

# **PEMROSESAN PARALEL**

## **Numerik**

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## Device dan Tools:

1. Ubuntu Desktop
  - Master
  - Worker1
  - Worker2
2. Python3
3. Mpi
4. Program Kode Numerik

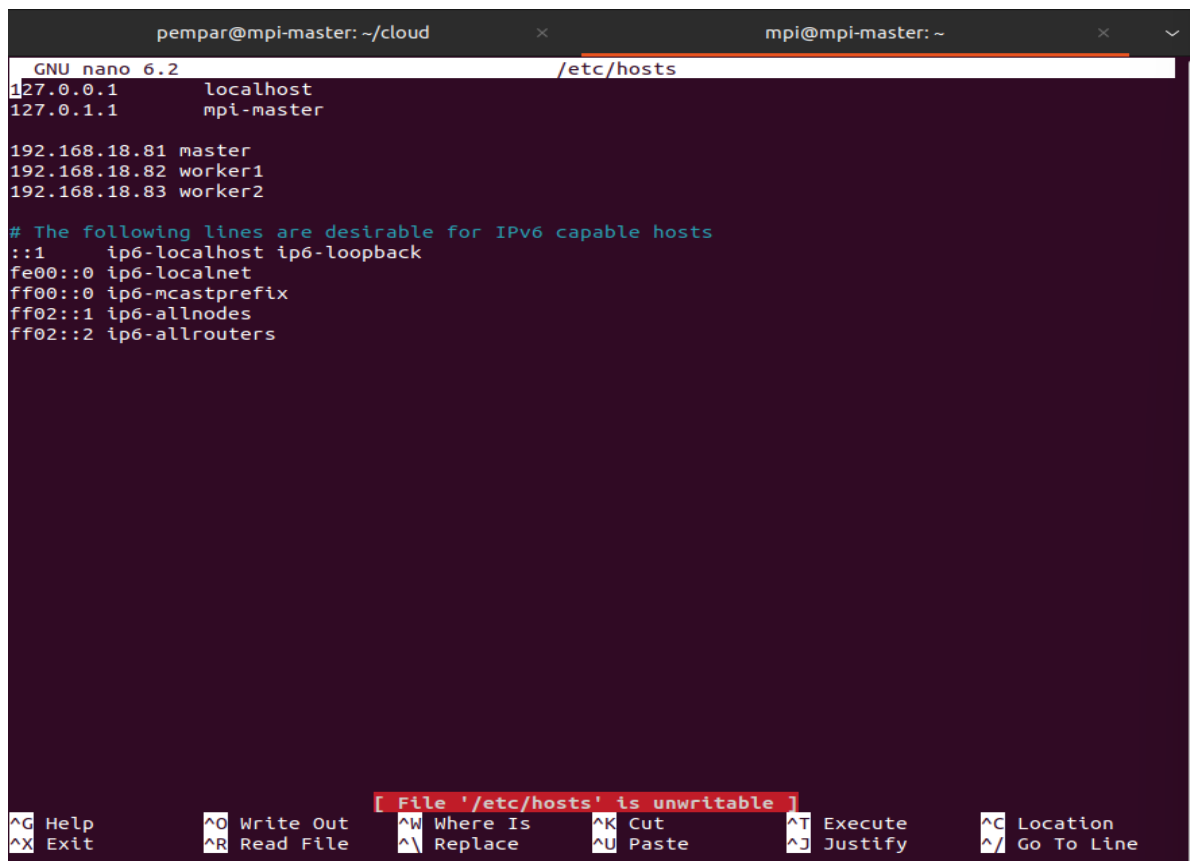
## Penjelasan Numerik

Program numerik adalah program yang menggunakan berbagai metode matematika dan komputasi untuk menyelesaikan masalah yang berhubungan dengan angka dan perhitungan. Program ini dapat digunakan untuk melakukan berbagai macam tugas seperti analisis data, prediksi, dan optimisasi. Contoh program numerik yang sering digunakan adalah program spreadsheet seperti Microsoft Excel, yang memiliki fitur-fitur yang memungkinkan pengguna untuk melakukan berbagai perhitungan dan analisis data secara efisien.

