

PEMROSESAN PARALEL



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PROGRAM STUDI SISTEM KOMPUTER
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1.Pastikan sudah dalam satu jaringan yang sama untuk setiap (master,worker1, worker2, dan worker3)

2.Melakukan update OS

\$ sudo apt update && sudo apt upgrade

```
ririnfabriana@ririnfabriana-virtual-machine:~$ sudo apt update && sudo apt upgrade
[sudo] password for ririnfabriana:
Ign:1 http://packages.linuxmint.com vanessa InRelease
Hit:2 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:5 http://packages.linuxmint.com vanessa Release [24.1 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:7 http://packages.linuxmint.com vanessa Release.gpg [833 B]
Get:8 http://packages.linuxmint.com vanessa/main amd64 Packages [17.5 kB]
Get:9 http://packages.linuxmint.com vanessa/main i386 Packages [17.0 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [953 kB]
Get:11 http://packages.linuxmint.com vanessa/upstream amd64 Packages [44.4 kB]
Get:12 http://packages.linuxmint.com vanessa/upstream i386 Packages [12.0 kB]
Get:13 http://packages.linuxmint.com vanessa/import i386 Packages [3,216 B]
Get:14 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1,162 kB]
Get:15 http://packages.linuxmint.com vanessa/import amd64 Packages [6,265 B]
Get:16 http://archive.ubuntu.com/ubuntu jammy-updates/main i386 Packages [526 kB]
Get:17 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [247 kB]
```

worker1

```
putridanty@putridanty-VirtualBox: ~
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

putridanty@putridanty-VirtualBox:~$ sudo apt update && sudo apt upgrade
[sudo] password for putridanty:
Get:1 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy InRelease [270 kB]
Get:3 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [953 kB]
Get:4 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:5 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:6 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 Packages [1.395 kB]
Get:7 http://id.archive.ubuntu.com/ubuntu jammy/main i386 Packages [1.040 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/main i386 Packages [363 kB]
Get:9 http://id.archive.ubuntu.com/ubuntu jammy/main Translation-en [510 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [188 kB]
Get:11 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 DEP-11 Metadata [423 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/main amd64 DEP-11 Metadata [43,0 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/main DEP-11 48x48 Icons [16,9 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/main DEP-11 64x64 Icons [26,5 kB]
18% [11 Components-amd64 242 kB/423 kB 57%] [14 Icons-64x64 17,9 kB/26,5 kB 68%] 563 kB/s 1min 34s
```

worker2

```
mpi@bilasin-virtual-machine: ~  
Berkas Sunting Tampilan Cari Terminal Bantuan  
mpi@bilasin-virtual-machine:~$ sudo apt update && sudo apt upgrade  
[sudo] katasandi untuk mpi:  
Und:1 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]  
Abai:2 http://packages.linuxmint.com vanessa InRelease  
Ada:3 http://packages.linuxmint.com vanessa Release  
Ada:5 http://archive.ubuntu.com/ubuntu jammy InRelease  
Und:6 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]  
Ada:7 http://archive.ubuntu.com/ubuntu jammy-backports InRelease  
Mengambil 229 kB dalam waktu 10s (24,0 kB/s)  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done  
23 paket dapat ditingkatkan. Jalankan 'apt list --upgradable' untuk melihatnya.  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done  
Calculating upgrade... Done  
Paket BARU berikut akan diinstal:  
  linux-headers-5.15.0-89 linux-headers-5.15.0-89-generic  
  linux-image-5.15.0-89-generic linux-modules-5.15.0-89-generic  
  linux-modules-extra-5.15.0-89-generic  
Paket berikut akan dimutakhirkan:  
  apt apt-utils avahi-autoipd avahi-daemon avahi-utils firmware-sof-signed  
  glib2.0-ibrowsercoreatk-4.0 glib2.0-webkit2-4.0 intel-microcode
```

