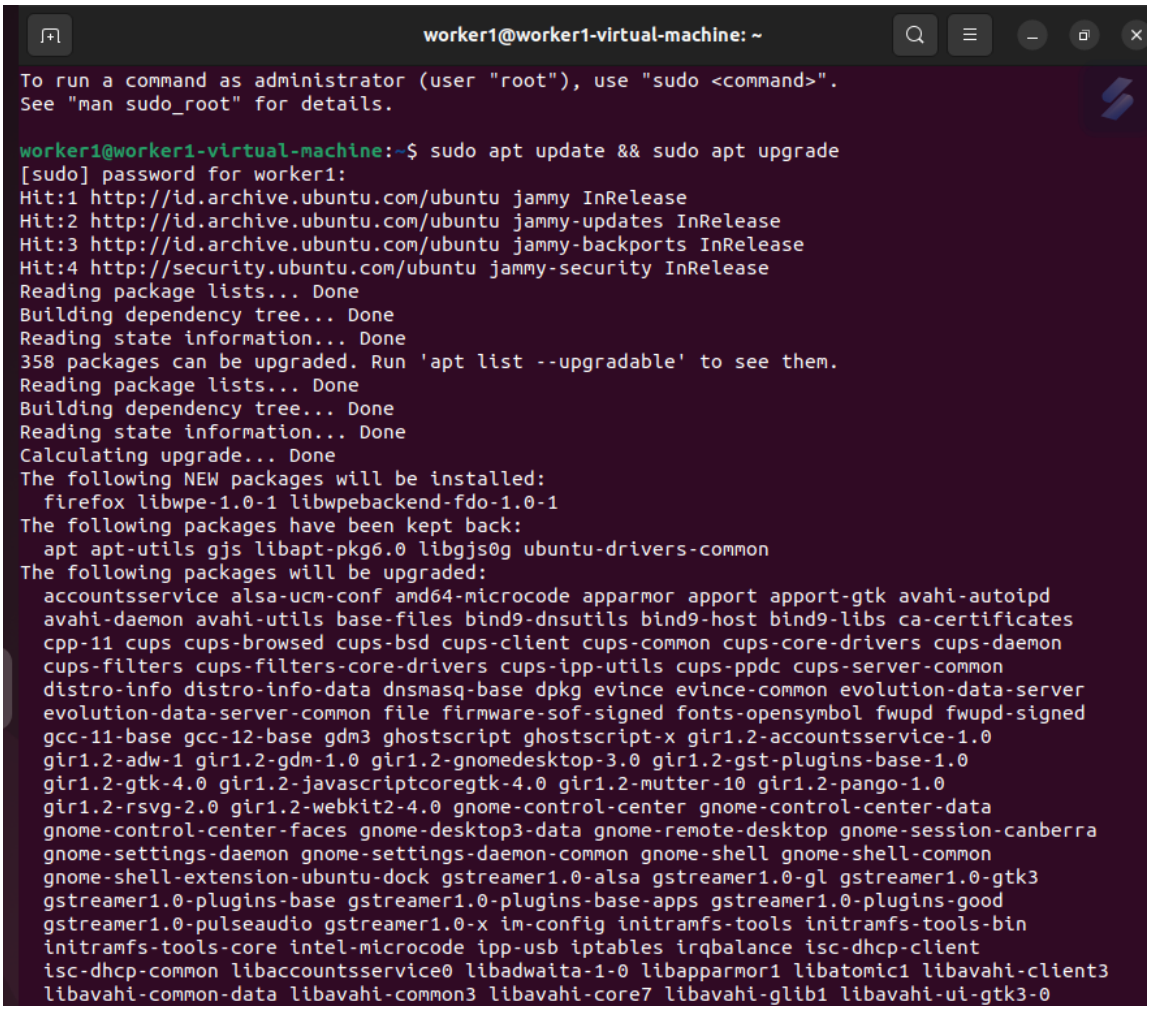
MPI-Bubblesort da menggunakan Python

Menyiapkan Ubuntu Server

1. **Pastikan sudah dalam satu jaringan yang sama untu setiap (Master , Worker, Worker1 dan Worker2)**
2. **Melakukan upgrade OS**





3. **Melakukan penginstalan berikut: net-tools untuk memeriksa IP, vim untuk editor teks.**

```
master@master-virtual-machine:~$ sudo apt install net-tools vim
[sudo] password for master:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  vim-runtime
Suggested packages:
  ctags vim-doc vim-scripts
The following NEW packages will be installed:
  net-tools vim vim-runtime
0 upgraded, 3 newly installed, 0 to remove and 6 not upgraded.
Need to get 8.773 kB of archives.
After this operation, 38,4 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

```
worker1@worker1-virtual-machine:~$ sudo apt install net-tools vim
[sudo] password for worker1:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  vim-runtime
Suggested packages:
  ctags vim-doc vim-scripts
The following NEW packages will be installed:
  net-tools vim vim-runtime
0 upgraded, 3 newly installed, 0 to remove and 6 not upgraded.
Need to get 8.773 kB of archives.
After this operation, 38,4 MB of additional disk space will be used.
Do you want to continue? [Y/n]
```

4. **Melakukan pengecekan IP dengan perintah berikut:**

```
master@master-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.1.24  netmask 255.255.255.0  broadcast 192.168.1.255
        inet6 fe80::ae78:10d2:f069:9498  prefixlen 64  scopeid 0x20<link>
        ether 00:0c:29:8b:d6:06  txqueuelen 1000  (Ethernet)
        RX packets 28588  bytes 42029400 (42.0 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 20746  bytes 1604428 (1.6 MB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

