

LAPORAN PRAKTIKUM ARSITEKTUR DAN ORGANISASI KOMPUTER



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**LABORATORIUM PERANGKAT KERAS
FAKULTAS ILMU KOMPUTER
UNIVERSITAS SRIWIJAYA
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Asti Ratna Shely (09030582226027) Sebagai Master

Widya Anggraini (09030582226025) Sebagai Slave 1

Wahyu Hidayat (09030582226009) Sebagai Slave 2

Muhammad Ivan (09030582226013) Sebagai Slave 3

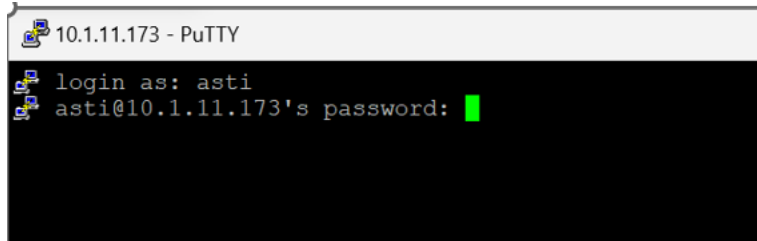
Msy. Nayla Vira (09030582226055) Sebagai Slave 4

Devices and Tools to Prepare

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

Penyusunan Master dan Slave:

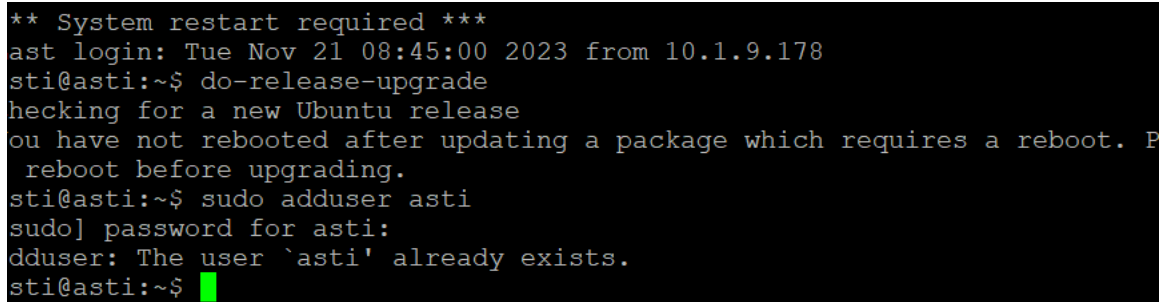
1. Pastikan setiap master dan slave menggunakan Network Bridge Adapter dan terhubung ke internet.
2. Tentukan perangkat mana yang akan menjadi master, slave1, slave2, slave 3 dan slave4.



```
10.1.11.173 - PuTTY
login as: asti
asti@10.1.11.173's password: █
```

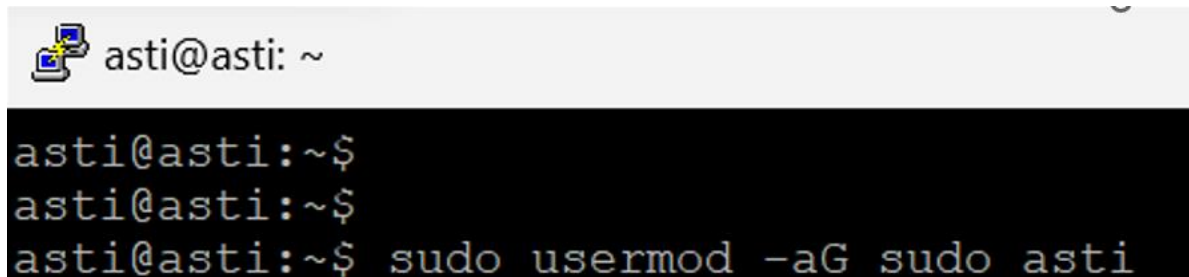
Pembuatan Pengguna Baru:

1. Buat pengguna baru dengan perintah berikut di master dan setiap slave: `sudo adduser mpiuser`



```
** System restart required **
ast login: Tue Nov 21 08:45:00 2023 from 10.1.9.178
sti@asti:~$ do-release-upgrade
Checking for a new Ubuntu release
You have not rebooted after updating a package which requires a reboot. Please
reboot before upgrading.
sti@asti:~$ sudo adduser asti
sudo] password for asti:
adduser: The user `asti' already exists.
sti@asti:~$ █
```

2. Berikan akses root kepada pengguna dengan perintah: `sudo usermod -aG sudo mpiuser`



```
asti@asti: ~
asti@asti:~$
asti@asti:~$
asti@asti:~$ sudo usermod -aG sudo asti
```

(Ulangi langkah di atas untuk setiap slave.)

