

LAPORAN PRAKTIKUM ARSIKOM

(Arsitektur dan Organisasi Komputer)



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FAKULTAS ILMU KOMPUTER

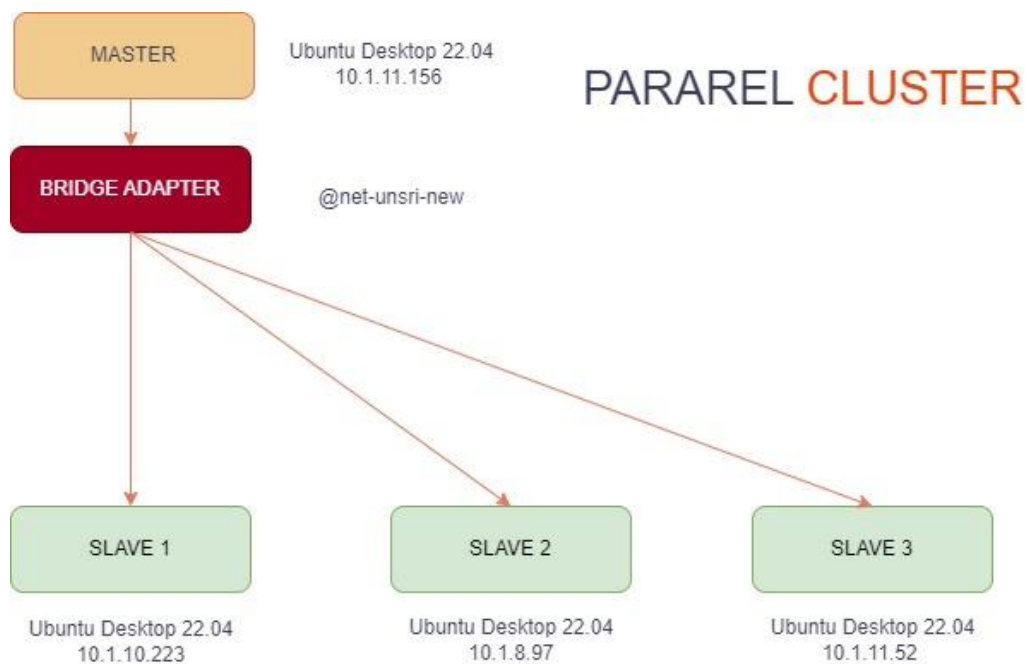
UNIVERSITAS SRIWIJAYA

PALEMBANG 2023

Device Dan Tools Yang di gunakan:

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. Codingan numerik python

Topology :



Pada percobaan kali ini digunakan empat komputer, dimana satu komputer sebagai master, dan tiga komputer lainnya sebagai slave. Pastikan sudah berada dalam satu jaringan yang sama.

Kemudian pada pengekseskuan ini terdapat komputer yaitu master (pipop-VirtualBox), dan 3 komputer lainnya yaitu (dayat-VirtualBox) sebagai slave1, (pio-VirtualBox) sebagai slave2, (zizi) sebagai slave3. Dan pengekseskuan ini bertujuan untuk computing.

• Konfigurasi file /etc/hosts

Lakukan pada master dan slave:

Edit file `/etc/hosts` melalui nano. Tambahkan isinya dengan beberapa IP dan aliasny. Di bawahini sebagai contoh. sesuaikan IP nya dengankomputer masing-masing. Untuk mengecek IP gunakan perintah `ifconfig`.

Tambahkan baris berikut dengan format

```
[10.1.11.156] [pipop-VirtualBox]
[10.1.10.223] [dayat-VirtualBox]
[10.1.8.97]   [pio-VirtualBox]
[10.1.11.52] [zizi]
```

Lakukan disetiap komputer.

