

PEMROSESAN PARALEL

“ Tugas III MPI CLUSTER”



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PROGRAM STUDI SISTEM KOMPUTER

FAKULTAS ILMU KOMPUTER

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MEMBUAT CLUSTER MPI

- **Sebelum membuat Mpi**
 1. Pastikan sudah dalam satu jaringan yang sama setiap (Master, Worker1, Worker2, dan Worker3)
 2. Melakukan Upgrade OS Master

```
ayulestari@ubuntu:~$ sudo apt update && sudo apt upgrade
[sudo] password for ayulestari:
Hit:1 http://security.ubuntu.com/ubuntu focal-security InRelease
Err:2 http://us.archive.ubuntu.com/ubuntu focal InRelease
  Connection failed [IP: 91.189.91.38 80]
Err:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease
  Connection failed [IP: 91.189.91.39 80]
Err:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease
  Connection failed [IP: 91.189.91.38 80]
Reading package lists... Done
Building dependency tree
Reading state information... Done
426 packages can be upgraded. Run 'apt list --upgradable' to see them.
W: Failed to fetch http://us.archive.ubuntu.com/ubuntu/dists/focal/InRelease  C
onnection failed [IP: 91.189.91.38 80]
W: Failed to fetch http://us.archive.ubuntu.com/ubuntu/dists/focal-updates/InRe
lease Connection failed [IP: 91.189.91.39 80]
W: Failed to fetch http://us.archive.ubuntu.com/ubuntu/dists/focal-backports/In
Release Connection failed [IP: 91.189.91.38 80]
W: Some index files failed to download. They have been ignored, or old ones use
d instead.
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following package was automatically installed and is no longer required:
```

Worker 1

[illegible]

Worker 2

```
ana@ubuntu: ~  
ana@ubuntu:~$ sudo apt update && sudo apt upgrade  
[sudo] password for ana:  
Hit:1 http://security.ubuntu.com/ubuntu focal-security InRelease  
Err:2 http://us.archive.ubuntu.com/ubuntu focal InRelease  
      Connection failed [IP: 91.189.91.38 80]  
Err:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease  
      Connection failed [IP: 91.189.91.39 80]  
Err:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease  
      Connection failed [IP: 91.189.91.38 80]  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
425 packages can be upgraded. Run 'apt list --upgradable' to see them.
```

Worker 3

```
febiyona@febiyona-virtual-machine: ~  
febiyona@febiyona-virtual-machine:~$ sudo apt update && sudo apt upgrade  
[sudo] password for febiyona:  
Ign:1 http://security.ubuntu.com/ubuntu jammy-security InRelease  
Ign:2 http://id.archive.ubuntu.com/ubuntu jammy InRelease  
Ign:3 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease  
Ign:4 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease  
Ign:1 http://security.ubuntu.com/ubuntu jammy-security InRelease  
Ign:2 http://id.archive.ubuntu.com/ubuntu jammy InRelease  
Ign:3 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease  
Ign:4 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease  
Ign:1 http://security.ubuntu.com/ubuntu jammy-security InRelease  
Ign:2 http://id.archive.ubuntu.com/ubuntu jammy InRelease  
Ign:3 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease  
Ign:4 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease  
Err:1 http://security.ubuntu.com/ubuntu jammy-security InRelease  
      Temporary failure resolving 'security.ubuntu.com'  
Err:2 http://id.archive.ubuntu.com/ubuntu jammy InRelease  
      Temporary failure resolving 'id.archive.ubuntu.com'  
Err:3 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease  
      Temporary failure resolving 'id.archive.ubuntu.com'  
Err:4 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease  
      Temporary failure resolving 'id.archive.ubuntu.com'  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done
```


3. Melakukan Penginstalan net-tools untuk melihat IP, vim untuk teks editor

Master

```
ayulestari@ubuntu:~$ sudo apt install vim
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  vim-runtime
Suggested packages:
  ctags vim-doc vim-scripts
The following NEW packages will be installed:
  vim vim-runtime
0 upgraded, 2 newly installed, 0 to remove and 0 not upgraded.
Need to get 7,120 kB of archives.
After this operation, 34.6 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://security.ubuntu.com/ubuntu focal-security/main amd64 vim-runtime a
ll 2:8.1.2269-1ubuntu5.20 [5,878 kB]
Get:2 http://security.ubuntu.com/ubuntu focal-security/main amd64 vim amd64 2:8
.1.2269-1ubuntu5.20 [1,242 kB]
Fetched 7,120 kB in 5s (1,524 kB/s)
Selecting previously unselected package vim-runtime.
(Reading database ... 163240 files and directories currently installed.)
Preparing to unpack .../vim-runtime_2%3a8.1.2269-1ubuntu5.20_all.deb ...
Adding 'diversion of /usr/share/vim/vim81/doc/help.txt to /usr/share/vim/vim81/
doc/help.txt.vim-tiny by vim-runtime'
Adding 'diversion of /usr/share/vim/vim81/doc/tags to /usr/share/vim/vim81/doc/
tags.vim-tiny by vim-runtime'
```