Worker3

```
viona@viona-virtual-machine:~$ sudo apt update && sudo apt upgrade  
[sudo] password for viona:  
Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease  
Hit:2 http://security.ubuntu.com/ubuntu jammy-security InRelease  
Hit:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease  
Hit:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease  
Ign:5 http://packages.linuxmint.com vanessa InRelease  
Hit:6 http://packages.linuxmint.com vanessa Release  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done  
547 packages can be upgraded. Run 'apt list --upgradable' to see them.  
Reading package lists... Done
```

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

\$ sudo apt install net-tools vim


```

ririnfebriana@ririnfebriana-virtual-machine:~$ sudo apt net-tools vim
[sudo] password for ririnfebriana:
apt
Usage: apt command [options]
       apt help command [options]

Commands:
  add-repository  - Add entries to apt sources.list
  autoclean       - Erase old downloaded archive files
  autopurge       - Remove packages with their configuration files and automati
cally remove all unused packages
  autoremove      - Remove automatically all unused packages
  build           - Build binary or source packages from sources
  build-dep       - Configure build-dependencies for source packages
  changelog       - View a package's changelog
  check           - Verify that there are no broken dependencies
  clean           - Erase downloaded archive files
  contains        - List packages containing a file
  content         - List files contained in a package
  deb             - Install a .deb package
  depends         - Show raw dependency information for a package
  dist-upgrade    - Upgrade the system by removing/installing/upgrading package

```

worker1

```

putridanty@putridanty-VirtualBox:~$ sudo apt install net-tools vim
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
net-tools is already the newest version (1.60+git20181103.0eebece-1ubuntu5).
vim is already the newest version (2:8.2.3995-1ubuntu2.13).
0 upgraded, 0 newly installed, 0 to remove and 3 not upgraded.

```

worker2

```
mpi@bilasin-virtual-machine: ~  
Berkas Sunting Tampilan Cari Terminal Bantuan  
mpi@bilasin-virtual-machine:~$ sudo apt net-tools vim  
apt  
Usage: apt command [options]  
       apt help command [options]  
  
Commands:  
  add-repository - Add entries to apt sources.list  
  autoclean      - Erase old downloaded archive files  
  autopurge      - Remove packages with their configuration files and automati  
cally remove all unused packages  
  autoremove     - Remove automatically all unused packages  
  build          - Build binary or source packages from sources  
  build-dep      - Configure build-dependencies for source packages  
  changelog      - View a package's changelog  
  check          - Verify that there are no broken dependencies  
  clean          - Erase downloaded archive files  
  contains       - List packages containing a file  
  content        - List files contained in a package  
  deb            - Install a .deb package  
  depends        - Show raw dependency information for a package  
  dist-upgrade   - Upgrade the system by removing/installing/upgrading package  
s  
  download       - Download the .deb file for a package  
  edit-sources   - Edit /etc/apt/sources.list with your preferred text editor
```

Worker3

```
viona@viona-virtual-machine:~$ sudo apt net-tools vim  
apt  
Usage: apt command [options]  
       apt help command [options]  
  
Commands:  
  add-repository - Add entries to apt sources.list  
  autoclean      - Erase old downloaded archive files  
  autopurge      - Remove packages with their configuration files and automati  
cally remove all unused packages  
  autoremove     - Remove automatically all unused packages  
  build          - Build binary or source packages from sources  
  build-dep      - Configure build-dependencies for source packages  
  changelog      - View a package's changelog  
  check          - Verify that there are no broken dependencies  
  clean          - Erase downloaded archive files  
  contains       - List packages containing a file  
  content        - List files contained in a package  
  deb            - Install a .deb package  
  depends        - Show raw dependency information for a package  
  dist-upgrade   - Upgrade the system by removing/installing/upgrading package  
s
```

Membuat MPI cluster

1. Konfigurasi hosts file /etc/hosts

Pada Master

```
GNU nano 6.2 /etc/hosts *
192.168.111.134 master
192.168.111.135 worker
192.168.111.136 worker2
192.168.111.137 worker3

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

Pada worker1

```
GNU nano 6.2 /etc/hosts
192.168.111.134 master
192.168.111.135 worker

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

Pada worker2

```
mpi@bilasin-virtual-machine: ~
Berkas Sunting Tampilan Cari Terminal Bantuan
GNU nano 6.2 /etc/hosts *
127.0.0.1 localhost
127.0.1.1 bilasin-virtual-machine

192.168.111.134 master
192.168.111.136 worker2

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

Pada Worker3