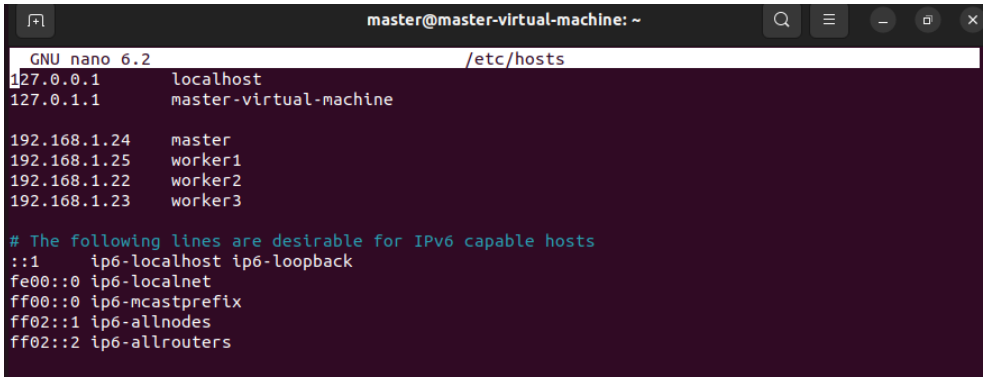
```
worker1@worker1-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.1.25  netmask 255.255.255.0  broadcast 192.168.1.255
        inet6 fe80::80b0:bfe9:6f07:f13  prefixlen 64  scopeid 0x20<link>
        ether 00:0c:29:d2:b5:e2  txqueuelen 1000  (Ethernet)
        RX packets 27877  bytes 41019562 (41.0 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 20116  bytes 1567869 (1.5 MB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

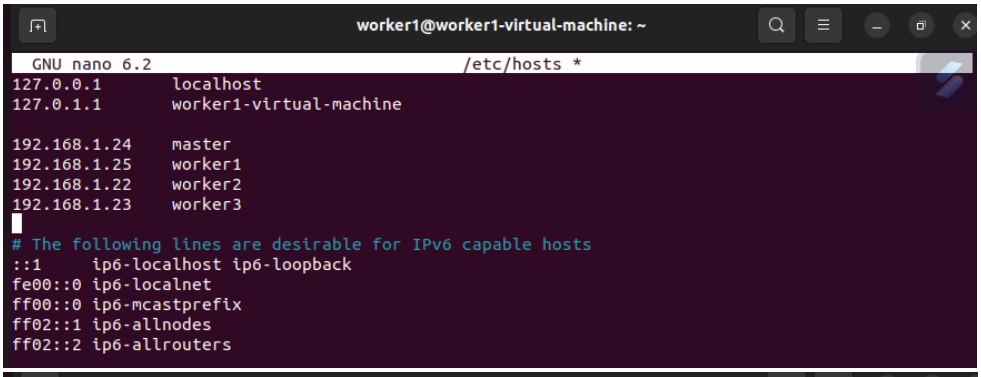
```
worker2@worker2-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.1.22  netmask 255.255.255.0  broadcast 192.168.1.255
        inet6 fe80::e5de:ad76:1431:3d3  prefixlen 64  scopeid 0x20<link>
        ether 00:0c:29:6f:d4:7d  txqueuelen 1000  (Ethernet)
        RX packets 7521  bytes 10697630 (10.6 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 5533  bytes 487832 (487.8 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

