

# HIGH PERFORMANCE COMPUTING DIGITAL ASSIGNMENT

SHANTANU - 17BCE1161

**SUBMITTED TO: DR S. HARINI**

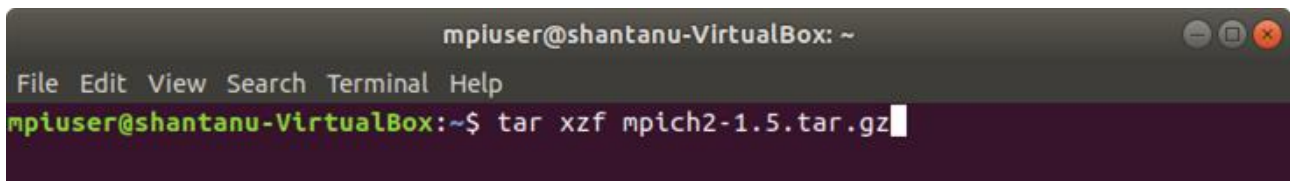
## MPICH2 CLUSTER ON A LAN (MPICH2)

**PREREQUISITE:**

- You should be able to ping between your devices(laptops/PC's).
- If working on Virtual Machines, then select Bridged Network Adapter under network settings.

**1)INSTALLING MPICH2:**

- a) Download the latest version of mpich2 from “mpich.org”.
- b) Unpack the tar file using the following command:

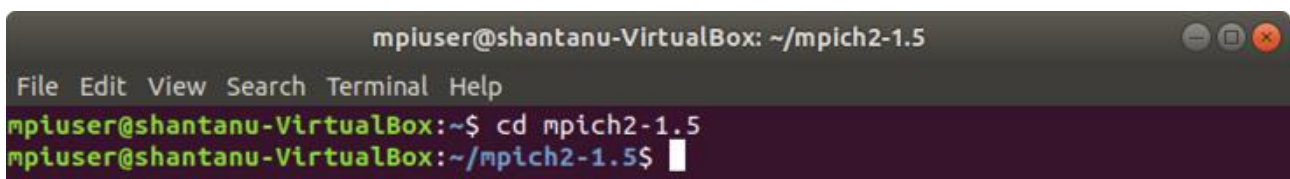
A terminal window titled 'mpiuser@shantanu-VirtualBox: ~' with a menu bar (File, Edit, View, Search, Terminal, Help). The command 'tar xzf mpich2-1.5.tar.gz' is entered at the prompt.

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ tar xzf mpich2-1.5.tar.gz
```

**NOTE:** If your tar doesn't accept the z option, use:

**gunzip mpich2-1.5.tar.gz  
tar xf mpich2-1.5.tar**

- c) Move to the top-level directory after unpacking the files:
- d) Choose an installation directory, say /home/<USERNAME>/mpich2-install, which is assumed to non-existent or empty. It will be most convenient if this directory is shared by all of the machines where you intend to run processes. If not, you will have to duplicate it on the other machines after installation.
- e) Configure the MPICH2 specifying the installation directory:

A terminal window titled 'mpiuser@shantanu-VirtualBox: ~/mpich2-1.5' with a menu bar (File, Edit, View, Search, Terminal, Help). The command 'cd mpich2-1.5' is entered at the prompt.

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ cd mpich2-1.5  
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$
```

**(NOTE:** If “FORTRAN” is not installed in your machine then either install it or disable it in this step.)

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ ./configure --prefix=/home/mpiuser/mpich2-install 2>&1 | tee c.txt
```

f) Build MPICH2:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ make 2>&1 | tee m.txt
```

g) Install the MPICH2 commands:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ make install 2>&1 | mi.txt
```

h) Add the bin subdirectory of the installation directory to your path in your startup script:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ PATH=/home/mpiuser/mpich2-install/bin:$PATH ; export PATH
```

**IMPORTANT NOTE:** The install directory has to be visible at exactly the same path on all machines you want to run your applications on. This is typically achieved by installing MPICH2 on a shared NFS file-system. If you do not have a shared NFS directory, you will need to manually copy the install directory to all machines at exactly the same location.

i) At this point we check whether everything is in order by executing the following commands:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ which mpicc
/usr/bin/mpicc
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ which mpiexec
/usr/bin/mpiexec
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ which mpirun
/usr/bin/mpirun
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$
```

ii) Executing the example program provided in the mpich2 package:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ mpirun -n 1 ./examples/cpi
Process 0 of 1 is on shantanu-VirtualBox
pi is approximately 3.1415926544231341, Error is 0.0000000008333410
wall clock time = 0.000444
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$
```

## 2) EDIT THE “/etc/hosts” FILE:

Edit the above mentioned file so that there is no need to remember the ip-addresses of every client every time. We can assign aliases to the ip-addresses so that we can refer the client using the aliases.

```
mpiuser@shantanu-VirtualBox: ~
File Edit View Search Terminal Help
mpiuser@shantanu-VirtualBox:~$ cat /etc/hosts
127.0.0.1    localhost
127.0.1.1    shantanu-VirtualBox

# 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

192.168.43.202 client
192.168.43.205 master
192.168.43.135 client2
mpiuser@shantanu-VirtualBox:~$
```

Here master and client are aliases for the master and client machines respectively.