Worker 1

```
mardaharyani@mardaharyani-virtual-machine:~$ sudo apt install net-tools vim
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 2 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] y
Get:1 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 net-tools amd64 1.60+git20181103.0eebece-1ubuntu5 [204 kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 vim-runtime all 2:8.2.3995-1ubuntu2.13 [6.834 kB]
Get:3 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 vim amd64 2:8.2.3995-1ubuntu2.13 [1.734 kB]
Fetched 8.773 kB in 10s (920 kB/s)
Selecting previously unselected package net-tools.
(Reading database ... 198978 files and directories currently installed.)
Preparing to unpack .../net-tools_1.60+git20181103.0eebece-1ubuntu5_amd64.deb ...
Unpacking net-tools (1.60+git20181103.0eebece-1ubuntu5) ...
Selecting previously unselected package vim-runtime.
Preparing to unpack .../vim-runtime_2%3a8.2.3995-1ubuntu2.13_all.deb ...
Adding 'diversion of /usr/share/vim/vim82/doc/help.txt to /usr/share/vim/vim82/doc/help.txt.vim-tiny by vim-runtime'
Adding 'diversion of /usr/share/vim/vim82/doc/tags to /usr/share/vim/vim82/doc/tags.vim-tiny by vim-runtime'
Unpacking vim-runtime (2:8.2.3995-1ubuntu2.13) ...
Selecting previously unselected package vim.
Preparing to unpack .../vim_2%3a8.2.3995-1ubuntu2.13_amd64.deb ...
Unpacking vim (2:8.2.3995-1ubuntu2.13) ...
Setting up net-tools (1.60+git20181103.0eebece-1ubuntu5) ...
Setting up vim-runtime (2:8.2.3995-1ubuntu2.13) ...
Setting up vim (2:8.2.3995-1ubuntu2.13) ...
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/vim (vim) in auto mode
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/vimdiff (vimdiff) in auto mode
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/rvim (rvim) in auto mode
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/rview (rview) in auto mode
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/vi (vi) in auto mode
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/view (view) in auto mode
update-alternatives: using /usr/bin/vim.basic to provide /usr/bin/ex (ex) in auto mode
Processing triggers for man-db (2.10.2-1) ...
```

Worker 2

```
ana@ubuntu: ~  
ana@ubuntu:~$ sudo apt install vim  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following packages were automatically installed and are no longer required:  
  libllvm9 linux-modules-5.4.0-1002-oem  
Use 'sudo apt autoremove' to remove them.  
The following additional packages will be installed:  
  vim-runtime  
Suggested packages:  
  ctags vim-doc vim-scripts  
The following NEW packages will be installed:  
  vim vim-runtime  
0 upgraded, 2 newly installed, 0 to remove and 0 not upgraded.  
Need to get 7,120 kB of archives.  
After this operation, 34.6 MB of additional disk space will be used  
.  
Do you want to continue? [Y/n] y  
Get:1 http://security.ubuntu.com/ubuntu focal-security/main amd64 vim-runtime all 2:8.1.2269-1ubuntu5.20 [5,878 kB]  
Get:2 http://security.ubuntu.com/ubuntu focal-security/main amd64 vim amd64 2:8.1.2269-1ubuntu5.20 [1,242 kB]
```

Worker 3

```
mpi@febiyona-virtual-machine:~$ sudo apt install vim  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following packages were automatically installed and are no longer required:  
  libllvm9 linux-modules-5.4.0-1002-oem  
Use 'sudo apt autoremove' to remove them.  
The following additional packages will be installed:  
  vim-runtime  
Suggested packages:  
  ctags vim-doc vim-scripts  
The following NEW packages will be installed:  
  vim vim-runtime  
0 upgraded, 2 newly installed, 0 to remove and 0 not upgraded.  
Need to get 7,120 kB of archives.  
After this operation, 34.6 MB of additional disk space will be used  
.  
Do you want to continue? [Y/n] y  
Get:1 http://security.ubuntu.com/ubuntu focal-security/main amd64 vim-runtime all 2:8.1.2269-1ubuntu5.20 [5,878 kB]  
Get:2 http://security.ubuntu.com/ubuntu focal-security/main amd64 vim amd64 2:8.1.2269-1ubuntu5.20 [1,242 kB]
```