Konfigurasi file `/etc/hosts`

Buka file `/etc/hosts` lalu tambahkan isinya dengan IP yang sesuai dengan masing-masing device (master, worker1 dan worker2).

Master:



The screenshot shows a terminal window with two tabs. The active tab is titled 'pempap@mpi-master: ~/cloud' and displays the contents of the `/etc/hosts` file using the GNU nano 6.2 editor. The file contains the following entries:

```
127.0.0.1 localhost
127.0.1.1 mpi-master

192.168.18.81 master
192.168.18.82 worker1
192.168.18.83 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
```

At the bottom of the terminal, a red error message is displayed: `[ File '/etc/hosts' is unwritable ]`. Below the error message, a row of keyboard shortcuts is visible: `^G Help`, `^O Write Out`, `^W Where Is`, `^K Cut`, `^T Execute`, `^C Location`, `^X Exit`, `^R Read File`, `^_ Replace`, `^U Paste`, `^J Justify`, and `^_ Go To Line`.

## Worker1

```
192.168.18.81 master
192.168.18.82 worker1
192.168.18.83 worker2
```

## Worker2

```
192.168.18.81 master
192.168.18.82 worker1
192.168.18.83 worker2
```

## Buat User Baru

Ketik perintah berikut pada master dan worker:

*Sudo adduser pempar*

Master:

```
mpi@mpi-master:~$ sudo adduser pempar
Adding user `pempar' ...
Adding new group `pempar' (1001) ...
Adding new user `pempar' (1001) with group `pempar' ...
Creating home directory `/home/pempar' ...
Copying files from `/etc/skel' ...
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
Sorry, passwords do not match.
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: password updated successfully
Changing the user information for pempar
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
```

Worker1

```
mpi@mpi-master:~$ sudo adduser pempar
Adding user `pempar' ...
Adding new group `pempar' (1001) ...
Adding new user `pempar' (1001) with group `pempar' ...
Creating home directory `/home/pempar' ...
Copying files from `/etc/skel' ...
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: password updated successfully
Changing the user information for pempar
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
```

Worker2

```
mpi@mpi-master:~$ sudo adduser pempar
Adding user `pempar' ...
Adding new group `pempar' (1001) ...
Adding new user `pempar' (1001) with group `pempar' ...
Creating home directory `/home/pempar' ...
Copying files from `/etc/skel' ...
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: password updated successfully
Changing the user information for pempar
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
```

Beri akses root ke user

Ketik perintah berikut pada master dan worker:

*Sudo usermod -aG sudo mpiusr*

Master:

```
mpi@mpi-master:~$ sudo usermod -aG pempar
Usage: usermod [options] LOGIN
```

Worker1

```
mpi@mpi-master:~$ sudo usermod -aG pempar
```

Worker2

```
mpi@mpi-master:~$ sudo usermod -aG pempar
```

Install SSH

Ketik perintah berikut pada master dan worker.

*sudo apt install openssh-server*

Generate Keygen

*ssh-keygen -t rsa*

```
pempar@mpi-master:~$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/pempar/.ssh/id_rsa):
Created directory '/home/pempar/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/pempar/.ssh/id_rsa
Your public key has been saved in /home/pempar/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:gguz4SOUi+Q32mv4zmsYWBm4V1jR0BNSDa2RTTmfPHU pempar@mpi-master
The key's randomart image is:
+---[RSA 3072]-----+
| . o=*+O.. |
| . o ..* * . E |
| . + . + + O . |
| . = .. = |
| .*+ . . S . |
| *o.= . . |
| ooBo. |
| +=+. |
| .=Bo |
+----[SHA256]-----+
```