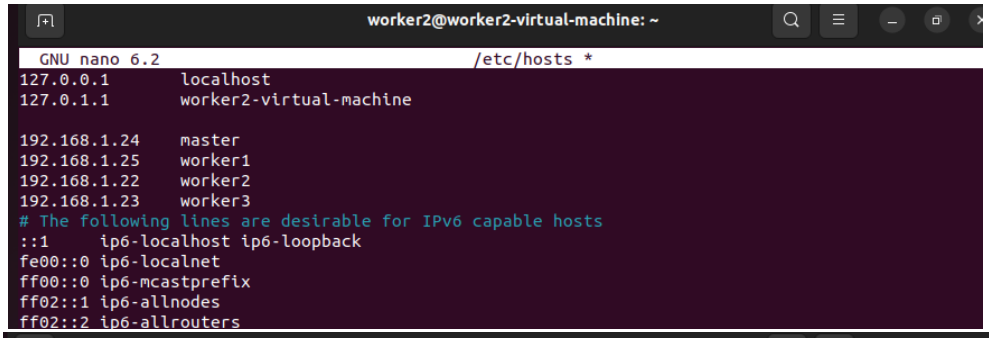
```
worker3@worker3-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.1.23  netmask 255.255.255.0  broadcast 192.168.1.255
        inet6 fe80::e363:cf50:bc75:7a0d  prefixlen 64  scopeid 0x20<link>
        ether 00:0c:29:9a:6a:3a  txqueuelen 1000  (Ethernet)
        RX packets 7511  bytes 10700529 (10.7 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 5599  bytes 490699 (490.6 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

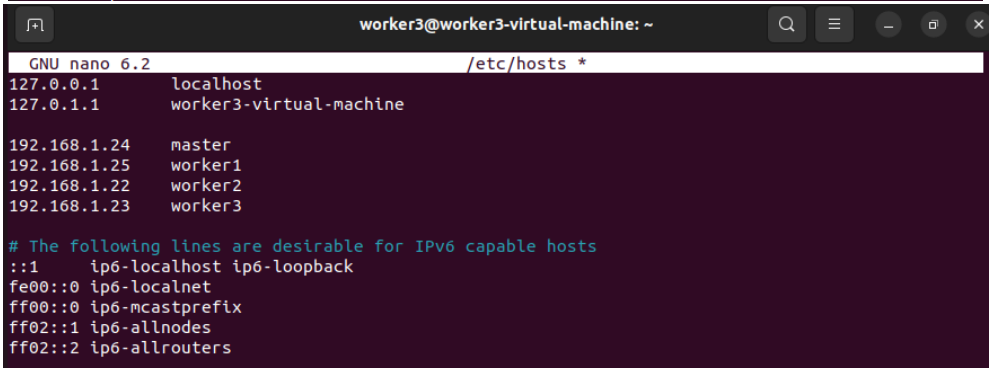
Membuat Klaster MPI

1. **Konfigurasi file host /etc/hosts**
2.





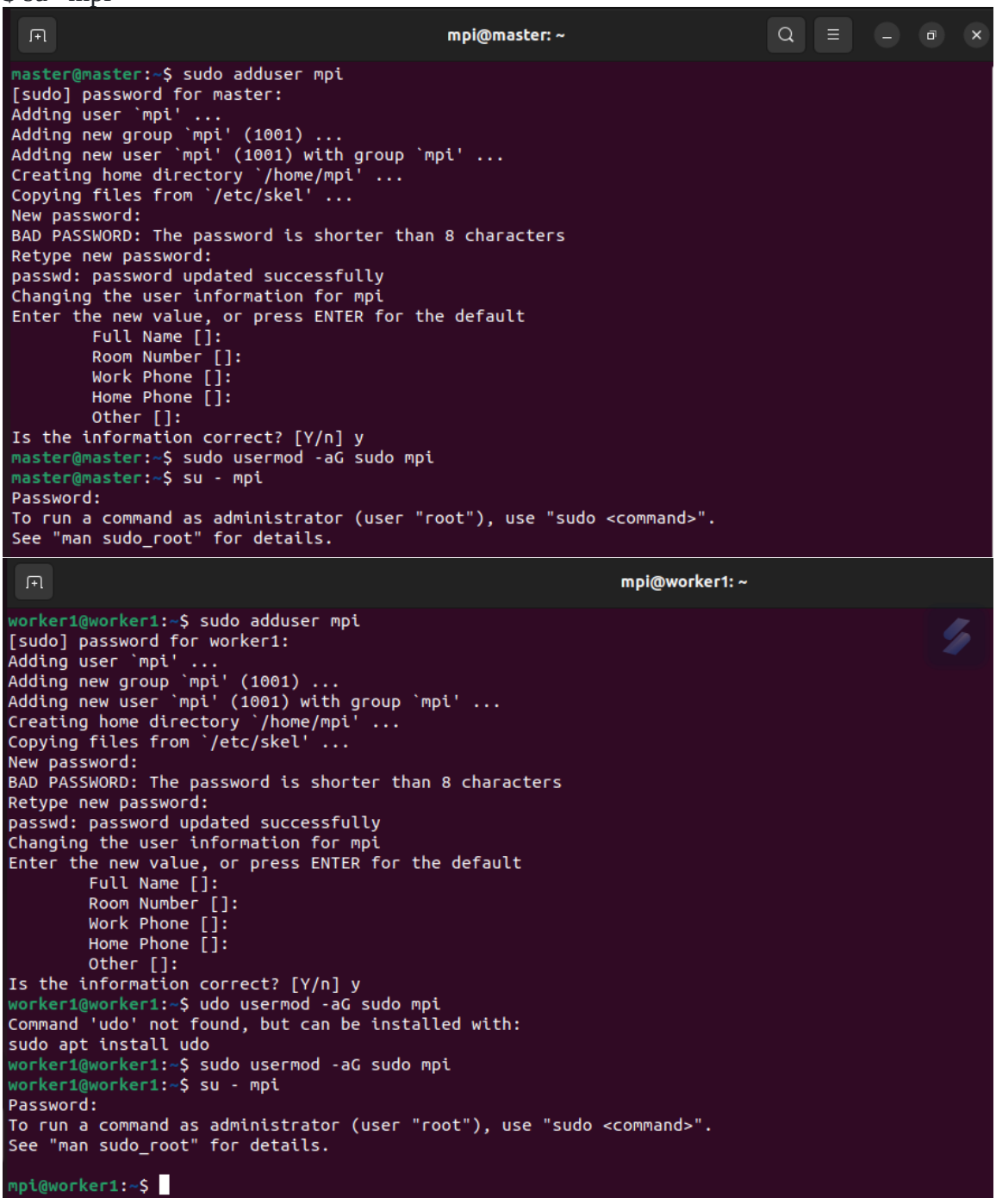


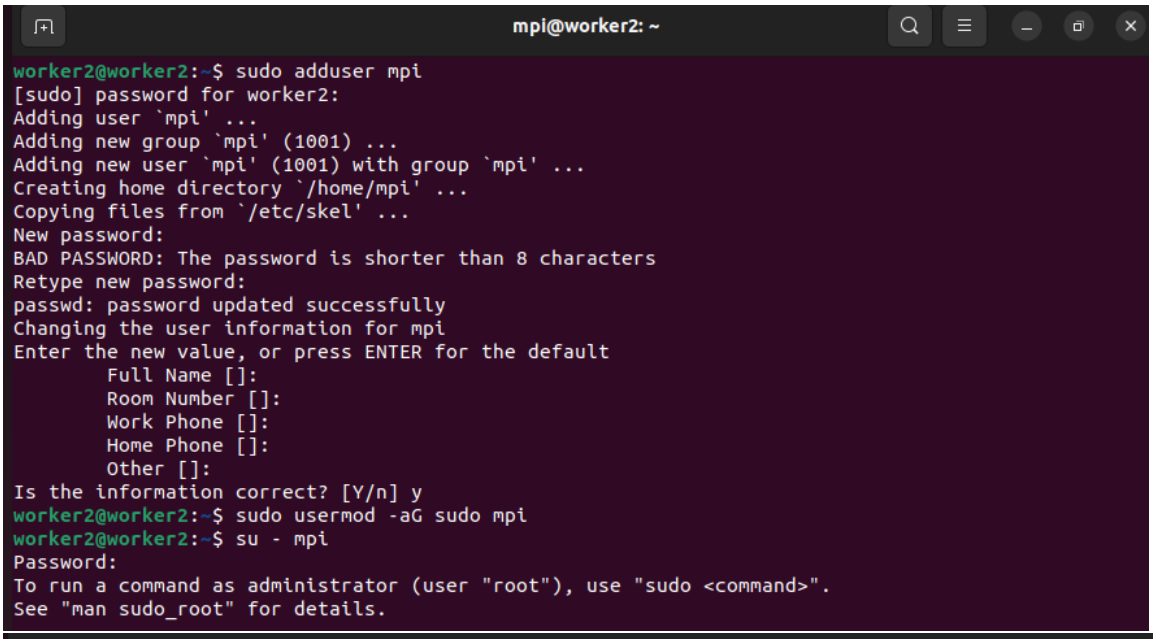


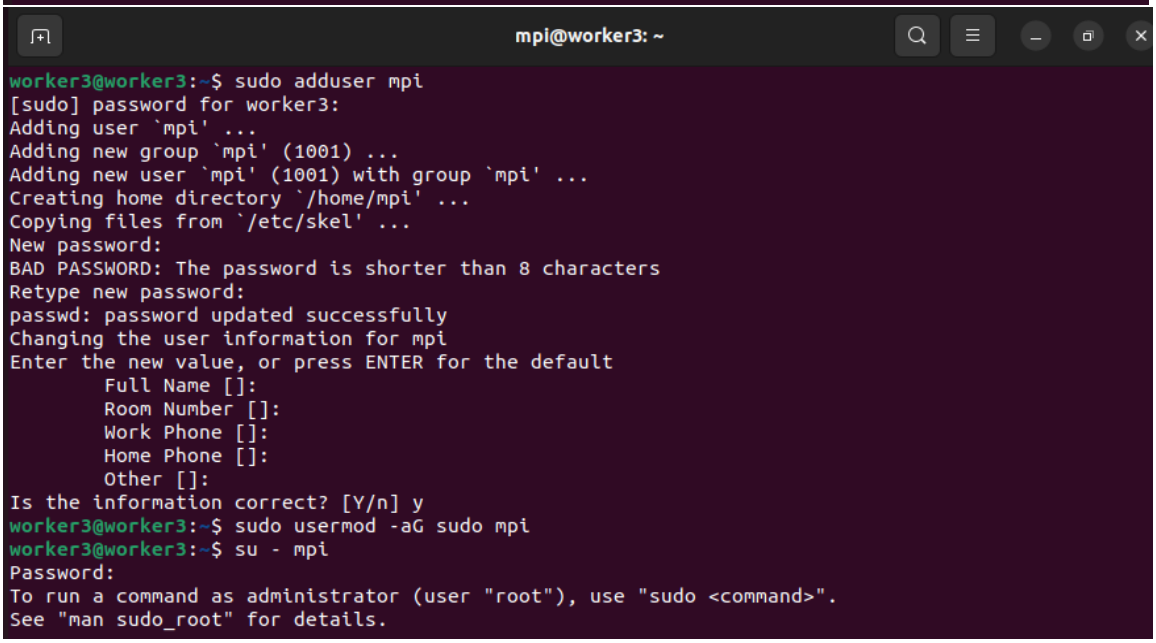
3. Membuat Pengguna Baru

Buat user baru di SERVER dan CLIENT. Nama user harus samo semua di seluruh komputer.

$ sudo adduser
$ sudo usermod -aG sudo
$ su –mpi




mpi@worker2: ~
worker2@worker2:~$ sudo adduser mpi
[sudo] password for worker2:
Adding user `mpi' ...
Adding new group `mpi' (1001) ...
Adding new user `mpi' (1001) with group `mpi' ...
Creating home directory `/home/mpi' ...
Copying files from `/etc/skel' ...
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: password updated successfully
Changing the user information for mpi
Enter the new value, or press ENTER for the default
Full Name []:
Room Number []:
Work Phone []:
Home Phone []:
Other []:
Is the information correct? [Y/n] y
worker2@worker2:~$ sudo usermod -aG sudo mpi
worker2@worker2:~$ su - mpi
Password:
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.


mpi@worker3: ~
worker3@worker3:~$ sudo adduser mpi
[sudo] password for worker3:
Adding user `mpi' ...
Adding new group `mpi' (1001) ...
Adding new user `mpi' (1001) with group `mpi' ...
Creating home directory `/home/mpi' ...
Copying files from `/etc/skel' ...
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: password updated successfully
Changing the user information for mpi
Enter the new value, or press ENTER for the default
Full Name []:
Room Number []:
Work Phone []:
Home Phone []:
Other []:
Is the information correct? [Y/n] y
worker3@worker3:~$ sudo usermod -aG sudo mpi
worker3@worker3:~$ su - mpi
Password:
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

4. Konfigurasi SSH

Setelah membuat dan masuk ke user, lakukan konfigurasi SSH.

1. Install SSH

$ sudo apt install openssh-server