4. Melakukan pengecekan IP dengan perintah berikut:

Nama	Master	Worker1	Worker2	Worker3
IP	10.9.59.106	10.9.57.99	10.9.59.115	10.9.59.211

- **Steps to Create an MPI Cluster**

1. Konfigurasi hosts file /etc/hosts

- Pada Master

```
mpi@ubuntu: ~  
GNU nano 4.8 /etc/hosts Modified  
127.0.0.1 localhost  
127.0.1.1 ubuntu  
  
10.9.59.106 master  
10.9.57.99 worker1  
10.9.59.115 worker2  
10.9.59.211 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  
127.0.0.1 localhost  
127.0.1.1 mardaharyani-virtual-machine  
  
10.9.59.106 master  
10.9.57.99 worker1  
  
# 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

```
ana@ubuntu: ~  
GNU nano 4.8 /etc/hosts  
127.0.0.1 localhost  
127.0.1.1 ubuntu  
  
10.9.59.106 master  
10.9.59.115 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

```

febiyona@febiyona-virtual-machine: ~
GNU nano 6.2 /etc/hosts *
127.0.0.1 localhost
127.0.1.1 febiyona-virtual-machine

10.9.59.106 master
10.9.59.211 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

```

- **Step2: Create a new user**

Buat user baru di Server dan Client. Nama User harus sama semua di seluruh Komputer.

Server

- Master

```

ayulestari@ubuntu:~$ sudo nano /etc/hosts
[sudo] password for ayulestari:
ayulestari@ubuntu:~$ 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:
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 []: ayumaster
  Room Number []:
  Work Phone []:
  Home Phone []:
  Other []:
Is the information correct? [Y/n] y

```

Client

- Worker1

```

mardaharyani@mardaharyani-virtual-machine:~$ 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:
BAD PASSWORD: The password fails the dictionary check - it is too simplistic/systematic
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 []: mardaworker1
  Room Number []:
  Work Phone []:
  Home Phone []:
  Other []:
Is the information correct? [Y/n] y

```



```

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

mpi@mardaharyani-virtual-machine:~$ █

```

- Worker2

```

ana@ubuntu:~$ 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:
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 []: anaworker2
    Room Number []:
    Work Phone []:
    Home Phone []:
    Other []:
Is the information correct? [Y/n] y
ana@ubuntu:~$ █

```

```

ana@ubuntu:~$ sudo usermod -aG sudo mpi
ana@ubuntu:~$ su - mpi
Password:
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

mpi@ubuntu:~$ █

```

- Worker3

```

febiyona@febiyona-virtual-machine:~$ 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:
BAD PASSWORD: The password fails the dictionary check - it does not contain enough DIFFERENT 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 []: febiworker3
    Room Number []:
    Work Phone []:
    Home Phone []:
    Other []:
Is the information correct? [Y/n] Y

```

```

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

```


- Konfigurasi SSH

Setelah membuat dan masuk ke user, lakukan konfigurasi SSH.

1. Install SSH

- Pada Master

```
mpi@ubuntu:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  ncurses-term openssh-sftp-server
Suggested packages:
  molly-guard monkeysphere ssh-askpass
Recommended packages:
  ssh-import-id
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server
0 upgraded, 3 newly installed, 0 to remove and 0 not upgraded.
Need to get 678 kB of archives.
After this operation, 5,963 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://security.ubuntu.com/ubuntu focal-security/main amd64 ncurses-term
all 6.2-0ubuntu2.1 [249 kB]
Get:2 http://security.ubuntu.com/ubuntu focal-security/main amd64 openssh-sftp-
server amd64 1:8.2p1-4ubuntu0.9 [51.7 kB]
Get:3 http://security.ubuntu.com/ubuntu focal-security/main amd64 openssh-serve
r amd64 1:8.2p1-4ubuntu0.9 [377 kB]
Fetched 678 kB in 5s (124 kB/s)
Preconfiguring packages ...
```

