

LAPORAN EKSEKUSI BUBBLE SORT DENGAN OPEN MPI PADA UBUNTU DESKTOP

Disusun untuk memenuhi tugas Mata Kuliah Pemrosesan Paralel



Disusun Oleh :

Diki Riskiyanto

(09011282227111)

Dosen Pengampu :

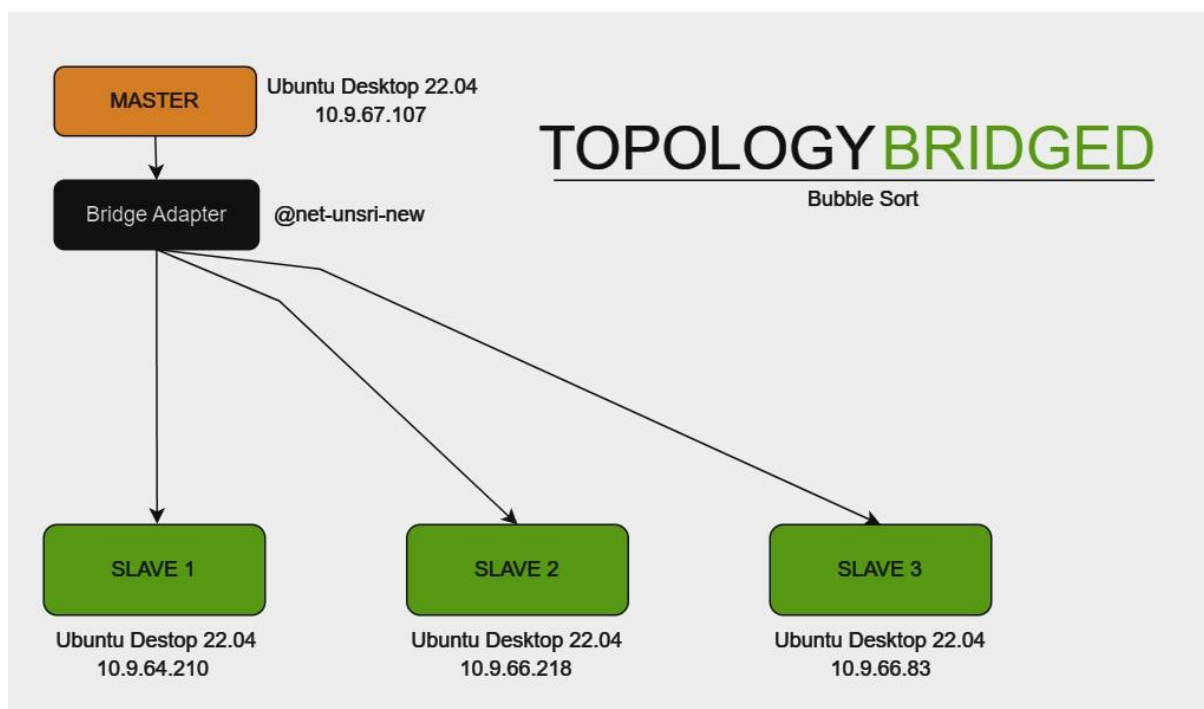
Adi Hermansyah, S.Kom., M.T.

**PROGRAM STUDI SISTEM KOMPUTER
FAKULTAS ILMU KOMPUTER
UNIVERSITAS SRIWIJAYA
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DEVICE DAN TOOLS YANG PERLU DISIAPKAN

1. Ubuntu Desktop
 - Ubuntu Desktop Master
 - Ubuntu Desktop Slave 1
 - Ubuntu Desktop Slave 2
 - Ubuntu Desktop Slave 3
2. MPI (Master dan Slave)
3. SSH (Master dan Slave)
4. NFS (Master dan Slave)
5. Kodingan Bubble Sort Python