Master:

```
127.0.0.1      localhost
127.0.1.1      pipop-VirtualBox

10.1.11.156 master
10.1.10.223 slave1
10.1.8.197  slave2
10.1.11.52  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
```

Slave1:

```
GNU nano 6.2 /etc/hosts
127.0.0.1      localhost
127.0.1.1      dayat-VirtualBox
10.1.11.156 master
10.1.10.233 slave1
10.1.8.197 slave2
10.1.11.52 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
```

Slave2:

GNU nano 6.2

```
27.0.0.1      localhost
27.0.1.1      pio-VirtualBox
```

```
0.1.11.156 master
0.1.10.223 slave1
0.1.8.197  slave2
0.1.11.52  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
```

Slave3:

```
mpiuserr@zizi: ~  
GNU nano 6.2 /etc/hosts  
127.0.0.1 localhost  
127.0.1.1 zizi  
  
10.1.11.156 master  
10.1.10.223 slave1  
10.1.8.197 slave2  
10.1.11.52 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
```

- **Buat User Baru**

1. **Buat user**

Buat user baru di master dan slave dengan perintah berikut:

`Sudo adduser <nama user>`

Pada percobaan ini digunakan nama user mpiuser. Nama user harus sama pada komputer master dan slave.

Master:

```
pipop@pipop-VirtualBox:~$ sudo adduser mpiuser  
[sudo] password for pipop:  
Adding user 'mpiuser' ...  
Adding new group 'mpiuser' (1002) ...  
Adding new user 'mpiuser' (1002) with group 'mpiuser' ...  
Creating home directory '/home/mpiuser' ...  
Copying files from '/etc/skel' ...  
New password:  
BAD PASSWORD: The password is a palindrome  
Retype new password:  
passwd: password updated successfully  
Changing the user information for mpiuser  
Enter the new value, or press ENTER for the default  
Full Name []:  
Room Number []:  
Work Phone []:  
Home Phone []:  
Other []:  
Is the information correct? [Y/n] y  
pipop@pipop-VirtualBox:~$
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo adduser mpiuser  
[sudo] password for mpiuser:
```

Slave2:

```
pio@pio-VirtualBox:~$ sudo adduser mpiuser
```

Slave3:

```
zizi@zizi:~$ sudo adduser mpiuser  
[sudo] password for zizi:
```

2. Memberi akses root ke user

Lakukan di master dan slave dengan perintah berikut:

```
Sudo usermod -aG sudo mpiuser
```

Perintah ini akan menjadikan user `mpiuser` akan memiliki hak akses superuser.

Master:

```
mpiuser@pipop-VirtualBox:~$ sudo usermod -aG sudo mpiuser
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo usermod -aG sudo mpiuser
```

Slave2:

```
pio@pio-VirtualBox:~$ sudo usermod -aG sudo mpiuser
```

Slave3:

```
zizi@zizi:~$ sudo usermod -aG sudo mpiuser
```


3. Masuk ke user

Lakukan di master dan slave dengan perintah berikut:

```
su - mpiuser
```

Master:

```
pipop@pipop-VirtualBox:~$ su - mpiuser  
Password:  
mpiuser@pipop-VirtualBox:~$
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo adduser mpiuser  
[sudo] password for mpiuser:
```

Slave2:

```
pio@pio-VirtualBox:~$ su - mpiuser  
Password:  
mpiuser@pio-VirtualBox:~$
```

Slave3:

```
zizi@zizi:~$ su - mpiuser  
Password:
```

- Meng update Ubuntu Dekstop dan Menginstall tools

1. Update dan Upgrade

Master:

```
mpiuser@pipop-VirtualBox:~$ sudo apt update && sudo apt upgrade
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo apt update && sudo apt upgrade  
Hit:1 http://id.archive.ubuntu.com/ubuntu jammy InRelease  
Get:2 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]  
Hit:3 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease  
Get:4 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]  
Reading package lists... Done
```

Slave2:

```
mpiuser@pio-VirtualBox:~$ sudo apt update && sudo apt upgrade
```

Slave3:

```
mpiuser@zizi:~$ sudo apt update && sudo apt upgrade  
[sudo] password for mpiuser:
```

2. Install net-tools

Master:

```
mpiuser@pipop-VirtualBox:~$ sudo apt install net-tools vim
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo apt install net-tools vim
```

Slave2:

```
appted.
mpiuser@pio-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).
Suggested packages:
  ctags vim-doc vim-scripts
The following NEW packages will be installed:
  vim vim-runtime
```

