Pemrosesan Paralel

MPI

Disusun Oleh :

Kelompok 3

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Dosen Pengampu :

Jurusan Sistem Komputer

Fakultas Ilmu Komputer

Universitas Sriwijaya

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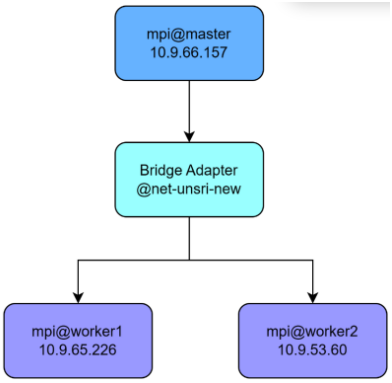
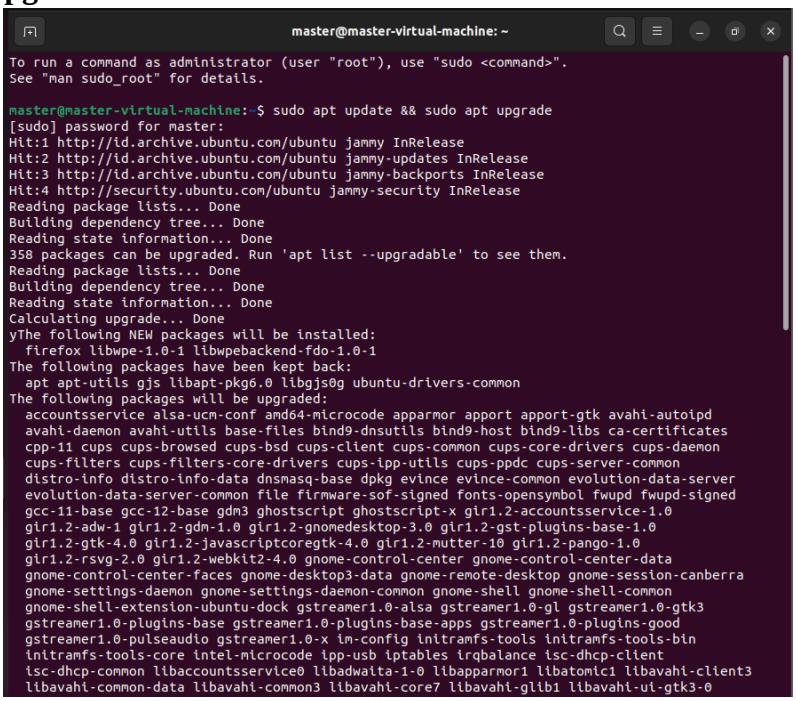
TOPOLOGI MPI

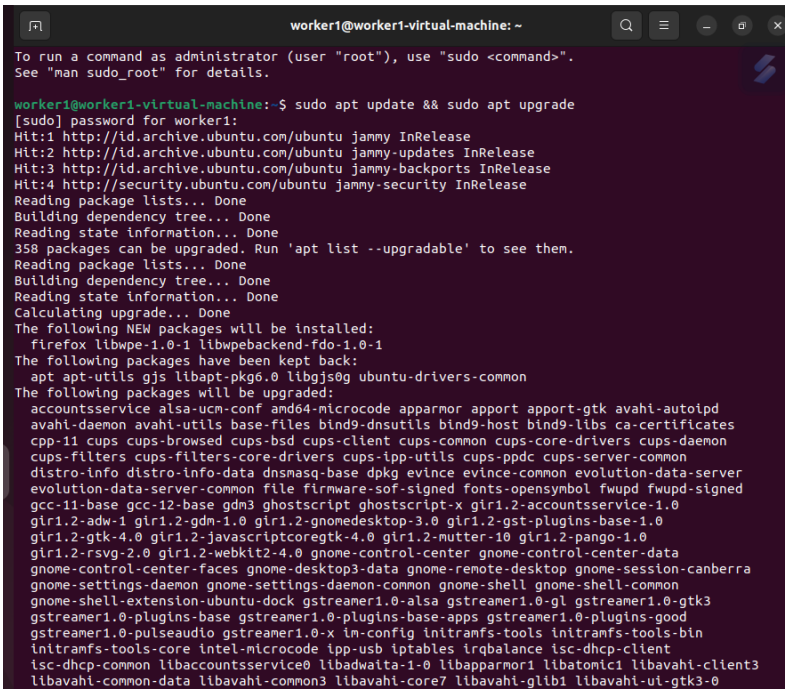


MPI-Bubblesort menggunakan Python

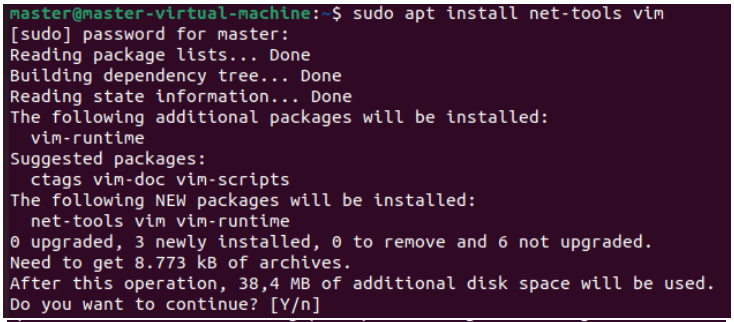
Menyiapkan Ubuntu Server dan Linux Mint

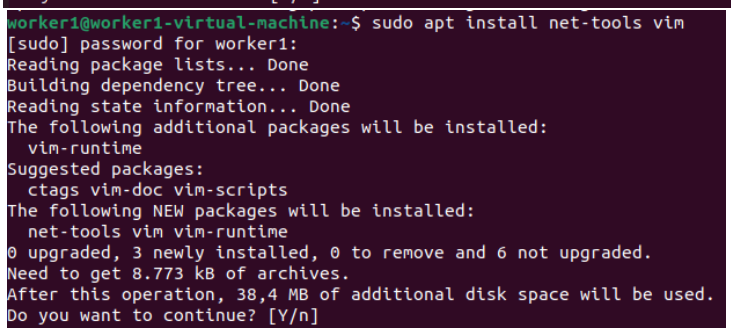
1. **Pastikan sudah dalam satu jaringan yang sama untu setiap (Master , Worker, Worker1 dan Worker2)**
2. **Melakukan upgrade OS**





3. **Melakukan penginstalan berikut: net-tools untuk memeriksa IP, vim untuk editor teks.**