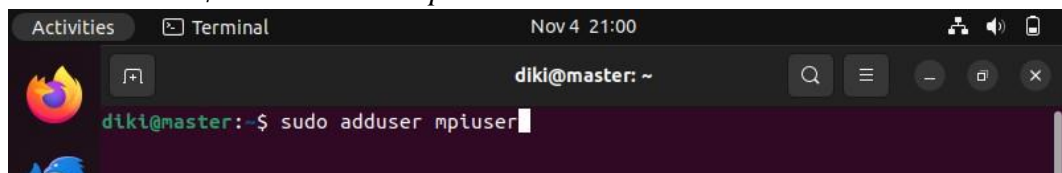
TOPOLOGI BRIDGED



PEMBUATAN MASTER DAN SLAVE

1. Sebelum menginstal pastikan master dan setiap slave menggunakan Network Bridge Adapter, dan menggunakan internet yang sama
2. Tentukanlah device mana yang sebagai master, slave1, slave2, slave3
3. Pertama, buatlah user baru dengan perintah dibawah ini

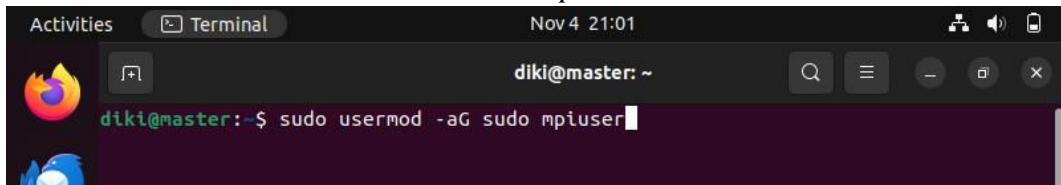
diki@master:~\$ `sudo adduser mpiuser`



Untuk dislave perintahnya sama, ganti bagian master menjadi slave1, slave2, dst.

4. Kemudian berikan akses kepada root dengan perintah dibawah ini

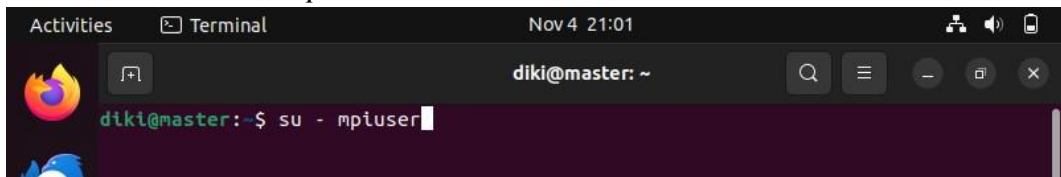
diki@master:~\$ sudo usermod -aG sudo mpiuser

A terminal window titled 'Terminal' with a timestamp of 'Nov 4 21:01'. The prompt is 'diki@master: ~'. The command 'sudo usermod -aG sudo mpiuser' is being typed at the prompt.

Lakukanlah perintah diatas disemua slave dengan merubah user master menjadi slave1, slave2, dst