Slave3:

```
mpiuser@zizi:~$ 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 2 not upgraded.
```

- Konfigurasi file pada master, slave1, slave2, dan slave3. Daftarkan IP dan nama host setiap komputer

Master:

```
mpiuser@pipop-VirtualBox:~$ sudo nano /etc/hosts
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo nano /etc/hosts
```

Slave2:

```
mpiuser@pio-VirtualBox:~$ sudo nano /etc/hosts
[sudo] password for mpiuser:
mpiuser@pio-VirtualBox:~$
```

Slave3:

```
mpiuser@zizi:~$ nano /etc/hosts
```

- Konfigurasi SSH

Setelah masuk ke user, lakukan konfigurasi SSH.

1. Install SSH

Lakukan di master dan slave:

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

Perintah tersebut akan menginstal perangkat lunak OpenSSH Server pada sistem jika belum terinstal, sehingga Anda dapat menggunakan layanan SSH untuk mengakses dan mengelola sistem secara remote dengan aman.

Master:

```
mpiuser@pipop-VirtualBox:~$ sudo apt install openssh-server
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo apt install openssh-server
```

Slave2:

```
mpiuser@pio-VirtualBox:~$ 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 5 not upgraded.
```

Slave3:

```
mpiuser@zizi:~$ 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 2 not upgraded.
```

2. Generate Keygen

Lakukan di master:

```
Ssh-keygen -t rsa
```

Perintah ini akan membuat kunci SSH baru.

Master:

```
mpiuserr@pipop-VirtualBox:~$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/mpiuserr/.ssh/id_rsa):
Created directory '/home/mpiuserr/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/mpiuserr/.ssh/id_rsa
Your public key has been saved in /home/mpiuserr/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:v5ck1V0p2qLLnEzMZJQuqAl2eAAkqPIUhRf8lA9aPIM mpiuserr@pipop-Virt
ualBox
The key's randomart image is:
+---[RSA 3072]-----+
|=. +o+ . .|
|+ o E 0 . ..|
|.. o = = o ...|
|o + . o + ..o|
|.* o . .S+ .o .|
|. = o *..o..|
| o +oo..|
| =...o|
| *o.|
+-----[SHA256]-----+
mpiuserr@pipop-VirtualBox:~$
```

3. Copy key publikkeslave

Lakukan di master:

Salin isidari file id_rsa.pub ke file authorized_keys ke semua slave menggunakan perintah berikut:

```
cd .ssh
cat id_rsa.pub | ssh <nama user>@<host>"mkdir .ssh; cat >>
.ssh/authorized_keys"
```

Lakukan penyalinan perintah berulang-ulang dari master ke slave dengan mengubah <host> menjadi nama host masing-masing slave.

master:

```
mpiusr@iren-VirtualBox:~$ cd .ssh
mpiusr@iren-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh mpiusr@slave1 "mkdir .ssh; cat
>> .ssh/authorized_keys"
The authenticity of host 'slave1 (10.8.143.246)' can't be established.
ED25519 key fingerprint is SHA256:i3W9XltXakgQMvuygRIJCq1pJvp4fbNV5xb5tRjxx30.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'slave1' (ED25519) to the list of known hosts.
mpiusr@slave1's password:
mpiusr@iren-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh mpiusr@slave2 "mkdir .ssh; cat
>> .ssh/authorized_keys"
The authenticity of host 'slave2 (10.8.143.239)' can't be established.
ED25519 key fingerprint is SHA256:iQoC++ukX96//9w25AGLTFJPUpeN0YvW74zvCCmunfk.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'slave2' (ED25519) to the list of known hosts.
mpiusr@slave2's password:
mpiusr@iren-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh mpiusr@slave3 "mkdir .ssh; cat
>> .ssh/authorized_keys"
The authenticity of host 'slave3 (10.8.143.46)' can't be established.
ED25519 key fingerprint is SHA256:RHIMsW7Y5zi01fGepVdFwgKOp7qoNRaSpr14U25LvRI.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'slave3' (ED25519) to the list of known hosts.
mpiusr@slave3's password:
```

Dengan membagikan kunci SSH, master akan dapat mengakses server slave jarak jauh dengan aman tanpa perlu memasukkan kata sandi setiap kali.