## 3) ADD ANOTHER USER

We add another user, here named “mpiuser”, such that we can have a common user in all the nodes to keep things simple.

```
shantanu@shantanu-VirtualBox: ~
File Edit View Search Terminal Help
shantanu@shantanu-VirtualBox:~$ sudo adduser mpiuser
```

**PS:** Do not use “useradd” instead of “adduser” as it does not create a separate home for different users.

#### 4) SETTING UP SSH:

The machines are going to talk over the ssh.

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo apt-get install openssh-server
```

#### 5) SWITCH TO THE NEWLY CREATED USER

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
shantanu@shantanu-VirtualBox:~$ su - mpiuser  
Password:  
mpiuser@shantanu-VirtualBox:~$
```

Since the ssh server is already installed, you must be able to login to other machines by ssh **username@hostname**, at which you will be prompted to enter the password of the username. To enable more easier login, we generate keys and copy them to other machines' list of `authorized_keys`.

#### 6) PASSWORDLESS LOGIN:

a) Generate a pair of authentication rsa keys using the ssh:

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ ssh-keygen -t rsa
```

b) Use ssh to create a directory `~/.ssh` as user on any Client(here Master) .  
(**Note:** The directory may already exist, which is fine):

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ ssh client mkdir -p .ssh
```

c) Append Master's new public key to `user@Client:~/.ssh/authorized_keys` and enter users's password one last time:

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ cat ~/.ssh/id_rsa.pub | ssh client 'cat >> ~/.ssh/authorized_keys'
```

d) The next login to the client will be passwordless.

```
mpiuser@abhishek-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@abhishek-VirtualBox:~$ ifconfig  
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
    inet 192.168.43.202 netmask 255.255.255.0 broadcast 192.168.43.255  
    inet6 2401:4900:2320:444a:1502:4352:31b2:410b prefixlen 64 scopeid 0x0  
<global>  
    inet6 fe80::cb26:bfc9:3481:ed24 prefixlen 64 scopeid 0x20<link>  
    inet6 2401:4900:2320:444a:ea5b:371:2baf:4253 prefixlen 64 scopeid 0x0<  
global>  
    ether 08:00:27:32:5d:14 txqueuelen 1000 (Ethernet)  
    RX packets 75 bytes 8262 (8.2 KB)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 188 bytes 27710 (27.7 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 716 bytes 51796 (51.7 KB)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 716 bytes 51796 (51.7 KB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
mpiuser@abhishek-VirtualBox:~$
```

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
    loop txqueuelen 1000 (Local Loopback)  
    RX packets 716 bytes 51796 (51.7 KB)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 716 bytes 51796 (51.7 KB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
mpiuser@abhishek-VirtualBox:~$ ssh master  
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 5.0.0-23-generic x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/advantage  
  
* Canonical Livepatch is available for installation.  
  - Reduce system reboots and improve kernel security. Activate at:  
    https://ubuntu.com/livepatch  
  
191 packages can be updated.  
109 updates are security updates.  
  
Your Hardware Enablement Stack (HWE) is supported until April 2023.  
Last login: Wed Nov  6 12:49:08 2019 from 192.168.43.202  
mpiuser@shantanu-VirtualBox:~$
```



## 7) INSTALLING NFS-SERVER:

You share a directory via NFS in **master** which the **client** mounts to exchange data.

a) Install the required packages:

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo apt-get install nfs-kernel-server
```

b) Create a common folder( here cloud) which we will share across the network.

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ mkdir cloud
```

c) To export the cloud directory, we will have to create an entry in the /etc/exports file.

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo nano /etc/exports
```

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
GNU nano 2.9.3 /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/mpiuser/cloud *(rw,sync,no_root_squash,no_subtree_check)  
  
[ Read 11 lines ]  
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos  
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
```

**PS:** Here instead of \* in the entry in the file you can add specific ip addresses

d) After making the entry in the /etc/exports file, we need to export the file system using **exportfs -a**

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo exportfs -a
```

e) After exporting the file system, restart the nfs server.

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo service nfs-kernel-server restart
```

## 8) NFS-CLIENT:

a) Install the required packages:

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo service nfs-common
```

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
loop txqueuelen 1000 (Local Loopback)  
RX packets 716 bytes 51796 (51.7 KB)  
RX errors 0 dropped 0 overruns 0 frame 0  
TX packets 716 bytes 51796 (51.7 KB)  
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
mpiuser@abhishek-VirtualBox:~$ ssh master  
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 5.0.0-23-generic x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:        https://ubuntu.com/advantage  
  
* Canonical Livepatch is available for installation.  
- Reduce system reboots and improve kernel security. Activate at:  
https://ubuntu.com/livepatch  
  
191 packages can be updated.  
109 updates are security updates.  
  
Your Hardware Enablement Stack (HWE) is supported until April 2023.  
Last login: Wed Nov 6 12:49:08 2019 from 192.168.43.202  
mpiuser@shantanu-VirtualBox:~$
```

d) Mounting the shared directory:

```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~$ sudo mount -t nfs master:/home/mpiuser/cloud ~/cloud
```

e) Checking the mounted directories:

```
mpiuser@abhishek-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@abhishek-VirtualBox:~$ df -h  
Filesystem      Size  Used Avail Use% Mounted on  
udev            1.5G   0    1.5G   0% /dev  
tmpfs           312M   1.6M  310M   1% /run  
/dev/sda1       40G    7.7G   30G   21% /  
tmpfs           1.6G   0    1.6G   0% /dev/shm  
tmpfs           5.0M   4.0K   5.0M   1% /run/lock  
tmpfs           1.6G   0    1.6G   0% /sys/fs/cgroup  
/dev/loop2      3.8M   3.8M   0 100% /snap/gnome-system-monitor/100  
/dev/loop3      90M    90M   0 100% /snap/core/7917  
/dev/loop6     157M   157M   0 100% /snap/gnome-3-28-1804/91  
/dev/loop4      15M    15M   0 100% /snap/gnome-characters/359  
/dev/loop10     1.0M   1.0M   0 100% /snap/gnome-logs/81  
/dev/loop8      89M    89M   0 100% /snap/core/7270  
/dev/loop13     1.0M   1.0M   0 100% /snap/gnome-logs/61  
/dev/loop7      55M    55M   0 100% /snap/core18/1223  
/dev/loop9      45M    45M   0 100% /snap/gtk-common-themes/1353  
/dev/loop1      3.8M   3.8M   0 100% /snap/gnome-system-monitor/107  
/dev/loop11     15M    15M   0 100% /snap/gnome-characters/296  
/dev/loop12     43M    43M   0 100% /snap/gtk-common-themes/1313  
/dev/loop15     55M    55M   0 100% /snap/core18/1066  
/dev/loop5      4.3M   4.3M   0 100% /snap/gnome-calculator/544  
/dev/loop14     4.3M   4.3M   0 100% /snap/gnome-calculator/536  
/dev/loop0     150M   150M   0 100% /snap/gnome-3-28-1804/71  
tmpfs           312M   32K   312M   1% /run/user/121  
tmpfs           312M   44K   312M   1% /run/user/1001  
master:/home/mpiuser/cloud 40G    8.1G   30G   22% /home/mpiuser/cloud  
mpiuser@abhishek-VirtualBox:~$
```

f) To make the mount permanent so you don't have to manually mount the shared directory everytime you do a system reboot, you can create an entry in your file systems table - i.e., /etc/fstab file like this:



```
mpiuser@shantanu-VirtualBox: ~  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~/cloud$ cat /etc/fstab  
# /etc/fstab: static file system information.  
#  
# Use 'blkid' to print the universally unique identifier for a  
# device; this may be used with UUID= as a more robust way to name devices  
# that works even if disks are added and removed. See fstab(5).  
#  
# <file system> <mount point> <type> <options> <dump> <pass>  
# / was on /dev/sda1 during installation  
#MPI CLUSTER SETUP  
M0:/home/mpiuser/cloud /home/mpiuser/cloud nfs  
UUID=22185d6f-ef73-4f9a-ac4f-c17fd0970de1 / ext4 errors=remount  
-ro 0 1  
/swapfile none swap sw  
0 0  
mpiuser@shantanu-VirtualBox:~/cloud$
```

## 9) RUNNING THE MPI PROGRAMS:

We will just run the sample program provided in the MPICH2 installation for now.

a) Running it on your own machine:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ mpirun -n 1 ./examples/cpi  
Process 0 of 1 is on shantanu-VirtualBox  
pi is approximately 3.1415926544231341, Error is 0.0000000008333410  
wall clock time = 0.000444  
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$
```

b) Running it on the master's machine:

```
mpiuser@shantanu-VirtualBox: ~/mpich2-1.5  
File Edit View Search Terminal Help  
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$ mpirun -n 1 ./examples/cpi  
Process 0 of 1 is on abhishek-VirtualBox  
pi is approximately 3.1415926544231341, Error is 0.0000000008333410  
wall clock time = 0.000444  
mpiuser@shantanu-VirtualBox:~/mpich2-1.5$
```