Copy Key Publik ke Setiap worker

```
cd .ssh
```

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

```
pempar@mpi-master:~/.ssh$ cat id_rsa.pub | ssh pempar@worker1 "mkdir .ssh; cat >> .ssh/authorized_keys"
The authenticity of host 'worker1 (192.168.18.82)' can't be established.
ED25519 key fingerprint is SHA256:NmgSP7K/1Z68yLaf/II7cPyWjhqsg03bcuYgziN7Wjg.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker1' (ED25519) to the list of known hosts.
pempar@worker1's password:
pempar@mpi-master:~/.ssh$ cat id_rsa.pub | ssh pempar@worker2 "mkdir .ssh; cat >> .ssh/authorized_keys"
The authenticity of host 'worker2 (192.168.18.83)' can't be established.
ED25519 key fingerprint is SHA256:SA7dFamHLvN34m8sFLCPv5b25Ckp218sl2/dGvSA0aE.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker2' (ED25519) to the list of known hosts.
pempar@worker2's password:
```

Konfigurasi NFS

Membuat direktory cloud

```
pempar@mpi-master:~$ mkdir ~/cloud
```

Install NSF Server

```
mpi@mpi-master:~$ sudo apt install nfs-kernel-server
```

## Konfigurasi file /etc/exports

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

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

## Install NFS Worker

### Worker1

```
mpi@mpi-master:~$ sudo apt install nfs-common
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common rpcbind
0 upgraded, 5 newly installed, 0 to remove and 3 not upgraded.
Need to get 475 kB of archives.
After this operation, 1.709 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```



## Worker2

```
mpi@mpi-master:~$ sudo apt install nfs-common
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common rpcbind
0 upgraded, 5 newly installed, 0 to remove and 3 not upgraded.
Need to get 475 kB of archives.
After this operation, 1.709 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

## Mounting

### Worker1

```
mpi@mpi-master:~$ sudo mount master:/home/pempar/cloud /home/pempar/cloud
```

### Worker2

```
mpi@mpi-master:~$ sudo mount master:/home/pempar/cloud /home/pempar/cloud
```

## Install MPI

```
pempar@mpi-master:~/cloud$ pip install mpi4py
Defaulting to user installation because normal site-packages is not writeable
Collecting mpi4py
  Downloading mpi4py-3.1.5.tar.gz (2.5 MB)
    2.5/2.5 MB 587.9 kB/s eta 0:00:00
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
  Preparing metadata (pyproject.toml) ... done
Building wheels for collected packages: mpi4py
  Building wheel for mpi4py (pyproject.toml) ... done
  Created wheel for mpi4py: filename=mpi4py-3.1.5-cp310-cp310-linux_x86_64.whl size=2746517 sha256=8b6247861867ff0407d96a728c7e2d69695072ad360ab7ff271c49277349bbf4
  Stored in directory: /home/pempar/.cache/pip/wheels/18/2b/7f/c852523089e9182b45fca50ff56f49a51eeb6284fd25a66713
Successfully built mpi4py
Installing collected packages: mpi4py
Successfully installed mpi4py-3.1.5
```

## Program Kode Numerik

```
pempar@mpi-master: ~/cloud
GNU nano 6.2 numerik.py
from mpi4py import MPI
import time

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

    if rank == 0:
        # Ambil input dari pengguna
        input_str = input("Masukkan data, dipisahkan dengan spasi: ")
        data = list(map(int, input_str.split()))
        data1 = data[:len(data)//2]
        data2 = data[len(data)//2:]
        comm.send(data1, dest=1, tag=11)
        comm.send(data2, dest=2, tag=22)
    elif rank == 1:
        data = comm.recv(source=0, tag=11)
    elif rank == 2:
        data = comm.recv(source=0, tag=22)

    local_sum = sum(data)

    total_sum = comm.reduce(local_sum, op=MPI.SUM, root=0)

    if rank == 0:
        print("Total hasil perhitungan:", total_sum)

if __name__ == '__main__':
    start = time.time()
    main()
    end = time.time()
    print("Waktu dikerjakan", end - start)
```

## Running Program MPI Numerik

```
pempar@mpi-master:~/cloud$ nano numerik.py
pempar@mpi-master:~/cloud$ mpirun -np 3 -host master,worker1,worker2 python3 numerik.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
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Masukkan data, dipisahkan dengan spasi: 4 8 3 0 3 4 5 8 6 1 3 2 1 2111 445748 2324
Waktu dikerjakan 37.51683974266052
Total hasil perhitungan: 900462
Waktu dikerjakan 36.42579007148743
Waktu dikerjakan 37.45608592033386
```



