PEMROSESAN PARALEL

Bubblesort

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2023

Device dan Tools:

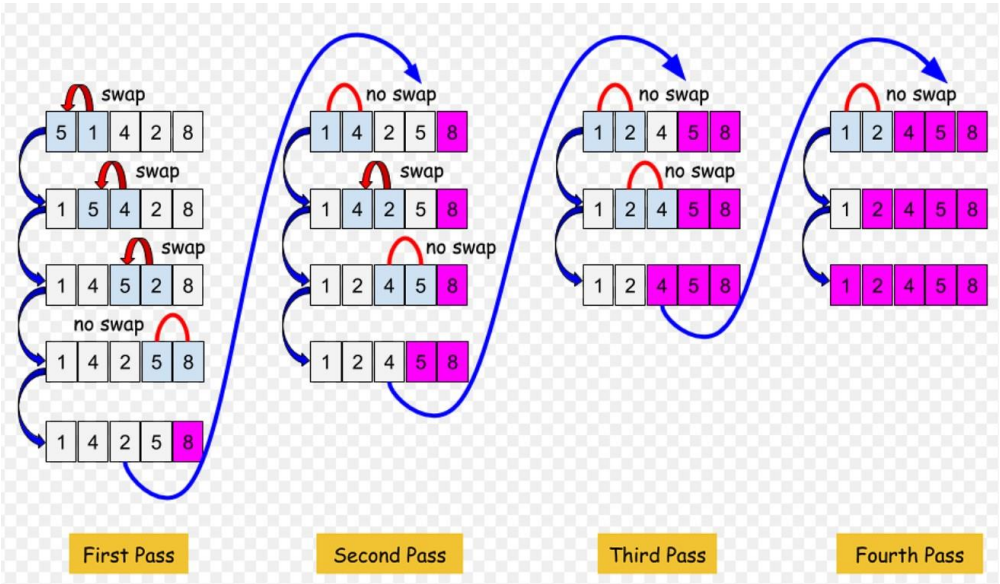
1. Ubuntu Desktop • Master
    - Worker1
    - Worker2
2. Python3
3. Mpi
4. Program Kode Bubblesort

Penjelasan Bubble Sort

Program bubble sort adalah salah satu algoritma pengurutan data yang sederhana dan sering digunakan. Algoritma ini bekerja dengan membandingkan dua data yang berdekatan dan menukar posisinya jika diperlukan. Proses ini diulangi sampai seluruh data terurut secara ascending atau descending. Nama "bubble sort" sendiri berasal dari proses pergerakan data yang mirip dengan gelembung yang naik ke atas. Algoritma ini sering digunakan dalam pemrograman karena mudah diimplementasikan dan dapat digunakan pada berbagai tipe data.