4. **Melakukan pengecekan IP dengan perintah berikut:**

```
master@master-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
       inet 192.168.1.24  netmask 255.255.255.0  broadcast 192.168.1.255
       inet6 fe80::ae78:10d2:f069:9498  prefixlen 64  scopeid 0x20<link>
       ether 00:0c:29:8b:d6:06  txqueuelen 1000  (Ethernet)
       RX packets 28588  bytes 42029400 (42.0 MB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 20746  bytes 1604428 (1.6 MB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
       inet 127.0.0.1  netmask 255.0.0.0
       inet6 ::1  prefixlen 128  scopeid 0x10<host>
       loop  txqueuelen 1000  (Local Loopback)
       RX packets 443  bytes 39129 (39.1 KB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 443  bytes 39129 (39.1 KB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

```
worker1@worker1-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
       inet 192.168.1.25  netmask 255.255.255.0  broadcast 192.168.1.255
       inet6 fe80::80b0:bfe9:6f07:f13  prefixlen 64  scopeid 0x20<link>
       ether 00:0c:29:d2:b5:e2  txqueuelen 1000  (Ethernet)
       RX packets 27877  bytes 41019562 (41.0 MB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 20116  bytes 1567869 (1.5 MB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
       inet 127.0.0.1  netmask 255.0.0.0
       inet6 ::1  prefixlen 128  scopeid 0x10<host>
       loop  txqueuelen 1000  (Local Loopback)
       RX packets 442  bytes 39285 (39.2 KB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 442  bytes 39285 (39.2 KB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

worker1@worker1-virtual-machine:~$
```

```
worker2@worker2-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
       inet 192.168.1.22  netmask 255.255.255.0  broadcast 192.168.1.255
       inet6 fe80::e5de:ad76:1431:3d3  prefixlen 64  scopeid 0x20<link>
       ether 00:0c:29:6f:d4:7d  txqueuelen 1000  (Ethernet)
       RX packets 7521  bytes 10697630 (10.6 MB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 5533  bytes 487832 (487.8 KB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
       inet 127.0.0.1  netmask 255.0.0.0
       inet6 ::1  prefixlen 128  scopeid 0x10<host>
       loop  txqueuelen 1000  (Local Loopback)
       RX packets 381  bytes 32311 (32.3 KB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 381  bytes 32311 (32.3 KB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

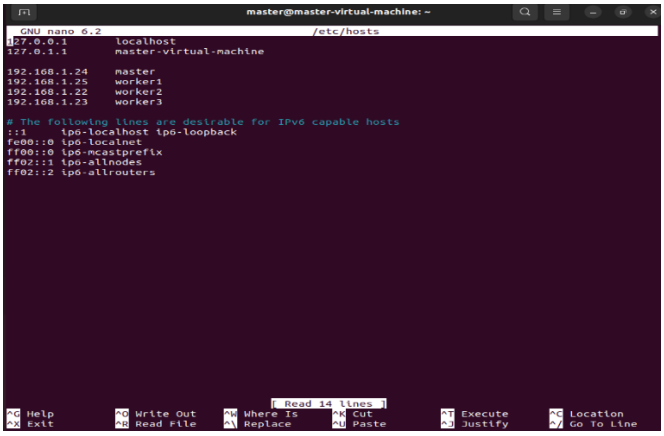
```
worker3@worker3-virtual-machine:~$ ifconfig
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
       inet 192.168.1.23  netmask 255.255.255.0  broadcast 192.168.1.255
       inet6 fe80::e363:cf50:bc75:7a0d  prefixlen 64  scopeid 0x20<link>
       ether 00:0c:29:9a:6a:3a  txqueuelen 1000  (Ethernet)
       RX packets 7511  bytes 10700529 (10.7 MB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 5599  bytes 490699 (490.6 KB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
       inet 127.0.0.1  netmask 255.0.0.0
       inet6 ::1  prefixlen 128  scopeid 0x10<host>
       loop  txqueuelen 1000  (Local Loopback)
       RX packets 388  bytes 33085 (33.0 KB)
       RX errors 0  dropped 0  overruns 0  frame 0
       TX packets 388  bytes 33085 (33.0 KB)
       TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

Nama	Master	Worker 1	Worker 2	Worker 3
IP	192.168.1.24	192.168.1.25	192.168.1.22	192.168.1.23

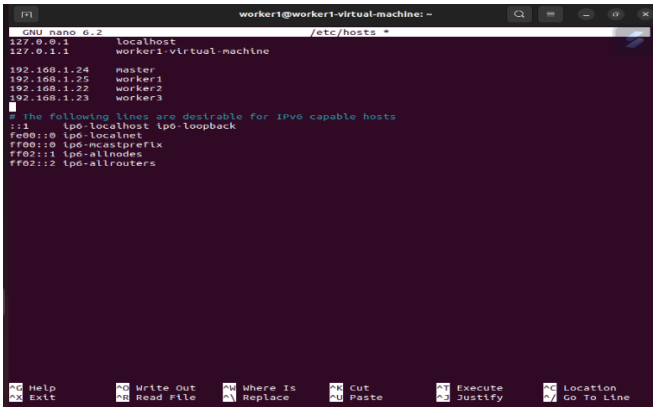
Membuat Klaster MPI

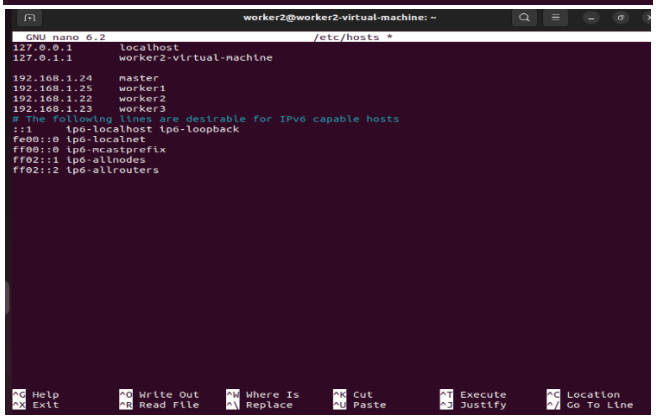
1. Konfigurasi file host /etc/hosts

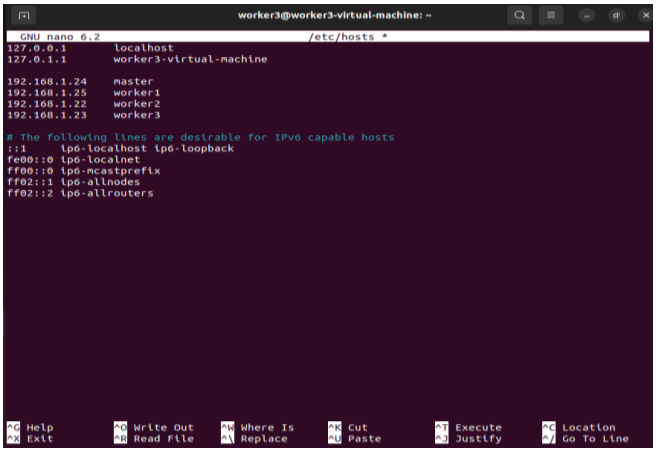
- Pada Master



- Pada Worker







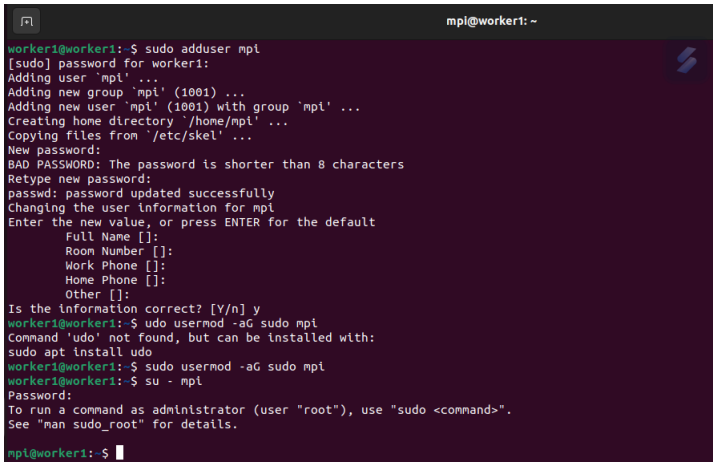
2. Membuat Pengguna Baru

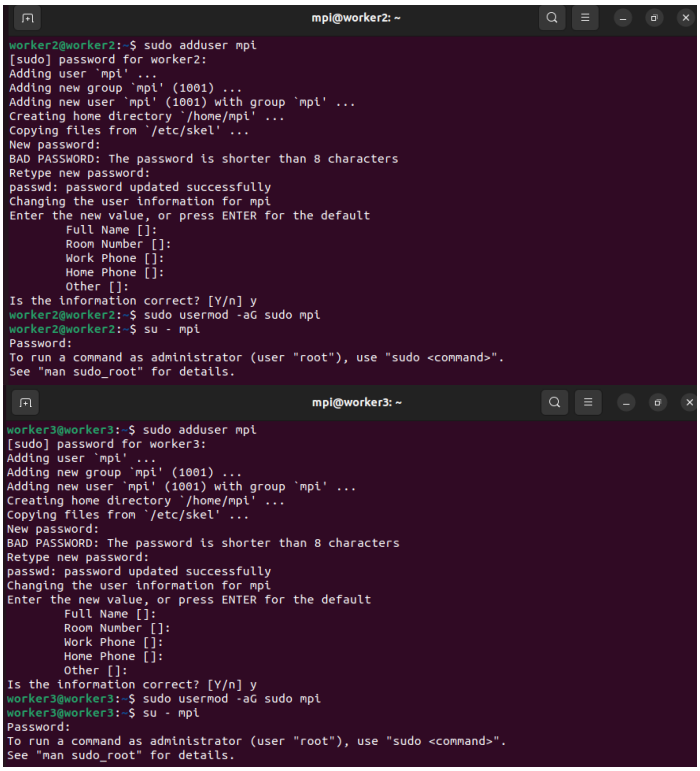
Lakukan pembuatan user terlebih dahulu karna harus menggunakan user yang memiliki nama yang sama. Dapat menggunakan command berikut untuk membuat user baru “sudo adduser mpi” (disini saya menggunakan user dengan nama mpi), setelah itu berikan akses root ke user baru tadi menggunakan command “sudo usermod -aG sudo mpi).

