

LAPORAN RESMI
PRAKTIKUM ORGANISASI DAN
ARSITEKTUR KOMPUTER



JUDUL:
OpenMPI Parallel Computing Linux Ubuntu

Disusun Oleh :

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PROGRAM STUDI TEKNIK KOMPUTER
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I. Tujuan

1. Praktikum ini mampu menginstall openMPI Linux Ubuntu di virtual machine.
2. Praktikum ini mampu menginstall sistem operasi Linux Ubuntu di virtual machine.
3. Mahasiswa dalam praktikum ini akan memahami konsep-konsep openMPI Parallel Computing dan protokol SSH.

II. Dasar Teori

A. Definisi Virtual Machine

Virtual Machine adalah sebuah mesin virtual yang berjalan di atas mesin fisik. Mesin virtual ini dapat menjalankan sistem operasi yang berbeda dari sistem operasi yang berjalan di mesin fisik. Virtual machine dapat digunakan untuk berbagai keperluan, seperti pengujian perangkat lunak, pengembangan aplikasi, dan pembelajaran. Virtual machine adalah sebuah software yang memungkinkan kita untuk menjalankan sistem operasi lain di dalam sistem operasi kita. Sistem operasi yang dijalankan di dalam virtual machine disebut dengan guest operating system, sedangkan sistem operasi yang menjalankan virtual machine disebut dengan host operating system.

Linux Ubuntu adalah salah satu sistem operasi Linux yang paling populer dan banyak digunakan. Sistem operasi ini bersifat open source dan dapat diunduh secara gratis. Ubuntu tersedia dalam berbagai edisi, mulai dari edisi desktop hingga edisi server. Linux Ubuntu adalah sistem operasi Linux yang dikembangkan oleh Canonical Ltd. Sistem operasi ini berbasis Debian dan menggunakan kernel Linux. Ubuntu tersedia dalam berbagai edisi, mulai dari edisi desktop hingga edisi server.

Edisi desktop Ubuntu dirancang untuk digunakan pada komputer pribadi, sedangkan edisi server Ubuntu dirancang untuk digunakan pada server. Ubuntu juga tersedia dalam berbagai bahasa, termasuk bahasa Indonesia.

III. Kegiatan Praktikum

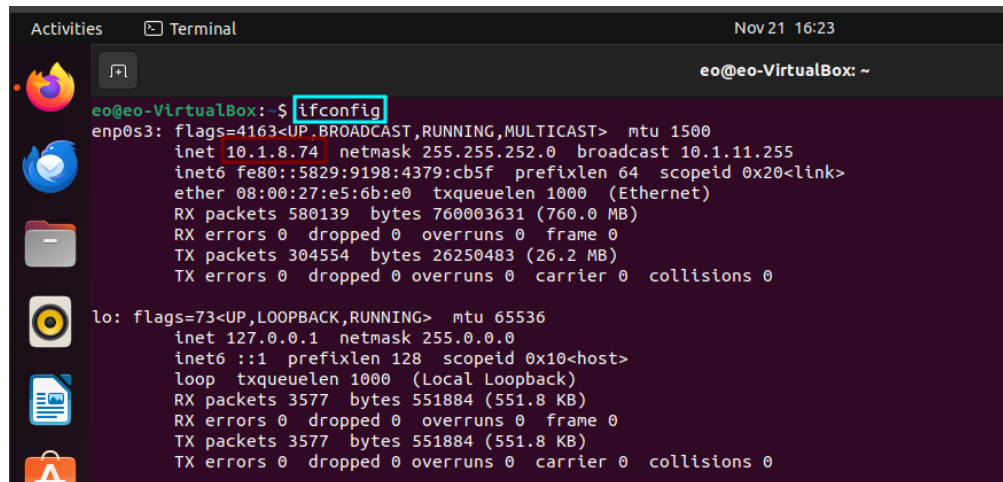
Komponen yang diperlukan :

1. Virtual Machine (Virtual Box 7.0.12)
2. Ip address
3. Putty

1. Hubungkan Linux Ubuntu dengan ip address

Disini saya akan memberikan cara, bagaimana menginstall os Linux Ubuntu di dalam Virtual Machine.