```
mpi@viona-virtual-machine: ~  
File Edit View Search Terminal Help  
GNU nano 6.2 /etc/hosts *  
127.0.0.1 localhost  
127.0.1.1 viona-virtual-machine  
  
192.168.111.134 master  
192.168.111.137 worker3  
# The following lines are desirable for IPv6 capable hosts  
::1 ip6-localhost ip6-loopback  
fe00::0 ip6-localnet  
ff00::0 ip6-mcastprefix  
ff02::1 ip6-allnodes  
ff02::2 ip6-allrouters
```

Membuat user baru

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

\$ sudo adduser

\$ sudo usermod -aG sudo

\$ su -

Server

Pada master

```
ririnfebriana@ririnfebriana-virtual-machine:~$ sudo adduser mpi  
adduser: The user 'mpi' already exists.  
ririnfebriana@ririnfebriana-virtual-machine:~$ sudo usermod -aG sudo mpi  
ririnfebriana@ririnfebriana-virtual-machine:~$ su - mpi  
Password:  
To run a command as administrator (user "root"), use "sudo <command>".  
See "man sudo_root" for details.  
mpi@ririnfebriana-virtual-machine:~$
```

client

worker1

```
putridanty@putridanty-VirtualBox:~$ sudo nano /etc/hosts  
putridanty@putridanty-VirtualBox:~$ sudo adduser mpi  
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:
```

worker2


```

mpi@bilasin-virtual-machine:~$ sudo adduser mpi
adduser: Pengguna `mpi' sudah ada.
mpi@bilasin-virtual-machine:~$ sudo usermod -aG sudo mpi
mpi@bilasin-virtual-machine:~$ su - mpi
Sandi:
mpi@bilasin-virtual-machine:~$

```

Worker3

```

viona@viona-virtual-machine:~$ sudo adduser mpi
adduser: The user `mpi' already exists.
viona@viona-virtual-machine:~$ sudo usermod -aG sudo mpi
viona@viona-virtual-machine:~$ su - mpi
Password:

```

Konfigurasi ssh

Setelah membuat dan masuk ke user, lakukan konfigurasi SSH.

1. Install SSH

```
$ sudo apt install openssh-server
```

Pada mater

```

mpi@ririnfabriana-virtual-machine:~$ 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 1 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
Ign:1 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 openssh-sftp-ser
ver amd64 1:8.9p1-3ubuntu0.4
Ign:2 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 openssh-server a
md64 1:8.9p1-3ubuntu0.4

```

Pada workee1


```

mpi@putridanty-VirtualBox:~$ 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
Terminal 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 3 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
Get:1 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 openssh-sftp-server amd64 1:8.9p1-3ubuntu0.4 [38,7 kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 openssh-server amd64 1:8.9p1-3ubuntu0.4 [434 kB]
36% [2 openssh-server 255 kB/434 kB 59%] 1.506 B/s 5min 3s

```

Pada worker2

```

mpi@bilasin-virtual-machine:~$ sudo apt install openssh-server
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
openssh-server sudah versi terbaru (1:8.9p1-3ubuntu0.4).
0 dimutakhirkan, 0 baru terinstal, 0 akan dihapus dan 23 tidak akan dimutakhirkan.
mpi@bilasin-virtual-machine:~$

```

Pada Worker3

```

mpi@viona-virtual-machine:~$ sudo apt install openssh-server
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
openssh-server is already the newest version (1:8.9p1-3ubuntu0.4).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.

```

Melakukan pengecekan SSH

\$ SSH @

SSH dari Master ke Worker

```

mpi@ririnfabriana-virtual-machine:~$ ssh mpi@worker
The authenticity of host 'worker (192.168.111.135)' can't be established.
ED25519 key fingerprint is SHA256:Zlrn4fRq7ileBoYCjVbQY2oqPg0IjrSX4eIUv14IiYY.
This host key is known by the following other names/addresses:
  ~/.ssh/known_hosts:1: [hashed name]
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker' (ED25519) to the list of known hosts.
mpi@worker's password:
Anda telah berhasil melakukan login user
Last login: Thu Nov 16 00:30:33 2023 from 10.9.58.225

```

SSH dari Worker ke Master

worker1