```
$ sudo adduser
$ sudo usermod -aG sudo
$ su –mpi
```

- Pada Master

- Pada Worker





3. Konfigurasi SSH

Setelah membuat dan masuk ke user, lakukan konfigurasi SSH.

a) Masuk ke user baru terlebih dahulu pada master dan workernya menggunakan command “su – mpi”.
b) Install SSH dahulu menggunakan command “sudo apt install openssh-server” di master dan worker.

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

```
mpi@master:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
Suggested packages:
  molly-guard monkeysphere ssh-askpass
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

```
mpi@worker1:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
Suggested packages:
  molly-guard monkeysphere ssh-askpass
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

```
mpi@worker2:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
Suggested packages:
  molly-guard monkeysphere ssh-askpass
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

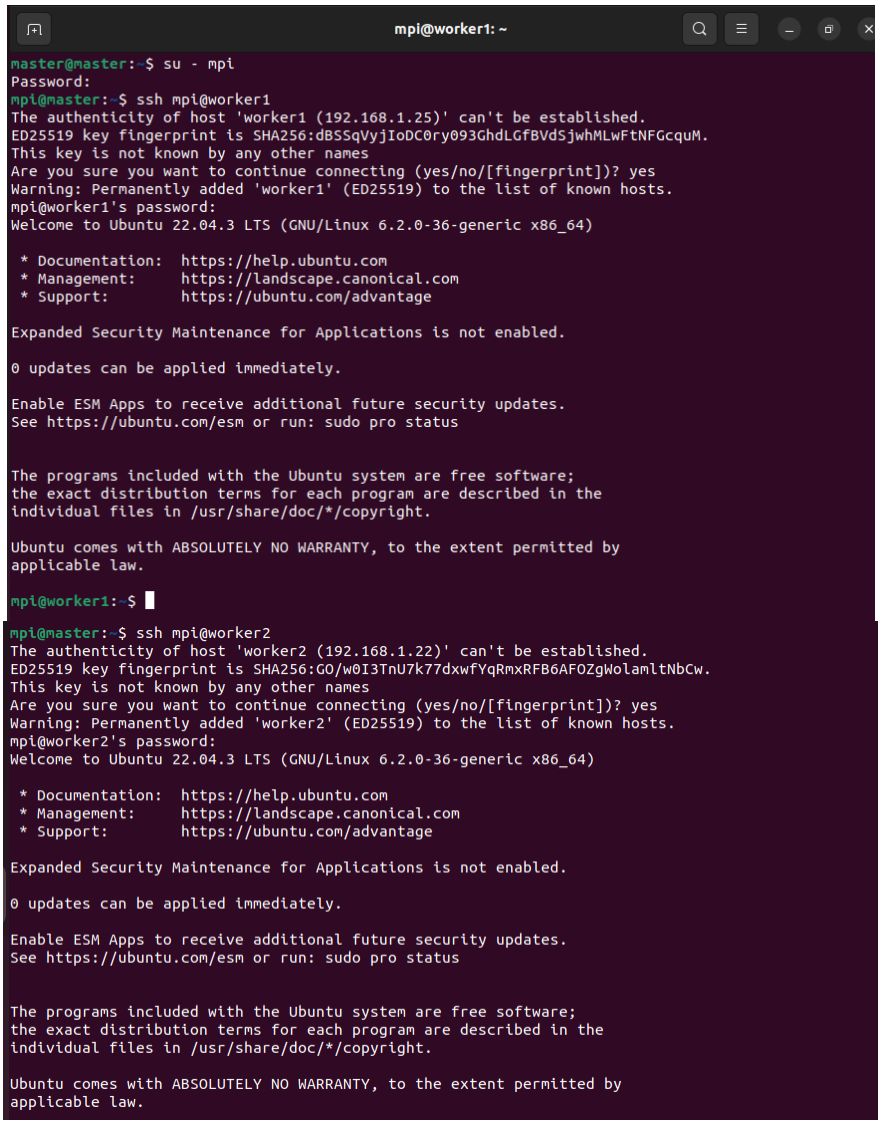
```
mpi@worker3:~$ sudo apt install openssh-server
[sudo] password for mpi:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  ncurses-term openssh-sftp-server ssh-import-id
Suggested packages:
  molly-guard monkeysphere ssh-askpass
The following NEW packages will be installed:
  ncurses-term openssh-server openssh-sftp-server ssh-import-id
0 upgraded, 4 newly installed, 0 to remove and 6 not upgraded.
Need to get 751 kB of archives.
After this operation, 6.046 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

c) Melakukan pengecekan SSH

Untuk pengecekan SSH bisa dilakukan dengan cara menghubungkan dari master ke worker dan sebaliknya.