```
mpi@master:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
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-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

```
mpi@worker1:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
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-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

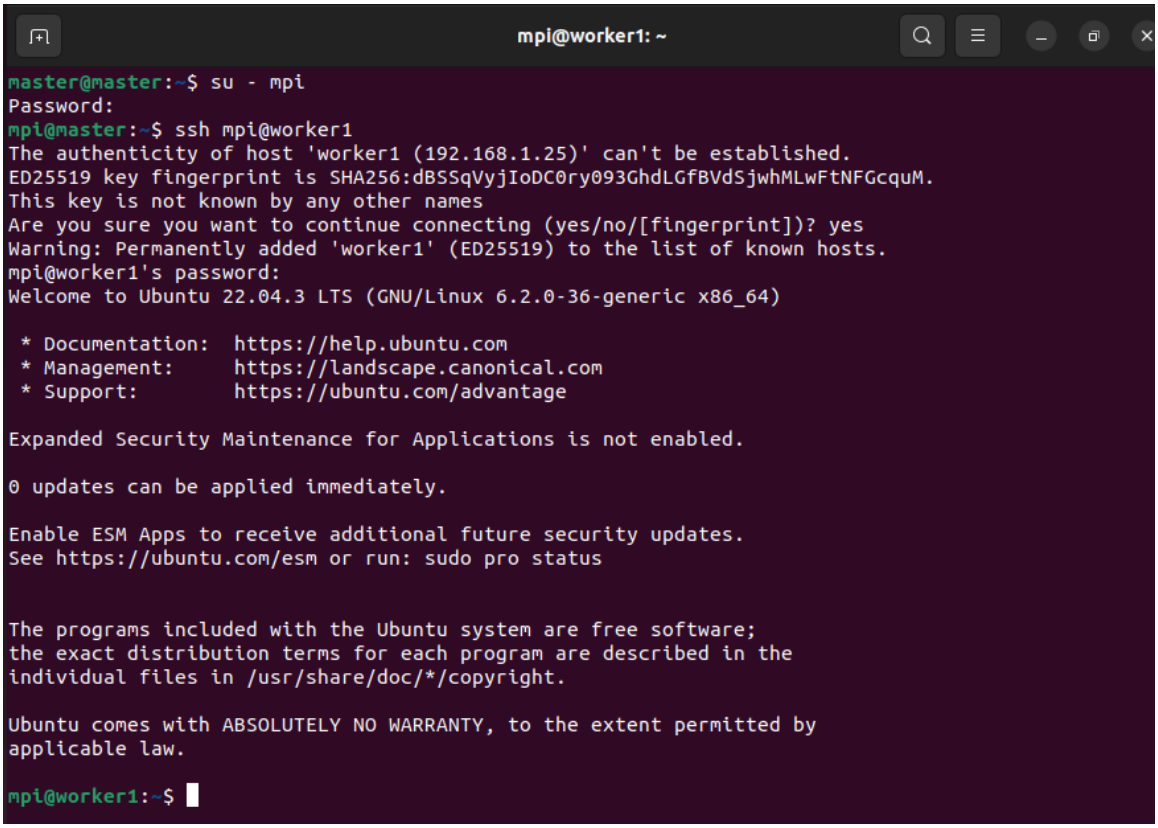
```
mpi@worker2:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
Suggested packages:
  molly-guard monkeysphere ssh-askpass
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

```
mpi@worker3:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
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-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

2. Melakukan pengecekan SSH

   $ ssh @

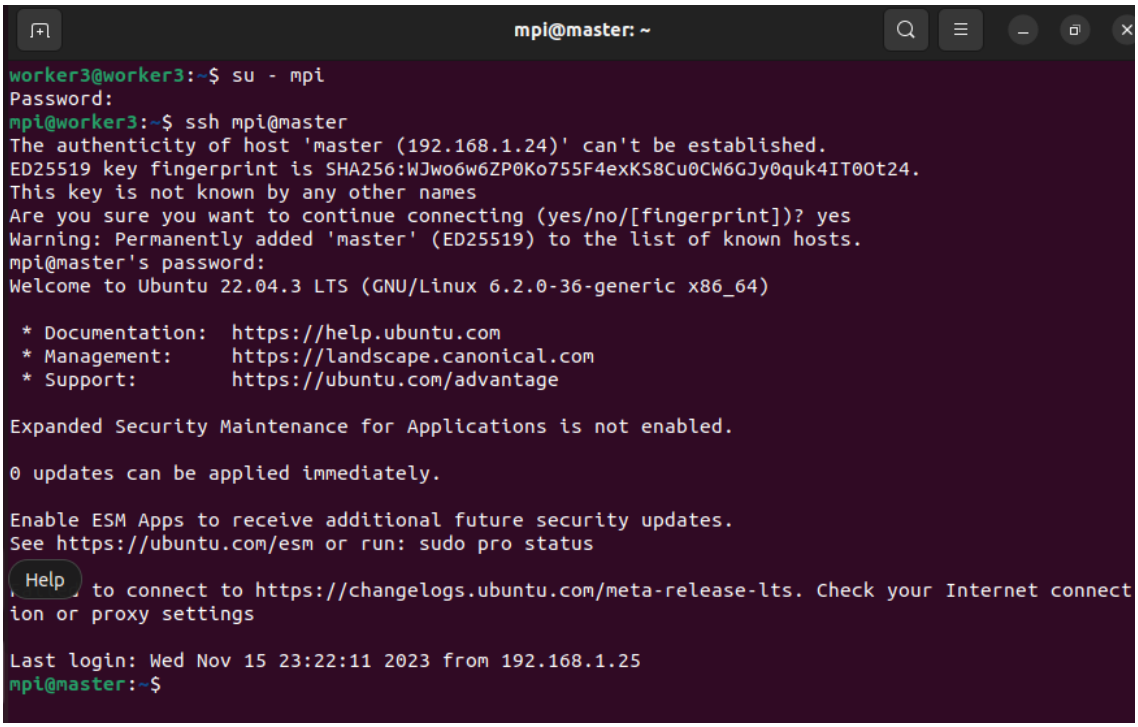
- SSH dari Master ke Worker