- Pada Worker1

```
mpi@mardaharyani-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 2 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]
Get:3 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 ncurses-term all 6.3-2ubuntu0.1 [267 kB]
Get:4 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 ssh-import-id all 5.11-0ubuntu1 [10,1 kB]
Fetched 751 kB in 6s (132 kB/s)
Preconfiguring packages ...
Selecting previously unselected package openssh-sftp-server.
(Reading database ... 200968 files and directories currently installed.)
Preparing to unpack .../openssh-sftp-server_1%3a8.9p1-3ubuntu0.4_amd64.deb ...
Unpacking openssh-sftp-server (1:8.9p1-3ubuntu0.4) ...
Selecting previously unselected package openssh-server.
Preparing to unpack .../openssh-server_1%3a8.9p1-3ubuntu0.4_amd64.deb ...
Unpacking openssh-server (1:8.9p1-3ubuntu0.4) ...
Selecting previously unselected package ncurses-term.
Preparing to unpack .../ncurses-term_6.3-2ubuntu0.1_all.deb ...
Unpacking ncurses-term (6.3-2ubuntu0.1) ...
Selecting previously unselected package ssh-import-id.
Preparing to unpack .../ssh-import-id_5.11-0ubuntu1_all.deb ...
Unpacking ssh-import-id (5.11-0ubuntu1) ...
Setting up openssh-sftp-server (1:8.9p1-3ubuntu0.4) ...
Setting up openssh-server (1:8.9p1-3ubuntu0.4) ...

Creating config file /etc/ssh/sshd_config with new version
Creating SSH2 RSA key; this may take some time ...
3072 SHA256:XFEqcm4JwJqmRjIuaxids9RjdZ7qqpf/nsoGnd5MG6c root@mardaharyani-virtual-machine (RSA)
```

- Pada Worker2

```
mpi@ubuntu:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  ncurses-term openssh-sftp-server
Suggested packages:
  molly-guard monkeysphere ssh-askpass
Recommended packages:
  ssh-import-id
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server
0 upgraded, 3 newly installed, 0 to remove and 0 not upgraded.
Need to get 678 kB of archives.
After this operation, 5,963 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://security.ubuntu.com/ubuntu focal-security/main amd64 ncurses-term
all 6.2-0ubuntu2.1 [249 kB]
Get:2 http://security.ubuntu.com/ubuntu focal-security/main amd64 openssh-sftp-
server amd64 1:8.2p1-4ubuntu0.9 [51.7 kB]
Get:3 http://security.ubuntu.com/ubuntu focal-security/main amd64 openssh-serve
r amd64 1:8.2p1-4ubuntu0.9 [377 kB]
Fetched 678 kB in 10s (71.3 kB/s)
```

- Pada Worker3

```
febiyona@febiyona-virtual-machine:~/Desktop$ sudo apt install openssh-server
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-client openssh-sftp-server ssh-import-id
Suggested packages:
  keychain libpam-ssh monkeysphere ssh-askpass molly-guard
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server ssh-import-id
The following packages will be upgraded:
  openssh-client
1 upgraded, 4 newly installed, 0 to remove and 115 not upgraded.
Need to get 1.655 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-client amd64 1:8.9p1-3ubuntu0.4 [905 kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 openssh-sftp-server amd64 1:8.9p1-3ubuntu0.4 [38,7 kB]
Get:3 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 openssh-server amd64 1:8.9p1-3ubuntu0.4 [434 kB]
Get:4 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 ncurses-term all 6.3-2ubuntu0.1 [267 kB]
Get:5 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 ssh-import-id all 5.11-0ubuntu1 [10,1 kB]
Fetched 1.655 kB in 1s (2.552 kB/s)
Preconfiguring packages ...
(Reading database ... 161840 files and directories currently installed.)
Preparing to unpack .../openssh-client_1%3a8.9p1-3ubuntu0.4_amd64.deb ...
Unpacking openssh-client (1:8.9p1-3ubuntu0.4) over (1:8.9p1-3ubuntu0.3) ...
Selecting previously unselected package openssh-sftp-server.
Preparing to unpack .../openssh-sftp-server_1%3a8.9p1-3ubuntu0.4_amd64.deb ...
Unpacking openssh-sftp-server (1:8.9p1-3ubuntu0.4) ...
Selecting previously unselected package openssh-server.
Preparing to unpack .../openssh-server_1%3a8.9p1-3ubuntu0.4_amd64.deb ...
Unpacking openssh-server (1:8.9p1-3ubuntu0.4) ...
Selecting previously unselected package ncurses-term.
Preparing to unpack .../ncurses-term_6.3-2ubuntu0.1_all.deb ...
Unpacking ncurses-term (6.3-2ubuntu0.1) ...
Selecting previously unselected package ssh-import-id.
Preparing to unpack .../ssh-import-id_5.11-0ubuntu1_all.deb ...
Unpacking ssh-import-id (5.11-0ubuntu1) ...
Setting up openssh-client (1:8.9p1-3ubuntu0.4) ...
Setting up ssh-import-id (5.11-0ubuntu1) ...
```