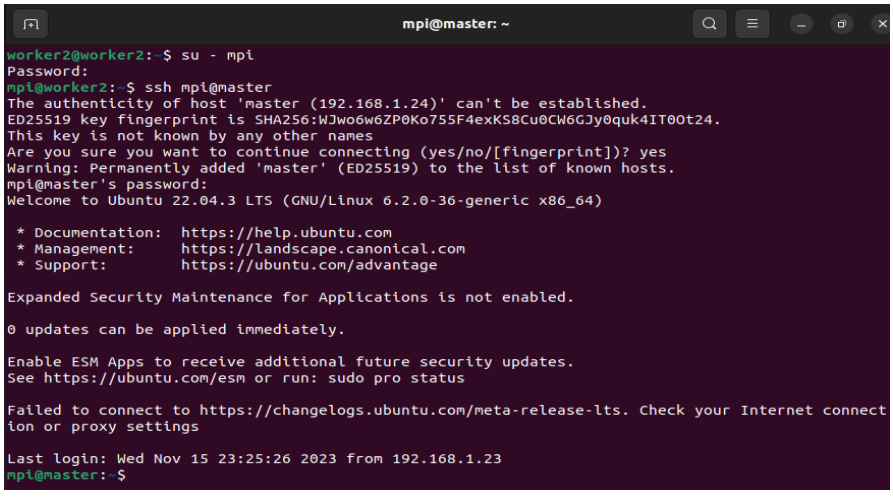
$ ssh @

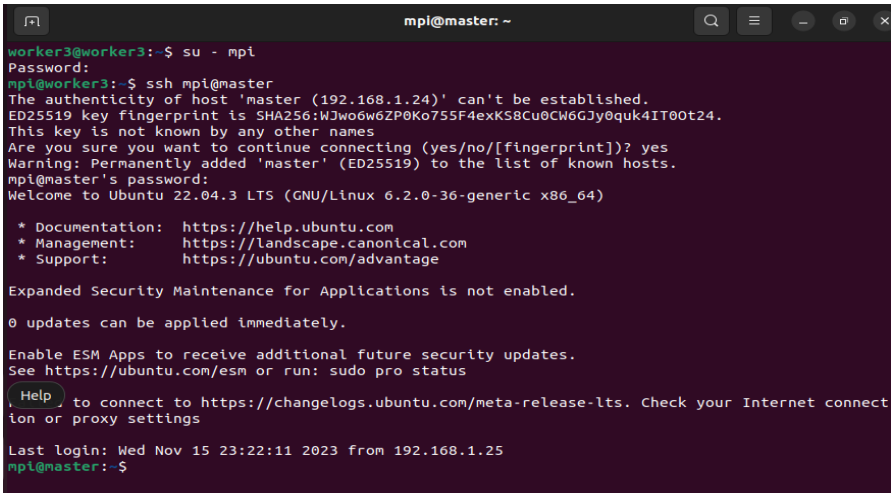
- SSH dari Master ke Worker



Bisa langsung masuk tanpa memasukkan password worker yang dituju.

- SSH dari Worker ke Master

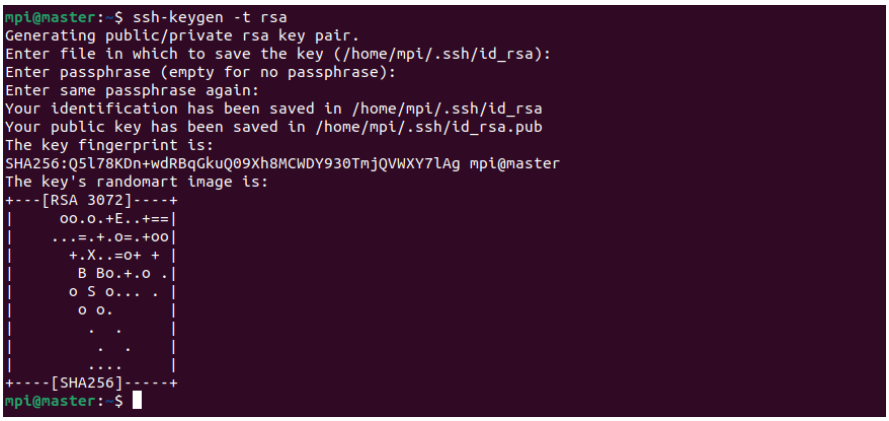




Jika dari worker ke master, harus memasukkan password dari master setiap kali worker ingin masuk.

d) Generate Keygen Lakukan di SERVER Selesai dari install, bisa lakukan keygen menggunakan command “ssh-keygen -t rsa” pada masternya

```
$ ssh-keygen -t rsa
```



e) Copy key publik ke client

```
$ cd .ssh

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

```
mpi@master:~$ cd .ssh
mpi@master:~/.ssh$ cat id_rsa.pub | ssh mpi@worker1 "mkdir .ssh; cat >> .ssh/authorized_keys"
mpi@worker1's password:
mkdir: cannot create directory ‘.ssh’: File exists
mpi@master:~/.ssh$ cat id_rsa.pub | ssh mpi@worker2 "mkdir .ssh; cat >> .ssh/authorized_keys"
mpi@worker2's password:
mkdir: cannot create directory ‘.ssh’: File exists
mpi@master:~/.ssh$ cat id_rsa.pub | ssh mpi@worker3 "mkdir .ssh; cat >> .ssh/authorized_keys"
The authenticity of host 'worker3 (192.168.1.23)' can't be established.
ED25519 key fingerprint is SHA256:Zx3Jyr8um9uqMEm4lgQAj1zy7pvUAQY2fx0YhHsjxmM.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'worker3' (ED25519) to the list of known hosts.
mpi@worker3's password:
mkdir: cannot create directory ‘.ssh’: File exists
mpi@master:~/.ssh$
```

3) Konfigurasi NFS

Selanjutnya membuat shared folder menggunakan NFS agar master dan worker dapat mengolah data dari folder yang sama secara langsung.

a) Pertama, buat folder baru di master dan worker dengan nama yang sama.