```
mpi@master:~$ ssh mpi@worker2
The authenticity of host 'worker2 (192.168.1.22)' can't be established.
ED25519 key fingerprint is SHA256:GO/w0I3TnU7k77dxwfYqRmxRFB6AFOZgWolamltNbCw.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker2' (ED25519) to the list of known hosts.
mpi@worker2's password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.2.0-36-generic x86_64)

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

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 programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.
```

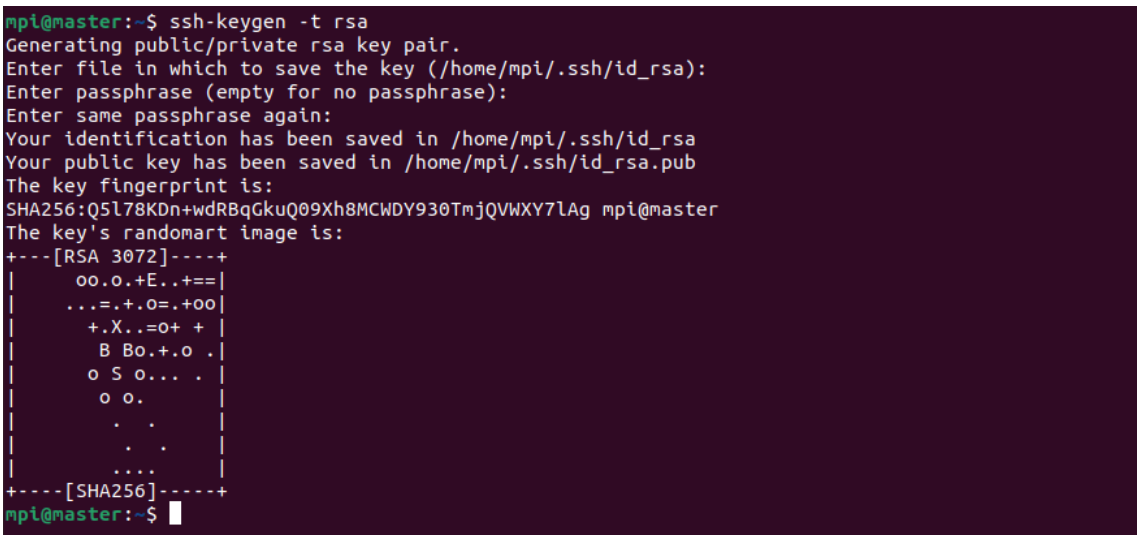
- SSH dari Worker ke Master

```
mpi@master: ~
worker2@worker2:~$ su - mpi
Password:
mpi@worker2:~$ ssh mpi@master
The authenticity of host 'master (192.168.1.24)' can't be established.
ED25519 key fingerprint is SHA256:WJwo6w6ZP0Ko755F4exKS8Cu0CW6GJy0quk4IT0Ot24.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'master' (ED25519) to the list of known hosts.
mpi@master's password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.2.0-36-generic x86_64)

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

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

Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your Internet connect
ion or proxy settings

Last login: Wed Nov 15 23:25:26 2023 from 192.168.1.23
mpi@master:~$
```



3. Generate Keygen Lakukan di SERVER

   $ ssh-keygen -t rsa



4. Copy key publik ke client

   $ cd .ssh

   $ cat id_rsa.pub | ssh @ "mkdir .ssh; cat >> .ssh/authorized_keys"

```
mpi@master:~$ cd .ssh
mpi@master:~/.ssh$ cat id_rsa.pub | ssh mpi@worker1 "mkdir .ssh; cat >> .ssh/authorized_keys"
mpi@worker1's password:
mkdir: cannot create directory ‘.ssh’: File exists
mpi@master:~/.ssh$ cat id_rsa.pub | ssh mpi@worker2 "mkdir .ssh; cat >> .ssh/authorized_keys"
mpi@worker2's password:
mkdir: cannot create directory ‘.ssh’: File exists
mpi@master:~/.ssh$ cat id_rsa.pub | ssh mpi@worker3 "mkdir .ssh; cat >> .ssh/authorized_keys"
The authenticity of host 'worker3 (192.168.1.23)' can't be established.
ED25519 key fingerprint is SHA256:Zx3Jyr8um9uqMEm4lgQAj1zy7pvUAQY2fx0YhHsjxmM.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker3' (ED25519) to the list of known hosts.
mpi@worker3's password:
mkdir: cannot create directory ‘.ssh’: File exists
mpi@master:~/.ssh$
```

4. Konfigurasi NFS

1. Membuat shared folder

$ mkdir cloud

```
mpi@master:~$ mkdir cloud
mpi@master:~$
```

```
mpi@worker1:~$ mkdir cloud
mpi@worker1:~$
```

```
mpi@worker3:~$ mkdir cloud
mpi@worker3:~$
```

```
mpi@worker2:~$ mkdir cloud
mpi@worker2:~$
```

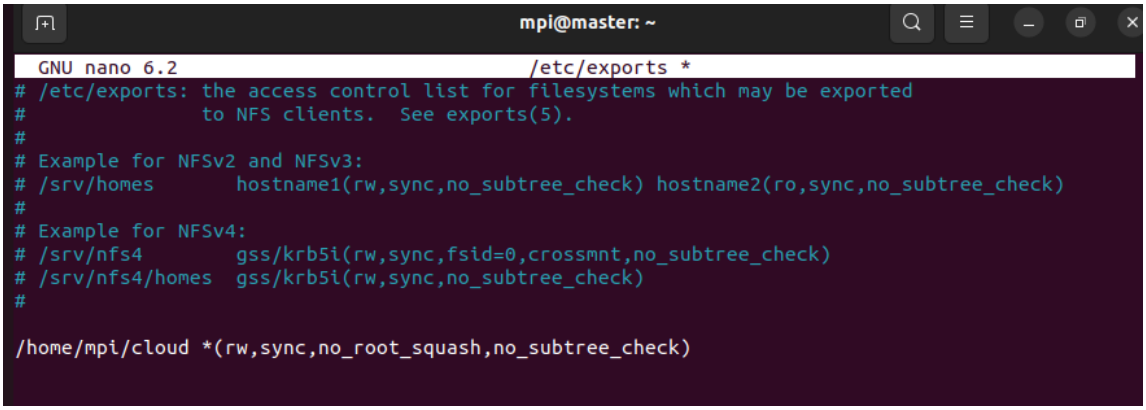
2. Install NFS Server

$ sudo apt install nfs-kernel-server