```

mpi@putridanty-VirtualBox:~$ ssh mpi@master
The authenticity of host 'master (192.168.111.134)' can't be established.
ED25519 key fingerprint is SHA256:TT8ISbTLFF40ejK564SiUEBLqHATzg0w9G/c3He8RI.
This host key is known by the following other names/addresses:
  ~/.ssh/known_hosts:1: [hashed name]
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

Last login: Sun Nov 19 09:27:32 2023 from 192.168.111.135

```

Worker3

```

mpi@viona-virtual-machine:~$ ssh mpi@master
mpi@master's password:
Last login: Tue Nov 21 09:48:08 2023 from 192.168.111.137

```

Generate Keygen Lakukan di SERVER

\$ Ssh-keygen -t rsa

```

mpi@ririnfebriana-virtual-machine:~$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/mpi/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/mpi/.ssh/id_rsa
Your public key has been saved in /home/mpi/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:CdSeILD+dFtnC0+/2LrDl0X0PMhy9JxdEbL97bToTeE mpi@ririnfebriana-virtual-machine
The key's randomart image is:
+---[RSA 3072]-----+
| .. .. . 00 |
| .... . 0 + . |
| . .00 . + B +. |
| . +00. = B + |
| . . . S 0+ 0+ |
| 0 . + 0 . 000 |
| . ... 0 . E. |
| 0+0 . 0 |
| +=+. . . |
+----[SHA256]-----+
mpi@ririnfebriana-virtual-machine:~$

```

Copy key publik ke client

\$ cd .ssh

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

```

mpi@ririnfebriana-virtual-machine:~$ cd .ssh
mpi@ririnfebriana-virtual-machine:~/.ssh$ cat id_rsa.pub | ssh mpi@worker "mkdir
.ssh; cat >> .ssh/authorized_keys"
mpi@worker's password:
mkdir: cannot create directory '.ssh': File exists
mpi@ririnfebriana-virtual-machine:~/.ssh$

```

Konfigurasi NFS

Buat shared folder

\$ mkdir cloud

Pada master

```

mpi@ririnfebriana-virtual-machine:~/.ssh$ mkdir cloud
mpi@ririnfebriana-virtual-machine:~/.ssh$

```

Pada worker1

```

mpi@putridanty-VirtualBox:~$ mkdir cloud
mpi@putridanty-VirtualBox:~$

```

Pada worker2

```

mpi@bilasin-virtual-machine:~$ mkdir cloud
mpi@bilasin-virtual-machine:~$

```

Pada Worker3

```

mpi@viona-virtual-machine:~$ mkdir cloud

```

Install NFS Server

\$ sudo apt install nfs-kernel-server

```

mpi@ririnfebriana-virtual-machine:~/.ssh$ 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:
  libevent-core-2.1-7 libnfsidmap1 nfs-common rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  libevent-core-2.1-7 libnfsidmap1 nfs-common nfs-kernel-server rpcbind
0 upgraded, 5 newly installed, 0 to remove and 5 not upgraded.
Need to get 565 kB of archives.
After this operation, 2,073 kB of additional disk space will be used.
Do you want to continue? [Y/n]

```

Konfigurasi file /etc/exports

*(rw,sync,no_root_squash,no_subtree_check)


```
mpi@ririnfebriana-virtual-machine: ~/.ssh
File Edit View Search Terminal Help
GNU nano 6.2 /etc/exports *
# /etc/exports: the access control list for filesystems which may be exported
# to NFS clients. See exports(5).
#
# Example for NFSv2 and NFSv3:
# /srv/homes hostname1(rw,sync,no_subtree_check) hostname2(ro,sync,no_sub
#
# Example for NFSv4:
# /srv/nfs4 gss/krb5i(rw,sync,fsid=0,crossmnt,no_subtree_check)
# /srv/nfs4/homes gss/krb5i(rw,sync,no_subtree_check)
#
/home/mpi/cloud *(rw,sync,no_root_squash,no_subtree_check)