5. Masuklah ke server dengan user dibawah ini dengan perintah berikut

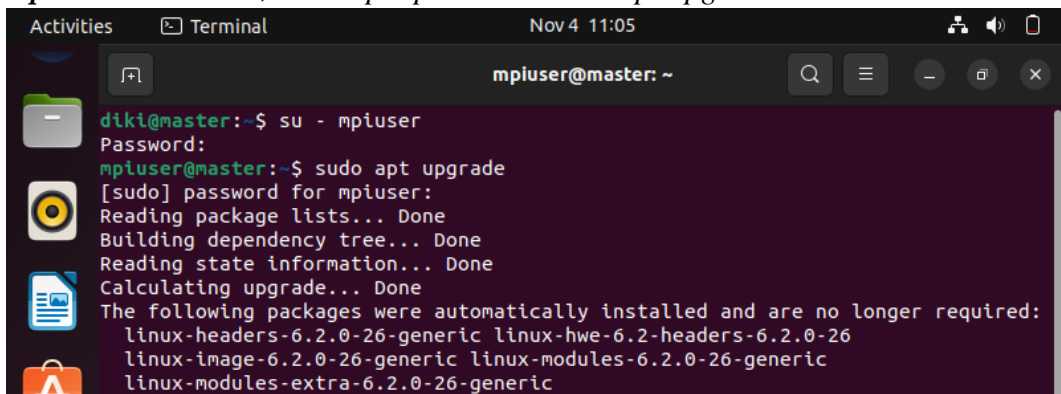
diki@master:~\$ su - mpiuser

A terminal window titled 'Terminal' with a timestamp of 'Nov 4 21:01'. The prompt is 'diki@master: ~'. The command 'su - mpiuser' is being typed at the prompt.

Menjadi *mpiuser@master:~\$*

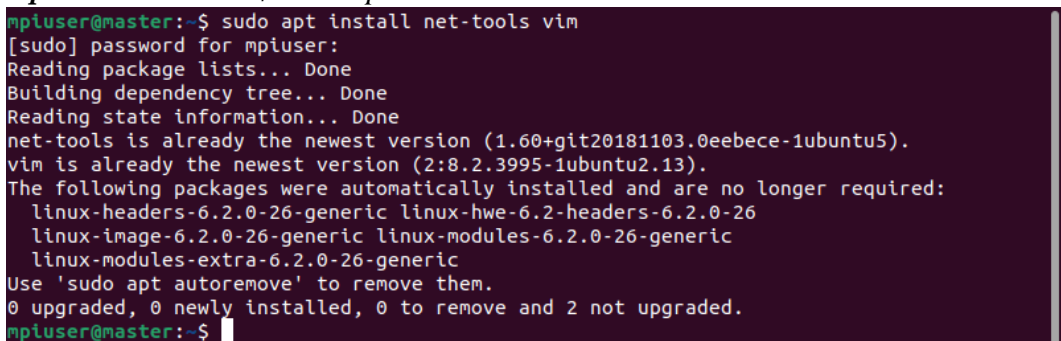
6. Langkah selanjutnya update ubuntu desktop dengan perintah berikut, lalu install tools untuk mengecek Ip, vim editor teks

mpiuser@master:~\$ sudo apt update && sudo apt upgrade

A terminal window titled 'Terminal' with a timestamp of 'Nov 4 11:05'. The prompt is 'mpiuser@master: ~'. The output of the command 'sudo apt update && sudo apt upgrade' is shown, including package lists, dependency tree, and a list of packages to be removed: linux-headers-6.2.0-26-generic, linux-hwe-6.2-headers-6.2.0-26, linux-image-6.2.0-26-generic, linux-modules-6.2.0-26-generic, and linux-modules-extra-6.2.0-26-generic.

Selanjutnya install tools dengan perintah dibawah ini

mpiuser@master:~\$ sudo apt install net-tools vim

A terminal window titled 'Terminal' with a timestamp of 'Nov 4 11:05'. The prompt is 'mpiuser@master: ~'. The output of the command 'sudo apt install net-tools vim' is shown, indicating that net-tools and vim are already the newest versions and that several packages will be removed: linux-headers-6.2.0-26-generic, linux-hwe-6.2-headers-6.2.0-26, linux-image-6.2.0-26-generic, linux-modules-6.2.0-26-generic, and linux-modules-extra-6.2.0-26-generic.

7. Selanjutnya konfigurasi file pada master, slave1, slave2, dan slave3

mpiuser@master:~\$ sudo nano /etc/hosts

MASTER

```
Activities Terminal Nov 4 13:22
mpiuser@master: ~
GNU nano 6.2 /etc/hosts
127.0.0.1 localhost
10.9.67.107 master
10.9.64.210 slave1
10.9.66.218 slave2
10.9.64.83 slave3
# 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
```

SLAVE 1

```
Nov 4 12:29
mpiuser@slave1: /etc
GNU nano 7.2 /etc/hosts
127.0.0.1 localhost
10.9.67.107 master
10.9.64.210 slave1
10.9.66.218 slave2
10.9.64.83 slave3
# 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
```