2. Melakukan pengecekan SSH

- SSH dari Master ke Worker

```
mpi@ubuntu:~$ ssh mpi@worker1
The authenticity of host 'worker1 (10.9.57.99)' can't be established.
ECDSA key fingerprint is SHA256:BeXMjPVy3Yy7EULOWkktD+rax8hpGZi0qnwq5kP8ME8.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker1,10.9.57.99' (ECDSA) to the list of known ho
sts.
mpi@worker1'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.

mpi@mardaharyani-virtual-machine:~$
```

- SSH dari Worker1 ke Master

```
mpi@mardaharyani-virtual-machine:~$ ssh mpi@master
The authenticity of host 'master (10.9.59.106)' can't be established.
ED25519 key fingerprint is SHA256:sjnmGkuvILG3sFGy3n2NjgXwMdPLFCfXA0yEiBjcxzg.
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 Focal Fossa (development branch) (GNU/Linux 5.4.0-166-generic x86_64)

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

0 updates can be installed immediately.
0 of these updates are security updates.

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 Worker2 ke Master

```
mpi@ubuntu:~$ ssh mpi@master
The authenticity of host 'master (10.9.59.106)' can't be established.
ECDSA key fingerprint is SHA256:QcBVGSfUITmZTu7Sl+kr4Nuv51eyOWuL1GDMUsELuJE.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'master,10.9.59.106' (ECDSA) to the list of known ho
sts.
mpi@master's password:
Welcome to Ubuntu Focal Fossa (development branch) (GNU/Linux 5.4.0-166-generic
x86_64)

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

0 updates can be installed immediately.
0 of these updates are security updates.

Last login: Wed Nov 15 00:55:50 2023 from 10.9.59.211
mpi@ubuntu:~$
```

- SSH dari Worker3 ke Master

```
Feblyona@febiyona-virtual-machine:~/Desktop$ ssh mpi@master
The authenticity of host 'master (10.9.59.106)' can't be established.
ED25519 key fingerprint is SHA256:sjnmGkuvILG3sFGy3n2NjgXwMdPLFcFxAOyEiBjcxzg.
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 Focal Fossa (development branch) (GNU/Linux 5.4.0-166-generic x86_64)

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

0 updates can be installed immediately.
0 of these updates are security updates.

Last login: Wed Nov 15 00:45:00 2023 from 10.9.57.99
```

3. Generate Keygen

- Lakukan di Server

```
mpi@ubuntu:~$ 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:QylkAoQdGFabn0yxJ66IyGJl0UI1l4DWQGJB8iN/XTY mpi@ubuntu
The key's randomart image is:
+---[RSA 3072]-----+
|+%B**++..          |
|*.,=++=O. .        |
|. =B. . E          |
| O.+OO = .         |
| .++.. S           |
| .+O .             |
| O.                |
|*..                |
|*O                 |
+---[SHA256]-----+
```

4. Copy key publik ke Client

- Copy Key

```
mpi@ubuntu:~$ cd .ssh
mpi@ubuntu:~/.ssh$ cat id_rsa.pub | ssh mpi@worker1 "mkdir .ssh; cat >> .ssh/authorized_keys"
mpi@worker1's password:
Permission denied, please try again.
mpi@worker1's password:
mkdir: cannot create directory '.ssh': File exists
mpi@ubuntu:~/.ssh$
```

- Konfigurasi NFS

1. Buat Shared folder

- Pada Master

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

- Pada Worker1

```
mpi@mardaharyani-virtual-machine:~$ mkdir cloud
mpi@mardaharyani-virtual-machine:~$
```

- Pada Worker2

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

- Pada Worker3

```
mpi@febiyona-virtual-machine:~$ mkdir cloud
mpi@febiyona-virtual-machine:~$
```

2. Install NFS Server

- Sudo apt install nfs-kernel-server