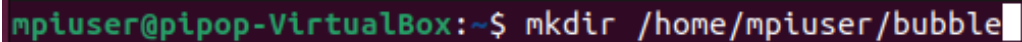
- **Konfigurasi NFS**

- 1. Buat shared folder**

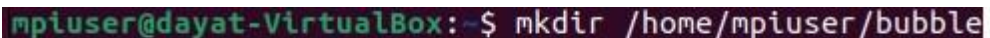
Lakukan di master dan slave dengan perintah mkdir :

```
mkdir /home/mpiuser/bubble
```

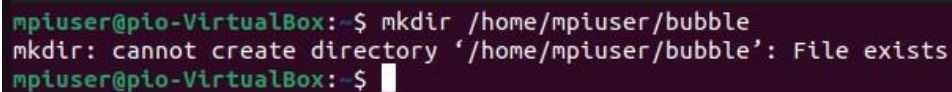
master:

A terminal window showing the command 'mkdir /home/mpiuser/bubble' being executed successfully on the master node. The prompt is 'mpiuser@pipop-VirtualBox:~\$'.

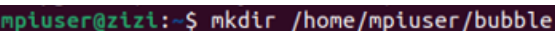
Slave1:

A terminal window showing the command 'mkdir /home/mpiuser/bubble' being executed successfully on Slave1. The prompt is 'mpiuser@dayat-VirtualBox:~\$'.

Slave2:

A terminal window showing the command 'mkdir /home/mpiuser/bubble' being executed on Slave2. It results in an error: 'mkdir: cannot create directory '/home/mpiuser/bubble': File exists'. The prompt is 'mpiuser@pio-VirtualBox:~\$'.

Slave3:

A terminal window showing the command 'mkdir /home/mpiuser/bubble' being executed on Slave3. The prompt is 'mpiuser@zizi:~\$'.

- 2. Install NFS Server**

Lakukan di master:

```
sudo apt install nfs-kernel-server
```

Perintah ini akan menginstall paket `nfs-kernel-server` pada master agar dapat berbagi direktori atau sistem berkas dengan slave.

- 3. Konfigurasi file /etc/exports**

Lakukan di master:

Edit file `/etc/exports` dengan editor nano

```
sudo nano /etc/exports
```

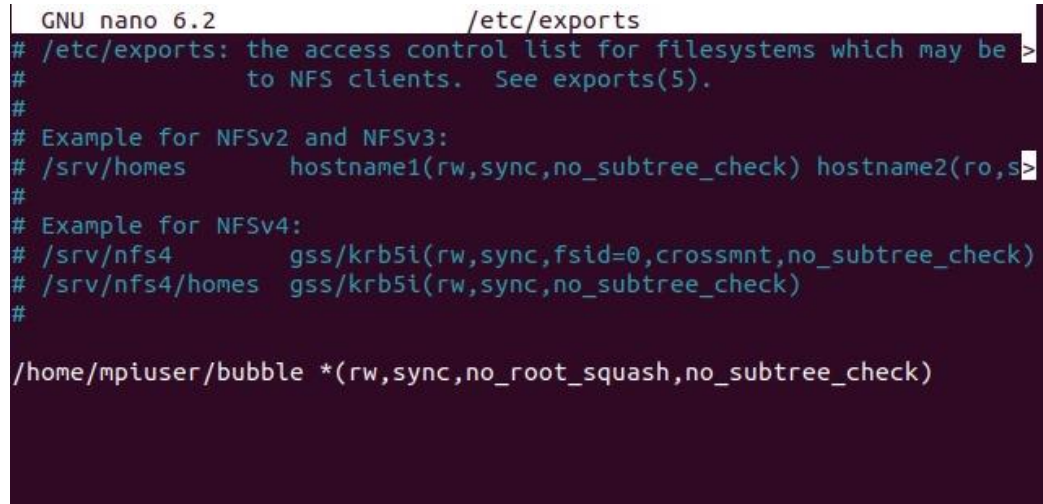
tambahkan baris berikut.