SLAVE 2

```
Activities Terminal Nov 4 11:21
mpiuser@slave2: ~
GNU nano 6.2 /etc/hosts
127.0.0.1 localhost
127.0.1.1 nauval-VirtualBox
10.9.67.107 master
10.9.64.210 slave1
10.9.66.218 slave2
10.9.64.83 slave3
# 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
```

SLAVE 3

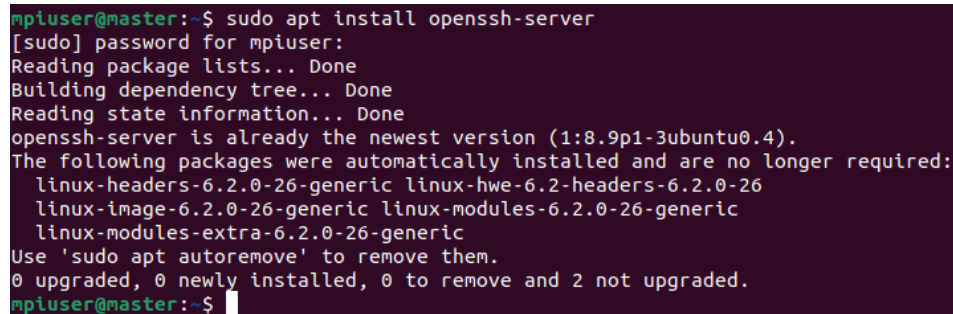
```
Activities Terminal Nov 4 11:41
fakhrinewtz@slave3: ~
GNU nano 6.2 /etc/hosts
127.0.0.1 localhost
10.9.67.107 master
10.9.64.210 slave1
10.9.66.218 slave2
10.9.64.83 slave3
# The following lines are desirable for IPv6 capable hosts
::1 ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
```

Daftarkan IP Master dan Slave berserta hostname masing masing komputer

KONFIGURASI SSH

1. Langkah berikutnya kita akan konfigurasi SSH, pertama kita install SSH. Lakukan pada master dan semua slave

mpiuser@master:~\$ sudo apt install openssh-server

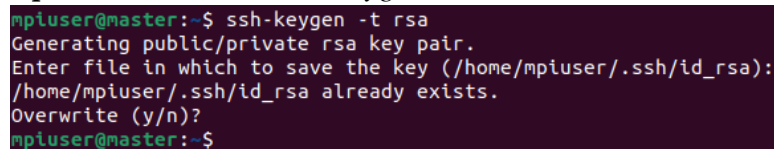


```
mpiuser@master:~$ sudo apt install openssh-server
[sudo] password for mpiuser:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
openssh-server is already the newest version (1:8.9p1-3ubuntu0.4).
The following packages were automatically installed and are no longer required:
  linux-headers-6.2.0-26-generic linux-hwe-6.2-headers-6.2.0-26
  linux-image-6.2.0-26-generic linux-modules-6.2.0-26-generic
  linux-modules-extra-6.2.0-26-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@master:~$
```

Pastikan semua slave menginstall OpenSSH server sampai selesai dan berhasil

2. Generate key lakukan pada master saja dengan perintah berikut

mpiuser@master:~\$ ssh-keygen -t rsa

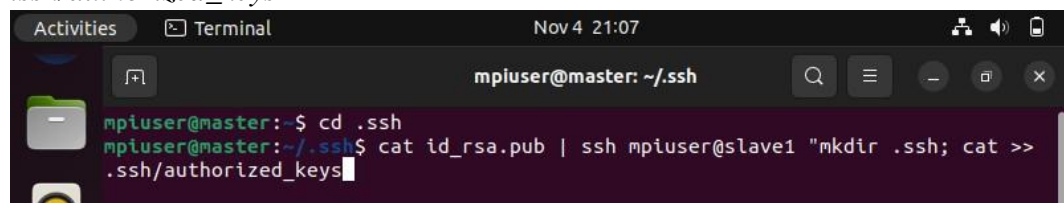


```
mpiuser@master:~$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/mpiuser/.ssh/id_rsa):
/home/mpiuser/.ssh/id_rsa already exists.
Overwrite (y/n)?
mpiuser@master:~$
```