```
mpi@ubuntu:~$ sudo apt install nfs-kernel-server
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  keyutils libevent-2.1-7 libnfsidmap2 libtirpc-common libtirpc3 nfs-common
  rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-2.1-7 libnfsidmap2 libtirpc-common libtirpc3 nfs-common
  nfs-kernel-server rpcbind
0 upgraded, 8 newly installed, 0 to remove and 360 not upgraded.
Need to get 642 kB of archives.
After this operation, 2,344 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtirpc-com
mon all 1.2.5-1ubuntu0.1 [7,712 B]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtirpc3 am
d64 1.2.5-1ubuntu0.1 [77.9 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/main amd64 rpcbind amd64 1.2.5-
8 [42.8 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 keyutils amd
64 1.6-6ubuntu1.1 [44.8 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libevent-2.1-7 amd64
2.1.11-stable-1 [138 kB]

```

3. Konfigurasi file /etc/exports

- <lokasi shared folder> *(rw,sync,no_root_squash,no_subtree_check)

```
GNU nano 4.8 /etc/exports Modified
# /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_subtree_check)
#
# 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/mpl/cloud *(rw,sync,no_root_squash,no_subtree_check)

mpl@ubuntu:~$ sudo nano /etc/exports
mpl@ubuntu:~$ sudo exportfs -a
mpl@ubuntu:~$ sudo systemctl restart nfs-kernel-server
mpl@ubuntu:~$
```

4. Install NFS Client

- Worker1

```
mpl@nurdaharyant-virtual-machine:~$ sudo apt install nfs-common
[sudo] password for mpl:
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 2 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
Get:1 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 libevent-core-2.1-7 amd64 2.1.12-stable-1build3 [93,9 kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 libnfsidmap1 amd64 1:2.6.1-1ubuntu1.2 [42,9 kB]
Get:3 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 rpcbind amd64 1.2.6-2build1 [46,6 kB]
Get:4 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 keyutils amd64 1:6.1-2ubuntu3 [50,4 kB]
Get:5 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 nfs-common amd64 1:2.6.1-1ubuntu1.2 [241 kB]
Fetched 475 kB in 0s (1.047 kB/s)
Selecting previously unselected package libevent-core-2.1-7:amd64.
(Reading database ... 203844 files and directories currently installed.)
Preparing to unpack .../libevent-core-2.1-7_2.1.12-stable-1build3_amd64.deb ...
Unpacking libevent-core-2.1-7:amd64 (2.1.12-stable-1build3) ...
Selecting previously unselected package libnfsidmap1:amd64.
Preparing to unpack .../libnfsidmap1_1%3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
Selecting previously unselected package rpcbind.
Preparing to unpack .../rpcbind_1.2.6-2build1_amd64.deb ...
Unpacking rpcbind (1.2.6-2build1) ...
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 .../nfs-common_1%3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-common (1:2.6.1-1ubuntu1.2) ...
Setting up libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
```

- Worker2

```
mpl@ubuntu:~$ sudo apt install nfs-common
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  liblvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  keyutils libevent-2.1-7 libnfsidmap2 libtirpc-common libtirpc3 rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-2.1-7 libnfsidmap2 libtirpc-common libtirpc3 nfs-common
  rpcbind
0 upgraded, 7 newly installed, 0 to remove and 360 not upgraded.
Need to get 543 kB of archives.
After this operation, 1,924 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtirpc-com
mon all 1.2.5-1ubuntu0.1 [7,712 B]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libtirpc3 am
d64 1.2.5-1ubuntu0.1 [77,9 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/main amd64 rpcbind amd64 1.2.5-
8 [42,8 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 keyutils amd
64 1.6-6ubuntu1.1 [44,8 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libevent-2.1-7 amd64
2.1.11-stable-1 [138 kB]
```

- Worker3