```
mpi@master:~$ sudo apt install nfs-kernel-server
[sudo] password for mpi:
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 6 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
```

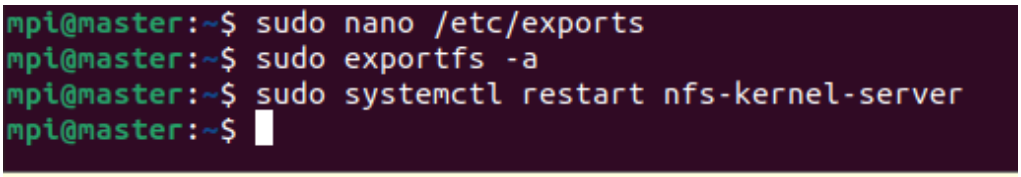
3. Konfigurasi file /etc/exports

*(rw,sync,no_root_squash,no_subtree_check)



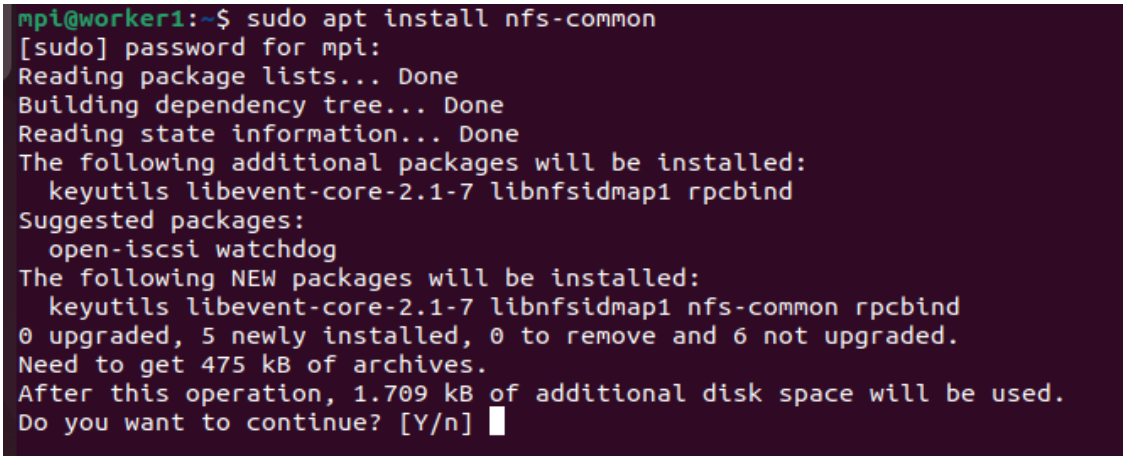
$ sudo exportfs -a

$ sudo systemctl restart nfs-kernel-server



4. Install NFS Client

   $ sudo apt install nfs-common



```
mpi@worker2:~$ sudo apt install nfs-common
[sudo] password for mpi:
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 rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common rpcbind
0 upgraded, 5 newly installed, 0 to remove and 6 not upgraded.
Need to get 475 kB of archives.
After this operation, 1.709 kB of additional disk space will be used.
Do you want to continue? [Y/n]
```

```
mpi@worker3:~$ sudo apt install nfs-common
[sudo] password for mpi:
CDROM ackage lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common rpcbind
0 upgraded, 5 newly installed, 0 to remove and 6 not upgraded.
Need to get 475 kB of archives.
After this operation, 1.709 kB of additional disk space will be used.
Do you want to continue? [Y/n]
```

5. Mounting

   $ sudo mount :

```
mpi@worker1:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@worker1:~$
```

```
mpi@worker2:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@worker2:~$
```

```
mpi@worker3:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@worker3:~$
```

5. Instalasi MPI

1. Install MPI

$ sudo apt install openmpi-bin libopenmpi-dev

```
mpi@master:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
```

```
mpi@worker1:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
Suggested packages:
```