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

Sesuaikan <lokasi shared folder> dengan lokasi folder yang telah dibuat:

```
/home/mpiusr/wa  
*(rw, sync, no_root_squash, no_subtree_check)
```

Master:



```
GNU nano 6.2 /etc/exports  
# /etc/exports: the access control list for filesystems which may be  
# to NFS clients. See exports(5).  
#  
# Example for NFSv2 and NFSv3:  
# /srv/homes hostname1(rw, sync, no_subtree_check) hostname2(ro, s  
#  
# 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)
```

Lakukan perintah berikut untuk memastikan bahwa perubahan konfigurasi yang dilakukan dalam file `/etc/exports` diterapkan tanpa harus memulai ulang layanan NFS.

```
Sudo exportfs -a
```

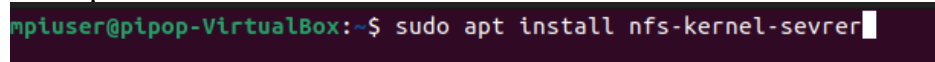
Jalankan perintah ini untuk memuat ulang layanan server NFS dan menerapkan perubahan konfigurasi terbaru dalam file konfigurasi `/etc/exports`.

```
Sudo systemctl restart nfs-kernel-server
```

4. Install NFS

Lakukan di Master dengan perintah berikut:

```
sudo apt install nfs-kernel-server
```



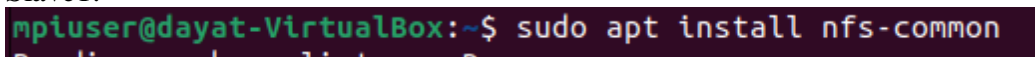
```
mpiuser@pipop-VirtualBox:~$ sudo apt install nfs-kernel-server
```

Lakukan di slave dengan perintah berikut:

```
sudo apt install nfs-common
```

Paket `nfs-common` akan diinstall, memungkinkan untuk mengakses dan menggunakan berkas yang dibagikan oleh master NFS yang telah dikonfigurasi dengan benar.

Slave1:



```
mpiuser@dayat-VirtualBox:~$ sudo apt install nfs-common
```

Slave2:

```
mpiuser@pio-VirtualBox:~$ 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 5 not upgraded.
mpiuser@pio-VirtualBox:~$
```

Slave3:

```
mpiuser@zizi:~$ sudo apt install nfs-common
[sudo] password for mpiuser:
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 2 not upgraded.
```

5. Mounting

Lakukan di slave dengan perintah berikut:

```
sudo mount <server host>:<lokasi shared folder di
master><lokasi shared folder di slave>
```


sesuaikan <server host>, <lokasi shared folder di master> dan <lokasi shared folder di slave>

```
sudo mount master:/home/mpiusr/fix /home/mpiusr/fix
```

Slave1:

```
mpiuser@dayat-VirtualBox:~$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
```

Slave2:

```
mpiuser@pio-VirtualBox:~$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
```

Slave3:

```
mpiuser@zizi:~$ sudo mount master:/home/mpiuser/wa /home/mpiuser/wa
```

6. Mpi Installation

Install open MPI di Master dan Seluruh Slave, dengan command
“Sudo apt install openmpi-bin libopenmpi-dev”

Install the MPI library via pip

Dengan Command sudo apt install python3-pip
“Pip install mpi4py”

7. Running python Code

Buat file python

```
mpiuser@pipop-VirtualBox:~$ touch /home/mpiuser/bubble/bubble.py
```

Masuk ke directory bubble

```
mpiuser@pipop-VirtualBox:~$ cd /home/mpiuser/bubble  
mpiuser@pipop-VirtualBox:~/bubble$
```

Masuk ke file python bubble.py dengan command sudo nano bubble.py

Dan masukkan code pythonnya

```
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}")

```

```

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}")

```

8. Jalankan code nya di master

Dengan command `mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py`

```
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
hello world
hello world
hello world
hello world
mpiuser@pipop-VirtualBox:~/bubble$ nano bubble.py
mpiuser@pipop-VirtualBox:~/bubble$ mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
List sorted with bubble sort in ascending order: [1, 2, 3, 4, 5]
mpiuser@pipop-VirtualBox:~/bubble$
```