`$ mkdir cloud`

```
mpi@master:~$ mkdir cloud
mpi@master:~$
```

```
mpi@worker1:~$ mkdir cloud
mpi@worker1:~$
```

```
mpi@worker3:~$ mkdir cloud
mpi@worker3:~$
```

```
mpi@worker2:~$ mkdir cloud
mpi@worker2:~$
```

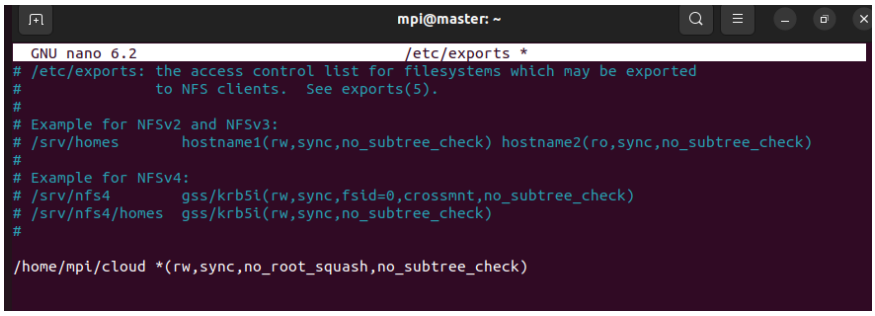
b) Pada master, lakukan installasi NFS server menggunakan command “sudo apt install nfs-kernel-server”

`$ sudo apt install nfs-kernel-server`

```
mpi@master:~$ sudo apt install nfs-kernel-server
[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 nfs-common rpcbind
Suggested packages:
  open-iscsi watchdog
The following NEW packages will be installed:
  keyutils libevent-core-2.1-7 libnfsidmap1 nfs-common nfs-kernel-server rpcbind
0 upgraded, 6 newly installed, 0 to remove and 6 not upgraded.
Need to get 615 kB of archives.
After this operation, 2.235 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

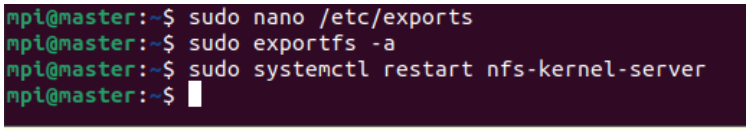
c) Konfigurasi file /etc/exports

`*(rw,sync,no_root_squash,no_subtree_check)`



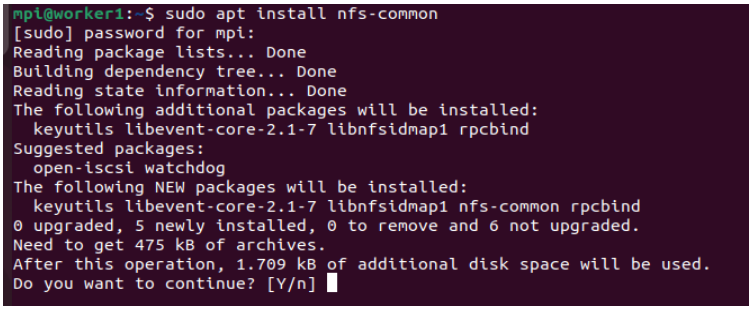
$ sudo exportfs -a

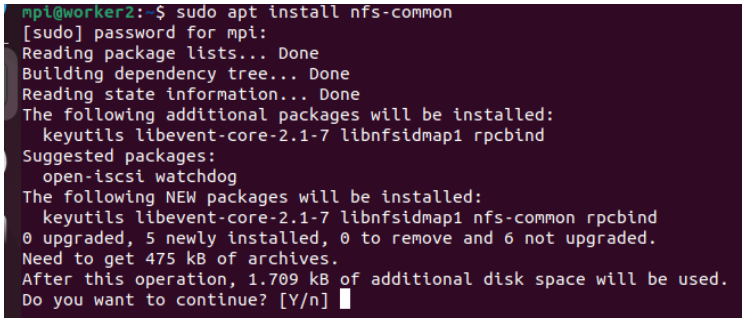
$ sudo systemctl restart nfs-kernel-server



d) Install NFS Client pada Worker

$ sudo apt install nfs-common





```
mpi@worker3:~$ sudo apt install nfs-common
[sudo] password for mpi:
CDROM 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 6 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]
```

e) Mounting

$ sudo mount :

```
mpi@worker1:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@worker1:~$
mpi@worker2:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@worker2:~$
mpi@worker3:~$ sudo mount master:/home/mpi/cloud /home/mpi/cloud
mpi@worker3:~$
```

4) Instalasi MPI

Ada 3 hal yang harus di download pada bagian ini, yaitu :

- MPI
- Python3
- Library mpi4py

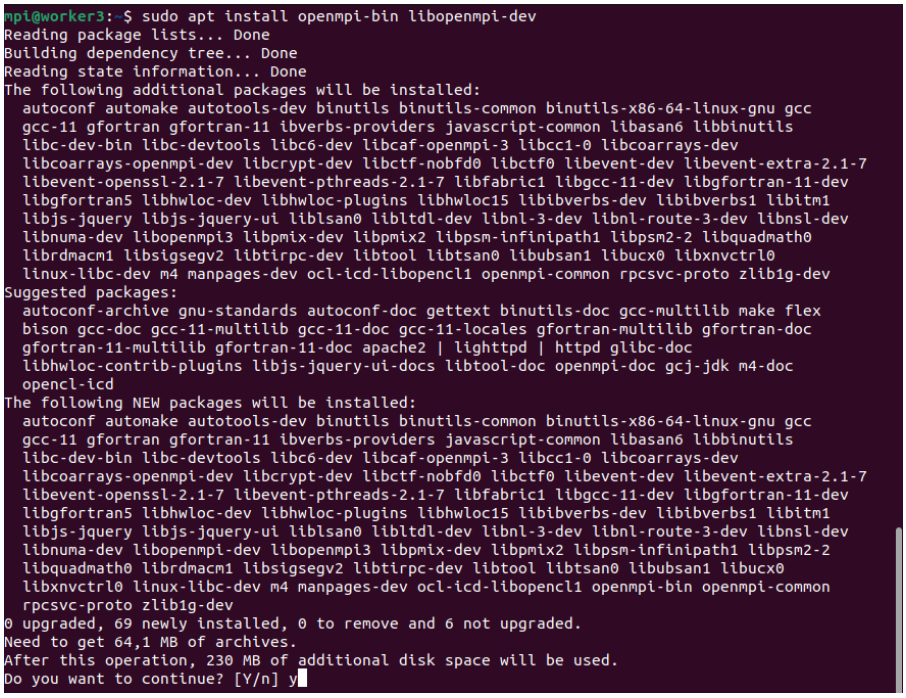
a) Install MPI

$ sudo apt install openmpi-bin libopenmpi-dev