```
mpi@worker2:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
```

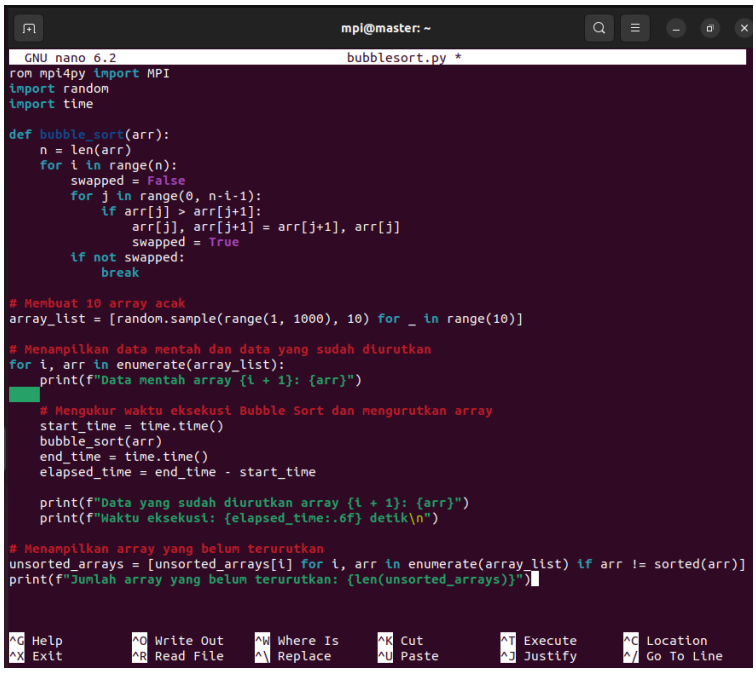
```
mpi@worker3:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
```

Menjalankan Program Bubblesort.py

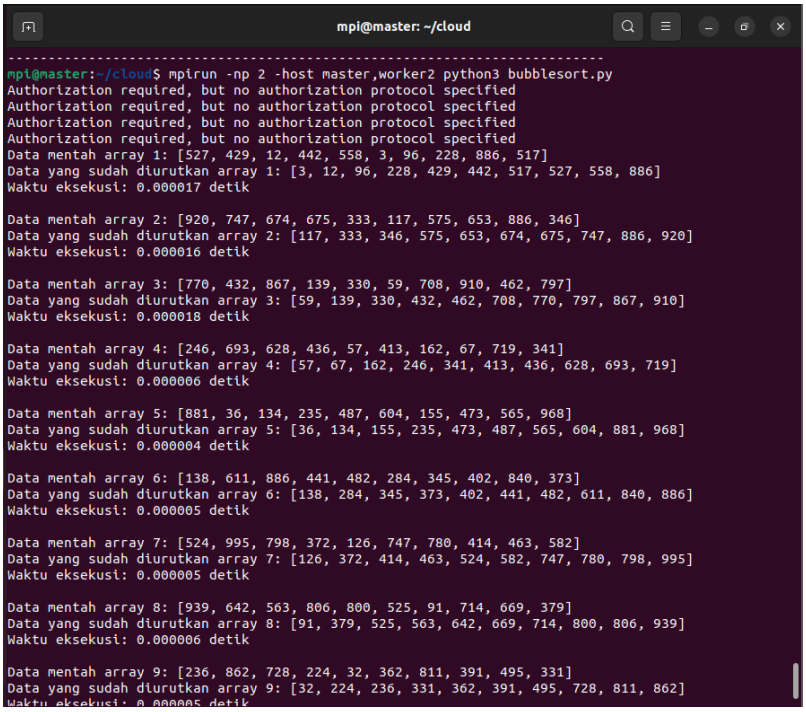
1. **Membuat Program**

   $ touch bubblesort.py

   $ sudo nano bubblesort.py



$ mpirun -np 3 -host master,worker,worker2,worker3 python3 bubblesort.py



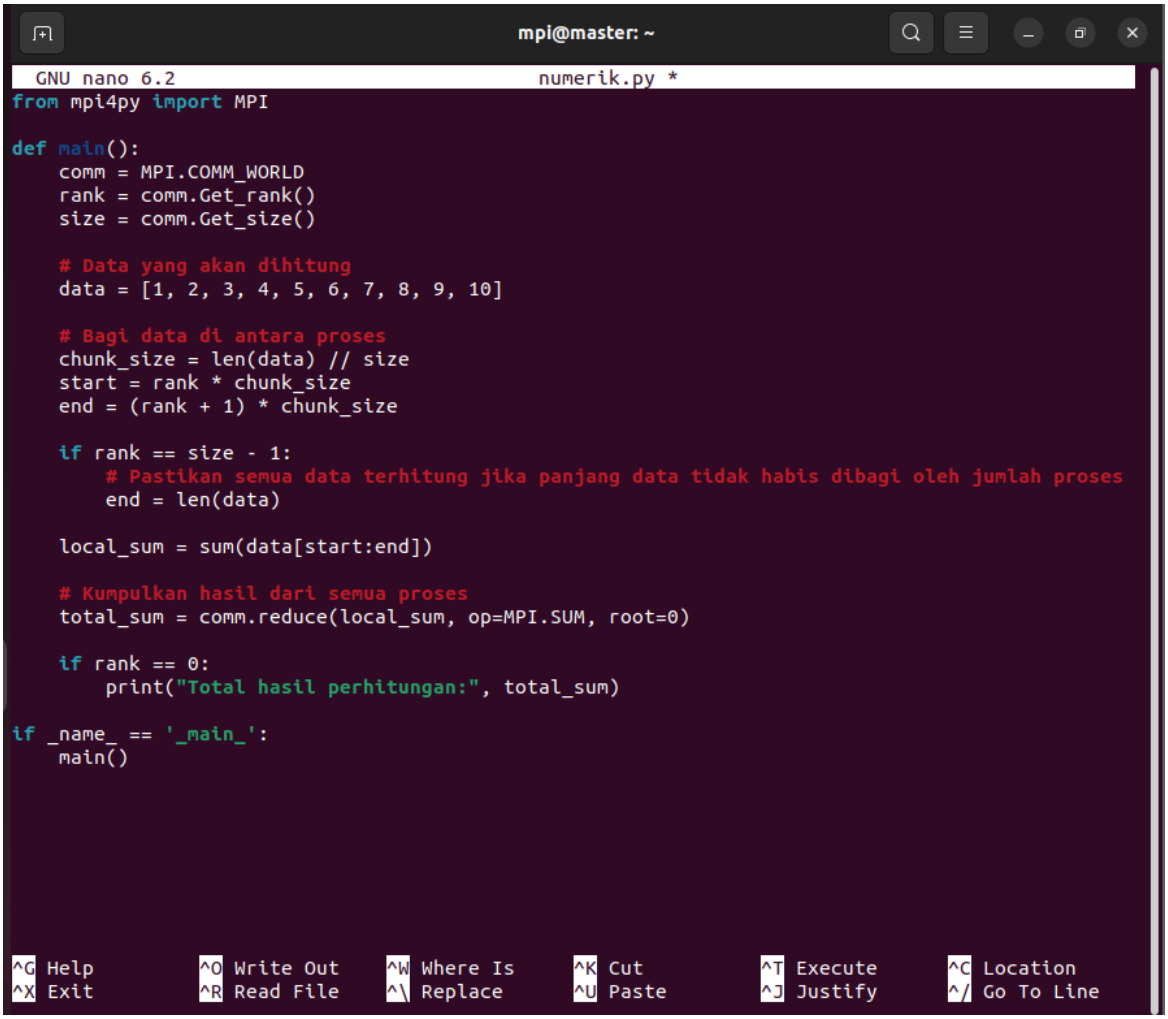
$ mpirun -np 3 -host master,worker,worker2,worker3 python3 bubblesort.py

2. Eksekusi Numerik menggunakan Python

$ touch numerik.py

$ sudo nano numerik.py

$ mpirun -np 2 -host master,worker,worker2,worker3 python3 numerik.py




```
mpi@master:~/cloud$ python3 numerik.py
Total hasil perhitungan: 55
Waktu dikerjakan: 0.0028977394104003906
mpi@master:~/cloud$ mpirun -np 1 -host master,worker1 python3 numerik.py
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Total hasil perhitungan: 55
Waktu dikerjakan: 0.0003764629364013672
mpi@master:~/cloud$
```