

LAPORAN EKSEKUSI BUBBLE SORT DENGAN OPEN MPI PADA UBUNTU DESKTOP

Disusun untuk memenuhi tugas Mata Kuliah Pemrosesan Paralel



Disusun Oleh :

Nama : Fakhri Naufal Dhaifullah
NIM : 09011282227108
Kelas : SK5C
Mata Kuliah : Pemrosesan Paralel

Dosen Pengampu :

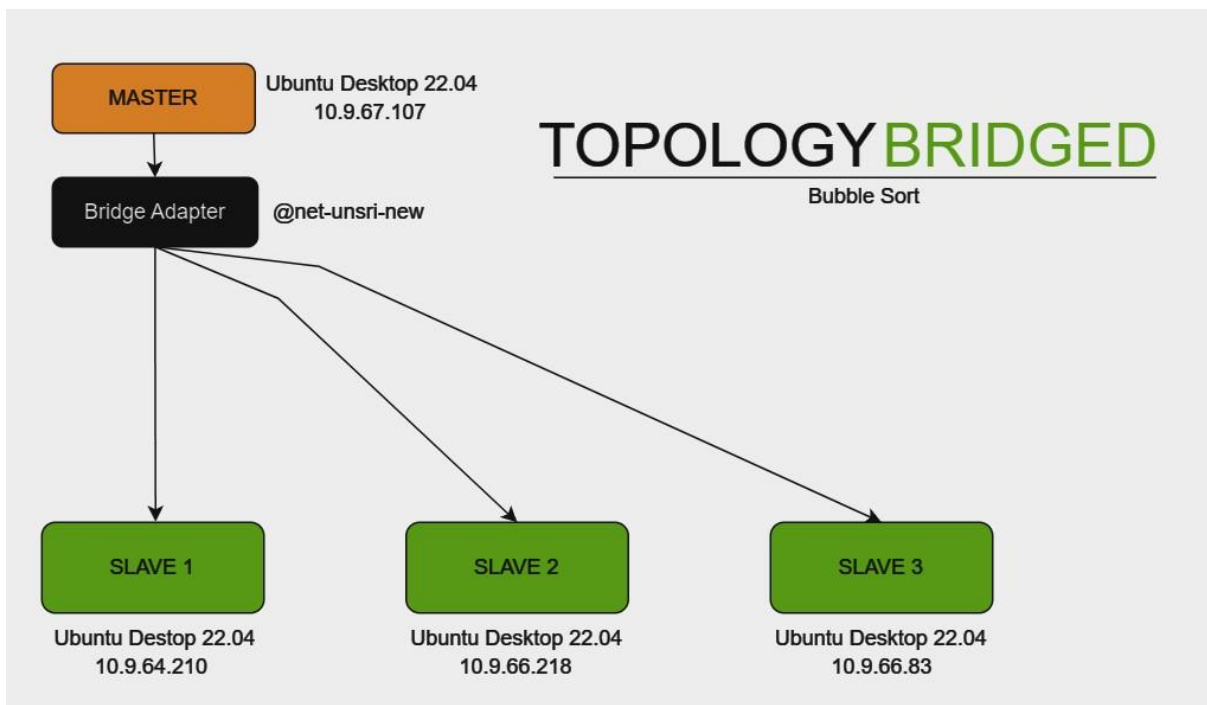
Adi Hermansyah, S.Kom., M.T.

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

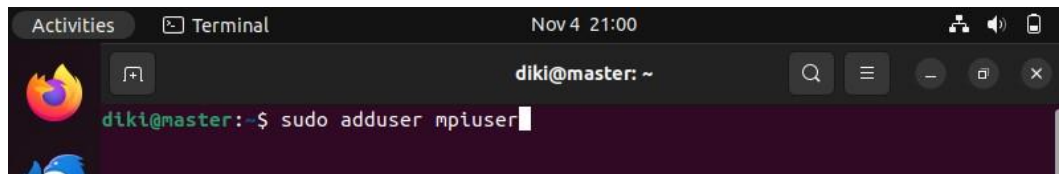
1. Ubuntu Desktop
 - Ubuntu Desktop Master
 - Ubuntu Desktop Slave 1
 - Ubuntu Desktop Slave 2
 - Ubuntu Desktop Slave 3
2. MPI (Master dan Slave)
3. SSH (Master dan Slave)
4. NFS (Master dan Slave)
5. Kodingan Bubble Sort Python