```
mpi@master:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
Suggested packages:
  autoconf-archive gnu-standards autoconf-doc gettext binutils-doc gcc-multilib make flex
  bison gcc-doc gcc-11-multilib gcc-11-doc gcc-11-locales gfortran-multilib gfortran-doc
  gfortran-11-multilib gfortran-11-doc apache2 | lighttpd | httpd glibc-doc
  libhwloc-contrib-plugins libjs-jquery-ui-docs libtool-doc openmpi-doc gcj-jdk m4-doc
  opencl-icd
The following NEW packages will be installed:
```

```
mpi@worker1:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
Suggested packages:
```

```
mpi@worker2:~$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2 libquadmath0
  librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
Suggested packages:
  autoconf-archive gnu-standards autoconf-doc gettext binutils-doc gcc-multilib make flex
  bison gcc-doc gcc-11-multilib gcc-11-doc gcc-11-locales gfortran-multilib gfortran-doc
  gfortran-11-multilib gfortran-11-doc apache2 | lighttpd | httpd glibc-doc
  libhwloc-contrib-plugins libjs-jquery-ui-docs libtool-doc openmpi-doc gcj-jdk m4-doc
  opencl-icd
The following NEW packages will be installed:
  autoconf automake autotools-dev binutils binutils-common binutils-x86-64-linux-gnu gcc
  gcc-11 gfortran gfortran-11 ibverbs-providers javascript-common libasan6 libbinutils
  libc-dev-bin libc-devtools libc6-dev libcaf-openmpi-3 libcc1-0 libcoarrays-dev
  libcoarrays-openmpi-dev libcrypt-dev libctf-nobfd0 libctf0 libevent-dev libevent-extra-2.1-7
  libevent-openssl-2.1-7 libevent-pthreads-2.1-7 libfabric1 libgcc-11-dev libgfortran-11-dev
  libgfortran5 libhwloc-dev libhwloc-plugins libhwloc15 libibverbs-dev libibverbs1 libitm1
  libjs-jquery libjs-jquery-ui liblsan0 libltdl-dev libnl-3-dev libnl-route-3-dev libnsl-dev
  libnuma-dev libopenmpi-dev libopenmpi3 libpmix-dev libpmix2 libpsm-infinipath1 libpsm2-2
  libquadmath0 librdmacm1 libsigsegv2 libtirpc-dev libtool libtsan0 libubsan1 libucx0
  libxnvctrl0 linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-bin openmpi-common
  rpcsvc-proto zlib1g-dev
0 upgraded, 69 newly installed, 0 to remove and 6 not upgraded.
Need to get 64,1 MB of archives.
After this operation, 230 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