^G Help ^O Write Out ^W Where Is ^K Cut ^T Execute ^C Location
^X Exit ^R Read File ^N Replace ^U Paste ^J Justify ^_ Go To Line
```

\$ sudo exportfs -a

\$ sudo systemctl restart nfs-kernel-server

```
mpi@ririnfebriana-virtual-machine:~$ sudo exportfs
/home/mpi/cloud
<world>
```

Install NFS Client

\$ sudo apt install nfs-common

worker1

```
mpi@putridanty-VirtualBox: $ 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 3 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] y
0% [Connecting to id.archive.ubuntu.com]
```

worker2

```
mpi@bilasin-virtual-machine:~$ sudo apt install nfs-common
[sudo] katasandi untuk mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
nfs-common sudah versi terbaru (1:2.6.1-1ubuntu1.2).
0 dimutakhirkan, 0 baru terinstal, 0 akan dihapus dan 23 tidak akan dimutakhirkan.
mpi@bilasin-virtual-machine:~$
```

Worker3

```
mpi@viona-virtual-machine:~$ sudo apt install nfs-common
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).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
mpi@viona-virtual-machine:~$
```

Mounting

\$ sudo mount :

worker1

```
mpi@putridanty-VirtualBox:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
Created symlink /run/systemd/system/remote-fs.target.wants/rpc-statd.service → /lib/systemd/system/rpc-statd.service.
```

worker2

```
mpi@bilasin-virtual-machine:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
[sudo] katasandi untuk mpi:
mount.nfs: access denied by server while mounting master:/home/mpi/cloud
mpi@bilasin-virtual-machine:~$
```

Worker3

```
mpi@viona-virtual-machine:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
[sudo] password for mpi:
mount.nfs: access denied by server while mounting master:/home/mpi/cloud
```

Instalasi MPI

\$ sudo apt install openmpi-bin libopenmpi-dev

```

mpi@ririnfabriana-virtual-machine:~$ sudo apt install openmpi-bin libopenmpi-dev
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev gfortran gfortran-11 ibverbs-providers
  javascript-common libcaf-openmpi-3 libcoarrays-dev libcoarrays-openmpi-dev
  libevent-dev libevent-extra-2.1-7 libevent-openssl-2.1-7
  libevent-pthreads-2.1-7 libfabric1 libgfortran-11-dev libhwloc-dev
  libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libjs-jquery
  libjs-jquery-ui libltdl-dev libnl-3-dev libnl-route-3-dev libnuma-dev
  libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 librdmacm1
  libtool libucx0 libxnvctrl0 openmpi-common zlibg-dev
Suggested packages:
  autoconf-archive gnu-standards autoconf-doc gfortran-multilib gfortran-doc
  gfortran-11-multilib gfortran-11-doc apache2 | lighttpd | httpd
  libhwloc-contrib-plugins libjs-jquery-ui-docs libtool-doc openmpi-doc
  gcj-jdk
The following NEW packages will be installed:
  autoconf automake autotools-dev gfortran gfortran-11 ibverbs-providers
  javascript-common libcaf-openmpi-3 libcoarrays-dev libcoarrays-openmpi-dev
  libevent-dev libevent-extra-2.1-7 libevent-openssl-2.1-7

```

Pada worker1

```

mpi@putridanty-VirtualBox:~$ 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
  libverbs-providers javascript-common libasan0 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 libnspr-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 zlibg-dev

```

Pada worker2

```

mpi@bilasin-virtual-machine:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
libopenmpi-dev sudah versi terbaru (4.1.2-2ubuntu1).
openmpi-bin sudah versi terbaru (4.1.2-2ubuntu1).
0 dimutakhirkan, 0 baru terinstal, 0 akan dihapus dan 23 tidak akan dimutakhirkan.
mpi@bilasin-virtual-machine:~$

```

Pada Worker3