TOPOLOGI BRIDGED



PEMBUATAN MASTER DAN SLAVE

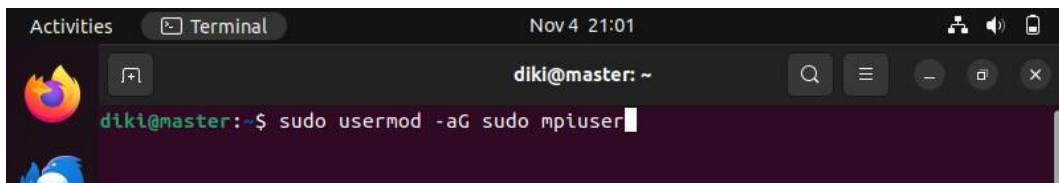
1. Sebelum menginstal pastikan master dan setiap slave menggunakan Network Bridge Adapter, dan menggunakan internet yang sama
2. Tentukanlah device mana yang sebagai master, slave1, slave2, slave3
3. Pertama, buatlah user baru dengan perintah dibawah ini *diki@master:~\$ sudo adduser mpiuser*



```
Activities Terminal Nov 4 21:00
diki@master: ~
diki@master:~$ sudo adduser mpiuser
```

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

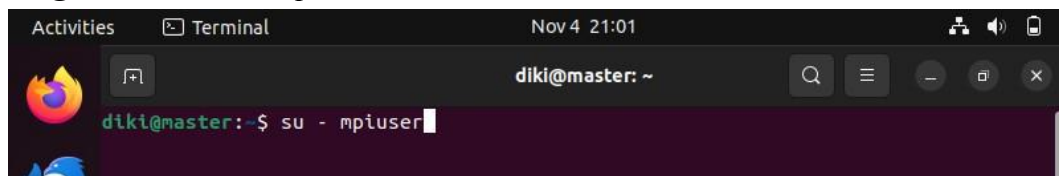
4. Kemudian berikan akses kepada root dengan perintah dibawah ini *diki@master:~\$ sudo usermod -aG sudo mpiuser*



```
Activities Terminal Nov 4 21:01
diki@master: ~
diki@master:~$ sudo usermod -aG sudo mpiuser
```

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

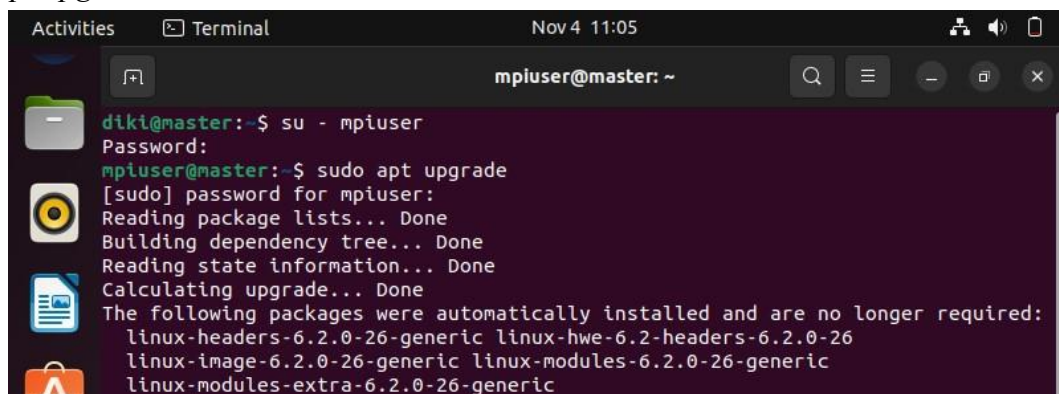
5. Masuklah ke server dengan user dibawah ini dengan perintah berikut *diki@master:~\$ su - mpiuser*



```
Activities Terminal Nov 4 21:01
diki@master: ~
diki@master:~$ su - mpiuser
```

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*



```
Activities Terminal Nov 4 11:05
mpiuser@master: ~
diki@master:~$ su - mpiuser
Password:
mpiuser@master:~$ sudo apt update
[sudo] password for mpiuser:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
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
```

Selanjutnya install tools dengan perintah dibawah ini *mpiuser@master:~\$ sudo apt install net-tools vim*

```

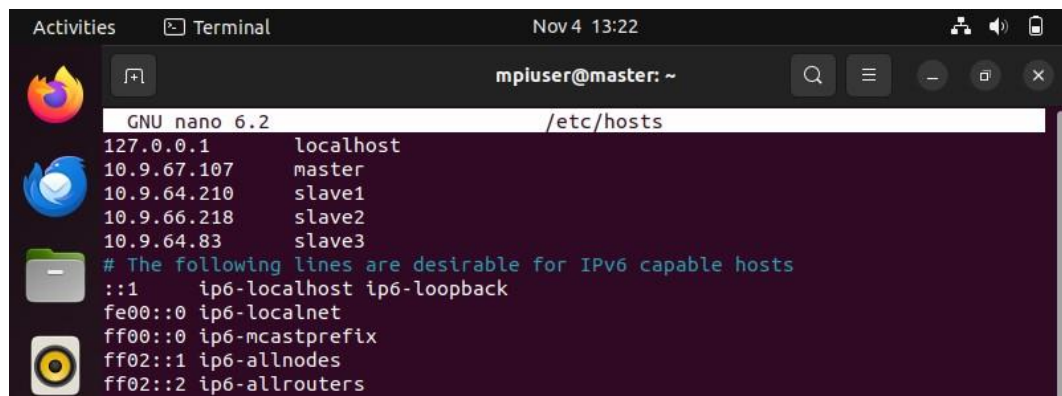
mpiuser@master:~$ sudo apt install net-tools vim
[sudo] password for mpiuser:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
net-tools is already the newest version (1.60+git20181103.0eebece-1ubuntu5).
vim is already the newest version (2:8.2.3995-1ubuntu2.13).
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:~$