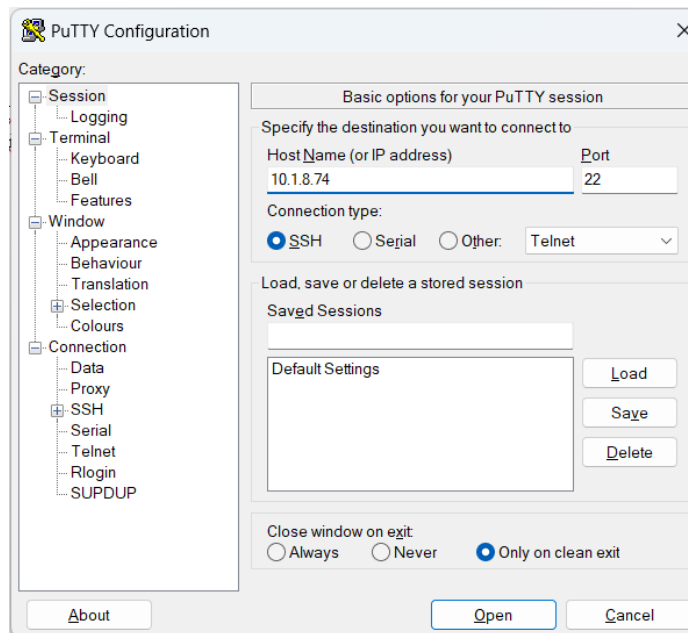
- Cek ip address kalian lewat linux ubuntu dengan perintah “ifconfig”



```
eo@eo-VirtualBox:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.1.8.74 netmask 255.255.252.0 broadcast 10.1.11.255
    inet6 fe80::5829:9198:4379:cb5f prefixlen 64 scopeid 0x20<link>
    ether 08:00:27:e5:6b:e0 txqueuelen 1000 (Ethernet)
    RX packets 580139 bytes 760003631 (760.0 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 304554 bytes 26250483 (26.2 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 3577 bytes 551884 (551.8 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 3577 bytes 551884 (551.8 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

- Buka Putty



2. Buat Master dengan Putty

- Masukan username dan password dan Update sistem agar terbaru dengan perintah “sudo apt update”

```
Putty (inactive)
login as: eo
eo@10.1.8.74's password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.2.0-36-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

*** System restart required ***
Last login: Wed Nov 15 10:05:42 2023 from 10.1.10.90
eo@eo-VirtualBox:~$ sudo apt update
[sudo] password for eo:
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
E: Release file for http://id.archive.ubuntu.com/ubuntu/dists/jammy-updates/InRelease is not valid yet (invalid for another 6d 2h 8min 38s). Updates for this repository will not be applied.
E: Release file for http://security.ubuntu.com/ubuntu/dists/jammy-security/InRelease is not valid yet (invalid for another 6d 3h 29min 49s). Updates for this repository will not be applied.
```

- Upgrade dengan perintah “sudo apt upgrade”

```
PuTTY (inactive)
eo@eo-VirtualBox:~$ sudo apt upgrade
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
The following packages were automatically installed and are no longer required:
  libaio1 libevent-pthreads-2.1-7 libmecab2 libprotobuf-lite23 mecab-ipadic
  mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
The following packages have been kept back:
  gjs libgjs0g
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
```

- Buat pengguna baru dengan perintah berikut pada master dengan perintah “sudo adduser mpiuser”
- Berikan akses root dengan perintah “sudo usermod -aG sudo mpiuser”
- Masuk ke setiap server dengan pengguna mpiuser “su - mpiuser”
- Perbarui sistem dan install vim dengan perintah “sudo apt update” & “sudo apt install net-tools vim”