Perbedaan Eksekusi Menggunakan Python dan MPI

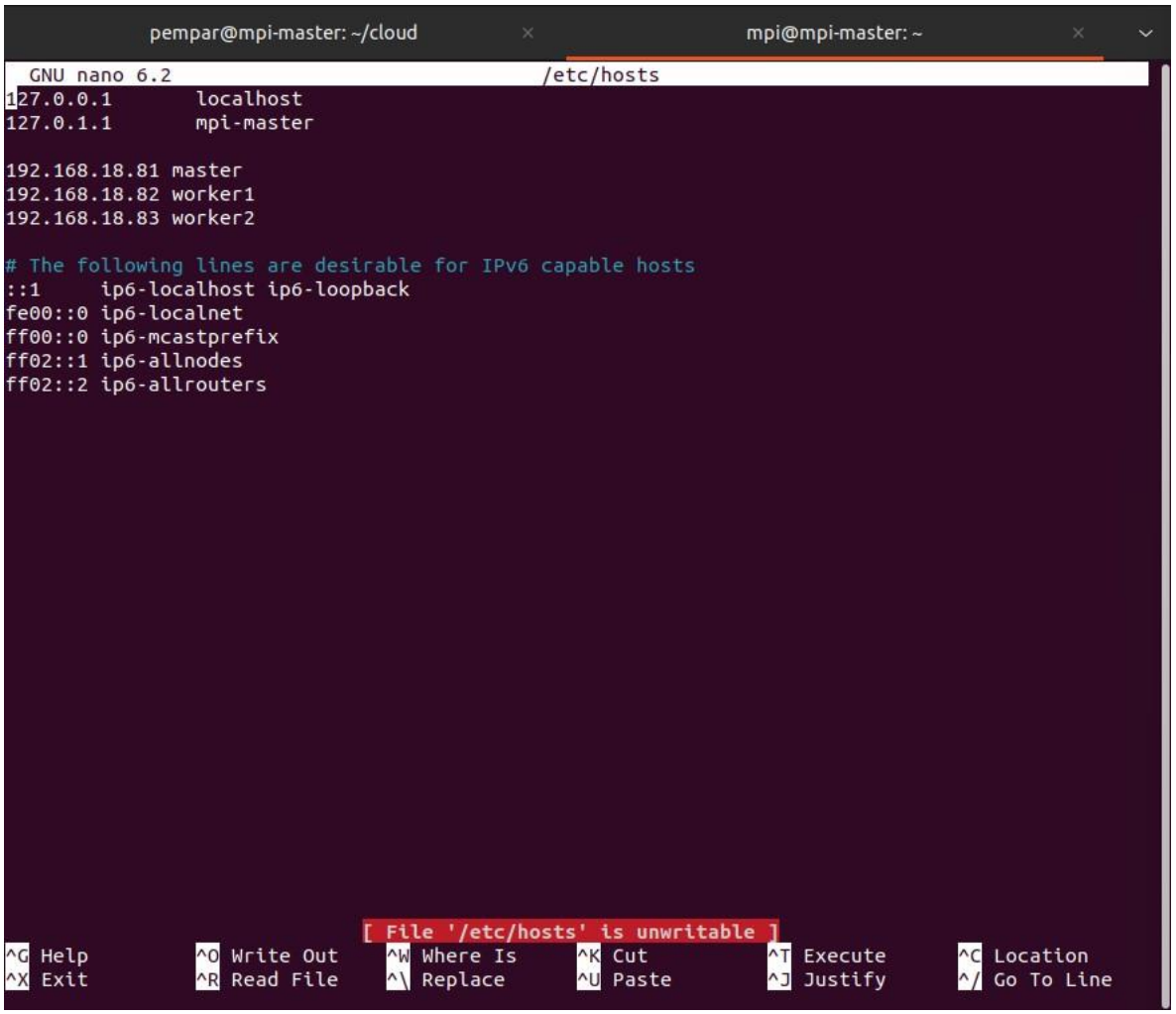
Ketika dieksekusi menggunakan Python, program bubblesort akan dijalankan secara serial, artinya semua operasi akan dilakukan oleh satu prosesor atau thread. Sedangkan ketika dieksekusi menggunakan MPI (Message Passing Interface), program bubble sort dapat dijalankan secara paralel dengan memanfaatkan banyak prosesor atau node yang terhubung dalam sebuah jaringan komputer. Hal ini memungkinkan proses pengurutan data dilakukan secara bersamaan dan lebih efisien. Selain itu, MPI juga memungkinkan komunikasi antar prosesor yang berjalan paralel, sehingga hasil akhir dapat dikombinasikan dengan lebih cepat.



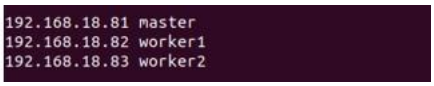
Bubble Sort

Konfigurasikan file /etc/hosts

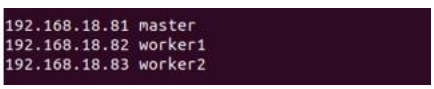
Buka file */etc/hosts* lalu tambahkan isinya dengan IP yang sesuai dengan masingmasing device (master, worker1 dan worker2).