3. Login ke Setiap Server:

Login ke setiap server dengan pengguna mpiuser: `su - mpiuser`

```
asti@asti:~$ su - asti
Password:
```

4. Pembaruan dan Instalasi Alat:

Perbarui Ubuntu Desktop dan instal alat yang diperlukan:

```
sudo apt update && sudo apt upgrade
```

```
sudo apt install net-tools vim
```

```
asti@asti:~$ sudo apt update && sudo apt upgrade
Hit:1 http://id.archive.ubuntu.com/ubuntu focal InRelease
Get:2 http://id.archive.ubuntu.com/ubuntu focal-updates InRelease [114 kB]
Hit:3 http://id.archive.ubuntu.com/ubuntu focal-backports InRelease
Hit:4 http://id.archive.ubuntu.com/ubuntu focal-security InRelease
Fetched 114 kB in 1s (192 kB/s)
Reading package lists... Done
Building dependency tree
Reading state information... Done
All packages are up to date.
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following packages were automatically installed and are no longer required:
  linux-headers-5.4.0-166 linux-headers-5.4.0-166-generic
  linux-image-5.4.0-166-generic linux-modules-5.4.0-166-generic
  linux-modules-extra-5.4.0-166-generic
Use 'sudo apt autoremove' to remove them.
Get another security update through Ubuntu Pro with 'esm-apps' enabled:
  libpmix2
Learn more about Ubuntu Pro at https://ubuntu.com/pro
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
asti@asti:~$ sudo apt install net-tools vim
Reading package lists... Done
Building dependency tree
Reading state information... Done
net-tools is already the newest version (1.60+git20180626.aebd88e-1ubuntu1).
vim is already the newest version (2:8.1.2269-1ubuntu5.20).
The following packages were automatically installed and are no longer required:
  linux-headers-5.4.0-166 linux-headers-5.4.0-166-generic
  linux-image-5.4.0-166-generic linux-modules-5.4.0-166-generic
  linux-modules-extra-5.4.0-166-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
asti@asti:~$
```

Konfigurasi File /etc/hosts:

Konfigurasi file /etc/hosts di master, slave1, slave2, slave3 dan slave4. Daftarkan IP dan nama host dari setiap komputer.

Konfigurasi SSH:

1. Instal OpenSSH di master dan semua slave: `sudo apt install openssh-server`

2. Buat kunci pada master: `ssh-keygen -t rsa`

3. Salin kunci publik ke setiap slave menggunakan perintah berikut di direktori `.ssh`:

`cd .ssh`

`cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"`

```
linux-headers-5.4.0-166 linux-headers-5.4.0-166-generic
linux-image-5.4.0-166-generic linux-modules-5.4.0-166-generic
linux-modules-extra-5.4.0-166-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
asti@asti:~$ ssh asti@slave2
ssh: Could not resolve hostname slave2: Temporary failure in name resolution
asti@asti:~$ cd .ssh
asti@asti:~/ssh$ cat id_rsa.pub | ssh asti@slave2 "mkdir .ssh; cat >> .ssh/
authorized_keys"
ssh: Could not resolve hostname slave2: Temporary failure in name resolution
asti@asti:~/ssh$ mkdir /home/asti/bubble
mkdir: cannot create directory '/home/asti/bubble': File exists
asti@asti:~/ssh$ sudo apt install nfs-kernel-server
Reading package lists... Done
Building dependency tree
Reading state information... Done
nfs-kernel-server is already the newest version (1:1.3.4-2.5ubuntu3.5).
The following packages were automatically installed and are no longer required:
linux-headers-5.4.0-166 linux-headers-5.4.0-166-generic
linux-image-5.4.0-166-generic linux-modules-5.4.0-166-generic
linux-modules-extra-5.4.0-166-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Ulangi perintah untuk setiap slave.

Konfigurasi NFS:

1. Buat folder bersama di master dan setiap slave: `mkdir /home/mpiuser/bubble`
2. Instal NFS di master: `sudo apt install nfs-kernel-server`
3. Konfigurasi file `/etc/exports` di master. Tambahkan baris berikut di akhir file:

```
/home/mpiuser/bubble *(rw,sync,no_root_squash,no_subtree_check)
```

4. Restart Server NFS:

```
sudo exportfs -a
```

```
sudo systemctl restart nfs-kernel-server
```

5. Instal NFS di setiap slave: `sudo apt install nfs-common`

6. Mount folder bersama dari master ke setiap slave: `sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble`

Ulangi perintah untuk setiap slave.

```
asti@asti:~/ssh$ /home/asti/bubble *(rw,sync,no_root_squash,no_subtree_check)
bash: /home/asti/bubble: Is a directory
asti@asti:~/ssh$ sudo exportfs -a
asti@asti:~/ssh$ sudo systemctl restart nfs-kernel-server
asti@asti:~/ssh$
asti@asti:~/ssh$ sudo apt install nfs-common
Reading package lists... Done
Building dependency tree
Reading state information... Done
```

```
asti@asti:~/ssh$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
libopenmpi-dev is already the newest version (4.0.3-0ubuntu1).
openmpi-bin is already the newest version (4.0.3-0ubuntu1).
The following packages were automatically installed and are no longer required:
  linux-headers-5.4.0-166 linux-headers-5.4.0-166-generic
  linux-image-5.4.0-166-generic linux-modules-5.4.0-166-generic
  linux-modules-extra-5.4.0-166-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
asti@asti:~/ssh$
```

Instalasi MPI:

1. Instal Open MPI di master dan semua slave: `sudo apt install openmpi-bin libopenmpi-dev`
2. Instal pustaka MPI melalui pip: `sudo apt install python3-pip` `pip install mpi4py`

```
asti@asti:~/ssh$ sudo apt install python3-pip
Reading package lists... Done
Building dependency tree
Reading state information... Done
python3-pip is already the newest version (20.0.2-5ubuntu1.10).
The following packages were automatically installed and are no longer required:
  linux-headers-5.4.0-166 linux-headers-5.4.0-166-generic
  linux-image-5.4.0-166-generic linux-modules-5.4.0-166-generic
  linux-modules-extra-5.4.0-166-generic
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
asti@asti:~/ssh$ pip install mpi4py
Defaulting to user installation because normal site-packages is not writeable
Collecting mpi4py
  Using cached mpi4py-3.1.5.tar.gz (2.5 MB)
  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) ... -
```

Menjalankan Kode Python - Bubble Sort:

1. Buat file Python baru: `touch /home/mpiuser/bubble/bubble.py`
2. Buka direktori tersebut dan edit file Python: `cd /home/mpiuser/bubble`

Isi file Python Bubble Sort, simpan dengan menekan CTRL + X dan tekan Y.

`nano bubble.py`

Menjalankan Kode:

Jalankan kode pada master: `mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py`

Hasil Keluaran:

Jika keluaran seperti ini muncul, prosesnya telah berhasil. Menampilkan hasil keluaran pada master dan slave, dengan keluaran adalah 4, yang merupakan keluaran dari master, slave1, slave2, dan slave3. Yang diurutkan di sini adalah array: [5, 3, 4, 1, 2] diurutkan menjadi [1, 2, 3, 4, 5].

```

asti@asti: ~/bubble
Preparing metadata (pyproject.toml) ... done
Building wheels for collected packages: mpi4py
Building wheel for mpi4py (pyproject.toml) ... !
Cancelled
ERROR: Operation cancelled by user
asti@asti:~/.ssh$ touch /home/asti/bubble/bubble.py
asti@asti:~/.ssh$ cd /home/asti/bubble
asti@asti:~/bubble$ mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py
ssh: Could not resolve hostname slave3: Temporary failure in name resolution
ssh: Could not resolve hostname master: Temporary failure in name resolution
ssh: Could not resolve hostname slave2: Temporary failure in name resolution
-----
ORTE was unable to reliably start one or more daemons.
This usually is caused by:

* not finding the required libraries and/or binaries on
  one or more nodes. Please check your PATH and LD_LIBRARY_PATH
  settings, or configure OMPI with --enable-orterun-prefix-by-default

* lack of authority to execute on one or more specified nodes.
  Please verify your allocation and authorities.