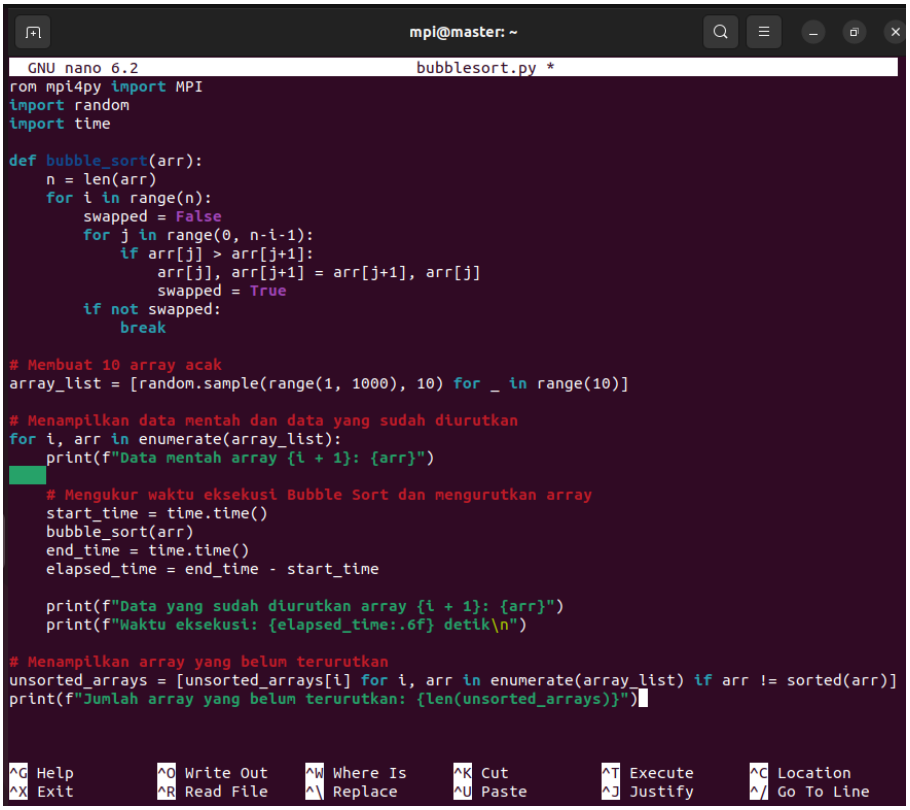


Menjalankan Program Bubblesort.py

1. **Membuat Program**

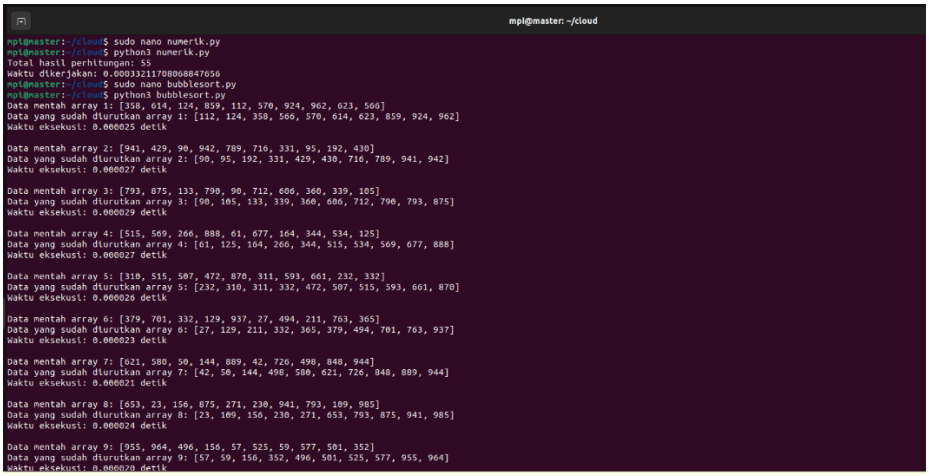
   ```
   $ touch bubblesort.py
   ```

   ```
   $ sudo nano bubblesort.py
   ```



2. Eksekusi Numerik menggunakan Python

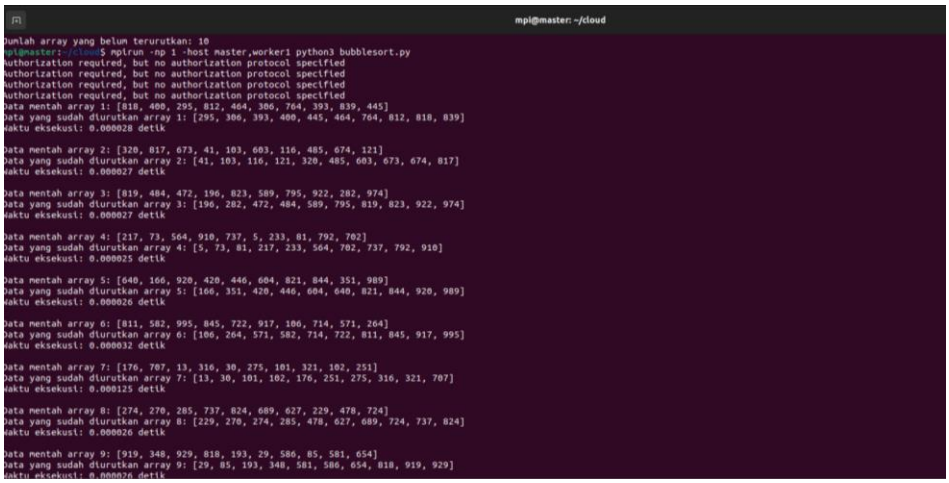
`$ python3 bubblesort.py`

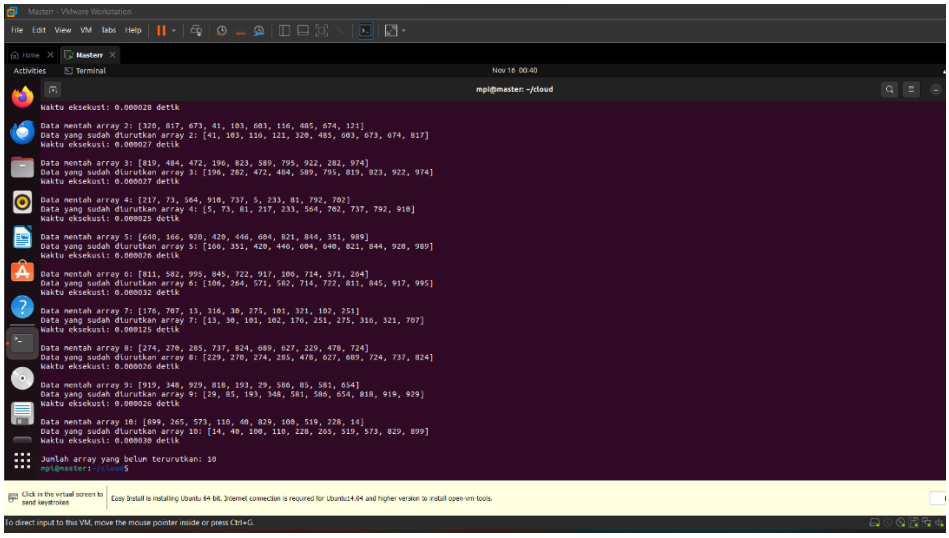


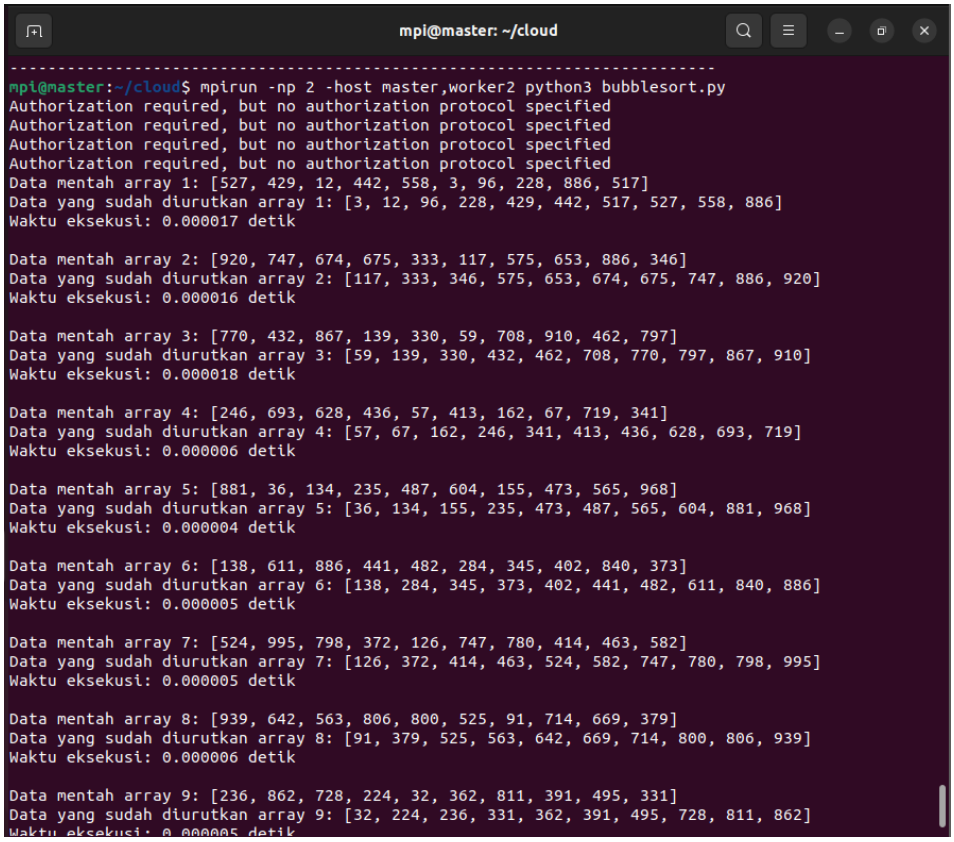
Dari 2 kodingan diatas, tahap pertama yang dilakukan adalah memanggil library mpi4py karna program yang dijalankan akan menggunakan mpi.