```

mpi@viona-virtual-machine:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
libopenmpi-dev is already the newest version (4.1.2-2ubuntu1).
openmpi-bin is already the newest version (4.1.2-2ubuntu1).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.

```

Program bubblesort


```
mpi@ririnfabriana-virtual-machine: ~  
File Edit View Search Terminal Help  
GNU nano 6.2 bubblesort.py  
from mpi4py import MPI  
import random  
import time  
def bubble_sort(arr):  
n = len(arr)  
for i in range(n):  
swapped = False  
for j in range(0, n-i-1):  
if arr[j] > arr[j+1]:  
arr[j], arr[j+1] = arr[j+1], arr[j]  
swapped = True  
if not swapped:  
break  
Menbuat 10 array acak  
array_list = [random.sample(range(1, 1000), 10) for _ in range(10)]  
# Menampilkan data mentah dan data yang sudah diurutkan  
for i, arr in enumerate(array_list):  
print(f>Data mentah array {i + 1}: {arr}")  
Mengukur waktu eksekusi Bubble Sort dan mengurutkan array  
^G Help      ^O Write Out ^W Where Is  ^K Cut       ^T Execute   ^C Location  
^X Exit      ^R Read File ^\ Replace   ^U Paste     ^J Justify   ^_ Go To Line
```

Eksekusi python

```
mpi@ririnfabriana-virtual-machine:~$ touch bubblesort.py  
mpi@ririnfabriana-virtual-machine:~$ sudo nano bubblesort.py  
mpi@ririnfabriana-virtual-machine:~$ sudo nano bubblesort.py  
mpi@ririnfabriana-virtual-machine:~$ sudo apt install python3-pip  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done  
The following additional packages will be installed:  
  build-essential g++ g++-11 libexpat1-dev libjs-sphinxdoc libjs-underscore  
  libpython3-dev libpython3.10-dev libstdc++-11-dev python3-dev  
  python3-distutils python3-lib2to3 python3-setuptools python3-wheel  
  python3.10-dev  
Suggested packages:  
  g++-multilib g++-11-multilib gcc-11-doc libstdc++-11-doc  
  python-setuptools-doc  
The following NEW packages will be installed:  
  build-essential g++ g++-11 libexpat1-dev libjs-sphinxdoc libjs-underscore  
  libpython3-dev libpython3.10-dev libstdc++-11-dev python3-dev  
  python3-distutils python3-lib2to3 python3-pip python3-setuptools  
  python3-wheel python3.10-dev  
0 upgraded, 16 newly installed, 0 to remove and 5 not upgraded.  
Need to get 21.1 MB of archives.  
After this operation, 82.1 MB of additional disk space will be used.  
Do you want to continue? [Y/n]
```

```

mpi@ririnfabriana-virtual-machine:~$ python3 bubblesort.py
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Data mentah array 1: [869, 817, 14, 930, 885, 862, 498, 585, 225, 848]
Data yang sudah diurutkan array 1: [14, 225, 498, 585, 817, 848, 862, 869, 885, 930]
Waktu eksekusi: 0.000023 detik

Data mentah array 2: [859, 915, 525, 651, 151, 393, 452, 336, 228, 564]
Data yang sudah diurutkan array 2: [151, 228, 336, 393, 452, 525, 564, 651, 859, 915]
Waktu eksekusi: 0.000008 detik

Data mentah array 3: [67, 381, 2, 334, 984, 948, 868, 143, 358, 791]
Data yang sudah diurutkan array 3: [2, 67, 143, 334, 358, 381, 791, 868, 904, 948]
Waktu eksekusi: 0.000005 detik

Data mentah array 4: [157, 888, 715, 188, 383, 34, 761, 67, 729, 652]
Data yang sudah diurutkan array 4: [34, 67, 157, 188, 383, 652, 715, 729, 761, 888]
Waktu eksekusi: 0.000006 detik

Data mentah array 5: [122, 445, 820, 667, 172, 677, 504, 68, 342, 98]
Data yang sudah diurutkan array 5: [68, 98, 122, 172, 342, 445, 504, 667, 677, 820]
Waktu eksekusi: 0.000006 detik