* the inability to write startup files into /tmp (--tmpdir/orte_tmpdir_base).
  Please check with your sys admin to determine the correct location to use.

* compilation of the orted with dynamic libraries when static are required
  (e.g., on Cray). Please check your configure cmd line and consider using
  one of the contrib/platform definitions for your system type.

* an inability to create a connection back to mpirun due to a
  lack of common network interfaces and/or no route found between
  them. Please check network connectivity (including firewalls
  and network routing requirements).
-----
ORTE does not know how to route a message to the specified daemon
located on the indicated node:

  my node:   asti
  target node: slave1

This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed=direct on the command line or
in your environment. We apologize for the problem.
-----
[asti:l20376] 2 more processes have sent help message help-errmgr-base.txt / no-pat
[asti:l20376] Set MCA parameter "orte_base_help_aggregate" to 0 to see all help / e
asti@asti:~/bubble$

```

```

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]

```

1. Ubuntu Desktop adalah sistem operasi berbasis Linux yang didesain untuk penggunaan desktop. Anda memiliki beberapa mesin Ubuntu Desktop yang akan berperan sebagai master dan slave dalam lingkungan komputasi terdistribusi.
2. MPI (Master and Slave) adalah standar komunikasi yang digunakan untuk memungkinkan komunikasi antar proses pada suatu sistem komputasi terdistribusi. Dalam konteks Anda, MPI akan digunakan untuk mengkoordinasikan komputasi di antara node-node (master dan slave) pada lingkungan terdistribusi.
3. SSH (Master and Slave) adalah protokol keamanan yang digunakan untuk mengamankan koneksi jaringan. Dalam konteks ini, SSH akan digunakan untuk mengelola akses dan komunikasi antara master dan slave. Misalnya, untuk mengirim perintah dari master ke slave atau untuk menjalankan kode di remote.
4. NFS (Master and Slave) NFS (Network File System) adalah protokol untuk berbagi sistem berkas (file system) di jaringan. Pada lingkungan ini, NFS akan digunakan untuk memungkinkan berbagi file atau direktori di antara master dan slave, sehingga semua node dapat mengakses sumber daya yang sama.
5. Python Bubble Sort Code Kode Python untuk Bubble Sort akan menjadi aplikasi atau tugas yang akan dijalankan di lingkungan terdistribusi ini. Kode ini akan dipecah menjadi tugas-tugas kecil yang akan dijalankan oleh setiap slave di bawah koordinasi master menggunakan MPI.

Asti Ratna Shely (09030582226027) Sebagai Master

```
asti@asti: ~/bubble
touch /home/mpiuser/bubble/bubble.py
^canceled
ERROR: Operation cancelled by user
asti@asti:~/ssh$ touch /home/asti/bubble/bubble.py
asti@asti:~/ssh$ cd /home/asti/bubble
asti@asti:~/bubble$ nano bubble.py
asti@asti:~/bubble$ mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py
ssh: Could not resolve hostname slave2: Temporary failure in name resolution
-----
ORTE was unable to reliably start one or more daemons.
This usually is caused by:

* not finding the required libraries and/or binaries on
  one or more nodes. Please check your PATH and LD_LIBRARY_PATH
  settings, or configure OMPI with --enable-orterun-prefix-by-default

* lack of authority to execute on one or more specified nodes.
  Please verify your allocation and authorities.

* the inability to write startup files into /tmp (--tmpdir/orte_tmpdir_base).
  Please check with your sys admin to determine the correct location to use.

* compilation of the orted with dynamic libraries when static are required
  (e.g., on Cray). Please check your configure cmd line and consider using
  one of the contrib/platform definitions for your system type.

* an inability to create a connection back to mpirun due to a
  lack of common network interfaces and/or no route found between
  them. Please check network connectivity (including firewalls
  and network routing requirements).

-----
ORTE does not know how to route a message to the specified daemon
located on the indicated node:

my node: asti
target node: master

This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed-direct on the command line or
in your environment. We apologize for the problem.