Worker1



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/authorize
d_keys"
The authenticity of host 'worker1 (192.168.18.82)' can't be established.
ED25519 key fingerprint is SHA256:NmgSP7K/1Z68yLaf/II7cPyWjhqsgO3bcuYgziN7Wjg.
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/authorize
d_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=274
6517 sha256=8b6247861867ff0407d96a728c7e2d69695072ad360ab7ff271c49277349bbf4
  Stored in directory: /home/pempar/.cache/pip/wheels/18/2b/7f/c852523089e9182b45fca50f
f56f49a51eeb6284fd25a66713
Successfully built mpi4py
Installing collected packages: mpi4py
Successfully installed mpi4py-3.1.5
```

Test

```
pempar@mpi-master:~/cloud$ nano test.py
pempar@mpi-master:~/cloud$ mpirun -np 3 -host master,worker1,worker2 python3 test.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
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Hello world from worker 0 of 3
Hello world from worker 2 of 3
Hello world from worker 1 of 3
```

Program Kode Bubble Sort

```
pempar@mpi-master: ~/cloud
pempar@mpi-master: ~/cloud  ×  mpi@mpi-master: ~  ×
 GNU nano 6.2                    bubblesort1.py
rom mpi4py import MPI
mport time
mport numpy as np

ef bubble_sort(arr):
    n = len(arr)
    for i in range(n):
        for j in range(0, n-i-1):
            if arr[j] > arr[j+1] :
                arr[j], arr[j+1] = arr[j+1], arr[j]
    return arr

omm = MPI.COMM_WORLD
ank = comm.Get_rank()

f rank == 0:
    # Ini adalah proses master
    data = np.random.randint(0, 100, 50)  # Membuat array acak
    print("Data awal: ", data)
    start_time = time.time()
    data1 = data[:25]
    data2 = data[25:]
    comm.send(data1, dest=1, tag=11)
    comm.send(data2, dest=2, tag=22)
lif rank == 1:
    # Ini adalah worker1
    data1 = comm.recv(source=0, tag=11)
    print("Worker1 menerima data: ", data1)
    data1 = bubble_sort(data1)
    print("Worker1 mengurutkan data: ", data1)
    comm.send(data1, dest=0, tag=33)
lif rank == 2:
    # Ini adalah worker2
    data2 = comm.recv(source=0, tag=22)
    print("Worker2 menerima data: ", data2)
                [ Read 47 lines ]
G Help    ^O Write Out  ^W Where Is   ^K Cut       ^T Execute   ^C Location
X Exit    ^R Read File  ^\ Replace    ^U Paste     ^J Justify   ^/ Go To Line
```

Running Program MPI Bubble Sort

```
pempar@mpi-master:~/cloud$ mpirun -np 3 -host master,worker1,worker2 python3 bubblesort1.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
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Authorization required, but no authorization protocol specified
Data awal:  [47 56  3 22 47 19 36 65 78 83 76  6 87 73 69 10 87 15 48 86 33  0 76 34
 51 48 55 36 55 64 30 49 45 44 61 36 15 69 48 40 20 27 51 15 62 81 19 80
 18 54]
Worker1 menerima data:  [47 56  3 22 47 19 36 65 78 83 76  6 87 73 69 10 87 15 48 86 33  0 76 34
 51]
Worker1 mengurutkan data:  [ 0  3  6 10 15 19 22 33 34 36 47 47 48 51 56 65 69 73 76 76 78 83 86
 87
 87]
Worker2 menerima data:  [48 55 36 55 64 30 49 45 44 61 36 15 69 48 40 20 27 51 15 62 81 19 80 18
 54]
Worker2 mengurutkan data:  [15 15 18 19 20 27 30 36 36 40 44 45 48 48 49 51 54 55 55 61 62 64 69
 80
 81]
Data akhir:  [ 0  3  6 10 15 15 15 18 19 19 20 22 27 30 33 34 36 36 36 40 44 45 47 47
 48 48 48 49 51 51 54 55 55 56 61 62 64 65 69 69 73 76 76 78 80 81 83 86
 87 87]
Waktu eksekusi: 0.678704023361206 detik
```