3. Copy key public ke slave (Lakukan di Master), ketikkan perintah berikut pada direktori “.ssh”

mpiuser@master:~\$ cd .ssh

mpiuser@master:~/.ssh\$ cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"




```
Activities Terminal Nov 4 21:07
mpiuser@master: ~/.ssh
mpiuser@master:~$ cd .ssh
mpiuser@master:~/.ssh$ cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"
```

Lakukan perintah diatas berulang kali sebanyak slave, untuk pengecekan file authorized_keys di slave, yang terletak di folder .ssh

KONFIGURASI NFS

1. Buatlah shared folder, lakukanlah dimaster dan per slave

mpiuser@master:~\$ mkdir bubble



```
File Edit View Search Terminal Help
mpiuser@master:~$ mkdir bubble
mpiuser@master:~$
```

2. Selanjutnya install NFS untuk master

mpiuser@master:~\$ sudo apt install nfs-kernel-server

```
File Edit View Search Terminal Help
mpiuser@master:~$ sudo apt install nfs-kernel-server
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
nfs-kernel-server is already the newest version (1:2.6.1-1ubuntu1.2).
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@master:~$
```

3. Lakukan konfigurasi file pada master, masuk ke file export dengan perintah

mpiuser@master:~\$ sudo vim /etc/exports

```
File Edit View Search Terminal Help
mpiuser@master:~$ sudo vim /etc/exports
```

Konfigurasi file tambahkan commend ini pada baris berikut, ketikkan pada baris terakhir.

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

```
File Edit View Search Terminal Help
# /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_
#               ck)
#
# 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/mpiuser/bubble *(rw,sync,no_root_squash,no_subtree_check)
~
~
~
```

Lokasi Shared Folder merupakan tempat direktori membuat file diatas tadi

4. Kemudian ketikkan perintah berikut ini, untuk memulai kembali atau merestart NFS Server

mpiuser@master:~\$ sudo exportfs -a

mpiuser@master:~\$ sudo systemctl restart nfs-kernel-server

```
File Edit View Search Terminal Help
mpiuser@master:~$ sudo exportfs -a
mpiuser@master:~$ sudo systemctl restart nfs-kernel-server
mpiuser@master:~$
```

5. Selanjutnya install NFS untuk slave

mpiuser@slave1:~\$ sudo apt install nfs-common

```
mpiuser@slave1:~$ sudo apt install nfs-common
[sudo] password for mpiuser:
```

mpiuser@slave2:~\$ sudo apt install nfs-common

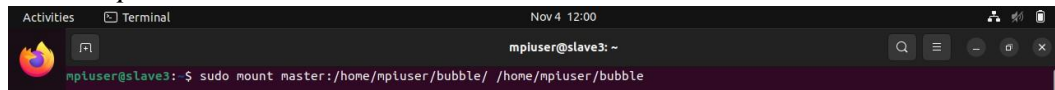
mpiuser@slave2:~\$ sudo apt install nfs-common

mpiuser@slave3:~\$ sudo apt install nfs-common

```
Activities Terminal Nov 4 11:58
mpiuser@slave3: ~/bubble
mpiuser@slave3:~/bubble$ sudo apt install nfs-common
```


6. Kemudian Mounting, lakukanlah pada semua slave
mpiuser@slave1:~\$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble

```
mpiuser@slave1:~$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
mpiuser@slave2:~$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
mpiuser@slave2:~$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
mpiuser@slave3:~$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
```