```
mpi@febiyona-virtual-machine:~$ 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 115 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
Get:1 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 libevent-core-2.1-7 amd64 2.1.12-stable-1build3 [93,9 kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 libnfsidmap1 amd64 1:2.6.1-1ubuntu1.2 [42,9 kB]
Get:3 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 rpcbind amd64 1.2.6-2build1 [46,6 kB]
Get:4 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 keyutils amd64 1.6.1-2ubuntu3 [50,4 kB]
Get:5 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 nfs-common amd64 1:2.6.1-1ubuntu1.2 [241 kB]
Fetched 475 kB in 0s (1.337 kB/s)
Selecting previously unselected package libevent-core-2.1-7:amd64.
(Reading database ... 164716 files and directories currently installed.)
Preparing to unpack .../libevent-core-2.1-7_2.1.12-stable-1build3_amd64.deb ...
Unpacking libevent-core-2.1-7:amd64 (2.1.12-stable-1build3) ...
Selecting previously unselected package libnfsidmap1:amd64.
Preparing to unpack .../libnfsidmap1_1%3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
Selecting previously unselected package rpcbind.
Preparing to unpack .../rpcbind_1.2.6-2build1_amd64.deb ...
Unpacking rpcbind (1.2.6-2build1) ...
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 .../nfs-common_1%3a2.6.1-1ubuntu1.2_amd64.deb ...
Unpacking nfs-common (1:2.6.1-1ubuntu1.2) ...
Setting up libnfsidmap1:amd64 (1:2.6.1-1ubuntu1.2) ...
Setting up rpcbind (1.2.6-2build1) ...
Created symlink /etc/systemd/system/multi-user.target.wants/rpcbind.service → /lib/systemd/system/rpcbind.service.
```

5. Mounting

- Sudo mount <server host>:<lokasi shared folder di server>lokasi shared folder di client>

```
mpi@mardaharyani-virtual-machine:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@mardaharyani-virtual-machine:~$
```

- MPI

1. Install MPI

- Pada Master

```
mpi@ubuntu:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common
  binutils-x86-64-linux-gnu cpp-8 gcc-8 gcc-8-base gcc-9 gfortran
  gfortran-8 gfortran-9 ibverbs-providers libasan5 libbinutils libc-dev-bin
  libc6 libc6-dbg libc6-dev libcaf-openmpi-3 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0
  libevent-core-2.1-7 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-8-dev
  libgcc-9-dev libgfortran-8-dev libgfortran-9-dev libgfortran5 libhwloc-dev
  libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1 liblsan0
  libltdl-dev libltdl7 libmpx2 libnl-3-200 libnl-3-dev libnl-genl-3-200
  libnl-route-3-200 libnl-route-3-dev libnuma-dev libopenmpi3 libpmix2
  libpsm-infinipath1 libpsm2-2 libquadmath0 librdmacm1 libsigsegv2 libtool
  libtsan0 libubsan1 libxnvctrl0 linux-libc-dev m4 manpages-dev
  ocl-icd-libopencl1 openmpi-common
Suggested packages:
  autoconf-archive gnu-standards autoconf-doc gettext binutils-doc
  gcc-8-locales gcc-multilib make flex bison gcc-doc gcc-8-multilib gcc-8-doc
  gcc-9-multilib gcc-9-doc libstdc++-9-dev libstdc++-6-dev gcc-8-multilib gcc-8-doc
```


- Pada Worker1

```
mpi@mardaharyani-virtual-machine:~$ 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:
  autoconf-archive gnu-standards autoconf-doc gettext binutils-doc gcc-multilib make flex
  bison gcc-doc gcc-11-multilib gcc-11-doc gcc-11-locales gfortran-multilib gfortran-doc
  gfortran-11-multilib gfortran-11-doc apache2 | lighttpd | httpd glibc-doc
  libhwloc-contrib-plugins libjs-jquery-ui-docs libtool-doc openmpi-doc gcj-jdk m4-doc
  opencl-icd
The following NEW 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 libopenmpi-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-bin openmpi-common
  rpcsvc-proto zlib1g-dev
0 upgraded, 69 newly installed, 0 to remove and 2 not upgraded.
Need to get 64,1 MB of archives.
After this operation, 230 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 libsigsegv2 amd64 2.13-1ubuntu3 [14,6
kB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 m4 amd64 1.4.18-5ubuntu2 [199 kB]
```

- Pada Worker2

```
mpi@ubuntu:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common
  binutils-x86-64-linux-gnu cpp-8 gcc gcc-8 gcc-8-base gcc-9 gfortran
  gfortran-8 gfortran-9 ibverbs-providers libasan5 libbinutils libc-dev-bin
  libc6 libc6-dbg libc6-dev libcaf-openmpi-3 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0
  libevent-core-2.1-7 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-8-dev
  libgcc-9-dev libgfortran-8-dev libgfortran-9-dev libgfortran5 libhwloc-dev
  libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1 liblsan0
  libltdl-dev libltdl7 libmpx2 libnl-3-200 libnl-3-dev libnl-genl-3-200
  libnl-route-3-200 libnl-route-3-dev libnuma-dev libopenmpi3 libpmix2
  libpsm-infinipath1 libpsm2-2 libquadmath0 librdmacm1 libsigsegv2 libtool
  libtsan0 libubsan1 libxnvctrl0 linux-libc-dev m4 manpages-dev
  ocl-icd-libopencl1 openmpi-common
Suggested packages:
  autoconf-archive gnu-standards autoconf-doc gettext binutils-doc
  gcc-8-locales gcc-multilib make flex bison gcc-doc gcc-8-multilib gcc-8-doc
  gcc-9-multilib gcc-9-doc gcc-9-locales gfortran-multilib gfortran-doc
  gfortran-8-multilib gfortran-8-doc gfortran-9-multilib gfortran-9-doc
  glibc-doc libhwloc-contrib-plugins libtool-doc openmpi-doc gcj-jdk m4-doc
  opencl-icd
```


- Pada Worker3