```

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

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

MASTER

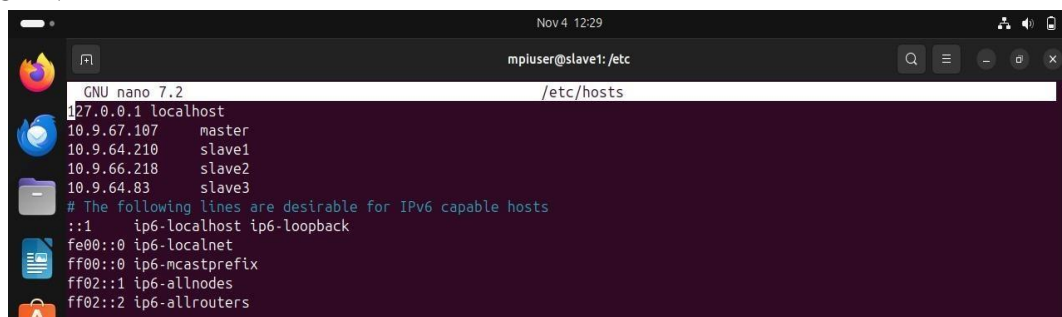


```

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
mpluser@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 beserta 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-6.2.0-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

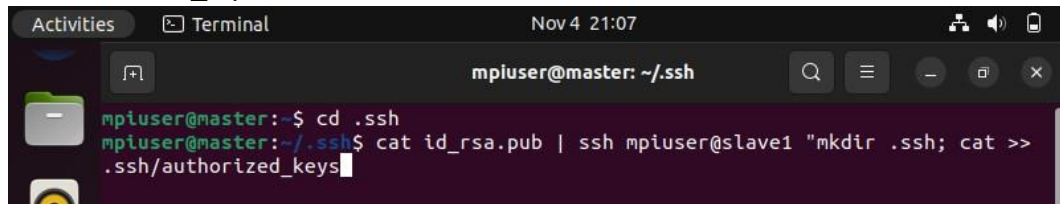
2. Generate key lakukan pada master saja dengan perintah berikut

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"

A terminal window titled 'Terminal' with a timestamp of 'Nov 4 21:07'. The prompt is 'mpiuser@master: ~/.ssh'. The user enters 'cd .ssh' and then 'cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"'.

```
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`

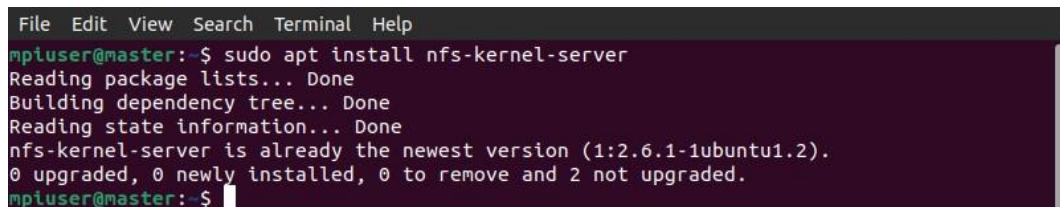
KONFIGURASI NFS

1. Buatlah shared folder, lakukanlah dimaster dan per slave ***mpiuser@master:~\$ mkdir bubble***

A terminal window with a menu bar (File, Edit, View, Search, Terminal, Help). The prompt is 'mpiuser@master:~\$'. The user enters 'mkdir bubble' and the prompt returns to 'mpiuser@master:~\$'.

```
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***

A terminal window with a menu bar (File, Edit, View, Search, Terminal, Help). The prompt is 'mpiuser@master:~\$'. The user enters 'sudo apt install nfs-kernel-server'. The output shows package lists, dependency tree, and state information. The prompt returns to 'mpiuser@master:~\$'.

```
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/export***

A terminal window with a menu bar (File, Edit, View, Search, Terminal, Help). The prompt is 'mpiuser@master:~\$'. The user enters '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
```

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

```
Activities Terminal Nov 4 12:00
mpiuser@slave3: ~
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 KODINGAN 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].