[asti:112971] 2 more processes have sent help message help-errmgr-base.txt / no-path
[asti:112971] Set MCA parameter "orte_base_help_aggregate" to 0 to see all help / error messa
ges
ssh: Could not resolve hostname master: Temporary failure in name resolution
asti@asti:~/bubble$
```

Widya Anggraini (09030582226025) Sebagai Slave 1

```
asti@asti: ~/bubble
Preparing metadata (pyproject.toml) ... done
Building wheels for collected packages: mpi4py
  Building wheel for mpi4py (pyproject.toml) ... |
^canceled
ERROR: Operation cancelled by user
asti@asti:~/ssh$ touch /home/asti/bubble/bubble.py
asti@asti:~/ssh$ cd /home/asti/bubble
asti@asti:~/bubble$ mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py
ssh: Could not resolve hostname slave3: Temporary failure in name resolution
ssh: Could not resolve hostname master: Temporary failure in name resolution
ssh: Could not resolve hostname slave2: Temporary failure in name resolution
-----
ORTE was unable to reliably start one or more daemons.
This usually is caused by:

* not finding the required libraries and/or binaries on
  one or more nodes. Please check your PATH and LD_LIBRARY_PATH
  settings, or configure OMPI with --enable-orterun-prefix-by-default

* lack of authority to execute on one or more specified nodes.
  Please verify your allocation and authorities.

* the inability to write startup files into /tmp (--tmpdir/orte_tmpdir_base).
  Please check with your sys admin to determine the correct location to use.

* compilation of the orted with dynamic libraries when static are required
  (e.g., on Cray). Please check your configure cmd line and consider using
  one of the contrib/platform definitions for your system type.

* an inability to create a connection back to mpirun due to a
  lack of common network interfaces and/or no route found between
  them. Please check network connectivity (including firewalls
  and network routing requirements).

-----
ORTE does not know how to route a message to the specified daemon
located on the indicated node:

my node: asti
target node: slave1

This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed-direct on the command line or
in your environment. We apologize for the problem.

[asti:120376] 2 more processes have sent help message help-errmgr-base.txt / no-path
[asti:120376] Set MCA parameter "orte_base_help_aggregate" to 0 to see all help / error messages
asti@asti:~/bubble$
```

Wahyu Hidayat (09030582226009) Sebagai Slave 2

```
* compilation of the orted with dynamic libraries when static are required
(e.g., on Cray). Please check your configure cmd line and consider using
one of the contrib/platform definitions for your system type.


* an inability to create a connection back to mpirun due to a
lack of common network interfaces and/or no route found between
them. Please check network connectivity (including firewalls
and network routing requirements).

-----
ORTE does not know how to route a message to the specified daemon
located on the indicated node:

my node:   asti
target node: slave2

This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed=direct on the command line or
in your environment. We apologize for the problem.

-----
asti@asti:~$
```



Muhammad Ivan (09030582226013) Sebagai Slave 3

```
asti@asti: ~/ssh
This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed=direct on the command line or
in your environment. We apologize for the problem.

-----
asti@asti:~/ssh$ mpirun -np 4 -host master,slave3 python3 bubble.py
ssh: Could not resolve hostname master: Temporary failure in name resolution

ORTE was unable to reliably start one or more daemons.
This usually is caused by:

* not finding the required libraries and/or binaries on
one or more nodes. Please check your PATH and LD_LIBRARY_PATH
settings, or configure OMPI with --enable-orterun-prefix-by-default

* lack of authority to execute on one or more specified nodes.
Please verify your allocation and authorities.

* the inability to write startup files into /tmp (--tmpdir/orte tmpdir base).
Please check with your sys admin to determine the correct location to use.

* compilation of the orted with dynamic libraries when static are required
(e.g., on Cray). Please check your configure cmd line and consider using
one of the contrib/platform definitions for your system type.

* an inability to create a connection back to mpirun due to a
lack of common network interfaces and/or no route found between
them. Please check network connectivity (including firewalls
and network routing requirements).