3. Eksekusi Bubblesort menggunakan MPI

`$ mpirun -np 3 -host master,worker,worker2,worker3 python3 bubblesort.py`


mpi@master: ~/cloud
Jumlah array yang belum terurutkan: 10
mpi@master:~/cloud$ mpirun -np 1 -host master,worker1 python3 bubblesort.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
Data mentah array 1: [818, 400, 295, 812, 464, 386, 764, 393, 839, 445]
Data yang sudah diurutkan array 1: [295, 386, 393, 400, 445, 464, 764, 812, 818, 839]
Waktu eksekusi: 0.000028 detik
Data mentah array 2: [320, 817, 673, 41, 103, 603, 116, 485, 674, 121]
Data yang sudah diurutkan array 2: [41, 103, 116, 121, 320, 485, 603, 673, 674, 817]
Waktu eksekusi: 0.000027 detik
Data mentah array 3: [819, 484, 472, 196, 823, 589, 795, 922, 282, 974]
Data yang sudah diurutkan array 3: [196, 282, 472, 484, 589, 795, 819, 823, 922, 974]
Waktu eksekusi: 0.000027 detik
Data mentah array 4: [217, 73, 564, 910, 737, 5, 233, 81, 792, 702]
Data yang sudah diurutkan array 4: [5, 73, 81, 217, 233, 564, 702, 737, 792, 910]
Waktu eksekusi: 0.000025 detik
Data mentah array 5: [640, 166, 920, 420, 446, 604, 821, 844, 351, 989]
Data yang sudah diurutkan array 5: [166, 351, 420, 446, 604, 640, 821, 844, 920, 989]
Waktu eksekusi: 0.000026 detik
Data mentah array 6: [811, 582, 995, 845, 722, 917, 106, 714, 571, 264]
Data yang sudah diurutkan array 6: [106, 264, 571, 582, 714, 722, 811, 845, 917, 995]
Waktu eksekusi: 0.000032 detik
Data mentah array 7: [176, 707, 13, 316, 30, 275, 101, 321, 102, 251]
Data yang sudah diurutkan array 7: [13, 30, 101, 102, 176, 251, 275, 316, 321, 707]
Waktu eksekusi: 0.000125 detik
Data mentah array 8: [274, 270, 285, 737, 824, 689, 627, 229, 478, 724]
Data yang sudah diurutkan array 8: [229, 270, 274, 285, 478, 627, 689, 724, 737, 824]
Waktu eksekusi: 0.000026 detik
Data mentah array 9: [919, 348, 929, 818, 193, 29, 586, 85, 581, 654]
Data yang sudah diurutkan array 9: [29, 85, 193, 348, 581, 586, 654, 818, 919, 929]
Waktu eksekusi: 0.000026 detik


Masterr - VMware Workstation
File Edit View VM Tabs Help
Home
Masterr
Activities
Terminal
Nov 16 00:40
mpi@master: ~/cloud
Waktu eksekusi: 0.000028 detik
Data mentah array 2: [320, 817, 673, 41, 103, 603, 116, 485, 674, 121]
Data yang sudah diurutkan array 2: [41, 103, 116, 121, 320, 485, 603, 673, 674, 817]
Waktu eksekusi: 0.000027 detik
Data mentah array 3: [819, 484, 472, 196, 823, 589, 795, 922, 282, 974]
Data yang sudah diurutkan array 3: [196, 282, 472, 484, 589, 795, 819, 823, 922, 974]
Waktu eksekusi: 0.000027 detik
Data mentah array 4: [217, 73, 564, 910, 737, 5, 233, 81, 792, 702]
Data yang sudah diurutkan array 4: [5, 73, 81, 217, 233, 564, 702, 737, 792, 910]
Waktu eksekusi: 0.000025 detik
Data mentah array 5: [640, 166, 920, 420, 446, 604, 821, 844, 351, 989]
Data yang sudah diurutkan array 5: [166, 351, 420, 446, 604, 640, 821, 844, 920, 989]
Waktu eksekusi: 0.000026 detik
Data mentah array 6: [811, 582, 995, 845, 722, 917, 106, 714, 571, 264]
Data yang sudah diurutkan array 6: [106, 264, 571, 582, 714, 722, 811, 845, 917, 995]
Waktu eksekusi: 0.000032 detik
Data mentah array 7: [176, 707, 13, 316, 30, 275, 101, 321, 102, 251]
Data yang sudah diurutkan array 7: [13, 30, 101, 102, 176, 251, 275, 316, 321, 707]
Waktu eksekusi: 0.000125 detik
Data mentah array 8: [274, 270, 285, 737, 824, 689, 627, 229, 478, 724]
Data yang sudah diurutkan array 8: [229, 270, 274, 285, 478, 627, 689, 724, 737, 824]
Waktu eksekusi: 0.000026 detik
Data mentah array 9: [919, 348, 929, 818, 193, 29, 586, 85, 581, 654]
Data yang sudah diurutkan array 9: [29, 85, 193, 348, 581, 586, 654, 818, 919, 929]
Waktu eksekusi: 0.000026 detik
Data mentah array 10: [899, 265, 573, 110, 40, 829, 108, 519, 228, 14]
Data yang sudah diurutkan array 10: [14, 40, 108, 110, 228, 265, 519, 573, 829, 899]
Waktu eksekusi: 0.000030 detik
Jumlah array yang belum terurutkan: 10
mpi@master:~/cloud$
Click in the virtual screen to send keystrokes
Easy Install is installing Ubuntu 64-bit. Internet connection is required for Ubuntu14.04 and higher version to install open-vm-tools.
To direct input to this VM, move the mouse pointer inside or press Ctrl+G.



Dari hasil program bubblesort dan numerik diatas, diketahui bahwa program yang dijalankan secara MPI dapat menghasilkan processing yang lebih cepat daripada yang tidak menggunakan MPI. Oleh karena itu, untuk program yang lebih rumit dan berat, akan sangat disarankan menggunakan multi-processing karena dapat sedikit menghemat waktu kerja.