```

eo@eo-VirtualBox:~$ sudo adduser mpiuser
adduser: The user 'mpiuser' already exists.
eo@eo-VirtualBox:~$ sudo usermod -aG sudo mpiuser
eo@eo-VirtualBox:~$ su - mpiuser
Password:
mpiuser@eo-VirtualBox:~$ sudo apt update && sudo apt upgrade
sudo apt install net-tools vim
[sudo] password for mpiuser:
Hit:1 http://id.archive.ubuntu.com/ubuntu jammy InRelease
Hit:2 http://id.archive.ubuntu.com/ubuntu jammy-backports InRelease
Get:3 http://id.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Reading package lists... Done
E: Release file for http://id.archive.ubuntu.com/ubuntu/dists/jammy-updates/InRelease is not
valid yet (invalid for another 6d 2h 6min 50s). Updates for this repository will not be appli
ed.
E: Release file for http://security.ubuntu.com/ubuntu/dists/jammy-security/InRelease is not v
alid yet (invalid for another 6d 3h 28min 1s). Updates for this repository will not be applie
d.
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).
The following packages were automatically installed and are no longer required:

```

3. Konfigurasi SSH

- Instal OpenSSH pada master dengan perintah “sudo apt install openssh-server”
- Buat kunci dengan perintah “ssh-keygen -t rsa”
- Salin kunci publik ke setiap budak menggunakan perintah berikut di direktori .ssh :
“cd .ssh
cat id_rsa.pub | ssh mpiuser@master "mkdir .ssh; cat >> .ssh/authorized_keys"”
- Save key dengan perintah “/home/mpiuser/.ssh/id_rsa”

```

PuTTY (inactive)
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@eo-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).
The following packages were automatically installed and are no longer required:
  libaio1 libevent-pthreads-2.1-7 libmecab2 libprotobuf-lite23 mecab-ipadic
  mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@eo-VirtualBox:~$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/mpiuser/.ssh/id_rsa): /home/mpiuser/.ssh/id_rsa
Created directory '/home/mpiuser/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/mpiuser/.ssh/id_rsa
Your public key has been saved in /home/mpiuser/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:7+M+lJfko07b1UEfzKSecQwjhhooz7MkoFpPhazx9tTA mpiuser@eo-VirtualBox
The key's randomart image is:
+---[RSA 3072]-----+
|      o . . .      |
|      o . . o . . |
| .      . o  * = . |
| . + . . .      * o |
| = = E . S      . |
| . O + + . . . . |
| . B = . . o + . |
| + . . . o = o = . |
|      = B = . o   |
+---[SHA256]-----+

```

4. Konfigurasi NFS

- Buat folder bersama pada master
“mkdir /home/mpiuser/bubble”
- Install NFS pada Master
“sudo apt install nfs-kernel-server”
- Konfigurasi /etc/exports file pada master:
“/home/mpiuser/bubble *(rw,sync,no_root_squash,no_subtree_check)”
- Mulai ulang dengan perintah :
“sudo exportfs -a
sudo systemctl restart nfs-kernel-server”
- Instal NFS pada setiap budak dengan perintah “sudo apt install nfs-common”
- Pasang folder bersama dari master ke setiap budak dengan perintah “sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble”

```
Putty (inactive)
|
|      =B=.o |
|      +----[SHA256]-----+
mpiuser@eo-VirtualBox:~$ cd .ssh
cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"
ssh: Could not resolve hostname slave1: Temporary failure in name resolution
mpiuser@eo-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"
ssh: Could not resolve hostname slave1: Temporary failure in name resolution
mpiuser@eo-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"
ssh: Could not resolve hostname slave1: Temporary failure in name resolution
mpiuser@eo-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh mpiuser@slave1 "mkdir .ssh; cat >> .ssh/authorized_keys"
ssh: Could not resolve hostname slave1: Temporary failure in name resolution
mpiuser@eo-VirtualBox:~/.ssh$ cat id_rsa.pub | ssh eo@master "mkdir .ssh; cat >> .ssh/authorized_keys"
ssh: Could not resolve hostname master: Temporary failure in name resolution
mpiuser@eo-VirtualBox:~/.ssh$ mkdir /home/mpiuser/bubble
mkdir: cannot create directory '/home/mpiuser/bubble': File exists
mpiuser@eo-VirtualBox:~/.ssh$ sudo apt install nfs-kernel-server
[sudo] password for mpiuser:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
nfs-kernel-server is already the newest version (1:2.6.1-1ubuntu1.2).
The following packages were automatically installed and are no longer required:
  libaiol libevent-pthreads-2.1-7 libmecab2 libprotobuf-lite23 mecab-ipadic
  mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@eo-VirtualBox:~/.ssh$ /home/mpiuser/bubble *(rw,sync,no root squash,no subtree check)
-bash: /home/mpiuser/bubble: is a directory
mpiuser@eo-VirtualBox:~/.ssh$ sudo exportfs -a
sudo systemctl restart nfs-kernel-server
mpiuser@eo-VirtualBox:~/.ssh$ 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).
The following packages were automatically installed and are no longer required:
  libaiol libevent-pthreads-2.1-7 libmecab2 libprotobuf-lite23 mecab-ipadic
  mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
```

5. Instalasi MPI

- Instal Open MPI pada master dan semua slave dengan perintah “sudo apt install openmpi-bin libopenmpi-dev”