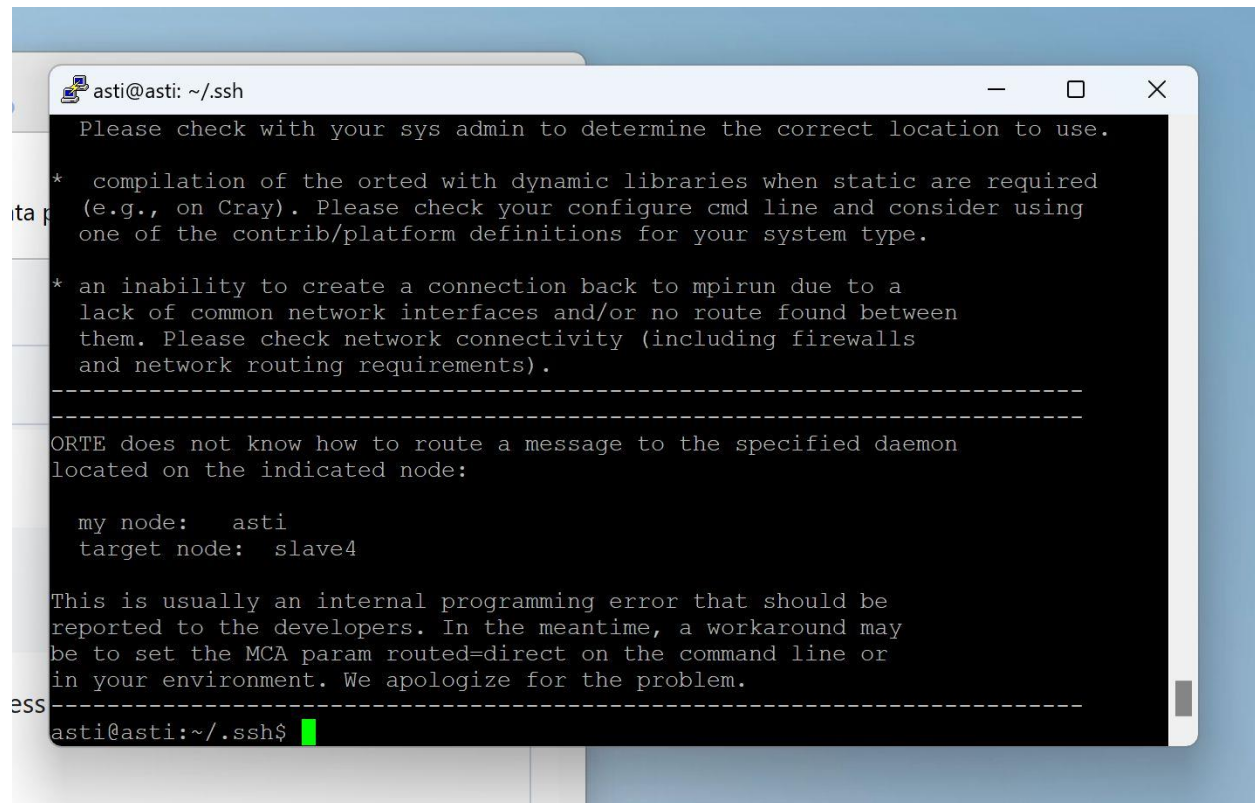
-----
ORTE does not know how to route a message to the specified daemon
located on the indicated node:

my node:   asti
target node: slave3

This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed=direct on the command line or
in your environment. We apologize for the problem.

-----
asti@asti:~/ssh$
```

Msy. Nayla Vira (09030582226055) Sebagai Slave4



A terminal window titled 'asti@asti: ~/.ssh' with standard window controls. The terminal displays an error message from ORTE. The message includes two bullet points: one about compilation of orted with dynamic libraries and another about network connectivity. It then states that ORTE does not know how to route a message to a daemon on a specific node, showing 'my node: asti' and 'target node: slave4'. A workaround is suggested: setting the MCA param 'routed=direct' on the command line or in the environment. The terminal ends with the prompt 'asti@asti:~/.ssh\$' and a green cursor.

```
asti@asti: ~/.ssh
Please check with your sys admin to determine the correct location to use.

* compilation of the orted with dynamic libraries when static are required
(e.g., on Cray). Please check your configure cmd line and consider using
one of the contrib/platform definitions for your system type.

* an inability to create a connection back to mpirun due to a
lack of common network interfaces and/or no route found between
them. Please check network connectivity (including firewalls
and network routing requirements).

-----
ORTE does not know how to route a message to the specified daemon
located on the indicated node:

    my node:  asti
    target node:  slave4

This is usually an internal programming error that should be
reported to the developers. In the meantime, a workaround may
be to set the MCA param routed=direct on the command line or
in your environment. We apologize for the problem.
-----
asti@asti:~/.ssh$
```