INSTALASI MPI

1. Instalasi MPI, lakukan pada master dan semua slave
mpiuser@master:~\$ sudo apt install openmpi-bin libopenmpi-dev

```
File Edit View Search Terminal Help
mpiuser@master:~$ 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 2 not upgraded.
mpiuser@master:~$
```

2. Selanjutnya install library untuk MPI melalui pip
mpiuser@master:~\$ sudo apt install python3-pip
mpiuser@master:~\$ pip install mpi4py

```
File Edit View Search Terminal Help
mpiuser@master:~$ sudo apt install python3-pip
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
python3-pip is already the newest version (22.0.2+dfsg-1ubuntu0.3).
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@master:~$ pip install mpi4py
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: mpi4py in ./local/lib/python3.10/site-packages (3.1.5)
mpiuser@master:~$
```

RUNNING KONDINGAN PYTHON

1. Buatlah sebuah file python baru dengan cara masukkan perintah dibawah ini
mpiuser@master:~\$ touch /mpiuser/bubble/bubble.py

```
Activities Terminal Nov 4 21:03
mpiuser@master: ~/bubble
mpiuser@master:~/bubble$ ls -l
total 4
-rw-rw-r-- 1 mpiuser mpiuser 448 Nov  4 12:34 bubble.py
mpiuser@master:~/bubble$
```

2. Selanjutnya masuk ke direktori tersebut lalu edit file python dan buatlah sebuah kodingan bubble sort python

```
mpiuser@master:~$ cd bubble
```

```
mpiuser@master:~/bubble$ nano bubble.py
```

```
File Edit View Search Terminal Help
mpiuser@master:~/bubble$ cd
mpiuser@master:~$ cd bubble
mpiuser@master:~/bubble$ nano bubble.py
mpiuser@master:~/bubble$
```

Lalu buatlah kodingan bubble sort (Jangan lupa disave “CTRL + X”)

```
GNU nano 6.2 bubble.py
from mpi4py import MPI

def parallel_bubble_sort(arr):
    comm = MPI.COMM_WORLD
    rank = comm.Get_rank()
    size = comm.Get_size()

    local_arr = arr[rank::size]

    for i in range(len(local_arr)):
        for j in range(0, len(local_arr) - i - 1):
            if local_arr[j] > local_arr[j + 1]:
                local_arr[j], local_arr[j + 1] = local_arr[j + 1], local_arr[j]

    sorted_arr = comm.gather(local_arr, root=0)

    if rank == 0:
        combined_arr = [item for sublist in sorted_arr for item in sublist]
        combined_arr.sort()
        for i in range(len(arr)):
            arr[i] = combined_arr[i]

if __name__ == '__main__':
    comm = MPI.COMM_WORLD
    rank = comm.Get_rank()

    if rank == 0:
        arr = [5, 3, 4, 1, 2]
    else:
        arr = None

    arr = comm.bcast(arr, root=0) # Broadcast the arr from rank 0 to all nodes

    comm.barrier()

    parallel_bubble_sort(arr)

    if rank == 0:
        print(f"List sorted with bubble sort in ascending order: {arr}")
```

3. Jalankan kodingan tersebut pada master

```
mpiuser@master:~/bubble$ mpirun -np 4 -host master,slave1,slave2,slave3 python3
bubble.py
```

```
mpiuser@master:~/bubble$ mpirun -np 4 -host master,slave1,slave2,slave3 python3
bubble.py
List sorted with bubble sort in ascending order: [1, 2, 3, 4, 5]
List sorted with bubble sort in ascending order: [1, 2, 3, 4, 5]
List sorted with bubble sort in ascending order: [1, 2, 3, 4, 5]
List sorted with bubble sort in ascending order: [1, 2, 3, 4, 5]
```

Jika sudah keluar output seperti ini sudah berhasil, mengeluarkan output disemua master dan slave, outputnya menjadi 4 yaitu output dari master, slave1, slave2, slave3. Jadi yang kami urutkan disini berupa array : [5, 3, 4, 1, 2] diurutkan menjadi [1, 2, 3, 4, 5].