```

PuTTY (inactive)
mpiuser@eo-VirtualBox:~/.ssh$ sudo mount master:/home/mpiuser/bubble /home/mpiuser/bubble
^C
mpiuser@eo-VirtualBox:~/.ssh$ sudo apt install openmpi-bin libopenmpi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libaiol libmecab2 libprotobuf-lite23 mecab-ipadic mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
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 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 libtirpc-dev libtool libtsan0 libubsan1 libucx0 libxnvctrl0
  linux-libc-dev m4 manpages-dev ocl-icd-libopencl1 openmpi-common rpcsvc-proto zlib1g-dev
Suggested packages:

```

- Instal perpustakaan MPI melalui pip dengan perintah :

“sudo apt install python3-pip

pip install mpi4py”

```

PuTTY (inactive)
Processing triggers for libc-bin (2.35-0ubuntu3.4) ...
Processing triggers for man-db (2.10.2-1) ...
mpiuser@eo-VirtualBox:~/.ssh$ sudo apt install python3-pip
pip install mpi4py
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libaiol libmecab2 libprotobuf-lite23 mecab-ipadic mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:

```

```

PuTTY (inactive)
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 2 not upgraded.
mpiuser@eo-VirtualBox:~/bubble$ sudo apt install python3-pip
pip install mpi4py
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libaiol libmecab2 libprotobuf-lite23 mecab-ipadic mecab-ipadic-utf8 mecab-utils
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  build-essential dpkg-dev fakeroot g++ g++-11 libalgorithm-diff-perl
  libalgorithm-diff-xs-perl libalgorithm-merge-perl libdpkg-perl libexpat1-dev libfakeroot
  libfile-fcntllock-perl libjs-sphinxdoc libjs-underscore libpython3-dev libpython3.10-dev
  libstdc++-11-dev lto-disabled-list make python3-dev python3-distutils python3-setuptools
  python3-wheel python3.10-dev

```

6. Jalankan Python

- Buat file Python baru:
“touch /home/mpiuser/bubble/bubble.py”

- Arahkan ke direktori itu dan edit file Python:

“cd /home/mpiuser/bubble

nano bubble.py”

- Jalankan pada master dengan kode :

“mpirun -np 4 -host master,slave1,slave2,slave3 python3 bubble.py”

Putty (inactive)

```
nano bubble.py
mpiuser@eo-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
ssh: Could not resolve hostname slave1: Temporary failure in name resolution
ssh: Could not resolve hostname slave2: Temporary failure in name resolution
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:  eo-VirtualBox
  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.

-----
[eo-VirtualBox:47522] 2 more processes have sent help message help-errmgr-base.txt / no-path
[eo-VirtualBox:47522] Set MCA parameter "orte_base_help_aggregate" to 0 to see all help / err
or messages
```


- **Kesimpulan**

Menginstall OpenMPI pada Ubuntu bertujuan untuk memungkinkan pengembangan dan eksekusi program paralel menggunakan Message Passing Interface (MPI). MPI adalah sebuah standar yang digunakan untuk komunikasi antar proses pada sistem komputasi paralel. Berikut adalah beberapa kesimpulan yang dapat diambil setelah menginstall OpenMPI pada Ubuntu

Kemampuan Komputasi Paralel OpenMPI memungkinkan pengguna untuk mengembangkan dan menjalankan program paralel, di mana tugas-tugas dapat dipecah menjadi potongan-potongan yang dapat dijalankan secara bersamaan pada beberapa prosesor atau node.

Peningkatan Kinerja Dengan menggunakan OpenMPI, Anda dapat memanfaatkan potensi komputasi paralel untuk meningkatkan kinerja aplikasi Anda. Program yang dirancang dengan MPI dapat dijalankan pada kluster komputer, superkomputer, atau bahkan mesin multiprosesor sederhana.

Komunikasi Antar Proses: OpenMPI menyediakan fungsi-fungsi komunikasi antar proses yang memungkinkan proses-proses yang berjalan secara paralel untuk saling berkomunikasi, bertukar data, dan bekerja bersama.