Data mentah array 6: [185, 880, 760, 247, 834, 823, 178, 685, 15, 867]
Data yang sudah diurutkan array 6: [15, 185, 178, 247, 685, 760, 880, 823, 834, 867]
Waktu eksekusi: 0.000006 detik

Data mentah array 7: [484, 326, 731, 303, 676, 795, 412, 820, 149, 837]
Data yang sudah diurutkan array 7: [149, 303, 326, 412, 484, 676, 731, 795, 820, 837]
Waktu eksekusi: 0.000006 detik

Data mentah array 8: [589, 823, 614, 754, 326, 573, 425, 497, 569, 221]
Data yang sudah diurutkan array 8: [221, 326, 425, 497, 569, 573, 589, 614, 754, 823]
Waktu eksekusi: 0.000007 detik

Data mentah array 9: [362, 689, 192, 52, 636, 338, 379, 418, 335, 874]
Data yang sudah diurutkan array 9: [52, 192, 335, 338, 362, 379, 418, 636, 689, 874]
Waktu eksekusi: 0.000005 detik

Data mentah array 18: [984, 8, 687, 721, 178, 1, 781, 445, 457, 242]
Data yang sudah diurutkan array 10: [1, 8, 178, 242, 445, 457, 687, 721, 781, 984]
Waktu eksekusi: 0.000006 detik

Jumlah array yang belum terurutkan: 0
mpi@ririnfabriana-virtual-machine:~$

```

Numerik pada master

```

mpi@ririnfabriana-master: ~
File Edit View Search Terminal Help
GNU nano 6.2 numerik.py
Contoh kode Python dengan operasi numerik dan fungsi matematika tambahan

# Eksponensiasi (pangkat)
angka1 = 2
angka2 = 3
hasil_pangkat = angka1 ** angka2
print("Hasil Pangkat:", hasil_pangkat)

# Pembagian sisa
angka3 = 10
angka4 = 3
hasil_sisa_pembagian = angka3 % angka4
print("Sisa Pembagian:", hasil_sisa_pembagian)

# Operasi campuran
angka5 = 5
angka6 = 2
hasil_campuran = (angka5 + angka6) * angka1 - angka2 / angka6
print("Hasil Operasi Campuran:", hasil_campuran)

[ Read 19 lines ]
^G Help      ^O Write Out ^W Where Is  ^K Cut       ^T Execute   ^C Location
^X Exit      ^R Read File ^\ Replace   ^U Paste     ^J Justify   ^_ Go To Line

```

```
mpi@ririnfebriana-master:~$ sudo nano numerik.py
mpi@ririnfebriana-master:~$ python3 numerik.py
Hasil Pangkat: 8
Sisa Pembagian: 1
Hasil Operasi Campuran: 12.5
mpi@ririnfebriana-master:~$
```

Numerik pada worker

```
viona@vionaauliameidy-Worker3: ~
File Edit View Search Terminal Help
GNU nano 6.2 numerik.py
# Eksponensiasi (pangkat)
angka1 = 2
angka2 = 3
hasil_pangkat = angka1 ** angka2
print("Hasil Pangkat:", hasil_pangkat)

# Pembagian sisa
angka3 = 10
angka4 = 3
hasil_sisa_pembagian = angka3 % angka4
print("Sisa Pembagian:", hasil_sisa_pembagian)

# Operasi campuran
angka5 = 5
angka6 = 2
hasil_campuran = (angka5 + angka6) * angka1 - angka2 / angka6
print("Hasil Operasi Campuran:", hasil_campuran)

[ Read 17 lines ]
^G Help      ^O Write Out ^W Where Is  ^K Cut       ^T Execute   ^C Location
^X Exit      ^R Read File ^\ Replace   ^U Paste     ^J Justify   ^_ Go To Line

viona@vionaauliameidy-Worker3:~$ touch numerik.py
viona@vionaauliameidy-Worker3:~$ sudo nano numerik.py
[sudo] password for viona:
viona@vionaauliameidy-Worker3:~$ python3 numerik.py
Hasil Pangkat: 8
Sisa Pembagian: 1
Hasil Operasi Campuran: 12.5
```