```

mpi@febiyona-virtual-machine:~$ 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 libc6-dbg 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:
  autoconf-archive gnu-standards autoconf-doc gettext binutils-doc gcc-multilib make flex bison gcc-doc gcc-11-multilib gcc-11-doc
  gcc-11-locales gfortran-multilib gfortran-doc gfortran-11-multilib gfortran-11-doc apache2 | lighttpd | httpd glibc-doc
  libhwloc-contrib-plugins libjs-jquery-ui-docs libtool-doc openmpi-doc gcj-jdk m4-doc opencl-icd
Recommended packages:
  libnss-nis libnss-nisplus
The following NEW 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 libopenmpi-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-bin openmpi-common rpcsvc-proto zlib1g-dev
The following packages will be upgraded:
  libc6 libc6-dbg
2 upgraded, 69 newly installed, 0 to remove and 113 not upgraded.
Need to get 81,2 MB of archives.
After this operation, 230 MB 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 libc6-dbg amd64 2.35-0ubuntu3.4 [13,9 MB]
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates/main amd64 libc6 amd64 2.35-0ubuntu3.4 [3,234 kB]
Get:3 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 libsigsegv2 amd64 2.13-1ubuntu3 [14,6 kB]
Get:4 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 m4 amd64 1.4.18-Subunit2 [199 kB]
Get:5 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 autoconf all 2.71-2 [338 kB]
Get:6 http://id.archive.ubuntu.com/ubuntu jammy/main amd64 autotools-dev all 20220109.1 [44,9 kB]

```

2. Testing

- Touch test.py

```

mpi@ubuntu:~$ touch bubblesort.py
mpi@ubuntu:~$ sudo nano bubblesort.py
mpi@ubuntu:~$ sudo apt install python3-pip
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libllvm9 linux-modules-5.4.0-1002-oem
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  build-essential dpkg-dev fakeroot g++ g++-9 libalgorithm-diff-perl
  libalgorithm-diff-xs-perl libalgorithm-merge-perl libexpat1-dev libfakeroot
  libpython3-dev libpython3-stdlib libpython3.8-dev libstdc++-9-dev make
  python-pip-whl python3 python3-dev python3-distutils python3-lib2to3
  python3-minimal python3-setuptools python3-wheel python3.8-dev zlib1g-dev
Suggested packages:
  debian-keyring g++-multilib g++-9-multilib gcc-9-doc libstdc++-9-doc
  make-doc python3-doc python3-tk python3-venv python-setuptools-doc
The following NEW packages will be installed:
  build-essential dpkg-dev fakeroot g++ g++-9 libalgorithm-diff-perl
  libalgorithm-diff-xs-perl libalgorithm-merge-perl libexpat1-dev libfakeroot
  libpython3-dev libpython3.8-dev libstdc++-9-dev make python-pip-whl
  python3-dev python3-distutils python3-lib2to3 python3-pip
  python3-setuptools python3-wheel python3.8-dev zlib1g-dev
The following packages will be upgraded:
  libpython3-stdlib python3 python3-minimal
3 upgraded, 23 newly installed, 0 to remove and 351 not upgraded.

```

- Running MPI Program

1. Code program

```
GNU nano 6.2                                     bubbleshort.py *
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

# Contoh penggunaan:
arr = [64, 34, 25, 12, 22, 11, 90]
bubble_sort(arr)

print("Hasil setelah Bubble Sort:")
for i in range(len(arr)):
    print(arr[i], end=" ")
```

2. Eksekusi bubblesort di python3

- Menggunakan worker

```
Hasil setelah Bubble Sort:
11 12 22 25 34 64 90 Hasil setelah Bubble Sort:
11 12 22 25 34 64 90 mpi@mardaharyani-virtual-machine:~/cloud$
```